CENTRAL RAILWAY
ZONAL RAILWAY TRAINING INSTITUTE
BHUSAWAL

Reading Material
ENGINEERING (WORKS)
NOTES
Organization and Administration

Civil Engineering Department –
The maintenance and renewal of Civil Engineering assets of the Railways is the responsibility of the Open Line Organisation of the Civil Engineering Department.
The construction activities of the Railways may be under the administrative control of a Chief Engineer (Construction) reporting directly to the General Manager of an Open line or under the independent administrative control of a Chief Administrative Officer (Construction) or General Manager (Construction) reporting directly to the Railway Board.

Structure of Open Line Organisation -
i. The open line organisation of the Civil Engineering Department is headed by a Chief Engineer who works under the control of General Manager. The Chief Engineer is the Administrative and professional head of his Department and is assisted by Chief Track Engineer, Chief Bridge Engineer, Chief Planning and Design Engineer and / or a Chief Engineer (General) in regard to their respective functions.
ii. It is the duty of Chief Engineer to see that adequate and detailed rules exist or are prescribed in departmental manuals for the efficient maintenance and renewal of all open line works / way / bridges and other structures of the Railway.
iii. At the close of each year the Chief Engineer will append a certificate to the Annual Report of the Railway that the Permanent Way and other structural works on the Railway have been maintained efficiently.
iv. The Chief Engineer shall arrange for the preparation and compilation of budget at every budgetary stage and shall co-ordinate the compilation of Railway's Annual Works Programme.
v. The Chief Engineer shall exercise control to see that no expenditure is in excess of the budget grant and that budget allotment are fully expended in so far as is consistent with actual requirements
vi. The Chief Engineer shall maintain in his office a Schedule of Rates for each Division and book of standard specifications.
vii. The Chief Engineer shall be in charge of Gazetted Staff Cadre with regard to planning, posting and training.

C.A.O. (Const) / Chief Engineer (Construction) -
i. C.A.O./ Const / Chief Engineer (Construction) shall provide necessary direction and control for the efficient and economical execution of all works under his charge.
ii. The CAO. / Const / Chief Engineer (Construction) shall maintain liaison with the Open Line Organisation and shall follow the general policies and procedure laid down for the execution of works. In cases where a different policy or procedure becomes necessary to be followed, he shall do so after due consultation with the Open Line Organisation to ensure proper co-ordination.
iii. The C.AO./ Const / Chief Engineer (Construction) shall exercise necessary budgetary control within the allotment of funds at his disposal and shall co-ordinate with the Chief Engineer for the Compilation of budget at every budgetary Stage.
iv. The C.AO./ Const / Chief Engineer (Construction) shall co-ordinate with the Chief Engineer with regard to the placement of personnel for the various assignments under his charge keeping in view the over all career development of such personnel.
Organisation set up at Division Level (Open Line) -
The organisational set up of the open line in a Division may consist of more than one Divisional Engineer (Senior Scale) or Senior Divisional Engineer (JA Grade) in charge of a territorial jurisdiction under the administrative control of DRM, and reporting to Chief Engineer, Chief Track Engineer or Chief Bridge Engineer as the case may be on departmental matters.

Organisation set up at Division Level (Construction) -

i. A construction division will generally be under the immediate charge of an Executive Engineer (Senior Scale) or Dy CE (Construction) (JA Grade) under the Administrative Control of the C.A O./ Const Chief Engineer (Construction) and reporting directly to that officer in all matters. In cases where such a construction division is made a part of open Line Divisional set up then the Executive Engineer will be placed under the Administrative Control of the Divisional Railway Manager.

ii. The Executive Engineer or Dy CE (Construction) should arrange for the proper execution of works in his division and superintend the works. He is responsible for the punctual execution of orders issued by the CAO / const / chief Engineer (const.) / Chief Engineer.

iii. Executive Engineers or Dy CE (Construction) are strictly prohibited from commencing the construction of any work of expending public funds or entering into any commitments without the sanction of competent authority;

iv. Executive Engineers or Dy CE (Construction) are responsible for the good quality of all work done under their orders.

v. Executive Engineers or Dy CE (Construction) will take the necessary steps for securing prompt payment for the works under their control.

vi. Executive Engineers or Dy CE (Construction) are responsible for the correctness, in all respects of the original records of cash and stores, receipts and expenditure and for seeing that complete vouchers are obtained.

vii. Every Executive Engineer or Dy CE (Construction) is required to report immediately to the Chief Engineer any important accident or unusual occurrence or financial losses by theft, misappropriation or other causes connected with his division, and to state how he has acted in consequence.

Organisation set up at Sub-Divisions Level -

i. The sub unit of a division both in the open line and construction is called a Sub-Division. The Sub Division will be in charge of an Assistant Engineer or a Divisional Engineer (Senior Scale)-holding direct charge’ of an upgraded post of an Assistant Engineer in the open line. In the case of a Divisional Engineer (Senior Scald) holding charge of a Sub Division in an upgraded post the power and duties prescribed in this Code for an Assistant Engineer shall be applicable to him.

ii. Engineering Supervisors should not as a rule be required to keep any public money beyond an imprest. They should keep muster rolls of all labour engaged by them and other prescribed accounts and it will be their duty at all times to see that labour receive full payment at prescribed periods.
## Zonal Railways with their head quarters –

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Modes of Investigation of Railway projects

Project Development Process –
The Project Development Process consists of the following sequences :-
   i. Assessment of future needs/requirements.
   ii. Project formulation, which is to determine the various options to meet the demand.
   iii. Project investigation which is to examine some selected alternatives as defined in the terms of reference to the Project Investigator and preparation of Techno Economic Survey Reports.
   iv. Project evaluation which may involve economic analysis, or Social Profitability Analysis, in addition to financial appraisal.
   v. Selection of a scheme based on such an appraisal.
   vi. Further detailed examination of the selected scheme by conducting a Preliminary survey.

Project formulation is an essential part of the planning process and the Project Investigator must be given clear indications regarding the objectives to be achieved and the options to be investigated. Pre-investment decision investigations may relate to long term planning and to decide priorities. Such investigations are in the form of Reconnaissance Surveys where much detailed investigations are not carried out and cost estimation will also be approximate. Investigations of this nature are termed "Feasibility Studies".

Techno-Economic Surveys –
Pre-investment decision investigations may also involve examination of various alternatives including optimisation of existing facilities to decide the best alternative from financial and operating point of view to make an ideal investment decision. Such investigations relating to new lines, doublings, gauge, conversions schemes, yard remodelling, passenger terminal etc. involving Preliminary Engineering-cum-Traffic Surveys, are termed as Techno-Economic Surveys. In these surveys, data, regarding the growth of traffic is collected, traffic projections are made the existing facilities are evaluated the possibility of optimising them and new alternative schemes are examined. An estimate prepared based on such an investigation should under ordinary circumstances be sufficiently accurate to permit investment decision being taken.

Techno-Economic Survey Reports.-
Techno-Economic Survey Reports based on Preliminary Engineering-cum-Traffic Surveys for new lines and traffic facilities may be compiled under chapters as indicated below:--
   (i) Introduction;
   (ii) Traffic Projection;
   (iii) Analysis of Alternatives;
   (iv) Characteristics of Project Area;
   (v) Standard of Construction (for new lines, multiple tracking schemes, gauge conversions);
   (vi) Route Selection/Project Description;
   (vii) Project Engineering (for new lines, multiple tracking schemes and gauge conversion);
   (viii) Cost, phasing and investment schedule;
   (ix) Financial Appraisal; and
   (x) Recommendation.

Categories of Lines –

Broad Gauge –
Broad Gauge lines on Indian Railways are classified into various categories indicated below, on the basis of future maximum permissible speed :-
(1) Group ‘A’ - For a sanctioned speed of 160 km. per hour -
   i. The minimum sleeper density shall be 1,660 numbers per Km.
   ii. The ballast cushion shall be 30 cm.
   iii. Bridges will be built to revised BG loading of 1975 with a maximum axle load of 22.5 tonnes for the locomotive and train load of 7.67 tonnes per meter behind the locomotives with a maximum axle load of 22.9 tonnes for the train load.

(2) Group ‘B’ - For a sanctioned speed of 130 km. per hour
   i. The minimum rail section to be adopted will be 60 Kg. in sections having traffic density of over 20 GMT and 52 Kg. in other sections.
   ii. The minimum sleeper density shall be M+7.
   iii. The ballast cushion shall be 25 cm.

(3) Group ‘C’ - Suburban sections.

(4) Group ‘D’ - Where the speeds up to 110 Kms / hour. And the annual traffic density is less than 20 GMT.

(5) Group ‘D’ Spl - Where the speeds up to 110 Kms / hour. And the annual traffic density is 20 GMT or more.

(6) Group ‘E’ - Other sections of branch lines with speed up to 100 Kmph..
   i. The minimum sleeper density shall be M+4. However, depending on local conditions a density higher than M+4 can be adopted where traffic density is 10 GMT and above subject to Railway Board approval.
   ii. The ballast cushion shall be 15 cms.

Meter gauge –

Meter gauge lines on Indian Railways is classified into various categories indicated below:-

(1) Trunk Routes.- Having a traffic density of 5 million G.T. Km per Km per annum and above or where the speed will be above 70 Km hour (45 mph).
   i. The rail section to be adopted shall be 37 Kgs (75 lbs.).
   ii. The sleeper density shall be M+7.
   iii. The ballast cushion shall be 25 cms.
   iv. Bridges will be built to MGML standard of loading i.e. 13.2 tonnes axle loads and a train of 3.87 tonnes per metre run behind the engine.

(2) Main lines (other than trunk routs). - Having a traffic density of 2.5 to 5.0 million G.T. Km per Km per annum.
   i. The rail section to be adopted shall be 30 Kg.
   ii. The ballast cushion shall be 20 cms.

(3) Other main lines and branch lines. - Having a traffic density of 1.25 to 2.5 million G.T. Km per Km per annum.
   i. The sleeper density shall be M+4.

(4) Tertiary lines.- Having a traffic density of below 1.25 million G. T. Km per Km per annum.
   i. The rail section to be adopted shall be 30 Kg (normally released second-handrail).
   ii. The minimum sleeper density shall be M+2.
   iii. Bridges will be built to MGBL standard of loading i.e. 10.7 tonnes axle loads and a train of 3.87 tonnes per metre run behind the engine.

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Introduction to Allied Railway Organization

Rail Vikas Nigam Limited (RVNL) –
Rail Vikas Nigam Limited is a special purpose vehicle created to undertake project development mobilization of financial resources and implement projects pertaining to strengthening up. Golden quadrilateral and port connectivity, Rail Vikas Nigam Limited had been registered as a company under company’s Act 1956 on dt. 24 – 10 2003. It is a holy owned Govt. company under the provisions of section 617 of companies act. Certificate of commencement of business was obtained on dated 18-2-2003. Authorized capital of Rail Vikas Nigam Limited is about Rs. 3000 crores and paid up capital Rs. 800 crores.

Rail India Technical and Economic Services Ltd. (RITES)
Rail India Technical and Economic Services Ltd. is a Government of India undertaking provides consultancy service on all aspects of railway from concept to completion. RITES is closely linked with Indian Railways and is in privileged position to draw freely upon the huge pool of experience expertise and technical. Know how an acquired over a century of operations of Indian Railways. RITES can provide consultancy services with regard to new lines, Track doubling and gauge conversions, bridges and rail road structures, Signalling and telecommunication, rolling stock and workshop technology, Railway electrification, Material handling systems, Railway operation management and training, transport economic studies inspection and such other allied field of railway working. RITES is already providing consultancy services about railway operation to around 15 developing countries of Asia & Africa.

Dedicated freight corridor -
Going on the lines of NHAI’s golden quadrilateral, the ministry of railways has recently announced the launch of a dedicated ‘freight corridor’, in order to decongest rail traffic. As of now, passenger and freight trains move on the same track, causing delays and fatal accidents. European countries as well as countries like the US and Australia have gained immensely from the network of rail freight corridors. As important ports and harbour cities have been well connected with their industrial counterparts, the freight transit period is minimised. The development of such dedicated freight corridors have helped in the structuring of the economy of the countries. It also provides a reliable, cost-effective and timely service to consumers.
A ‘freight corridor’ project is expected to be exclusively reserved railway tracks laid for freight trains along the golden quadrilateral. As per the plans the freight trains would be able to travel at speeds of above 100 km an hour.

Container Corporation of India (CONCOR) -
Container Corporation of India is a public sector undertaking under Ministry of Railways for developing multi model transport infrastructure for India’s international & domestic trade and industry. In 1989 Container Corporation of India had taken over the management of seven Inland Container Depots (ICDs) at New Delhi, Ludhiana,
Banglore, Coimbatore, Guntur, Anaparti and Amingaon (Gowhati) which were managed by the Indian Railways. The Container Corporation of India has established a network of ICDs & CFSs (Container Freight Stations) to promote & facilitate the international freight traffic.

**Mumbai Railway Vikas Corporation Ltd (MRVC Ltd),**

Mumbai Railway Vikas Corporation Ltd (MRVC Ltd), a Public Sector Undertaking of Govt. of India under Ministry of Railways (MoR) was incorporated under Companies Act, 1956 on 12th July 1999 with an equity capital of Rs. 25 crore shared in the ratio of 51:49 between Ministry of Railways and Government of Maharashtra. MRVC is responsible to execute the projects under Mumbai Urban Transport Project (MUTP) as sanctioned by Ministry of Railways. The Corporation will execute a number of suburban rail improvement projects for enhancing suburban rail transportation capacity thereby reducing the overcrowding and meeting future traffic requirements. The corporation will also be involved in the planning and development of Mumbai Suburban Rail system.

**Railway Land Development Authority (RLDA)** -

**Mission** -

Development of Land/Air Space entrusted to the Authority on sound commercial principals for generation of non-tariff revenue and creation of assets for Indian Railways.

**Vision** -

To emerge as India's leading Public Land Development Authority.

**Corporate Objectives** -

1. Total dedication and commitment to the Corporate Mission
2. Redevelopment of Railway Station buildings, staff colonies and other Railway infrastructure along with generation of revenue through innovative use of land resources.
3. Develop expertise in consultancy, construction and management services in the field of real estate.
4. Developing sound commercial models of development and implementing projects on the model that assures highest revenue return with adequate safeguards.
5. Constantly striving to standardize the development process and the financial and legal documentations.
6. To develop the Railway land/air space following sound architectural principles in synergy with existing surroundings and State urban development norms.
7. Involving private sector, PSUs and other Central/State Government bodies as partners towards achieving its Corporate Mission.
8. Maintaining full transparency in all decisions and transactions.
9. To have a lean, efficient, accountable and effective organization.

**Indian Railway finance Corporation (IRFC)** –

It is a public undertaking under Ministry of Railway
Bridge Engineering

Definition of Bridge – It is a structure constructed spanning road, river, valley or any other structure with a purpose to have through passage for communication. The bridges are constructed for Roadways as well as Railways.

Classification of Bridges-
1. Important Bridges- The bridges having total waterway of 1000 sq.m or total linear waterway of 300 m or more and the bridges classified as important by Chief Engineer / Chief Bridge Engineer, depending upon consideration such as depth of water way, extent of river training works and maintenance problems.
2. Major Bridges- Major bridge is one of which has a total linear waterway of 18 m or more for multiple span and total linear water way of 12 m or more for single span.
3. Minor Bridges- Major bridge is one of which has a total linear waterway less than 18 m for multiple span and total linear water way less than 12 m for single span.
4. Culvert – Bridge having linear water way less than 6.00 m called as culvert.

Definition –
Free Board – This is the vertical distance between the high flood level inclusive of afflux and the formation level.
Clearance - This is the vertical distance between the high flood level inclusive of afflux and the bottom most part of bridge super structure like slab girder etc.
Via duct – When the bridge is constructed to cross a valley for railway instead of filling it the bridge as called via duct.
Skew Bridge – When the bridge is not right angle to the axis of river or other such opening it is called a skew bridge.
Cause Way – It is a bridge constructed to pass a flood water over the railway track is called cause way.
Clear Span – It is the clear distance between any two bridge supports like abutments piers etc.
Effective span – It is the distance between centers of two adjacent bridge supports.
Over all Span – It is the over all length of girder.
Water Way – The Water way is the area of the opening which should be sufficient to pass the max flood discharge that would ever pass under the bridge with out increasing the velocity to a dangerous limit called water way.
Linear Water way – The length available in the bridge between extreme edge of a water surface at the highest flood level measured at right angles to the abutment faces.
Head Room – In a through bridge it is the distance between the highest point of a vehicle and the lowest point of any member of the bridge.
Super Structure – The Super Structure is that part of the bridge over which the traffic moves with safety.
Sub Structure – The function of the sub structure is similar to that of foundations, piers, abutments, wing walls and approaches.
Abutment Pier – It is a heavier pier built in the arch bridges designed to take the horizontal thrust of the arch in case of bridge failure usually every fourth or fifth is designed as Abutment Pier.
Apron – It is a layer of concrete masonry stone etc. which is placed at the entrance or outlet of the culvert or water way to prevent the scouring.
Economic Span of a Bridge. –
The span for which the total cost of bridge will be minimum is known as the economic span.
The ratio of Cost of super structure and Cost of Sub structure = 1
Economical Span = $\sqrt{\frac{P}{a}}$,  
Where - $a = \frac{p}{l^2}$, $p =$ Cost of pier (Super structure), $l =$ Span,  
$P =$ Cost of Pier (Sub Structure), $a =$ Constant of variation.

**Depth of Scour**-
Score is the rise in the distance from rail level and bottom of rivers. The maximum scour depth in a stream can be ascertained when ever possible by actual sounding at or near the site proposed for the bridge during or immediately after a flood. Before the scour holes have had time to silt up due to allowance should be made in the observed depth for increase in scour resulting from-  

i. The designed discharge being greater than the flood discharge during which the scour was observed.  

ii. The increase in velocity due to the obstruction in flow caused by construction of the bridge.  

Where the above practical method of determining scour is not possible the following theoretical method may be used as a guide when dealing with natural streams is alluvial beds.  

$$D = 0.473 \left( \frac{Q}{F} \right)^{\frac{1}{3}}$$  

Where $D =$ Depth of scour below HFL for regime conditions in a stable channel in meters.  
$Q =$ Design discharge in cumecs.  
$F =$ Silt factor = $1.76 \sqrt{m}$, $m$ is the mean diameter of particles in mm.

**Afflux in a river**—  
Afflux is the rise in the flood level of the river up stream of the bridge as a result of obstruction to natural flow caused by the construction of the bridge. Afflux is normally measured as difference in water level between up stream and down stream of the bridge.  

Afflux is calculated by following formula—  

Molesworth’s formula—  

$$ha = \frac{V^2}{17.9} + 0.015 \left[ \left( \frac{A}{a} \right)^2 - 1 \right]$$  

Where – $ha =$ Afflux in meter. $V =$ Velocity of approach in meter per second. $A =$ Natural water way area at the site. $a =$ Contracted area in square meters.

**Types of Girder Bridge:—**  
(1) **Deck Type Girders** - These Span used for Span Varies from 9.20m. To 24.40m.
(2) **Under Slung Girders** – These span used for span varies from 30.5 m. & above and where water flow very such as Vio duct.

(3) **Through Type Girders** - These span used for span varies from 30.5 m. & above.
(4) Semi Through Type Girders – These Span used for Span Varies from 9.20m. To 24.40m.

Purpose of bridge inspection
Specific purposes of bridge inspection can be identified as detailed below:
   i. To know whether the bridge is structurally safe, and to decide the course of action to make it safe.
   ii. To identify actual and potential sources of trouble at the earliest possible stage.
   iii. To record systematically and periodically the state of the structure.
   iv. To impose speed restriction on the bridge if the condition/situation warrants the same till the repair / rehabilitation of the bridge is carried out.
   v. To determine and report whether major rehabilitation of the bridge is necessary to cope with the natural environment and the traffic passing over the bridge.
   vi. To provide a feedback of information to designers and construction engineers on those features which give maintenance problems.

Different Railways follow different practices in regard to the responsibility of annual inspection and maintenance of bridges.
By Works Inspectors: -
Once a year during the prescribed months prior to the monsoon season, the Inspector shall inspect every bridge including road under/over bridges in his section. The inspection shall cover the following:

i) Foundations and substructures,
ii) Protective works
iii) Superstructures of all RCC, PSC slab and masonry bridges,
iv) Detailed inspection of steel works of girders less than 12.2 m clear span once in five years, about 20% being done each year,
v) General condition of superstructure of all other types of bridges and their bearings,
vii) Obstruction of waterways.

Specifically by Permanent Way Inspectors: -
Once a year during the prescribed months prior to monsoon, the Permanent Way Inspector shall inspect the following:

i) the track and approaches of all the bridges,
ii) run off frames if any and foot path on bridges.

Record of Bridge Inspection: -

a) The Inspectors shall record results of their inspection in a register in manuscript form which shall contain particulars of the date of inspection.
b) Certificate of Inspection: - The Inspector shall submit to the Assistant Engineer by the prescribed date a certificate in duplicate to the effect "I certify that I have carried out pre-monsoon bridge inspection of my section in accordance with standing orders for the year.... and append herewith a list of important defects, for which your instructions are requested.'

The Assistant Engineer shall issue such orders as deemed necessary to the Inspector, countersign and forward one copy of the certificate of inspection to the Divisional Engineer with remarks, if any, within a month. The Inspector should carry out repairs as early as possible.

By Bridge Inspectors: -
The Bridge Inspector shall inspect in detail:

a) The steel work and bearings of all girders 12.2 m clear span and above including that of road under/over bridges once in five years, about 20% of the inspection being carried out every year.
b) Welded girders once in three years, the initial inspection being carried out one year after installation.
c) Superstructure of all prestressed concrete bridges, composite girder bridges once in five years, the initial inspection being carried out one year after installation.
d) Girders which are overstressed and kept under observation at least once a year.
e) Floor system of early steel girders once in a year. Other members once in five years.

Registers to be maintained by the Bridge Inspectors: -
The following registers should be maintained by the Bridge Inspector:

i) Inspection register for steel work in bridges.
ii) Rivet Testing Register
iii) Weld Test Register,
iv) PSC Bridge / Composite Girder Bridge Inspection Register,
v) Annual Inspection Register for overstressed girder.

Inspection By Assistant Engineers

a) The Assistant Engineer shall inspect every bridge including road over / under bridges once a year after the monsoon. The inspection should commence soon after the cessation of the monsoon and completed by a date to be specified by the Chief Engineer.
b) Bridges, whose condition warrants special attention should be inspected more frequently.
c) The Assistant Engineer along with his counterpart of the PWD or Irrigation Department of the State Government shall jointly inspect canal and irrigation crossings, wherever necessary.
d) The inspection shall in detail cover all aspects. In regard to steel work, the general condition of the girders and bearings should be examined paying special attention to places liable to corrosion and stress concentration (in welded girders) and the condition of paint.
e) Scaffolding or cradles as may be required for the purpose of detailed inspection should be arranged.

