LOCAL SELF GOVERNMENT DEPARTMENT

PUBLIC WORKS MANUAL

(DRAFT)

CONTENTS

SECTION -1

INTRODUCTION

Consequent to the introduction of Panchayati Raj Act 1994 and Municipal Act 1994, the Government introduced a system of decentralization of powers by which certain powers and functions that have been carried out by PWD, Irrigation Departments and Water Authority were transferred to Local Self Government Institutions. The Engineering Wing of LSGD started functioning since 2003. The Government vide GO (MS) No. 253/07/LSGD dated 13/11/2007 decided to form a permanent Engineering Cadre for LSGD. This new Department came into existence with effect from 01/01/2008 under a Chief Engineer. The present strength of the wing including technical and ministerial staff is 5121. LSGD Engineering Wing is a body formed for the execution of public works at the grass root level in the state. By the formation of this Wing, Government is effectively implementing various projects as per people's need in a time bound manner. People got their dream projects implemented at the Local body level. Kerala is the best example for successive implementation of Decentralisation. In LSGD, the engineering wing is carrying out various types of projects such as construction and maintenance of roads, buildings, culverts, bridges, retaining walls, waste management schemes and water supply schemes. The Engineering Wing of the department is responsible for giving building permits in accordance with KPBR and KMBR and fitness certificates for schools and other buildings under LB.

The main objective of LSGD Engineering Wing is to assist the Local Self Government Institutions, namely Urban Local Bodies like the Corporations and Municipalities and three tier Rural Local Bodies like District/ Block/ Grama Panchayaths, in implementing various infrastructure related works and its maintenance. The department is headed by two Chief Engineers; one is the administrative head of the department; the other is responsible for the centrally sponsored rural road project namely, Pradhan Mantri Grameena Sadak Yojana (PMGSY).

LSGD Engineering Wing is implementing various e-Governance applications for performing its various functions. The department is using various software applications for Project Formation, Estimate Preparation, Tendering and Payment of work bills which helps to ensure effective implementation and transparency. Other softwares are also used in the department such as software for issuing building permits and that for digitizing the data of the Assets of the Local Self Government Institutions etc. These Software applications are developed by the Information Kerala Mission (IKM) and National Information Centre (NIC).

Since its creation in 2007, the Local Self Government Department Engineering wing has carried out various projects and today the department is capable of dealing with new diplomatic challenges independently. PWD manual, the key manifest that outlines the functioning of the State Public Works Department is considered as the standard guidelines manual for carryingout various projects in LSGD, till now. LSGD has also adopted the rules and procedures followed in various departments from which it has been originated. But the functions, nature of work and responsibilities of LSGD are entirely different from other departments. Normally, LSGD is carrying out large number of low-budget projects. The project formulation and implementation are happening at the grass-root level. LSGD staffs are responsible to the department and to the Council/ Committee of elected representatives of the local bodies.

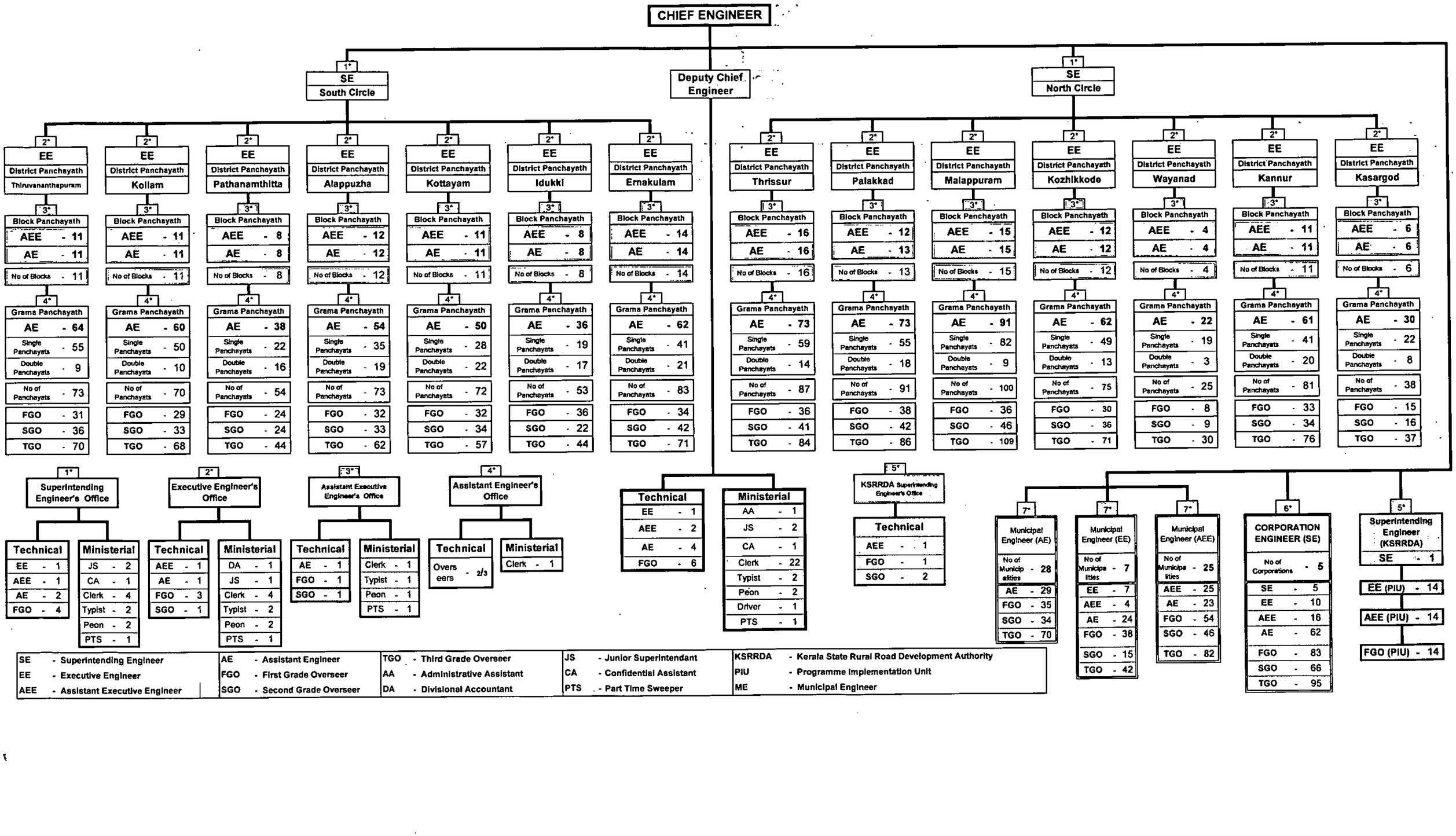
The projects are typically selected in Grama Sabhas and finalized by the concerned LSGIs. As implementing officers, the engineers in the department are considered as the Ex-officio Secretaries of the Local Bodies concerned. It is the responsibility of the Ex-officio Secretaries to guide the local bodies according to the government norms and guidelines. Hence it is necessary to have a manual for the department.

Various sources of funds allotted for developmental works in a fiscal year are Plan fund (around Rs. 4000 crores), World Bank fund, Finance Commission, MLA-ADF, MLA-SDF, NCFRW, SC-CORPUS Fund, MP Fund, NABARD, RIDF, other centrally sponsored schemes, local schemes like Endosulphan package, Idukki Package etc.

CPWD Specifications and Delhi Schedule of Rates for buildings, MoRD and MoRTH specifications for roads and bridges are being implemented in Local Self Government Department. The adoption of these specifications enables the use of modern techniques and technologies in the public work and enhances the quality of the construction work.

ORGANISATIONAL SETUP

ORGANISATION CHART UNDER CHIEF ENGINEER , LSGD



SECTION- 2

1. DUTIES AND RESPONSIBILITIES

The Engineers of LSGIs are equally responsible to the department and the corresponding LSGI. Engineers shall:

i. Provide technical advice to the LSGIs in a suitable way on the basis of the guideline received from the government from time to time.

ii. Assist the local government institution for timely implementation of the public works.

iii. Participate in the formation of the committee of beneficiaries, explain the technical aspect of the projects and give necessary guidance for its execution.

iv. Assist the local government institution to update asset registers, road connectivity map and other similar documents by providing necessary technical details. Timely consultation with the IKM shall be done for the same.

v. To verify the economical viability and technical feasibility of the projects proposed by the LSGI.

vi. Prepare the detailed project documents of the all public works which includes Detailed Estimates, Drawings, Reports and other supporting documents.

vii. The Executive Engineers at District level shall utilise the service of the Assistant Executive Engineer at the Subdivision and Assistant Engineer and Overseer at Section offices for the execution of District Panchayat public works.

viii. The execution of Block Panchayat public works shall be done by utilising the service of the Assistant Engineer and Overseers in the subdivision.

ix. The Assistant Engineer and Overseer of a Section shall attend to all public works within the GramaPanchayat taken up using the fund comes throughGramaPanchayatand District Panchayat.

x. In the case of Corporations and Municipalities, the Head of the Office shall utilise the service of the technical subordinate staff for the implementation of the public works.

xi. Shall provide technical support to other implementing officers of other transferred institutions to the local body, if necessary.

xii. Ensure all public works are done as per rules and instructions of the government and in compliance with the guidelines of the particular scheme.

xiii. Conduct site inspection and certify on stability / fitness of the public buildings in the LSGI as per prevailing GOs, on written requests. If required, shall direct the concerned authorities to rectify the defects and to arrange for necessary structural stability assessments.

xiv. Take action to get necessary permissions from other departments for the public works in the LSGI, if necessary.

xv. Gets approval from the LSGI regarding the mode of execution of the public works.

xvi. Take necessary action for making payments of the public works executed.

xvii. Maintain proper account details of the public works executed and submit the records for audit/ inspection.

xviii. Prepare progress report of the public works and submit it to the concerned authorities in a time bound manner.

xix. Inform the concerned ward members/ Councillors of the LSGI regarding starting of a public work.

In addition, the following shall be considered as part of the duties of every officer of the department.

i. The officers shall also be responsible for the duties and responsibilities assigned to the subordinate officers reporting to him in the office.

ii. Every officer shall, if called upon by his superior officers, carry out as a temporary measure, in addition to his duties and responsibilities, those of another officer who is on leave or otherwise not available.

iii. Every officer shall also carry out any duties as assigned to him by his superior officers.

iv. If an officer has to be absent from his post on leave or for other reasons, he, or his superior officer shall make necessary arrangement, for the conduct of the work in the absence of the officer.

v. Every officer shall bestow adequate care on the protection of Government/ LSGI property entrusted to his charge.

vi. Every officer shall carry out such work as he may be called upon to do from time to time by Department or LSGI.

vii. Every officer must safeguard the interest of the State particularly, in emergencies and unforeseen circumstances.

viii. Every officer shall co-operate with other officers of the department and officers of other departments wherever necessary for the proper conduct of Government business.

ix. Officers who control works shall see that the provisions of the safety code and protection arrangements are strictly adhered to. Inspecting officers shall take necessary action in this regard.

x. Wherever necessary, adequate fencing or other means of isolating weak spots in structures under use shall be provided until the weakness is removed.

xi. In respect of structures under maintenance, vulnerable portions shall be inspected and if any weakness is noticed steps shall be taken urgently to strengthen or replace the weak portions of the structure.

xii. Officers shall see that sufficient environment protection arrangements are strictly observed in the office premises as well as at work sites. Inspecting officers shall take necessary action in this regard.

xiii. Every officer in charge of project preparation and execution shall see that minimum destruction is caused to individuals or community in terms of loss of physical assets, access and livelihood.

xiv. If there is obstruction in the discharge of duties of any officer by an outsider, it will be proper for the officer to have the obstruction removed either directly or with the help of the police.

xv. Every officer shall guide and control the work of his subordinates. If there is any disobedience, malingering, insolence, etc on the part of the subordinates, it is open to the controlling officer to initiate disciplinary proceedings against them after reporting the matter to the higher authority.

2.1 CHIEF ENGINEER

It shall be the responsibility of Chief Engineer to ensure that the functions relating to Engineering wing are carried out efficiently. For this purpose, he shall among other things arrange to:

i. Ensure that policies of government in regard to development programmes are implemented in a timely manner.

ii. Plan, organise and co-ordinate works based on budget allocations.

iii. Advise Government and LSGIs on all technical matter, Administration & Designs or those referred by the Government and LSGIs. Give timely instructions and guidance to subordinate officers on various matters.

iv. Issue approval for publishing the information on the website relating to his wing

v. If the implementing officer requests, inspect major work sites and works which require guidance or instruction, record the comments in the work spot order book and circulate the inspection note to all concerned for follow up action.

vi. Distribute funds under various heads as per budget allocation to the various divisions.

vii. See that the rules regarding accounting and financial control at various levels are properly enforced

viii. Exercise administrative, financial and technical powers delegated to the CE.

ix. Prepare details for answering legislative assembly questions, submissions and budget speech for the Government.

x. Make a system of monitoring the progress of work and the appropriate corrective steps wherever required

xi. If requested, the CE shall, submit clarifications on paragraphs and reviews included in Audit Reports, C & A G Reports indicating the action taken or proposed to be taken.

xii. Submit statements showing progress of clearance of audit objections of LSGD Engineering Wing to the Administrative Department of the Secretariat and take necessary steps to clear such objections.

xiii. Report to Government on old curiosities, relics, coins, minerals and any other item of archaeological importance found on excavation any ancient masonry or other old work of interest be opened up, or any religious edifice or relic be involved in removal or destruction in the execution of a work.

xiv. Accord TS to projects as per prevailing GOs.

xv. Finalize structural design(once design wing is formed).

xvi. CE shall be responsible for all administrative and establishment matters of all employees of LSGDEngineering wing.

xvii. CE shall be responsible to all matters relating to Vigilance.

xviii. CE shall ensure that all the inputs and infrastructure facilities are provided to all the offices under the LSGD to carry out the entrusted duties.

xix. Forward the cases to be placed before the Government Pleader/Arbitration Committees with relevant proforma details and sufficient number of copies of notes etc. to the Government.

xx. Checking expenditure against budget grant and taking timely steps to move for re-appropriations, surrender of funds or supplementary grant as may be necessary.

xxi. Controlling the matters connected with the establishment under his jurisdiction such as leave, transfers and postings, promotions, disciplinary action etc.

xxii. Approval of plan projects of all the Corporations in the state as per prevailing GOs.

In addition to the above, the Chief Engineer shall also carry out functions assigned by government by virtue of any Act or Rules.

2.2 DEPUTY CHIEF ENGINEER

Superintending Engineers posted in the Chief Engineer's office shall be designated as Deputy Chief Engineer and shall assist Chief Engineer in all official matters.

Deputy Chief Engineer shall be the Vigilance Officer of the Department.

The Deputy Chief Engineer shall be controlling officer of all other staff in the absence of Chief Engineer

2.3 SUPERINTENDING ENGINEERS (CIRCLE OFFICES)

The Superintending Engineer shall be controlling a circle and has to exercise administrative andtechnical control over the various Divisions/ Municipalities under his jurisdiction in order to ensure efficient functioning of the departmental activities in that circle. His responsibilities shall include:

i. If required, giving guidance in the matter of design to be followed for major public works.

ii. Obtain the Detailed Project Reports of works from the EE/ Head of Municipalities and process as per delegation of powers.

iii. Scrutinizing estimates, revised estimates and supplemental estimate within the delegation of powers of SE.

iv. Inviting tenders through e-tender/ print media if required and arranging contracts of works, supplies, etc in accordance with rules and delegation of the powers for specially assigned works.
v. Periodically inspecting all important public works and also the works, which require supervisory guidance in the matter of execution; Inspections shall cover examination of quality, progress, difficulties in execution, etc and record the comments in the work spot order book and circulate the inspection note to all concerned for follow up action.
vi. Conduct initial scrutiny of all the prequalification documents before forwarding them to the Chief Engineer.
vii. Ensuring that sanctioned staff is made available in the various offices.
viii. Inspecting the Offices under his jurisdiction periodically with a view to ensure that the work of the offices is carried out efficiently.
ix. Controlling the matters connected with the establishment under his jurisdiction.
x. Giving technical advice or opinion on matters referred to him by Government/Chief Engineer.
xi. Directing relief and protection measures to be taken with the resources available under his jurisdiction in the event of unforeseen calamities like flood, fire, earthquake etc. In the event of such work being organized by other departments, cooperating with such work to the extent necessary.
xii. Superintending Engineer shall hold regular meetings with Executive Engineers/ Heads of Engineering Wings of Municipalities under his control and circulate the minutes and report to the Chief Engineer, suggesting measures for improving the technical and administrative efficiency of the department taking into account the technical development, which has taken place and other relevant matters.
xiii. Conduct an independent quality assurance and technical audit of works
xiv. Approval of all plan projects under his jurisdiction as per prevailing GOs.
xv. Accord Technical Sanction to projects as per delegation of the powers.

In addition to the above, the Superintending Engineer shall also carry out functions assigned by government or Chief Engineer.

2.4 SUPERINTENDING ENGINEER (CORPORATION)

The Superintending Engineer (Corporation) shall be controlling a Corporation and has to exercise administrative and technical control under his jurisdiction in order to ensure efficient functioning of the departmental activities in that office. His responsibilities in addition to the above shall include:

i. Accord Building Permits/ Occupancy as per KMBR and other prevailing GOs.

In addition to the above, the Superintending Engineer shall also carry out functions assigned by government or Chief Engineer.

2.5 DEPUTY SUPERINTENDING ENGINEER

i. Executive Engineer posted in the Circle Offices shall be designated as Deputy Superintending Engineer.
ii. The Deputy Superintending Engineer shall assist the Superintending Engineer in all official matters and shall be the drawing and disbursing officer for the pay and allowances in the Circle office.
iii. The Deputy Superintending Engineer shall be controlling officer of all other staff in the absence of Superintending Engineer.

2.6 EXECUTIVE ENGINEER (DIVISION)

The Executive Engineer shall be responsible for the proper execution of all public works of concerned LSGI Divisions. For this purpose the EE shall take timely action for the following:

i. Ensure that the project reports are prepared and sanctioned in time.
ii. Approval of all plan projects under his jurisdiction as per prevailing GOs.
iii. Accord TS to projects as per delegation of the powers.
iv. Arrangement of contracts for the LSGI following the prescribed rules in the case of works implemented by him.
v. Inspect the sites during scrutiny of estimates for verification of the correctness of the estimates and adequacy of the provisions and give instructions, wherever required.
vi. Move and obtain possession of land required for the execution of public works of District Panchayat.
vii. Invite tenders as per rules and to make contract arrangements.
viii. Engage adequate staff as per the operational needs of the LSGIs. To supervise and manage these staff to ensure that they carry out the duties adequately and in a professional manner. The rearrangement of staff if any done shall be intimated to the appointing authority.
ix. Inspect works during execution and give instructions wherever required.
x. Arrange periodical payments and monitor expenditure.
xi. Test check 10% of works having value beyond the TS power of Assistant Executive Engineer and to maintain a register for such check measurements.
xii. Submit annual proposals for development, new construction, maintenance or repair of LSGIs assets and public works with all necessary information based on the Procurement, Asset Management and Budget.
xiii. Review progress of works in monthly conferences. Observations shall be recorded in the minutes, which shall be forwarded to all subordinate officers.
xiv. Inspect and approve the foundation of works above the TS power of Assistant Executive Engineer.
xv. Plan in accordance with the schedule of work and to fix the time frame of the project, in respect of contracts entered into by him and Superintending Engineer

xvi. Approve materials, mix design, job mix formulae, etc.

xvii. Record the comments in the work spot order book and circulate the inspection note to all concerned for follow up action.

xviii. Report to the Chief Engineer on old curiosities, relics, coins, minerals and any other item of archaeological importance found on excavation of any ancient masonry or other old work of interest be opened up, or any religious edifice or relic be involved in removal or destruction in the execution of a work.

xix. Should ensure that no tendering of works is done before getting encumbrance free land for a project in the case of agreements executed by him.

xx. To inspect major buildings /structures periodically under his charge

xxi. He shall be responsible for the proper maintenance and upkeep of all structures under the maintenance charge of the Division. In particular, he shall see that.

a. The structures are systematically and carefully inspected by himself or through his subordinates' particularly vulnerable portions thereof.
b. Timely action is taken to carry out essential works to prevent deterioration.
c. Regular maintenance works are carried out at the appropriate time.

xxii. The Executive Engineer shall exercise administrative control over the entire establishment of his Division and regulate the establishment expenditure in accordance with rules and orders in force. He shall also conduct periodical inspections of the Subdivision offices under his control at least once in a year with a view to see that the administration of the subdivision is carried on properly in accordance with rules and/or special instructions. Custodian of Service Books of all Non-Gazetted Staff under his control and timely updation of the SBs.

xxiii. As an ex-officio member of the District Development Council, the Executive Engineer shall keep the council informed about the progress of works and other activities of his Division and also give technical advice on matters connected with works if called upon. He shall keep the Superintending Engineer informed of the decision of the council in regard to matters concerning his Division.

xxiv. In case of emergencies such as serious natural calamities the Executive Engineer shall liaison with the District Collector and other authorities in protecting the life and property under threat or damaged within the limit of his jurisdiction.

xxv. Test check of design, and estimate etc., sanctioned by Assistant Executive Engineer.

xxvi. For all the works implemented by the Executive Engineer, he shall:

a. Ensure quality and environmental aspects.
b. Adopt the relevant quality control measures to ensure the desired quality of work.
c. Ensure proper quality of work as per specifications and for achieving designed life of the structure
d. Ensure that approved materials are used in the work.

xxvii. Wherever necessary the Executive Engineer shall approve the sources or Samples for respective materials.

xxviii. Prepare list of selected contractors for limited tender.

xxix. Submit monthly expenditure statements regarding the expenditure under each head operated by the Chief Engineer.

In addition to the above, the Executive Engineer shall also carry out functions assigned by government or Chief Engineer.

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2.7 EXECUTIVE ENGINEER (CORPORATION)

His responsibilities in addition to the above shall include:

i. Accord Building Permits/ Occupancy as per KMBR and other prevailing GOs.

2.8 EXECUTIVE ENGINEER (MUNICIPALITY HEAD)

The Executive Engineer (Municipalities) shall be controlling a Municipality and has to exercise administrative and technical control under his jurisdiction in order to ensure efficient functioning of the departmental activities in that office. His responsibilities in addition to the above shall include:

i. Accord Building Permits/ Occupancy as per KMBR and other prevailing GOs.

In addition to the above, the Executive Engineer shall also carry out functions assigned by government or Chief Engineer.

2.9 DEPUTY EXECUTIVE ENGINEER

Assistant Executive Engineer posted in the Division shall be designated as Deputy Executive Engineer. The Deputy Executive Engineer shall be the controlling officer of all staff in the absence of the Executive Engineer.

