TNEA PWD
1910
1985
PLATINUM JUBILEE
MADRAS 5

TNEA
PWD

# ENGINEERS' GUIDE

TAMIL NADU ENGINEERING ASSOCIATION, PWD

# Engineers' Guide

*Compiled by :*

**Er. A. M. Babu** LCE, BE, MIE

*Published by :*

**Tamil Nadu Engineering Association, PWD.**

Chepauk, Madras — 600 005.

First Edition June 1985.

# Foreward

The Tamil Nadu Engineering Association, P.W.D. is bringing out with much jubilance this Engineers' Guide in commemoration of Platinum Jubilee, for the daily reference of member engineers in particular and the Engineers at large.

The important assignment of compilation of facts and figures, rather a task was entrusted to our senior member engineer Thiru A. M. Babu, LCE, BE, MIE. It is simply to be acknowledged that he has fulfilled the assignment to the commendable magnitude. The T.N.E.A. records his name in its annals of history.

Our heart-felt thanks are due to one and all who co-operated in publishing this valuable book.

Suggestions from every quarter are heartily welcome so that they could be incorporated in further editions.

**Er. C. P. Shanmugam**
President

**Er. R. Sriraman**
General Secretary

Madras
May 28th 1985.

**Er. A. Subramaniam**
Secretary - Publication

# Preface

Tamil Nadu Engineering Association, P.W.D. is proudly presenting this Engineers' Guide during its Platinum Jubilee. This Engineers' Guide consists of 14 chapters dealing with mainly Civil Engineering and certain extent of Electrical Engineering applicable to P.W.D. for day-to-day reference. Accordingly particulars have been furnished in most cases briefly and pointedly. However detailed notes and guidelines are given on some chapters, wherever found necessary.

Engineering is a growing science and hence certain datas are liable for change in the years to come. Such change can be noted in the blank pages left with this book at the end. It is to be borne in mind that this book has to be taken purely as a Guide and not to be produced as a code book of authority.

Personally speaking, I have been entrusted to project this voluminous work which could not have been achieved but for the guidance, assistances and helps rendered by Central Office bearers, our Senior Engineers Er. I. Abbas Manthri, Er. A Balasubramanian, Er. A. S. Ramaswamy and Er. A. E. S. Mariadoss, pioneers of association, Member Engineers Er. R. Pattayan, Er. B. Veeraragavan, Er. P. N. Sankara Raman, Er. M. Shankar, Er. S. Hanif, Er. M. Bhoopalan and others. I thank all of them.

It is to be acknowledged that M/s. Sri Vinayaka Instant Photo Typeset have undertaken the photo typesetting process, a computer method of work, which is required for offset printing, with zeal of dedication. Particularly Mr. R. Sundar, Proprietor and Mr. S. V. Mohan Rau, Chief Operator are to be mentioned here for their sincere efforts.

Again our sincere thanks are due to M/s. Colour Lithography, Madras 6, and M/s. Print Systems & Products, Madras 14, for their kind co-operation for quick accomplishment of printing work.

Here is the proper place to express my benevolent thanks to the TNEA for this historical work of bringing out this Engineers' Guide on the eve of Platinum Jubilee on June 1st and 2nd 85 at Madras.

Madras.
May 28th 1985.

**Er. A. M. Babu**

GRAMS : "PORIYALAR" PHONE : 841986

# TAMIL NADU ENGINEERING ASSOCIATION

## PUBLIC WORKS DEPARTMENT

(Established 1910)

(Recognised by the Govt. in G. O. Ms. No. 822, dated 27th September 1928)

## CHEPAUK, MADRAS — 600 005.

PORIYIYAL ILLAM : No. 10, Lal Mohamed Street, Triplicane, MADRAS – 600 005.

### MEMBERS OF CENTRAL CABINET

| | |
|---|---|
| President | **Er. C. P. Shanmugam**, L.C.E., B.E. |
| Vice-President | **Er. R. Venkatasubbu**, L.C.E. |
| General Secretary | **Er. R. Sriraman**, L.C.E., B.E. |
| Secretary-Organisation | **Er. V. Parthiban**, L.C.E. |
| Secretary-Headquarters | **Er. V. Kothandaraman**, L.C.E. |
| Secretary-Publication | **Er. A. Subramaniyam**, L.C.E., B.E. |
| Secretary-Finance | **Er. A. E. S. Mariadoss**, D.C.E. |
| Secretary-Legal | **Er. V. S. Janakiraman**, L.C.E., B.E. |
| Secretary-Porkum Nidhi | **Er. R. Ayyaswami**, L.C.E. |

Zonal Secretaries :

| | |
|---|---|
| North Zone | **Er. D. Rajkumar**, D.C.E. |
| East Zone | **Er. K. Pattabiraman**, L.C.E. |
| South Zone | **Er. A. R. Ramamoorthy**, L.C.E., B.E. |
| West Zone | **Er. M. Arumugam**, D.C.R.E., B.E. |

Important dates and events to be remembered by Members

| Date | Event |
|---|---|
| | |

## PERSONAL MEMORANDA

Name

Designation

Staff No.

Residential Address

Telephone No. Office ... Res

Date of Birth

Height ... Weight

Chest ... Blood Group

Date of last increment

Season Ticket No.

Bicycle/Scooter/M.C./Car No.

Regisrration expires on

Insurance Policy No. ... Expires on

Driving Licence No. ... Expires on

Bank Pass Book Nos.

Premium due

Premium due

G. P. F. Account No.

Gas Service Consumer No.

## History of Member's Service

Date of First appointment ..................................................

Date of Commencement of Probation ......................................

Date of Completion of Probation ..........................................

Year of TNPSC Selection : .................... Rank ......................

CE (Gl.) authority for
commencement of Probation :

CE (Gl.) authority for
Completion of Probation :

Year of passing Account Test : ........................ Reg. No.

Details of place of work :

| Period | | Posts held |
|---|---|---|
| From | To | |
| | | |

| Period | | Posts held |
|---|---|---|
| From | To | |
| | | |

## Details of Amount Paid to the Association by Members

| Receipt No. date | Name of Branch | Purpose |
|---|---|---|
| | | |

# Contents


| | | Page No. |
|---|---|---|
| I | **General Informations** | |
| 1.1. | Telegraphic greeting codes | 1 |
| 1.2. | Check your weight | 2 |
| 1.3. | State abreviated addresses | 3 |
| 1.4. | Distances between the important cities in India | 7 |
| 1.5. | Logrithms | 8 |
| 1.6. | Antilogrithms | 10 |
| 1.7. | Account Test for P.W.D. Officers and subordinates | 12 |
| 1.8. | Table of daily pay | 14 |
| II | **Technical Informations** | |
| 2.1. | Symbols, Atomic Numbers, Weights etc. of elements | 1 |
| 2.2. | Temperature | 2 |
| 2.3. | Decimal equivalents of fraction of an inch | 2 |
| 2.4. | Metric measures | 3 |
| 2.5. | Functions of 'g' | 3 |
| 2.6. | Table of regular polygons | 3 |
| 2.7. | Trignometrical ratios | 4 |
| 2.8. | Signs of the functions | 4 |
| 2.9. | Functions of angle in any quadrant | 4 |
| 2.10. | Functions of 0° to 360° | 4 |
| 2.11. | Value of $\pi$ | 5 |
| 2.12. | Soil Weight and angle of repose | 6 |
| 2.13. | Conversion factors | 7 |
| 2.14. | Conversion tables | 8 |
| 2.15. | Area of plane figures | 9 |
| 2.16. | Volume and surface of solids | 12 |
| 2.17. | Weight of engineering materials | 15 |
| 2.18. | Common steel tables for square and round bars | 17 |
| 2.19. | Area of bars in given spacings | 18 |
| 2.20. | Areas of givn number of bars | 19 |
| 2.21. | Weight of steel sections | 20 |
| 2.22. | Weight of wrought iron | 21 |

| | | |
|---|---|---|
| 2.23. | Weight of steel sheets and plates | 21 |
| 2.24. | Weight of G. I. Sheets | 22 |
| 2.25. | Dimensions of A. C. Sheets | 22 |
| 2.26. | Weight of G. I. pipes | 23 |
| 2.27. | Weight of P. V. C. pipes | 23 |
| 2.28. | Safe permissible loads different soils | 24 |
| 2.29. | Coefficient of measurement for painting | 25 |
| 2.30. | Strength of stored cement | 26 |
| 2.31. | Production of coloured finishes | 26 |
| 2.32. | Physical requirement for various cements | 27 |
| 2.33. | Different types of cements | 28 |
| 2.34. | Field test for contamination of cement | 30 |
| 2.35. | Field test for sand | 31 |
| 2.36. | Removal of farmworks for concrete structures | 31 |
| 2.37. | Cement adequecy statement | 32 |
| 2.38. | Approximate working stress of engineering materials for dead loads | 34 |
| 2.39. | Safe permissible loads on masonry | 35 |
| 2.40. | Safe bearing capacity on soils | 36 |
| 2.41. | Economic standards of carpet area required | 36 |
| 2.42. | Rough estimation of cost of buildings | 37 |
| 2.43. | Inspection of temple car | 38 |

## III Departmental Informations

| | | |
|---|---|---|
| 3.1. | Powers of various officers | 1 |

## IV Service Informations

| | | |
|---|---|---|
| 4.1. | Fundamental service rules | 1 |
| 4.2. | Loans and advances | 14 |
| 4.3. | Disciplinary proceedings | 18 |
| 4.4. | Miscellaneous | 25 |

## V Association Informations

| | | |
|---|---|---|
| 5.1. | Constitution of TNEA | 1 |
| 5.2. | Rules and regulations for Ponkum Nidhi | 20 |

## VI Surveying and Levelling


| | | |
|---|---|---|
| 6.1. | Permanent adjustment for levelling instrument | 1 |
| 6.2. | Plane surveying | 3 |
| 6.3. | Ordinary leveling | 6 |
| 6.4. | Tacheometry | 8 |
| 6.5. | Arial Photogrammetry | 10 |
| 6.6. | Measurement of Land areas | 10 |
| 6.7. | Earthwork quantities | 11 |
| 6.8. | Elements of Curve setting | 13 |


## VII Architecture


| | | |
|---|---|---|
| 7.1. | Architectural designs | 1 |
| 7.2. | Colours | 4 |
| 7.3. | Planning of residential buildings | 7 |
| 7.4. | Horticulture | 11 |


## VIII Buildings


| | | |
|---|---|---|
| 8.1. | Loads and weight on foundations | 1 |
| 8.2. | Permissible loads on masonry | 2 |
| 8.3. | Superimposed (live) loads or floors | 3 |
| 8.4. | Design of foundation for buildings | 5 |
| 8.5. | Tamilnadu buildings (Lease and rent control) amendment act 1973 | 6 |
| 8.6. | Standards of Cinema Theatre buildings | 15 |
| 8.7. | Construction joints | 16 |
| 8.8. | Flush doors | 18 |
| 8.9. | Casement windows | 21 |
| 8.10. | Plinth area rates of buildings in Tamilnadu | 24 |
| 8.11. | For pile foundation rough cost | 25 |
| 8.12. | Rough cost godown and bus stands in moffussil | 26 |
| 8.13. | Types of footings showing economical and uneconomicl | 27 |

## IX Structural Engineering

| | | |
|---|---|---|
| 9.1. | Limit State Design Notes | 1 |
| 9.2. | Limit State Designs | 11 |
| 9.3. | Compression Members | 22 |
| 9.4. | Shear and Torsion | 24 |
| 9.5 | Bending Moment and Shearing Force in Members | 27 |
| 9.6. | Permissable design Stresses for Steel and concrete | 28 |
| 9.7. | Load Carrying capacity of R.C.C. columns | 30 |


## X Water Supply Engineering

| | | |
|---|---|---|
| 10.1. | Drinking water standards | 1 |
| 10.2. | Design Criteria | 4 |
| 10.3. | Yield from ground sources (water supplies) | 7 |
| 10.4. | Design for estimation of water supply | 14 |
| 10.5 | Allowable pressure in pipes | 15 |
| 10.6. | Approximate quantities, materials and labour required for joining pipes | 17 |
| 10.7. | Submergible pumps | 18 |
| 10.8. | Well linings or steining | 18 |
| 10.9. | H. P. required to lift water | 20 |
| 10.10 | Data for water supply works | 20 |


## XI Sanitary Engineering

| | | |
|---|---|---|
| 11.1. | Sewage project | 1 |
| 11.2. | Design considerations | 4 |
| 11.3. to 11.5 | Pipe diameter and gradient | 6 |
| 11.6. | Small septic tank | 6 |
| 11.7. | Disposal of sludge | 11 |
| 11.8. | Disposal of septic tank effluent | 11 |
| 11.9. | Commissioning of septic tank | 15 |
| 11.10. | Maintenance | 15 |
| 11.11. | Large septic tank | 15 |
| 11.12. | Data for sanitary works | 16 |

## XII Electrical Engineering


| | | |
|---|---|---|
| 12.1 to 12.5 | General guide lines | 1 |
| 12.6. | Testing and installations | 3 |
| 12.7. | H.P. of motors | 4 |
| 12.8. | Voltage drop | 5 |
| 12.9. | Refrigeration | 5 |
| 12.10. | Air-conditioning | 6 |
| 12.11. | Wattage of various electrical domestic appliances | 7 |
| 12.12. | Recommended levels of illuminations for interiors | 8 |
| 12.13. | Estimated current rating of cables sheathed with tough rubber | 9 |
| 12.14. | Electrical formulae for determining H.P., KVA., K.W. and Amps. | 10 |
| 12.15. | Scale for procedure for electrical fittings in Government buildings | 11 |
| 12.16. | Electrical standard data in common buildings | 13 |


## XIII Irrigation


| | | |
|---|---|---|
| 13.1. | Guide lines for ivestigation for irrigation projects | 1 |
| 13.2. | Duty and yield from catchment | 6 |
| 13.3. | Flood discharge | 7 |
| 13.4. | Formulae used in irrigation and hydraulics | 8 |
| 13.5. | Standards for minor irrigation projects | 19 |
| 13.6. | Standards of typical section of embankments for tank bunds | 20 |
| 13.7. | Design of channels | 22 |
| 13.8. | Design of anicut or weirs across rivers | 30 |
| 13.9. | Design of canal drops | 32 |
| 13.10. | Discharge through syphon | 35 |
| 13.11. | Discharge table for various types of weirs | 36 |
| 13.12. | Discharge through acquducts | 38 |
| 13.13. | Discharge through bridge openings | 38 |
| 13.14. | Dimension of spears and screw threads | 39 |
| 13.15. | Salient features of special minor irrigation progrdmme | 41 |
| 13.16. | Standards of tank sluice barrel | 41 |
| 13.17. | Stability calculations | 41 |
| 13.18. | Pond schemes | 42 |
| 13.19. | Fixing sill level of tank sluice | 42 |
| 13.20. | Fixing the crest level of anicut | 42 |
| 13.21. | Scouring sluice | 43 |
| 13.22. | Design aspects of permeable foundation | 43 |

# Highway Engineering


| | | |
|---|---|---|
| 14.1. | Geometrics of road | 1 |
| 14.2. | Width of carriage way and road way | 6 |
| 14.3. | Width of carriage on road bridges | 7 |
| 14.4. | Minimum land width for roads | 7 |
| 14.5. | Gradient of highways | 8 |
| 14.6 | Extra width in pavement in curves | 8 |
| 14.7. | Camber | 9 |
| 14.8. | Maximum size of stone metal for road work | 9 |
| 14.9. | Purpose for various grades of bitumen | 9 |
| 14.10. | Quantities for binder and grit | 9 |
| 14.11. | Quantity for spreading of coarse aggregate | 10 |
| 14.12. | Quantity for spreading bitumenous binder | 10 |
| 14.13. | Lives of various types of roads | 10 |
| 14.14. | Patch repairs in roads | 10 |
| 14.15. | Suitable roads for particular traffic | 11 |
| 14.16. | Sight distances at road junctions | 11 |
| 14.17. | Essentials for an ideal road | 12 |
| 14.18. | Ruling and absolute minimum radius of curve | 12 |
| 14.19. | Horizontal clearance of poles of street lighting | 12 |
| 14.20. | Bridges and Culverts | 13 |
| 14.21. | Arboriculture | 17 |

# I. GENERAL INFORMATION

## 1.1. TELEGRAPHIC GREETING CODES

**Festivals:**

| | | |
|---|---|---|
| One | ... | Heartiest Diwali Greetings. |
| Two | ... | Id Mubarak. |
| Three | ... | Heartiest Bijova Greetings. |
| Four | ... | A Happy New Year to you. |
| Nine | ... | A Merry Christmas to you. |
| Twenty | ... | My Heartiest Holi Greetings to you. |
| Twenty-six | ... | Heartiest Pongal Greetings. |
| Twenty-seven | ... | Heartiest Gurparb Greetings. |

**Weddings**

| | | |
|---|---|---|
| Eight | ... | Best wishes for a long and happy married life. |
| Sixteen | ... | May Heaven's choicest blessings be showered on the young couple. |
| Seventeen | ... | Wish you both a happy and prosperous wedded life. |
| Twenty-five | ... | Convey our blessings to the newly married couple. |

**Examination:**

| | | |
|---|---|---|
| Ten | ... | Hearty congratulations on your success in the examination. |
| Twenty-three | ... | Best wishes for your success in the examination. |

**Independence and Republic Days:**

| | | |
|---|---|---|
| Eighteen | ... | Kind remembrances and all good wishes for the Independence Day. |
| Nineteen | ... | Sincere greetings for the Republic Day, Long Live the Republic. |

**Miscellaneous:**

| | | |
|---|---|---|
| Five | ... | Many happy returns of the day. |
| Six | ... | Hearty congratulations on the new arrival. |
| Seven | ... | Congratulations on the distinction conferred on you. |
| Eleven | ... | Best wishes for a safe and pleasant journey. |
| Thirteen | ... | Many thanks for your good wishes which I/we reciprocate most heartily. |
| Fourteen | ... | Congratulations. |
| Fifteen | ... | Loving greetings. |
| Twenty-one | ... | Wishing the function every success. |
| Twenty-two | ... | Many thanks for your kind message of greetings. |

# 1.2. CHECK YOUR WEIGHT

**IDEAL HEIGHT AND WEIGHT CHART FOR MEN**

25 years and above

| Height in inches (with shoes) | LBS | KG |
|---|---|---|
| 62 | 124-133 | 56.3-60.3 |
| 63 | 127-136 | 57.6-61.7 |
| 64 | 130-140 | 58.9-63.5 |
| 65 | 134-144 | 60.8-65.3 |
| 66 | 137-147 | 62.2-66.7 |
| 67 | 141-151 | 64.0-68.5 |
| 68 | 145-156 | 65.8-70.8 |
| 69 | 149-160 | 67.6-72.6 |
| 70 | 153-164 | 69.4-74.4 |
| 71 | 157-168 | 71.2-76.2 |
| 72 | 161-173 | 73.0-78.5 |
| 73 | 166-178 | 75.3-80.7 |
| 74 | 171-184 | 77.6-83.5 |
| 75 | 176-189 | 79.8-85.7 |

**IDEAL HEIGHT AND WEIGHT CHART FOR WOMEN**

25 years and above

| Height in inches (with shoes) | LBS | KG |
|---|---|---|
| 60 | 112-120 | 50.8-54.4 |
| 61 | 114-122 | 51.7-55.3 |
| 62 | 117-125 | 53.1-56.7 |
| 63 | 120-128 | 54.4-58.1 |
| 64 | 124-132 | 56.3-59.9 |
| 65 | 127-135 | 57.6-61.2 |
| 66 | 130-140 | 58.9-63.5 |
| 67 | 134-144 | 60.8-65.3 |
| 68 | 137-147 | 62.2-66.7 |
| 69 | 141-151 | 64.0-68.5 |
| 70 | 145-155 | 65.8-70.3 |
| 71 | 148-158 | 67.1-71.7 |
| 72 | 151-163 | 68.5-73.9 |

*Do you weigh more than you should? If so, do some thing about it soon, as it may adversely affect your health and longevity apart from comfort and appearance.*

**Normal blood pressure = 100 + Age in years.**

Keep physically Fit for Serving to your family as well as to the Country.

# 1.3. STATE ABBREVIATED ADDRESSES

| Address | Code |
|---|---|
| **Tamil Nadu Engineering Association, P.W.D., Chepauk, Madras - 5** | **Poriyalar** |
| Accountant-General, 82-C, Mount Road, Teynampet Madras - 18. | Accounts. |
| Director of Agriculture, Chepauk, Madras - 5. | Agriculture. |
| The Station Director, All India Radio (next to the Office of the I. G. of Police), South Beach Road, Mylapore, Madras - 4. | Akashvan. |
| Life Insurance Corporation of India, Madras Zonal Office, Multi-storeyed Buildings, Mount Road, Madras - 2. | Bimapradesh. |
| Secretary, Board of Revenue (Land Revenue and and Settlement), Chepauk, Madras - 5. | Board Revenue. |
| **Chief Secretary to the Government of Tamil Nadu Fort St. George Madras - 9.** | **Chiefsec.** |
| The Honourable Chief Justice, High Court, Madras - 1. | Chieftice. |
| Superintending Engineer, Technical (Civil), 157, Mount Road, Madras - 2. | Civitec. |
| Collector of Customs, North Beach Road, Madras -1. | Customs. |
| Director, Tamil Nadu Transport Department, Madras -2. | Directrans. |
| Director of Information and Publicity, Government, Fort St. George, Madras - 9. | Dirinfor. |
| **Director of Technical Education (College of Engineering Campus), Guindy, Madras - 25.** | **Dote.** |
| Chairman, Tamil Nadu Electricity Board, 157, Mount Road, Madras - 2. | Electricboard. |

| Address | Code |
|---|---|
| Secretary to the Government of Tamil Nadu Law Department, Fort St. George, Madras - 9. | Madraslaw. |
| **Chief Engineer (Buildings), Chepauk, Madras - 5.** | **Kattidam.** |
| **Chief Engineer for Irrigation, Chepauk, Madras - 5.** | **Irrigation.** |
| Commissioner of Labour and Director of Employment, Chepauk, Madras - 5. | Labcom. |
| Private Secretary to His Excellency The Governor of Tamil Nadu, Guindy, Madras - 32. | Govsec. |
| Chief Engineer (Highways), Chepauk, Madras - 5. | Highways. |
| Manager, Reserve Bank of India, Reserve Bank Building, Madras - 1. | Reservist. |
| Director of State Raffle, Fort St. George, Madras - 9. | Raffle. |
| Secretary, Tamil Nadu Legislative, Fort St. George, Madras - 9. | Secleg. |
| The Chairman, State Housing Board, 36, Mount Road, Nandanam Colony, Madras - 35. | Statehouse. |
| **Executive Engineer, Saidapet, Division, Triplicane, Madras - 5.** | **Tempest.** |
| **Superintending Engineer, P. W. D., Madras — Chingleput Circle, Madras - 5.** | **Thunder.** |
| Registrar of University, Chepauk, Madras - 5. | University. |
| Director of Vigilance and Anti-Corruption, No. 9, Vijayaraghavachari Road, Madras - 17. | Vac. |
| Director of Industries & Commerce, Chepauk, Madras - 5. | Indcom. |

| Address | Code. |
|---|---|
| Chief Electrical Inspector to Government, 157, Mount Road, Madras - 2. | Electricity. |
| Director of Fire Service, 17-A, Marshalls Road, Egmore, Madras - 8. | Firepro. |
| **Secretary, Public Service Commission, Govt. Estate, Mount Road, Madras - 2.** | **Pubsercom.** |
| **Chief Engineer P. W. D., General Triplicane, Madras - 5.** | **Quyadamica.** |
| **Secretary to the Government, P. W. D. Madras - 9.** | **Quyaddensa.** |
| Chief Engineer for Electricity, 157, Mount Road, Madras - 2. | Quyanulata. |
| The Chairman, Madras Port Trust, Port Trust Office, Trust's New Administrative Office Buildings, Opposite Reserve Bank Buildings, Madras - 1. | Portrust. |
| The Postmaster-General, Madras - 2. | Postbur. |
| Inspector-General of Police, Mylapore, Madras - 4. | Nystagmus. |
| Director of Stationery and Printing, Government Press, Madras - 1. | Orsilochus. |
| Regional Passport Officer, 12 Haddows Road, Madras - 6. | Passem. |
| **General Superintendent, Public Works Workshops and Stores, Old Jail Road, G. T. Madras - 1.** | **Perdissiez.** |
| Secretary to the Government of Tamil Nadu Finance Department, Fort St. George, Madras - 9. | Madrasfinance. |
| Secretary, Home Department Fort St. George, George, Madras - 9. | Madrashome. |


INDIA
IMPORTANT TRUNK ROADS
PAKISTAN
CHINA
NEPAL
BURMA
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
Srinagar
Jammu
Amritsar
Ludhiana
Simla
Chandigarh
Ambala
Delhi
Agra
Kanpur
Jaipur
Udaipur
Jaisalmer
Barmer
Bikaner
Ahmedabad
Gandhinagar
Indore
Bhopal
Jabalpur
Lucknow
Allahabad
Gorakhpur
Patna
Ranchi
Calcutta
Cuttack
Haldia
Bhubaneswar
Sambalpur
Raipur
Nagpur
Dhulia
Nasik
Bombay
Pune
Sholapur
Hyderabad
Bijapur
Belgaum
Panaji
Kurnool
Vijayawada
Chitradurga
Bangalore
Madras
Mangalore
Calicut
Salem
Coimbatore
Madurai
Cochin
Trivandrum
Mandapam
Kanyakumari
Shillong
Imphal
Kohima
Agartala
BANGLADESH
BHUTAN
Jagdalpur
Porbandar
Rajkot

# 1.4 DISTANCES BETWEEN THE IMPORTANT CITIES IN INDIA

(in kilometres)

| Name of the Places | Bangalore | Bhopal | Bhubaneshwar | Bombay | Calcutta | Chandigarh | Delhi | Ahmedabad | Hyderabad | Jaipur | Lucknow | Madras | Patna | Simla | Srinagar | Trivandrum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bangalore | — | 1653 | 1551 | 1027 | 3169 | 2551 | 2277 | 1608 | 774 | 2041 | 2247 | 333 | 2591 | 2625 | 3188 | 821 |
| Bhopal | 1653 | — | 1963 | 789 | 1637 | 991 | 745 | 650 | 906 | 658 | 715 | 1986 | 1220 | 1093 | 1656 | 2474 |
| Bhubaneshwar | 1551 | 1963 | — | 1798 | 869 | 2016 | 1770 | 2490 | 1069 | 1955 | 1300 | 1281 | 1040 | 2118 | 2681 | 1968 |
| Bombay | 1027 | 789 | 1798 | — | 2305 | 1659 | 1413 | 560 | 734 | 1176 | 1382 | 1363 | 1888 | 1761 | 2324 | 1348 |
| Calcutta | 3169 | 1837 | 869 | 2305 | — | 1664 | 1418 | 2116 | 1899 | 1603 | 1080 | 2070 | 600 | 1765 | 2329 | 3990 |
| Chandigarh | 2551 | 991 | 2016 | 1659 | 1664 | — | 246 | 1234 | 2231 | 554 | 744 | 2857 | 1247 | 113 | 782 | 3344 |
| Delhi | 2277 | 745 | 1770 | 1413 | 1418 | 246 | — | 988 | 1984 | 307 | 497 | 2610 | 1001 | 348 | 911 | 3098 |
| Ahmedabad | 1506 | 650 | 2490 | 560 | 2116 | 1234 | 988 | — | 1215 | 681 | 1227 | 1839 | 1748 | 1336 | 1899 | 2327 |
| Hyderabad | 774 | 906 | 1069 | 734 | 1889 | 2231 | 1984 | 1215 | — | 1748 | 1587 | 698 | 1674 | 2332 | 2895 | 1595 |
| Jaipur | 2041 | 658 | 1955 | 1176 | 1603 | 554 | 307 | 681 | 1748 | — | 602 | 2374 | 1186 | 655 | 1218 | 2861 |
| Lucknow | 2247 | 715 | 1300 | 1383 | 1080 | 744 | 497 | 1227 | 1587 | 602 | — | 2580 | 663 | 845 | 1408 | 3067 |
| Madras | 333 | 1986 | 1281 | 1363 | 2070 | 2857 | 2610 | 1839 | 698 | 2374 | 2580 | — | 2924 | 2988 | 4070 | 750 |
| Patna | 2591 | 1220 | 1040 | 1888 | 600 | 1247 | 1001 | 1748 | 1674 | 1186 | 663 | 2924 | — | 1349 | 1912 | 3412 |
| Simla | 2625 | 1093 | 2118 | 1761 | 1765 | 113 | 348 | 1336 | 2332 | 655 | 845 | 2988 | 1349 | — | 822 | 3446 |
| Srinagar | 3188 | 1636 | 2681 | 2324 | 2329 | 782 | 911 | 1899 | 2895 | 1218 | 1408 | 4070 | 1912 | 822 | — | 4009 |
| Trivandrum | 821 | 2474 | 1968 | 1848 | 3990 | 3344 | 3098 | 2327 | 1595 | 2861 | 3067 | 750 | 3412 | 3446 | 4009 | — |

# 1.5. LOGARITHMS

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Mean Differences | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 0000 | 0043 | 0086 | 0128 | 0170 | 0212 | 0253 | 0294 | 0334 | 0374 | 4 | 8 | 12 | 17 | 21 | 25 | 29 | 33 | 37 |
| 11 | 0414 | 0453 | 0492 | 0531 | 0569 | 0607 | 0645 | 0682 | 0719 | 0755 | 4 | 8 | 11 | 15 | 19 | 23 | 26 | 30 | 34 |
| 12 | 0792 | 0828 | 0864 | 0899 | 0934 | 0969 | 1004 | 1038 | 1072 | 1106 | 3 | 7 | 10 | 14 | 17 | 21 | 24 | 28 | 31 |
| 13 | 1139 | 1173 | 1206 | 1239 | 1271 | 1303 | 1335 | 1367 | 1399 | 1430 | 3 | 6 | 10 | 13 | 16 | 19 | 23 | 26 | 29 |
| 14 | 1461 | 1492 | 1523 | 1553 | 1584 | 1614 | 1644 | 1673 | 1703 | 1732 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 |
| 15 | 1761 | 1790 | 1818 | 1847 | 1875 | 1903 | 1931 | 1959 | 1987 | 2014 | 3 | 6 | 8 | 11 | 14 | 17 | 20 | 22 | 25 |
| 16 | 2041 | 2068 | 2095 | 2122 | 2148 | 2175 | 2201 | 2227 | 2253 | 2279 | 3 | 5 | 8 | 11 | 13 | 16 | 18 | 21 | 24 |
| 17 | 2304 | 2330 | 2355 | 2380 | 2405 | 2430 | 2455 | 2480 | 2504 | 2529 | 2 | 5 | 7 | 10 | 12 | 15 | 17 | 20 | 22 |
| 18 | 2553 | 2577 | 2601 | 2625 | 2648 | 2672 | 2695 | 2718 | 2742 | 2765 | 2 | 5 | 7 | 9 | 12 | 14 | 16 | 19 | 21 |
| 19 | 2788 | 2810 | 2833 | 2856 | 2878 | 2900 | 2923 | 2945 | 2967 | 2989 | 2 | 4 | 7 | 9 | 11 | 13 | 16 | 18 | 20 |
| 20 | 3010 | 3032 | 3054 | 3075 | 3096 | 3118 | 3139 | 3160 | 3181 | 3201 | 2 | 4 | 6 | 8 | 11 | 13 | 15 | 17 | 19 |
| 21 | 3222 | 3243 | 3263 | 3284 | 3304 | 3324 | 3345 | 3365 | 3385 | 3404 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 22 | 3424 | 3444 | 3464 | 3483 | 3502 | 3522 | 3541 | 3560 | 3579 | 3598 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 15 | 17 |
| 23 | 3617 | 3636 | 3655 | 3674 | 3692 | 3711 | 3729 | 3747 | 3766 | 3784 | 2 | 4 | 6 | 7 | 9 | 11 | 13 | 15 | 17 |
| 24 | 3802 | 3820 | 3838 | 3856 | 3874 | 3892 | 3909 | 3927 | 3945 | 3962 | 2 | 4 | 5 | 7 | 9 | 11 | 12 | 14 | 16 |
| 25 | 3979 | 3997 | 4014 | 4031 | 4048 | 4065 | 4082 | 4099 | 4116 | 4133 | 2 | 3 | 5 | 7 | 9 | 10 | 12 | 14 | 15 |
| 26 | 4150 | 4166 | 4183 | 4200 | 4216 | 4232 | 4249 | 4265 | 4281 | 4298 | 2 | 3 | 5 | 7 | 8 | 10 | 11 | 13 | 15 |
| 27 | 4314 | 4330 | 4346 | 4362 | 4378 | 4393 | 4409 | 4425 | 4440 | 4456 | 2 | 3 | 5 | 6 | 8 | 9 | 11 | 13 | 14 |
| 28 | 4472 | 4487 | 4502 | 4518 | 4533 | 4548 | 4564 | 4579 | 4594 | 4609 | 2 | 3 | 5 | 6 | 8 | 9 | 11 | 12 | 14 |
| 29 | 4624 | 4639 | 4654 | 4669 | 4683 | 4698 | 4713 | 4728 | 4742 | 4757 | 1 | 3 | 4 | 6 | 7 | 9 | 10 | 12 | 13 |
| 30 | 4771 | 4786 | 4800 | 4814 | 4829 | 4843 | 4857 | 4871 | 4886 | 4900 | 1 | 3 | 4 | 6 | 7 | 9 | 10 | 11 | 13 |
| 31 | 4914 | 4928 | 4942 | 4955 | 4969 | 4983 | 4997 | 5011 | 5024 | 5038 | 1 | 3 | 4 | 6 | 7 | 8 | 10 | 11 | 12 |
| 32 | 5051 | 5065 | 5079 | 5092 | 5105 | 5119 | 5132 | 5145 | 5159 | 5172 | 1 | 3 | 4 | 5 | 7 | 8 | 9 | 11 | 12 |
| 33 | 5185 | 5198 | 5211 | 5224 | 5237 | 5250 | 5263 | 5276 | 5289 | 5302 | 1 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 12 |
| 34 | 5315 | 5328 | 5340 | 5353 | 5366 | 5378 | 5391 | 5403 | 5416 | 5428 | 1 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 11 |
| 35 | 5441 | 5453 | 5465 | 5478 | 5490 | 5502 | 5514 | 5527 | 5539 | 5551 | 1 | 2 | 4 | 5 | 6 | 7 | 9 | 10 | 11 |
| 36 | 5563 | 5575 | 5587 | 5599 | 5611 | 5623 | 5635 | 5647 | 5658 | 5670 | 1 | 2 | 4 | 5 | 6 | 7 | 8 | 10 | 11 |
| 37 | 5682 | 5694 | 5705 | 5717 | 5729 | 5740 | 5752 | 5763 | 5775 | 5786 | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 9 | 10 |
| 38 | 5798 | 5809 | 5821 | 5832 | 5843 | 5855 | 5866 | 5877 | 5888 | 5899 | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 9 | 10 |
| 39 | 5911 | 5922 | 5933 | 5944 | 5955 | 5966 | 5977 | 5988 | 5999 | 6010 | 1 | 2 | 3 | 4 | 5 | 7 | 8 | 9 | 10 |
| 40 | 6021 | 6031 | 6042 | 6053 | 6064 | 6075 | 6085 | 6096 | 6107 | 6117 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 9 | 10 |
| 41 | 6128 | 6138 | 6149 | 6160 | 6170 | 6180 | 6191 | 6201 | 6212 | 6222 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 42 | 6232 | 6243 | 6253 | 6263 | 6274 | 6284 | 6294 | 6304 | 6314 | 6325 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 43 | 6335 | 6345 | 6355 | 6365 | 6375 | 6385 | 6395 | 6405 | 6415 | 6425 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 44 | 6435 | 6444 | 6454 | 6464 | 6474 | 6484 | 6493 | 6503 | 6513 | 6522 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 45 | 6532 | 6542 | 6551 | 6561 | 6571 | 6580 | 6590 | 6599 | 6609 | 6618 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 46 | 6628 | 6637 | 6646 | 6656 | 6665 | 6675 | 6684 | 6693 | 6702 | 6712 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 7 | 8 |
| 47 | 6721 | 6730 | 6739 | 6749 | 6758 | 6767 | 6776 | 6785 | 6794 | 6803 | 1 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 |
| 48 | 6812 | 6821 | 6830 | 6839 | 6848 | 6857 | 6866 | 6875 | 6884 | 6893 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 |
| 49 | 6902 | 6911 | 6920 | 6928 | 6937 | 6946 | 6955 | 6964 | 6972 | 6981 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 |
| 50 | 6990 | 6998 | 7007 | 7016 | 7024 | 7033 | 7042 | 7050 | 7059 | 7067 | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 7 | 8 |
| 51 | 7076 | 7084 | 7093 | 7101 | 7110 | 7118 | 7126 | 7135 | 7143 | 7152 | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 7 | 8 |
| 52 | 7160 | 7168 | 7177 | 7185 | 7193 | 7202 | 7210 | 7218 | 7226 | 7235 | 1 | 2 | 2 | 3 | 4 | 5 | 6 | 7 | 7 |
| 53 | 7243 | 7251 | 7259 | 7267 | 7275 | 7284 | 7292 | 7300 | 7308 | 7316 | 1 | 2 | 2 | 3 | 4 | 5 | 6 | 6 | 7 |
| 54 | 7324 | 7332 | 7340 | 7348 | 7356 | 7364 | 7372 | 7380 | 7388 | 7396 | 1 | 2 | 2 | 3 | 4 | 5 | 6 | 6 | 7 |

# 1.5. LOGARITHMS

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Mean Differences 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | 7404 | 7412 | 7419 | 7427 | 7435 | 7443 | 7451 | 7459 | 7466 | 7474 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 56 | 7482 | 7490 | 7497 | 7505 | 7513 | 7520 | 7528 | 7536 | 7543 | 7551 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 57 | 7559 | 7566 | 7574 | 7582 | 7589 | 7597 | 7604 | 7612 | 7619 | 7627 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 58 | 7634 | 7642 | 7649 | 7657 | 7664 | 7672 | 7679 | 7686 | 7694 | 7701 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 |
| 59 | 7709 | 7716 | 7723 | 7731 | 7738 | 7745 | 7752 | 7760 | 7767 | 7774 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 |
| 60 | 7782 | 7789 | 7796 | 7803 | 7810 | 7818 | 7825 | 7832 | 7839 | 7846 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 |
| 61 | 7853 | 7860 | 7868 | 7875 | 7882 | 7889 | 7896 | 7903 | 7910 | 7917 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 |
| 62 | 7924 | 7931 | 7938 | 7945 | 7952 | 7959 | 7966 | 7973 | 7980 | 7987 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 6 |
| 63 | 7993 | 8000 | 8007 | 8014 | 8021 | 8028 | 8035 | 8041 | 8048 | 8055 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 | 6 |
| 64 | 8062 | 8069 | 8075 | 8082 | 8089 | 8096 | 8102 | 8109 | 8116 | 8122 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 | 6 |
| 65 | 8129 | 8136 | 8142 | 8149 | 8156 | 8162 | 8169 | 8176 | 8182 | 8189 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 | 6 |
| 66 | 8195 | 8202 | 8209 | 8215 | 8222 | 8228 | 8235 | 8241 | 8248 | 8254 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 | 6 |
| 67 | 8261 | 8267 | 8274 | 8280 | 8287 | 8293 | 8299 | 8306 | 8312 | 8319 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 | 6 |
| 68 | 8325 | 8313 | 8338 | 8344 | 8351 | 8357 | 8363 | 8370 | 8376 | 8382 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 5 | 6 |
| 69 | 8388 | 8395 | 8401 | 8407 | 8414 | 8420 | 8426 | 8432 | 8439 | 8445 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| 70 | 8451 | 8457 | 8463 | 8470 | 8476 | 8482 | 8488 | 8494 | 8500 | 8506 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| 71 | 8513 | 8519 | 8525 | 8531 | 8537 | 8543 | 8549 | 8555 | 8561 | 8567 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| 72 | 8573 | 8579 | 8585 | 8591 | 8597 | 8603 | 8609 | 8615 | 8621 | 8627 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| 73 | 8633 | 8639 | 8645 | 8651 | 8657 | 8663 | 8669 | 8675 | 8681 | 8686 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| 74 | 8692 | 8698 | 8704 | 8710 | 8716 | 8722 | 8727 | 8733 | 8739 | 8745 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| 75 | 8751 | 8756 | 8762 | 8768 | 8774 | 8779 | 8785 | 8791 | 8797 | 8802 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 5 | 5 |
| 76 | 8808 | 8814 | 8820 | 8825 | 8831 | 8837 | 8842 | 8848 | 8854 | 8859 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 5 | 5 |
| 77 | 8865 | 8871 | 8876 | 8882 | 8887 | 8893 | 8899 | 8904 | 8910 | 8915 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 78 | 8921 | 8927 | 8932 | 8938 | 8943 | 8949 | 8954 | 8960 | 8965 | 8971 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 79 | 8976 | 8982 | 8987 | 8993 | 8998 | 9004 | 9009 | 9015 | 9020 | 9025 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 80 | 9031 | 9036 | 9042 | 9047 | 9053 | 9058 | 9063 | 9069 | 9074 | 9079 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 81 | 9085 | 9090 | 9096 | 9101 | 9106 | 9112 | 9117 | 9122 | 9128 | 9133 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 82 | 9138 | 9143 | 9149 | 9154 | 9159 | 9165 | 9170 | 9175 | 9180 | 9186 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 83 | 9191 | 9196 | 9201 | 9206 | 9212 | 9217 | 9222 | 9227 | 9232 | 9238 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 84 | 9243 | 9248 | 9253 | 9258 | 9263 | 9269 | 9274 | 9279 | 9284 | 9289 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 85 | 9294 | 9299 | 9304 | 9309 | 9315 | 9320 | 9325 | 9330 | 9335 | 9340 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 86 | 9345 | 9350 | 9355 | 9360 | 9365 | 9370 | 9375 | 9380 | 9385 | 9390 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 87 | 9395 | 9400 | 9405 | 9410 | 9415 | 9420 | 9425 | 9430 | 9435 | 9440 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 88 | 9445 | 9450 | 9455 | 9460 | 9465 | 9469 | 9474 | 9479 | 9484 | 9489 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 89 | 9494 | 9499 | 9504 | 9509 | 9513 | 9518 | 9523 | 9528 | 9533 | 9538 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 90 | 9542 | 9547 | 9552 | 9557 | 9562 | 9566 | 9571 | 9576 | 9581 | 9586 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 91 | 9590 | 9595 | 9600 | 9605 | 9609 | 9614 | 9619 | 9624 | 9628 | 9633 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 92 | 9638 | 9643 | 9647 | 9652 | 9657 | 9661 | 9666 | 9671 | 9675 | 9680 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 93 | 9685 | 9689 | 9694 | 9699 | 9703 | 9708 | 9713 | 9717 | 9722 | 9727 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 94 | 9731 | 9736 | 9741 | 9745 | 9750 | 9754 | 9759 | 9763 | 9768 | 9773 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 95 | 9777 | 9782 | 9786 | 9791 | 9795 | 9800 | 9805 | 9809 | 9814 | 9818 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 96 | 9823 | 9827 | 9832 | 9836 | 9841 | 9845 | 9850 | 9854 | 9859 | 9863 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 97 | 9868 | 9872 | 9877 | 9881 | 9886 | 9890 | 9894 | 9899 | 9903 | 9908 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 98 | 9912 | 9917 | 9921 | 9926 | 9930 | 9934 | 9939 | 9943 | 9948 | 9952 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 99 | 9956 | 9961 | 9965 | 9969 | 9974 | 9978 | 9983 | 9987 | 9991 | 9996 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 |

# 1.6 ANTI LOGARITHMS

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Mean Differences | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| .00 | 1000 | 1002 | 1005 | 1007 | 1009 | 1012 | 1014 | 1016 | 1019 | 1021 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| .01 | 1023 | 1026 | 1028 | 1030 | 1033 | 1035 | 1038 | 1040 | 1042 | 1045 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| .02 | 1047 | 1050 | 1052 | 1054 | 1057 | 1059 | 1062 | 1064 | 1067 | 1069 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| .03 | 1072 | 1074 | 1076 | 1079 | 1081 | 1084 | 1086 | 1089 | 1091 | 1094 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| .04 | 1096 | 1099 | 1102 | 1104 | 1107 | 1109 | 1112 | 1114 | 1117 | 1119 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| .05 | 1122 | 1125 | 1127 | 1130 | 1132 | 1135 | 1138 | 1140 | 1143 | 1146 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| .06 | 1148 | 1151 | 1153 | 1156 | 1159 | 1161 | 1164 | 1167 | 1169 | 1172 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| .07 | 1175 | 1178 | 1180 | 1183 | 1186 | 1189 | 1191 | 1194 | 1197 | 1199 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| .08 | 1202 | 1205 | 1208 | 1211 | 1213 | 1216 | 1219 | 1222 | 1225 | 1227 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |
| .09 | 1230 | 1233 | 1236 | 1239 | 1242 | 1245 | 1247 | 1250 | 1253 | 1256 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |
| .10 | 1259 | 1262 | 1265 | 1268 | 1271 | 1274 | 1276 | 1279 | 1282 | 1285 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |
| .11 | 1288 | 1291 | 1294 | 1297 | 1300 | 1303 | 1306 | 1309 | 1312 | 1315 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .12 | 1318 | 1321 | 1324 | 1327 | 1330 | 1334 | 1337 | 1340 | 1343 | 1346 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .13 | 1349 | 1352 | 1355 | 1358 | 1361 | 1365 | 1368 | 1371 | 1374 | 1377 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| .14 | 1380 | 1384 | 1387 | 1390 | 1393 | 1396 | 1400 | 1403 | 1406 | 1409 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| .15 | 1413 | 1416 | 1419 | 1422 | 1426 | 1429 | 1432 | 1435 | 1439 | 1442 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| .16 | 1445 | 1449 | 1452 | 1455 | 1459 | 1462 | 1466 | 1469 | 1472 | 1476 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| .17 | 1479 | 1483 | 1486 | 1489 | 1493 | 1496 | 1500 | 1503 | 1507 | 1510 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| .18 | 1514 | 1517 | 1521 | 1524 | 1528 | 1531 | 1535 | 1538 | 1542 | 1545 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| .19 | 1549 | 1552 | 1556 | 1560 | 1563 | 1567 | 1570 | 1574 | 1578 | 1581 | 0 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 |
| .20 | 1585 | 1589 | 1592 | 1596 | 1600 | 1603 | 1607 | 1611 | 1614 | 1618 | 0 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 |
| .21 | 1622 | 1626 | 1629 | 1633 | 1637 | 1641 | 1644 | 1648 | 1652 | 1656 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 |
| .22 | 1660 | 1663 | 1667 | 1671 | 1675 | 1679 | 1683 | 1687 | 1690 | 1694 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 |
| .23 | 1698 | 1702 | 1706 | 1710 | 1714 | 1718 | 1722 | 1726 | 1730 | 1734 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 |
| .24 | 1738 | 1742 | 1746 | 1750 | 1754 | 1758 | 1762 | 1766 | 1770 | 1774 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 |
| .25 | 1778 | 1782 | 1786 | 1791 | 1795 | 1799 | 1803 | 1807 | 1811 | 1816 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 |
| .26 | 1820 | 1824 | 1828 | 1832 | 1837 | 1841 | 1845 | 1849 | 1854 | 1858 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 |
| .27 | 1862 | 1866 | 1871 | 1875 | 1879 | 1884 | 1888 | 1892 | 1897 | 1901 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 |
| .28 | 1905 | 1910 | 1914 | 1919 | 1923 | 1928 | 1932 | 1936 | 1941 | 1945 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| .29 | 1950 | 1954 | 1959 | 1963 | 1968 | 1972 | 1977 | 1982 | 1986 | 1991 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| .30 | 1995 | 2000 | 2004 | 2009 | 2014 | 2018 | 2023 | 2028 | 2032 | 2037 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| .31 | 2042 | 2046 | 2051 | 2056 | 2061 | 2065 | 2070 | 2075 | 2080 | 2084 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| .32 | 2089 | 2094 | 2099 | 2104 | 2109 | 2113 | 2118 | 2123 | 2128 | 2133 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| .33 | 2138 | 2143 | 2148 | 2153 | 2158 | 2163 | 2168 | 2173 | 2178 | 2183 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| .34 | 2188 | 2193 | 2198 | 2203 | 2208 | 2213 | 2218 | 2223 | 2228 | 2234 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .35 | 2239 | 2244 | 2249 | 2254 | 2259 | 2265 | 2270 | 2275 | 2280 | 2286 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .36 | 2291 | 2296 | 2301 | 2307 | 2312 | 2317 | 2323 | 2328 | 2333 | 2339 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .37 | 2344 | 2350 | 2355 | 2360 | 2366 | 2371 | 2377 | 2382 | 2388 | 2393 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .38 | 2399 | 2404 | 2410 | 2415 | 2421 | 2427 | 2432 | 2438 | 2443 | 2449 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .39 | 2455 | 2460 | 2466 | 2472 | 2477 | 2483 | 2489 | 2495 | 2500 | 2506 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 5 | 5 |
| .40 | 2512 | 2518 | 2523 | 2529 | 2535 | 2541 | 2547 | 2553 | 2559 | 2564 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| .41 | 2570 | 2576 | 2582 | 2588 | 2594 | 2600 | 2606 | 2612 | 2618 | 2624 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| .42 | 2630 | 2636 | 2642 | 2649 | 2655 | 2661 | 2667 | 2673 | 2679 | 2685 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| .43 | 2692 | 2698 | 2704 | 2710 | 2716 | 2723 | 2729 | 2735 | 2742 | 2748 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 5 | 6 |
| .44 | 2754 | 2761 | 2767 | 2773 | 2780 | 2786 | 2793 | 2799 | 2805 | 2812 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 5 | 6 |
| .45 | 2818 | 2825 | 2831 | 2838 | 2844 | 2851 | 2858 | 2864 | 2871 | 2877 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 | 6 |
| .46 | 2884 | 2891 | 2897 | 2904 | 2911 | 2917 | 2924 | 2931 | 2938 | 2944 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 | 6 |
| .47 | 2951 | 2958 | 2965 | 2972 | 2979 | 2985 | 2992 | 2999 | 3006 | 3013 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 | 6 |
| .48 | 3020 | 3027 | 3034 | 3041 | 3048 | 3055 | 3062 | 3069 | 3076 | 3083 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 |
| .49 | 3090 | 3097 | 3105 | 3112 | 3119 | 3126 | 3133 | 3141 | 3148 | 3155 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 |

# 1.6. ANTILOGARITHMS

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Mean Differences 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 3162 | 3170 | 3177 | 3184 | 3192 | 3199 | 3206 | 3214 | 3221 | 3228 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 |
| 51 | 3236 | 3243 | 3251 | 3258 | 3266 | 3273 | 3281 | 3289 | 3296 | 3304 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 52 | 3311 | 3319 | 3327 | 3334 | 3342 | 3350 | 3357 | 3365 | 3373 | 3381 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 53 | 3388 | 3396 | 3404 | 3412 | 3420 | 3428 | 3436 | 3443 | 3451 | 3459 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 54 | 3467 | 3475 | 3483 | 3491 | 3499 | 3508 | 3516 | 3524 | 3532 | 3540 | 1 | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 55 | 3548 | 3556 | 3565 | 3573 | 3581 | 3589 | 3597 | 3606 | 3614 | 3622 | 1 | 2 | 2 | 3 | 4 | 5 | 6 | 7 | 7 |
| 56 | 3631 | 3639 | 3648 | 3656 | 3664 | 3673 | 3681 | 3690 | 3698 | 3707 | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 7 | 8 |
| 57 | 3715 | 3724 | 3733 | 3741 | 3750 | 3758 | 3767 | 3776 | 3784 | 3793 | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 7 | 8 |
| 58 | 3802 | 3811 | 3819 | 3828 | 3837 | 3846 | 3855 | 3864 | 3873 | 3882 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 |
| 59 | 3890 | 3899 | 3908 | 3917 | 3926 | 3936 | 3945 | 3954 | 3963 | 3972 | 1 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 |
| 60 | 3981 | 3990 | 3999 | 4009 | 4018 | 4027 | 4036 | 4046 | 4055 | 4064 | 1 | 2 | 3 | 4 | 5 | 6 | 6 | 7 | 8 |
| 61 | 4074 | 4083 | 4093 | 4102 | 4111 | 4121 | 4130 | 4140 | 4150 | 4159 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 62 | 4169 | 4178 | 4188 | 4198 | 4207 | 4217 | 4227 | 4236 | 4246 | 4256 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 63 | 4266 | 4276 | 4285 | 4295 | 4305 | 4315 | 4325 | 4335 | 4345 | 4355 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 64 | 4366 | 4375 | 4385 | 4395 | 4406 | 4416 | 4426 | 4436 | 4446 | 4457 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 65 | 4467 | 4477 | 4487 | 4498 | 4508 | 4519 | 4529 | 4539 | 4550 | 4560 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 66 | 4571 | 4581 | 4592 | 4603 | 4613 | 4624 | 4634 | 4645 | 4656 | 4667 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 10 |
| 67 | 4677 | 4688 | 4699 | 4710 | 4721 | 4732 | 4742 | 4753 | 4764 | 4775 | 1 | 2 | 3 | 4 | 5 | 7 | 8 | 9 | 10 |
| 68 | 4786 | 4797 | 4808 | 4819 | 4831 | 4842 | 4853 | 4864 | 4875 | 4887 | 1 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 10 |
| 69 | 4898 | 4909 | 4920 | 4932 | 4943 | 4955 | 4966 | 4977 | 4989 | 5000 | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 9 | 10 |
| 70 | 5012 | 5023 | 5035 | 5047 | 5058 | 5070 | 5082 | 5093 | 5105 | 5117 | 1 | 2 | 4 | 5 | 6 | 7 | 8 | 9 | 11 |
| 71 | 5129 | 5140 | 5152 | 5164 | 5176 | 5188 | 5200 | 5212 | 5224 | 5236 | 1 | 2 | 4 | 5 | 6 | 7 | 8 | 10 | 11 |
| 72 | 5248 | 5260 | 5272 | 5284 | 5297 | 5309 | 5321 | 5333 | 5346 | 5358 | 1 | 2 | 4 | 5 | 6 | 7 | 9 | 10 | 11 |
| 73 | 5370 | 5383 | 5395 | 5408 | 5420 | 5433 | 5445 | 5458 | 5470 | 5483 | 1 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 11 |
| 74 | 5495 | 5508 | 5521 | 5534 | 5546 | 5559 | 5572 | 5585 | 5598 | 5610 | 1 | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 12 |
| 75 | 5623 | 5636 | 5649 | 5662 | 5675 | 5689 | 5702 | 5715 | 5728 | 5741 | 1 | 3 | 4 | 5 | 7 | 8 | 9 | 10 | 12 |
| 76 | 5754 | 5768 | 5781 | 5794 | 5808 | 5821 | 5834 | 5848 | 5861 | 5875 | 1 | 3 | 4 | 5 | 7 | 8 | 9 | 11 | 12 |
| 77 | 5888 | 5902 | 5916 | 5929 | 5943 | 5957 | 5970 | 5984 | 5998 | 6012 | 1 | 3 | 4 | 5 | 7 | 8 | 10 | 11 | 12 |
| 78 | 6026 | 6039 | 6053 | 6067 | 6081 | 6095 | 6109 | 6124 | 6138 | 6152 | 1 | 3 | 4 | 6 | 7 | 8 | 10 | 11 | 13 |
| 79 | 6166 | 6180 | 6194 | 6209 | 6223 | 6237 | 6252 | 6266 | 6281 | 6295 | 1 | 3 | 4 | 6 | 7 | 9 | 10 | 11 | 13 |
| 80 | 6310 | 6324 | 6339 | 6353 | 6368 | 6383 | 6397 | 6412 | 6427 | 6442 | 1 | 3 | 4 | 6 | 7 | 9 | 10 | 12 | 13 |
| 81 | 6457 | 6471 | 6486 | 6501 | 6516 | 6531 | 6546 | 6561 | 6577 | 6592 | 2 | 3 | 5 | 6 | 8 | 9 | 11 | 12 | 14 |
| 82 | 6607 | 6622 | 6637 | 6653 | 6668 | 6683 | 6699 | 6714 | 6730 | 6745 | 2 | 3 | 5 | 6 | 8 | 9 | 11 | 12 | 14 |
| 83 | 6761 | 6776 | 6792 | 6808 | 6823 | 6839 | 6855 | 6871 | 6887 | 6902 | 2 | 3 | 5 | 6 | 8 | 9 | 11 | 13 | 14 |
| 84 | 6918 | 6934 | 6950 | 6966 | 6982 | 6998 | 7015 | 7031 | 7047 | 7063 | 2 | 3 | 5 | 6 | 8 | 10 | 11 | 13 | 15 |
| 85 | 7079 | 7096 | 7112 | 7129 | 7145 | 7161 | 7178 | 7194 | 7211 | 7228 | 2 | 3 | 5 | 7 | 8 | 10 | 12 | 13 | 15 |
| 86 | 7244 | 7261 | 7278 | 7295 | 7311 | 7328 | 7345 | 7362 | 7379 | 7396 | 2 | 3 | 5 | 7 | 8 | 10 | 12 | 13 | 15 |
| 87 | 7413 | 7430 | 7447 | 7464 | 7482 | 7499 | 7516 | 7534 | 7551 | 7568 | 2 | 3 | 5 | 7 | 9 | 10 | 12 | 14 | 16 |
| 88 | 7586 | 7603 | 7621 | 7638 | 7656 | 7674 | 7691 | 7709 | 7727 | 7745 | 2 | 4 | 5 | 7 | 9 | 11 | 12 | 14 | 16 |
| 89 | 7762 | 7780 | 7798 | 7816 | 7834 | 7852 | 7870 | 7889 | 7907 | 7925 | 2 | 4 | 5 | 7 | 9 | 11 | 13 | 14 | 16 |
| 90 | 7943 | 7962 | 7980 | 7998 | 8017 | 8035 | 8054 | 8072 | 8091 | 8110 | 2 | 4 | 6 | 7 | 9 | 11 | 13 | 15 | 17 |
| 91 | 8128 | 8147 | 8166 | 8185 | 8204 | 8222 | 8241 | 8260 | 8279 | 8299 | 2 | 4 | 6 | 8 | 9 | 11 | 13 | 15 | 17 |
| 92 | 8318 | 8337 | 8356 | 8375 | 8395 | 8414 | 8433 | 8453 | 8472 | 8492 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 15 | 17 |
| 93 | 8511 | 8531 | 8551 | 8570 | 8590 | 8610 | 8630 | 8650 | 8670 | 8690 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 94 | 8710 | 8730 | 8750 | 8770 | 8790 | 8810 | 8831 | 8851 | 8872 | 8892 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 95 | 8913 | 8933 | 8954 | 8974 | 8995 | 9016 | 9036 | 9057 | 9078 | 9099 | 2 | 4 | 6 | 8 | 10 | 12 | 15 | 17 | 19 |
| 96 | 9120 | 9141 | 9162 | 9183 | 9204 | 9226 | 9247 | 9268 | 9290 | 9311 | 2 | 4 | 6 | 8 | 11 | 13 | 15 | 17 | 19 |
| 97 | 9333 | 9354 | 9376 | 9397 | 9419 | 9441 | 9462 | 9484 | 9506 | 9528 | 2 | 4 | 7 | 9 | 11 | 13 | 15 | 17 | 20 |
| 98 | 9550 | 9572 | 9594 | 9616 | 9638 | 9661 | 9683 | 9705 | 9727 | 9750 | 2 | 4 | 7 | 9 | 11 | 13 | 16 | 18 | 20 |
| 99 | 9772 | 9795 | 9817 | 9840 | 9863 | 9886 | 9908 | 9931 | 9954 | 9977 | 2 | 5 | 7 | 9 | 11 | 14 | 16 | 18 | 20 |

# 1.7. ACCOUNT TEST FOR PWD OFFICERS AND SUBORDINATES

Account test for P.W.D. Officers and subordinates are being conductd in **May** and **November** every year.

## 1.7.1. Details of Paper

**1.7.1.1 First Paper** (Duration 2 hours.)

Total Marks : 120

(1) The Madras Public Works Department Code.
(2) " Financial Code Vol. I
(3) " Financial Code Vol. II

**1.7.1.2 Second Paper** (Duration 3 hours.)

Total Marks : 120

(1) The Madras Public Works Accound Code
(2) " Treasury Code Vol. I
(3) " Account Code Vol. II
(4) " " Vol. III
(5) " Pension Code.

For **First Class** Total Marks **120 and above.**
For **Second Class** Total Aggregate **Mark 96.**
**Minimum marks** required for each Paper 35% or **42.**
" **Aggrgate** marks required for passing the examination 96.

## 1.7.2 Syllabus.

**FIRST PAPER:**

1. The Madras P. W. D. Code :—
   Chapter I (Paragraph 50 and 59)
   " II ( " 112-120, 123-152, 140, 147-148, 151, 157-158, 161, 173, 184, 189-190, 192-212, 216-220 and 222-224.)
   " III (Paras 225-234, 236, 238-245, 249, 251, 253 and 257-289)

Chapter IV (Paras 290, 293-297, 300-302, 304-313, 316, 328, 331-342 and 345-366)

" V (Paras 367-369, 385-440 and 433-448 and appendices (except Appendix III).

2. The Madras Financial Code — Vol. I.
   Chapter I
   " III (Articles 7-23, 28 and 31-37).
   " IV, V and VI (Art 91-112, 115 and 120).
   " VIII, XII and XIV (317, 319 and 326).

3. The Madras Financial Code — Vol. II Appendices IV, XIV and XXV.

**SECOND PAPER**

1. The Madras Account Code — Vol. I chapter 36.

2. The Madras Treasury Code — Vol. III chapter I-IV.

3. The Madras Treasury Code — Vol. Part I.
   " Rules Part II.

   Treasury Rule (Instruction 2 under T.R. 7 (2) (d) and 18 Instructions 5, 15 and 64-66). Treasury Rule II Subsidiary Rule I and Instruction (2) Treasury Rule B and Instruction. T. R. 7 (Subsidiary) Rules 1, 2(a), 4, 5, 28, 29-52, 54-56, 61 and 63 Instruction 3, 10, 40-43, 46, 49, 52 and 57-58) Treasury Rule 32 (S.R. 1-4 and Instructions 3-10)

4. The Madras P. W. A. Code — Chapter XVII Appendices VI & VIII.

5. The Madras Pension Code

**Please note that passing of the Account test within the probation period is a must. Otherwise you will be peanlised.**

# 1.8 TABLE OF DAILY PAY

| Pay per week or month | When per week | When per Month | | | |
|---|---|---|---|---|---|
| | | 28 days | 29 days | 30 days | 31 days |
| Rs. | Rs. | Rs. | Rs. | Rs. | Rs. |
| 1 | .143 | .036 | .034 | .033 | .032 |
| 2 | .286 | .071 | .069 | .067 | .065 |
| 3 | .429 | .107 | .103 | .100 | .097 |
| 4 | .571 | .143 | .138 | .133 | .129 |
| 5 | .714 | .179 | .172 | .167 | .161 |
| 6 | .867 | .214 | .207 | .200 | .194 |
| 7 | 1.000 | .250 | .241 | .233 | .226 |
| 8 | 1.143 | .286 | .276 | .267 | .258 |
| 9 | 1.143 | .286 | .276 | .267 | .258 |
| 9 | 1.286 | .321 | .310 | .300 | .290 |
| 10 | 1.429 | .357 | .345 | .333 | .323 |
| 15 | 2.143 | .536 | .517 | .500 | .484 |
| 20 | 2.857 | .714 | .690 | .667 | .645 |
| 25 | 3.571 | .893 | .862 | .883 | .806 |
| 30 | 4.286 | 1.071 | 1.034 | 1.000 | .968 |
| 35 | 5.000 | 1.250 | 1.207 | 1.167 | 1.129 |
| 40 | 5.714 | 1.429 | 1.379 | 1.333 | 1.290 |
| 45 | 6.429 | 1.607 | 1.552 | 1.500 | 1.452 |
| 50 | 7.143 | 1.785 | 1.724 | 1.667 | 1.613 |
| 55 | 7.857 | 1.964 | 1.897 | 1.833 | 1.774 |
| 60 | 8.571 | 2.143 | 2.069 | 2.000 | 1.935 |
| 65 | 9.286 | 2.321 | 2.241 | 2.167 | 2.097 |
| 70 | 10.000 | 2.500 | 2.414 | 2.333 | 2.258 |
| 75 | 10.714 | 2.679 | 2.586 | 2.500 | 2.419 |
| 80 | 11.429 | 2.857 | 2.759 | 2.667 | 2.581 |
| 85 | 12.143 | 2.936 | 2.931 | 2.833 | 2.742 |
| 90 | 12.857 | 3.214 | 3.103 | 3.000 | 2.903 |
| 95 | 13.571 | 3.393 | 3.276 | 3.167 | 3.065 |
| 100 | 14.286 | 3.571 | 3.448 | 3.333 | 3.226 |
| 150 | 21.429 | 5.357 | 5.172 | 5.000 | 4.839 |
| 200 | 28.571 | 7.143 | 6.897 | 6.667 | 6.452 |
| 250 | 35.714 | 8.929 | 8.621 | 8.333 | 9.065 |
| 300 | 42.857 | 10.714 | 10.345 | 10.000 | 9.677 |
| 350 | 50.000 | 12.500 | 12.069 | 11.667 | 11.290 |
| 400 | 57.543 | 14.286 | 13.793 | 13.333 | 12.903 |
| 500 | 71.429 | 17.857 | 17.241 | 16.667 | 16.129 |

# II. TECHNICAL INFORMATIONS

## 2.1. Symbols, Atomic numbers, Weight & Melting points of Elements

| Name of Element | Symbol | Atomic Number | Atomic Weight | Melting Point Deg. C | Name of Element | Symbol | Atomic Number | Atomic Weight | Melting Point Deg. C |
|---|---|---|---|---|---|---|---|---|---|
| Actinium... | Ac | 89 | 227 | — | Molybdenum | Mo | 42 | 95.95 | 2625 |
| Aluminium... | Al | 13 | 26.97 | 660.0 | Neodymium | Nd | 60 | 144.27 | 840 |
| Antimony... | Sb | 51 | 121.76 | 630.5 | Neon... | Ne | 10 | 20.183 | -248.6 |
| Argon... | A | 18 | 39.944 | -189.4 | Nickel... | Ni | 28 | 58.69 | 1455 |
| Arsenic | As | 33 | 74.91 | 814 | Niobium... | Nb | 41 | 92.91 | 2500 |
| Astatine... | At | 85 | (210) | — | Nitrogen... | N | 7 | 14.008 | -210.0 |
| Barium... | Ba | 56 | 137.36 | 704 | Osmium... | Os | 76 | 190.2 | 2700 |
| Berkelium... | Bk | 97 | — | — | Oxygen... | O | 8 | 16.0000 | -218.8 |
| Beryllium... | Be | 4 | 9.013 | 1280 | Palladium | Pd | 46 | 106.7 | 1554 |
| Bismuth... | Bi | 83 | 209.00 | 271.3 | Phosphorus. | P | 15 | 30.98 | — |
| Boron... | B | 5 | 10.82 | 2040 | Platinium... | Pt | 78 | 195.23 | 1773.5 |
| Bromine... | Br | 35 | 79.916 | -7.2 | Potassium... | K | 19 | 39.096 | 63 |
| Cadmium... | Cd | 48 | 112.41 | 320.9 | Promethium | Pm | 61 | (147) | |
| Calcium... | Ca | 20 | 40.08 | 850 | Proactinium... | Pa | 91 | 231 | 3000 |
| Carbon | C | 6 | 12.010 | 3700 | Radium... | Ra | 88 | 226.05 | 700 |
| Cerium... | Ce | 58 | 140.13 | 600 | Rhenium... | Re | 75 | 186.31 | 3170 |
| Cesium... | Cs | 55 | 132.91 | 28 | Rhodium... | Rh | 45 | 102.91 | 1966 |
| Chlorine... | Cu | 29 | 63.54 | 1083.2 | Selenium... | Se | 34 | 78.96 | .... |
| Fluorine... | F | 9 | 19.00 | -223 | Silicon... | Si | 14 | 28.06 | 1415 |
| Gadolinium... | Gd | 64 | 156.9 | — | Silver... | Ag | 47 | 107.880 | 960.5 |
| Gallium... | Ga | 31 | 69.72 | 29.78 | Sodium... | Na | 11 | 22.997 | 97.7 |
| Germanium... | Ge | 32 | 72.60 | 958 | Strontium... | Sr | 38 | 87.63 | 770 |
| Gold... | Au | 79 | 197.2 | 1063.0 | Sulphur... | S | 16 | 32.066 | — |
| Hafnium... | Hf | 72 | 178.6 | 1700 | Tantalum... | Ta | 73 | 180.88 | 3000 |
| Helium... | He | 2 | 4.003 | -271.4 | Tellurium... | Te | 52 | 127.61 | 450 |
| Hydrogen... | H | 1 | 1.0080 | -259.2 | Terbium... | Tb | 65 | 159.2 | 327 |
| Indium... | In | 49 | 114.76 | 156.4 | Thallium... | Tl | 81 | 204.39 | 300 |
| Iodine... | I | 53 | 126.92 | 114 | Thorium... | Th | 90 | 232.12 | 1800 |
| Iridium... | Ir | 77 | 193.1 | 2454 | Thulium... | Tm | 69 | 169.4 | — |
| Iron... | Fe | 26 | 55.85 | 1539 | Tin... | Sn | 50 | 118.70 | 231.9 |
| Krypton... | Kr | 36 | 83.7 | -157.0 | Titanium... | Ti | 22 | 47.90 | 1820 |
| Lanthanum... | La | 57 | 138.92 | 826 | Uranium | U | 92 | 238.07 | 1133 |
| Lead... | Pb | 82 | 207.21 | 327.4 | Vanadium... | V | 23 | 50.95 | 1735 |
| Lithium... | Li | 3 | 6.940 | 186 | Xenon... | Xe | 54 | 131.3 | -112 |
| Magnesium... | Mg | 12 | 24.32 | 650 | Yttrium... | Y | 39 | 88.92 | 1490 |
| Manganese... | Mn | 25 | 54.93 | 1260 | Zinc... | Zn | 30 | 65.38 | 419.5 |
| Mercury... | Hg | 80 | 200.61 | -38.87 | Zirconium... | Zr | 40 | 91.22 | 1750 |

## 2.2 TEMPERATURE.

Let $F$ = temperature Fahrenheit,
$C$ = temperature Centigrade,
$R$ = temperature Reaumur, then

$$F = \frac{9C}{5} + 32 = \frac{9R}{4} + 32 = C + R + 32$$

$$C = \frac{5(F-32)}{9} = \frac{5R}{4}$$

$$R = \frac{4(F-32)}{9} = \frac{4C}{5}$$

## 2.3 DECIMAL EQUIVALENTS OF FRACTION OF AN INCH IN INCH AND MM

| Fraction | Inch | Mm | Fraction | Inch | Mm |
|---|---|---|---|---|---|
| 1/64 | 0.015625 | 0.3969 | 33/64 | 0.515625 | 13.0969 |
| 1/32 | 0.03125 | 0.7938 | 17/32 | 0.53125 | 13.4473 |
| 3/64 | 0.046875 | 1.1906 | 35/64 | 0.54875 | 13.8906 |
| 1/16 | 0.0625 | 1.5875 | 9/16 | 0.5625 | 14.2875 |
| 5/64 | 0.078125 | 1.9844 | 37/64 | 0.578125 | 14.6844 |
| 3/32 | 0.09375 | 2.3812 | 19/32 | 0.59375 | 15.0812 |
| 7/64 | 0.109375 | 2.7781 | 39/64 | 0.609375 | 15.4781 |
| 1/8 | 0.125 | 3.1750 | 5/8 | 0.625 | 15.8750 |
| 9/64 | 0.140625 | 3.5719 | 41/64 | 0.640625 | 16.2719 |
| 5/32 | 0.15625 | 3.9687 | 21/32 | 0.65625 | 16.6687 |
| 11/64 | 0.171875 | 4.3656 | 43/64 | 0.671875 | 17.0656 |
| 3/16 | 0.1875 | 4.7625 | 11/16 | 0.6875 | 17.4625 |
| 13/64 | 0.203125 | 5.1594 | 45/64 | 0.703125 | 17.8594 |
| 7/32 | 0.21875 | 5.5562 | 23/32 | 0.71875 | 18.2562 |
| 15/64 | 0.234375 | 5.9531 | 47/64 | 0.734375 | 18.6531 |
| 1/4 | 0.25 | 6.3500 | 3/4 | 0.75 | 19.0500 |
| 17/64 | 0.265625 | 6.7469 | 49/64 | 0.765625 | 19.4464 |
| 9/32 | 0.28125 | 7.1437 | 25/32 | 0.78125 | 19.8437 |
| 19/64 | 0.296875 | 7.5406 | 51/64 | 0.796875 | 20.2406 |
| 5/16 | 0.3125 | 7.9375 | 13/16 | 0.8125 | 20.6373 |
| 21/64 | 0.328125 | 8.3344 | 53/64 | 0.828125 | 21.0343 |
| 11/32 | 0.34375 | 8.7312 | 27/32 | 0.84375 | 21.4312 |
| 23/64 | 0.359375 | 9.1281 | 55/64 | 0.859375 | 21.8281 |
| 3/8 | 0.375 | 9.5250 | 7/8 | 0.875 | 22.2250 |
| 25/64 | 0.390625 | 9.9219 | 57/64 | 0.890625 | 22.6214 |
| 13/32 | 0.40625 | 10.3187 | 29/32 | 0.90625 | 23.0187 |
| 27/64 | 0.421875 | 10.7156 | 59/64 | 0.921875 | 23.4156 |
| 7/16 | 0.4375 | 11.1125 | 15/16 | 0.9375 | 23.8125 |
| 29/64 | 0.453125 | 11.5094 | 61/64 | 0.953125 | 24.2094 |
| 15/32 | 0.46875 | 11.9062 | 31/32 | 0.96875 | 24.6062 |
| 31/64 | 0.484375 | 12.3031 | 63/64 | 0.984375 | 25.0031 |
| 1/2 | 0.5 | 12.7000 | 1 | 1.000 | 25.4000 |

# 2.4 METRIC MEASURES

| Linear measure | | Square measure | | Weight | |
|---|---|---|---|---|---|
| Name | mm | Name | Sq.mm. | Name | Grammes |
| Millimetre | 1 | Sq. millimetre | 1 | Milligram | 0.001 |
| Centimetre | 10 | Sq. centimetre | $10^2$ | Centigram | 0.01 |
| Decimetre | $10^2$ | Sq. decimetre | $10^4$ | Decigram | 0.1 |
| Metre | $10^3$ | Sq. metre or centiare | $10^6$ | Gram | 1 |
| Dekametre | $10^4$ | | | Dekagram | 10 |
| Hectometre | $10^5$ | Sq. dekametre or | | Hectogram | $10^2$ |
| Kilometre | $10^6$ | are | $10^8$ | Kilogram | $10^3$ |
| Myriametre | $10^7$ | Sq. hectometre or | | Myriagram | $10^4$ |
| | | hectare | $10^{10}$ | Quintal | $10^5$ |
| | | Sq. kilometre | 10 | Millier | |
| | | Sq. myriametre | 10 | (tonne) | $10^6$ |

# 2.5 FUNCTIONS OF 'G'

| Unit of g in M. K. S. = metres/sec$^2$. | | | Unit of g in F. P. S = feet/sec$^2$ | | |
|---|---|---|---|---|---|
| | In M. K. S. | In F. P. S. | | In M. K. S. | In F. P. S. |
| $g$ | 9.81 | 32.2 | $\log \sqrt{g}$ | 0.49583 | 0.75393 |
| $2g$ | 19.62 | 64.4 | $\log \sqrt{2g}$ | 0.64635 | 0.90444 |
| $\sqrt{g}$ | 3.1321 | 5.6745 | $1/g$ | 0.10194 | 0.031056 |
| $\sqrt{2g}$ | 4.4295 | 8.025 | $1/2g$ | 0.050967 | 0.015528 |
| $\log g$ | 0.99167 | 1.50786 | $1/\sqrt{g}$ | 0.31928 | 0.17622 |
| $\log 2g$ | 1.2927 | 1.80889 | $1/\sqrt{2g}$ | 0.22575 | 0.12461 |
| $g^2$ | 96.236 | 1036.84 | $g^3$ | 944.08 | 33386.248 |

# 2.6 TABLE OF REGULAR POLYGONS

If $S$ = side of polygon, $R$ = radius of circumscribed circle, $r$ = radius of inscribed circle, and $A$ = angle formed by the intersection of sides, then

| Name | No. of sides | $A°$ | Area = $S^2$ X | $S = R$ X | $S = r$ X |
|---|---|---|---|---|---|
| Triangle | 3 | 60° | 0.4330 | 1.732 | 3.4641 |
| Pentagon | 5 | 108° | 1.7205 | 1.1756 | 1.4536 |
| Hexagon | 6 | 120° | 2.5980 | 1.0000 | 1.1547 |
| Octagon | 8 | 135° | 4.8284 | 0.7653 | 0.8284 |
| Decagon | 10 | 144° | 7.6942 | 0.6180 | 0.6498 |

Area of any regular polygon = radius of inscribed circle X ½ number of sides X length of one side

## 2.7 TRIGONOMETRICAL RATIOS

Sine (sin) $\alpha = \dfrac{\text{Perpendicular}}{\text{hypotenuse}}$ ; Cosine (cos) $\alpha = \dfrac{\text{base}}{\text{hypotenuse}}$

Tangent (tan) $\alpha = \dfrac{\text{perpendicular}}{\text{base}} = \dfrac{\sin\alpha}{\cos\alpha}$

Contangent (cot) $\alpha = \dfrac{1}{\tan\alpha}$ ; Secant (sec) $\alpha = \dfrac{1}{\cos\alpha}$

Cosecant (cosec) $\alpha = \dfrac{1}{\sin\alpha}$ ; Exsecant (exsec) $\alpha = \sec\alpha - 1$

Versine (vers) $\alpha = 1 - \cos\alpha$ ; Coversine (covers) $\alpha = 1 - \sin\alpha$

## 2.8 SIGNS OF THE FUNCTIONS

| Quadrant | Sin | Cos | Tan | Cot | Sec | Cosec |
|---|---|---|---|---|---|---|
| First | + ve | + ve | + ve | + ve | + ve | + ve |
| Second | + ve | − ve | − ve | − ve | − ve | + ve |
| Third | − ve | − ve | + ve | + ve | − ve | − ve |
| Fourth | − ve | + ve | − ve | − ve | + ve | − ve |

## 2.9 FUNCTIONS OF ANGLE IN ANY QUADRANT
### (In terms of angles in First Quadrant)

| Trigonometrical | $-\alpha$ | $90^0 \pm \alpha$ | $180^0 \pm \alpha$ | $270^0 \pm \alpha$ | $n(360^0)\ \alpha$ |
|---|---|---|---|---|---|
| sin | $-\sin\alpha$ | $+\cos\alpha$ | $\mp\sin\alpha$ | $-\cos\alpha$ | $\pm\sin\alpha$ |
| cos | $+\cos\alpha$ | $\mp\sin\alpha$ | $-\cos\alpha$ | $\pm\sin\alpha$ | $+\cos\alpha$ |
| tan | $-\tan\alpha$ | $\mp\cot\alpha$ | $\pm\tan\alpha$ | $\mp\cot\alpha$ | $\pm\tan\alpha$ |
| cot | $-\cot\alpha$ | $\mp\tan\alpha$ | $\pm\cot\alpha$ | $\mp\tan\alpha$ | $\pm\cot\alpha$ |
| sec | $+\sec\alpha$ | $\mp\text{cosec}\,\alpha$ | $-\sec\alpha$ | $\pm\text{cosec}\,\alpha$ | $-\sec\alpha$ |
| cosec | $-\text{cosec}\,\alpha$ | $+\sec\alpha$ | $\mp\text{cosec}\,\alpha$ | $-\sec\alpha$ | $\pm\text{cosec}\,\alpha$ |

## 2.10 FUNCTIONS OF 0° TO 360°

| Angle | $0^0$ | $30^0$ | $45^0$ | $60^0$ | $90^0$ | $120^0$ | $135^0$ | $150^0$ | $180^0$ | $270^0$ | $360^0$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| sin | 0 | 1/2 | $1/\sqrt{2}$ | $\sqrt{3}/2$ | 1 | $\sqrt{3}/2$ | $1/\sqrt{2}$ | 1/2 | 0 | -1 | 0 |
| cos | 1 | $\sqrt{3}/2$ | $1/\sqrt{2}$ | 1/2 | 0 | -1/2 | $-1/\sqrt{2}$ | $-\sqrt{3}/2$ | -1 | 0 | 1 |
| tan | 0 | $1/\sqrt{3}$ | 1 | $\sqrt{3}$ | ∞ | $-\sqrt{3}$ | -1 | $-1/\sqrt{3}$ | 0 | ∞ | 0 |
| cot | ∞ | $\sqrt{3}$ | 1 | $1/\sqrt{3}$ | 0 | $-1/\sqrt{3}$ | -1 | $-\sqrt{3}$ | ∞ | 0 | ∞ |
| sec | 1 | $2/\sqrt{3}$ | $\sqrt{2}$ | 2 | ∞ | -2 | $-\sqrt{2}$ | $-2/\sqrt{3}$ | -1 | ∞ | 1 |
| cosec | ∞ | 2 | $\sqrt{2}$ | $2/\sqrt{3}$ | 1 | $2/\sqrt{3}$ | $\sqrt{2}$ | 2 | ∞ | -1 | ∞ |
| vers | 0 | $2-\sqrt{3}$ | $\dfrac{\sqrt{2}-1}{\sqrt{2}}$ | 1/2 | 1 | 3/2 | $\dfrac{\sqrt{2}+1}{\sqrt{2}}$ | $\dfrac{2+\sqrt{3}}{2}$ | 2 | 1 | 0 |

# 2.11 VALUE OF $\pi$

$\pi = 3.14159265358979323846264338327950$ (correct value)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $\log \pi$ | = | 0.4971499 | $\pi\sqrt{2}$ | = | 4.44288 | $\sqrt{2}/\pi$ | = | 0.4501582 |
| $180/\pi$ | = | 57°296 | $\sqrt{(2/\pi)}$ | = | 0.7978846 | $1/\pi^3$ | = | 0.032252 |
| $\pi/180$ | = | 0.01745328 | $\pi/\sqrt{2}$ | = | 2.2214415 | $\pi^2$ | = | 9.869604 |
| $1/\pi^2$ | = | 0.1013212 | $\sqrt{(\pi/2)}$ | = | 1.2533 | $\pi^3$ | = | 31.006277 |
| $1/\sqrt{\pi}$ | = | 0.5641896 | $\sqrt{\pi}$ | = | 1.7725 | $\sqrt[4]{\pi}$ | = | 1.464022 |

| $n$ | $\pi \times n$ | $\pi/n$ | $n/\pi$ | $\pi^2 \times n$ | $\pi^2/n$ | $n\sqrt{\pi}$ |
|---|---|---|---|---|---|---|
| 1 | 3.14159 | 3.14159 | 0.31831 | 9.8669 | 9.8696 | 1.7725 |
| 2 | 6.28318 | 1.57080 | 0.63662 | 19.7372 | 4.9348 | 3.5449 |
| 3 | 9.42478 | 1.01720 | 0.95493 | 29.8088 | 3.2899 | 5.3174 |
| 4 | 12.56637 | 0.785398 | 1.27324 | 39.4784 | 2.4674 | 7.0898 |
| 5 | 15.70790 | 0.628319 | 1.59155 | 49.3480 | 1.9739 | 8.8623 |
| 6 | 18.84956 | 0.523599 | 1.90986 | 59.2176 | 1.6449 | 10.6347 |
| 7 | 21.99115 | 0.448799 | 2.22817 | 69.0872 | 1.4099 | 12.4072 |
| 8 | 25.13274 | 0.392899 | 2.54648 | 78.9568 | 1.2337 | 14.1796 |
| 9 | 28.27433 | 0.349066 | 2.86479 | 88.8264 | 1.0966 | 15.9521 |

## 2.12. SOILS WEIGHT AND ANGLE OF REPOSE:

| Nature of Soil | Weight in kg/cu. m. | Angle of repose in degrees |
|---|---|---|
| Dry sand | 5.6 to 6.2 | 30 to 35 |
| Damp sand | 6.2 to 7.0 | 35 |
| Wet sand | 7.0 to 7.5 | 25 to 26 |
| Sand dry and consolidated | 7.5 | 35 |
| Vegetable earth dry | 5.6 | 20 to 30 |
| Vegetable earth moist | 6.2 to 7.0 | 45 to 49 |
| Vegetable earth wet | 7.0 to 7.5 | 15 to 17 |
| Vegetable earth consolidated and dry | 5.4 | 49 |
| Clean gravel | 5.6 | 40 |
| Gravel and sand | 6.2 to 7.0 | 26 to 30 |
| Rubble stone | 6.2 to 7.0 | 45 |
| Dry clay | 7.5 to 9.0 | 30 |
| Damp clay | 7.5 to 10 | 45 |
| Wet clay | 7.5 to 10 | 15 |
| Mud | 6.2 to 7.5 | 0 |
| Ashes | 2.5 | 40 |

In formula $P = \dfrac{wh^2}{2} \times \cos\alpha \dfrac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi}} = K \times \dfrac{wh^2}{2}$

Value of $K$ can be obtained by the following table directly.

| ↓ $\alpha$ / $\phi$ → | 15° | 20° | 25° | 30° | 35° | 40° | 45° |
|---|---|---|---|---|---|---|---|
| 10° | 0.70 | 0.57 | 0.46 | 0.37 | 0.29 | 0.23 | 0.17 |
| 20° | — | — | 0.54 | 0.42 | 0.32 | 0.25 | 0.19 |
| 25° | — | — | — | 0.49 | 0.37 | 0.27 | 0.21 |
| 30° | — | — | — | — | 0.44 | 0.32 | 0.23 |
| 35° | — | — | — | — | — | 0.39 | 0.27 |
| 40° | — | — | — | — | — | — | 0.34 |

# 2.13 CONVERSION FACTORS

| *Multiply by* | *To convert* | *To* | |
|---|---|---|---|
| 2.54 | Inches | Centimetres | 0.3937 |
| 30.48 | Feet | Centimetres | 0.0328 |
| 0.914 | Yards | Metres | 1.094 |
| 1,609.3 | Miles | Metres | 0.000621 |
| 6.45 | Square Inches | Square centimetres | 0.155 |
| 0.093 | Square feet | Square metres | 10.764 |
| 0.839 | Square yards | Square metres | 1.196 |
| 16.39 | Cubic inches | Cubic centimetres | 0.016 |
| 28.3 | Cubic feet | Litres | 0.0353 |
| 6.24 | Cubic feet | Gallons | 0.1602 |
| 0.765 | Cubic yards | Cubic metres | 1.308 |
| 0.3732 | Pounds (Troy) | Kilogrammes | 2.68 |
| 31.10 | Ounces (Troy) | Grammes | 0.03216 |
| 0.4536 | Pounds (Avoir.) | Kilogrammes | 2.2045 |
| 50.8 | Hundredweight | Kilogrammes | 0.01968 |
| 1,016.50 | Tons | Kilogrammes | 0.000984 |
| 4.546 | Gallons | Litres | 0.22 |
| 10 | Gallon of water | Pounds | 0.1 |
| 0.454 | Pounds of water | Litres | 0.2202 |
| 70.3 | Pounds/sq.in. | Grammes/sq.cm. | 0.0142 |
| 2.3 | Pounds/sq.in. | Head of water (ft) | 0.434 |
| 0.7 | Pounds/sq.in. | Head of water (m) | 1.4285 |
| 0.068 | Pounds/sq.in. | Atmospheres | 14.7 |
| 1.575 | Pounds/sq.in. | Kilogramme/sq.mm | 0.635 |
| 4.883 | Pounds/sq.ft. | Kilogramme/sq.m | 0.205 |
| 16.02 | Pounds/cu.ft. | Kilogramme/cu.m | 0.0624 |
| 0.0998 | Pounds/Gallon | Kilogramme/Litre | 10.02 |
| 33,000 | Horse power | Foot pound/minute | — |
| 88 | Miles/hour | Foot/minute | 0.01134 |
| 197 | Metres/second | Foot/minute | 0.00508 |
| 1.488 | Pounds/foot | Kilogramme/metre | 0.672 |
| 3,333.33 | Tons/foot | Kilogramme/metre | 0.00033 |
| 10.936 | Tons/sq.ft. | Tonnes/sq.metre | 0.0914 |
| 48.905 | Gallon/sq.ft. | Litres/sq.metre | 0.0204 |
| 25.8 | Inch-tons | Kilogramme-metre | 0.0387 |
| | *To* | *To convert* | *Multiply by* |

# 2.14. CONVERSION TABLES

## 2.14.1 Rate per 100 R. Ft. to Rate for 1 Metre

(Based on 100 R. ft = 30.48 M & 1 M = 3.28084 R. ft.)

| Rs./100 R. Ft. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Rs./ Cu. m | | | | | | |
| 0 | 0 | 0.03 | 0.07 | 0.10 | 0.13 | 0.16 | 0.20 | 0.23 | 0.26 | 0.30 |
| 10 | 0.33 | 0.36 | 0.39 | 0.43 | 0.46 | 0.49 | 0.52 | 0.56 | 0.59 | 0.62 |
| 20 | 0.66 | 0.69 | 0.72 | 0.75 | 0.79 | 0.82 | 0.85 | 0.89 | 0.92 | 0.95 |
| 30 | 0.98 | 1.02 | 1.05 | 1.08 | 1.12 | 1.15 | 1.18 | 1.21 | 1.25 | 1.28 |
| 40 | 1.31 | 1.35 | 1.38 | 1.41 | 1.44 | 1.48 | 1.51 | 1.54 | 1.57 | 1.61 |
| 50 | 1.64 | 1.67 | 1.71 | 1.74 | 1.77 | 1.80 | 1.84 | 1.87 | 1.90 | 1.94 |
| 60 | 1.97 | 2.00 | 2.03 | 2.07 | 2.10 | 2.13 | 2.17 | 2.20 | 2.23 | 2.26 |
| 70 | 2.30 | 2.33 | 2.36 | 2.40 | 2.43 | 2.46 | 2.49 | 2.53 | 2.56 | 2.59 |
| 80 | 2.62 | 2.66 | 2.69 | 2.72 | 2.76 | 2.79 | 2.82 | 2.85 | 2.89 | 2.92 |
| 90 | 2.95 | 2.99 | 3.02 | 3.05 | 3.08 | 3.12 | 3.15 | 3.18 | 3.22 | 3.25 |
| 100 | 3.28 | ... | ... | ... | ... | ... | ... | ... | ... | ... |

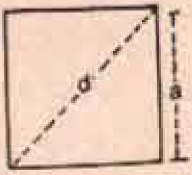
## 2.14.2 Rate per 100 Sq. Ft. to Rate for 1 Sq. Metre

(Based on 100 sq. ft = 9.2903 Sq. m)

| Rs./100 sq. ft. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Rs./ sq. m | | | | | | |
| 0 | 0 | 0.11 | 0.22 | 0.32 | 0.43 | 0.54 | 0.65 | 0.75 | 0.86 | 0.97 |
| 10 | 1.08 | 1.18 | 1.29 | 1.40 | 1.51 | 1.61 | 1.72 | 1.83 | 1.94 | 2.05 |
| 20 | 2.15 | 2.26 | 2.37 | 2.48 | 2.58 | 2.69 | 2.80 | 2.91 | 3.01 | 3.12 |
| 30 | 3.23 | 3.34 | 3.44 | 3.55 | 3.66 | 3.77 | 3.88 | 3.98 | 4.09 | 4.20 |
| 40 | 4.31 | 4.41 | 4.52 | 4.63 | 4.74 | 4.84 | 4.95 | 5.06 | 5.17 | 5.27 |
| 50 | 5.38 | 5.49 | 5.60 | 5.70 | 5.81 | 5.92 | 6.03 | 6.14 | 6.24 | 6.35 |
| 60 | 6.46 | 6.57 | 6.67 | 6.78 | 6.89 | 7.00 | 7.10 | 7.21 | 7.32 | 7.43 |
| 70 | 7.53 | 7.64 | 7.75 | 7.86 | 7.97 | 8.07 | 8.18 | 8.29 | 8.40 | 8.50 |
| 80 | 8.61 | 8.72 | 8.83 | 8.93 | 9.04 | 9.15 | 9.26 | 9.36 | 9.47 | 9.58 |
| 90 | 9.69 | 9.80 | 9.90 | 10.01 | 10.12 | 10.23 | 10.33 | 10.45 | 10.55 | 10.66 |
| 100 | 10.66 | ... | ... | ... | ... | ... | ... | ... | ... | ... |

# 2.15 AREAS OF PLANE FIGURES

$A$ = Area

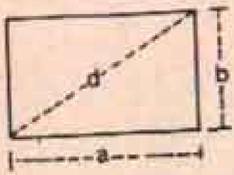



**1. Square**

$A = a^2$

$= \frac{1}{2} d^2$

$d = a\sqrt{2}$




**2. Rectangle**

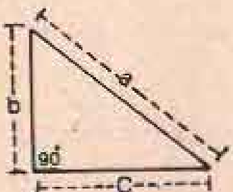
$A = ab$

$= a\sqrt{d^2 - a^2} = b\sqrt{d^2 - b^2}$

$d = \sqrt{a^2 + b^2}$


**3. Parallelogram**

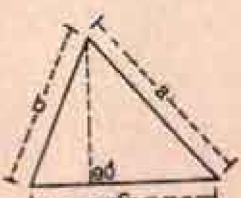
$A = ab$




**4. Right-angled triangle**

$A = \frac{1}{2} bc$

$a = \sqrt{b^2 + c^2}$

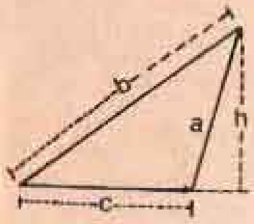



**5. Acute-angled triangle**

$$A = \frac{ch}{2} = \frac{c}{2}\sqrt{a^2 - \left[\frac{a^2 + c^2 - b^2}{2c}\right]^2}$$

If $s = \frac{1}{2}(a + b + c)$, then

$$A = \sqrt{s(s-a)(s-b)(s-c)}$$

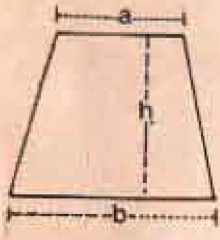



## 6. Obtuse-angled triangle

$$A = \frac{ch}{2} = \frac{c}{2}\sqrt{a^2 - \left[\frac{b^2 - a^2 - c^2}{2c}\right]^2}$$

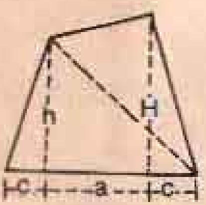
If $s = \frac{1}{2}(a + b + c)$, then

$$A = \sqrt{s(s-a)(s-b)(s-c)}$$




## 7. Trapezoid

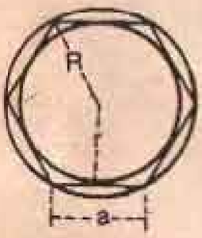
$$A = \frac{(a+b)h}{2}$$




## 8. Trapezium

$$A = \frac{(H+h)a + bh + cH}{2}$$

If the sides of trapezium and length of dash line are given the trapezium can also be divided into two triangles as shown. The areas of two triangles is computed and added to obtain the required area.