Certificate by the Assistant Engineer -
On completion of his annual bridge inspection, the Assistant Engineer shall certify at the end of the register as follows:
"I have personally inspected all the bridges shown in this register during the year ending December.... and have issued detailed orders in writing to the Inspectors concerned, except the following.
Bridge No...... are referred to for further orders. Bridge No........... have one or more CRN as 0 during more than one consecutive inspections".
All registers should be sent to the Divisional Engineer by a specified date. They may be sent in a regular flow as and when bridge inspection on a section is over without waiting for the completion of inspection of all the bridges.

By Divisional Engineers and Territorial HODs

a) The Divisional Engineer shall carefully scrutinise the Assistant Engineer's Bridge Inspection Register and inspect all important bridges and such bridges as called for his inspection. He shall record his orders regarding the points which require a decision by him and initial against every bridge in token of scrutiny.
b) He will complete his inspections and scrutiny by a specified date.

Certificate by Divisional Engineer.

He should endorse on each register, below the Assistant Engineer's certificate as follows:
"I have personally scrutinised this register and inspected all important bridge and bridges referred to me and have issued orders regarding all essential points requiring a decision by me. And points are submitted to the Territorial Head of the Department for orders. The Divisional Engineer shall inspect all those bridges for which the ORN is 1, 2 or 3 and revise / confirm the rating given by the AEN. Bridges which have, after review, an ORN of 1 shall be placed in the distressed category.

Action by Divisional Engineer.

He should then send the register to the Assistant Engineer for noting his orders with instructions to return them within ten days. The Assistant Engineer should then extract the orders issued by the Divisional Engineer, intimate the same to the Inspectors concerned and ensure expeditious compliance.

Scrutiny by Territorial HOD and action thereon:
The registers should then be forwarded by the Divisional Engineer to the Territorial HOD by a specified date, who will examine each register, issue orders regarding matters referred to him duly endorsing the registers to the effect and return them to the Divisional Engineer latest by a specified date. Subsequent action taken on the Territorial HOD's orders should be entered in the register by the Assistant Engineers.

By Assistant Engineer / Divisional Engineer (Bridge).
The officer nominated for the purpose of maintenance and inspection of steel work of bridges shall scrutinise the registers sent by Bridge Inspector and endorse the registers below the
Bridge Inspector’s certificate and forward it through the concerned Divisional Engineer by a specified date to the Dy. Chief Engineer/ (Bridges) nominated by Chief Bridge Engineer. He will inspect:
a) Bridges which have been referred to him,
b) Bridges which call for the inspection after scrutiny of the Bridge Inspector’s registers.
c) All the overstressed girders where camber loss is noted.
He will test check 10% of the inspection work carried out by the Bridge Inspector.

Certificate of Inspection:
After scrutiny of the registers and inspection of bridges the nominated officer will append a certificate on each register to the effect:
"I certify that I have personally scrutinised this register and issued instructions on essential points requiring a decision by me. I have carried out test checks as required during the year and points are referred to the Dy. Chief Engineer/ (Bridges) for orders".

By Dy. Chief Engineer / (Bridges)

Scrutiny of the register :-
The nominated Dy. Chief Engineer (Bridges) shall examine the entries in the Bridge Inspector’s register and record his orders on the points referred to him by the Divisional Engineer (Bridges) / Assistant Engineer (Bridges).
The registers should be returned by a prescribed date with necessary endorsements to the Bridge Inspectors through the nominated officer for taking prompt action thereon.
He shall inspect the steel work of such bridges,
a) as called for his inspection after scrutiny of the registers.
b) as directed by the Chief Bridge Engineer and enter his notes and ensure prompt action thereon.
He will list out the defects considered sufficiently important and bring them to the notice of the Chief Bridge Engineer through the Territorial HOD.

Schedule of inspection:-
All the bridges are to be inspected by PWIs / IOWs once a year before monsoon and by AENs once a year after monsoon, and important bridges by DENs once a year. All the steel structures are inspected by BRIIs once in 5 years and selected bridges by Bridge Engineers / Dy.CE (Bridges) as and when found necessary. Side by side, the track on the bridge should also be inspected thoroughly. The bridges that have been referred by AEN / DEN / Sr.DEN for inspection by a higher authority, should be inspected by the higher authority in good time. Bridges which are of early steel, and bridges which are overstressed should be inspected more frequently.

Bridge Inspection Register :
The Assistant Engineer should record the results of his inspection in ink in the Bridge Inspection Register, separate registers being maintained for major and minor bridges. For each one of the important bridges and river training works there to be specified by the Chief Engineer, a separate Bridge Inspection Register should be maintained.

Numerical Rating System ( NRS ) For Bridges
In the numerical rating system, the condition of a bridge is represented by a number consisting of eight digits. This eight digit number is called as unique rating number ( URN ).
In this eight digit URN, the first digit describes the over all condition of the bridge and this number is known as over all rating number ( ORN ).
The remaining seven digits are known as condition rating number ( CRN ) and these describes the physical condition of the different components of the bridges.

<table>
<thead>
<tr>
<th>Digit</th>
<th>Part of the Bridge which is described by the digit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>lst</td>
<td>Over all condition of the bridge.</td>
</tr>
<tr>
<td>lind</td>
<td>Condition of the Foundation &amp; Flooring.</td>
</tr>
</tbody>
</table>
IIIrd | Condition of the Masonry / concrete sub-structure.
Ivth | Condition of the Bed training / Protective works.
Vth | Condition of the Bed Block.
VIth | Condition of the Bearing & expansion arrangement.
VIIth | Condition of the super structure – girder / slab / arch / pipe etc.
VIIIth | Condition of the track structure.

Condition Rating Number
1. A Condition which warrants rebuilding / re-habilitation immediately.
2. A Condition which requires rebuilding / re-habilitation on program basis.
3. A Condition which requires major / special repairs.
4. A Condition which requires routine maintenance.
5. Sound Condition.
6. Not applicable.
7. Not inspected.

Over all rating number will be lowest CRN given to a Bridge except 0.
Numerical code given to a bridge helps in identifying the progressive deterioration in the bridge.
NRS is convenient for storage of the date in the computer.
NRS is not in any way linked to the load carrying capacity of the bridge.

EXAMPLE –
• Suppose a major arch bridge given a number as 20456625.
• The first digit, which indicate the over all rating, is given a number 2. It indicates that rebuilding / re-habilitation on programmed basis.
• The second digit, which indicate the Condition of the Foundation & Flooring. Is given a number 0. 0 indicates that foundation / flooring is not inspected.
• The third digit rated as 4 represented that, condition of the masonry / concrete substructure requires routine maintenance.
• The fourth digit rated as 5 represented that, condition of the training / protective works, is sound.
• The fifth digit rated as 6 represented that, condition of the bed block, Number 6 stands for “ Not applicable “, because no bed block is provided in the arch bridge.
• The sixth digit is also rated as 6. Sixth digit represents the bearing / expansion arrangement. In case of arch bridge, No bearing are provided. Number 6 stands for “ Not applicable “.
• The seventh digit is rated as 2. It represents that the superstructure of the bridge requires rebuilding / re-habilitation on programme basis.
• The eight digit rated as 5 represents the sound condition of the Track.

Under Water inspection of Bridges-
The underwater inspection of bridges is becoming key activity to be undertaken for maintaining bridge substructure and foundation. Underwater inspection has four primary purposes – ensuring public safety, protecting public assets, preventing or reducing facility downtime and initiating proactive maintenance.
There are three general methods of performing underwater inspection of bridge elements.
  i. Wading inspection
  ii. Scuba diving
  iii. Surface supplied air diving
Wading inspection is the basic method of underwater inspection used on structures over wadable streams. A wading inspection can often be performed by regular bridge inspection teams. A probing rod, sounding rod or line, waders, and possibly a boat can be used for evaluation of a substructure unit.
The acronym “Scuba” stands for self contained underwater breathing apparatus. In scuba diving, the diver is provided with portable air supply through an oxygen tank, which is strapped
to the diver’s back. Air is inhaled from the supply tank and the exhaust is vented directly to the surrounding water. The diver is connected through an umbilical cable with the surface and has sufficient freedom of movement.

Surface supplied air diving uses a body suit, a hard helmet covering the head, and a surface supplied air system. Air is supplied to the diver through umbilical hoses connected to the surface air compressor tank. It requires more equipment than the Scuba diving. In addition to the air hose, a communication cable, a lifeline, and a pneumatic Fathometer are usually attached to the diver.

Under-water bridge inspection, especially the initial inspection, requires careful planning to ensure that work is performed effectively and economically. Prior site reconnaissance can reduce the cost by leading to selection of methods and equipment best suited to the work.
Details of Bridge Inspection -

1. Flooring and foundations :-
   i. Scour has taken place particularly around the piers and near abutments and also along
      curtain walls and downstream of drop walls,
   ii. there is any settlement or undermining of the foundations.
   iii. The conditions of the flooring, drop walls, curtain walls, apron and pitching should be
      examined.

2. Masonry in substructure:
   i. The masonry is in any way cracked, shaken or crushed, particularly under the bed blocks
      in the ballast walls, abutments and piers,
   ii. There is any bulging, shearing, tilting (out of plumb) and apparent signs of movement in
      abutments, wing and return walls,
   iii. There is any deterioration due to weathering or any damage to the stone or brick or
      leaching of the mortar in the joints.
   iv. Seepage of water through the joints in the masonry.

3. Arch bridges –
   i. Longitudinal cracks in arch barrel.
   ii. Horizontal crack and bulging of spandrel wall.
   iii. Sliding forward of spandrel wall,
   iv. Transverse or diagonal cracks in arch intrados.
   v. Cracks in the vicinity of the crown of the arch,
   vi. Leaching out of mortar,
   vii. Weathering of masonry,
viii. Loosening of key stone and voussoirs of arch,
ix. Adequacy of cushion,
x. Adequacy of weep holes and drainage,
xii. Presence of cracks in parapet wall / leaning of parapet wall.

4. Protective works and water ways :-
i. The protective works such as pitching, toe wall, flooring, drop / curtain walls, guide bunds, launching aprons, spurs / groynes, approach banks, marginal bunds.
ii) the waterway is adequate and clear of obstruction,
iii. The marginal embankments maintained by the State Governments should be inspected.
iii. It should be examined whether there has been any disturbing influence noticed like excessive velocity, parallel flow, heavy afflux, tank bursts in catchments and increase in spill from adjacent catchment.

5. Girder alignment and seatings:-
i. The position of girders in respect of line and level relative to the piers and abutments is correct.
ii. The bearings are fully and evenly seated on the bed blocks and the holding down bolts are in position and anchored in the bed blocks,
iii. The bed blocks are cracked, crushed, shifted or shaken, particularly under the bearings.
iv. The rollers and the sliding plates provided at the expansion ends.
v. The date of lubrication of girder bearings is conspicuously painted,
vi. The metal bearings are cracked or corroded,
vii. The bearings provided with oil bath are covered free of dust and proper oil level is maintained.
viii. Where possible, girders should be observed under train load for any abnormal movement or evidence of settlement.

6. Structural condition of girders:--
i. Loss of camber in the main girders.
ii. Distortion of members,
iii. High incidence of loose rivets.
iv. Bottom chord members & top chord member
   Diagonal web members and tension members made up of flats,
v. Top flanges of plate girders.
vi. Tightness of rivets, loose and distorted rivets
vii. Butt welds in tension flange or tension member & welds at ends, ends of welded cover plates, intersecting weld,
viii. Shear connector and girder connections,
ix. Any vertical separation between girder and slab.

7. The condition of steel work :-
i. Steel work of girders and the under side of over bridges which are liable to corrosion by the action of fumes from engines and whether they are protected by smoke guards,
ii. Steel column footings of over bridges where buried in ground,
iii. Roots of flanges and angles where defects in rolling can initiate cracks.
iv. Joints where heavy shear is transmitted,
v. Badly corroded members,
vi. Bent plates
vii. Steel work in wrought iron or manufactured before 1905.

8. Track on the bridge approaches :
i. Rail bearers and the main girders are in good line and level,
ii. Incorrect seating of girders, shifting of girders laterally or longitudinally, incorrect seating of sleepers on girders and rails on sleepers, varying gauge or creep.
iii. The condition of sleepers and fastenings.
iv. Hook bolts & Creep and joint gaps. & Guard rails.
v. The gauge and level of track.
vi. Track on approaches & Rail joints.
vii. Trolley and safety refuges & Foot paths.

9. Painting –
i. Marking HFL and Danger level, providing foundation particulars and bridge name boards.
ii. The date of last painting
iii. The Highest Flood Level and the year.
iv. The danger level has been fixed and marked on the pier / abutment.
v. The direction of the flow has been distinctly marked on the abutment or pier.
vi. Name boards have been fixed at either approach of important bridge.
vii. The Full Supply Level (FSL) has been marked distinctly at all canal crossings.
viii. The Bridge Number Tablets.
ix. The flood gauges have been provided at important bridges for recording flood levels and afflux.

10. Road over / under bridges:-
a) Road over bridges :
i) to ascertain whether the structures are on sound condition,
ii) to check the vertical clearance available is as per schedule of dimensions,
iii) to check the thickness of road way.
iv) In electrified areas, safety or protective screens.
v) to examine the condition and adequacy of smoke guards,
vi) to examine the condition of the deck slab for spalling or deterioration of concrete,
vii) to check the condition of any waterproofing treatment given to concrete deck,
ix) whether speed breakers have been provided.
b) Road under bridges:
i) to check up whether height gauges are provided,
ii) to check up whether the bottom of girders have been covered.

11. Concrete bridges :
i. The condition of bed blocks and bearings,
ii. The camber of prestressed concrete girder.
iii. The surface of concrete should be checked by a magnifying glass for any cracks.
iv. It should also be checked as to whether water proof layer, if provided is intact.
v. It should be examined whether rust streaks / stain marks are visible parallel to reinforcement.
vii. It should be checked whether there is spalling, caused by separation of the concrete from the reinforcement.
ix. It should be checked whether there are signs of disintegration of concrete.
ixi. Seepage, leakage and efflorescence should be looked for.

Distressed Bridge and its rehabilitation -

Distressed Bridge - A distressed bridge is one which shows any physical sign of deterioration of its physical condition, indicating the need for rehabilitation through special repairs, strengthening or rebuilding (including replacement of girders)

Distressed condition & Categories :-
1. When in the course of inspection of bridge, defects are noticed the inspecting official should examine the bridge thoroughly.
2. Based on the detailed inspection, the inspecting official may impose a suitable speed restriction as appropriate. The inspecting official may suspend traffic, if the bridge is
considered unsafe, restoration of traffic shall either be after a further detailed examination or after adequate relieving measures are undertaken.

3. If the cracks have been detected, tell tales should be fixed. All defects should be recorded, sketches prepared and a detailed report sent to the Divl.Office.

4. The bridge may then be classified as “Distressed” by the Sr.Divisional /Divisional Engineer after personal inspection, if necessary. A detailed report should also be sent to the HQ. Office.

**Classification of distressed bridges**
- **Category I**: Those requiring rehabilitation to be done immediately say within a years time.
- **Category II**: Those requiring to be kept under observation and to be taken up for rehabilitation on programmed basis.

**Rehabilitation of distressed bridges**
1. The Divisional / Senior Divisional Engineer, while including a bridge in the distressed bridge list, should also indicate the priority classification depending on nature and severity of distress.
2. Some Bridges may have to be kept under observation after minor attention like grouting with provision of tell tales. During the period of observation, if it is found that the defects reappear, the bridge may be included in category I or II, as the case may be.

**Reasons of Rehabilitation**
- Bridge may require rehabilitation on account of various reasons as under:-
  1. Physical distress.
  2. Vulnerability on hydrological consideration.
  3. Use of obsolete/non standard materials such as :-
     i. Early steel girders.
     ii. Late rite stones.
     iii. Cast iron screw piles.
     iv. Corrugated steel pipes [ARMCO PIPES]
     v. Rail or timber tops & stone slat and
     vi. Earthenware pipes.

In case of introduction of new type of locomotives, rolling stock & other train compositions with increased loads [vertical & longitudinal] special strengthening measures may be required as per relevant code provisions & guide lines.

In addition to this conversion of gauge, doubling, provision of extra span are the other reasons.

**Special inspection of distressed bridges**

<table>
<thead>
<tr>
<th>Category</th>
<th>Inspected By</th>
<th>Periodicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Inspector[concerned ]</td>
<td>Once in a month.</td>
</tr>
<tr>
<td></td>
<td>Asstt.Engineer / Asstt.Bridge Engineer</td>
<td>Once in two months.</td>
</tr>
<tr>
<td></td>
<td>DEN/Sr.DEN</td>
<td>Once in three months.</td>
</tr>
<tr>
<td>II</td>
<td>Inspector[concerned ]</td>
<td>Once in three months.</td>
</tr>
<tr>
<td></td>
<td>Asstt.Engineer / Asstt.Bridge Engineer</td>
<td>Once in six months.</td>
</tr>
<tr>
<td></td>
<td>DEN,SR.DEN</td>
<td>Once in a year.</td>
</tr>
</tbody>
</table>

Concerned SAG Officers may inspect these bridges as considered necessary or if referred to by the Division.

**Distressed Bridge Diagram**
The Railways should maintain a diagram of distressed bridges containing relevant information

**Danger level at Bridges**
The danger level is that level which when reached, safety of the bridge is likely to be adversely affected.
The danger level shall be fixed for each bridge by the Divisional Engineer with great caution and due regard to the conditions obtaining at site. In deciding danger level, various factors such as nature of soil, depth of foundations, existence of drop and curtain walls, flooring, depth of maximum permissible scour, the highest recorded flood level, the level of the bottom of girders, the springing level of arch, top of the guide bunds, free board to be allowed, velocity of water observed at bridge site, afflux noticed and past history of the bridge are to be taken into account. In fixing the danger level, a margin of safety should be allowed taking into consideration the characteristics of the river or stream such as, whether it is subjected to sudden flood or gradually rising floods. Fixing of danger level at a higher level than necessary may result in unnecessary restrictions to traffic and may lead to nonseriousness with regard to implications of action required in case of water level approaching or exceeding danger level.

Danger level shall be the level which is lower of the following:

i. The level which provides adequate vertical clearances;

ii. The level which provides minimum free board to approach banks and guide bunds.

iii. The level of water which is likely to cause an unduly large afflux, say more than 0.5 m, which may cause large scour endangering the bridge.

iv. The water level which if exceeded may cause excessive scour endangering the bridge.

v. In cases, where there is no past history of damage, the broad guidelines for fixing Danger Level are given below:

- a) Girder and Slab Bridges:
  
<table>
<thead>
<tr>
<th>Waterway</th>
<th>Clearance below bottom of girders/slabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6.10m</td>
<td>150 to 300 mm depending on the span and site conditions.</td>
</tr>
<tr>
<td>&gt; 6.10 &lt; 12.2 m</td>
<td>450 mm</td>
</tr>
<tr>
<td>&gt; 12.20 &lt; 30.5 m</td>
<td>600 mm</td>
</tr>
<tr>
<td>&gt; 30.50 &lt; 61.0 m</td>
<td>750 mm</td>
</tr>
<tr>
<td>&gt; 61.00m</td>
<td>1200mm</td>
</tr>
</tbody>
</table>

- b) Arch Bridges:
  
  i. For small arch bridges of spans less than 4.0m, the danger level shall normally be at the springing level;

  ii. For larger spans and for multiple span arches, the danger level shall be at 2/3rd rise below the crown of the arch;

  iii. Where higher HFLs have been recorded in the past, without any dangerous afflux or scour, or damage to approach embankments, danger level may be raised suitably at the discretion of Chief Bridge Engineer.

- c) Box Culverts: Danger level at the bottom of slab.

- d) Pipe Culverts: Danger level at the top of inside of pipe.

- e) Balancing Culverts and bridges: Danger level at 50mm below top of pier/abutments in case of culverts with girders and slabs or the crown intrados of the arch.

All danger levels should be recorded in the bridge inspection register.

Marking danger level:

The danger level should be marked on the abutments or on the first and last pier of the bridge. In the case of long multiple span bridges, the danger level mark should be repeated suitably on intermediate piers. These marks should be fixed on the upstream side of the bridge, conspicuously visible to the inspecting officials, patrolmen and
watchmen. The danger level should be marked with a bright red band 5 cm wide centrally over a white band 10 cm wide for a length of 60 cms.

Setting out bridges Layout with out or with Base line -
Setting out bridges Lay out without a base line : -
Where deep excavations are not involved and where there is no water flow in the river during the working season, setting out primarily involves fixing the alignment correctly using a theodolite. The distance between the abutment at either end and the nearest pier and the pier-to-pier distance can be set out by directly measuring and marking the centres using a good steel tape.
The centre points of each structure (pier or abutment) should be punch marked on a flat or angle iron piece fixed flush with the top of a concrete block at the correct location.

Setting out bridges Layout with the help of a base line : -
a) Where deep excavation, pile driving or well sinking is involved, and where there is standing water, base lines are set out at right angle to the centre line of the bridge, one on either end on the high banks, or on one side of the bridge or anywhere between the abutments where level ground is available.
b) The actual position of the piers/abutments is determined by the intersection of three sight lines, one along the alignment sighted from stations located on either end, a second from a station on the base line on the down stream side and a third from a point on the base line on the upstream side. Theoretically all these three lines should intersect at one point. Normally a triangle of error gets formed and the correct centre is fixed by judgment within this triangle.

Important points to be observed while setting out base lines: -
a) Linear measurement should be carried out with invar tape or Electronic distance measuring equipment.
b) Concrete pillars with steel plates fixed over them should be located at tape lengths for accurate measurements.
c) Spring balances should be used for giving specified tension to the tape.
d) Tape readings should be corrected for tension, temperature and slope.

Foundation design discharge for a bridge -
To provide for an adequate margin of safety against any abnormal flood exceeding the design discharge (Q), the foundations, protection works and training works shall be designed for a higher flood discharge. This discharge shall be computed by increasing the design discharge (Q) estimated for waterway shall be based on (a) actual hydro-meteorological observations of the same or similar catchments (b) the computed flood with probable recurrence intervals of 50 years. The recurrence interval can be modified at the discretion of Chief Bridge Engineer based on the importance of the line.

<table>
<thead>
<tr>
<th>i)</th>
<th>Catchment up to 500 sq.km.</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii)</td>
<td>Catchment more than 500 sq. km. and up to 5000 sq. km.</td>
<td>30% to 20% (decreasing with increase in area)</td>
</tr>
<tr>
<td>iii)</td>
<td>Catchment more than 5000 sq.km. and up to 25,000 sq.km.</td>
<td>20% to 10% (decreasing with increase in area)</td>
</tr>
<tr>
<td>iv)</td>
<td>Catchment more than 25,000 sq.km.</td>
<td>Less than 10% (at the discretion of the Chief Bridge Engineer).</td>
</tr>
</tbody>
</table>

Selection of well foundation or pile foundation for a bridge -
**Well Foundations** - Well foundation provides a solid and massive foundation for heavy loads and large horizontal forces. This has a larger cross sectional area and hence the total foundation bearing capacity is much larger than what may be offered by a cluster of piles. The
well provides a very good grip when taken sufficiently deep and hence is most suited for river beds subjected to heavy scour.