2.10 ASSISTANT EXECUTIVE ENGINEER (SUBDIVISION)

An Assistant Executive Engineer is responsible for the proper execution of all public works in the subdivision. This shall include the following:

i. Approval of all plan projects under his jurisdiction as per prevailing GOs.
ii. Accord TS to projects as per delegation of powers.
iii. Check and approve setting out of works under his jurisdiction.
iv. Inspect and approve foundations of structures as per design within the TS power of AEE.
v. Forecasting the requirements of important materials to be supplied departmentally and make arrangements to procure them according to prescribed rules.
vi. Forecast requirements of various tools and plants for departmental execution.
vii. Conduct soil tests and other tests wherever necessary as per general or special instructions.
viii. Personally supervise all works under the jurisdiction.
ix. Give suitable guidance to subordinates in regard to works under construction.
x. For all the works implemented by the Asst Executive Engineer, he shall:

a. Arrange contracts for the works
b. Watch and take steps to see that progress as per schedule is maintained.
c. Administer the contract to ensure that the terms and conditions are adhered to.
d. Ensure before the start of the work, initial levels and details of material collection reports are furnished to Chief Technical Examiner's office, if required
e. Make payments for the works

xi. To check measure all concealed item of work and in addition 50% value of item of each work which are not concealed, and measured by Assistant Engineer (High value items in descending order). He shall also super check 50% value of each concealed item of work check measured by Assistant Engineer and 10% value of item of each work check measured by Assistant Engineer which are not concealed.

xii. Scrutinise and pass bills as per prevailing rules.

xiii. Take timely actions regarding the approval of deviations from and additions or deletions to the works as per sanctioned estimates, if found necessary during execution.

xiv. Ensure quality of works and compliance with environmental regulations

xv. Adopt the relevant Quality Control measures to ensure the desired quality of work.

xvi. Ensure proper quality of work as per approved specifications and for achieving designed life of the structure.

xvii. If required, furnish details of mandatory tests verified by the Assistant Executive Engineer along with running account bill.

xviii. Assistant Executive Engineer should be present in all major RCC works.

xix. The Assistant Executive Engineer shall also be responsible for conducting proper investigation and scrutinising plans and estimates for new works in accordance with general and special instructions in this regard. This shall include:

a. Giving suitable directions to subordinates regarding information to be collected and nature and extent of survey work to be done.
b. Checking site surveys, levels, nature of soil, sub soil, result of borings and all field data.
c. Verification of the correctness of plans and adequacy of provisions in estimates by site inspection.

xx. For the proper maintenance of structures under his charge, the Assistant Executive Engineer shall :

a. Periodically inspect all the building/ structures, particularly the vulnerable parts in accordance with general or special instructions in this regard.
b. Inform the concerned Local Body for taking timely action for special repairs where these are needed to prevent deterioration of structures under maintenance.
c. Making arrangements for the execution of maintenance works.

xxi. Issuing First time Fitness Certificates for building which require Fitness certificate after remittance of 1.25% of construction cost as supervision fee, on getting receipt of stages of construction of building from the owner in writing.

xxii. The Assistant Executive Engineer shall be responsible for the administrative control of the subordinates in his Subdivision and this shall include the following:

a. See that subordinate staff and labourers are posted in the concerned Sections and if any vacancies exist, take action for the same being filled up while at the same time make interim arrangements for carrying on the work.
b. Periodically examine the adequacy or excess otherwise of subordinate executive staff and labour and take action for posting additional staff or for transfer of surplus staff according to circumstances.
c. Oversee the work of the subordinate staff and see that lapses in regard to proper discharge of duties by any such personnel are dealt with promptly according to rules.
d. See that the subordinate staff and labour are paid their wages/ salary promptly.
e. Custodian of Service Books of all Non Gazetted Staff under his control and timely updation of the service books.

xxiii. Periodically examine whether Government materials, Tools and Plants etc., under control of are properly looked after and where necessary take steps to correct inadequacies.

xxiv. Maintaining accounts as per rules and rendering the required accounts to the Executive Engineer for onward transmission to the Chief Engineer.

xxv. Check and approve bench marks

xxvi. Plan execution in accordance with the schedule of work and to fix the time frame of the project, in respect of agreements entered into by him

xxvii. Check the reinforcement bars placed before concreting works

xxviii. Record the comments in the work spot order book and circulate the inspection note to all concerned for follow up action.

xxix. While setting out works implemented by him, check whether the works proposed are well within the land under the ownership LSGIs.

xxx. Maintain and update periodically the basic documents of properties of Government/ Department

xxxi. Check periodically the log book of the equipments, machineries, plants and vehicles if any.

2.11 ASSISTANT EXECUTIVE ENGINEER (MUNICIPALITY HEAD)

The Assistant Executive Engineer (Municipalities) shall be controlling a Municipality and has to exercise administrative and technical control under his jurisdiction in order to ensure efficient functioning of the departmental activities in that office. His responsibilities in addition to the above shall include:

i. Accord Building Permits/ Occupancy as per KMBR and other prevailing GOs.

2.12 ASSISTANT EXECUTIVE ENGINEER (CORPORATION/ MUNICIPALITY)

His responsibilities in addition to the above shall include:

i. Accord Building Permits/ Occupancy as per KMBR and other prevailing GOs.

2.13 ASSISTANT ENGINEER (GRAMA PANCHAYAT)

An Assistant Engineer posted in control of a section office is responsible for the proper execution of all public works under his jurisdiction. This shall include:

i. While setting out works check whether the works proposed are well within the land under the ownership of concernedLSGI.
ii. Setting out works/ checking the same to see that works are carried out according to approved plans.
iii. Forecasting and reporting the requirements of materials, tools and plant etc. required for works sufficiently early so that they could be arranged for and got supplied in time.
iv. Recording accounts of materials, if any, issued for works
v. Supervising the progress of works and taking steps to remove bottlenecks, if any.
vi. Ensuring, in the case of contract works, that all the conditions of contract are properly observed and taking appropriate action if any of these are violated.
vii. Keeping close watch of departmental works and taking necessary steps for ensuring the effective execution of all works.
viii. The upkeep and maintenance of structures under his charge.
ix. Survey, Investigation and collection of all field data necessary for construction of new works or alterations and additions to existing works or maintenance of existing structures which fall within his jurisdiction.
x. Preparing preliminary as well as detailed estimates and reports for new works, maintenance works and ensuring its correctness and adequacy.
xi. Seeing that subordinate field staffs are well acquainted with their duties.
xii. Controlling and overseeing the work of subordinate staff.
xiii. The safe custody and rendering proper account (as per rules) of cash, materials, scientific instruments, tools and plant etc. entrusted to him or which pass through the section accounts.
xiv. Making arrangements for claiming and disbursing pay and allowances etc., for all subordinate staff and labourers as per rules.
xv. Arranging urgent necessary action in case of an emergency to protect life and Government property.
xvi. Furnishing information required in so far as they relate to his Section, to answer interpellations in the Assembly, Parliament etc,
xvii. Making on the spot enquiries and submitting reports on matters referred to the Assistant Engineer by Government Departments, Courts, Commissions etc.

xviii. Making timely arrangements for disposal of unserviceable or surplus materials, tools and plant, scientific instruments etc.

xix. Preparing and submitting valuation report of buildings and structures, as required.

xx. Adopting the relevant quality control measures to ensure that the quality of work is as per approved specifications so as to achieve designed life of the structure.

xxi. Incorporate details of mandatory tests done with the running account bill, if required.

xxii. Obtain the requirements of the concerned transferred institutions in advance and shall consult them while preparing estimates for public works related to that institutions.

xxiii. Implement/ communicate to the contractor in writing the instructions and orders issued through the work spot order book by the higher officers.

xxiv. Forward progress report of works in the prescribed form

xxv. Plan execution in accordance with the schedule of work and to fix the time frame of the project, in respect of agreements entered.

xxvi. Handover the site to the contractor or the authorised agent within ten days after executing the agreement.

xxvii. Measure and record the reinforcement bars placed prior to casting concrete

xxviii. Check the quality of works and to see that the specifications are properly followed

xxix. Extend/ Recommend application with comments for extension of time of completion if requested by the contractor

xxx. Submit the completion certificate to the higher officers for approval

xxxi. Take over the completed structure/work from the contractor after ensuring that all debris, balance materials, temporary construction etc. are removed and site cleaned up.

xxxii. Hand over the completed assets to the concerned department/ LSGI

xxxiii. Arrange for removal/ demolition of inferior quality work if contractor fails to do so and charging the expenses to the contractor.

xxxiv. To fix rent as per the guidelines prescribed and to furnish in the specified proforma as per delegation of powers.

xxxv. Inspect all buildings /structures periodically under his charge.

xxxvi. Responsible for the verification, receipt, custody and issue of the stock materials

xxxvii. Accord technical sanction for works within the powers of sanction of Assistant Engineer.

xxxviii. To check measure all concealed item of work and a minimum 50% value of item of each work which are not concealed, for works of TS power of Assistant Engineer.

xxxix. Taking and recording measurements of works executed by him and assisting in check measurements / super check measurements. Assistant Engineer is fully responsible for all the measurements recorded.

xl. Obtain quality certificate before submitting work bill, if required.

xli. Prepare detailed programme of execution for projects in consultation with the contractor and ensure its achievements.

xlii. Petty repairs and maintenance shall be arranged by the Assistant Engineers directly engaging labour under proper administrative sanction and technical sanction, if required. Payment shall be made through HR claim.

xliii. Issue annual fitness certificate to buildings which require fitness certificate after remittance of required fees as per prevailing GOs.

xliv. Ensure before the start of the work, initial levels and details of material collection reports are furnished to Chief Technical Examiner's office through the Assistant Executive Engineer, if required

xlv. While issuing permit forbuildings which require Fitness Certificates, on getting receipt of stages of construction of building from the owner in writing.

xlvi. In the case of GramaPanchayaths, inspect all building permits above 300 m2 and give technical report to the LSGI.

xlvii. Ensure that the work files with all supporting documents are submitted to the audit team in time and assist them in site inspection when warranted.

xlviii. Duly verify and submit the reply prepared by overseers for the audit queries within the prescribed time.

2.14 ASSISTANT ENGINEER (MUNICIPALITY HEAD)

The Assistant Engineer (Municipalities) shall be controlling a Municipality and has to exercise administrative and technical control under his jurisdiction in order to ensure efficient functioning of the departmental activities in that office. His responsibilities in addition to the above shall include:

i. Accord Building Permits/ Occupancy as per KMBR and other prevailing GOs.

2.15 ASSISTANT ENGINEER (CORPORATION/ MUNICIPALITY/ SUBDIVISION)

An Assistant Engineer posted in a corporation / municipality/ subdivision is responsible for the proper execution of all public works under his jurisdiction. His responsibilities in addition to the above shall include:

i. Accord Building Permits/ Occupancy as per KMBR and other prevailing GOs.

2.16 ASSISTANT ENGINEER (AS HEAD DRAUGHTSMAN)

An Assistant Engineer posted in Chief Engineer's Office/ Circle Office/ Division is responsible for the proper management of all technical papersunder his jurisdiction.

2.17 OVERSEERS (FGO, SGO &TGO)

When an Overseer is posted for supervision of works carried out on contract, he shall exercise proper care over the execution of the works and in particular attend to the following:

i. Assist the Assistant Engineer for collection of all field data for preparing layout, designs and preliminary estimates.
ii. Prepare detailed drawings based on field data and approved designs.
iii. Assist the AE to prepare detailed estimates as per approved designs, after obtaining instructions on provisions and rates from the Assistant Engineer.
iv. To see that the plans and specifications are followed in the execution of each item of work.
v. Assist in setting out and in checking setting out of the structure.
vi. Check the quality of materials on arrival at site, and to see that the materials comply with the specifications while in use.
vii. To watch the proportion of ingredients in mortars, concrete and bituminous premix, and ensure that they are as per standards specified for the particular item of work concerned.
viii. Check and see that the workmanship in the execution of work is good. Ensure that quality is maintained. Ensure the proper curing for cement works. The work of cement concrete / cement concrete with skin reinforcement shall be done under his direct supervision and ensure quality of all items of works measured by him.
ix. The overseer shall be responsible for ensuring quality of certain items of work like earthwork filling for various purposes, rubble and brick masonry, plastering, road works, and formwork for R.C.C. and foundations of structures and usage of departmental materials as per specification.
x. Ensure that proper care and protection is taken to avoid accidents or danger to workmen and third parties or to adjacent properties as per the safety code.
xi. Monitor that the contractor faithfully observes the general conditions of contract.
xii. In the event of violation of any of the items (iv) to (viii) above, report the matter in writing to the Assistant Engineer immediately and abide by the AEs orders.
xiii. Maintain a work spot order book as per rules.
xiv. Take charge of unserviceable dismantled materials obtained during the execution of the work and arrange for their disposal as ordered by higher officers.
xv. Ensure all safety provisions during the execution of work
xvi. Ensure that all materials at work site are kept in a safe manner.
xvii. Keep in safe custody all scientific and mathematical instruments and tools & plant issued for a work.
xviii. Report the progress achieved at all stages of a work, and shortfall if any, with reasons.
xix. Report completion of fixing of formwork.
xx. Supervise reinforcement work as directed by Assistant Engineer and report its completion.
xxi. Report requirements of tools & plant required for a work in time and keep a watch over the proper use of tools and plant, if any, issued to contractors.

xxii. Carry out any instruction received from higher offices from time to time regarding proper execution of a work.

xxiii. Assist in taking levels and marking of level of structures during execution.

xxiv. Plot the Cross Section (CS) and longitudinal section (LS) sheets and compute quantity of earth work.

xxv. Assist the Assistant Engineer in preparing bills and making payments.

xxvi. Prepare draft letters and reports and put up for the approval of the Assistant Engineer and assist the Assistant Engineer in office works.

xxvii. Furnish details on petitions after proper investigations, sanctions for road cuttings and other similar matters, with detailed site plans, wherever necessary.

xxviii. Bring to the notice of Assistant Engineer, encroachments on LSGI roads/ land.

xxix. Take measurements; prepare plans and detailed calculations for fixing fair rent and valuation of buildings and collection of details of structures for verifying stability, as directed by the Assistant Engineer.

xxx. To inspect and give reports related to construction works for the implementation of projects of other implementing officers of the local body as per prevailing GOs.

xxxi. Take and record measurements of work up to TS power of Assistant Engineer and assisting in check measurements by Assistant Engineer and Assistant Executive Engineer.

xxxii. Carry out any work assigned to him by higher officers.

xxxiii. Affix signature on all documents and records prepared.

xxxiv. Maintaining a record of the out turn of work every day, including issues of departmental materials, if any, and periods of working of departmental machinery, if any. All this information shall be noted down in a work spot order book.

xxxv. Making systematic examination of the various structures under his charge and report the condition and maintenance requirements to the Assistant Engineer.

xxxvi. Supervising maintenance works and keeping accounts of materials used, departmental tools & plant etc, if any.

xxxvii. He shall be responsible for the correctness of the survey work, levelling or any other fieldwork or collection of data entrusted to his charge.

xxxviii. Assist in checking the detailed estimates for works and submit notes for issuing technical sanction or forwarding to higher offices.

xxxix. Assist the Assistant Engineer in inviting tender, prepare tender schedule, acceptance of tender, executing agreement for works, passing bills and making payments and submitting notes for issuing orders.

xl. Prepare bills of works.

xli. Maintain files and registers relating to works and other general files in the office in the absence of the clerk.

xlii. Presenting the work files with all supporting documents to the audit team and assist them in site inspection when warranted.

xliii. Prepare reply for audit queries raised by the audit team within the prescribed time and submit it to the Assistant Engineer.

xliv. Assist the superior officers in field work and submit the documents, reports etc to the higher officer under due authentication by affixing signature.

2.18 OVERSEERS (CORPORATION/ MUNICIPALITIES)

An overseer posted in a corporation / municipality is responsible for the proper execution of all public works under his jurisdiction. His responsibilities will be same as of above.

2.19 DRAFTSMAN (FGO & SGO)

A Draftsman posted in Chief Engineer's Office/ Circle Office/ Division/subdivision is responsible for the proper management of all technical papersunder his jurisdiction.

2.20 MINISTERIAL STAFFS

Administrative Officer

He shall be under the direct control of Chief Engineer Administration & Designs Administration, and shall be responsible for all administrative matters in general. He shall also be responsible for the following:

1. The establishment matters including transfer and posting of all non-gazetted ministerial staff of PWD.
2. To record opinion about members of the staff in their Confidential Reports, prepare the confidential reports of the Superintendents and Administrative Assistants and submit them direct to the Chief Engineer, Administration & Design.
3. To sanction destruction of old records of the headquarters unit as laid down in the Manual of Office Procedure.
4. To dispose off papers of routine nature.
5. To address Government on routine matters and to communicate with Government on all matters on the lines of the Chief Engineer's orders.
6. To address the Accountant General direct in all matters except in cases where the provisions of the concerned Acts or Rules there under require that the orders and instruments have to be signed by the Chief Engineer himself.
7. To organise and distribute work in the headquarters unit in respect of staff whom he in competent to appoint.
8. To conduct fortnightly review of the "Register of Establishment Audit objections" and to conduct monthly inspection of the "Register of Draft Para".
9. To conduct administrative inspection of all offices in the P.W.D. and forward reports with review thereof to the respective Chief Engineer.
10. To sanction TA bills for December and previous months preferred after March of the succeeding years

11.To sanction pension to all officers, whom he is competent to appoint.
12.To sanction reimbursement of medical expenses subject to rules.
13.To countersign TA bills of non-gazetted officers below the rank of Administrative Officer.
14.To exercise the powers of the Chief Engineer regarding temporary withdrawals from Provident Fund Deposits of subordinates in the Department.
15.To correspond with Public Service Commission, Accountant General and other Heads of Departments and Institutions in routine matters such as making interim correspondence, sending reminders, furnishing information etc.
16.To exercise the powers of the Chief Engineer in the matters of loans, Cycle advance, advance for the purchase of motor car/cycles, mosquito nets etc. according to rules.

Administrative Assistants

The Administrative Assistant shall assist the Chief Engineer (Administration & Design)/ Superintending Engineer in managing establishment matters. He is also responsible for:

1. Guiding and controlling the work of all ministerial staff in the office to ensure that business rules/Manual of Office Procedure are properly observed.
2. Reviewing the work of the section heads under his control to see that they carry out the work systematically and promptly.
3. Ensuring prompt action being taken on important and urgent matters and where necessary bringing such cases personally to the notice of the Chief Engineer/Deputy Chief Engineer/Superintending Engineer/ Administrative Officer.
4. Examining relevant documents and notes and issuing orders of purely routine matters subject to general or special instructions of Chief Engineer/Deputy Chief Engineer/ Superintending Engineer/ Administrative Officer.
5. Making temporary arrangements for carrying out the work on subordinate ministerial or Class IV officers who may be absent, on leave etc.
6. Maintaining order and discipline in the office, in accordance with instructions of Chief Engineer/Deputy Chief Engineer/ Superintending Engineer/ Administrative Officer.
7. Seeing that registers, books, accounts etc. as per prescribed rules are maintained and kept up-to-date and to checking accuracy of postings at intervals.
8. The safe custody of documents and other valuables entrusted to his care.
9. Scrutinizing files, notes etc. on matters requiring orders of higher authority and putting up such cases promptly with his own remarks.
10. Yearly preparation of list for each categories of staff for transfers and postings according to transfer norms
11. Preparing monthly list of vacant posts in each categories for filling up vacancies by promotion or by posting through PSC or posting through employment exchange
12. Ensuring safe custody of office furniture and maintenance of accounts, thereof.
13. Exercising supervisory control over the custodians of typewriter, Furniture, stationery and other valuables in Chief Engineers Office and circle office.

14. Carrying out any other duties specifically assigned to him by superior officers.

Senior Superintendents

Senior Superintendent shall be the head of Establishment Branch in accordance with the procedure prescribed in the Manual of Office Procedure and shall assist in the administrative control of the ministerial staff working in that section. Their responsibility shall include

1. The marking of the papers received in the Establishment Branch to the concerned clerks and ensuring that the papers are duly delivered to the clerks concerned.
2. The scrutiny of the papers and files attended to by the clerks in their section.
3. Putting up notes on matters requiring orders of superior authorities.
4. The scrutiny of personal registers and such other register needed for the prompt business transactions of office in the manner detailed in the Manual of Office procedure and KPWA Code.
5. Receiving tapals and putting up to Deputy Executive Engineer /Executive Engineer /Deputy Chief Engineer.
6. Making alternate arrangements to distribute the works due to the temporary absence of a subordinate employee with the approval of head of office.
7. Ensuring prompt action being taken on urgent matters.
8. Ensuring the orderly arrangements of files, registers etc., by the clerks to enable any file being traced out without much difficulty.
9. Periodically reviewing the old files and records with a view to close them as per rules laid down in the manual of office procedure.
10. Controlling the work of Class IV staff.
11. Carrying out any other duties specially assigned to them by superior officers.

Junior Superintendents

Junior Superintendent shall be the head of Establishment Branch, if there is no post of Senior Superintendent in an office. Their responsibilities as head of the Establishment Branch shall be the same as that of Senior Superintendent. Their duties shall include

1. Safe custody of chequebooks and preparing cheques on passed bills.
2. Ensuring the safe custody of cash and other valuables and documents entrusted to their care by head of office, proper remittance of cash to the treasury, and maintenance of cashbook and other accounts in the proper form as per rules.
3. The scrutiny of personal registers and such other registers needed for the prompt business transactions of office in the manner detailed in the Manual of Office Procedure and KPWA Code.
4. Scrutinising contractor's bills. This shall include checking arithmetical calculation, checking MAS account, WBO's, Works Abstract, Contractors' Ledger and Checking quantities with schedule provisions.

5. Assisting the Deputy Executive Engineer, in preparation of works budget, and establishment budget performance budget, Revised budget and re-appropriation of funds.
6. Bringing to the notice of the Deputy Executive Engineer /Executive Engineer, power of attorney relating to a work.
7. Maintenance of registers relating to MAS account, Survey Report, Work Abstract and contractors Ledger.
8. Scrutinising survey reports.
9. Overseeing the preparation of monthly accounts.
10. Preparation of schedule of settlement with treasuries.
11. Initiating action on audit notes of Accountant General.
12. Any other work entrusted by his superior officers.

Head Clerk

He shall be responsible for:

i. The distribution and scrutiny of the work of each Clerk
ii. The scrutiny of bills and files attended to by the Clerks, submission of returns on the due dates, maintenance of accounts etc.
iii. Ensuring that cash deposits other than cash, and other valuables are kept in safe custody and the cash book and other records as prescribed in the rules are properly maintained.
iv. Disbursing salaries and allowances to the staff
v. The Head Clerks shall also carryout any other work assigned to them by their superior officers.

A Head Clerk when posted in a Sub Division shall in addition to the above be responsible for:

vi. Receiving tappals and putting up to the Assistant Engineer (Works), if such an officer is posted or to the Assistant Executive Engineer.
vii. Safe custody of power of attorney/bank guarantee relating to a work and bringing to the notice of the Assistant Executive Engineer while passing bills.
viii. Preparing cheques on passed bills.
ix. Safe custody of furniture of sub division office.
x. Assisting the Assistant Engineer (Works) and the Assistant Executive Engineer in maintaining order and discipline in office.
xi. Handing over cash and all other items in his custody on transfer as directed by the Assistant Executive Engineer.
xii. Assisting the Assistant Executive Engineer and Assistant Engineer (Works) in all matters entrusted to him.

Upper Division Clerks & Lower Division, Clerical Attender

Clerks shall carryout any or all the ministerial duties involved in the business transactions of the office to which they are attached as prescribed in the Manual of Office Procedure. The actual scope of their work in any office will be decided by the head of the ministerial section with the approval of the head of office or subordinate officer entrusted with the responsibility. Clerks (LD clerks and UD Clerks) in the PWD Office will also function as accountants. The responsibilities of clerks shall, include:

i. Maintaining files and registers up-to-date.
ii. Safe custody of registers, files, papers, documents, books or any other valuables entrusted to their care.
iii. Putting up papers including correspondence files, connected files, notes etc., for orders of competent authority without delay.
iv. Bringing to the notice of the superior officer matters that need special attention.
v. Taking prompt action on unanswered references by issue of timely reminders, putting up draft, Demi Official letters etc.
vi. Carrying out the accounting work in the office such as checking bills, posting of accounts, maintaining various account registers, compiling returns etc., as prescribed in KPWA Code and other Codes, when posted in the accounts branch.
vii. Handling and safe custody of cash, timely remittance of cash to Treasury, maintenance and rendering of prescribed account etc., as per rules.
viii. Carrying out any other duties of a ministerial nature assigned to them by superior officers.