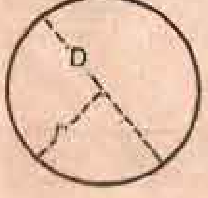

## 9. Regular polygon

$n$ = No. of sides

$$A = \frac{nar}{2} = \frac{na}{2}\sqrt{R^2 - \frac{a^2}{4}}$$

$$R = \sqrt{r^2 + \frac{a^2}{4}}\,; \quad r = \sqrt{R^2 - \frac{a^2}{4}}\,;$$

$$a = 2\sqrt{R^2 - r^2}$$

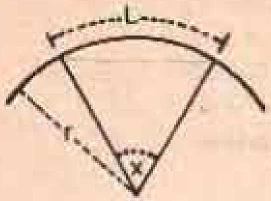



## 10. Circle

$C$ = Circumference

$$A = \pi r^2 = \frac{\pi d^2}{4}$$

$$C = 2\pi r = \pi d$$

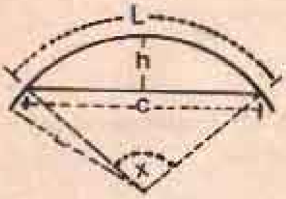


**11. Sector**

$$A = \tfrac{1}{2}rl = \tfrac{1}{2}r^2\alpha \ (\alpha \text{ in radians})$$

$$= \pi r^2 \cdot \frac{\alpha}{360} = \frac{\alpha}{60} \cdot \frac{\pi d^2}{4}$$

$$l = \frac{\alpha}{360} \cdot 2\pi r = \frac{\alpha}{360} \cdot \pi d$$

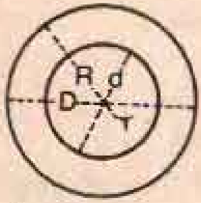


**12. Circular segment**

$$A = \tfrac{1}{2}\left[rl - c(r - h)\right]$$

$$= \frac{4}{3}h\sqrt{\frac{1}{4}c^2 + \frac{2}{5}h^2}\ ;\ c = 2\sqrt{h(2r - h)}$$

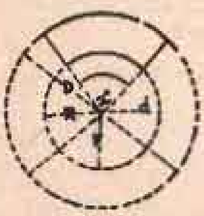
$$r = \frac{c^2 + 4h^2}{8h}\ ;\ h = r - \tfrac{1}{2}\sqrt{4r^2 - c^2}$$



**13. Circular ring**

$$A = \pi(R^2 - r^2)$$

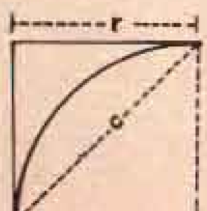
$$= \frac{\pi}{4}(D^2 - d^2)$$



**14. Circular ring sector**

$$A = \quad \cdot \pi \ (R^2 - r^2)$$

$$= \alpha \ \frac{\pi}{4}(D^2 - d^2)$$



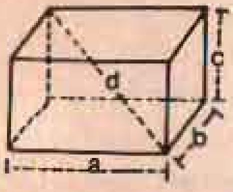
**15. Spandril or fillet**

$$A = r^2\left(1 - \frac{\pi}{4}\right)$$

$$\frac{c^2}{2}\left(1 - \pi\right)$$

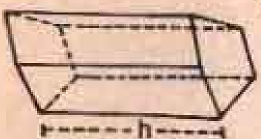
# 2.16 VOLUME & SURFACE OF SOLIDS

$V$ = *Volume*
$C$ = *Curved Surface*
$S$ = *Total Surface*
$L$ = *Lateral Surface*



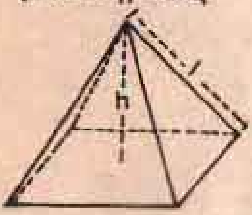

## 1. Rectangular prism

$V = abc$
$d = \sqrt{a^2 + b^2 + c^2}$
$S = 2(ab + bc + ca)$
In case of cubes put $a = b = c$.



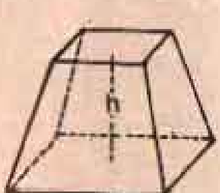

## 2. Prism

$V = h \times$ area of end
$S = 2 \times$ area of end $+ h \times$ perimeter of end
$L = h \times$ perimeter of end




## 3. Pyramid

$V = \frac{1}{3}h \times$ area of base
$L = \frac{1}{2}l \times$ perimeter
$S = L +$ area of base



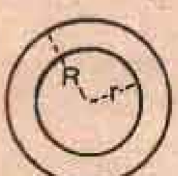

## 4. Frustum of Pyramid

$A_1$ = Area of top; $P_1$ @ Perimeter of top
$A_2$ = Area of base; $P_2$ = Perimeter of base

$V = \frac{h}{3}(A_1 + A_2 + \sqrt{A_1 A_2})$
$L = \frac{1}{2}(P_1 + P_2) \times$ Slant height
$S = L + A_1 + A_2$


## 5. Wedge

$$V = \frac{(2a + c)bh}{6}$$

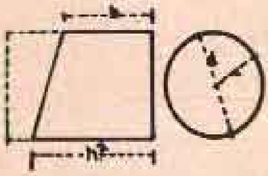



## 6. Cylindrical ring

$V = \pi R^2 . 2\pi r$
$S = 2\pi R . 2\pi r$

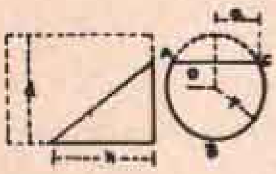
## 7. Cylinder

$$V = \pi r^2 h = \tfrac{1}{4}\pi d^2 h$$
$$C = 2\pi r h = \pi d h$$
$$S = \pi r\,(r + 2h) = \pi d\,(\tfrac{1}{2}d + h)$$



## 8. Frustum of Cylinder

$$V = \tfrac{1}{2}\pi r^2\,(h_1 + h_2) = \tfrac{1}{8}\pi d^2\,(h_1 + h_2)$$
$$C = \pi r\,(h_1 + h_2) = \tfrac{1}{2}\pi d\,(h_1 + h_2)$$

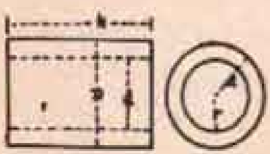


## 9. Frustum of Cylinder

$$V = (\tfrac{2}{3}a^3 \pm b \times \text{area } ABC)\ \frac{h}{r \pm b}$$

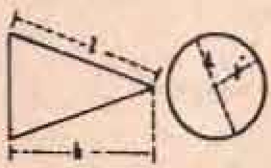
$$C = (ad \pm b \times \text{arc } ABC)\ \frac{h}{r \pm b}$$

Use + when base are is larger, and — when base area is less than one-half the base circle.



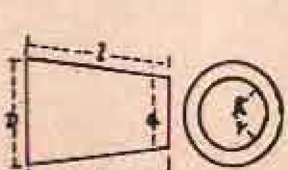
## 10. Hollow Cylinder

$$V = \pi h\,(R^2 - r^2) = \tfrac{1}{4}\pi h\,(D^2 - d^2)$$
$$C = 2\pi h\,(R + r) = \pi h\,(D + d)$$
$$S = 2\pi h\,(R + r) + 2\pi\,(R^2 - r^2)$$



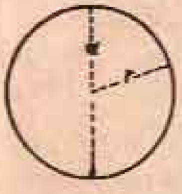
## 11. Cone

$$V = \tfrac{1}{3}\pi r^2 h = 1/24\,\pi d^3 h$$
$$C = \pi r l = \tfrac{1}{2}\pi d l$$
$$S = \pi r\,(l + r)$$
$$l = \sqrt{h^2 + r^2}$$



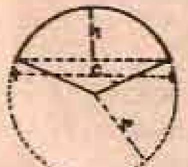
## 12. Frustum of cone

$$V = \tfrac{1}{3}\pi h\,(R^2 + r^2 + Rr)$$
$$C = \pi l\,(R + r)$$
$$S = \pi\,[R^2 + r^2 + (R + r)\,l]$$



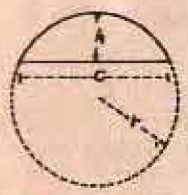
**13. Sphere**

$$V = \frac{4}{3}\pi r^3 = \frac{1}{6}\pi d^3$$
$$S = 4\pi r^2 = \pi d^2$$



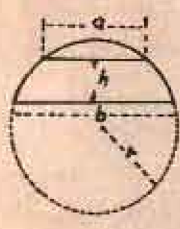
**14. Spherical sector**

$$V = \frac{2}{3}\pi r^2 h = \frac{1}{6}\pi d^2 h$$
$$S = \pi r\left(2h + \tfrac{1}{2}c\right)$$
$$c = 2\sqrt{h(2r-h)}$$



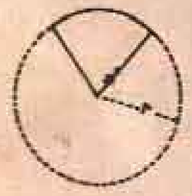
**15. Spherical segment**

$$V = \frac{1}{6}\pi h\left(\tfrac{3}{4}c^2 + h^2\right)$$
$$C = 2\pi rh$$
$$S = \pi\left(2rh + \tfrac{1}{4}c^2\right)$$
$$r = \frac{c^2 + 4h^2}{8h}\ ;\ c\ @\ 2\sqrt{h(2r-h)}$$



**16. Spherical cone**

$$V = \frac{1}{6}\pi h\left(\tfrac{3}{4}a^2 + \tfrac{3}{4}b^2 + h^2\right)$$
$$C = 2\pi rh$$
$$S = 2\pi rh + \frac{1}{4}\pi a^2 + \frac{1}{4}\pi b^2$$



**17. Spherical wedge**

$$V = \frac{\alpha}{360} \times \frac{4}{3}\pi r^3 \ (\alpha \text{ in degrees})$$

$$C = \frac{\alpha}{360} \times 4\pi r^2$$

**18. Spherical Shell**

$$V = \frac{4}{3}\pi\left(R^3 - r^3\right) = \frac{1}{6}\pi\left(D^3 - d^3\right)$$
$$S = 4\pi\left(R^2 + r^2\right) = \pi\left(D^2 + d^2\right)$$

# 2.17 WEIGHT OF ENGINEERING MATERIALS

| | | |
|---|---|---|
| 1. | Aluminium sheet (per 1 mm thickness) | 2.8 kg / sq.m. |
| 2. | Asbestos Board | 2.43 kg / cu.m. |
| 3. | Corrugated or Trafford sheets (6 mm thickness) | 17.09 kg / sq.m. |
| 4. | Flat sheets (6 mm thickness) | 12.21 kg / sq.m. |
| 5. | Bitumen | 1340 kg / cu.m. |
| 6. | Brass | 8550 kg / cu.m. |
| 7. | Bricks | 1600 kg / cu.m. |
| 8. | Cement | 1440 kg / cu.m. |
| 9. | Glass | 2560 kg / cu.m. |
| 10. | Timber | 720 kg / cu.m. |
| 11. | Cork | 240 kg / cu.m. |
| 12. | Copper sheet (Per 1 mm thickness) | 8.69 kg / cu.m. |
| 13. | Chromium | 6.848 kg / cu.m. |
| 14. | Copper | 8.938 kg / cu.m. |
| 15. | Copper wire | 8891 kg / cu.m. |
| 16. | Fire brick | 2083 kg / cu.m. |
| 17. | Fire clay | 2243 kg / cu.m. |
| 18. | Gold | 19224 kg / cu.m. |
| 19. | Gravel | 1800 kg / cu.m. |
| 20. | Gun metal | 8780 kg / cu.m. |
| 21. | Ice | 913 kg / cu.m. |
| 22. | Iridium | 22428 kg / cu.m. |
| 23. | Iron ore | 3813 kg / cu.m. |
| 24. | Wrought iron | 7700 kg / cu.m. |
| 25. | Pig iron | 7200 kg / cu.m. |
| 26. | Cast iron | 7650 kg / cu.m. |
| 27. | Lead | 11374 kg / cu.m. |
| 28. | Lead sheet (Per 1 mm thickness) | 11 kg / sq.m. |

| | | |
|---|---|---|
| 29. | Cement mortar | 2080 kg / cu.m. |
| 30. | Lime mortar | 1760 kg / cu.m. |
| 31. | Castor oil | 960 kg / cu.m. |
| 32. | Diesel | 960 kg / cu.m. |
| 33. | Turpentine | 865 kg / cu.m. |
| 34. | Petrol | 690 kg / cu.m. |
| 35. | Platinum | 21499 kg / cu.m. |
| 36. | Plywood (Per 1 mm thickness) | 0.70 kg / cu.m. |
| 37. | Porcelain | 2355 kg / cu.m. |
| 38. | Rubber | 960 kg / cu.m. |
| 39. | Sand | 1600 kg / cu.m. |
| 40. | Silver | 104.93 kg / cu.m. |
| 41. | Steel | 10493 kg / cu.m. |
| 42. | Corrugated | 7800 kg / cu.m. |
| | Steel sheets Galvanised as laid | |
| | 16 Gauge (Big) | 16.405 kg / cu.m. |
| | 18 Gauge (Big) | 13.085 kg / cu.m. |
| | 20 Gauge (Big) | 10.204 kg / cu.m. |
| | 22 Gauge (Big) | 8.398 kg / cu.m. |
| | 24 Gauge (Big) | 6.933 kg / cu.m. |
| 43. | Granite | 2640-2800 kg / cu.m. |
| 44. | Marble | 2620 kg / cu.m. |
| 45. | Laterite | 2080-2400 kg / cu.m. |
| 46. | Lime stone | 2650 kg / cu.m. |
| 47. | Zinc | 7464 kg / cu.m |
| 48. | Zinc sheet (Per 1 mm thickness) | 71 kg / cu.m. |
| 49. | A. C. Sheets | 17 kg / cu.m. |
| 50. | Brick masonry | 1920 kg / cu.m. |
| 51. | Concrete | 2306 kg / cu.m. |
| 52. | Mangalore Tiles with Batters | 69 kg / cu.m. |
| 53. | Random Rubble Masonry in LM or CM | 2240 kg / cu.m. |
| 54. | Coursed Rubble Masonry in LM or CM | 2240 kg / cu.m. |
| 55. | Laterlite in L. M. | 2000 kg / cu.m. |
| 56. | Cuddappah Slab | 2720 kg / cu.m. |
| 57. | Rain forced concrete | 2400 kg / cu.m. |
| 58. | Water | 1000 kg / cu.m. |

# 2.18 COMMON STEEL TABLES FOR SQUARE AND ROUND BARS

*Based on 0.7843 kg/cm² per metre or 1cft of Steel = 490 lbs.*

| Dia/ width | Weight per metre | | Sectional Area | | Perimeter | |
|---|---|---|---|---|---|---|
| mm. | □ kg. | ○ kg. | □ $cm^2$ | ○ $cm^2$ | □ cm. | ○ cm. |
| 5.0 | 0.20 | 0.15 | 0.25 | 0.20 | 2.0 | 5.71 |
| 5.5 | 0.24 | 0.19 | 0.30 | 0.24 | 2.2 | 1.73 |
| 6.0 | 0.28 | 0.22 | 0.36 | 0.28 | 2.4 | 1.88 |
| 7.0 | 0.38 | 0.30 | 0.49 | 0.38 | 2.8 | 2.20 |
| 8.0 | 0.50 | 0.39 | 0.54 | 0.50 | 3.2 | 2.51 |
| 9.0 | 0.64 | 0.50 | 0.81 | 0.64 | 3.6 | 2.83 |
| 10 | 0.78 | 0.62 | 1.00 | 0.79 | 4.0 | 3.14 |
| 11 | 0.95 | 0.75 | 1.21 | 0.95 | 4.4 | 3.46 |
| 12 | 1.13 | 0.89 | 1.44 | 1.13 | 4.8 | 3.77 |
| 14 | 1.54 | 1.21 | 1.96 | 1.54 | 5.6 | 4.40 |
| 16 | 2.01 | 1.58 | 2.56 | 2.01 | 6.4 | 5.03 |
| 18 | 2.54 | 2.00 | 3.24 | 2.54 | 7.2 | 5.65 |
| 20 | 3.14 | 2.47 | 4.00 | 3.14 | 8.0 | 6.28 |
| 22 | 3.80 | 2.98 | 4.84 | 3.80 | 8.8 | 6.91 |
| 25 | 4.91 | 3.85 | 6.25 | 4.91 | 10.0 | 7.85 |
| 28 | 6.15 | 4.83 | 7.84 | 6.16 | 11.2 | 8.80 |
| 32 | 8.04 | 6.31 | 10.24 | 8.04 | 12.8 | 10.05 |
| 36 | 10.17 | 7.99 | 12.96 | 10.18 | 14.4 | 11.31 |
| 40 | 12.56 | 9.86 | 16.00 | 12.57 | 16.0 | 12.57 |
| 45 | 15.90 | 12.49 | 20.25 | 15.90 | 18.0 | 14.14 |
| 50 | 19.62 | 15.41 | 25.00 | 19.64 | 20.0 | 15.71 |
| 56 | 24.62 | 19.34 | 31.36 | 24.63 | 22.4 | 17.59 |
| 63 | 31.16 | 24.47 | 39.69 | 31.17 | 25.2 | 19.79 |
| 71 | 39.57 | 31.08 | 50.41 | 39.59 | 28.4 | 22.31 |
| 80 | 50.24 | 39.46 | 64.00 | 50.27 | 32.0 | 25.13 |
| 90 | 63.58 | 49.94 | 81.00 | 63.62 | 36.0 | 28.27 |
| 100 | 78.50 | 61.66 | 100 | 78.54 | 40.0 | 31.42 |

## 2.19 AREA OF BARS IN GIVEN SPACINGS IN CM²

*Values in cm² per Meter Width*

| SPACING | BAR DIAMETER, mm | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cm | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 25 | 28 | 32 |
| 5 | 5.65 | 10.05 | 15.71 | 22.62 | 30.79 | 40.21 | 50.89 | 62.83 | 76.03 | 98.17 | 123.15 | 160.85 |
| 6 | 4.71 | 8.38 | 13.09 | 18.85 | 25.66 | 33.51 | 42.41 | 52.36 | 63.36 | 81.81 | 102.68 | 134.04 |
| 7 | 4.04 | 7.18 | 11.22 | 16.16 | 21.99 | 28.72 | 36.35 | 44.88 | 54.30 | 70.12 | 87.96 | 114.89 |
| 8 | 3.53 | 6.28 | 9.82 | 14.14 | 19.24 | 25.13 | 31.81 | 39.27 | 47.52 | 61.36 | 76.97 | 100.53 |
| 9 | 3.14 | 5.58 | 8.73 | 12.57 | 17.10 | 22.34 | 28.27 | 34.91 | 42.24 | 54.54 | 68.42 | 89.36 |
| 10 | 2.83 | 5.03 | 7.85 | 11.31 | 15.39 | 20.11 | 25.45 | 31.42 | 38.01 | 49.09 | 61.57 | 80.42 |
| 11 | 2.57 | 4.57 | 7.14 | 10.28 | 13.99 | 18.28 | 23.13 | 28.56 | 34.56 | 44.62 | 55.98 | 73.11 |
| 12 | 2.36 | 4.19 | 6.54 | 9.42 | 12.83 | 16.75 | 21.21 | 26.18 | 31.68 | 40.91 | 51.31 | 67.02 |
| 13 | 2.17 | 3.87 | 6.04 | 8.70 | 11.84 | 15.47 | 19.57 | 24.17 | 29.24 | 37.76 | 47.37 | 61.86 |
| 14 | 2.02 | 3.59 | 5.61 | 8.08 | 11.00 | 14.36 | 18.18 | 22.44 | 27.15 | 35.06 | 43.98 | 57.45 |
| 15 | 1.88 | 3.35 | 5.24 | 7.54 | 10.26 | 13.40 | 16.96 | 20.94 | 25.34 | 32.72 | 41.05 | 53.62 |
| 16 | 1.77 | 3.14 | 4.91 | 7.07 | 9.62 | 12.57 | 15.90 | 19.63 | 23.76 | 30.68 | 38.48 | 50.27 |
| 17 | 1.66 | 2.96 | 4.62 | 6.65 | 9.05 | 11.83 | 14.97 | 18.48 | 22.36 | 28.87 | 36.22 | 47.31 |
| 18 | 1.57 | 2.79 | 4.36 | 6.28 | 8.55 | 11.17 | 14.14 | 17.45 | 21.12 | 27.27 | 34.21 | 44.68 |
| 19 | 1.49 | 2.65 | 4.13 | 5.95 | 8.10 | 10.58 | 13.39 | 16.53 | 20.01 | 25.84 | 32.41 | 42.33 |
| 20 | 1.41 | 2.51 | 3.93 | 5.65 | 7.70 | 10.05 | 12.72 | 15.71 | 19.01 | 24.54 | 30.79 | 40.21 |
| 21 | 1.35 | 2.39 | 3.74 | 5.39 | 7.33 | 9.57 | 12.12 | 14.96 | 18.10 | 23.37 | 29.32 | 38.30 |
| 22 | 1.28 | 2.28 | 3.57 | 5.14 | 7.00 | 9.14 | 11.57 | 14.28 | 17.28 | 22.31 | 27.99 | 36.56 |
| 23 | 1.23 | 2.18 | 3.41 | 4.92 | 6.69 | 8.74 | 11.06 | 13.66 | 16.53 | 21.34 | 26.77 | 34.97 |
| 24 | 1.18 | 2.09 | 3.27 | 4.71 | 6.41 | 8.38 | 10.60 | 13.09 | 15.84 | 20.54 | 25.66 | 33.51 |
| 25 | 1.13 | 2.01 | 3.14 | 4.52 | 6.16 | 8.04 | 10.18 | 12.57 | 15.20 | 19.63 | 24.63 | 32.17 |
| 26 | 1.09 | 1.93 | 3.02 | 4.35 | 5.92 | 7.73 | 9.79 | 12.08 | 14.62 | 18.88 | 23.68 | 30.93 |
| 27 | 1.05 | 1.86 | 2.91 | 4.19 | 5.70 | 7.45 | 9.42 | 11.64 | 14.08 | 18.18 | 22.81 | 29.79 |
| 28 | 1.01 | 1.79 | 2.80 | 4.04 | 5.50 | 7.18 | 9.09 | 11.22 | 13.58 | 17.53 | 21.99 | 28.72 |
| 29 | 0.97 | 1.73 | 2.71 | 3.90 | 5.31 | 6.93 | 8.77 | 10.83 | 13.11 | 16.93 | 21.23 | 27.73 |
| 30 | 0.94 | 1.68 | 2.62 | 3.77 | 5.13 | 6.70 | 8.48 | 10.47 | 12.67 | 16.36 | 20.52 | 26.81 |
| 32 | 0.88 | 1.57 | 2.45 | 3.53 | 4.81 | 6.28 | 7.95 | 9.82 | 11.88 | 15.34 | 19.24 | 25.13 |
| 34 | 0.83 | 1.48 | 2.31 | 3.33 | 4.53 | 5.91 | 7.48 | 9.24 | 11.18 | 14.44 | 18.11 | 23.65 |
| 36 | 0.78 | 1.40 | 2.18 | 3.14 | 4.28 | 5.58 | 7.07 | 8.73 | 10.56 | 13.63 | 17.10 | 22.34 |
| 38 | 0.74 | 1.32 | 2.07 | 2.98 | 4.05 | 5.29 | 6.70 | 8.27 | 10.00 | 12.92 | 16.20 | 21.16 |
| 40 | 0.71 | 1.26 | 1.96 | 2.83 | 3.85 | 5.03 | 6.36 | 7.85 | 9.50 | 12.27 | 15.39 | 20.11 |

# 2.20 AREAS OF GIVEN NUMBER OF BARS IN $CM^2$

| No. of | Bar Diameter mm | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bars | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 25 | 28 | 32 | 36 |
| 1 | 0.28 | 0.50 | 0.79 | 1.13 | 1.54 | 2.01 | 2.54 | 3.14 | 3.80 | 4.91 | 6.16 | 8.04 | 10.18 |
| 2 | 0.56 | 1.00 | 1.57 | 2.26 | 3.07 | 4.02 | 5.08 | 6.28 | 7.60 | 9.81 | 12.31 | 16.08 | 20.35 |
| 3 | 0.84 | 1.50 | 2.35 | 3.39 | 4.61 | 6.03 | 7.63 | 9.42 | 11.40 | 14.72 | 18.47 | 24.12 | 30.53 |
| 4 | 1.13 | 2.01 | 3.14 | 4.52 | 6.15 | 8.04 | 10.17 | 12.56 | 15.20 | 19.63 | 24.63 | 32.17 | 50.71 |
| 5 | 1.41 | 2.51 | 3.92 | 5.65 | 7.69 | 10.05 | 12.72 | 15.70 | 19.00 | 24.54 | 30.78 | 40.21 | 50.89 |
| 6 | 1.69 | 3.01 | 4.71 | 6.78 | 9.23 | 12.06 | 15.26 | 18.85 | 22.80 | 29.45 | 36.94 | 48.25 | 61.07 |
| 7 | 1.97 | 3.51 | 5.49 | 7.91 | 10.77 | 14.07 | 17.81 | 21.99 | 26.60 | 34.36 | 43.10 | 56.29 | 71.25 |
| 8 | 2.26 | 4.02 | 6.28 | 9.04 | 12.31 | 16.08 | 20.35 | 25.13 | 30.41 | 39.27 | 49.26 | 64.34 | 81.43 |
| 9 | 2.54 | 4.52 | 7.06 | 10.17 | 13.85 | 18.09 | 22.90 | 28.27 | 34.21 | 44.17 | 55.41 | 72.38 | 91.60 |
| 10 | 2.82 | 5.02 | 7.85 | 11.31 | 15.39 | 20.10 | 25.44 | 31.41 | 38.01 | 49.08 | 61.57 | 80.42 | 101.78 |
| 11 | 3.11 | 5.52 | 8.63 | 12.44 | 16.93 | 22.11 | 27.99 | 34.55 | 41.81 | 53.99 | 67.73 | 88.46 | 111.96 |
| 12 | 3.39 | 6.03 | 9.42 | 13.57 | 18.47 | 24.12 | 30.53 | 37.69 | 45.61 | 58.90 | 73.89 | 96.51 | 122.14 |
| 13 | 3.67 | 6.53 | 10.21 | 14.70 | 20.01 | 26.13 | 33.08 | 40.84 | 49.41 | 63.81 | 80.04 | 104.55 | 132.32 |
| 14 | 3.95 | 7.03 | 10.99 | 15.83 | 21.55 | 28.14 | 35.62 | 43.98 | 53.21 | 68.72 | 86.20 | 112.59 | 142.50 |
| 15 | 4.24 | 7.54 | 11.78 | 16.96 | 23.09 | 30.15 | 38.17 | 47.12 | 57.02 | 73.63 | 92.36 | 120.63 | 152.68 |
| 16 | 4.52 | 8.04 | 12.56 | 18.09 | 24.63 | 32.17 | 40.71 | 50.26 | 60.82 | 78.54 | 98.52 | 128.68 | 162.86 |
| 17 | 4.80 | 8.54 | 13.35 | 19.22 | 26.17 | 34.18 | 43.26 | 53.40 | 64.62 | 83.44 | 104.67 | 136.72 | 173.03 |
| 18 | 5.08 | 9.04 | 14.13 | 20.35 | 27.70 | 36.19 | 45.80 | 56.54 | 68.42 | 88.35 | 110.83 | 144.76 | 183.21 |
| 19 | 5.37 | 9.55 | 14.92 | 21.48 | 29.24 | 38.20 | 48.34 | 59.69 | 72.22 | 93.26 | 116.99 | 152.80 | 193.39 |
| 20 | 5.65 | 10.05 | 15.70 | 22.62 | 30.78 | 40.21 | 50.89 | 62.83 | 76.02 | 98.17 | 123.15 | 160.85 | 203.57 |

# 2.21 WEIGHTS OF STEEL SECTIONS

## OCTAGONS

| Sections in inches | Weights (kg/m) TATA | IISCO | H. S. |
|---|---|---|---|
| ¾ in | 2.36 | — | — |
| ⅞ in | 3.21 | — | — |
| 1 in | 4.19 | — | — |
| 1⅛ in | 5.30 | — | — |
| 1¼ in | 6.57 | — | — |
| 1½ in | 9.43 | — | — |

## RAILS

| | TATA | IISCO | H. S. |
|---|---|---|---|
| 20 lbs/yard | — | 9.92 | |
| 24 lbs/yard | — | 11.91 | — |
| 30 lbs/yard | 14.88 | 14.88 | |
| B. S. 50 R | — | 24.80 | — |
| B. S. 60 R | — | 29.76 | 29.76 |
| B. S. 75 R | — | 37.13 | — |
| B. S. 90 R | — | 44.61 | 44.61 |
| B. S. 90 Bullhead | — | 44.61 | — |
| B. S. 100 Bullhead | — | 49.60 | — |

## RIBBED REINFORCING BARS

| | TATA | IISCO | H. S. |
|---|---|---|---|
| 12 mm | 0.89 | — | — |
| 16 mm | 1.58 | — | — |
| 18 mm | 2.00 | — | — |
| 20 mm | 2.47 | — | — |
| 22 mm | 2.98 | — | — |
| 25 mm | 3.85 | — | — |
| 28 mm | 4.83 | — | — |
| 32 mm | 6.41 | — | — |
| 36 mm | 7.99 | — | — |

## STEEL SHEET FILINGS

| | TATA | IISCO | H. S. |
|---|---|---|---|
| 400 x 180 x 7.5 (INPS 1021 Z) | 49.25 | — | — |
| 437 x 172 x 13 (ISPS 1625 U) | 65.37 | — | — |
| 458 x 194.5 x 14 (ISPS 2222 U) | 82.70 | — | — |

Note:— TATA:— *Tata Iron & Steel Co. Ltd.* H. S. *Hindustan Steel Ltd.*
IISCO:— *Indian Iron Steel Co. Ltd.*

## 2.22 WEIGHT OF FLAT IRON

*Based on 0.7843 kg/cm²/metre or 1 cft of Steel = 490 lbs.*

| Width in mm | Thickness in mm | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 5.5 | 6 | 7 | 8 | 10 | 11 | 12 | 14 | 16 |
| | Weight in kg per metre | | | | | | | | | |
| 12 | 0.5 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.3 | 1.5 |
| 16 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.3 | 1.4 | 1.5 | 1.8 | 2.0 |
| 20 | 0.8 | 0.9 | 0.9 | 1.1 | 1.3 | 1.6 | 1.7 | 1.9 | 2.2 | 2.5 |
| 25 | 1.0 | 1.1 | 1.2 | 1.4 | 1.6 | 2.0 | 2.2 | 2.4 | 2.7 | 3.1 |
| 32 | 1.3 | 1.4 | 1.5 | 1.8 | 2.0 | 2.5 | 2.8 | 3.0 | 3.5 | 4.0 |
| 40 | 1.6 | 1.7 | 1.9 | 2.2 | 2.5 | 3.1 | 3.5 | 3.8 | 4.4 | 5.0 |
| 50 | 2.0 | 2.2 | 2.4 | 2.7 | 3.1 | 3.9 | 4.3 | 4.7 | 5.5 | 6.3 |
| 63 | 2.5 | 2.7 | 3.0 | 3.5 | 4.0 | 4.9 | 5.4 | 5.9 | 6.9 | 7.9 |
| 80 | 3.1 | 3.5 | 3.8 | 4.4 | 5.0 | 6.3 | 6.9 | 7.5 | 8.8 | 10.0 |
| 100 | 3.9 | 4.3 | 4.8 | 5.5 | 6.3 | 7.8 | 8.6 | 9.4 | 11.0 | 12.6 |
| 125 | 4.9 | 5.4 | 5.9 | 6.9 | 7.8 | 9.8 | 10.8 | 11.8 | 13.7 | 15.7 |
| 160 | 6.3 | 6.9 | 7.5 | 8.8 | 10.0 | 12.6 | 13.8 | 15.1 | 17.6 | 20.1 |
| 200 | 7.8 | 8.6 | 9.4 | 11.0 | 12.6 | 15.7 | 17.3 | 18.8 | 22.0 | 25.1 |
| 250 | 9.8 | 10.8 | 11.8 | 13.7 | 15.7 | 19.6 | 21.6 | 23.6 | 27.5 | 31.4 |

## 2.23 WEIGHT OF STEEL SHEETS AND PLATES

*Based on 0.7843 kg/cm² per metre.*

| *Black Sheets* | | | *Plates* | | *Chequered Plates* | |
|---|---|---|---|---|---|---|
| Thickness in mm | B G. | Wt.per sq. metre in kg. | Thickness in mm. | Wt.per sq. metre in kg. | Thickness in mm. | Wt.per sq. metre in kg. |
| 3.15 | 10 | 24.70 | 5 | 39.2 | 7 | 61.1 |
| 2.50 | 12 | 19.61 | 7 | 55.0 | 10 | 84.6 |
| 2.00 | 14 | 15.69 | 10 | 78.5 | 12 | 100.3 |
| 1.66 | 16 | 12.55 | 12 | 94.2 | | |
| 1.25 | 18 | 9.80 | 14 | 109.9 | | |
| 1.00 | 20 | 7.84 | 16 | 125.6 | | |
| 0.80 | 22 | 6.27 | 18 | 141.3 | | |
| 0.63 | 24 | 4.94 | 20 | 157.0 | | |
| 0.50 | 26 | 3.91 | 22 | 172.7 | | |
| 0.44 | 28 | 3.10 | 25 | 196.2 | | |

## 2.24 NOMINAL WEIGHTS OF G. I. SHEETS

*(Based on IS 277-1963 revised)*

Plain and corrugated steel sheets, produced by hot dip galvanizing process shall be of the following four classes :—

Class 1 — Extra heavy coating of zinc, nominal 750 g/sq.m.
Class 2 — Heavy coating of zinc, nominal 600 g/sq.m.
Class 3 — Medium coating of zinc, nominal 450 g/sq.m.
Class 4 — Light coating of zinc, nominal 375 g/sq.m.

In the corrugated galvanized sheets, the depth of corrugation shall be 18 mm. and the pitch shall be 75 mm. The number of corrugation shall be 8 or 10 per sheet. The sheets are available in two width of 90 cm and 75 cm. Each width is available in lengths of 1.8 m, 2.2 m, 2.5 m, 2.8 m, 3.2 m.

| Thickness in mm. | Weight of sheets in kg/sq.m. | | | |
|---|---|---|---|---|
| | Class 1 | Class 2 | Class 3 | Class 4 |
| 1.60 | 13.31 | 13.16 | 13.01 | 12.94 |
| 1.25 | 10.56 | 10.41 | 10.26 | 10.19 |
| 1.00 | 8.60 | 8.45 | 8.30 | 8.22 |
| 0.80 | 7.03 | 6.88 | 6.72 | 6.66 |
| 0.63 | 5.70 | 5.55 | 5.40 | 5.32 |

## 2.25 DIMENSIONS OF A. C. SHEETS

*(Based on IS 277-1963 revised)*

| Pitch of corrugation in mm | Depth of corrugation in mm | Overall width in mm | Effective width in mm | Nominal thickness in mm | Length of sheets in metres |
|---|---|---|---|---|---|
| *Corrugated sheets* | | | | | |
| 146 | 48 | 1050 | 1010 | 6 | 1.5, 1.75, |
| 146 | 48 | 1050 | 1010 | 7 | 2.0, 2.25, |
| | | | | | 2.5, 2.75 |
| *Semi-corrugated sheets* | | | | | and 3.00 |
| 338 | 45 | 1100 | 1014 | 6 | |
| 338 | 45 | 1100 | 1014 | 7 | |

## 2.26 WEIGHT OF G. I. PIPES

| Nominal weights of Black Tubes to IS : 1329/58 | | | | | | |
|---|---|---|---|---|---|---|
| Internal | Light | | Medium | | Heavy | |
| dia in mm | Kg/M | M/Ton | Kg/M | M/Ton | Kg/M | M/Ton |
| 6 | .364 | 2747 | .410 | 2439 | .496 | 2016 |
| 8 | .521 | 1919 | .654 | 1529 | .773 | 1299 |
| 10 | .680 | 1470 | .858 | 1166 | 1.03 | 971 |
| 15 | .961 | 1040 | 1.23 | 813 | 1.46 | 685 |
| 20 | 1.42 | 704 | 1.59 | 629 | 1.91 | 524 |
| 25 | 2.03 | 493 | 2.46 | 407 | 2.99 | 334 |
| 32 | 2.61 | 383 | 3.17 | 316 | 3.87 | 258 |
| 40 | 3.29 | 304 | 3.65 | 274 | 4.47 | 224 |
| 50 | 4.18 | 239 | 5.17 | 193 | 6.24 | 160 |
| 65 | 5.92 | 169 | 6.63 | 151 | 8.02 | 125 |
| 80 | .6.98 | 143 | 8.64 | 116 | 10.3 | 98 |
| 90 | 8.92 | 112 | 9.90 | 101 | 11.8 | 84.7 |
| 100 | 10.2 | 98 | 12.4 | 80.6 | 14.7 | 68 |

## 2.27 WEIGHT OF P. V. C. PIPES

| O. D. in mm | Pressure $kg/cm^2$ | Wall thickness | I. D. in mm | Weight kg/m | Metres/tonne Weight |
|---|---|---|---|---|---|
| 16 | 10 | 1.30 | 13.4 | 0.085 | 11.765 |
| 20 | 10 | 1.30 | 17.4 | 0.103 | 9.259 |
| 25 | 10 | 1.60 | 21.8 | 0.167 | 5.988 |
| 32 | 10 | 2.00 | 28.0 | 0.268 | 3.731 |
| 40 | 6 | 1.60 | 36.8 | 0.274 | 3.650 |
| 50 | 6 | 1.90 | 46.2 | 0.408 | 2.451 |
| 63 | 4 | 1.70 | 59.6 | 0.465 | 2.151 |
| 63 | 6 | 2.45 | 58.1 | 0.662 | 1.511 |
| 75 | 4 | 2.00 | 71.0 | 0.651 | 1.536 |
| 75 | 6 | 2.85 | 69.3 | 0.917 | 1.091 |
| 90 | 4 | 2.35 | 85.3 | 0.917 | 1.091 |
| 90 | 6 | 3.40 | 83.2 | 1.313 | 762 |
| 110 | 4 | 2.75 | 104.5 | 1.315 | 760 |
| 110 | 6 | 4.00 | 102.0 | 1.891 | 529 |
| 125 | 4 | 3.15 | 118.7 | 1.712 | 584 |

## 2.28 SAFE PERMISSIBLE LOADS ON DIFFERENT SOILS

*(Assuming Factor of safety as 2)*

| No. | Description | Safe load in Tonnes/sq.m. | Safe load in Tons/S.ft. |
|---|---|---|---|
| 1 | Soft, wet pasty or muddy clay and marshy clay | 2.7 to 3.6 | 0.5 to 0.33 |
| 2 | Alluvial deposits of moderate depths in river beds | 2.2 to 3.8 | 0.20 to 0.35 |
| 3 | Alluvial clay in beds of rivers | 3.8 to 10.9 | 0.35 to 1.00 |
| 4 | Black cotton soil | 5.5 to 8.2 | 0.50 to 0.75 |
| 5 | Alluvial earth, loams, sandy loams, (clay, and 40 to 70 per cent of of sands) and clay loams clay and about 30 per cent of sand) | 8.2 to 16.4 | 0.75 to 1.50 |
| 6 | Moist clay | 10.9 to 19.1 | 1.00 to 1.75 |
| 7 | Compact clay nearly dry | 21.9 to 27.3 | 2.00 to 2.50 |
| 8 | Solid clay mixed with very fine sand | 43.7 | 4.00 |
| 9 | Dry compact clay of considerable thickness | 32.8 to 54.7 | 3.00 to 5.00 |
| 10 | Loose sand in shifting river beds, the safe load increasing with depth | 16.4 to 27.3 | 1.50 to 2.50 |
| 11 | Silted sand of uniform and firm character in a river bed, secure from scour, and at depths below 25 feet | 38.3 to 43.7 | 3.50 to 4.00 |
| 12 | Compact sand | 21.9 to 32.8 | 2.00 to 3.00 |

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| 13 | Compact sand, prevented from spreading | 54.7 to 82.0 | 5.00 to 7.50 |
| 14 | Sandy gravel or kankar | 21.9 to 32.8 | 2.00 to 3.00 |
| 15 | Sandy gravel, but compact, dry and prevented from spreading | 43.7 to 65.6 | 4.00 to 6.00 |
| 16 | Very firm, compact, sand at depth not less than 20 feet and compact sandy gravel | 65.6 to 76.6 | 6.00 to 7.00 |
| 17 | Firm shale protected from weather and clean gravel | 65.6 to 87.5 | 6.00 to 8.00 |
| 18 | Compact gravel | 76.6 to 98.4 | 7.00 to 9.00 |
| 19 | Rock | From laterite 22 tonnes to granite 273 tonnes and upwards | 2 to 25 tons and upwards |

## 2.29 COEFFICIENT OF MEASUREMENT FOR PAINTING *(Based on MDSS)*

| | |
|---|---|
| Batten doors and windows | ... 2¼ |
| Panel doors and windows | ... 2¼ |
| Panel and venetian doors | ... 3¼ |
| Panel and venetian doors with glazed top | ... 3 |
| Iron barred doors | ... 1½ |
| Iron barred doors with batten and sheet | ... 3¾ |
| Batten windows with iron bars | ... 2¾ |
| Venetian windows | ... 3½ |
| Venetian windows with iron bars | ... 4 |
| Venetian windows with glazed top and iron bars | ... 4½ |
| Venetian windows with iron bars and glass shutters | ... 5 |
| Glazed windows with iron bars | ... 2 |
| Glazed windows without iron bars | ... 1½ |
| Glazed shutters (measured over shutters only) | ... 1 |
| Weld mesh | ... ¾ |

# 2.30 STRENGTH OF STORED CEMENT

| | | |
|---|---|---|
| 1. | Fresh Cement | 100% |
| 2. | After 3 months | 80% |
| 3. | After 6 months | 75% |
| 4. | After 1 year | 70% |
| 5. | After 1¼ years | 65% |
| 6. | After 1½ years | 60% |
| 7. | After 1¾ years | 55% |
| 8. | After 2 years | 50% |

# 2.31 PRODUCTION OF COLOURED FINISHES

*(Based on IS 269—1968)*

| Colour desired | Pigment to be added | Approx. quantity of pigment per 50 kg. bag of white cement in kg. | |
|---|---|---|---|
| | | Light Shade | Medium Shade |
| Gray, blue-black and | Germantown lamp black or | 0.27 | 0.55 |
| black | Carbon black or | 0.27 | 0.55 |
| | Black oxide of manganese | 0.55 | 1.10 |
| | or Mineral black | 0.55 | 1.10 |
| Blue | Ultramarine blue | 2.70 | 4.85 |
| Brownish red to dull brick red | Red oxide of iron | 2.70 | 4.85 |
| Bright red to vermilion | Mineral turkey | 2.70 | 4.85 |
| Red sandstone to purplish red | Indian Red | 2.70 | 4.85 |
| Brown to reddish brown | Metallic brown (oxide) | 2.70 | 4.85 |
| Buff, colonial tint and | Yellow ochre or | 2.70 | 4.85 |
| yellow | Yellow oxide | 1.10 | 4.40 |
| Green | Chromium oxide or | 2.70 | 5.50 |
| | Greenish ultramarine blue | 3.25 | — |

## 2.32 PHYSICAL REQUIREMENTS FOR VARIOUS CEMENTS

| Property | Ordinary Portland cement (IS 269—1958) | Rapid hardening Portland cement (IS 269—1958) | Low heat Portland cement (IS 269—1958) | Blast furnace cement (IS 455—1962) | Pozzolanacement (IS 1489—1962) |
|---|---|---|---|---|---|
| 1. Fineness - Maximum residue by weight on IS 90 micron sieve (percent) | 10 | 5 | — | 10 | 10 |
| Minimum specific surface by air permeability method in gm/$cm^2$ | 2250 | 3250 | 3200 | 2250 | 3000 |
| 2. Setting time in minutes | | | | | |
| Initial (Min.) | 30 | 30 | 60 | 30 | 30 |
| Final (Max.) | 600 | 600 | 600 | 600 | 600 |
| 3. Minimum compressive strength of 1:3 cement sand mortar cubes in kg/$cm^2$ | | | | | |
| At 1 day | — | 115 | — | — | — |
| At 3 days | 115 | 210 | 70 | 115 | — |
| At 7 days | 175 | — | 115 | 175 | 140 |
| At 14 days | — | — | — | — | 210 |
| At 28 days | — | — | 265 | — | — |
| 4. Minimum tensile strength of 1:3 mortar briquettes kg/$cm^2$ | | | | | |
| At 1 day | — | 20 | — | — | — |
| At 3 days | 20 | 30 | — | 20 | — |
| At 7 days | 25 | — | — | 25 | — |
| 5. Soundness | | | | | |
| (a) Maximum expansion of unaerated sample (mm.) | 10 | 10 | 10 | 10 | 10 |
| (b) Maximum expansion of aerated sample (mm.) | 5 | 5 | 5 | 5 | 5 |
| 6. Maximum heat of hydration in in cal/gm. | | | | | |
| At 7 days | — | — | 65 | — | — |
| At 28 days | — | — | 75 | — | — |

# 2.33 DIFFERENT TYPES OF CEMENT

By slightly changing the chemical composition, it is possible to obtain cement exhibiting the desired properties. Ordinary portland cement is good for all construction works except where sulphates are present in the soil or ground-water leading to expansion and breaking of concrete, known by the term "sulphate action".

## 2.33.1 Rapid Hardening Portland Cement (R.H.P.C.)

The rate of setting is the same as for O.P.C. Fine grading and increased tricalcium silicate content ensure seven days strength of O.P.C. to be obtained in three days. Where form work is to be removed early, for winter concreting and urgent repair works, R.H.P.C. is used. It should not to be used for mass concreting due to the high rate of heat evolution. It costs 10% more than ordinary portland cement.

## 2.33.2 Quick Setting and Extra Rapid Hardening Cement

By intergrinding 2% by weight of calcium chloride with R.H.P.C., high early strength (25% more than R.H.P.C.) and quick setting (5 to 30 minutes) can be achieved. This cement is used for cold weather concreting and for under-water concreting works.

## 2.33.3 Blast Furnace Slag Cement

When granulated blast furnace slag (a mixture of lime, silica and alumina) obtained as a waste product in the manufacture of pig iron, is interground with portland cement clinker and mixed to a proportion of 2:1, this special cement is manufactured. The rate of hardening is slower and hence the heat of hydration is less. It is resistant to sulphate action and is used for mass concrete and in sea water construction. Trief cement is another version of this special cement produced by the wet grinding process.

## 2.33.4 Low Heat Portland Cement

The rise of temperature in the interior of mass concrete will lead to serious cracking. Lowering of the heat of hydration of cement can be obtained by increasing the proportion of dicalcium silicate and reducing tricalcium aluminate and restricting tricalcium silicate. The development of strength is slow but the ultimate strength is the same as that of portland cement.

## 2.33.5 Sulphate Resistant Cement

Two per cent of sulphate in soil or ½% in groundwater reacts with cement leading to the formation of supho-aluminates which have expansive properties and cause disintegration of concrete.By restricting tricalcium silicate to 5% and grinding to a fineness higher than O.P.C., high resistance to sulphate action is produced. Early strength is low but the ultimate strength is quite high. Carbonisation in air gives a hard surface to the concrete. It is expensive and is used in sea water construction and for structures in sulphatic soil.

## 2.33.6 White Portland Cement

Restricting the iron oxide to less than 1% is useful in avoiding the characteristic grey colour of cement. By adopting an oil fuel for burning and using chalk with a low iron content, white clay or "snow crete" is manufactured. This forms the base for coloured cements used in the manufacture and joining of mosaic tiles, terracotta, etc. Coloured portland cements are got by adding strong pigments up to 10% to O.P.C. Light colours can be got by adding pigments to white portland cement.

## 2.33.7 Natural Cements

Naturally occurring cement rocks may be burnt and used as natural cement but the properties may vary and be quite different from O.P.C.

## 2.33.8 Super Sulphate Cement

This form of cement is made from well granulated slag (80 to 85%), calcium sulphate (10 to 15%) and O.P.C. (1 to 2%). It sets quickly, the heat of hydration is low and it is highly resistant to chemical attack. It can be used for all purposes without mixing with other cements or admixtures.

## 2.33.9 Masonry Cement

Composed of portland cement clinker, limestone, gypsum and an air entraining agent, masonry cement has the advantages of fattiness, high workability and retention of the mixed water from the sucking action of bricks. This is used extensively in masonry works.

### 2.33.10 Expansive Cement

Concrete shrinks when it sets. For repair work, this is a disadvantage. By the addition of an expansive agent — calcium sulpho-aluminate up to 5% — expansion up to 12 to 15 mm/cm can be got. This can be used for prestressing and for setting right the damage due to settlement, etc.

### 2.33.11 Special Cements

For lining of oil wells where cement is to harden quickly and possess pumping quality for three hours working at a pressure of 1400 kg/cm2 at a temperature of 150°C, special oil well cement, making very little use of tricalcium silicate and retarders is used. By adding agents like stearic acid, oleic acid and boric acid to O.P.C. during grinding, hydrophobic cement is produced which does not lump during storage. Waterproof cement is produced by adding substances like calcium stearate or aluminium stearate to O.P.C.

### 2.33.12 High Alumina Cement

By fusing limestone and bauxite (hydrated alumina and iron oxide) at 1600°C and grinding the clinker, high alumina cement is produced. Eighty per cent of the ultimate strength is developed in 24 h. Due to the large amount of heat evolved, its use is restricted to thin sections and lifts, restricted to 30 cm at a time. Twice the amount of water, required for O.P.C., is necessary for full hydration of high alumina cement and the workability is quite high. The resistance to chemical attack and heat being high, this cement is used in sea water construction and refractory works. It should not be mixed with O.P.C. to avoid flash set.

## 2.34 FIELD TESTS FOR CONTAMINATION OF CEMENT

Out of the two simple field tests given below any one can be performed to determine if the cement has been contaminated.

In the first test a sample of cement is burnt for about 20 minutes on a steel plate. An adulterated sample will change in colour. The colour of an unadulterated sample will, on the other hand, remain unchanged.

In the second test small pats of 5 x 5 x 2 cm size should be made. If the cement is unadulterated, the pat will have hardened sufficiently in 24 hours to resist any impression of the thumb nail. In 48 hours it should not be easy to break it with the pressure of the fingers.

If the cement fails to pass these tests, it should be sent to laboratory to determine the extent which its properties have been affected.

## 2.35 FIELD TESTS FOR SAND

*(Based on IS 1542 — 1960)*

To check the suitability of sand for being used in mortar or concrete it may be put to the following tests in the field :—

(i) Taste of sand shall provide check for the presence of salts.

(ii) Rub a little sand between the fingers. Stains left on fingers will indicate the presence of clayey impurities.

(iii) Vigorously stir a sample of sand in a glass of water and allow it to rest. Amount of clay or silt present in it would settle on the Sand.

(iv) Stir a sample of sand in a 3% solution of caustic soda and keep the bottle corked for 24 hours. If the colour of the liquid turns brown, then the present of organic matter is indicated.

## 2.36 REMOVAL OF FORM WORK FOR CONCRETE STRUCTURES

| | | |
|---|---|---|
| a) | Walls, columns and vertical sides of beams | 24 to 48 hr as may be decided by the engineer-in-charge |
| b) | Slabs sides [ props left under ] | 3 days |
| c) | Beam soffits [ props left under ] | 7 days |
| d) | Removal of props to slabs : | |
| | 1. Spanning up to 4.5 m | 7 days |
| | 2. Spanning over 4.5 m | 14 days |
| e) | Removal of props to beams and arches | |
| | 1. Spanning up to 6 m | 14 days |
| | 2. Spanning over 6 m | 21 days |

# 2.37 CEMENT ADEQUACY STATEMENT

*(Adopting 1 cum of cement = 1440 kg. and Metric Data)*

| | | | Per | Cement in kg. |
|---|---|---|---|---|
| **C.C. 1 : 4 : 10 using** (0.38/4 X 1440 kg) | (1½" metal) | 40 mm Metal | $M^3$ | 136.80 |
| **C.C 1 : 4 : 8 using** (0.45/4 X 1440 kg) | (1½" metal) | do | $M^3$ | 162.00 |
| **C.C. 1 : 5 : 10 using** (0.45/5 X 1440 kg) | (1½" metal) | do | $M^3$ | 129.60 |
| **C.C. 1 : 2 : 4 using** (0.45/2 X 1440 kg) | (¾" metal) | 20 mm Metal | $M^3$ | 324.00 |
| **C.C. 1 : 1½ : 3 using** (0.45 X ⅔ X 1440 | (¾" metal) | do | $M^3$ | 432.00 |
| **C.C. 1 : 3 : 6 using** (0.45/3 X 1440 kg) | (¾" metal) | do | $M^3$ | 216.00 |

**BRICK WORK using I Class bricks** (Metric 19cm X 9cm X 9 cm)

| | | | | | |
|---|---|---|---|---|---|
| 1 : 3 | 0.22/3 X 1440 $M^3$ | 105.60 | 1 : 5 | 0.22/5 X 1440 $M^3$ | 63.36 |
| 1 : 4 | 0.22/4 X 1440 $M^3$ | 79.20 | 1 : 6 | 0.22/6 X 1440 $M^3$ | 52.80 |

**BRICK WORK using II & III bricks** (19cm X 9cm X 5.7cm)

| | | | | | |
|---|---|---|---|---|---|
| 1 : 3 | 0.27/3 X 1440 $M^3$ | 129.60 | 1 : 5 | 0.27/5 X 1440 $M^3$ | 77.76 |
| 1 : 4 | 0.27/4 X 1440 $M^3$ | 97.20 | 1 : 6 | 0.27/6 X 1440 $M^3$ | 64.80 |

**BRICK WORK using stock bricks** (9" X 4.3/8" X 2.3/4")

| | | | | | |
|---|---|---|---|---|---|
| 1 : 3 | 0.25/3 X 1440 $M^3$ | 120.00 | 1 : 5 | 0.25/5 X 1440 $M^3$ | 72.00 |
| 1 : 4 | 0.25/4 X 1440 $M^3$ | 90.00 | 1 : 6 | 0.25/6 X 1440 $M^3$ | 60.00 |

**BRICK WORK using Wire cut bricks** (9" X 4½" X 3")

| | | | | | |
|---|---|---|---|---|---|
| 1 : 3 | 0.20/3 X 1440 $M^3$ | 96.00 | 1 : 5 | 0.20/5 X 1440 $M^3$ | 57.60 |
| 1 : 4 | 0.20/4 X 1440 $M^3$ | 72.00 | 1 : 6 | 0.20/6 X 1440 $M^3$ | 48.00 |

**BRICK WORK using Country bricks** (8¾" X 4¼" X 2")

| | | | | | |
|---|---|---|---|---|---|
| 1 : 3 | 0.30/3 X 1440 $M^3$ | 144.00 | 1 : 5 | 0.30/5 X 1440 $M^3$ | 86.40 |
| 1 : 4 | 0.30/4 X 1440 $M^3$ | 108.00 | 1 : 6 | 0.30/4 X 1440 $M^3$ | 72.00 |

**PLASTERING WITH C. M. 12mm thick**

| | | | | | |
|---|---|---|---|---|---|
| 1 : 2 | 0.14/2 X 1440 $10M^2$ | 100.00 | 1 : 4 | 0.14/4 X 1440 $10m^2$ | 50.40 |
| | | | 1 : 5 | 0.14/5 X 1440 $10m^2$ | 40.32 |
| 1 : 3 | 0.14/3 X 1440 $10m^2$ | 67.20 | 1 : 6 | 0.14/6 X 1440 $10m^2$ | 33.60 |

**PLASTERING WITH C. M. 20mm thick**

| | | | | | |
|---|---|---|---|---|---|
| 1 : 2 | 0.22/2 X 1440 $10m^2$ | 158.40 | 1 : 4 | 0.22/4 X 1440 $10m^2$ | 79.20 |
| | | | 1 : 5 | 0.22/4 X 1440 $10m^2$ | 63.36 |
| 1 : 3 | 0.22/3 X 1440 $10m^2$ | 105.60 | 1 : 6 | 0.22/6 X 1440 $10m^2$ | 52.80 |

**CUT STONE MASONRY**

| | | | | | |
|---|---|---|---|---|---|
| 1 : 4 | 0.16/4 X 1440 $M^3$ | 57.60 | 1 : 5 | 0.16/5 X 1440 $M^3$ | 46.08 |

**RANDOM RUBBLE MASONRY (Arch)**

| | | |
|---|---|---|
| 1 : 4 | 0.28/4 X 1440 $M^3$ | 100.80 |
| 1 : 5 | 0.28/5 X 1440 $M^3$ | 80.64 |

**RANDOM RUBBLE MASONRY**

| | | |
|---|---|---|
| 1 : 3 | 0.34/3 X 1440 $M^3$ | 163.00 |
| 1 : 4 | 0.34/4 X 1440 $M^3$ | 122.40 |
| 1 : 5 | 0.34/5 X 1440 $M^3$ | 97.90 |

**COURSED RUBBLE MASONRY (First Sort)**

| | | |
|---|---|---|
| 1 : 4 | 0.28/4 X 1440 $M^3$ | 100.80 |
| 1 : 5 | 0.28/5 X 1440 $M^3$ | 80.64 |

**D. P. C. with C. M. 1 : 3, 20 mm thick 10 sq.m.**

0.21/3 X 1440 10$M^2$ 100.80

**ELLIS PATTERN FLOORING**

| | |
|---|---|
| **IN C.C. 1 : 3 using Stone cuttings 3/4"/10 $M^2$** | 117.00 |
| 1" thick 10 $M^2$ | 146.25 |

**Special Ceiling plastering in C. M. 1 : 3 - 10 mm thick**

0.1/3 X 1440 10 sq.m. 48.00

**MOSAIC FLOORING & MOSAIC DADOOING WITH TILES**

| | | |
|---|---|---|
| Coloured Cement | 10 sq.m. | 22 kg |
| For C.M. 1 : 3 0.21/3 X 1440 | 10 sq.m. | 100.80 |

**POINTING WITH C. M. 1 : 3 for 10 sq.m.**

0.04/3 X 1440 19.20

**FLUSH POINTING FOR BRICK WORK Etc.**

| | | | |
|---|---|---|---|
| 1 : 3 | 0.06/3 X 1440 | 10 sq.m. | 28.80 |
| 1 : 4 | 0.06/4 X 1440 | 10 sq.m. | 21.60 |
| 1 : 5 | 0.06/5 X 1440 | 10 sq.m. | 17.28 |
| 1 : 6 | 0.06/4 X 1440 | 10 sq.m. | 14.40 |

**FLUSH POINTG FOR R.R. MASONRY Etc.**

| | | |
|---|---|---|
| 1 : 3 | 0.09/3 X 1440 | 43.2 |
| 1 : 4 | 0.09/4 X 1440 | 32.4 |
| 1 : 5 | 0.09/5 X 1440 | 25.92 |
| 1 : 6 | 0.09/6 X 1440 | 21.60 |

**Laying of pressed tiles in C. M. 1 : 3**

| | | | |
|---|---|---|---|
| C. M. 1 : 3 0.12/3 X 1440 | 57.60 | 10 sq.m. | 76.80 |
| Pointing with C.M. 1 : 3 10 $M^2$ | 19.20 | | |

**Laying flat tiles 2 course in C. M. 1 : 3**

| | | | |
|---|---|---|---|
| C.M. 1 : 3 0.27/3 X 1440 | 129.60 | 10 sq.m. | 148.80 |
| Pointing with C.M. 1 : 3 10 $M^2$ | 19.20 | | |

## 2.38 APPROXIMATE WORKING STRESS ON ENGINEERING MATERIALS FOR DEAD LOADS

| Wt. per Cft. in Lbs. | Material | Kind of Stress | | Allowable Stress | |
|---|---|---|---|---|---|
| 490 | Structural Steel | T 8-6-5 T | □' | 12-6.10.2 | kg/M² |
| | do | C 8-6-5 | do | 12-6-10.2 | do |
| | Ribbed Steel | S 5 | do | 7-9 | do |
| 480 | Wrought Iron | T 5 | do | 7.9 | do |
| | do | C 5 | do | 7.9 | do |
| | do | S 5 | do | 7.9 | do |
| 480 | Cast Iron | T 2 | do | 3.2 | do |
| | do | C 4 | do | 6.3 | do |
| | do | S 1.5 | do | 2.4 | do |
| 150 | Cement mortar 1.5 | C 1.5 T | □' | 14.1 | MT/M² |
| 120 | Brick in cement | C 4-5 | do | 3-7-4-7 | do |
| 165 | Granite | C 70 | do | 65.6 | do |
| | Sandstone | C 35 | do | 32.8 | do |
| 35 | Timber | T 500-5000 lbs/□' | | 35.70 | kg/cm² |

T : *Tension* C : *Compression* S : *Shear*

# 2.39 SAFE PERMISSIBLE LOADS ON MASONRY

*(Factor of safety as 8 against crushing and 3 against cracks)*

| Sl. No. | Description of masonry | Safe load in Tonnes per sq. metre |
|---|---|---|
| 1. | Brick in mud | 14 |
| 2. | Brick jelly concrete in lime mortar | 22 |
| 3. | Cochin laterite in lime mortar | 22 |
| 4. | Nellore laterite in lime mortar | 33 |
| 5. | Stone concrete in lime mortar | 33 |
| 6. | Random rubble in lime mortar | 33 |
| 7. | Country brick in lime mortar | 22 to 38 |
| 8. | Coursed rubble (Bezwada stone) in lime mortar | 44 |
| 9. | Stock brick in lime mortar | 44 |
| 10. | Coursed rubble (Granite) in lime mortar | 55 |
| 11. | Country brick in cement mortar | 44 to 66 |
| 12. | Random rubble (Bezwada stone) in cement mortar | 66 |
| 13. | Concrete (Bezwada stone) in cement mortar | 66 |
| 14. | Random rubble (granite) in cement mortar | 87 |
| 15. | Coursed rubble (Bezwada stone) in cement mortar | 87 |
| 16. | Stock brick in cement mortar | 87 |
| 17. | Concrete (granite) in cement mortar 1 : 3 : 6 | 109 |
| 18. | Concrete (granite) in cement mortar 1 : 2 : 4 | 131 to 164 |
| 19. | Coursed rubble granite in cement mortar | 131 |
| 20. | Cut granite in cement mortar | 164 |

*NOTE :*

(i) *Where there is considerable variation in strength (e.g. country bricks) it is incumbent on users to test their materials before use.*

(ii) *The figures given above are subject to slight variation according to shell lime, stone lime, or surki is employed.*

(iii) *Cement mortar is 1 Cement to 3 sand, except for items 19 and 20 which are 1 cement to 2 sand.*

(iv) *In using high pressure for cut granite etc., care must be taken that the allowable pressure on underlying masonry is not exceeded at the disperation angle from the load of 45° and that the mortar will have time to develop adequate strength before the load is applied.*

## 2.40 SAFE BEARING CAPACITY OF SOILS

Building codes and engineers' handbooks usually contain tables for safe bearing capacity for various types of soils. The values are compiled from the records of foundation successes and failures. **IS 1904:1961** gives the values for safe bearing capacity according to Indian Standards are as follows:

| | *Soils* | *Safe bearing capacity (tonnes/sq. metre)* |
|---|---|---|
| | *Cohesionless Soils* | |
| 1. | Gravel, sand and gravel, compact and offering high resistance to penetration when excavated by tools | 45 |
| 2. | Coarse sand, compact and dry | 45 |
| 3. | Medium sand, compact and dry | 25 |
| 4. | Finesand, silt (dry lumps easily pulverised by the fingers) | 15 |
| 5. | Loose gravel or sand gravel mixture, loose coarse to medium sand, dry | 10 |
| | *Cohesive Soils* | |
| 1. | Soft shale, hard or stiff clay in deep bed, dry | 45 |
| 2. | Medium clay readily indented with a thumb nail | 25 |
| 3. | Moist clay and sand clay mixture which can be indented with strong thumb pressure | 15 |
| 4. | Soft clay indented with moderate thumb pressure | 10 |
| 5. | Very soft clay which can be penetrated several cms. with thumb | 5 |
| 6. | Black cotton soil or other shrinkable or expansive clay in dry condition (5% saturation) | 15 |

## 2.41 ECONOMIC STANDARDS OF CARPET AREA REQUIRED

*Based on G. O. M. S. No. 884 PW dated 12—5—70*

| | | | |
|---|---|---|---|
| 1. | Head of department | 300 sq. ft. | 30 sq.metres |
| 2. | Personal Assistant and other Gazetted officers | 150-200 sq. ft. | 15 to 20 sq. metres |
| 3. | Manager and Supdt. 80-100 sq. ft. (100 being applicable only in respect of non-gazetted heads of officers like sub-registrars, Thasildars etc.) | | 7.5 to 10.00 sq. metres |
| 4. | Technical Staff non-gazetted | 60 sq. ft. | 6 sq. metres |
| 5. | Asst. Junior Asst. and typists | 45 sq. ft. | 4 sq. metres |
| 6 | Attender | 20 sq. ft | 2 sq. metres |
| 7. | Inspector of police | 200 sq. ft. | 20 sq. metres |

## 2.42 ROUGH ESTIMATION OF COST OF BUILDINGS

| | Name of Items | | Percentage of total cost |
|---|---|---|---|
| 1. | Labour | | 30 to 35 |
| 2. | Cost of materials | | 70 to 65 |
| 3. | Foundation upto and including plinth | | 15 to 20 |
| 4. | Superstructure | | 85 to 80 |
| 5. | Second storey | | 75 to 85 of I storey |
| 6. | Direct and overhead cost :— | | |
| | a) | Direct on actual work | 85 |
| | b) | Overhead cost due to establishment, supervision, incidental etc. | 15 |
| 7. | Sanitation and electrification :— | | |
| | a) | Sanitary and water supply | 7 to 9 |
| | b) | Electric installation without fans | 7 |
| | c) | Electric fans | 5 |
| 8. | Cost break-up of different parts : — | | |
| | a) | Earthwork in excavation and filling | ½ to 1 |
| | b) | Foundation concreting | 4 to 6 |
| | c) | Damp proof course | 1 |
| | d) | Brick work | 34 |
| | e) | Roofing | 20 |
| | f) | Doors and windows | 16 |
| | g) | Plastering and pointing | 10 |
| | h) | White and colour washing, painting | 2 |
| | i) | Miscellaneous | 4 |
| 9. | Cost of material and labour :— | | |
| | a) | Bricks | 25 |
| | b) | Cement | 10 |
| | c) | Steel bars | 10 |
| | d) | Timber | 15 |
| | e) | Lime | 5 |
| | f) | Labour | 30 |
| | g) | Miscellaneous | 5 |
| 10. | Material required on plinth area basis for single storey buildings :— | | |
| | a) | Brick | 500 Nos. per sq. m. of plinth area |
| | b) | Cement | 1.5 bags per sq. m. of plinth area. |
| | c) | Steel bars | 12 kg. per sq. m. of plinth area. |
| | d) | Coal for burning bricks | 1.5 quintals per sq. m. of plinth area. |
| 11. | Annual repair and maintenance | | 1 to 1½% of capital cost of building. |

# 2.43 INSPECTION OF TEMPLE CARS

Whenever new cars made and put in service, the Chief Engineer directs that the detailed calculation should be made and approved by the Executive Engineer before certificate is issued. Succeeding certificates issued year after year are, however, only cetificates of soundness of the car to prevent a detoriorated car being hauled and becoming a public danger.

*(Based on C. E. memorandum No. 2580 AD/35-CP dated 20-9-35.)*

## 2.43.1 GUIDE LINES :—

1. Examine the wheels and satisfy yourself that they are not cracked but sound, well finished with that iron plates and rivets.
2. Examine the capacity of the axles to carry the loads including the live load.
3. Examine the tendency for the car to overturn.
4. Determine the maximum pull on the coir rope.

(a) The size of the ropes should be fixed with reference to the formulae $C^2K$ if they are not coir as they generally are.

(b) The weight of the car is taken as W and the friction of the wheels on the ground is assumed as 0.13.

5 The capacity of the car to right itself when it is pulled at a speed (V) per second and brake wedges are applied are examined as follows:

The kinetic energy of the moving car will be $\frac{1}{2} MV^2$ ft. lbs. The car before righting itself takes up the position and then the C. G. of the car will be lifted through a height (h) and the work involved in the car so lifted up, viz. Mgh should be equated to $\frac{1}{2} M. V^2$. In order to limit h to 6" and V should be calculated.

The length of the ropes used for pulling should be defined with reference to the pull got under item 5 above and calculating approximately on the basis of one man of every 9" or one foot exerting a pull of 35 lbs. By restricting the length of the rope the chances of the car being pulled too far will be limited.

## 2.43.2 EXAMPLE :

Tiruvatteeswaranpet Temple car.

For the design of axles the maximum probable weight of the car is taken. Steel axles 2½" diameter are provided.

DATA: Since the top and body of the car are hollow 50% of the volume will be taken for calculating weight.

Weight per C. ft. of wood 50 lbs.

a) Top portion :

Volume (6' X 6' X 8/3) cft.

Weight = 50/100 X 8/36 X 50 = 2400 lbs.

b) Pillar 16 Nos.:

Weight = 16 X 4/12" X 4/12" X 6¼' X 50 = 556 lbs.

c) Central Portion :

(i) Top platform:

Volume = 4¼' X 3¼" X 1½" = 663/32 cft.

Weight = 663/32 X 50/100 X 50 = 518 lbs.

(ii) Lower platform :

Volume = 6'-0" X 6'-" X 1¾" = 63cft.

Weight = 63 X 50/100 X 50 = *1575 lbs.*

*d) Lower portion of the body*

$$\text{Volume} = \frac{(8'\text{-}4" \times 3'\text{-}8\tfrac{1}{2}") + (7' \times 3')}{2} \times 6'\text{-}6" = 172.44 \text{ cft.}$$

Weight = 172.44 X 50/100 X 50 = *4311 lbs.*

e) Crowd load or live load at 30 lbs. sq. ft.

= 6' X 6' X 30 = 1080 lbs.

Total = 10440 lbs.

Add Impact allowance 50% = 5220 lbs.

Grand Total = 15660 lbs.

Load per axle = 15660/2 = 7830 lbs. or 3½ tons

Add self weight of axle ½ ton

Total weight 4 ton

Shear at one support = 4/2 = 2 tons.

(ii) Area required for the section of axle allowing shear strength for Shell at 5 tons per sq. inch = 2/5 or 0.4 sq. inch.

The section provided 2½" dia. is too much.

$$\text{Maximum B. M.} = WL/8 = \frac{4 \times 2 \times 3.5 \times 12}{8} = 42 \text{ inch Tons.}$$

Z required = 42/8 = 5.25.

A section 2" X 2" enough $\frac{\Pi d^2}{4} = 5.25 \quad d = 2.58"$

An axle 2" X 2" section and turned into 1'9" at the end

(iii) Tendency of the car to overturn and maximum pull on the coir rope.

For this the minimum probable weight of the car is taken with 30% for volume instead of 50% as previously taken.

Top portion 8/3 X 6' X 6' X 30/100 X 50 = 1,440 lbs.

At a height of 15⅓ ft. from the axle;

PILLARS 556 lbs.at a height of 9½'

CENTRAL PORTION :

Lower platform 1575 X 3/5 = 945 at 5½' from axle.

Top platform 518 X 3/5 = 310 lbs. at 7⅛' from axle.

Lower portion of the body 4311 X 3/5 = 2587 lbs. at 3 ft. from axle.

Total weight = 5,838 lbs.

Find C. G. of the car i.e.

5838x = 1440 X 15⅓ + 556 X 9½ + 310 X 7⅛ + 945 X 5½ + 2587 X 3
= 7.28 FT.

The C. G. is 7.28 ft. from the centre of the wheel or 8.76 feet from the ground.

When it is not pulled and if C. G. is lifted by 0.63 foot, it will turn over.

Maximum pull on the coir that can be expected without making the car turn over is P X 2'9" = 5709 X 3.25

P = 6900 lbs.

Maximum pull for each line 3450 lbs.

If the average pull is 35 lbs; 98 people can drag the car. ■

# III DEPARTMENTAL INFORMATIONS

## 3.1 POWERS OF VARIOUS OFFICERS

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| | Rs | Rs | Rs. | Rs. | |
| **3.1.1 BUILDINGS,** | | | | | |
| **Administrative Approval:** | | | | | |
| Works other than Residential Buildings : | 2,00,000 | 50,000 | 20,000 | — | C. O. Ms. No. 1819 PWD Dt. 1.9.84 read with G. O. Ms. No. 862 Finance dt. 6.8.76. |
| Residential Buildings | 10,000 | 2,500 | 500 | — | — do — |

Note: 1. Proposals relating to residential buildings should be in accordance with latest type design approved by the Government.

2. Sanction for improvements to an existing Residential Building may be accorded subject to the condition that the standard rent of the building will not thereby exceed 10% of the average emoluments of the occupant for whom it is intended.

The above delegation is not applicable in connection with rent free quarters or with any proposal for acquisition of land to be added to the compound of a residence whatever the cost of the land may be.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Quarters for employees in the inferior service | — | — | 10,000 | — | Para 439 (2) of TNPWD code G.O. MS No. 1819 PWD dt. 1.9.84. |

Note: (i) The proposal should be in accordance with the latest type design.
(ii) Outside works should be restricted to minor sanitary works such as drains, latrines, wells and the like.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Contribution works : | | | | | |
| Non-Residential | 80,000 | 30,000 | 15,000 | — | GO. Ms. No. 1819 PWD dt. 1.9.84 |
| Residential | 20,000 | 5,000 | 2,500 | — | — do — |
| **Technical sanction:** | | | | | |
| Building works | Full powers | 10,00,000 | 2,00,000 | 10,000 on standard plans | GO. Ms. No. 574 PWD dt. 30.4.74 (Upto 10% of the estimates administratively approved by competent authority) |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| **3.1.2 ELECTRICAL WORKS :** | | | | | |
| **Administrative Approval :** | | | | | |
| Electrical Works in Non-residential Buildings | 20,000 | 10,000 | 5,000 | — | GO. Ms. No. 1819 PWD dt. 1.9.84 |
| | This was made applicable to Electrification of Anicut, Dam sites, Head sluices approach roads etc. in GO. Ms. No. 1066 PWD dt. 2.7.73 | | | | |
| | *Note*: For scale of provision of fans etc. please refer to G.O. Ms. No. 737 PWD dt. 25.3.66. | | | | |
| Electrical works in residential Buildings | 10,000 | 4,000 | 2,000 | — | GO. Ms. No. 1819 PWD dt 1.9.84 |
| | *Note*. For scale of provision for residential buildings please refer to GO. Ms. No. 1269 PWD dt. 14.8.73. | | | | |
| **Techaical sanction :** | | | | | |
| Electrical Works for Buildings | Full powers | 40,000 | 15,000 | 2,000 | Para 255 A of TNPWD Code introduced in GO. Ms. No. 931 PWD dt. 24.6.76. Electrical Engrs. are empowered upto Rs. 30,000 vide GO. Ms. 574 PWD dt. 30.4.74. |
| | *Note*: For norms for obtaining provision of funds & execution of Electrical works please refer to GO. Ms. 931 PWD dt. 24.6.76 & CE. (Gl.) Memo No. AC. 4/122638/76-2 dt. 6.8.76 | | | | |
| **3.1.3 IRRIGATION WORKS :** | | | | | |
| **Administrative Approval :** | | | | | |
| 533 Capital outlay on Irrigation etc. works (commercial) | 50,000 | 11,250 | 3,000 | — | GO. Ms. No. 1600 PWD dt. 11.10.73 read with GO. Ms.No. 862 Finance dt. 6.8.76. |
| | which stipulates that whenever ryots' interests are affected in the distribution of water, prior approval and counter signature of the Board of Revenue should be obtained to the scheme. Cases of disagreements between PWD and Board of Revenue should be referred to Govt. for orders through Board of Revenue | | | | |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| 333. A Irrigation etc. works (commercial) original works (E & I works) | 50,000 | 25,000 | 10,000 | — | G.O. Ms. No.574 PWD dt. 30.4.74 as clarified in Govt. memo No. 142148 (a)/P3/75.4/dt. 3.5.76 read with G.O. Ms. No. 862/Finance dt. 6.8.76. |
| — do — (Non-comml.) Original works (E & I works) | 50,000 | 25,000 | 10,000 | — | — do — |
| 333 B. Irrigation etc. works (Non Commercial) other expenditure. | 7,500 non recurring in each case subject to a maximum limit of Rs.10,000 in a year. | 4,000 | 2,500 | — | G.O. Ms.No.574 PWD dt. 30.4.74 as amended in Govt. memo No. 142148/P3/74/4/dt. 3.5.76. |
| | *Note:* The power should not be exercised in any case unless there is specific Budget appropriation for the purpose and the expenditure is non-recurring. | | | | |
| Full contribution works: | Full powers | 15,000 | 5,000 | — | G.O. Ms. No. 574 PWD dt. 30.4.74 |
| **Technical sanction :** | | | | | |
| Original works 333 Irrigation etc. works (commercial) | Full powers | 10,00,000 | 2,00,000 | 10,000 | G.O. Ms. No. 1819 dt. 1.9.84 |
| 333 Irrigation etc. works (Non-commercial works) | Full powers | 10,00,000 | 2,00,000 | 10,000 | G.O. Ms. No. 574 PWD dt. 30.4.74. |
| — do — (Non commercial) other expenditure. | — do — | — do — | — do — | — | — do — |
| 333 Irrigation etc. works (commercial) and (Non-comml.) | | | | | |
| (a) Ordinary repairs | Full powers | 5,00,000 | 1,00,000 | — | G.O. Ms. No. 574 PWD dt. 30.4.74. |
| (b) Special repairs | Full powers including repairs under famine relief. | 5,00,000 | 1,00,000 | — | — do — |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Full contribution works and repairs : | Full powers | 5,00,000 | 1,00,000 | — | G.O. Ms. No. 574 PWD dt. 30.4.74 as clarified in Govt. lr. No. 36409/G2/74.5/dt. 13.9.76. |
| 533 Capital outlay etc. works (commercial) | — do — | 5,00,000 | 10,000 | — | — do — |

## 3.1.4 Spl. M.I.P., D.C.R. and T.R.S. works :

**Administrative approval :**

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| (a) 533 Capital outlay on Irrigation works (Non-commercial) Spl. M.I.P. works | 1,50,000 | 75,000 | 15,000 | — | G.O. Ms. No. 1600 PWD dt. 11.10.73. But in G.O. Ms. NO. 574 PWD dt 30.4.74 the existing powers are shown as 1,00,000, 50,000 and 10,000 respectively. |

In Govt. (PWD) memo No. 90334/SI/76-1 dt. 26.11.76, CE (I) and his subordinate officers are permitted to accord administrative approval to the new SMIP and DCR schemes upto the financial powers delegated to them in GO. Ms. No. 1600 PWD dt. 11.10.73. Before according administrative approval, the schemes should be included in the consolidated list sent to Govt. annually for selection and approval for implementation by the Govt.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| (b) — do — D. C. R. Schemes | 1,50,000 | 75,000 | 15,000 | — | |

*Note*: This limit is subject to the observance of cost and benefits of the scheme and if it exceeds the cost and benefits and other conditions fixed, the sanction of Govt. may have to be obtained vide orders in G. O. Ms. No. 298 PWD dt. 9.6.75 and further clarified in Govt. Lr. No. 127438/75/20.12.75 on Chief Engineer's Lr. no. N2/60131/71-12/17.11.75.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Tank restoration schemes (TRS) Extension and Improvements : | Works costing not more than | 25,000 | 10,000 | — | G. O. Ms. No. 574 PWD dt. 30.4.74 and also in G.O. Ms. 862, Finance dt. 6.8.76 where no ceiling is laid. |

Rs. 50,000/- subject to a maximum of Rs. 7.5 lakhs in a year.

| | | | | | |
|---|---|---|---|---|---|
| Powers to sanction Spl. M.I.P. DCR & Pond schemes with reference to cost per tonne and cost per acre (paddy) : | | | | | G. O. Ms. No. 949/F and A dt. 13.3.63 continued in G. O. Ms. NO. 91. PWD dt. 12.1.72 upto IV plan. |
| 1) Spl. M. I. P. WORKS : | | | | | |
| a) Cost per tonne. | | | | | Note: The Board of Revenue in its ref. No. B3/19058/75 dt 14.10.75 has suggested revised norms for SMIP, DCR and Pond Schemes with reference to existing availability of water and the water that would be available after executing the schemes. Orders of Govt. thereon are awaited. |
| i) Salem and Coimbatore Districts. | 3,500 | Rs. 2,000/- per ton. | 1,000 | — | |
| ii) Other districts excluding delta areas. | 3,000 | Rs. 400/- per acre. | | | |
| iii) In delta areas covered by Cauvery, Vennar, G.A. Canal & L.C.A. Systems. | 2,000 | | | | |
| b) Cost per acre. | | | | | |
| * iv) Ex-zamin areas | Rs. 500/- per acre | Rs. 400/- per acre | — | — | |
| 2) D.C.R. works | Rs. 3,000* per ton | Rs. 2,000 per ton | Rs. 1,000 per ton | — | * G.O. Ms. 3610 F & A dt. 12.12.63 G.O. Ms. No. 1757 PWD dt. 20.8.71. |
| 3) POND Schemes | Rs. 1,500 | Rs. 1,000 per ton | — | — | G.O. Ms. No. 3345/PWD dt 4.10.60 G.O. Ms. No. 3345/PWD dt. 4.10.60 and Govt. memo No. 65295/B3/70-5 dt. 20.8.70. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Spl. M. I. P. Works : | | | | | |
| Yard stick for working out yield rate of dry crops and the rete per ton for dry products (Ragi) | | | | | G. O. Ms. NO. 755 PWD dt. 21.4.72. |
| i) Salem,Coimbatore and Dharmapuri Dists. | Rs. 800 per ton | Rs. 600 per ton | Rs. 250 per ton | — | Note: Yard stick for production of Ragi per acre is 1.7 tons and the cost per ton is Rs. 800/- |
| ii) Other districts excluding delta. | Rs. 700 per ton | — | — | — | |
| **Technical Sanction :** | | | | | |
| The special repairs estimates under Special M. I. P. without administrative approval with reference cost per tonne and cost per acre (paddy) | Full Powers | 2,00,000 | 40,000 | — | SR works cannot be taken up under SMIP as per Govt. PWD memo No. 77195/B1/74-1 dt. 15.6.1975. Only schemes with substantial additional Irrigation potential by way of new ayacut or for covering the gap between rated and actual Irrigation will be taken up under SMIP |
| 1) *Cost per tonne* : | | | | | |
| i) Delta areas | 2,000 | 2,000 | 1,000 | — | |
| ii) Coimbatore, Salem and Dharmapuri Dists. | 3,500 | — | — | — | |
| iii) Other areas | 3,000 | | | | |
| 2) *Cost per acre* | 500 | 400 | — | — | In certain cases the cost per acre may be within the power of technical sanction of an officer but the cost per tonne may exceed his limit. In that case the estimate will have to be administratively approved by competent authority. *Note:* i) Collector's concurrence is to be obtained before according sanction to Special repair estimates. ii) As regards the original works the existing procedure may be followed |
| Tank restoration schemes (TRS) works extension and impts. | Full powers | 5,00,000 | 1,00,000 | — | G.O. Ms. No. 574 PWD dt. 30.4.74 as clarified in Govt. Lr. No. 36409/G2/74-5 Dt. 13.9.76. |

## 3.1.5 NORMS FOR TAKING UP A. M. I. P. SCHEMES

**I. PWD and Ex-zamin Tanks**

| | | | |
|---|---|---|---|
| 1. | Tanks with Ayacut less than 200 acres. | Rs. 30,000 | C. E. (I) has to give general approval. |
| 2. | Tanks with Ayacut more than 200 acres. | Rs. 50,000 | vide Govt. PWD memo No. 77194/B1/74-1 dt. 15.6.1974. |

*Note:* For Schemes costing above Rs. 50,000/- Govt approval has to be obtained.

**II. Panchayat Union Tanks :**

| | | Less than 50 acres | Above 50 acres |
|---|---|---|---|
| 1) | Standardisation work involving earthwork only such as desilting and excavating of supply channel. | Rs. 10,000 | Rs. 15,000 |
| 2) | Standardisation work involving earth work such as desilting, excavation of supply channel, repairs to sluices, provision of proper supply discharges etc. | Rs. 20,000 | Rs. 30,000 |

*Note:* All Schemes under Panchayat Union sources have to be selected by the Dist. Collectors and the orders of Govt. obtained in Rural Development and Local Administration Dept.

The above Limit as per Govt. R.D. & L.A. Dept. Memo No. 80547/P.V.I/74-1 dt. 22.7.1974.

## 3.1.6 TOOLS AND PLANTS: STORES, STOCKS ETC.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| **Administrative Approval :** | | | | | |
| Purchase of Tools and Plants, equipments and Livestock (Within the limit of budget allotment) | Full Powers | 25,000 | 15,000 | 2,000 | G.O. Ms. No. 574 PWD dt. 30.4.74 and G.O. Ms. No. 862 Finance dt.6.8.76. |
| Purchase of office furniture (subject to budget provision) | 10,000 | 5,000 | 2,500 | 500 | G.O. Ms. No. 584 PWD dt. 30.4.74 G.O. Ms. No. 1819 PWD dt. 1.9.84 |
| *Note*: For scale of furniture please refer to G.O. Ms. No. 1171/PWD dt. 22.5.71. | | | | | |
| Purchase of stores for each estimate. | — | 50,000 | 25,000 | 1,000 | G.O. Ms. No. 1819 PWD dt. 1.9.84 |
| *Note*: i) E. E. can make 100% advance to reputed Indian firms vide G.O. Ms. No. 1143/PWD dt. 29.7.76. ii) 90% advance payment can be made to Tansi Units vide G.O. Ms. No. 387 (Industries) dt. 16.3.76. | | | | | |
| Purchase or improvements to floating plants for which no rent or hire is chargeable. | 45,000 | 25,000 | 5,000 | — | G.O. Ms. No. 574 PWD dt.30.4.74 read with G. O. Ms. No. 862/Finance dt. 6.8.76. |
| — do — for which rent or hire is chargeable. | 15,000 | 10,000 | 5,000 | — | — do — |
| Purchase or manufacture of stock. | — | — | E.E. can purchase or manufacture stock sufficient to keep the stock of the Division upto the reserve limit as referred to in para 323 and 324 of T.N. PWD Code. | — | Para 432 (a) v of T.N.P.W.D. code |
| **Technical Santion :** | | | | | |
| Tools and plant estimates charged to Irrigation Head of Accounts. | Full Powers | 5,00,000 | 1,00,000 | — | G.O. Ms. No. 574 PWD dt. 30.4.74 - as clarified in Govt. Lr. No. 36409/68/74-5/Dt. 13.9.76. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Ordinary maintenance of Spl. Tools and Plants like lorries power rollers etc. per year for each plant. | — | — | 60,000 | — | G. O. Ms. No. 1819 PWD dt. 1.9.84 |
| To sanction estimates for regular repairs of Special Tools & Plants other than running or working expenses. | — | 10,000 | 5,000 | — | |
| To sanction estimates for regular repairs for ordinary Tools & Plants | — | — | 5,000 per year | — | G.O. Ms. No. 1819 PWD dt. 1.9.84 |
| To sanction estimates for losses due to depreciation of stock. | — | upto Rs.10,000 | — | — | Para 423 (a) of T. N. PWD code. |
| **Sundries :** | | | | | |
| Fixing use rate for machinery and vehicles. | — | S.E. to fix with the approval of the A. G. | Executive Engineer to work out | — | Circular memo No. 7117/59/A1 dt. 3.9.59 of the Chief Engineer (Irrigation) G.O. Ms. No.923 PWD dt. 16.4.71. |
| Duration for hiring out Tools and plants and machinery to local bodies and private parties | For any period in excess of two years. | For any period not exceeding 2 years. | For a period not exceeding 3 months. | — | Para 340 (11) of TNPWD Code. |

## 3.1.7 TENDERS, ACCEPTANCE OF CONTRACTS ETC.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| To invite tenders for works | Full Powers will be exercised by all CEs and when occasion demands | Full Powers for SEs of all branches | 1,00,000 | 10,000 AEEs of all branches | G.O. Ms. No. 574 PWD dt. 30.4.74 as amended in G.O. No. 293 PWD dt. 22.2.77.<br>*Note:* Executive Engrs. of Electrical Divisions are empowered full in respect of Electrical works. |
| To accept tenders for works | Upto Rs. 25,00,000 with 5% excess and upto 5,00,000 with 10% excess over technically sanctioned estimate. | Upto Rs. 5,00,000 with 5% excess and upto 1,00,000 with 10% excess over technically sanctioned estimate. | Upto Rs. 1,00,000 with 5% excess over Technically sanctioned estimate. | Upto Rs. 10,000 without any excess over technically sanctioned estimate. | *Government*<br>1) All cases with tender excess over 10%<br>2) All tender cases costing above Rs. 50/- lakhs.<br>3) All tender cases costing above Rs. 25/- lakhs with tender excess over 5%.<br>*Board of Engineers*<br>Upto Rs. 25/- lakhs with 10% excess over technically sanctioned estimates. |
| | Between 25/- lakhs and 60 lakhs with 5% excess over technically sanctioned estimates. G.O. Ms. No. 739 PWD dt. 26.5.76. | | | | |
| To accept agreements : | G.O.Ms. No. 1104 PWD dt. 18.7.77 says that the authority which calls for or invites tenders on behalf of Govt. should also accept the aggrements. Therefore no monetary limit is said as in the cases of excess over estimates vide CE (GI) circular memo No. Wks.II/51273/72-5 dt. 23.10.74. | | | | |
| To accept tenders and agreements for electrical works of ordinary and special repairs by AEE. | — | — | — | Rs.1,000 | G.O. Ms. No. 501 PWD dt. 17.2.65.<br>*Note:* The Chief Engineer (B) has recommended to Govt. to enhance this limit to Rs. 3,000/- in Lr. No. Works II (2) 70658/77-1 dt. 9.7.77. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Waiver of tender call and entrustment of works on nomination WITHOUT splitting up of a major work. | 1,00,000 | 30,000 | 7,500 | — | G.O. Ms. No. 574, PWD dt. 30.4.74. |
| Powers to entrust flood repair works on nomination with waiver of EMD. | — | 30,000 | 7,500 | — | G.O. Ms. No. 501 PWD dt. 7.2.65. |
| To entrust electrical works on nomination | — | — | 2,000 | — | Para 255 of TNPWD code as amended in G.O. Ms. No. 835 PWD dt. 8.5.72. |

To split up major works into parts applicable to both Buildings and Irrigation branches of the PWD and Highways

The Government in G.O. Ms. No. 805 PWD dt. 7.6.76 have permitted the Chief Engineer to split up works into different components with suitable break up in the main estimates while seeking administrative approval as indicated below so that they can be taken up for execution independently with refernce to the code rules with the following objectives.