**Pile foundations** - Pile foundation can be quite economical, particularly where the foundations have to be built very deep or taken through deep layers of soil subjected to little scour. Larger diameter piles can be provided to take care of large horizontal forces when the foundations are deep. Larger diameter piles can also be provided for foundation depths beyond the limit of pneumatic operations.

**Various Types of pile based on transfer of load & Construction method** -

Piles may be classified as under :

1. **Based on the manner of transfer of load** -
   a) **Friction piles** - These piles transfer the load primarily by skin friction developed along their surface. They are used in soils not subjected to scour.
   b) **Bearing piles** - These piles transfer the load primarily by bearing resistance developed at the pile tip or base, without taking into account the frictional resistance. They are generally used in hard stratum.
   c) **Bearing-cum-friction piles** - These piles transfer the load both by bearing and friction

2. **Based on construction methods** -
   a) Driven Pre-cast piles;
   b) Driven cast in-situ piles;
   c) Bored cast-in-situ piles.

Large diameter bored piles of more than one meter diameter are normally used for Railway bridge construction.

**Loss of camber in steel girders** -

Steel triangulated (open web) girders are provided with camber to compensate for deflection under load. Out of the total design camber, the part corresponding to dead load is called dead load camber. The balance is called live load camber which should be available as visible and measurable camber in the girder when not carrying load.

Loss of camber can be mainly attributed to:

a) Overstressing of members beyond the elastic limit
b) Overstressing of joint rivets
c) Loose rivets

**Camber in Triangulated Girders** –

Camber in Triangulated Girders should be provided at the time of fabrication. Length of all member of truss are to be fabricated to camber lengths as indicated in camber sheet of fabrication drawing with the group of connection holes of main gussets which are drilled on nominal layout. For this purpose, hole drilling jig is to be manufactured for each member with the distance between the group of end holes altered by the amount of camber allowance i.e. difference between nominal length and camber length. Bottom chords camber length are same as nominal length to facilitate the fabrication of stringer.

Track structure over the stringers or top chord is provided with same thickness of sleeper throughout the length of span hence track will have the same camber profile of truss during unloaded state.

**Replacement of loose rivets** -

i) Slight slackness of rivet does not cause loss of rivet strength.
ii) Renewal of slack rivets should be done only when the slack rivets are in groups or are bunched up.

iii) Rivet is to be considered finger loose when the looseness can be felt by touch, without tapping. Rivets should be considered hammer loose, when the looseness can be felt only with the aid of a hand hammer.

iv) All rivet renewals in a bridge girder shall be done only with pneumatic rivetting. The following points should be kept in mind while carrying out the rivetting work.

a) In pneumatic rivetting, the driving of the rivet, filling of the hole and formations of the head should be done by snap mounted pneumatic hammer by delivering quick hard blows on practically white hot rivet.

b) The rivet shank should be about 1.5mm less than the diameter of the drilled hole.

c) While rivetting a loose joint, not more than 10% rivets should be cut at a time.

d) It is preferable to drill a rivet out than to use a rivet buster as the latter cuts the rivet head in shear, imparting very heavy shock to the adjoining group of rivets.

e) The loose rivets in a joint are replaced, it is very necessary that all the rivets in the assembly are rechecked for tightness.

f) At locations where replacing rivets is difficult, turned bolts of appropriate diameter and length may be used.

g) The rivet must be driven straight, while hot, keeping the hammer coaxial.

h) Rivets conforming to IRS specifications only should be used.

Types of bearings:

The bearing transfers the forces coming from the superstructure to the substructure. It also allows for necessary movements in the superstructure which are caused by temperature variations. The following types of bearings are generally used.

a) Sliding bearing - permitting rotation and translation

b) Rocker and roller bearings - permitting rotation and translation respectively. In this type of the bearing at the fixed end the girder end is fixed in apposition but rocking due to deflection under load is permitted by the curved knuckle pin. At the free end the arrangement for rocking is similar but the knuckle assembly is mounted on a set of roller to take liner expansion. It has to be ensured during inspections that the knuckle pin and the rollers are well lubricated.

c) Elastomeric bearings - Made of natural or synthetic rubber of shore hardness of approximately 50 to 70. They are very stiff in resisting volume change but are very flexible when subjected to shear. They are generally reinforced with steel plates in alternate layers to reduce bulging. When used with a steel or concrete girder these permit moderate longitudinal movements and small rotations at the ends. These are provided for bridges having RCC or Pre stressed girders and can take deflection a well as movement

d) P.T.F.E. Bearings - The PTFE can be unfilled or filled with glass fibre or other reinforcing material. These are used either to provide rotation by sliding over cylindrical or spherical surfaces or to provide horizontal sliding movement over flat surface or a combination of both. Where there are large displacements accompanied with relatively small loadings, as in case of centrifugal loads, wind loads or seismic loads, PTFE sliding bearings are utilised.

R. H. Girder –

R.H. Girder are the box type built up duplicated girder. These are special girders ‘ Restricted Head way having over all depth 0.85 m. are used to relieve the existing bridge or its approaches. It would be observed that majority of the old culverts and bridge up to 12.2 m openings are arches and at the time of carrying in situ repairs to these arches under traffic, The severe restrictions of the clearance that could be made available for inserting these girders being merely equal to the cushion that has been provided above the crown of the arch and below the sleeper has to be 1.00 m. The length of R.H. Girder should be decided taking into
consideration height of embankment, slope of exaction depth. R.H. Girder are normally available for span in the Central Railway 53'-6", 44' & 24'. Alternatively if some released girders are available these can also be used as service girders for temporary arrangements. The following speed restriction should be imposed while using R.H.Girder.
Non stop 16 Kmph if height of sleeper crib is up to 1.52 m.
Stop dead and 8 kmph if height of sleeper crib is above 1.52 m.

Example - It is proposed to rebuild a 1 x 6 ft. girder bridge as 1 x 2 m. RCC slab culvert on a BG single line section under traffic by using RH girder span having an over all length of 17 m and a depth of 1 m from Rail level to bottom of girder with the following data – Rail level to bottom of foundation = 4.5 m.
Bottom width of proposed foundation for each abutment = 2.00 m.
Draw a neat dimensioned free hand sketch of the above showing the seating arrangement under the end of RH girder span depth of the supporting crib and the calculate slopes of earth to be level of excavation for the foundation.

Solution.- R.H Girder 17 m., Depth of Girder 1.00 m., sleeper Crib 1.50 m. Height.
Proposed Bridge 1 x 2.00 m. RCC Slab.
Space available for Construction = (Width of both pier at foundation = 2 x 2.00 ) + (Space between Both Abutment = 2.00 – 2(0.25 +0.125 ) + ( 2 x Excavation slope 1 : 1 = 3.3 ) = 4.00 + 1.25 + 6.6 = 11.85 m.
Field survey has to be taken the extent of regarding dicided and get done.
Arrangements to be made to get the RH girder 17 .00 m. long for insertion of RH girder & CRS sanction to be obtained, DCN to be prepared for Phase working and published for sanctioning of block.
Phase I – Unloading of RH Girder at site with two cranes under Block.
Phase II -Excavation the formation for sleeper Crib portion under traffic imposing speed restriction, supporting the Track with sand bags for passing the traffic.

Phase III – Take suitable block to insert the sleeper crib in proper position.
Phase IV – Start excavation for girder portion under traffic supporting the track by sand bags.
Phase V – Arrange Crane specified minimum two cranes of 15 T capacity take under block minimum 3 hrs. for insertion of RH girder and remove the existing Girder on bridge. Insert the RH Girder. Erect the speed restriction boards and imposed stop dead and proceed speed restriction.
Phase VI – Dismentale the Existing girder bridge.
Phase VII – Construction new 1 / 2.00 m. RCC Slab Bridge.
Phase VIII – After curing is over arrange special 2 Cranes with 15 MT capacity for removing the RH Girder and place on the cess and Insert RCC slab. Remove the sleeper crib and fill up the gap and link the track. Relax / remove speed restrictions suitably.
Phase IX – Arrange crane special with BFRs and take suitable block for loading the RH girder.

**Early steel girders –**
There are a number of steel girders on Indian Railways fabricated before 1895. During those early times, the steel manufacturing technology was not fully developed and steel manufactured in those times contained excessive phosphorous. Concepts of quality control were apparently vague and steel used in the different parts of even the same bridge was found to have varying content of phosphorous. Higher phosphorous content makes the steel brittle and such girders can collapse suddenly because of brittle fracture.
Therefore, it is necessary to conduct detailed examination of such steel girders at an increased frequency with a careful and critical eye. It is also necessary to ascertain the chemical composition of steel.
Even steel which was manufactured between 1895 and 1905 should be treated as ‘suspect’ and inspected at an increased frequency.

**Advantage of welded girder –**
- i. Welded girder with riveted intermediate stiffeners result in saving of steel up to 25%.
- ii. Welded girder eliminates the need of rolled sections of non standard sizes and shapes. Also due to non availability of particular rolled section using higher section leading to uneconomical construction is avoided.
- iii. Eliminates drilling of holes and hence gross area is net area for tension members.
- iv. Welded girder eliminated cumbersome connections and water pockets.
- v. Welded girder requires less maintenance due to elimination of rivet heads on top flange thereby facilitating the painting of sleeper seats frequently thus reducing maintenance repairs cost.
  - vi. Aesthetic superiority and higher production rates with lesser input.

**Different method of launching of Girder -**
Different method of launching of Girder are as under -
- i. Launching with rail cluster method : - This method can be adopted when the number of spans to be launched are few in number and where the depth of the bed level below H.F.L. is quiet high. This method is not normally used when large number of spans are involved.
- ii. Launching by dip lorry method :- This is a safer, more convenient and quicker method for launching of multiple spans up to 18.3m.
- iii. Girder erection with the help of cranes – The method can be used for erection of girders for new bridges for small spans of 12.2 m. and 18.3 m.
- iv. Jacking up or lifting girders from the river bed.
  - v. Side Slewing method :- This method is quiet popularly used in the field. This method is suitable when there is adequate space to accommodate old and new spans on the abutment and piers.
  - vi. Cantilever launching.
- vii. Cantilever launching of spans by linking (coupling) and rolling.
- viii. Cantilever launching with the help of derricks.
- ix. Launching with the help of launching nose and launching tail.
- x. Launching of girders with the help of a BFR.
- xi. Erection with the help of launching pad.
xii. Assembling on bank and floating to site.

xiii. Replacing by sliding method – This method when there is no space to accommodate old and new spans on the abutment and piers, the new spans are erected with the help of trusses.

xiv. Replacing by Rolling method – In rolling method the new spans are erected on the approaches hence that line is blocked. Diversion should be avoided by inserting the turnout before commencing the replacing work.

xv. Replacing by Service span method or Enveloping method – This is the most reliable method by launching the service span and replacing can be carried out advantage of this method. Before taking the work of replacing CRS should be approached for his sanction along with the method of replacing. CRS sanction should be obtained.

Draft circular notice to be prepared and published for the phase working and blocks.

Phase I – Obtain suitable block and launch the service span for the 1st span.

Phase II – Obtain suitable block, change the floor system from old spans to service span and allow the traffic with restricted speed.

Phase III – Remove the old spans under suitable blocks.

Phase IV – Launch the new spans in positions with the help of check trolley under suitable block.

Phase V – Under suitable blocks change the floor system from service span to the new span.

Phase VI – Under the suitable block roll the service span to the next span.

This process is repeated till all the ten five spans are replaced.

**Box pushing’ method** –

Technique of Box pushing is used an opening without causing disruption to traffic. The process of box pushing consists of the following steps.

A reinforced concrete thrust wall of adequate height, Thrust bed, Jacking pit, reaction frame is constructed from the slope of bank at the proposed bed level as per approved drawing. Then the work consists of construction of RCC box over the thrust bed and a cutting edge frame to be fixed at the end of box and pushing same by using Jacks under the existing railway embankment.

A jacking rig having pockets for provided 6 hydraulic jacks of 50 MT capacity each is fixed vertically against the thrust wall. Oil pressure is than applied to the Hydraulic jack which forces the shield and the box in to the slope of the bank. The earth falling inside the shield is removed manually.

The process of pushing continues till the cutting edge comes out from the other end and is taken out by providing some temporary arrangements to protect the slope of the bank.

While jacking of the precast boxes to form of opening under the railway under traffic conditions maximum allowable deviation at any time from the theoretical alignment will be limited to 200 mm horizontally and 100 mm vertically. Any deviation beyond this tolerance will have to be rectified.

Grouting of all joints after completion of pushing with epoxy compound so as to make then water tight. Removal of all existing under ground as well as over head obstruction in the railway area near the site of the work which are likely to obstruct the work of box pushing is to be removed before operation of pushing.

Adequate precautions are taken to watch the bank on top so that no disturbance to the running traffic takes place. Also alignment of pushing is checked from time to time with the help of a theodolite.

Necessary provision of opening in the roof of Boxes for bentonite pumping if required for pushing of boxes safely to be made and bentonite slurry to be injected. The work will be carried out under suitable speed restriction.

**Advantages –**
In this method work can be done with out any traffic block.
In this method Crane not required.

**Disadvantages** –
At the time pushing alignment, level of track should be disturbed which is to be attended frequently.
At the time pushing should be keep close watch of Railway Track.
At the time pushing RCC Box alignment should be disturbed which is to be rectified.
**Maintenance of Bridge**

Cement pressure grouting -
Cement pressure grouting of masonry structures are to be done by following equipments – Air compressor, Grout injecting machine, Flexible hose, Drilling equipment, 25 mm dia holes are drilled to a depth of 200 mm in a staggered manner in the area in which pressure grouting is to be done, particularly along cracks and hollow joints. G.I. pipes 12 to 20 mm dia and 200 mm long with a threaded end are inserted and fixed with rich cement mortar.

Any crack and annular space around the G.I. pipes are sealed with rich cement mortar. All the cracks are cut open to a ‘V’ shaped groove, cleaned and sealed. Grout holes should be sluiced with water one day before grouting so as to saturate the masonry. Sluicing is circulation and filling of water. This is carried out by using the same equipment as for grouting. All holes are plugged with wooden plugs. Bottom most plugs in holes 1, 2 and 9 are removed. Water is injected in hole 1 under pressure. When the water comes out through holes 2 and 9, injection of water is stopped. Plugs in holes 1 and 9 are restored. The process is repeated in all the holes. After 24 hours all plugs are removed to drain out excess water. The plugs are restored after draining. Cement grouting with water-cement ratio of 0.4 to 0.5 is done from bottom to top and left to right using grout injecting machine. The cement grout should be completely used within 15 minutes of mixing. The procedure for grouting is similar to sluicing in terms of removal and re-fixing of plugs and sequence of operation. The recommended proportion may be altered if admixtures are used to attain flow ability of the grout. In case admixtures are used, manufacturer's specifications should be adopted for grout proportioning. Curing with water is to be done for 14 days over the grouted portion.

**Guniting**

![Diagram showing the process of grouting and guniting](image-url)
This process of depositing a dense layer of sand cement mixture can be used profitably for repairing spalled concrete structures or weathered stone or brick masonry.

The equipment used for this process is a cement gun which is operated throughout by compressed air. The sand used should comply with the requirements and graded evenly from fine to grading with a nominal maximum size of 6 mm. One part of cement shall be added to 3 parts of sand. The optimum moisture content for sand is in the range of 3 to 6%. This mixture is placed in the feeding chamber and by the action of compressed air it is fed into the working chamber through a cone valve controlled from outside. The mixture is then agitated through an agitator mounted on a vertical shaft. The mixing time shall be not less than 1 minute. The mixed material is carried in suspension by compressed air through the delivery hose to a nozzle. As the material passes through the nozzle body, it is hydrated with water introduced in the form of a fine needle spray controlled through a valve in the nozzle body. The water-cement ratio for concrete used in this process is normally in the range of 0.35 to 0.50. For a length of hose up to 30 m the air pressure at the nozzle shall be 3.0 kg per sq.cm or more. Where the length exceeds 30 m, the pressure shall be increased by 0.35 kg per sq.cm for each additional lead of 15 m that a nozzle is raised above the gun. The water pressure at the discharge nozzle shall be sufficiently greater than the operating air pressure to ensure that water is intimately mixed with the other material.

In case of repairs to existing deteriorated concrete all unsound materials shall be first removed. The exposed reinforcement shall be cleaned free of rust, scales, etc. In the case of stone masonry all weathered or disintegrated part of stone shall be knocked down with a chisel and/or a heavy hammer so as to expose sound and undamaged part of the stones. The stone or brick masonry surface shall be cleared of all loose mortar, dust, moss, etc. and washed down with a strong jet of air or water. If mortar at the joint is weak, the joint shall be raked to about 10 mm depth and all loose and dry mortar scraped out from inside. The formwork, if required, shall be of plywood or other suitable material fixed in proper alignment and also to proper dimensions. For repair work the reinforcement shall be fixed to existing masonry or concrete by using wire nails or dowels at one metre intervals. Depending on the thickness and nature of work, reinforcement may consist of either round bars or welded wire fabric. Hard-drawn wire fabric consisting 3 mm dia wires at 10 cm centers in both directions can be used. The minimum clearance between reinforcement and formwork shall be 12 mm for mortar mix and 50 mm for concrete mix.

Each layer of shotcrete (concrete placed by guniting) is built up by making several passes or loops of the nozzle over the working area. The distance of the nozzle from the working face is usually between 0.5 and 1.5 m. The nozzle shall be held perpendicular to the surface of application. The amount of rebound concrete varies with the position of work, angle of nozzle, air pressure, cement content, water content, size and grading of aggregate, amount of reinforcement and thickness of layer.

**Jacketing :-**

Railways are often required to undertake strengthening of existing bridge substructures in connection with works of following nature.

1. Increase in vertical clearance to satisfy codal provisions.
2. Regrading of track and Increase the barrel length.
3. Introduction of heavier type of locomotives and other rolling stock with higher longitudinal forces. With the raising of formation levels, the existing substructures are subjected to higher loading by way of higher earth pressure and increased moments.

To strengthen the substructure, the cross-sectional area may require to be increased. For this purpose jacketing of existing substructure is resorted to. Jacketing should be undertaken only when the existing structure is fairly sound and does not show signs of distress. but is of
inadequate section or has extensive surface weathering, For the jacketing to be effective, it has
to be taken right up to the foundation and integrated at this level with the existing foundation.
Jacketting with cement concrete with minimum thickness of 150mm,
Before jacketting is taken up, existing cracks should be thoroughly grouted. It should also be
ensured that the resulting reduction of waterway due to jacketting is within permissible limit. The
face of the existing masonry or the concrete should be thoroughly cleaned free of all dirt. In
case of concrete, the smooth surface should first be made rough. Before laying the new
concrete, neat cement grout should be applied uniformly over the face of the old masonry /
concrete. The new concrete layer should be of minimum cube strength of 250 kg per sq.cm at
28 days. Or 1 : 2 : 4 mix although the maximum size of the aggregate may go up to 40mm. A
mat of steel reinforcement with a minimum of 10mm bars spaced at 200mm horizontally and
vertically may be provided as distribution reinforcement. Suitably dowelled into the old masonry /
concrete may be done. The dowel bars consisting of 20mm diameter MS deformed bar (HYSD
bars) hooked at the exposed end or MS tie bar flats (45 x 10mm size) with the ends split, may
be fixed into old masonry / concrete. These dowels should be taken down to a depth of not less
than 200mm inside the masonry/concrete. The spacing of dowels should not be more than
450mm horizontally and vertically. Dowels should be provided in staggered manner.
The concrete should be cured for a minimum period of 28 days by covering with gunny bags or
similar material and splashing with water
The following precautions should be taken while carrying out the jacketing works :
\ i. Foundation shall be exposed for only limited width at a time so as to avoid endangering the
  safety of the structure.
\ ii. Pumping of water from foundation should be avoided as far as possible, as it may endanger
  the safety of the structure.
\ iii. These holes must be drilled and not made by pavement breakers.
\ iv. Site and soil conditions including water table shall be considered for deciding the width of
  foundation to be exposed at a time.

The work of jacketting should be done under suitable speed restriction. Depending upon
location, extent of exposure, type of soil etc., speed restriction may be as under:

| 1. Jacketting below bed level. | 15 km/h to 30 km/h depending on the extent of exposure, type of soil etc. |
| 2. Jacketting from bed level to spring level. | 30 km/h to 50 km/h depending on condition of masonry. |
| 3. Jacketting of arch ring full design load | 30 km/h to 50 km/h depending on the condition of arch ring and cushion. |
| 4. Jacketting of arch ring when designed by taking composite action with existing arch. | 15 km/h. |

The above speed restrictions may be relaxed after the completion of work as per the following
guidelines, if jacketting is carried out using ordinary Portland cement conforming to IS: 269 :
\ i) 50 km/h after 7 days of last concreting;
\ ii) 75 km/h after 14 days of last concreting; and
\ iii) Normal sectional speed after 28 days of last concreting.
To reduce the duration of speed restriction, rapid hardening cement to IS: 8041 may be used.

**Epoxy resin grouting of masonry structures** :-
The structures built of stone masonry, brick masonry or concrete get affected by prolonged
weathering action. The ingress of moisture sometimes associated with the extraneous
chemicals such as nitrates, chlorides and sulphates combined with either proximity of sea or
aggressive ground soil conditions accelerate the deterioration of the structures. Stone masonry
built with inferior stones such as sand stones, laterite, etc. is prone to spalling by ingress of
moisture. Brick masonry built with porous bricks is subjected to similar action. Leaching of cement and lime on account of poor drainage and consequential deterioration of strength also takes place.

It is a known fact that adhesion between the old damaged masonry or concrete and newly-laid masonry or concrete is poor. Besides this, the cement does not get enough time for setting and hardening before traffic is allowed over the newly repaired structures. This also leads to frequent repairs at the same spot.

Epoxy resins have the following advantages over cement as a bonding medium.
1. Quick setting
2. Low viscosity to fill up hair cracks
3. Low shrinkage
4. High adhesion to any material
5. Stable at all temperatures.

Epoxy resins consist of condensation products of Epichlorohydrin and Bisphenol-A. They are thermosetting with high adhesive strength and practically no shrinkage with good resistance to wear and to most of the chemicals. The resin and hardener have to be mixed for starting the chemical reaction of hardening. The pot life of the mixture varies between 30 minutes and 2 hours depending on the ambient temperature and the type of hardener. For preparing mortars, silica flour is added. It is important to follow the manufacturer’s recommendations for the best application procedure, temperatures and pot life. For mixing epoxy components, the use of polythene vessels is recommended.