Clerk when posted in a section office shall be responsible for:

i. Receiving tappals and assisting the Assistant Engineer in all matters entrusted to him.
ii. Maintaining inward and despatch registers.
iii. Putting up audit notes for passing bills within powers of the section officer.
iv. Safe custody of agreements executed for works, deposits other than cash and imprest cash allotted to Assistant Engineer.
v. Safe custody of power of attorney/bank guarantee relating to a work and bringing to the notice of the Assistant Engineer while passing bills.
vi. Safe custody of cash received in section office and timely remittance to the treasury.
vii. Keeping under lock & key, field books and measurement books issued to the section office and maintaining movement register.
viii. Receiving all cheques issued to the Assistant Engineer
ix. Disbursing salaries, allowance, advance etc. relating to the staff of section office.
x. Assisting the section officer in maintaining imprest and other accounts..
xi. Handing over files, registers, cash, service books and other valuable items in his custody while on transfer as per directions of the Assistant Engineer.

xii. Preparing draft letters on all matters and putting up for approval of the Assistant Engineer.

xiii. Posting entries in Service book and keeping the same.

Confidential Assistant

Duties as per Manual of Office Procedure

Typist

Duties as per Manual of Office Procedure

Clerk/Typist

Duties as per Manual of Office Procedure

Fair Copy Superintendent

Duties as per Manual of Office Procedure

Driver

Their duties will include:

1. Drive the vehicles carefully within the prescribed speed limits observing all the traffic regulations.
2. Keep the vehicles in road worthy condition. This will include washing and cleaning of vehicles.
3. Check water levels in radiator and battery, oil level in crankcase, fuel level in fuel tank and tyre pressures every day before the vehicle is taken out.
4. Once a fortnight check oil level in gearbox and brake fluid.
5. Report any mechanical fault or damage immediately to controlling officer or the officer in-charge. Attend to routine maintenance as prescribed such as topping up of oil, filling radiator, cleaning of oil and fuel filters, inflating tyres, applying grease where required, etc.
7. When the vehicle is taken out for servicing point out any items needing special attention and be available at the servicing station or work- shop to see that servicing is done properly.
8. When the vehicle is taken for maintenance or for special repairs, assist in the completion of the repairs or carry out such other jobs as are ordered to be done by the officer in charge of the vehicle.
9. In case of accidents the driver shall report the matter to the nearest police station and the officer in charge of the vehicle and abide by instructions of the police in regard to further movement of the vehicle.
10. Be in charge of the tools and spares of the vehicle entrusted to him.
11. Keep account of materials like fuel, lubricating oil etc. entrusted to his care.
12. Maintain log books as prescribed.
13. Take order from the officer in charge of the vehicle in regard to trips to be made, passengers or materials to be carried etc.
14. Intimate in advance the date of renewal of tax, insurance, pollution test, fuel tests etc.
15. They will also carry out any other duties that may be specifically assigned to him by their superior officers.

Peon:

Duties as per Manual of Office Procedure

KERALA STATE RURAL ROAD DEVELOPMENT AGENCY (KSRRDA)

It is the nodal office under **Local Self Government Department (LSGD)** having overall responsibility for the implementation of PMGSY in the State.

2.21 CHIEF ENGINEER (KSRRDA)

The Chief Engineer (KSRRDA) shall manage through a dedicated Project Management Unit (PMU) in the SRRDA. He is the Chief Technical officer of KSRRDA.It shall be the responsibility of Chief Engineer to ensure that the functions relating to his wing are carried out efficiently. For this purpose he shall among other things arrange to:

i. Ensure that policies of both Central and State governments in regard to development programmes are implemented in a timely manner.
ii. Plan, organise and co-ordinate works based on budget allocations.
iii. Advise government on all technical matters under his control referred by the government.
iv. Give timely instructions and guidance to subordinate officers on various matters.
v. Inspect work sites which require his guidance or instruction, record the comments in the work spot order book and circulate the inspection note to all concerned for follow up action.
vi. Accord Technical sanction for all works under his control.
vii. Inviting tenders through Website/print media and arranging contracts of all works, supplies etc, in accordance with rules and for all prequalification works Ensure that works being tendered has sufficient fund allocation.
viii. Exercise administrative, financial and technical powers delegated to him.
ix. Accepting variation of not more than 10% between the amount cleared and Technical Sanction and excess can be absorbed within the sanctioned amount of the district, and failing that, within thesanctioned amount of the State.
x. See that the rules regarding accounting and financial control at various levels are properly enforced
xi. Prepare details for answering legislative assembly questions, submissions and budget speech for the government.
xii. Monitoring the progress of work and the appropriate corrective stepswherever required.
xiii. Periodically review and monitor the quality control system.
xiv. Participate in meetings of Government Tender Committee.
xv. Take timely action in filling the vacancy of all Technical officers in the department.
xvi. Review the performance of SQMs in accordance with NRRDA guidelines and submit the reports to higher-ups for appropriate action.
xvii. Review the status of updating of DRRP,CUCPL and PCI survey regularly.

In addition to the above, the Chief Engineer will also carry out such other functions assigned to him by government by virtue of any act or rules.

2.22 SUPERINTENDING ENGINEER (KSRRDA)

Superintending Engineershall assist the Chief Engineer in achieving Technical perfection of PMGSY implementation with due responsibility.The Superintending Engineer's responsibilities shall include:

i. Issue of appropriate instructions in regard to investigation for new works wherever necessary.
ii. Shall take timely initiation in formulation of new proposals, its timely approval by STAs, NRRDA and finally by MoRD.
iii. Giving guidance in the matter of design to be followed for works of a complicated nature.
iv. Obtain the DPR of original works from the Executive Engineer and process the DPR within his powers and submit to the Chief Engineer if exceeding his powers of Technical sanction.
v. Scrutinizing estimates and revised estimates, supplemental estimate and sanctioning them or seeking sanction thereof after verifying through site inspection the correctness and adequacy for the proposal within his powers and submit to the Chief Engineer if exceeding his powers of Technical sanction.
vi. Periodically inspecting all important works and also the works, which require his guidance in the matter of execution; Inspections shall be purposeful and shall cover examination of quality, progress, difficulties in execution etc.
vii. Inspecting the Division offices annually with a view to ensure that the work of the Divisions is carried out efficiently.
viii. Giving technical advice or opinion on matters referred to him by Government, heads of department etc.
ix. He shall hold quarterly conference with Executive Engineers under his control to review the progress of various works record and circulate the minutes and report to the Chief Engineer so as to accomplish the completion of works in time.
x. Suggesting measures for improving the technical and administrative efficiency of the department taking into account the technical development, which has taken place and other relevant matters.
xi. Forward the cases to be placed before the Government Pleader/Standing Empowered Committees with relevant Performa details and sufficient number of copies of notes etc. to the Government.
xii. To conduct an independent quality assurance and technical audit of works
xiii. To suggest remedial action required to rectify the defects mentioned in the Inspection Report of Quality Control Cell.
xiv. To initiate action against contractors doing inferior quality works based on the report of the Quality Control team.

xv. To conduct technical audit in files in respect of all Divisions under the circle every year and also check the bills finalized during the last year.

xvi. To review functioning of the field testing laboratories and suggest remedial measures for improving the standard of their performance.

2.23 STATE QUALITY COORDINATOR (SQC)

The Agency should appoint a Senior Engineer (not below the rank of Superintending Engineer) to function as State Quality Coordinator (SQC) at the state level. His function will be to oversee the satisfactory functioning of Quality Management mechanism within the State.

i. This would also involve overseeing the follow up action on the reports of the NQMs.

ii. Supervise the first tier Quality Management arrangement.

iii. The 2nd tier Quality Management will be headed by the State Quality Coordinator (SQC).

iv. Coordinate and control the activities of State Quality Monitoring arrangement (the 2nd tier), and ensure compilation by PIUs of action on the reports of State Quality Monitors. (SQM)

v. Facilitate and coordinate the activities of the National Quality Monitoring arrangement (the 3rd tier) and ensure compilation by PIUs of action on the reports of National Quality Monitors.

vi. Prepare monthly abstracts of SQM visits and an Annual Quality Report based on the Reports of SQMs and NQMs, Identifying systemic and procedural deficiencies in the Quality Management System and submit the Report for the consideration of the SRRDA and the State Level Standing Committee.

vii. To assess training requirements at PIU level and to arrange for and coordinate training programmes in coordination with STAs.

viii. To act as nodal point for request of public complaints and for taking action thereon. The State Quality Coordinator/Head of PIU shall be the authority to receive and inquire into complaints/

ix. Representations in respect of quality of works and they would be responsible for sending a reply, after proper investigation, to the complaint. The State Quality Coordinator shall register all complaints and will get them enquired into by the PIU or if circumstances so require, by deputing a State Quality Monitor.

x. The SQC should examine the reports with regard to their adequacy and counsel SQMs in case of deficiency.

xi. The State Quality Coordinator should send the Monitor's reports to the Project Implementing Unit with a copy to the SE. Compliance reports to the SQC should be routed through the CE/SE. All cases of delay in reporting compliance and major cases of deviation from acceptable quality standards should be taken seriously.

xii. Each month, the SQC will compile an abstract of the SQM visits giving the District-wise grading and send copies to the DPIU, CE, Nodal Department and NRRDA in the prescribed Format

xiii. The State Quality Control Coordinator should send an Annual Report to NRRDA through the State Nodal Agency comprising the analysed performance of the State Quality Monitoring System in a prescribed format. The analysis should include the SQM reports, NQM reports, Action taken in individual cases and systemic deficiencies detected and remedied.

xiv. The State Quality Coordinator will be the State Rural Road Safety Officer and shall ensure:

xv. Adequate coordination with the State Road Safety Council and road safety programmes.

xvi. Formulation of rural road safety awareness programme proposals (for funding under PMGSY).

xvii. Implementation and coordination of rural road safety awareness programmes in the field.

xviii. Hold quarterly meeting with DRRSO and take feedback for improving safety standards.

2.24 EXECUTIVE ENGINEER (R&D)

The Executive Engineer shall be responsible for the proper execution of all works under his charge. For this purpose he shall take timely action for the following:

i. Ensure that the R&D project reports are prepared and sanctioned in time.

ii. To forecast and take steps to procure required materials and tools and plant for departmental work and for meeting departmental obligation in contract work in the R&D projects.

iii. To inspect works during execution and give instructions wherever required in the R&D project.

iv. To submit annual proposals for R&D projects

v. To consolidate progress report of works in his division to the Chief Engineer and Superintending Engineer before 15th of every month in the R&D projects.

vi. To check and submit the workable rate for the departmental execution in the R&D projects.

vii. To submit initial social assessment checklist along with all proposals for works to be reviewed

viii. Ensure quality and environmental aspects of all R&D projects.

ix. Ensure that approved R&D materials are used in the work.

x. Wherever necessary the Executive Engineer shall approve the sources or Samples for R&D materials

2.25 ASSISTANT EXECUTIVE ENGINEER

i. Controlling and overseeing the work of subordinate staff.
ii. Scrutiny of estimates and Revised Estimates: Any modification in the provisions in an estimate received from the subordinate office shall be made only after the specific orders of the head of the office.
iii. Scrutiny of Application for time extension: Any application for time extension shall be made only after the specific orders of the head of the office.
iv. To recommend application for extension of time of completion requested by the contractor
v. Submission of tenders to higher authorities.
vi. Scrutiny of tenders.
vii. Any other work entrusted by the head of office.
viii. Checking tender schedules and agreements.
ix. Checking tabulations of tenders.
x. Formulation and scrutiny of DRRP, CUCPL and DPR of Projects
xi. Assisting in Administrative and Technical sanction.
xii. Accuracy of Designs and estimates submitted for approval.
xiii. Monthly progress statement of ongoing projects and maintenance projects with up to date status and issues to facilitate the review.

2.26 ASSISTANT ENGINEER

i. Controlling and overseeing the work of subordinate staff.
ii. Sorting out various issues in formulation and scrutiny of DRRP, CUCPL and DPR of Projects.
iii. Making on the spot enquiries and submitting reports on matters referred to the Assistant Engineer by superior officers.
iv. To recommend application for extension of time of completion requested by the contractor
v. Scrutiny of estimates: Any modification in the provisions in an estimate received from the subordinate office shall be made only after the specific orders of the head of the office.
vi. Scrutiny of Application for time extension: Any application for time extension shall be made only after the specific orders of the head of the office.
vii. Checking of initial and final level calculations.
viii. Submission of tenders to higher authorities.
ix. Scrutiny of tenders.
x. Ensure the accuracy of all estimates as per the approved SOR.
xi. Any other work entrusted by the head of office.
xii. Prepare the monthly physical progress and compare with OMMAS and submit for periodical review.
xiii. Shall assist SQC in quality aspects.
xiv. Shall assist in Research and Development projects.

2.27 FIRST GRADE DRAUGHTSMAN

i. Assist in checking the detailed estimates for works and submit notes for issuing technical sanction or forwarding to higher offices.
ii. Assist the Assistant Engineer in inviting tender, prepare tender schedule, acceptance of tender, executing agreement for works etc
iii. Check plotted sections and surveys received with field book entries including checking reduction of levels.
iv. Prepare draft letters and reports.
v. Carryout any other work that may be specifically assigned to him by Assistant Engineer and other superior officers.
vi. Preparation of tender schedule, tabulation of tenders.
vii. Submission of tenders to higher authorities.
viii. Scrutiny of tenders.
ix. Preparation of agreement documents.
x. Maintenance of files for items of work entrusted to technical branch and work files
xi. Checking of initial and final level calculations.
xii. Maintenance of various registers relating to work, agreement etc
xiii. Correspondence on all technical matters and works
xiv. Any other work entrusted by the head of office.

DISTRICT PROGRAMME IMPLEMENTATION UNITS (DPIUs)

The Programme Implementation Units (PIU) are the basic units for project planning, execution and accounting. The PIU would be directly responsible for contracting implementation and Quality Management of PMGSY works. The PIU would also be the financial and accounting centre at the field level.A PIU is headed by an Executive Engineer, assisted by Assistant Executive Engineer and First Grade Overseer.

2.28 EXECUTIVE ENGINEER (PIU)

i. The Executive Engineer shall be responsible for the proper execution of all works under his charge.
ii. Prepare, check and certify the accuracy of the provisions in the Detailed Project Report with Rural Road manual and instructions issued from time to time.
iii. Consultation with the local community through the mechanism of the GramaPanchayatinorder to determine the most suitable alignment, sort out issues of land availability including forest land, etc.
iv. To inspect works during execution and give instructions wherever required.
v. To review the progress of the work monthly in the PMC meeting chaired by Collector.

vi. TheRuralRoadsconstructedunder PMGSY-II mustmeetthetechnicalspecificationsandgeometricdesignstandards givenintheMoRD's Specifications for Rural Roads.

vii. Forwarding the proposals after approval by the District Panchayath to Hon'ble Member of Parliaments in the requisite formats.

viii. Vetting the new proposals from State Technical Agencies both online and offline in OMMAS by forwarding the annual proposals along with Detailed project Reports for scrutiny of the design and estimates. Ensure that the project reports are prepared and sanctioned in time.

ix. Monitor the works and complete the work within the agreed time from the date of issue of the work order.

x. Ensure that all the materials utilised and the workmanship in execution conform to the prescribed specifications. As the first tier, the EE will supervise the site quality control laboratory set up by the contractor. It shall also ensure that all the tests prescribed are carried out at the specified time and place by the specified person/ authority.

xi. He shall be responsible for the proper maintenance and upkeep of all structures under the maintenance charge of the Division.

xii. Preparation of District Rural Road Plan(DRRP), ComphrehensiveUpgrdationcum Consolidation Priority List and updating the same using PCI survey.

xiii. Ensuring proper management of the DPIU computers and peripherals including the software, data backup etc.

xiv. Supervising data entry in all modules of the OMMAS and ensuring in particular that the payment and fund flow module is working satisfactorily.

xv. Using the PMGSY email system at PIU level and liaising with the NIC's DIO and the IT Nodal Officer on all aspects.

xvi. Printing monthly quarterly MIS outputs and forwarding them to the IT Nodal officer along with his comments on the reliability of the data.

xvii. Facilitate Members of Parliament in knowing the status of implementation of the road works in their areas in case they visit their District.

xviii. During maintenance period the following are the duties:

a) The Executive Engineer shall inspect the road at least once in six months. One of the inspections of the Executive Engineer shall be before the monsoons and one after the monsoons.
b) Inspection and recording of observations
c) Planning and finalizations of nature of maintenance activity e.g. surface renewal, repair to CD works etc.
d) Arranging men, materials and machinery in advance as per requirements.
e) Finalising action on reports of Assistant Engineers and also on safetymeasures, diversion in case of breaches and flood damages

f) Coordination with various agencies like traffic police, local administration, publicity media etc., in case of emergent repairs, interruption to traffic by road blockage, etc.

g) Initiate steps for finalizing permanent restoration work.

xix. To inspect the sites during scrutiny of estimates for verification of the correctness of the estimates and adequacy of the provisions and give instructions wherever required.

xx. To move and obtain possession of land required for the execution.

xxi. As the disbursing officer of the Department in regard to works, supplies and services under his charge, he has to exercise proper control over the expenditure on these items in accordance with the rules and orders in force and render proper accounts for the same to the Accountant General in the prescribed manner.

xxii. The Executive Engineer shall exercise administrative control over the entire establishment of his Division and regulate the establishment expenditure in accordance with rules and orders in force.

xxiii. Adopt the relevant quality control measures to ensure the desired quality of work.

xxiv. Ensure proper quality of work as per specifications and for achieving designed life of the structure

xxv. Ensure that approved materials are used in the work.

2.29 ASSISTANT EXECUTIVE ENGINEER (PIU)

i. To give all assistance and support to the Executive Engineer.

ii. Check and approve setting out of works.

iii. Conduct soil tests and other tests wherever necessary as per general or special instructions.

iv. Personally supervise all works under his jurisdiction.

v. Give suitable guidance to subordinates in regard to works under construction.

vi. Watch and take steps to see that progress as per schedule is maintained.

vii. Administer the contract to ensure that the terms and conditions are adhered to.

viii. To check measure all concealed item of work

ix. Ensure before the start of the work, initial levels and details of material collection reports are furnished to Chief Technical Examiner's office

x. Ensure quality of works and compliance with environmental regulations

xi. Adopt the relevant Quality Control measures to ensure the desired quality of work.

xii. Ensure proper quality of work as per approved specifications and for achieving designed life of the structure

xiii. Furnish details of mandatory tests verified by him along with running account bill.

xiv. Assistant Executive Engineer should be present in all major RCC works.

xv. The Assistant Executive Engineer shall also be responsible for conducting proper investigation and scrutinising plans and estimates for new works in accordance with general and special instructions in this regard. This shall include giving suitable

directions to subordinates regarding information to be co1lected and nature and extent of survey work to be done.

xvi. Checking site surveys, levels, nature of soil, sub soil, result of borings and all field data.

xvii. Verification of the correctness of plans and adequacy of provisions in estimates by site inspection.

xviii. To check the reinforcement bars placed before concreting works

2.30 FIRST GRADE DRAUGHTSMAN (PIU)

Assist the Executive Engineer and Assistant Executive Engineer in all works starting from preparation of DRRP, DPR, execution and maintenance of works, preparation of bills and taking measurements etc.

DELEGATION OF POWERS

1. Administrative Powers

Sl. No.	Nature of powers	Chief Engineer	Superintending Engineer	Executive Engineer	Assistant Executive Engineer	Assistant Engineer	Administrative Officer	Remarks
1.	Creation of posts	Part time contingency post & make appointments						
2.	Appointments subject to PSC rules of Sanctioned posts	CE to make appointments up to lowest gazetted post	Upto lowest Gazetted Posts in circles (temporary)	Upto lowest Gazetted Posts in offices under the Division (temporary)				
			Menials charged to office contingencies					
3.	Transfers and postings	All officers whom he is competent to appoint	All NGOs & AEs within the circle (temporary with ratification to the Appointing Authority)	All NGOs within the Division(temporary with ratification to the Appointing Authority)	All NGOs within the subdivision(temporary with ratification to the Appointing Authority)	Assign duties of overseers under his control	Within the headquarters Unit with the consent of the Chief Engineer	
		Post any officer whom he is competent to appoint for special duty for a period not exceeding one year..	Post all non-gazetted officers working under him on working arrangements for a period not exceeding six months.	Same as SE but for a period not exceeding three months				
		Provided the strength in the cadre is not exceeded, no special allowance is payable on account of the special duty. Postings in gazetted cadre						

		shall be intimated to government The officer ordering working arrangement is authorised to order payment of TA and meet the MO charges for sending their pay, as and when found necessary.						
		To detach officers whom he is competent to appoint from one office and fix another office as their headquarters on working arrangements for a period not exceeding six months in exigencies ofpublic service.						
		Fix the headquarters andjurisdiction of all section offices including individual works	Recommend removals and transfers of Divisional and Sub divisional Officers from his Circle					
4.	Sanction of Leave	Casual leave to all subordinate officers.						
		Surrender of earned leave, subject to eligibility, to all officers working under him.						
		All kinds of leave except study leave, leave without allowance exceeding 120 days and special disability leave to all officers and staff under him						CE to sanction charge allowance for additional charge as per rules
5.	Impose minor punishment on any officer serving under him	Other than Superintending Engineers or officers of equivalent rank.	Other than ExecutiveEngineers.	Other than Asst.Executive Engineers	Other than Assistant Engineers	AnyNon-gazettedofficer Workingunder him.		Powers subject to Kerala Services Rules
		Dismiss, degrade, suspend, effect recovery from pay, discharge and retire under rules, or to accept resignation of any officer whom he is competent to appoint.				Suspendany non-gazetted officersworking underhim		Subject to KeralaServices Rules andother rules laid downby Government fromtime to time
6.	Sanction of Tours for subordinate staff	Within the country, except forjourney by air	Within the state and in theadjoining districts of neighbouring states	Tourwithin the state.	Tour within Hisjurisdiction	Tourwithin hisjurisdiction		Journey outside the state for CEs require Govt. sanction. All journeys by air also require Govt.

								sanction
	No separate sanction is required for sanctioning travelling allowance to an officer for journey outside jurisdiction undertaken on the orders of competent authority. Attendance certificate shall be produced by non-gazetted officers. CE to sanction the cancellation charges already incurred by an officer for journey approved by the Chief Engineer and subsequently cancelled for valid reasons.							
7.	Provident Fund	Sanction temporary withdrawals from provident fund deposits withoutmonetary limit &nonrefundable withdrawals from PF upto 3/4th of the balance at the credit of the subscriber	Sanction NRA equal to an amount of Rs 1 lakh or ½ the amount standing to the credit of subscriber or 5 times basic pay, whichever is less	Sanction NRA equal to anamount of Rs 75,000 or ½ theamount standing to the credit of subscriber or 5 times basic pay, whichever is less.	Sanction NRA equal to anamount of Rs 50,000 or ½ theamount standing to the credit of subscriber or 5 times basic pay, whichever is less.		To countersign and forwardapplications for admission to Provident Fund frommembers of staff of theheadquarters and Sanctiontemporary withdrawals from providentfund deposits without monetary limit to hissubordinate officers	Subject to conditions and limitations under GPF(Kerala) Rules
8.	Increments	To execute agreement in respect of advance sanctioned and to execute agreements and reassignments of Insurance policies offered as collateral security to all officers under hisadministrative control.	Deputy CE shall sanction increments to all non-gazetted staff in the Circle. To fix pay of all nongazetted officers	Sanction increments to all nongazetted staff in the Division. To fix pay of all non-gazetted officers.	Sanction increments to all nongazetted staff in the Division and Subdivision. To fix pay of all non-gazetted officers.		To fix pay of all nongazetted officers.	DCE admin to sign Increment Certificates of non-gazetted technical staff of the headquarters unit
9.	Advance TA	Sanction advance TA, 15 daysbefore the actual journey	Nil	Nil	Nil	Nil	Nil	