(i) To obviate the difficulty of lack of contracts for taking composite works for want of finance.

(ii) Attract local contractors to a large extent leading to competitive bids; and

(iii) early execution of works :

*Bridge works:* (a) Construction of bridge (b) Formation of approach road (c) dismantlement of existing structure (d) protective works (e) Lighting bridges etc.

*Culverts:* Masonry works and cross drainage works etc.

*Road works:* Initial formation, black topping, water bound macadum etc.

*Irrigation works:* Earth work excavation for dam, canals distributories, masonry works for dams, spillways, aquaducts, lining, cross drainage works, culverts, etc.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|

*Buildings:* Foundation, superstructure, sanitary and water supply arrangements, electrical installations.

*Note:* (i) The Chief Engineer should ensure that while splitting up works, the intentions should not be to avoid sanction or acceptance by next higher authority.

(ii) There should be adequate safeguards to prevent the abuse of powers by the subordinate officers.

(iii) There should not be extra financial commitments to Government on account of such splitting up of works.

(iv) According to Chief Engineer (B) Circular memo. No. Wks. II (2)/4902/74/15.7.75 Mosaic works costing Rs. 25,000/- and more in an estimate for a building work can be treated as a separate item and awarded to a contractor other than the contractor for the main work by tender.

(v) In G.O. Ms. No. 951 PWD dt. 12.6.75 Govt. have ordered that in regard to works involving pile foundation, separate tender may be called therefore if need be.

**3.1.8 CONTRACTS :**

Powers of officers in regard to intermediate steps which have a bearing on the final decision of the Government.

*Delegation :*

Vide G.O. Ms. No. 1282 PWD dt. 24.8.1977. As clarified in Chief Engineer (Gl.) Endt. No. Wks II (3) 52052/71/dt. 24.9.1977.

(i) Government have empowered the officers of the PWD in accordance with their powers to accord technical sanction to the estimates for works and decide the intermediate steps such as rejection of tenders, calling for tenders afresh or quotations, or award of work otherwise except in cases where the tender amount or the tender excess or both fall within the purview of the Govt. for final acceptance of tenders.

(ii) In the case of award of work after negotiation or nomination to selected contractor etc. the relevant rules for obtaining the orders of competent authority should be followed and works have to be awarded in accordance with the powers for acceptance of tenders on nomination already delegated to the officers concerned.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| | | | | | (iii) As for splitting up of works the officers of the PWD can split up the work costing up to Rs. 5/- lakhs in accordance with their powers to accord technical sanction to the estimates following the procedure outlined in para 160 of TNPWD code.<br>( iv) In cases where the value of works exceeds Rs. 5/- lakhs the splitting up proposals should be indicated in the report to accompany the estimate for obtaining administrative approval as outlined in G.O. Ms. No. 805 PWD dt. 7.6.76. Any proposal or further proposals for splitting up works costing above Rs. 5/- lakhs after obtaining the administrative approval of the Government will require specific prior orders of Government. |
| To accept tender for Spl. M.I.P. and D.C.R. | 25% | 15% | 5% | — | G.O. Ms. No. 1600 PWD dt. 11.10.73. Procedure for entrustment for Spl. M.I.P. and D.C.R. works:<br>(i) Tenders for the execution of the works should be called for in the first instance.<br>(ii) If any local ayacutdar offers to execute the work at the lowest rate tendered, the work may be entrusted to the ayacutdar at the lowest rate tendered.<br>(iii) If once of the local ayacutdars is forthcoming to execute the works then the work may be entrusted to the contractor who has quoted the lowest rate and who is capable of doing the work satisfactory and quickly; and<br>The works may be entrusted to a contractor on nomination at estimated rates for execution only after altenatives (i) to (iii) above are exhausted (G.O.Ms.No.1768 PWD dt. 20.5.63). |
| To entrust additional ITEMS of works fairly contingent on the main work to the main contractor at estimate rates. | 10% of value of contract or Rs. 1,00,000 which ever is less | 10% of value of contract or Rs. 30,000 which ever is less | 10% of value of contract or Rs. 7,500 which ever is less | No. powers | G.O. Ms. No. 619 PWD dt. 16.5.78.<br>*Note*: I. This limit will be after taking into account the enhancement of the limit of 5% for acceptance of Tenders ordered in G.O Ms. No. 739 dt. 26.5.76. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| To entrust additional QUANTITIES of works fairly contingent on main work to the main contractor. | 25% of value of contract or Rs. 1,00,000 whichever is less | 25% of value of contract or Rs. 30,000 whichever is less | 25% of value of contract or Rs. 7,500 whichever is less | No powers | 2. The practice of giving substituted items of works to the main contractor be continued without any change with limitation passing the excess over the sanctioned estimates by the officers of PWD. |

## 3.1.9 WORKS : MISCELLANEOUS

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Sanctioning and keeping estimates in readiness repair estimates for raising the bunds of tanks. | — | — | — | — | Para 419 of TNPWD Code. |
| Alteration of designs of works during the course of execution | -- | Upto the limit to deal finally with excess over estiamtes. | Upto the limit to deal finally with excess over estimates. | — | Para 417 (e) and para 429 (d) of TNPWD code. If such altenations affect the administrative side of the works, they should be effected only after consulting the administrative department vide G. O. Ms. No. 294 PWD dt. 24.2.75. |
| To pass excess over the estimate | 5% or Rs.5,000 | 5% or Rs.1,500 | 5% or Rs.750 of | — | SE/EE has no powers to sanction any excess over a revised estimate sanctioned by a higher authority vide para 417 (i) (d) and 428 (e) of TNPWD code. EE can however pass excess over expdr. of Rs.750/- on all works irrespective of the amount of sanctioned estimate. |
| | any secntioned estimates provided that the total amount of the excess is within the limit of powers to sanction estimates technically. This delegation applies to electrical works also in respect of Cheif Engineers vide G.O.Ms.No.862 Finance Dept. dt. 6.8.76. | | | | |
| To divert the provision under contingencies to meet unforeseen items of works in any estimate for work. | SE ** Superintending Engineer can divert the provision for contingencies to new works or repairs which are not provided for in the estimate vide para 417 (f) (g) of TNPWD code. | | | | |

<table>
<tr><th>Description</th><th>CE</th><th>SE</th><th>EE</th><th>AEE</th><th>Remarks</th></tr>
<tr><td></td><td colspan="5">EE: Executive Engineers can divert the provision for contingencies to new works or repairs not provided for in the estimates upto a maximum of Rs. 2,500/- for each item.<br>2. The Executive Engineers can divert the provision under contingencies in an estimate to meet the excess due to increased rates or any cause whatever, provided the total amount of the estimates after the revision does not exceed by more than 5% of the sanctioned amount inclusive of contingencies and provided that the excess is within the EE's powers of sanction para 428 (e) (f) TNPWD code.<br>Note: In the estimates for major works, provision may ordinarily be made for unforeseen works. When found necessary this provision may be utilised for new items of works which are required by the administrative authority and which are essential for the fulfilment of the precise object for which the estimate for the main work is intended. The working estimates for such works will be sanctioned by the Executive Engineers and Superintending Engineers according to the powers vested in them (para 117 A of PWD code.)</td></tr>
<tr><td>Utilisation of savings in the estimates.</td><td colspan="5">Any anticipated or actual savings on a sanctioned estimate for a definite work should not, without special authority, be applied to carry out additional work not contemplated in the original project or fairly contingent on its actual execution. Savings due to abandonment of a substantial section of any project sanctioned by any authority are not to be considered as available for work on other sections without the further sanction of that authority. A substantial section of a project shall be considered to have been abandoned if the estimated cost of the works in such section is not less than 5% of the total sanctioned cost of the project excluding, in the case of Irrigation projects, the estimated cost of the head works as originally vide para. 182 of TNPWD code.</td></tr>
<tr><td>To prescribe lump-sum provision for repairs to buildings.</td><td>Full Powers</td><td>Rs. 2,000 for each building</td><td>Rs. 1,000 for each building</td><td>—</td><td>G.O. Ms. No. 574 PWD dt. 30.4.74.<br>Note: For norms for maintenance of Govt. Buildings please refer to G.O. Ms. 1227 PWD dt. 11.8.77.</td></tr>
<tr><td>To prescribe lump-sum for annual electrical maintenance.</td><td>10,000</td><td>—</td><td>Rs. 2,500 for Ele. Engr.</td><td>Rs. 1000 for A.Ele.E.</td><td></td></tr>
</table>

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Urgent periodical repairs | — | SE can authorise the commencement of of urgent periodical repairs in anticipation of formal sanction to estimates. | — | — | Paras 148 and 418 (d) of TNPWD code. |
| Emergent repairs | — | SE can sanction emergent repairs to works to any reasonable and necessary amount in case of imminent danger to the structure. | same powers as for SE. | — | For SE para 418 (e) of TNPWD code. for EE para 419 of TNPWD code. |
| Annual inspection of public buildings borne of on the register of PWD. | — | All bldgs. costing above Rs. 2 lakhs constructed prior to 1.1.46 and all Bldgs. costing Rs.5 lakhs constructed after 1.1.46 | All bldgs. costing above Rs. 25,000 to 2 lakhs constructed prior to 1.1.46 and costing from Rs.50000 to 5 lakhs constructed after 1.1.46 | All bldgs. costing above Rs. 5,000 and upto 25000 constructed prior to 1.1.46 and costing from Rs.10000 to Rs.50000 constructed after 1.1.46 | Section Officers should inspect all Bldgs. costing upto Rs. 5000 constructed prior to 1.1.46 and upto Rs. 10,000 for Buildings constructed after 1.1.46. *Authority :* Para 260 of TNPWD code as amended in G.O. Ms. No.1235/PWD/ dt. 14.7.72. |

*Note:* (1) The CE (B) has issued instructions in his Memo No. D Dis. Works II (1) 144053/ 29.11.75 that all the buildings should be inspected in rainy days in particular.

2) For norms for ordinary and special repair works please refer to G.O. Ms. No.1227/ PWD dt. 11.8.77.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Limit of purchase of stores under limited tender system under article 125 of MFC Vol. I (Rule III instructions. 9) | — | — | Rs. 10,000 | — | G.O. Ms. No. 613 PWD dt 16.5.78. |

*Note:* In the case of purchase of stores in respect of large contracts the time limit of one month from the date of first advertisement shall be made applicable if the value of stores is more than Rs. 2 lakhs. In the case of Tender for purchase of stores a minimum limit of 15 days shall be fixed if the value is below Rs.2 lakhs vide Govt. memo No.46501/D1/78-1 dt. 15.5.78.

## 3.1.10 MEASUREMENTS, PAYMENT, ETC.

Check measurement of departmental works

*S.E.:* Should inspect in detail all works above a value of Rs. 3 lakhs and certify as to their conformity to approved design and estimates.

Para 297 (1) (b) and 297 (2) and 297 (7) of TNPWD Code as amended in GO.No.75/PWD dt. 20.1.76.

*E.E.* should checkmeasure 10% of all measurement of works valued at Rs.50,000 and above. The No. of checkmeasurements should be at least 24 per annum.

*A.E.E.:* 50% of all recorded measurements; 75% of all hidden items of high unit value subject to coverage of 75% of the value of the work.

*Note:* 1. The CE. (GI) has clarified in his memo codes 71132/74/dt. 21.4.76 that the orders in the above G.O. will be applicable in respect of works taken up prior to the date of G.O., but continue to be in progress and all the new works taken up after the date of the G.O. Ms. 574/PWD/30.4.74.

2. (a) Sub. Dl. officers should necessarily checkmeasure before payment and in proper time in the following cases.

(i) All final bills on running accounts.

(ii) All first and final bills over Rs. 500/- &

(iii) Works (included in all kinds of bills over Rs.200/- which will not be susceptible of CM after certain stage, for example, works in channel, river or tank bed, foundation which will be covered up etc.

(b) As regards other bills not pertaining to the works of the kind mentioned in item (iii) in the above sub clause viz. (1) intermediate bill on running accounts and (ii) first and final bills over Rs.25/- and not over Rs.500/- sub-divisional officers should checkmeasure a large portion of them. If in such cases, it is not possible for the sub-divisional officer to checkmeasure before payment owing to pressure of work etc. then the reasons for not having done the checkmeasurement before payment should be recorded by him in the remarks column of the measurement book concerned and checkmeasurement should be done by him at the earliest opportunity after payment has been done.

(c) The following will be exception to the above rules :

(i) In the case of the korambu work where the qualities of perishable materials used such as brushwood nanal etc, cannot be checkmeasured after use the Section Officer and Sub-divisional officers should inspect, stay on the works for as long a period as possible having regard to the importance of the works and certify to the satisfactory execution of the works. On such certificates payments may be made.

(d) Checkmeasurement is not necessary in the case of articles received by one PW. Division from another and in the case of materials obtained from firms Departmentally for use on works when the cost of materials purchased at a time is Rs.500/- or less. Provided however that checkmeasurement will be necessary when supplies are arranged by the PW. Stores Division from the firms direct to the Division concerned.

(e) In the case of supplies when it is not possible for the Asst. Executive Engineer to checkmeasure before payment he should satisfy himself to the extent possible at the earliest possible opportunity after payment that the supplies have been actually received and used on the works for which they were obtained and record to that effect in the concerned M. Book vide para. 297 (1) of TNPWA. code.

(f) For repairs etc. to machinery, the following certificates of checkmeasurements on the bills should be furnished (vide A.G's Lr. No.5/DHB/627/31.10.64 addressed to CEs)

(i) Certified that the machinery has been properly tested and found to be in good working condition.

Certified further that the worn out parts have been returned by the firm and brought into accounts.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Pre-checkmeasurement of Jungle clearance works | — | — | — | All works except works costing less than Rs.50 in out-of-the-way places | Note. 2 under para 297 of TNPWA code. |
| Inspection of jungle clearance works after clearance and before payment. | — | — | — | Works costing more than Rs. 300/- | — do — |
| Payment of First and Final bills by SDOs without pre-audit in Dn.Office | — | — | — | Rs. 500/- | Para 286 of TNPWA code. |
| *Note:* Annual scheme maintenance estimates connected with irrigation works are exempted from this purview. | | | | | |
| Payment of intermediate bills by SDOs without pre-audit by Dn.Office | — | — | — | Rs. 10,000/- | Para 286 of TNPWA Code as amended in Govt. memo No. 80346/Codes/73-1 dt.27.9.73. |
| *Note:* This is also the limit upto which Sub. Dl. Officer can make payment on a work in a month. This limit is not effected by bills paid after "Pre-audit" in Divl. Office. | | | | | |
| To pass Firms bills by SDOs on their own authority for supplies ordered by themselves. | — | — | — | Rs. 500/- | Article 125 of MAC. vol. III as amended in G.O. Ms No. 302/PWD dt. 29.3.75. Para 309 (b) of TNPWA Code as amended in G.O. Ms. 1756 PWD dt. 9.12.74. |

### 3.1.11 WRITE OFF, LOSSES, WAIVERS, SALES, DISPOSAL, ETC.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Waiver of checkmeasurements | 5,000 | 1,500 | 400 | — | G.O. Ms. No. 1600 PWD dt. 11.10.73. |
| Losses in manufacture | 1,000 | 1,500 | — | — | G.O. Ms. No. 1819 PWD dt. 1.9.84. |
| Irrecoverable value of stores unprofitable outlay on works etc. | 15,000 | 3,000 | 800 | — | — do — |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| — do — Immovable property | 10,000 | — | — | — | — do — |
| — do — Losses due to disposal of all unserviceable or surplus stores. | — | 1,000 (including Tools and Plants) | 500 (excluding Tools and Plants) | — | — do — as clarified in Govt. memo No. 36409/G2/74/5/dt. 13.9.75. (The existing powers in Para 423 (b) and 432 (c) of TNPWD code is retained. (To be read with para 336 (a) of TNPWA code). |
| To approve the sale of dead and fallen trees. | — | — | Above Rs. 50/- | Rs. 50/- | Para 436 (b) of TNPWD. code as amended vide G.O.Ms.4252/18.11.50. |
| To approve sale of materials of insignificant value received from works dismantled such as bricks, debris, etc. | — | — | Above Rs. 50/- | Rs. 50/- | — do — |
| To approve the lease of miscellaneous property such as grass, fruits, fisheries etc. | — | — | Above Rs. 50/- | Rs. 50/- | Para 436 (b) of TNPWD code as amended vide G.O. Ms. No. 4252 dt. 18.11.1950. |

*For AEEs :*

*Note:* (1) Sales confined to trees fit for use as firewood only. In respect of Timber trees the maximum girth is 4 feet.

(2) Wide publicity should be given which must be certified in the sale accounts.

(3) Objections if any within 15 days, orders of Executive Engineer should be taken. Unobjectionable cases should be got confirmed by Executive Engineer after a fortnight.

| | | | | | |
|---|---|---|---|---|---|
| To WRITE OFF THE LOSSES OF M.Books, L.F. Books and Survey field Books. | — | — | — | — | Para 296 of TNPWD. Code as amended in G.O.Ms.No.4646 PWD dt. 16.12.43. |

*Note:* Losses of these books will be immediately reported to the SE who will write off the losses and take disciplinary action, if necessary.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| To sanction the sale or dismantlement of Govt. buildings. | 10,000 | 5,000 | 1,000 | — | Para 235 of TNPWD. code |

*Note:* 1. Reference to the book value of each building or group of buildings in a compound.

Vide CE PWD (B) circular memo No.22893 Wks. III (1) 59-22/64/65, it is clarified that only the bookvalue of the particular building or buildings to be dismantled partly or wholly at a time is to be taken into account in deciding the authority competent to accord such sanction and not the total book value of all buildings in the compound.

2. Also Vide Memo. No. R. Dis. Wks. III (3)/95544/72 dt. 15.7.72 of CE, PWD (B).

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Waiver of collection of EMD from interested ryots for works and to deduct 5% of the value of work done from all running account bill. | — | — | — | — | Para 154 of TNPWD code as amended in G.O.Ms.No.2233/PWD dt.16.12.69. |
| To sanction for the issue of any materials from store yards to private persons without inconvenience to public service. | — | Full value including storage plus the usual charge 10% supervision vide para 423 (b) (1) TNPWD. code. | Upto a sum of Rs. 1,000 including storage & centage charges vide para 432 C (i) of TNPWD. code. | — | To supervision charge of 10% can be waived in the case of surplus stock which in the opinion of the officer otherwise be unsaleable, vide para 321 (a) of TNPWD code read with para. 328 (c) of PWA. code |
| To write off famine Tools that have been lost or become unserviceable | — | No limit is set forth | — | — | Para 423 (b) (ii) of TNPWD code. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Deficiency or surplus in the issue of materials to contractors. | — | — | 5% | — | CE. (Gl) memo No. Ac/1/103036/66 dt. 10.3.77 read with Govt. memo. No. 10311/B/56-61/dt. 29.6.69. |
| | *Note:* (1) The 5% variation is the limit upto which EEs are competent to pass and the variation is not be allowed as a matter of course. The actual deficiencies or surplus have to be calculated after the completion of the work and the EE. should examine as to whether the surplus or deficit is reasonable and according to merit of each case and then pass the variation limits. The note to para 342 (a) of TNPWD code is not intended to mean that 5% excesses can be automatically allowed. If the variation exceeds 5% the authority competent to sanction the rates for supplemental items in respect of that contract should accept the variation before the final bill of the contractor is passed. | | | | |
| Waiver of fine imposed to a contractor. | Fines imposed by SEs. | Fines imposed by EEs. | — | — | GO. Ms. No. 2094 PWD/dt. 5.8.46 says that fine can be waived by the authority higher than the one which imposed the fine. |
| Waiver of sales tax to be collected. | Rs. 25/- | — | — | — | GO. Ms. No. 3365, Revenue dt. 3.12.69. |
| | *Note:* (1) The powers should be exercised only after satisfying the circumstances of each case. (2) Copies of the proceedings should be sent to Board of Revenue (CT) for information. | | | | |
| To approve the loss of petrol stored by Department due to evaporation under normal conditions. | 1% of the quantity stored | — | — | — | CE. (I) Endt. No. B2/10897/68 dt. 11.1.69. |
| — do — HSD Oil | Value upto Rs. 1,000/- | — | — | — | — do — |
| Waiver of petty issues of materials not covered by agreement from existing stock by the subdivisional officer in any month for any one contract. | — | — | In all cases exceeding Rs. 50/- EE should fix the rate. | Rs. 50/- | Para 328 (a) of TNPWA. code. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Ratification of excess over Reserve stock limits. | 10% over the total reserve stock limit | — | — | — | GO. Ms. No. 1978 PWD dt. 27.7.64. |

## 3.1.12 CONDONATION OF IRREGULARITIES:

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Payment of bills by SDOs. without preaudit (in Division as required in para 286 of TNPWD. Code. | — | SE. shall be the competent authority subject to post audit in division office completely. | — | — | GO. Ms. No. 3922/PWD/dt. 8.11.54 (Go. Ms. 1070/PWD/dt. 2.7.73 amendment to note 6 under para 286 .of TNPWD Code.) |
| Condonation of Non-checking of Nominal Muster Rolls costing in aggregate Rs. 500/- and above by the Asst. Executive Engineer. | *C.E.:* Upto the limit of powers to sanction write off. *S.E.:* Upto the limit of powers to sanction write off. *E.E.:* Upto the limit of powers of to sanction write off. | | | | GO. Ms. No. 3922/PWD/dt. 8.11.54. G.O. Ms. No. 1070/PWD/dt. 2.7.73. *Note:* (1) under para 291 of TNPWD. Code. |
| Payment without check measurement by Sub. Divisional Officers due to ignorance or wrong interpretation of rules. | As above | | | | GO. Ms. No. 1070 PWD dt. 2.7.73. |

*Note:* (1) In the case of payment made or to be made without checkmeasurements becoming impossible after certain stage, the Chief Engineer shall be the competent authority to condone the irregularity, provided that the value of works done is within the limit of the powers to waive checkmeasurements and authorise payments.

(2) The value of work done as a whole against the contract less the value of bills on running account paid after checkmeasurement should be the criterion for determining the authority competent to exercise this power vide GO. Ms. No. 2095/PWD/dt. 9.11.54.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Cases of payment made by section officers in excess of the limit prescribed without the vouchers being passed by Sub. Dl. officers before payment. | — | — | — | — | GO. Ms. No. 4034/PWD/dt. 25.9.56. |
| *Note:* Under para 176 of TNPWA Code. | | | | | GO. Ms. No. 3922/PWD/dt. 2.11.54. |
| Condonation of any shortfall in the No. of checkmeasurements by Executive Engineer. | C.E. (GI) | — | — | — | CE (I)'s No. C2/3865/72-1/dt. 3.3.72. GO. Ms. 1070 PWD dt. 2.7.73 and note 2 under para 297 (2) of TNPWA. Code. |
| Cash payment exceeding the prescribed limit Viz. Rs. 100/- payment by cheques below the prescribed limit. | Nil | Nil | Nil | — | GO. Ms. 1081 PWD dt. 21.6.72 (Irregularity to be got condoned by Government only) |
| Irregularities connected with opening and reduction of imprests. | Upto the limit to sanction write off of losses. | | | | GO. Ms. 3922/PWD/dt. 8.11.54. |
| Irregularities connected with the payment of Labour engaged by the contractors. | — do — | — do — | — do — | — | — do — |
| Cases of acquisition of stores in advance or in excess or actual requirements resulting in locking up of the capital. | C.E. | — | — | — | GO. Ms. 3922/PWD/dt. 8.11.54. |
| Belated verification of materials at site and Tools and Plant etc. | C.E. | — | — | — | GO. Ms. 3922/PWD/dt. 8.11.54. |
| Authority for approving the particular firm for purpose of payment upto 90% (para 305 (5) of TNPWD. Code. | C.E. upto Rs. 1 Lakh | — | — | — | GO. Ms. 4034/PWD/25.9.56. |

*Note:* The amount of advance outstanding at a time against a firm in respect of an indent should not be more than Rs. 1 Lakh.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| **3.1.13 MISCELLANEOUS (GENERAL):** | | | | | |
| Permission for shooting of film in project areas. | CEs | — | — | — | GO. Ms. No. 1767 PWD dt. 10.10.69 and GO. Ms. No. 336 PWD dt. 3.2.71 subject to the payment of a fee of Rs.250/- per day and on a deposit of Rs.3000/- read with partial modification ordered in GO.Ms.No.727/PWD/6.5.77 |
| To sanction the payment of demurrage and wharfage at a time. | 300 | 100 | 50 | — | GO. Ms. No. 1819 PWD dt. 1.9.84. |

*Note:* When such charges cannot be recovered from persons responsible all sanctions thus made should be communicated to the Accountant General.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| *Expenditure on inaugural function and foundation stone laying ceremonies.* | | | | | |
| (i) For schemes costing Rs: 5 lakhs and below : | 500 | — | — | — | GO. Ms. No. 990/Finance dt. 14.9.76 in modification of the orders in GO. Ms. No. 1297/Finance dt. 28.9.72. |
| (ii) For schemes costing Rs. 5 lakhs and above but below Rs.10lakhs. | 1,000 | — | — | — | CE. (I)'s Endt. No. 90791/78/CP/ 16.11.76. |
| (iii) For schemes costing Rs.10/- lakhs and above. | 2,000 | — | — | — | |
| Establishment of Telephone connection required as a temporary measure connected with the execution of work. | — | SE vide para 426 of TNPWD code. | — | — | Subject to the condition that the cost of the connection has been provided for in the estimate for works. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Alteration of date of birth entered in the Service Books of Non-Gazetted Establishment of the Circle. | — | SE vide para 427 of TNPWD code. | — — | — — | *Note:* According to the General Rule 49 (c) of Tamil Nadu State Subordinate Service Rules any application for alteration of date of birth received after 5 years after entry into service shall be summarily rejected as amended in GO. Ms. No 2475 Public (Services. A) Dept. dt. 27.10.1970. |
| Photographic charges. | — | SE vide para 420 of TNPWD. code. | — | — | *Note:* (i) Should be within the limit of budget provisions. (ii) In case where the photographs taken are of completed works and for general purposes and not in the interest of works themselves the charges should be debited to Estt. contigencies. |
| Re-appropriation of funds from one Major work to another in the same head of account. | 40,000 | 15,000 | 4,000 | — | GO. Ms. No. 1600 PWD dt. 11.10.73, GO. Ms. No. 1819 PWD dt. 1.9.84. |
| To sanction monthly rent for private buildings hired for office purposes | 2,500 | Divn. Rs. 1,000 Sub. Divn. Rs. 375 Section Rs. 150 | Sub. Divn. Rs. 250 Section Rs. 75 | — | GO. Ms. No. 671 PWD dt. 31.5.78. |
| Dispensing with the issue of certificate of reasonableness of rent and issue of non-availability of Public Buildings Certificate. | — | — | Upto 100/- in Dist. H.Qrs. and in city; Upto Rs.75 in other places. | — | GO. Ms. No. 636 PWD dt. 16.5.76 and GO. Ms. No. 1170 PWD dt. 2.8.77. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Issue of certificate of reasonableness of rent for private bldgs. occupied for Govt. purposes (Non-Residential) with necessary certificate of Non-availability of Public Buildings. | — | In respect of bldgs. whose carpet area is more than 1000 sft. in Madras City and Coimbatore town. | In all other cases with the exemption above. | — | Govt. Memo No. 94469/G2/68-2 dt. 29.7.70 read with CE (B)'s circular memo No. Wks. II (3)/67092/73 dt. 15.10.73 |
| | *Note:* (1) For charging fees for buildings occupied by Central Govt. Departments, please refer to GO. Ms. No. 683/PWD/dt. 21.3.67. | | | | |
| | (2) For standards to space requirements for office-cum-residence, please refer to GO. Ms. No. 884/PWD/dt. 12.5.70 read with GO. Ms. 1274/PWD/dt. 17.5.61. | | | | |
| | (3) For appointment of rent between office and residential portions please refer to item 44 II (iv) of Appendix 5 to TNF code. Vol II as amended in GO. Ms. No. 1053 (Finance Department) dt. 14.10.76. | | | | |
| Issue of certificate of reasonableness of rent in respect of private buildings occupied by Govt. servants with eligibility to claim rent from Govt. | — | In the case of buildings in Madras city where the carpt area of the building taken on rent exceeds 1000 sft. | In other cases where the rent exceeds Rs. 50/- per month | — | GO. Ms. No. 2268 PWD dt. 18.12.69. |
| | *Note:* In other cases where the rent is Rs. 50 (Rupees Fifty) and below, the certificate of reasonableness of rent may be dispensed with. | | | | |
| Limit for opening permanent imprest for works. | — | — | 1,000 | — | Para 168 of TNPWD Code. |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Refund of deposits. | — | — | Normally Executive Engineer. | SDOs can refund-deposits credited in the Sub-divisional Cash Book after necessary verification under the production of original receipt vide Para. 286 (4) of TNPWD Code. | Deposits confiscated under the provision of para 463 of TNPWD code cannot be repaid without preaudit of Acct. Genl. vide para 464 of TNPWD. Code. |
| Sanction of hire of office furniture, electric fans, heaters coolers, clocks and call bells under emergent circumstances. | Rs.1,000 per annum | — | — | — | Item 20 (iii) of Appendix 5 to TNF Code Vol. II. as amended in GO. Ms. No. 1053 Finance Department Dt. 14-10-76. |
| To accord sanction for the institution of Law suits. | 15,000 | — | — | — | GO. Ms. No. 574/PWD/dt 30-4-74. |

*Note:* (1) The point whether a case does not involve a question of principle shall be decided by Chief Engineer.

(2) Before according sanction, the Chief Engineer should consult Govt. Solicitor in respect of cases in the city and local Govt. Pleaders in respect of local cases.

(3) If the Chief Engineer finds himself unable to accept the legal advice obtained in any case, he should report it for the orders of Government.

(4) The SE or the EE should send records for appeals, defence etc. along with the opinion of the Collector affecting his Dept. (vide) Note under para 415 (vii) of TNPWD Code.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| *Sanction of law charges :* | | | | | |
| (1) Government pleaders. | Rs. 250/- Appendix 14 (10) of T.N.F.C. Vol. II. | | | | Head of Depts. are empowered to sanction fees to Law officers in the High Court, Madras as below: |

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| (2) Private counsels | Rs. 300/- | (For classification of Expr. in connection with Law suits please refer to para 486 of TNP WA Code). | | | (i) *Without financial limit:* In cases in in which there are no complications in payment of fees to the Law Officers and which are recoverable from other parties. |
| | (ii) Upto a monetary limit of Rs. 100/- in cases where the costs are not recoverable from other parties. | | | | |
| | (iii) The above delegation will cover writ petitions and civil miscellaneous petitions arising out of writ and other cases. It will not cover writ petitions and writ appeals for which defence will have to be sanctioned at Government level. The santioning authority should quote relevant rules for the sanctions. | | | | |
| Inspection of the strong rooms of the Treasuries. | — | — | E.E. will issue the certificate based on A.E.E.'s Inspection | AEE should make the inspection Report. | CE (B)'s circular memo No. 93177/ Wks/1-2/64-10/dt. 25-9-68. and send a report to the E.E. |
| | *Note:* The Assistant Executive Engineer should examine the condition of walls, floors, leakage in roof, condition of wiring and existence of white ants etc. | | | | |
| Limit upto which payment to parties, companies, etc can be made in cash. | — | — | — | — | Rs. 100/- vide para 139 of TNPWD. Code, as amended in GO. Ms. No. 406 PWD dt. 10-3-73. |
| Time limit for remittance of Misc. collections upto Rs. 10/- | — | — | — | — | One month vide para 149 of TNPWA. Code as amended in GO. Ms. No. 1081 PWD dt. 21-6-72 and GO. Ms. No. 406 PWD. dt. 10-3-73. |
| Limit for passing Bills by imprest holders on their own responsibility. | — | — | — | — | As per note under Sub para 2 of para 170 of TNPWA Code as amended in GO. Ms. No. 406 PWD dt. 10-3-73, the limit is Rs. 50/- (Rupees Fifty only). |

## 3.1.14 ESTABLISHMENT CONTINGENCIES

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|
| Repairs to and condemnation of Typewriters. | (i) Head of office can make payment upto a value of Rs. 50/- without estimates | | | | GO. Ms. No. 571, Transport dt. 18-9-73 as amended in Govt. memo. No. 6140/D2/78 (Transport Dept.) dt. 17-6-78. |
| | (ii) Estimates above Rs. 50/- but upto Rs. 300/- can also be approved and paid by the Heads of offices-Estimates above the limit should be accepted by the Heads of Depts. and the repair bill should be sent to the Director of Stationery and Printing for payment. | | | | |
| | (iii) Condemnation should be authorised by the Director of Stationery and Printing in respect of Typewriters, Duplicators, Calculators etc. | | | | |
| Purchase of Rubber stamps | Heads of offices can incur expenditure not exceeding Rs. 10/- per rubber stamp at a time towards purchase. | | | | *Purchase:* GO. No. 336, Transport, dt. 25-6-76. |
| Repairs to Rubber stamp | — do — Rs. 5 per Rubber stamp | | | | *Repairs:* GO. Rt. No. 561 (S.W. Dept)., dt. 2-3-70. |
| Purchase of Stationery articles | *Heads of Depts :* Rs. 500<br>Regional and Dist. officers Rs. 200<br>Taluk level officers: Rs. 100 | | | | GO. Ms. No. 285, Transport Dept., dt. 20-5-76. |
| Initial purchase of Bicycles and for the purchase of new Bicycles in the place of condemned ones. | Heads of Depts. | — | — | — | Appendix 5 (6) of T.N.F.C. Vol. II. |
| Placing Indent with Jail Dept. direct for articles like waterproof coats and turbans and to settle the bills. | Heads of Depts. | — | — | — | GO. Ms. No. 327 Transport Dept., dt. 15-6-77. |
| Purchase of Non-Government Publications. | Full powers | Rs. 100 | Rs. 50 | — | GO. Ms. No. 1266, PWD, dt. 23-4-59. |

| Description | CE | SE | EE | AE | Remarks |
|---|---|---|---|---|---|
| Purchase of Govt. Publications | Full powers | — | — | — | Item 8 of appendix 5 to TNF Code Vol. II as amended in GO. 1063, Finance, dt. 14-10-76. |
| Purchase of Newspapers | CEs only (Heads of Depts) | — | — | — | GO. Ms. No. 1192, Finance (Salaries) Department dt. 4-9-74. |

*Note:* 1. Four newspapers only is authorised

2. The newspapers should be supplied as far as possible at the office.

3. Should be passed on to the other officers of the office on the same day.

4. One officer in the office should be made responsible for collection and disposal of Newspapers and for crediting the sale proceeds to Government.

5. In no other cases should expr. be incurred from office contingencies for purchase of papers vide item-8B (2) of appendix 5 of TNFC Vol. II as amended in GO. Ms. 1053, Finance (Salaries) dt. 14-10-76.

*Hot and Cold Weather charges:* (Item 25 in Appendix 5 to TNF. Code Vol. II as amended in GO. No. 1053, Finance, dated 14-10-76).

(1) A controlling authority should make a specific allotment to each officer under his control for hot and cold weather charges.

(2) The supply of goglets and tumbers in all offices during hot weather should not exceed the scale laid down below.

*Gazetted Government servants:* One glass tumbler and one earthemware goglet for each, once a year.

*Non-Gazetted Govt. servants:* (a) One glass tumbler for each Non-Gazetted Govt. servant and one earthemware goglet for a group of four Non-Gazetted Government servants, once in a year in cases not covered by clause (b) below.

(b) One glass tumbler for each one of the Record Clerks and subordinates of similar steps, LGGS and other contingent staff in an office, once a year.

| Description | CE | SE | EE | AEE | Remarks |
|---|---|---|---|---|---|

*Entertainment and Refreshment charges :*

Heads of Departments (including Deputy Secretaries to Government and Collectors) are empowered to incur expenditure under this item as detailed below (Item 31 in Appendix 5 to TNFC Vol. II as amended in GO. Ms. No. 1053, Finance, dt. 14-10-76).

*Category I :* Visits of VIPs, Foreign Trade delegations etc : Rs. 100 on each occasion.

*Category II :* For Departmental meeting, Annual conference, Press Conference, Advisory committee meeting, etc : Rs. 2.50 per head to an annual limit of Rs. 3,000 for every head of department.

*Advertisement charges :*

(Item 34 of Appendix 5 to TNFC Vol. II as amended in GO. No. 1053, Finance, dt. 14-10-76) Advertisement charges have to be incurred only with the sanction of the Heads of Dept.; Tender notices, Appointment Notification to be published in *Tamil Arasu* Only, other than those of major items of statewide and national importance. ■

# IV. SERVICE INFORMATIONS

## 4.1. FUNDAMENTAL SERVICE RULES

Service Rules of Government servants of Tamil Nadu Government Service are laid down in code book called "Fundamental Rules of Tamil Nadu Government Service". This covers all the aspects of Govt. service like joining time duty, Leave rules, T.A. Rules, Other Allowance Rules, Increments, Loans and Advances, Suspension, G.P.F. Rules, Retirement benefits Rules, etc.

### 4.1.1. Joining Time

1) Joining time is the time allowed to a Govt. Servant to Govt. servant to join a new post
   i) either at the same station or at a new station without availing any leave
   ii) on return from leave not exceeding 6 months (leave includes surrender leave)
   iii) to proceed to transfer.
2) Full joining time may also be allowed if the transfer is made at the request of the Govt. servant. However the transfering authority may restrict the joining time.
3) Duration of Joining time:
   Preparation 6 days:

| Kinds of journey | No. of days |
|---|---|
| Rail | 1 day for every 400 K.M. or part thereof |
| Motor vehicle: | 1 day for every 130 K.M. or part thereof |
| Bullock Cart/Cycle: | 1 day for every 25 K.M. or part thereof. |

4) One day joining time is admissible for transfer in the same station.
5) Travel by road not exceeding 8 K.M. to or from a Railway Station at the beginning or end of a journey does not count for joining time.
6) All Sundays at the beginning, at the end and intervening can be availed of in addition to the joining time calculated.
7) Maximum joining time admissible is 30 days.
8) If an official in transit on transfer is directed to a different place other than the one in the original transfer orders, he will be entitled to fresh joining time in addition to the joining time already availed.
9) Fresh joining time should be counted from the day following the date of receipt of orders.
10) Preparation time is not admissible for the second transfer.

11) If an official on transit is reposted to the original post, it should be construed as a transfer to a new post.

12) If an official is transferred to the station where he is spending the leave, one day Joining Time is admissible. If however he actually goes to the old Headquarters to wind up his personal affairs Joining Time will be admissible from the old to the new headquarters.

13) If an official joins his post before the expiry of his leave plus full joining time the unavailed portion will be considered as leave not availed and leave account adjusted.

14) Joining Time for officials on deputation to other Govts. should be calculated under the rules of the borrowing Govt. both for onward and return journeys.

15) If in transit, leave without Medical Certificate is taken, leave will commence from the date of relief. If leave is taken on Medical Certificate, joining time already availed will stand and leave will commence thereafter.

16) The Government authorise the Heads of Departments/Controlling officers to grant special casual leave to Govt. servants who have not availed Joining Time in full or part and who desire to go within 6 months of their transfer back to their old station to some other place where their family reside in order to bring them to the new station. The period of special casual leave should be limited to the extent of Joining Time not availed of. (G.O. Ms. 929 P & A.H. Dept. dt. 13.8.79)

17) Transit Pay:

a) While on duty: Joining Time pay equal to the pay in the old post or new post whichever is less.

b) While on Earned Leave: Joining Time pay is equal to his leave salary.

c) While on leave other than Earned Leave: Joining Time pay is equal to the leave salary that he would draw had be been on Earned Leave.

d) An increment accruing during the period of Joining Time may be drawn if the transfer is while on duty.

e) If excess Joining Time is not regularised, the period will not count for leave/increment/pension.

18) All Government servants will be permitted to draw their pay and allowances for the period upto the date of their relief at the old station itself at any time during the month. Pay and allowances can be drawn at the new station on the basis of the Last Pay Certificate with the Government servant without waiting for direct copy from the old station.

## 4.1.2. LEAVE RULES

Government servants can avail the following kinds of leave:

1. Casual Leave;
2. Compensatory Leave;
3. Earned Leave;
4. Unearned Leave on Private affairs;
5. Unearned Leave on M.C.;
6. Surrender Leave;
7. Extra-ordinary Leave;
8. Maternity Leave;
9. Hospital Leave;
10. Sp. Disability Leave;
11. Study Leave.

### 4.1.2.1 Casual Leave:

A Govt. servant is entitled to casual leave of 20 days per annum with effect from 1.1.80. It can be availed along with Govt. holidays. But it should not exceed 10 days at a time. Casual leave cannot be taken in combination with any other leave, with joining time or with vacation.

### 4.1.2.2. Compensatory Leave:

The ceiling for the compensatory leave is 20 days with provision to avail of it within a period of 6 months. This leave account is transferable so that it can be availed even if the Govt. servant is transferred to other offices. When a Govt. servant has neither casual leave nor compensatory leave to his credit, a Day's earned leave shall be cut for every three days of late attendance.

### 4.1.2.3. Earned Leave:

(a) A permanent Govt. servant in superior service earns leave at 1/11th of duty subject to a maximum accumulation of 180 days.

(b) An approved probationer earns leave from the date of completion of his probation at 1/11th of duty.

(c) A probationer earns leave at 1/22nd of duty subject to a maximum of 30 days. On confirmation, the officials leave account will be recast at 1/11th of duty from the beginning of continuous service in a regular capacity. The recasting will be done in the case of approved probationers who have put in a total service of 5 years.

(d) Earned leave can be taken upto 180 days at a time.

(e) If there is a break in service during probation, the leave earned till then will lapse. In the case of approved probationer, the leave at credit at the time of their ousting will be credited to his account at the time of re-appointment.

(f) Basic servants who have put in a service of 15 years are eligible for 1/11th of duty subject to a maximum of 180 days.

### 4.1.2.4. Unearned Leave:

Permanent Govt. servants in superior service / Approved Probationers in superior service — are eligible for unearned leave on private affairs

Basic servants who have put in a service of 15 yearsand on M.C.

**Unearned leave on Private affairs:**

| | |
|---|---|
| (a) First 10 years of service: | 3 months |
| Beyond 10 years: | 6 months |

(b) 3 months at any one time

It may be granted by combining with Earned Leave but total leave should be limited to 6 months.

Basic servants are not entitled for this kind of leave.

Leave salary will be half the pay admissible during E.L., subject to a maximum of Rs. 750/- P.M.

### 4.1.2.5. Unearned Leave on M.C.

| (1) | (2) | |
|---|---|---|
| (a) Upto 5 years | 3 months | Leave mentioned in col. 2 will be reduced by the period of leave, if any, availed. |
| (b) More than 5 years but less than 10 years | 6 months | |
| (c) More than 10 years but less than 15 years | 9 months | |
| (d) More than 15 years but less than 20 years | 12 months | |
| (e) More than 20 years | 18 months | |

Basic Service: Permanent officials can avail sick leave for 6 months in all on full pay. Non permanent officials excluding temporary officials may be granted leave on M.C. for a maximum period at the rate of 10 days for every completed year of service provided they have completed one year's continuous service.

Leave Salary during U.E.L. on M.C.: Full pay may be paid instead of half pay for the entire period of 18 months w.e.f. 1.7.74

### 4.1.2.6. Extra-ordinary Leaves (E.O.L.)

E.O.L. may be granted under special circumstances when there is no other leave to his credit, or when the Govt. servant applies in writing for the grant of such leave.

It is not debitable to any leave account.

No leave salary is admissible.

E.O.L. may be granted in combination with or in continuation of any leave.

If the official is on E.O.L. for treatment of T.B., Leprosy or cancer and if his pay is less than Rs. 1000/- P.M. be will be entitled to a maximum of Rs. 75/- P.M. and a minimum of Rs. 40/- P.M.

### 4.1.2.7. Maternity Leave:

(a) Admissible to married women Govt. servants.

(b) Granted upto 90 days to a permanent or A.P.

(c) Non permanent officials are eligible to be given such period of maternity leave as will make up to 90 days if added the earned leave at their credit at the time of applying for maternity leave.

(d) Those employed under emergency service (not in regular capacity) should have completed one year of continuous service including leave if any to become eligible for the grant of Maternity Leave.

(c) Granted upto 6 weeks in the case of abortions.

(f) Leave salary equal to leave on full pay.

(g) Leave of any other kind may be combined with Maternity Leave but M.C. is necessary for such extension.

(h) Maternity Leave is not debited to the leave account. Counts as service for increments/pensions.

(i) Not admissible to women with more than three children.

### 4.1.2.8. Surrender Leave:

(a) All Government servants are permitted to surrender 15 days of E.L. in a year and get corresponding leave salary and allowances in lieu thereof.

(b) The interval between two spells should be not less than 12 months.

(c) If the interval is not less than 24 months, one can surrender 30 days.

(d) For getting this benefit, one need not go on leave (w.e.f. 1.4.74).

(e) Leave salary will be equal to that on E.L. but excluding C.C.A. and H.R.A.

(f) Deductions on account of P.F., Advances and other dues will not be made from the surrender leave salary.

### 4.1.2.9. Hospital Leave:

(a) This leave is granted only to those whose duties expose them to special risk of accident or illness.

(b) Such leave may be granted upto six months in every three years of service.

(c) Such leave is not debited to leave account.

(d) Persons who are eligible are given in instructions 2 under F.R. 101(b).

(e) Leave salary is equal to half pay for six months. If he is detained in hospital due to an injury or any disease contracted during the course of duty, full pay for the first three months and half pay for the remaining three months.

### 4.1.2.10. Special Disability Leave:

(a) This leave may be sanctioned to a Govt. servant who is disabled by injury in consequence of the due performance of his official duties.

(b) The period will be such as certified by the Medical Board subject to maximum leave for 24 months.

(c) Certificate from Medical Board is necessary.

(d) Heads of Department are competent to grant this leave.

(e) It may be combined with any other kind of leave.

(f) It will count as service for pension.

(g) It will not be debited to the leave account.

(h) Leave salary for the first 120 days will be pay last drawn and for the rest it will be equal to leave on half pay.

### 4.1.2.11. Study Leave

(a) May be granted to all Government servants and approved probationers with not less than 5 years of service to study scientific and technical problems or to undergo special course of instruction in or outside India.

(b) It should not be granted to an official who is due to retire or has option to retire within 3 years of his return to day after study leave.

(c) Maximum period is 12 months leave at a time and 24 months in entire service.

(d) May be combined with any other leave due but maximum period of continuous absence including vacation but excluding E.O.L. should not exceed 28 months.

(e) Not debited to the leave account.

(f) Will count as service for increment, promotion, seniority and pension but not for leave.

(g) Leave salary will be half pay as in the case of U.E.L. on Personal Affairs.

## 4.1.3. T.A. RULES

No journey is reckoned as journey on tour that does not return a point outside a radius of more than 8 K.M. from H.Q. But one travelling on duty within 8K.M. is entitled to recover the actual fares for journeys by Railway or other public conveyance (M.T.A. Rule 64).

A supplemental claim for T.A. is permissible if the pay is raised with retrospective effect by sanction of increment in the usual course.

Grades of Government Servants:

For the purpose of T.A., the Government servants are divided into four grades.

| Grade | Pay for month |
|---|---|
| I | Rs. 1200 and above |
| II | Rs. 500 and above but below Rs. 1200 |
| III | Rs. 350 and above but below Rs. 500 |
| IV | Less than Rs. 350 |

Pay includes personal pay granted to protect an offical from loss of emoluments but not include personal pay granted on other occasions. Pay does not include special pay or any additional pay.

### 4.1.3.1. Journey on Tour

The entitlement of an official on tour is as follows:

| Grade | Rail Class | Road | | Other Modes | Daily Allowance |
|---|---|---|---|---|---|
| | | By Bus | By Car | | Rs. P. |
| I | I | Actual fare | 60 p. per K.M. | 36 p. per K.M. | 17.00 |
| II | I | " | " | 24 p. per K.M. | 11.50 |
| III | II | " | " | 18 p. per K.M. | 7.00 |
| IV | II | " | " | " | 5.00 |

Officers who is drawing basic pay of Rs. 1750/- or more may travel by air or Air Conditioned I Class within/outside the States. Others may travel by Air on IClass for journeys outside the state.

Cost of reservation and sleeper accommodation is also reimbursable.

Mileage allowance for journey by car is admissible only to officers drawing pay of Rs. 900/- or more. Others are entitled to mileage for use of scooter/motor cycle.

Daily allowance is admissible for absence from H.O. at the following rates:

(i) Absence not exceeding 6 hours 30%

(ii) Absence exceeding 6 hours but nor exceeding 12 hours: 70%

(iii) Absence exceeding 12 hours: Full

No daily allowance is admissible for casual leave/Restricted holidays or for holidays spent outside the camp.

If boarding and lodging are allowed free at the camp daily allowance is admissible at 1/4th the normal rate. If boarding only or lodging only is allowed free, ½ the normal rate of daily allowance can be claimed.

Daily Allowance can be claimed at the full rate for the first thirty days of halt at camp. For the remaining days, daily allowance is admissible at half the normal rates. Sanction of Govt. is necessary for payment of daily allowance at full rates in excess of 30 days.

Increased rates of Daily Allowance and Road mileage allowance is admissible for travel or halt in specified class I and class II localities. The eligibility for higher/lower rate will be determined w.r.t. place of halt after journey. Officials with H.Q. in a Spl. locality can claim D.A. at ordinary rates only for a journey from and to H.Q. on the same day.

### 4.1.3.2. Additional Half Daily Allowances (porterage)

For the day of departure from Headquarters to camp, one half daily allowance will be admissible in addition to the daily allowance to meet the extra expenses like porterage etc. Likewise for the day or arrival also, one half daily allowance is admissible. However only one additional half daily allowance will be paid for each block of 24 hours of absence from Headquarters, though spread over two calendar days. It is not admissible for journeys by own car or by Govt. vehicles.

### 4.1.3.3. Mileage Allowance for journeys between Railway Station/ Bus Terminal and Residence or Place of halt.

The following is the amount admissible to the different grades of officials for their journeys between Railway Station/Bus terminal and Residence/Place of halt.

| Grade | Place of Departure/Arrival | | |
|---|---|---|---|
| | Madras | Madurai, Coimbatore, Salem, Trichy | Others |
| I & II | Rs. 5/ | Rs. 3/- | Rs. 2/ |
| III & IV | Rs. 3/- | Rs. 2/ | Rs. 1/- |

A certificate to the effect that the distance between residence to Railway Station/Bus Terminal is more than half-a-Km. is essential.

### 4.1.3.4. Road journeys by own Car/Scooter/Motor-cycles

Officers, who have been detailed in Annexure VI to T.A. Rules, are entitled to mileage at the following rates for either journeys performed from Headquarters/ Camp:

| For the | Car | Motor cycle/Scooter |
|---|---|---|
| first 100 K.M. | 1.10/Per K.M. | 0.55 P/K.M. |
| Next 100 K.M. | 0.90/Per K.M. | 0.45 P/K.M. |
| remaining: | 0.85/Per K.M. | 0.40 P/K.M. |

Officers who are permitted to transport Motor cycles/Scooter on Transfer, can draw mileage allowance at half the above rates if they perform the road journeys by motor cycle/scooter. In respect of journeys performed by car/scooter, daily allowance will be admissible for the absence from H.Q./camp in addition to the mileage allowance. For journeys between places not connected by bus and made by conveyance other than Car/motor cycle, mileage will be admissible at the ordinary rates.

### 4.1.3.5. Journeys on Transfer:

For journeys on transfer, the entitlements will be as for journeys on tour.

### Daily Allowance:

For journeys upto 24 hours — on D.A. each for self and family members.

For journeys in excess of 24 hours –

| | |
|---|---|
| Upto 6 hours: | 30% |
| 6 to 12 hours: | 70% |
| More than 12 hrs. | 100% |

Children below 12 years of age will be eligible at half the above rates.

### 4.1.3.6. Additional Half Daily Allowance:

The Additional Half D.A. to cover extra charges on porterage etc. in cases of travel by bus/rail will be admissible only at the point of embarkation and disembarkation subject to a maximum of one half D.A. for every block of 24 hours irrespective of the number of embarkations and disembarkation.

**Family includes:–**

(a) Wife (one wife only)

(b) Children dependent on the official adopted children and step children are included.

(c) Married daughter not under her husband's protection.

(d) Widowed daughter wholly dependent.

(e) Husband dependent on the women Govt. servant.

(f) Parents dependent on the Govt. servant.

### 4.1.3.7. Lumpsum Grant:

| Grade | If the new station is within 60 K.M. | If the new station is beyond 60 K.M. |
|---|---|---|
| I | 200/- | 300/- |
| II | 150/- | 250/- |
| III | 100/- | 150/- |
| IV | 50/- | 75/- |

### 4.1.3.8. Transport of personal effects:

| Grade: | By Goods Train Kg. | By Pass Train Kg. | Total Kg. | Places not connected by train |
|---|---|---|---|---|
| I | 4300 | 200 | 4500 | Two mileages will be admissible |
| II | 1925 | 75 | 2000 | |
| III & IV | 960 | 40 | 1000 | |

Subject to the maximum admissible, the Govt. servant can transport personal effects by goods/passenger or both, either from (a) the old to the new station or (b) from the old to the any other station or (c) from any other station to the new station.

### 4.1.3.9. Personal Servants:

Second class fare or actual bus fare between places not connected by rail will be admissible for journeys performed by personal servants in respect of Grade I and II Officers as below:

Grade – I 2 personal servants
Grade – II 1 personal servant

Daily allowance is not admissible for the personal servants

### 4.1.3.10. Transport of Conveyance:

The Govt. servant should be entitled to transport the Motorcar/Scooter/Motor cycle on transfer. No charges are admissible if the distance between the old and new station does not exceed 130 KMs. If it exceeds 130 KMs:–

| Mode of transportation | Amount admissible |
|---|---|
| By Rail | Actual charges paid to the Railway. |
| By Road not under its own propulsion | 25 Paise per K.M. for motor car and 13 Paise per KM for Motor cycle or Scooter. |
| By road under its own propulsion | Rs. 1/- per K.M. for car and Rs. 0.50 Per K.M. for motor cycle/scooter. |

### 4.1.3.11. T.A. on Retirement:

T.A. on retirement is admissible as T.A. on Transfer. It is admissible to the Govt. servant, members of his family and for transportation of personal effects from his last HQ. to any place in India as mentioned in his pension papers. The grade of the Govt. servant will be decided w.e.f. the pay drawn by him on the last day of his duty. It can be availed of while on leave preparatory to retirement or within 6 months from the date of retirement. But the claim should be preferred within 3 months from the date of journey.

### 4.1.3.11. T.A. to the family of the decease Govt. Servant:

Actual fares (Railway) paid plus one extra rail fare will be admissible as T.A. to the family members. Their journey may be:

(i) from H.Q. of the Govt. Servant to his home town or any other place; or

(ii) from the place of death to his home town or any other place,

subject to the condition that the amount does not exceed that admissible from HQ. to home town. The claim should be preferred within one month of the completion of the journey or 3 months from the date of the official's death whichever is earlier.

### 4.1.4. G.P.F. Rules:

**Subscription:** Temporary and officiating Government servants shall join the fund from the month following that in which they completed 6 months of continuous service. Head of the office shall send a statement indicating the name, date of birth etc., to Accountant General who will assign the account number. G.P.F. account numbers should be noted in the service book of the Govt. servant. The minimum rate of subscription shall be as follows w.e.f. 1.4.76.

| Emolument (Pay & D.A.) | | | Min. monthly rate of subscription |
|---|---|---|---|
| 185 | – | 250 | 15 |
| 251 | – | 350 | 20 |
| 351 | – | 500 | 30 |
| 501 | – | 650 | 40 |
| 651 | – | 800 | 50 |
| 801 | – | 1000 | 60 |
| 1001 | – | 1150 | 70 |
| 1151 | – | 1300 | 80 |
| 1301 | – | 1500 | 90 |
| 1501 | – | 1650 | 100 |

The amount of subscription may be raised voluntarily twice a year (i.e.) in the pay for March payable in April and in the pay for September payable in October. But reduction in subscription can be made only once in a year.

Subscription to G.P.F. shall be stopped four months prior to retirement on superannuation of the subscriber. No temporary advance sanctioned once the subscriptions are stopped. While sanctioning temporary advance prior to the period of stoppage of subscriptions, the number of instalments for recovery of the advance shall be so fixed that the entire advance is recovered fully before four months prior to the date of retirement on superannuation.

Nominations in respect of those whose minimum of the time scale is below Rs.1000/- should be kept by the Head of office and one copy attached to service book. the nominations of those whose minimum of the time scale is Rs.1000/- and above shall be maintained by Accountant General. Fresh nomination shall be filed after marriage of the Govt. servant as previous one becomes invalid.

### 4.1.4.1. Drawal of advances:

Temporary advance may be granted for the following purposes:

(a) to pay expenses in connection with the illness, confinement or disability including where necessary the travel expenses of the Govt. servant or any of his dependent.

(b) in cases necessitating prolonged medical attending, prolonged stay in a hospital or protracted treatment.

(c) to meet the cost of higher education of his dependents for all academic, medical, engineering or other tech. or scientific courses provided that the period of study is for not less than three years in the aggregate.

(d) to pay obligatory expenses on the scale appropriate to his status in connection with his marriage or other ceremonies or marriages formeral or other ceremonies of his dependents.

(e) to meet the cost of legal proceedings instituted by the subscriber.

As advance shall not except for special reasons exceed 2 months pay or half the amount of the credit in the fund whichever is less. An advance upto 3/4th of the balance of credit may be sanctioned under special circumstances. There should be an interval of six months between the drawl of two advances.

### 4.1.4.2. Recovery:

If the advance is drawn before 16th of a month, recovery shall commence from the pay for that month itself. Otherwise the recovery shall commence from the pay for the subsequent month. Recovery may be postponed at the subscriber's request during the recovery of an advance of pay granted to the subscriber. Recovery should be made only with subscribers' consent while the subscriber is in receipt of subsistence grant or is on leave on half pay or leave without pay.

### 4.1.4.3. Part final withdrawal:

**Purposes:**

(a) Meeting expenses in connection with illness;

(b) Cost of higher education of children-in the case of N.G.Os for all academic medical, engineering or scientific courses beyond the high school stage if the period of study is or not less than 3 years in the aggregate; in the case of Govt. Officers for any medical, engineering or other tech. or specialised course beyond high school if the period of study is for not less than 3 years in the aggregate.

(c) Expenditure in connection with betrothel/marriage of the subscriber's sons/ daughters and any other female dependent relation.

(d) Building or acquiring suitable house for his residence including cost of site or repaying any outstanding loan taken for purpose or reconstruction/ making additions alterations to a house already owned or acquired.

(e) Purchasing a house site and or constructing a house on the site.

(f) Acquiring farm land and or business premises.

(g) Purchasing a motor car.

(h) Extensive repairs or overhauling the motor car.

**Limit:**

Normally 6 months pay or half the amount at credit whichever is less or at the discretion of the sanctioning authority upto ¾th of the balance at credit. If availed an advance from Central or State schemes for grant of House Building Advances, the amount of withdrawal should not exceed Rs. 1,25,000 or 75 months pay whichever is less. For purchase of car, one third of the amount at credit or Rs. 16000 or the actual price of the car whichever is less. Major repairing of the car, one third amount at credit or Rs. 3000/- or the actual cost whichever is less.

## 4.1.4.4. Eligibility

After completion of 20 years of service (including broken periods if any) or within 10 years befor ethe date of retirement on superannuation whichever is earlier.

For purchasing a farm land or business premises – within 6 months of the date of retirement.

For purchasing a car – After 25 years of service or within five years before the date of retirement on superannuation whichever is earlier. The officials pay shell be Rs. 1000 P.M. or more.

For extensive repair of Car: After 28 years of service or within 3 years of attaining the age of superannuation whichever earlier. The officials pay shall be Rs. 1100 or more.

**General:** Only one withdrawal will be allowed for the same purpose. Both advance and withdrawal should not be sanctioned for one and the same purpose. There should be an interval of one year between two part final withdrawals irrespective of the purpose. Withdrawals may be made for paying the premium towards Life Insurance Corporation Policy. The policy should be in the name of the subscriber or in the joint lives of subscribers. It should be assigned in favour of Accountant General. The premium should be payable annually. The maximum number of policies will be four.

**Interest:**

8% for an amount upto Rs. 25,000/- and 7.5% for the balance in excess of Rs. 25,000. Interest will be rounded off to the nearest rupee.

## 4.2. LOANS & ADVANCES:

### 4.2.1. Loans and Advances:

Loans to Government Servants bearing Interest are

(a) Advance for the purchase of motor cars

(b) Advances for the purchase of other conveyances.

(c) Advances for the purchase of construction of House

(d) Advances for the purchase of horrest saddlery.

(e) Other advances.

### 4.2.1.1. Conveyance Advance:

The Heads of Departments may sanction advances for the purchase of conveyance to Govt. servants under their respective controls subject to the principles in Art. 227 and 229-232. The Govt. will be the authority to sanction advances to Heads of Departments. For relaxation of pension Govt. previous sanction is necessary.

### (a) Motor Car Advance:

Officers who on transfer eligible to draw railway freight for transporting a motor car and who also have the touring work and those listed in Article 230 of M.F.C. Vol. I are eligible to get motor car advance and gazetted officers who are drawing Rs. 1000/- and above in the varied scale of pay (exceeding Rs.750/- in 1970 pay scale)

i) For purchasing a new car advance should not exceed Rs. 20000/- or 20 months pay or anticipated price of the car whichever is less.

ii) For the purchase of second hand car Rs. 15000/- or 20 months pay whichever is less is admissible.

iii) The Govt. servant should send an application with an agreement executed by him in the prescribed form.

iv) The A.G. should certify the availability of funds.

v) In the sanction, the date by which the advance should be drawn will be mentioned.

vi) Within one month from the date of drawing the advance, purchase should be made.

vii) The sanctioning authority can sanction extension of time not exceeding one month.

viii) The car should be mortgaged to the Govt. as security and the security Bond after scrutiny by Director of Treasuries and accounts be kept in the safe custody of the Head of the Department or the Govt. who sanctioned the advance.

ix) The car should be insured against loss or damages by fire, theft or accident.

x) If the advance is more than Rs. 14000/- the recovery is to be made in 80 instalments. If the advance is less than Rs. 14000/- 70 instalments.

xi) Thereafter the interest at the rate fixed by Government and calculated on the monthly balances should be received in instalments not exceeding the usual instalments of principal.

**b) Scooter or Motor Cycle Advance:**

Government servants who are drawing a basic pay of Rs. 400/- (1970 scale of pay) and above are eligible for scooter, Motor cycle advance.

Government servants whose basic pay is Rs. 550 and above and below Rs. 1250/- are eligible for allotment of scooter (Bajaj) from out of Government allotment (1970 Scale of Pay).

**Amount of advance:**

| | |
|---|---|
| (a) Purchase of Motor cycle | : Cost of vehicle or Rs. 6000/- or 10 months pay which ever is lower Recoverable at Rs. 100/- per month when the loan is Rs. 4000/- and above. |
| (b) Purchase of scooter | : Cost of vehicle or Rs. 4500/- or 8 monthly pay whichever is lowest. Recovered at Rs. 75/- per month |
| (c) Purchase of mopeds | : Cost of vehicle or Rs. 2500/- or 6 months pay whichever is lowest. |

The other conditions applicable to the motor car advance hold good for motor cycle advance also.

**(c) Cycle advance:** Cycle advance can be granted to all non-Government servant who are approved probationeris and to LGGS who have put in 5 years of regular service.

The quantum of advance is Rs. 600/-

Instalment of recovery : 40 Instalments.

The second advance is permissible when 6 years have not lapsed from the date of first advance.

The government servant should furnish a certificate to the head of the office that the conveyance is in his possession and is in good order. This certificate is to be furnished before the pay is disbursed and it should be attached with the pay bill or in the acquittance as the case may be. When ever a government servant sells motor conveyance purchased with Government loans he should apply the sale process towards the repayment of the outstanding value (it principle and interests). No second advance will be granted to him.

### 4.2.1.2. House Building Advance:

1) House building advance may be sanctioned to the Government servants, whether permanent or non permanent, if they have rendered 6 (six) years continuous service.

2) Application will not be entertained from persons who will retire from service with in 5 years from the date of application.

3) Advance to state Govt. servants for constructing a new house including acquisition of site for the urpose of for enlargement of existing house, purchasing a ready buit house provided the ready built house should be in good condition to the satisfaction of the Head of the Department on the certificate from the officer of the P.W.D. not below the rank of an Executive Engineer.

4) **Ceiling Loan:** 60 months pay and Dearness allowance of Rs. 70,000/- whichever is less in the case of both purchase of site and construction of a House and Rs. 60,000/- for construction of House only.

5) The maximum period of recovery of the advance and interest is 20 years, or the available period of service before retirement.

6) The advance together with interest should not exceed the amount that will be recovered from the salary of Govt. servant during his service period itself and at the rate 1/6 of his pay and Death cum Retirement Gratuity which he can surrender towards the repayment of advance.

7) Recovery shall commence from the month following the month of occupation or completion of 18 months after disbursement of 1st instalment which ever is earlier.

8) Collector is the authority to sanction House Building Advance as far as the district is concerned as per the recent orders.

9) For enlargement of advance maximum of Rs. 25,000/- subject to the ceiling the total amount should not exceed the maximum limit of house building advance.

10) **Disbursement of Advance:**

1) 20% of the advance for the purchase of plot.
2) 30% on mortgaging the land purchased on the value of advance.
3) 40% of the amount remaining after deducting from the sanctioned amount of the advance, the instalment given for the purchase of land, when the construction of the house reaches plinth level.
4) Balance when the house reaches roof level.

**Without Land:**

1) 30% on mortgage of the land purchased.
2) 40% when the house has reached plinth level.
3) 30% when the house has reached the roof level.

### 4.2.1.3. Marriage Advance:

1) For Government servant themselves and for their sons and daughters.
2) Age in respect of male — 21 years. In respect of female 18 years. Heads of Department in the city are the sanctioning authority and in the moffussel, Collectors of the District.
3) 5 months pay or 1000/- in the case of male government servants and sons and Rs. 2000/- in the case of female government servants and daughters of government servants.
4) 75% of the advance will be sanctioned and disbursed at the first instance. The reminder will be disbursed after the celebration of the marriage and after production of utilisation certificate in the prescribed form with 2 witnesses.
5) **Approved probationeries in a service are eligible for the advance.**
6) The advance is recoverable in not more than 60 monthly instalments.
7) Government servants who have put in a service of more than 10 years and drawing pay not less than the pay of the loanee can stand surety.
8) Surety should belong to the same department to which loanee belongs.
9) The interest shall be calculated on the following formula.

$$\text{Interest} = \frac{\text{Amount of advance}}{500} \times \text{No. of instalments}$$

10) Sanction of marriage advance shall be entered in the service book.
11) Medical Identity card should be produced for verification of required by the sanctioning authority.

### 4.2.1.4. Other Advances:

a) Advances for the Purchase of typewriters.
b) Advance for the purchase of warm-clothing.
c) Special advance such as those occasionally granted to Government servants who go abroad, to pursue higher studies.

a) Advance purchase of typewriters: see Art: 235 of MPC Vol. I.
b) Advance purchase for warm clothing: Art: 227 to 229 of the Vol. I.

Rs. 300/- or 4 monthly pay which ever is less, may be sanctioned for all government servants posted to any hill stations specified in rule 7 (i) under partI of Tamil Nadu Manual of Special Pay and Allowances.

Recoverable in 20 instalments and interest as per conveyance advance.

No second advance is admissible within 3 years of a previous advance.

c) **Advance for purchase of Khadi:** is granted upto one month's pay and is recoverable in six monthly instalments of less than Rs. 300 and in 8 instalments, when more amount is given.

## 4.3. DISCIPLINARY PROCEEDINGS

The Tamil Nadu Civil Services (Classification, Control and Appeal) Rules have been framed by the Govt. of Tamil Nadu under the proviso to Article 309 of the Constitution of India. These rules came into force on and from 1st January 1955.

The following penalties may be imposed upon a member of the Civil Service of the State and a person holding a Civil post under the State for good and sufficient reasons.

### 4.3.1. Minor Penalties:

(1) Censure

(2) Fine (in the case of persons for whom such penalty is permissible under these rules).

(3) With holding of increments or promotion including stoppage at an efficiency bar.

(4) (a) Recovery from pay of the whole or part of any primary loss caused monetary to the State Government or the Central Government or to a **Local-body by negligence or breach of orders**

(b) Recovery from pay to the extent necessary of the monetary value equivalent to the amount of increments ordered to be with held where such an order cannot be given effect to.

(c) Recovery from pay to the extent necessary of the monetary value equivalent to the amount of reduction to a lower stage in a time scale ordered where such an order cannot be given effect to.

**Explanation:** In cases of stoppage of increment with cumulative effect the moonetary value equivalent to three times the amount of increments ordered to be withheld may be recovered.

(5) Suspension: Where a person has already been suspended under rule 17(e) to the extent considered necessary by the authority imposing the penalty.

### 4.3.2. Major Penalties:

(1) Reduction to a lower rank in the seniority list or to a lower post or time scale whether in the same service or in another service State or Subordinate or to a lower stage in a time scale.

(2) Compulsory retirement otherwise than under article 465(2) or under Note-I to Art. 465-A of the Civil Service Regulations.

(3) Removal from the Civil Service of the State Government.

(4) Dismissal from the Civil Service of the State Government.

The authorities competent to impose the punishment are detailed in Para 14 of the Tamil Nadu Services Manual Vol. I.

Every disciplinary case is mostly preceded by a preliminary inquiry or investigation, which will be conducted either by the Directorate of Vigilance and Anti-corruption or by the department itself. This investigation is purely a fact finding inquiry to determine whether there is a prima facie case for a formal enquiry. Such an enquiry is only meant for the information of the Government or the disciplinary authorities concerned.

The classification control and Appeal Rules provide for two procedures namely now for the imposition of a major penalty and the other for the imposition of a minor penalty. Once a decision has been taken after a preliminary enquiry or an investigation that a prima facie case exists and that formal disciplinary proceedings should be instituted against a delinquent servant under the classification, Control and Appeal Rules, the disciplinary authority will need to decide whether proceedings should be taken under sub rule (a)(i.e. for imposing a minor penalty) or under sub rule (b) (i.e. for imposing a major penalty) of rule 17 of the said rules. The choice of the rule is a matter of vital importance.

The procedure for the imposition of a minor penalty under sub rule(a) of Rule 17 is comparatively simple and the disciplinary proceedings can be conducted quickly. The procedure under sub rule (b) of the Rule-17 is much more elaborate and the oral enquiry is held more or less on the pattern of the Court Trial. This is necessitated in the event of the satisfactory substantiation of the allegations.

## 4.3.2.1. Suspension meaning and effect:

Suspension is an executive action thereby a Government is kept out of duty temporarily pending final action being taken against him for acts of indiscipline, delinquency (failure to do 'one's duty), miscemanour (i.e. indicatable fit to be charge sheeted) but not a ferocious affence (Grave affence) etc. An order or suspension has the effect of debarring a Government servant from exercising the powers and discharging the duties of his office for the period the order is in force. A standard form of order of suspension [Rule-17(e) of the Tamil Nadu Civil Services, Classification Control and Appeal Rules] is appended to these notes vide Appendix-I. By reason of suspension, the person suspended does not lose his office nor does he suffer any reduction in rank. The only causes to exercise the powers and discharge the duties of his office for the time being.

(i) During the period of suspension i.e. for the first 6 months, he is paid only subsistence allowance which is normally 50% of his last pay drawn i.e. an amount equal to the leave salary on half pay. The authority ordering the suspension is competent in respect of the period of suspension in excess of 6 months to vary the subsistence allowance by an increase/a decrease not exceeding 50% of the same, if on his opinion the period of suspension has been prolonged due to reasons not directly attributable/directly attributable to the Government servant vide F.R. 53.

(ii) Dearness Allowance if admissible in the basis of such leave salary.

(iii) Other compensatory Allowances admissible from time to time on the basis of pay which the Govt. servant was in receipt on the date of suspension subject to the satisfaction of the competent authority.

No subsistence Allowance shall be drawn unless the Government servant furnishes a certificate that he is not engaged in any other employment, business, profession or vocation and that he continues to reside in the place fixed from time to time by the competent authority. The last place of duty is usually fixed as the headquarters of the Government servant during the period of suspension. Leave cannot be granted to a Govt. servant while under suspension. According to the orders contained in G.O. Ms. No. 211 (Personnel) and Administration) dated 27.2.1980 the disciplinary proceedings against a suspended Govt. Employee should be finalised within 3 months and normally the period of suspension should not exceed this limit. When the matter has been referred to the Director of Viglance and Anti-corruption, the period of suspension should not exceed 6 months.

## 4.3.2.2. Subsistence Allowance:

### a) Compulsory Deductions:

(1) Income Tax.

(2) House Rent and allied charges.

(3) Repayment of Loans and Advances taken from Govt. at such rates as the head of the department deems it right to fix.

### b) Optional Deductions:

These deductions should not be made without the written consent of the Government servant.

(1) Subscription to G.P.F.

(2) Amounts due to Co operative Stores and Co-operative Credit Societies.

(3) Refund of Advances taken from the G.P.F.

### c) Deductions that should not be made:

(1) Subscription to G.P.F.

(2) Amount due on court attachment.

(3) Recovery of loss to Govt.for which a Govt. servant is responsible. Subsistence Allowance is exempted from Court Attachment.

The procedure for imposing of any of the minor penalties referred to above is to give the delinquent Govt. servant a reasonable opportunity for making any representation that he may desire to make and take into consideration such representation before the order imposing the penalty is passed under Rule-17(a).

The procedure for imposing of any of the major penalties is prescribed in rule 17(b). In those cases, the ground on which it is proposed to take action shall be reduced to the form of a definite charge(s), which shall be communicated to the person charged together with a statement of allegations on which each charge is based. The accused Govt. Servant shall also be required with a reasonable time to put in a written statement of defence and to state whether he desires an oral enquiry or to be heard in person or both. Charge should be framed with great care because the success of any disciplinary case depends primarily on the soundness of the charges.

The following guide lines will be useful

(a) Each charge should be expressed in clear and precise terms it should not be vague.

(b) A separate charge be framed in respect of each allegation.

(c) Multiplication or splitting up of charges on the basis of same allegation should be avoided.

(d) The wording of the charges should not appear to be an expression of opinion as to the guilt of the accused.

(e) The charges should be definite and clear for example in an enquiry into alleged corruption or incompetence a single charge at a general nature such as corruption or Incompetence cannot be regarded as sufficiently precise.

A separate charge should be framed in respect of each instance of corruption or incompetence. The charges based on particular instances may however be combined with a General charge of corruption and incompetence.

The Govt. have issued instructions that it is desirable that no mention is made about the penalty in the charge memo issued under rule 17(b)(i) though mention of the penalty would not be itself (constitute an illegality in the procedure to vitiate the enquiry.

*The chrge memo* should contain the following:

Para (1) Preamble.

(2) The basis for the charge.

(3) List of statements and allegations against the accused officer

(4) The format of spoecific charge.

(5) Giving the accused officer reasonable opportunity of making a written statement of defence and if he wants an oral enquiry or desires to be heard in person or both.

(6) Enclosing the questionnaire form.

The charge sheet should be accompanied by a list of witnesses who are proposed to be examined during the oral enquiry in support of the charges. Copies of complaints made by the complainants and copies of statements taken from witnesses which form the basis of the charges should be furnished to him at the time of communication of the charge memo. A list of documents which are proposed to be produced in support of the charges should also accompany the charge sheet.

The charge memo should be delivered to the Govt. servant concerned together with the required enclosures in person or it may be sent to him by Registered Post with acknowledgement due or if such person is not found by delivering it at his last known place at duty or by giving it to an adult member of his family.

If none of the aforesaid means are available, it has to be served by affixing it in some conspicuous part of his last known place of duty.

The Government servant should be required to submit his reply to the charge memo by the date fixed. The form of questionnaire is to be resubmitted by him duly filled in. It should be carefully noted that furnishing along with the questionnaire form of the above charge memo cannot be a substitute for asking him specifically in the charge memo whether he desires an oral enquiry or to be heard in person or both and that the failure in this regard will initiate the proceedings. On receipt of the written statement of defence, the disciplinary authority should examine it carefully. If the disciplinary authority finds that any or all the charges have not been admitted by the Govt. servant in his written statement of defence, the disciplinary authority may itself enquire into such charges or appoint an Inquiry Authority to require into the truth of the charges which are not admitted by the delinquent officer. The Inquiry Authority has no power to compel attendance of witnesses and production of documents. The witnesses cited by the prosecution as well as by the defence may be requested by the Inquiry Authority to appear before him on the date, time and place mentioned in the notice of request. The Inquiry Authority may consider the relevancy of the witnesses cited by the accused before summoncing them. He may, for special and sufficient reasons to be recorded in writing, refuse to call a witness, failure to record, the reasons will vitiate the enquiry.

Before the regular hearings commence, the accused officer has to be allowed for preparing his defence, the inspection documents, relied upon by the prosecution in support of the charges. The accused officer is free to take extracts from the documents. Preosecution witness mentioned in the list of witnesses furnished to the accused Govt. servant have to be examined at the oral enquiry. Witnesses may be numbered as PW-1, PW 2 and so on. The right of the Govt. servant to cross examine a witness who has given evidence against him in a departmental proceeding is a safe guard implicit in the reasonable opportunity to be given to him under Article 311(2) of the constitution of India. Cross-examination in a departmental enquiry should as far as possible conform to the accepted principles of cross examination under the Indian Evidence Act.

Documentary evidence produced at the inquiry should be properly proved as in a court. The evidence should in all cases be recorded in the presence of the persons charged. As far as possible, cross examination should be done immediately after the examination in chief is over the officer charged is also entitled to give evidence in person. The evidence should be taken down in writing the irrelevant questions and answers shall be ruled out by the Inquiry Officer. The depositions are to be read over and signed by the persons concerned in token of their having been correctly recorded. If the departmental enquiry is conducted on the complaint at a private person or body the complainant should not be allowed to cross examine the officer charged but the complainant may suggest the question to the Inquiry Officer to be put to the witnesses produced in defence of the officer charged or the Inquiry Officer may in his discretion permit the complainant himself to cross examine the said witness.

After the completion of the production of evidence on both sides, the Inquiry Officer will ask the accused Govt. servant to put in any further statement of his defence, if he so desires.

After having heard and recorded, the whole or part of the evidence if there is a change of Inquiry Officer for any reason, the new officer appointed as Inquiry officer may proceed with the enquiry from the stage left by the predecessor. If however, the new Inquiry Officer is of the opinion that a further fresh examination of any witness whose evidence has already been recorded, is necessary in the interest of justice, he may recall such witness for examination.

If the accused Govt. servant to whom charge memo has been delivered does not submit the written statement of defence on or before a date specified for the purpose or does not appear in person before the Inquiry Officer or otherwise fails or refused to comply with the provisions of the classification, Control and Appeal Rules, the Inquiry Officer may hold the enquiry exparty. In exparty proceedings also, the entire quantum of the enquiry has to be gone through.

The officer holding the enquiry should record his findings on each charge separately after carefully considering the evidence adduced in support of it as well as that for the defence.

It is left open to the Enquiry Officer to make recommendations in cases taken up by him. In case where he is directed to hold the enquiry, it is left open to the officer ordering the enquiry to direct the Enquiry Officer to make recommendations or not as he desires fit.

The report of the Inquiry Officer should contain among other things his findings on each article of charge.

The findings and recommendations of the Inquiry Officer are advisory in character and are not binding on the disciplinary authority who can disagree with them and come to his own assessment of the evidence forming part of the record of enquiry.

The disciplinary authority will examine the report and record of enquiry carefully and dispossionately and after justifying himself that the Govt. servant has been given a reasonable opportunity to defind himself will record his findings in respect of each charge, say whether in his opinion stands, proved or not. If the disciplinary authority disagrees with the findings of the Inquiry Officer, or any charge, the reasons for such disagreement shall be recorded. Having regard to his own findings on the charges, if the disciplinary authority is of the opinion that any of the minor penalties may be imposed on the Govt.

servant, such a minor penalty can be imposed on the Govt. servant, such a minor penalty can be imposed on the Govt. servant straight away by furnishing a copy of the report of the Inquiry Officer without issuing a second show cause notice.

In the case of imposition of Major Penalties, the competent authority will have to arrive at a provisional conclusion having regard to the penalty to be imposed. The accused Govt. servant shall then be supplied with the copies of the full report of the inquiry authority and the calling upon to show cause within a reasonable time not oridinarily exceeding one month against the imposition of the particular penalty proposed to be inflicted.

The Accused Govt. servant is entitled to make a representation in reply to the show cause notice on the merits of the case and on the quantum of punishment proposed or he may point out procedural lacunae and defects in the inquiry. The Govt. servant concerned must confine his representation to the evidence produced during the enquiry. No new evidence, documentary or oral can be permitted to be produced.

The person charged shall be heard in person at any stage if he so desires before passing a final order.

When a person charged demands a personal hearing, after the issue of a show cause notice he may be given a personel hearing provided no such hearing was given in the first, instance and the facts brought out in the personal hearing and the representation to the show cause notice may be considered together and final orders passed without any need for issuing a fresh show cause notice after such personal hearing. The orders of the competent authority imposing the penalty should shown that various aspects of the findings which are dealt with by the accused Officer in his representation are considered and it is the duty of the punishing authority to examine the findings and satisfy himself that the finding does prove the guilt of the accused. It is obligatory on the part of the authority concerned to consider the further representations after the issue of show cauce notice in all its aspects before confirming the provisional conclusion. It is open to the authority to impose a lesser penalty than the one proposed in the show cause notice no material of which the Govt. servant was not given prior notice and he was not given adequate opportunity of rebutting or defending himself against should be taken into account for deciding the quantum of punishment to be awarded. The final order should be a speaking order and should be signed by the disciplinary authority competent to impose the penalty. The order must be communicated to the persons charged and communication of the order is complate as soon as an order is issued and sent out to the Government servant concerned, no matter when he actually received it.

## 4.4. Miscellaneous

### 4.4.1. Service Register:

A record of the service of Govt. servant should be maintained in accordance with the rules framed by the govt. under Fundamental Rules. A service book in F.R. Form No. 10. should be opened at his own cost as soon as he is selected for admission to a Govt. service and is on probation for that service. This will be kept in the custody of the Head of office in which he may be serving. All entries should be made and attested by the Head of office. It will be sent from Office to office on transfer.

It is the duty of every Govt. servant to see that his service book is properly maintained and that all entries in it are attested.

The following particulars of a Govt. servant's official life would be regularly and consecuently recorded in the service register. Such entry should be verified with reference to departmental orders, pay bills and leave statements. Each entry should be made by the Head of office.

(1) Temporary and officiating promotion of all kinds.

(2) The date of commencement of probation and the date on which the period of probation is satisfactorily completed.

(3) Increment and refixation of Pay and allowances.

(4) Transfers, date of relief, date of joining etc.

(5) Leave or absence taken.

(6) Special Tests.

The date of birth should be duly verified and certificate of verification should be recorded in the Service registers.

The Service Registers are to be verified annually (in January) and a certificate should be recorded.

The officers inspecting subordinate offices, inspect the service books maintained and see that they are maintained properly as per rules and upto date.

A quinquonnial verification should be done and the entries attested once in five years.

Common mistakes found in the service registers due to their not being properly checked are:

1. Date of birth not verified, date of birth not written in words, date of birth altered and not regularised.
2. Qualification not recorded correctly or falsely recorded.
3. Leave account not written up and mistakenly by worked out.
4. Nominations for G.P.F. F.B.F., D.C.R. Gratuity etc. not properly signed by the Government servant and attested by a Gazetted officer.

A questionnaire should be pasted in rear of the front cover indicating all checks for the proper maintenance of the Service Registers. Every Govt. servant should see in his own interest that his service register is maintained regularly and properly and is available always.

The Government servants are bound by Govt. servant conduct rules, Fundamental rules, the Madras Civil Services (Classification Control Appeal) rules and pension code with reference to the service conditions.

## 4.4.2. Government Servants Conduct Rules (1973)

These rules are very important as any violation of these rules is likely to lead to very serious consequences with regard to continuing and holding the post in Govt. service. These rules are therefore to be observed and followed very strictly by every Govt. servant. These rules contain 22 rules annexures and forms and set out norms for the behaviour of a Govt. servant in respect of the following items.

(1) Gifts, (2) Public Demonstrations in honour of Govt. servants, (3) Subscriptions, (4) Investments, lending & borrowing, (5) Acquisition of movable and immovable property, (6) Private trade and employment, (7) Taking part in politics and elections, (8) Integrity and devotion to duty, (9) Consumption of intoxicating drinks and drugs, (10) States and demonstrations and the like.

According to these rules every Govt. Servant is required to submit annual terms movable and immovable properties and returns of assets and liabilities once in five years.

To introduce you to the fundamental of the rules a brief note on the important rules are given below.

### 4.4.2.1. Gifts:

No Govt. servant shall except with the previous sanction of the Govt. accept or permit his wife or any member of his family to accept from any person any gift. Definition for the various sorts of gifts are specified in the rule.

### 4.4.2.2. Public demonstration in honour of Government Servants:

No Govt. servant shall, except with the previous sanction of the Government, receive any complimentary or valedictory address or accept any testimonial or attend any meeting or entertainment held in his honour.

### 4.4.2.3. Subscription:

No Govt. servant shall except with the prior permission of the Govt. ask for or accept contribution to or otherwise associate himself with the raising of any fund or other collections in cash or in kind in pursuance of any object.

### 4.4.3.4. Investments, lending and borrowing:

No Government servant shall except after notice to the prescribed authority, acquire or dispose of any immovable property by lease, mortgage, purchase, sale gift, exchange or otherwise either in his own name or in the name of any member of his family.

### 4.4.3.5. Private trade or employment:

No Government servant shall, except with the previous sanction of Government engage himself directly or indirectly in any trade or business or undertake any employment.

### 4.4.3.7. Insolvency and babitual indebtedness:

A Government servant shall endeavour to avoid habitual indebtedness or insolvency.

### 4.4.3.8. Unauthorised communications of information:

No Govt. servant shall except with the previous sanction of the Govt. communicate directly or indirectly any official document or any part thereof or information to any Govt. servant or any other person to whom be is not authorised to communicate such documents or information.

### 4.4.3.9. Sanction with press and Radio:

No Govt. Servant shall except with the previous sanction of the Government. own wholly or in part of conduct or participate in the editing or managing of any newspaper or other periodical publication.

### 4.4.3.10. Criticism of Government

No Govt. servant in any radio broadcast or any document published anonymously or in his own name or in the name of any other person or in any communication to the Press or in any public utterance, make any statement of fact or opinion which has the effect of an adverse criticism of any current or recent policy or action of the Central or State Government.

### 4.4.3.11. Evidence before Committee:

No Govt. servant shall, except with the previous sanction of the Govt. give evidence in connection with any enquiry conducted by any person, committee or authority.

### 4.4.3.12. Taking part in politics and election:

No Government servant shall be a member of or a otherwise associated with any political party or any organisation which takes part in politics nor shall be takes part in subscribe in aid of, or assist in any other manner, any political movement or activity.

### 4.4.3.13. Violation of Acts and Character of Govt. Servants:

No Govt. servant, shall except with the sanction of Govt. have recourse to press for the indication of any official act which has been the subject matter of adverse criticism or an attach of defamatory character.

### 4.4.3.14. Employment under or with near relatives in service and employment of near relatives in firm employing Govt. patronage.

Every member of State Service shall inform his immediate official superior if a member of State closely related to him is posted to work under him.

### 4.4.3.15. Canvassing of Non-official or Other outside influence.

No Govt. servant shall bring or attempt to bring any political or other outside influence to bear upon any superior authority to further his interest in respect of matters pertaining to his services under the Government.

### 4.4.3.16. Bigamous Marriages:

No Govt. servant who has a wife living shall contract another marriage without first obtaining the permission of Government.

### 4.4.3.17. Integrity and devotion of duty:

Every member of service shall at all times maintain absolute integrity and devotion to duty and shall to nothing which is unbecoming of a member of service.

### 4.4.3.18. Consumption of intoxicating Drinks and Drugs

A Government Servant shall strictly abide by any law, relating to intoxicating drinks or drugs inforce in any area which he may happens to be for the time-being.

### 4.4.3.19 Divisional

### Article 3 11(2) of the Constitution of India, lays down as follows:

"No such person (who is a member of Civil Service) shall be dismissed or removed or reduced in rang except after an enquiry in which he has been informed of the charges against him and given a reasonable opportunity of being heard in respect of those charges and where it is proposed after such enquiry, to impose on him any such penalty, until he has been given a reasonable opportunity of making representations on the penalty proposed, but only there basis of the evidence adduced during such enquiry"

The elaborate procedure to be adopted to meet with the above requirements, rules regarding appeals etc. are given in these rules.

### 4.4.3.20. Confidential Reports:

The confidential reports on work and conduct of subordinates are written by officers periodically i.e. Half Yearly or Yearly in respect of Gazetted Officers and Non-Gazetted Officers who are to be promoted to Gazetted Posts. This report is important one for a subordinate to get his completion of probation and also promotion to next higher post. ■

# V. ASSOCIATION INFORMATIONS

## 5.1 CONSTITUTION OF TNEA.

### 5.1.1. Title

The Title of the Association shall be "TAMILNADU ENGINEERING ASSOCIATION, P.W.D., MADRAS-5"

### 5.1.2. Head Quarters

The Headquarters for this association shall be "MADRAS"

### 5.1.3. Recognition

This Association was established in 1910 and recognised in G.O.Ms. No. 822 Public(s) Dept. dated 27-9-1928, Vide Appendix I.