The surface over which epoxy is to be applied must be strong and sound as well as dry and clean. It should be free from oil, grease, loose materials, laitance, dust and debris. Low viscosity resins may be adopted for thin cracks. In case of vertical crack, the injection of resin should be done from bottom to the top to ensure complete filling. A “V” groove about 10 mm deep is made all along the crack by mechanical or manual means. All loose fragments of concrete are removed by using a jet of air. Nails are driven into the cracks at 15 to 30 cm interval. Holes of 7-10 mm dia should be drilled along the cracks and copper, aluminum or polythene pipe pieces 40 to 50 mm long and 6 to 9 mm dia are inserted around the nails and allowed to rest on them. All the cracks along the groove are now sealed with epoxy putty. The tubes furnish an unobstructed passage for the epoxy resin into the crack and also forms an outlet for the entrapped air. Epoxy of suitable formulation is injected from the bottom most pipe, keeping all other pipes, except the adjacent one, blocked by wooden plugs. The injection is done using suitable nozzles connected to air compressor or by modified grease guns or hand operated guns. Pressure of 3.5 to 7 kg per sq.cm is normally used. As soon as the epoxy comes out from the adjacent open pipe, it is plugged and the pressure increased to the desired level and maintained for 2 to 3 minutes. The injection nozzle is then withdrawn and the hole sealed with epoxy mortar. This operation is continued for the other pipes also. Any resin that remains or overflows the copper pipe is scraped off with a metal spatula and the surface cleaned with a rag soaked in non-inflammable solvent. For this purpose, it is recommended that persons who work with epoxy wear rubber gloves. The grease gun or syringe should be washed with acetone immediately after the completion of the work. In the case of a network of fine cracks, which do not endanger the stability of the structure, it may be sufficient to apply a coating (300 to 400 micron thick) of a solvent-free epoxy system. Wider cracks which do not endanger the concrete structure can be filled at least partially with epoxy putty (epoxy, hardener and china clay).

Since epoxy is a costly material, its use should be restricted to areas where dynamic forces are transmitted (e.g. areas below and around the bed blocks, cracks in PSC / RCC slabs or girders etc.).
Oiling and Greasing of Important Bridge-
Oiling and greasing of bearings is done to ensure that the bearings are well lubricated and working freely to permit expansion and contraction due to variations in temperature. The bearing of the free and fixed ends of all triangulated spans and free ends of plate girders are to be greased.

Greasing is to be done with a mixture of Graphite & Grease normally in the proportion of 1 : 1. The proportion to be used in such that maximum amount of graphite is retained and forming a workable paste.

Oiling & Greasing of bearing is done once in 3 years on a programmed basis.

Painting of Girder Bridge –
Girder painting is essentially an application of surface coating to the steel work so as to inhibit corrosion. The basic principle underlying maintenance painting is not to allow deterioration of existing paint film to reach such a stage that rusting starts underneath the paint film.

Surface Preparation :-
Correct surface preparation is the most important single factor in ensuring good performance of a painting scheme applied to steel work. Removal of rust, oil, grease and dirt is also necessary to ensure adequate adhesion of paint film to the surface.

a) The minimum requirements of a surface prepared for painting are:
   i) It should be clean, dry and free from contaminants.
   ii) It should be rough enough to ensure adhesion of the paint film. However, it should not be so rough that the film cannot cover the surface peaks.

b) Any one or a combination of the following methods for surface preparation may be used, where rust has appeared in many places and existing primary coat of paint has developed cracks, blistering, peeling, brittleness etc.
   i) Manual hand cleaning : The cleaning of surface is done with the use of emery paper, wire brushes, scrapers, etc. This is adopted for spot cleaning during normal maintenance to remove rust, scale or old coatings.
   ii) Cleaning with power driven tools : Oil and grease are first removed. Heavy scale and rust are then removed by hand tools. Residual rust and mill scales are removed by hammer or rotary action of hand held power driven tools.
   iii) Blast cleaning (sand or grit blasting) : It consists of cleaning the surface with the help of high velocity impact of abrasives (sand or grit) against the surface. It removes rust, mill scale (oxidisation) and old paints along with some of the base metals and creates a base for good adhesion. It is the most effective method of surface preparation.
   iv) Flame cleaning : The process consists of localised application of an oxy-acetylene flame on the steel surface. After the application of the flame the rust can be removed by wire brushes. Flame cleaning should not be done on plates with thickness 10mm or less as it may lead to permanent distortion of such plates.
   v) In the case of maintenance painting where only the finishing coat of paint shows signs of deterioration and the primary coat of paint is sufficiently in good condition adhering to the metal firmly and there are no signs of rust, the surface should be washed with lukewarm water containing 1 to 2% detergent to remove salt deposits and grime. After this, the surface is to be dried, lightly wire brushed and sand papered. On this prepared surface only the finishing coat of paint should be applied.
   vi) Temporary coatings : If, for any reason, painting can not immediately follow surface preparation, corrosion can be prevented for a short time by means of temporary coating of Linseed oil applied uniformly and thinly (one third litre on 10m2 area will be sufficient). Modern prefabrication primers which are easier to apply and give better protection are also available.
Choice of suitable paints:
The following system of paints may be adopted for painting of Bridge girders:
a) In areas where there is no severe corrosion
   i) "Priming Coat :- One coat of ready mixed paint Zinc chromate priming to IS : 104 followed by
      one coat of ready mixed paint red oxide, Zinc Chrome priming paint to IS : 2074.
      Or
      "Two coats of zinc chromate, red oxide primer to IRS – P – 31."
   ii) Finishing coat:
      Two cover coats of red oxide paint to IS : 123 or any other approved paint applied over the
      primer coats.
b) In areas where corrosion is SEVERE
   i) "Priming Coat :- One coat of ready mixed paint Zinc chromate priming to IS : 104 followed by
      one coat of Zinc Chrome red oxide priming to IS : 2074.
   ii) Finishing coat:
      Two coats of aluminium paint to IS : 2339.
c) In case where the priming coat is in good condition the steel work is painted with two coats of
      ready mixed red oxide paint to IS : 123 or paint aluminium to IS : 2339 depending on the
      severity of corrosion.

Important precautions for obtaining good painting:
   i. Painting should be done in dry and reasonably warm conditions. The relative humidity
      should not be above 90%.
   ii. Dew frequently condenses on a structure during night and hence painting at night and in the
      early hours of morning should be avoided.
   iii. Painting should be avoided during rainy season and in adverse weather conditions (dust
      storm, mist, fog, etc.)
   iv. Paints from approved manufacturers only should be used.
   v. Special care should be taken to shift sleepers on girders or rail bearers to clean the seating
      very thoroughly before applying the paint.
   vi. Paint should be mixed in small quantities sufficient to be consumed within 1 hour in the case
      of red lead paint and 5 days in the case of red oxide paint.
   vii. While painting with red oxide paint, a little quantity of lamp black shall be added to the paint
      while doing the first coat to distinguish it from the second coat. Similarly, in the case of
      aluminium paint a little blue paint can be added, instead of lamp Black for 1st coat.
   viii. Paints should be used within the prescribed shelf life from the date of manufacture. The
      quantity of paint procured should be such that it is fully utilised before the period prescribed
      for its use.
   ix. The shelf life of various paints used in the Railways are as follows:
   x. Dust settled after scraping shall be cleaned before applying paint.
   xi. When the paint is applied by brush, the brush shall be held at 450 to the surface and paint
      applied with several light vertical / lateral strokes turning the brush frequently and
      transferring the paint and covering the whole surface. After this, the brush shall be used
      crosswise for complete coverage and finally finished with vertical / lateral strokes to achieve
      uniform and even surface.
   xii. Rags, waste cotton, cloth or similar articles should not be used for applying paint.
   xiii. The coat of paint applied shall be such that the prescribed dry film thickness is achieved by
      actual trial for the particular brand of paint. The applied coat of paint shall be uniform and
      free from brush marks, sags, blemishes, scattering, crawling, uneven thickness, holes, lap
      marks, lifting, peeling, staining, cracking, checking, scaling, holidays and allegatoring.
xiv. Each coat of paint shall be left to dry till it sufficiently hardens before the subsequent coat is applied. The drying time shall not be less than 3 days in the case of Red lead paint.

xv. The entire contents of a paint drum should be mixed thoroughly either by pouring a number of times or by mechanical mixing to get uniform consistency. The paint should not be allowed to settle down during painting by frequent stirring or mixing.

xvi. Driers such as spirit or turpentine should not be used. Mixing of kerosene oil is strictly prohibited.

xvii. The maximum time lag between successive operations as indicated below shall not be exceeded.

**Painting schedule** - The entire steel work of a girder should be painted at regular intervals which may vary from six years in arid zones to one year in highly corrosive areas. The chief Engineer shall prescribe the periodicity of painting. Floor system of girders etc. where corrosion is heavy, may require painting more frequently. Their periodicity should be as specified by the chief Engineer.

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**Rivers and Floods**

Flood records:-
A list of bridges across large alluvial rivers and such other rivers as identified by Chief Bridge Engineer should be prepared to maintain the flood records as noted below:

a) Soundings around piers and abutments during and after high floods.

b) Gauge readings of flood level during monsoon.

c) Observations of afflux and velocity during monsoon.

d) Cross sections of river during and after floods.

e) Survey of the river course after monsoon.

f) Cross section of guide banks/protection works and their aprons.

g) Annual survey of scour holes.

The details of flood records that are to be maintained should be specified for each of the bridges.

Flood records during monsoon :-

1. Sounding During Floods:
   a) Soundings at specified bridges should be taken in mid span and around piers and structures, when flood is at or about the danger level.
   
b) Special care should be exercised when taking soundings, specially in rapid water, to ensue that they are trust-worthy.
   
c) Safe scour depth below rail level should be fixed by the Chief Bridge Engineer for all the bridges having well / pile foundations by making reference to completion drawings.
   
d) Should the sounding at any pier exceed the safe scour depth, the Inspector-In-Charge will stop traffic and commence dumping of boulders advising all concerned.

2. Gauging, Velocity and Afflux Measurements During Monsoon :-
   a) Water level should be recorded daily at the specified bridges, during the monsoon period and a register should be maintained.
   
b) Divisional and Assistant Engineers should ensure that gauges are erected and maintained at all specified bridges both on the upstream and downstream side.
   
c) Levels painted on gauges should be accurate and all gauges must refer to the same datum.
   
d) Afflux gauges should be fixed at a distance of about 30 meter upstream and downstream of the bridge opening.
   
e) Velocity of flow should be recorded using floats or current meter at all the specified bridges.

3. Cross section of rivers during floods :-
For such bridges as specified, cross section diagrams of the river bed near about the high flood level at specified locations on the up stream and down stream side should be prepared to a fixed scale in the Divisional Engineer’s office from particulars submitted by the Assistant Engineer and copies sent to the Headquarters office by the prescribed date each year.

Flood records after the monsoon :-

1. Cross Section Diagram After Floods:
Soon after the monsoon, as practicable, sections across the bed of such rivers as specified by the Chief Bridge Engineer should be taken on the up and down stream sides, clear of piers and abutments by sounding if necessary and particulars submitted to the Divisional Engineer.
2. Annual survey of scour holes at bridges:--
It is necessary to survey scour holes both on the upstream and downstream after monsoon to find out the size and depth of the scour holes and the distance of the same from the foundation so that remedial measures can be planned in time and the works executed before the onset of the next flood season, as necessary.

3. Survey of the course of the river:--
a) At each specified bridge, survey of the course of the river to a fixed scale should be made soon after the monsoon extending to at least 3 km upstream and 1 km downstream of the bridge to afford general idea of the efficiency of training works.
b) Where a river course runs parallel to the track with a tendency to encroach towards the Railway embankment, the course of the river should be surveyed to get a general idea of the rate of erosion.

4. Cross section of guide, subsidiary and retired bund:--
At the end of the monsoon, cross sections should be taken at every 30 meters along each stone protected bund or groyne and at every 15 meters apart round each stone.

Training / Protection of various types of rivers
The object of river training/protection works is to prevent the river from damaging railway formation, bridges and other structures. The training/protection works will have to be decided depending on the reach in which the river is situated namely:
 a) Upper reaches (Mountainous Rivers)
b) Submontane reaches (Foot hills)
c) Quasi-alluvial reaches (Trough)
d) Alluvial reaches, and
e) Tidal reaches

Upper Reaches (Mountainous Rivers) :-
These streams have narrow and deep cross section with very steep bed slopes.
Suggested protective measures: -
The following protective measures are suggested/recommended for adoption:--
a) Suitable protective fenders of concrete, rolled steel or rails may be provided upstream of the bridge to reduce the impact on piers and abutments.
b) Measures for controlling soil erosion and landslips, improving stability of side slopes
c) The formation of gullies by the water coming down the hills can be prevented by afforestation, construction of gully/check dams, contour bunding, debris basins, chambers or wells. These should be cleaned as frequently as necessary.

Submontane Reaches (Foot Hills) :-
The rivers in these regions have a flatter bed slopes generally form 1 in 50 to 1 in 500. Medium size boulders, gravel and coarse sand are generally found in the beds.
Suggested protective measures: -
a) Suitable slope protection with boulders or concrete slabs,
b) adequate toe protection in the form of two rows of in-situ concrete blocks or boulders in wire crates.
c) boulders in wire crates forming flexible type apron may be provided.

Quasi-Alluvial Reaches (Trough) :-
In this reach, the bed slope varies from 1 in 500 to 1 in 2,500. The bed consists of small size gravel and medium sand. The channel has generally a well defined course.
Suggested protective Measures: -
Bridging such rivers normally involves constriction in width and provision of guide bunds.
Alluvial Reaches :-
In this reach, the river bed slope varies from 1 in 2,500 to 1 in 25,000. The river flows on an almost flat bed built by its alluvium.

Suggested protective Measures :
The training of alluvial rivers is generally on the same lines with guide bund system as described for quasi-alluvial rivers. The meanders do not remain fixed but usually travel down stream.

South Indian Rivers :-
The river system in south India is geologically older and stable. Tendency for shifting of the river bed course and aggradation / degradation is insignificant. Problems of river training and protection normally do not arise except in the deltaic region/tidal reaches.

River Training Works :-
The following types of river training works are generally adopted on the Indian Railways:
1. Guide Bunds;
2. Spurs (Groynes);
3. Marginal Bunds;
4. Closure Bunds; and
5. Assisted cut offs.

Guide Bunds :-
Guide bunds are meant to confine and guide the river flow through the structure without causing damage to it and its approaches. They also prevent the out flanking of the structure.

Shape and Design Features:-
a) The guide bund can either be divergent upstream or parallel. In the case of divergent guide bund, there is possibility of formation of a shoal at the center. Parallel guide bunds minimise obliquity and separation of flow along the flanks. According to geometrical shape, the guide bunds may be straight or elliptical.
b) Normally the up stream shank of the guide bund is between 1.0 to 1.5. times the length of the bridge, while the downstream shank is between 0.2 to 0.4 times the length of the bridge.
c) The tail bund on the down stream side is provided to afford an easy exit to the water and to prevent formation of vertical whirl pools or rollers which give rise to scour.
d) The guide bund is provided with a mole head on its up stream side.

Apron Protection :-
Apron is provided beyond the toe of the slope of the guide bund.

Maintenance :-
a) Substantial reserve of pitching stone should be maintained on the guide bund for use during emergency. This should be stacked at the top of the guide bund.
b) The track on the guide bund, where provided, should be maintained in a satisfactory condition and should be capable of taking boulder trains at any time.
c) Every effort should be made to ascertain whether the apron is launching to the intended position and this should be done by probing after the flood season is over.
d) Disturbance of pitching stone on the slope indicates dangerous condition and additional stones should be placed in position immediately as necessary.

Failures and remedial measures :-
The conditions under which an apron of the guide bund can fail and remedial measures to be adopted are stated below:

a) If the launching takes place beyond the capacity of the stone in the apron and results in leaving the bank material exposed to the current and wave action, more stone will have to be added to the apron.
b) If stones are carried away by high velocity current from the launching apron and the toe of the bund, the apron should be strengthened against severe attack by laying large sized stones at the outer edge of the apron.
c) If slips and blow-outs in the bund occur due to a steep sub soil water gradient resulting from a rapidly falling flood in the river.
d) Wherever disturbance is noticed in rear of guide bund due to wave lash or other causes, the slope pitching should be adopted as a remedial measure.
e) An apron can launch satisfactorily only if the material scours easily and evenly and the angle of repose of the underlying material is not steeper than that of the stone.

Spurs (Groynes):

A spur / groyne is a structure constructed transverse to the river flow and is projected form the bank into the river.

Type of spurs / groynes:

i. Permeable spurs - are constructed by driving wooden bullies or bamboos, filled in with brush wood, with sarkanda mattresses or other suitable material.

ii. Impermeable spurs - are made of solid core, constructed of stones or earth and stones with exposed faces protected by pitching.

iii. Repelling (deflecting) spurs - are those which incline upstream at an angle of 60 degree to 70 degree to the river course and deflect the current towards the opposite bank.

iv. Attracting spurs - incline downstream and make the deep channel flow continuously along their noses.

v. Normal (holding or sedimenting) spurs are those which are built at right angles to the bank to keep the stream in a particular position and promote silting between the spurs.

vi. Full height spurs - Where top level is higher than HFL, it is called a full height spur.

vii. Part height spurs.

viii. "T" head or hockey stick shaped head spurs.

Location and salient features of a spur/groyne:

i) The space between spurs or groynes generally bears a definite ratio to their length. The common practice is to keep the spacing at about 2 to 2.5 times the length so as to effectively protect the bank.

ii) If designed as a full height spur, care should be taken to see that spurs are built sufficiently high so that they are not overtopped and out flanked by the current during high floods. Free board of 1 metre is provided.

iii) The side slope of spurs are generally 2:1.

iv) The spurs should be anchored on to high ground.

v) The head of the spur is most vulnerable point for scour and should be well protected on slopes by pitching and at toe by an apron designed for scour depth of 2.5 to 2.75 times.

vi) Spurs should never be constructed at a point where severe attack is taking place but at some distance upstream.

vii) Spurs/groynes should be used only in-situation where they are absolutely necessary.
viii) The design of spurs may be finalised preferably through hydraulic model studies.

**Maintenance of spurs/Groynes:**
In all cases, satisfactory arrangement should be made for the maintenance of spurs/groynes by providing access to them during all seasons of the year and keeping boulders as reserve.

**Marginal Bunds:**
Marginal bunds are provided to contain the spread of the river when the river in flood spills over its banks upstream of the bridge site over wide area and likely to spill in the neighbouring water courses or cause other damages. The marginal bund should normally be built well away from the active area of the river. The slope should be well protected by turfing. Where a marginal bund has to be built in the active area of the river, it should be protected with pitching and apron. The earth for the construction of marginal bund should preferably be obtained from the river side. The upper end of the marginal bund should be anchored into high ground well above HFL. Marginal bunds should be inspected every year along with the annual bridge inspection and necessary repairs should be carried out before the onset of monsoon. Cattle crossing and rodent holes across the marginal bund should be specially watched and deficiencies made good.

**Closure Bunds:**
Sometimes it may be necessary to entirely block one or more channels of the river in order to prevent the discharge of such channels developing into a main river channel after the construction of the bridge. This is done by providing a closure bund. The bund is designed as an earthen dam. The same is generally constructed at some distance from the railway line. Special care should be exercised to guard it against its failure. It should be inspected every year after the monsoon and necessary repairs carried out.

**Assisted Cut-Offs:**
Sometimes when very heavy meandering develops near bridges and there is a danger of its encroaching too heavily into the still water area or otherwise dangerously approaching the railway embankment, it becomes necessary to dig a cut-off channel which will ultimately develop and help in the diversion of water through it. To effect economy, a pilot channel cut is usually made when there is low flow in the river and full development of the channel takes place during the flood. This cut-off channel should preferably have at least three times the river’s straight regime slope and the upstream end should take off from where the bed load of main channel has less than the average amount of coarse material. The entrance to the pilot cut should be bell shaped to facilitate entry of water. The chord loop ratio should normally be greater than 1 to 5 if a successful channel is to develop.
**Inspection and maintenance of Tunnels**

**Inspection by Engineering Inspectors**
The Permanent way Inspector shall inspect every tunnel on his section once a year during the prescribed month after the monsoon season but where specified by the Chief Engineer, the structural part shall be inspected by the Works Inspector.

**Inspection by Assistant Engineer**
The Assistant Engineer shall inspect every tunnel on the sub division once a year before the monsoon during the prescribed months and record the results in ink in the tunnel inspection register.

**Inspection by Divisional / Sr. Divisional Engineers**
The Divisional/Sr. Divisional Engineers shall carefully scrutinise the Assistant Engineer tunnel inspection register and inspect such tunnels as called for his inspection. He shall record his orders regarding the points which require a decision by him and initial against every entry of tunnel in the registers in token of scrutiny.

**Items to be covered in the Inspection**
The inspection shall cover:
- a) Tunnel approaches and cuttings.
- b) Portals at either end.
- c) Tunnel walls, lining and roofing (lined and unlined).
- d) Drainage.
- e) Refuges.
- f) Ventilation shafts / Adits.
- g) The section in relation to moving dimensions.
- h) The track.
- i) Lighting equipment and special tools with the maintenance gang.

**Record of Inspection**
1. The Inspector / Inspectors shall record the results of their inspection in a manuscript register which shall contain particulars of date of inspection, condition of tunnel and approaches at the time of inspection and repairs carried out during the year. Two or three sheets may be allotted for each tunnel with the tunnel number, its length and kilometreage.
2. The Inspector / Inspectors should promptly attend to the repair required.
3. The Inspector shall submit to the Assistant Engineer by the prescribed date a list of important defects with a certificate in duplicate to the effect.

   "I certify that I have personally carried out tunnel inspection of my section in accordance with standing orders for the year ending...... and append herewith a list of important defects."
4. The Assistant Engineer shall issue such orders as deemed necessary to the Inspector and counter sign and forward one copy of the certificate of inspection to the Divisional Engineer with remarks if any.
5. The Inspector shall accompany the Assistant Engineer on the latter’s Annual inspection of tunnels.

**Details of tunnel inspection**
The details of inspection to be carried out are as follows:

1. **Tunnel Approaches and Cutting**
   Normally the tunnel approaches will be in deep cuttings. The inspection of these cuttings should be carried out
2. **Portals at either end**
   During inspection it should be checked as to whether there are any signs of slips in the slopes above the portals; whether the masonry is in any way cracked, shaken or bulging
and signs of movement are apparent. "Catch-water drains above the portals should drain away and not be allowed to percolate into the tunnel or behind the portal masonry.

3. Section of tunnel in relation to moving dimensions :-
   It should be checked as to whether the dimensions of the tunnel section on straights and curves conform to the diagrams given in the Schedule of Dimensions.

4. Tunnel walls and roofing :-
   a) Lined section: During inspection it should be ascertained whether the lining is in a satisfactory condition. Seepage through joints in the masonry should be looked for.
   b) Unlined Sections: The unlined portions should be examined to find out whether they are sound.

5. Drainage :-
   The drainage arrangements inside the tunnel and up to the outfall should be inspected. It should be ensured that the side drains are adequate and function satisfactorily.

6. Tunnel refuges :-
   It should be checked up as to whether these are well maintained and free of vegetation and other growth.

7. Ventilation shafts / Adits :-
   It should be ascertained whether these are adequate and maintained free of vegetation and other growth. For tunnels more than 200m long, level of pollution and temperature condition should be enquired from the gang and Key man working in that location of tunnel keeping in view passenger comfort and working conditions for working inside the tunnel.