10.	Sanction Reimbursement of medicalexpenses	To all subordinate officers	Nil	Nil	Nil	Nil	Nil	Subject to Govt ServantsMedical Benefit Rules.
11.	Investigation of arrear claims	To sanction investigation of arrear claims including claims which cannot be verified by audit due to limited period of preservation						
12.	Training facilities to officers	To depute technical hands to seminars, short term coursesand for study purposes withinIndia.						Training programme shall be monitored by HRD Cell.
13.	Sanction shifting of telephones	To sanction shifting of or disconnection of the phones in his jurisdiction						
14.	Sanctioning of TA bills	To sanction TA Bills of all staff working under him and his TA Bills	To sanction TA Bills of all staff working under him.				Countersign TA bills of nontechnical Gazetted Officers in the headquarters unitbelow the rank of the Administrative Officers	TA Bills shall be sanctioned within 15 daysafter receipt and keptready for payment

2. Financial Powers

		Chief Engineer	Superintending Engineer	Executive Engineer	Assistant Executive Engineer	Assistant Engineer	Remarks
1.	**Administrative Sanction**	Nil	Nil	Nil	Nil	Nil	Administrative

							Sanction accorded by the respective local bodies or government
2.	**Technical Sanction**						
	(i) Original, maintenance and investigation & contribution	Unlimited	Rs. 200 Lakhs (Annual Plan) Rs. 100 Lakhs (Roads) Rs. 250 Lakhs (Buildings)	Rs. 45 Lakhs (Annual Plan) Rs. 50 Lakhs (Roads) Rs. 100 Lakhs (Buildings)	Rs. 15 Lakhs	Rs. 1 lakh	
	(ii) Electrification/ Electronics works	Unlimited	Rs. 50 lakhs	Rs. 20 lakhs	Rs. 200000	Rs. 15,000	
3.	**Sanction for Purchase, Manufacture and Repairs of Stores including T&P**						
	(i) Sanction for purchase of T&P charged to work	Rs. 15 lakhs	Rs. 10 lakhs	Rs. 5 lakhs	Rs. 100,000	Rs. 15,000	
	(i) Sanction for purchase of T&P not charged to work (Excluding Motor Vehicles)	Rs. 15 lakhs	Rs. 10 lakhs	Rs. 5 lakhs	Rs. 100,000	Rs. 15,000	
	(iii) Sanction for materials other than T&P	Unlimited	Rs. 10 lakhs	Rs. 5 lakhs	Rs. 100,000	Rs. 15,000	
	(iv) Sanction for purchase of Stock articles T&P required for electrical/ electronic works	Unlimited	Rs. 3 lakhs	Rs. 100,000	Rs. 25,000	Rs. 5,000	
	(v) Sanction for repairs of Motor Vehicles	LMV Rs. 50000 others Rs. 50000	LMVRs. 30000 others Rs. 40000	LMV Rs. 10000 others	Rs. 15,000	LMV Rs. 3,000 othersRs. 4,000	AE LMV Rs. 1,000
	(vi) Sanction for repairs and carriage of T&P	Unlimited	Rs. 7 lakhs	Rs. 200,000	Rs. 25,000	Rs. 5,000	
4.	**Sanction of Survey Reports**						
	(i) For disposal of stores	Unlimited	Rs. 5 lakhs	Rs. 200,000	Rs. 50,000	Rs. 10,000	
	(ii) For disposal of buildings	Unlimited	Rs. 50 lakhs	Rs. 25 lakhs	Rs. 5 lakhs	Nil	
	(iii) unserviceable articles including T7P and improvements in acquired	Unlimited	200000	100000	50000	50000	Go (P) no. 128/PW Dated17.6.1968

	lands and trees (both living and dead)						

PART – II

WORK METHODOLOGY

SECTION- 4

4. PROJECT FORMATION

Working Groups formed by the LSGI shall prepare a draft project proposal on public works after reviewing Status Report and recommendations of the Grama Sabha. Relevant points on the proposals shall to be presented in stakeholder discussions and Development Seminar conducted by the LSGIs. Standing Committee concerned shall discuss all dimensions of the proposal and submitting the same with suitable recommendations to the General Committee of the LSGI.

The LSGI shall approve the final list of Projects after reviewing its priority for which estimate has to be taken by the Implementing Officers concerned. The list shall be given to the Implementing Officer without any delay, so that the officer can conduct a site inspection and prepare estimate and projects and submit it to the DPC in time, after getting vetted by the concerned Vetting Officer. The Implementing Officer shall ensure all the public works are done as per rules and instructions issued by the government and in compliance with the guidelines of the particular scheme. The execution of public works of Central or State government schemes shall be done as per the guidelines issued by the Central or the State Government in this regard.

SECTION- 5

5. INVESTIGATION AND DESIGN

5.1 GENERAL

It is most important that every work shall be properly investigated and all relevant data collected and correlated before finalizing the design and estimate for the work. Wrong choice of site or designs based on incorrect or insufficient data can result in considerable avoidable expenditure and delays. Hence maximum attention shall be given to investigation and furnishing of full and correct field data required. Modern equipments shall be used as far as possible.

Investigation may often have to be carried out in two phases; viz. preliminary investigation and detailed investigation. In the preliminary investigation phase, various alternative sites or alignments etc. shall be examined and a comparative study of the merits of the different alternatives possible to serve the purpose intended shall be made. Based on such study, the final choice of the site or alignment as well as broad features of the proposals shall be made. The financial implication of each proposal shall be looked into and the most economical one shall be finally recommended without sacrificing the technical feasibility. In the detailed investigation phase, all the data required for designing the work at the site or along the alignment finally chosen should be collected.

The implementing Officer concerned shall decide whether the investigation shall be done by the department or entrusted to any other agencies considering the special nature and urgency of the work.

The Assistant Engineer will be responsible to conduct the preliminary investigations with the approval of his controlling officers i.e., they will indicate the various alternatives to be considered, and the preliminary data to be collected to enable a final choice, of site or alternate alignment. On the basis of the preliminary investigation, the Assistant Engineer must send a report to the authority competent to issue technical sanction for the work, through ~~Assistant Executive Engineer concerned~~ proper channel, giving the comparative merits of the different alternatives studied and his own recommendations. The authority competent to approve the proposal shall then make a final choice of the alternatives examined, or if additional data is required, he shall call for the same. The economic aspect shall be looked into before the final selection. After the final choice is made, detailed investigation shall be conducted. The Engineer responsible for designing the work shall also inspect the site to acquaint himself with all the site conditions if found necessary. Wherever shifting of utility services is required the concerned department may be informed well in advance so as to enable them to take further steps for shifting the same.

In the case of works for the use of other Departments of the State, the concerned engineer must keep the local officers of the respective Departments informed of the investigation work being done. The opinions of the officers of the concerned Department may also be taken into account in regard to choice of site and features required for the work. If sub soil exploration is found necessary, this shall be mentioned in the proposal submitted for approval.

The benchmarks and survey reference points shall be carefully selected and properly established so that there is no likelihood of these being missed when the work is taken up for execution. Wherever possible, the benchmarks may be connected to the nearest permanent Mean Sea Level (M. S. L.) Bench Mark.

5.2 ROAD WORK

5.2.1 Investigations, Design and Construction of New Pavements

The following investigations are to be carried out during the planning stage, before the design and preparation of estimates and tender documents for the construction of new road pavements, both for new roads and for widening of existing carriageway.

i) Topographic surveys and investigations for surface and sub-surface drainage requirements for the new road pavements.

ii) Soil Survey, material surveys and laboratory tests (wet sieve analysis, liquid limit, plastic limit, ISHeavy/Modified Proctor compaction test, soaked CBR test on soil and specified tests on aggregates to be used in GSB and GB layers) to assess their properties and

decision on the choice of different pavement materials/layers, their availability and location of borrow pits/quarries, if necessary.

iii) Traffic studies, particularly classified traffic volume of all heavy vehicles.

iv) Axle load studies on heavy vehicles and evaluation wheel load distribution and design value of cumulative standard axle loads by conducting relevant studies on 20 percent sample or by making use of available/secondary data and assumed values of vehicle damage factors, if necessary.

For more details refer

1) IRC:SP:19-2001, manual for Survey, Investigation and Preparation of Road Projects, First Revision
2) IRC: 37-2001 Guidelines for Design of Flexible Pavements, Second Revision
3) IRC:58-2002, Guidelines for Plain jointed Rigid pavements for Highways, Second Revision (Indian Roads Congress Publications)

5.2.1.1 Design and Drawings

i. Study of various underground utilities present, if any and possible future requirements.
ii. Design of sub-surface and surface drainage system.
iii. Decision on type of pavement to be adopted on the entire road and on some identified stretches depending on site condition, problems pertaining to traffic and utility lines and cost considerations.
iv. Design of total thickness requirement of selected type of pavement and the thickness and other details of the pavement layers (for flexible/ICBP/CC pavement) for the particular road stretch under consideration or a selected group of roads of identical features/characteristics. In the case of CC pavement, the details of transverse contraction and expansion/construction joints and longitudinal joints are also to be designed.
v. Suggesting the specifications to be adopted and special materials/ conditions/ instructions such as compaction standards to be followed, equipment/machinery to be used, etc.
vi. Preparation of working drawings for each road showing all the details including drainage system, cross drainage structures and the details of pavement layers, their levels etc.

The estimates, tender details and tender documents with all conditions of contract are to be prepared in conformity with the design and drawings prepared as above.

5.2.1.2 Road Alignment Considerations

The location or layout of the centre line of the road on the ground is called alignment. The alignment of road shall be decided only after conducting proper surveys and investigation. The horizontal alignment includes straight paths, horizontal deviations and

curves. Changes in gradient and vertical curves are covered under vertical alignment of road.

In general, new roads will have to follow the existing cart tracks and other such existing alignments. The provisions of IRC SP 19 and IRC SP 48 shall be followed. The ideal alignment between two points shall satisfy the requirement as given under:

a) **Short:** It is desirable to have a short (or shortest) alignment between two terminal stations. A straight alignment would be shortest, though there may be several practical considerations, which would require deviations from the shortest path.
b) **Easy:** The alignment shall be such that it is easy to construct and maintain the road with minimum subsequent problems. Also, the alignment shall be easy for the operation of vehicle with easy gradients and curves.
c) **Safe:** The alignment shall be safe enough for construction and maintenance from the viewpoint of stability of natural hill slopes, embankment and cut slope and foundation of embankment. Also, it shall be safe for the traffic operation in terms of safe geometric features.
d) **Economical:** The road alignment would be considered economical only if the total cost including initial cost, maintenance cost and operational costs, is the lowest.
e) **Sound:** The alignment shall be on the firm ground and shall not be susceptible to large settlement, deformation, landslide, etc.
f) **Aesthetic**s: While selecting the alignment, the aesthetics of the area shall be borne in mind.
g) **Environment:** The alignment shall be decided giving consideration to environment protection, particularly in eco sensitive hill, forest areas and coastal zone areas. Tree cutting shall be avoided as far as possible while finalising the road alignment.
h) **Social:** Land acquisition and displacement shall be kept minimum.

5.2.1.3 Factors Controlling Alignment

The various factors, which control the road alignment, may be listed as:

a) **Obligatory Points:** These are control points governing the alignment of the roads. These control points may be divided broadly into two categories:
   - Points through which the alignment is to pass
   - Points which the, alignment shall avoid.

   Obligatory points through which the road alignment has to pass may cause the alignment to often deviate from the shortest path. The various examples of this category may be a bridge site, intermediate town, a mountainous pass or a quarry.
b) **Traffic:** In most of the cases, the people use certain routes traditionally. These may either be due to convenience, social connection with other areas, etc. The proposed alignment shall keep in view this traffic flow pattern. At the same time one shall also have a fair judgement of future trends in mind.

c) Geometric Designs: Geometric design factors, such as, gradient, radius of curve and sight distance would also govern the final alignment of the road. As far as possible, steep gradient shall be avoided and limited to the ruling or design gradient. Thus, it may be necessary to change the alignment in view of the design, speed and maximum allowable super-elevation. It may be necessary to make adjustments in the horizontal alignment of roads keeping in view the minimum radius of curve.

The absolute minimum sight distance, which shall invariably be available in every section of the road, is the safe stopping distance for the fast moving vehicles. Also, there shall be enough distance visible ahead for safe overtaking operations of vehicles. Hence, the alignment shall be finalised in such a way that the obstructions to visibility do not cause restrictions to the sight distance requirements.

d) Economy: The alignment finalised based on the above factors shall also be economical. Avoiding high banking, deep cutting, major crossing and balancing of the cuts and fills can decrease initial cost of construction. At the same time, care shall be taken to see that it is not likely to involve costly maintenance and operational expenses. The vehicle operating costs may be given due consideration while designing the alignment.

e) **Drainage and Other Considerations:** Various other factors that may govern the alignment are drainage considerations, hydrological factors, social obligations, etc. The vertical alignment (particularly the gradient and change of grade) is often guided by drainage considerations. The sub-surface water level, seepage flow and high flood level are also the factors to be kept in view.

f) **Special Consideration for Hill Roads:** For selection of road alignment in hilly area, reference may be made to Hill Roads Manual (IRC: SP: 48). In hill roads, additional care has to be taken for ecological considerations, such as:

- Stability against geological disturbances
- Land degradation and soil erosion
- Destruction and denudation of forest
- Interruption and disturbance to drainage system
- Aesthetic considerations
- Siltation of water reservoirs

5.2.1.4 Surveys

Final location of the alignment is based on ground verification, and therefore, the engineering surveys are to be carried out. The surveys may be completed in four stages as below:

a) Reconnaissance Survey
b) Preliminary Survey
c) Determination of Final Centre Line
d) Final Location and Detailed Survey

To facilitate the survey team in the tentative selection of alternative alignments for subsequent detailed ground reconnaissance, it will be advisable to make use of modem techniques like, aerial survey, photogrammetry and remote sensing.

a) Reconnaissance Survey:

Keeping in view the obligatory points the next step will be to undertake reconnaissance survey in the following sequence:

- Study of topographical survey sheets, revenue maps, geological and meteorological maps, and aerial photographs or GIS maps where available
- Preliminary aerial survey/ satellite imagery reconnaissance (as against Aerial Photographs), where practicable and feasible.
- Ground reconnaissance
- Final reconnaissance of inaccessible and difficult stretches

b) Preliminary Survey:

The preliminary survey is a relatively large scale instrument survey conducted for the purpose of collecting all the physical information which affects the proposed location of a new highway or improvements to an existing highway preliminary surveys include census surveys, traffic surveys, soil and material surveys, topographic surveys and drainage studies. The main objectives of the preliminary survey are:

- To survey the various alternative alignments proposed after the reconnaissance and to collect all the necessary details of topography, drainage and soil.
- To compare the different proposals in view of the requirements of a good alignment.
- To estimate the quantity of earthwork, materials and other construction aspects and to work out the tentative costs of alternate alignments.
- To finalise the best alignment from all considerations.

The survey procedure and map preparation is explained in IRC SP 19.

c) Determination of Final Centre Line:

Making use of the maps from preliminary survey showing the longitudinal profile, cross-sections and contours, a few alternative alignments for the final centre line of the road are drawn and studied and the best one satisfying the engineering, aesthetic, environmental, social and economic requirements is selected. Horizontal curves are designed and the final centre line is marked on the map. The vertical curves are designed and the profile is then determined.

d) Final Location and Detailed Survey:

The alignment finalised after the preliminary surveys is to be translated on the ground by establishing the centre line. The line to be established in the field shall follow as closely as practicable the line finalised after the preliminary survey and conforming to the major and minor control points established and the geometric design standards. However, modifications in the final location may be made in the field if necessary.

5.2.2 Investigation for the Design, Estimation and Construction of Flexible Pavement Overlay on Existing Flexible Road Pavements

The following investigations are to be carried out during the planning stage, before the design, preparation of estimates and tender documents for the strengthening of existing road pavements/construction of overlay over existing road pavements.

a) Basic data on existing road, such as (i) road length, (ii) width of carriageway, shoulders/foot path, road side drains, traffic data, subgrade soil type and if these vary at different stretches the details of the same, (iii) assessment of the present condition of the drainage system including the necessary maintenance works, (iv) history of the road construction and maintenance works undertaken in the past.

b) Pavement condition studies, such as (i) pavement surface condition, indicating details/percentage cracked area, pot holes, rutting, undulations and longitudinal profile, cross slope, etc, (ii) Unevenness/Roughness index measurement by standard Bump integrator or any other reliable method.

c) Location of various utility/service lines such as underground drainage system, water supply pipes and various other utility services including electricity, telephone, cable system, etc and making provision for shifting /relocation of all/some of the service lines to edges of the road land and also ducting system to avoid road cutting across the road in future.

d) Decision regarding improvement of the subsurface / pavement drainage system for the existing road including widened portion, if any.

Refer IRC:81-1997. Tentative Guidelines for strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique, First Revision (Indian Roads Congress Publication).

5.2.2.1 Design and Preparation of Estimates

i) Design of pavement overlay thickness as per IRC: 81-1997.

ii) Design of overlay thickness and decision on the choice of overlay type and thickness of the layers.

iii) Preparation of estimates as per the details of design and special materials, layers etc.

iv) Preparation of estimates by considering (a) patching of pot-holes (b) patching of isolated cracked areas (c) cutting open and refilling badly filled up trenches which continue to settle down, leading to repeated formation of depressions or ruts-the existing pavement layer over the badly filled up trenches to be cut and removed including 300 mm depth of sub grade soil and refilled using cohesion-less and compacted using plate vibrator in two to three layers, and relaying of the other pavement layers similar to the existing pavement layers and (d) profile correction of existing pavement surface, as separate items.

v) Preparation of tender details and special conditions in conformity with the design and estimates.

5.2.3 Bituminous Road Construction

i) The compaction of embankment/fill and sub grade adopted is as per Standard Proctor Compaction. This has to be upgraded to IS heavy compaction as per MoRTH/ MoRD specification. In fact, compaction in any granular/stabilised layer must refer to IS heavy compaction as specified in IRC/MoRTH/ MoRD specifications.

ii) In case of stabilization, in each case mix is to be designed separately and strictly followed.

iii) Coarse grade sub base materials as per IRC/ MoRTH/ MoRD specification only should be used as per wet sieve analysis.

iv) For base course only WBM has been specified. For high density traffic corridors WMM or CRM etc are more appropriate for performance and constructability. IRC/MoRTH specifies 100mm for WBM-1 (G-1) and 75 mm for WBM-II (G-II) and WBM-III (G-III).

v) The specifications for materials e.g. aggregates and bitumen are lower (less strict for quality) than those recommended by MoRTH. For example, the water absorption, combined flakiness and elongation index, stripping value etc are much lower in case of aggregate, and similarly for bitumen quality.

vi) Priming and tack coat specifications are very elemental without much clarity; priming even allowing cut-back bitumen which is not allowed now except exceptional cases. Moreover, they are specified with excessive bitumen content per unit area in comparison with MoRTH specifications. Further, the use of pressure distributor is to be specified.

vii) Seal Coat type A and B are specified.

viii) DBM, SDBC, OGPC, MSS surface dressing etc are commonly used.

5.2.9 Materials

The quality of materials leads to quality construction. Similarly the appropriate equipments are required for construction of road layer as per the specifications.

i. Selection of materials shall be strictly as per IRC/MoRTH/ MoRD guidelines/requirements for the specific construction specifications.

ii. There should be acceptance criteria for the materials also rather than only the quality control of construction specification. Materials should be rejected if not found to meet acceptance criteria.

iii. Manufacturer's certificate shall not be considered in lieu of the tests. While contractor shall test at the site laboratory, the District level laboratory also should test samples randomly.

iv. Use of alternate materials for various pavement layers is to be specified with details of their construction methods etc. For example, use of fly ash and slag in embankment/fill, subgrade and drainage layer, the demolished cement concrete for GSB layer, etc are to be promoted.

5.2.10 Design of roads

All major roads shall be designed in accordance with the relevant IS/IRC codes and practises. For this purpose the following list of codes may be made referred.

1. IRC: 32-1969 Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads
2. IRC: 38-1988 Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
3. IRC: 39-1986 Standards for Road-Rail Level Crossings (First Revision)
4. IRC: 41-1997 Type Designs for Check Barriers (First Revision)
5. IRC: 54-1974 Lateral and Vertical Clearances at Underpasses for Vehicular Traffic
6. IRC: 65-1976 Recommended Practice for Traffic Rotaries
7. IRC: 66-1976 Recommended Practice for Sight Distance on Rural Highways
8. IRC: 69-1977 Space Standards for Roads in Urban Areas
9. IRC: 73-1980 Geometric Design Standards for Rural (Non-Urban) Highways
10. IRC: 80-1981 Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways
11. IRC: 86-1983 Geometric Design Standards for Urban Roads in Plains
12. IRC: 92-1985 Guidelines for the Design of Interchanges in Urban Areas
13. IRC: 98-1997 Guidelines on Accommodation of Underground Utility Services Along and Across Roads in Urban Areas (First Revision)
14. IRC: 99-1988 Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads
15. IRC: 103-1988 Guidelines for Pedestrian Facilities
16. IRC: SP: 121973 Tentative Recommendations on the Provision of Parking Spaces for Urban Areas
17. IRC: SP: 231983 Vertical Curves for Highways
18. IRC: SP: 411994 Guidelines on Design of At-Grade Intersections in Rural & Urban Areas
19. IRC: 58-2002 Guidelines for the Design of Plain Jointed Rigid Pavements for Highways (Second Revision)

Latest Revision of relevant codes shall be followed.

5.2.11 Design Parameters

The main parameters involved in the design of any road is the traffic volume it has to cater to, the speed at which the traffic flows, and the safety of vehicles in terms of sight distance considerations.

a) **Speed:** The design speed is the expected 95th percentile speed of the motorised traffic on the new road in the design year. The 95th percentile speed is the speed, which only 5% of vehicles will exceed. The choice of design speed has a big influence on key aspects of highway design, especially curvature.

   In practice it is rarely possible to adopt a uniform design speed for the whole road - design speeds need to vary from section to section to reflect differences in the road environment, terrain, etc. IRC SP 73 specifies the design speeds for different types of terrain.

b) **Volume:** Traffic data is critically important in the design of roads. Traffic surveys must cover motorised as well as non-motorised traffic. For new roads on completely new alignments it will be necessary to assign traffic to them from existing roads and then make an allowance for generated traffic. Usually mixed traffic volumes are expressed in PCU. The PCU factor for various vehicle types are available in IRC 73 and the PCU ranges for various class of roads are in IRC 86

c) **Sight distance:** The need to achieve minimum sight distance standards sets limits on how sharp the curves can be. The details of sight distance for horizontal curves and vertical curves are given in IRC 73 and IRC SP 23 respectively. In the case of Rural Highways, IRC 66:1976 may be referred. There are three main types of sight distance to consider:

   Stopping Sight Distance (SSD) -This is the visibility necessary for a driver to be able to see an obstruction in time to bring the vehicle to a halt without a collision. This is a basic minimum standard for two-lane single carriageway roads. It is assumed that the driver's eye height is 1.2m and the height of the obstruction is at least 0.15m above the road surface.

   Overtaking Sight Distance (OSD) -This is the visibility necessary for a driver to be able to see whether the road ahead is sufficiently clear to enable him to overtake a vehicle in front - even if an oncoming vehicle appears after he has started the overtaking manoeuvre. It is a very long distance, especially at the higher speeds, and it can be difficult to achieve.