### 5.1.4. Objects

The objects of this association shall be as follows:—

a) To render efficient service to the Nation and participate in building up a Socialistic Society.

b) To safeguard and promote the interests and rights of members of the association and to get redressal of their grievances.

c) To elevate the Engineering profession and to raise the standard of the profession.

d) To promote social, educational, economical, moral and cultural uplift of members as well as Nation.

e) To putforth an economic solution in the implementation of Schemes.

f) To provide further education for members on Engineering.

g) To conduct journals for the uplift of Technical and General-knowledge of members.

h) To strive for solving unemployed and under-employed problem of Engineering personnel.

i) To get affiliated with any of the like-minded Association in this nation.

### 5.1.5. Definitions

*"Member"* means the person who have been qualified and enrolled by paying the annual subscription to any of the branches in Tamilnadu in a year.

*"Associate member"* means the person who have been fully qualified to hold the post of "Members" and are under-employed for want of vacancy but enrolled by paying the subscription to any one of the branches in Tamilnadu in a year.

*"Honorary Member"* means a retired member on superannuation who was requested by this association to continue his activities for this association. No enrolment fee is necessary for such of those members.

*"Life Members"* means persons who paid the subscription covering the life time of the mêmber as per subscription fixed from time to time.

*"Association"* means the central unit of this association having jurisdiction of entire Tamilnadu with its headquarters at Madras.

*"Branch-Association"* means the sub-unit of the Association having defined jurisdiction as authorised by this association.

*"Year"* means normally the calender year beginning with January to December.

*"B.G.C."* means Branch Governing Council comprising of Branch office bearers and Branch working committee members.

*"BWC member"* means the elected member at the rate of one per every ten member.

*"B.G.B."* means the General-body of the branch association consisting of all the members in the rolls of respective branch.

*"GC"* means the General Council of the association comprising of Central Office bearers and branch office bearers.

*"CEC"* means the Central Executive Committee comprising of Central Office bearers, branch secretaries and One Central Executive Committee member from all the branches.

*"CC"* means the Central Cabinet of the association comprising of all the Central Office bearers.

## 5.1.6. Structure of the Association

### 5.1.6.1 Branch Unit:

"Branch Cabinet" consists of the following office bearers elected by the Branch General-body once in a year.

| | |
|---|---|
| Chairman | 1 |
| Vice-Chairman | 1 |
| Branch-Secretary | 1 |
| Joint-Secretary | 2 |
| Treasurer cum CEC Member | 1 |
| Total | 6 Nos. |

In addition, Branch working committee members at the rate of not less than one for every ten members in the branch are also to be elected. While fixing the No. of B.W.C. members the No. is to be arrived by rounding off to the next higher even number. Branch Cabinet and Branch working committee members constitute the "Branch Governing Council"

The Term for the office bearers so elected by the Brânch General Body will be one year from the date of election

**5.1.6.2 Central Unit:**

"Central Cabinet" consists of the following office bearers elected by the "General Council" of this association.

| | |
|---|---|
| President | 1 |
| Vice-President | 1 |
| General Secretary | 1 |
| Secretary-Organisation | 1 |
| Secretary-Publication | 1 |
| Secretary-Finance | 1 |
| Secretary-Legal | 1 |
| Secretary-Head Quarters | 1 |
| Secretary-Pongum Nidhi | 1 |
| Zonal Secretary North | 1 |
| Zonal Secretary South | 1 |
| Zonal Secretary East | 1 |
| Zonal Secretary West | 1 |
| Total | 13. |

The General Council consists of Central Office bearers and Branch Cabinet members. The election is to be preferably conducted in a central place of Tamilnadu (viz). Tiruchy to have a fairly uniform expenditure to all the branches. The "Central Executive Committee" constitutes of Central Cabinet with Branch Secretaries and one C.E.C. Member from every branch besides the members of the previous Cabinet who have not elected in the succeeding election.

The Term of Central Cabinet, General Council and Central Executive Committee shall be one year from the date of election.

## 5.1.7 Relation between Central / Branch Units

All the Branches in Tamil Nadu will be under the overall control of Central Unit. Any issue affecting the interests of the members purely within the respective branch jurisdiction shall be dealt with by the Branch Unit directly as it decides. But on all issues of common nature, proposals are to be sent to the Central Unit as and when felt by the Branch Unit. Central Unit in turn will review the matter in detail and can deal directly or issue directive to Branches.

Any resolution passed in Central Unit has to be adhered to by all the Branches.

## 5.1.8. Functions of various structures

### 5.1.8.1. Branch Genral Body:

**General:** Branch General body comprising of every member in the rolls of respective Branch or any other branches members, transferred on duty to one of the places having jurisdication to the branch recently. The membership-certificate issued on payment of subscription fees is to be brought by the respective member during General body meeting. In case of dispute the member unable to produce the Membership certificate to the General-body shall not be allowed to avail voting power. Branch General body shall be convened not less than twice a year on February and August. The quorum shall be 15 members or 50% of total members whichever is less. Members' incidental charges are to be borne by themselves. The branch shall incur expenditure for light refreshments served during meeting hours subject to the availability of funds. Meeting shall be convened by Branch Secretary with 15 days time notice atleast.

**Function:** The activities of Branch General Body shall be as follows:—

i) To discuss and pass resolutions on any object of this association.
ii) To run Technical clubs for improving the technical knowledge of members.
iii) To consider and admit the audited accounts.
iv) To elect Branch Governing Council members.
v) To raise funds for the benefit of association.
vi) To donate any amount from its funds to official organisation directly.

### 5.1.8.2 Branch Governing Council:

**General:** Branch Governing Council constitutes of all elected Branch Cabinet members and Branch working Committee Members. This meeting shall generally be convened by the Branch Secretary before the conduct of Central Executive Committee with a notice of 7 days time. The quorum shall be 60% of the total members. All the incidental and travelling charges for these meetings shall be borned from the Branch funds if branch desires.

**Functions:** The Activities of the BGC shall be as follows:

i) To discuss and pass resolutions on the subject included in "Agenda" for the ensuing CEC.
ii) To give directives to Branch Secretary and CEC Member in respect of Branch association's stand.

iii) To include any other subject for the CEC.

iv) To putforth any practical difficulties in settling the arrears due to association and to find out a solution.

v) To bring to the notice of any anti-association propaganda or mis-propaganda by anymember in its jurisdication for proposing disciplinary action.

vi) To donate any amount from its funds to official organisations directly.

**5.1.8.3 Branch Cabinet:**

**Functions:** The following activities of the BC shall be as follows:—

i) To represent in person and explain the grievance to the local official on the issues by BGC and BGB.

ii) To effectively organise the branch day by day and to try to enroll all the qualified members of their branch.

iii) To inform the Central Cabinet members regarding the views under consideration.

iv) To evaluate a solution for clearance of arrear funds from members.

v) To meet the Hon. Minister and authorities concerned while on camp in their jurisdiction for presenting copies of memoranda drafted from Central Unit and to explain in detail, wherever time is permitted.

vi) To keep informed on the major demands in details such of those to be passed by legislature to the local M.L.A.'s and M.L.C.'s and its development then and there.

**5.1.8.4. General Council:**

**General:** General Council consists of all the Central Cabinet and Branch Cabinet members. The quorum for all its meetings shall be 60% of its full strength. General Council shall be convened not less than once in a year during August-September. The expenditure for the branch office bearers for their journey to be borne by the respective branches in full and in case by Central Office bearers, by the Central Unit in full. The meeting shall be convened by the President in the Centre of State preferably at Tiruchy with a notice of not less than 15 days time. All branches to remit 100/- to the Host branch arranging the General Council. In addition, the Central Unit will pay Rs.500/- for the above purpose.

General Council shall be convened by the President more than once a year when atleast 60% of the branches write to Central Unit or when the president feels necessary in the interest of the assocaition activities.

**Functions:** The activities of the General Council shall be as follows:

i) To discuss and decide any issue as a Supreme body of this association.

ii) To elect the Central Office bearers.

iii) To control the funds of this association.

iv) The General Council is empowered to pass no confidence motion on Central Office bearers by a majority of not less than 2/3 of members.

### 5.1.8.5 Central Executive Committee:

**General:** Central Executive Committee consists of all Central Office bearers, Branch Secretaries and one CEC member from each Branch besides the ex-office bearers of the previous set up. CEC to be convened atleast once in 3 months by rotation at each Branch headquarters or in places as decided by the Branch concerned, by General Secretary with a notice of not less than 15 days time. The quorum shall be 67% of its member.

The expenditure towards to Convening of the meeting shall be met with by remitting Rs.75/- by all branches. In addition Rs.300/- to be paid by the Central Unit.

CEC shall be convened by the General Secretary when atleast 67% of the branches write so to the General Secretary or when the president feels necessary.

**Functions:** The activities of the CEC shall be as follows:

i) To discuss and pass any resolution on any of the subjects in the interest of association.

ii) To suggest various proposals for the effective and economical administrative in P.W.D.

iii) To nominate sub-committees on defined subjects and to fix up their jurisdiction.

iv) To raise funds and to fix up targets to branches.

v) To reappropriate the funds alloted under each head.

vi) To consider and pass on the audited annual accounts.

**Powers:**

i) The CEC has to authorise for filing 'Suits in any Court on the issues affecting the interests of atleast 10 members after obtaining the legal opinions.

ii) To affiliate with other Engineering association in this nation having similar objects provided that this association is governed by its own constitution in respect of the activities affecting the members.

iii) To donate funds to any official organisation in the interest common cause in cases of cyclone, flood, famine and other natural calamities.

iv) To amend the constitution endorsed by not less than 67% of the members attend the meeting.

v) To fill up the vacancy in CC till next GC.

## 5.1.8.6 Central Cabinet:

**General:** Central Cabinet consists of all the Central Office bearers. The quorum shall be eight members including three member from moffusal. Central Cabinet shall be convened by the General Secretary once in a month preferably at Madras. Incidental and travelling charges to members shall be borne by the Central Unit in full.

**Functions:** The activities of the Central Cabinet shall be as follows:

i) To discuss and decide the mode of follow up action on the lines of resolutions passed in CEC.

ii) To meet and discuss with authorities concerned on the affairs in consideration.

iii) To devote any timely consideration on any emergent issues affecting the interests of this association.

iv) To meet the Honourable Ministers concerned in delegation for explaining the demands in person.

v) To nominate Honorary members of this association.

## 5.1.9. Membership:

a) All the Government servants employed under the Tamil Nadu Engineering Services and Tamil Nadu Engineering Subordinate Services are qualified to be "Members" of the association.

b) Persons qualified to enter in service in any of the above two services but are under employed in P.W.D. for want of vacancy are permitted to be "Associate Members" of the association.

c) Persons retired from any one of the above two services and who had been requested by the Central Unit to be "Honorary Member" of this association.

d) All the members should abide by the 'Code for members'.

## 5.1.10 Subscription from Members:

a) The annual-subscription means the subscription for one calender year. The annual subscription for membership will be Rs.50/- per annum, payable in one instalment before the end of January in the respective year.

b) Membership fee at the above rates shall be collected from 'Members' and 'Associate Members'. No fee will be collected from Hony. members. But donations will be accepted.

c) The annual subscription from members who joined in service in middle of the year shall be collected within two months period from the date of joining duty in the middle of the year.

d) The member of the preceeding year shall be member in succeeding year till the due dates fixed above.

e) Membership from any branch will be transferable to any other branches consequent of transfer on duty. In such cases it shall be the duty of member concerned to inform both the branches and Central unit quoting old and new address with the Membership No. assigned to every individual.

## 5.1.11. Allocation of Subscription Fee:

The allocation of subscription fee collected shall be made as decided from time to time.

## 5.1.12. Privilages to Members:

a) All the members will be allowed to avail the benefits obtained, subscribe articles to journals, to express their views freely and frankly in the appropriate meetings or to correspond through the branch concerned. However common issues on the interest of not less than 5 members of the association shall alone be considered in addition to the objects of this association.

b) A copy of monthly journal shall be sent to every member directly by post regularly till the membership continues.

c) Full pledged members shall be allowed to vote in the Branch general body meetings.

## 5.1.13. Release of Diary:

a) For this purpose a 'Diary Committee', of 5 members be nominated by the CEC every year by the month of July. The 'Central Cabinet' members shall be the Ex-officio members to this Sub Committee. This Committee is fully empowered for fixing tariff to advertisements, compilation of diary collection of advertisements directly through branches, Selection of Printers, Proof correction and for the release of 'Diary' before 15th December of that year.

b) The 'Diary-fund' shall be transacted by the Central Unit under the control of Diary Committee. Any drawal shall be regulated on written requesition from the Diary-Committee Chariman.

## 5.1.14. Resignation:

a) Resignation of membership shall be considered and accepted by the concerned Branch General body if there is no loss to association on the grounds furnished by members in writing to the Branch-Secretary.

b) Resignation of any Central Office bearers shall be addressed by member concerned to President in writing. The grounds shall be considered in CEC meeting and can be accepted if there is no loss to the association.

c) In cases of any charges which cannot be ratified a legal proceedings is to be taken on the concerned, by Branch general body or CEC on cases of Branch and Central respectively.

d) Vacancy caused so shall be filled by the respective BGC or CEC as the case may be.

## 5.1.15 Suspension of Members:

Any number of the association shall be first served with a show cause-notice by the President or Chairman stating why not the member be suspended on finding fault either one of the following grounds or any other ground as decided by BGC or CEC as the case may be:

a) Anti-association movements.
b) Disobediense on the "Code for Members".
c) Evasion for the remittance of funds collected on behalf of association.
d) Misappropriation of machinery for personal benefits.
e) Misuse of association machinery.
f) Non-cooperative in association movements.
g) Dismissal from service on reasons where there is no chance for any appeal in court of law.

A time limit of 10 days shall be allowed for offering concerned member's reply. Failing which, or on unjustifiable reply the BGC or CEC is empowered to suspend the member either temporarily or permanently in cases of Branch and Central respectively.

## 5.1.16. Duties of Office Bearers

The following shall be the duties and lookouts of the respective members.

### 5.1.16.1 Central Unit

**a) President:**

i) To have overall Control on central unit and all the branches of the association.

ii) To convene emergent meetings of CC, CEC and GC over looking the normal notice to members considering the depth of issues.

iii) To convene emergent meetings of CC CEC and GC over looking the normal notice to members considering the depth of issues.

iv) To watch closely the interest of all sections of service.

**b) Vice-President:**

To perform the duties of President in the event of absence.

**c) General Secretary**

i) To represent, explain and discuss with authorities and Hon'ble Ministers concerned on the stand of this association.

ii) To convene GC and CEC meetings.

iii) To operate in the joint account of this association.

iv) To scrutinise the justification of bills received and to pass them before payment.

v) To engage the services of a part-time or full time clerk and office-boy to assist in his work considering the funds available.

vi) To issue "Press-releases" on the lines of resolutions passed in GC, CEC and CC meetings.

vii) To participate in other like minded association's meetings for gathering support as to express the association stand and activities etc.

viii) To obtain legal opinion on such of the issues, the GC decides.

ix) To present an annual Budget in the CEC by February of evry year.

x) To incur expenditure on purchase of articles in the interest of upkeep of association office. Such of those items cannot be met with from the funds available, a specific approval of CEC shall be obtained.

d) **Secretary-Organisation**

i) To effectively organise, to build up the association day by day.

ii) To perform the duties of General-Secretary in his absence.

The following records are to be maintained.

1) Membership Register
2) Minutes book
3) Register of Resolutions
4) Register of activities
5) History book

iii) To communicate the minutes of GC, CEC, and GC meetings within a week's time.

iv) To correspond with the branches on the activities in move.

e) **Secretary-Publication:**

i) To be the Editor and Publisher of the monthly journal "Poriyiyal Kadir".

ii) To select and publish articles strictly on the lines of decisions taken by the association.

f) **Secretary-Finance:**

i) To receive and acknowledge by issuing necessary printed receipts for the sums received due to this association and to remit all such collections then and there into Joint-Account in favour of TNEA, PWD., Madras-5" in one of the Nationalised Banks.

ii) To disburse on all the claims with proper acknowledgement and preserve them under his custody.

iii) To maintain the following Registers:

1) Cash Book 2) General Ledger 3) Register of Receipt Books.

iv) To prepare receipt and charges statement twice in a year (viz) to end of March and July.

v) To close the cash book at the end of every month and should be got reviewed by the CC.

vi) To keep a cash balance of Rs.1000/- for meeting out incidental charges then and there. Transactions more than Rs.100/- shall be issued by cheque wherever possible.

vii) To admit and reimburse the permanent imprest at Rs.200/- to all Central Cabinet member.

g. **Secretary-Legal:**

i) To obtain the legal opinion on such of issues, the GC decides.
ii) To follow up the legal activities of the association.
iii) To effectively organise the collection of legal fund and to maintain a separate ledgers showing the details of legal fund received from the individual members branch wise and legal expenses incurred upto date.

h. **Secretary-Head quarters:**

i) To be incharge of the office functioning, administration and its upkeep.
ii) To be incharge of all the movable and immovable properties of the association.
iii) To look after the personal grievences received from the members through the concerned branches.
iv) To effectively watch the Quarterly meetings convened by the Superintending Engineers.
v) To maintain the following records:
   1. Register of Tools & Plants.
   2. Register of immovable properties.
   3. Register of Library books.
   4. Register of Telephone calls.

i. **Secretary-Ponkum Nidhi:**

i) To be incharge of the Ponkum Nidhi transaction as per Ponkum Nidhi Rules.
ii) To maintain all the related records, cash book of Ponkum Nidhi.
iii) To effectively watch on the Ponkum Nidhi functioning.

**5.1.16.2 Branch Office Bearers:**

a) Chairman

i) To function as a leader of the Branch.
ii) To preside all the General body, informal, working Committee and Branch Cabinet meetings.
iii) To issue press-release on respective Branch unit activities.
iv) To represent and explain the authorities incharge within the branch jurisdication on the association demands.

b) **Vice-Chairman:**

i) To assist the Chairman to render his duties on all the activities.

ii) To perform all the duties of Chairman on his absence.

iii) To guide the Branch Office bearers.

c) **Branch-Secretary:**

i) To be incharge of the respective branch in all its activities.

ii) To communicate the minutes of all the meetings to Central Unit and Branch members within a week time.

iii) To convene BGB Informal, BWC meetings etc. considering the necessity and circumstances prevailing.

iv) To represent the views of Branch members in CEC Meetings.

v) To enroll members.

vi) To have a control of all receipts of "TNEA, PWD Branch" is to be maintained in any one of the Nationalised Banks.

vii) To close the Receipts and charges account at the end of March and July of every year and to present the same to the ensuing BGB, BWC, CEC meetings.

viii) To represent and explain the authorities in charge within the respective Branch jurisdiction for the redressal of grievances on the lines of the association's stand.

ix) To maintain the following records and to keep custody of them.

1. Membership Register
2. Minutes Book
3. Register of Resolutions passed
4. Register of articles and Books
5. Stock file
6. Correspondence files
7. Despatch Register
8. Stamp account

x) To administrate a small office and to keep custody of all the belongings to the association with the assitance of members in head quarters and if necessary with a part-time employee, subject to the availability of funds.

d) **Joint Secretaries:**

i) To assist the Secretary for rendering his duties.

ii) To perform all the duties of Branch Secretary in his absence by the Joint Secretary nearer to the Branch Head Quarters.

iii) To mobilise and strengthen the Branch Association by explaining the activities of this association then and there to members by allocating the Branch jurisdiction among both the joint Secretaries.

**e) Branch-Treasurer-cum-CEC Member:**

i) To receive and acknowledge by issuing necessary printed receipts for the amount due to association.

ii) To disburse on all the claims for the claims made to the association.

iii) To have a cash balance of Rs.100/- for such incidental expenses and any amount than that shall be paid by cheques wherever possible.

iv) To maintain the following registers.

1. Cash book
2. General Ledger
3. Register of Receipt books

v) To keep custody of all the records on every transaction in the respective branch.

vi) To prepare Receipts and Charges statement twice in a year (viz) March and July and to present them in the ensuing BGB, BGC & CEC.

vii) To reimburse a permanent imprest of Rs.50/- with the Branch Secretary for petty expenses.

viii) To be liason member between branch and central unit by representing the Branch Members views in CEC Meetings and to explain the discussions taken in CEC to the Branch meeting.

ix) To be representative of Central unit in the Branch for the collection of arrear funds, subscription fees to the Central Unit.

x) To accelerate the movement of members by explaining the causes for success, evasion and failure on the association activities.

## 5.1.17. Upkeep of Accounts

### 5.1.17.1 Central:

All the receipts and charges shall be credited and debited respectively to the Joint account in favour of 'TNEA, PWD, Madras-5' in one of the Nationalised Banks. The Secretary Finance to maintain the cash book and general ledger. The funds under various heads (viz) members subscription, Diary-funds, Poriyiyal Kadhir, Building fund etc. shall be detailed in the general ledger which shall be a ready reference. The Chairman of any sub committee nominated shall have powers to draw on request in wirting.

### 5.1.17.2 Branch:

Similar to Central Unit a joint account in favour of 'TNEA, PWD ........ Branch' shall be operated in the branch of the bank so that 'Mail transfer system can be adopted with least expenses to branch association. The other rules govern Central Unit shall hold good to Branches also.

## 5.1.18. Audit of Accounts

An audit committee of 3 members including a Chairman shall be elected in the General Council or General body as the case may be of Central or Branch unit once in a year.

## 5.1.19. Formation of Sub-committees

The CEC is empowered to nominate any sub-committee on defined subject, jurisdiction, time limit, persons in the interest of a clear concentration to carry out the association activities. In all such committees, the central cabinet shall be ex-officio body to guide in appropriate time.

## 5.1.20 Publication of Monthly Journal

*'Poriyiyal Kadir'* shall be the monthly journal to all members for enlightening the development of various activities of this association and like minded association. It shall be despatched to all members directly by post every month. All members shall avail the previlege of contributing articles to this journal and they are to be sent to the 'Secretary-Publication-cum Editor'

## 5.1.21 Code for Membrs

The code for members shall be as in Appendix II.

## 5.1.22 Conduct of Meetings

The code for Conduct of meetings shall be as in Appendix III.

## 5.1.23 Conduct of Elections

The rules governing the conduct of elections shall be in Appendix IV.

## 5.1.24 Term for Office Bearers

It shall be normally one year from the date of election and shall be continued till next elections are conducted.

## 5.1.25 Interpretation

In case of interpretation in this constitution the decision of CEC shall be final.

## 5.1.26 Amendment

The CEC is empowered to amend this constitution on endorsing by 67% of the members attend the meeting.

## Appendix I

Copy of G.O.Ms. No: 822, Public (Services) Department dated 27.9.1928.

SUB : Service Associations – Madras Engineering Association – Recognised

Read :

1. From the Secretary and Treasurer,
   Madras Engineering Association,
   Madras Letter dated 12-6-1928.

2. From the Chief Engineer (General, Buildings and Roads),
   Letter No. 1469-Ad/28-1 dated 18-7-1928.

Order :—

The Government hereby accord official recognition to the Madras Engineering Association, Madras subject to the Rules appended to G.O. No. 1772, Public, dated 9th November 1921 and to any rules which may hereafter be brought into force in respect of such associations of Government servants.

The recognition of Government is subject to the condition that the Association shall not include non-officials as members.

Sd/ ......................................

Chief Secretary to Government

**Appendix No. II : "Code for Members"**

All the members of this association should be

— honest in rendering duties.

— decent in activities.

— judicious in raising demands.

— efficient and able Investigator, Designer, Executer Controller, Organisor and Observer and be co-operative with the Nation Builders (viz.) Engineers.

'Oath of confidence' from all the members shall be taken in the commencement of meeting once in a year, as below:

These codes shall be read out by the Chairman/President in respective meetings of the various structures by including *'I will be'* in the beginning of every code and shall be repeated by all other members.

**Appendix No. III : "Code for conduct of meetings"**

1. The agenda for respective meeting should be sent to the respective members direct in accordance with the time limits stipulated. The members should handover their resolution proposed in duplicate to the General Secretary or Branch Secretary as the case may be before the commencement of meetings. Another copy may be circulated among other members for their discussion before starting the meeting and out of meeting hours. As per Agenda, the matters may be taken up for discussion. If any new resolution is to be made at the time of meeting, then the same is to be neatly written and to be handed over to the President in Chair.

2. The minutes of the last respective meeting should be readout first and action taken by the respective office bearers on the resolutions passed should be explained at the commencement of meeting.

3. When any member is unable to attend the meeting due to some unavoidable circumstances, the respective members should give an authorisation for another member of this Association by writing a letter to the President and General Secretary. Then only the authorised member can be allowed to represent in the meeting. If no authorisation was produced, the non-members can be permitted to be an observer of the meeting, but no voting chance be given. This will surely minimise the frustrations, unwanted discussion, unnecessary displeasure and mainly it will save the precious time of everybody.

4. During discussion any member, who want to express his views get up and obtain the permission of President in Chair. Nobody should be allowed to interrupt another member views before the first member concludes his views. The members can take a note of others and should be allowed to express their views in their turn.

5. The observers should be alloted separate seats.
6. The elected members of either branches or Central Unit unable to attend the respective meetings should mention the reason for his absence. Such office bearers absent for 2 meetings consequently, should express their regret in writing and a note is to be recorded in the minutes.
7. In case of differece of opinions, the majority members view shall be final, which shall be known by voting.
8. As soon as a ruling was passed by the President-in-Chair the matter is deemed to have been concluded and there should not be any further discussion. This will promote some better sense of regard to our association's leaderhsip.
9. Whenever a special invitee is invited to any meeting an announcement is to be made by the President at the outset of the meeting.
10. All the meetings should end with National Anthem.

**Appendix No. IV: "Election of office bearers".**

a) BRANCH :

The branch general body to be convened once in every year in July shall elect the branch office bearers for one year time from the date of election. All the members of this association, who have paid the minimum amounts fixed then and there in various heads, qualifies for contest in this election: 'Associate members' and 'Honorary Members' are not qualified for contest, though they are also empowered for voting. In case of contest the majority votes of members attend the meeting shall be final. Members can be selected in absentia provided the proposer produce the consent letter from the persons who is proposed for officerbearer. In case of equal number of voting in contest the result of a lot shall be the final.

b) CENTRAL :

The GC to be convened by the General Secretary with 15 days time at the Centre of Tamil Nadu during August - September of every year shall elect the Central Office Bearers Any 'member' as defined under clause (5.1.9(a) of this constitution is eligible for contest in the election provided they are ready to work in the association head quarters during his term of office bearer. Last date for receipt of nominations can be fixed 10 days earlier to the GC meeting and to be published in the monthly journal of this association. The nominations should be sent to the President in the proforma given in conclusion, through the respective branches and advance copies can be sent direct.

All the nominations so received shall be scrutinised and the final list of members in context is to be announced in the GC meeting. Some time shall be allowed for withdrawal from contest. On completion of withdrawal, members in field can be allowed to express their views in the GC meeting. In all the case of contest the majority of votes shall be final. The President in chair shall be in neutral. In case of equal number of votes the result of lot shall be final.

## 5.1.27 PROFORMA FOR NOMINATION

To
The President,
Tamilnadu Engineering Association, P.W.D.
Madras — 600 005.

Through .................................. Branch

Dear Sir,

I proposed Er. ........ L.M. No. (or) M. No. .......... a Member of ........ Branch to be .............. of the Central Unit of Tamilnadu Engineering Association, PWD, Madras for the year ....................

Yours faithfully,

Dear Sir,

I second the above nominee,

Yours faithfully,

Dear Sir,

I am willing to hold the post of .............. for the year ..............

I am quite aware of the Constitution of our association and I will be loyal to our association whether I win or loose in the contest.

Yours faithfully,

### CERTIFICATE OF BRANCH SECRETARY

This is to certify that all the above three members are members in this branch and have no dues to this association.

Branch Secretary

................ Branch

# 5.2 RULES AND REGULATIONS FOR PORIYALAR KUDUMBA NALA NIDHI (PONKUM NIDHI)

**5.2.1.** The name of the Nidhi shall be the PORIYALAR KUDUMBA NALA NIDHI, herein after refer briefly as PONKUM NIDHI.

**5.2.2.** The scheme and the Rules of PONKUM NIDHI shall come into force from the 1st day of January 1983.

**5.2.3.** The aims and objectives of the PONKUM NIDHI are :—

i) to provide immediate reliefs to the nominee or the family of the members of the Nidhi, who die while in service.

ii) to provide immediate financial assistance to the Members of the Nidhi who are obliged to retire prematurely on account of total or partial disability, either physical or mental or both.

**5.2.4** In these rules, unless the context otherwise requires or where it has been specifically stated otherwise :

a) *Committee :* Means the TNEA Central Cabinet constituted in accordance with these rules, for the purpose of administering the Nidhi in accordance with the aims and objectives of the Nidhi and include the adhoc committee nominated by the general council of TNEA for the purpose of initial formation and administration of the Nidhi, till elections are conducted and for conducting the first election.

b) *Death :* Means the death of the Members of the Nidhi, during the membership of the Nidhi, whether due to natural causes, or by accident, suicide or otherwise.

c) *Disability :* Means the total or partial disablement of the member of the Nidhi and deprivation of earning capacity of the member during his membership of the Nidhi due to accident, decease, mental causes or otherwise.

d) *Family :* In relation to a Member, shall be deemed to consist of

i) in the case of the male member, himself, his wife, his children whether married or unmarried, his dependant parents, the widow and children of his pre-deceased son, if any.

ii) in case of female member, herself, her husband her children whether married or unmarried, her dependant parents, the dependant parents or her husband, the widow and children of her pre-deceased son, if any.

Provided that if a female member, by notice in writing to the Secretary of PONKUM NIDHI, expresses her desire to exclude the dependant parents of her husband, they shall no longer be deemed, for the purposes of getting benefits under the PONKUM NIDHI Scheme, to be included in the family of such female member.

Explanation : i) Where the personal law of any member permits the adoption of a child, any child so lawfully adopted by the said member shall be deemed to be included in the family of such member.

ii) Where the personal law or any members permits him to many more than one wife, all the or such members shall be deemed to be member of his family.

*e)* Fund means PORIYALAR KUDUMBA NALA NIDHI (PONKUM NIDHI).

*f)* Financial assistance means the amount payable to the member or his nominee in accordance with the reliefs provisions under these Rules, in the event of total or partial disability, either physical or mental or both, to the member who is obliged to retire prematurely.

*g) Member :* Means any person, male or female in Engineering Service of PWD, either working in the parent department or on deputation to any other department and who is a Member of TNEA and who has fully contributed the prescribed subscription to the fund, as stipulated under these Rules.

*h) Nominee :* Means a person or persons nominated in writing by the member in Form I, at the time of his enrolment as a member, for receiving the relief, assistance or refund, as the case may be.

EXPLANATION :

i) A member in his nomination may distribute the amount payable to him among more than one nominee and may specify the ratio of division among them.

ii) If the member has a family at the time of making the nomination, the nomination shall be made infavour of one or more members of his family and any nomination made by such member in favour of a person who is not a member of his family, shall be void.

iii) If at the time of making the nomination, the member has no family, the nomination may be made in favour of any person or persons but if the member subsequently acquires a family, such nomination shall forthwith become invalid and the member shall, within one month of such acquisition of family, make a fresh nomination in favour of one or more members of his family.

iv) A nomination, may be, subject to the provisions of sub-rule (ii) and (iii) above, modified by any member at any time after giving to the Secretary of the Fund, a written notice of his intention to do so. Such modification of nomination has to be incorporated in the certificate of membership issued by the patern mids and has to be signed by the members and countersigned by the Secretary.

v) If the nominee predeceased the member, the interest of the nominee shall revert back to the member who shall make fresh nomination within one month of the death of the nominee, in respect of such interest.

*i) Refund* : Means the amount payable to the member of the Fund in accordance with the provisions of these Rules, on the retirement of the member, either voluntary or due to superannuation from service or on termination of his membership for reasons other than death or total or partial disability.

*j) Relief* : Means the amount payable to the nominee of a member or where there is no valid nomination, to the family members of the member, in the event of the death of the member of the Fund.

**5.2.5** a) The member-ship of the Fund shall commence on and from the 1st day of the month, in which the Committee's acceptance of the application for member-ship is communicated to the applicant on payment of full subscription.

b) The decision of the Committee regarding the acceptance or non-acceptance of the application for member-ship shall be final. The Committee has the right to reject any application with or without assigning any reasons in the interest of the TNEA and its members.

c) No application for member-ship shall be accepted by the Committee unless the application is accompanied by the nomination form prescribed in Schedule II hereunder, duly filled in and signed by the applicant and forwarded by the Branch Secretary of TNEA.

d) The member-ship of a member may continue even in the event of the transfer of such member to any other Engineering Organisation on deputation or lien, provided that the member-ship is not terminated for any of the reasons laid down in these Rules and the member expresses in writing, his deisre to continue his member-ship.

**5.2.6** (a) Every member shall pay a sum of Rs. 500/- to the fund either in lumpsum or in five equal instalments of Rs. 100/- each or in less number of instalments but within a period of six months from the date of acceptance of the first instalment. The first instalment shall however be not less than Rs.100/-.

b) The payment of the sum as provided in sub-rule (a) above shall be made in crossed Bank Drafts only to the Committee and shall be sent through the concerned Branch Secretary of TNEA or directly to the Committee's Office at Madras under intimation to the concerned Branch Secretary.

c) An admission fee of Rs.5/- (Rupees five only) shall be paid by each applicant at the time of sending his application for member-ship after 1.1.1983.

d) The Secretary (Ponkum Nidhi) of the Fund shall issue a receipt to the applicant immediately after receipt of the sums paid towards the subscription of the applicant.

**5.2.7** a) If any member happens to die while in service, due to accident, suicide, disease or other causes, his nominee or the members of his family as the case may be shall be paid the sum specified in col. (a) hereunder depending on the period of member-ship of such member in the fund, as given in the statement of amount payable, Vide 5.2.25.

b) On receipt of information about the death of the member, the concerned Branch Secretary shall contact the nominee or any of the members of the family and obtain from him a letter in the prescribed form given in Form II hereunder, along with a copy of the death certificate from the concerned Panchayat, Municipality or Corporation, or the Engineer under whom the member was working at the time of his death and forward it to the Committee with the recommendations. The Committee shall meet within 15 days of the receipt of the claim and pass the amount for payment by cheque to the nominee or the person or persons entitled thereto, personally by the Branch Secretary or a Committee member. The claim shall as far as possible, be settled within 30 days of the receipt of the claim.

**5.2.8** a) If a member sustains total or partial disability, either physical or mental due to accident, disease or otherwise, and thereby he loses the earning capacity either permanently or temporarily, he, or his nominee or his family members as the case may be, shall be paid such sum as may be specified by the FUND hereafter, depending on the period of membership of such member in the fund.

b) On receipt of information regarding the disability of the member, the concerned Branch Secretary, shall contact the member of his nominee or any of the members of the family, as the case may be and obtain from his, a letter in the prescribed form No. III hereunder, along with a Medical Certificate from Registered Medical Practitioner working in any Government Hospital and forward them to the Committee with his recommendations. The Committee shall meet within 15 days on receipt of the claim and pass the amount of financial assistance for payment by cheque to the member, his nominee or his family member as the case may be, personally by the Branch Secretary or the Committee member. The claim shall, as far as possible, be settled immediately but not later than 30 days on receipt of the claim.

c) The Medical Certificate specified in Sub-Rule (a) above shall state the nature of disability whether partial or total, and physical or mental.

d) A member who receives the financial assistance, shall be entitled to get refund from the Fund.

**5.2.9** a) A member who does not come under the category specified under Rule 7 or 8 above, and who retires from service due to superannuation or by voluntary retirement or whose services have been prematurely terminated for any reason, shall be entitled to refund of the sum specified in the statement (5.2.25) depending on the period of membership of such member in the Fund, as given in the col. (b) of the statement.

b) A member who is entitled to refund by virtue of superannuation or voluntary retirement shall apply through the Branch Secretary not less than one month before the date of such superannuation or voluntary-retirement, giving details of his certificate number etc. in Form IV and the Branch Secretary shall forward the same to the Committee with his remarks. The Committee shall deal with the application expeditiously and pass the amount for payment by cheque to the member but not later than 30 days from the date of superannuation or voluntary retirement.

c) A member whose services have been terminated or who is removed from service or retired due to superannuation on or out of his own voluntary retirement shall apply for refund and the procedure prescribed in sub-rule (f) shall be applicable regarding the mode of application and payment of sum to the member.

d) If a member dies or suffers disability, after termination of service but before the refund is made, the refund shall be paid to the nominee or the family member, as the case may be, in case the member is unable to receive the sum due to the disability.

**5.2.10** No sum shall be refunded to a member in case of voluntary withdrawal from membership within one year of admission and in such cases all subscription paid, shall stand forfeited to the fund and the member shall not claim any sum whatsoever.

**5.2.11** A member cease to be so, on his attainment of the age of superannuation or termination of service by voluntary retirement or otherwise.

**5.2.12** a) The General Council of TNEA shall elect, annualy, Secretary (Ponkum Nidhi).

b) The Secretary (Ponkum Nidhi) shall be elected among those stationed at Madras.

c) Any vacancy caused in the office of the Secretary (Ponkum Nidhi) due to transfer, retirement, resignation, death or disability shall be filled in by any one of the remaining members of central cabinet.

**5.2.13** The Committee shall meet atleast once in a month and review accounts and registers maintained by the Secretary (Ponkum Nidhi).

**5.2.14** The Committee shall be responsible for overall administration of the fund, for consideration of application for membership for the proper maintenance of the accounts of the fund, for making proper investments of the finance of the fund, for early settlement of the claims made by the members, for the general efficient running of the fund and for submitting annual account and balance sheet to the General Council of TNEA.

**5.2.15** No withdrawals or diversions are allowed other than for the payment of relief, refund or assistance or Administrative as stipulated in the Rules.

**5.2.16** The bank accounts of this Committee shall be operated jointly by the Secretary and Treasurer. Treasurer shall be responsible for maintenance of accounts of all the moneys received and paid by the fund. He shall be responsible for and on behalf of the Committee for presentation of the annual accounts before the General body.

**5.2.17** The Secretary shall be the main executive of the committee and shall have powers to incur expenditure upto Rs. 100/- at a time for purchase of stationery or printing or any miscellaneous items. Any expenditure above this limit shall require the proper approval of the Committee.

**5.2.18** The Committee is empowered to receive any grants or donations or other monies for and on behalf of the fund, and such sums when received shall forthwith be deposited in the bank account of the PONKUM NIDHI and invested, or disbursed in accordance with the provision of these Rules.

**5.2.19** No member of the Committee shall be personally liable for any acts of Commission or omission done by him for and on behalf of the fund, in good faith in discharge of his duties or in accordance with the decisions taken by the Committee or the general body.

**5.2.20** The account of the PONKUM NIDHI shall be audited every year by an auditor appointed by the General Council of the TNEA. The Secretary (Ponkum Nidhi) accounts are duly audited before presentation to the annual general council meeting of the TNEA.

**5.2.21** The finances of the fund shall be invested by the Committed in one or more savings deposit accounts with cheque facility in a nationalised schedule bank upto the extend required for normal requirements. Any amount in excess of this limit shall be invested in Fixed Deposits for higher rate of interest in any nationalised Scheduled Bank or any quasi Government, Statutory Board or Corporation or any registered society or saswathanidhi which gives a good rate of interest. Decisions for investments in Fixed Deposit shall be made by PONKUM NIDHI Committee depending upon the accumulations in the savings deposit accounts.

**5.2.22** The CEC of TNEA, shall have power to review the functions and administration of the Fund and shall have over all control and superintendance over the affairs of the fund. The President is also empowered to summon the CEC of TNEA and place before the Council the difficulties if, any, in the constitution or functions of the Fund and shall abide by the decision taken by the CEC council of TNEA in that regard. The power to amend , delete or add to these rules shall vest with the Central Executive Committee of TNEA. The Committee may however adopt local rulings under these rules so far as they are not in conflict with main rules.

**5.2.23** The PONKUM NIDHI may be dissolved by a resolution to the effect in General Council Meetings of TNEA, if the members voting direct or by writing for dissolution constitute not less than 75% of the total membership of the fund on that day. On disolution, the monies of the fund shall be applied in the following manner and paid in the order of priority indicated below :

a) All taxes or debts due to Government or any other agency of the Government.

b) The salaries and allowances due, if any, to the employees of the fund.

c) All debts of the fund or claims of the fund due and payable on the date of dissolution.

d) Refundable contribution and interest therein, if any due on the date of dissolution to the fund members.

e) Any surplus amount including the assets of the fund remaining after meeting all the payments as stated above shall be transfered to the TNEA.

**5.2.24** The scheme shall be reviewed after 5 years.

# PORIYALAR KUDUMBA NALA NIDHI (PONKUM NIDHI)

## 5.2.25 STATEMENT SHOWING THE AMOUNT PAYABLE (Read with 5.2.7)

| | Sum payable in the event of | | |
|---|---|---|---|
| Duration of membership of the fund since enrolment | Death (a) | retirement (b) | premature retirement on account of disability (c) |
| Upto calender months | Rs. | Rs. | Rs. |
| 12 | 3,000 | 600 | 1000 |
| 24 | 5,000 | 600 | 1500 |
| 36 | 5,000 | 700 | 2000 |
| 48 | 6,000 | 700 | 2000 |
| 60 | 6,000 | 800 | 2000 |
| 72 | 7,000 | 800 | 2500 |
| 84 | 7,000 | 800 | 2500 |
| 96 | 8,000 | 900 | 3000 |
| 108 | 8,000 | 900 | 3000 |
| 120 | 9,000 | 900 | 3500 |
| above 120 calender months | 10,000 | 1,000 | 4000 |

## Form I

# பொறியாளர் குடும்ப நலநிதி

1. பெயர்
2. தகப்பனார் பெயர் :
3. பிறந்த நாள் :
4. பதவி :
5. முகவரி : (தற்காலிகம்) :

   (நிரந்தரம்) :

6. பணியில் சேர்ந்த நாள் :
7. பணியிலிருந்து ஓய்வு பெறும் நாள் :
8. வாரிசுதாரர் பெயர் / உறவு (மணமானவராக இருந்தால் மனைவி இன்றேல் பெற்றோர் பெயர்)
9. வாரிசுதாரர் முகவரி :

10. எந்த கிளையைச் சேர்ந்தவர் :

மேலே கொடுக்கப்பட்டுள்ள குறிப்புகள் யாவும் சரியானவை என்பதை உறுதி செய்வதோடு, இந்த ''பொறியாளர் குடும்ப நலநிதி'' திட்டத்தில் என்னை ஓர் உறுப்பினராக ஈடுபடுத்திக் கொள்ளவும், இத் திட்டத்தில் தற்போதுள்ள விதிமுறைகளுக்கும், மற்றும் காலக்கட்டத்தில் மாறுதல் செய்யப்படும் ஏனைய விதிமுறைகளுக்கும் என்னை ஆட்படுத்திக் கொள்ள முழுமையாக உள்ள உணர்வோடு உறுதி அளிக்கிறேன்.

இடம் : கையொப்பம்

நாள் : (பெயர்)

# Form II

## இறந்த உறுப்பினரின் வாரிசுதாரர் நிவாரணத் தொகைக்கான விண்ணப்பப்படிவம்

1. உறுப்பினர் பெயர் :

2. தகப்பனார் பெயர்

3. பிறந்த நாள் :

4. பதவி :

5. (அ) பதவி காலத்தில் முகவரி :

6. பொங்கும் நிதி உறுப்பினர் எண் :

7. உறுப்பினர் இறந்த நாள் :

8. உறுப்பினர் இறப்பின் விபரம் :

9. உறுப்பினர் இறப்புச் சான்றிதழ் இணைக்கப்பட்டுள்ளதா?
   ஆம், எனில் விபரங்கள் :

10. வாரிசுதாரர் பெயர், உறவு மற்றும் வாரிசுதாரர் முகவரி :

11. வாரிசுதாரர் கையொப்பம் :

**உறுப்பினர் சார்ந்துள்ள கிளைச் செயலரின் பரிந்துரைகள்**

*செயலர்.*

*கிளை.*

# பொங்கும் நிதி நிர்வாகக் குழுவின் செயல்முறை

1. உறுப்பினர் இறந்த நாள் :

2. வாரிசுதாரர் விண்ணப்பித்த நாள் :

3. கிளைச்செயலர் பரிந்துரையுடன் குழுவுக்கு வந்து சேர்ந்த நாள் :

4. நிவாரணம் அனுமதிக்கப்பட்ட நாள் :

5. உறுப்பினர் திட்டத்திலிருந்து கால இடைவெளி :

6. உறுப்பினர் வாரிசுதாரருக்கு அனுமதிக்கப்படும் குடும்பநல நிதி தொகை :

7. நிவாரணத் தொகை வழங்கப்பட்ட காசோலை எண் :

8. வழங்கப்பட்ட நாள் :
   தேதி :

செயலர்

பொங்கும் நிதி

# Form IV

## பணியினின்று ஓய்வு பெறும் உறுப்பினர் குடும்பநல நிதி பெறவேண்டி கோரும் விண்ணப்பம்

(ஓய்வு பெறும் நாளிலிருந்து 30 நாட்கள் முன்னதாக அனுப்பப்பட வேண்டும்)

1. உறுப்பினர் பெயர் மற்றும்
   பொங்கும் நிதி உறுப்பினர் எண் :

2. தகப்பனார் பெயர் :

3. பிறந்த நாள்

4. பதவியிலிருந்து ஓய்வு பெறும்
   நாளில் வகித்த பதவி :

5. உறுப்பினர் முகவரி :

   (அ) தற்போதயது

   (ஆ) நிரந்தரம்

6. பணியில் சேர்ந்த நாள் :

7. பணியிலிருந்து ஓய்வு பெற்ற நாள் :

8. பொங்கும் நிதித் திட்டத்தில்
   உறுப்பினராக இருந்தகால இடைவெளி

9. உறுப்பினர் சார்ந்த கிளையின் பெயர் :

மேலே கொடுக்கப்பட்டுள்ள குறிப்புகள் யாவும் சரியானவை என்பதை உறுதி செய்வதோடு இந்த பொறியாளர் குடும்பநல நிதித் திட்டத்திலிருந்து எனக்கு சேர வேண்டிய குடும்பநல நிதி ரூ. - - அளிக்கும்படி கேட்டுக் கொள்கிறேன்.

உறுப்பினர் கையொப்பம்

**உறுப்பினர் சார்ந்துள்ள கிளைச்செயலரின் பரிந்துரைகள்**

*செயலர்*

*கிளை*

# பொங்கும் நிதிக் கமிட்டியின் செயல்முறை

1. உறுப்பினர் விண்ணப்பித்த நாள் :

2. கிளைச் செயலரின் பரிந்துரையுடன் குழுவுக்கு வந்து சேர்ந்த நாள் :

3. குடும்பநல நிதி அனுமதிக்கப்பட்ட நாள் :

4. உறுப்பினர் இத்திட்டத்திலிருந்த கால இடைவெளி :

5. உறுப்பினருக்கு வழங்கப்பட வேண்டிய குடும்பநல நிதி தொகை

6. உறுப்பினக்கு வழங்கப்பட்ட குடும்பல நிதி தொகை

7. குடும்பநல நிதி வழங்கப்பட்ட விபரங்கள் (காசோலை மற்றும் தேதி விபரம்)

8. வழங்கப்பட்ட நாள் :

*செயலர்*

பொங்கும் நிதி [redacted]

# VI. SURVEYING AND LEVELLING

## 6.1. PERMANENT ADJUSTMENT OF LEVELLING INSTRUMENT

### 6.1.1. To make the axis of Bubble Tube Perpendicular to Vertical Axis.

(i) Set up the instrument and level it. The bubble must be at centre in two positions at right angles to each other to the third foot screw.

(ii) Bring the telescope over one foot screw and turn through 180° in azimuth. If the bubble remains at centre, the adjustment is correct. If not, do the following adjustment.

Adjustment :

Note down the deviations as $2n$ divisions. Bring the level halfway $n$ division by raising or lowering one end of the bubble tube by means of capstan headed nut at one end of tube and the remaining half with the footscrew beneath the telescope. Repeat the same until the bubble remains at centre.

### 6.1.2. To make the line of Collimation parallel to the axis of bubble tube.

Test: Two peg Method (See figure)

(i) Set up the level at O and take readings on staff held at A & B, and A, O, B should be on one straight line with a distance D between A & B, O being at centre. (D may be of the order of 60 metres and bubble must be at centre in each position.) Let readings be $a$ and $b$ respectively.

(ii) Shift the level and set it over $O_1$. $O_1$ should be at a distance of $d$ from A on the line. BA produced. ($d$ may be of the order of 20 metres) Take staff readings at A & B. Let readings be $a_1$ & $b_1$ respectively.

$a \sim b$ = ture difference.

$a_1 \sim b_1$ = apparent difference.

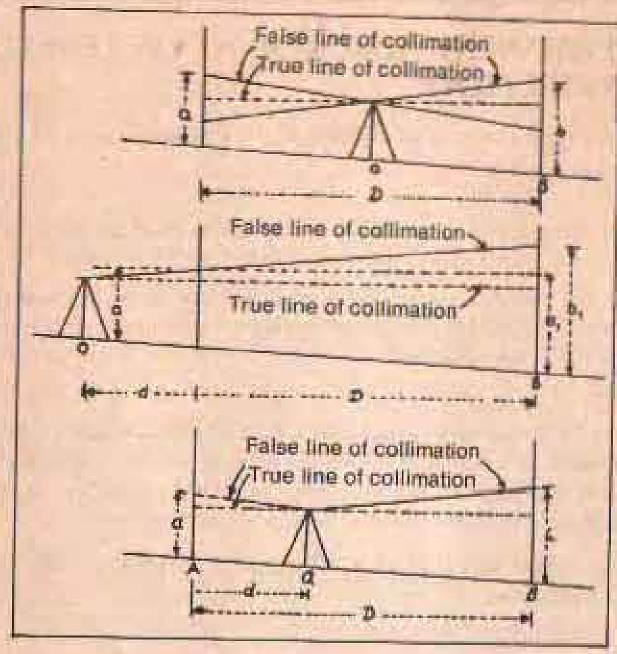
Adjustment:

(i) Determine whether the true difference is a rise or fall, if $a > b$, peg A is lower than B and vice versa.

(ii) Add the true difference to the reading on peg. A near the instrument if it is a fall, deduct from the reading on peg A, if it is a rise, to obtain the reading on the far off peg A at the same level as $a_1$ Let the reading be $e_1$.

$\therefore$ $e_1 = a_1 \pm$ true difference (+ for fall & − for rise).

(iii) Compare $e_1$ and $b_1$. If $b_1 > e_1$ line of collimation is inclined upwards. If $b_1 < e_1$ line of collimation is inclined downwards.




$\therefore b_1 - e_1$ = collimation error in the distance D

correction to the reading of far off peg B = $c_1 = \frac{D+d}{D} \times b_1 - e_1$

correction to the reading on near peg A = $c_2 = \frac{d}{D} \times (b_1 - e_1)$

Hence correct reading on the far off peg B = $b_1 \pm c_1$

[+... downwards −... upwards]

and correct reading on the peg A = $a_1 \pm c_2$

[+... downwards − ...upwards]

After arriving at the correct reading, the telescope is focussed on the staff at the far off peg B. Diaphragm screw on the eye piece side (Hair line Diaphragm) is suitably adjusted to obtain the correct reading ($b_2 \pm c_1$) on the staff at peg B. By loosening the bottom screw and tightening the top screw simultaneously or vice versa. After obtaining the correct reading on peg B, the reading on the near peg A is noted. This reading should be exactly the correct reading ($a_1 \pm a_2$) already calculated by applying correction $c_2$ The above procedure is repeated until the reading obtained are exactly correct.

# 6.2. PLANE SURVEYING

Linear measurements are required at some stage, in all survey work. These may be obtained by steel tape or band or by optical or electronic means. In measuring a line length, correct ranging, straightening and uniformity of pull on the tape are essential. Difficulty may be experienced in ranging or in chaining, because of obstructions on the line, e.g., buildings, wooded ground, streams, etc. The application of some simple geometrical construction will normally enable the work to be continued beyond the obstruction. Attention must be given to the rise and fall of the ground, bearing in mind that the required line length is the length in plan.

## 6.2.1. Corrections

The following are the corrections which may be applied to the measured tape lengths.

1. *Tape laid flat on the ground*

$$\text{Corrected length} = L \pm eL - \frac{h_2}{2L} + \frac{(P-Ps)L}{AE} + cL(T-Ts)$$

$L$ = nominal length of tape or line.

$eL$ = correction to be applied when the actual length of the tape, under standard conditions, does not equal the nominal length. (+ ve when tape is longer than its nominal length.)

$e$ = correction in length per unit of nominal length.

$\frac{h^2}{2L}$ = correction for slope of ground, where $h$ is the difference in height between ends of distance $L$ (assuming uniform slope over distance $L$).

$\frac{(P-Ps)L}{AE}$ = correction for stretch due to pull on the tape. $P$ is the pull actually applied during the measurement and $Ps$ is the pull at which the tape was standardised.

$A$ = C/S area of tape. $E$ = Young's Modulus of Elasticity of the tape.

$cL(T-Ts)$ = correction for thermal expansion where $c$ is the coefficient of linear expansion. $T$ is the atmospheric temperature during length measurements and $Ts$ is the temperature at which the tape was standardised.

*2. Tape supported on straining trestles, i.e., hung in category.*

The above corrections have again to be applied in this case, and, in addition, it is necessary to allow for the sag of the tape between the trestles.

$$\text{Sag correction} = -\frac{L}{24}\left(\frac{W^2}{P}\right) \text{ where } W = \text{weight of tape of length of } L$$

Typical values of the constants are:

| *Property* | *Steel tape* | *Invar Tape* |
|---|---|---|
| $E(kN/m^2)$ | $196.5 \times 10^6$ | $152 \times 10^6$ |
| $c$(per K) | $10.1 \times 10^{-6}$ | Variable but almost negligible. Less than $0.9 \times 10^{-6}$ |

## 6.2.2. Accuracy

For careful work of ordinary accuracy in which no corrections have been applied other than those for slope and nominal length the error of measurement of a line length should not exceed about 1 in 1000. For very precise work of the order of geodetic base line measurement, the error may be about 1 in 500,000.

## 6.2.3. Chain surveys

These require linear measurements only. The area to be surveyed is divided into a framework of connected triangles, or bound by a polygon, or polygons, the directions of whose sides are fixed by forming triangles at the vertices. A careful preliminary reconnaissance will enable the work to be set out so that it yelds the required information with the minimum of labour. For reliable work, an adequate number of check measurements must be made. Points of detail are located from the main lines of the framework, by offsets and ties.

## 6.2.4. Traverse surveys

These involve angular, in addition to linear, measurements. In this case, the framework of lines (from which points of detail can be located as in chain surveys) consists of a series of connected lines not necessarily forming a closed figure. The directions of these lines, usually expressed as bearings from some reference direction, are observed, and the line lengths measured. Bearings may be referred to magnetic north (e.g. compass bearings, duly corrected for local attraction), true north (azimuth readings involving, at some stage, astronomical observations), grid north (as set out from a map) or some local reference direction.

The commonly used system of reckoning angles, in the field, is the whole circle system. In this, line directions are reckoned clockwise from the reference direction from 0° to 360°. For convenience in computing co-ordinates, these bearings may be subsequently reduced to the quadrantal system. These reduced bearings are angles of less than 90°, measured on either side of the N.S. line, the quadrant being specified by noting whether it lies to the E. or W. of this line, e.g.:

N.37° E. (or 37°) S. 15° W. (or 195°).

The back bearing of a line differs from its forward bearing by 180°.

Measurement of line direction may be made by observing the internal angles of the framework of lines (or the external deflection angles) and knowing the bearing of one line, the bearings of the others can be deduced. This method would be used in precise traverse surveys where repeated measurements of each angle are made (face right, face left etc. on the theodolite).

Where a single observation of each direction is considered to be adequate, the bearings will normally be carried forward from one line to the next, by correctly orienting the instrument by backsight at each station.

As in chain surveys, sufficient check measurements must be made to detect gross errors. In this case, these checks will normally consist of extra angular measurements to stations across or farther along the traverse.

Also, in a closed traverse,
$\Sigma$(interior angles) = $(2n - 4) \times 90°$
where $n$ = number of sides in the figure
$\Sigma$(exterior of deflection angles) = 360°

When a small closing error in bearing exists this should be distributed round the traverse on the assumption that the error is accumulated equally at each station occupied. If the least count of the instrument is, say, 30 seconds, then the error of closure in the bearings should not exceed $30\sqrt{N}$ seconds, where $N$ is the number of stations occupied.

## 6.2.5. Reduction of field data to co-ordinates

In work of a low grade of accuracy, the framework of lines may be plotted direct from the bearings and distances.

For normal accuracy, however, rectangular co-ordinates of survey stations are computed and adjusted, before plotting of detail commences. These station co-ordinates are given in terms of their latitudes and departures.

*Latitude* of a station is its distance, measured in the N. or S. direction ($+X$ or $-X$) from the E.W. (or $Y$) axis of reference. These latitudes representing the $X$ co-ordinates are sometimes called northings or southings.

*Departure* of a station is its distance measured in the E. or W. direction ($+Y$ or $-Y$) from the N.S. (or $X$) axis. These departures, representing the $Y$ co-ordinates are sometimes called eastings and westings.

If a given line is of length $L$ and its reduced bearing is $\theta$ then the *latitude difference* of the line is $L \cos \theta$ (northing or southing, or $+X$ or $-X$, according to the quadrant into which the line is situated from the observer). The *departure difference* is $L \sin \theta$ (easting or westing or $+Y$ or $-Y$). Working from the origin of the co-ordinates or from a station of known or selected co-ordinates, these *differences* can be summed algebraically to give the latitudes and departures (i.e., the co-ordinates) of the stations.

Note that in a closed traverse, if no error is present

$\Sigma$ latitude differences $= 0$
$\Sigma$ departure differences $= 0$

Even with careful work, satisfying the various check observations made, there will generally be small residuals in these summations. This closing error can be distributed by a rule, such as the following:

$$\text{correction to} \left.\begin{matrix}\text{latitude}\\ \text{departure}\end{matrix}\right\} \text{ difference of a line}$$

$$= \frac{\text{closing error in} \left\{\begin{matrix}\text{latitude}\\ \text{departure}\end{matrix}\right.}{\text{total length of traverse}} \times \text{length of line}$$

If an open traverse begins and ends on stations of known co-ordinates, similar principles may be applied to its adjustment.

For a good class of work, the actual closing error, in terms of the length of the traverse, will not exceed about 1 in 3000.

## 6.3. ORDINARY LEVELLING

Ordinary levelling has as its purpose the determination of the altitudes of points above, on, or below the ground relative to a level datum, or their difference in level. The level surface of reference in the United Kingdom is Mean Sea Level at Newlyn, Cornwall, i.e., Ordnance Datum (O.D.). Numerous Bench Marks (O.B.M.) of known Reduced Levels above O.D. have been established over the country, so that by using one, or more, of these as reference levels, the Reduced Level (R.L.) of any other point can be deduced.

The operations consist of using a graduated staff to determine the difference of height of points on the ground, etc., from the horizontal line of sight of a dumpy level (or equivalent instrument). The first sight, on a staff, observed from an instrument position is termed a *backsight* (B.S.). The last sight observed is a *foresight* (F.S.). All other sights are *intermediate sights* (I.S.). The R.L. of the line of sight can be determined by taking a sight to a staff held on an O.B.M. Levels are carried forward from one instrument station to the next by taking a F.S. and a B.S. on to one firm point. Such a point is known as a *change point* (C.P.).

The R.L.'s of points on which staff readings have been observed, can easily be deduced. In the *Collimation Height* system, the R.L.'s of the lines of sight at the various instrument stations are deduced, and by subtracting the staff readings from the R.L.'s of the appropriate lines of sight, the R.L.'s of the points themselves are obtained. The alternative system of reduction is the *Rise and Fall* system in which the R.L. of a point is obtained from the R.L. of the previous point by noting the amount of rise or fall in level from the previous point to the point in question.

### 6.3.1. Checks on accuracy

A check on field work is best made by repeating the work, but a good check against gross error is obtained by levelling back to the first point observed (usually a B.M.), calculating its R.L. on the basis of the survey data and comparing this with initially known value.

A check on the accuracy of the arithmetical work can be made by ensuring that the following conditions are satisfied.

sum of B.S.– Sum of F.S. – Sum of rises – Sum of *falls*, and – Difference in R.L. of first and last points observed.

For a series of levels taken along a line *M* km in length, the total error in ordinary levelling, should not exceed $12\sqrt{M}$ to $25\sqrt{M}$ mm. Sights should not exceed 120-150 m in length, less for importance sights. Beyond this distance accurate reading becomes difficult and the effects of curvature and refraction began to be appreciable. B.S. and F.S. lengths to C.P. should be equal or nearly so.

The operations of levelling are used extensively for running sections of ground surface, measuring or setting out levels for pipe inverts, column footings, etc., and for contouring.

For contouring work, adequate accuracy and increased speed and convenience (especially in steep, uneven country) are obtained by using tacheometrical methods.

# 6.4. TACHEOMETRY

A system of surveying in which the labour of taping distances is eliminated. Distances and differences in height to points, as measured from the instrument station are deduced from observations taken on a staff held at these points. If the bearings of these points are also observed from the instrument station, then the points will be completely located.

## 6.4.1. Stadia System

The *stadia system* of tacheometry is commonly used. For this, a theodolite fitted with a special diaphragm is required. The diaphragm is fitted with two additional horizontal cross hairs, one above and one below the normal central hair. This forms the stadia. To make an observation on a point, the theodolite is directed on to a staff held on the point and the staff graduations coinciding with the three cross hairs read ($r_1$, $r_2$ and $r_3$). In addition the angle of elevation $\theta$ is accurately read, and the bearing of the point observed; to an accuracy depending on the nature of the point. If the latter is important, e.g., a station, the bearing will be accurately observed. If it is an isolated point of detail, and the bearing is to be read so that the point can be directly plotted on the plan, an accuracy of say 15 minutes will be adequate.


With the staff held vertically on the point the distance *in plan* from the instrument to the point is

$$H = As\cos^2\theta + B\cos\theta.$$

where $A$ = multiplying constant (usually 100, or perhaps 50).

$s = r_3 - r_1$ = stadia intercept on staff.

$B$ = additive constant (zero in anallactic instruments).

Values $A$ and $B$ can be measured or checked by taping out over level ground several distances $H$ from the instrument, and then reading the corresponding values of $s$ for the case of $\theta = 0°$. The above equation becomes $H = As + B$. Insert corresponding values of $H$ and $s$ and solve equations in pairs to get the best value of $A$ and of $B$.

Difference in elevation between station peg at instrument and ground, or peg, level at point

$= \pm V + h - r$ (+ $V$ for angles of elevation

− $V$ for angles of depression)

where $h$ = height of the trunnion axis of the instrument above the station peg and $V = \frac{1}{2} As\sin 2\theta + B\sin\theta$

Where sights at a considerable angle of elevation are being observed, it will be preferable to hold the staff normal to the line of sight. In such cases, the reduction formulae become

$$H = As\cos\theta + B\cos\theta + r_2\sin\theta$$

Difference in elevation = $\pm$ $(As\sin\theta + B\sin\theta) - r_2\cos\theta + h$. Reduction of stadia observations can be simplified by the use of special techniques of reading and with the aid of tabulated constants (e.g. Williamson's method). Instruments such as the Wild RDS provide automatic reduction, i.e., they allow direct reading of distance and height.

*Accuracy* should be of the order of 1 in 500 for distance measurements and about 50 – 100 mm in height for a sight of moderate length.

## 6.4.2. Tangential tacheometry

Another useful system of tacheometry is the *tangential system*, in which an ordinary theodolite is used. To locate a point by this method, two sights have to be taken on a staff held vertically at the point. If for sights at angles of elevation $\alpha$ and $B$, the corresponding staff readings against the centre cross hair, are $r_a$ and $r_b$ ($r_a$ being the higher) then, distance, in plan, from the instrument to the point is

$$H = \frac{s}{\tan\alpha - \tan B} \text{ for angles of elevation}$$

$$\text{or } H = \frac{s}{\tan B - \tan\alpha} \text{ for angles of depression}$$

where $s = r_a - r_b$

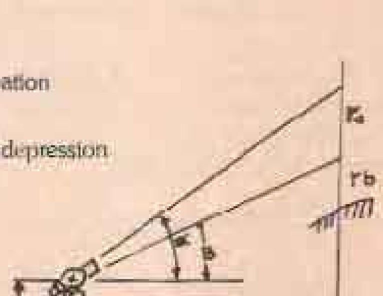
Difference in elevation

$= \pm H\tan\alpha - r_a + h$

$= \pm H\tan B - r_b + h$

+ if $a$ or $b$ are angles of elevation.

– if they are angles of depression.




As with the stadia system, instruments have been designed which simplify the reduction of the field observations.

Theodolite observations on a subtense bar afford another optical means of distance measurement.

Methods requiring precise measurement of time of transmission of signals between survey stations (tellurometer and mekometer techniques) are also successfully employed. These allow accurate deduction of line lengths for survey by trilateration.

## 6.5. AERIAL PHOTOGRAMMETRY

Increasing use is made of aerial photogrammetry methods of ground survey. The use of data logging equipment linked to the stereo comparator allows the operator to record ground co-ordinates direct from photographs. This data can then be processed by computer with respect to highway alignments, etc., to yield data on adjusted survey station positions, preferred routes, earthwork quantities and other pertinent items.

## 6.6. MEASUREMENT OF LAND AREAS

By the area of a piece of land is meant its area in plan. The unit of measurement of land area is ie. hectare.

Areas will normally be computed from the plotted plan, by a method such as one of the following:

1. By planimeter.
2. By dividing the area into simple geometrical figures (e.g., triangles) whose areas can be calculated. Irregularity of boundaries can be allowed for when the straight lines of the simple figures are drawn, by arranging that the straight lines, replacing the boundaries, add to and omit equal areas from the area in question. A similar method is to place a piece of squared tracing paper over the plan, and count the number of squares or parts of squares enclosed by the boundary.
3. By Simpson's rule. The area is divided into an even number of divisions by a series of parallel lines distance $d$ apart, such that these lines, as cut by the boundary of the area are of lengths $l_1, l_2, l_3 \ldots l_n$. (Normally in an irregular area $l_1$ and $l_n$ are both zero).

   $$\text{Area} = \frac{d}{3}\left[l_1 + 4l_2 + 2l_3 + 4l_4 + \ldots + 2l_{n-2} + 4l_{n-1} + l_n\right]$$

4. By Double Longitudes. If the area contained by the survey lines of a closed traverse is required, then this area can be conveniently computed from the station co-ordinates. Using the reference meridian of the co-ordinates, the longitude of a line is the perpendicular distance from this reference meridian to the mid point of the line.

   The area enclosed by the lines of a traverse survey is the algebraic sum of the products of the latitude difference of each line by its longitude.

   It is more convenient to work in terms of the double longitude. D.L. of a line = D.L. of previous line + Departure difference of previous line + Departure difference of the line itself.

   This can be conveniently tabulated.

   Then area enclosed by lines:

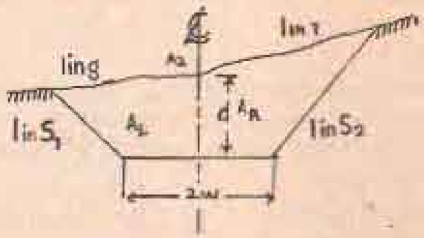
   = ½ Σ(latitude difference × double longitude)

# 6.7. EARTHWORK QUANTITIES

In computing earthwork quantities in embankment and cutting for roadworks, etc., areas will first have to be calculated for cross sections at frequent intervals along the route. In such work, it will be convenient to measure these areas in terms of the formation width $2w$, the side slopes $s_1$ and $s_2$ of the bank and the depth (or height) $d$ from ground level to formation at the centre line of the formation.

For the cross section shown in the sketch, the area to the left of the centre line.

$$A_L = a_L d^2 d + b_L d - C_L$$




Area to the right of the centre line.

$$A_R = a_R d^2 + b_R d + C_R$$

where $a_L = \dfrac{gS_1}{2(g + S_1)}$

$$a_R = \frac{rS_2}{2(r - S_2)}$$

$$b_L = \frac{2wg}{2(g + S_1)} \quad b_R = \frac{2wr}{2(g - S_2)} \quad C_L = \frac{w^2}{2(g + S_1)} \quad C_R = \frac{w^2}{2(r - S_2)}$$

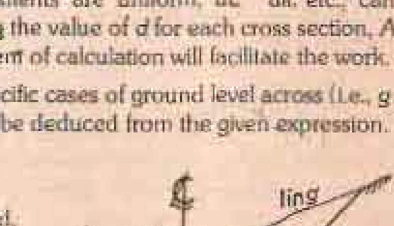
Hence the total area of cross section $A = A_L + A_R$

In stretches where the cross gradients are uniform, $a_L$ $a_R$ etc., can be calculated at the start, and by using the value of $d$ for each cross section, $A$ can be calculated. A tabular arrangement of calculation will facilitate the work.

The above is the general case. Specific cases of ground level across (i.e., $g = r = \infty$) or $g = r$, $S_1 = S_2$, etc., can be deduced from the given expression.

## 6.7.1. Hillside sections

In this case three areas are involved,




$$A_1 = \frac{(w - gd)^2}{2(g + S)}$$

$$A_2 = \frac{gd^2}{2}$$

$A_3 = a_R d^2 + b_R d + C_R$ *where $a_R$ and $c_R$ are as in the above case.*

Where the ground surface is very uneven, it may be necessary to use one of the methods of area measurement given on paras 6.6 & 6.7.

## 6.7.2. Volume of bank of cutting

A good approximation to the volume is given by the *average end area method*. This gives the volume between two adjacent parallel cross sections as the product of the average of their areas and their distance apart.

$V = \frac{1}{2}L.(A_1 + A_2)$

i.e., Total volume $= \frac{1}{2}L(A_1 + 2A_2 + 2A_3 + \ldots 2A_{n-1} + A_n)$ where $L$ is the perpendicular distance apart of adjacent cross sections (i.e., equal intervals $L$ between successive cross-sections of areas $A_1$, $A_2$, $A_3$ ... etc.).

This method tends to overestimate volumes and the method generally accepted as being accurate for earthwork calculations is that using the *prismoidal rule*.

From this rule the volume is $V = 1/6L(A_1 + 4A_m + A_2)$ between cross sections of areas $A_1$ and $A_2$ distance $L$ apart. $A_m$ is the cross-sectional area midway between $A_1$ and $A_2$, and is normally *not* equal to the average of $A_1$ and $A_2$.

Where the extra ground survey, or calculation to obtain areas $A_m$ is considered unjustified, then an approximation to the Prismoidal volume can be obtained by considering the *end* areas at *2L* apart. This gives Simpson's rule for volumes, i.e.,

total volume $= 1/3L(A_1 + 4A_2 + 2A_3 + 4A_4 + 2A_5 + \ldots + A_n)$ for an odd number of cross sections.

Frequently the practice is to calculate the volumes using the average end area method and then to apply a *Prismoidal Correction* (i.e., the final volume being the volume which would have been obtained by using the Prismoidal Rule initially).

Prismoidal correction for a length $L$ between cross-sections of areas $A_1$ and $A_2$ $= -1/3L(A_1 + A_2 - 2A_m)$, e.g., for cut, of uniform cross slope 1 : g and side slopes both 1 : s,

$$P.C. = \frac{L.g^2s}{6(g^2 - s^2)}(d_1 - d_2)^2 \text{ and so on.}$$

In the above calculations for the volume of embankment, etc. the longitudinal centre line was assumed straight. Where the centre line follows a curve whose radius is fairly short in comparison with the width of cross-section, it may be necessary to *allow for the curvature*, in accurate measurement.

The method is to calculate volumes by the prismoidal rule, but using *equivalent areas*. Equivalent area

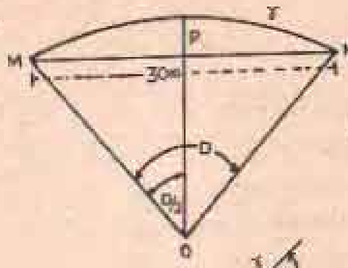
$= A(1 = \frac{e}{R})$ where A is the actual area of the cross-section,

and $e$ is the eccentricity of the centroid of area $A$ from the centre line of the formation. $R$ is the radius of the curve.

It should also be noted that when soil material is excavated it occupies more bulk than before and, when it is subsequently deposited and compacted as fill, it will generally show a decrease in bulk, relative to the original volume, in the region of 10% Solid rock broken up and placed as fill will increase in bulk in the region of 60−70% relative to the original volume.

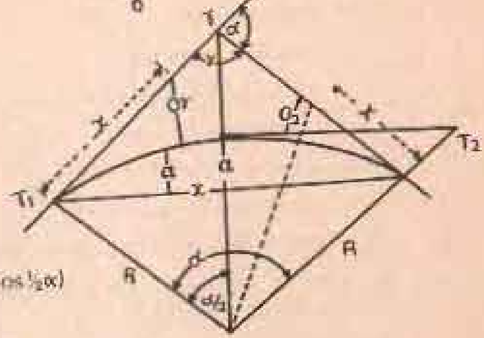
# 6.8. ELEMENTS OF CURVE SETTING

## 6.8.1. Simple Curves −




For 30 m chord

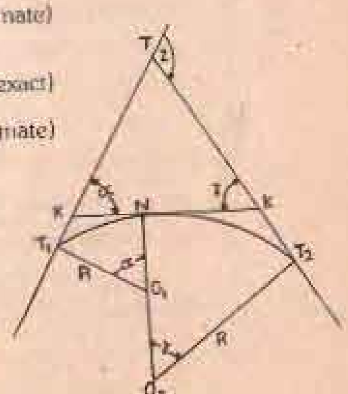
1. $R = \dfrac{1719}{D}$ (approximate)
2. $R = \dfrac{15}{\sin \frac{1}{2} D}$ (exact)
3. $l = \dfrac{30\alpha}{D}$




For any chord

4. $T = R \tan \frac{1}{2}\alpha$
5. $L = 2R \sin \frac{1}{2}\alpha$
6. $l = \dfrac{\pi R \alpha}{180^\circ}$
7. $n = T \tan \frac{1}{2}\alpha$
8. $v = R \operatorname{versin} \frac{1}{2}\alpha = R(1 - \cos \frac{1}{2}\alpha)$
9. $R = \dfrac{L^2}{8v}$
10. $O_0 = R - \sqrt{R^2 - \left(\dfrac{L}{2}\right)^2}$
11. $O_1 = \sqrt{R^2 - x^2} - (R - O_0)$ (exact)
12. $O_1 = \dfrac{x(L-x)}{2R}$ (approximate)
13. $O_2 = \sqrt{R^2 + y^2} - R$ (exact)
14. $O_2 = \dfrac{y^2}{2R}$ (approximate)
15. $O_3 = R - \sqrt{R^2 - a^2}$ (exact)
16. $O_3 = \dfrac{a^2}{2R}$ (approximate)

## 6.8.2. Compound Curves −




17. $t_1 = R_1 \tan \frac{1}{2} X$
18. $t_2 = R_2 \tan \frac{1}{2} Y$
19. $T_1 = t_2 + \dfrac{(t_1 + t_2)\sin Y}{\sin Z}$
20. $T_2 = t_2 + \dfrac{(t_1 + t_2)\sin X}{\sin Z}$

(c) Superelevation —

21. $h = \dfrac{wV^2}{gR}$ (on roads)

22. $h = \dfrac{GV^2}{gR}$ (on railways)

Notation —

$R$ = radius of curve

$D$ = degree of curve

$l$ = length of curve

$\alpha$ = deflection angle of curve

$T$ = tangent length

$L$ = length of long chord

$a$ = distance $PT_2$ in the figure

$v$ = versed sine of curve

$O_0$ = offset at midpoint of $T_1T_2$ = EG

$O_1$ = offset at a distance $x$ from E so that EP = $x$

$O_2$ = radial offset at K at a distance $y$ from tangent point along tangent

$O_3$ = offset perpendicular to tangent at J at a distance $z$ from tangent point along tangent

$R_1$ = smaller radius

$R_2$ = greater radius

$T_1$ = smaller tangent = $T_1V$

$T_2$ = greater tangent = $T_2V$

$t_1$ = tangent length towards smaller radius arc = $T_1K$

$t_2$ = tangent length towards smaller radius arc = $T_2K$

$X$ = deflection angle of curve of smalle radius

$Y$ = deflection angle of curve of greater radius

$Z = X + Y$

$h$ = superelevation in metre

$w$ = width of road in metre

$V$ = speed of vehicle in metre/sec.

$g$ = acceleration due to gravity, 9.81 metre/sec$^2$

$G$ = distance between the centres of the rails in metre ■

# VII. ARCHITECTURE

## 7.1. ARCHITECTURAL DESIGN

Architectural design is made up of two process — are mental and the other combining mental and physical. The first is the conception of the idea, which comes as an inspiration. The second is the development of this idea upon paper and its later realization in the permanent form of building.

The process of building grows from a demand stimulated by a definite need. There is practically no aimless building, for no same person erects a structure that has no purpose. Architecture is therefore the result of.

1) **Need for a Building :—** due to changes in physical, spiritual economical and social conditions.
2) **Solution of the Need :—** solving of the need by the following considerations in the process of designs.

   a) **Function :—** purpose of building-requirements, size, shape and location of individual units — Interests of occupants — Influences on site, materials and character.

   b) **Location :—** Country, climate, social structure — site, contan, shape Influences on materials and character.

   c) **Materials :—** accessibility, Influence of function upon. Influence on construction and character.

   d) **Creative Principles :—** Aesthetic organisation — influence on volume, plan, uniterior, and exterior composition.

   e) **Character :—** Functional character of building — Personal character reflected in materials and arrangement — Location character — influence of site and adjacent architecture.

Human element is very important in architecture. Therefore considerable thought must be given to social, economic and geographic influence upon the development of a structure. The architect of the present and the future must be about to changing modes of life.

Aesthetic considerations may constitute the spirit of architecture. Along with a study of harmony, balance and unity, should go that of materials, costs and equipment. As soon as an idea takes form in the plan the designer should begin to get the FEEL for construction.

The information growing out of the answers to the following questions is always expected from the architect.

1) How does the structure – to serve the client after it is built ?
2) Appr. how much it will cost ?
3) Is it economical in its use of materials and in its arrangement of parts
4) What materials should be used ?
5) What relation should be maintained between the aesthetic design and the construction.
6) How is the building to be operated after erection ?

The answers to the questions will indicate the success of the solution.

Architectural design to be successful, the solutions for a building should be arrived at by the following approach:

1) **Functional Considerations:**

Arrangement of volumes affected by

a) Use
b) Site
c) Climate
d) Construction.

2) **Structural Considerations:**

Construction influenced by

a) Function
b) Materials
c) Climate
d) Cost

3) **Aesthetic Considerations:**

Composition of plan and enclosing surfaces influenced by

a) Function
b) Site
c) Climate
d) Materials
e) Creative Principles

4) **Economic Considerations:**

Service rendered to client or to occupants of the building

a) Finance
b) Equipment
c) Operation

All these will make Architectural design seem move real.

Architecture is undoubtedly one of the most enjoyable professions. It offers a wealth of interest in a variety of fields which few other professions can match, and provides an emotional satisfaction which only the other arts can stimulate.

Architecture in general may therefore have to contend with the following activities:

**Design:** Architectural design is the creative planning for space — a three dimensional concept of the building based on our culture and way of life (living). This concept (or idea) is put down on paper in the form of a plan. On acceptance and approval of the plan by the client/owner, and with the necessary funds provided, the building plan is executed and translated into reality.

**Structural design:** Along with architectural planning and design we have to simultaneously consider the most economical structural planning and design for the building structure keeping in view the following:—

**Material:** Its availability, cost and use; the technology and skills (labour) available and other facilities required for the execution of the building project.

The architect considers himself to be the leader of the building team. To be successful he work closely with the other specialists in the team, such as, the Structural Engineer, the general builder (Contractor) and other allied specialists like water supply and sanitation, lighting, landscape architects, interior designers etc.

Present day architectural design demands that the plan should satisfy the following requirements:

1. Municipal and Corporation Building By laws and conform to Town planning regulations.
2. The requirements as per the National Building Code and various I.S.I. codes pertaining to Building construction.

The following have a bearing on our planning.

1. **Need:** Based on the need and social behaviour and culture the building is designed to suit the functional requirements.
2. **Land:** The availability of suitable land for the purpose; and other amenities have an important bearing in our planning. Land in urban areas is very scarce and costly. To have a workable cost we may have to consider vertical expansion of buildings for optimum space utilisation and economic cost.
3. **Material:** It is desirable that as far as possible the locally available building materials are used. In modern building construction, Cement, Steel, and timber are the essential and costly building materials which have a dominating influence on the total cost. Hence great care and attention will have to be observed in the use of these essential, building materials in building construction. There are other new building materials like aluminium, glass, plastics, fibre glass etc., which can be advantageously considered as alternate materials.
4. It should be ensured that the desired technology and skill (labour) is available to execute the building project conceived.
5. The finishing items to the building and the installation of service fittings etc. deserve our special care and attention. This will render easy maintenance of the installed equipments.

6. Elegant furniture and pleasing interior decoration, together with exquisite art pieces, murals, sculptures etc. adroitly, placed at strategic positions enhance the aesthetics and decor of the building.
7. Planting of ornamental trees and plants, and providing lawns will improve the environment and comfort conditions. Elegant fountains, lily ponds, drives and pathways etc. can be considered from the point of view of aesthetics.
8. It is desirable that the building is symbolic of the functional use to which the building is put to and it is good to follow the motto "Form follows Function"

## 7.2. Colour

Appreciation of colour is largely an emotional process felt by every one. Colour is a source of universal pleasure. Light is a source of colour. Light is the impression received by mind from its stimulation of the ritina. Colour occurs because objects reflects the light, enters the eye, acts on the nurve and use the sensation of the colour is in the brain. The fundamental colours of *Violet, Blue, Green, Yellow, Orange* and *Red* from a spectrum of the white light.

If an object appears green, it absorbs all colours of white light that falls on it and reflects only green. An object appears white because it reflects all the colours. An object appears black because it absorbs all the colours.

### 7.2.1. Pigment Colour Theory

Red, Yellow and Blue are the fundamental or primary colours. The secondary colours orange, violet, green are made by mixing two primary colours. The teritory colour is made by mixing two primary with adjoining secondary colour. The six colours yellow, green, blue, violet, red and orange are called the standard colours.

When any pair of complements (opposite) are combined equally it becomes grey. One of the best method of sub-ducing a bright colour is to add some of its complementary colour.

### 7.2.2. Qualities of Colours

Colour has three qualities. They are hue value and intensity.

Hue indicates the name of colour. The name refers to the spectrum colour of white light that is reflected.

Value is the amount of light of darnkess in colours, the lightest value is white. The darkness value is black. There are many degrees in between.

Intensity refers to the brightness or dullness of colours. For decoration, colours are subdued to some extent.

#### 7.2.2.1. Warmth or Coolness-

One of the most important factors in colour decoration to be considered is warmth or coolness. Colours of red and yellow are considered as warm and blue is regarded as cool. In any colour scheme either warm or cool should dominate. Equal value of colours are unpleasant.

### 7.2.2.2. Heaviness or Lightness

Violet is the lightness of all colours. Yellow is the heaviest of all colours. In any colour scheme heavy colour forms the base or lower portion. Heavy colours are suitable for men's room. Light colours for women and children's room.

### 7.2.2.3. Advancing and Receding Colours:

These qualities are realwarm colours advance. Cool colours recede. In decoration warm colour makes a room smaller. Cool colour makes a room larger.

### 7.2.2.4. Emotional effect of colour

Other reactions to colour are due to the meanings that are become associated with them. White suggestes innocence. Black suggests evil or death. Red suggests love and sacrifice. Yellow, the colour of the sun suggests cheerfulness, gaiety, optimism and even prosperity. It is considered as sacred colour throughout world in most of countries.

Red is the colour of fire and blood. It expresses primitive passion, warm, vigour, power movement aggression boldness and love. Red is the most beloved of colours. Blue is the colour of sky and deep water and so it expresses coolness. It expresses distance, space, loftiness, dignity, calmness, serinity etc.

Natural colours are white, black and grey. These are most valuable for large back-ground and the effect is cool.

Black suggests mysteries, wisdom, sophistication and usually creates dramatic or extreme effects.

White is serenity of coolness. White and off-white are generally used for both exteriors and interiors. An inexperienced person might usually use white-wash through-out the entire house. Pure white is the best with cool colours, where as green and off-white go well with warm schemes.

Grey got by mixing black and white has no particular character of its own. In light shadows dignified. Pale grey is pleasing for exteriors and white house with sleeping rooms and shutters look well with slate grey.

### 7.2.3. Colour Schemes:

It is highly desirable that anyone should develop his own colour sense by experimenting and by observation of beautiful examples elsewhere. The following formulae are of some help.

### 7.2.3.1. Monochromatic Colour Scheme:

This is the scheme in which only one colour is used with varying intensity and values.

### 7.2.3.2. Analogous Colour Scheme

This scheme is made by combining adjacent three colours of pigment colour circle. Adjacent colours are harmonious because it contains portions of same colour. They may likely to be too hot or too cool. Only one primary should be included.

*Examples:* a) Yellow green, Yellow and Yellow orange.

b) Red violet, Violet and Blue violet

### 7.2.3.3. Trial Colour Scheme

This is three colours on the points of equilateral triangle on the colour circle. It is well balanced one.

*Examples:* a) Yellow, Blue and Red

b) Orange, Green and Violet

c) Yellow orange, Blue green and Red violet.

In this scheme, the colours should be subdued.

### 7.2.3.4. Complementary Colour Scheme:

Colours that are opposite in colour circle are in this scheme.

*Examples:* Yellow and Violet/Red and Green/Blue and Orange.

It is usually a balanced colour scheme. Colour should be subdued and one colour should dominate.

### 7.2.3.5. Spilit complementary colour scheme:

In this system, one colour is used with two colours that adjoin its complement in the colour circle.

*Examples:* Yellow, Red violet, and Blue violet

Factors in colour scheme for room.

1) The room size, shape and exposure.
2) Mood
3) Style
4) Fashion
5) Personal Preference
6) Furnishings.
7) Use of the room.

A living room should express cheerfulness and hospitability with an atmost use of restfulness and relaxation. Therefore the colour should be cheerful but not over stimulating. Fairly light warm colours are mostly desirable.

The dining room is conservating and dignified. Certain pleasant surprises in colour and decorations can be used. Warm colours are refreshing and delicious. Kitchen should be cheerful, light and bright. A bed room is of usually personal choice and might well have favorite colour of the occupant.

### 7.2.3.6. General suggestions for a colour scheme

1. Use definite schemes such as complementary.
2. A safe scheme consists of tints and shades of colour only.
3. An easy scheme is white off-white with one or two colours.
4. Three colours, and their variations.
5. A colour scheme is often begun with teritary colour.
6. A colour scheme should be definitely dark or light.
7. A neutralised colour is the best for large areas.
8. A more definite colour is suitable for medium areas.
9. A complementary colour to a dominate colour in small areas.
10. If a colour is not brilliant, a contrasting colour or white may be added.
11. Equal areas of different colours are monotonous.

## 7.3. Planning of Residential Buildings :

These may be classified as Individual House and Apartment buildings.

In the early ages, the private houses were subordinated to other types of buildings socially for thousands of years. It was the temple that was given priority by society and the temples influenced other type of constructions. In the European architecture, the temple was supplemented by baths etc. and attention was given to houses belonging to certain sections of the population close to the hinge. It was given to Frank Lloyd Wright and Lecorbusur who both developed theories and shifted the emphasis and influenced the entire world of architecture as a result of their study of the design problems presented by the individual private houses.

It was the Italian renaissnce that marked the house architecture and it took precendance over church or temple. Previously house was in reality a place or a willa and it was limited to a minute fraction of the community. Such buildings were scattered over the country side.

In England by 1800, the "Country House" had reached a high point of development. Social changes started taking place and the industrial revolution created a middle class and upper class sufficiently affluent to build houses of their own. Wealth was getting distributed and there was sudden upsurge in architecture, spreading throughout the length and breadth of the country to all classes of people.

The present century abandoned the rules and percepts which have dignity to earlier types of buildings. Now conditions of freedom were created, the general direction was constructive and creative.

The concept of "open plan" with large glass panels for windows, sliding doors, use of windows in long rows was given birth to.

### 7.3.1. Basis of Contemporary House :

The house is to shelter a family and to provide for its necessary activities. Technological, social and phyohological conditions fistered the growth of the modern house.

A man requires a house open on the ground floor and closed on the second Building large houses were given up because they have become unmanageable and unsustainable.

House is now a "machine for living". The houses had to become man efficient in terms of maintenance. This had lead to shrinking house types to reduce house keeping problems and in most cases to the reduced amount of money available for the houses.

A small house does not mean uncomfortable house. A room in it may be small but with a large window opening it seems bigger. A several small rooms may be so designed that they merge into one large room to get an increased sense of space.

## 7.3.2. Analysis of Contemporary House:

The demands of the family are to be satisifed sleeping, cooking, eating, bathing, study, wash, social activities and relaxation. These activities may require a series of distinct areas but it is vintually impossible because of the cost of the building and the difficulties in maintenance. Hence the function of rooms are combined. A larger proportion of the population has been educated and a great deal of time may be spent in reading. A storage problem has not been created.

Television sets, radios and record players offer a kind of entertainment at home and they introduce a new element in building. Orient is also needed in our homes and more privacy may be needed. Extra space may be required for community work. The living pattern of to-day is largely changing.

## 7.3.3. Living Room:

This should be as large as owner can afford to make it. It may also include dinning space. In extreme cases it may be even merged with kitchen. It is lined to outside by means of large window walls to a porch, terrace or garden. This room is used for a variety of activities. It is used for indoor games, for study, reading learning for parties family meals and formal dinners. It's furniture should include storage units for various activities.

## 7.3.4. Kitchen:

A generation ago, the concept was to separate the living room from the kitchen by a pantry a dining room or often a corridor. To day guests are likely to be invited into the kitchen may shrink as the techniques of preparing food get changed.

Pre cooked and frozen means may one day come when the house wife will be able to store complete meals in a deep-freezer and to serve them with no preparation at all.

Several facts point to a tendency in that direction. Ultimately the kitchen may reduce to a cubicle.

## 7.3.4.5. Dinning Room:

Today there is the disappearance of the dinning room. There is only one to 2 hours of activity in a day in this room and a dinning room becomes un warranted and a waste. The most common procedure today to establish a dinning area. Somewhere in the living room and to supplement this with a permanent dinning alone in the kitchen or immediately adjacent to it.

## 7.3.4.6. Sleeping Areas:

The trend to-day is a minimum house due to high building costs. hence our attempt is to at the smallest possible house with adequately designed sleeping areas.

Bed room is a large room 12' × 15' which is by no means extravagant. Here is the space devoted to sleeping and dressing with a double bed or twin beds, a bureamor dressor a chest of drawers, one or two night tables and one or two chairs.

The average bed room has to be large otherwise there will be no possibility of moving a round it or even of placing the furniture. Bureaus and chests may be eleminated by installing the necessary drawers and trays in either than the wall or a closet. Beds have been reduced inside and a space 8' × 12' is large enough for sleeping requirements of any couple.

The need for privacy is steadily increasing with the dining room gone and the living room developed as one large area designed for a vareity of family uses, the bed room has become the last refuge in the house.

Bed room serves as a secondary sitting room, the purpose of which is to allow parents and children to carry on their own activities here.