8. Lighting equipment and special tools :-
   The lighting equipment and special tools where supplied should be in a state of good repair.

9. The Track :
   The track should be examined for good line and level including the approaches. Rails, sleepers and fastenings should be particularly examined for corrosion, inside the tunnels.

**Tunnel inspection Register**

Entries in Tunnel Inspections Register :-
1. Entries should be made under each of the heads 1 to 8 mentioned under " Inspection of Tunnels ".
2. Under each head the first entry should state whether the previous year’s notes have been attended to.
3. Entries in the column “condition of tunnels at the time of inspection” should be in the nature of statements, A defect once mentioned should not be omitted in future years unless it has been eliminated by rebuilding or repair in which case a note should be made to that effect.
4. In the column " Action taken " the remarks should be in the form that orders have been issued.
   i) Permanent Way Inspector instructed to renew rails;
   ii) Permanent Way Inspector / Works Inspector instructed to grout cracks;
   iii) Bridge Inspector instructed to put in steel support stagings.
5. No tunnel in which the lining is shaken, crushed, bulging, deteriorating or shows signs of movement or in which any of the unlined portion is loose, should be described as “ sound”.
6. A tunnel is to be noted “requiring special repairs” when any part of it has to be relined or undergo heavy repairs.
An Index to be opened in the register giving the tunnel No. and Page No. etc.

Index

Page No. .......................... Kilometreage (Mileage) ............. Tunnel No. ............

Separate pages should be allotted for each tunnel and the following details should be furnished for each one of them:

Tunnel No. ........... Section Between stations .............. Total length ........ Kilometreage.

Year of Construction ............ Curve / Straight ........... Details of construction .......

Brief particulars of soil met with .................................................................

Portions lined and thickness of lining .........................................................

Brief particulars of ventilation ......................................................................

Brief particulars of lighting (if any) .............................................................

Brief particulars of drainage ...........................................................................

Minimum height above rail level along centre line of track in millimeters. ............

Minimum distance from centre line of track in millimeters. .............................

Reference to Plan. ............................................................................................

Previous History of Tunnel .............................................................................

Here all the records, such as details of damage to the tunnels and the repairs, if carried out with cost, special care to be taken in the maintenance of tunnel etc. are to be shown.

Extract of page of Tunnel Inspection Register

<table>
<thead>
<tr>
<th>Details of Inspection</th>
<th>Year 1997 – 98</th>
<th>Year 1998-99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of Inspection</td>
<td>Date of Inspection</td>
<td>Condition at the time of Inspection</td>
</tr>
<tr>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

**Items to be inspected** -

1. Tunnel approach & cutting
2. Condition of portals
3. Tunnel walls & roofing. Comment about tunnel conforming to moving dimension
4. Drainage inside tunnel and out fall
5. Condition of tunnel refuges & ventilation shafts
6. Tracks in the tunnel
7. Lighting equipment & tools
8. Any other items.

***********************************
Commissioning of Railway project

Commissioning of new lines –

Opening for Goods Traffic. –
A line under construction should not be left unremunerative longer than is absolutely necessary. As soon as possible after the rails have been linked through a section of a line under construction. reasonable facilities for the receipt and despatch of goods and parcels should be provided at all the important stations on that section, so that it may be opened for goods traffic. Reasonable facilities for goods and parcels traffic at a station should include the following :-

i. A siding or part of a siding of a suitable length set apart for the exclusive use of the goods wagons. when loading and unloading.

ii. A suitable space properly dressed and free from all construction material or debris for the stocking of inward and outward goods.

iii. A goods shed, if provision for one is included in the sanctioned estimate of the project, otherwise tarpaulins should be provided for the protection of goods.

iv. A small office for the goods clerk when a goods shed is not provided.

v. Office furniture according to the scale prescribed by the open line administration.

vi. A weighing machine anti weights of standard types for the goods shed.

vii. Residential accommodation for the traffic staff.

viii. Supply of drinking water for the staff.

The Chief Engineer (Construction) or the Senior Engineer Administrative Officer, under whose Administrative control the line under construction is vested should fix the date of opening of the line or a section there for goods traffic in consultation with the General Manager of the connected open line Administration. Before fixing the date the General Manager should arrange to have an inspection of the line proposed to be opened for goods traffic by responsible officers of the Commercial and Operating Departments so that they may, satisfy themselves that adequate facilities will be provided before the date fixed. He should it the same time arrange for:

i. The compilation and issue of the necessary rates and fare tables in accordance with regulations;

ii. Advertising the opening of the line to goods traffic;

iii. The posting of the necessary goods booking clerks etc. to all the stations to be opened;

iv. The supply of the station scale, consumable stores, forms, stationery etc. required by the goods booking staff at in the stations to be opened.

Opening for Passenger Traffic -
Every new line or a section thereof should before sanction can be obtained for its opening for public carriage of passengers be inspected and passed by the Additional Commissioner of Railway Safety concerned, in accordance with the "Rules for the opening of a Railway for the public carriage of passengers". No new line or a section thereof should be offered for the inspection of Additional Commissioner of Railway Safety until it has been completely equipped. No temporary or make--shift arrangements, however safe should be permitted.

Fixing Date for opening for Passenger Traffic.----The date for the opening of a line for the public carriage of passengers should be fixed by the Chief Engineer (Construction) or the Senior Engineering Administrative officer under whose administrative control of the line is vested, in consultation with the General Manager of the connected open line; Administration so that the latter may make suitable arrangements for working the new line for public traffic from the date fixed. After fixing the date the Additional Commissioner of Railway Safety concerned should be
invited to inspect the new line and give the necessary permission for the opening of the line. At least one month's notice should be given to the Additional Commissioner of Railway safety of the date on which it is desired that the inspection should take place.

The date for the inspection of a line by the Additional Commissioner of Railway Safety Prior to the opening for the public carriage of passengers should in consultation with that Officer be fixed a week or so prior to the date of opening, so as to allow time for complying with the Inspecting Officer's requests or recommendations before actual opening of the new line. The Chief Engineer (Construction) or the Senior Engineering Administrative Officer under whose administrative control the new line is vested is responsible for seeing that the new line offered for inspection of the Additional Commissioner of Railway Safety is in every respect fit for opening by the date fixed for the inspection and is fully equipped.

A new line should not ordinarily be considered fit for opening unless:

- All station buildings and quarters included in the construction estimate are completed and really for occupation and use;
- The track is thoroughly packed and boxed throughout;
- All station and locomotive yards provided in the construction estimate are completed;
- All station signals, point indicators, derails or Scotch blocks are in position and in perfect working order;
- All points and crossings are correctly and truly laid;
- Watering arrangements are complete;
- All "Special", "A" and "R" class level crossings are manned by gatemen; and
- Adequate arrangement is made for the maintenance of track and other infrastructure facilities.

Handling over of New Lines to Open Line -

All new lines should be taken over by Open line organisation within six months of the date of opening for goods traffic. Ballasting and other residual works if any should be got done by the open line against the construction estimates.

Completion of railway Projects

Completion- Estimates.—

In the case of Railway Projects costing over rupees one crore, the Construction or Abstract Estimate should be closed at the end of one of the first three financial half years after the date of "opening" as may be convenient and a "completion estimate" prepared. The completion estimate is a "stock taking estimate". and all works not started on that date are excluded from the scope of the project and are to be dealt with separately. The financial half year in which the project is opened should be excluded for determining the date of closing of project estimate and preparation of completion estimate. The completion estimates should invariably be signed by or on behalf of the Financial Adviser and Chief Accounts Officer, and by or on behalf of competent executive authority.

The date of "opening" in the case of new line should be held to be the date of opening for passenger traffic of the whole line included in a construction estimate. If different sections of a project are likely to be opened at intervals exceeding one year separate completion estimate should be submitted for each section. In the case of lines justified solely for the movement of goods traffic shall be the date on which the line is opened to goods traffic. In the case of open line projects the date of "opening" should be held to be the date on which the project fulfils the purpose for which it was sanctioned. In the case of doubling or quadrupling of lines or provision of third line the purpose for which the project has been sanctioned will be deemed to have been fulfilled when the new line is opened for goods traffic.
Completion estimates, which involve any material modifications in a project sanctioned by the Railway Board, or an excess over the estimate beyond the powers of sanction of the General Manager should, after verification by the Accounts Officer be submitted for the sanctioned of the Railway Board. Completion estimates which involve no such modifications or excess may be sanctioned by the General Manager, the Railway Board being informed, when sanction has been accorded, and an abstract of the completion estimate being at the same time forwarded for the information of the Railway Board. The completion estimate should reach the authority competent to sanction it, within four months, after the close, of the financial half year up to which it shows actual expenditure.

**Project Completion Report.**

*compilation and object of submission.*

The object of a Completion Report is to compare the cost of work actually constructed with those provided in the last sanctioned estimate. The completion report of a project duly verified by the Accounts Officer should be submitted to the Railway Board within 18 months after the end of the financial half year in which the completion estimate is submitted. It should state the expenditure in the same details as the abstract estimate sanctioned by the Railway Board and should indicate any material modifications thereto. In addition it may contain such other information as would in the opinion of the Railway Administration be of interest to the Railway Board.

**Form of Completion Report.**

The Completion Report should be prepared in the following form and brief explanations should be furnished for:

- Excess of not less than 10 per cent or Rs. 25,000 whichever is less over the estimated provision under each sub work;
- Saving of not less than 20 per cent or Rs. 1 lakh whichever is less, occurring under any sub-work.

The Divisional Superintendent / Deputy Chief Engineer concerned may be empowered by the General Managers to approve the completion reports of works within the General Managers competence in the works Registers if variations are within 5 per cent of the sanctioned estimate.

**Form E. 1706**

**Completion Report For The Work...............**

<table>
<thead>
<tr>
<th>Particular Heads of Account and Description of works</th>
<th>Amount of Estimate with reference to authority for sanction</th>
<th>Actual Expenditure</th>
<th>Difference Excess</th>
<th>Savings</th>
<th>Remarks &amp; Explanations</th>
</tr>
</thead>
</table>

**Completion Statements**

As a general rule, completion report should be submitted in respect of each completed work. Never the less, in the case of works the expenditure on which is within the competence of the head of the railway to sanction a formal completion report on the prescribed form need not be prepared. In such cases all the information required in the Completion Report Form, the certificate of the Accounts Officer and the sanction of the competent executive authority may be recorded in the register of works under the relevant accounts. Completion Statements showing the following information being prepared and recorded under the orders of the competent executive authority, after verification by the Accounts Officer:

- Reference to estimate.
- Amount of sanctioned estimate.
- Actual expenditure as finally booked.
- Brief explanation of excess or saving.

*-----------------------------*
Miscellaneous Works

Works required for Defense Purposes -
The cost of works constructed to meet the special requirement of Defence Department / Ministry is divided between Railway estimate and Defence Estimate.

Strategic Lines. –
The entire expenditure of Defence works carried out on strategic line will be borne by the Railways subject to the same rules of exemption from payment of dividend as are applicable to the expenditure incurred on strategic lines. All such works costing up to Rs. 25,000 will be charged to Open Line Works Revenue and works costing above this limit will be charged to Capital.

Commercial Lines. - The Railway estimates bear :-

i. The cost of all recoverable material used in the construction of troops sidings and platforms etc., such as permanent way, girders, signals and other movable things, which are unlikely to be required for Defence services;

ii. The cost of land acquired for troop sidings and platforms etc. if the railway administration chooses to acquire it for its own purpose; and

iii. In the case of large Defence projects where, at least a full gang has to be exclusively employed in the maintenance of railway sidings etc., the cost of residential accommodation for the Railway staff so employed.

The Defence estimates bear:-

i. The cost of construction of troop sidings, platforms, etc., including the signalling arrangements required in the event of the siding or platform taking off from the main line beyond the limits of station yard, except the cost of recoverable material.

ii. The cost of land acquired for troop sidings, platforms etc., if the railway Administration does not choose to acquire it for its own purpose;

iii. The interest and maintenance charges on Railway's share of the cost in respect of Defence works executed by Railways on behalf of Defence services.

iv. Maintenance charges at the rate of 4.50 per cent on the cost of residential accommodation constructed at the cost of Defence Department for the Railway staff required for the maintenance of Defence works;

v. The cost of taking out and returning to stores the materials.

vi. Supervision charges at the rate of 12% of the entire cost of the work including Railway's share of cost.

vii. Works Establishment charges.

viii. Code charges :- Freight and incidental charges at 7% and Contingencies at 3% .

iv. Compensation for the quarters constructed by the Railway at their cost in the event of quarters being rendered surplus or the project abandoned. If the quarters are on Defence owned land the Ministry of Defence will take over the quarters at a fair valuation of their market cost. The quarters constructed on Railway owned land will be taken over by the Railways and if they can not be utilised by the Railways the Ministry of Defence will pay fair Compensation therefore.

Defence works. –
The cost of building and maintaining works for the defence of railway bridges, stations and tunnels, which are designed for occupation by regular troops, or which may in certain circumstances be garrisoned by them is debitable to the Defence estimates. But the Railway
estimates bear the cost of maintaining buildings, which are required to be garrisoned by regular troops only in certain circumstances and which the railway administration concerned retains the right to occupy free of rent when not required by the military authorities and which are suitable for occupation by railway servants.

Similarly, where the railway administration changes the site of bridges, necessitating the provision of new defences thereon, the cost of provision of such defence works, when they are considered necessary from a military point of view, will be a charge against Defence estimates.

The cost of staff, whether railway, police or military, employed on protecting railway bridges will be borne by the Railway, but when the service is taken over, on general grounds of Government policy, by the police, Defence Services or other public service department as part of their regular duties, the charges will be borne by the police Defence Services or the public service department concerned, as the case may be.

Works required to meet the requirement of the Civil and Defense department / Ministries, Road cum rail bridges and public foot paths over rail bridges. -

Roadways over Railway Bridges. –
The necessity for a roadway for other than railway traffic on a Railway bridges, will be decided on its merits, the State Government being afforded an opportunity in each case of offering to share in the cost of the combined structure, but the final decision in an individual case will rest with the Central Government.

Cost of Construction and Renewal –
(a) New Bridges -

Common Deck road-cum-rail bridge - In view of the increasing road and rail traffic, common decking cannot be retained permanently. The road traffic can be permitted only so long as it does not adversely affect the railway traffic. Common decks shall not be permitted where the rail traffic exceeds 10 trains per day each way. The State Government / Road Authority need not share the original cost of the bridge, but they shall have to bear the initial cost of the road decking and agree to bear the cost of the dismantlement of the same and restoration of the bridge for proper railway working

Roadway on a separate deck above the railway track-New Bridge- (1) In the case of Broad Gauge single track with 7.2 M. roadway and 1.8 M. wide foot paths, the total cost of the combined structure inclusive of piers, abutments, protection and training works will be divided in the proportion of 60 per cent to the Railway and 40 per cent to the Road Authority and in the case of double track with 7.2 M. wide roadway and 1.8 M. wide foot paths, the division of cost will be in the proportion of 72 per cent to the Railway and 28 per cent to the road Authority.
(2) For Meter Gauge bridges, the division of cost will be in the proportion of 50 per cent to the Railway and 50 per cent to the road for single track with 7.2M. road way with 1.8 M. wide foot paths, and 64 per cent to the Railway and 36 per cent to the road in the case of double track with 7.2M. road way and 1.8 M (6 ft.) wide footpaths.

(b) Bridges regirdered - -
The division of cost when a roadway is provided is regirdered will be as follows i.e. the actual cost of the regirdering including the provision of the road ways, will be divided as in (a), but no contribution will be required of the Road Authority as a share of the cost previously incurred on the piers, protection works, etc.
(c) Existing roadways on Bridges - (those in existence on 15th May, 1942) :-
No division of the cost on the revised basis will be attempted in these cases, until the bridges come to be rebuilt or regirdered, when they will be dealt in accordance with the foregoing principles.

Maintenance. –
This should be considered under two heads –
(1) The general upkeep of the bridge structure excluding the permanent way and ballast but including painting of girders, repairs to piers, protection and training works, etc., which are essential both for the railway and the road and

(ii) The upkeep of the road-surface as well as the annual charges for gatemen lighting, signalling, etc., in case, where these have to be provided.

(a) New Roadway –
(I) In the case of new roadways, i.e., whether on new or regirdered bridges, item (1) will be carried out by the Railway Administration but the annual cost will be divided between the Railway and the Road Authority in the same proportion as the division of the capital cost.

(ii) The annual charges be borne entirely by the Road Authority.

(b) Existing roadways - (those in existence on 15th May, 1942). –
No division of the maintenance cost shown under head (1). The charges shown under head (ii) borne by the Road Authority.

Footways over Railway Bridges. –
These rules do not apply to footways over railway bridges. Footways will be considered on their merits as each case arises under the general principles that the requiring Department / Ministry shall meet the first cost and the maintenance charges thereof.

Works for Civil Departments/Ministries Level crossing, over and under bridges -

Level-crossing, road over bridges and under bridges. –
The cost of level-crossings, road over and under bridge s constructed at the time of construction of a railway line or at any time thereafter in order to meet Railway's statutory, liability under the Railway Act is chargeable to the Railway.

If the construction of a bridge is found necessary otherwise than in pursuance of a Railway's liability its cost will be borne by the Railway if its necessity has arisen from railway requirements, and by the Road Authority if its necessity has arisen from the growth of road traffic or other requirements of the Road Authority, provided that in either case any extra cost due to additional width or length or other facilities required on account of probable future developments will be borne by the Authority requiring such addition or facilities.

If an existing busy level crossing originally provided at Railway's cost is to be replaced by a road over or under bridge the apportionment of the cost of replacement will be as under :-

i. The Railway will bear 50 per cent of the total cost of the over or under-bridge including approaches.

ii. The bridge will generally be of 7.2m. width to suit two lanes of road traffic. In area within or close to cities and towns, two foot paths may also be provided if required by the Road Authority.

iii. If provision is required to be made in the bridge structure for crossing additional railways tracks in future the, cost of such extra length of the bridge structure will be borne by the Railway in addition to its share of the cost for the rest of the bridge and its approaches.

iv. If additional width of roadway is required by the Road Authority over and above the limits of the width the cost of this additional width will be borne-
a) Fully by the Road Authority for the length of the bridge required to span the existing tracks.
b) Equally by the Road and Railway Authorities for any extra length provided for crossing additional railway tracks in future.

If an existing road over or under-bridge is required to be raised, lowered, extended widened or rebuilt on a new site, the cost will be borne by the authority requiring such raising, lowering, extension or relocation. Any extra cost due to additional width or length or other facilities required by any authority shall be borne by that authority.

The maintenance and lighting of the roadway of the bridge and its approaches after its opening to public traffic is a charge against the Road Authority.

If the construction of a new level crossing or an improvement or alterations in an existing one, whether necessitated by local conditions or any other cause, is asked for by a State Government or local authority, the capital cost of the works asked for will be borne by such Government or authority, except in cases where the liability is that of a Railway under the Railway Act.

If a level crossing provided initially and maintained at the cost of the Railway in compliance with the statutory obligation under the Indian Railways Act is required to be manned (if it is unmanned) or upgraded / provided with additional gatekeepers due to subsequent increase in both road and rail traffic, the initial cost of such manning, additional manning or upgrade is to be borne by the State Government / Road Authority concerned, and the recurring and maintenance cost by the Railway.

If a 'D' class cattle crossing is required to be converted into a regular level crossing to suit the requirements of the vehicular traffic, the cost involved both initial as well as recurring and maintenance has to be borne by the State Government / Road Authority concerned.

Assisted Sidings -
Terms and Conditions. - Sidings to serve a factory, mill collieries or other industrial premises, other than in a mining area, may be provided by a railway administration, subject to the terms and conditions

Land. –
The land to be acquired for assisted siding outside the applicant's premises should be paid for by the applicant; ownership of such land should vest in the Central Government absolutely.

Deposit Towards Preliminary Expenses. –
A deposit to cover the cost of survey and preparation of the necessary plans and estimates should be made by the applicant.

The incidence of the cost of the assisted sidings as between the Railway Administration and the applicant should be in accordance with the following general principles: -

( i ) Outside the applicant's premises, the cost of all works which would have to be abandoned in the event of the siding being closed, e.g., earthwork, bridges (exclusive of girders), culverts, ballast, buildings, etc., should be borne by the applicant,

( ii ) Outside the applicant's premises, the cost of all works which would be removed by the Railway Administration in the event of the siding being closed, e.g., sleepers, rails, fastenings, points and crossings, girders of bridges, fencing, signalling and inter-locking appliances and machinery of any kind, should be borne by the Railway Administration;

( iii ) The entire cost of the siding within the applicant's premises should be borne by the applicant;
Maintenance of Assisted Sidings. –
The applicant should pay annually to the Railway Administration maintenance charges as follows:–
Repair and maintenance charges at the rate of 4 ½% on the cost of the portion of siding borne
by the railway or its present day cost, whichever is higher. For calculating these charges, the
cost of the portion of siding borne by the Railway will be re-valued every five years in
accordance with such general or special orders as may be issued by the Railway Board from
time to time. This payment will ordinarily cover the maintenance by the railway of the works
paid for by the applicant outside his premises. The maintenance of the works inside the
applicant's premises is the applicant's own concern. Railway should however ensure that the
maintenance of works by the applicant beyond the railway limits conforms to the requisite
standard prescribed by the railway. For this purpose railway should undertake periodical
inspections and the cost of sick periodical inspection should be a charge against the applicant.

Execution of Private and Assisted Sidings. –
All works relating to construction of private and assisted sidings should be normally done by the
Railway. If the party concerned desire to carry out portion of such works themselves. according
to Railway specifications and the work is carried out under Railway's supervision.

Departmental charges. -
When a portion of work concerning an assisted or private siding is allowed to be carried out by
the party asking for the siding departmental charges shall be levied at a reduced rate of 6 ¼
percent of the cost of the work carried out by the party.
When the work of survey and construction of a private siding is allowed to be carried by the
party through an approved Consultant / Consulting Firm / Consulting Engineer, total charges
(including departmental charges) to be recovered from the Consultant / Consulting Firm /
Consulting Engineer shall be as follows:–

<table>
<thead>
<tr>
<th>Surveys:</th>
<th>(a) 1% of the assessed cost of the project at the stage the party’s proposal for undertaking the survey is approved by the Railways.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(b) Balance amount to complete 2% of the estimated cost of the project at the stage of conveying approval to Survey/Plans and Estimates.</td>
</tr>
<tr>
<td>Final Inspection:</td>
<td>2% of the cost of project while applying for the final approval of the completed works.</td>
</tr>
</tbody>
</table>

Deposit of Estimated Cost. –
The estimated amount of the cost to be borne by the applicant for the execution of assisted /
Private Sidings should be deposited with the Railway Administration before the construction of
the sidings is taken in hand. In the case of works costing Rs. 3 lakhs or more, if the applicant is a
private firm of established repute and reliability or an public sector, undertaking, the work may be
commenced against an initial cash deposit of 20 per cent of the estimated cost of the work or
Rs. 3 lakhs, whichever is more, by the applicant.