   Intermediate Sight Distance (ISD) -This is the visibility necessary for a driver to be able to see whether the road ahead is sufficiently clear to enable him to overtake, assuming that he will abort the manoeuvre if an oncoming vehicle appears before he has got level with the slower vehicle. ISD is much less than OSD yet it permits reasonably safe overtaking. ISD is about twice SSD. It is assumed that the observer and the obstruction are at eye height (1.2m).

d) **Geometric Design Standards:** Geometric Design Standards for Urban Roads in Plains shall be as per IRC: 86-1983 and for Rural (Non-Urban) Highways as per IRC: 73-1980. The space standards for Roads in Urban Areas shall be IRC: 69-1977. In the case of Hill Roads Recommendations About the Alignment Survey and Geometric Design of Hill Roads IRC: 52-2001 may be followed.

5.2.12 Cross Sectional Elements

a) **Building Lines, Control Lines, Land Width, ROW:** Desirable land width in metre for different classes of roads is shown in Figure 3.1

b) **Culverts:** Culverts must be designed for the entire carriageway width. IRC SP 13 may be referred for details of Culvert design. Typical drawings are also given. IRC SP 20:2002 also details the different type of culverts.

c) **Utilities:** Provision for Underground Utility Services Along and Across Roads in Urban Areas shall be as per IRC: 98-1997

d) **Bus Bays:** In the case of ~~highways~~ roads, bus bays are to be provided to ensure that the other vehicles in the stream are not obstructed due to stoppage of buses. The bus bays are usually of one lane width and the length varies depending on number of buses that stop simultaneously.

e) **Footpath:** Roads passing through urban locales with considerable pedestrian traffic must be provided with footpaths. From safety considerations, fencing may be appropriate. IRC 103 shall be referred for pedestrian facilities.

f) **Truck Lay Byes:** ~~Highways usually cater to~~For long distance truck traffic, ~~and~~ facilities shall be provided for their parking. These laybyes shall offer resting facilities for the drivers also. Length of lay bye shall be adequate to cater to peak parking demand estimated on volume projections and average delay expected.

g) **Passing Places:** On hill roads, passing places are required to facilitate crossing of vehicles. These shall be provided at the rate of 2 to 3 per km and each shall be of 20 to 30 m length and of 5.5m widths.

h) **Lateral and Vertical Clearances:** Lateral clearance is the distance between the extreme edges of the carriageway to the face of the nearest support, whether it is a solid abutment, pier or column.

Vertical clearance stands for the height above the highest point of the travelled way i.e. the carriageway and part of the shallers meant for vehicular use (crown/ super elevated edge) to the lowest point of the overhead structure/ overhangs. For details refer IRC 54. Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads shall be as perIRC:32-1969

i) **Embankments:** The details of embankment design are given in IRC 36 and IRC SP 20, and the Guidelines for the Design of High Embankments as per IRC: 75-1979

j) **Drains:** Drains are an integral part of road and must be provided for all roads. These must be permanent structures, considering the heavy monsoons that the state is subjected to. Moreover, these must be properly maintained, as otherwise, the entire road gets damaged. The main objective of drainage is to prevent early damage of the

pavement due to entry of excess of water and preventing saturation up to a depth of 1 m below the top of the sub grade. This can be achieved by providing proper drainage. The two types are surface drains and subsurface drains.Details may be referred in IRC SP 42 and IRC SP 50.

k) Horizontal Alignment

- The alignment shall be as directional, fluent and matching well with the surrounding topography as possible and also to avoid abrupt changes.
- On new roads, the curve shall be designed to have the large practical radius, generally not less than the ruling value corresponding to ruling design speed given in IRC: 38-1988.
- Absolute minimum values based on minimum design speed may be used where economics of construction and sight conditions so dictates. The radii below absolute minimum shall not be provided
- Straight section exceeding 3 km length must be avoided
- A curvilinear alignment with long curve is better from point of safety and aesthetics.
- Sharp curve shall not be introduced at the end of long tangents, since this can be extremely hazardous.
- Curve shall be sufficiently long and shall have transition curves at either end to eliminate shock due to application of centrifugal force. Deflection angle less than 1^{o} no curve is required to be designed.
- Reverse curves may be needed in difficult terrain. Sufficient length between 2 curves shall be provided for introduction of requisite transition curve.
- To avoid distortion, in appearance, the alignment shall coordinate with longitudinal profile.

l) Horizontal Curves: The radius of curvature in horizontal curves is decided by the design speed of the road, side friction. In general Horizontal curves shall consist of a circular portion flanked by spiral transition at both ends. Refer IRC 38 and IRC 73 for details of horizontal curves, extra-widening super-elevation and setback distances.

m) Vertical Alignment: The general alignment of the road shall follow the terrain as far as possible. Economy and aesthetics are also of importance is choosing the longitudinal profile.

n) Gradient: The rate of rise or fall with respect to the horizontal along the length of road expressed as ratio or a percentage is termed as gradient. Recommended gradients for different terrain conditions are given inIRC 73 and IRC SP 23

o) Vertical Curves: Formula and length of Summit curves and Valley curves are as per IRC SP 23.

Coordination of Horizontal and vertical alignment

Vertical and horizontal curves shall coincide and result in a smooth flowing appearance. If not possible, the horizontal curve shall be somewhat longer than the vertical curve. Sharp horizontal curve shall be avoided. If the horizontal scale is large

and the vertical scale is relatively small, it may be satisfactory to include two vertical movements on one long horizontal curve.

Grade and curvature shall be in proper balance. Flat horizontal curves at the expense of steep or long grades or sharp curvature with flat grades shall be avoided. Broken-back curves (two curves in same direction with short tangent in between) both in alignment and profile shall be replaced by a single curve. Proper coordination in this respect will ensure safety improve utility and enhance aesthetics of the road.

p) Hairpin Bends: A hairpin bend may be designed as a circular curve with transition at each end. Alternately, compound circular curves may be provided. The general design criteria are as per IRC 73

q) Sub grade and Pavement: The road structure may be divided into four major components, Viz. Land, Earthwork, pavement and cross drainage works. The types of pavement are

- Flexible Pavement
- Rigid Pavement
- Composite Pavement (Semi rigid and Roller Compacted Concrete)

In case of rural roads, in view of the stage development strategy and the initial cost advantage, the flexible pavement may be the appropriate choice. Generally, the choice of pavement will be further guided by several other factors such as

- Rainfall and temperature
- Type and strength of soil along the alignment
- Availability of good aggregates
- Availability of Industrial wastes like Fly ash slag etc in the proximity.

In all designs, economies in the initial cost as well as in life cycle costs are crucial and very important. Components of Pavement are detailed in the section on Execution of Road Works.

5.2.13 Design of Flexible Pavement

Pavement Thickness: The thickness of pavement is designed on the basis of projected number of commercial vehicles, for the design life using the current commercial vehicles per day and its growth rate. Based on the strength of granular materials that are used, the total design thickness is divided into base and sub-base thickness. The principle criteria for determining the thickness of a flexible pavement with a thin bituminous surfacing is the vertical compressive strain on top of the subgrade imposed by standard axle load of magnitude 8.17 KN (870 Kg) Excessive vertical Subgrade strain causes permanent deformation in the subgrade, which is manifested in the form of rutting on the pavement surface. The minimum recommend pavement thickness is 150 mm. For rigid and semi rigid pavements, tensile stress is taken as design criteria. The detail design for flexible pavement may be as per IRC: 37

Design of Rigid Pavements: The main type of rigid pavement usually practiced is cement concrete pavements and Roller Compacted Concrete Pavements (RCCP). Strict quality control shall be exercised during construction.

Cement Concrete Pavement (CC): Design of cement concrete pavement shall be as per IRC 58. IRC 15 gives the detailing of joints. These may be used in Special cases only where drainage problem is acute and continuous and may be used in limited length. However drainage arrangements shall be ensured even for concrete pavements.

Roller Compacted Concrete Pavement: RCCP is a technique which makes use laying of zero slump concrete manually and compacting with vibratory or static road roller.

For rural roads, concrete pavements are preferred in the following cases;

i. If enough width is not available for consolidation using power roller.
ii. Where there is a steep gradient (greater than 1 in 12 ruling gradient)
iii. Water logging areas

In the above cases, a GSB layer is provided having a minimum thickness of 20 cm before laying the concrete. Before that soil stabilisation shall be done, if necessary. Over the GSB layer, a base course of M15 mix with a minimum thickness of 10cm and a 5 cm wearing course of M20 mix or 15 cm thick M20 mix using 40mm broken stones as a single layer shall be provided, depending upon the site condition. Expansion joints shall be given for every 15 m interval for both the layers. If the width is more, widthwise expansion joints shall also be given. Traffic shall be allowed only after curing period.

For heavy traffic roads, the rigid pavements shall be designed in accordance with relevant IRC codes. It is the responsibility of the Assistant Engineer to decide the type of pavement to be used.

5.2.14 Need of New Materials

With tremendous increase in traffic volume as well as in the load carried by the commercial vehicles per axle, it is necessary to introduce better materials in road works - both new construction as well as in maintenance works. Moreover, the road technology has advanced tremendously and lot of new materials and techniques are available for better performance and durability of road. There are many high performance bituminous and cementations materials available for both flexible and rigid pavement construction.

5.2.14.1 Cationic Bituminous Emulsion

Bitumen emulsion is a liquid product in which a substantial amount of bitumen is suspended in a finely divided condition in an aqueous medium and stabilized by means of one or more suitable materials. In India, among various types, normally cationic type of emulsion is used. A small proportion of an emulsifier is also used to facilitate dispersion and to keep the globules of dispersed binder in suspension. The bitumen content in emulsions is around 60 percent and the remaining is water. When cold mix with emulsion is used on the road, it breaks down resulting in release of water and the mix starts to set. Bituminous emulsion based construction is very efficient in terms of avoiding wearing of the ingredient of the mix and preparation of the mix. However, emulsion based technology is somewhat

more stringent in terms of compliance to the proportion and requirements about the cleanliness of the aggregates. The special advantage is that moist aggregates can be used for preparation of the mix. Emulsion is advantageous for both new constructions as well as for the repair and maintenance.

5.2.14.2 Modified bitumen

Properties of bitumen binders and bituminous mixes can be improved to meet requirements of pavements with the incorporation of certain additives or blend of additives. These blends of additives are known as modifiers and bitumen premixed with these additives are known as Modified Bitumen. IRC:SP:53-2002 deals with "Guidelines for Use of Polymer Modified Bitumen in Road Construction". The specification of modified bitumen by BIS has also been published recently (IS:15462-2004). The advantages of using polymer and rubber-modified bitumen are given as under.

i. Lower susceptibility to daily and seasonal temperature variations
ii. Higher resistance to deformation at elevated pavement temperature
iii. Better age resistance properties
iv. Better adhesion between aggregate and binder
v. Higher fatigue life of mixes
vi. Delay of cracking and reflective cracking
vii. Overall improved performance in extreme climatic conditions and under heavy traffic conditions.

The modified bitumen are classified as:

PMB - Polymer Modified Bitumen (EMB or PMB)
NRMB - Natural Rubber Modified Bitumen
CRMB - Crumb Rubber Modified Bitumen

The issues related to handling of modified bitumen and mixes at sites are very important. It is extremely important that modifier is thoroughly blended with bitumen before preparation of mix so that modified bitumen retains its premium properties. The other precautions shall be as under:

i. Preferably be blended at refinery or proper mixing plant.
ii. Product supplied hot in tankers or if supplied in drums shall be agitated in melted conditions with suitable device.
iii. Penetration, softening point, separation and elastic recovery test shall be conducted at site for a lot of 10 tonnes.
iv. Multiple heating shall be avoided.
v. In case of NRMB, material shall be supplied at 130-150^{O} C and shall be used within 24 hours of its filling.

5.2.14.3 Modified bitumen emulsions

Modified emulsion are those whose residue is modified bitumen. Modified emulsion may be classified as mono phase and bi phase system. The types of modifying agents used for production of mono phase modified emulsions are EVA, SBS, SIS etc. In case of bi phase modified emulsions, latex of natural or synthetic origin having extremely fine particles are used for modification in aqueous phase. The main property of this modifier is their elastic rubber behaviour of residue that allows them to accept and recover from large strains when they are exposed to temperature. This property of residue from modified emulsion can be observed by elastic recovery test. The merits of modified emulsions over normal emulsions are many but some are listed below:

i. High cohesion at medium and high service temperature
ii. Improved performance at low temperature
iii. Improved theological behaviour.
iv. Increased plasticity interval (P1=TR&B-T Fraass)
v. Better resistance to ageing.

5.2.14.4 Multigrade Bitumen

Multigrade bitumen performs over a wide temperature range than conventional bitumen and re formulated to resist both pavement rutting/deformation at high summer temperature and pavement cracking at low winter temperature. These bitumen are mainly characterized by high value of penetration index, typically greater than 0 but less than 2. Multigrade bitumen can either be considered to bridge the performance gap between conventional bitumen and Polymer Modified Bitumen. These bitumen are in most cases applied in thick wearing courses although in special situations of very heavily trafficked roads. Multigrade bitumen can be applied in both the binder and wearing course to increase overall performance including resistance to rutting like polymer modified bitumen. Multigrade bitumen will require higher mixing and compaction temperature than those of conventional bitumen.

5.2.14.5 Mastic Asphalt

Bitumen mastic, alternatively known as Mastic Asphalt, is a mixture of bitumen, mineral filler and fine aggregates in suitable proportions designed to yield a void less compact mass. Its consistency is such that it flows like a viscous fluid at temperatures of around 200^0C, but on cooling to normal temperature; it solidifies into a dense mass. Thus, its construction required no compacting effort. Mastic Asphalt is used as wearing course material for heavy-duty pavement, city street carrying high volume of traffic, bus stops where heavy tangential forces are expected due to deceleration and acceleration, junctions where cornering stresses are predominant and on bridge decks. Thin mastics are also used for footpaths.

5.2.14.6 Milling/Recycling of Bituminous Pavement

Cold and hot recycling of the bituminous pavement is in vogue all over the world, specially for the urban roads where increasing the levels of the road surface is often not

possible. Moreover the top 1-2 cm of the bituminous surface get oxidized and become brittle to develop micro-cracks under traffic load, and bituminous materials in lower part of the bituminous layers are much better which can be reused after rejuvenating. Moreover, the most voluminous part of the road pavement, i.e the aggregates; can be reused for a fresh layer after correction of the grading by additional of required sizes. Presently, only a part of the recycled materials from bituminous layers is used in the lower layer of granular base course. However, it must be used in bituminous binder course and surfacing layer also using hot or cold recycling method approximately correcting the mix for the specifications.

5.2.14.6 Stone Matrix Asphalt

Stone Mastic Asphalt (SMA) is a substitute to dense graded bituminous mix. It is a tough, stable, rut resistant mixture that relies on Stone-on-Stone contact to provide strength and a rich mortar binder to provide durability. SMA consists of two parts: a coarse aggregate skeleton with high binder and stabilizing additive. The coarse aggregate skeleton provides stone-on-stone contact, and the stabilizing additive acts to hold the asphalt binder from drain down in the mixture during the high temperatures of production and placement. SMA has proved superior performance on heavily trafficked roads in city traffic condition. The applications of SMA are given below;

With high trucks frequency	On bridges
Intense wheel tracking	In bus lanes
At traffic lights	At bus-stops
At intersections	In car parks
On highways	On airport runways
On gradients	On unloading areas

5.2.14.7 Slurry Seal

The slurry seal is a mixture of fine aggregates, Portland cement as filler, bitumen emulsion and water. It is like a slurry of thick consistency to be laid in a layer of 1.5-5 mm thickness to seal the cracks and to fill any voids left in the surface course. Emulsion of modified bitumen provides better result. Slurry seal may be used on top of single coat surface dressing. The surface shall be opened to traffic in about 2 hours.

5.2.14.8 Micro Surfacing

Micro sufacing is a high performance mixture of polymer modified emulsified bitumen, dense graded crushed mineral aggregate, filler (normally Portland Cement), Water chemical additive to facilitate early setting of mix. A typical micro surfacing mix contain 12% modified emulsion, 86% dense graded aggregate, 1% cement, 1% additive and sufficient water for workability. It is applied by synchronized machine through spreader box. The micro sufacing is a similar specification as that of slurry seal. This can be laid in thickness of 4mm to 16 mm depending on the present undulations of the surface. Structurally adequate

pavements having the bituminous surface oxidized and with micro-cracks are most suited for this treatment as preventive maintenance intervention. Micro surfacing have the following advantages over convention hot mixed techniques:

i. Marginal raise in pavement height
ii. Least environment pollution
iii. Life comparable to hot mix renewals
iv. Increased skid resistance
v. Faster laying process
vi. High durability due to rubber additives

5.2.14.9 Wet Mix Macadam (WMM)

In most of the road construction work the normal WBM technology is still in use and rarely in some special cases only WMM is considered. In view of the weakness left out in WBM construction due to non-uniformity over the surface area of the road (due to largely manual construction process), and the excessive water required to construct WBM specification, it is no longer popular for higher category of roads as well as city roads. WMM is a mix prepared from clean crushed aggregates and fine aggregates with proper grading, premixed with water, to form a dense mass, which is laid by pavers in the required thickness providing the needed camber and compacted to the finished thickness. WMM so laid is popular now a day for all types of road and is a much better specification than WBM in many ways. WMM can be laid in thickness from 75mm to 200mm in one layer depending on the compacting equipment available. WMM specifications given in clause 406 of MoRTH specification should be used directly.

5.2.14.10 Fibre Reinforced Concrete

Fibre Reinforced Concrete is a Composite material, which consists of conventional concrete reinforced by randomly, dispersed short length fibres of specific geometry, made of steel, synthetic (polymeric) or natural fibres. The secondary reinforcement (fibres) is used to uniformly improve the structural quality and also the inherent flexural strength of concrete. Internal stresses due to shrinkage are restrained by uniformly mixed fibers in the concrete. Secondary reinforcement is the approach to modify the brittle properties of concrete. The fibres are capable of carrying load across the crack.

5.2.14.11 Roller Compacted Concrete (RCC)

RCC is a technique which makes use of zero slump concrete with or without fly ash, laying manually or with mechanical spreader and compacting with vibratory road roller of 4-6 tonnes capacity. Construction of RCC layer is fast and it is a suitable alternative technique for providing a surfacing layer for medium to low traffic roads. The grade of concrete may be M-35. The riding quality of roller compacted concrete pavement (RCCP) is not as good as cement concrete roads, but it is comparable to the bituminous roads. While the flexible

pavement layers require high volume proportions of good quality aggregates (coarse and fine), this provides a very good alternative as semi-rigid base course also. Moreover, bituminous surfacing can be provided on RCC as it is done in case of DLC.

5.2.14.12 Ready Mixed Concrete

Ready mixed concrete (RMC) is a need of today's concrete construction industry to produce and deliver high quality produce economically. It is extremely useful on congested sites or in road construction where limited space is available for keeping a mixing plant as well as aggregate stock piling. It is a concrete delivered at site or into the purchaser's vehicle in plastic condition and requiring no further treatment before placing in the position in which it is to set and harden. By using RMC, there may be less chances of spillage of concrete and its constituents and the concrete mix would be of better quality than conventionally mixed concrete, since better quality control measures are adopted in making RMC is not only a "quality material" but also a "service".

5.2.14.13 High Performance Concrete (HPC)

High Performance Concrete (HPC) is defined as concrete specially designed to meet long term strength and durability. Use of HPC in pavements may result in extended service life, and improvement of compressive/flexural strength and performance of the concrete. HPC is generally characterized by low water/cement ratio and may contain silica fume and fly ash as mineral admixtures as replacement of cement. The cost of the production of HPC is higher (by 16-32 percent) as compared to that of the normal concrete at equivalent mix proportion. However, there is 20 to 50 percent increase in the compressive and flexural strength as compared to conventional or normal concrete. Further, the benefits accrued from the use of HPC, such as low maintenance cost. Longer life of the structure, higher strength, trouble free service etc, shall compensate the high initial cost of the HPC. Possible benefits include:

i. Reduced construction times
ii. For rapid repair of distressed pavements and bridges
iii. Chloride resistance
iv. Reduced Permeability
v. Reduced corrosion of steel bars
vi. Improved durability, and serviceability, and
vii. Enhancement of the life of concrete pavements and bridges.

5.2.14.15 Ready to use patching mixes/materials for repair

Carbon core asphalt is a cold mix commercially available which is a ready to use mix that can be used for resurfacing, patching and filling of potholes. It is available in disposable bags or drums. Similarly, other brands are also available like Shellmac etc, which are also

capable of doing the same job. There are other polymeric cement and resin materials available commercially which can be used even in wet climate for emergency repair of roads as they set very fast.

Quality Control for New Materials

All such new materials will require appropriate quality control for the material as well as for the construction specification to derive the true advantage. Therefore, specifications and quality control requirements of each of these are to be understood clearly before their use. The quality control tests as required for use of some of these materials are given in MoRTH specification also;.Each of these new materials may be adopted for use of appropriate, but with due care for actual method of its use. Moreover, the material should be tested by more than one equipped laboratory for that purpose to prove the efficacy of the same as per available specification. If it is not used anywhere in India under similar conditions, it must be used first for experimental purpose as test sections of the actual road for evaluation under normal traffic. For such experimentation, the manufacturer of the material should also contribute to fund the study. Such study shall comply to the following equipments.

i. The quality control and quality assurance for such experimental (construction) sites shall be more stringent.
ii. The proper plan for monitoring the performance of the road be made and data recorded over sufficiently long period to justify the use of such materials.
iii. The proper record of planning and design of the experimental section is also to be maintained so as to replicate and to develop design methodology after the successful experimentation.
iv. The manufacturer of the material should provide minimum period (normal performance) guarantee for the performance of the material under experimentation.

5.3 BRIDGES

The investigation for bridges shall be done as per the IRC SP 54 and IRC Codes.

5.3.1 Selection of Sites

Adequate efforts made in selection of a good site for locating a bridge will be amply rewarded in the form of reduced cost of the project and trouble free performance of the bridge. The cardinal principles to be kept in view at the time of selection of a particular bridge site including river training works are to provide a suitable crossing consistent with safety and economy and acceptable detour from the existing road alignment.

5.3.1.1 Factors Deciding Site Selection:

The site of a bridge shall be carefully selected after considering the following points: -

a) **Presence of high and stable banks:** The presence of high non-erodable banks generally offers an ideal site, which reduces the cost of approach embankments and their protection works.

b) **Narrowness of the channel and large average depth compared to maximum depth:**This ensures large average depth of flow compared to maximum depth of flow and reduced waterway, which greatly reduces the overall cost of the bridge structure.

c) **Presence of good founding strata at shallow depth:**A site, which requires a shallow foundation, shall be preferred to one, which may require a deep foundation.

d) **Straight reach of the river u/s and d/s of the proposed site:**The course of river or stream over which the bridge is constructed shall have a straight reach for at least 100 metres on either side of the proposed crossing. Straightness of the reach both u/s and d/s ensures uniform distribution of discharge/velocity. Curvature in the stream especially on the u/s leads to obliquity and concentration of the flow on the convex side leading to higher scour, and consequent cost of foundation and protection works. If the bank on the convex side is erodable, it may lead to heavy recurring expenditure in protecting the abutments and the embankment on that side.

e) **Possibility of right angled crossing:**Right angled crossing offers minimum possible bridge length and reduces chances of obliquity of flow with respect to the substructure.

f) **Possibility of good approach alignment:**Curves except gentle one are preferably to be avoided on approaches and bridge proper from visibility and safety considerations. The approaches on both sides shall have a minimum straight reach of 15m for major bridges and 10m for minor bridges. Also steep gradients shall be avoided on approaches.

g) **Where existing two-lane highway is proposed for widening to four-lane:**The additional two-lane bridge shall be sited as close to the existing bridge as possible. However, in case of bridges having well foundations, distance sufficient for generation of passive resistance of soil shall be provided.