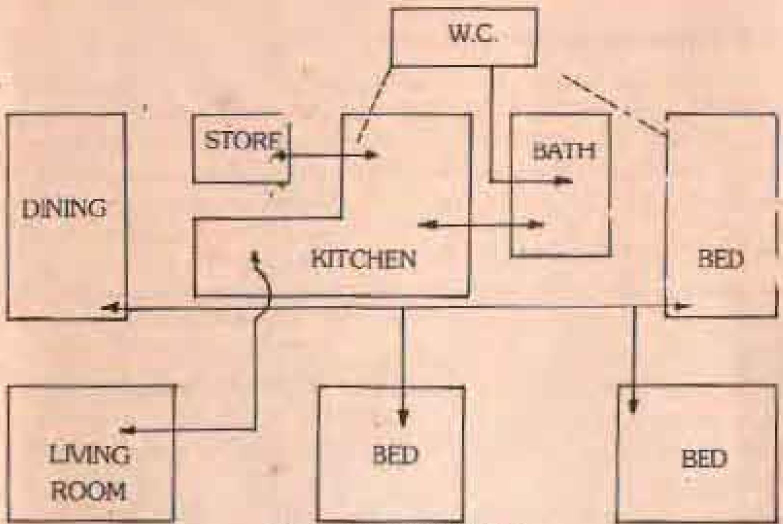
## 7.3.7. Storage Spaces:

There should be enough closet space for storage in the house. Provision for book storage, storage for clothing and well storage systems all become necessary. The concept should be "Adequate closet space"

## 7.3.8. Bathroom:

The modern bathroom is the one room in the house which has been squazed down to an absolutely irreducible minimum and the reason is that bath rooms are designing for fixures instead of for the people who use them minimum area is 30 sq.ft. (6' × 5). The costly part of the bathroom is the fixtures and plumbing. Minimum bathroom is the standard even in expensive houses.

Some wasteful modern bathrooms are luxuriously furnished with telephones, build-in-radios, ash trays for by the tube reading lights, a shower as well as a tube, a lounge curved with water proof fabric, sun lamps, medicine chests, materials and equipments for exercise. In other words given to imagination and luxurey, the bathroom turned out to be elaborate and unconventional. There is a feeling with certain people that the bathroom should be used for after wider range of activities than normally carried on it is. A pleasant relaxed feeling may be made in a bath room by provision of these amentities.




HOUSE PLANNING

## 7.4. HORTICULTURE

The word 'HORTICULTURE' means growing of fruits. But in its general application it includes Floriculture, Olericulture and plantation crops besides fruits. It can be said that the development of horticulture commenced from the period when man has identified the edible fruits and tubers from among the innumerable kinds and varieties available in nature. The mango, jack and banana are some of the important fruits mentioned in early Tamil Literature. These early literature also mention about the different kinds of flowers used for different purposes like Vagai (Albesia) for the celebration of victories and Malli, Arali etc., for pujas. Similar there are mentions about spices like Pepper and Cardamum.

No doubt that, the land in its undisturbed state is beautiful. The hill ranges with green or desiduous forest or grass land with swift flowering streams, are as pleasing as the vast stretch of desert with its shining sand and occasional oasis. But with the growing needs of man non-interference in the natural conditions of the land has become impossible. Such interferences had caused not only serious damages but also created a number of ugly spots. It is in this context horticulture has special reference to Civil Engineers.

As Civil Engineers are involved in a number of construction works which vary widely. It may be large dams for irrigation and Electricity or small wells for drining water. It may be a big structure for steel plant or small huts for the under previleged sections of our societies. It may be winding road up a steep hill or a straight road in a slushy valley. Whatever may be type of work when the natural condition of the area is disturbed, where is scope for leaving a number of ugly scars. The development of the area around these constructions in such a way not only to erase the ugly scars but also to make the constructions merge with the surrounding s what is called landscaping.

## 7.4.1 Preservation of Landscape:

This aspect is more important for large constructions like Dams Industrial Complexes, Satellite towns and even individual houses with large surrounding area.

While considerable Research and developments have been made in the designs of the structures suited to the locality, comparatively very little attention is given to landscape development in the plan and construction stage. This is evident in most of the gardens developed near the dams in our state.

For landscape development adjoining dams, it is essential to have areas in proportion to the length and height of the masonary structure. In the Mettur Dam, if the hump between the two outlets had been covered with good trees, the appearance and atmosphere of the area would have very different than what is is now. No doubt it contains rocky area. But if proper assessment of the spicies of trees that existed at the time of construction of the dam was made, these could have been either preserved or re-established to form a Woodland. With well laid out footpaths and location of flowering trees that entire slope could have been developed into one of the beautiful tree park. The would have not only changed the atmosphere of the new industrial township there, but also enhanced the importance of Mettur Dam as a Tourist Centre. The existing garden below the masonary wall does not help to merge the dam structure with the surrounding mainly because of its size which is too small for the gigantic masonary structure of the dam.

The large industrial complexes where there may be more than one structure, it is essential to include in the plan itself the landscape development between such structures. This will help to provide sufficient space for the suitable kinds of trees. Since trees form an important item in any landscape gardening, fixing the type of trees, either full and slim like *Polyalthea Pendula*, or medium and spreading like *Cassia* or large like *Peltophora*, suitable for the location is more important. Besides its ornamental value selection of suitable trees is important depending on the type of industries, as they help to prevent movement of dust, serve as sunshade etc.

The above concept holds good also for the new townships that are being developed around most of the big cities. Chandigarh is one such city developed with a good plan for the landscape development. Apart from this city, New Delhi and Bangalore have also such well developed areas.

In Western countries like West Germany most of the big cities have a well developed tree parks and these are known as the lung of the cities. But in our States, even the few existing avenue trees in the most of the towns may also be lost in the next few years.

But there are a number of large houses with well developed landscape gardens in our State, particularly on the Nilgiris. In this hill station, where large Tea

Plantations exist, proper care has been bestowed in most of these planations, in the selection of the location for the house and development of the surroundings to merge with the green and undulating Tea fields. Similarly in Madras and other cities also quite a few large houses have well developed gardens. These house gardens indicate the possiblities and scope for development.

With these examples, it is stressed that Civil Engineering and 'Horticulture' have great role to play. in providing the living and working places of the people with surroundings that will be pleasing to the eyes and good for health. ■

# VIII. BUILDINGS

## 8.1. LOADS AND WEIGHTS ON FOUNDATIONS

### 8.1.1. Safe loads on common soils:

| Rocks | tonnes/sq.m. | Rocks | tonnes/sq.m. |
|---|---|---|---|
| Hard rock | above 220 | Moorum | 20 to 45 |
| Ordinary rock | above 110 | Clay shales | 110 |
| Sand stone | 130 to 220 | Marl & firm shale | 65 |
| Limestone | 100 to 200 | Hard chalk | 45 to 65 |
| Soft rock | 20 to 90 | Soft chalk | 17 |

Intensity of pressure on a rock foundation should at no point exceed one-eighth pressure which would crush the rock.

### 8.1.2. Safe loads on cohesive soils:

| | |
|---|---|
| Very stiff boulder clays | 65 |
| Hard or stiff clays and sandy clays | 30 to 44 |
| Firm clays and sandy clays | 20 |
| Ordinary clays | 20 |
| Sandy and clay mixed or in layers | 20 |
| Red earth | 30 |
| Moist clay | 10 to 20 |
| Soft clays and silts | 10 |
| Very soft clays and silts and peat | 5 to nil |
| Black cotton soil | 5 to 10 |
| Alluvial loams | 9 to 17 |
| Alluvial soil | 3 to 9 |
| Made ground (consolidated) | 5 |
| Hoggin (compact) | 65 |

### 8.1.3. Safe loads on non-cohesive soils:

| | |
|---|---|
| Compact gravel or sand well cemented | 55 to 80 |
| Compact gravel or sand and gravel | 43 to 55 |
| Loose gravel or sand and gravel | 30 |
| Compact coarse sand (confined) | 45 |
| Loose coarse sand | 20 |
| Compact fine sand (confined) | 32 |
| Loose fine sand | 10 |
| Sand with clay | 20 |
| Kankar | 32 |

Note:

(i) *The above values are only approximate and the allowable bearing pressure for individual soils may differ considerably. The figures have a factor of safety of 2 to 3.*

(ii) *If the ground water level in sand or gravel soil is likely to approach foundation level the safe bearing pressure should be reduced to above one of the values given.*

(iii) *For eccentric loads the maximum safe pressures may exceed by about 10 precent.*

(iv) *The safe bearing pressure can be exceeded where the foundation is taken well down in the ground by an amount equal to the weight of the material which is displaced by the foundation itself.*

*In the case of non-cohesive soils the bearing pressure may be increased by one-eight of a ton for each foot of depth of the loaded area below the lowest ground surface immediately adjacent.*

*For foundations supported on cohesive soils, the settlements of footings for a given unit pressure increase with the linear dimensions of the footings. There would therefore be a different allowable pressure for each size of footing on a given cohesive soil if uniform settlement were required.*

(v) *The ultimate bearing capacity of soils under long rectangular footings should be taken only ¾ th of the bearing capacity under square footings.*

## 8.2. PERMISSIBLE LOADS ON MASONRY

*(For good class materials)*

| | | tonnes/sq.m. |
|---|---|---|
| Cement concrete | 1 : 1 : 2 | 420 |
| — do — | 1 : 1½ : 3 | 350 |
| — do — | 1 : 2 : 4 | 310 |
| — do — | 1 : 3 : 6 | 200 |
| — do — | 1 : 2½ : 5 | 165 |
| — do — | 1 : 4 : 8 | 110 |
| Mass cement concrete | 1 : 6 | 200 |
| — do — | 1 : 8 | 165 |
| — do — | 1 : 10 | 110 |
| — do — | 1 : 12 | 55 |
| Lime concrete | | 45 |

| | | |
|---|---|---|
| Brick work in cement | 1 : 3 | 100 |
| – do – | 1 : 4 | 90 |
| – do – | 1 : 6 | 55 |
| – do – in lime | | 45 |
| – do – in mud | | 27 |
| – do – sundried | | 10 |
| – do – do – in mud | | 16 |
| – do – country, in lime | | 35 |
| Stone masonry, ashlar, in cement | 1 : 3 | 175 |
| – do – do – | 1 : 6 | 90 |
| – do – in lime | | 80 |
| Coursed rubble masonry in cement | 1 : 4 | 110 |
| – do – – do – | 1 : 6 | 55 |
| – do – in lime | | 50 |
| Random rubble masonry in cement | 1 : 4 | 90 |
| – do – – do – | 1 : 6 | 45 |
| – do – in lime | | 35 |
| Block masonry in 1 : 3 cement mortar, average crushing strength of block not less than | | |
| 35 kg/sq.cm. | | 27 |
| 70 " | | 65 |
| 140 " | | 105 |
| Solid cement concrete block masonry in cement | 1 : 3 | 165 |

## 8.3. SUPERIMPOSED (LIVE) LOADS ON FLOORS *— Kg/sq.metre

| | |
|---|---|
| 1. Floors for residences, hostels, hospitals etc. | 200* |
| 2. Floors for offices, schools, assembly halls, banking halls, etc. | 250 — 400* |
| 3. Floors for factories, warehouses etc., for light weight loads and office rooms for filing and storage | 500 |
| 4. Stairs, landings, corridors of residencies, balconies, not liable to over-crowdings | 300 |
| 5. Floors for factories, warehouses etc. for medium and heavy weight loads. | 750 — 1000 |
| 6. — do — , subject to over-crowding | 500 |
| 7. Telephone exchange rooms, transformer rooms | 1000 |

SUBJECT TO A Min : Total load of 2.5 times for slabs and 6 times for beams, uniformly distributed. Beams, ribs and joists spaced not more than one metre centres may be calculated for slab loadings.

"Superimposed loads" consists of persons occupying the rooms, furniture, equipment etc.

Average weight of men = 68 kg each 5 men should in a space of 1 sq. yard (0.84 sq.m.)

Experiments show that it is possible for a crowd of people to exert as high a weight as 880 kg/sq.m. of floor area. A weight of 680 kg/sq.m. is quite possible where there are throngs of people. A load of 400 kg/sq.m. is quite frequent in buildings and private houses at social gatherings. A crowd of men pushing against a balastrade may exert a horizontal pressure of about 250 kg/m run when they are three deep.

Minimum load for slabs of less than 6 sq.m area shoud be taken as for 6 sq.m and for beams of less than 2.44 m span load should be taken as for 2.44 m. Beams, ribs and joists spaced at not more than 0.9 m centres may be calculated for slab loadings.

Weights to be taken for the design of foundations:—

(i) Dead loads of : Foundation concrete, walls, roofs, floors, projections and any concentrated loads.

(ii) Superimposed loads on floors, roofs, staircases, etc. Vertical components of any horizontal thrusts in warehouses or workshops, or from arches.

In buildings where the superimposed load does not exceed 500 kg/sq.m. the following reduction is made in the superimposed loads for the design of columns and foundation in multi-storey buildings:— The superimposed load on the top most storey is in accordance with the above table but a reduction of 10, 20,30, 40 and 50 percent is made on the superimposed load on the Ist, 2nd, 3rd, 4th and 5th storeys respectively below the top most storey and 50 percent for all the succeeding storeys where the building consists of more than 6 storeys. It is highly improbable that full load will ever be imposed over all the floors at one time except in the case of warehouses in which full load conditions might occur. Some engineers take only 50 percent of the total superimposed load on all the storeys except the Ist.

An ordinary single storey residential building imposes a weight on the foundations of about 10 to 15 tonnes per sq.metre, a 2-storey building, of about 15 to 20 tonnes, and a 3 storey building of about 20 to 25 tonnes per sq.metre. A 3 storey building of the heavier type may have a weight of about 40 to 45 tonne per sq.metre.

# 8.4. DESIGN OF FOUNDATIONS FOR BUILDINGS

**Deapth of Foundations :—**

Minimum depth of foundation is given by:

$$h = \frac{P}{W}\left[\frac{1 - \sin\phi}{1 + \sin\phi}\right]^2$$ Rankine's formula applicable to loose soils.

Where: h = min. depth of foundation in m below ground level; P = safe permissible pressure on the base in kg/sq.m.; w = weight of the soil in kg/cu.m.; $\phi$ : angle of repose of the soil material.

For tall structures such as chimneys and towers, ¾ th of the safe load on the soil should be taken and the depth 'h' increased by 1/3.

Foundations are generally taken down to about 90 to 120 cm for main walls, 45 to 60 cm for partition walls and 30 cm for boundary walls in ordinary soils 2 to 3 storey buildings weights. But foundations must be taken down to a firm soil and below weathering effects. When part of a footing is weaker soil, that part should be taken down deeper and separated or measures adopted for equal distribution of pressures according to the bearing capacity of the respective soils.

## 8.4.1. Rankine Coefficients

| Slope | Angle $\phi$ | $\frac{1 - \sin\phi}{1 + \sin\phi}$ | $\frac{1 + \sin\phi}{1 - \sin\phi}$ |
|---|---|---|---|
| 1:6 | 5° | 0.840 | 1.19 |
| | 10° | 0.704 | 1.42 |
| 1:5 | 11°20' | 0.672 | 1.49 |
| 1:4 | 14°0' | 0.610 | 1.64 |
| | 15°0' | 0.589 | 1.70 |
| 1:3 | 18°30' | 0.518 | 1.93 |
| | 20°0' | 0.490 | 2.04 |
| 1:2 | 26°30' | 0.383 | 2.61 |
| | 30° | 0.333 | 3.00 |
| 1:1½ | 33°40' | 0.287 | 3.49 |
| | 40°0' | 0.217 | 4.60 |
| 1:1 | 45° | 0.172 | 5.83 |

### 8.4.2. Soils Weights and Angle of Repose

| Materials | Weight Dry | Angle of repose degrees | |
|---|---|---|---|
| | kg/m³ | Dry | Wet |
| 1. Gravel & Sand | 1600 | 30-35 | 30 |
| 2. Gravel | 1600 | 30-35 | 30-35 |
| 3. Loam | 1520 | 35-40 | 25-30 |
| 4. Fine Sand | 1600 | 30-35 | 30 |
| 5. Coarse Sand | 1600 | 35 | 30-35 |
| 6. Shingle | 1600 | 35 | 35 |
| 7. Clay | 1920 | 35-50 | 15-25 |
| 8. Sandy clay | 1840 | 30-40 | 25-30 |
| 9. Peat | 560 | 45 | 15-30 |
| 10. River mud | 1440 | 15-29 | 5-10 |
| 11. Sand & Gravel filling | 1440-1600 | 35 | 30 |
| 12. Clay filling | 1600 | 35-45 | 15-25 |
| 13. Rock filling | 1440-1760 | 45 | 45 |

## 8.5. TAMILNADU BUILDINGS (Lease and Rent Control) Amendment Act 1973

This new Act came into force from 30th June 1973, vide Chief Engineer (Building) circular memo No. Wks II (3) 67092/73-8 dated 15-10-73.

The Government in their memo. No. 907/Q/47-2 PW dated 2-4-47 have already ordered that the provisions contained in section 4 of the Tamilnadu Buildings (Lease and Rent control) Act should be given due consideration for calculating the resonableness of rent for private buildings taken on lease for Govt. purposes, the following revised instructions in lieu of the circular Memo. R. DIS Wks. II (3) 1014131-72 dated 23-8-72 and WKs II (3) 67092/73-1 dated 8-5-73 of CE(B) are issued in accordance with the principles contained in the latest Act for further guidance of this departmental officers and strict compliance.

(a) The resonable rent of any Residential Building shall be 9% gross return per annum on the Total cost of the building.

Note: *Residential building includes Hostels also vide Govt. Memo. No. 17312-A. C 1/72-9 Home dated 11-11-76.*

(b) The reasonable rent of any Non Residential building shall be twelve percent gross return per annum on the Total cost of the building.

(c) The reasonable rent for any residential or non residential building located in non-Municipal or Corporation areas shall be 7% gross return on the total cost of such building.

(d) The total cost referred to above shall include the following.

## 8.5.1. Cost of construction:

The cost of construction of a building shall be the probable cost of reproducing the building at the same condition and at the prevailing market rates. For this purpose the Suptg. Engrs. of P.W. Circles are required to prepare and furnish annually to Exe. Engineers and local accommodation controllers, the Schedule of plinth area rates as per G.O. Ms. No. 2433 Home dated 12-9-73 vide copy communicated in this office circular Memo. No. Wks. II (3) 67092/73-6 dated 21-9-73. The schedule of plinth rates will indicate the plinth area rates for various classes of buildings in accordance with prevailing market rates in the locality and also the maximum percentage upto which provision can be made for internal water supply sanitary and electrical installations. The probable cost of construction of a building calculated on the basis of the rates and percentage indicated in the schedule of plinth rates, should be reduced proportionate to the age and nature of construction of the building in the manner prescribed in G.O. Ms. No. 1370 P.W. dated 4-7-67.

In special cases where the nature of construction of a building in the opinion of the rent certifying officers, requires a higher or lower rates or percentages for fittings than the rates of percentages prescribed in the schedule of plinth area rates; then the rent certifying officers may allow or disallow an amount not exceeding 30% of the cost of construction. This provision should be sparingly and judicially exercised by the Rent certifying officers themselves. The Executive Engineers, should however report in detail such cases to Suptg. Engrs. and obtain their prior approval before issuing rent certificates in such cases as it involves fixing rates higher/lower than the rates prescribed in the schedule of plinth area rates.

## 8.5.2. Market value of land:

The maximum extent of land to be taken into consideration for this purpose should not exceed one and half times of the actual built up area of the building. If the total extent of land available in a building compound is less than the maximum limit prescribed above, then the land value should be restricted to the actual extent of land available. The extent of land in excess to the maximum limit prescribed can be treated as amenity.

Note: *The market value of land shall always be assessed and fixed in consultation with the Revenue Officers not below the rank of Tahsildars of the Taluk concerned.*

## 8.5.3. Cost of amenties:

The items which are to be treated as amenities and separately valued for are indicated in the Annexure to this circular.. The cost towards such amenities should be restricted to the limits indicated below.

(a) In the case of residential buildings 15%

(b) In the case of Non residential building 25%

Of the cost of construction and the market value of land determined in the manner prescribed in para 2 (d) (i) and 2 (d) (ii) above.

Note: *The rates and percengages indicated in the schedule of plinth area rates should be exclusive of the cost of amenities.*

(i) If the rent demanded by the house owner is less than the calculated rent, then the certificate should be restricted to the rate of rent actually demanded by the House owner.

(ii) In any case, the reasonable rent certified should not be higher than the prevailing market rate of rent for similar type of accommodation in the same locality.

(iii) For any special or peculiar conditions, if it is considered necessary to recommend a higher rate of rent than the calculated rent in the manner prescribed above, then such cases should be reported, to Chief Engineer, Buildings with full details; working sheets plans and the special or peculiar conditions warranting such higher rates of rent etc.; for obtaining the approval of the Govt. as the case may be.

## 8.5.4. Enhancement of rent:

Enhancement of rent is not admissible except under the following circumstances.

(i) Where additions, alterations or improvements to the building has been carried out by the house owner.

(ii) Where the local body was imposed a new tax or cess or increased the tax/cess on the building on the grounds other than increase in the rate for the building.

(iii) Once in 3 years, vide G.O. Nos. No. 753/PW/Dt. 7.4.84 the rent can be revised.

Note: *The both of the above two circumstances, the amount of increase in rent should be equal to the rent for additions alternations improvements new tax or cess or additional tax or cess as the case may be.*

## 8.5.5. Special concession:

In cases where the reasonable rent for a building has already been fixed before the commencement of the Tamilnadu Building (Lease and Rent control) Amendment Act. 1937 i.e. before 1-7-1973 in accordance with the principles underlined in the previous act, then the reasonable rent for such buildings may be revised in the manner prescribed above provided the house owners of such buildings specifically asks for such revision of revised or enhanced rent in such cases should be given effect only from the date of application from the house owner or from 1-7-1973 whichever is later.

## 8.5.6. General Procedure:

(i) In respect of buildings exceeding 1000 S.Ft. of carpet area in Madras city and Coimbatore town, the Superintending Engineers concerned should issue the reasonableness of rent certificate Govt. Memo No. 96908/G2/68-7 P.W. date 6-8-69 and Govt. Memo No. 91969/68-9 P.W. date 29-7-70. In all other cases, the Executive Engineers concerned will issue the certificates.

(ii) Care should be taken to issue the certificate within a month's time from the date of receipt of requisition from the officer concerned. There should be no delay in issuing reasonable rent certificate beyond this one month period.

(iii) (a) The section officer should prepare the line sketch as of the building after personal inspection of the premises and record correct measurements in the line sketches. The Sub Divisional Officer should countercheck the line sketches and affix his signature therein after certifying as 'vertified and found correct'. The line sketches should be drawn to scale. No technical officer should submit his report to his higher officers with line sketches or plans 'drawn not to scale' The Section Officer who prepared the line sketch for the building should also workout the total cost of construction of the building in the manner prescribed in para 2 above. The Sub Divisional Officer concerned then inspect the building and check the calculation of the total cost of the building. The Sub Divisional Officer shall be responsible for the correctness of the line sketch for the building, the plinth area rates to be-adopted, value for amenities, percentage to be adopted for electrical, sanitary and water supply fittings probable age of the building correct extent of land suitable depreciation for the building.

(b) On receipt of report from the S.D.O. the Exe-Engineer shall after personal satisfaction of the reasonableness of the rent for the building will issue the certificate in cases where he is competent to issue the certificate or forward the proposals with his report to the S.E. concerned in cases where the S.E. is competent to issue the certificate. The rent certifying officers will be personally responsible for the reasonableness of the rent certified by them and for the correctness of all working sheets and plans prepared in this connection.

Note: *The total cost of construction should be worked out and calculated only by technical officers in the Division Circle office. Such calculations should be checked by the Head Draftsman and on no account it should be allowed to be done by ministerial staff. The Divisional Accountant/ Manager will check only the correctness of the procedure followed in calculating the reasonable rent with reference to the above instructions, Government orders, Code rules and Chief Engineer's circular instructions i.e. issued from time to time on this subject.*

(c) "A register of rent certificate issued" may be maintained in Divisional offices and in Madras Chingleput Circle and Coimbatore Nilgris circle office, with full details about the Certificates issued by the concerned office, indicating the date of receipt or requisition, date of issue, plinth area of the building, location i.e. address, rate of rent certified etc. This register should be made available for inspection in Division office by S.E and in circle offices by Chief Engineer.

## 8.5.7. List of Amenities

1. Air-conditioner
2. Lift
3. Water cooler
4. Electrical Heater
5. Fridge
6. Mosaic flooring
7. Side dadoos
8. Compound walls
9. Garden
10. Over Head tank for water supply
11. Electric pump and motor for water supply
12. Playground
13. Badminton and Tennis courts
14. Sun Breakers
15. Vacant land appurtenant to the building in excess of the maximum limit of one and a half times the built-up area referred to in para 2 (d)(ii)
16. Usufructs, if any enjoyed by the tenant
17. Features or special architectural interest

Note: *The procedure of treating electrical water supply, and sanitary fittings as amenities, and providing allowance for 'Locality etc. has been dropped in the present amended Act of 1973."*

## 8.5.8. Proforma

**Part I To be filled by the occupying department.**

1. Name of the Office
2. Location of office.
   (Name of street, Door No. etc.)

3. Date of Occupation :
   b Whether the entire building has been occupied or only a portion thereof. :
   c. No. of electric light and fan points in the building or portion under occupation :
   d. Whether the building is provided with a compound if, so, open space, if any available inside the compound :
   e. Monthly rent of building or portion of building :
4. Strength of office
   a. Gazetted. :
   b. Non Gazetted :
   c. Ministerial :
   d. Others :
5. Carpet area. :
   a. Available in the building :
   b. Required as per year stick prescribed in G.O. MS. No. 1274/F public works Dt. 17-5-61 :
      For Officers :
      For Subordinate staff :
      For records :
      For other purposes (to be sepecified) :
      Total :

(c) Balance of space if any available (a) − (b) :

**Part II**

**To be filled by the Exe. Engr. PWD. concerned**

6. Total carpet area available for occupation :
7. Estimated capital cost of building or portion rented. :
8. Monthly rent certified :
9. Remarks on (5C) above. :
10. Any other remarks :

Signature of the E.E./PWD

## 8.5.9. Standard Rate of Depreciation

| Kind of building | Rate of Depreciation per annum |
|---|---|
| 1. Building built in lime mortar in which teak has been used throughout ... | 1% |
| 2. Buildings built partly in brick in mortar and partly in brick in mud and in which teak has been used ... | 1½% |
| 3. Buildings built in brick in mud and in which country wood has been used ... | 2% |
| 4. Building like police lines which are inferior to those of class 3 above, with brick in mud unplastered walls, mud floor and in which cheap country wood has been used ... | 4% |

Note: *The depreciation shall be calculated for each year on the previous net value arrived at after deducting the amount of depreciation of the previous year.*

Property tax on Government Building Rate at which the amount of Depreciation shall be calculated.

(i) The amount of depreciation shall in no case be less than 10% of the present estimated cost of the building.

For a building aged 'n' years the depreciated value 'p' is to be worked out as follows:

$$p = A\left(\frac{100 - r}{100}\right)^n$$

Where

P = depreciated value of the building at the end of 'n' years

A = The original value of the building if known or the value arrived at current rates for a building of the same accommodation.

r = the rate of depreciation per annum

n = the number of years (age of building)

The amount of depreciation will be equal to (A − P) subject to a minimum of 10% of A

# RATES OF DEPRECIATION

| No. of years | Amount of depreciation at 1% | 1½% | 2% | 4% |
|---|---|---|---|---|
| 1 | .01000 | .01500 | .02060 | .04000 |
| 2 | .01990 | .02978 | .03988 | .07840 |
| 3 | .02970 | .04143 | .05863 | .11526 |
| 4 | .03940 | .05866 | .07703 | .15065 |
| 5 | .04901 | .07278 | .09608 | .18463 |
| 6 | .05852 | .08669 | .11416 | .21724 |
| 7 | .06793 | .10039 | .13187 | .24855 |
| 8 | .07725 | .11389 | .14924 | .27861 |
| 9 | .08648 | .12718 | .16625 | .30747 |
| 10 | .09562 | .14027 | .18293 | .33517 |
| 11 | .10466 | .15317 | .19927 | .36176 |
| 12 | .11361 | .16587 | .21528 | .38729 |
| 13 | .12248 | .16838 | .23098 | .41160 |
| 14 | .13125 | .19070 | .24636 | .43533 |
| 15 | .13994 | .20285 | .26143 | .45791 |
| 16 | .14854 | .21480 | .27620 | .47960 |
| 17 | .15706 | .22658 | .29068 | .50041 |
| 18 | .16549 | .23818 | .30486 | .52040 |
| 19 | .17389 | .24961 | .31877 | .53958 |
| 20 | .18209 | .26086 | .33239 | .55800 |
| 21 | .19027 | .27195 | .34574 | .57568 |
| 22 | .19837 | .28287 | .34883 | .59265 |
| 23 | .20639 | .29363 | .37165 | .60895 |
| 24 | .21432 | .30422 | .38422 | .62459 |
| 25 | .22218 | .31466 | .39653 | .63960 |
| 26 | .22996 | .32494 | .40860 | .65402 |
| 27 | .23766 | .33507 | .42043 | .66786 |
| 28 | .24528 | .34504 | .43202 | .68114 |
| 29 | .25283 | .35487 | .44338 | .69390 |
| 30 | .26030 | .36454 | .45451 | .70614 |

# RATES OF DEPRECIATION

| No. of Years | Amount of depreciation at 1% | 1¼% | 2% | 4% |
|---|---|---|---|---|
| 31 | 26770 | .37407 | .46542 | .71790 |
| 32 | 27502 | .38845 | .47612 | .72918 |
| 33 | 28227 | .39271 | .48659 | .74001 |
| 34 | 28945 | .40182 | .49686 | .75041 |
| 35 | 29655 | .41079 | .50692 | .76040 |
| 36 | .30359 | .41963 | .51679 | .76998 |
| 37 | .31055 | .42834 | .52645 | .77918 |
| 38 | .31745 | .43691 | .53592 | .78801 |
| 39 | .32427 | .44536 | .54520 | .79649 |
| 40 | .33103 | .45368 | .55430 | .80463 |
| 41 | .33772 | .46187 | .56321 | .81245 |
| 42 | .34434 | .46995 | .57195 | .81995 |
| 43 | .35090 | .47790 | .58051 | .82715 |
| 44 | .35739 | .48573 | .58890 | .83407 |
| 45 | .36381 | .49344 | .59712 | .84070 |
| 46 | .37018 | .50104 | .60518 | .84708 |
| 47 | .37647 | .50582 | .61308 | .85312 |
| 48 | .38271 | .51590 | .62081 | .85607 |
| 49 | .38888 | .52316 | .62840 | .86470 |
| 50 | .39499 | .53031 | .63583 | .87011 |
| 51 | .40104 | .53736 | .64311 | .87531 |
| 52 | .40703 | .54430 | .65025 | .88030 |
| 53 | .41296 | .55113 | .65725 | .88509 |
| 54 | .41883 | .55787 | .66410 | .88968 |
| 55 | .42464 | .56450 | .67282 | .89410 |
| 56 | .43040 | .57103 | .67740 | .89833 |
| 57 | .43609 | .57746 | .68385 | .90240 |
| 58 | .44173 | .58380 | .69018 | .90630 |
| 59 | .44732 | .59005 | .69637 | .91005 |
| 60 | .45284 | .59619 | .70245 | .91365 |

# 8.6. STANDARDS OF CINEMA THEATRE BUILDINGS

*(Based on Tamil Nadu cinematograph Manual as corrected upto 31.12.82)*

## 8.6.1. Requirements for Permanent Cinema Building(Para 53 and 54)

(1) Road frontage on the Public throughfare.

(2) Suitable booking windows and room for queues of would be purchasers to form within premises.

(3) Hand railing, 1.2 metre high in front of booking window, of G.I. pipes at 0.2286 M to 0.3048 M centres in Tubular post as per M.D.S.S. No. 88 Width of passage not less than 60 cm.

(4) Shelters and hand railing to be sufficient to accomodate at-least one third of would be purchasers.

(5) Three sides of the building with an open space not less than 6.10 M in width exception if adequate space is provided in Ground Floor or basement floor over which auditorium is located.

(6) Eaves shall have height not less than 3.10 M.

## 8.6.2. Scale of sanitary accommdation – (para 55)

Men:– Urinals one stall (seat, for every 100 persons.
Latrines – one stall (seat) for every 200 persons.
Women – same scale as for men.

## 8.6.3. Ceiling:– To confirm to clause 9.4 of IS : 1942 – 1960 (para 56)

## 8.6.3. Balcony – (para 57)

(1) First tieror balcony extending over pit or stalls height between to floor of stall and tier-not less than 3 metres.

(2) Height between the floor or the highest part of gallery and the lowest part of the ceiling over the same — not less than 3.75 metres.

(3) Height between any tier and the tier or ceiling about its not less than 2.75 metres.

(4) Corridor leading to stair case communicating with exit-not less than 1.5 Metres width

(5) Gradients and inclined planes instead of steps but not steeper than 1 in 10.

## 8.6.5. Door – (para 60)

(1) Outside doors for the use of public — to open outwards.

(2) Size doorways not less than 2.25 M by 1.5 M (clear width).

(3) No door shall open out directly on to a flight of steps — Landing atleast 1.5 M flush with the door.

### 8.6.6. Staircases – (para 61)

(1) (i) Treads not less than 27.5 cm
(ii) Risers not more than 15 cm
(iii) Flights not more than 15 or less than 3 steps.

(2) Enclosed staircases-strong hand rails about 7.5 cm clear from wall.

(3) At least two staircases each not less than 1.25 metre wide.

(4) Stairs turning at an angle to have proper landing without window.

### 8.6.7. Passages – 1 metre width for every ten rows of seating accommodation.

### 8.6.8. Exit – (para 62) 1.5 linear metre of exit for 45 sq.metres of sitting space inside.

### 8.6.9. Seating accommodation – (para 63)

(1) Gangways-to be not less than 1.25 m width and no seat to be more than 10 seats from a gangway.

(2) Angle of Elevation substended at the eye of person seated in the row nearest to the screen by the length of the vertical line dropped from the centre of the top edge of the picture to the horizontal plane passing through the observer's eye, shall not exceeds 35 degrees, the height to the eye of the person so seated being 1.10 M above floor level.

(3) Angle between the vertical plane containing the upper edge of the picture and the vertical plan containing the observer's eye and the remote end of the upper edge of the picture-to be not less than 25° degrees.

### 8.6.10. Capacity – (para 83)

(1) The No. of persons admitted into any part of auditorium at the ratio of 20 persons for 10 sq.metres of floor area for portions with chairs having backs and arms. For other portions-25 persons per 10 sq. metre excluding entrances, passages and gang ways.

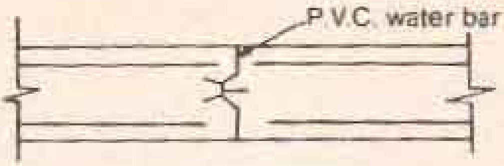
### 8.6.11. Seating arrangements – (para 84)

Chairs: Intervening space of at least 35 cm between back of one seat and the front of the seat immediately behind measured between perpendiculars.

## 8.7. CONSTRUCTION JOINTS

### 8.7.1. Contraction Joints

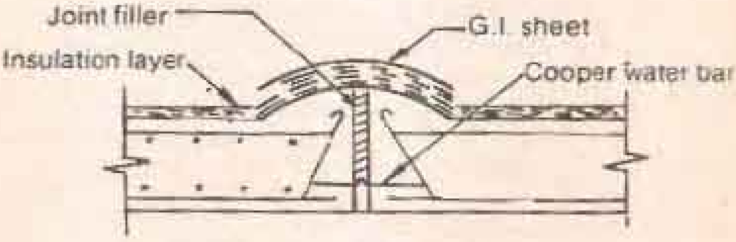
Contraction joints are provided to prevent random cracking developing in a concrete structure owing to shrinkage stresses. The bond between the adjacent sections is broken by painting with a bituminous compound or inserting a waterproof paper on the first face before laying the next section. In the case of water-retaining structures, water bars may be provided ( Figure.) It may be provided as a partial contraction joint if a continuity is provided by the reinforcement running through the joint or by providing planes of weakness by forming a groove for one-third to one-fifth of the thickness of the member




Contraction joint (Tank bottom slab)

### 8.7.2. Expansion Joints

In structures where one or two dimensions are more than 20 m, expansion joints are provided to accommodate movements due to thermal effects. Gaps are formed at predetermined intervals by setting compressive material against the face of one section before laying the next. The joint filler must be durable and non-extruding when compressed and of sufficient rigidity for handling. Bitumen with mineral, a filler like sand, a cork strip, etc. usually serves well as a joint filler. The joint filler left in the member should be duly protected by a sealing compound at the top against intrusion of water or foreign materials

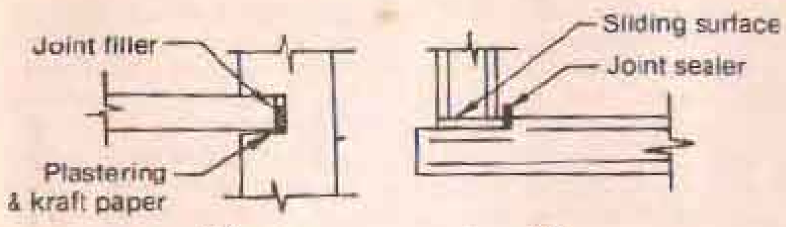



Expansion joint (Roof slab)

Though contraction can also be absorbed by these joints, their spacing usually is not sufficient. A common length between the expansion joints in a building is about 30 m, sufficient reinforcement being used in-between to control cracking. Movement joints in buildings completely separating the structure from top to bottom are known as vertical joints. These joints should be waterproof and preferably made by means of a double column and double beam.

### 8.7.3. Sliding Joints

Where variation in temperature, moisture movement or loading results in a tendency for one part of a structure to move in a plane at right angles to the plane of another, it is necessary to provide a slip joint between the two parts enabling freedom of movement in both planes. The movement occurring in a roof slab, resting over walls, is a typical example. The sliding joints are usually formed by applying a layer of bituminous material over one of the surfaces plastered smoothly or setting a layer of waterproof paper before the other part is laid. Occasionally, a joint filer may also be used at the end face to accommodate expansion.




Sliding joint:
a) Sliding expansion joint (Floor slab)
b) Sliding joint (Tank)

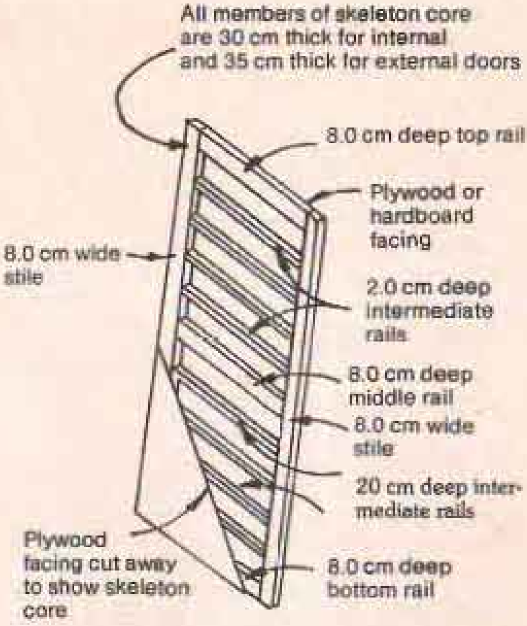
## 8.8. Flush Doors

The present trend in buildings is for plain surfaces, devoid of decorative moulding which will collect dust. Hence, flush doors are surfaced with sheets of plywood or hardboard and fixed to either a skeleton frame or a solid core.

### 8.8.1. Skeleton core flush doors

A core of small section timbers is constructed as illustrated in Figure. The main members of this structural core are the stiles, top, bottom and middle rail all of which are 3 × 8 cm. Intermediate rails of smaller section are used as a rigid base for the plywood facings which are glued to the frame. The members of the skeleton core can be jointed with tongues cut on the ends of the rails and glued into grooves in the stiles. A continuous groove is cut in the stiles into which the tongues on the stiles are glued and the intermediate rails are similarly jointed to the stiles.

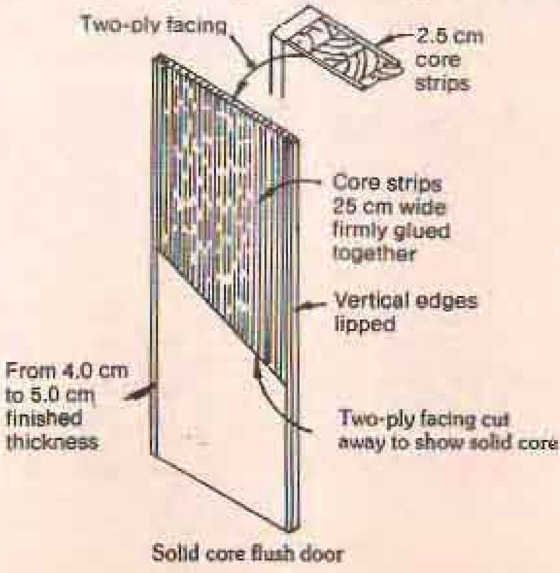
Plywood as a facing for doors is usually three ply, 6.5 mm thick, for external doors and 5 mm for internal doors. Plywood with face plies of some decorative hard wood is made so that the ply boards can be polished or varnished to show the colour and grain of the wood. This class of plywood is used for facing the more expensive flush doors. The whole plywood is used for each face of flush doors. The plywood is strongly glued under pressure to the skeleton core.




Skeleton core flush door

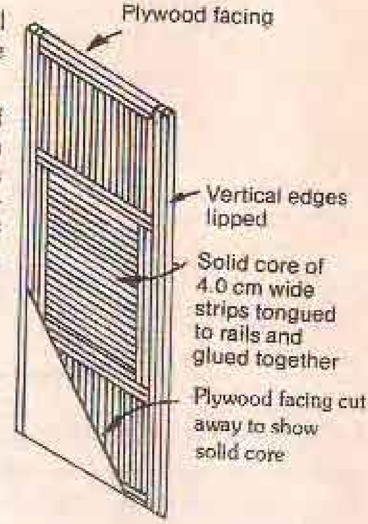
## 8.8.2. Solid core flush doors

Plywood facing bonded to a skeleton core do not always remain absolutely flat and waves on their surfaces may be apparent particularly if doors with skeleton




Solid core flush door

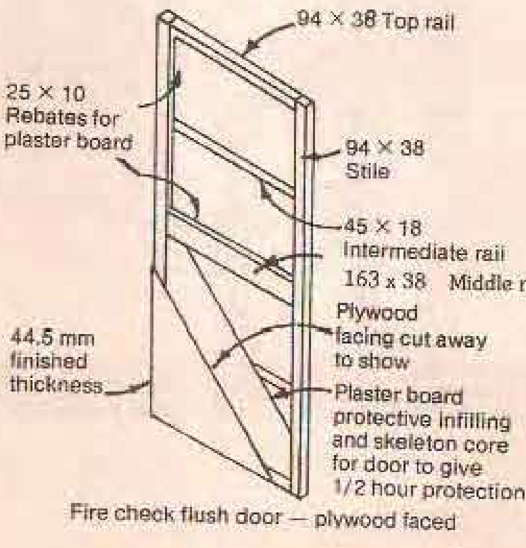
cores do not completely exclude sound. Figure shows the construction of a flush door with a solid core of 25 mm wide strips of timber solidly glued together with two-ply facings on both sides. In effect, the door is a fibre plywood board with a central core of solid strips. Two-ply facings can be used here, as the solid core acts as the centre (or core) ply in restraining any shrinkage in the plies glued to it. This type of ply board is sometimes called block board because of the centre core of blocks of timber. An alternative arrangement of the strips of timber in the solid core of this type of door is sketched in Fig. This arrangement of the core strips produces a rigid door which will not twist or lose shape. Providing the strips of wood used in a solid core are well seasoned, straight of grain and firmly glued together, their arrangement, vertically or horizontally or both will not change the strength and rigidity of the door.




Flush doors are also made with a core of wood shavings glued together to which three-ply facings are glued. These doors are neither true solid core flush doors nor skeleton core flush doors. The surface of these doors remains truly flat. These doors are costlier than skeleton frame flush doors.

## 8.8.3. Fire-check flush doors

These doors are able to resist the spread of fire for periods of half-to-one hour depending upon the buildings. These doors are constructed with a skeleton core to which four sheets of 9.5 mm thick plaster board are fixed in rebates in stiles and




Fire check flush door — plywood faced

rails and over which the plywood facings are glued. Plaster board is fixed behind the plywood facings because it has good resistance to damage by fire. It is made up of a core of gypsum plaster which has been cast between sheets of thick paper. The flush doors, which are constructed to give about an hour's protection against fire, have a skeleton core and plaster board protection in filling, with sheets of asbestos wall board below the plywood facings.

# 8.9. CASEMENT WINDOWS

Windows are usually designed to allow natural light into buildings. Windows also serve to ventilate rooms. The area of the windows must be equal to one-tenth of the area of the floor. The manner, in which a part, or the whole of a window is arranged to open, affects its construction and appearance. The common ways in which a part or the whole of a window is made to open are with

a. side-hinged casements,
b. pivoted sashes,
c. vertically sliding sashes, and
d. horizontally sliding sashes

Figure illustrates the above types of windows.

The casement window consists of a square or rectangular window frame of wood or metal, with a casement hinged at one side to the frame to open out. Casement is the side-hinged opening part of the window and consists of glass surrounded and supported by wood or metal. Figure illustrates the casement window.

An outward opening casement can more readily be made to exclude rain and wind. Hence the casement which is hinged to open out is restricted to 60 cm width to reduce the dead weight on the hinges. A window with two casements can be designed with the casements hined on both sides. The disadvantage of this arrangement is that due to expansion or sinking, or both, the casements may in time jam together and be difficult to open. The window frames are constructed with vertical wood or steel members, called mullions on to which the casement closes. Casemennt windows are designed with ventlights (small openings above the casements). Ventlights are usually hinged at the top to open out. The window frame is constructed with a horizontal member called a "transion" on to which ventlights and casements

Figure illustrates a window with casements and ventlights.

Casement windows ventlights are designed so that the transom is above the average eye level of the people using the room.

## 8.9.1 DEADLIGHTS

Many casement windows are constructed so that only a part of them can be opened. That part of the window which is permanently fixed is called a deadlight.

Most casement windows used in modern buildings are of standard steel, aluminium or wood sections made up in various standard arrangements of casements, ventlights and deadlights. In casement windows the moving parts, hinges, are simple and unlikely to fail. The disadvantage of a casement window is that the casements and ventlights and mullion and transoms reduce possible unobstructed area of glass.

## 8.9.2. STANDARD STEEL CASEMENTS

These windows are made from a standard section of mild steel, which is used for the frame, casements and ventlights. The standard section is roughly Z-shaped, Lengths of this section of mild steel are cut, trimmed and welded together to from a range of standard sized windows.

By adopting the standard section for making frames, casements and ventlights and the standard mullion and transom sections, wide range of standard window sizes can be madc.

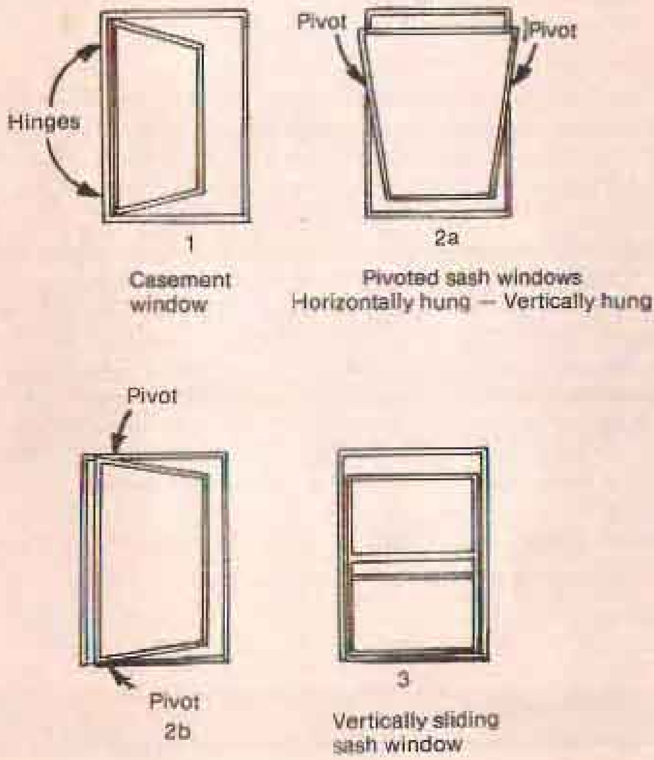
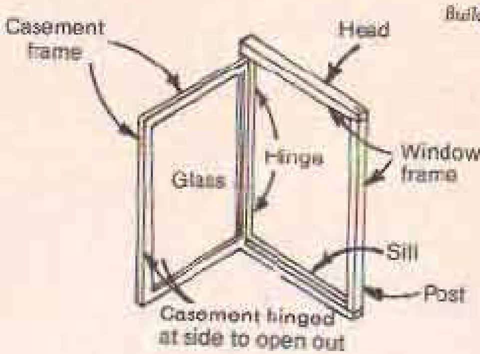
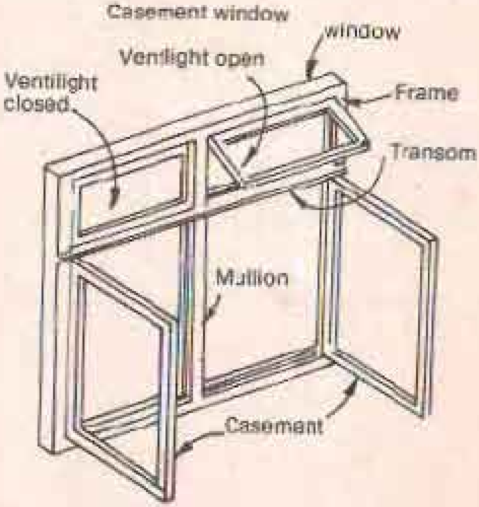


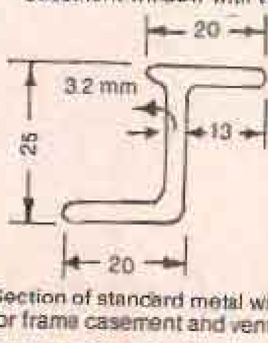

Fig. Types of window (seen from inside)




Casement window




Casement window with ventlights




Section of standard metal window for frame casement and ventlight

Figure illustrates a range of standard steel windows.

A rubber strip is fitted to the sash to reduce air infiltration and heat loss. These windows are designed for glazing from inside and for easy glass replacement, the glass being secured with metal heads.

# 8.10. PLINTH AREA RATES OF BUILDINGS IN TAMIL NADU

| Year | Residential Buildings | | | | | | | | Non Residential Buildings | | | | | | | | Medical Buildings | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ground Floor | | | | First Floor & above | | | | Ground Floor | | | | First Floor & above | | | | Ground Floor | | | | First Floor & above | | | |
| | Madras City | | Mofussil | | Madras City | | Mofussil | | Madras City | | Mofussil | | Madras City | | Mofussil | | Madras City | | Mofussil | | Madras City | | Mofussil | |
| | L | F | L | F | L | F | L | F | L | F | L | F | L | F | L | F | L | F | L | F | L | F | L | F |
| | Amount in Rupees per square metre of plinth area | | | | | | | | | | | | | | | | | | | | | | | |
| 1977—78 | 420 | — | 380 | — | 400 | — | 360 | — | — | — | — | — | — | — | — | — | 500 | — | 450 | — | 480 | — | 430 | — |
| 1978—79 | 480 | — | 430 | — | 450 | — | 400 | — | 450 | — | 400 | — | 420 | — | 370 | — | 560 | — | 500 | — | 530 | — | 470 | — |
| 1979—80 | 650 | — | 575 | — | 575 | — | 500 | — | 600 | 770 | 525 | 700 | 525 | 700 | 450 | 630 | 675 | 850 | 600 | 780 | 600 | 780 | 525 | 700 |
| 1980—81 | 715 | — | 690 | — | 630 | — | 600 | — | 690 | 850 | 630 | 850 | 600 | 770 | 540 | 725 | 745 | 1020 | 690 | 935 | 660 | 935 | 600 | 845 |
| 1981—82 | 820 | 1010 | 775 | 975 | 725 | 985 | 675 | 885 | 790 | 980 | 725 | 925 | 690 | 890 | 625 | 835 | 850 | 1175 | 795 | 1075 | 750 | 1080 | 690 | 980 |
| 1982—83 | 945 | 1210 | 940 | 1180 | 835 | 1110 | 820 | 1070 | 900 | 1135 | 875 | 1090 | 785 | 1030 | 755 | 985 | 980 | 1315 | 960 | 1280 | 865 | 1210 | 830 | 1165 |
| 1983—84 | 1135 | 1390 | 1035 | 1360 | 1000 | 1275 | 900 | 1230 | 1080 | 1360 | 960 | 1200 | 940 | 1240 | 830 | 1085 | 1175 | 1580 | 1035 | 1410 | 1040 | 1450 | 915 | 1260 |
| 1984—85 | 1190 | 1460 | 1085 | 1430 | 1050 | 1340 | 945 | 1290 | 1135 | 1430 | 1010 | 1260 | 985 | 1300 | 870 | 1140 | 1235 | 1660 | 1110 | 1480 | 1095 | 1525 | 960 | 1345 |

Note : L = Load bearing structure; F = Framed structure

## 8.11. FOR PILE FOUNDATIONS ROUGH COST

| Depth upto which pile is likely to be driven from G.L. | Rates per Square metre of cumulative Plinth area (in Rupees) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980-81 | | 1981-82 | | 1982-83 | | 1983-84 | | | 1984-85 | | |
| | Upto 4 Storeys | Upto 8 Storeys | Upto 4 Storeys | Upto 8 Storeys | Upto 4 Storeys | Upto 8 Storeys | Upto 4 Storeys | Upto 8 Storeys | Upto 10 Storeys | Upto 4 Storeys | Upto 8 Storeys | Upto 10 Storeys |
| Upto 10 m depth | 45 | 55 | 70 | 85 | 80 | 90 | 110 | 120 | 150 | 120 | 130 | 165 |
| Upto 15 m depth | — | — | — | — | — | — | 125 | 140 | 170 | 140 | 155 | 190 |
| Upto 20 m depth | 65 | 80 | 100 | 120 | 115 | 130 | 140 | 160 | 190 | 155 | 175 | 210 |
| Upto 25 m depth | — | — | — | — | — | — | 160 | 175 | 205 | 175 | 195 | 225 |
| Upto 30 m depth | 90 | 100 | 135 | 150 | 155 | 160 | 180 | 190 | 220 | 200 | 210 | 240 |

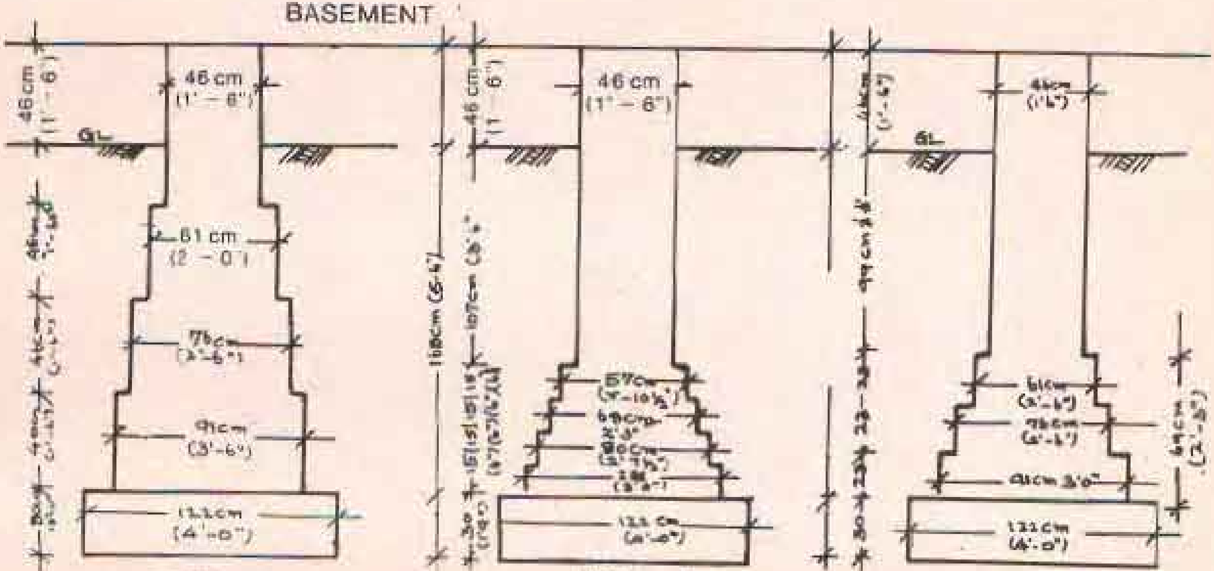
The rates are inclusive of cost of providing column dowel bars.

The above plinth area rates for pile foundations are per square metre of cumulative plinth area and to be applied for total plinth area in all floors added together to arrive at the provisions to be made in the estimate (i.e.) the approximate estimate cost of the pile foundation will be rates as above x (into) n x (into) plinth area in each floor, where n = number of storeys.

## 8.12. ROUGH COST FOR GODOWNS AND BUS STANDS IN MOFUSSIL

| Sl.No. Description | Rate per square metre area in Rupees | | | |
|---|---|---|---|---|
| | 1981-82 | 1982-83 | 1983-84 | 1984-85 |
| 1. Godowns with steel trusses and purlins and A.C. Sheet Roofing ... | 575 | 655 | 720 | 750 |
| 2. Bus bays and waiting platforms open to sky ... | 115 | 135 | 150 | 160 |
| 3. Bus bays, waiting hall with R.C. roofing and toilets ... | 700 | 775 | 850 | 895 |
| 4. Bus bays, waiting hall and commercial complex with R.C.C. Roofing | | | | |
| a) Bus bays and waiting platforms without roofing ... | 115 | 135 | 150 | 160 |
| b) Waiting hall with R.C. Column roofing & toilets ... | 585 | 685 | 755 | 795 |
| c) For portion where shops, banks etc are proposed (Load bearing structures) ... | 725 | 875 | 960 | 1010 |
| d) for framed structure for shops etc. ... | 925 | 1090 | 1200 | 1260 |

## 8.13. TYPES OF FOOTING SHOWING ECONOMICAL AND UNECONOMICAL.




TYPE – I
UNECONOMICAL FOOTING

To be avoided.

TYPE – II
TYPICAL FOOTING IN RESPECT OF BRICK WORK (Savings 20.6%)

Recommended for Brick work Footings.

TYPE – III
TYPICAL FOOTING IN RESPECT OF RUBBLE WORK (Savings 17.6%)

Recommended for R.R. Footings.

# IX. STRUCTURAL ENGINEERING

There are various methods of designs. Since the Limit state Method is now found latest, the same is given for R.C.C. members.

## 9.1 LIMIT STATE DESIGN

The philosophy of Limit State Design was developed mainly by the Comite European du Beton (CEB) and the Federation Internationale de la Precontrainte (FIP) and is gaining international acceptance. A structure must be designed to sustain safely all the loads and deformations which may occur during construction and in use and should have adequate durability during the life of the structure. It must also aim at guaranteeing adequate safety against the structure being rendered unfit for use. When a structure or part of a structure, is rendered unfit for use, it is said to have reached a Limit State i.e. the structure has ceased to fulfil the function or satisfy the condition for which it was designed. There are two categories of Limit States.

### 9.1.1. Limit State of Collapse:

Limit State of Collapse is said to be reached when the structure (or part of it) collapses. Collapse may arise from the rupture of one or more critical sections, from the transformation of the structure into a mechanism, from elastic or in elastic instability or from loss of equilibrium as a rigid body and so on.

### 9.1.2. The serviceability Limit States:

The serviceability Limit States are those of excessive deflection with respect to normal use of structure, premature or excessive cracking, undesirable damage (corrosion), excessive displacement without loss of equilibrium and excessive vibration etc.

Following are some of the special features of this method:

(i) It is possible to take into account number of limit states depending upon the particular instance. Some of the criteria for the ultimate Limit State are:
   (a) Bearing failure at a support or under a concentrated load.
   (b) Bond or anchorage failure of reinforcement.
   (c) Bursting of prestressed concrete end blocks.
   (d) Elastic instability.
   (e) Failure of connections.
   (f) Flexural failure.
   (g) General Instability.
   (h) Shear Failure.
   (i) Torsion Failure.

(ii) Different safety factors can be applied to different limit states which are more rational than applying one common load factor as in the ultimate load method. For example, structural collapses often have serious consequences. Therefore in design the probability of reaching the collapse limit state is made very low, say $10^{-6}$. Since the loss resulting from unserviceability is generally much less than that from collapse a probability much higher than $10^{-6}$, of reaching a serviceability limit state may still be acceptable.

(iii) Any new knowledge of the structural behaviour, loading and materials can be readily incorporated.

Limit State Design philosophy uses the concept of probability and is based on the application of the methods of statistics to the variations that occur in practice in the loads acting on the structure or in the strength of the materials. It is assumed that the normal or Gaussian distribution represents the nature of these variations sufficiently closely for practical purposes. According to this distribution that although the probability of the occurrence of an exceptionally high or low value is very small, it is never zero. This means that a limit state may be reached in a structure when an exceptionally high load or force occurs at a point where the strength is abnormally low. Hence the probability of a particular limit state (such as the one mentioned above) reaching during the life of the structure can be kept below any figure chosen but can never be zero. However according to limit state philosophy, a structure may be regarded as well designed if it can be shown that the probabilities of each limit state being reached is about the same for all the members in the structure and is appropriate to that limit state, the probabilities being such the cost is a minimum. It should be realised that much of the data needed for the calculation of the probabilities is not available.

## 9.1.3. Characteristic Strengths & Loads:

The materials used in any structure may actually have a strength lesser than the design values due to the variability of materials and the loads to be supported by the structure may be greater than the anticipated. These variations in the strength of materials and the loads to be supported are taken care of by using their "Characteristic values". For example the characteristic strength of concrete or steel 'f' is defined as

$f = f_m - K.S.$ where $f_m$ = mean strength

K — a value which depends upon the probability of the actual strength exceeding the characteristic strength

S = Standard deviation.

IS 456 — 78 (as well as British Code CP 110) defines the characteristic strength of concrete as that 28 day cube strength below which not more than 5 percent of the test results may be expected to fall. The characteristic strengths of concrete are given in Table-2, with modifications regarding increase in strength with age. For reinforcing steel and prestressing wire the relevant I.S. Specifications have to be modified to include the concept of characteristic strength and till such time, the characteristic value shall be assumed as the minimum yield/0.2 percent proof stress specified in the relevant I.S. Specifications.

Similarly the characteristic load, F is defined as

$$F - F_m + KS \text{ where}$$

$F_m$ — the mean of the highest peak loads of a number of similar structures that occur during the life time of the structures.

S — Standard deviation

KS — a coefficient depending on the probability of the maximum load, exceeding the characteristic load.

According to the Indian Standard Code of practice characteristic load F is the mean strength plus 1.64 times the standard deviation i.e. that value of load which has a 95 percent probability of not being exceeded during the life of the structure. However, because of lack of statistical data, it is not yet possible to express loads in statistical terms and hence dead loads worked out on the basis of IS — 1911 — 1967, live and wind loads given in IS — 875 — 1964 and seismic forces given in IS — 1893 — 1975 are assumed as the characteristic loads.

## 9.1.4. Partial Safety Factors:

In limit state design, the load actually used for each limit state is called the DESIGN LOAD Fd for the limit state and is given by

$$Fd = F.\gamma f.$$

F — characteristic load.

$\gamma f$ — partial Safety Factor appropriate to the nature of loading and the limit state being considered.

The partial safety factor is intended to cover those variations in loading, in design or in construction which are likely to occur after the designer and the constructor have each used carefully their skill and knowledge. (Eg. Effect of creep, shrinkage and temperature introduces extra loads) It also takes into account the nature of the limit state in question. In this respect there is an element of judgement and experience related to the relative values a community places on human life, permanent injury and property damage with possible increase in initial investment.

The values of $\gamma f$ are given in Table 12 of IS 456 — 78.

## 9.1.5. Values of Partial Safety Factors:

| Load Combination | Limit State of Collapse I.S. 456 | CP 110 | Serviceability Limit State I.S. 456/CP 110 |
|---|---|---|---|
| I. Dead & Live (Imposed) Load: | | | |
| γf for dead load GK | 1.5 | 1.4 | 1.0 |
| γf for Live (imposed ) Load QK | 1.5 | 1.6 | 1.0 |
| II. Dead & Wind Load: | | | |
| γf for dead load GK | 1.5 or 0.9* | 1.4 or 0.9* | 1.0 |
| γf for wind load WK | 1.5 | 1.4 | 1.0 |
| III. Dead Load, Live (Imposed) Load and Wind Load | | | |
| γf for dead load GK | 1.2 | 1.2 | 1.0 |
| γf for live (imposed) Load QK | 1.2 | 1.2 | 0.8 |
| γ f for wind load WK | 1.2 | 1.2 | 0.8 |

*Use 0.9 when the dead load contributes to the stability and 1.5/1.4 when the dead load assists the overturning of the structure.

Similarly the design strength, fd for a given material and limit state is given by

$$fd = \frac{f}{\gamma m}$$

f — Characteristic strength of material

γm — Partial safety factor appropriate to the material and the limit state being considered

The factor γm takes into account the possible differences between the strength of the materials in the actual structure and the strengths derived from tests. These differences may be due to the variability of the materials as a result of their method of manufacture or as a result of the degree of compaction being not the same as in samples.

## 9.1.6. Partial Safety Factory γm for material strength

| Material | Limit state of Collapse IS 456 | CP. 110 | Serviceability Deflection IS 456 | CP. 110 | State Cracking IS 456 | CP. 110 |
|---|---|---|---|---|---|---|
| Concrete | 1.5 | 1.5 | * | 1.0 | — | 1.3 |
| Steel: | 1.15 | 1.15 | * | 1.0 | — | 1.0 |

(*when assessing the deflection, the material properties such as modulus of elasticity should be taken as those associated with the characteristic strength of the material)

### 9.1.7. General Design Procedure:

In the design of structures all relevant limit states are to be considered to ensure the safety and serviceability. Usually the structure is designed for the limit state of collapse which is the most critical one and then checked that the serviceability limit states are not reached. To start with the design loads for the limit state of collapse is obtained by adopting the partial safety factors given in Table-12 of IS-456 for the various load combinations and choosing, the most critical case. The sections are then designed to conform to the specifications laid down in section 5 of IS. 456-78. The design strength of concrete and steel to be used are given by their characteristic values divided by the partial safety factors, applicable to limit state of collapse. The section thus designed, is then checked for the various serviceability limit states. The partial safety factors to be used for obtaining the design load and strength will be different and will correspond to the limit state under consideration. Generally deflection and cracking are considered to be the two most important serviceability limit states.

### 9.1.8. Limit State Requirements:

Limit State of Collapse : The limit state of collapse of the structure could be assessed from rupture of one or more critical sections and from buckling due to elastic or plastic instability or overturning. The resistance to bending, shear, torsion and axial loads at every section shall not be less than the appropriate value at that section produced by the probable most unfavourable combination of loads on structure using the appropriate partial safety factors.

### 9.1.9. Limit State of Deflection:

Deflections may be calculated (according to Appendix B of IS 456-1978) and shall not exceed the permissible values given below.

(i) The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as cast level of the supports of floors, roofs and all other horizontal members, should not normally exceed span/250

(ii) The deflection including the effects of temperature, creep and shrinkage occurring after erection of partitions and the application of finishes should not normally exceed span/350 or 20 mm whichever is less.

In normal cases, however, the deflection of a beam will not be excessive if the ratio of its span to its effective depth is not greater than the appropriate ratio obtained from Tables 1 & 2 or the modified Tables 3 & 4 where appropriate.

### Table — 1

The basic span/effective depth ratios for rectangular beams are given below. These are based on limiting the deflection to span/250 and this should normally avoid damage to finishes and partitions for beams of upto 10 metre span.

Basic Span/effective depth ratios for rectangular beams:

| Support conditions | Ratio |
|---|---|
| Cantilever: | 7 |
| Simply Supported: | 20 |
| Continuous: | 26 |

**Table – 2**

To avoid damage to finishes or partitions in spans greater than 10 metre, the deflection is further restricted and is given below:

Special span/effective depth ratios for rectangular beams:

| Span in metre | Cantilever | Simply supported | Continuous |
|---|---|---|---|
| 10 | | 20.00 | 26 |
| 12 | Value to | $\frac{10}{12} \times 20 = 16.667$ | 21.666 |
| 14 | be justified | $\frac{10}{14} \times 20 = 14.285$ | 18.571 |
| 16 | be calculation | $\frac{10}{16} \times 20 = 12.500$ | 16.250 |
| 18 | | $\frac{10}{18} \times 20 = 11.111$ | 14.444 |
| 20 | | $\frac{10}{20} \times 20 = 10.00$ | 13.000 |

Deflection is influenced by the amount of tension reinforcement and the type of steel and therefore the span/effective depth ratios should be modified according to the area of the tension reinforcement provided. Values of Table 1 & 2 should therefore be multiplied by the appropriate factor obtained from Table 3.

**Table – 3**

**Modification Factor for Tension Reinforcement**

*(Taken from Fig. 3 of IS 456)*

| Type of steel | 100 As/bd | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.25 | 0.5 | 0.75 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 |
| Mild Steel: | 2.00 | 1.90 | 1.57 | 1.42 | 1.24 | 1.12 | 1.06 | 1.02 |
| $F_e$ 415 | 1.50 | 1.18 | 1.04 | 0.97 | 0.89 | 0.84 | 0.80 | 0.75 |
| $F_e$ 500 | 1.26 | 1.00 | 0.91 | 0.86 | 0.80 | 0.76 | 0.72 | 0.70 |

Compression reinforcement also influences deflection and the value of the span/effective depth ratio obtained from Table-1 or 2 modified by the factor obtained from Table-3 may be multiplied by a further factor obtained from Table-4.

Table – 4

**Modification Factor for Compression Reinforcement**

*(Taken from Fig. 4 of IS 456 – 1978)*

| $100\frac{Ac}{bd}$ | 0.25 | 0.50 | 0.75 | 1.00 | 1.50 | 2.00 | 3.00 |
|---|---|---|---|---|---|---|---|
| Factor: | 1.07 | 1.14 | 1.20 | 1.25 | 1.33 | 1.40 | 1.50 |

## 9.1.10. Span to effective depth ratio for a Flanged Beam:

For a flanged beam, the span/effective depth ratio may be determined as above, and further modified by a reduction factor as given below. Calculation of percentage of reinforcement should be based on area of section equal to bfd where bf = effective flange width.

| Ratio of web width to flange width ≤ | Reduction Factor |
|---|---|
| 0.3 | 0.8 |
| 0.4 | 0.82857 |
| 0.5 | 0.85714 |
| 0.6 | 0.88571 |
| 0.7 | 0.91428 |
| 0.8 | 0.94285 |
| 0.9 | 0.97142 |
| 1.0 | 1.0 |

## 9.1.11. Limit State of Cracking:

In general the reinforcement spacing rules given in I.S. 456 – 78 will be sufficient to control flexural cracking. Cracks due to bending in a compression member subjected to a design axial load greater than 0.2 $f_{ck}$ Ac where $f_{ck}$ is the characteristic compressive strength of concrete and Ac is the area of the gross section of the member, need not be checked. A member subjected to lesser load than 0.2 $f_{ck}$Ac may be considered as a flexural member for the purpose of crack control.

Cracking of concrete should not adversely affect the appearance or durability of the structure. The engineer must satisfy himself that any cracking will not be excessive, having regard to the requirements of the particular structure. According to CEB-FIP classification concrete structures have been classified as class 1, 2, 3 and 4 structures. Class 1 and 2 come under fully prestressed structures. In class 1 no tensile stresses are allowed where as in cl 2, tensile stresses are allowed but cracking is not permitted class 3 beiqngs to the class of partially prestressed structures in which both prestressing tendon and ordinary reinforcements are used. Hence cracking is permitted to a certain extent. Non prestressed structures with ordinary reinforcement are classified as class 4 structures. RCC comes under this classification.

## 9.1.12. Recommendations of CP 110:

The surface width of crack in RCC(Cl. 4) structures should not, in general, exceed 0.3 mm. Where members are exposed to particularly aggressive environments, the assessed surface width of cracks at points nearest the main reinforcement should not, in general, exceed 0.004 times the nominal cover to the main reinforcement. It should be recognized that in a reinforced concrete structure, under the effects of load and environment, the actual widths of cracks will vary between wide limits, and the prediction of an absolute maximum width is not possible. The possibility of some cracks being wider than the above must be accepted unless special precautions are taken.

For prestressed concrete — cl 3 structures the surface width of cracks should not exceed 0.1 mm for members exposed to a particularly aggressive environment and should not exceed 0.2 mm for all other members

## 9.1.13. Development of Stress in Reinforcement

The calculated tension or compression in any bar at any section shall be developed on each side of the section by an appropriate development length or end anchorage or by a combination thereof.

### 9.1.13.1. *Development Length of Bars*

The development length $L_d$ is given by

$$L_d = \frac{\phi \, \sigma_s}{4 \, \gamma_{bd}}$$

where

$\phi$ = nominal diameter of the bar,

$\sigma_s$ = stress in bar at the section considered at design load, and

$\gamma_{bd}$ = design bond stress.

*Note 1* — The development length includes anchorage values of hooks in tension reinforcement.

*Note 2* — For bars of sections other than circular, the development length should be sufficient to develop the stress in the bar by bond.

## 9.1.14. Limit State of Collapse for flexure

The Indian Standard code of practice for plain and reinforced concrete (IS456 – 1978) suggests that the maximum strain in concrete at the outermost compression fibre be taken as 0.0035 in bending. The stress strain curve for concrete is assumed as given in Fig. 20 of IS code. For design purposes, the compressive strength of concrete in the structure shall be assumed as 0.67 times the characteristic strength. Partial safety factor of 1.50 is to be applied in addition to this. The maximum stress is thus 0.446 $f_{ck}$ and is constant beyond a strain of 0.0020 irrespective of the grade of concrete. The area of the stress block comes to 0.36 $f_{ck}$ $x_u$ acting at a depth of 0.416 $x_u$ from the extreme fibre in compression.

The stress in the reinforcement is derived from representative stress-strain curve for the type of steel used. Typical curve are given in I.S. 456 (Fig. No. 22) For design purposes, the partial safety factor of 1.15 shall be applied.

In order to ensure ductile failure ie. to ensure that the tensile reinforcement undergoes a certain degree of inelastic deformation before the concrete fails in compression, the maximum strain of the tension reinforcement in the section at failure is not to be less than $\frac{f_y}{1.15\,E_s} + 0.002$ where fy is the characteristic strength of steel and Es is the modulus of elasticity of steel.

*The limiting values of the depth of neutral axis for different grade of steel*

according to the code are given by
$$\frac{0.0035}{0.0055 + 0.87\,f_y / E_s}$$

Limiting values of $\frac{x_{u,max}}{d}$ thus obtained are given in the following table.

**Table – 5**

Values of $\frac{x_{u,max}}{d}$ for various grades of steel

| $f_y$, N/mm$^2$ | 250 | 415 | 500 |
|---|---|---|---|
| $\frac{x_{u,max}}{d}$ | 0.531 | 0.479 | 0.456 |

### 9.1.15. General Guide Line

*The following notes are given for general guidance in regard to design of R.C.C. members.*

1) The *Limit state design* can be made only by refering tables and charts given in **'Design Aids for R.C. to I.S. 456 – 1978'**. Therefore it is inevitable to have a copy of the same to proceed with the *Limit state design*. Salient examples are also worked out in its respective chapters. Cost of the book is Rs.100/- and it was published by Indian Standards Institution, New Delhi - 2. Copies can be had from its branches.

2) Another ready reference book **'Design of Concrete Members with Ribbed – Tor Steel'** of **Er. R. Chandra,** *B.Tech. (Hons), M.Sc. (Engg), C.Eng., A.M.I. Struct. E.*, published by Torsteel Research Foundation in India, 25, Cresent Road, Bangalore – 560 001. This book gives details of reinforcement straight, once the design control moments are known. This book is based on Ultimate strength design. This will be very useful Book for Engineers in execution, who can't afford much time in working out detailed design calculation. Its present cost is Rs.15/- It covers R.C.C. Slabs, Beams, Columns with foundation etc. in respect of Buildings.

## 9.2. LIMIT STATE DESIGNS

### 9.2.1. Assumptions

The basic assumptions in the design of flexural members for the limit state of collapse are given below:

a) Plane sections normal to the axis of the member remain plane after bending. This means that the strain at any point on the cross section is directly proportional to the distance from the neutral axis.

b) The maximum strain in concrete at the outermost compression fibre is 0.003 5.

c) The design stress-strain relationship for concrete is taken as indicated in Fig. 1.

d) The tensile strength of concrete is ignored.

e) The design stresses in reinforcement are derived from the strains using the stress-strain relationships given in Fig. 2 and 3.

f) The strain in the tension reinforcement is to be not less than

$$\frac{0.87 f_y}{E_s} + 0.002.$$

This assumption is intended to ensure ductile failure, that is, the tensile reinforcement has to undergo a certain degree of inelastic deformation before the concrete fails in comporession.

(For charts and tables referred to, see the Design aids for RCC to I.S.456 — 1978).

Assumptions (b) and (f) govern the maximum depth of neutral axis in flexural members. The strain distribution across a member corresponding to those limiting conditions is shown in Fig. 9.1. The maximum depth of neutral axis $x_{u,max}$ is obtained directly from the strain diagram by considering similar triangles.

$$\frac{x_{u,max}}{d} = \frac{0.003\,5}{(0.005\,5 + 0.87\, f_y/E_s)}$$

The values of $\dfrac{x_{u,max}}{d}$ for three grades of reinforcing steel are given in Table B.

TABLE B VALUES OF $\frac{x_{u,max}}{d}$ FOR

DIFFERENT GRADES OF STEEL

*(Clause 2.2)*

| | | | |
|---|---|---|---|
| $f_y$, N/mm$^2$ | 250 | 415 | 500 |
| $\frac{x_{u,max}}{d}$ | 0.531 | 0.479 | 0.456 |

## 9.2.3. Rectangular Sections

The compressive stress block for concrete is represented by the design stress-strain curve as in Fig. It is seen from this stress block (see Fig.9.1) that the centroid of compressive force in a rectangular section lies at a distance of 0.416 $x_u$ (which has been rounded off to 0.42 $x_u$ in the code) from the extreme compression fibre; and the total force of compression is 0.36 $f_{ck}$ $bx_u$. The lever arm, that is, the distance between the centroid of compressive force and centroid of tensile force is equal to $(d - 0.416\ x_u)$. Hence the upper limit for the moment of resistance of a singly reinforced rectangular section is given by the following equation.

$$M_{u,lim} = 0.36 f_{ck}\, bx_{u,max} \times (d - 0.416\ x_{u,max})$$

Substituting for $x_{u,max}$ from Table B and transposing $f_{ck}\ bd^2$, we get the values of the limiting moment of resistance factors for singly reinforced reactangular beams and slabs. These values are given in Table C. The tensile reinforcement percentage, $p_{t,lim}$ corresponding to the limiting moment of resistance is obtained by equating the forces of tension and compression.

$$\frac{p_{t,lim}\ bd\ (0.87\ f_y)}{100} = 0.36\ f_{ck}\ bx_{u,max}$$

Substituting for $x_{u,max}$ from Table B, we get the values of $p_{t,lim}\ f_y/f_{ck}$ as given in Table C.

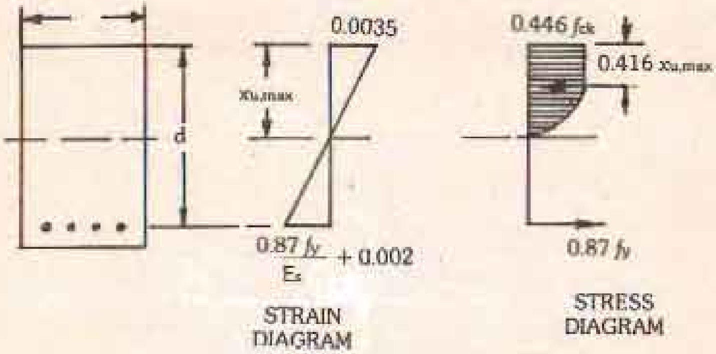



Fig. 9.1. Singly Reinforced Section

TABLE C LIMITING MOMENT OF RESISTANCE AND REINFORCEMENT INDEX FOR SINGLY REINFORCED RECTANGULAR SECTIONS

*(Clause 2.3)*

| | | | |
|---|---|---|---|
| $f_y$, N/mm$^2$ | 250 | 415 | 500 |
| $\frac{M_{u,lim}}{f_{ck}\,bd^2}$ | 0.149 | 0.138 | 0.133 |
| $\frac{p_{t,lim}\,f_y}{f_{ck}}$ | 21.97 | 19.82 | 18.87 |

The values of the limiting moment of resistance factor $M_u/bd^2$ for different grades of concrete and steel are given in Table D. The corresponding percentages of reinforcements are given in Table E. These are the maximum permissible percentages for singly reinforced sections.

TABLE D LIMITING MOIMENT OF RESISTANCE FACTOR $M_{u,lim}/bd^2$, N/mm$^2$ FOR SINGLY REINFORCED RECTANGULAR SECTIONS

*(Clause 2.3)*

| $f_{ck}$, N/mm$^2$ | $_y$, N/mm$^2$ | | |
|---|---|---|---|
| | 250 | 415 | 500 |
| 15 | 2.24 | 2.07 | 2.00 |
| 20 | 2.98 | 2.76 | 2.66 |
| 25 | 3.73 | 3.45 | 3.33 |
| 30 | 4.47 | 4.14 | 3.99 |

TABLE E MAXIMUM PERCENTAGE OF TENSILE REINFORCEMENT $p_{t,lim}$ FOR SINGLY REINFORCED RECTANGULAR SECTIONS

*(Clause 2.3)*

| $f_{ck}$, N/mm² | $f_y$, N/mm² | | |
|---|---|---|---|
| | 250 | 415 | 500 |
| 15 | 1.32 | 0.72 | 0.57 |
| 20 | 1.76 | 0.96 | 0.76 |
| 25 | 2.20 | 1.19 | 0.94 |
| 30 | 2.64 | 1.43 | 1.13 |

## 9.2.3.1. Under-Reinforced Sections

Under-reinforced section means a singly reinforced section with reinforcement percentage not exceeding the appropriate value given in Table E. For such sections, the depth of neutral axis $x_u$ will be smaller than $x_{u,max}$. The strain in steel at the limit state of collapse will, therefore, be more than $\frac{0.87 f_y}{E_s} + 0.002$ and, the design stress in steel will be $0.87 f_y$.

The depth of neutral axis is obtained by equating the forces of tension and compression.

$$\frac{p_t bd}{100}(0.87 f_y) = 0.36 f_{ck} b x_u$$

$$\frac{x_u}{d} = \left(\frac{p_t}{100}\right)\frac{0.87 f_y}{0.36 f_{ck}}$$

The moment of resistance of the section is equal to the product of the tensile force and the level arm.

$$M_u \quad \frac{p_t bd}{100}(0.87 f_y)(d - 0.416 x_u)$$

$$= 0.87 f_y \left(\frac{p_t}{100}\right)\left(1 - 0.416 \frac{x_u}{d}\right) bd^2$$

Substituting for $\frac{x_u}{d'}$ we get

$$M_u = 0.87 f_y \left(\frac{p_t}{100}\right) \times \left(1 - 1.005 \frac{f_y}{f_{ck}} \left(\frac{p_t}{100}\right)\right) bd^2$$

For determining the area of Steel this equation is useful. But the solution of this equation takes time and hence charts and tables have been proposed to save designer's time.

**9.2.3.1.1.** *Charts 1 to 18* have been prepared by assigning different values to $M_u/b$ and plotting $d$ *versus* $p_t$. The moment values in the charts are in units of kN.m per metre width. Charts are given for three grades of steel and two grades of concrete, namely M 15 and M 20, which are most commonly used for flexural members. Tables 1 to 4 cover a wider range, that is, five values of $f_y$ and four grades of concrete up to M 30. In these tables, the values of percentage of reinforcement $p_t$ have been tabulated against $M_u/bd^2$

**9.2.3.1.2.** The moment of resistance of slabs, with bars of different diametres and spacings are given in Tables 5 to 44. Tables are given for concrete grades M 15 and M 20, with two grades of steel. Ten different thicknesses ranging from 10 cm to 25 cm, are included. These tables take into account 25.5.2.2 of the Code, that is, the maximum bar diameter does not exceed one-eighth the thickness of the slab. Clear cover for reinforcement has been taken as 15 mm or the bar diameter, whichever is greater [*see* *25.4.1*(d) of the Code]. In these tables, the zeros at the top right hand corner indicate the region where the reinforcement percentage would exceed $p_{t,lim}$; and the zeros at the lower left hand corner indicate the region where the reinforcement is less than the minimum according to *25.5.2.1* of the Code.

## Singly Reinforced Beam

Determine the main tension reinforcement required for a rectangular beam section with the following data:

| | |
|---|---|
| Size of beam | 30 X 60 cm |
| Concrete mix | M 15 |
| Characteristic strength of reinforcement | 415 N/mm$^2$ |

* Factored moment 170 kN.m

Assuming 25 mm dia bars with 25 mm clear cover.

$$\text{Effective depth} = 60 - 2.5 - \frac{2.5}{2} = 56.25 \text{ cm}$$

From Table D, for $f_y = 415$ N/mm² and $f_{ck} = 15$ N/mm²

$$M_{u.lim}/bd^2 = 2.07 \text{ N/mm}^2$$

$$= \frac{2.07}{1000} \times (1000)^2$$

$$= 2.07 \times 10^3 \text{ kN/m}^2$$

$$\therefore M_{u.lim} = 2.07 \times 10^3 bd^2$$

$$= 2.07 \times 10^3 \times \frac{30}{100} \left(\frac{56.25}{100}\right)^2$$

$$= 196.5 \text{ kN.m}$$

Actual moment of 170 kN.m is less than $M_{u.lim}$. The section is therefore to be designed as a singly reinforced (under-reinforced) rectangular section.

**Method of Referring to Flexure Chart**

For referring to Chart, we need the value of moment per metre width.

$$M_u/b = \frac{170}{0.3} = 567 \text{ kN.m per metre width.}$$

Referring to *Chart 6*, corresponding to

$M_u/b = 567$ kN.m and $d = 56.25$ cm,

$$\text{Percentage of steel } p_t = \frac{100A_s}{bd} = 0.6$$

---

* The term 'factored moment' means the moment due to characteristic loads multipled by the appropriate value of partial safety factor $\gamma f$.

$$\therefore A_s = \frac{0.6\,bd}{100} = \frac{0.6 \times 30 \times 56.25}{100} = 10.1 \text{ cm}^2$$

**Method of Referring of Tables**

For referring to Tables, we need the value of $\frac{M_u}{bd^2}$

$$\frac{M_u}{bd^2} = \frac{170 \times 10^6}{30 \times 56.25 \times 56.25 \times 10^3}$$
$$= 1.79 \text{ N/mm}^2$$

From *Table 1*,

Percentage of reinforcement, $p_t = 0.594$

$$\therefore A_s = \frac{0.594 \times 30 \times 56.25}{100} = 10.02 \text{ cm}^2$$

## Slab

Determine the main reinforcement required for a slab with the following data:

| | |
|---|---|
| Factored moment | 9.60 kN.m per metre width |
| Depth of slab | 10 cm |
| Concrete mix | M 15 |
| Characteristic strengh of reinforcement | a) 415 N/mm$^2$<br>b) 250 N/mm$^2$ |

**Method of Referring to Tables for Slabs**

Referring to *Table* (for $f_y$ = 415 N/mm$^2$), directly we get the following reinforcement for a moment of resistance of 9.6 kN.m per metre width:

8 mm dia at 13 cm spacing

or 10 mm dia at 20 cm spacing

Reinforcement given in the tables is based on a cover of 15 mm or bar diameter whichever is greater.

**Method of Referring to Flexure Chart**

Assuming 10 mm dia bars with 15 mm cover

$$d = 10 - 1.5 - \frac{1.0}{2} = 8 \text{ cm}$$

a) For $f_y = 415 \text{ N/mm}^2$

From Table D, $M_{u,lim}/bd^2 = 2.07 \text{ N/mm}^2$

$$\therefore M_{u,lim} = 2.07 \times 10^3 \times \frac{100}{100} \times \left(\frac{8}{100}\right)^2$$

$$= 13.25 \text{ kN.m}$$

Actual bending moment of 9.60 kN.m is less than the limiting bending moment.

Referring to *Chart 4*, reinforcement percentage, $p_t = 0.475$

Referring to *Chart 90*, provide

8 mm dia at 13 cm spacing

or 10 mm dia at 20 cm spacing.

Alternately,

$$A_s = 0.475 \times 100 \times \frac{8}{} = 3.8 \text{ cm}^2 \text{ per metre width.}$$

From *Table 96*, we get the reinforcement as before.

b) For $f_y = 250 \text{ N/mm}^2$

From Table D, $M_{u,lim}/bd^2 = 2.24 \text{ N/mm}^2$

$$M_{u,lim} = 2.24 \times 10^3 \times 1 \times \frac{8}{100}^2$$

$$= 14.336 \text{ kN.m}$$

Actual bending moment of 9.6 kN.m is less than the limiting bending moment.

Referring to *Chart 1*, reinforcement percentage, $p_t = 0.78$.

Referring to *Chart 90*, provide 10 mm dia at 13 cm spacing.

## 9.2.3. T-SECTIONS

The moment of resistance of a T-beam can be considered as the sum of the moment of resistance of the concrete in the web of width $b_w$ and the contribution due to flanges of width $b_f$.

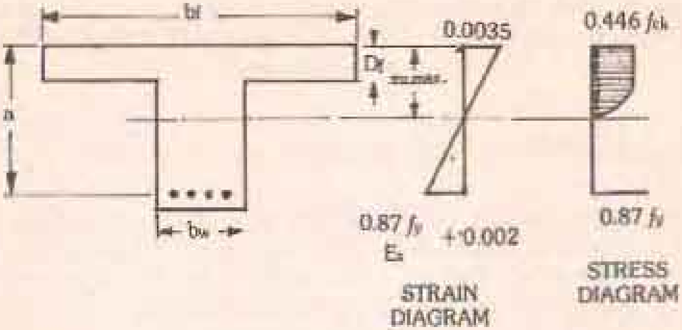



Fig. 9.2 T-Section

The maximum moment of resistance is obtained when the depth of neutral axis is $x_{u,max}$. When the thickness of flange is small, that is, less than about 0.2 $d$, the stress in the flange will be uniform or nearly uniform (see Fig. 9.2) and the centroid of the compressive force in the flange can be taken at $D_f/2$ from the extreme compression fibre. Therefore, the following expression is obtained for the limiting moment of resistance of T-beams with small values of $D_f/d$.

$$M_{u,lim,T} = M_{u,lim,web} + 0.466\, f_{ck} \times (b_f - b_w)\, D_f \left(d - \frac{d_f}{2}\right)$$

where $M_{u,lim,web} = 0.36\, f_{ck}\, b_w x_{u,max}\, (d - 0.416\, x_{u,max})$.