Deposit Works -
Definition. - The term "Deposit Work" is applied to works of construction or repair, the cost of
which is met, not out of railway funds, but out of funds from non-railway sources. Works
executed by a railway for other Government Departments, municipalities and other local bodies,
and private Firms and individuals fall under this category.
Procedure for Undertaking Deposit Works –
As a general rule, all works within railway premises should be executed only by or under the direct supervision of the railway authorities. When, therefore, any other Government Department or a non-railway party wants any work to be executed in railway premises a level crossing required by the public Works or Canal.

Cost of Plans and Estimates –
On receipt of applications for Deposit Works, the applicants should, in the case of a Government Department, be called upon to accept and in all other cases to deposit.

Register of Works –
A separate register of works should be maintained for all Deposit Works in a division. In this register. A separate account should be kept for each deposit work undertaken in the division.

Completion of Deposit Works –
On the completion of a Deposit Work, an intimation of the date of completion and of handing over to the party concerned should be sent to the Accounts Officer; the account of the work should as a whole be carefully scrutinized.

Maintenance of Deposit Works –
All Deposit Works in railway premises should, as a rule, be maintained by the Railway Administration concerned at the cost of the parties who applied for them. Charges for maintaining Deposit Works should be recovered from the parties concerned on the basis of -

(1) either a fixed percentage of the cost of the works, the rate being fixed by the General Manager.

(2) or actual expenditure (including departmental charges).

The basis to be adopted in respect of particular classes of Deposit Works is left to the discretion of the General Manager.

Recovery of Maintenance and Other Charges. –
The Accounts Officer of a railway in responsible for the correct recovery of the maintenance charges and the cost of extra establishment if any, pertaining to all Deposit Works on that railway. Maintenance charges.

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Building and Rents

Staff Quarters -

Conditions for Provisions of Staff Quarters. –
While residential quarters for staff may be provided by railways where conditions are such that private enterprise does not adequately meet the demand for housing the staff, or where it is necessary for special reasons to provide quarters for certain staff near to their work, no employee has any right to be provided with quarters.

Classification of Quarters. –
For the purpose of assessment of rent, quarters should be divided by the General Manager into separate classes approximately according to the standard of accommodation approved for various classes of staff.

Scale of Accommodation for Staff –
The scale of accommodation and the unit cost for each class of quarters are prescribed by the Railway Board. Motor garages should not as a rule be provided in staff quarters. In exceptional cases, however, where the General Manager considers that the provision of a garage is essential in the interest of an official's work it may be provided. In such cases, the cost of the garage should be taken into account in assessing the rent for the quarters on arriving at the requisite return of six per cent on the total capital cost of all the quarters of the particular class concerned.

Accommodation for officers-- The scale of accommodation and the unit cost for each class of officer's quarters is prescribed by the Railway Board. No expenditure should be incurred on building houses or on making alterations and or additions to existing houses for officers without the specific and prior approval of the Railway Board except to the extent of expenditure not exceeding Rs. 10,000/- on essential new works which include provision of electricity and sanitary installations (other than repairs and maintenance) on any one officer's quarter subject to the total expenditure in a financial year on this account on an individual Railway not exceeding Rs. 3,00,000/- per annum. In the case of class III staff quarters temporarily occupied by officers, the specific approval of the Railway Board will be necessary if any additions and alterations are to be made to such quarters. Temporary garages may be provided in officer's quarters which are not entitled to garages and in quarters meant for staff which are temporarily upgraded for the use of officers at the request of officers who own cars. The cost of such temporary garages should not exceed Rs. 2000 in each case. The garage except flooring should be built with such materials only which can be fully reclaimed and should be dismantled as soon as the quarter is downgraded or is allotted to an officer who does not own a car. Extra rent should be charged from the officer on whose request the temporary garage is provided at the rate of six percent per annum on the cost of the garage including cost of flooring, erection and dismantlement plus depreciation and maintenance charges to be calculated according to the life of the garage and cost of maintenance. Life of the garage should be determined on the basis of the average occupancy spread over the life of the assets and not on the basis of life of the assets only.

Rent of Staff quarters –
The assessed rent for each class of quarters should be fixed at six per cent of the total cost of all the quarters in that class- whether the total cost is charged to Capital Development Fund or Open Line Works Revenue.
In the case of officers' quarters all the quarters on each Railway should be pooled in one class and the rent to be charged for such pooled accommodation calculated on the floor area basis. The assessed rent of staff quarters should also be fixed on floor area basis wherever possible. Substandard quarters not provided with essential basic amenities such as kitchen, store, lavatory and without source of water supply in the vicinity and with very low roof should be excluded from the general, pool of quarters and constituted into a separate pool and their rent fixed at six per cent of the total outlay on such quarters.

Rent should be reassessed once in five years on the basis of the total cost as on 31st March. The approximate Capital cost of electric, sanitary and water supply installations should be segregated from the capital cost of the building proper so that a reasonable assessment of the increase in the pooled rent on account of the provision of such installations is made and added separately to the pooled rent only in respect of quarters within a pool which are provided with such amenities.

Assessed Rent -

In the case of leased and requisitioned buildings, the rent paid to the landlord should be treated as the assessed rent.

Cost.—

For the purpose of assessment of rent the total cost of quarters should include the entire cost of construction irrespective of its allocation including sanitary, water supply and electric installations and fittings but not the cost of land and its development.

Development of land will include the following:-

i. Raising, levelling and dressing of sites.
iii. Storm water drainage.
iv. Approach roads and paths within the Compound.
v. Sewerage, Street lighting including transformer house distribution mains etc., water supply arrangements including ground reservoir, overhead tank, distribution system etc., and plantation in the colony.

It is permissible to pool the total cost of electric installations in all the quarters belonging to a class at each station and to adopt the average total cost for purpose of assessing rent on electric installations. The average will be applicable to railway employees only and not quarters let to other Government departments or outsiders.

Fittings. –

Only the following should be regarded as fittings -

**Electric Fittings**

i. Lamp fittings of all kinds.
ii. Fans, including switches and regulators, the hire of which is not charged separately.
iii. Meters, the hire of which is not charged separately.
iv. Electric heaters and water heaters furled to the buildings.

**Sanitary and water supply Fittings.**

i. Apparatus for hot water supply fixed to the building.
ii. Baths, basins and lavatory equipment, and
iii. Meters, the hire of which is not charged separately.

Electric bulbs may be provided from railway funds as first equipment their cost being included in the first cost for purposes of charging rent. The cost of all subsequent 'replacements should be charged to the occupants,
Provision of Furniture and Other amenities.—
The provision of other special installations and fittings such as heating installations, electric lifts, refrigerators, and of furniture requires the prior sanction of the Railway Board. Chicks may be provided or replaced only against specific requests from allottees of residences and wherever they are so supplied / or replaced. hire charges should be recovered in addition to the normal rent of the quarter. The rate for the charges will be the rate prescribed from time to time by the Railway Board. For portable heaters or water heaters which obtain their electrical energy by means of movable plug in a socket in the wiring system should be classed as furniture.

Cost of Buildings partly used as on Office.—
When a building is used partly as a residential and partly as an office for which no rent is paid, the cost of the portion occupied as residence should be separately estimated by the General Manager for the purpose of assessing rent. When separate office accommodation is provided for the occupant and the use of part of his residence for office purposes is optional, no deduction from the rent is permissible on this account.

Hire of Private Buildings.--
The hiring by the Administration of a private building for use as residence by a gazetted officer requires the prior sanction of the Railway Board. The General Manager may hire private buildings for use as residence by non-gazetted staff subject to the following conditions
i. That it is necessary, in the interest of the railway, for the employee to reside in a particular locality and suitable accommodation owned by the railway does not exist in that locality, and
ii. That houses are not engaged which provide a scale of accommodation in excess of that usually allowed to the employees in question. There is no restriction on the powers of the Railway Administrations or of Chief Engineers to rent officer accommodation.

Rent for temporary huts and tented accommodation.—
No rent is to be recovered from the staff who are temporarily accommodated in huts built of bamboo framing grass mat walling and thatched roofs at ghats and also from staff who are provided with tented accommodation on relaying, surveys and construction.

Hire charges for furniture.-
Hire charges for furniture let out to Railway officers by Railway administrations should be recovered at 14 per cent per annum on the cost of furniture supplied in respect of durable articles and at 24.75 percent per annum for non-durable articles.

Payment of Service charges to Local bodies.—
For "Service Charges" in respect of Central Government properties on the following basis :-
The Railways will make payment in respect of their properties for "Specific Charges" rendered by local authorities but payment of such "Service Charges" shall be treated not as payment of taxes but of compensation payable in quasi contract. "Specific Charges" will include not only direct services such as water and electric supplies, scavenging etc., but also general services such as street lighting, town drainage, approach roads connecting the Railway properties etc. But such items as educational, medical or public health facilities will be excluded.
For large and compact blocks of these properties the Railway will not pay for such specific services as they themselves arrange.
The assessment of "Service Charges" should be on actual basis in case of metered water or electricity etc., or where services like drainage and scavenging etc. are charged for separately. But where some or all such specific services are not charged for separately but are part of a consolidated property tax.
Railway Administrations may also enter into separate contract with any local authority for the supply of water and electricity or scavenging or any other services.

The annual ratable value of the properties for arriving at the service charges payable to local bodies whether as consolidated tax or as distinct and separate taxes for different services provided based on the annual ratable value shall be 9 per cent of the 'Capital Value' of the property concerned both in respect of residential and non-residential properties.

In the case of taxes being levied separately for each item of service the share of general services rendered by a local body to be borne by the Railway will be on the following basis--

**Water and Drainage Tax:**

| 1. | Where a Railway Administration derives no direct benefit. | 1/3 of the tax |
| 2. | Where a Railway Administration derives only partial benefit | ½ of the tax |
| 3. | Where a Railway Administration derives full benefit. | full tax |

**Scavenging Tax:**

| 1. | Where a Railway Administration has made efficient arrangements of its own for the daily removal and disposal of rubbish, filth etc, from its premises. | No tax |
| 2. | Where the Railway Administration has made arrangements for removal of filth etc., but where the local authority is responsible for its final disposal. | ½ of the tax |

**Lighting Tax:**

| 1. | Where the Railway Administration does not take power from the local authority for lighting its premises and where the roads leading to be Railway station are also not lit by the local authority. | No tax |
| 2. | Where the Railway Administration does not take power from the local authority for lighting its premises but the roads leading to the Railway Station are lit by the local authority. | ½ of the tax |
| 3. | Where the Railway Administration takes power from the local authority for Full tax in lighting its premises. | Full tax in addition to the charges for energy consumed |

In the case of residential buildings occupied by officers, taxes which are by local law, rule or custom ordinarily leviable on tenants should be paid by the occupants during the term of his occupancy. If by local law, rule or custom the tax is chargeable to the owner it will be payable by the railway.

The municipal taxes assessed on the annual value of residential buildings in which office accommodation is also provided or on the land appertaining to them should be treated as separate from the rent. The officer occupying the residential portion should pay the share of such tax corresponding to the share of the rent payable by him and the railway should be debited with the balance.

Staff are exempted from the payment of local taxes leviable on railway buildings (as opposed to taxes of a personal nature available on railway employees such as Haisiyat Tax, Circumstances anti Property Tax etc.) whether the services are rendered by the railway or by a Municipality or similar local bodies. This concession is also admissible to staff during the period they officiate as officers.

**Buildings not Essential to Railway Working**

Except as specifically provided in the following paragraphs no expenditure should be incurred by a Railway Administration on buildings and other works not essential to Railway working.

In ordinary circumstances the Railway Administration should endeavour to keep the expenditure during the year on existing schools for children of staff, institutes, hospitals, dispensaries, etc. within the amount provided for such works in the sanctioned budget subject to the limitations.
and other extent orders on the subject Special cases involving expenditure in excess of these limits, such as, the provision of institutes, etc. as part of a new railway colony, should be submitted for the orders of the Railway Board.

**Schools—**
No new Railway school should be opened without prior sanction of the Railway Board. The Railway Administration may, however, incur expenditure on the existing schools in each case up to Rs. 15000. The previous sanction of the Railway Board should be obtained to all expenditure proposed to be incurred on the existing railway schools in excess of the provision in the sanctioned budget.

Railway school includes quarters for teaching staff but does not include schools, intended for the training of Railway staff and apprentices, such as the Chandausi Training School and Loco or Traffic Training Schools.

The Railway Administration should exercise considerable care in dealing with proposals for expenditure on all such works so as to ensure a proper distribution of expenditure over the various classes of the staff.

**Conversion of Existing Building.—**
When an existing building of the Railway is converted for the purpose of accommodating an institute, etc. the original cost of such building as also the cost of conversion should be taken into account for balancing against the budgetary provision.

**Incidence of Maintenance and Upkeep of Institutes—**
A Railway Institute should be looked upon as a club provided by the railway rent-free for the benefit of its employees. As a general principle, therefore, the railway should provide everything which a landlord ordinarily would and the institute should pay for all that a tenant would usually be liable.

**Accordingly, the Railway Administration will bear:**

i. The first cost of the building including the cost of electric installations with necessary furniture, road, fences, tennis courts and other playing grounds. The term "Furniture" is not intended to include billiard tables, pianos and pictures. It includes lamps, other than billiard table lamps, and keys of almirahs and book boxes.

ii. The cost of maintenance and alterations, except as provided in the case of tennis courts and other playing grounds, the railway administration will bear only the ordinary engineering repairs.

The expenditure incurred by the Railway Administration will be allocated in accordance with the rules and orders on the subject.

**The institute funds will bear:**

i. The cost of rolling, watering grass-cutting and other maintenance charges of playing grounds, other than engineering repairs;

ii. The cost of maintenance of its gardens and ornamental grounds;

iii. The cost of maintenance and renewal, whether partial or complete, of electric installations payable at a flat rate of 5 per cent per annum on the capital cost of installation;

iv. The cost of electric current consumed and hire of meter;

v. Occupier's share of municipal taxes for specific direct services rendered to an institute by a Municipality, such as conservancy, water and the like taxes, as distinct from taxes of a general nature;

vi. Water charges calculated at so much per tap, each railway administration fixing its own scale of charges.

In cases where large quantities of water are supplied by Railway Administrations, as in the case of swimming baths, the actual cost of water supplies should be recovered.

**Note:** No charges for supply of water to swimming baths should be recovered in cases where waste water from such baths is utilized for definite Railway purposes, e.g. flushing of sewers and watering of gardens, etc.
Club House for Officers-
Club houses may be provided for the use of Railway Officers on the same basis as Railway institutes will apply to Officer clubs also.

Other Structures for the Benefit of Railway Staff-Works, such as structures for the Hut on the local markets, for the benefit of the Railway staff at a station where 3 Station Committee exists may at the discretion of the General Manager and within the amount provided in the sanctioned budget, be constructed at the request of the station committee out of the funds of the Railway. In such cases, the station committee should pay to the Railway Revenues such rent as may be fixed by the Railway Administration. In fixing the rate of the rate of rent, it should be seen that an adequate return on the amount expended is ensured so as to cover the interest maintenance and depreciation charges in respect of the structure. Formal agreement should be executed by the station committee before an arrangement outlined above is entered into.

Railway buildings occupied by other Government Departments and private individuals or vice-
verse
No railway building may be occupied by any person not in the service of the railway without the sanction of the General Manager of the Railway.

Railway buildings, including residential quarters, permanent allotted for the exclusive use of other Government Department
Rent—
In the case of buildings, including residential quarters, permanently allotted for the exclusive use of other Departments of the Central Government other than Post & Telegraphs Department and of the State Government, rent shall be recovered in accordance with the following rules:--
(i) Rent charged by Railway Administration to all Government departments will be uniform except in the case of Post and Telegraphs Department for which separate rules have been evolved and will cover interest maintenance and depreciation in respect of both of the buildings and the electric installations therein.
(ii) There will be only two classes of building viz. pucca (permanent) and kutcha (temporary).
(iii) The rate of interest will be the rate prescribed from time to time by the Railway Board. The rate of interest to be adopted in the case of buildings and of the electric installation is the rate in force on the date on which each was completed.
(iv) The following uniform rates will be adopted to cover the maintenance and depreciation-
For Permanent buildings ... ... 3 per cent
For Temporary buildings ... ... 7 ½ per cent
For Electric installations in either case ... ... 8 per cent
(v) The charges under (iii) and (iv) above shall in either case be calculated on the total cost the cost of land being included in the case of buildings. The total cost for this purpose will in either case, include the usual departmental charges for supervision and storage besides freight and incidental charges, whether the buildings and installations are newly provided or provided in replacement of old ones.
(vi) The rates prescribed above do not include municipal and other taxes payable under local laws. The actual charges on account of such taxes will be recovered from the occupying department of Government in addition to the percentage payable as rent. Similar taxes if payable under the local laws by occupiers, will be paid direct by the occupying department to the local authorities concerned.
(vii) The buildings and / or installations will be replaced or renewed out of railway funds when the occasion arises, but the charges for interest and maintenance after such replacements or renewals will be recalculated on the book values of the new buildings and/or installations, the original transaction in each case being considered as having been finally closed on the assumption that the railway administration has recovered the total cost of the original building and or installations through the provision for depreciation included in the rates prescribed in rule (iv) above.
Recovery of rent from Post and Telegraphs Department--
The recovery of rent for buildings constructed for Post and Telegraphs department shall be calculated on the following basis:--

(a) Interest Charges.
   (i) On capital invested from 1st April 1964 at the prevalent dividend rate i.e. 6 per cent.
   (ii) On capital invested prior to 1st April 1964 at 4.5 per cent.

(b) Depreciation and Maintenance charges for Civil Works:
   (i) Depreciation charges at 2 per cent of the original cost of the building as mentioned in the note above but excluding the cost of land.
   (ii) Maintenance Charges:
      (1) For service buildings at 2.4 per cent of the original cost of building as mentioned in the note above but excluding the cost of land.
      (2) For residential building at 3.5 per cent of the original cost of the building as mentioned in the note above but excluding the cost of land.
   (c) Depreciation and Maintenance Charges of electrical installation--at 8 per cent of the original cost.

Surrender of buildings—
If the buildings are not required by the using department any loss sustained by railways consequent on the surrender of the buildings will be borne by such departments provided that the abandonment is not effected in the interest of, or necessitated by changes introduced by the railways. The loss should be assessed in the following manner:--

The Department concerned should be debited with-
   (i) the depreciated value of the building and
   (ii) the cost of dismantlement of the buildings, and credited with the sale proceeds of recovered material, no allowance being made for land.

2. If, in any case, a railway administration decides to use (after surrender) a building permanently allotted to the Police Department, that Department should be debited with the depreciated value of the building and credited with the depreciated value of a building of the type required for railway purposes, provided that depreciation should for the purpose of the credit, be reckoned on the present day cost of providing such a building and on the assumption that it is as old as the building surrendered by the Police Department. A claim for the recovery of loss in the aforesaid circumstance, should, however, not be made unless the loss involved in a particular case is substantial.

3. The provisions above will apply to the Posts and Telegraphs and Defence Departments except that the compensation, if payable, should be determined by negotiations between those departments and the railway administration concerned.

4. Depreciation should not be calculated from a date earlier than the date on which the new rates of rent for all Government Departments. It should, however; be calculated for the period the building may have remained in the occupation of the railway.

5. Depreciated value should be arrived at by assuming the normal life of buildings to be 50 years allowing for depreciation at 1/50th of the original cost per year.

6. The sale proceeds will be the net sale price after taking into account the cost of carriage, if any of dismantled materials.

7. The provisions of this rule, will, for the present, apply only to railway building specially constructed for other departments and not to building originally constructed for railway purposes but subsequently allotted to other departments.

Surrender of fittings—
When electric and other fitting provided in the buildings are not required by the using department the loss consequent on the surrender of such fittings should be borne by such departments. The loss should be calculated on the same except that for fittings other than
electrical instead of the depreciated value of such fittings the original value should be taken into account for debit to the department concerned.

Notice to surrender of buildings and fittings—
In all cases, where the buildings or electric or other fittings provided therein are dentrepaired the using departments will have to give the railway administration at least, three months notice of their intention either to vacate a building and surrender it finally or to dispense with the use of electrical and other fittings. If such notice is not given, the departments concerned will be liable for rent up to three months from the date of actual surrender or up to the date on which dismantlement of the buildings or the fittings is commenced, whichever is less.

Defence and Posts and Telegraphs Departments Quarters constructed for railway servants -
In the, case of Defence Department and Posts and Telegraphs Department quarters specifically constructed for occupation by railway servants, the standard rent according to the rules of those departments shall be payable to the department concerned.

For the purpose of maintenance of telegraph lines the Posts and Telegraphs Department will at its own cost keep linemen at convenient stations of the Railway for which it supplies telegraph wires and the railway authorities will provide accommodation for such linemen and also cable jointers and cable mechanics in electrified sections to live on the premises, in the immediate vicinity of those stations and will afford them all reasonable facilities for constantly inspecting its telegraph lines cables. The accommodation will be such as is provided for railway men of corresponding pay and rent for it will be charged.

Railway buildings including residential quarters temporarily allotted to other Government Departments.
Railway Buildings including quarters may be let out temporarily to other departments of the Central Government or State Governments. The rent for such buildings shall be recovered. In this case the quarter is placed at the disposal of the department of Central Government or the State Government who makes the allotment at its own discretion.

Railway residential quarters temporarily allotted to non-railway Government employees.
When available railway quarters may be let out temporarily for occupation by employees of non-railway Departments of the Central and of State Governments by official arrangements. Residential accommodation will be deemed to have been procured by official arrangement only if it is done under orders of an authority competent to assume on behalf of Government responsibility to provide residential accommodation. In this case the names of the employees are sponsored by the Department or State Governments and the allotment is made by the Railway direct to the employee in question.

Whatever may be the rules of each Government for providing rent free or concession rent quarters to their respective employees, when accommodation is provided by one Government to the employees of the other Government, the former Government would recover assessed rent or 10 per cent of the occupant’s emoluments whichever is less,

Occupation of Railway Rest Houses or Rest Rooms –
Railway Rest Houses and Railway Rest Rooms are primarily intended for the use of Railway officers. They can be allotted to retired Railway officers also when they are not required by serving Railway officers, for a maximum period of 7 day at a time on payment of charges which will be computed on daily basis at the rate of 15% of the last pay drawn by the retired Railway officer and on the basis of a month constituting 30 days.

Members of Estimates committee of Parliament, Members of Railway Convention Committee, officers and staff of Lok Sabha Secretariat accompanying the Convention Committee may be permitted to occupy Railway Rest Houses and Rest Rooms whenever they undertake tours on behalf of Railways on payment of Rs. 5/- per day per suite.