Although it may not be feasible to satisfy all desirable attributes simultaneously, the selected site shall represent the most desirable mix of the attributes consistent with overall economy, including the cost of approaches. Sometimes more than one site may have to be examined at the preliminary stage and comparisons made regarding cost and relative advantages and disadvantages. Based on such study, the final choice of site shall be made.

5.3.2 Investigation for Major and Minor Bridges

Investigation for Major and Minor Bridges shall be done as per the provisions in IRC SP 54

a) Sub-Surface Investigation:

The objective of sub-surface exploration is to determine the suitability of the soil or rock, for the foundation of bridges. The sub-surface investigation for bridges is carried out in two stages, namely, preliminary and detailed. Sometimes, it may require

additional/confirmatory exploration during construction stage.Guidance may be taken from the following:

i) IS1892 - Code of Practice for Site Investigation for Foundations may be utilized for guidance regarding investigation and collection of data.

ii) Test on soils shall be conducted in accordance with relevant parts of IS: 2720 - Methods of Test for Soils. The tests on undisturbed samples to be conducted as far as possible at simulated field conditions to get realistic values.

iii) IS: 1498 - Classification and Identification of soils for general engineering purposes.

b) Preliminary Investigation:

Preliminary investigation shall include the study of existing geological information, previous site reports, geological maps, etc. and surface geological examination. These will help to narrow down the number of sites under consideration and also to locate the most desirable location for detailed sub-surface investigation. If the bridge site is pre-determined due to other reasons, the preliminary investigation is not necessary and shall straight away conduct the detailed investigation.

c) Detailed Investigation:

Based on data obtained after preliminary investigations, the bridge site, the type of structure with span arrangement and the location and type of foundations, the programme of detailed investigations, etc. shall be tentatively decided in consultation with the **higher officers.** If preliminary investigation is not conducted, the Assistant Engineer shall decide a suitable interval, not greater than 20 metres along the alignment for taking trial pits/bore holes. The exploration shall cover the entire length of the bridge and also at either end a distance of zone of influence, i.e., about twice the depth below bed of the last main foundation to assess the effect of the approach embankment on the end foundations. Generally, the subsurface investigations shall extend to a depth below the anticipated founding level equal to about one and a half times the width of the foundation. However, where such investigations end in any unsuitable or questionable foundation material, the exploration shall be extended to a sufficient depth into firm and stable soils or rock.

The abstract of the investigation details and design data shall be prepared as per the provisions in section 1403 and IRC SP 13 and IRC SP 54.

5.3.3 Design of bridges

The design of Bridges shall be carried out as per the provisions and recommendations IRC/IS codes as per list below.

List of Codes to be referred for Design of Bridges

1.	IRC: 5-1998	Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design (Seventh Revision)

2.	IRC: 6-2000	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses (Fourth Revision)
3.	IRC: 18-2000	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (Third Revision)
4.	IRC: 21-2000	Standard Specifications and Code of Practice for Road Bridges, Section III – Cement Concrete (Plain and Reinforced) (Third Revision)
5.	IRC: 22-1986	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (First Revision)
6.	IRC: 24-2001	Standard Specifications and Code of Practice for Road Bridges, Section V – Steel Road Bridges (Second Revision)
7.	IRC: 40-2002	Standard Specifications and Code of Practice for Road Bridges, Section IV – Brick, Stone and Block Masonry (Second Revision)
8.	IRC: 78-2000	Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure (Second Revision)
9.	IRC: 83-1999	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part I : Metallic Bearings (First Revision)
10.	IRC: 83-1987 (Part II)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part II: Elastomeric Bearings
11.	IRC: 83-2002 (Part III)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part III: POT, POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS
12.	IRC: 87-1984	Guidelines for the Design and Erection of False work for Road Bridges
13.	IRC: 89-1997	Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)
14	IRC SP 20	Specifications for Rural Roads
15.	IRC: SP: 33-1989	Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structures
16	IS 456-2000	Plain and Reinforced Concrete - Code of Practice

Latest revision of above codes shall be followed.

The competent authority shall approve the design of Bridges and culverts. For any structure for which detailed investigations are required the same may be conducted by the Assistant Engineer and supervised by the Assistant Executive Engineer, and details shall be furnished for final design and got approved by the competent authority.

5.3.4 Design Procedure for Bridges

a) Preliminary Design: The Assistant Engineer shall study the investigation details and alignment plan of a particular bridge and shall make any modification required for the alignment plan considering the various design aspects. The Assistant Engineer shall also make preliminary design of the bridge in the form of a proposal drawing and submitted

to the superior officers, if the modifications required in the alignment plan are of trivial nature

b) Detailed Design: Based on the feasibility report furnished and the approved alignment plan the Assistant Engineer shall do a general and detailed design of the bridge. The design shall be done by manually or by using approved computer software. The Assistant Executive Engineer shall check the general arrangement and detailed design drawing designed by the Assistant Engineer and submit it to the competent authority for approval.

5.3.5 Geometrical Criteria

a) Width of Carriageway, Footpath, Median and Kerb: This shall be as per the provisions of IRC 5.

b) Longitudinal Gradient: The Engineer in charge of design has to consider all aspects such as construction costs, practical problems in construction at the site and the vehicle operation cost, before finalizing the gradients. Based on the topography of site, IRC has recommended the following categories of gradients for roads which shall be applicable to bridges also.

Terrain	Ruling Gradient	Limiting Gradient	Exceptional Gradient
a) Plain or rolling	3.3 % (1 in 30)	5 % (1 in 20)	6.7 % (1 in 15)
b) Mountainous terrain	5 % (1 in 20)	6 % (1 in 16.7)	7 % (1 in 14.5%)
c) Steep terrain	6 % (1 in 16.7)	7 % (1 in 14.5%)	8 % (1 in 12.5%)

Where non-motorised vehicle are likely to use the structure more appropriate lower gradients shall be utilized, but may need to a balance against cost and other environmental issues.

c) Cross Gradient: The deck cross gradient shall be adopted with a view that in localities with lower rainfall, a flatter camber and in places with high rainfall, a steeper camber. The values of cross gradient recommended by IRC for different types of road surfaces are as follows, which shall be applicable to bridges also.

Type of Surface Coat	Range of Cross Gradient in Areas of Rainfall
	Heavy to Light
a) Cement concrete	2.0% (1 in 50) to 1.7% (1 in 60)
b) Bituminous	2.5% (1 in 40) to 2.0% (1 in 50)

d) Gradients, Super Elevation: If there is a change of gradient on the bridge deck, suitable vertical curve shall be introduced conforming to the stipulations contained in IRC: SP-23. The super elevation on the deck of a bridge on a horizontal curve shall be provided in accordance with the relevant IRC Road Standards.

e) **Clearances:**The minimum vertical and horizontal clearance (clear height and width respectively available for passage of traffic) to be provided on bridges shall be as specified in IRC:5. For vertical and horizontal clearances at under passes and / rail over bridges the essential provisions of the code has to be followed.

5.3.6 Hydraulic Criteria

a) **Design Discharge:**The design discharge, for which the waterway of the bridge is to be designed, shall be based on maximum flood discharge of 50 years return cycle. In case where the requisite information is not available, the design discharge shall be the maximum estimated discharge determined by the methods suggested in IRC:5 or any other rational method. The investigation report shall contain the discharges obtained by the different methods suggested in IRC: 6.

b) **Effective Linear Waterway, Afflux and Scour Depth:**The effective linear waterway may be compared with that provided under other bridges in the vicinity over the same river after duly considering their performance. IRC 5 may also be referred.For calculation of afflux IRC SP: 13 may be referred to. To calculate the maximum scour depth, IRC: 5 and IRC SP: 13 shall be followed.

c) **Loading Criteria:**The Loading criteria to be adopted for all the bridges are as per IRC.

5.3.7 Selection of Type of Bridge and Span Arrangement

a) **General Considerations:** Specific site characteristics like width of crossing, nature of stream, depth of flow, depth of flow during different seasons, subsoil characteristics, and the capabilities of contracting agencies, who would be interested in building the structure including the availability of skilled and unskilled labour are mostly the major considerations in selecting the type of structure and span arrangements in specialized structures like long span bridges. The attempt of the engineers shall be towards minimising the overall cost of the total structure including approaches within the site-specific constraints as obtained. For normal simply supported structures, it has been observed that the total cost of the bridge proper tends to be the minimum, when the cost of superstructure approaches to that of foundation and substructure put together which may be applied as a thumb rule for initial trial.

b) **Environmental Considerations:** Aesthetic and environmental considerations are increasingly becoming major factors in the selection of the type of structure including its foundation to be adopted for a specific site. To achieve aesthetically pleasing view of bridge structure, attention shall be paid to produce a clean, simple, well proportioned structured form. In most cases, achieving the desired structural quality may add little to the overall cost of structure. Aesthetic considerations include harmony with the general topography of the site, optimisation in the use of materials etc. Environmental considerations include limitation of noise levels during and after construction of the bridge and the level of pollution due to air and water during construction and service, conservation of flora and fauna etc.

c) Economical Range of Span Lengths for Different Type of Superstructures: Piers and abutments shall be so located as to make the best use of the foundation conditions available. The number of supports and their locations shall be so fixed as to provide the most economical design of the bridge and at the same time to satisfy special requirements, if any, for navigation, railways or other crossings in consultation with the concerned authorities, floating logs or debris and bridge aesthetics, etc. Placing a pier at the deepest portion of an active channel may be avoided by suitably adjusting the number and length of the spans. The ranges of span length within which a particular type of superstructure can be economical along with other considerations like type of foundation etc. are given below:

	Type of Superstructure	Span (metres)
i)	RCC single or multiple boxes	1.5 to 15
ii)	Simply supported RCC slabs	3 to 10
iii)	Simply supported RCC T beam	10 to 25
iv)	Simply supported PSC girder	25 to 45
v)	Simply supported RCC voided slab	10 to 15
vi)	Simply supported / continuous PSC voided slab	15 to 30
vii)	Continuous RCC voided slab	10 to 20
viii)	RCC box sections; simply supported /Balanced cantilever continuous	25 to 50
ix)	PSC box sections; simply supported /Balanced cantilever continuous	35 to 75
x)	PSC cantilever construction / continuous	75 to 150
xi)	Cable stayed bridges	100 to 800
xii)	Suspension bridges	300 1500

However, whenever an economical span arrangement and type of structure is decided, it has to be ensured that the required infrastructure facilities, design and construction capabilities, specified materials etc. are available.

5.3.8 Bridge Foundations

The foundations for piers and abutments shall be at such depths that they are safe against scour and large impacts where necessary and are protected against it. They shall be taken down to a level sufficient to secure firm foundation from consideration of bearing capacity, overall stability and suitability of the strata at founding level and sufficient depth below it. The subsoil characteristics obtained at a particular site and consequently the type of foundations feasible is one of the major considerations in selection of type of structure and span arrangement.

It is necessary to evaluate, in advance, at the preliminary design stage, the pros and cons of choice of a particular type of foundation. The selection of wrong type of foundation may lead to delay in construction, increase in cost, and distress during construction and sometimes impossibilities of realizing technical requirement. In order to avoid such difficulties that may arise during execution stage, alternative foundation types shall be suggested in the Proposal Drawing. The concerned authority in the field office shall study the pros and cons of constructing the suggested types of foundations and shall record a note about the same in the feasibility report. Based on the above report, the type of foundation shall be fixed by the engineer responsible for the design. Refer IRC 78 for different types of foundations.

a) General Considerations and Design

All Bridges within 20 km of the sea cost shall be given anti corrosive treatment for reinforcements as per specifications for Road and Bridge Works published by (MoRTH) and IS 13260. Epoxy painting may be given to all exposed surface of RCC structural elements in the seacoast area; similar treatment may also be done in areas prone to industrial/environmental pollution.

i. **Open Foundations:** The design aspects of open foundations can be obtained from IRC: 21 and IRC: 78. Excavation on open foundations shall be done after taking necessary safety precautions for which guidance may be taken from IS: 3764.
ii. **Well Foundations:** Well foundation shall be designed to withstand the loads and forces as specified in IRC: 6, the stability and design of well foundations shall be done under the most critical combination of loads and forces as specified in IRC: 78. The pressure on foundations shall also satisfy the provisions of IRC: 78. For allowable stresses and other design requirements, IRC: 21 shall be followed.
iii. **Pile Foundations:** Piles shall be designed to carry uplift and lateral loads besides direct vertical load. The worst combination of forces and factors of safety shall be as specified in IRC: 78. For design of piles guidance may be taken from IS: 2911 subject to limitations/stipulations given in IRC: 78. For allowable stresses and other design requirements, IRC: 21 shall be followed.

5.3.9 Sub-structure

Substructure include those portions of a bridge which are above the foundation which include piers, abutments, abutment and pier caps, dirt wall, returns, wing wall etc. but excludes bearings and superstructure. It can be built of brick/stone masonry, plain/reinforced/pre-stressed concrete, steel. Selection of a particular type of sub structure depends upon the span and type of superstructure, the height of substructure, availability of construction material and construction equipments, period and time of construction and above all on overall economy. The shape of piers and abutments in general, shall be such as to cause minimum obstruction to flow of water.

a) **General Considerations:**The following general conditions are to be followed for the construction of substructures:

i. On all exposed faces of concrete member a minimum reinforcement equivalent to 2.5 kg/sqm shall be provided to withstand stresses due to temperature and shrinkage with maximum spacing limited to 200 mm.

ii. The width of abutment and pier cap shall be fixed on the basis of design and construction requirement. Further it shall be sufficient to accommodate not only the bearings but also an offset of 150 mm beyond the edges of the bearings and also facilitate inspection and repairs of bearings. The thickness of such caps shall not be less than 225mm up to a span of 25 m.

iii. In skew bridges, where bearings are placed at right angles to the longitudinal axis of the bridge, the top width of the piers/abutment has to be more compared to right bridges in order to have a clear distance of 150 mm beyond the edges of bearings.

iv. It is desirable to lay the abutment caps and the dirt walls over abutments with the same concrete and in one operation, and make them monolithic by detailing the reinforcement properly, to avoid cracking at the junction of the two components.

v. The top of wing return walls shall be carried 100 mm above the top of the slope of embankment to prevent any soil from being blown or washed away by rain.

vi. Length of cantilever returns where adopted, shall not be more than 3.5 metres.

vii. All abutments shall be designed for a live load surcharge equivalent to 1.2 m height of earth fill.

viii. All wing walls or return walls provided for full height of approaches shall be designed to withstand a live load surcharge equivalent to 0.6 m height of earth fill.

ix. The fill behind abutments, wing walls, and return walls shall conform to specifications given in IRC:78.

x. Suitably designed cut and ease waters shall be provided in piers up to affluxes High Flood Level or higher from consideration of waves, etc.

xi. If the height of pier exceeds 6 metres, R.C.C. piers may be preferred.

b) **Design:** Sub-structure shall be designed to withstand the loads and forces as specified in IRC:6, the worst combination of forces and factors of safety shall be as specified in IRC:78. For allowable stresses and other design requirements, IRC Codes depending upon the type of construction material shall be followed.

c) **Bearings:** The design of metallic bearings and neoprene bearings shall be in conformity with IRC: 83 Parts II & I. and clause 2000 of Specifications for Road and Bridge Works published by Ministry of Road Transport and Highways (MoRTH). MoRTH carries out pre-qualification of the manufacturers of bearings from time to time. The pre-qualification is valid for a certain period. Bearings have to be procured from such manufacturers only.

5.3.10 Superstructure

It is the superstructure of a bridge that directly supports the traffic and facilitates its smooth uninterrupted passage over natural/man-made barriers like rivers, creeks, railways, roads, etc. by transmitting the loads and forces coming over it to the foundation through the bearings and substructure. Consistent with economy and local availability of the materials, labour and technology for a particular type of superstructure selection may have to be made out of the following:

i. **Reinforced Cement Concrete Superstructure:** These are the most popular type of superstructure in the present day which may take the form of solid slab, voided slab, T-beam and slab, box girder, rigid frame, arch, balanced cantilever or bow-string girder.

ii. **Pre-Stressed Concrete Superstructure:**This may also take any of the above forms referred in the previous paragraph. Care shall be taken about the provision of future pre-stressing to the extent of 20 per cent of total pre-stress force. For this purpose, dummy cables may be laid in the structure, which can be used for further pre-stressing if the need arises afterwards.

iii. **Steel Superstructure:**With increasing availability of quality steel at international prices in recent years the use of steel for superstructure is becoming attractive option. The forms these may take are steel beam, plate girder, box girder, steel truss, arch, cantilever suspension bridges and cable stayed bridges.

Any combination of above materials considering their distinct advantages for particular elements may be adopted. Most common types of composite construction are cast in situ or pre-cast girder in pre-stressed concrete with RCC deck or steel beam/plate girders with RCC deck or cable stayed bridgeswith RCC or PSC deck.

a) **Design:** Relevant IRC Codes which have to be complied in the design of superstructure are IRC: 40, IRC:21, IRC: 18, IRC: 24, IRC: 22 for Masonry, RCC, PSC, Steel and Composite Structures respectively. Other codes applicable for all types of superstructures are IRC: 5 and IRC: 6. Other major guidelines also include IRC: 85. In case of IRC codes silent about some design aspects, provisions in the IS/International Codes may be followed.

b) **Standard Plans (Type Designs):** Wherever possible the adoption of standard plans prepared by the MoRTH shall be followed for superstructure. These will obviate detailed individual designs for bridge decks and ensure that drawings are available on time and also maintain accuracy in design.

Ministry of Road Transport & Highways have brought out various standard plans which include standard plan for:

No.	Type of Deck	Skew Angle	Overall width of deck (m)	Effective span (m)
1.a.	RCC Solid Slab without footpath	0°	8.45	3.37, 4.37, 5.37, 6.37, 7.37, 8.37, 9.37, 10.37
1.b.	RCC Solid Slab with footpath	0°	11.05	3.37, 4.37, 5.37, 6.37, 7.37, 8.37, 9.37, 10.37

1.c.	RCC Solid Slab without footpath	15°, 30° 45°, 60°	8.45	5.37, 6.37, 8.37
1.d.	RCC Solid Slab with footpath	15°, 30° 45°, 60°	11.05	4.37, 6.37 & 8.37
1.e.	RCC Solid Slab with and without footpath	0°	12.00	3.00, 4.00, 5.00, 6.00, 7.00, 8.00, 9.00, 10.00
1.f.	RCC Solid Slab without footpath	15°,	12.00	4.00, 6.00, 8.00, 10.00
		22.5°, 35°		
2.a.	RCC T-beam and slab without footpath (3 girders)	0°	8.45	10.5, 12.5, 14.5, 16.5, 18.75, 21.75, 24.75
2.b.	RCC T-beam and slab with footpath (3 girders)	0°	11.05	10.5, 12.5, 14.5, 16.5, 18.75, 21.75, 24.75
2.c.	RCC T-beam and slab with & without footpath (4 girders)	0°	12.00	10.0, 12.0, 14.0, 16.0, 18.0, 21.0, 24.0
3.a.	PSC Girder and RC Slab without footpath (3 girders)	0°	8.58	30.0 & 40.0
3.b.	PSC Girder and RC Slab with footpath (3 girders)	0°	11.23	30.0 & 35.0

c) Expansion Joints: Expansion joints are provided at the end of deck and cater for movement of deck due to temperature, shrinkage, creep etc. Expansion joints make the deck joint leak proof, protect the edges of slab/girder and allow smooth passage of loads from one span to other by bridging the gap. Depending upon the gap width to be bridged, there are various types of expansion joints in use at present. IRC 83-part Part II and I may be referred for details regarding expansion joints.

Specifications for Road and Bridge Works published by (MoRTH) have issued interim specifications for expansion joints and subsequent modifications in the list of manufacturers/suppliers, which may be followed. Further, a warranty of 10 years of trouble free performance may be insisted upon from the contractors/suppliers for all type of joints except for buried joints and filler joints.

d) Railings, Parapets or Guide Posts and Crash Barriers: The forces to be considered in design of Railings, Parapets or Guide Posts and Crash Barriers shall be shall be as per relevant stipulations of IRC:6. For R.O.Bs across railway lines, those for railway's safety shall govern these requirements.

e) Surface Finishes and Drainage of Carriageway: All carriageway and footpath surfaces shall have anti-skid characteristics. Average 75 mm thick M20 cement concrete with temperature steel shall be provided for wearing coat with necessary camber and over it

a uniform treatment of 25mm mastic asphalt top layer for waterproofing. Alternately wearing coat as specified in Specifications for Road and Bridge Works published by (MoRTH) may be provided depending on site condition.

The deck has camber or super elevation, which guides rainwater towards kerbs, and waterspouts located near the kerb further disposes the water out. One waterspout per 20 sq.m. of the deck area is considered adequate and the spacing shall not exceed 10 m. The spout shall have diameter not less than 100 mm and shall be of corrosion resistant material such as galvanised steel, with suitable clean out fixture. The arrangement of waterspout shall be detailed along with the Detailed Design Drawing of the Superstructure.

For drainage of a road over bridge or flyover, a suitably designed drainage arrangement shall be provided. This may consist of vertical C.I. or rigid PVC pipes connecting the down spouts below the deck with funnels and along the pier up to ground level and eventually joined to the road drainage system. Suitable vertical recess in the piers may be provided to accommodate the drainage pipes rather than providing drip courses underneath the deck slab.

If the height of abutment and return wall above bed level is more than 2 metres, weep holes shall be provided 150 mm above low water level or ground level whichever is higher at centre of 2 metres horizontally and 1metre vertically (Slope of 1 in 20) and shall be staggered. Normally 100 mm diameter PVC pipe shall be used. Provision made in IRC: 40 may also be referred.

f) **Utilities:** In all bridges with footpaths, a service duct shall be made under one or both footpaths to take water supply mains, electric and telephone cables etc. The size and other requirement may be as per standards in practice. Where footpaths are not provided, provision shall be made for supporting a suspended service duct under the cross girder. For this purpose suitable boot holes may be left in the cross girders, which can later be used for fixing steel supports for a suspended deck with due, care for durability and serviceability of the bridge and its approaches. For details refer IRC 98

g) **Access for Inspection and Maintenance:** The design of the bridge shall be such as to provide for adequate access to all parts of the bridge to facilitate future inspection and maintenance operations.

h) **Illumination of Bridge Deck:** Provision for Illumination for bridges, grade separators and interchanges shall be an integral part of the estimate. This shall be done in consultation with the Electrical wing. The installation, lighting arrangement, and method of control, switches etc. shall all conform to the provision contained in IS: 1944. Illumination levels for the vehicular and pedestrian subway/underpasses may be kept same as those on the approaches at either end of the subway/underpass.

5.3.11 Approaches to Bridges

The approaches on either side of a straight bridge shall have a minimum straight length of 15 meters in the case of State Highways and MDRs and 10 meters in the case of

ODRs and shall be suitably increased to where necessary to provide for the minimum sight distance for the design speed.

Where horizontal curves have to be provided on the approaches beyond the straight portion on either side, the minimum radius of curvature, the super elevation and transition length for various speed and the curve radii shall be provided in accordance with relevant stipulations contained in IRC: 38. If there is a change of gradient, suitable vertical curves shall be introduced conforming to relevant stipulations contained in IRC: 23. Minimum surfaced width of these straight lengths of approaches shall be equal to the carriageway width on the bridge.

Reinforced concrete approach slab covering the entire width of roadway shall be provided as per the details given in the Detailed Design Drawing of the particular bridge. The minimum length of approach slab shall be 3.5 meters and the minimum thickness as 150 mm. If the approaches is in filling, borrow pits shall not be dug close to the embankment to avoid risk of parallel flow being developed which may endanger safety of the embankment. In this connection, provision made in IRC: 10 may also be kept in view.