The equation given in *E-2.2* of the Code is the same as above, with the numericals rounded off to two decimals. When the flange thickness is greater than about 0.2 $d$, the above expression is not correct because the stress distribution in the flange would not be uniform. The expression given in *E-2.2.1* of the Code is an approximation which makes allowance for the variation of stress in the flange. This expression is obtained by substituting $y_f$ for $D_f$ in the equation of *E-2.2* of the Code; $y_f$ being equal to $(0.15\, x_{u,max} + 0.65\, D_f)$ but not greater than $D_f$. With this modification,

$$M_{u,lim,T} = M_{u,lim,web} + 0.446\, f_{ck} \times (b_f - b_w) y_f \left(d - \frac{y_f}{2}\right)$$

Dividing both sides by $f_{ck}\, b_w\, d^2$,

$$\frac{M_{u,lim,T}}{f_{ck}\, b_w\, d^2} = \frac{M_{u,lim,web}}{f_{ck}\, b_w\, d^2} + 0.446 \times \left(\frac{b_f}{b_w} - 1\right) \frac{y_f}{d} \left(- \frac{y_f}{2d}\right)$$

where $\dfrac{y_f}{d} = 0.15\, \dfrac{x_{u,max}}{d} + 0.65\, \dfrac{D_f}{d}$ but $\dfrac{y_f}{d} \le \dfrac{D_f}{d}$

Using the above expression, the values of the moment of resistance factor $M_{u,lim,T}/f_{ck}\, b_w d^2$ for different values of $b_f/b_w$ and $D_f/d$ have been worked out and given in Tables 57 to 59 for three grades of steel.

## 9.2.4. CONTROL OF DEFLECTION

**9.2.4.1.** The deflection of beams and slabs would generally be within permissible limits if the ratio of span to effective depth of the member does not exceed the values obtained in accordance with *22.2.1* of the Code. The following basic values of span to effective depth are given :

| | |
|---|---|
| Simply supported | 20 |
| Continuous | 26 |
| Cantilever | 7 |

Further modifying factors are given in order to account for the effects of grade and percentage of tension reinforcement and percentage of compression reinforcement.

### Control of Deflection

Check whether the depth of the member in the following cases is adequate for controlling deflection:

a) Beam of Example 1, as a simply supported beam over a span of 7.5 m
b) Beam of Example 3, as a cantilever beam over a span of 4.0 m
c) Slab of Example 2, as a continuous slab spanning in two directions the shorter and longer spans being, 2.5 m and 3.5 m respectively. The moment given in Example 2 corresponds to shorter span.

a) Actual ratio of $\dfrac{\text{Span}}{\text{Effective depth}} = \dfrac{7.5}{(56.25/100)} = 13.33$

Percentage of tension reinforcement required, $p_t = 0.6$

Referring to *Chart 22*, value of $\text{Max}\left(\dfrac{\text{Span}}{d}\right)$

corresponding to $p_t = 0.6$, is 22.2

Actual ratio of span to effective depth is less than the allowable value. Hence the depth provided is adequate for controlling deflection.

b) Actual ratio of $\dfrac{\text{Span}}{\text{Effective depth}} = \dfrac{4.0}{56.25/100} = 7.11$

Percentage of tensile reinforcement, $p_t = 1.117$

Referring to *Chart 22*.

Max value of $\left(\dfrac{\text{Span}}{d}\right) = 21.0$

For cantilevers, values read from the Chart are to be multiplied by 0.35.

∴ Max value of *l/d* for cantilever $= 21.0 \times 0.35 = 7.35$

∴ The section is satisfactory for control of deflection.

c) Actual ratio of $\dfrac{\text{Span}}{\text{Effective depth}} = \dfrac{2.5}{0.08} = 31.25$

(for slabs spanning in two directions, the shorter of the two is to be considered)

i) For $f_y = 415\ \text{N/mm}^2$

$p_t = 0.476$

Referring to *Chart 22*,

Max $\left(\dfrac{\text{Span}}{d}\right) = 23.6$

For continuous slabs the factor obtained from the Chart should be multiplied by 1.3.

∴ Max $\left(\dfrac{\text{Span}}{d}\right)$ for continuous slab $= 23.6 \times 1.3 = 30.68$

Actual ratio of span to effective depth is slightly greater than the allowable. Therefore the section may be slightly modified or actual deflection calculations may be made to ascertain whether it is within permissible limits.

ii) For $f_y = 250\ N/mm^2$

$p_t = 0.78$

Referring to *Chart 21*,

$$\text{Max}\ \left(\frac{\text{Span}}{d}\right) = 31.3$$

$\therefore$ For continuous slab, Max $\frac{\text{Span}}{d} = 31.3 \times 1.3 = 40.69$

Actual ratio of span to effective depth is less than allowable value. Hence the section provided is adequate for controlling deflection.

# 9.3. COMPRESSION MEMBERS

## 9.3.1. Axially Loaded Compression Members

All compression members are to be designed for a minimum eccentricity of load in two principal directions. Clause *24.4* of the Code specifies the following minimum eccentricity, $e_{min}$ for the design of columns :

$e_{min} = \frac{l}{500} + \frac{D}{30}$, subject to a minimum of 2 cm.

where

$l$ is the unsupported length of the column (*see 24.1.3* of the Code for definition of unsupported length), and

$D$ is the lateral dimension of the column in the direction under consideration.

After determining the eccentricity, the section should be designed for combined axial load and bending (*see 3.2*). However, as a simplification, when the value of the minimum eccentricity calculated as above is less than or equal to $0.05D$, *38.3* of the Code permits the design of short axially loaded compression members by the following equation :

$P_u = 0.4\, f_{ck}\, A_c + 0.67\, f_y\, A_{sc}$

where

$P_u$ is the axial load (ultimate),

$C_c$ is the area of concrete, and

$A_{sc}$ is the area of reinforcement.

The above equation can be written as

$$P_u = 0.4 f_{ck} \left( A_g - \frac{pA_g}{100} \right) + 0.67 f_y \frac{pA_g}{100}$$

where

$A_g$ is the gross area of cross section, and $p$ is the percentage of reinforcement.

Dividing both sides by $A_g$.

$$\frac{P_u}{A_g} = 0.4 f_{ck} \left( 1 - \frac{p}{100} \right) + 0.67 f_y \frac{p}{100}$$

$$= 0.4 f_{ck} + \frac{p}{100} (0.67 f_y - 0.4 f_{ck})$$

*Charts 24* to *26* can be used for designing short columns in accordance with the above equations. In the lower section of these charts, $P_u/A_g$ has been plotted against reinforcement percentage $p$ for different grades of concrete. If the cross section of the column is known, $P_u/A_g$ can be calculated and the reinforcement percentage read from the chart. In the upper section of the charts, $P_u/A_g$ is plotted against $P_u$ for various values of $A_g$. The combined use of the upper and lower sections would eliminate the need for any calculation. *This is particularly useful as an aid for deciding the sizes of columns at the preliminary design stage of multistoreyed buildings.*

## Axially Loaded Column

Determine the cross section and the reinforcement required for an axially loaded column with the following data :

| | |
|---|---|
| Factored load | 3 000 kN |
| Concrete grade | M20 |
| Characteristic strength of reinforcement | 415 N/mm$^2$ |
| Unsupported length of column | 3.0 m |

The cross-sectional dimensions required will depend on the percentage of reinforcement. Assuming 1.0 percent reinforcement and referring to *Chart 25*, Required cross-sectional area of column,

$A_g = 2\,700\ cm^2$

Provide a section of 60 x 45 cm.

Area of reinforcement, $A_s = 1.0 \times \frac{60 \times 45}{100} = 27\ cm^2$

We have to check whether the minimum eccentricity to be considered is within 0.05 times the lateral dimensions of the column. In the direction of longer dimension.

$$e_{min} = \frac{l}{500} + \frac{D}{30}$$

$$= \frac{3.0 \times 10^2}{500} + \frac{60}{30} = 0.6 + 2.0 = 2.6 \text{ cm or, } e_{min}/D = 2.6/60 = 0.043$$

In the direction of the shorter dimension,

$$e_{min} = \frac{3.0 \times 10^2}{500} + \frac{45}{30} = 0.6 + 1.5 = 2.1 \text{ cm or, } e_{min}/b = 2.1/45 = 0.047$$

The minimum eccentricity ratio is less than 0.05 in both directions. Hence the design of the section by the simplified method of *38.3* of the Code is valid.

# 9.4. SHEAR AND TORSION

## 9.4.1. Design Shear Strength of Concrete

The design shear strength of concrete is given in Table 13 of the Code. The values given in the Code are based on the following equation.

$$\gamma_c = \frac{0.85\sqrt{0.8 f_{ck}}\,(\sqrt{1+5\beta} - 1)}{6\beta}$$

where

$\beta = 0.8\, f_{ck}/6.89\, p_t$, but not less than 1.0, and $p_t = 100\, A_{st}/b_w d$.

The value of $\gamma_c$ corresponding to $p_t$ varying from 0.20 to 3.00 at intervals of 0.10 are given in Table 61 for different grades of concrete.

### 9.4.2. Nominal Shear Stress

The nominal shear stress $\gamma_v$ is calculated by the following equation :

$$\gamma_v = \frac{V_u}{bd}$$

where

$V_u$ is the shear force.

When $\gamma_v$ exceeds $\gamma_c$ shear reinforcement should be provided for carrying a shear equal to $V_u - \gamma_c bd$. The shear stress $\gamma_v$ should not in any case exceed the values of $\gamma_{c,max}$ given in Table J. (If $\gamma_v$) $> \gamma_{c,max}$, the section is to be redesigned.

Table J Maximum Shear Stress $\gamma_{c,max}$

| Concrete Grade | M15 | M20 | M25 | M30 | M35 | M40 |
|---|---|---|---|---|---|---|
| $\gamma_{c,max}$ N/mm² | 2.5 | 2.8 | 3.1 | 3.5 | 3.7 | 4.0 |

### 9.4.3. Shear Reinforcement

The design shear strength of vertical stirrups is given by the following equation:

$$V_{us} = \frac{0.87 f_y A_{sv} d}{s_v}$$

where

$A_{sv}$ is the total cross sectional area of the vertical legs of the stirupps, and

$s_v$ is the spacing (pitch) of the stirupps.

The shear strength expressed as $V_{us}/d$ are given in Table 62 for different diameters and spacings of stirrups, for two grades of steel. For a series of inclined stirrupps, the value of $V_{us}/d$ for vertical stirrups should be multiplied by (sin ∝ + cos ∝) where ∝ is the angle between the inclined stirrups and the axis of the member. The multiplying factor works out to 1.41 and 1.37 for 45° and 60° angles respectively.

For a bent up bar, $V_{us} = 0.87 f_y A_{sv} \sin \propto$

Values of $V_{us}$ for different sizes of bars, bent up at 45° and 60° to the axis of the member are given in Table 63 for two grades of steel.

### 9.4.4. Torsion

Separate Charts or Tables are not given for torsion. The method of design for torsion is based on the calculation of an equivalent shear force and an equivalent bending moment. After determining these, some of the Charts and Tables for shear and flexure can be used. The method of design for torsion is illustrated in Example 11

**Shear**

Determine the shear reinforcement (vertical stirrups) required for a beam section with the following data :

| | |
|---|---|
| Beam size | 30 x 60 cm |
| Depth of beam | 60 cm |
| Concrete grade | M 15 |
| Characteristic strength of stirrup reinforcement | 250 N/mm² |
| Tensile reinforcement percentage | 0.8 |
| Factored shear force, $V_u$ | 180 kN |

Assuming 25 mm dia bars with 25 mm cover,

$$d = 60 - \frac{2.5}{2} - 2.5 = 56.25 \text{ cm}$$

$$\text{Shear stress, } \gamma_v = \frac{V_u}{bd} = \frac{180 \times 10^3}{30 \times 56.25 \times 10^2} = 1.07 \text{ N/mm}^2$$

From *Table J* for M15, $\gamma_{c,max} = 2.5$ N/mm² $\gamma_v$ is less than $\gamma_{c,max}$

From *Table 61*, for $P_t = 0.8$, $\gamma_c = 0.55$ N/mm²

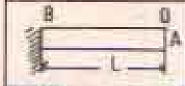
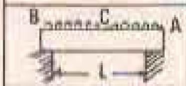
Shear capacity of concrete section $= \gamma_c\, bd = 0.55 \times 30 \times 56.25 \times 10^2/10^3 =$ 92.8 kN.

Shear to be carried by stirrups, $V_{us} = V_u - \gamma_c bd = 180 - 92.8 = 87.2$ kN

$$\frac{V_{us}}{d} = \frac{87.2}{56.25} = 1.55 \text{ kN/cm}$$

Referring to *Table 62*, for steel $f_y = 250$ N/mm². Provide 8 mm diameter two legged vertical stirrups at 14 cm spacing.

## 9.5. Bending Moment and Shearing Force in Members

| Method of Loading | Location of Maximum | | Bending Moment | | Shearing Forces | | Maximum Deflection and slope |
|---|---|---|---|---|---|---|---|
| | Bending | Deflection | Maximum | Diagram | Maximum | Diagram | |
|  | B | A | $P = WL$ |  | $P = W$ |  | $\frac{WL^3}{3EI}$ $\frac{WL^2}{2EI}$ |
|  | B | A | $P = \frac{WL}{2}$ |  | $P = W$ |  | $\frac{WL}{8\,EI}$ $\frac{WL^2}{24EI}$ |
|  | C | C | $P = \frac{WL}{4}$ |  | $P = \frac{W}{2}$ $Q = \frac{W}{2}$ |  | $\frac{WL^3}{48EI}$ $\frac{WL^2}{16EI}$ |
|  | C | C | $P = \frac{WL}{8}$ |  | $P = \frac{W}{2}$ $Q = \frac{W}{2}$ |  | $\frac{5WL^3}{384EI}$ $\frac{WL^2}{24EI}$ |
|  | C | D not max at C | $P = \frac{Wab}{L}$ |  | $P = \frac{Wb}{L}$ $Q = \frac{Wa}{L}$ |  | $\frac{Wa^2 b^2}{3EIL} = \delta c$* |
|  | at AB & C | C | $P = \frac{WL}{4}$ $Q = \frac{WL}{8}$ |  | $P = \frac{W}{2}$ $Q = \frac{W}{2}$ |  | $\frac{WL^3}{192EI}$ |
|  | A or B C | C | $P = \frac{WL}{8}$ $Q = \frac{WL}{12}$ |  | $P = \frac{W}{2}$ $Q = \frac{W}{2}$ |  | $\frac{WL^3}{384EI}$ |

* At D, distant $\sqrt{a(2L-a)} \div 3$ from B, $\delta = W(L-a)\,(2aL-a^2)^{3/2} \div 9\sqrt{3}\,EIL$

## 9.6.1. Permissible Design Stresses for Concrete

| Type of concrete and mix | Compressive strength at 28 days (i) (kg/cm²) | | Permissible stress in compression (kg/cm²) | | Permissible stress in shear (kg/cm²) | Permissible stress in bond (kg/cm²) | | Permissible bearing pressure on full area (plain concrete only) (kg/cm²) |
|---|---|---|---|---|---|---|---|---|
| | preliminary test | works test | Direct | Bending | | Average for anchorage | Local | |
| Ordinary concrete | | | | | | | | |
| M. 250 1 : 1 : 2 mix | 320 | 250 | 60 | 85 | 8.0 | 9.0 | 15.0 | 50 |
| M. 200 1 : 1½ : 3 mix | 260 | 200 | 50 | 70 | 7.0 | 8.0 | 13.0 | 40 |
| M. 150 1 : 2 : 4 mix | 200 | 150 | 40 | 50 | 5.0 | 6.0 | 10.0 | 30 |
| M. 100 1 : 3 : 6 mix | 135 | 100 | 25 | 30 | 3.0 | 4.0 | 7.0 | 20 |

(1) The values of ordinary concrete apply for tests on cubic specimens. For cylinder strengths they are to be multiplied by 1.25.
(2) Permissible stress in tension, in bending may be taken to the same as permissible stress in shear.

### 9.6.2. Design Stresses for Steel

| Grade | Units | Ultimate strength Method of Design | | Working Stress Method of Design | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Tension | | Compression | | Tension in shear reinforcement |
| | | Tension | Compression | Upto dia 20 mm | More than dia 20 mm | Columns | Slabs beams | |
| Mild Steel | $Kg/cm^2$ | 4250 | 3700 | 2300 | 2100 | 1750 | 1900 | 1750 |
| TOR 42 | $Kg/cm^2$ | 2500 | 2400 | 1400 | 1400 | 1300 | 1400 | 1400 |
| TOR 50 | $Kg/cm^2$ | 5000 | 4200 | 2700 | 2500 | 2000 | 2100 | 2000 |

### 9.6.3. Tibbed Torsteel

*Substitution as tension reinforcement*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mild Steel (mm) | 8 | 10 | 12 | 16 | 20 | 22 | 25 | 28 | 32 | 36 | 40 |
| Tor 42 Steel (mm) | 6* | 8 | 10 | 12* | 16 | 18 | 20 | 22 | 25 | 28 | 32 |

*Original spacing should be reduced by 10%

Substitution as compression reinforcement

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mild Steel (mm) | 12 | 14 | 20 | 22 | 25 | 28 | 32 | 36 | 40 |
| Tor 42 Steel (mm) | 10 | 14 | 2 × 12 | 18 | 20 | 22 | 2 × 18 | 2 × 20 | 32 |

## 9.7.1. Load Carrying Capacity of R.C. Columns (as per limit state design method)

**(For M 15 grade concrete)**

Working load $P = \frac{BD}{98.07}(4 + 1.81367p)$ Tonnes where B & D are in Cm and p = % of steel

| Column Size B × D | Load carrying capacity (Tonnes) % of Steel | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.8 | 1.0 | 1.2 | 1.5 | 1.8 | 2.0 | 2.2 | 2.5 | 2.8 | 3.0 | 3.2 | 3.5 | 3.8 | 4.0 | 4.5 | 5.0 |
| 20 × 30 | 22.2 | 23.7 | 25.2 | 27.4 | 29.6 | 31.1 | 32.5 | 34.8 | 37.0 | 38.4 | 40.0 | 42.2 | 44.4 | 45.9 | 49.6 | 53.2 |
| 20 × 30 | 33.3 | 35.6 | 37.7 | 41.1 | 44.5 | 46.6 | 48.8 | 52.2 | 55.5 | 57.7 | 60.0 | 63.3 | 66.6 | 68.8 | 74.3 | 79.9 |
| 20 × 40 | 44.5 | 47.4 | 50.4 | 54.8 | 59.2 | 62.2 | 65.2 | 69.5 | 74.0 | 77.0 | 79.9 | 84.4 | 88.8 | 91.8 | 99.2 | 106.6 |
| 20 × 50 | 55.6 | 59.2 | 62.9 | 68.5 | 74.0 | 77.7 | 81.5 | 87.0 | 92.6 | 96.3 | 99.9 | 105.4 | 111.0 | 114.7 | 124.0 | 133.3 |
| 23 × 23 | 29.4 | 31.3 | 33.2 | 36.2 | 39.2 | 41.1 | 43.0 | 46.0 | 49.0 | 50.9 | 52.8 | 55.8 | 58.7 | 60.7 | 65.6 | 70.5 |
| 23 × 30 | 38.3 | 40.9 | 43.4 | 47.2 | 51.1 | 53.6 | 56.2 | 60.1 | 63.8 | 56.4 | 68.9 | 72.8 | 76.6 | 79.1 | 85.6 | 91.9 |
| 23 × 45 | 57.5 | 61.3 | 65.2 | 70.9 | 76.7 | 80.5 | 84.3 | 90.0 | 95.7 | 99.6 | 103.4 | 109.2 | 114.9 | 118.8 | 128.3 | 137.9 |
| 23 × 50 | 64.0 | 68.1 | 72.4 | 78.8 | 85.1 | 89.4 | 93.7 | 100.0 | 106.4 | 110.6 | 114.9 | 121.3 | 127.7 | 131.9 | 142.6 | 153.3 |
| 25 × 25 | 34.7 | 37.0 | 39.4 | 42.8 | 46.3 | 48.5 | 50.9 | 54.3 | 57.8 | 60.2 | 62.4 | 65.9 | 69.3 | 71.7 | 77.5 | 83.2 |
| 25 × 40 | 55.6 | 59.2 | 62.9 | 68.5 | 74.0 | 77.7 | 81.5 | 87.0 | 92.6 | 96.3 | 99.9 | 105.4 | 111.0 | 114.7 | 124.0 | 133.3 |
| 25 × 45 | 62.5 | 66.7 | 70.9 | 77.1 | 83.3 | 87.5 | 91.7 | 97.9 | 104.1 | 108.3 | 112.5 | 118.7 | 124.9 | 129.1 | 139.5 | 149.9 |
| 25 × 50 | 69.4 | 74.0 | 78.7 | 85.7 | 92.6 | 97.2 | 101.8 | 108.7 | 115.6 | 120.3 | 124.9 | 131.8 | 138.8 | 143.5 | 155.0 | 166.5 |
| 25 × 60 | 83.3 | 88.9 | 94.4 | 102.8 | 111.2 | 116.7 | 122.2 | 130.5 | 138.8 | 144.4 | 149.9 | 158.8 | 166.5 | 172.1 | 166.0 | 199.9 |
| 30 × 30 | 50.0 | 53.3 | 56.7 | 61.7 | 66.7 | 69.9 | 73.3 | 78.3 | 83.3 | 86.6 | 89.9 | 94.9 | 99.9 | 103.3 | 111.6 | 119.0 |
| 30 × 40 | 66.7 | 71.1 | 75.6 | 82.2 | 88.8 | 93.3 | 97.8 | 104.4 | 111.0 | 115.5 | 119.9 | 126.5 | 133.3 | 137.7 | 148.8 | 159.9 |
| 30 × 45 | 75.0 | 80.0 | 85.0 | 92.5 | 99.9 | 104.9 | 109.9 | 117.5 | 124.9 | 129.9 | 134.9 | 142.4 | 149.9 | 164.9 | 167.4 | 179.9 |
| 30 × 50 | 83.3 | 88.8 | 94.4 | 102.8 | 111.0 | 116.7 | 122.2 | 130.5 | 138.8 | 144.4 | 149.9 | 158.3 | 166.5 | 172.1 | 186.0 | 199.9 |
| 30 × 60 | 100.0 | 106.7 | 113.3 | 123.3 | 133.3 | 140.0 | 146.6 | 156.6 | 166.6 | 173.2 | 179.9 | 189.9 | 199.9 | 206.6 | 223.2 | 239.8 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 × 45 | 87.5 | 93.3 | 99.1 | 107.9 | 116.7 | 122.5 | 128.3 | 137.0 | 145.8 | 151.6 | 157.4 | 166.5 | 174.9 | 180.7 | 195.3 | 209.8 |
| 35 × 70 | 136.1 | 145.2 | 154.3 | 167.8 | 181.5 | 190.5 | 199.6 | 213.2 | 226.8 | 235.9 | 244.9 | 268.5 | 272.1 | 281.1 | 303.8 | 326.4 |
| 40 × 40 | 88.9 | 94.8 | 100.7 | 109.6 | 118.5 | 124.4 | 130.3 | 139.2 | 148.1 | 154.0 | 159.9 | 168.8 | 177.6 | 183.5 | 198.4 | 213.2 |
| 40 × 50 | 111.1 | 118.5 | 125.9 | 137.0 | 148.2 | 155.5 | 162.9 | 174.1 | 185.1 | 192.5 | 199.9 | 211.0 | 222.1 | 229.5 | 248.0 | 266.4 |
| 40 × 60 | 133.4 | 142.2 | 151.2 | 164.5 | 177.7 | 186.6 | 195.5 | 208.8 | 222.1 | 231.1 | 239.9 | 253.2 | 266.5 | 275.4 | 297.5 | 319.8 |
| 40 × 70 | 155.6 | 166.0 | 176.3 | 191.8 | 207.4 | 217.7 | 228.1 | 243.6 | 259.2 | 269.5 | 273.9 | 295.4 | 310.2 | 321.3 | 347.2 | 373.1 |
| 40 × 80 | 177.8 | 189.7 | 101.5 | 219.2 | 237.0 | 248.8 | 260.7 | 278.5 | 296.2 | 308.0 | 319.9 | 337.6 | 355.4 | 367.2 | 396.8 | 426.4 |
| 40 × 100 | 222.3 | 237.1 | 251.9 | 274.1 | 296.3 | 311.1 | 325.9 | 348.0 | 370.2 | 385.0 | 399.8 | 422.0 | 444.2 | 459.1 | 496.0 | 533.0 |
| 45 × 45 | 112.6 | 120.0 | 127.5 | 138.8 | 150.0 | 157.4 | 165.0 | 176.2 | 187.4 | 195.0 | 202.4 | 217.4 | 224.8 | 232.4 | 251.0 | 269.8 |
| 45 × 60 | 150.0 | 160.0 | 170.0 | 185.0 | 200.0 | 210.0 | 219.9 | 234.9 | 249.9 | 259.9 | 269.9 | 289.9 | 299.9 | 309.8 | 335.0 | 359.7 |
| 45 × 80 | 200.1 | 213.4 | 226.7 | 246.7 | 266.6 | 280.0 | 293.3 | 313.2 | 333.2 | 346.5 | 359.8 | 386.6 | 399.8 | 413.1 | 446.4 | 479.7 |
| 45 × 90 | 225.0 | 240.0 | 255.0 | 277.6 | 300.0 | 315.0 | 330.0 | 352.4 | 374.8 | 389.8 | 404.8 | 434.8 | 449.8 | 464.8 | 502.2 | 539.6 |
| 50 × 50 | 138.9 | 148.2 | 157.4 | 171.3 | 185.2 | 194.5 | 203.6 | 217.5 | 231.4 | 240.6 | 249.9 | 268.4 | 278.7 | 286.8 | 310.0 | 333.1 |
| 50 × 70 | 194.6 | 207.4 | 220.4 | 239.8 | 259.2 | 272.2 | 285.1 | 304.6 | 324.0 | 336.9 | 349.9 | 375.8 | 388.7 | 401.7 | 434.0 | 466.4 |
| 50 × 80 | 222.3 | 237.1 | 251.9 | 274.1 | 296.3 | 311.1 | 325.9 | 348.0 | 370.2 | 385.0 | 399.8 | 429.4 | 444.2 | 459.1 | 496.0 | 533.0 |
| 50 × 90 | 250.1 | 266.8 | 283.4 | 308.4 | 333.3 | 350.0 | 366.6 | 391.6 | 416.5 | 433.2 | 449.8 | 483.1 | 499.7 | 516.4 | 558.0 | 599.6 |
| 50 × 100 | 277.9 | 296.4 | 314.9 | 342.6 | 370.3 | 388.8 | 407.4 | 435.1 | 462.8 | 481.3 | 499.8 | 536.8 | 555.3 | 573.8 | 620.0 | 666.3 |
| 60 × 60 | 200.1 | 213.4 | 226.7 | 246.7 | 266.6 | 280.0 | 293.3 | 313.2 | 333.2 | 346.5 | 359.8 | 386.5 | 399.8 | 413.1 | 445.4 | 479.8 |
| 60 × 80 | 266.8 | 284.5 | 302.2 | 329.0 | 355.6 | 373.3 | 391.0 | 417.7 | 444.3 | 462.8 | 479.8 | 515.3 | 533.1 | 550.8 | 595.2 | 640.0 |
| 60 × 90 | 300.1 | 320.1 | 340.1 | 370.0 | 400.0 | 419.9 | 439.9 | 469.9 | 499.8 | 519.8 | 539.8 | 579.7 | 599.7 | 619.7 | 669.6 | 719.9 |
| 60 × 100 | 333.4 | 355.7 | 377.9 | 411.1 | 444.4 | 466.6 | 488.8 | 522.1 | 555.4 | 577.5 | 599.8 | 644.1 | 666.4 | 688.5 | 744.1 | 799.9 |

## 9.7.2. Load Carrying Capacity of Concrete in Circular Columns (tonnes)

| Column Dia (cm) | Gross Area $A_c$ (sq.cm.) | Load on Concrete | | | | | | Load on Bars Min: 0.008 $A_c$ qsc Max: 0.040 $A_c q_{sc}$ | |
|---|---|---|---|---|---|---|---|---|---|
| | | M150 | M200 | M250 | M300 | M350 | M400 | Min | Max |
| 20 | 314 | 12.5 | 15.7 | 18.8 | 25.1 | 28.2 | 31.4 | 4.2 | 21.3 |
| 25 | 491 | 19.6 | 24.5 | 29.4 | 39.2 | 44.2 | 49.1 | 6.6 | 33.4 |
| 30 | 707 | 28.2 | 35.3 | 42.4 | 56.5 | 63.6 | 70.7 | 6.9 | 48.1 |
| 35 | 962 | 38.4 | 48.1 | 57.7 | 76.9 | 86.5 | 96.2 | 13.1 | 65.5 |
| 40 | 1257 | 50.2 | 62.8 | 75.4 | 100.5 | 113.1 | 125.7 | 17.1 | 85.5 |
| 45 | 1590 | 63.6 | 79.5 | 95.4 | 127.2 | 143.1 | 159.0 | 21.6 | 108.0 |
| 50 | 1963 | 78.5 | 98.1 | 117.8 | 157.0 | 176.6 | 196.3 | 26.7 | 133.4 |
| 60 | 2827 | 113.0 | 141.3 | 169.6 | 226.2 | 254.4 | 282.7 | 38.4 | 192.0 |
| 70 | 3848 | 153.9 | 192.4 | 230.9 | 307.8 | 346.3 | 384.8 | 52.3 | 261.5 |
| 80 | 5026 | 201.0 | 251.3 | 301.5 | 402.0 | 452.3 | 502.6 | 68.3 | 341.7 |
| 90 | 6362 | 254.4 | 318.1 | 381.7 | 508.9 | 572.5 | 636.2 | 86.5 | 432.5 |
| 100 | 7854 | 314.1 | 392.7 | 471.2 | 628.3 | 706.8 | 785.4 | 106.8 | 534.0 |

### 9.7.3. Load Carrying Capacity of Longitudinal Reinforcement in Columns

| Bar Dia. (mm) | Area (sq.cm.) | Force per Bar | No. of Bars | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
| 12 | 1.13 | 1.9 | 7.7 | 11.5 | 15.4 | 19.2 | 23.0 | 26.9 | 30.7 |
| 16 | 2.01 | 3.4 | 13.7 | 20.5 | 27.4 | 34.2 | 41.0 | 47.9 | 54.7 |
| 18 | 2.54 | 4.3 | 17.3 | 25.9 | 34.6 | 43.2 | 51.8 | 69.5 | 69.1 |
| 20 | 3.14 | 5.3 | 21.4 | 32.0 | 42.7 | 53.4 | 64.1 | 74.8 | 85.4 |
| 22 | 3.80 | 6.4 | 25.8 | 38.8 | 51.7 | 64.6 | 77.5 | 90.4 | 103.4 |
| 25 | 4.91 | 8.3 | 33.4 | 50.1 | 66.8 | 83.5 | 100.2 | 116.9 | 133.6 |
| 28 | 6.16 | 10.4 | 41.9 | 62.8 | 83.8 | 104.7 | 125.6 | 146.6 | 167.5 |
| 32 | 8.04 | 13.6 | 54.7 | 82.0 | 109.4 | 136.7 | 164.0 | 191.4 | 218.7 |
| 36 | 10.18 | 17.3 | 69.2 | 103.9 | 138.5 | 173.1 | 207.7 | 242.3 | 277.0 |
| 40 | 12.57 | 21.3 | 85.5 | 128.2 | 171.0 | 213.7 | 256.4 | 299.2 | 341.9 |

# X. WATER SUPPLY ENGINEERING

## 10.1. DRINKING WATER STANDARDS.

### 10.1.1. Standards for Physical and Chemical Quality

| Substance or Property | Acceptable* | Cause for Rejection** |
|---|---|---|
| 1 | 2 | 3 |
| **Physical Quality** | | |
| Turbidity (Units on J.T.U. Scale) | 2.5 | 10 |
| Colour (Units on Platinum Cobalt scale) | 5.0 | 25 |
| Taste and odour | Unobjectionable | Objectionable |
| **Chemical Quality** | | |
| pH | 7.0 to 8.5 | $<6.5>9.2$ |
| Total dissolved solids (mg/l) | 500 | 1500 |
| Total hardness (as $CaCO_3$) (mg/l) | 200 | 600 |
| Calcium (as Ca) (mg/l) | 75 | 200 |
| Magnesium (as Mg) (mg/l)† | 30 | 150 |
| Chlorides (as Cl) (mg/l) | 200 | 1000 |

*Figures indicated under the column acceptable are the limits upto which the water is generally acceptable to the consumers.

**Figures in excess of those mentioned under acceptable limits render the water not acceptable, but still may be tolerated in the absence of alternative and better source but upto the limits indicated under column "cause for rejection", above which the supply will have to be rejected.

† If there are 250 mg/l of sulphates, Mg. content can be increased to a maximum of 125 mg/l with the reduction of sulphates at the rate of 1 unit per every 2.5 units of sulphates.

| 1 | 2 | 3 |
|---|---|---|
| Sulphates (as $SO_4$) (mg/l) | 200 | 400 |
| Iron (as Fe) (mg/l) | 0.1 | 1.0 |
| Manganese (as Mn) (mg/l) | 0.05 | 0.5 |
| Copper (as Cu) (mg/l) | 0.05 | 1.5 |
| Zinc (as Zn) (mg/l) | 5.0 | 15.0 |
| Phenolic Compounds (as phenols) (mg/l) | 0.001 | 0.002 |
| Anionic detergents (as MBAS) (mg/l) | 0.2 | 1.0 |
| Fluorides (as F) (mg/l) | 1.0 | 1.5 |
| Nitrates (as $NO_3$) (mg/l) | 45 | >45 |

**Toxic Materials**

| | | |
|---|---|---|
| Arsenic (as As) (mg/l) | 0.05 | >0.05 |
| Barium (as Ba) (mg/l) | | 1.00 |
| Cadmium (as Cd) (mg/l) | 0.01 | >0.01 |
| Chromium (as hexavalent Cr) (mg/l) | 0.05 | >0.05 |
| Cyanides (as CN) (mg/l) | 0.05 | >0.05 |
| Lead (as Pb) (mg/l) | 0.1 | >0.1 |
| Mercury (total as Hg) (mg/l) | 0.001 | >0.001 |
| Selenium (as Se) (mg/l) | 0.01 | 0.05 |
| Silver (as Ag) (mg/l) | – | 0.05 |
| Poly nuclear Aromatic Hydrocarbon (PAH) | 0.2 ug/l | >0.2 ug/l |

| | | |
|---|---|---|
| **Radio activity‡** | 1 ug – 0.001 mg | |
| Gross Alpha activity | 3 pCi/l | >3 pCi/l |
| Gross Beta activity | 30 pCi/l | >30 pCi/l |
| | | (pCi – pico Curie) |

‡ It is possible that some mine and spring waters may exceed these radio activity limits and in such cases it is necessary to analyse the individual radio nuclides in order to assess the acceptability or otherwise for public consumption.

## 10.1.2. Standards for Bacteriological Quality

(i) Water entering the distribution system.

Coliform count in any sample of 100 ml. should be zero. A sample of the water entering the distribution system that does not confirm to this standard calls for an immediate investigation into both the efficacy of the purification process and the method of sampling.

(ii) Water in the distribution system shall satisfy all the three criteria indicated below:

E Colicount in 100 ml of any sample should be zero.

Coliform organisms not more than 100 per ml shall be present in any sample.

Coliform organisms should not be detectable in 100 ml of any two consecutive samples or more than 50% of the samples collected for the year.

If coliform organisms are found, resampling should be done. The repeated finding of 1 to 10 coliform organisms in 100 ml. or the appearance of higher numbers in any sample should necessitate the investigation and removal of the source of pollution.

(iii) Individual or small community supplies.

E Colicount should be zero in any sample of 100 ml. and coliform organisms should not be more than 3 per 100 ml. (If repeated samples show the presence of coliform organisms, steps should be taken to discover and remove the source of pollution. If coliform exceed 3 per 100ml. the supply should be disinfected.)

## 10.1.3. Standards for Virological Quality

0.5 mg/l of free chlorine residual for one hour is sufficient to inactivate virus, even in water that was originally polluted. This free chlorine residual is to be insisted in all disinfected supplies in areas suspected of endemicity of infectious hepatitis to take care of the safety of the supply from virus point of view which incidentally takes care of the safety from the bacteriological point of view as well. For other areas, 0.2 mg/l of free chlorine residual for half an hour should be insisted.

# 10.2. DESIGN CRITERIA

## 10.2. 1. Period of Design

| Items | Design Period (Years) | Remarks |
|---|---|---|
| 1 | 2 | 3 |
| 1. Storage by dams | 50 | The dam may be constructed in two stages. In the first stage, the height of dam may be kept just sufficient for the requirements of the 30 year period. |
| 2. Infiltration works | 30 | The infiltration works may be designed and constructed for the intermediate requirements of 15 years and may be extended later to meet the ultimate requirements. |
| 3. Pumpsets | | |
| (i) All prime movers except electric motors | 30 | |
| (ii) Electric motors and pumps | 15 | |
| 4. Water treatment units | 15 | |
| 5. Pipe connections to the several treatment units and other small appurtenances | 50 | |
| 6. Raw water and clear water conveying mains | 30 | The comparative merits to cover the full 30 years period vs. a main to cover the first 15 years supplemented by another either for the entire length or part of it for the next 15 years should be examined to decide on the most economical arrangement. |
| 7. Clear water reservoirs at the headworks, balancing tanks and service reservoirs (overhead or ground level) in the distribution net work | 15 | Additional units may be added after the 15 year period. |
| 8. Distribution system | 30 | Feeder mains to areas under-developed however may be limited to the needs of the first 15 years, and replaced or additional mains added after that period to meet the ultimate requirements. |

## 10.2.2. Water Supply Requirements

### 10.2.2.1. For Residences

Where possible, 135 litres (30 gallons) per capita per day, for residences provided with water carriage sanitation with the barest minimum however as:

| | | Litres/Capita/day |
|---|---|---|
| 1. For population upto 10,000 | : | 70 to 100 |
| 2. For population from 10,000 to 50,000 | : | 100 to 125 |
| 3. For population above 50,000 | : | 125 to 200 |
| 4. For rural communities | : | Not less than 40 |

### 10.2.2.2. For Industrial Purposes

The per capital rates of supply recommended will ordinarily include the requirements of small industries distributed within a town. For specific industries separate provision will have to be made as indicated below;

| Industry | Unit of production | Water requirement in Kilo-litres per unit |
|---|---|---|
| Automobile | Vehicle | 40 |
| Distillery | Kilolitres | 60-170 |
| Fertilizer | Tonne | 80-300 |
| Tannery | 100 kg (tanned) | 3-4 |
| Pulp and Paper | Tonne | 200-500 |
| Special quality paper | Tonne | 900-1000 |
| Straw board | Tonne | 75-100 |
| Petroleum refinery | Tonne (crude) | 10-30 |
| Steel | Tonne | 100-250 |
| Sugar | Tonne (cane crushed) | 1-15 |
| Textile: Cotton | 100 kg (goods) | 1-25 |
| Wool | 100 " | 40 |
| Rayon | 100 " | 200 |
| Dairy | Kilolitre (milk) | 4-10 |
| Meat | 100 kg | 2.3 |
| Poultry | 100 kg | 0.6-4.3 |
| Cement | Tonne | 1.0-4.0 |
| Sago | Tonne | 4-10 |
| Coal | Tonne | 1.0 |
| Coke | Tonne | 5.0 |
| Laundry | 100 kg (washed goods) | 3-5 |
| Electric power | Kwh | 0.2 |

### 10.2.2.3. For buildings other than residences

| No. | Type of Building | Litres per person per day |
|---|---|---|
| 1. | Factories where bath rooms are required to be provided | 45 |
| 2. | Factories where no bath rooms are required to be provided | 30 |
| 3. | Hospitals (including laundry) | |
| | a. No. of beds less than 100 | 340 |
| | b. No. of beds exceeding 100 | 455 |
| 4. | Nurses Homes and Medical Quarters | 135 |
| 5. | Hostels | 135 |
| 6. | Hotels (per bed) | 180 |
| 7. | Offices | 45 |
| 8. | Restaurants (per seat) | 70 |
| 9. | Air ports and Sea ports | 70 |
| 10. | Railways and Bus Stations | |
| | **Junctions:** | |
| | Where bathing facilities are provided | 70 |
| | Where bathing facilities are not provided | 45 |
| | Intermediate stations: | |
| | Where bathing facilities are provided | 45 |
| | Where bathing facilities are not provided | 25 |
| | **Terminal stations:** | 45 |
| 11. | Cinemas, Concert Halls and Theatres (per seat) | 15 |
| 12. | Schools/Colleges | |
| | 1. Day Schools/Colleges | 45 |
| | b. Boarding Schools/Colleges | 135 |

# 10.3. YIELD FROM GROUND WATER SUPPLIES:

In the case of the ground water supplies, the maximum safe yield is limited by the capacity of the water bearing strata to supply water without suffering a continous lowering of the water table. The specific yield of a well is the discharge per foot of draw-down at the well. If a well is not developed to the full capacity of the acquifier, the maximum yield is limited by maximum permissible draw-down at the well which is determined by the critical velocity to prevent sand-blows. For a given draw-down the yield can be increased by surrounding the well screen with gravel backing having a higher permeability than the material of the acquifer. Draw-down can be increased for increasing the yield by suitably plugging the bottom of the well with graded material to prevent sand-blows.

In the case wells and infiltration galleries the adequacy of the yield will have to be satisfied by full power tests carried out for a sufficient length of time during dry weather. The capacity of the gallery should be calculated on a 20 hours yield basis giving 4 hours for rest and recuperation.

## 10.3.1. YIELD TESTS:

The yield from each infiltration well or gallery is determined by one of the following preliminary tests:

### 10.3.1.1. DISCHARGE TEST

In the discharge test, a pump is fixed close to the well and water is pumped out. The quantity of water pumped is measured in a V notch chamber consisting a V notch at one end of a steel or masonry chamber constructed for the purpose. The water discharging from V notch chamber if it is near the well, should be lot away in a channel lined with impervious clay so that the water pumped out, does not find out its way into the soil and to the well. As water from the well is pumped out, the water level in the well is depressed and a stage will be reached when the quantity pumped out is equivalent to the water entering the well and at that stage the depression head would remain constant. The rate of pumpage in this depression head would remain constant. The rate of pumpage in this position is the yield from the well for the head of depression. The V notch readings observed in a particular case are tabulated in a statement as given-below and all the levels are recorded with reference to a guage fixed to the well as shown in the table below:

# DISCHARGE TEST TABLE

| Date | Hour | Interval in minutes | Depression of water level during the interval in ft. | Average head of depression during interval in feet | Quantity discharged in the interval in gallons | Quantity of water in well in gallons | Inflow into the well during interval in gallons | Yield in gallons per min. | Specific vertical yield gallons per min. per foot of depression head. |
|---|---|---|---|---|---|---|---|---|---|
| | | dt | dh | h | pdt | Adh | Khdt. | kn | K |
| 1-5-1941 | 7.0 | | | | | | | | |
| | 7.5 | 5 | 1.9 | 0.95 | 1567 | 1342.5 | 224.5 | 44.9 | 47 |
| | 7.10 | 5 | 0.96 | 2.38 | " | 676.2 | 800.8 | 178.2 | 75 |
| | 7.15 | 5 | 0.6 | 3.16 | " | 422.5 | 1144.5 | 228.9 | 72 |
| | 7.20 | 5 | 0.38 | 3.65 | " | 268.2 | 1298.8 | 269.8 | 71 |
| | 7.25 | 5 | 0.250 | 3.96 | " | 176.8 | 1390.2 | 278.0 | 70 |
| | 7.30 | 5 | 0.125 | 4.15 | " | 88.4 | 1478.6 | 295.7 | 71 |
| | 7.35 | 5 | 0.083 | 4.26 | " | 58.9 | 1508.1 | 301.6 | 71 |
| | 7.40 | 5 | 0.042 | 4.32 | " | 29.5 | 1537.5 | 307.5 | 71 |
| | 7.45 | 5 | 0.040 | 4.36 | " | 29.5 | 1537.5 | 307.5 | 71 |
| | 7.50 | 5 | 0.020 | 4.39 | " | 14.8 | 1552.2 | 310.4 | 71 |
| | 8.00 | 10 | 0.021 | 4.41 | 3134 | 14.8 | 3119.2 | 312.9 | 71 |
| | 8.45 | 45 | 0.042 | 0.44 | 14103 | 29.5 | 1407.5 | 313.1 | 70 |

Dia. of well = 12' 0"

A. 113.14 sq.ft.

The yield from the well at different depths of depression are worked out and shown in column 10 of the statement.

Let A = Area of the well.

h = The head by which the water level, in the well is depressed.

H = The head at which the rate of pumping is equal to yield of the well.

K = The specific vertical yield of the well under a head of 10' in gallons per minute.

p = Yield from the well at depression head H.

p = Rate of pumping

The water level, before pumping is commenced, is say, at zero and as pumping is continued, the water level goes on falling in the well. The rate of pumping is equivalent to the volume of water by which the water level in the well depressed, plus infiltration flow in the well. If readings are observed, for every 5 minutes interval starting from zero level the dependable yield of the well at different depression heads can be found out as given in the statement above.

Suppose in time 'dt' the water level in the well is depressed from h ft. to (h + dh) ft. The quantity of water pumped out during that period is:—

$$\text{pdt} = \text{Adh} + \text{Khdt.}$$

$$\text{dt (p} - \text{kH)} = \text{Adh}$$

$$\text{dt} = \frac{\text{Adh}}{\text{p} - \text{Kh}}$$

Integrating

$$t = (-)\frac{A}{K}\log(p - Kh) + C$$

when t = 0, h = 0

$$\therefore O = (-)\frac{A}{K}\log p + C$$

$$\therefore C = \frac{A}{K}\log p$$

$$t = \frac{A}{K}\log p - \frac{A}{K}\log(p - Kh)$$

or

$$t = \frac{A}{K}\log\frac{p}{p - Kh} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

From this, the time taken to depress the water level from zero to h can be determined.

In this formula, p, h and t are determined by experiments. Therefore K can be found out by calculation, vide column 10 of the above statement. As pumping is continued, a stage will be reached when the quantity of water pumped out is equivalent to the inflow into the well. At that stage P = KH. Substituting this in formula (1).

$$t = \frac{A}{K}\log\frac{KH}{KH - Kh}$$

$$t = \frac{A}{K}\log\frac{H}{H - h}$$

$$e^{Kt/A} = \frac{H}{H - h}$$

In these tests the critical head beyond which the water level should not be depressed should also be determined by careful observation. The critical head is the head at which soil or sand particles are being drawn continuously from the bottom of the well. It is ascertained by collecting the water delivered from the pump at frequent intervals in a bucket and examining it for sand particles after they have had time to settle. The point at which there is a continual pumping of sand from the well bottom defines the critical depression head. This head can be increased in fine sandy soils by providing the coarse sand plug already described. The yield tests should be conducted for a long time, say not less than a month to ascertain the dependable yield. Then a curve is to be drawn with the average depression head as ordinate and the yield in gallons per minute as abscissae.

## 10.3.1.2. RECUPERATION TEST

In the Recuperation test, the rate of recuperation in the well is observed and the rate of inflow at different levels of depression calculated. After conducting the discharge test, pumping is stopped and water allowed to rise in the well. The time taken for the water level is to rise for every half a foot is observed and tabulated in a statement given below:

| Date | Hour | Interval | Rise in water level during the interval in inches | Average depression head in feet | Inflow during the interval in gallons | Rate of inflow in gallons per min. | Specific vertical yield in gallons per min. |
|---|---|---|---|---|---|---|---|
| | | dt | dh | h | Khdt | Kh | K |
| | h.m.s. | h.m.s. | | | | | |
| | 4-30-0 | | | | | | |
| | 31-10 | 0-1-10 | 6 | 4.25 | 353.6 | 303.1 | 71 |
| | 32-25 | 0-1-15 | 6 | 3.75 | " | 282.9 | 71 |
| | 33-50 | 0-1-25 | 6 | 3.25 | " | 249.5 | 71 |
| | 35-30 | 0-1-40 | 6 | 2.75 | " | 212.2 | 71 |
| | 37-35 | 0-2-55 | 6 | 2.25 | " | 169.7 | 70-5 |
| | 40-15 | 0-2-40 | 6 | 1.75 | " | 132.6 | 71 |
| | 43-00 | 0-2-45 | 6 | 1.15 | " | 128.6 | 103 |
| | 49-50 | 0-6-5 | 6 | 0.75 | " | 58.1 | 77 |
| | 5-3-0 | 0-13-55 | 6 | 0.25 | " | 28.8 | 117 |

In this case the water level at the beginning is h ft. below zero in a short interval dt. the water level rises by dh

then Kh, dt = (−) Adh

$$\frac{A}{K}\,dt = (-)\,\frac{dh}{h}$$

Integrating

$$\frac{A}{K} t = \log_e + C$$

$t = 0$ when $h = H$

$$\log_e H = C$$

Substituting this –

$$\frac{K}{A} t = -\log_e h + \log_e H$$

$$t = \frac{A}{K} \log_e \frac{H}{h}$$

Yield tests are to be conducted during the period when the ground water level is at its lowest in summer and preferably in a year of draught or below average. During the test the cone of depression in the ground outside the well also should be observed by putting in tell-tale borings. As the curve of the cone of depression is Steeper near the well, the tell-tale borings should be spaced at closer intervals near the well. The first tell-tale boring may be just outside the well, second 5' third 10', and the next ones 25', 50' and 100' from the well. The yield from wells of 10' to 12' diameter in a good coarse sand strata is about 300 g.p.m. at a depression head of 4' to 5' and the yield from galleries in the bed of the rivers from 1 gallon per minute to gallons per minute per running foot of gallery.

## 10.3.1.3. JONE'S FORMULA FOR YIELD FROM WELLS:

Jone's formula for the yield from well sunk in Homogeneous stratum which is generally applicable to India is –

$$y = \frac{h\sqrt{h}}{10} S^2 + \left(\frac{hd}{5} S\right)$$

Where y = Yield in gallons per hour.

h = Head of water in feet i.e., difference between the normal ground water level and the level inside the well when pumping is in progress.

d = The total dia, of the well in feet.

S = The longitudinal slope of the water table i.e., the length per foot fall.

Water supply requirements per capita for. various purposes — Gallons per head per day.

| CLASS | A | B | C | D | E |
|---|---|---|---|---|---|
| Domestic consumption | 5 | 6 | 6 | 6 | 6 |
| Bathing and washing purposes | 5 | 6 | 6 | 6 | 6 |
| Public Latrines and urinal road watering and public gardens including public fountaining etc. | — 2 | 3 | 5 | 5 | 5 |
| Sewer and drain flushing etc. and private water — closets | — 3 | 3 | 3 | 3 | 3 |
| Leakage from main is etc. | — 0.5 | 0.5 | 1 | 1 | 1 |
| Filter wash water | — 0.5 | 0.5 | 1 | 1 | 1 |
| Sundries (stables, cowhouses Dhobi ghats etc.) | — 2 | 3 | 3 | 3 | 3 |
| Private Gardens | — 2 | 3 | 3 | 5 | 5 |
| Industries etc. | — Special provision according to size | | | | |
| Fire Services | spl. provision according to circumstances. | | | | |
| Total | — 20 | 25 | 28 | 30 | 30 |

Reference class A — Town of less than 13,000 population
B — Town of 10,000 to 25,000 "
C — Town of 25,000 to 50,000 "
D — Town of 50,000 to 1,00,000 "
E — Town of 100,300 to 200,000 "

For fire fighting: — 0.21 P gallons per. capita per day

where P = Population in thousands:

The population to be served: The scheme that is designed is expected to serve an ultimate population at the end of 30 years from the date of completion of the schemes. In predicting the ultimate population at the end of the period of design the following formula is generally used.

$$Pn = P(1 + \frac{r}{100})^n$$

Where Pn = Ultimate population after 'n' decades.
P = Present Population
n = No. of decades.
r = average rate of increase (expressed in percentage) per decade.

In working out the rate, the rates obtained in the past as well as rates obtaining in towns similar in nature and similarly situated are studied comparatively and reasonable rate arrived at.

Works connected with purification of water are broadly classified as follows:—

(a) Plain Sedimentation.

(b) Filtration through slow sand filters or mechanical filters.

(c) Chemical treatment —
(i) Coagulation for removal of colloids, etc.
(ii) Water softening for removal of hardness.
(iii) Removal of iron and manganese
(iv) Removal of fluorides.
(v) Disinfection.

Frictional losses in pipes : $hf = \frac{4Fl^2}{2gd}$

where V = Velocity of flow in ft. sec.
L = length of pipe in feet.
d = diameter of pipe in feet;
2g = 64.4
f = co-efficient of friction 0.005 to 0.01 for G.I. pipes.
hf = loss of head due to friction.

## 10.4. DESIGN FOR ESTIMATION OF WATER SUPPLY

### 10.4.1. Estimation of Population

By Arithmetical Analysis

$$P = P_o + K_n (t_n + t_o)$$

$$\text{where: } K = \frac{(P_x - P_o)}{(t_x - t_o)}$$

By Geometrical Analysis

$$\log P_n = \log P_o + K_n (t_o)$$

$$\text{where, } K_n = \frac{(\log P_x - \log P_o)}{(t_x - t_o)}$$

Po = Present population (as per census during $t_o$ years).
Px = Population before 'x' years (i.e., $t_x$ years).
Pn = Population after 'n' years (i.e., $t_n$ years).

10.4.2. Design periods for different components of a Water Supply Scheme:

| Population | Design periods for: Pumps (Years) | Distribution (Years) | Reservoirs (Years) | Lag Periods (Years) |
|---|---|---|---|---|
| 1. Less than 50,000 | 20 | 25 | 40 | 5 |
| 2. 50,000 to 2,00,000 | 15 | 20 | 40 | 3 |
| 3. Above 2,00,000 | 15 | 15 | 40 | 3 |

## 10.5. ALLOWABLE PRESSURES AND OTHER DETAILS OF PIPES GENERALLY USED FOR CONVEYING MAINS.

| Material | Class | Allowable pressure: Test Pressure $kg/cm^2$ | Test Pressure metres of water | Working Pressure $kg/cm^2$ | Working Pressure metres of water | Average Value of C | Available sizes (Diameter) | Available lengths of pipes |
|---|---|---|---|---|---|---|---|---|
| Cast Iron | LA | 12.0 | 120 m | 6.0 | 60 m | 100 | 80 mm to 1200 mm | 3.66m, 4m, 4.88m, 5.0m, 5.5 m |
| | A | 18.0 | 180 m | 9.0 | 90 m | | 80 mm to 1200 mm | 3.66m, 4m, 4.88m, 5.5m |
| | B | 24.0 | 240 m | 12.0 | 120 m | | 80 mm to 1200 mm | 3.66mm, 4m, 4.88m, 5.5m |
| Steel | Class 1 | 15.0 | 150 m | 7.5 | 75 m | 95 | 200 mm to 2000 mm | 3m to 5m |
| | Class 2 | 20.0 | 200 m | 10.0 | 100 m | | | |
| | Class 3 | 25.0 | 250 m | 12.5 | 125 m | | | |
| R.C.C. | $P_1$ | 2.0 | 20 m | 1.33 | 13 m | 120 | 80 mm to 600 mm | 2m, 2.5m, 3m |
| | $P_2$ | 4.0 | 40 m | 2.0 | 20 m | | 80 mm to 600 mm | 2m, 2.5m, 3m |
| | $P_3$ | 6.0 | 60 m | 3.0 | 30 m | | 80 mm to 450 mm | 2m, 2.5m, 3m |
| A.C. | Class 5 | 5.0 | 50 m | 2.5 | 25 m | 130 | 80 mm to 300 mm | 3m, 4m |
| | Class 10 | 10.0 | 100 m | 5.0 | 50 m | | 80 mm to 300 mm | 3m, 4m |
| | Class 15 | 15.0 | 150 m | 7.5 | 75 m | | 80 mm to 300 mm | 3m, 4m |
| P.V.C. | 2.5 $kg/cm^2$ | 5.0 | 50 m | 2.5 | 25 m | 140 | 90 mm to 315 mm | 3m, 5m, 6m |
| | 4.0 $kg/cm^2$ | 8.0 | 80 m | 4.0 | 40 m | | 50 mm to 315 mm | 3m, 5m, 6m |
| | 6.0 $kg/cm^2$ | 12.0 | 120 m | 6.0 | 60 m | | 40 mm to 315 mm | 3m, 5m, 6m |
| | 10.0 $kg/cm^2$ | 20.0 | 200 m | 10.0 | 100 m | | 16 mm to 125 mm | 3m, 5m, 6m |

*Note: 1. Working pressures are generally specified as half of Test pressures for pumping mains and two thirds for gravity mains.*

*2. The sizes indicated against P.V.C. pipes are outer dimensions.*

## 10.5. CEMENT CONCRETE PIPES

*(Clssifications are according to IS : 458-1971)*

| Class | Description | Conditions were normally used |
|---|---|---|
| $NP_1$ | Unreinforced concrete, non-pressure pipes | for drainage and irrigation use, above ground or in shallow trenches |
| $NP_2$ | RC, light duty, non-pressure pipes. | For culverts carrying light traffic. |
| $NP_3$ | RC, heavy duty, non-pressure, pipes. | For culverts carrying heavy traffic. |
| $NP_4$ | RC. — do — | For culverts carrying very heavy traffic, such as railway loading. |
| $P_1$ | RC pressure pipes tested to a hydrostatic pressure of 2.0 kg/sq. cm. [20 m head] | For use on gravity mains the actual working pressure not exceeding 2/3 of the test pressure. |
| $P_2$ | RC pressure pipes tested to a hydrostatic pressure of 4.0 kg/sq.cm. [40 m head] | For use on pumping mains, actual working pressure not exceeding ½ of the test pressure |
| $P_3$ | RC pressure pipes tested to a hydrostatic pressur eof 6.0 kg/sq.cm. [60 m head] | — do — |

# 10.6. APPROXIMATE QUANTITIES OF MATERIALS AND LABOUR REQUIRED FOR JOINTING CAST IRON PIPES OF DIFFERENT DIAMETERS PER 10 JOINTS.

| Dia of pipe | Lead | Spun yarn | Fuel wood | Kerosene oil | Labour | | |
|---|---|---|---|---|---|---|---|
| | | | | | Fitter | Asst. fitter | Mazdoor |
| mm. | kg. | kg. | kg. | litres | No. | No. | No. |
| 80 (3") | 19 | 1.0 | 19 | 0.4 | 1 | 1 | 2 |
| 100 (4") | 25 | 1.8 | 29 | 0.5 | 1 | 1 | 2 |
| 125 (5") | 30 | 2.0 | 38 | 0.8 | 1½ | 1½ | 3 |
| 150 (6") | 38 | 2.0 | 43 | 0.8 | 1½ | 1½ | 3 |
| 200 (8") | 50 | 3.0 | 57 | 0.9 | 1¾ | 1¾ | 3½ |
| 9 inches | 55 | 3.2 | 62 | 1.2 | 1¾ | 1¾ | 3½ |
| 250 (10") | 63 | 3.5 | 66 | 1.3 | 2 | 2 | 4 |
| 300 (12") | 77 | 4.8 | 76 | 1.5 | 2¼ | 2¼ | 4½ |
| 350 (14") | 90 | 6.0 | 90 | 1.7 | 2½ | 2½ | 4½ |
| 15 inches | 98 | 6.7 | 100 | 1.8 | 2¾ | 2¾ | 5½ |
| 400 (16") | 110 | 7.5 | 110 | 2.0 | 3 | 3 | 6 |
| 450 (18") | 130 | 9.5 | 125 | 2.8 | 3½ | 3½ | 7 |
| 500 (20") | 150 | 10.0 | 130 | 2.8 | 4 | 4 | 8 |
| 21 inches | 160 | 10.8 | 140 | 2.9 | 4½ | 4½ | 9 |
| 600 (24") | 185 | 12.0 | 170 | 3.0 | 6 | 6 | 12 |
| 700 (28") | 220 | 13.5 | 210 | 3.2 | 7 | 7 | 14 |
| 750 (30") | 250 | 14.5 | 240 | 3.5 | 7½ | 7½ | 15 |
| 800 (32") | 280 | 15.3 | 260 | 3.8 | 8 | 8 | 16 |
| 900 (36") | 340 | 18.8 | 290 | 4.5 | 9 | 9 | 18 |
| 1000 (40") | 410 | 20.5 | 350 | 4.8 | 10 | 10 | 20 |
| 1100 (44") | 460 | 24.0 | 380 | 5.0 | 11 | 11 | 22 |
| 1200 (48") | 500 | 26.0 | 420 | 6.0 | 12 | 12 | 24 |
| 1500 (60") | 660 | 28.0 | 500 | 7.5 | 14 | 14 | 28 |
| 1800 (72") | 900 | 31.0 | 600 | 8.5 | 16 | 16 | 32 |

# 10.7. SUBMERSIBLE PUMPS

The submersible pump is a compact sealed in unit which is lowered in to a bored tube-well casing pipe while motor is located at ground level and drives a vertical shaft extending down to the pump. This pump is often used for drawing water from drilled wells in which the water level is at a considerable depth below the ground. Deep well pumps are generally multi stage centrifugal turbine pumps having two or more impellers of relatively small diameter with a discharge column extending to the top of the well, and suction piping can be eliminated. These pumps are made for diameters as small as 100 mm, although 150 mm is the recommended minimum up to 330 mm, and the usual length of the pump is 200 mm to 600 mm. Bore hole pumps are electrically driven and are quick starting, require no priming, have high efficiencies, produce larger volume of water from a small well than any other type, and are very popular in modern well installations. The cost of installation and running of a bore-hole pump is higher than an ordinary pump; is not suitable for shallow depths of water as the pump requires adequate submergence.

It is desirable that the bowls of bore-hole pumps should be kept at a sufficiently low level so that they remain submerged below water under working conditions. Where full submergence is not possible, the foot valve should remain submerged, or suction tube may be attached below the foot valve so that the lower end of this suction tube always remains submerged. Before starting the motor the delivery valve should be opened about two turns for the air from the rising mains to escape.

It is of utmost importance that the bore of the pump is perfectly vertical and it should never be out of plumb more than the clearance between the inside surface of the well pipe and the outside diameter of the pump bowls. Bore-hole pumps revolve with a high speed and eccentricity will have great damaging effect. Methods for finding out eccentricity in tube wells has been explained under "Methods of Boring"

# 10.8. WELL LININGS OR STEENING

In alluvial soils open dug wells with steenings can be made economically upto a depth of 30 m and wells without lining [and curbs] are practicable only up to a depth of about 5½ to 6 metres. The steening is usually made of brick work or masonry. Large cement concrete rings 60 to 90 cm high are also used. Where dry masonry is used in between dry masonry some bonds of pucca masonry are also provided for strength. Bricks with mortar are sometimes used for a height of about 3 metres, from the ground surface with dry joints below.

To prevent infiltration of dirty surface water into the well, the steening should be made water tight and also when filling up the excavation to back the lining with some impermeable material, such as puddle, for 2½ to 3 metres from the surface and about one metre thick.

Where the whole of the lining is made impervious, the water can percolate into the well from the bottom only Weep holes 150 × 75 mm for the admission of water are left at intervals in the steening and which should be omitted in shallow wells.

## 10.8.1. Thickness of Steening of wells

| Depth of well from ground level in m | Suggested thickness in centimetres for Diameter of well in m | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1½ m | 3 m | 4½ m | 6 m | 9 m | 12 m | |
| 3 m | 40 | 40 | 40 | 50 | 50 | 50 | Where high skin |
| 6 m | 40 | 50 | 50 | 50 | 60 | 70 | friction in |
| 9 m | 50 | 50 | 50 | 60 | 70 | 90 | anticipated |
| 12 m | 50 | 60 | 60 | 70 | 80 | 100 | thickness of |
| 18 m | 60 | 70 | 70 | 80 | 90 | 110 | steening should |
| 24 m | 60 | 80 | 80 | 90 | – | – | be increased. |
| 30 m | 70 | 90 | 90 | 110 | – | – | |
| 36 m | 70 | 100 | 100 | – | – | – | |

For rubble masonry steening depths, the thickness may be 7½ to 15 cm more than the respective figures given above for brick work steening.

Stell or RCC tubing can be used as lining up to 1.8 metres in loose and sandy soils.

Kachha wells without lining which are of temporary nature can be made only where the spring level and the soil can stand vertically or with a slight slope in practice.

## 10.9. HORSE POWER REQUIRED TO LIFT DIFFERENT QUANTITIES OF WATER TO ELEVATIONS OF 3 TO 30 m

$$HP = \left[\frac{\text{Quantity in lpm} \times \text{Head in metres} \times 2}{60 \times 76}\right]$$

*(assuming 50% efficiency of pump)*

| QTY IN LPM | HP REQD. FOR THE ELEVATION OF | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 m | 5 m | 10 m | 15 m | 20 m | 25 m | 30 m |
| 500 | 0.66 | 1.10 | 2.19 | 3.29 | 4.39 | 5.48 | 6.58 |
| 1000 | 1.32 | 2.19 | 4.39 | 6.58 | 8.77 | 10.96 | 13.16 |
| 1500 | 1.97 | 3.29 | 6.58 | 9.87 | 13.16 | 16.45 | 19.74 |
| 2000 | 2.63 | 4.39 | 8.77 | 13.16 | 17.54 | 21.93 | 26.32 |
| 2500 | 3.29 | 5.48 | 10.96 | 16.45 | 21.93 | 27.41 | 32.89 |
| 3000 | 3.95 | 6.58 | 13.16 | 19.74 | 26.32 | 32.89 | 39.47 |
| 3500 | 4.61 | 7.68 | 15.35 | 23.03 | 30.70 | 38.38 | 46.05 |
| 4000 | 5.26 | 8.77 | 17.54 | 26.32 | 35.09 | 43.86 | 52.63 |
| 4500 | 5.92 | 9.87 | 19.74 | 29.61 | 39.47 | 49.34 | 59.21 |
| 5000 | 6.58 | 10.96 | 21.93 | 32.89 | 43.86 | 54.82 | 65.79 |
| 5500 | 7.24 | 12.06 | 24.12 | 36.18 | 48.25 | 60.31 | 72.37 |
| 6000 | 7.89 | 13.16 | 26.32 | 39.47 | 52.63 | 65.79 | 78.95 |
| 6500 | 8.55 | 14.25 | 28.51 | 42.76 | 57.02 | 71.27 | 85.53 |
| 7000 | 9.21 | 15.35 | 30.70 | 46.05 | 61.40 | 76.75 | 92.10 |
| 7500 | 9.87 | 16.45 | 32.89 | 49.34 | 65.79 | 82.24 | 98.68 |

## 10.10. DATA FOR WATER SUPPLY WORKS

Note : *1. All materials should be of approved quality and make and they should be got approved by E.E. before use on works. 2. Works should be done complying with relevant standard specification as directed by the Departmental officers.*

| Quantity Unit (1) | Description of Work (2) |
|---|---|

### 10.10.1. Internal Water Supply:

Supplying, fixing and jointing Galvanised Iron Pipes to walls, with all the required specials, including cutting and threading, and including dismantling masonry and RCC works, and making good of the dismantled portion and with necessary teakwood plugs, clamps, screws, white lead, spun yarn etc., including painting the pipes and fittings.

**For 10 Metres**

| | |
|---|---|
| 10 m. | Cost, of Galvanised Pipe<br>For cost of iron specials add 20% of the pipe cost. |
| 0.75 No. | Plumber 1st Class |
| 0.75 No. | Mazdoor |
| 0.25 No. | Painter 2nd Class |
| L.S. | Teakwood plugs, clamps, screws, white lead, spun yarn. |
| L.S. | Dismantling, making good of the dismantled portion, paint etc., cutting, threading. |

### 10.10.2. EXTERNAL WATER SUPPLY

Supplying, Laying and Jointing, Galvanised Iron Pipes with all the required specials including cutting and threading, wherever necessary and including Earthwork excavation, (wrapping the pipes with tarred gunny tapes sealed in tar) wherever the pipes are laid outside the building portion below ground level including dismantling masonry and RCC works and making good of the dismantled portion, and fixing the pipes with necessary teakwood plugs, clamps, screws, white — lead, spun-yarn etc., including painting the pipes and fittings.

**For 10 Metres**

| | |
|---|---|
| 10 Metres | Cost of Galvanised Iron Pipes of different diameters. |
| 15% of the cost of pipes | Cost of Galvanised Iron specials |
| 0.75 No. | Plumber 1st Class |
| 0.25 No. | Mason 1st Class |
| 0.75 No. | Mazdoor |
| 0.25 No. | Painter |
| L.S. | Teakwood plugs, clamps, screws, white-lead spun yarn |
| L.S. | Dismantling, making good of the dismantled portion. Earth work excavation, refilling painting etc. cutting, threading etc. |
| | For 10 Metres — Total |

**10.10.3. Supplying and fixing in position Gun Metal wheel valve full way, check valve, flanges, bend, tees etc.,**

FOR EACH

| | |
|---|---|
| 1 No. | Cost of Gun Metal wheel/valve full way, check valve/flanges Bends, Tees of various sizes etc. |
| 0.33 No. | Plumber 1st Class |
| 0.33 No. | Mazdoor |
| L.S. | Sundries for white lead etc. |
| | Total Rate Per No. |

**10.10.4. Supplying and fixing in position 12 mm dia Nickel plated screw down taps Brass/Chromium including cutting and threading and jointing with G.I. Pipes etc.**

FOR EACH

| | |
|---|---|
| 1 No. | Cost of 12 mm dia Brass/Chromium/or Nickel plated screw down tap. |
| 0.5 No. | Fitter 1st Class |
| L.S. | Sundries including white lead cutting threading etc. |
| | Total |

**10.10.5. Supplying and fixing in position 15 cm dia Chromium plated shower rose with required Gun-Metal wheel valve of 20 mm**

FOR EACH

| | |
|---|---|
| 1 No. | Cost of 15 cm dia Chromium plated shower rose. |
| 1 No. | Cost of 20 mm Gun-Metal wheel valve |
| 0.2 No. | Plumber 1st Class |
| 0.2 No. | Mazdoor |
| L.S. | Sundries for jointing, materials, clamps, threading etc. |
| | Total |

**10.10.6.** Supplying, and fixing best Indian make Cast Iron soil pipes and providing molten lead caulked leak proof joints with hemp yarn including fixing to the wall with necessary teakwood plugs, clamps, screws etc., and making connections to the sanitary fittings, dismantling masonry or RCC works or flooring and making good the dismantled portion including painting the pipes and fittings with 2 coats of paint the pipe fixed in position to true alignment.

FOR 10 METRES

| | |
|---|---|
| 10 Metres | Cost of Cast Iron Soil Pipes |
| 0.5 No. | Plumber 1st Class |
| 0.25 No. | Mason 1st Class |
| 1.50 Nos. | Mazdoor |
| 0.25 No. | Painter |
| L.S. | Lead and Hemp yarn for joints T.W. Plugs, Clamps, Screws |
| L.S. | Dismantling, making good the dismantled portion paint etc. |
| | Total |

# XI. SANITARY ENGINEERING

## 11.1. SEWAGE PROJECT

### 11.1.1. Preparation of Report

The following points are to be looked into in their sequential order while considering any public sewage project:

1. Population of the city to be served, 2. Available finance for the purpose. 3. Quality of sewage to be handled. 4. Rainfall in the locality. 5. Rate of sewage expected to be available. 6. Sources of sewage. 7. Present arrangements of disposal. 8. Topographical features of the area. 9. Treatment methods and 10. Future development trends of the city.

Drawings:– Contour plan of the area, 2. Detailed drawings of all units of project 3. Site plan exhibiting location of the scheme, 4. Topographical map, and 5. Flow diagram of proposed treatment methods.

Report:– The report should include – 1. Land acquisition. 2. Existing methods of disposal and necessity in their modifications, 3. Alignment and longitudinal slopes of sewer lines, 4. Financial aspects, 5. Nature of industrial sewage, 6. Detailed designs of various units of project. 7. Outline of specifications of construction work, 8. Present and future population to be served by the project, 9. Quality of sewage and mode of disposal of effluent, 10. Extent or standard of purification. 11. System of layout, whether sewage and storm water are to be tackled together or separately, and 12. Any other information which may be useful.

### 11.1.2. Water Consumption and Sewage Production in Cities

| Population | Water consumption in litres/head/day | Sewage production in litres/head/day |
|---|---|---|
| 1,00,000 | 135 | 115 |
| 2,00,000 | 160 | 135 |
| 5,00,000 | 180 | 160 |
| 10,00,000 | 200 | 180 |
| 10,00,000 and above | 225 | 200 |

### 11.1.3. Multiplying Factors for design of Sewers

| S.No. | Sewers | Times of average rate of annual flow for which sewer is to be designed |
|---|---|---|
| 1. | Domestic sewers | 6 |
| 2. | Lateral sewers | 4-6 |
| 3. | Branch sewers | 3 |
| 4. | Main sewers | 2.5 |
| 5. | Trunk or outfall sewers | 2 |

## 11.1.4. Self-cleansing Velocity and Grades

The velocity which can cause automatic self-cleansing effect can be found out by the following fomula given by Shield:—

$$V = \sqrt{\frac{8K}{f}\left(\frac{S-P}{P}\right) \times gd}$$

Where $f$ — Darcy's coefficient of friction being 0.03 for usual type of sewers. $K$ — Characteristics of solid particles carried in suspension by the sewage. Its value in M.K.S. units varies from 0.06 to 0.04 for organic and inorganic solids respectively, $S$ — specific gravity of the particles. Its value for organic and inorganic particles is 1.20 and 2.65, $P$ — Specific gravity of transporting liquid which is water in the case of sewage, and $d$ — Dia-meter of the particle to be carried in suspension.

The velocity which is essential to keep the particles in suspension works out to be nearly 0.5 m/sec. For design purposes velocity may be assumed as 1 m/sec.

| Diameter of sewer in mm | 0.75 m/sec. | 0.90 m/sec. | 1.05 m/sec. |
|---|---|---|---|
| 100 | 90 | 75 | 60 |
| 150 | 150 | 105 | 78 |
| 225 | 265 | 180 | 135 |
| 300 | 385 | 270 | 195 |
| 375 | 520 | 355 | 265 |
| 450 | 660 | 460 | 340 |
| 525 | 820 | 570 | 415 |
| 600 | 970 | 680 | 500 |
| 675 | 1100 | 790 | 580 |
| 750 | 1300 | 910 | 670 |
| 900 | 1700 | 1200 | 850 |
| 1050 | 2100 | 1450 | 1050 |
| 1200 | 2500 | 1700 | 1250 |

As per N.B.O. the following gradients have been commonly adopted as being sufficient to prevent interference with flow due to build up of solids in the case of small size sewers. These gradients are suitable for use in branch drains and with irregular flow. Approximate velocity and discharge flowing half-full are as below.

| Diameter | Gradient | Velocity in m/sec. | Discharge in $m^3$/min. |
|---|---|---|---|
| 100 mm | 1 in 60 | 0.58 | 0.14 |
| 150 mm | 1 in 100 | 0.61 | 0.33 |
| 225 mm | 1 in 120 | 0.79 | 0.97 |

As per Badwin Latham following values of self-cleansing velocities may be adopted for different size of sewers –

150 to 300 mm dia – 1 m/sec., 300 to 600 mm dia. – 0.75 m/sec., above 600 mm dia. – 0.60 m/sec.

### 11.1.5. Limiting Velocities in Sewers to Attain Self-Cleansing

| S.No. | Type of Sewers | Velocity in m/sec |
|---|---|---|
| 1. | Brick sewers | 2.0 to 2.5 |
| 2. | Stoneware or vitrified clay sewers | 3.0 to 3.5 |
| 3. | Concrete sewers | 2.5 to 3.0 |
| 4. | Cast iron sewers | 3.5 to 4.0 |

### 11.1.6. Spacing (c/c) of Manholes for larger sewers

*(IS 1742-1960)*

| Sewer size | Spacing of manhole |
|---|---|
| Upto 30 cm diameter | 45 m |
| Upto 60 cm diameter | 75 m |
| Upto 90 cm diameter | 90 m |
| Upto 120 cm diameter | 150 m |
| Upto 150 cm diameter | 250 m |
| For larger than 150 cm | 300 m |

### 11.1.7. Minimum internal Clear Size of Manhole Chambers

*(IS 1742-1960)*

(a) For depth of 0.8 m or less = 0.75 m × 0.75 m

(b) For depth between 0.8 and 2.1 m = 1.2 m × 0.9 m

(c) For depth more than 2.1 m – Circular chambers with a minimum diameter of 1.4 m or rectangular chamber with minimum internal dimensions of 1.2 × 0.9 m.

(d) Min. size of access shaft = 0.50 × 0.50 m

(e) Min. wall thickness – 20 cm.

## 11.1.8. Requirements of Fitments in Office Building

*(IS 1172-1963)*

| Fitments | For accomodation other than for Head of Office | |
|---|---|---|
| | For male personnel | For female personnel |
| W.C.s | One for 25 or part thereof | One for 15 or part thereof |
| Ablution taps | One in each W.C. | One in each W.C. |
| | One water tap with draining arrangements should be provided for every 50 persons or part thereof in the vicinity of W.C. and urinals. | |
| Urinals | Nil upto 6 persons<br>1 for 7- 20 persons<br>2 for 21- 45 persons<br>3 for 46 70 persons<br>4 for 71-100 persons<br>From 101 to 200 add at the rate of 3% and above add at the rate of 2.5% | Nil |
| Wash basin | One for 25 or part thereof | Same as for males |
| Drinking water fountains | One for every 100 with a minimum of one on each floor | Same as for males |
| Baths | Preferably one for each floor | Same as for males |
| Cleaner's sinks | One per floor, minimum preferably in or adjacent in sanitary room. | Same as for males |

## 11.2. DESIGN CONSIDERATIONS :

The design considerations for both small and large installations are furnished below in accordance to IS. 2470 (Pt. I) 1968 and IS. 2470 (Pt. II) 1971.

**General** — In unsewered areas, every house should have a arrangements for its sewage being treated in a septic tank, effluent from which should be given secondary treatment either in a biological filter or on the land, or in a subsurface disposal system.

1) Surface and subsoil water should be excluded from finding way into the septic tank. Waste water may be passed into the septic tank provided the tank and the means for effluent disposal are designed to cope up with this extra liquid.

2) Depending on the location of the water-table and the nature of the strata, the type of disposal for, the effluent from the septic tank may be decided (see 11.8.1.)

3) Under no circumstances should effluent from a septic tank be allowed into an open channel drain or body of water without adequate treatment.

### 11.2.1. Layout

The layout should be as simple and direct as practicable. A typical arrangement is illustrated in Fig. 11.1.

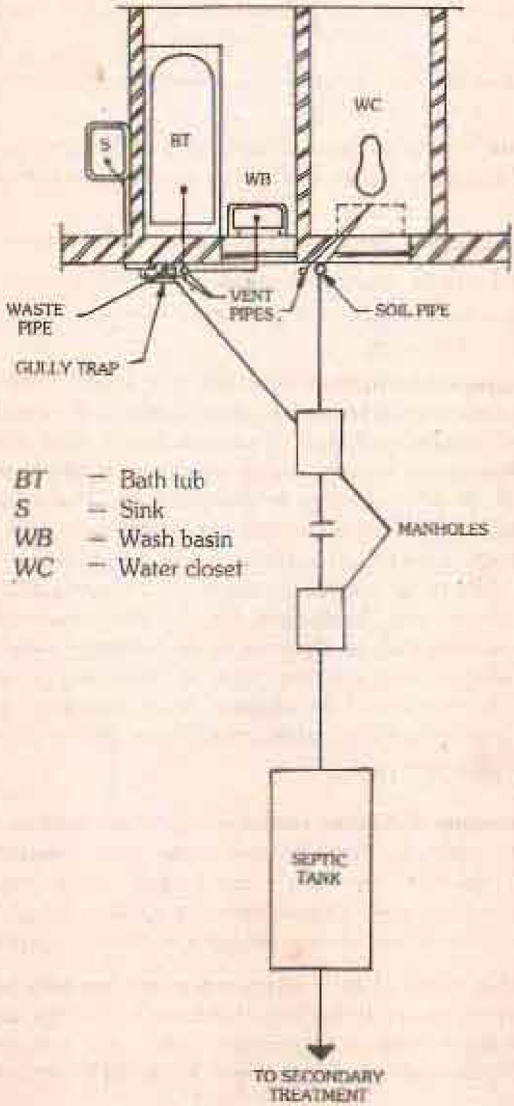



Fig. 11.1. Typical Layout of a Septic Tank Sewerage System

**11.2.2.** The pipes should be laid, as far as possible, in straight lines in both vertical and horizontal planes; however, where bends are unavoidable, they should be long radius bends with cleaning eyes. Anything that is likely to cause irregularity of flow should be avoided.

**11.2.3.** At junctions of pipes in manholes, direction of flow from a branch connection should not make an angle exceeding 45° with the direction of flow in the main pipe.

**11.3. Pipe Diameter** — From practical considerations a minimum nominal diameter of 100 mm is recommended.

**11.4. Gradients** — The gardients of land drains, under drainage as well as the bottom of dispersion trenches and soakaways should be between 1 : 300 and 1 : 400.

## 11.5.Location of Septic Tank and Subsurface Absorption Systems

**11.5.1. Septic Tank:—** Septic tank should be located at a place open to sky, as far away as possible from the exterior of the wall of building. It should also be accessible for cleaning.

**11.5.2. Subsurface Absorption Systems:—** A subsoil dispersion system be closer than 18 m from any source of drinking water, such as well to mitigate the possibility of bacterial pollution of water supply. It shall also be as far removed from the nearest habitable building as economically feasible but not closer than 6 m, to avoid damage to the structures. The actual distance, however shall be based on the soil conditions in relation to both percolation and bearing capacity. Care should be taken that the ground below the adjacent building is not likely to be affected by the effluent seeping into the soil. In limestones or crevice rock formations, the soil absorption system is not recommended as there may be channels in the formation which may carry contamination over — long distance; in such cases, and generally where suitable conditions do not exist for adoption of soil absorption systems, the effluent, where feasible should be treated in a trickling filter or chlorinated.

## 11.6. SMALL SEPTIC TANK

**11.6.1. Dimensions of Septic Tanks** — Septic tank shall have minimum width of 75 cm, minimum depth of one metre below water level and a minimum liquid capacity of one cubic metre. Length of tanks shall be 2 to 4 times the width. Suitable sizes of septic tanks for use of 5, 10, 15, 20 and 50 persons based on certain assumptions are given in Table I for guidance.

**11.6.2.** A detention period of 24 to 48 hours is usually available based on the average daily flow of sewage. It may be noted however, that the average daily flow varies considerably from one installation to the other and the detention period should not be considered as a criterion for design of septic tank.

## TABLE I RECOMMENDED CAPACITIES AND SIZES OF SEPTIC TANKS

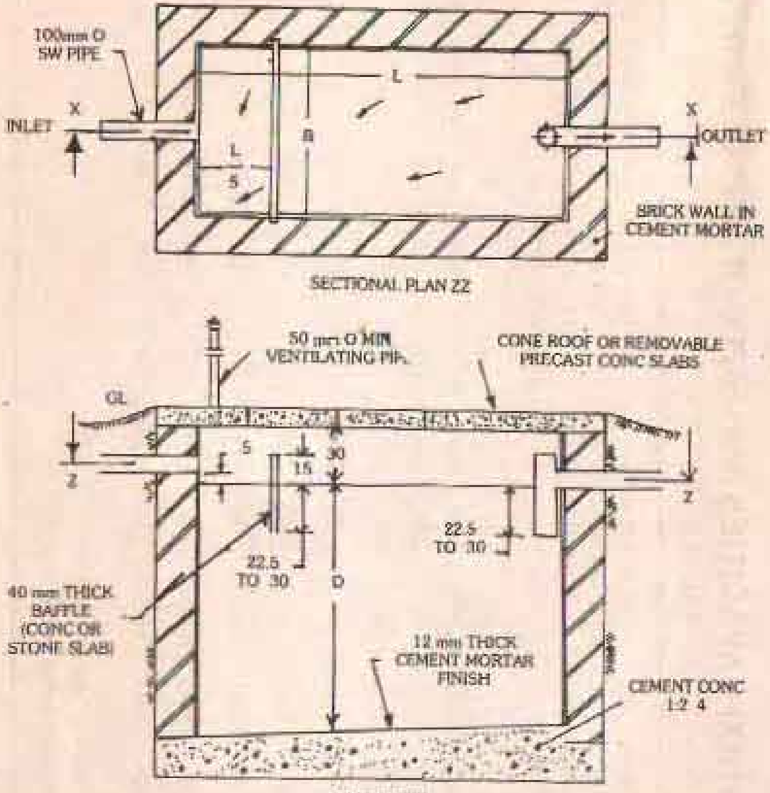
*(Clause 11.6. and Fig. 11.2., 11.3. & 11.4.)*

| No. of Users | Length $L$ | Breadth $B$ | Liquid Depth $D$ (For Cleaning Interval of) | | | Liquid Capacity (For Cleaning Interval of) | | | Sludge to be Removed (For Cleaning Interval of) | | | Depth of Sludge to be Withdrawn in | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 6 months | 1 year | 2 years | 6 months | 1 year | 2 years | 6 months | 1 year | 2 years | 6 months | 1 year | 2 years |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| | m | m | m | m | m | $m^3$ | $m^3$ | $m^3$ | $m^3$ | $m^3$ | $m^3$ | m | m | m |
| 5 | 1.50 | 0.75 | — | 1.00 | 1.05 | — | 1.12 | 1.18 | — | 0.36 | 0.72 | — | 0.32 | 0.64 |
| 10 | 2.00 | 0.90 | — | 1.00 | 1.40 | — | 1.80 | 2.52 | — | 0.72 | 1.44 | — | 0.40 | 0.80 |
| 15 | 2.00 | 0.90 | — | 1.30 | 2.00 | — | 2.34 | 3.60 | — | 1.08 | 2.16 | — | 0.60 | 1.20 |
| 20 | 2.30 | 1.10 | 1.00 | 1.30 | 1.80 | 2.53 | 3.30 | 4.55 | 0.72 | 1.44 | 2.88 | 2.28 | 0.57 | 1.14 |
| 50 | 4.00 | 1.40 | 1.00 | 1.30 | 2.00 | 5.60 | 7.28 | 11.20 | 1.80 | 3.60 | 7.20 | 0.32 | 0.64 | 1.28 |

Note 1 — *The capacities recommended provide for waste water also.*

Note 2 — *A provision of 30 cm should be made for free board.*

Recommended Designs — Figures 11.2 to 4 give tyical designs of septic tanks.



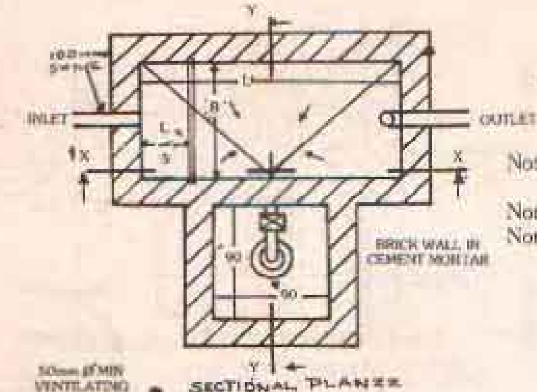

Note 1 — A bottom slope of 5 to 10 percent towards inlet is preferred.
Note 2 — To be desludged preferably by portable pump.
Note 3 — For dimensions *L*, *B* and *D*, *see* Table I.

*All dimensions in centimetres, unless otherwise specified.*

Fig. 11.2. Septic Tank — Type I

11.6.3. Construction — Septic tanks may be constructed of brickwork, stone masonry, concrete or other suitable materials.

11.6.3.1. Brickwork and stone masonry — Walls built out of brick should not be less than 20 cm thick and should be plastered to a minimum thickness of 12 mm inside and outside with cement mortar not weaker than 1 : 3; where they are built out of stone masonry, they should have a minimum thickness of 37 cm.




Note 1 — A bottom slope of 5 to 10 percent towards the sludge outlet is preferred.

Note 2 — Provision for desludging hydraulically is made.

Note 3 — For dimensions L, B and D, see, Table 1.

All dimensions in centimetres unless otherwise specified.

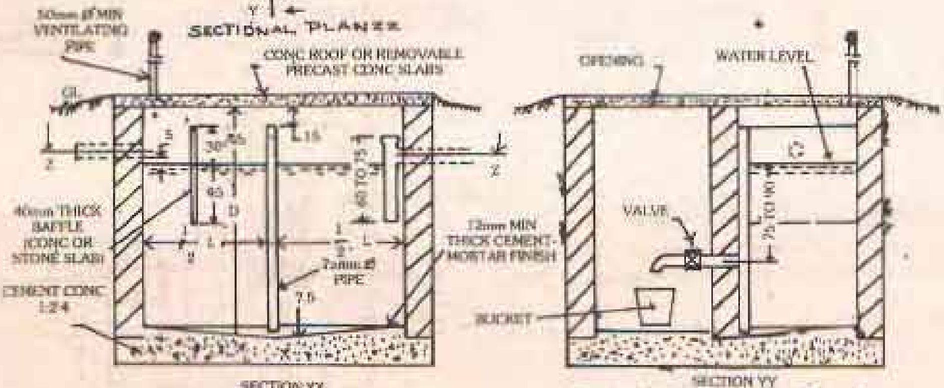
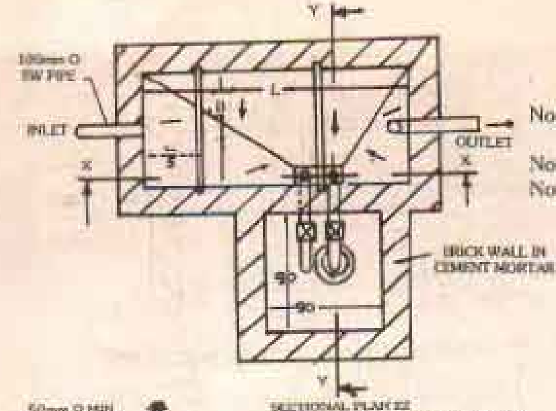



Fig. 11.3. Septic Tank — Type 2




Note 1 – A bottom slope of 5 to 10 percent towards the sludge outlet is preferred.

Note 2 – Provision for desludging hydraulically is made.

Note 3 – For dimensions $L$, $B$ and $D$, see Table 1.

All dimensions in centimetres unless otherwise specified.

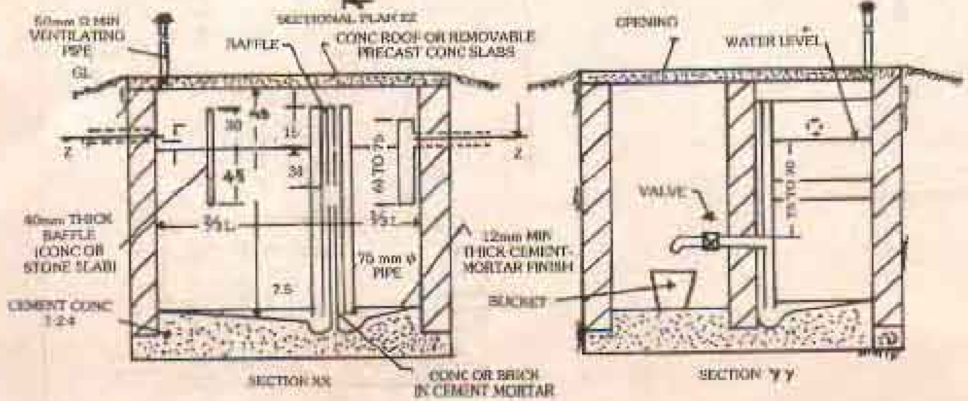



Fig. 11.4. Septic Tank – Type 3

**11.6.3.2. Floor** — The floor should be of cement concrete of Grade M150 and should be sloped towards the sludge outlet, if any.

**11.6.3.3. Pipes and fittings** — Inlet and outlet pipes and other fittings should be built in as the work proceeds. At the outlet ends, only tees are preferred but baffle walls may also be used where so desired.

**11.6.3.4. Concrete** — Septic tanks may be built out of precast or cast *in-situ* concrete and shall have a mix of proportion not leaner than 1 : 2 : 4 or Grade M 150

**11.6.3.5. Other materials** — Where septic tanks are constructed with materials other than brick, stone or concrete, they should be of adequate thickness and quality to ensure water-tightness and strength.

**11.6.3.6. Cover** — Every septic tank shall be provided with a cover of adequate strength. Access openings shall be provided for purposes of desludging and inspection. If circular, the clear opening shall be 500 mm dia, minimum and if rectangular, the opening shall have minimum dimensions of 600 × 450 mm.