The Rest Houses and Rest Rooms may, however, be occupied by non-railway Government officers on tour on payment. The non-Railway officers may have to vacate the Rest House when
required by the Railway in an emergency. Rest Houses and Rest Rooms may be booked for a
period of 4 days only at a time after which the occupants may be required to vacate the
accommodation if required by other and no booking can be made more than one month in
advance. The rest rooms at Victoria Terminus station at Bombay are excluded from the scope of
allotment to non-Railway Government Officers.
Charges for the occupation of Railway Rest Houses and Rest Rooms by non-Railway officers,
as a contribution towards the maintenance of such establishments shall be levied at rates which
will be notified from time to time.
For the purpose of these rules 24 hours from the time of arrival will be reckoned as a day and
charges recovered accordingly. Officers who book the Rest Houses and Rest Rooms and who
for any reason fail to occupy them shall be charged half rates.
Notwithstanding the provisions non-Railway officers indicated below will be treated as Railway
Officers on duty in the matter of recovery of charges:--

i. Officers of the Posts and Telegraphs department having free duty passes in the area
covered by the Railway Pass.

ii. Officers of the Special Police Establishment and Government Railway Police working on
Railways.

iii. All officers serving under the conciliation officers, Railways and Supervisor Railway
Labour.

iv. The Officers of the Audit department (Railway Wing) and Special Railway Magistrates.

v. The Officers of the Industrial Security Inspection Team of the Intelligence Bureau (Ministry
of Home Affairs).

vi. The Commissioners of Departmental Enquires Central Vigilance Commission, New Delhi.

Any addition or alteration if required to be made to the above list of officers may be made by the
Railway Administration in consultation with the Financial Adviser and Chief Accounts Officers of
the Railway under advice to the Railway Board.

Military buildings on railway Lands

In the case of railway units of Territorial Army the expenditure of which is borne by the Ministry
of Defence, the works connected with such units on railway land will be constructed, maintained
and kept in repair through the agency of the Railway Administration concerned at the cost of
Ministry of Defence, a fixed charge of 21h per cent per annum on the capital cost. In the event of
the head-quarters of such units being changed the railway administration will take over the
buildings at a fair valuation.

Buildings for Railway Police

The Railway Administration will own the buildings already built and to be built in future within
railway premises and the State Governments will own the rest. The rent of quarters built by
Railway Administration for the Police.
Reasonable accommodation should be provided free of rent at railway stations on the Indian
Railways for Police stations, including malkhanas and Godowns, and lock-ups having due
regard to the needs of the railway station. Where, however, electric installations and water
meters are provided, rent for the installations and the meters should be recovered together with
the cost of current and water consumed.
The railways are responsible for payment to the local administrations concerned of the entire
cost of "Order" Police employed on Indian Railways. Railway Administrations will debit State
Governments with the full standard rent for all railway buildings occupied by the "Order" Police
staff (including supervising staff) the State Governments debiting the railways with:--
(1) the difference between the standard rent and actual rent recovered in the case of staff other
than supervising, and
(2) one-forth of this difference in the case of supervising staff.
Accommodation for Railway Co-operative Societies.—
Where convenient, suitable existing premises may be offered to the Consumer Go-operative
Societies on rent. If these are not available, private accommodation may be taken ensuring that
the rent is reasonable and the accommodation is not excessive. It neither of the courses is
feasible new buildings may be constructed with Railway Board’s sanction. The buildings should
be so designed as to admit of their conversion into staff quarters later if necessary. In the newly
established railway colonies it should be possible to provide accommodation to consumer, co-
operative societies where provision for construction of a market exists. Where, however, a
market is not provided the construction of a building for allotment to the society on a reasonable
rent should be dealt with separately for each case on merits and with prior approval of the
Railway Board.

Building to house Staff Welfare Organisations—
Spare Railway building may be allotted after obtaining Board’s prior approval, to Staff Welfare
Organisations like Handicraft Centers, Homeopathic dispensaries, Vocational Training Centres,
Social Welfare Centre, Staff Canteens, Bharat Scout and Guides Associations, privately
managed schools in the railway colonies, Temple Committees etc. A nominal fee is recovered in
such cases at a uniform rate of Rs. 100/- per annum.

Accommodation for Refreshment Rooms—
For the buildings, furniture and other allied equipment provided by the railway for any contract
catering establishment a rent will be charged, which will be equitable and not more than eleven
per cent per annum of the capital cost of the building and equipment provided. The rent fixed
should have an approximation to that for similar type of premises in the local area.

Service Buildings -
Service buildings are those which are used as stations, offices, depots, workshops, etc., No rent
is chargeable for such class of building, Buildings designed to provide certain facilities to staff in
the discharge of their duties such as running rooms of drivers and guards, officers’ and
subordinates’ rest houses, etc., should be considered as service buildings and no rent should
be charged in respect of such buildings for so long as they are used for the purposes for which
they were designed. If at any time such buildings are with the permission of the head of the
railway used as residences, standard rent for the portions occupied should be recovered from
the occupant. The power to permit the temporary use of rest houses, etc., as residences may be
delegated to DRM.

No rent should be charged for accommodation provided for the offices of the Government
Inspectors of Railways or for Statutory Audit Offices.

Recovery of charges for the maintenance of the Lawn in staff quarters and bungalows -
The maintenance of community parks, common gardens, hedges, plantation of trees in
children’s play grounds in Railway colonies will be done by the Railways at their own cost. The
Railways will also undertake the maintenance of lawns inside the compounds of bungalows of
officer and quarters of senior staff in grade Rs. 1600--2660 and above. The maintenance
charges of such lawns will be recovered at a rate to be fixed by the Railway Administration in
consultation with the Financial Adviser and Chief Accounts Officer so as to realise 25 per cent of
the cost incurred by the Railway on such maintenance the recoveries from various grades of
staff being on a graded scale.

In the case of Multi-storeyed and Double storeyed buildings the charges recoverable for
maintenance of lawns should be distributed prorate among all the occupants provided the lawns
are community ones. If a lawn is serving six occupants, one sixth of the charges should be
recovered from all the occupants concerned. In cases, however, the lawns are demarcated for
each occupant of the building or specifically allotted to an occupant living in a particular floor the
charges should be recovered from the individuals concerned at the rates laid down.
In the event of any lawns inside a bungalow or quarters not being maintained on account of shortage of water or any other difficulties charges may not be recovered from the occupants for such period of non maintenance.

The occupants of the quarters may be allowed to derive the benefits of the harvest from the trees grown in the compound. The trees will, however, remain the property of the Railway Administration and the occupants of the Railway quarters will not be permitted to sell the fruits. For assessing proportion of the cost incurred by the Railway to be recovered from the staff it is sufficient if the total expenditure is assessed on an approximate Basis in consultations the Financial Adviser Chief Accounts Officer taking into account the emoluments of malis, cost of water, fertilizer manure, depreciation on tools and plants and other allied expenditure, The for maintenance of lawns are to be revised once in five years

**Rent Rolls.-**

At the commencement of each financial year, the various engineering supervisors concerned will furnish information regarding quarter No. whether allotted to officers or staff, the type of quarter the cost of the building the period for which the quarter was tenanted or vacant the details of accommodation and the area in triplicate in respect of each residential building in his charge and get this signed by the concerned officer of the engineering department. One copy of the form should be sent to the pay prepare unit and another to the Accounts Office, the third copy being retained as office record. In the case of transfer of buildings from one railway to another or from one division to another the forms relating to such buildings should also be the transferred to the new bill preparing authority and to the new Accounts Office. "Change Statement" intimation changes of tenants, the rate of rent and other connected charges should be sent by the engineering supervisor every month to the pay preparing unit of the occupant.

**List of Building.**

Railway Administration is responsible for maintaining a complete and up to date list of all buildings both residential and service, in each division. The list should be maintained. This register should be reviewed by the Divisional once in every quarter to see that the information is compiled properly and the register maintained up-to-date.

Whenever work of construction of new buildings or of additions and alterations to and dismentlements of existing buildings are under taken-necessary addenda or corrigenda to the list of building should on type of such works be prepared and incorporated in the list of buildings. Copies of such addenda or corrigenda should also be furnished to the Accounts Officer and to the department to which the buildings affected are allotted.

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**Duties of Section Engineer (Works)**

1. Inspection and maintenance of: - Service buildings, staff quarters and other structures Approach roads, Water supply, drainage and sewerage systems.
2. Inspection of bridge works as assigned.
3. Execution of all new buildings/structural works.
4. Accountal and periodical verification of stores and tools in his charge.
5. Maintenance of land boundaries, as specified and Removal of encroachments at his headquarters and at other places in his jurisdiction as specified.
6. Afforestation and other horticulture works.
7. He shall ensure proper training of the staff under him as prescribed in the training modules of the Civil Engineering Department.
8. Knowledge of Rules And Regulations:-
   i. He should be in possession of books, codes, manuals and compendium.
   ii. He shall be well acquainted with the rules, regulations and procedures contained in these books concerning his work.
   iii. He shall ensure that all staff under him are well acquainted with the relevant rules and working methods and efficiently perform their duties.
9. Co-ordination with Permanent Way, Bridge and other staff – The Section Engineer (Works) should co-operate effectively with the permanent way, bridge, signalling, electrical staff, etc. where they are required to work jointly.
10. Inspections –
   i. The Section Engineer (Works) shall systematically inspect all buildings and structures in his charge and record brief details of repairs to be carried out.
   ii. The Section Engineer (Works) shall maintain petty repair books at all station buildings and other important buildings and shall check them during his inspections and ensure prompt action/repairs.
   iii. The Section Engineer (Works) shall inspect bridge foundations and substructures.
11. Inspection of water supply arrangements –
   i. Every Section Engineer (Works) shall have details of total requirement of water, sources of water and their yield, storage capacity and shortfall etc., along with complete water supply plans of yards and staff colonies in his charge.
   ii. The Section Engineer (Works) shall also have complete history and data of tube wells under his jurisdiction and ensure testing of yield of tube wells and other sources of water, once every year in co-ordination with Electrical staff at the time when the sub-soil water is at the lowest.
   iii. Water supply timings and pumping hours should be decided in consultation with the Electrical Department.
   iv. The Section Engineer (Works) shall ensure cleaning of overhead /underground storage tanks. He shall be responsible for the disinfection of water supply.
12. **Inspection of Sewerage and Drainage System** - Senior Section Engineer (Works) shall periodically inspect sewerage and drainage system and ensure their efficient performance.
13. Section Engineer (Works) shall periodically inspect land and land boundaries in his jurisdiction and furnish necessary certificates to the Assistant Engineer.
14. Musters -
   i. The attendance of artisans, helpers and other staff under him should be checked by the Section Engineer (Works).
   ii. The leave availed of by staff should be recorded in the leave register in the leave account before the musters are dispatched to the Divisional office.
15. Execution of Works :-
i. The Section Engineer (Works) shall be personally responsible for the accurate setting out and execution of all works under his charge according to approved drawings and specifications.

ii. He should plan every work, organise labour in an efficient manner and maintain detailed accounts of materials and tools received and issued. He should exercise frequent checks on the quality and quantum of work being done in his charge and submit progress reports periodically as prescribed.

iii. Additions and alterations to buildings and structures carried out should be carefully noted and quantities shown in the Standard Measurement Register amended as necessary with the approval of the Assistant Engineer /Divisional Engineer.

16. Measurement of Works - Every Section Engineer (Works) shall be responsible for proper measurement of contractual works. He shall maintain movement register of Measurement Books and Standard Measurement Registers for works.

17. Works Affecting Moving Dimensions - The Section Engineer (Works) shall refer to the Assistant Engineer for instructions regarding works likely to affect moving dimensions.

18. Imprest of Tools and Materials:
   i. The Section Engineer (Works) shall examine all tools and plant with the artisans once a month and replace the unserviceable or defective ones or arrange repairs.
   ii. He shall ensure that the materials and tools as per scales specified for maintenance of building, water supply and drainage works etc. are available and are adequately distributed at various points according to requirement. Recoupment of shortages should be effected without delay.

19. Accompanying Important Inspections - When the Section Engineer (Works) accompanies a periodical or special inspection, he should be in possession of the following, besides the Works Manual, Schedule of Rates and the Standard Specification for Materials and Works.
   i. Plans and details of all important works, recently completed, on hand or contemplated.
   ii. Progress report of works and any other papers and plans that are likely to be required for discussion;
   iii. Tape (15m & 2m), and other tools and surveying equipment required during inspection.

20. Witnessing Payment to Staff -
   i. Payment to both permanent and temporary staff will be made by the Pay Clerk in the presence of the Section Engineer (Works) who is responsible for correct identification of the payee and to satisfy himself that the correct amount is paid.
   ii. The certificate at the foot of the pay sheet should be filled in by the Section Engineer (Works) as payment of each batch of workmen is completed. If a person is not present, "Not paid" should be immediately written against his name.
   iii. If the witnessing official is not available, the Assistant Engineer may authorise another Subordinate to witness payment on the section.

21. Journal of Daily Duties - The Section Engineer (Works) shall enter the works performed daily in the T.A. journal showing therein his movements by train, trolley or road-vehicle and submit the same to the Assistant Engineer every month.

22. Establishment -
   i. General conditions of Railway service and rules relating to the conduct and discipline of Railway Servants are contained in the Indian Railway Establishment Codes, and Discipline and Appeal Rules. Section Engineer (Works) should acquaint himself with these and meticulously follow them.
   ii. Medical Examination - The Section Engineer (Works) shall ensure that all Group ‘D’ staff working under him is sent for medical examination for fitness for service.
   iii. Service Books - (i) Service books for Group ‘D’ staff should be prepared by the Section Engineer (Works) on the prescribed form as soon as appointments in temporary/permanent vacancies are made and submitted to the Assistant Engineer for
verification and signature. These should be carefully maintained in the Assistant Engineer's or Section Engineer (Works)' office as may be prescribed. All increments and promotions should be noted in the service books, duly attested by the Assistant Engineer.

iv. Promotion to higher grades - The Section Engineer (Works) should maintain in manuscript form records of staff working under him in which he shall enter awards or penalties of each staff as and when such entries are justified.

v. Provisions in the Payment of Wages Act, the Workmen's Compensation Act and other regulations - The Section Engineer (Works) shall ensure that the rules laid down in the Acts and Regulations, as modified from time to time, are strictly complied with.

vi. Correspondence and Records - The Section Engineer (Works) shall keep his correspondence up to date and see that all office records, registers and stores ledgers are maintained properly and posted regularly.

23. Relinquishment of Charge -

a) On relinquishing charge, the Section Engineer (Works) shall prepare, in triplicate, the specified "Transfer-of-charge" statement which will briefly contain the following-

   i. Extent of section;
   ii. Establishment matters (service and leave records);
   iii. Works in progress;
   iv. Water sources that give trouble;
   v. Certificate of stores check and correctness of stock;
   vi. General notes.

b) The statement should be signed by both the relieved & relieving Section Engineer (Works) Engineer, and two copies submitted by the relieving subordinate to the Assistant Engineer who will forward one copy to the Divisional/Executive Engineer for record.

c) The relieving Section Engineer will examine all books pertaining to rules and orders in vogue and all registers pertaining to the section to see that they are kept up to date and initial them with date.

d) The Section Engineer (Works) handing over and taking over charge should together visit over the whole section, inspect each work in progress, check staff, all tools and plant and materials. Errors and discrepancies, which are noticed, should be recorded in the statement and the Assistant Engineer's special attention invited to them.

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Engineering Estimates

Definition –
To calculate cost of work inclusive of labour material ever heads, plant and equipments is called estimating

Necessity of an Estimate -
To get the approximate idea of the amount required and make provision of funds against respective budget grants.

Estimates Prepared for -

a) The construction or purchase of new works or assets.
b) The renewals and replacements of existing works or assets chargeable to Depreciation Fund / Development Fund or Open Line Works-Revenue when estimates to cost more than Rs. 10,000; or if chargeable to Revenue when estimated to cost more than Rs. 50,000.
c) The scrapping, dismantlement or abandonment of existing works or assets,
d) The repairing or reconditioning of the existing works or assets, if estimated to cost more than Rs.50,000/- and that of a single housing unit, if estimated to cost more than Rs.20,000/-,
e) Temporary and experimental works,
f) Renewals and replacements on worked lines, and
g) Renewal of ballast.

Should subject to the provisions of regarding urgent works, be scrutinised by the authority competent to sanction them before any expenditure or liability is incurred there on. For the purpose of this scrutiny, all such proposals should be presented in the form of one or other of the following estimates.

For "New Minor Works" costing Rs. 5000 and less, for renewals and replacement works chargeable to Revenue costing Rs. 50,000 repairing and "Reconditioning Works" costing Rs. 50,000 and less detailed estimates need not be prepared for formal sanction.

In those cases of spot renewals of permanent way, detailed estimate need not be prepared.

Various Types of Engineering Estimates-

i. Approximate estimate.
ii. Abstract estimate.
iii. Detailed estimate.
iv. Supplementary estimate.
v. Revised estimate.
vi. Project Abstract estimate.
vii. Construction estimate.
viii. Completion estimate.

Approximate estimate.
Approximate estimate are required for preliminary consideration of proposals. These should be submitted by Engineers when any proposal is received for remarks. These estimates are based on area of land / Plinth area of buildings / cubic contents of items / length of track / number of points & crossings.

Abstract Estimate.-
An abstract estimate is prepared in form No E 702. in order to enable the authority competent to give administrative approval to the expenditure of the nature and the magnitude contemplated,
to form a reasonably accurate idea of the probable expenditure and such other data sufficient to enable that authority to gauge adequately the financial prospects of the proposal. Abstract estimates avoid the expense and delay of preparing estimates for works in detail at a stage when the necessity or the general desirability of the works proposed has not been decided upon by competent authority. An abstract estimate should contain a brief report and justification for the work, specifications, and should mention whether funds are required in the current year and to what extent. It should also show the cost subdivided under main heads and sub-heads or specific items, the purpose being to present a correct idea of the work and to indicate the nature of the expenditure involved. The allocation of each item as between Capital Development Fund, Open Line Works-Revenue, Depreciation Reserve Fund and Revenue should be indicated.

**Detailed Estimates**

On receipt of administrative approval to a project or scheme other than for which construction estimate in Form E 553 is prepared conveyed through the sanction to the abstract estimate relating there to detailed estimates for various works should be prepared and submitted for technical sanction of the competent authority. It should be prepared in sufficient detail to enable the competent authority to make sure that the abstract estimate sanctioned by a higher authority is not likely to be exceeded. No work included in an abstract estimate should be commenced till a detailed estimate for the same is prepared and sanctioned and adequate funds are allotted by the competent authority. The detailed estimate of an open line work will comprise.

i. Statement is showing details of estimated cost and.

ii. An outer sheet giving the abstract of cost of work, the report, the financial justification and the allocation.

**Technical Sanction** -- The sanction of the competent authority to the detailed estimate of a work is called the "technical sanction". The authority according technical sanction should satisfied it self that –

i. That the details of the scheme as worked out are satisfactory.

ii. The method proposed for the execution off the work are adequate.

iii. The cost has been estimated from reliable data and likely to be reasonably accurate.

In the case of works within his power of sanction, the General Manager may, in lieu of the procedure of preparing Abstract Estimates for administrative approval, prescribe that both the administrative approval and the technical sanction should be accorded on the detailed estimates.

It is prepared on Forms No. E-704, E-705, and E-706 for various works.

**Details of Cost of Permanent-Way Material** - In the case of estimates for permanent-way renewal, on open lines, the details of estimated cost may with advantage be supported by statement showing details and cost of material required for one kilometer of permanent-way.

**Supplementary estimate** –

Supplementary estimate should be prepared for any item of work, which ought to have been included in the first instance in an estimate already sanctioned but has not been so included, or which it is found later, should be considered as being a part or a phase of an estimate already prepared and sanctioned if it cannot be met out of contingencies. Such a supplementary estimate should be prepared in the same form and the same degree of detail as the main estimate and for all purposes be treated as a part of the main estimate.

**Revised estimates** –

As soon as it becomes apparent that the expenditure on a work or Project is likely to exceed the amount provided there for in the detailed estimate or construction estimate a revised estimate should be prepared and submitted for the sanction of the competent authority. It should, unless otherwise ordered by the sanctioning authority, be prepared in the same form and the same
degree of detail as the original estimate, and should be accompanied by a comparative statement showing the excess or saving under each sub-head of account against the latest sanction. In cases where a supplementary estimate or a previous revised estimate has been sanctioned by the Railway Board, it should be made clear how the original sanction has been modified by such further sanctions.

**Project Abstract Estimate.**
The abstract estimate of a Construction project should be submitted for the approval of the Railway Board on Form E. 554 "Abstract cost of Railway" accompanied by –

- An abstract estimate of junction arrangements.
- A narrative report explaining the salient features and Major items of expenditure.
- Detailed estimates on Form E. 553 prescribed for a construction estimate under the following heads:
  - Capital, Land, Structural Engineering Works, Tunnels, Major Bridges, Minor Bridges, Ballast and Permanent-Way (Detailed estimate for one Kilometer), General Charges, Establishment and General charges, Other than Establishment, Rolling Stock.

**Construction estimates**
When it is decided to undertake the execution of a new line gauge conversion or doubling of lines, a final location survey should be made; and based on the information collected in that survey detailed estimates of all the works included in the project as a whole should be prepared. These detailed estimates are collectively called the "Construction Estimate" of the project. It should be prepared after a careful examination of the various details of construction involved in the project. It should be in such detail as to render it possible to dispense with working estimates or any other further estimating after the construction estimate has been sanctioned. It should provide for the buildings and equipment of the railway up to a standard that will be sufficient for working such traffic as may be expected during the first year or two after opening of the line. It is the basis on which technical sanction to the various works included in the construction of a project is accorded.

The following sub-works may be sanctioned progressively by the authority competent to sanction the detailed estimate for the whole project:

- Preliminary works including final location survey etc.
- Setting up of project offices and organisation including office accommodation, construction equipment minimum vehicles and provision for gazetted and non-gazetted staff etc.
- Land acquisition.
- Formation and bridge works for whole or part of the project where survey has been done and alignment determined.
- Minimum service buildings in case of new line works required to meet immediate needs of construction organisation and subsequently required for operation of the project.
- Minimum residential quarters required to meet immediate needs of construction staff. The number and location of quarters should be within the overall requirement of Open Line for operation of the project.

Before forwarding part estimates duly concurred by FA & CAO and approved by General Manager for sanction to the Rly. Board, it should be certified that no works included in the part estimates are likely to become redundant when estimate for the whole project is prepared.

**Completion estimates**
A Completion estimate is prepared in super session of construction estimate. Following particulars are included in the Completion estimates.

- Amount of sanctioned estimate.
- Actual expenditure on all works up to the date of construction estimate.
iii. Commitments on that date.
iv. Anticipated further outlay.
v. Total estimated cost and
vi. Difference between the sanctioned estimate and the estimated cost.

It is prepared on form No E 713.

Estimates for Railway Project

Scope.- A Construction Estimate should be prepared in such detail as to reduce to a minimum the probability of omission of any item of expense which is capable of being foreseen. It should be remembered particularly that the provision for contingencies allowed in the estimate is not intended to meet items of expense which can before been and which are reasonably likely to occur. With good estimating it should seldom be necessary to encroach, to any appreciable extent on the provision for contingencies.