Where the ground level falls continuously away from the banks of the stream, the overflow spreads far and away from banks. In such cases, it is impossible to force the overflow back into the main stream. The correct thing to do is to pass the overflow through relief culverts at suitable points in the road embankment. They shall not be too small to cause detrimental ponding up of the overflow, resulting in damage to the road or some property. Nor, shall they be so big as to attract the main current. Also protection work has to be designed at downstream of the culverts so as to dissipate the energy of the falling water, where the water from the relief culvert, rejoins the main stream somewhere lower down.

5.3.12 River Training and Protection Work

River training and protective works are required for ensuring the safety of bridges and their approaches on either side. The selection of the type of river training or protective work will depend upon terrain, overall behaviour of the river, location of the bridge vis-a-vis the areas of attack of the river, span arrangement, nearness of the approaches from the influence zone of the river, etc. The types of river training and protective works generally being used are as follows:

- **i.** Guide bunds
- **ii.** Spurs or groynes
- **iii.** River bank protection
- **iv.** Approach road protection
- **v.** River bed protection

The details of river training measures shall be referred to in Section 2500 of Specifications for Road and Bridge works published by (MoRTH)

5.3.13 Road Signs and Signals

All multi-lane bridges, complex interchanges and grade-separated structures shall be provided with overhead signs and signals conforming to the provision contained in IRC: 67. Non-luminous signs, however, shall not be permitted. IRC SP 31 may be referred for new sign and IRC: 5 for overhead structures.

5.4 BUILDINGS

5.4.1 General

In areas which have already been developed, advantage shall be taken of existing local knowledge, records of trail pits, bore holes, etc, in the vicinity, and the behaviour of existing structures, particularly those of similar nature to those proposed. If the existing information is not sufficient or inconclusive, the site shall be explored in detail so as to obtain knowledge of the type, uniformity, consistency, thickness, sequence and dip of strata and of the ground water conditions.

5.4.2 Selection of Site

Wherever master plans for town or country development have been prepared or are under preparation, the District Town Planner or the Development Authority having jurisdiction over the area may also be consulted before finalising the selection of site. In selecting a site the following desirable features shall be kept in view.

a) The neighbourhood must be suitable for the purpose for which the building is to be constructed.
b) The site must be easily accessible from the main roads.
c) As far as possible other buildings of no consequence in the locality shall be such that the building constructed in it does not hide the site.
d) The site must be fairly level or gently undulating without steep slopes, rock out-crops, abandoned laterite or rock quarry pits etc.
e) The site must not be subjected to water logging and shall be capable of easy drainage.
f) The subsoil shall be hard enough to provide good foundation at reasonable depth.
g) It shall be possible to locate sources of drinking water for use of the occupants either at the site or within reasonable distance there from.
h) The site shall have good ventilation. At the same time it shall not be exposed to heavy wind without any protection.
i) The site shall not contain places of worship, graveyards, monuments, or any other structure or feature of religious or sentimental value whose demolition may cause offence to any section of the population.
j) For building in the vicinity of airports aviation clearance may be sought.
k) The site shall have minimum displacement of residences and livelihood.

If more than one site is available, the relative merits of the several sites shall be examined before a final choice is made. Wherever available, previous investigation reports may be utilised as also the local knowledge. Reference may be made to geological and agricultural soil maps if available. Where these are inconclusive, site exploration may be required. Refer IS 4453: 1980 code for site exploration.

There shall be an index map showing the site in relation to the nearest public road, railway line and important institutions in the neighbourhood. The index plan may be a tracing from the village map or town map or a good sketch containing the information required.

A detailed site map may be prepared showing the boundaries and ground features as well as structures if any, trees of more than one metre girth, abandoned laterite quarries wells etc. It shall also show portions of adjacent property, and structures if any, abutting or close to the site. Spot levels shall be taken throughout the site so that contours at 1-metre intervals can be plotted. The existing natural drainage courses within the property if any, as well as outside shall be marked. The approach road to the site up to where it joins any public road shall also be surveyed and marked. A few cross sections shall also be taken at convenient intervals. The survey may be done with a plane table or chain in small areas, and with theodolite triangulation or suitable electronics devices in larger plots. A reference line shall be established at a suitable place in the plot. It shall be permanently fixed by means of concrete blocks at its extremities. One or two permanent B. Ms. shall be established. The reference line and the B. Ms. shall be marked in the site survey. The north point shall also be marked. The site survey shall be of a scale not smaller that 1 cm = 10 m. ~~The preliminary investigation details are forwarded to the architectural wing for preparing layout.~~

A report containing information on the nature of soil and subsoil and the bearing capacity etc. shall be submitted. The location of the trial pits and boreholes shall be marked in the site survey. It is desirable that ~~the Executive Engineer~~competent authority inspects sites where foundations are poor and indicates the number and location and minimum depth of bore holes to be taken. It is necessary that the samples of soil obtained from boreholes are taken and sent for examination. Where undisturbed samples are required, other approved laboratory may be consulted. Where test piles are done to ascertain the bearing capacity, the results shall be included the investigation data. The investigation report must also include details on the following:

i. The subsoil water level during rainy season and dry season shall be observed and recorded.
ii. Maximum flood level expected in the locality.
iii. Direction of prevailing wind during different season.
iv. Source of water supply for construction as well as for use when the building is occupied.
v. If there is electric supply in the vicinity, the distance of the nearest point from which power supply has to be tapped.

vi. The source from where the principal construction materials like stones, bricks, metal, lime etc. are to be procured.

vii. Distance of building/ bridge from water front/ beach so as to be in conformity with the CRZ regulations

viii. Present condition of existing buildings/ bridges in the vicinity with respect to corrosion induced distress.

5.4.3 Structural Design

The competent authority as prescribed in the delegation of powers shall approve the design of any kind of structure before the detailed estimate is prepared. The Assistant Engineer/Assistant Executive Engineer and the Executive Engineer shall personally inspect the site and see that the proposed design can be implemented on ground.

5.4.4 Design of buildings

This section deals with the general building requirements to ensure safety of public health through open spaces, adequate room sizes and limitations on area and height of building.

Based on the preliminary investigation report, ~~the architectural wing prepares~~ a layout plan of the structure in consultation with client and the Electric Wing shall be prepared, which shall be got approved by the concerned department. ~~The architect wing shall then prepare~~ detailed architectural plan shall also be prepared. This shall comply with The National Building Code 2005 and the Kerala Municipal/ Panchayat Building Rules.

R.C.C. design of all load bearing structures and framed structures up to two stories shall be prepared by the Assistant Engineers and approved by the superior officers as per their powers. Necessary wind and seismic analysis must be performed.

5.4.5 Design Philosophy

R.C.C design of buildings is being carried out mainly by three methods of design. They are namely: (1) Working stress method, (2) Ultimate load method and (3) Limit state method.

The Limit state method is now in vogue in all government design offices and premier private consulting firms .The B.I.S. have published I.S.: 456-2000 incorporating the use of Limit State Method of design.

Working Stress Method: Used over decades, this method is now practically outdated in many advanced countries of the world, because of its inherent limitations.

The I.S: 456-2000 code gives emphasis on Limit State Method which is the modified form of Ultimate Load Method .

Besides analytical part of structural design, following factors shall also be kept in mind while designing the structure.

- Strength of structure.
- Durability of structure.

- Serviceability of structure, during construction as well as during design life time of structure.
- Economy in building materials and ease of constructions.
- Economy in entering and formwork.
- Aesthetics and functional use of structure.

5.4.6 Classification of Buildings

Buildings are classified based on occupancy and type of construction as per the provisions of National Building Code 2005 part III Clause 7.

5.4.7 List of I.S. Codes generally required to be referred for Building Design

The National Building Code published by the Bureau of Indian Standards and Kerala Municipal Building Rules has to be followed for the purpose of design of Buildings. The important I.S. Codes (with their latest editions/ amendments) to be referred to for design of building are as follows:

1.	I.S. 456-2000	Code of practice for plain and reinforced concrete
2	I.S. 800-1962	Code of practice for use of structural steel in general building constriction
3	I.S. 875-1987	Designs load other than (part I to V) earthquake for building Design.
		Part-I: Dead loads.
		Part-II: Imposed loads.
		Part-III: Wind loads.
		Part IV: Snow loads.
		Part V: Special loads and load combinations.
4	I.S. 1080-1965	Code of practice for design and construction of shallow foundation in soils(other than Raft, Ring and shell)
5	I.S: 1642-1988	Fire safety of buildings (General) Detail 3 of construction
6	I.S.: 1643-1988	Code of practice for Fire safety of buildings (General) Exposure Hazard.
7	I.S. 1644-1988	Code of practice for Fire safety of buildings (General) Exit requirements and personal Hazards.
8	I.S. 1888-1972	Methods of load test on soils
9	I.S.: 1893-1984	Criteria for earthquake resistant design of structures.
10	I.S: 1904-1986	Code of practice for design & construction of pile foundation in soil structural safety of building foundation

11	I.S. 2911-1990	Code of practice for design and construction of pile (Part I to IV) foundation
12	I.S. 2950-1981	Code of practice for design and construction of raft foundation.
13	I.S. 3370-1965	Code of Practice for water retaining structures
14	I.S. 3414-1987	Code of Practice for Design and Installation of joints in buildings
15	I.S. 4326-1993	Code of practice for earthquake resistant design of structure.
16	I.S. 6403-1981	Code of practice for Determination of bearing pressure of shallow foundation
17	I.S.13920-1993	Code of practice for ductility detailing of reinforced concrete structures subjected to seismic forces

Latest revisions of above code shall be followed.

I.S. Codes are also available for design of special types of structures like folded plate, shell structures etc. Refer publication list of BIS for the same.Similarly there are special publications of I.S., which are useful for design of buildings such as

1. SP-16 Design Aids to I.S.: 456-1978
2. SP-22 Explanation to I.S.: 1893 & I.S.: 4326.
3. SP-23 Concrete Mix.
4. SP-24 Explanation of I.S. 456-1978.
5. SP-25 Cracks in buildings and their repairs.
6. SP- 34 Detailing in R.C.C. structures.
7. SP-38 Design of steel trusses.

For aspects, which are not covered by any other I.S. codes available, relevant International Standard Codes may be referred to. While designing R.C.C. structures, important provisions (as detailed below) of I.S. 456 must be borne in mind.

General Provisions

Clause No. 20 Deals with stability of the structure against overturning and sliding.

Clause No. 26.2.1: Development length of bars.

Clause No. 26.3.2: Minimum distance between individual bars.

Clause No.26.3.3: Maximum distance between bars in tension.

Clause No.26.4: Cover to reinforcement.

Clause No.27: Expansion joints.

Provision Regarding Slabs

Clause No.22.2: Effective span.

Clause No.22.4.1: Arrangement of live load.
Clause No.22.5: Moment and shear co-efficient for continuous beams .
Clause No.23.2: Control of deflection.
Clause No.24.1: Provisions regarding solid slabs.
Clause No. 26.5.2.1: Minimum reinforcement.
Clause No.26.5.2.2: Maximum diameter.

Provisions Regarding Beams

Clause No.22.2: Effective span
Clause No.22.4.1: Arrangement of live load.
Clause No. 22.5: Moment and shear co-efficient for continuous beams.
Clause No. 23.2: Control of deflection.
Clause No. 23.3: Slenderness limits for beams.
Clause No. 26.5.1.1: Tension Reinforcement.
Clause No. 26.5.1.2: Compression reinforcement.
Clause No. 26.5.1.3: Side face reinforcement.
Clause No.26.5.1.5: Maximum spacing of shear reinforcement.
Clause No.26.5.1.6: Minimum shear reinforcement.
Clause No.26.5.1.7: Distribution of torsion reinforcement.

Provisions for Columns;

Clause No.25.1.2: Short and slender compression members.
Clause No.25.1.3: Unsupported length.
Clause No.25.2: Effective length of compression members.
Clause No.25.3: Slenderness limits for columns.
Clause No.25.4: Minimum eccentricity.
Clause No.26.5.3.1: Longitudinal reinforcement.
Clause No. 26.5.3.2: Transverse reinforcement.
Clause No.43: Cracking Consideration.

Provisions for Footings

Clause No. 33.1.2: Thickness at the edge of footing.
Clause No.34.4: Transfer of load at the base of column.

5.5 MINOR IRRIGATION STRUCTURES

Some of the MI Structures used in LSGIs are:

5.5.1 Weirs

The weir is a solid obstruction put across the river to raise its water level and divert the water into the canal. If a weir also stores water for tiding over small periods of short supplies, it is called storage weir. The main difference between the storage weir and a dam is only in height and the duration for which the supply is stored. A dam stores the supply for a comparatively longer duration.

Weirs are classified into two heads, depending upon the criterion of the design of their floors.

1. Gravity Weirs
2. Non- gravity weirs

A gravity weir is the one in which the uplift pressure due to the seepage of water below the floor is resisted entirely by the weight of the floor. In the non-gravity type, the floor thickness is kept relatively less, and the uplift pressure is largely resisted by the bending action of the reinforced concrete floor.

Depending upon the material and certain design features gravity weir can further be sub-divided into the following types;

1. Vertical drop weir
2. Sloping weir:
    (a) Masonry or concrete slope weir
    (b) Dry stone slope weir
3. Parabolic weir

5.5.1.1 Vertical Drop Weir

A vertical drop weir consists of a vertical drop wall or crest wall, with or without crest gates. At the upstream and downstream ends of the impervious floor cutoff piles are provided to safeguard against scouring action, launching aprons are provided both at upstream and downstream end of the floor. A graded inverted filter is provided

immediately at the downstream end of the impervious floor to relieve the uplift pressure. Vertical drop weirs are suitable for any type of foundation.

5.5.1.2 Masonry or Concrete Slope Weir

Weirs of this type are suitable for soft sandy foundation and are generally used where the difference in weir crest and downstream river bed is limited to 3 meters. When water passes over such a weir, hydraulic jump is formed on the sloping glacis.

5.5.1.3 Dry Stone Slope Weir

A dry stone weir or a rockfill weir consists of a body wall and upstream and downstream rockfills laid in the form of glacis, with few intervening core walls.

5.5.1.4 Parabolic Weirs

A parabolic weir is similar to the spillway section of a dam. A cistern is provided at the downstream side to dissipate the energy. The upstream and downstream protection works are similar to that of a vertical drop or sloping glacis weir.

5.5.1.5 Flow measurement

Weirs allow hydrologists and engineers a simple method of measuring the volumetric flow rate in small to medium-sized streams or in industrial discharge locations. Since the geometry of the top of the weir is known and all water flows over the weir, the depth of water behind the weir can be converted to a rate of flow.

5.5.2 Check dams

A check dam is a barrier constructed across waterways such as open channel, canals or drains. Check dam can either be a temporary or permanent structure which is built to retain and maintain the desired ground water level within the land.

5.5.2.1 Objective :

The broad objectives of Check Dams (In-stream Storage Structures) are:

- To provide drinking water facilities in the villages along both the sides of the river after monsoon period.

- Ground Water recharge
- To provide incidental irrigation by storing water at the end of monsoon mainly through lifting devices.

5.5.2.2 Selection Criteria:

The Check Dams will store or divert surplus water flowing to the sea at the end of monsoon. While selecting locations for construction of in-stream storage structure or check dams the following principles & priorities are to be followed.

- Blocks having less than 35% irrigation coverage to be considered.
- Areas where farmers are using traditional irrigation by constructing temporary cross bunds on streams.
- Where the farmers are willing to take up operation & maintenance of thestructure.
- The newly constructed structure should not have any adverse impact on the hydrological efficacy of the existing, ongoing and future major, medium, minor (flow) irrigation and minor (lift) irrigation projects.
- In-stream storage will be developed near urban centers if suitable rivers and locations available for multipurpose domestic and irrigation use.

Though the purpose of the scheme is to be demand driven, hydrologically and technically feasible sites may be considered and local people are to be consulted prior to taking any action for implementation. The main emphasis on selection of a site will be proper use of water through people's participation.

5.5.2.3 Salent Features & Types of Check Dams:

The check dams or in-stream storage structures with or without gated arrangements are to be capable of safely releasing the anticipated design flood without affecting the safety of the structures with minimum afflux in the upstream. Water can be stored in such a pond / reservoir towards the end of monsoon. Basing on the type of stream where the structure is proposed to be constructed the check dams may be divided into three categories. To achieve these objectives three types of check dams have been selected primarily basing on the type of the stream.

1. Check dams, upto a height of 2.0 m can be constructed across small tributaries / drainage channel within the banks and streams in middle and higher reaches (within approx. 50 m wide)
2. Check dams in deltaic rivers/ drainage channel (lower reaches) (within approx 50 m wide).
3. Storage across major rivers and streams having higher width and huge flood water discharge.

Check dams upto a height of 2.0m: It can be constructed across small tributaries/ drainage channel within the banks and in hill streams. These storage schemes will be low cost

structures and will be primarily used for the purpose of irrigation through lift, re-charging of ground water and providing drinking water facility to nearby villages.

Check dams in deltaic rivers/ drainage channel: These structures will be constructed on deltaic rivers / drainage channel with alluvial bed and will be primarily used for providing irrigation facility by lifting water during later part of monsoon. At places existing, ongoing and future foot bridges may be used for storing water by providing wooden planks / steel shutters between the piers or through putting sand bags considering safety of the structure.

Storage across major rivers and streams having higher width and huge flood water discharge: These structures can be used for the purpose of drinking water facilities to nearby villages, irrigation facility to the nearby areas with minimum lift, useful for meeting industrial demands during lean periods. The sites will be selected after detail survey & investigation. These structures will be constructed, operated and maintained by the department.

5.5.2.4 Design Aspect:

1. Check dams on small streams / drainage channel:

All the structures shall be designed as per standard practices for ensuring the safety & economy. The height of these structures will be normally within 2.0 m. The storage arrangement can be made through provision of alternate piers with two grooves on each side for providing wooden planks/ steel shutters inposition and gates of wooden planks/ shutter / sand bags to store water. These structures are to be constructed in series to make them more effective by storing more water for attaining their objectives.

2. Check dams on main streams.

As these are important structures on main streams, the design of these structures shall confirm to prevailing codes & references.

5.5.2.5 Location of Site

The selection of the location of check dam is crucial as its will determine its effectiveness in controlling the ground water table. Some of the considerations when selecting the location are: -

1. The general topography of land so that the limited ground water can be stored and the water level maintained over a longer duration. If possible, the site selected should be able to provide a long length and large volume of stored water.
2. Existing drainage system so that water can be blocked effectively, and if necessary a series of check dams is incorporated into the system.
3. Percentage of potential fire hazard peat lands on either side of the length of stored water should be high.
4. Accessibility of site with regards to access to vehicles/machinery for construction as well as operation and maintenance of structures.

5. The risk of submergence to any cropped lands, residential areas and other infrastructures during flash floods.

5.6 MINI WATER SUPPLY SCHEMES

5.6.1 Introduction

The objective of a public water supply system is to supply safe and clean water in adequate quantity, conveniently and as economically as possible. It is well recognised that the minimum water requirements for domestic and other essential beneficial uses should be met through public water supply. Other needs for water may have to be supplemented from other systems depending upon the constraints imposed by the availability of finances and the proximity of water sources having adequate quantities of acceptable quality which can be economically utilised for public water supplies.

Engineering decisions are required to specify the area and population to be served, the design period, the per capita rate of water supply, other water needs in the area, the nature and location of facilities to be provided and points of water supply intake. The design population will have to be estimated with due regard to all the factors governing the future growth and development of the project area. Water demand shall be calculated for the projected population for the design period of the project which is 30 years for rising main and distribution lines and 15 years for water works structures and machinery.

5.6.2 Sources of supply

The origin of all sources of water is rainfall. Water can be collected as it falls as rain before it reaches the ground; or as surface water when it flows over the grounds; or is pooled in lakes or ponds; or as ground water when it percolates into the ground and flows or collects as groundwater; or from the sea into which it finally flows. Where the quantity of ground water is insufficient or quality of ground water is not of required standards, surface sources are chosen depending upon the availability. The mini water supply schemes with bore wells and open wells are economically viable and easy to operate and maintain, whereas schemes designed with surface water as source are not economically viable and are often difficult to operate and maintain by the Communities. Hence, in order to make the surface source schemes viable, which required skilled operation and maintenance, it is preferable to design schemes with surface sources for a large group of beneficiaries. In cases where in the surface water is to be transmitted from a long distance and wherever limited quantity of ground water is available dual supplies for such areas shall also be examined thereby satisfying both quality and quantity requirements.

5.6.2.1 Ground Water

Ground water has been traditionally the main sources of drinking water. With the advent of drilling rigs and consequent indiscriminate extraction of ground water from deeper aquifers, mainly for agricultural purposes, the yield from the tubewell sources is depleting at a fast rate. Apart from depleting ground water table, there had been an increase in concentration of Total Dissolved Solids that seriously affect the quality of drinking water. Hence, there is a need to select the tubewell sites on a scientific basis, which will have sustenance as sources of water and amenable for recharge.

The subsurface sources include springs, wells and galleries. The wells may be shallow or deep. Shallow wells may be of the dug well type, sunk or built, of the bored type or of the driven type. They are of utility in abstracting limited quantity of water from shallow pervious layers, overlying the first impermeable layer.

Deep wells are wells taken into pervious layers below the first impermeable stratum. They can be of the sunk well type or the bored or drilled type. They are of utility in abstracting comparatively larger supplies from different pervious layers below the first impervious layer. Because of the longer travel of groundwater to reach pervious layers below the top impermeable layers, deep wells yield a safer supply than shallow wells.

Dug well of the built type has restricted application in semi-permeable hard formations. The depth and diameter are decided with reference to the area of seepage to be exposed for intercepting the required yield from the sub-soil layers. Unsafe quality of water may result if care is not taken in the well construction. It is necessary to provide a water-tight steiningupto a few metres below the vertical zone of pollution which usually extends 3 to 5 m or more below natural ground surface. Thesteining should extend well above the ground surface and a water-tight cover provided with water-tight manholes.

5.6.2.2 Surface Sources

Surface water accumulates mainly as a result of direct runoff from precipitation (rain or snow). Precipitation that does not enter the ground through infiltration or is not returned to the atmosphere by evaporation, flows over the ground surface and is classified as direct runoff. Direct runoff is water that drains from saturated or impermeable surfaces, into stream channels, and then into natural or artificial storage sites or into the ocean in coastal areas. The quantity of available surface water depends largely upon intensity & duration of rainfall and will vary considerably between wet and dry years.

Surface water supplies may be divided into river, lake, and reservoir supplies. Dams are constructed to create artificial storage. Surface water can be conveyed from Canals/ open channels to the schemes through intake structure/ flow regulator and transmission pipes by gravity / pumping. Managing lakes and reservoir used for domestic supplies vary widely depending on local condition.

The probability of contamination of surface water is very high. The factor affecting water qualities are waste water, agriculture waste, domestic and Industrial discharge, grazing of livestock, drainage from mining area. The method of treatment of water depends upon row water quality and range from disinfection only to complete treatment.

Waters in lakes and ponds would be more uniform in quality than water from flowing streams. Long storage permits sedimentation of suspended matter, bleaching of colour and the removal of bacteria. Self-purification which is an inherent property of water to purify itself is usually less complete in smaller lakes than in larger ones. Deep lakes are also subject to periodic overturns which bring about a temporary stirring up of bottom sediment. The microscopic organisms may be heavy in such waters on occasions. If the catchment is protected and unerodible, the stored water may not require any treatment other than disinfection.