**11.6.3.7. Ventilating pipe** — Every septic tank shall be provided with ventilating pipe of at least 50 mm diameter. The top of the pipe shall be provided with a suitable cage of mosquito proof wire mesh.

The ventilating pipe shall extend to a height which would cause no smell nuisance to any building in the area. Generally the ventilating pipe may extend to a height of about 2 m when the septic tank is at least 15 m away from the nearest building and to a height of 2 m above the top of the building when it is located closer than 15 metres. The ventilating pipe may also be connected to the normal soil ventilating system of the building where so desired.

**11.7. Disposal of Sludge** -The sludge from septic tanks may be delivered into covered pit or into a suitable vehicle for removal from the site. Spreading of sludge the ground in the vicinity should not be allowed.

11.8. Secondary Treatment and Disposal of the Septic Tank Effluent

11.8.1. The effluent from septic tank should be disposed of by one of the methods given in Table 2 depending on the position of the subsoil water level soil and subsoil conditions and the size of the installation.

### 11.8.2. Construction of the Soil Absorption Systems

a) *Seepage pit* — The seepage pit may be of any suitable shape with the least cross-sectional dimension of 90 cm and not less than 100 cm in depth below the invert level of the inlet pipe. The pit may be lined with store, brick or concrete blocks with dry open joints which should be backed with at least 7.5 cm of clean coarse aggregate (see Fig. 11.5A). The lining above the inlet level should be finished with mortar. In the case of pits of large dimensions, the top portion may be narrowed to reduce the size of the RCC cover slabs. Where no lining is used, specially near trees, the entire pit should be filled with loose stones. A masonry ring may be constructed at the top of the pit to prevent damage by flooding of the pit by surface run off (see Fig. 11.5B). The inlet pipe may be taken down a depth of 90 cm from the top as an anti-mosquito measure. Illustrations of typical constructions of seepage pits are given in Fig. 11.5A and B.

**TABLE 2 RECOMMENDED METHOD OF DISPOSAL FOR SEPTIC TANK EFFLUENT**

*(Clause 11.8.1.)*

| Position of the Subsoil Water Level from Ground Level | Soil and Subsoil Condition | | |
|---|---|---|---|
| | Porous Soil with Percolation Rate | | Dense and Clays Soil with Percolation Rate Exceeding 60 min. |
| | Not exceeding 30 min | Exceeding 30 min but not exceeding 60 min. | |
| Within 180 cm | Dispersion trench located partly or fully above ground level in a mound | Dispersion trench located partly or fully above ground level in a mound | Biological filter partly or fully above ground level with under-drains and the effluent led into a surface drain or used for gardening |
| Below 180 cm | Seepage pit or dispersion trench | Dispersion trench | Subsurface biological filter with under-drains and the effluent led into a drain or used for gardening |

Note — Where the above mentioned methods are not feasible and where the effluent has to be discharged into open drain it should be disinfected.

**b) Dispersion trench** — Dispersion trenches shall be 50 to 100 cm deep and 30 to 100 cm wide excavated to a slight gradient and shall be provided with 15 to 25 cm of washed gravel or crushed stones. Open jointed pipes placed inside the trench shall be made of unglazed earthenware clay or concrete and shall have minimum internal diameter of 75 to 100 mm. Each dispersion trench should not be longer than 30 m and trenches should not be placed closer than 1.8 m.

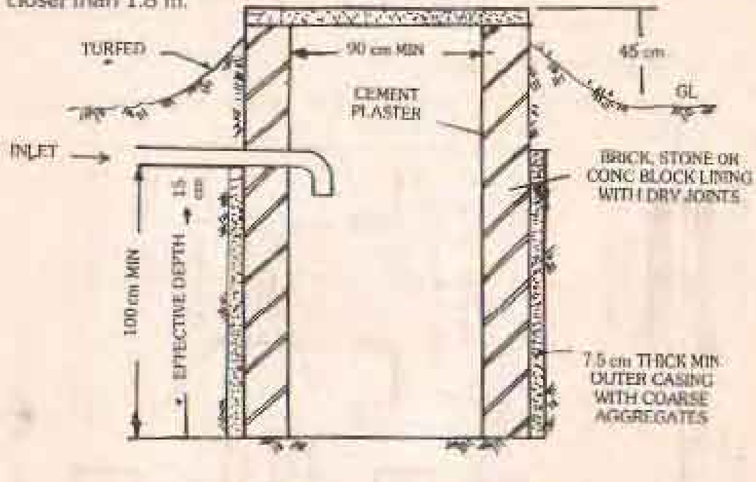
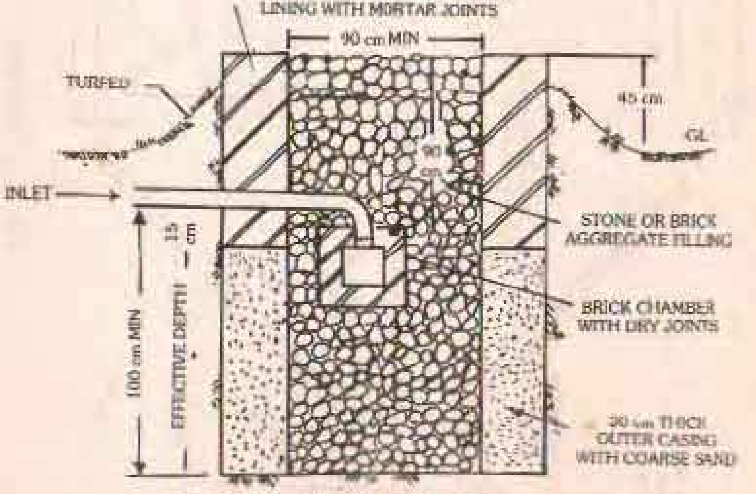



Fig. 11. 5A Empty pit with lining




11.5.B. Pit with filling without lining

Fig. 11.5. Typical Illustrations of Seepage Pits

The covering for the pipes on the top should be with coarse aggregate of uniform size to a depth of approximately 15 cm. The aggregate above this level may be graded with aggregate 12 to 15 mm to prevent ingress of top soil while the free flow of water is no way retarded. The trench may be covered with about 30 cm of ordinary soil to form a mound and turfed over. Dispersion trenches are not recommended in areas where fibrous roots of trees or vegetation are likely to penetrate the system and cause blockages. The finished top surface may be kept at least 15 cm above ground level to prevent direct flooding of the trench during rains.

## 11.8.3. Despersion trenches

Illustration of a typical soil absorption system through dispersion trenches is given in Fig. 11.6.

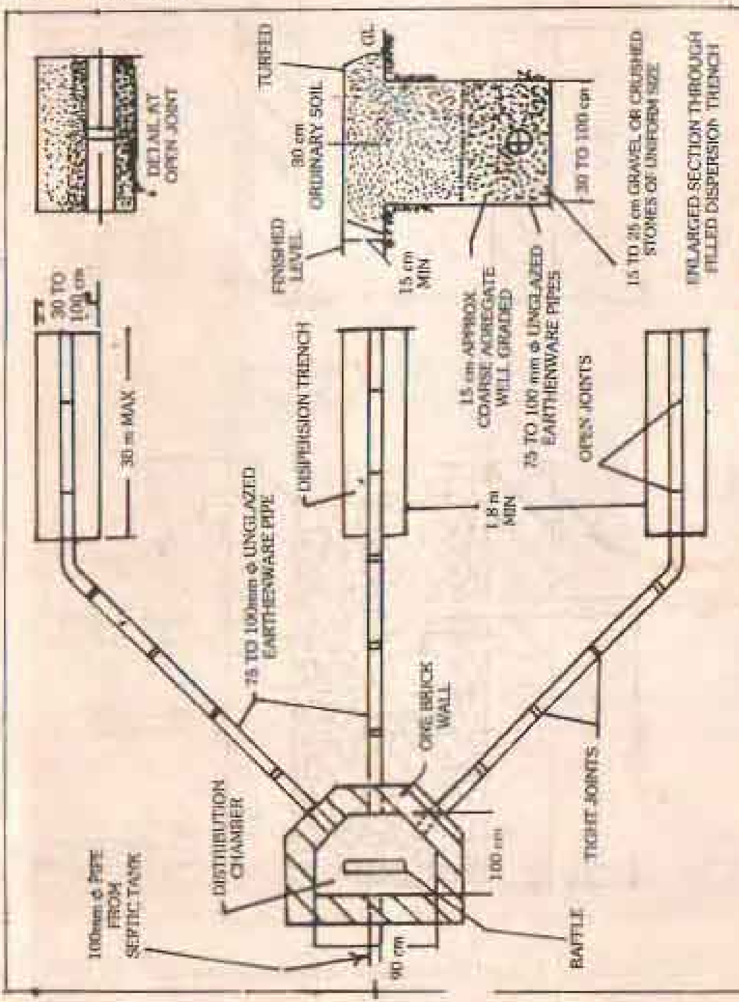



Fig. 11.6. Typical Soil Absorption System with Dispersion Trenches

**11.8.4. Inspection** — The work should be carefully inspected at all stages to ensure that it is being carried out according to the recommendations of this code.

**11.8.5. Testing** — Before the tank is commissioned for use, it should be tested for water-tightness by filling it with water and allowing it to stand for 24 hours. It should then be topped up, if necessary, and allowed to stand for a further 24 hours, during which time the fall in the level of the water should not be more than 1.5 cm.

# 11.9. COMMISSIONING OF SEPTIC TANKS

**11.9.1.** The sewerage system should be complete and ready for operation before connection is made to the building.

**11.9.2.** The tank should be filled with water to its outlet level before the sewage is let into the tank. It should preferably be seeded with well digested sludge obtained from septic tanks or sludge digestion tanks. In the absence of digested sludge a small quantity of decaying organic matter, such as digested cow dung may be introduced.

# 11.10. MAINTENANCE

**11.10.1. Desludging of Septic Tanks** — Septic tanks should be desludged periodically in accordance with the procedure given in 11.10.1.1., the interval of the desludging depending upon the design of the septic tank and the capacity in relation to the users. Desludging may be done when the sludge level reaches a predetermined level.

**11.10.1.1.** A rod, pole or any other suitcble means may be inserted vertically into the septic tank up to the bottom to find the depth of the sludge. Sludge may then be removed until its depth is reduced to about 25 mm from the bottom of the tank; where more accurate quantities of sludge to be removed are desired values given in col. 10, 11 and 12 of Table 1 may be used for guidance.

## 11.11. LARGE SEPTIC TANK

**11.11.1. Dimensions of Septic Tanks** — Sizes and capacities of septic tanks are given in Tables 1 & 2 for guidance. Table 1 gives the dimensions of septic tanks suitable for housing colonies for use of 100, 150, 200 and 300 persons; Table 2 gives the dimensions of septic tanks suitable for hostels and boarding schools for use of 50, 100, 150, 200 and 300 persons. The main assumptions on which these tables are based are given in Appendix B.

## TABLE 3 RECOMMENDED CAPACITIES AND SIZES OF SEPTIC TANKS FOR HOUSING COLONIES

*(Clause 11.11.1)*

| No. of Users | Length L | Breadth B | Liquid Depth (D) for Stated Interval of Sludge Withdrawal | | Liquid Capacities for Stated Interval of Sludge Withdrawal | | Distance of the Partition Wall from the Inlet End |
|---|---|---|---|---|---|---|---|
| | | | Once in a Year or Less | Once in 2 Years | Once in a Year or Less | Once in 2 Years | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | m | m | m | m | $m^3$ | $m^3$ | m |
| 100 | 8.0 | 2.8 | 1 | 1.04 | 22.4 | 23.3 | 5.3 |
| 150 | 10.6 | 2.7 | 1 | 1.15 | 28.6 | 32.9 | 7.1 |
| 200 | 12.4 | 3.1 | 1 | 1.15 | 38.4 | 44.2 | 8.3 |
| 300 | 14.6 | 3.9 | 1 | 1.15 | 56.9 | 65.5 | 9.7 |

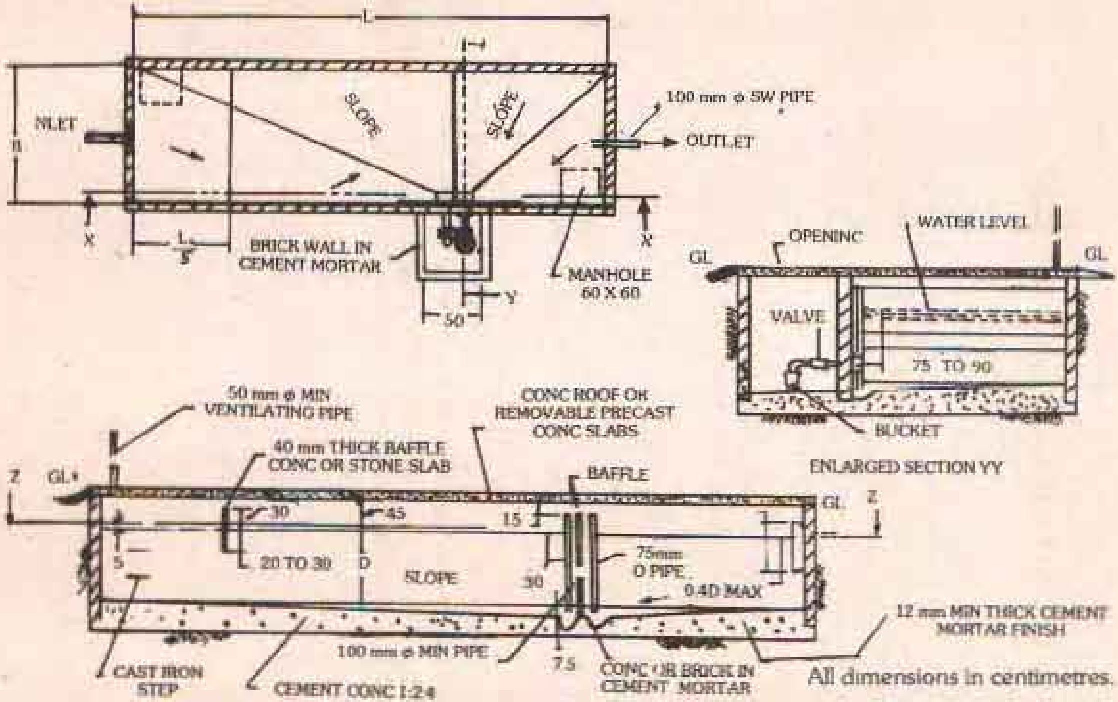
## TABLE 4 RECOMMENDED CAPACITIES AND SIZES OF SEPTIC TANKS FOR HOSTELS AND BOARDING SCHOOLS

*(Clause 11.11.1)*

| No. of Users | Length L | Width B | Liquid Depth (D) for Stated Intervals of Sludge Withdrawal in Months | | Liquid Capacities for Stated Intervals of Sludge Withdrawal in Months | | Distance of the Partition Wall from the Inlet End |
|---|---|---|---|---|---|---|---|
| | | | Once in a Year | Once in 2 Years | Once in a Year | Once in 2 Years | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | m | m | m | m | $m^3$ | $m^3$ | m |
| 50 | 5 | 1.6 | 1.3 | 1.4 | 10.4 | 11.2 | 3.3 |
| 100 | 5.7 | 2.1 | 1.4 | 1.7 | 16.8 | 20.4 | 3.8 |
| 150 | 7.7 | 2.4 | 1.4 | 1.7 | 25.8 | 31.4 | 5.2 |
| 200 | 8.9 | 2.7 | 1.4 | 1.7 | 33.6 | 41.0 | 6.0 |
| 300 | 10.7 | 3.3 | 1.4 | 1.7 | 49.5 | 60.0 | 7.2 |

11.11.1.1. A detention period of 24 to 48 hours is usually available based on the average daily flow of sewage. It may, however, be noted that the average daily flow varies considerably from one installation to another and the detention period should not be considered as a criterion for design of septic tanks.

11.11.2. Recommended Designs – A typical design of a septic tank for large installations is given in 11.7.




All dimensions in centimetres.

Fig. 11.7. Typical Design of a Septic Tank for Large Installations

Note 1 — A bottom slope of 10 percent or more towards the outlet is preferred.

Note 2 — Provision for desludgings made hydraulically.

Note 3 — For dimensions *L*, *B* and *D*, see Tables 3 and 4

Note 4 — Where inlet is located much below ground level only manhole shaft may be raised above the ground level.

## 11.12. DATA FOR SANITARY WORKS

| Quantity | Description of Work |
|---|---|

**11.12.1.** Supplying and fixing in position the following Cast Iron Soil Specials with necessary lead caulked joints and hemp yarn including dismantling the masonry or RCC or floor and making good the dismantled portion including painting the specials with 2 coats of paint and the specials fixed in position.

| | |
|---|---|
| 1 No. | (a) Cost of single or double Tee or Y junctions or cowl. |
| 0.5 No. | Plumber 1st Class |
| 0.25 No. | Mazdoor |
| L.S. | Dismantling, making good the dismantled portion, paint, etc. |
| L.S. | Sundries for lead, Hemp yarn etc., for joint. |
| | Total |

| | |
|---|---|
| 1 No. | (b) Cost of Cast Iron Bend |
| 0.5 No. | Plumber 1st Class |
| L.S. | Dismantling, making good the dismantled portion, paint etc. |
| L.S. | Sundries for Lead, Hemp yarn for joints. |
| | Total |

**11.12.2.** Supplying, laying and jointing glazed Stoneware pipes with spigot and socket ends in dry condition with spun yarn and cement joints including necessary eqrthwork excavation to the required depth for trenches including shorting and strutting and refilling the same, laying pipe in true alignment and gradient and giving required water supply tests with necessary tools and plants etc.

(a) 100 mm dia Stoneware Pipe.

| | |
|---|---|
| | (a) Rate for 30 Metres |
| 30 Metres | Cost of 100 mm dia Stone-ware Pipes. |
| L.S. | Earthwork excavation |
| 45 Kg. | Cement for 50 joints |
| 0.04 $m^3$ | River Sand for 50 Mortar Joints |
| 3.63 Kgs. | Spun yarn or tarred yarn |
| 2 Nos. | Mason 1st Class |
| 1 No. | Fitter 2nd Class |
| 5 Nos. | Mazdoors |
| 2 Nos. | Mazdoors |
| L.S. | Testing, Charges including conveyance of water, tools and plant etc., |
| L.S. | Refilling, shoring, strutting, alignment, levelling etc. |
| | for 30 Metres Total Rate per metre. |

(b) 150 mm dia S.W. Pipes

| | |
|---|---|
| 30 Metres | Cost of 150 mm dia stone-ware pipes |
| L.S. | Earthwork excavation |
| 68 Kg. | Cement for 50 joints |
| 0.07 $m^3$ | River Sand for 50 mortar joints. |
| 5.45 Kg. | Spun yarn or tarred yarn |
| 3 Nos. | Mason 1st Class |
| 2 Nos. | Fitter 2nd Class |
| 6 Nos. | Mazdoors |
| 3 Nos. | Mazdoors |
| L.S. | Testing charges including conveyance of water, tools and plant etc. |
| L.S. | Refilling shoring, strutting, alignment levelling, etc. |
| | for 30 Metres Total |
| | Rate Per metre. |

(c) 230 mm Dia Stone-Ware Pipes:

| | |
|---|---|
| 30 Metres | Cost of 230 mm dia Stone-Ware Pipes |
| L.S. | Earthwork excavation |
| 104 Kg. | Cement for 50 Joints. |
| 0.10 $m^3$ | River Sand for 50 Mortar Joints |
| 8.17 Kg. | Spun yarn or tarred yarn |
| 5 Nos. | Mason 1st Class |
| 3 Nos. | Fitter 2nd Class |
| 7 Nos. | Mazdoors |
| 5 Nos. | Mazdoors |
| L.S. | Testing charges including conveyance of water, Tools and Plants etc. |
| L.S. | Refilling, shorting, strutting levelling etc. |
| | For 30 Metres Total |
| | Rate Per Metre. |

**11.12.3.** Suppluing and fixing in position glazed stone-ware pipe specialssuch as Bend, single or Double "Y" junctions with spun yarn and cement joints including necessary Earthwork excavation for trenches including shoring, strutting and refilling the same, curing etc., laying to proper gradient and giving required water supply tests with necessary tools and plant etc.

Data for 1 No.

| | |
|---|---|
| 1 No. | Cost of Stone-ware bend or single or Double "Y" Junction of approved quality |
| 1 No. | Spun yarn and cement joint |
| 0.25 No. | Plumber 1st Class |
| L.S. | Earthwork excavation, refilling, alignment, levelling etc. |
| L.S. | Testing charges with water, tools and plants etc. |

**11.12.4.** Supplying and fixing in position Indian Type Water closet of size 58cm (23") white glazed Earthenware with "P" or "S" trap and a pair of porcelain foot rests with sand cushion and forming flooring alround the water closet, using 40 mm broken brick jelly in lime concrete 1 : 2 : 5, 10 cm thick, and plastered in C.M. 1 : 3, 20 mm thick, and giving necessary connections to C.I. Stacks etc.

Data for 1 No.

| | |
|---|---|
| 1 No. | Cost of Indian Water Closet 58 cm size of white-glazed Earthenware with "P" or "S" trap |
| 1 Pair | Cost of Porcelain foot rests |
| 0.2 m³ | Brick jelly Concrete in L.M. 1 : 2 : 5 |
| 0.5 m³ | Sand filling |
| 1.10 m² | Plastering in C.M. 1 : 3, 20 mm thick |
| 0.5 No. | Plumber 1st Class |
| 0.5 No. | Mason 1st Class |
| 1 No. | Mazdoor |
| L.S. | Sundries for finishing etc. |
| | Total |

**11.12.5.** Supplying and fixing in position Cast Iron High Level flushingtank of 3 gallons capacity including all internal fittings on C.I. brackets with pull chain 12 mm lead and brass connection, 12 mm G.M. Wheel valve, 32 mm lead or G.I. flush pipe and painting with 2 coats of paint including dismantling masonry and re-doing the same to the original condition complete.

Data of 1 No.

| | |
|---|---|
| 1 No. | Cost of High flushing tank of 3 gallons capacity |
| 1 No. | Cost of 12 mm lead and brass connection. |
| 1 Pair | Cost of C.I. brackets |
| 1 No. | Cost of 12 mm G.M. Wheel valve |
| 1 No. | Cost of 32 mm lead or G.I. flushpipe |
| 6 Nos. | Wooden plugs. |
| 1 litre. | Anti-corrosive paint of approved quality. |
| 0.5 No. | Plumber 1st Class. |
| 0.5 No. | Mason 1st Class |
| 0.5 No. | Mazdoor |
| 0.25 No. | Painter |
| L.S. | Sundries for dismantling re-doing finishing, cement, sand grit etc. clamps, screws etc. |
| | Total |

**11.12.6.** Supplying and fixing in position white glazed European water closet with "P" trap and double flapped seat cover, 3 gallons capacity porcelain Low Level flushing tank including all internal fittings fixed on C.I. brackets 12 mm PVC or brass connection, 12 mm G.M. Wheel valve, 12 mm brass nipple, chromium plated brown headed stop cock 12 mm in nylon connection with necessary T.W. plugs. Clamps and screws to the portion coming with walls and floors, including dismantling masonry and redoing the same to the original condition.

Data of 1 No.

| | |
|---|---|
| 1 No. | Cost of white glazed European water closet with "P" trap. Double flapped seat cover 3 gallons capacity Low Level flushing tank of approved quality. |
| 1 Pair. | Cost of Brackets. |
| 1 No. | Cost of 12 mm G.M. Wheel valve |
| 1 No. | Cost of 12 mm P.V.C. or lead brass connection |
| 1 No. | Cost of 12 mm brass Nipple. |
| 1 No. | Cost of Chromium plated brown headed stop cock 12 mm. |
| 6 Nos. | T.W. Plugs for flushing tank. |
| 0.5 No. | Mason 1st Class |
| 1 No. | Plumber 1st Class |
| L.S. | Sundries for dismantling, redoing finishing, cement, sand, grit, clamps screws. |
| | Total |

**11.12.7.** Supplying and fixing in position Indian Make White glazed Earthern ware lipped mouth or flat back lipped urinal with 32 mm bell mouth PVC or lead waste pipe, 12 mm PVC or lead and brass connection, 12 mm G.M. Wheel valve and fixing the urinal in position with necessary T.W. plugs, Clamps, Screws, White lead etc., including dismantling masonry and redoing the same to the original condition.

Data of 1 No.

| | |
|---|---|
| 1 No. | Cost of best white glazed earthenware lipped mouth or flat lipped urinal of approved quality. |
| 1 No. | Cost of 32 mm Bell mouth PVC or lead waste pipe. |
| 1 No. | Cost of 12 mm PVC or lead brass connection |
| 1 No. | Cost of 12 mm G.M. Wheel valve |
| 0.5 No. | Plumber 1st Class. |
| 0.5 No. | Mazdoor |
| L.S. | Sundries for dismantling |
| | Total |

**11.12.8.** Supplying and fixing in position Indian Make white glazed Earthern ware Wash-Hand Basin with a pair of C.I. brackets, 12 mm C.P. Pillar tap, 32 mm C.P. waste Pipe rubber plug and chain 32 mm PVC or lead waste pipe, 12 mm PVC or lead brass connection, 12 mm G.M. Wheel valve, 12 mm brass nipple and giving necessary connections including cost of white lead, T.W. plugs, Clamps, screws, rubber washers, painting 2 coats of paint over lead pipe.

Data of 1 No.

| | |
|---|---|
| 1 No. | Cost of White glazed Earthernware washhand Basin. |
| 1 No. | Cost of 12 mm C.P. pillar tap. |
| 1 Pair | Cost of C.I. Brackets |
| 1 No. | Cost of 32 mm PVC or lead waste pipe |
| 1 No. | Cost of 32 mm C.P. Waste Pipe |
| 1 No. | Cost of 32 mm rubber plug and chain. |
| 1 No. | Cost of 12 mm PVC or Lead brass connection |
| 1 No. | Cost of 12 mm G.M. Wheel valve |
| 1 No. | Cost of 12 mm Brass Nipple |
| 0.5 No. | Fitter 2nd Class for fixing brackets |
| 0.5 No. | Plumber 1st Class |
| 0.5 No. | Mason 2nd Class |
| 1 No. | Mazdoor |
| 0.25 No. | Painter |
| L.S. | Sundries for Paint, Cement, sand, grit, T.W. plugs, screws, washers white lead, etc. |
| | Total |

**11.12.9.** Supplying and fixing in position Indian make white glazed kitchen sink with a pair of C.I. brackets, 32 mm lead waste pipe, 12 mm C.P. Pillar tap with rubber plug and chain, 32 mm C.P. Waste Pipe and fixing the sink in position with necessary T.W. plugs, screws, washers, white lead etc., including painting 2 coats.

Data for 1 No.

| | |
|---|---|
| 1 No. | Cost of White-glazed kitchen sink. |
| 1 Pair | Cost of C.I. Brackets |
| 1 No. | Cost or 12 mm C.P. Pillar tap |
| 1 No. | Cost of 32 mm lead pipe |
| 1 No. | Cost of 32 mm C.P. Waste Pipe |
| 1 No. | Cost of 32 mm Rubber plug and chain |
| 0.5 No. | Fitter 2nd Class |
| 0.5 No. | Plumber 1st Class |
| 0.5 No. | Mason 2nd Class |
| 1 No. | Mazdoor |
| 0.25 No. | Painter |
| L.S. | Sundries for paint, Cement, Sand, grit, T.W. Plugs, screws, washers, white-lead etc. |
| | Total |

**11.12.10.** Supplying and fixing in position 150 × 100 mm stoneware gully trap with C.I. double grating of size 150 × 150 mm and 230 × 230 mm at bottom and top respectively with necessary E.W. excavation over a bed of lime concrete 1 : 2 : 5, 15 cm thick using 40 mm size broken brick jelly, side walls 112 mm thick B.M.-1 : 5, using country bricks and plastered both sides with C.M. 1 : 3 12 mm thick including dismantling masonry works, and making good the damaged portions to the original condition and giving necessary connections.

Data for 1 No.

| | |
|---|---|
| 1 No. | Cost of 15 × 10 cm Stonware Gully trap. |
| 2 Nos. | Cost of C.I. Gratings (Top & Bottom) |
| 0.05 $m^3$ | Brick Jelly Concrete in L.M. 1 : 2 : 5 |
| 0.035 $m^3$ | Brick work in C.M. 1 : 5 using country bricks |
| 0.40 $m^2$ | Plastering in C.M. 1 : 3 12 mm thick |
| 0.75 No. | Mason 1st Class for fixing |
| 0.75 No. | Mazdoor |
| L.S. | Sundries for dismantling, redoing giving connections etc., |
| | Total |

**11.12.11.** Supplying and fixing in position Cast Iron floor or Nahni trap with necessary C.I. gratings including fixing with required brick jelly concrete and finishing with cement plaster in C.M. 1 : 3

Data for 1 No.

| | |
|---|---|
| 1 No. | Cost of Cast Iron floor or Nahni trap |
| 1 No. | Cost of Gratings |
| 0.33 No. | Mason 1st Class |
| 0.33 No. | Mazdoor |
| L.S | Sundries for concrete, finishing with cement plaster etc. |
| | Total |

**11.12.12.** Supplying and fixing in position Indian Make bevelled edge mirror of approved quality of size 60 cm × 45 cm with necessary teakwood ply backing, rubber buttons, CP screws, plugs.

Data for 1 No.

| | |
|---|---|
| 1 No. | Cost of bevelled edge Mirror of size 60 × 45 cm |
| 4 Nos. | Cost of Rubber buttons |
| 4 Nos. | Cost of T.W. Plugs |
| 4 Nos. | Cost of C.P. Screws |
| 0.33 No. | Carpenter 2nd class |
| 0.33 No. | Mazdoor |
| L.S. | Sundries for T.W. ply backing etc. |
| | Total |

**11.12.13.** Supplying and fixing in position Indian Make Chromium plated

Towel rail of 60 cm length and 20 mm dia with C.P. brackets including fixing with necessary T.W. Plugs, C.P. Screws and dismantling masonry, and redoing the same to the original condition.

Data for 1 No.

| | |
|---|---|
| 1 No. | Cost of C.P. Towel rail 60 cm. long 20 mm dia. |
| 2 Nos. | Cost of C.P. brackets |
| 6 Nos. | Cost of C.P. Screws |
| 2 Nos. | Cost of T.W. Plugs. |
| 0.25 No. | Carpenter 2nd Class |
| 0.25 No. | Mazdoor |
| L.S. | Sundries for dismantling, redoing etc. |
| | Total ■ |

# XII. ELECTRICAL ENGINEERING

## 12.1. General Guide Lines:

### 12.1.1. Selection of wiring

The points to be considered are:

Durability : The wiring to be selected must be able to withstand wear and tear due to the action of weather, fuffles, dampness, etc.

Safety : It is the most important point to be considered. The system selected should be such that even with poor workmanship, no dangerous result may be produced.

Mechanical : The wiring must be protected from damage of a physical protection nature, during its use in building.

Appearance: Appearance is an important consideration from the architectural point of view.

### 12.1.2. Layout of wiring:

Power and heating wiring should be kept separate and distant from lighting wiring. All wiring should be done on the distribution system with main and branch distribution boards at convenient physical and electrical load centres and without isolated fuses. All conductors should be run as far as possible, along the walls and near the ceiling so as to be easily accessible and capable of being thoroughly inspected. In all types of wiring due consideration must be given for neatness and good appearance.

Balancing of circuits must be arranged before hand. All runs of wiring and the exact positions of all points and switchboxes should be first marked on the plan.

On completion of the work, a wiring diagram should be prepared and submitted to the owner. All wiring diagrams indicate clearly in the plan, the main switchboard, the runs of various main and submains and the position of all points and their controls. All circuits should be clearly indicated and numbered in the wiring diagrams and all points should be given the same number as the circuit to which they are electrically connected.

In estimating the current to be carried by any conductor, the incandescent lamp should be rated at 60 W, ceiling fans 100 W; 5A socket outlets at 60W; and 15A socket outlets at 100 W unless the actual values are specified.

In any system of wiring no bare twist joints should be made at intermediate points in the through runs of cables, unless the length of a final sub-circuit or submain or main is more than the length of the standard coil. If any jointing becomes unavoidable, such joints should be made through proper cutouts or through proper junction boxes, open to easy inspection.

All conductors, switches and accessories should be of sizes so as to be capable of carrying the maximum current which will normally flow through them.

## 12.1.3. Calculation of power, current and circuits

$P = V \times I$ — $P$ = power in watts; $V$ = voltage; and $I$ = current in amperes.

The total power requirements shoudl be calculated after estimating the number of light points, fan points and the 5A socket outlet points.

Then the voltage should be determined, i.e. whether it is single phase of 220V or three of 440V.

Having determined the power and voltage the total current of the installation can be calculated. $I = P/V$. Once the current capacity is known the rating of the main switch can be determined.

No circuit should have more than 8 points and the maximum power on these 8 points should not exceed 1000 W.

$$\text{No. of circuit} = \frac{\text{Total points}}{8}$$

Having found out the number of circuits, the distribution box can be designed.

## 12.1.4. Types of Wiring

### 12.1.4.1. C.T.S. (Cotton/P.V.C., toughened/Sheathed) Wiring

The conductor is provided with insulation which is not water-or heat-proof. Over the insulation of the conductor a tough rubber (nowadays P.V.C.) sheath is provided for additional insulation and protection against wear, tear and moisture.

This type of wiring is suitable for damp circuits, but cannot sustain much heat and is not suitable for places in very hot weather. There is also the danger of mechanical hazard. It is also not suitable for outdoor wiring. It should not be exposed to direct sunlight and areas where there are corrosive acids or alkali fumes.

### 12.1.4.2. Conduit Wiring

In this system wires with single insulation are used. The wires are run in steel/P.V.C. conduits giving good protection from mechanical injury or fire risks. This type of wiring is used for industries.

### 12.1.4.3. Concealed Conduit Wiring

This system is the same as conduit wiring except that the conduits are buried in the chase made on the walls. This system is used where aesthetics is the main consideration and not the additional cost of conduit.

## 12.1.5. Earthing

As the earth potential is taken as zero for all practical purposes, any electrical appliances when connected to earth attain zero potential and are said to be "earthed". The voltage of these earthed appliances will fall or increase to zero if their voltage is higher or lower respectively than the earth potential.

Uses of Earthing

(i) To save human life from the danger of shock, death in case it comes in contact with a charged frame due to any fault leakage current.

(ii) To maintain the line voltage current.

(iii) To protect large buildings from atmospheric lightning

(iv) To protect all machines fed from overhead lines.

The resistance of the earthing system depends upon:

(i) Soil condition.
(ii) Temperature of the soil.
(iii) Water contents of the soil
(iv) Spacing and sizing of earth electrodes.
(v) Depth at which the electrode is embedded.
(vi) Material of conductor.

Types of Electrodes

Plate earthing: In this system the earth wire is bolted to the earth plate made up of copper size 60 × 60 cm × 3.18 mm (2' × 2' × ⅛") embedded 3 m in the ground. The efficiency of the system increases with the increase in area of plate, s and the depth of the embedding. The earth wire is drawn through a G.I. pipe fitted with a cap on the top through which salt water is poured in the pit from time to time for efficient earthing.

Pipe earthing: In this system of earthing a G.I. pipe of 30 mm dia. and 2 m length is embedded vertically in the ground to work as an earth electrode. The earth wire is fastened to the top section of the pipe above ground level. The pit area around the G.I. pipe is filled with salt and coal mixture for improving the efficiency of the earthing system.

# 12.6. TESTING AN INSTALLATION

Insulation tests must be made with a D.C. voltage at least twice the declared voltage, but not necessarily exceeding 500 volts. The most convenient method is to use a 500 volt testing set of the "Megger" type.

*Test to Earth* — This is made with all fuse links in place, all switches on, and all lamps in position. The result must be not less than 50 megohms divided by the number of outlets, i.e., points and switch positions, except that it need not exceed 1 megohm for the whole installation.

Control rheostats, heating and power appliances, and electric signs may, if desired, be disconnected for this test, but, if so, their insulation resistances must, in each case be not less than that given in the appropriate Indian Standard Specification, or, where there is no such Specification, be not less than half a megohm.

*Test between Conductors* — Where practicable, a test should be made between all the conductors connected to one pole or phase conductor of supply and all the conductors connected to the middle wire or total or the other pole or phase conductors of the supply.

For this test, all lamps should be removed and all switches on. The result, again, must be 50 megohms divided by the number of outlets, i.e., points and switch positions, but need exceed 1 megohm for the whole installation.

Leakage at cable ends is one of the commonest causes of low readings: all stray ends of cotton thread should be carefully removed when connecting up to switches, ceiling roses, etc.

*Polarity of S.P. Switches* — Tests should be made to verify that all non-linked S.P. Switches are on an outer or phase conductor and not on the neutral or earthed conductor.

*Earth Continuity Test* — In the case of cables encased in metal, whether conduit or metallic sheathing the total resistance of the conduit or sheathing from the earthing point to any other position in the completed installation shall not be more than 1 ohm.

## 12.7. H.P. OF MOTORS

One horse-power = 550 foot-pounds per second = 33000 ft. lb. per minutes = 746 kW = 746 watts.

Brake horse-power is the net effective mechanical horse-power available at the pulley or coupling of a motor,

i.e., the actual horse-power available after all losses in the motor itself have been deducted.

The efficiency of a motor $1 = \dfrac{\text{power output}}{\text{power input}}$

The power factor is usually taken at 0.8 (as an all-round figure) but this varies with the size and speed or motor.

The efficiency varies from 85 per cent, in small motors to 90 per cent. and over in large motors.

The current required to supply a three-phase motor at full load

$$= \frac{\text{Brake horse-power} \times 746 \times 100}{1.732 \times E \times \%\ \text{efficiency of motor} \times \text{power factor}}$$

*where E is the voltage between phases.*

Electric motors are rated in two ways — continuous rating and short time rating. Unless otherwise stated, the rating is continuous. But in the case of railway and crane motors, which work under intermittent service, and where heavy drafts of current are following by coasting or stand still which allow the motor to cool, the short time rating is also stated.

This short-time rating is usually the horse-power the motor is built to deliver for one hour only, without danger.

For instance, a railway motor with 50 h.p. short time rating will deliver 50 h.p. for one hour without dangerous temperature rise, but might be good for, say, only 30 h.p. continuously.

Similarly, where a 200 h.p. load, say, is to be handled only occasionally, and for short periods, a much smaller motor than 200 h.p. continuous rating is used; and, in such a case, the motor is given a short-time-rating such as 200 h.p. for ten minutes. From this it follows that the size of cable required to supply a motor also depends on the rating of the motor, i.e., on the continuous or intermittent nature of the load.

## 12.8. VOLTAGE DROP

The I.E.E. Regulation 304 limits the voltage drop at normal full load in lighting circuits to 1 vol. 2% of the supply voltage, between consumers' terminals (or main busbors and any point on the installation. The approximate drop in average circuits such as lighting and domestic heating loads may be found as follows, neglecting increased resistance due to temperature rise.

D.C. and single Phase A.C. Two wire circuits.

Drop = current × total resistance of cables, lead and return.

= 2 IR, where I = *current and R = Resistance of and conductor only (not lead and return)*

## 12.9. REFRIGERATION

In general refrigeration is defined as any process of heat removal. More specifically, refrigeration is defined as that Branch of Science which deals with the process of reducing and maintaining the temperature of a space or material below the temperature of the surroundings.

Refrigerating and Heating are actually opposite end of the same process.

*System Capacity*: The capacity of any refrigerating system is the rate at which it will remove heat from the refrigerated space and is usually stated in 'Btu' per hour or in terms of its ice melting equivalent.

Factors depending on are

(1) The weight of the refrigerant circulated per minute.

(2) Refrigerating effect of each pound circulated.

1T.R. = 12,000 Btu/hr. or 200 Btu per min.

(T.R. means refrigerating capacity in tons)

*Compressor Capacity:* In any mechanical refrigerating system the capacity of the compressor must be such that vapour is drawn from the evaporator at the same rate that the vapour is produced by the boiling action of the **liquid refrigerant**

*Refrigerant:* A refrigent is a body or substance which acts as a cooling agent by absorbing heat from another body or substance.

Important Refrigerants:

| | |
|---|---|
| 1. Ammonia: | $NH_3$ |
| 2. Sulphur Dioxide: | $SO_2$ |
| 3. Carbon Dioxide: | $CO_2$ |
| 4. Refrigerant – 11: | $CCL_3F$ |
| 5. Refrigerant – 12: | $CCL_2F_2$ |
| 6. Refrigerant – 22: | $CHCLF_2$ |

— *Roy J. Dossat.*

## 12.10. AIR-CONDITIONING

Air-conditioning is defined as the simultaneous control of temperature, humidity, air-motion and air purity in any given space.

Winter air-conditioning, summer air-conditioning, and complete air-conditioning are some of the process when considering air-conditioning for comfort.

An air-conditioning system consist essentially of a fan or a blower, which mixes some fresh out door air or some air from the space to be conditioned and forces the mixers through a series of devices which act upon the air (1) to clean it (2) to increase or decrease its temperature and (3), to increase or decrease the water vapour content in humidity of the air. The air-motion in the room is caused by the jet of the air-emanating from the conditioning system is beneficial because of its exhilarating effect upon people.

## 12.11. WATTAGE OF VARIOUS ELECTRIC DOMESTIC APPLIANCES

| Watts | Name of appliances |
|---|---|
| 100 | Clothes dryer (centrifuge) |
| 10 | Electric shaver |
| 300 | Floor polisher |
| 500 | Hair dryer |
| 60 | Heating pad |
| 1,000 | Heating screen |
| 1,500 | Hotplate, single |
| 700 and 1,000 | Immersion heater |
| 1,000 | Iron, automatic |
| 500 | Iron, non-automatic |
| 1,500 and 1,800 | Ironing machine |
| 2,200 and 2,500 | Miniature range |
| 1,500 | Radiant heater (elec. fire) |
| 1,500 | Radiator, hot-water |
| 30 | Radio, single-circit |
| 50 to 100 | Radio, superheat |
| 6,500 to 7,800 | Range, kitchen |
| 1,200 and 1,600 | Rapid cooker |
| 100 to 160 | Refrigerator |
| 1,500 | Roaster |
| 150 | Television set |
| 500 | Toaster |
| 150 to 300 | Vacuum cleaner |
| 300 | Washing machine, without heater |
| 6,300 | Washing machine, with electric heater |
| **Water heater** | |
| 1,200 and 2,000 | small, 8 litres |
| 2,000 and 4,000 | medium, 15 litres |
| 4,000 and 6,000 | large, 60 litres |
| 4,000 to 6,000 | large, 80 litres |

# 12.12. RECOMMENDED LEVELS OF ILLUMINATION FOR INTERIORS

| Mean intensity of illumination lx | Kind of rooms and work |
|---|---|
| | Schools: |
| 120 | Auditoriums, music rooms, gymnasiums |
| 250 | Chemistry and physics laboratories |
| 250 – 600 | Art rooms, needle-work rooms |
| | Sales Rooms: |
| 120 | For bright-coloured goods in small cities |
| 250 | For bright-coloured goods in large cities |
| 600 | For dark-coloured goods in large cities |
| | Homes, Hotels etc.: |
| 120 | Living; music and hotel rooms, restaurants |
| 120 – 250 | School work, writing |
| 250 | Needle work |
| | Work shops |
| 60 | Blooming mills, forges, sawmills, chemical baths |
| 120 | Moulding, turning, dyeing, printing |
| 250 | Sorting, spinning, office work |
| 250 – 600 | Inspection, checking, weaving, knitting, drawing |
| 4000 | Cutting precious stones, invisible mending |

## 12.13. ESTIMATED CURRENT RATINGS OF CABLES SHEATHED WITH TOUGH RUBBER.

*(Twin 3 & 4 core)*

| Conversional Copper sizes | Continuous Current ratings | | Aluminium conductor | |
|---|---|---|---|---|
| | One twin core D.C. or A.C. amps. | One 3 or 4 core cable balanced 3 ph. amps. | Area mm$^2$ | Stonc mm. |
| 1/.004 | 5 | 5 | – | – |
| 3/.029 | 10 | 8/7 | 1.5 | 1/1.40 |
| 3/.036 | 15 | 10/11 | 2.5 | 1/1.80 |
| 1/.064 | – | – | – | – |
| 7/.029 | 20 | 15/14 | 4 | 1/2.24 |
| – | 27 | 19 | 6 | 1/1.80 |
| 7/.036 | 28 | 20 | – | – |
| – | 34 | 24 | 10 | 1/3.55 |
| 7/.044 | 36 | 25 | – | – |
| 7/.052 | 43 | 30 | 16 | 7/1.70 |
| 7/.064 | 53 | 37 | – | – |
| – | 59 | 42 | 25 | 7/2.24 |
| 19/.044 | 62 | 43 | – | – |
| – | 69 | 48 | 35 | 7/2.50 |
| 19/.052 | 74 | 52 | – | – |
| – | 91 | 62 | 50 | 7/3.00<br>19/1.80 |
| 19/.064 | 97 | 68 | – | – |
| 10/.072 | 115 | 78 | – | – |
| – | 118 | 82 | 70 | 19/2.24 |
| – | 135 | 94 | 95 | 19/2.50 |

## 12.14. ELECTRICAL FORMULAE FOR DETERMINING HORSE-POWER, K.V.A., KILOWATTS AND AMPERES

| To Find | ALTERNATING CURRENT | | | |
|---|---|---|---|---|
| | Single-Phase | Two-Phase, Four-Wire | Three-Phase Three-Wire | Three Phase Four-Wire |
| Amperes when Kilowatts is Known | $\frac{K.W. \times 1000}{E \times P.F.}$ | $\frac{K.W. \times 1000}{2 \times E \times P.F.}$ | $\frac{K.W. \times 1000}{1.73 \times E \times P.F.}$ | $\frac{K.W. \times 1000}{3 \times e \times P.F.}$ |
| Amperes when K.V.A. is Known | $\frac{K.V.A. \times 1000}{E}$ | $\frac{K.V.A. \times 1000}{2 \times E}$ | $\frac{K.V.A. \times 1000}{1.73 \times E}$ | $\frac{K.V.A. \times 1000}{5 \times e}$ |
| Amperes when Horse-power is Known | $\frac{H.P. \times 746}{E \times Eff \times P.F.}$ | $\frac{H.P. \times 746}{2 \times E \times Eff \times P.F.}$ | $\frac{H.P. \times 746}{1.73 \times E \times Eff. \times P.F.}$ | $\frac{H.P. \times 746}{3 \times e \times Eff \times P.F.}$ |
| Horse Power (Out-put) | $\frac{I \times E \times Eff \times P.F.}{746}$ | $\frac{I \times E \times 2 \times Eff \times P.F.}{746}$ | $\frac{I \times E \times 1.73 \times Eff \times P.F.}{746}$ | $\frac{I \times e \times 3 \times Eff \times P.F.}{746}$ |
| Kilowatts | $\frac{I \times E \times P.F.}{1000}$ | $\frac{I \times E \times 2 \times P.F.}{1000}$ | $\frac{I \times E \times 1.73 \times P.F.}{1000}$ | $\frac{I \times e \times 3 \times P.F.}{1000}$ |
| K.V.A. | $\frac{I \times E}{1000}$ | $\frac{I \times E \times 2}{1000}$ | $\frac{I \times E \times 1.73}{1000}$ | $\frac{I \times e \times 3}{1000}$ |

K.W. = Kilowatts  E = Volts from line to line or phase to phase  P.F. = Power factor  K.V.A. = Kilovolt-Amperes

e = Volts from phase to neutral  H.P. = Horsepower  Eff. = per cent efficiency  I = Amperes

The current in common conductor, for three wire, two phase circuits is 1.41 times that in either of the other two conductors.

# 12.15. SCALE FOR THE PROVISION OF ELECTRICAL FITTINGS IN GOVERNMENT BUILDING

*(Based on G.O. Ms. No. 732 P.W., dated 25th March 1966)*

## 12.15.1. Non-Residential Buildings

### 12.15.1.1. Provision of Fans

| *Description of Buildings* | *SCALE PRESCRIBED* |
|---|---|
| a) Office in General: | |
| (i) Office: | One ceiling fan 56" sweep for every 300 sq.ft. One ceiling fan of 48" sweep for every 200 sq.ft. and one ceiling fan of 36" sweep for isolated area of less than 200 sq.ft. irrespective of the number of persons working therein |
| (ii) Gazetted Officer in his room | One ceiling fan of 48" or 56" sweep depending upon the size of the room |
| b) COURT HALLS | |
| (i) Dais | One ceiling fan of 48" Sweep. |
| (ii) Bar table | One ceiling fan of 48" sweep for every 4 persons, the fans being provided at not less than 8 ft. centre to centre. |
| (iii) Presiding Officer's retiring room | One ceiling fan of 48" to 56" sweep depending on the floor area. |
| (iv) Sheristadar's room or Head Clerk's room | One ceiling fan 48" sweep. |
| c) HOSPITALS | |
| (i) Wards | One 56" sweep fan for every 4 beds. |
| (ii) Nurses' duty room | One ceiling fan 48" or 56" sweep depending on the floor area of the room. |
| (iii) Single bedded operation Theatre | Two ceiling fans of 48" sweep and two exhaust fans of 12" sweep. |
| (iv) X Ray room | One exhaust fan and one ceiling for size depending on the floor area. |
| (v) Dark room | One exhaust fan and one ceiling fan size depending on the floor area. |
| (vi) Blood bank | One ceiling fan size depending on the floor area. |
| (vii) Opthalmic and E.N.T. dark room | One ceiling fan size depending on the floor area. |
| (viii) Dining halls, dressing rooms, special ward with single bed, dispensary etc. | One ceiling fan of 48" sweep for every 200 sq.ft. or one ceiling for 56" sweep for every 300 sq.ft. |

d) EDUCATIONAL, TECHNICAL OR RESEARCH INSTITUTIONS

| | |
|---|---|
| (i) An individual Gazetted Officer | One ceiling fan 48" or 56" sweep depending upon the size of the room. |
| (ii) Lecturer at Lecture Hall | One ceiling fan 56" sweep. |
| (iii) Common room of professors lecturers and Assistants | One ceiling fan 56" sweep for every 300 sq.ft. of floor area. |
| (iv) Class rooms Lecture Halls, Demonstration halls etc. | One ceiling fan of 56" for every 300 sq.ft. floor area for one ceiling fan of 48" sweep for every 200 sq.ft. floor area. |
| (v) Laboratories, Store room and workshops | (a) One ceiling fan of 48" or 56" sweep depending on the floor area. (b) One exhaust fan of 18" sweep for every 200 sq.ft. depending upon the cubical contents of air to be evacuated. |

HOSTELS

| | |
|---|---|
| (a) Dining hall. | One ceiling fan of 56" sweep for every 10 persons or part thereof. |
| (b) Common room | One fan of 56" sweep for every 200 sq.ft. of floor area. |
| (c) Warden's room | One fan of 48" sweep. |

(e) LABORATORIES OR WORK SHOPS IN GENERAL

(a) One ceiling fan of 48" or 56" sweep depending on the floor area.

(b) One exhaust fan of 18" sweep for every 200 sq.ft. depending upon the cubical contents of air to be evacuated.

f) INSPECTION BUNGALOWS:

| | |
|---|---|
| (i) Common room | One ceiling fan of 56" sweep. |
| (ii) Each suit | One ceiling fan of 56" sweep. |

g) POLICE STATION:

| | |
|---|---|
| The room occupied by the Inspector of Police. | One ceiling fan of 48" |

h) JAILS

| | |
|---|---|
| (i) Office room of the Superintendent, Central Jail, District Jail, or Borstal Institution or Superintendent of Approved Schools. | One ceiling fan of 48" or 56" sweep depending upon the floor area. |

# 12.16. ELECTRICAL STANDARD DATA IN COMMON USE

## 12.16.1. (S.D.4) Wiring with 2.5 sq.mm. PVC. SC. AL. Cable on TW. fillets for lights.

**For 4 Points**

| | |
|---|---|
| 90 mts. | 2.5 sq.mm. PVC sheathed SC aluminium cable. |
| 4 pkts. | Link clips 1¾" (44 mm) |
| 45 mts. | TW fillets ½" (13 mm × 13 mm) |
| 100 gms | Brass panel pins |
| 75 Nos. | TW plugs 1½" × 1½" × ¾" (38 × 25 × 19 mm) |
| ½ gross | Brass screw 1¾" (44 mm) |
| 4 Nos. | 5 amps. SP switches |
| 4 Nos. | 2 way ceiling roses |
| 8 Nos. | TW round blocks 3½" |
| 1 pkt. | Distember |
| 1/6 bag | Cement |

Masonry works and transport charges and sundries such as TW bends, corners 1½" screws and pipes etc.

Detailed labour: Jointly do 4 points per day

1 No Maistry
2 Nos. Wiremen Gr. I.
3 Nos. Helpers
2 Nos. Wiremen Gr. II.

## 12.16.2. (S.D.8) Wiring with 2.5 sq.mm. PVC sheathed AC. cable on TW. fillets for fans with 1 No. 5 amps SP switch.

**For 4 Points**

| | |
|---|---|
| 90 mts. | 2.5 sq.mm. PVC sheathed SC Alu. cable. |
| 4 pkts. | Link clips 1¾" |
| 45 mts. | TW fillets ½" (13 mm × 13 mm) |
| 75 Nos. | TW plugs 1½" × 1" × ¾" |
| 100 gms. | Brass panel pins |
| 4 Nos. | TW board 12" × 8" (31 cm × 20 cm) |
| ½ gross | Brass screws 1¼" No. 6 |
| 4 Nos. | 5 amps. SP switches |
| 4 Nos. | 2 way ceiling roses |
| 4 Nos. | TW round blocks 3½" |
| 1/6 bag | Cement |
| 1 pkt | Distember |

Masonry work and sundries such as TW Bends corners, screws, pipes VIR leads etc.

Labour detailed as in Data 1 above.

**12.16.3. (S.D.10) Wiring with 2.5 sq.mm. PVC. sheathed AL cable on TW. fillets for 5 amps. 3 pin CS. plug non-interlocking S & F the plug pin on a suitable TW. board (6" × 4" × 2¼") and with continuous earth wire connection by 14 SWG. TC wire.**

**Materials & labour for 8 points**

| | |
|---|---|
| 90 mts | 2.5 sq.mm. PVC sheathed SC alu cable |
| 4 pkts. | Link clips 1¾" |
| 45 mts. | TW fillets ½" × ½" |
| 75 Nos. | TW plugs 1½" × 1" × ¾" |
| 100 gms. | Brass panel pins |
| ½ gross | Brass screws 1¼" |
| 8 Nos. | TW box × 6" × 4" × 2¼" |
| 1 pkt | Distember |
| 8 Nos. | 5 amps. 3 pin (non interlocking plugs porcelain base with pin) |
| 1/6 bag | Cement |
| 1.35 kg. | 14 SWG TC wire |
| | Masonry works and sundries as detailed |

Detailed labour: Jointly do 8 plug points per day

1 No. Maistry
2 Nos. Wiremen Gr. I.
3 Nos. Helpers
4 Nos. Wiremen Gr. II

**12.16.4. (S.D.14) Wiring with 2.5 sq.mm. PVC unsheathed AL. SC. cable in suitable conduit pipe for lighting with continuous earth connection by 14 SWG. TC. wire.**

**Materials & labour for 4 points**

| | |
|---|---|
| 90 mts. | 2.5 sq.mm. PVC unsheathed SC cable |
| 45 mts. | Conduit pipe 5/8" (heavy guage) |
| 150 Nos. | TW plugs 1½" × 1" × ¼" |
| 75 Nos. | Saddles 5/8" |
| 1 gross | Brass screws 1" No. 6 |
| 8 Nos. | Conduit bends 5/8" |
| 4 Nos. | Conduit tee 5/8" |
| 4 Nos. | 5 amps. SP switch |
| 4 Nos. | 3 way ceiling roses |
| 4 Nos. | MS conduit round box |
| 5 Nos. | M. [illegible]nt box 4" × 4" |
| 1/6 bag | Cement |
| 1.35 kg | 14 SWG TC wire |
| | Sundries |

Detailed Labour: Jointly do 4 points per day

1 No. Maistry
2 Nos. Wiremen Gr. I
3 Nos. Wiremen Gr. II
4 Nos. Helper

**12.16.5. (S.D.20) Wiring with 2.5 sq.mm. PVC unsheathed AL cable in suitable conduit pipe for fans with 5 amps. SP. switches with continuous earth wire connection by 14 SWG. TC. wire.**

**Materials & labour for 4 points**

| | |
|---|---|
| 90 mts | 2.5 sq.mm. PVC unsheathed SC cable |
| 45 mts. | Conduit pipe 5/8" |
| 150 Nos. | TV plugs 1½" × 1" × ¾" |
| 75 Nos. | Saddles 5/8" |
| 1 gross | Brass screw 1" |
| 8 Nos. | Conduit bends 5/8" |
| 4 Nos. | 3 way ceiling rose |
| 4 Nos. | Conduit tees 5/8" |
| 4 Nos. | MS box 12" × 8" × 4" |
| 4 Nos. | Conduit round box |
| 4 Nos. | 5 amps. SP switch. |
| 1/6 bag | Cement |
| 1.35 kg. | 14 SWG TC wire |
| | Sundries |

Detailed Labour: Jointly do 4 points per day

1 No. Maistry
2 Nos. Wiremen Gr. I.
3 Nos. wiremen Gr. II.
4 Nos. Helper

**12.16.6.. (S.D.23) Wiring with 2.5 sq.mm. PVC unsheathed AL cable in suitable conduit pipe for 5 amps. 3 pin plug including S & F the 5 amps. 3 pin plug with continuous earth connection by 14 SWG. TC. wire.**

**Materials & labour for 8 points**

| | |
|---|---|
| 90 mts. | 2.5 sq.mm PVC unsheathed SC cable |
| 45 mts. | Conduit pipe 5/8" |
| 150 mts. | TW plugs 1½" × 1" × ¾" |
| 75 Nos. | Saddles 5/8" |
| 1 gross | Brass screw 1" |

| | |
|---|---|
| 8 Nos. | Conduit bends 5/8" |
| 4 Nos. | Conduit tees 5/8" |
| 8 Nos. | MS box 6" × 4" × 3" |
| 1/6 bag | cement |
| 8 Nos. | 5 amps. 3 pin CS plugs |
| 1.35 kg. | 14 SWG TC wire |
| | Sundries |

Detailed labour: Jointly do 8 points per day

1 No. Maistry
2 Nos. Wireman Gr. I.
3 Nos. Wiremen Gr. II.
4 Nos. Helper

**12.16.7. (S.D.27) Wiring with 2.5 sq.mm. PVC unsheathed AL. Sc. cable in suitable PVC rigid pipe for lights.**

**Materials & labour for 4 points**

**As per data 12.16.4. Complete Material & labourl**

Less:

| | |
|---|---|
| 45 mts. | Conduit pipe 5/8" |
| 8 Nos. | conduit bends 5/8" |
| 4 Nos. | Conduit tees 5/8" |
| 5 Nos. | MS joint box |
| 4 Nos. | MS box |
| 1.35 kg | 14 SWG TC wire |
| | Labour charges Less 1/3 of Data 14 |

Add:

| | |
|---|---|
| 45 mts. | PVC pipe 5/8" |
| 8 Nos. | PVC bends 5/8" |
| 4 Nos. | PVC bends 5/8" |
| 5 Nos. | TW box 6" × 4" |
| 4 Nos. | TW box × 4" × 4" |

**12.16.8. (S.D.34) Wiring with 2.5 sq.mm. PVC unsheathed SC. AL. cable in suitable PVC rigid pipe for fans with 1 No. 5 A.SP. switch.**

**Materials & labour for 4 points**

**Rate as per Data 12.16.5. – Complete material & labour**

Less:

| | |
|---|---|
| 45 mts. | Conduit pipe 5/8" |
| 8 Nos. | Conduit bends 5/8" |

| | |
|---|---|
| 4 Nos. | Conduit tees 5/8" |



| | |
|---|---|
| 4 Nos. | Conduit round box |
| 4 Nos. | MS box 12" × 8" |
| 1.35 kg | 14 SWG TC wire |
| | Less 1/3 of labour charges of Data 12.16.5. |

Add:

| | |
|---|---|
| 45 mts. | PVC pipe 5/8" |
| 8 Nos. | PVC bends |
| 4 Nos. | PVC end box |
| 4 Nos. | TW box 12" × 8" × 2½" |

**12.16.9. (S.D.37) Wiring with 2.5 sq.mm. PVC. unsheathed SC. AL. cable on suitable rigid PVC. pipe for 5 A. Pin CS. plug including S. & F. plug pin in TW. box with continuous earth connection by 14 SWG. TC. wire.**

**As per 12.16.6. – Complete Material & labour**

**Materials & labour for 4 points**

Less:

| | |
|---|---|
| 45 mts. | Conduit pipe 5/8" |
| 8 Nos. | Conduit bends 5/8" |
| 4 Nos. | Conduit pipes 5/8" |
| 8 Nos. | MS box |

Add:

| | |
|---|---|
| 45 mts. | PVC pipe 5/8" |
| 8 Nos. | PVC bends 5/8" |
| 4 Nos. | PVC tees 5/8" |
| 8 Nos. | TW box |

Less 1/3 labour of Data 12.16.6.

**12.16.10. (S.D.45) Run of 2 of 6 sq.mm. PVC. sheathed AL.Sc. cable on TW fillets for mains with continuous earth connection by 14 SWG. TC wire. Materials & labour for 90 metres run of 2 of 6 sq.mm.**

Materials & labour for 90 metres run of 2 of 6 sq.mm.

| | |
|---|---|
| 180 mts. | 6 sq.mm. PVC sheathed SC. Al. cable |
| 90 mts. | TW fillets ¾" (19 mm × 13 mm) |
| 150 Nos. | TW plugs 1½" × 1" × ¾" |
| 8 pkts. | Link clips 2" (51 mm) |
| 150 gms. | Brass panel pins |
| 1 gross | Brass screws 1¼" No. 8 |
| 2 pkt. | Distember |
| 2.7 kg. | 14 SWG Tinned Copper binding wire |
| 1/3 bag | Cement |

Masonry work and sundries such as screws, pipes, corner pipes, joint boxes etc. as detailed below.

Labour Nos.: Jointly do 90 metres run of 2 of 6 sq.mm. for mains per day.

1 No. Maistry
2 Nos. Wireman Gr. I
2 Nos. Wireman Gr. II
3 Nos. Helpers
1 No. Carpenter

**12.16.11. (S.D.48) Run of 2 of 6 sq.mm. PVC. unsheathed AL.SC. cable in suitable conduit pipe for mains with continuous earth connection by 14 SWG TC. wire**

**Materials and labour for 90 metre run of 2 of 6 sq.mm.**

| | |
|---|---|
| 180 mts. | 6 sq.mm. PVC unsheathed SC cable |
| 90 mts. | Conduit pipe ¾" (19 mm) |
| 1 gross | saddles ¾" |
| 300 Nos. | TW plugs 1" × ¾" × 1½" |
| 1 gross | Brass screws 1¼" |
| 1/3 bag | Cement |
| 2.7 kgs. | 14 SWG TC wire |
| | Sundries and masonry work |
| | Labour charges (as per Data 14 × 1.5 times) |

**12:16.12. (S.D.59) Run of 2 of 6 sq.mm. PVC unsheathed SC. AL. cable in PVC pipe for mains with continuous earth connection by 14 SWG TC wire.**

**As per Data 12.16.11.**

**Materials and labour for 90 metre run of 2 of 6 sq.mm.**

| | |
|---|---|
| Less: | 90 mts. conduit pipe ¾" |
| Less: | Labour charges for conduit wiring in Data 48 |
| Add: | 90 mts. PVC pipe ¾" |
| Add: | Labour charges for PVC wiring (as per Data 27 × 1.5 times) |

**12.16.13. (S.D.66) Run of 2 of 6 sq.mm. WPSC. AL. cable on bearer wire for mains with angle iron upright.**

**Materials and labour for 90 metres run of 2 of 6 sq.mm. for mains**

| | |
|---|---|
| 180 mts. | 6 sq. mm. WPSC 250 V. Grade |
| 4 kg. | 7/20 as bearer wire |
| 5 mts. | G.I. pipe 1" (25 mm) |
| 5 mts. | Angle iron 1½" × 1½" ¼" or 17½ kg |
| 180 Nos. | Reel Insulator |
| 2 Nos. | G.I. Bends 1" |

Labour Nos.: Jointly do 90 metres run of 2 of 6 sq.mm. for mains per day.

1 No. Maistry
2 Nos. Wireman Gr. I.
2 Nos. Wireman Gr. II.
3 Nos. Helpers
1 No. Plumber

**12.16.14. (S.D.70) Supplying and fixing El shade and 40 watts bulb for BH point.**

**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | El shade |
| 1 No. | 40 Watt bulb |
| | Sundries |
| | Labour as below/20 |

Detailed labour: Jointly do 20 fixtures per day

2 Nos. Wireman Gr. II.
2 Nos. Helper

**12.16.15. (S.D.74) Supplying and fixing SL. pendant with El shade lamp lock and 40 W bulb only.**

**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | El Shade (10" × 3½") |
| 1 No. | Lamp holder (Bakelite) |
| 1 No. | 40 W bulb |
| 1 mt. | Flex wire |
| | Labour as detailed Below/20 |

Detailed labour: Jointly do 20 such fixtures per day.

| | |
|---|---|
| 2 Nos. | Wireman G. II. |
| 2 Nos. | Helpers |

**12.16.16. (S.D.77) Supplying and fixing 12" SL. bracket with EI shade and 40 W bulb.**

**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | SL bracket 12" with holder |
| 1 No. | E.I. Shade |
| 1 No. | 40 W bulb |
| | Sundries such as screws etc |

Labour Charges : as detailed below/15

Detailed Labour : Jointly do 15 fixtures per day

2 Nos. Wireman Grade II.

3 Nos. Helper

**12.16.17. (S.D.83) Supplying and fixing WT. bulk head fitting suitable for 60 W lamps with guard and bulb.**

**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | WT bulk head fitting suitable for 60 W bulb with guard |
| 1 No. | 60 W bulb. |
| | Sundries such as conduit bend pipe. TW plug brass screws VIR leads painting |
| | Labour charges as in S.D. 77 |

**12.16.18. (S.D.90) Supplying and fixing of box type 4' 40 W single fl. fitting complete with TW round block, tube on ceiling of wall with connection.**

**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | 4'40 W Box type single fl. fitting complete for one no. 4'40 W fl. tube |
| 1 No. | 4'4 W fl. tube |
| 2 Nos. | TW round block |
| L.S. | Sundries such as screws, flex TW plug, Brass screws. distembering etc. |
| | Labour as detailed below/16 |

Labour: Jointly do 16 Nos. fixtures per day

1 No. Wireman Gr. I.

2 Nos. Wireman Gr. II.

3 Nos. Helpers

**12.16.19. (S.D.94) Supplying and fixing 4'40W twin street light fl. fitting with S & F of ¾" GI. pipe complete on existing post including supplying and fixing of 15 amps aerial fuse unit on MS plate with PVC unsheathed leads MS clamps and aluminium paint etc.**
**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | 4'40W twi9n street light fl. fitting complete without tube. |
| 2 Nos. | 4'40W fl. tube. |
| 4 mts. | GI pipe |
| 2 Nos. | GI pipe |
| 7 mts. | 2.5 sq.mm. PVC unsheathed SC cable |
| 1 No. | 15A aerail fuse unit on suitable MS plate, nuts and painting |
| | Sundries such as TW bush screws, bolts and nuts and painting |
| | Labour as detailed below/5 |

Labour: Jointly do five fixtures per day

2 Nos. Wireman Gr. I.
2 Nos. Wireman Gr. II.
2 Nos. Helpers

**12.16.20. (S.D.101) S. & E. of 2½" dia. GI pipe and 4 meters length with concreting and construction of masonry pedestal with MS box and door with lock and key arrangements and supply and erection of cylindrical or conical post of lantern with 4 nos. 2'20W fl. tubes complete with all accessories on the above post complete with PVC unsheathed leads and fixing of 5A. S.P. switch and fuse unit inside the MS box and painting in suitable colour.**

**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | 2½" GI pipe 4 mts. complete |
| 1 No. | Concreting and masonry as pedestal work for lining the post and MS box. |
| 1 No. | MS box with angle iron frame work for housing condenser fuse unit, and SP switch with whole lock and key arrangements. |
| 1 No. | Post top lantern fitting complete with 4 Nos. 2'20W fitting and choke condenser and accessories with tubes. |
| 1 No. | TW blank with Fuse unit and 1 SP switch |
| | Sundries such as bolts, nuts, painting connectors etc. |
| | Labour charges/2 |

Labour: Jointly do two fixtures per day.

1 No. Wireman Gr. I.
2 Nos. Wiremen Gr. II.
2 Nos. Helpers.

**12.16.21. (S.D.113) S. & F. 48" sweep AC ceiling fan complete with regulator with 1 metre down rod including S. & F. of fan clamp with side plates and cross arm.**

**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | AC ceiling fan 48" sweep with regulator |
| 1 No. | Fan clamp with side plate & 18" cross |
| 3 mts. | arm 1.5 sq.mm. unsheathed wire |
| 1 mt. | steam pipe |
| | Sundries such as screws, coach screw etc. |
| | Labour/4 |

Labour For 4 fixtures

1 No. Wireman Gr. I.
1 No. Wireman Gr. II.
2 Nos. Helpers

**12.16.22. (S.D.118) S & F of 48" Sweep AC ceiling fan complete with regulator with 1 foot down rod on existing clamp.**

**Materials and labour for each fixture**

| | |
|---|---|
| 1 No. | 48" sweep AC ceiling fan complete |
| 30 cm. | Steam pipe |
| 1 mt. | 1.5 sq.mm. PVC unsheathed wire |
| | Sundries such as screws etc. |
| | Labour charges/5 |

Labour: Jointly do five fixtures per day

1 No. Wireman Gr. I.
1 No. Wireman Gr. II.
2 Nos. Helpers

Service Metre

**12.16.23. (S.D.127) S & F 10 amps/25 amps. AC. 50 cycles single phase watthour meter on suitable TW board with earth connection only.**

**Materials and labour for each fixutre**

| | |
|---|---|
| 1 No. | 10 amps/25 amps or AC single phase 50 cycle 230/250V watt hour meter. |
| 1 No. | TW board 12" × 8" × 2½" |
| | Sundries such as screws plugs etc. |
| | Labour charge |

**12.16.24. S & F 4 way DB with 15 amps. DPIC switch with F & N on suitable TW board with earthing.**

**Materials and labour for each unit**

| | |
|---|---|
| 1 No. | 4 way DB with neutral link |
| 1 No. | 15 amps DPIC switch F & N 25 OV |
| 1 No. | TW board 16" × 12" × 2½" |
| 1 No. | earthing as per PWD Standard |
| | Sundries such as screws, plugs, cement etc. |
| | Labour/2 |

Labour details: Jointly do 2 units per day

1 No. Wireman Gr. I.
1 No. Wireman Gr. II.
1 No. Helper

**12.16.25. (S.D.154) S & F of 30 A. DPIC switch with 8 way DB on suitable angle iron frame work with trunking box and with earthing.**

**Materials and labour for each unit**

| | |
|---|---|
| 1 No. | 30A DPIC switch with F & N |
| 1 No. | 8 way DB with F & N link |
| 1.75 mt. | Angle iron frame |
| 1 No. | MS trunking box |
| 1 No. | Earthing |
| | Sundries such as nuts, bolts, links cement etc. |
| | Labour charges/2 |

Labour: Jointly do 2 units per day

1 No. Wireman Gr. I.
2 Nos. Wireman Gr. II.
3 Nos. Helpers

**12.16.26. (S.D. 173) S & F of brass cable gland suitable for 2 core or 4 core PVC UG cable.**

Materials and labour for each unit.

| | |
|---|---|
| 1 No. | Cable gland for 4 core of 6 sq.mm. PVC cable |
| L.S. | Sundries such as copper, earthing clamp, copper wire etc. |
| | Labour charges for 10 units Jointly do 10 units per day |

1 No. Wireman Gr. I.
2 Nos. Wireman Gr. II.

**12.16.27. (S.D.179.) S & Laying of 2 core 6 sq.mm. LTUG cable in a trench to be excavated at a depth of 2.5' putting 6" Layer of sand and covering the cable with brick and sand refilling the earth to make good.**

Materials and labour for 90 metres run of 2 core 6 sq.mm.

| | |
|---|---|
| 90 mts. | 2 × 6 sq. mm. LTUG cable |
| | Cost of brick sand including transport charges |
| | Labour charges for excavating the trench and refilling to make good |
| | Labour charges for laying the cable covering it with brick, sand and other incidental charges such as transport. |

**12.16.28. (S.D. 197.) S & Clamping of 2 core 6 sq.mm. PVC LT UG cable by MS clamps on wall.**

Materials and labour for 90 metres run of 2 core 6 sq.mm.

| | |
|---|---|
| 90 mts. | 2 × 6 sq.mm. PVC LT UG cable |
| 150 sets | MS clamp, saddles, complete |
| | Sundries such as screws and cement etc. |
| | Labour charges |

Labour: Jointly do 90 metres run of 2 core sq.mm. in two days.

3 Nos. Wireman Gr. I.
3 Nos. Wireman Gr. II.
4 Nos. Helpers.

**12.16.29. (S.D.213.) Earthing as per the ISI specification with necessary masonry work.**

Materials and labour for one No. earthing

| | |
|---|---|
| 7' | G.I. Pipe 1½" |
| ½' | G.I. Pipe |
| 1 No. | Funnel with wire mesh 5" dia |
| 1 No. | Copper flat 5" × 2" |
| 1 No. | Reducer |
| 3 Nos. | ¾" GI check nuts |
| Brick masonry | |
| 1 bag | Charcoal |
| 1½" | thick RCC cover |
| | Common salt |
| | Labour charges |
| | Sundries |

**12.16.30. (S.D. 214.) Earthing as per PWD standard complete with necessary masonry work.**

Materials and labour for one No. earthing

| | |
|---|---|
| 2 mts. | G.I. Pipe 1½" |
| 1 bag | Charcoal |
| 6 mes. | Common salt |
| ½ Kg. | G.I. wire |
| | Civil Work |
| | Sundries charges such as bolts, nuts, sockets resin etc. |
| | Labour charges ■ |

# XIII. IRRIGATION

## 13.1. GUIDE LINES FOR INVESTIGATION OF IRRIGATION PROJECTS

### 13.1.1. General:

1) Primary need for agriculture is land and water. Irrigation is the process of using water on land. Earth gets water only from rain. The rain falling on the ground is disposed of in three ways.

   (a) Transo Evaporation.
   (b) Run off – and
   (c) Percolation.

   In this context we deal with run off water only.

2) There are three types of irrigation Process:

   (a) Rainfed – using direct rainfall only.
   (b) Surface water – canal irrigation.
   (c) Lift irrigation using under ground water.

   Here we deal with the surface water.

3) Ancient irrigation methods of using the river water are, just leading the river water to the lands commandable and cultivating them. This was improved upon by constructing anicuts across the rivers to raise the water level to reach even higher lands. These methods hold good only when there is flow in the rivers. Later on the methods of storing water in the reservoirs, formed across rivers, were thought of, so that irrigation can be done even when there is no flow in the river. (Such reservoirs are artificial ones where as the under ground reservoirs are natural).

### 13.1.2. Prime Requisites:

(1) The prime requisites of an irrigation project are

   (a) Water-in sufficient quantity and of suitable quality.
   (b) Ayacut (Land) – commandable and of suitable soil.

(2) When an irrigation project is thought of in a stream, the water in off season-when the flow is meagre-and during the monsoon – when the flow is full-should be taken and analysed to find out the quality of water and its fitness for crops. If the water is totally useless or harmful the proposal should be rejected. If it is quite useful, any crop can be raised. If it is conditionally agreeable, the cropping pattern should be so chosen with the recommended remedies.

(3) Similarly the soil samples are taken from the proposed ayacut at random and tested for their suitablity for raising crops. Here too the cropping pattern is to be adopted based on the results of the tests. The area commandable can roughly be fixed from contour maps.

(4) Having tested the quality of water, the quantity available is to be assessed. This is done by taking the useful rainfall which will contribute to the run off in the catchment multiplied by the catchment area and allowing for the intermediate water storages. This will give the quantum of water available for the project. The requirements for the lower down irrigation must also be taken care of.

(5) Based on this availability of water and the duty adopted for that region (14Ac/M.cft for dry and 7 Ac/M.cft for wet) the ayacut is fixed.

### 13.1.3. Reconnoitering Survey:

(1) Preliminary selection of sites for locating a dam can be done from a study of G.T.S. maps.

(2) Then the sites are to be inspected to select a suitable one based on:

(a) Narrowness of the valley with a big water spread.

(b) Availability of foundation rock for masonry structures.

(c) Availability of construction materials like earth and stones.

(d) Proximity to habitation.

(e) Less submersion of villages and costly land.

(3) By the above two methods the choice becomes limited and we may have to consider only two or three sites at this stage. The different dam alignments are to be fixed on the ground by some indications on both ends. For such alignments you must have your own language of signs as the distance will be a K.M. & even more. Among these different alternatives one can be finalised, when survey is completed based on the comparative cost of the dam.

(4) Now the type of dam is to be decided. If the foundation is rocky and ample stones are available nearby and if the length of dam is short, masonry structure can be decided for the full length. If otherwise, the conditions are favourable for an earth dam, that can be decided upon.

(5) The ayacut area is to be inspected for the evenness of the area, type of soil, for any crops raised on that date, to note any ups and down, for any major road crossings, cross drainages etc.

(6) The water spread area is to be inspected for any submersion of valuable properties, ayacut etc. Huts, Houses, Yielding Trees, Patta land, Monuments, Post & Telegraphs lines, Power lines should be detailed and listed out. Any low lying area along the fringe of the water spread should be noted for raising it above F.R.L.

(7) The catchment is to be seen for its topographical conditions, vegetation, gradients, type of soil etc. to have an idea of the run off and to fix the constant value for the Ryve's formula.

(8) Details of any irrigation works and their ayacut lower down the site are to be collected and water is to be allowed for these from the reservoir through a river sluice.

## 13.1.4. Detailed Survey & Connected Works:

(i) Head works:

(a) Block levels in water spread area are taken, contours drawn upto the proposed dam line, and capacity table prepared for the reservoir. Full reservoir level is fixed for the required storage of water.

(b) We have already computed the total quantity of water available per annum in the stream. Now it is to be foundout how this quantity is spread out during the monsoon. If the rainfall is concentrated in a few days, to store the required water a huge reservoir is required. Whereas if the rainfall is spread over in two or three months a reservoir of a comparatively smaller capacity will suffice. This is arrived at by a working table commuting the incoming water to the reservoir and the draw from it for the fields during every month. This method fixes the capacity of the reservoir and there by the F.R.L. and thereby rules over the cost of the scheme.

(c) The next main point to be considered is the surplus disposal in a dam. The dam is constructed to hold a certain quantity of water, and when the reservoir is filled the flood coming in the river is to be disposed off safely. The maximum flood which can be expected in the river is calculated by two ways:

(i) by Ryve's formula $Q = CM^{2/3}$ and

(ii) by actual flood marks observed. The highest of the two is taken. The value C in the Ryve's formula is decided based on the topography of the country, by the incidence of rainfall etc. The personal experience in such surveys plays a major part in decidng this value. The following is given as a guide-line in P.W.D.

$C = 1000$ for flat tracts along the coastal area.

$C = 1200$ in tracts with slopes interior of the land.

$C = 1500$ in limited areas near the hill.

$C = 2000$ in hilly tracts.

Having arrived at the flood capacity, the arrangement to pass it over the dam safely is to be though off. We can decide on a gated spillway or an open crested weir. The considerations to take this decision are:

(i) Proximity to the village for the operator to stay.
(ii) Proper foundation.
(iii) Comparative cost for both.
(iv) Drops required to negotiate the difference in level.
(v) Surplus course — Nature of bed, length, etc.

The location of the spillway also is to be judiciously decided whether at river bed or at the flank. Sufficient protective works at sides and stilling arrangements are to be provided. The water should be lead to the rivers far below the dam such that the toe of the dam is not affected. Site survey for the spillway and the surplus course is taken in detail and plotted.

(d) L.S. & C.S. for the bund alignment is taken and plotted. The earth for forming bund is usually taken from the water spread with advantage of increasing the storage capacity. So the earth from the borrow area is taken analysed for its composition and quality. Based on the results, the slopes of the bund and section is designed.

(e) Site surveys for canal sluice, river sluice, etc. are taken and plotted.

(f) Village maps are collected and the surveyed portion for the head works are marked on them and the area is computed with details of S.F. Nos. The lands required for acquisition is tabulated as per the kind of land – Dry, Wet, Patta, Poramboke, Forest, etc. Then the Land Acquisition statement is prepared.

## 13.1.5. Canals:

Having roughly fixed the area for the ayacut and the sill level for canal sluice based on the storage capacity of the reservoir, the fixing of the canal alignment and the ayacut is taken up. This can be done simultaneously with the head works survey. Either ridge canal or contour canal can be fixed to suit the country in the ayacut area.

(a) Bench marks are fixed on the proposed area by check levels. Block levels at 30 m. intervals are taken and plotted on correct S.F.No. on village maps. The canal alignment is roughly drawn on the map. With this guidance the L.S. & C.S. canal alignment is taken and plotted for preparing detailed estimate. While this is in progress identifications are made on the field to mark the alignment. The details of cross masonries are also noted down.

(b) After plotting the L.S. of the canal, a study of the plan and the L.S. sheet will show any kinks and bends in the canal course which can be straightened based on the comparative cost of the two courses. The heavy cutting and high embankments can also be studied and field inspections can be done again to minimise the cost. Thus a final course is arrived. Then trial pits are dug along this course to know the type of soil to be excavated, and the canal course is marked by stones if necessary at convenient places.

(c) When the canal course is finally marked on the village maps, the ayacut area is divided into convenient blocks and the locations of sluices are marked on the canal course considering the command level of channel. Then these blocks are marked in different colours and this map is known as the ayacut map. This is usually in scale (1 : 4000 (app.)

## 13.1.5. Preparation of Estimates:

1) Estimates are prepared for individual items based on the current schedule of rates, for the head works and canals separately and combined together finally. Provisions for all subsidiary items like land acquisition, shifting post and telegraph lines, H.T. & L.T. lines, compensation for land, houses, trees, etc. Highways works, Railway works, etc. are to be made without any omission.

Required other percentage charges are also to be provided for like T & P. audit, allowances, etc. A sample form of the two estimates and a combined classified abstract is appended herewith.

The lead for the different materials should be fixed with care as the cost of the estimate depends on this, cost of materials and labour having been fixed in the schedule of rates. The responsibility for these leads are on the field officers.

## 13.1.6. Report:

A comprehensive report on the scheme is to be prepared starting from the history of the scheme and furnishing the financial details what it would be after the completion of the scheme. The different chapters in a scheme report are:

(1) Synopsis;
(2) History of scheme;
(3) Hydrology;
(4) Details of works;
(5) Availability of materials, programme of execution and concurrence from other departments;
(6) Abstract of estimate and Financial statements;
(7) Conclusion.

The hydrology portion should be dealt in detail to convince the success of the scheme. In effect this report is the essence of the scheme high lighting its various benefits to the Public and Financial aspects of the scheme. In most of the cases the report is not given its due importance by engineers. Being technical minded, the perfection and care they take in design and estimate is not taken in preparation of the report. Only this report goes to Government for getting the scheme sanctioned. The estimates and drawings stop with the Chief Engineer who gives the technical sanction. The economy of the scheme is judged by the three factors:

(a) Cost per acre of ayacut.
(b) Cost per tonne of food grain.
(c) Benefit cost ratio (The ratio between the benefit derived by implementing the scheme and the recurring cost involved.)

A statement of working the above is appended.

### 13.1.7. Other Miscellaneous Points:

Wherever other departments are involved they must be addressed for their concurrence and for their estimates of their affected work – Highways – Rural Works – Electricity Board – etc.

## 13.2. DUTY and YIELD FROM CATCHMENT

### 13.2.1. Duty

Relations between different expression for duty of water:–

1 cusec flowing for one day

= 0.0864 million cubic feet.
= 2 acre feet. (1.98 exactly)
= 24 acre inches. (23.76 exactly)

1 million cubic feet

= 11.574 cusec flowing for one day
= 23 acre feet (nearly)

1 acre foot or 12 acre inches

= ½ cusec flowing 24 hours (nearly)

One acre per million cubic feet is equivalent (approximately) to a duty of 12 acres per cusec for a crop period (base) of 140 days.

$$\Delta = \frac{24B}{d}$$

where $\Delta$ = equivalent depth in inches.
B = base in days
d = duty in acres per cusec.

### 13.2.2. Yield from a catchment

Yield from a catchment area can be calculated by two methods. 1. Stranger's Table Method, and 2. Dry-Damp-Wet Method. In practice run off from a catchment area is expressed in so many million cubic feet of water per square mile.

### 13.2.3. Dependable Yield for various rain fall stations

*(Based on C.E.(I) circular for dry damp-wet method)*

| Name of Raifall Station | Yield in M. Cft./ Sq. Mile | Name of Railfall Station | Yield in M. Cft./ Sq. Mile |
|---|---|---|---|
| | **Chinglepet District** | | |
| Chinglepet | 14.43 | Sriperumbudur | 12.17 |
| Maduranthakam | 13.83 | Tiruttani | 11.19 |
| Ponneri | 20.04 | Trivellore | 14.00 |
| Poonamallee | 16.07 | Uttiramerur | 13.77 |
| Saidapet | 20.15 | | |

## North Arcot District

| | | | |
|---|---|---|---|
| Arani | 9.48 | Tirupathur | 10.82 |
| Chengam | 11.93 | Tiruvannamalai | 12.00 |
| Polur | 9.97 | Vaniambadi | 7.82 |

## South Arcot District

| | | | |
|---|---|---|---|
| Srimushnam | 15.21 | Panrutti | 14.71 |
| Tittagudy | 12.47 | Ulundurpet | 11.21 |
| Cuddalore | 4.97 | Kallakurichi | 10.23 |
| Vridachalam | 14.72 | | |

## Trichy District

| | | | |
|---|---|---|---|
| Kulithalai | 8.031 | Ponneri | 20.04 |
| Manapparai | 9.324 | Thattiyangarpet | 7.630 |
| Ariyalur | 12.260 | Marugapuri | 10.300 |
| Perambalur | 10.412 | Ponnamaravathi | 10.190 |
| Lalgudy | 10.060 | Kulathur | 9.039 |
| Karur | 5.550 | Illuppur | 7.633 |
| Ulundurpet | 11.210 | Uthamapalayam | 3.735 |
| Thirumayam | 8.479 | Nandiar | 2.801 |
| Viralimalai | 6.527 | Alangudy | 8.395 |
| Musiri | 5.540 | Chettikulam | 8.482 |
| Aravankuruchi | 5.710 | Udayarpalayam | 5.524 |
| Uppliyapuram | 9.390 | Udayalpatti | 5.524 |
| Jayankondan | 12.860 | Keelanailai | 8.736 |
| Thuraiyur | 8.635 | Pudukottai | 11.5 |

## Madurai District

| | | | |
|---|---|---|---|
| Dindigul | 7.283 | Periyakulam | 6.850 |
| Gudalur | 4.970 | Periyar | 43.86 |
| Kodaikanal | 16.830 | Chathrapatti | 9.357 |
| Mettupatti | 6.060 | Usilampatti | 9.497 |
| Nelakottai | 7.308 | Bodynaickanur | 4.098 |

### Ramnad District

| | | | |
|---|---|---|---|
| Watrap | 15.00 | Sathur | 6.40 |
| Srivilliputhur | 9.00 | Velathakulam | 4.50 |
| Virudhunagar | 7.80 | Ambasamudram | 10.30 |
| Sivakasi | 5.40 | | |

### Tirunelveli District

| | | | |
|---|---|---|---|
| Tirunelveli | 6.10 | Ottapidaram | 3.35 |
| Kovilpatty | 4.54 | Shencottah | 11.03 |
| Vedasendur | 5.837 | Annavasal | 8.84 |
| Kadayanallur | 3.35 | | |

### Coimbatore District

| | | | |
|---|---|---|---|
| Bhavani Rainfall Staions | 8.350 | Perundurai | 5.346 |
| Coimbatore | 2.000 | Sathyamangalam | 6.120 |
| Gobi | 7.190 | Tiruppur | 4.864 |
| Kodumadai | 3.774 | Udumalpet | 4.500 |
| Kangayam | 4.125 | Erode | 8.076 |
| Mulanur | 4.699 | Palladam | 3.00 |
| Mettupalayam | 6.637 | Darapuram | 4.0 |
| Periyanaickenpalayam | 5.362 | | |

### Salem & Dharmapuri Districts

| | | | |
|---|---|---|---|
| Attur | 12.460 | Pennagaram | 8.506 |
| Denkanikotta | 7.720 | Rasipuram | 12.390 |
| Dharmapuri | 9.505 | Royakotta | 9.395 |
| Hosur | 8.160 | Sankari | 6.742 |
| Karur | 6.040 | Thali | 10.620 |
| Krishnagiri | 7.424 | Valapadi | 7.118 |
| Namakkal | 7.040 | Sankari | 5.39 |
| Omalur | 11.085 | Venkatagirikota (A.P.) | 4.233 |

## 13.3. FLOOD DISCHARGE

For free catchment:–

Ryve's formula – $D = C.M.^{2/3}$

Dicken's formula – $D = C.M.^{3/4}$

For combined catchment:–

Ryve's formula . $D = C.M.^{2/3} - cm^{2/3}$

Dicken's formula $D = C.M.^{3/4} - cm^{3/4}$

where M = combined catchment in square miles

m = area intercepted (combined minus free)

D = Local coefficient depending on rainfall soil, slope and nature of catchment

C = 1/5th C to 1/3 C often fixed at 200

and D = Discharge in cusecs from catchment

The values of C for Ryve's formula adopted in Tamilnadu State are as follows.

C = 1000 for flat tracts along the coast.

C = 1200 in tracts with greater slope 15 to 100 miles from the coast.

C = 1500 in limited areas near the hills.

C = 2000 in Kodaikanal hills as adopted in Manjalar Project and Marudhanadhi Scheme.

Inglis formula $Q = \frac{700A}{\sqrt{A+4}}$

where Q = Flood intensity in cusecs.

and A = Area of catchment in square miles.

*Model Calculation:*

Precipitation method should be followed assuming a rainfall of 12 inches in 24 hours over the catchment. (Vide C.E. (I) Circular Memo. No. M1/3849/67 ER dated 2-5-1967)

Therefore flood discharge from a catchment of

$$\text{of 3 Square miles} = \frac{3 \times 5280' \times 5280' \times 12''}{24 \times 60 \times 60 \times 12} \text{ cusec}$$

$$= 3 \times 322.67 \text{ cusec.}$$

# 13.4. FORMULAE USED IN IRRIGATION AND HYDRAULICS

## 13.4.1. Flood Discharge:

(a) Dicken's formula $Q = CM^{3/4}$

Q = Max. Discharge in $m^3$/sec.

M = Catchment area in $Km^2$

C = a constant

(b) Ryve's formula

$Q = CM^{2/3}$ C = a constant

## 13.4.2. Open Channels:

(a) Chzey's formula

$V = C\sqrt{RS}$

V = Velocity in m/sec

R = Hyd. mean depth in m

S = Slope

C = Chezy's constant

(b) Manning's formula

$V = \frac{1}{n} R^{2/3} S^{1/2}$ n=roughness coefficient

(c) Kutter's formula for the value of

$$C = \left\{ \frac{23 + \frac{0.00155}{S} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{S}\right) \frac{n}{\sqrt{R}}} \right\}$$

## 13.4.3. Weirs:

(a) Crest width of weir $a = \frac{\sqrt{H} + \sqrt{d}}{1.811}$

and not less than $\frac{3d}{2p}$

a = Crest width in m

H = Height of body wall in m

d = depth of water on weir crest in m

$\rho$ = sp.gr. of the material of wall.

(b) Bottom width of weir $b = \frac{(H + d)}{\sqrt{\rho}}$

b = bottom width of weir in m.

(c) Depth of scour $R = 1.35 \left(\frac{q^2}{f}\right)^{1/3}$

R = depth of scour in m
q = discharge in $m^3$/sec. per metre run
f = Lacey's silt factor

(d) Total length of downstream apron including Talus in M

$$L_1 = 3c\sqrt{\frac{Hs}{3}} \times \sqrt{\frac{q}{7}}$$

Hs = Height of weir crest above low water level in m.
C = Creep coefficient

(e) Minimum Length of percolation in M L = CHs

(f) Length of solid apron in m $L_2 = 12C\sqrt{\frac{Hs}{39}}$

(g) Length of upstream inpervious apron in m

$L_3 = L - L_2$

(h) Discharge over ogee crested weir

$Q = 2.20 \times L \times d^{3/2}$

Q = Discharge in $m^3$/sec

L = Length of weir at crest in m

## 13.4.4. Head Sluices:

Discharge $Q = Cd \times A \times \sqrt{2gH}$

Q = Discharge in $m^3$/sec.

$C_d$ = Coefficient of discharge

A = Area of cross section in $m^2$

H = Head of water in m

g = acceleration due to gravity in m/$sec^2$

## 13.4.5. Surplus Weirs:

(a) Discharge over the weir (clear overfall) with velocity of approach.

$$Q = \frac{2}{3} C_d L \sqrt{2g}[(h + h_a)^{3/2} - h_a^{3/2}]$$

Q = Discharge in $m^3$/sec.
L = Length of weir in m
h = head of water in m
$C_d$ = Coefficient of discharge
$h_a$ = head due to velocity of approach $= \frac{V^2}{2g}$

(b) Discharge over the weir, (submerged) with velocity of approach.

$$Q = \frac{2}{3} C_1 L \sqrt{2g}[(h + ha)^{3/2} - ha^{3/2}] + C_2 L \times d \sqrt{2g(h + ha)}$$

$C_1$ and $C_2$ are constants
d = difference in level between the weir crest and water level below the anicut in m
Put ha = Q, in the above formula for discharge without velocity of approach

## 13.4.6. Trapezoidal Notch:

(free overfall) Discharge
$Q = 2.96\, C_d\, d^{3/2}\, [1 + 0.4dn]$
Q = Discharge in $m^3$/sec
$C_d$ = Coefficient of discharge
d = the depth in m over the sill of the notch
l = the width of the horizontal sill of notch in m
n = 2 tan α where α is the angle made by each of the sides of the notch with the vertical

## 13.4.7. Canal Drop:

(a) Dropwall top width

$$a = \left(\frac{d}{2}\ 0.1524\right) \text{ to } \left(\frac{d}{2} + 0.3028\right)$$

where a = top width in m

d = depth of water over sill of notch in m

(b) Drop wall bottom width

$$b = \frac{H + d}{\sqrt{\rho}}$$

b = bottom with in m

H = height of wall in m

(c) Length of apron

$L = 2d + 2\sqrt{dh}$ or

$1.22 + 2\sqrt{d\,h}$ or

$1.22 + 2\sqrt{de\,h}$ whichever is greater

L = Length of apron in m

h = Difference between u/s and d/s water level in m

(d) Downstream apron width in m $W = L + \frac{d}{2}$

Thickness of apron

$$\text{Minimum } t = \frac{\sqrt{d + h}}{1.811}$$

5. d & h are in m

(f) Bed pitching u/s $l_1 = 1\frac{1}{2}d$

(g) Bed pitching d/s $l_2 = 2d$

(h) Depth of water cushion

$(d_w + d_1) = 0.905d\sqrt{h}$

d = depth of water cushion in m

$d_1$ = depth of d/s apron in m

### 13.4.8. Storage capacity of tanks

$$Q = \frac{H}{3} \times (A1 + A2 + \sqrt{A1 . A2})$$

A1 = area at FTL

A2 = area at lowest sill levels

H = Diff. in ht. between A1 & A2

Q = Storage

## 13.4.9. Flow Over Notches

A notch is an opening (having sides and bottom only) in one side of a tank over which the liquid flows.

General Notations used in the foramulae

$Q$ = Discharge over the Notch.
$C_d$ = Coefficient of discharge.
$b$ = breadth of the notch
$H$ = Height of liquid above the sill of the Notch.
$\theta$ = angle of the Notch
$A$ = Surface area of the notch
$H_1$ = Initial height of liquid
$H_2$ = Final height of liquid
$T$ = Time required in Seconds

### (i) Discharge over a Rectangular notch:

$Q = {}^2/_3\, C_d\, b\, \sqrt{2g}\,(H)^{3/2}$ (without end contraction)

$Q = {}^2/_3\, C_d\, \sqrt{2g}(L - 0.\text{ln}\, H)$ with end contraction).

### (ii) Discharge over Triangular notch:

$$Q = \frac{8}{15} C_d \sqrt{2g} \tan \frac{\theta}{2} (H)^{5/2}$$

### (iii) Discharge over a trapezoidal notch:

The sum of the discharges over rectangular notch and Triangular notch:

### (iv) Time of emptying a tank over a rectangular notch:

$$T = \frac{2A}{{}^2/_3\, C_d\, b \sqrt{2g}} \left( \frac{1}{\sqrt{H_2}} - \frac{1}{\sqrt{H_1}} \right)$$

## 13.4.10. Flow Over Weir

A structure used to dam up a stream or a river over which the water flows is called a weir.

General Notations used in the formulae:

$Q$ = Discharge over weir

$C_d$ = Coefficient of discharge

$L$ = Length of weir

$H$ = Height of water over the crest of the weir.

$n$ = No. of end contractions (Twice the number of bays of the weir).

$v$ = velocity approach

$Ha$ = Additional height of water due to velocity approach

$Hs$ = $(H + Ha)$ is called as still water head

$H_1$ = Height of water on the upstream side over the crest of the weir.

$H_2$ = Height of water over crest of the weir on the downstream side.

$g$ = acceleration due to gravity m/Sec$^2$

### (i) (a) Discharge over a rectangular weir without velocity of approach.

$$Q = {}^2/_3\, C_d L \sqrt{2g}(H)^{3/2}$$

*(b) Francis' formulae for discharge over rectangular weir (with end contraction)*

$$Q = 1.84\,(L - 0.1\,nH)H^{3/2} \qquad \left[\begin{array}{c} {}^2/_3\, C_d \sqrt{2g} = 1.84 \\ \text{where } C_d = 0.623 \end{array}\right]$$

(c) Bazin's Formula for discharge over rectangular weir.

$$Q = mL\sqrt{2g}(H)^{3/2} \text{ Where } m = 0.405 + \frac{0.003}{H}$$

*(ii) Discharge over Cippoletti weir Francis' formula:*

(without end contraction) $Q = 1.84\,L\,(H)^{3/2}$

(This weir having side slope of 1 horizontal to 4 vertical)

*(iii) Discharge over a weir considering velocity of approach*

$$Q = {}^2/_3\, C_d L \quad 2g\,[H_s{}^{3/2} - H_a{}^{3/2}]$$

Where $H_a = \dfrac{v^2}{2g}$

$H_s = H + H_a$

**(iv) Discharge over a narrow-Crested weir:**

$$Q = \frac{2}{3} C_d . L . \sqrt{2g} (H)^{3/2}$$

**(v) Discharge over a broad-crested weir:**

$$Q = C_d L \sqrt{2g(H H_1^2 - H_1^3)}$$

**(vi) Maximum discharge over a broad-crested weir:**

(a) $Q\ max = 1.71\ C_d\ L\ (H)^{3/2}$ assume $C_d = 0.95$

$Q\ max = C\ L\ H^{3/2}$ (without end contraction)

Where $C = 1.71\ C_d$

The emperical value of $C = K\left(0.70 + 0.185 \frac{H}{L_1}\right)$

$L_1$ = Weir crest width

$$K = \left(0.405 + \frac{0.003}{H}\right)\sqrt{2g}$$

**(vii) Discharge over submerged weir or Drowned weir:**

$$Q = \frac{2}{3} C_d L \sqrt{2g}\ (H_1 - H_2)^{3/2} + C_d\ L H_2 \sqrt{2g\ (H_1 - H_2)}$$

**(viii) Discharged over submerged or Drowned weir considering velocity approach:**

$$Q = \frac{2}{3} C_d L \sqrt{2g}\left[(H + h_a)^{3/2} - h_a^{3/2}\right] + C_d L H_2 \sqrt{2g\ (H + H_a)}$$

where $H = H_1 - H_2$

**(ix) Discharge over a sharp crested and ogee weir**

$$Q = \frac{2}{3} \widehat{C_d L} \sqrt{2g} (H)^{3/2}$$

**(x) Discharge over Trapezoidal weir:**

$$Q = \frac{2}{3} C_d \sqrt{2g}\, L H^{3/2} + \frac{8}{15} C_d \sqrt{2g} \tan\frac{\theta}{2} H^{5/2}$$

Where $\theta$ = angle of weir.

## 13.4.11. Discharge in sluices, and Notches etc.

**Clear Overfall**

(1) Notches without end contraction like a lock weir with shutters clear.

$D = 2/3\ CL.h\ \sqrt{2gh} - 3.25\ Lh^{3/2}\ C - 0.61$ and h

depth of water over crest.

(2) Vent without end contractions like a lock weir or a masonry sluice with shutters not clear.

$D = 3.25L\ (h_2^{3/2} - h_1^{3/2})$

Where $h_2$ is depth of water in front over crest of weir $h_1$ is depth of water above bottom of shutter.

Note:

In case where the depth of water on the crest of the notch or vent with clear overfall is less than the width of the crest, the weir shall be treated as broad crested and c may be tăken to be 0.57. The corresponding formulae for discharges are.

$D = 3.1L.h^{3/2}$ for a notch; $D = 3.1\ L(h_2^{3/2} - h_1^{3/2})$ for a vent.

(3) Pipe sluices where D the diameter is small compared with h the head measured to the centre as in direct pipe sluices in the main canals.

$Q = C.A\ \sqrt{2gh}$

$Q = 6.A\ \sqrt{h}$

Where $C = 0.78$

**Submerged**

(4) Pipes in channels $D = 6A\ \sqrt{h}$ where $c = 0.75$ and h is the difference of front and rear water level.

(5) Culvert in lock gates, $D = 5A\ \sqrt{H}\ C = 0.62$

(6) Drowned orifice like a masonry head sluice with shutters not clear.

$D = 6A\ \sqrt{h}\ c = 0.78$

(7) Drowned weir or rectangular notch like a masonry head sluice with shutter clear.

$D = L(3.25\ h^{3/2} + 5\ dh^{1/2})$

Where $c = 0.61$ for the overfall portion and 0.62 for the submerged portion, d is depth of tail water on crest.

(8) Drowned weir or notch with shutters not clear.

$D = L\,[3.25(h_1^{3/2} - h^{3/2}) + 5(h_2 - h)^{1/2}]$

Where c = 0.61 for the overfall portion and 0.62 for the submerged portion. for h vide (4) above: $h_1$ & $h_2$ vide (2) above;

(9) Pipes in General (water service):

$V = 32 \sqrt{ds}$ where d = diameter of pipe.

s = slope.

$$D = \frac{\pi d_2}{4}$$

$$d = 0.2545 \frac{D^2}{s}$$

### 13.4.12. Flow through pipes:

Q = discharge

H = Height of water level above the centre line of Pipe at exit:

d = Diameter of the pipe

l = length of pipe

f = Coefficient of Friction

$$Q = \frac{\pi}{4} d^2 v$$

$$\text{velocity of flow } (v) = \sqrt{\frac{2g.d.H.}{4f.l}}$$

Loss of heads in pipes:

$v_1$ = Velocity in contracted section.

$v_2$ = Velocity in enlarged section

v = Velocity in the pipe

A = Area of the full pipe

$C_c$ = Coefficient of contraction

a = Area blocked by the obstruction

(i) Sudden enlargement $H_e = \frac{(V_1 - V_2)^2}{2g}$

(ii) Sudden contraction $H_c = 0.375 \frac{V_2^2}{2g} = K \frac{V_2^2}{2g}$

(iii) Obstruction $H_0 = \frac{V^2}{2g} \left| \frac{A}{(A-a) C_c} - 1 \right|^2$

(iv) At entrance $= \dfrac{0.5v^2}{2g}$

(vi) At Exit $= \dfrac{v^2}{2g}$

(v) Change of direction $= \dfrac{Kv^2}{2g}$

K depends upon bend.

For 90° bend K = 1.

frictional resistance $h_f = \dfrac{4flv^2}{2gd}$.

## 13.5. Standards for Minor Irrigation Projects

### 13.5.1. Project Planning

#### 13.5.1.1. Yield Calculation :

Yield at a tank site is calculated using Strange's tables Based on the topography and slopes, the catchments are classified as good, average or bad. Only 90% of the average rainfal (which is the Monsoon rainfall) is considered for the computation of the yields.

#### 13.5.1.2. Storage Planning : (Number of fillings of the tank)

(i) (a) Two fillings where the average rainfall is more than 35"

(b) One and half where the average rainfall is between 25" and 35"

(c) One where the average rainfall is less than 25"

(ii) In case where irrigation water is used mainly after the Monsoon for maturing the monsoon crop, the entire requirement of water including losses in the monsoon period has to be stored.

#### 13.5.1.3. Dead Storage :

Usualy 10% of the Live Storage is allowed.

#### 13.5.1.4. Allowance :

Allowance for absorption and evaporation losses from the reservoir: 10% of the Live Storage (capacity) irrespective of the rainfall and the number of fills.

#### 13.5.1.5. Area irrigated per M.cft. of Water :

For the areas where the monsoon rainfall is upto 30"

(a) Wet crops — 6 acres per M. cft. (1st crop) and 3 acres per M. cft. for 2nd crop.

(b) Irrigated dry crops — Khariff (Summer Crops) — 20 acres/M. cft. (June to October).

Rabi (Winter Crop) — 10 acres/M.cft. November to March)

For the areas where the monsoon rainfall exceeds 30" irrigation demand will have to be worked out considering the total demand of 66" for the paddy crops inclusive of rainfall, to be distributed equally over each month of the crop period. Additional 6" should be added for 1st month for transplantation purposes.

## 13.6. STANDARDS OF TYPICAL SECTIONS OF EMBANKMENTS FOR TANK BUNDS

*[Based on CE's (Irrigation) circular memo No. 63 75/63 A6 dt. 20-8-1963]*

| Sl. No. | Depth of water | Top width of bund | Free board | Side slopes Front | Side slopes Rear | Berm at | Width of berm | Revetment | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 0 to 3 m | 2 m | 1 m | 1½ : 1 | 2 : 1 | — | — | — | For Small tank |
| 2. | over 3 m to 4.5 m | 2 m | 1.25 m | " | 2 : 1 | — | — | 0.3 m above M.W.L. | For Good Sized Tanks |
| 3. | over 4.5 m to 6.0 m | 2.75 m | 1.5 m | " | 2 : 1 | 6 m intervals | 1.5 m | 0.3 m above M.W.L. | For Big tanks. |
| 4. | over 6 m | 3 m | 2 m | 2 : 1 upto 6 m from TBL & then 2½ : 1 | 2 : 1 upto upto 6 m from TBL then 3 : 1 | " | 1 : 5 m | To top of Bund | For Major tanks |

*Note :*

Where the bunds face either North—East or East, the free board should be $h = 0.762 + 0.361/F - 0.2714/F^3$ where h = height of wave in metres.

F = Fetch in Kilometres

Generally the free board would be raised above MWL to a height somewhat greater than h.

### 13.6.1. Impervious Zone and cut off Trench

Whenever the depth of water upto F.T.L., in a particular cross section of the bund exceeds 10 feet, then Impervious Zone should be invariably proposed. The top of the Impervious Zone should be 1 foot above the maximum water level and the top width of that will be 2/3 of the top width of the bund.

The side slops will be ½ to 1 (½ horizontal to 1 vertical) and hence the bottom width of the Impervious zone will be the height of Impervious Zone plus the top width of the impervious zone. The depth of the cut off trench will be half the height between the average ground level and the F.T.L. The bottom width of cut off trench will be 10 feet and its outer edges will be connected with that of impervious zone.

### 13.6.2. Key Trenches

Key trenches will be provided in the upstream half of the bund at 15 feet centre to centre from the upstream outer bottom edge of the impervious zone. In the cross sections where there is no I.P.Z., key trenches should, invariably be provided throughout the bottom width of the bund to have proper bond of the bund with the earth below. The size of the trenches will invariably be a trapezium in shape having a bottom width of 5 feet with side slopes 1 to 1 and a depth of 1 foot from the average ground level.

### 13.6.3. Hydraulic Gradient

The hydraulic gradient line will be drawn in the cross section of a bund from a point at which the F.T.L. meets the upstream face of the bund and its slope will be 1 in 4 in S.P.Z. and 1 in 3 in I.P.Z. When the hydraulic gradient line cuts the bottom surface of the bund beyond ¾th of the width of the bund from the upstream edge, filters should invariably be provided at the downstream edge of the bund.

### 13.6.4. Filters

As stated in the para above, graded filters of size 9'0" to 3'0" will be provided in the downstream edge of the bund. Graded filters alone are provided upto 20 feet depth of water in the upstream side. When the depth of water exceeds 20 feet then zoned filter with graded filter should be provided.

### 13.6.5. Toe drain

Toe drain should invariably be provided in all cross sections of the bund in the rear side, to discharge the rain water falling over the bund to the adjacent drainage course. The bottom width will be 3 feet and the side slopes will be 1 to 1. The bottom level will be at the same level of the bottom of the filter.

### 13.6.6. Toe wall

Whenever revetment with gravel backing is proposed in the cross sections of the bund, then a square toe wall of size 3'0" × 3'0" shown in the sketch in the page 277 of Ells Manual of Irrigation (1963 Edition) should be provided at the bottom of the revetment.

## 13.7 DESIGN OF CHANNELS OR CANAL:

1. The mean velocity which may be calculated by any of the Formulae:

**(1) Chezy's formula:**

$V = C\sqrt{rs}$

Where r = hydraulic mean depth = $\frac{\text{Sectional Area}}{\text{Wetted perimeter}}$

s = Longitudional slope of water surface.

c = Chezy's constant.

n = Rugosity coefficient.

The chezy's constant 'C' is found out by any one the following Formulae.

**(a) Bazin's formula:**

$C = \frac{157.6}{1 + \frac{n}{\sqrt{r}}}$  r = 2.35 for earthen channel 0.833 for rubble masonry.

**(b) Mannings formula:**

$C = \frac{1.49}{n} \times r^{1/6}$  n = Manning's coefficient

**(c) Kutter's formula:**

$$C = \frac{41.65 + \frac{1.811}{n} + \frac{0.00281}{s}}{1 + \frac{n}{\sqrt{r}}\left[41.65 + \frac{0.00281}{s}\right]}$$ n = Kutter's coefficient (vide table)

**(2) Manning formula** $V = \left(\frac{1.486}{N}\right) R^{2/3} S^{1/2}$

**Design:**

The following item must be known:

(i) The design discharge of the channel.

(ii) The slope of the channel, S

(iii) The Rugosity coefficient n

(iv) The critical velocity ratio $m = \frac{V}{V_o}$

Channel discharge Q = A × V

Where $V = C\sqrt{rs}$

Kutter's coefficient for Chezy's constant (C)

$$C = \frac{41.66 + \dfrac{1.811}{n} + \dfrac{0.00281}{S}}{1 + |41.66 + \dfrac{0.000281}{S}| \sqrt{n/r}}$$

Substituting the C value we get

$$V = \frac{\left\{\dfrac{1.811}{n} + \left[41.66 + \dfrac{0.00281}{S}\right]\right\} \sqrt{S} \times \sqrt{r}}{1 + (41.66 + \dfrac{0.00281}{S}) \quad \dfrac{n}{\sqrt{r}}}$$

Multiply numerator and denominator by $\sqrt{r}$

$$V = \frac{[\dfrac{1.811}{n} (41.66 + \dfrac{0.00281}{S})] \sqrt{s}] r}{\sqrt{r} + |(41.66 + \dfrac{0.00281}{S}) n|}$$

$$\text{Put } N = | \frac{1.811}{n} + (41.66 + \frac{0.00281}{S})| \sqrt{S}$$

$$\text{Put } D = (41.66 + \frac{0.00281}{S}) n$$

Then the equation becomes

$$V = \frac{N.r}{\sqrt{r} + D}$$

The value of N & D shown in the Table.

| Sl. No. | Pipe of Channel's inside surface | Value of n |
|---|---|---|
| 1. | Well-Planed timber | 0.009 |
| 2. | Smooth cement plaster or planned wood (including wood-stave pipes) | 0.010 |
| 3. | Cement plaster with one third sand | 0.011 |
| 4. | Pipes of Iron or Steel, Cement or terracorta | 0.011 |
| 5. | Unplaned timber, new brick work, ordinary Iron pipe | 0.012 |
| 6. | Rubble Masonry | 0.017 |
| 7. | Earth of very good surface in faultless condition | 0.018 |
| 8. | Earth of good surface | 0.020 |
| 9. | Natural Earth | 0.025 |
| 10. | Canal and River of Rough surface with weeds | 0.030 |
| 11. | Rivers and canals in earth obstructed by detritus and in bad order and regime or rock cutting | 0.035 |
| 12. | Torrents encumbered with detritus | 0.035 |

Values of N & D of the

| Fall in 1 Mile | | Fall 1 in | $\sqrt{s}$ | n = 0.020 | | n = 0.0225 | |
|---|---|---|---|---|---|---|---|
| Feet | Inches | | | N | D | N | D |
| 0.250 | 3 | 21120 | .0069 | 1.318 | 2.019 | 1.249 | 2.271 |
| 0.292 | 3½ | 18103 | .0074 | 1.361 | 1.849 | 1.286 | 2.081 |
| 0.333 | 4 | 15840 | .0079 | 1.404 | 1.723 | 1.324 | 1.938 |
| 0.375 | 4½ | 14080 | .0084 | 1.447 | 1.624 | 1.363 | 1.827 |
| 0.417 | 5 | 12672 | .0089 | 1.491 | 1.545 | 1.401 | 1.738 |
| 0.458 | 5½ | 11520 | .0093 | 1.533 | 1.480 | 1.440 | 1.665 |
| 0.500 | 6 | 10560 | .0097 | 1.571 | 1.426 | 1.477 | 1.604 |
| 0.542 | 6½ | 9748 | .0101 | 1.612 | 1.381 | 1.515 | 1.553 |
| 0.583 | 7 | 9051 | .0105 | 1.652 | 1.341 | 1.551 | 1.509 |
| 0.625 | 7½ | 8448 | .0109 | 1.696 | 1.308 | 1.587 | 1.471 |
| 0.667 | 8 | 7920 | .0112 | 1.736 | 1.278 | 1.623 | 1.438 |
| 0.708 | 8½ | 7454 | .0116 | 1.774 | 1.252 | 1.657 | 1.408 |
| 0.750 | 9 | 7040 | .0119 | 1.811 | 1.229 | 1.692 | 1.382 |
| 0.792 | 9½ | 6669 | .0122 | 1.848 | 1.208 | 1.725 | 1.359 |
| 0.830 | 10 | 6336 | .0126 | 1.884 | 1.189 | 1.758 | 1.338 |
| 0.875 | 10½ | 6034 | .0129 | 1.921 | 1.172 | 1.791 | 1.319 |
| 0.917 | 11 | 5760 | .0132 | 1.955 | 1.157 | 1.823 | 1.301 |
| 0.958 | 11½ | 5510 | .0135 | 1.999 | 1.143 | 1.854 | 1.286 |
| 1.000 | 12 | 5280 | .0139 | 2.024 | 1.130 | 1.885 | 1.271 |
| 1.083 | 13 | 5874 | .0143 | 2.090 | 1.107 | 1.946 | 1.245 |
| 1.167 | 14 | 4526 | :0149 | 2.155 | 1.087 | 2.005 | 1.223 |
| 1.250 | 15 | 4224 | .0154 | 2.117 | 1.070 | 2.062 | 1.204 |
| 1.333 | 16 | 3960 | .0159 | 2.278 | 1.056 | 2.118 | 1.188 |
| 1.417 | 17 | 3727 | .0164 | 2.337 | 1.043 | 2.172 | 1.173 |
| 1.500 | 18 | 3520 | .0169 | 2.395 | 1.081 | 2.226 | 1.160 |

Formulae: $V = \frac{Nr}{\sqrt{r} + D}$

| n = .025 | | n = .030 | | n = .035 | | n = .050 | |
|---|---|---|---|---|---|---|---|
| N | D | N | D | N | D | N | D |
| 1.193 | 2.524 | 1.110 | 3.029 | 1.051 | 3.533 | 0.944 | 5.048 |
| 1.226 | 2.312 | 1.136 | 2.775 | 1.072 | 3.237 | 0.957 | 4.624 |
| 1.260 | 2.153 | 1.164 | 2.584 | 1.096 | 3.015 | 0.972 | 4.307 |
| 1.295 | 2.030 | 1.191 | 2.436 | 1.120 | 2.843 | 0.990 | 4.060 |
| 1.330 | 1.931 | 1.222 | 2.317 | 1.416 | 2.703 | 1.008 | 3.862 |
| 1.365 | 1.850 | 1.252 | 2.202 | 1.172 | 2.590 | 1.027 | 3.700 |
| 1.399 | 1.783 | 1.281 | 2.139 | 1.198 | 2.496 | 1.046 | 3.565 |
| 1.433 | 1.726 | 1.310 | 2.071 | 1.223 | 2.416 | 1.066 | 3.443 |
| 1.466 | 1.677 | 1.340 | 2.012 | 1.249 | 2.358 | 1.086 | 3.354 |
| 1.500 | 1.640 | 1.369 | 1.961 | 1.275 | 2.288 | 1.105 | 3.269 |
| 1.532 | 1.597 | 1.396 | 1.917 | 1.299 | 2.236 | 1.125 | 3.195 |
| 1.561 | 1.565 | 1.424 | 1.878 | 1.324 | 2.191 | 1.144 | 3.129 |
| 1.096 | 1.536 | 1.450 | 1.843 | 1.349 | 2.150 | 1.164 | 3.071 |
| 1.626 | 1.510 | 1.497 | 1.812 | 1.373 | 2.114 | 1.183 | 3.019 |
| 1.657 | 1.486 | 1.506 | 1.783 | 1.397 | 2.081 | 1.202 | 2.972 |
| 1.687 | 1.465 | 1.532 | 1.758 | 1.420 | 2.051 | 1.221 | 2.930 |
| 1.717 | 1.446 | 1.558 | 1.735 | 1.444 | 2.024 | 1.239 | 2.892 |
| 1.746 | 1.428 | 1.588 | 1.714 | 1.467 | 2.000 | 1.258 | 2.857 |
| 1.774 | 1.412 | 1.608 | 1.695 | 1.490 | 1.977 | 1.276 | 2.824 |
| 1.831 | 1.384 | 1.658 | 1.660 | 1.534 | 1.937 | 1.312 | 2.767 |
| 1.885 | 1.359 | 1.705 | 1.631 | 1.577 | 1.903 | 1.346 | 2.718 |
| 1.988 | 1.338 | 1.752 | 1.603 | 1.619 | 1.873 | 1.381 | 2.676 |
| 1.990 | 1.319 | 1.798 | 1.583 | 1.661 | 1.847 | 1.414 | 2.639 |
| 1.041 | 1.303 | 1.843 | 1.564 | 1.702 | 1.824 | 1.447 | 2.606 |
| 2.090 | 1.289 | 1.886 | 1.546 | 1.747 | 1.804 | 1.479 | 2.577 |

Values of N & D of the

| Fall in 1 Mile | | Fall 1 in | $\sqrt{s}$ | n = 0.020 | | n = 0.0225 | |
|---|---|---|---|---|---|---|---|
| Feet | Inches | | | N | D | N | D |
| 1.750 | 21 | 3017 | .0182 | 2.561 | 1.033 | 2.378 | 1.128 |
| 2.000 | 24 | 2640 | .0195 | 2.718 | 0.981 | 2.522 | 1.104 |
| 2.250 | 27 | 2347 | .0206 | 2.865 | 0.965 | 2.658 | 1.086 |
| 2.500 | 30 | 2112 | .0218 | 3.006 | 0.952 | 2.787 | 1.071 |
| 2.750 | 33 | 1920 | .0228 | 3.141 | 0.941 | 2.911 | 1.059 |
| 3.000 | 36 | 1760 | .0238 | 3.270 | 0.932 | 3.030 | 1.049 |
| 3.250 | 39 | 1625 | .0248 | 3.393 | 0.924 | 3.144 | 1.040 |
| 3.500 | 42 | 1509 | .0257 | 3.513 | 0.918 | 3.254 | 1.033 |
| 3.750 | 45 | 1408 | .0267 | 3.629 | 0.912 | 3.361 | 1.026 |
| 4.000 | 48 | 1320 | .0275 | 3.741 | 0.907 | 3.464 | 1.021 |
| 4.50 | 54 | 1173 | .0292 | 3.957 | 0.899 | 3.663 | 1.011 |
| 5.00 | 60 | 1056 | .0308 | 4.160 | 0.893 | 3.850 | 1.004 |
| 5.50 | 66 | 960 | .0323 | 4.355 | 0.887 | 4.303 | 0.998 |
| 6.00 | 72 | 880 | .0337 | 4.541 | 0.883 | 4.207 | 0.993 |
| 6.50 | 78 | 812 | .0351 | 4.720 | 0.879 | 4.367 | 0.999 |
| 7.0 | 84 | 754 | .0364 | 4.892 | 0.875 | 4.526 | 0.985 |
| 8.0 | 96 | 660 | .0389 | 5.219 | 0.870 | 4.827 | 0.979 |
| 9.0 | 108 | 587 | .0413 | 5.256 | 0.886 | 5.111 | 0.974 |
| 10.0 | 120 | 528 | .0435 | 5.819 | 0.863 | 5.381 | 0.971 |
| 11.0 | 132 | 480 | .0456 | 6.097 | 0.860 | 5.637 | 0.968 |
| 12.0 | 144 | 440 | .0477 | 6.363 | 0.858 | 5.883 | 0.966 |
| 13.0 | 156 | 406 | .0496 | 6.619 | 0.856 | 6.120 | 0.963 |
| 14.0 | 168 | 377 | .0515 | 6.865 | 0.854 | 6.347 | 0.961 |
| 15.0 | 180 | 352 | .0533 | 7.100 | 0.848 | 6.594 | 0.959 |
| 16.0 | 192 | 330 | .0550 | 7.330 | 0.842 | 6.776 | 0.958 |

Formulae: $V = \dfrac{Nr}{\sqrt{r} + D}$

| n = .025 | | n = .030 | | n = .035 | | n = .050 | |
|---|---|---|---|---|---|---|---|
| N | D | N | D | N | D | N | D |
| 2.232 | 1.253 | 2.012 | 1.504 | 1.855 | 1.754 | 1.573 | 2.507 |
| 2.365 | 1.227 | 2.130 | 1.472 | 1.964 | 1.718 | 1.660 | 2.444 |
| 2.491 | 1.206 | 2.242 | 1.447 | 2.064 | 1.689 | 1.744 | 2.412 |
| 2.612 | 1.190 | 2.349 | 1.428 | 2.162 | 1.666 | 1.824 | 2.379 |
| 2.727 | 1.176 | 2.452 | 1.412 | 2.255 | 1.647 | 1.901 | 2.353 |
| 2.838 | 1.165 | 2.550 | 1.398 | 2.344 | 1.631 | 1.974 | 2.330 |
| 2.944 | 1.156 | 2.644 | 1.387 | 2.430 | 1.618 | 2.045 | 2.314 |
| 3.047 | 1.147 | 2.736 | 1.377 | 2.514 | 1.606 | 2.114 | 2.295 |
| 3.146 | 1.140 | 2.825 | 1.368 | 2.595 | 1.597 | 2.181 | 2.281 |
| 3.243 | 1.134 | 2.911 | 1.361 | 2.673 | 1.588 | 2.246 | 2.268 |
| 3.428 | 1.124 | 3.075 | 1.348 | 2.825 | 1.573 | 2.370 | 2.247 |
| 3.602 | 1.116 | 3.231 | 1.339 | 2.966 | 1.562 | 2.488 | 2.231 |
| 3.770 | 1.109 | 3.380 | 1.331 | 3.102 | 1.552 | 2.601 | 2.218 |
| 3.930 | 1.103 | 3.523 | 1.324 | 3.232 | 1.545 | 2.709 | 2.207 |
| 4.084 | 1.099 | 3.661 | 1.318 | 3.358 | 1.538 | 2.813 | 2.197 |
| 4.433 | 1.094 | 3.793 | 1.313 | 3.479 | 1.532 | 2.914 | 2.189 |
| 4.514 | 1.088 | 4.044 | 1.305 | 3.708 | 1.524 | 3.104 | 2.176 |
| 4.778 | 1.083 | 4.280 | 1.299 | 3.924 | 1.516 | 3.283 | 2.165 |
| 5.011 | 1.079 | 4.506 | 1.294 | 4.125 | 1.510 | 3.454 | 2.157 |
| 5.270 | 1.075 | 4.719 | 1.290 | 4.325 | 1.505 | 3.617 | 2.150 |
| 5.499 | 1.072 | 4.923 | 1.287 | 4.512 | 1.501 | 3.772 | 2.145 |
| 5.721 | 1.070 | 5.121 | 1.284 | 4.692 | 1.498 | 3.921 | 2.140 |
| 5.932 | 1.068 | 5.310 | 1.282 | 4.866 | 1.495 | 4.066 | 2.136 |
| 6.135 | 1.066 | 5.492 | 1.279 | 5.032 | 1.493 | 4.204 | 2.132 |
| 6.333 | 1.065 | 5.668 | 1.278 | 5.193 | 1.491 | 4.491 | 2.129 |

## Design of channel on Kennedy's Theroy:

$V_0 = 0.84 d^{0.84}$ $V_0$ = Kennedy's Critical velocity.
= depth of water in feet.

Reduced value of Kennedy's Critical velocity for Different depth of flow as follows:

| d - in feet | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_0$ - in feet/sec | 0.84 | 1.30 | 1.70 | 2.04 | 2.35 | 2.64 | 2.92 | 3.18 | 3.43 | 3.67 | 4.12 | 4.75 |

The equation was applicable to the grade of silt available at upper Bari – Doab canal only.

To take account of varying grades of silt another factor in the equation was introduced which is called the critical velocity ratio (C.V.R.) denoted by 'm'.

$$m = \frac{V}{V_0} \text{ Where } V_0 = 0.84\ d^{0.64}$$

$$V = 0.84\ m.\ d^{0.84}$$

The General form of the Kennedy's Equation $V = Kd^{n}$

Where K vary according to the silt grade

## Designs of Channel on Lacey's Theory:

Lacy employing Kennedy's date and treating the hydraulic mean depth as fundamental variable whereas Kennedy introduced silt grade as the variable obtained the following equations:

Fundamental Equation:

$V_0 = 1.17 \sqrt{fr}$ Q = discharge
f = silt factor
r = hydraulic mean depth

(a) Silt factor (f) = $1.76 \sqrt{d}$
where 'd' = mean particle diameter of silt.

(b) Velocity flow (V) = $16 r^{2/3} S^{1/3}$

(c) Bed slope $S = \dfrac{f^{5/3}}{1844\, Q^{1/6}}$.

(d) Wetted Perimeter $P = 2.67\, Q^{1/2}$

(e) Cross Sectional Area $A = \dfrac{1.07\,Q^{5/6}}{d^{1/6}}$

$$= 1.26\,\frac{Q^{5/6}}{f^{1/3}}$$

(f) Hydraulic mean depth is $\dfrac{A}{P}$

$$r = 0.47247\,\frac{Q^{1/3}}{f^{1/3}}$$

From known values of A and P calculate bed width 'B' and depth 'D' of the channel section. The side slope of an irrigation channel is usually ½ : 1

$$\text{hence } A = BD + \frac{D^2}{2}$$

Where $B = P - 2.236D$.

## Maximum mean Velocities Safe Against Erosions

| Material | | Mean velocity in feet per second |
|---|---|---|
| Very light pure sand of quick sand character | ... | 0.75 to 1.00 |
| Very light loose sand | ... | 1.00 to 1.50 |
| Coarse sand or light sandy soil | ... | 1.50 to 2.00 |
| Average sandy soil | ... | 2.00 to 2.50 |
| Sandy loam | ... | 2.50 to 2.75 |
| Average loam, alluvial | ... | 2.75 to 3.00 |
| Firm loam, clay loam | ... | 3.00 to 3.75 |
| Stiff clay soil, ordinary gravel soil | ... | 4.00 to 5.00 |
| Coarse gravel shingles | ... | 5.00 to 6.00 |
| Cemented gravel, soft slate soft sedimentary rock | ... | 6.00 to 8.00 |
| Hard rock | ... | 10.00 to 15.00 |
| Concrete | ... | 13.00 to 20.00 |

**Permissible Canal Velocities**

| Original material excavated for canal | Velocity in feet per sec. after ageing of canal carrying: Clear water | Water transporting colloidal silts | Water transporting non-colloidal silts sand; gravel etc. |
|---|---|---|---|
| Fine sand (non-colloidal) ... | 1.50 | 2.50 | 1.50 |
| Sandy loam ... | 1.75 | 2.50 | 2.00 |
| Silt loam ... | 2.00 | 3.00 | 2.00 |
| Alluvial silts when noncolloidal ... | 2.00 | 3.50 | 2.00 |
| Ordinary firm loam ... | 2.50 | 3.50 | 2.25 |
| Fine gravel ... | 2.50 | 5.00 | 3.75 |
| Stiff clay very colloidal ... | 3.75 | 5.00 | 5.00 |
| Alluvial soils when colloidal ... | 3.75 | 5.00 | 3.00 |
| Graded silt ... | 4.00 | 5.50 | 5.00 |
| Coarse gravel (non-colloidal) ... | 4.00 | 6.00 | 6.50 |
| Shingle ... | 5.00 | 5.50 | 6.50 |

*Note:*— This figures are for depth of 3 feet & less.

## 13.8. DESIGN OF ANICUTS OR WEIRS ACROSS RIVERS

Anicut is nothing but a weir over which the water flows. During flood periods anicut will behave like a drowned weir.

$Q$ = discharge
$C_d$ = Coefficient of discharge
$L$ = Length of the weir
$h$ = depth of over flow water
$h_a$ = head due to velocity of Approach
$h_1$ = difference of water levels between front and Rear
$d$ = Depth of tail water over crest

Calculation of Discharge:

For free overflow condition: (with velocity approach).

$Q = C.L.[(h+h_a)^{3/2} - h_a^{3/2}]$

The value C adopted are 3.00 for broad crested and 3.32 for narrow crested weirs. If the overflow depth is equal to or exceeds the width of the weir crest, the weir is called narrow crested weir otherwise broad crested.

For Submerged condition:

$$Q = \frac{2}{3} C_1 L \sqrt{2g}[(h_1 + h_2)^{3/2} - h_a^{3/2}] + C_2 \times d\sqrt{2g(h_1 + h_a)}$$

Where $C_1 = 0.577$

$C_2 = 0.60$ for depths of tail water over crest 1 to 5 feet.

Value of $C_2$

| Depth of Tail water | 6 | 7 | 8 | 9 | 10 | 11 | 12 & more |
|---|---|---|---|---|---|---|---|
| Value of $C_2$ | 0.62 | 0.66 | 0.75 | 0.84 | 0.90 | 0.93 | 0.95 |

## 13.8.1. EMPIRICAL FORMULAE FOR DESIGN OF WEIRS OR ANICUT

H = Height of weir

d = depth of water passing over the crest of weir

$\rho$ = Specific Gravity of Masonry

C = Creep coefficient depends upon the nature of soil (classifications of bed sand (Generally assumed as 12 for coarse sand).

$H_s$ = Height of weir crest shutters above low water level.

$H_b$ = Height of weir crest above L.W.L.

q = Discharge is C/s per foot Run of weir crest

R = Depth of scour in feet

f = Lacey's silt factor

L = minimum length of creep required for protections against piping.

c = The classification number of the bed and sand (Generally 12).

**(i) Crest width of weir** (a) = $\sqrt{H} + \sqrt{d}$ but not less than $\frac{2P}{3d}$

**(ii) Basewidth of weir**

(a) For impervious masonry and foundation (b) = $\frac{H+d}{\sqrt{\rho}}$

(b) For pervious " " " " $= \frac{H+d}{\sqrt{\rho - 1}}$

(iii) Minimum length of Percolation $L = CH_2$

(iv) Apron:

(a) Length of Main solid (impervious) d/s Apron from body of wall of weir

$$L_1 = 4c \quad \frac{H_b}{10}$$

(b) Length of U/s inpervious Apron $L_2 = L - L_1$

(c) (1) Total length of d/s apron including Talus * ie. Solid + Loose Apron $\Big\}$ $L_3 = 10c \sqrt{\dfrac{H_b + q}{750}}$

(2) For sloping and rock fill Apron $L_3$ should be increased by about 10%

$$L3 = 11c \sqrt{\frac{H_b + q}{750}}$$

(d) Length of d/s talus or loose Apron $= L_3 - L_1$

(e) Length of U/s loose pitching in contintion of solid U/s Apron $\dfrac{L_3 - L_1}{2}$

(f) Thickness of Apron:

1. D/s. Main solid Apron $\nless$ 4 ft.
   Talus $\nless$ 5 ft.
2. U/s. Main sold Apron $\nless$ 2 ft.
   Talus $\nless$ 4 ft.
3. Thickness of Impervious Aprons $\sqrt{h + h_B}$

(v) Check for minimum safe depth against scour.

$$R = 0.9\left(\frac{q^2}{f}\right)^{1/3}$$

The foundation should be taken upto 1.5R depth from M.E.L. in front and Rear side.

## 13.9. DESIGN OF CANAL DROPS

Where the natural slope of the ground over which a canal is carried is greater than the slope of the canal the difference is adjusted by constructing vertical 'drops' or 'falls' at suitable intervals.

## Discharge of Trapezodial Notch

E — In case of Submersion, the depth of tail water over the sill of the Notch.
d = Depth over sill of Notch
c — Coefficient of discharge of the Notch.
n = 2 tan $\alpha$ where $\alpha$ angle of inclination of sloping sides of Notch to the vertical
L = Base width of Notch.

Submersion Condition: (General equation)

$$Q = c\sqrt{2g}\,(d-E)^{1/2}\,(L + \tfrac{1}{2}En)\,E + \frac{2}{3}c\sqrt{2g}\,(d-E)^{\frac{2}{3}} \times \{L + En + 0.4n\,(d-E)\}$$

The above equation may be expressed as follows:

$$Q = 5.35c\sqrt{d-E}\,\{(\tfrac{1}{2}E + d)\,L + [\tfrac{3}{4}E^2 + (d-E)E + 0.4(d-E^2)n]\}$$

Clear over fall condition:

(There is no submersion F = 0)

$$D = 5.35\,C.d^{3/2}\,[1 + 0.4dn]$$

Design:

1. Dropwall:

| | | | |
|---|---|---|---|
| (i) Top Length | | (L): | Should not be less than ⅞ bed width and not more than full bed width of canal U/s of drop. |
| (ii) Top width | | (a) = | (½d + ½) To (⅓d + 1) |
| (iii) Bottom | width | (b) = | $\frac{H + d}{\sqrt{\rho}}$ |
| | | Where H = | height of dropwall. |
| | | d = | depth of the water over the crest. |

### No. and Sill of Notches:

(a) The No. and location of Notches should be such as to equally distribute the discharge over the entire length.

(b) The Sill of Notches should be at bed level of canal.

(c) Top width of Notch should not be greater than ¾d when free; and not greater than d when submerged.

Notch Piers:

(a) Width at F.L.S. not less than $\frac{d}{2}$

(b) The Bottom width of end piers adjacent to the abutments should be ¾th normal bottom width of other pier.

**Apron:**

Down Stream Side:

(a) Width W = (L + ½d) or bed width of canal d/s of drop whichever is greater.

(b) Length: $2d_c + 2\ d\ h$ or $4 + 2\sqrt{d_c\ h}$ whichever is greater

(c) Thickness: Minimum = $\sqrt{d_c + h}$

Revetment:

(a) Length of upstream revetment + 3¾ subject to minimum of 10'0"

(b) Length of downstream revetment = 4(d + h) or 20 whichever is greater.

(c) Bed Pitching

(i) U/s Side — 1½d

(ii) D/s Side = 2d.

Water Cushion Apron:

On the d/s Side of drop wall is cushioned with water as to absorb the dynamic impact of falling water.

$d_c$ = depth over silt of Notch U/S

h = difference between U/S and D/S water level

$d_w$ = depth of water cushion Below Bed level canal on the down stream side

$d_1$ = depth is the d/s portion of canal.

(a) Depth of Cushion:

By Dya's formula = $(d_w + d_1) = \frac{1}{2} d \sqrt{h}$

In case $d_1 = d_c$ then $d_w + d_1 = \frac{1}{2} d_1 \sqrt{h}$

$\therefore$ When h = 4, $d_w + d_1 = d_1$ i.e. $d_w = 0$.

In other words the value of h upto 4'0" no water cushion is necessary. a mere solid apron will do.

(b) D/s Reverse slope: Not steeper than 1 in 5

(c) length: $2d + 2\ \sqrt{d_c\ h}$ or $2 + 2\ \sqrt{d_c\ h}$ whichever is greater.

# 13.10. DISCHARGE THROUGH SYPHON

h = Loss of head of difference of water level up and down stream.
L = Length of barrel in ft.
R = Hydraulic Mean depth of the barrel.
V = Velocity through barrel.
$f_1$ = Coefficient for loss of head at entry
0.505 for unshaped mouth.
0.100 for bell mouth.
$f_2$ = Coefficient which provides for loss of head due to friction.

By Unwin's formulae

$$h = [1 + f_1 + f_2 \frac{L}{R}] \frac{V^2}{2g}$$

$f_2$ is a coefficient such that the loss of head by friction through barrel is

(i) $f_2 = \frac{L}{R} \times \frac{V^2}{2g}$

(ii) $f_2 = a[1 + \frac{b}{R}]$

Where 'a' and 'b' have the following values.

| Surface pipe or culvert | a | b |
|---|---|---|
| Smooth Iron pipe | 0.00497 | 0.084 |
| Encrusted Iron pipe | 0.00996 | 0.084 |
| Smooth cement plaster or planed wood | 0.00316 | 0.10 |
| Brick or Ashlar work | 0.00401 | 0.23 |
| Rubble masonry or stone pitching | 0.00507 | 0.83 |

If ($V_a$) the velocity approach to the Symphon is considered then the formula becomes.

$$h = \frac{V^2}{2g} (1 + f_1 + f_2 \frac{L}{R}) - 0.0155 (V_a^2)$$

## 13.11. DISCHARGE TABLE FOR VARIOUS TYPES OF WEIRS *(Based on MDSS)*

Formula $D = \frac{2}{3} clh \quad 2gh$

| Head of water in feet | 1 Sharp edged crests $C = \frac{2}{3} = .667$ Discharge in cusecs. | 2  $C = \frac{10}{16} = .625$ Discharge in cusecs. | 3  $C = \frac{9}{16} = .562$ Discharge in cusecs. | 4  $C = \frac{8}{16} = .500$ Discharge in cusecs. | 5  $C = \frac{7}{16} = .437$ Discharge in cusecs. | 6 Natural byewash $C = \frac{6}{16} = .375$ Discharge in cusecs. | Head of water in feet |
|---|---|---|---|---|---|---|---|
| .25 | .44 | .41 | .37 | .33 | .29 | .25 | .25 |
| .50 | 1.25 | 1.17 | 1.06 | .94 | .82 | .70 | .50 |
| .75 | 2.30 | 2.16 | 1.94 | 1.73 | 1.51 | 1.29 | .75 |
| 1.00 | 3.55 | 3.33 | 3.00 | 2.66 | 2.33 | 2.00 | 1.00 |
| 1.25 | 4.96 | 4.68 | 4.19 | 3.72 | 3.26 | 2.79 | 1.25 |
| 1.50 | 6.53 | 6.12 | 5.51 | 4.89 | 4.28 | 3.67 | 1.50 |
| 1.75 | 8.23 | 7.71 | 6.94 | 6.17 | 5.40 | 4.63 | 1.75 |
| 2.00 | 10.05 | 9.42 | 8.48 | 7.54 | 6.59 | 5.65 | 2.00 |
| 2.25 | 12.00 | 11.25 | 10.12 | 9.00 | 7.87 | 6.75 | 2.25 |
| 2.50 | 14.05 | 13.17 | 11.86 | 10.54 | 9.22 | 7.90 | 2.50 |
| 2.75 | 16.21 | 15.20 | 13.68 | 12.16 | 10.64 | 9.12 | 2.75 |
| 3.00 | 18.47 | 17.32 | 15.58 | 13.85 | 12.12 | 10.39 | 3.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3.25 | 20.83 | 19.53 | 17.57 | 15.62 | 13.67 | 11.71 | 3.25 |
| 3.50 | 23.28 | 21.82 | 19.64 | 17.46 | 15.28 | 13.09 | 3.50 |
| 3.75 | 25.82 | 24.20 | 21.78 | 19.36 | 16.94 | 14.52 | 3.75 |
| 4.00 | 28.44 | 26.66 | 24.00 | 21.33 | 18.66 | 16.00 | 4.00 |
| 4.50 | 33.94 | 31.82 | 28.63 | 25.45 | 22.27 | 19.09 | 4.50 |
| 5.00 | 39.75 | 37.26 | 33.54 | 29.81 | 26.09 | 22.36 | 5.00 |
| 5.50 | 45.86 | 42.99 | 38.69 | 34.39 | 30.09 | 25.79 | 5.50 |
| 6.00 | 52.25 | 48.98 | 44.09 | 39.19 | 34.29 | 29.39 | 6.00 |
| 6.50 | 58.92 | 55.23 | 49.71 | 44.19 | 38.66 | 33.14 | 6.50 |

(1) Sharp edged crests.
(2) Narrow-crested masonry weirs.
(3) Broad-crested weirs — where $w > h$ ($w$ being width of weir and $h$ depth on crest).
(4) Rough stone escapes.
(5) Paved bye-washes.
(6) Natural escapes with uneven surface.

The discharge for a drowned weir for one foot length $= \frac{D}{L}$

$$\frac{D}{L} = 3.1\,[(h + ha)^{3/2} - ha^{3/2}] + 8\,c\,d\,(h + ha)^{1/2}$$

were 'h' represents the known difference of water level between front and rear, 'ha' = head due to velocity of proach either gauged or otherwise known, d = depth of tail water over crest. Different values of C are given in E.I's No. 2973/17C., dated 4th October 1917, for various depths of tail water and a diagram is included therein.

| Depths of tail water | c | | |
|---|---|---|---|
| 1 to 5 ft. | 0.60 | 9 ,, | 0.84 |
| 6 ,, | 0.62 | 10 ,, | 0.90 |
| 7 ,, | 0.66 | 11 ,, | 0.93 |
| 8 ,, | 0.75 | 12 ,, & over | 0.95 |

## 13.12. DISCHARGE THROUGH AQUEDUCTS

Aqueducts are the most commonly adopted cross drainage work. An aqueduct is suitable, when it is possible to pass a canal over a drainage, without the necessity of dropping or lowering the bed level of the drainage work at the point of crossing

The main factor in fixing the actual place of crossing is "headway" i.e. enough free board above the M.F.L. of the drainage.

Calculation of head required.

General formula for entry into contracted aqueduct of velocity ($V_2$), from a canal of velocity ($V_1$) is the same as for flow through notch of similar cross sectional area as follows:

$$D = cl\sqrt{2g}\left[\frac{2}{3}\left\{\left(h_e + \frac{V_1^2}{2g}\right)^{3/2} - \left(\frac{V_1^2}{2g}\right)^{3/2}\right\} + d\left(h_e + \frac{V_1^2}{2g}\right)^{1/2}\right]$$

Where D = Discharge

d = depth of water in the aqueduct

$h_e$ = the heading up above the aqueduct trough that is the head of entry.

l = The mean width of the aqueduct (or notch)

c = 0.95 to 0.90 for a well shaped and gradual entry

The approximate head of entry for co-efficient unity may be obtained from the following simple equation.

$$h_e = \frac{V_2^2 - V_1^2}{2g}$$

The recovery of level or exit (Theoritical head at exit)

$$h_t = \frac{V_1V_2 - V_1}{g}$$

The net heading up at the aqueduct $(h) = h_e - \frac{3}{4}h_t$

## 13.13. DISCHARGE THROUGH BRIDGE OPENINGS

A bridge constructed over a river consists of piers and abutments which act as obstructions to the flow of river water. The river water then passes through the piers, contracting the water cross-section, due to which the depth of water on the upstream side rises. Such a rise of water level is known as afflux

The water passing through the bridge piers acts, as if it is passing over a totally drowned weir and calculation of discharge as follows:

Let $V_0$ = the velocity of approach.

$h_a$ = The head due to velocity of approach

$v_1$ = The velocity of water below the bridge, through the piers at cross-section $A_1$

$l_1$ = the width of waterway through the bridge pier.

v = normal velocity of River on the d/s side of bridge.

l = normal width of River on the d/s side as well as U/s side of bridge.

d = The normal depth of river on the d/s side of bridge.

x = The actual rise water level i.e. afflux in feet.

Tottal head responsible for velocity $V_1 = x + h_a$

$$V_1 = \sqrt{2g(x + h_a)}$$

and $Q = C_d A_1 V_1$

$= C_d (l_1 d) \sqrt{2g(x+h_a)}$. (with velocity approach)

also $Q = V_0(d+x)\, l$

$= v.d.l$

$$V_0 = \frac{d}{d+x} v$$

Further the water section through the piers will contract and therefore coefficient of contraction is to be used to arrive at the true area.

$A_1 = C_c l_1 d \quad C_c =$ Coefficient of Contraction.

Calculating the afflux.

$$x = \frac{V^2}{2g} \left| \frac{1.1 l^2}{l_1^2} - 1 \right|$$

neglecting velocity approach

$$x = \frac{V_1^2}{2g} - \frac{V^2}{2g} \left( \frac{1.1 l^2}{l_1^2} \right)$$

$Q = C_d A_1 \sqrt{2gx}$ (without velocity of approach)

Moles worth's formula: $\quad$ Afflux (x) $= \left| \frac{V^2}{58.6} + 0.05 \right| \left( \left(\frac{A}{a}\right)^2 - 1 \right)$

A = Natural way area at site water way

a = artificial water way i.e. (area of bridge openings)

## 13.14. DIMENSION OF SPEARS AND SCREW THREADS

The greatest stress is placed on spears when the shutters of sluices are being forced down under the pressure of the maximum head of water to which they can be subjected.

The following equation for finding the diameter of solid mild steel screw rod which is based on Gordon's formula for struts hinged at both ends

$$A \times H = \frac{82300 d^4}{350 d^2 \times 144 L^2}$$

Where A = the area of the shutter in sft.

H = Maximum head on the shutter in ft.

L = Maximum unsupported length of screw shaft in feet

d = least diameter of above inches.

This allows a factor of safety of 6 and coefficient 'C' in Gordons formula of $\frac{1}{350}$

The following table gives diamensions in inches of the size of spears and pitch of screw commonly cut for screw rod.

| Serial No. | Finished diameter over all D | Least diameter (d) | Depth of thread (d) | Pitch of thread P |
|---|---|---|---|---|
| 1 | 3 5/8 | 2 7/8 | 3/8 | 1 |
| 2 | 3 | 2 5/8 | 1/2 | 1 1/4 |
| 3 | 3 1/4 | 2 1/2 | 3/8 | 1 1/2 |
| 4 | 3 | 2 3/8 | 5/16 | 1 |
| 5 | 3 | 2 3/8 | 5/16 | 3/4 |
| 6 | 2 7/8 | 2 1/4 | 5/16 | 1 |
| 7 | 2 5/8 | 2 1/2 | 3/16 | 1 |
| 8 | 2 1/2 | 1 7/8 | 5/16 | 1 |
| 9 | 2 3/8 | 2 1/8 | 1/8 | 1 |
| 10 | 2 3/8 | 1 7/8 | 1/4 | 1/2 |
| 11 | 2 3/8 | 1 3/4 | 5/16 | 1 |
| 12 | 2 1/4 | 1 3/4 | 1/4 | 1 |
| 13 | 2 | 1 1/2 | 1/4 | 3/4 |
| 14 | 2 | 1 3/8 | 5/16 | 1 |
| 15 | 1 7/8 | 1 3/8 | 1/4 | 3/8 |
| 16 | 1 1/2 | 1 1/8 | 1/8 | 1/8 |

## 13.15. SALIENT FEATURES OF

Special Minor Irrigation Programme

*(Based on Chief Engineer (Irrigation) Circular Memo. No. A2/58322/77.1/ dt. 19-7-77.*

Good Catchment: Normally the funnel shaped catchments with hilly terrain;

Average Catchment: Catchment in the plains:

Bad Catchment: Catchment with lesser rainfall, dense growth of vegetation, permeable soil and sub soil.

Fixing the capacity of tank:

1 Method:

$$\text{Tank Capacity} = \frac{\text{Run off available at the tank site after meeting the requirements of the existing Irrigation and proposed schemes}}{\text{Number of fillings for the tank based on working tables.}}$$

*II Method:*

$$\text{Tank Capacity} = \frac{\text{The commandable cultural ayacut under the proposed tank}}{\text{(Memoir or prevailing duty)} \times \text{(Number of fillings for the tank based on working tables).}}$$

Duty for the tank: For all the new schemes, 25% over and above the normal duty in the adjoining tank (or) the basin.

[Vice C.E. (I) Memo. No. R1/30363/67-1 dt. 28-9-67.]

## 13.16. STANDARDS OF TANK SLUICE BARREL

*(Based on C.E. (I)'s Memo. No. K.Dis N2/5937/76 dt. 24-1-76).*

| Depth of water at F.T.L. over sill of sluice | Specification of barrel | Size of barrel or pipe |
|---|---|---|
| 1. 2.50 m and more | Masonry or R.C.C. barrel | 0.60 m × 0.75 m |
| 2. Between 1.20 m and 2.50 m | R.C.C. hume pipes | Minimum Dia of 45 cm |
| 3. Upto 1.20 m | do | Minimum Dia of 30 cm |

Note: Limiting velocity through the barrel/pipe is 4.57 m/sec. (15'/sec.)

## 13.17. STABILITY CALCULATIONS:

The section of the anicut/weir has to be checked for the following conditions:

13.17.1. Anicut:

(1) When the front water is upto crest level/top of shutters, and no rear water;

(2) When the rear water is upto crest level and front water above crest;

(3) When the rear water is at $H\sqrt{K}$ and front water above crest, where H is height of weir body wall;

$K = \frac{d}{D}$, where d is depth of flow over the crest; & D is Tail water depth;

13.17.2. Tank/Pond Weirs:

1. When front water is just at F.T.L./F.P.L.:

When front water is at M.W.L. and when the tank/pond is surplusing fully:

## 13.18. POND SCHEMES:

Pond Schemes are intended to store up water and to raise water table in the adjoining wells. No direct ayacut is contemplate under these schemes. The pond schemes are executed with a view to raise wet crops under the adjoining wells. Dry crops are not contemplated under the ponds.

The yardsticks fixed for the pond schemes are:

(i) ¼ ton per acre for stabilisation of supply to the existing ayacut (for two crops in a season)

(ii) 1 ton per acre for newly brought under cultivation or for the gap to be bridged (at ½ ton per acre per crop for two crops)

It is assumed that the wells situated within 3000 feet in the lower reach of the pond will get recharge of subsoil water from the pond. One Million cft of storage in the pond is capable of benefiting either 25 acres gap or 100 acres of existing ayacut under the wells.

## 13.19. FIXING SILL LEVEL OF TANK SLUICE:

The sill level of the tank sluice should be fixed w.r. to the levels of the ayacut in rear of the sluice (i.e.,) ¼ foot above the mean level of the highest field irrigated by it and where the land to be irrigated is at a considerable distance from the outlet, it is necessary to make a further allowance for surface fall in the field channel. Where a small fraction of the whole area is at a high level and the rest at a low one, the average level of the area irrigated by the pipe should be taken in place of the highest.

## 13.20. FIXING THE CREST LEVEL OF ANICUT:

This is fixed with reference to the F.T.L. of the first tank to be fed on either side of the anicut or the highest field level of the lands to be fed, in the case of direct ayacut, the slope of the canal, driving head...etc.

Pier: The pier in the head sluice/regulator has to be checked for longitudinal thrust and the following conditions of cross thrust:

(a) Water upto the top of shutters, one shutter fully opened and the remaining shutters closed;

(b) Flood conditions with one shutter closed, as for instance, if the gear were broken, and all other shutters lifted clear;

## 13.21. SCOURING SLUICE:

1. The sill level may be fixed at a level as low as possible so as to facilitate success in operation.
2. The linear waterway should be 1 to 1¼ times that of the head sluice
3. Scour Vents may be located perpendicular both to the anicut and the head sluice.

## 13.22. DESIGN ASPECTS FOR PERMEABLE FOUNDATION:

1. The outer faces of the end sheet piles are much more effective than the inner ones and the horizontal length of floor.
2. The intermediate piles act as secondary lines of defence. They, if smaller in length than the outer ones, are ineffective except for local redistribution of pressures.
3. Undermining of floors start from the exit end (tail end). If the hydraulic gradient at exit is more than the critical gradient for the particular sub-soil, the soil particles would move with the flow of water thus causing progressive degradation of the sub-soil, resulting in cavities and ultimate failure.
4. It is absolutely essential to have a reasonably deep vertical cut off at the down-stream end to prevent undermining.

# XIV HIGHWAY ENGINEERING

## 14.1. GEOMETRICS OF ROADS

### 14.1.1. Introduction :

Roads in a country can be taken as an index for the level of development of the country. Due to the enormous increase of road traffic by different type of vehicles, the design of good roads has assumed a very great importance. The purpose of this lecture is to be expose to the participants some salient features of the geometric design of roads.

### 14.1.2. Geometric Design :

Geometric design of roads deals with alignment, grades, widths, sight distances, curves, slopes, etc. Structural design was given more importance till the last decade. Now geometric layout of road is given more importance. Specifications have been laid down by I.R.C., the Ministry of Transport (Road wing) etc.

Geometric design of a road should aim at the maximum benefit to traffic at the least cost while causing minimum interference to agriculture, industry, etc. and the same time fitting into the landscape, so as to present an aesthetically pleasing appearance.

### 14.1.3. Classification of roads :

Roads are classified broadly as follows :

1. National Highways (NH)
2. State Highways (SH)
3. Major District Road (MDR)
4. Other District Roads and (ODR)
5. Village Roads. (VR)

Sometimes they are classified according to the terrain over which they are formed.

Level Terrain — Cross slope less than 10%.

Rolling Terrain — Cross slope 10 to 25%.

Mounanious Terrain — Cross slope 25 to 60%

Steep Terrain — Cross slope greater than 60%.

## 14.1.4. Capacity :

Capacity of road is the maximum number of vehicles that can pass over a given section of roadway during a given period of time (Usually an hour). It is expressed in terms of passenger car units (P.C.U.S). Ministry of Transports (M.O.T.) and Central Road Research Institute (C.R.R.I) specify the Passenger Car Eqivalent (PCES) for various types of vehicles on the road.

| Vehicle | Equivalent Factory of PCU |
|---|---|
| Passenger Car, Tempo and Auto-rickshaw | 1.0 |
| Cycle, Motor Cycle, Scooter | 0.5 |
| Cycle-rickshaw | 1.5 |
| Truck, Bus, Agricultural Tractor-Trailer | 3.0 |
| Horse-drawn vehicle | 4.0 |
| Bullock-cart small | 6.0 |
| Bullock-cart large | 8.0 |

M.C.T. — Technical Group has recommended the following specifications:

| Road Type | Recommended capacity |
|---|---|
| 1. Single lane with earth shoulders. | Upto 1000 P.C.U's per day. |
| 2. Single lane with 1.5 width all weather shoulders on either side. | Over 1000 P.C.U's but less than 2500 P.C.U's per day. |
| 3. Two lanes under Ideal conditions. | Over 3500 P.C.U's but upto 10000 P.C.U's per day. |

## 14.1.5. Vehicle Data :

I.R.C. specifications in respect of maximum dimensions for road design vehicle are furnished below :

| | | |
|---|---|---|
| Width of vehicle : | | 2.44 m |
| Height — | Single decked : | 3.80 m |
| | Double decked : | 4.70 m |
| Length — | Single unit — 2 axles | 10.70 m |
| | Single unit — more than 2 axles | 12.20 m |
| | Semi trailor combination | 15.20 m |
| Tractor Trailor combination | | 18.30 m |

### 14.1.6. Sight Distance :

Sight distance is the length of road ahead visible to driver. This must be provided on straight lengths, intersections, horizontal curves and vertical curves. This can be classified as :

(i) Stopping Sight Distance.
(ii) Overtaking Sight Distance.
(iii) Meeting Sight Distance.
(iv) Headlight Sight Distance.

### 14.1.7. Reaction Distance :

The reaction time is the total period between the hazard coming into view and the instant the brakes take effect. It comprises of

(i) Perception Time.
(ii) Intellection Time.
(iii) Emotion Time. PIEV TIME
(iv) Volition Time.

This PIEV TIME depends upon

(i) Physical characteristics of the driver.
(ii) Physchological factors.
(iii) Environmental conditions.
(iv) Purpose of trip and
(v) Speed of vehicle.

The total reaction time of an average driver is 0.5 second for simple situation and 3 to 4 seconds for complex situations. I.R.C. has recommended the following reaction times

| | | |
|---|---|---|
| for speeds | 50 KMPH | 3 seconds. |
| | 65 KMPH | 2.75 seconds. |
| | 80 KMPH | 2.50 seconds. |

Reacting distance is the distance travelled by the vehicle during total reaction time.

### 14.1.8. Braking Distance :

Braking distance is the distance travelled by the vehicle after application of brakes. It is given by the formula.

$$L = \frac{(0.278\ V)^2}{2\,g\,f}$$

| | | |
|---|---|---|
| where | L | is the braking distance. |
| | V | is the design speed. |
| and | f | is the coefficient of friction (0.4) |

## 14.1.9. Stopping Distance :

Stopping distance is the sum of reaction distance and braking distance.

Stopping distance = Reaction distance + Braking distance.

$$= 0.28\,V\,t + 0.01\,V^2$$

Safe stopping distance for different speeds are given below :

| Speed in KMPH | 20 | 25 | 30 | 35 | 40 | 50 | 65 | 80 | 100 |
|---|---|---|---|---|---|---|---|---|---|
| Safe stopping distance in metres. | 20 | 30 | 35 | 45 | 50 | 70 | 90 | 120 | 170 |

It is essential to provide sufficient corner sight distance to allow an approaching driver unobstructed view of the entire intersection.

## 14.1.10. Horizontal Curves :

Straight alignment induces monotony to the driver causing accidents. Flat curves should be used in conjuction with transmission curves. Compound and Reverse curves should be avoided. Sharp Curves should not be introduced at the ends of long tangents.

| Highway | Minimum radius of curve in metres | | | |
|---|---|---|---|---|
| | Plain Terrain | | Rolling Terrain | |
| | Absolute minimum | Ruling minimum | Absolute minimum | Ruling minimum |
| NH, SH | 250 | 370 | 155 | 250 |
| MDR | 155 | 250 | 93 | 155 |
| ODR | 93 | 155 | 60 | 93 |
| Village roads | 60 | 53 | 45 | 60 |

## 14.1.11. Super Elevation :

In India, the majority of vehicles travel at less than the design speed. The super elevation is so designed as to counteract the centrifugal force developed at 3/4 design speed.

Super elevation = $V^2/255\ r$

The super elevation

i) allows design speed even in curves.
ii) helps to keep the vehicle to the correct side.
iii) lessens the danger of skidding.
iv) results in less wear & tear of tyres & springs.

## 14.1.12. Extra widening of curves :

Due to the difficulty experienced in steering the vehicle at bends, extra widening at bends is quite essential. This is given by the following formula for each lane.

$W = L^2/2R_c$ where

W is the extra width in metres.

L is the length of wheel base of vehicle.

and $R_c$ is the radius of curve in metres.

## 14.1.13. Vertical alignment :

The vertical alignment should be smooth and economical. It is desirable to have grade lines with minimum breaks and long lengths of grades. IRC recommends the following gradients.

For roads in plain and rolling terrain

| | |
|---|---|
| Ruling gradient | 3.33% |
| Limiting | 5% |
| Exceptional | 6.66% |

The length of exceptional gradient should not exceed 60 m in a length of 1 K.M.

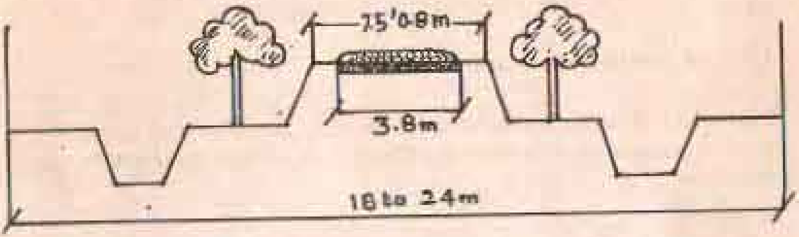
For ghat roads

| | ruling gradient | Limiting gradient |
|---|---|---|
| Maintain terrain and steep over 3000 M height above M. S. L. | 5% | 6% |
| Steep terrain upto 3000 M height above M. S. L. | 6% | 7% |

### 14.1.14. Vertical Curves :

Vertical curves are provided in elevation at change of gradients. There may be convex or concave. These curves are not necessary when the total grade change from one tangent to the other does not exceed 0.5% vertical curves are usually parabolic.

### 14.1.15. Typical Highway Cross Section :




## 14.2. Width of Carriage way and Roadway

(As per Indian Road Congress)

| Type of road | Width of carriage way in metres | | | | Width of roadway or formation width(in metres | |
|---|---|---|---|---|---|---|
| | Single lane in metres | Two lanes without raised kerbs in metres | Two lanes with raised kerbs in metres | Multi-lane pavement per lane in metres | Single lane in metres | Two lanes in metres |
| National and State highways | 3.8 | 7.0 | 7.5 | 3.5 | 12.0 | 12.0 |
| Major district roads | 3.8 | — | — | — | 10.0 | — |
| Other district roads | 3.8 | — | — | — | 8.0 | — |
| Village roads | 3.8 | — | — | — | 7.5 | — |

For multi-lane carriage ways, the width of roadway will be governed by central verge, footpaths, cycle tracks etc. and width of roadway or formation is to be designed according to the requirements in each case.

## 14.3 Width of Carriage way on Road Bridges

(As per IRC)

| Type of bridge | Clear width of carriage way on road bridges in metres |
|---|---|
| Single lane bridge | 3.8 |
| Two lane bridge | 7.5 |
| Bridges on divided highways with four lane dual carriage way (two lanes on either side of the central dividing verge.) | 7.5 m for each two lane carriage way |

## 14.4 Minimum Land Width for Roads

(As per IRC)

Open area and agricultural country

| Class of road | Width of road land | | Building lines overall width in metres | Control lines overall width in metres |
|---|---|---|---|---|
| | Normal in metres | Range in metres | | |
| National and state highways | 30 | 30 — 60 | 60 — 65 | 140 |
| Major district roads | 20 | 20 — 30 | 50 | 100 |
| Other district roads | 15 | 15 — 25 | 25 | 40 |
| Village roads | 15 | 15 — 20 | 25 | 30 |

Urban and industrial areas

| Class of road | Width of road land | | Building or set back line width of strip beyond road boundry in metres |
|---|---|---|---|
| | Normal in metres | Range in metres | |
| National and state highways | 25 | 25 — 60 | 3 — 6 |
| Major district roads | 15 | 15 — 20 | 3 |
| Other district roads | 10 | 10 — 15 | — |
| Village roads | 10 | 10 — 15 | — |

**14.5. Gradients of Highways**

*(As per IRC)*

| Terrain | Ruling grade | Limiting grade | Exceptional grade |
|---|---|---|---|
| Plains | 1 in 30 | 1 in 20 | 1 in 15 |
| Hills | 1 in 20 | 1 in 15 | 1 in 12 |

Limiting Radii of Curves beyond which no Superelevation is essential for different Surface Cambers and Speeds

*(As per Indian Road Congress)*

| Design speed in kilometres per hour | Radius in metres beyond which no super elevation is necessary for different type of surface | | | |
|---|---|---|---|---|
| | Water-Bound-Macadam | | Black top | Cement concrete |
| | Camber 1 in 36 | Camber 1 in 48 | Camber 1 in 60 | Camber 1 in 72 |
| 25 | 100 | 130 | 170 | 200 |
| 30 | 180 | 230 | 300 | 360 |
| 40 | 270 | 360 | 400 | 560 |
| 50 | 400 | 530 | 700 | 800 |
| 60 | 700 | 960 | 1200 | 1400 |
| 80 | 1100 | 1500 | 1900 | 2300 |
| 100 | 1600 | 2200 | 2500 | 2500 |

**14.6. Extra width of Pavement in Curves**

*(As per IRC)*

| Radius of curve in metres | Upto 60 m | 60 m to 150 m | 150 m to 300 m | 300 m 500 m | Above 500 m |
|---|---|---|---|---|---|
| Extra width in metres | 1.2 m | 90 cm | 60 cm | 30 cm | nil |

## 14.7. Camber

*(As per IRC)*

As per I.R.C. the minimum values of camber for different pavements are given below:—

| | |
|---|---|
| 1. For concrete pavements | 1 in 72 |
| 2. For bituminous surface | 1 in 60 |
| 3. For water-bound macadam | 1 in 36 to 1 in 48 |

## 14.8. Maximum size of Stone metal for Road work

*(As per IRC)*

| Type of stone | Hand broken in mm | Machine crushed in mm |
|---|---|---|
| 1. Heavy soft stone like lime stone, laterine etc. | 75 | — |
| 2. Harder stone like granite gneiss quartezite sand stone etc. | 50 | 38 |
| 3. Hard tough stones like basalt, hard trap etc. | 38 | 25 |

## 14.9. Purpose for various grades of Bitumen

*(As per IRC)*

| Grade | Purpose |
|---|---|
| 85/25 and 95/15 | Expansion and contraction joints in structures, fixing of insulation coats in building. |
| 85/25 and 115/15 | D.P.C., insulation of cold storages, coating of pipes. |
| 85/25 and 85/40 | Sticking of bitumen felts. |
| 115/15 and 135/10 | Manufacture of bitumen felts. |

## 14.10. Quantities for Binder and Grit

*(As per IRC)*

| Coat | Binder | Grit |
|---|---|---|
| 1. First coat | 1.7 to 1.95 kg/sq.m. | 1.4 to 1.5 cu.m./100 sq.m. |
| 2. Second coat | 1.0 to 1.22 kg/sq.m. | 0.9 to 1.1. cu.m./100 sq.m. |
| 3. Renewal coats or subsequent coats | 0.9 kg/sq.m. | 0.6 to 0.75 cu.m./100 sq.m. |

### 14.11. Quantity for spreading of Coarse Aggregate

*(As per IRC)*

| Compacted thickness | Quantity |
|---|---|
| 50 mm | 0.63 cu.m./10 sq.m. |
| 75 mm | 0.90 cu.m./10 sq.m. |

### 14.12. Quantity for spreading of Bituminous Binder

*(As per IRC)*

| Compacted thickness | Binder | Quantity in kg/10 sq.m. |
|---|---|---|
| 5 cm | (i) Straight run bitumen | 50 |
| | (ii) Road-Tar RT-4/RT-5 | 60-65 |
| 7.5 cm | (i) Straight run bitumen | 68 |
| | (ii) Road-Tar RT-4/RT-5 | 82-88 |

### 14.13. Lives of various types of Roads

*(As per IRC)*

1. W.B.M. Road with regular repair .. .. 2 years
2. Surface dressing (single coat) .. .. 3 years
3. Bituminous grouted macadam .. .. 8 years
4. Premix bituminous carpet .. .. 8 to 15 years
5. Sheet asphalt surfacing .. .. 15 years
6. All concrete roads .. .. 25 to 40 years

All these lives are approximate and depend on the nature of traffic, intensity of traffic, rainfall in the area, characteristics of road metal and other climatic agencies.

### 14.14. Patch repairs in Roads

For estimating purpose the following quantities in metal may be taken for patch repairs actually per kilometre of road length and 3.8 metre width of road:

Light traffice — 12 to 15 cu.m.
Medium traffic — 16 to 25 cu.m.
Heavy traffic — 30 to 60 cu.m.

For portions on gradients, add about 25% extra.

## 14.15. Suitable Roads for particular Traffic

*(As per IRC)*

| Nature of traffic | The intensity of traffic t/m width/day | Suitable roads |
|---|---|---|
| Light | Less than 160 | Earth, moorum, gravel, kankar, creteways and stabilized soil roads etc. |
| Medium | 160—330 | W. B. M. surface dressing, creteways, 15 cm plain concrete road, bounded concrete 5 cm thick laid on existing W. B. M. surface. |
| Heavy | 330—500 | Surface dressing (two coat) grouted bituminous macadam, 15 cm plain concrete road, bituminous carpet. |
| Very heady | 500—1400 | Bituminous grouted macadam, asphalt concrete road, 17.5 cm R. C. C. road. |
| | 1400—3500 | Sheet asphalt, 20 cm R. C. C. road. |
| | 3500—5000 | 22.5 cm R. C. C. road, or hard stone paving (granite). |

As general rule concrete roads prove more economical than bituminous roads in the long run though the initial cost of construction of concrete roads is much more that of bituminous roads.

## 14.16. Sight distances at Road Junctions

*(As per IRC)*

| Speed in km/hour | 25 | 32 | 40 | 50 | 56 | 60 | 80 |
|---|---|---|---|---|---|---|---|
| Sight distance in metres | 20 | 30 | 40 | 50 | 70 | 80 | 120 |

For Indian conditions above sight distances at road junctions are recommended which are taken on the centre lines of the road.

## 14.17. Essentials for an Ideal Road

*(As per IRC)*

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. Straight road speed in km/hour | 30 | 40 | 50 | 60 | 80 | 100 |
| 2. Rotary turning speed in km/hour | 25 | 30 | 40 | 50 | 56 | 60 |
| 3. Min diameter of central island | | | | | | |
| (a) without super-elevation | 30 | 50 | 70 | 90 | 160 | 210 |
| (b) with 1/8 super-elevation | 30 | 40 | 60 | 80 | 120 | 180 |
| 4. Min. radius of edge of pavement or Kerb (For trucks and buses) | 18 m | 18 m | 30 m | 40 m | 60 m | 80 m |
| 5. Width of carriageway around island | 7.8 m ← | | | to | → | 10 m |
| 6. Weaving length Min. | 3 m | 40 m | 50 m | 60 m | 70 m | 80 m |
| Max. | — | 70 m | 100 m | 130 m | 170 m | 200 m |

## 14.18. Ruling and absolute minimum radius of curve in metres in round figures

*(As per IRC)*

As far as possible curves in a road alignment should be avoided. But whenever have to be introduced they should be of large radius. As per I.R.C. recommendations, radii of horizontal curves in relation to the speed of the vehicles should be as given in Table.

| | Flat or rolling country | | Hilly country and restricted localities | |
|---|---|---|---|---|
| Design speed in km/hour | Ruling minimum radius in metres | Absolutely minimum in metres | Ruling minimum in metres | Absolutely minimum in metres |
| 25 | — | — | 50 | 30 |
| 30 | 100 | 50 | 60 | 50 |
| 40 | 130 | 60 | 100 | 60 |
| 50 | 170 | 100 | 130 | 100 |
| 60 | 250 | 150 | — | — |
| 80 | 300 | 250 | — | — |

## 14.19. Horizontal Clearances of poles of street lighting

| | |
|---|---|
| For roads with raised kerbs | — Minimum 30 cm from edge of raised kerb, 60 cm preferable. |
| For roads without raised kerbs | — At least 1.5 m from edge of carriage way, subject to minimum of 5 m from centre line of carriage way. |

### 14.20. Bridges and Culverts

#### 14.20.1 Determination of Linear Waterway

In large natural streams in alluvial bed and having undefined banks, the linear waterway shall be determined by —

$$L = C\sqrt{Q}$$

where $L$ = the linear waterway in metres, $Q$ = the designed maximum discharge in cumecs., and $C$ = a constant usually taken as 4.8 but its value varies from 4.5 to 6.3 according to local conditions.

#### 14.20.2. Minimum Vertical Clearance

For high level bridges which are approximately rectangular or with a very flat curve of the soffit of superstructure the minimum clearance shall be — Upto 0.3 cumec-15 cm, from 0.3 to 3 cumecs — 45 cm, From 3 to 30 cumecs — 60 cm, From 30 to 300 cumecs — 90 cm, From 300 to 3000 cumecs — 120 cm, and for more than 3000 cumecs — 150 cm.

The minimum clearance shall be measured from the lowest point of the deck structure inclusive of main girders in the central half of the clear opening.

#### 14.20.3. Maximum Depth of Scour

The following theoretical method may be used as a guide while dealing with natural streams in alluvial bed —

$$D = 0.473\,(Q/f)^{1/3}$$

where $D$ = depth of scour below H. F. L. for regime conditions in stable channel in metres, $Q$ = designed discharge in cumecs, and $f$ = Lacey's silt factor for a representative sample of the bed material.

The maximum depth of scour may be taken as : In a straight reach – 1.27 $D$, at a moderate bend – 1.50 $D$, at a severe bend-1.75 $D$, at right-angled bend – 2.00 $D$, at nose of piers – 2.00 $D$, and at upstream noses of guide banks – 2.75 $D$.

#### 14.20.4 Top width of Abutments and Piers for Simple Slabs and Girder Bridges just below caps

| Clear span in metres. | Cement masonry | | Lime masonry | |
|---|---|---|---|---|
| | 'A' of abutment in cm | 'B' of pier in cm | 'A' of abutment in cm | 'B' of pier in cm |
| 3 | 40 | 50 | 50 | 60 |
| 6 | 75 | 100 | 120 | 130 |
| 12 | 100 | 120 | 130 | 140 |
| 24 | 130 | 160 | 170 | 190 |
| 40 | 170 | 190 | 200 | 220 |
| 60 m and above | 190 | 220 | 240 | 250 |

### 14.20.5. Loading Classification

*(As per IRC)*

*I.R.C. Class AA loading:–*

This loading is to be adopted within certain municipal limits, in certain existing or contemplated industrial areas, in other specified areas and along certain specified highways. Bridges designed for Class AA loading should be checked for Class A loading also, as under certain conditions, heavier stresses may be obtained under Class A loading. Where specified class 70R loading shall be used instead of I.R.C. AA loading.

*I.R.C. Class A loading:–*

This loading is to be normally adopted on all roads on which permanent bridges and culverts are constructed.

*I.R.C. Class B loading:–*

This loading is to be normally adopted for temporary structures and for bridges in specified areas. Structures with timber spans are to be regarded as temporary structures for this purpose.

### 14.20.6. Length of Clear Span

| | |
|---|---|
| For masonry arched bridges | $S = 2.0\,H$ |
| For R.C.C. slab bridges | $S = 1.5\,H$ |

where $S$ = clear span in metres, and $H$ = total height of abutment or pier from the bottom of its foundation to its top. For arched bridges it is measured from foundation to the intrados of the key stone.

### 14.20.7. Earth Cushions for different height of Abutments

For 1.50 metres height of abutment – 1.20 metres earth cushion; for 3.00 metres – 1.20 metres, for 5.30 metres – 1.05 metres, and for 6.00 metres – 0.90 metres earth cushion.

### 14.20.8. Width of Wall to retain Haunch filling

| Span | Base width | | Top width | |
|---|---|---|---|---|
| | Stone | Brick | Stone | Brick |
| Upto 3 m | 30 cm | 34 cm | 30 cm | 34 cm |
| 6 m | 45 cm | 45 cm | 30 cm | 34 cm |
| 9 m | 53 cm | 56 cm | 30 cm | 34 cm |
| 12 m | 60 cm | 68 cm | 30 cm | 34 cm |

### 14.20.9. Afflux

The afflux is calculated due to two reasons: (a) to see that there is not much heading up of water above the bridge, and (b) to ascertain the fact that the increased velocity due to afflux does not exceed the permissible velocity under the bridge. The afflux is calculated by one of the following formulae:

(a) Merriman's formula $h_a = \frac{V^2}{2g} \left[ \left( \frac{A}{C_d} \right)^2 - \frac{A}{A_1} \right]$

(b) Molesworth's formula $h_a = \left( \frac{V^2}{58.6} + 0.05 \right) \left[ \left( \frac{A}{a} \right)^2 - 1 \right]$

where $C_d = 0.75 + 0.35 \left( \frac{a}{A} \right) - 0.1 \left( \frac{a}{A} \right)^2$ approx.

$h_a$ = height of afflux in feet, $V$ = velocity of approach which is approximately equal to the natural velocity of the streams at the site if the obstruction is not large, $A$ = natural waterway at site, $C_d$ = coefficient of discharge $A_1$ = enlarged area upstream of bridge, a = artificial waterway.

Since both the formulae are emperical, the value of $h_a$ in metres can be obtained by conversion (1 foot = 0.3048 metres).

### 14.20.10. Free Board

The vertical distance from the springing level or the level of the bottom of girder to the highest flood level is termed as free board. Its following values are adopted generally.

Girder bridges – 60 to 90 cm, Arch bridges – 30 cm, and for a navigable rivers – 2.40 to 3.0 metres.

### 14.20.11. Loads, Forces and Stresses

The following loads, forces and stresses should be considered in designing road bridges and culverts:

1. Dead load, 2. Live load, 3. Impact or dynamic effect of live load, 4. Wind load, 5. Horizontal forces due to water currents, 6. Longitudinal forces caused by tractive efforts of vehicles or by braking of vehicles etc., 7. Centrifugal forces 8. Buoyancy, 9. Earth pressure, 10. Temperature stresses, 11. Deformation stresses, 12. Secondary stresses, 13. Erection stresses, and 14. Seismic forces.

### 14.20.12. Equivalent heights and Surcharge of Earth

*(As per IRC)*

Particularlyincase of bridge abutments, the concentrated surface loads due to the wheel or track load of any of the I.R.C. standard vehicles placed on the back-fill shall be considered to have the same effect as equivalent heights of surcharge of earth shown below:

| Depth of abutment below the road level in metres | I.R.C. Class AA and Class 70R loading | | I.R.C. Class A loading | | I.R.C. Class B loading | |
|---|---|---|---|---|---|---|
| | Single lane bridge | Multilane bridge | Single lane bridge | Multilane bridge | Single lane bridge | Multilane bridge |
| 0.2 | 26.0 | 15.4 | 14.3 | 17.2 | 8.0 | 10.0 |
| 1.0 | 15.0 | 9.1 | 8.5 | 10.0 | 5.1 | 5.8 |
| 2.0 | 8.0 | 5.5 | 5.1 | 6.1 | 3.0 | 3.7 |
| 3.0 | 6.8 | 4.1 | 3.8 | 4.6 | 2.3 | 2.7 |
| 4.0 | 5.5 | 3.3 | 3.0 | 3.5 | 1.8 | 2.1 |
| 6.0 | 3.8 | 2.3 | 2.2 | 2.6 | 1.3 | 1.5 |
| 8.0 | 3.0 | 1.8 | 1.7 | 2.0 | 1.0 | 1.2 |
| 10.0 | 2.6 | 1.5 | 1.4 | 1.7 | 0.9 | 1.0 |

Height in metres for the concentrated surface loads due to the wheel or track loads of the following I.R.C. standard loading.

**14.20.13. Top widths of Piers for I.R.C. Class AA Loading for Spans other than Arches**

| Span in metres | Upto 3 m | 3 m to 5 m | 5 m to 7 m | 7 m to 10 m |
|---|---|---|---|---|
| Top width | 60 cm | 70 cm | 80 cm | 95 cm |

Minimum top width for simply supported spans should be such as to accommodate the bridge seat with clearance of 15 cm between the bays. Length of the pier is usually made to extend 1½ times the top width beyond the centre line of the outer girders or trusses. The depths of cut and ease waters are not counted in the length. Piers are usually given a batter of 1 in 30 for brick in cement mortar and 1 in 24 for brick in good lime mortar. Maximum batter given is 1 in 12.

**14.20.14. Rolling Stock Weights**

*(As per IRC)*

| Description | Loaded weight in tonnes | Unloaded weight in tonnes |
|---|---|---|
| 1. Single truck single deck | 9.6 | 7.9 |
| 2. Single deck Bogie car | 15.3 | 12.2 |
| 3. Double deck Bogie car | 21.5 | 16.0 |

### 14.20.13. Data for R.C.C. slabs for bridges

*(As per IRC)*

This data is for R.C.C. slabs for road bridges freely supported with 8 cm wearing coat for I.R.C. Class A loading:

| Clear span in metres | B.M. per metre width in kg cm. | Shear per metre width | Total thickness of slab excluding wearing coat in cm | Reinforcement | | | |
|---|---|---|---|---|---|---|---|
| | | | | Main | | Distribution | |
| | | | | Bar dia in mm | Spacing c/c in cm | Bar dia in mm | Spacing c/c in cm |
| 0.90 | 117500 | 5558 | 18 | 10 | 8 | 8 | 17 |
| 1.20 | 164300 | 6216 | 19 | 12 | 10 | 12 | 25 |
| 1.50 | 200000 | 6328 | 20 | 12 | 10 | 12 | 25 |
| 1.80 | 333000 | 7938 | 23 | 12 | 8 | 12 | 21 |
| 2.10 | 403500 | 8470 | 25.4 | 16 | 11 | 12 | 20 |
| 2.40 | 493000 | 8750 | 27.5 | 16 | 10 | 12 | 18 |
| 2.70 | 568000 | 9226 | 30 | 18 | 13 | 12 | 18 |
| 3.00 | 678500 | 9324 | 32 | 18 | 12 | 14 | 28 |
| 3.60 | 892800 | 9994 | 36 | 18 | 10 | 14 | 26 |
| 4.20 | 1142800 | 10682 | 40 | 18 | 10 | 14 | 25 |
| 4.50 | 1274900 | 11004 | 42.5 | 25 | 15 | 14 | 25 |
| 4.80 | 1407000 | 11124 | 44 | 25 | 15 | 14 | 24 |
| 5.40 | 1692750 | 12082 | 48 | 25 | 14 | 14 | 24 |
| 6.00 | 2024870 | 12964 | 53 | 25 | 12 | 14 | 23 |
| 6.60 | 2364150 | 13664 | 56 | 25 | 12 | 14 | 23 |
| 7.20 | 2696300 | 14532 | 60 | 25 | 11 | 18 | 30 |
| 7.50 | 2964100 | 15050 | 62.5 | 25 | 10 | 18 | 30 |
| 8.10 | 3432000 | 16128 | 68 | 25 | 10 | 18 | 28 |
| 9.00 | 4249700 | 18032 | 75 | 25 | 9 | 18 | 27 |

### 14.21. Arboriculture

Tree planting to be proposed well in advance, when the proposal of laying the road is made, of course with due considerations for the future expansions of Road width at latter date. Once the road side avenue trees grown, the travel on road by any mode of conveyance including pedestrians are made quite comfortable apart from the travel fatigue relief. ■

"Engineers are National Builders"

— *Pandit* ***Jawaharlal Nehru.***

"Don't ask what the Country has done to you
Think what you have done for the Country"

— *John* ***F. Kennedy***

"It is by Planning step by step as also by deriving strength through Self-reliance, progress can be achieved"

— *Srimathi* ***Indira Gandhi***

"Too much importance is being given to Politics and Politicians It is not good. I feel that importance is not being given to Writers. Scientists, Engineers and Architects. This should change.

— *Perarignar* ***Anna***

"A Diploma Engineer is no way inferior to a Degree Engineer for the purpose of Government service"

— *Justice* ***Das*** *in Central Pay Commission Report*