Waters from rivers, streams and canals are generally more variable in quality and less satisfactory than those from lakes and impounded reservoirs. The quality of the water depends upon the character and area of the watershed, its geology and topography, the extent and nature of development by man, seasonal variations and weather conditions. Streams from relatively sparsely inhabited watersheds would carry suspended impurities from eroded catchments, organic debris and mineral salts. Substantial variations in the quality of the water may also occur between the maximum and minimum flows. In populated regions, pollution by sewage and industrial wastes will be direct. The natural and man-made pollution results in producing colour, turbidity, tastes and odours, hardness, bacterial and other micro-organisms in the water supplies.

5.6.3 Artificial Impounding Reservoirs (Storage and Sedimentation Tanks):

Rural water supply systems are planned with large impounding reservoirs as sources. If an existing impounding reservoir is available nearby, it can be used as source for rural water supply also, since construction of impounding reservoirs exclusively for rural water supply schemes will be expensive. Where water is drawn from canal or from a non-perennialriver, it may be necessary to create a storage reservoir with capacity equal to the closure period of canal or equal to the dry flow period in the river or streams. Usually, the canal closure period will be about 2 weeks and the river or streams may be dry for 3-4 months. The raw water from stream/ river/ canal may have to be pumped over long distances and larger heads for storage in the impounding reservoirs resulting in higher power charges. The capacity of impounding reservoirs to be constructed shall be equal to the canal closure period/ dry season of stream or river plus the evaporation and seepage losses. The pumping plant from pumping the raw water from the canal / river/ stream shall be designed such that the pumps, in addition to pumping the daily requirement will also have capacity to fill the impounding reservoir before commencement of the closure period of the canal or before stream/river goes dry.

The preferred technology option for treatment of surface water for rural communities is plain sedimentation followed by balancing tank, slow sand filtration and disinfections (with bleaching powder), pure water sump or filter water sump. Usually a jackwell is constructed in the canal/ stream or river and water is pumped to the elevated storage reservoirs for distribution to the villages thus resulting in higher power charges. In

view of the treatment cost and higher power charges and larger skilled manpower involved, user charges for supplying treated water from streams and lakes are likely to be higher. Hence, the community is to be informed for the high user charges and their willingness should be obtained for such surface schemes before selecting as technology option.

Surface Schemes shall be designed only where the following conditions prevail:

1) Where ground water is insufficient or having quality problems such as high fluorides and / or high TDS.
2) For the surface schemes to become viable the number of villages must be minimum 3. However lack of cooperation among the villages may create problems in operation and hence affect supply to the villages beyond the source. Hence this aspect is also to be considered before a surface scheme is proposed.
3) Since the cluster of villages requiring surface water has to be large to make the scheme viable, some en-route villages (Which do not have quality problem) can also be clubbed with the surface scheme. However, with increasing number of villages, communication problems may affect operation and maintenance.

5.6.4 Yield of Source

An accurate assessment of the yield of the source is essential to decide which source can be dependable. The yield of borewells is to be assessed preferably in the lowest seasonal water level conditions. Yield test units are available which can be used to pump out the water from the borewell for a maximum period of six hours at a time. Care should be taken that the water pumped out is led away from the source and does not re-enter the source. The draw down and discharge are measured and the results tabulated from which the safe yield is calculated. The assessed yield is multiplied by a coefficient to arrive at the safe yield from the source to account for the seasonal variations and also to prevent over exploitation from the borewell, which may lead to collapsing of the borewell. In case the yield test is conducted during non-summer months, a suitable coefficient for assessing the safe yield has to be used.

5.6.5 Quality of water

The quality of the water varies according to the source as well as the media through which it flows. Rainwater collected from roofs or prepared catchments for storage in small or big reservoirs, is soft, saturated with oxygen and corrosive. Micro organisms and other suspended matters in the air are entrapped but ordinarily the impurities are not significant. But the collecting cisterns or reservoirs are liable to contamination.

Water that is clear and colourless gives an impression that is safe for human consumption. This may not be correct, since both disease causing bacteria and objectionable matter may be present but invisible to naked eye. Water quality parameters are classified as physical, chemical and biological nature. The environmental significance of some common parameters of water quality is given below.

5.6.5.1 Physical Parameters:

Turbidity: Any turbidity in water is associated with pollution and health hazards arising out of it. Increased turbidity makes treatment difficult and costly due to increase in chemical coagulation costs and increased frequency of cleaning the filters. In turbid waters, the pathogenic organisms may be trapped in the turbid particles and hence protected from the disinfectant. Ground water is less likely to contain turbidity. Turbidity of surface water may settle down by plain sedimentation.

Colour: Natural colour may be acquired by water from decay in swamps and forests; but the colour may not be harmful. The fact is that if the potable water is having colour and hence aesthetically not acceptable, the consumers tend to seek water from other sources which may not be safe. Ground water is less likely to contain colour and surface water may contain colour due to industrial activity. However colour is not removed in conventional treatment adopted in Rural Water Supply Schemes.

Taste and Odour: Both should not be noticeable to consumers. Taste is not measurable but should not be objectionable. For odour, Threshold Odour Numbers (TON) are given to indicate the dilutions required for the odour to disappear. It should be preferably one and not greater than three. However, odour is not removed in conventional treatment adopted in Rural Water Supply Schemes.

5.6.5.2 Chemical Parameters

Carbon dioxide And Mineral Acidity: Water that contains mineral acidity is unpalatable. Acidity causes corrosion and affects the consumption of chemicals in water softening.

Alkalinity: Measures the content of bicarbonates, carbonates and causticity of waters. Waters that contain high alkalinity are unpalatable. Chemically treated water sometimes may have high alkalinity. Alkalinity is important in coagulation and corrosion control. However alkalinity is not removed in conventional treatment adopted in Rural Water Supply Schemes.

Hardness: Calcium and Magnesium compounds cause hardness-soap consuming property. Hardness is derived by water largely from contact with soil and rock formations. In general hard waters originate in areas where top soil is thick and limestone formations are present. Soft waters originate where topsoil is thin and limestone formations are absent. However Hardness is not removed in conventional treatment adopted in Rural Water Supply Schemes.

Total Dissolved Solids (TDS): Waters with TDS of less than 500 mg/lt are suitable for domestic use. Waters with higher TDS have a laxative effect upon people who are not accustomed to it. Conventional treatment methods don't address the removal of TDS. This can be removed only through distillation and reverse osmosis membrane filtration, However TDS is not removed in conventional treatment adopted in Rural Water Supply Schemes as this is not economically viable and cannot be maintained by the rural communities.

Chlorides: Chlorides impart salty taste if present beyond 250 –mg/lt. Unusual presence of Chlorides in water indicates contamination of ground water with wastewater. However Chlorides are not normally removed in conventional treatment adopted in Rural Water Supply Schemes.

Nitrogen Salts: They may be reported in the form of free ammonia and Nitrates (nitrates in terms of Nitrogen). When present beyond trace amounts, indicate pollution by human wastes. Water containing organic and ammonia nitrogen indicate recent pollution; water-containing nitrogen in the form of nitrates indicate pollution that has occurred a long time back. Waters with appreciable amounts of nitrites are of questionable character. The amount of ammonia nitrogen determines the efficacy of chlorinating. Nitrates in water may be due to, agricultural run-off, water source, due to fertilizer use, leaches from septic tanks, sewerage and erosion of natural deposits. Nitrates are not removed in conventional treatment adopted in Rural Water Supply Schemes.

Dissolved Oxygen: Dissolved Oxygen (DO) is of significance in corrosion of iron and steel particularly in distribution systems. However DO is not removed in conventional treatment adopted in Rural Water Supply Schemes.

Fluorides: Minimum of 1 mg/lt may be required to prevent dental carries; but beyond 1.5 mg/lt may cause staining of teeth/dental fluorosis and also skeletal fluorosis. Treatment units set up in India for removal of excessive fluorides in Rural Water Supply Schemes are so far not functioning satisfactorily.

Iron: Iron may be present in water as a dissolved impurity from the earth's crust or enter the water supplies from corroded pumps and pipes. Excess iron may cause staining of clothes during washing, stains on plumbing fixtures and encrustation and deposits on the interior surfaces of the pipe. Treatment units set up in India for removal of excessive Iron in Rural Water Supply Schemes are so far not satisfactory.

Manganese: Manganese at lower concentrations causes troublesome deposits in mains. However Manganese is not removed in conventional treatment adopted in Rural Water Supply Schemes.

5.6.6 Intake structure

An Intake is a device or structure placed in a surface water source to permit withdrawal of water from this source and its discharge into an intake conduit through which it will flow into the water works system. Types of intake structures consist of intake towers, submerged intakes, intake pipes or conduits, movable intakes, and shore intakes. Intake structures over the inlet ends of intake conduits are necessary to protect against wave action, floods, stoppage. Intake towers are used for large waterworks drawing water from lakes, reservoirs and rivers.

5.6.7 Pumping machinery

In a water supply system, pumping machinery serves the purpose of pumping water from bore wells or for pumping raw water from source to treatment plant and treated water to the service reservoir. In water supply schemes the pumps may be centrifugal or submersible pumps are used for pumping water from sumps to overhead tanks. The centrifugal pump essentially consists of one or more impellers equipped with vanes mounted on a rotating shaft and enclosed by a casing. Centrifugal pumps commercially available have a speed range of 980 to 2900 rpm and the most common speed is 1440 rpm. High-speed pumps have smaller life span due to increased wear and tear though the size of the pump set is small. Sometimes Vertical Turbine Pumps are used for pumping water from jack wells.

Generally Submersible pump set conforming to IS:8034-1976 shall be provided . The pumping hours shall be determined keeping in view availability of electricity. Capacity of pump shall be sufficient to fill the elevated tank with in the stipulated pumping hours. In the submersible pumps, the bowl assembly is directly connected to a submersible vertical electric motor suitable for working under water and the compact assembly thus formed operates below the surface of the water in the well. Delivery of water to the surface is through the riser pipe on which the assembly is suspended. The power is supplied to the motor through a flat type cable designed for working in under water condition. These pumps are usually operated at a motor speed of about 2900 rpm.

5.6.7.1 Criteria for Pump Selection

Prior to the selection of a pump for pumping station, detailed consideration has to be given to various aspects. The hours of pumping are decided and the quantity of water available in the source is also calculated. Then the discharge of the pump set is calculated in terms of the lps (liters per second). Friction head and the total head for the pump set are calculated for the given diameter of the pumping main. Assuming a suitable efficiency and knowing the discharging head, the horsepower of the pump set is calculated by referring to the pump manufacturer's catalogue. After the required HP/KW is calculated; if water is to be lifted from the tube well submersible pump is chosen or if a centrifugal pump is chosen

for other locations, reference is to be made to the relevant (either submersible or centrifugal)catalogue of the commercially available pump sets.

The final selection of the pump shall be based on the commercially available KW/HP for the given discharge (Q) and Head (H). Selection tables based on above referred consideration is given below.

Table

5.6.7.2 Limitation on Suction Head

For centrifugal pump sets suction head shall be limited to 4.50m. In case where suction lift exceeds 4.5m, the centrifugal pump may be installed at suitable elevation with reference to the water level to restrict suction lift to 4.5 m. Where the suction lift exceeds 6m, it is preferable to provide submersible pump or turbine pump depending on the site conditions.

5.6.7.3 Pump Efficiencies

The efficiency of pump sets depends on the friction and turbulence within the pumpset and mechanical and leakage loss. A pump set is chosen depending on the discharge andhead i.e. Q and H. Pump performance curves are provided by the manufacturers. Choice ofpump set from among the various manufacturers shall be such that the pump set has thehighest efficiency for the given duty conditions. Though the pump is chosen for the designduty conditions, in practice the head may vary depending on the actual water level in thesource and friction head on the delivery point. Such a condition will result in the pumpdelivering more water due to reduction in the head. This will decrease the efficiency of thepump set and may also increase the power consumption. Sometimes, the variation may be so high that the amperage of the motor will also increase resulting in failure of motor winding. Hence, it is desirable to avoid over design of the pump sets. And it is suggested that the pump chosen shall work within plus 5%or minus 25% of the range of the maximum efficiency point of O & H given in the family curve. Performance curve for each type of pump will be given in the pump manufacturer's catalogue. In some catalogue instead of performance curve, water-rating charts will be given. These indicate range of head and discharges applicable to the particular type of pump. Hence, for a known head and discharge, from the range of pumps available, the most efficient one is the pump in which the required head and discharge lies near the middle of performance curve or water rating table. This also ensures satisfactory performance of the pump under varying head and discharge during pumping.

5.6.8 Transmission & Distribution system

The treated water shall be pumped into the ground level reservoir situated at elevated places in the village or to the overhead water tanks. The stored water shall be

distributed through appropriate pipe network system in the designed quantity at adequate pressure.

Water supply system broadly involves transmission of water from the sources to the area of consumption, through free flow channels or conduits or pressure mains. Depending on topography and local conditions, conveyance may be in free flow and/ or pressure conduits. Transmission of water accounts for an appreciable part of the capital outlay and hence careful consideration of the economics is called for, before deciding on the best mode of conveyance. While water is being conveyed, it is necessary to ensure that there is no possibility of pollution from surrounding areas. Transmission and distribution pipes shall be laid only after taking levels. Design shall be done for laying the transmission pipes. The cross sectional area of trench for transmission main shall be 30 x 90 cm. The trench shall be taken as per the diameter of the pipe.

Include TABLE

The bottom of trench shall be levelled. Pressure testing shall be done after every 150 m. In case of road crossings, the trench shall have a depth of 90 cm and GI covering shall be provided for the pipes. If trenching is done in hard rock, an earth cushion of 20 cm shall be given below and above the pipeline. If pipe is to be laid vertically, then laterite pitching shall be done along the trench. Conveyance of water may be by gravity flow and/or pressure. Pipelines used for transmission of water, normally follow the profile of the ground surface closely. Gravity pipelines have to be laid below the hydraulic gradient. PVC Pipes are normally used for rural water supply schemes. MS/CI/GI pipes shall be used at all road crossings and in hard rocky strata regions.

5.6.9 Open Channels

Economical sections for open channels are generally trapezoidal while rectangular sections prove economical when rock cutting is involved. Uniform flow occurs in channels where the dimensions of the cross-section, the slope and the nature of the surface are the same throughout the length of the channel and when the slope is just equal to that required to overcome the friction and other losses at the velocity at which the water is flowing.

Open channels have restricted use in water works practice in view of the losses due to percolation and evaporation as also the possibility of pollution and misuse of water. Also they need to be taken aJong the gradient and therefore the initial cost and maintenance cost may be high. While open channels and canals are not recommended to be adopted for conveyance of treated water, they may be adopted for conveying raw water. Sometimes diversion channels meant for carrying floodwaters from other catchments are also used to augment the yield from the reservoirs.

5.6.10 Gravity Aqueducts and Tunnels

Aqueducts and tunnels are designed such that they flow three quarter full at required capacity of supply in most circumstances. For structuraland not hydraulic reasons, gravity tunnels aregenerally horseshoeshaped.

Gravity flow tunnels are built to shorten the route, conserve the head and to reduce the cost of aqueducts, traversing uneven terrain. They are usually lined to conserve head and reduce seepage but they may be left unlined when they are constructed by blasting through stable rock Mean velocities, which will not erode channels after ageing, range from 0.30 to 0.60 mps for unlined canals and l to2 metres per second for lined canals.

5.6.11 Pressure Aqueducts and Tunnels

They are ordinarily circular in section. In the case of pressure tunnels, the weight of overburden is relied upon to resist internal pressure. When there is not enough counter-balance to the internal pressure, steel cylinders or other reinforcing structure, for example, provide necessary tightness and strength.

5.6.12 Pipelines

Pipelines normally follow the profile of the ground surface quite closely. Gravity pipelines have to be laid below the hydraulic gradient. Pipes are of cast iron, ductile iron, mild steel, prestressed concrete, reinforced cement concrete, GRP, asbestos cement, plastic etc

5.6.12.1 Coefficient of Roughness

In today's economic climate, it is essential that all water utilities ensure that their resources are invested judiciously and hencethereisanurgentneedtoavoidoverdesigning ofthepipelines. Despite technological advancements, improved methods of manufacturing of an types of pipes and advent of new pipe materials, the current practice of adopting conservative Coefficient of Roughness (C values) is resulting in under utilization of the pipe materials.(CHECK)

The coefficient ofroughnessdependsonReynoldsNumber(henceonvelocityand diameter)and relativeroughness(d/k). ForReynoldsNumbergreaterthan 107, the friction factor f'(andhencetheCvalue)isrelativelyindependentofdiameterand velocity. However, for normal ranges of Reynolds number of 4000 to 106 the friction factor ' f' (and hence the C value) do depend on Diameter, Velocity and relative roughness.

PVC,GlassReinforcedPlastic(GRP)andother plastic pipes are inherently smoother comparedtoAsbestosCement(AC),Concreteandcementmortar/epoxylinedmetallic pipes. Dependingonqualityof workmanshipduringmanufactureandthemanufacturing process, theAC, Concreteandcementmortar/epoxylined metallicpipestendtobeas smoothas PVC, GRP and other plastic pipes.

The metallic pipes lined withcement mortar or epoxy and Concrete pipes behave as smooth pipesand have shown C values ranging from 140 to 145 depending on diameter and velocity.

Withaviewtoreducecorrosion, increasesmoothness, andprolongthelife ofpipe materials,the metallic pipes are being provided with durable smoothinternal linings. AC, Concrete and cement mortar/ epoxylined metallic pipes, PVC, GRP and other plastic pipes rnay not show any significant reduction in their carrying capacity with age and therefore the design roughness coefficient values (C values) should not be substantially different from those adopted for new pipes.

However, pipes carrying raw water are susceptibletodepositionofsiltand development of organic growth resulting in reduction of carrying capacityof such pipes. In case of buildup of substantialgrowth/buildupof depositsinsuchpipes, they can be removed by scraping and pigging the pipelines.

Unlinedmetallicpipesunderseveralfieldconditionssuchascarryingwatershaving tendencyfor incrustationand corrosion,lowflowvelocity and stagnantwater and alternate wetanddryconditions(resultingfromintermittentoperations),undergosubstantial reduction intheircarryingcapacitywithage. Thereforelower'C' valueshavebeen recommended for designof unlinedmetallicpipes. Assuch, useofunlined metallic pipesshouldbe discouraged.

5.6.12.2 Pipe Materials

Pipesrepresentalargeproportionofthecapitalinvestedinwatersupply undertakingsandthereforeare ofparticularimportance. Therefore pipematerialsshallhaveto be judiciouslyselectednotonlyfromthepointofviewofdurability,lifeandoverall costwhich includes,besidesthepipecost,theinstallationand maintenancecostsnecessaryto ensure the requiredfunctionandperformanceof thepipelinethroughoutits designedlife time.

5.6.12.2.1 Choice of Pipe Materials

Thevarioustypesof pipesusedare:

I. Metallic pipes
   (i) UnlinedMetallicpipes
   (ii) Metallic pipeslined withcementmortarorepoxylining;

II. Non Metallic pipes
   (i) Reinforced Concrete, Prestressed Concrete, Bar wrapped Steel CylinderConcrete, Asbestos Cement
   (ii) PlasticPipes :

Thedeterminationof thesuitabilityin all respectsof the pipesandspecials,for any work isamatterofdecisionbytheEngineerconcernedonthebasisofrequirementsforthe scheme.Severaltechnicalfactorsaffectthefinalchoiceof pipematerialsuchas internal pressures, coefficientof roughness,hydraulicandoperatingconditions,maximum

permissiblediameter, internalandexternalcorrosionproblems,laying andjointing,typeof soil, specialconditions, etc.

Thelife anddurabilityofthepipedependsonseveralfactorsincludinginherentstrengthofthepipematerial, themanufacturingprocessalong with quality control, handling, transportation, layingand jointing of the pipeline,surroundingsoilconditionsandquality of water.Normally, thedesignperiodofpipelinesisconsideredas30years.Wherethepipelineshavebeen manufactured properlyasper specifications,designedandinstalled with adequatequalitycontrol and strict supervision,someof them have lasted more than the designed life provided the quality of water is non-corrosive.

5.6.13 Appurtenances

Sluice Valves:- The size of SV is same as the size of the main upto 300 mm and for bigger diameters the size of valves is about 2/3 the size of mains subject to a min of 300 mm. Sluice valves are not used for continuous throttling as there wise erosion of the scales & body cavitations will occur. It is recommended the change the frequently when the working is affected. (CHECK)

Scour Valves:-In pressure conduits, small gated take-offs known as blow-off or scour valves are provided at the low points in the line such that each section of the line between valves can be emptied and drained completely. They discharge into natural drainage channels or empty into a sump from which the water can be pumped to waste. There should be no direct connection to sewers or polluted water courses but through a specially designed trapped chamber or pit. Their sizes depend upon local circumstances especially upon the time in which a given section of line is designed to be emptied and upon the resulting velocities of flow. Calculations are based upon orifice discharge under a failing head equal to the differences in an elevation of the water surface in the conduit and the blow-off less the friction head. Frequency of operation depends upon the quality of the water carried especially on silt loads. In the distribution system scour valves are inserted in the scour branch from the main at low points and at all dead ends. The size of the scour valve depends upon the length of the main to be scoured. It is, however, about half the size of the main which is to be scoured. The scour branch takes off from the main through a scour tee which is a special tee with its branch connection having its invert at the same level as the main with a view to drain out the bottom sediments.

Reflux Valves:-Reflux valves are valves through which flow can proceed in one direction only. Any tendency for the flow to reserve causes a reflux valve to close and to remain closed until flow is re-established, in the unique direction. It should close without causing shock. They are also called non return valves, check valves and retaining valves. In one application, a reflux valve can be described as a foot valve. The term check valve is generally

restricted to small size mains and which are of the disc type. Check valve can be had for the vertical as well as horizontal flow conditions. They are used in the house plumbing system as well as in industrial installation. It has the advantage of rapid closure but has simultaneously the disadvantage of causing water hammer associated with rapid closure and causing high resistance to flow. Single door type reflux valves should conform to IS : 5312 (Part 1)-1984.

Pressure Reducing Valves: Pressure reducing valves shall be provided at the entry point of distribution system to the low lying areas to control excessive flow of water to the low lying areas.

Air Valves:-These are sited to release the air automatically when a pipe line is being filled and also to permit air to enter the pipe line when it is being emptied. In an intermittent system the distribution pipes are becoming empty when the supply is stopped and draw in air and expel air when the water supply is resumed. Since the house service connections/ public taps are above the ground level air is expelled or drawn in through the open taps since these taps are usually kept open in an intermittent system even after the supply hours are over. However, to cater for situations wherein air has to be expelled or drawn in, Air Valves are sometimes provided at the highest point in the network.

The highest point is normally at the OHSR premises where an air valve is essentially required. Air valves may have to be provided in the network, if the network pipes are having several valleys and ridges. In such case the smallest diameter air valve available are provided at the peaks. However, for these air valves to function effectively they have to be mounted above the road level and hence the pipe connecting the main pipeline to the valve is taken away upto the road boundary and housed in a secured chamber. In view of the complicated arrangement required for air valves in a rural water distribution system, it is recommended that instead of providing Air Valves. This will take care of the expulsion of air from the distribution system. While designing the distribution network, the stand post at the highest level shall be marked distinctly for using as Air Valve.

Air Valves are provided at all peaks. Peaks are not judged solely w.r.t. to horizontal datum but also with respect to the maximum hydraulic gradient. Air valves are necessary at all points where the pipe line approaching the hydraulic gradient changes its slope to recede from this gradient.

5.6.14 Overhead services reservoirs

The water from the ground water source or treated water from surface shall be stored properly and then distributed through network of pipes by gravity. Elevated service reservoirs are the most commonly adopted structures for the above purpose as they can be constructed at a suitable location within the village. Following are the parameters to be considered in design of such overhead water tanks.