Detailed Estimates for works included in a project need not be submitted to the Railway Board but they must never the less be prepared care fully and be readily available when required. In the detailed estimates, the estimated cost of a work should be shown by items, when such cost is over Rs. 50,000. Individual works included in an Abstract estimate should not be commenced until detailed or working estimates therefore have been sanctioned, by the competent authority. The progressive totals of the detailed or working estimates thus sanctioned should be controlled against the provision in the Abstract estimate by means of a register.

Commencement of Construction.- The Construction of a new railway or extension of branch of a railway should not be commenced without the specific sanction of the Railway Board. As a rule, the Railway Board approve of the project for the construction of a Railway on consideration of a Traffic Survey Report and the Abstract Estimate of the cost of the proposed line. Such approval is not, however, a permission to commence construction. In special cases. However, where construction appears to be easy and present no engineering problems of great difficulty, the Railway Board may sanction the commencement of construction on the first abstract estimate, but under no circumstances whatsoever may construction be commenced without the specific sanction of the Railway Board.

When application is made for sanction to the commencement of Construction a certificate should invariably be given that the Construction Estimate has been scrutinized by an engineer of experience within three years of the date of application and any change in the amount of the estimate, which may have been found necessary owing to change of rates or other conditions since the estimate was originally prepared, should be reported to the Railway Board with an explanation of the causes necessitating the change.

Estimate of Open Line Works

Detailed Estimates in support of Abstract Estimates.- On open lines of railways, no works pertaining to any of the categories should, as a rule, be started before the sanction of detailed estimates by competent authorities. In the case of open line projects, the abstract estimates of which have been sanctioned by the Railway Board or a higher authority. Works should not be started until :-

i. An estimate for the whole work has been prepared in sufficient detail to enable the competent authority to make sure that the total of the sanctioned abstract estimate is not likely to be appreciably exceeded, and

ii. A detailed estimate has been prepared for each sub-work (i.e., distinct unit of work which is sufficiently large or important to be kept separate, for purpose of accounts) which is proposed to commence.
So long as these two conditions are satisfied, it is not necessary that detailed estimates for all sub-works that go to comprise any one item of the sanctioned abstract estimate should be ready before any particular sub-work is started. It is left to the discretion of General Managers to progressively prepare and sanction detailed estimates for such sub-works as are to be carried out against the sanctioned abstract estimate provided they are satisfied that the sum of such detailed estimates as are sanctioned by them will not cause an excess over the total amount of the sanctioned abstract estimate beyond the limits.

The detailed estimates for the annual programme of permanent way renewals should, as far as practicable,

i. Be prepared for convenient lengths of permanent-way such as Permanent-Way Inspectors sections or Kilometrage of track.

ii. Include such works only as can be completed within the financial year in which they are sanctioned so that the accounts of the works are not kept open long after the close of the financial year.

The papers to be submitted with the project for a work will consist of a list of references, a report, plans, a specification, and a detailed statement of quantities and rates with an abstract showing the total estimated cost of each item.

**Report and Justification**

The report on the estimate should give a brief abstract of the correspondence that has passed with reference to the project. and a brief but clear description of the work to be carried out. It should state in clear terms the object to be gained by the execution of the work estimated for, the financial justification of the proposed expenditure in accordance with the rule the reasons for the adoption of the estimated project or design in preference to others, and any preference to others, and any peculiarities which require elucidation. It should indicate the nature and extent of recurring expenditure, if any, consequent on the execution of the work. The time within which the work may be expected to be completed should also be mentioned.

When the project is of an important nature, involving scientific points or other considerations of special character, the report should contain a complete account of the basis on which every part of it has been framed, the various considerations that have guided the designer on question of engineering details, economy of construction, utility or the practical working of the project when carried out and the Method in which it is proposed to execute any portion of the work involving unusual difficulties of construction. Any local considerations which may affect the project and particularly any circumstances affecting the rates. Should also be fully entered into.

**Specification** - The report will be followed by a specification, showing fully and but as briefly as possible the details of the work, how each portion will be done, and what materials will be used. In the case of items of works proposed to be executed in accordance with the standard specification of the railway, it is enough if reference is made to such specifications.

**Rates**- The rates of the various descriptions of work are intended to cover all charges usual to, or necessary for, the execution of the work. And should generally agree with the schedule of rates.

**Provision for Contingencies**- Provision for unforeseen contingencies should be made in all estimates at 3 per cent of the total estimated cost. All incidental expenditure which can be foreseen such as works establishment, sheds for workmen and stores should be separately estimated And provided for in the estimates. The provision for contingencies should not be diverted to any new work or repair which is not provided for in the estimate, and of which the cost exceeds Rs. 1000/- without the sanction of the authority who sanctioned the estimate.
Standard Specifications- Standard specification of each kind of artificer’s work, commonly executed, should be kept up for each railway under the orders of the General Manager.

Covering letter for Estimates- All classes of estimates (and completion reports) beyond the powers of sanction of General Manager should be submitted to the railway Board with an explanatory covering letter containing information on the amount of existing sanctioned estimates (if any) with allocation, outlay incurred to end of previous financial year. funds provided in the current year’s budget and all other relevant points.

Estimates of Deposit Works -
A Railway Administration is occasionally required to execute works for and at the cost of other Government departments, local bodies, private persons. Such works are referred to in this Code as "Deposit Works". To meet the cost of plans and estimates of such works as also those to be carried out for other Departments out of railway funds, which are subsequently not carried out. charges at the following sliding scale shall be levied on the total of the estimate inclusive of departmental charges:-

For works costing over Rs. 1,00,000 2%
For works costing over Rs. 60,000 but not more than 1,00,000 2½ %
For works costing over Rs. 30,000 but not more than 60,000 3%
For works costing over Rs. 20,000 but not more than 30,000 3½ %
For works costing over Rs. 10,000 but not more than 20,000 4%
For works costing over Rs. 1,000 but not- more than 101,000 4½ %
For works costing over Rs. 1,000 and below 5% subject to a minimum of Rs. 25

The acceptance of the government departments or the payment in cash by the local bodies or private individuals concerned should be obtained to the above percentage charges before the work of preparation of plans and estimates is taken in hand. In cases where the proposed works are subsequently carried out, these percentage charges should be adjusted against departmental charges.

The scale of charges prescribed in this rule does not apply to assisted sidings, recovery of preliminary expenses in respect of which has been separately.

Not with standing the stipulations for advance payment of charges at siding scale mentioned above, the parties shall be asked to deposit on amount of Rs. 2000/- only, for deposit works of value not exceeding Rs. 5 lakhs, while making a request. Subsequently, this amount shall be adjusted against request. Subsequently, this amount shall be adjusted against the total cost of the deposit work, as per approved plans and estimates, before physical execution of the work at site.

All estimates of deposit works should be got accepted by the parties ordering the works before submission to the competent railway authority for sanction. In the case of works, which under the rules are required to be maintained after completion by the Railway department at the cost of the department, local body, private firms or individuals ordering the work, the acceptance of the party concerned should also be obtained for the recurring expenditure that is likely to be incurred on repairs, maintenance, etc.

General Rules Applicable to all Estimates -
Design and Execution-
The designs of all new works and alterations to existing works should, as a rule, conform to the "Schedules of Dimensions" prescribed by the Railway Board for the various gauges of railways, and unless prior sanction has been obtained from the Railway Board through the Additional Commissioner of Railway Safety, no work which will infringe the "Schedules" should be executed.
All estimates for the construction of or addition or alterations to staff quarters or other rentreturning buildings should be accompanied by the following information which should be given in a separate paragraph in the report to the estimate. These quarters are intended for staff drawing pay between Rs. ............... and Rs. ............... The minimum and maximum rent livable from the staff on the basis of assessed rent at 6% of the total cost subject to 7½% / 10% of their emoluments will be between Rs. ............... and Rs. ............... The anticipated return on the total cost of the proposed quarters is, therefore, expected to be between ............ per cent and ............... per cent.

Works Executed on Contract-
Estimates for works which are intended to be executed not departmentally but by contractors should be prepared at the minimum rates shown in the Schedule of Rates and any reduction (or addition) to be made on account of the tender rate of contractors should be made at the foot of the abstract estimate.

Units of Measurements-
The following measures are prescribed for general use :-
Length -The Standard Metre. As a general rule, the metre will be divided decimally. For long distances the Standard Kilometer (1 Km -1000 mts.)
Area -The 'square metre' divided as a general rule decimally, 100 square metres being termed one ‘Acre’. For land, the standard Hectares (1 hectare = 100 acres) and decimals; or for small areas, square metres.
Capacity or solidity - The ‘cubic metre’ and ‘litre’ divided as a general rule, decimally.
Value.-All rates in estimates, tender documents, schedules of rates, bills, should be quoted in rupees and paise.
Velocity.- Metres per second.
Angular Velocity.- Revolution per second.
Work.-Kilogram force metre.
Heaviness or weight.- Kilogram, divided as a general rule decimally; 100 kilograms being termed as 1 quintal and 1000 kilograms as one tonne.
Power.- Kilogram - metres per second or one 'Metric Horse Power' of 75 kilogram - metres per second.
Water discharge-Cubic metres per second.
Note.-In the case of road metalling, where the depth up to which the old road is to be broken up and new stone metalling and rolling is to be completed is specified 100 sq. m. may be adopted as the unit of rate.

Drawings.- Every drawing submitted with an estimate should have a clear title, which should be shown on the back on two opposite corners, so as to shown outside whichever way the paper be rolled up. The signature of every officer, through whose hands the design passes, should be affixed. All drawings and plans should be registered in the offices of origin and should be referred to not only by their titles but also by their registration numbers. For the purpose of registering drawings and plans a manuscript register should be kept in each drawing office.

Verification of Estimate -
One phase of the control of expenditure railway is a regular check by the Accounts Officer of all estimates before they are sanctioned by the competent authority. The object of this preliminary check of estimates is to avoid irregular sanction to expenditure and the main points which require consideration are :-
( i ) the propriety of the expenditure,
( ii ) The incidence and classification of charges;
The existence of budget provision to meet the proposed expenditure during the financial year,
Freedom from errors and omissions; and
competency of sanction.
The checks relating to these points should be exercised with reference to the rules.

Propriety of Expenditure.- It is the duty of the Accounts Officer, in his capacity as Financial Adviser, to examine zealously all proposals for expenditure with a view to see-
that the expenditure proposed to be charged to railway funds in the estimate, is properly and legitimately so chargeable;
that proper financial justification is forthcoming in the case of all works requiring such financial justification. And
that in the case of estimates for staff quarters and other rent returning building, the anticipated yield of rent as shown in the ‘Rent Statement’ will not have the effect of reducing the return on the cost of each class of quarters to less than 6 per cent per annum

Incidence and Classification of Charges.-
These should be verified in an estimate in accordance with the rules of incidence and the classification of expenditure.
The submission of an estimate to the sanctioning authority should not be delayed when there arises any doubt as to the correct allocation of estimated cost and the question at issue will take time to settle. In such cases, the approximate allocation between Capital or Development Fund, Open Line Works - Revenue, Depreciation Reserve Fund and Revenue may be certified by the Accounts Officer

Competency of Sanction -
The previous sanction of an authority higher than the General Managers of Indian Railways is necessary :-
To expenditure on new lines or rolling stock or surveys not provided in the sanctioned budget, for the year or carried forward from the sanctioned budget of the previous year;
To expenditure on other works not provided in the sanctioned budget or carried forward from the sanctioned budget of any previous year except :-
Track renewal works costing not more than Rupees two lakhs;
Other works-costing not more than Rupees one lakh;
Machinery & Plant-costing not more than Rupees fifty thousands.
Provided that the total lump-sum provision made in the budget for such works is not exceeded;
On line capacity works costing above Rupees one lakh but not more than Rupees ten lakhs each;
On track renewal works costing above Rupees two lakhs but not more than Rupees five lakhs each;
On other than line capacity and track renewal-works costing above Rupees one lakh but not more than Rupees five lakhs each,
Subject to ceiling of Rupees one crore in all in a financial year provided that the sanctioned budget for works in these categories is not exceeded.

Note.- (1) The works thrown forward from previous years may be taken up only if the funds required for them can be found by re-appropriation within the sanctioned allotment.
(2) The savings in the lump sum provision made in the sanctioned budget shall not be utilized for the category of works in (b) above without the prior approval of the Railway Board.
(3) The General Manager may sanction expenditure on new works out of turn in respect of users amenities including goods shed and booking offices not exceeding Rupees one lakh in each case provided the funds required for such works as provided in the sanctioned budget for
works in these categories is not exceeded; and expenditure up to Rupees fifty thousand in each case. in respect of existing railway schools, institutes, hospitals and dispensaries provided the lump sum provision in the sanctioned budget is not exceeded.

To expenditure on works provided in the sanctioned budget for the year or carried forward from the sanctioned budget of any previous year as follows:-

(a) Works sanctioned under the lump sum provision-
To an excess over the total lump sum provision in the sanctioned budget for such works;

(b) Works outside the lump sum provision.-
Rolling Stock, Track renewals and other works-
to an excess over the estimated cost as entered in the sanctioned budget or sanctioned separately, as follows :-
( l ) of more than 25% over the original estimated cost;
( ii ) of more than 15% over the first revised cost;
( iii ) of more than 10% over the second and further revised estimated cost.

(c) Surveys - To an excess over 10% on original estimate sanctioned by higher authority.

Grouping of Works-
When two or more works are so connected, either by their situation or by the purpose or purposes which they are designed to serve, that construction of one necessarily involve that of the other or others, the works should be considered as one scheme and the aggregate estimated cost of the work so connected determine the authority competent to sanction expenditure on the scheme.

Subsidiary Points to be checked.-
In the check of estimates the following subsidiary points also require attention. It should be seen-
( l ) That the particulars of work to be done are furnished in sufficient detail and that a proper distribution is made of the estimated outlay between cash and stores;
( ii ) that the allocation of each item is given and that an abstract allocation is made;
( iii ) that all incidental expenditure that can be foreseen has been provided for in the estimates;
( iv ) that in case of a renewal, replacement or dismantlement, credit for released material has been provided for;
( v ) that in the case of a work to be done for other government departments, other railways and private bodies, provision has been made for the necessary departmental charges;
( vi ) that in the case of estimates for manufacturing operations the outlay and out-turn are distinctly shown; and
( vii ) that in case of estimates for staff-quarters and other rent-returning buildings a rent statement accompanies the estimate.

Certificate of Accounts Verification.-
All estimates verified by the Accounts Officers should bear a certificate of such verification. The form of the certificate may be as under:-
"Incidence and allocation verified (subject to the cheek note attached).
This requires the sanction of (..................................………………..")
In forwarding an estimate for sanction it should be clearly mentioned whether it has been accepted by the Accounts Officers as unobjectionable. In case where the Accounts Officer has
recorded any objection the attention of the sanctioning authority should be drawn to the Accounts Officer's check note stating the objection.

**Sanction to Estimates**
Advice of all sanctions to estimates by the competent authority should be communicated to the Accounts Officers and to the Chief Auditor of the railways in such form as may be prescribed by such authorities. A copy of the sanctioned estimate should also be furnished to the Accounts Officer.

**Currency of Sanction**
The sanction to an estimate will ordinarily remain current for five years from the date on which it has been accorded, unless it has been renewed for a further term by the acceptance of a revised estimate. Acceptance by competent authority, however, of a budget estimate which includes specific provision for expenditure on a work which is in progress, may be regarded as reviving for the year in which provision is invited, the sanction to the estimate regardless of the five years' limit. But if no work has been commenced on sanctioned scheme within two years of the date on which the sanction was accorded to the estimate, such sanction should be held to have lapsed and fresh sanction should be obtained from the competent authority by the submission of an up-to-date estimate necessary. The currency of sanction begins from the date of sanction to estimate itself and not from the date on which the allocation of the estimate is finally accepted.

**Scope of the sanction to an Estimate**
The authority granted by a sanction to an estimate should, on all occasions, be looked upon as strictly limited to the precise objects for which the estimate was intended to provide. Accordingly, any anticipated or actual saving on a sanctioned estimate for definite project should not, without special authority, be applied to carry out additional work not contemplated in the original project or fairly contingent on its actual execution. Saving due to the abandonment of a substantial sanction of any project should not be considered as available for work on other sections.

**Register of Estimates**
All estimates should before they are submitted for accounts verification or for the sanction of the competent authorities be registered in the office of origin.
Cement Concrete

Ingredient of cement concrete –
Various ingredient used in cement concrete are cement, sand, coarse aggregate and water.

Cement –
Cement is an artificially prepared mixture which is used as a binding agent for material.

Sand –
Sand used in concrete should be washed so that it is free from silt, clay, salts and other organic matters. Coarse sand gives better strength than fine sand.

Coarse Aggregates –
Coarse Aggregates or stone piece used in concrete should be angular in shape, made from hard stone and have mix of different sizes so that the density produced is maximum. Common size of Coarse Aggregate is 20 mm used for slabs, beams and columns where as it can be 40 mm or even larger for use in bigger structures.

Mixing of Concrete -
Mixing should ensure that mass becomes -
   i. Homogeneous
   ii. Uniform in colour
   iii. Uniform in consistency

Types of mixing -
Hand mixing – ( generally not recommended. If used then 10% extra cement to be used but not to the advantage of contractor ).

Machine mixing – efficient and economical.

Machine mixing -
   i. Batch mixer.
   ii. Continuous.

Batch Mixers -
   i. Pan type
   ii. Drum type -
       a) Tilting
       b) Non tilting
       c) Reversing or forced action

Designation of mixers (As per IS : 1791 – 1968)
Tilting – 85T, 100T, 140T, 200T
Non Tilting – 200 NT, 280 NT, 340 NT, 400 NT, 800 NT
Reversing – 200R, 280 R, 340R, 400R.

Mixing Time -
25 to 30 revolution @ 15-20 rpm is minimum required for proper mixing. Therefore 2 minute mixing is desirable.
Mixing is faster in natural aggregates.

Placement of Concrete -

**Methods of transportation**-

i. Mortar pan
ii. Wheel barrow/hand cart
iii. Bucket & rope way
iv. Truck mixer & dumper
v. Belt conveyor
vi. Chute
vii. Skip & hoist
viii. Pump & pipe line (8-70 cum concrete/hr) 8 - 20 cm pipe, mix should be truly plastic Spherical ball to clean the pipe called 'GO DEVIL'

Compaction -

i. Expulsion of entrapped air
ii. Each 1% entrapped air reduces 6% strength

**Methods of compaction** -

i. Rodding
ii. Ramming
iii. Tamping
iv. Internal vibration
v. External vibration
vi. Surface vibration
vii. Platform or table vibration

**Details of equipment** -

**Frequency Range** -

- 100 Hz for 40 mm agg.
- 150 Hz for 20 mm agg.
- 200 Hz for 10 mm agg.

**Needle Diameter** - 20 mm to 75 mm (length-25 to 90 cm.)

**Thickness of layer** - Not less than 100 mm, not more than 600 mm. preferably bet. 2/3 L to L of needle.

**Proper Internal Vibration** -

i. Increase compressive strength & bond
ii. Decrease permeability
iii. Decrease cold joints
iv. Decrease honeycombing
v. Decrease excessive entrapped air
vi. Decrease segregation

**Spacing tips** -

i. Overlapping field of action
ii. Watch the concrete
iii. High powered vibrators
iv. High slump concrete
v. Field of action 8 times vibrators' head diameter

**Stop vibration - When**

i. Concrete surface- shining appearance
ii. Large air bubbles no longer escape
iii. Vibration change pitch or tone
iv. Over vibration is preferable to under vibration.

**Curing of Concrete -**
Curing is a procedure used for Promoting the hydration of cement Control of temp and humidity. As a result of curing Strength is improved Durability is improved and permeability of concrete is reduced.

**Why Curing is important ?**
Hydration progresses only when pores are saturated (80% relative humidity is reqd.) Initially the concrete has sufficient amount of water to begin with hydration. Water is lost with time due to
i. Evaporation
ii. Self desiccation (Relative humidity fall below 80% due to hydration reaction)

**Method of Curing -**
**Replenishing lost water -**
i. Immersion
ii. Ponding
iii. Sprinkling
iv. Saturated covering i.e. Jute bags

**Preventing moisture loss -**
i. Curing compounds
ii. Impermeable membrane covering.

**Period of Curing -**
As per IS : 456 for OPC – 7 days
As per IRS : CBC for OPC – 14 days

**Curing mainly depends upon -**
i. Type of cement
ii. Ambient atmospheric condition
iii. Mass to surface area ratio

The process of curing shouldn’t be interrupted because Partial hydration makes capillaries discontinuous & on curing again water may not enter the concrete
High strength concrete should be cured at an early stage.

**Practical aspects in relation to curing -**
i. Widespread belief that humid climate is sufficient for curing
ii. Generally the person responsible for curing is most unskilled. He doesn’t appreciate the importance & therefore doesn’t care much
iii. Curing is not a measurable item in the agreement.
iv. It is better to
   a) Use curing compounds
   b) Curing be kept as a separately payable item in bill of payment
   c) Keep a set of cube in vicinity of structure & let it be cured in the same way as the structure. Strength & Permeability test on these cubes will reveal the history
   d) Educate the person responsible for curing.

**Effect of curing on permeability and porosity**

<table>
<thead>
<tr>
<th>Permeability (m/sec unit x 10^-17)</th>
<th>1</th>
<th>3</th>
<th>7</th>
<th>28</th>
<th>90</th>
<th>1</th>
<th>3</th>
<th>7</th>
<th>28</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curin (days)/W/C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.32</td>
<td>5.60</td>
<td>0.30</td>
<td>0.12</td>
<td>Very low</td>
<td>Very low</td>
<td>20.80</td>
<td>19.7</td>
<td>14.4</td>
<td>9.80</td>
<td>5.90</td>
</tr>
<tr>
<td>0.40</td>
<td>18.70</td>
<td>0.59</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>33.30</td>
<td>28.6</td>
<td>20.9</td>
<td>16.80</td>
<td>11.10</td>
</tr>
</tbody>
</table>
Corrosion of steel in concrete -

i. Carbonation
ii. Carbon dioxide diffuses into concrete through pore system
iii. Carbon dioxide reacts with calcium hydroxide and other compounds to produce carbonates
iv. Alkalinity reduced to less than pH 10
v. Passive layer on steel lost when alkalinity lost
vi. Corrosion commences.

Depth of Carbonation –

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Carbonation Rate (mm² / Year)</th>
<th>Depth of Carbonation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>30</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>100</td>
<td>15</td>
<td>55</td>
</tr>
</tbody>
</table>

Grades of Concrete

<table>
<thead>
<tr>
<th>Grade Designation</th>
<th>Specified Characteristic Compressive Strength at 28 days (N / mm²)</th>
<th>Grade Designation</th>
<th>Specified Characteristic Compressive Strength at 28 days (N / mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M10</td>
<td>10</td>
<td>M40</td>
<td>40</td>
</tr>
<tr>
<td>M15</td>
<td>15</td>
<td>M45</td>
<td>45</td>
</tr>
<tr>
<td>M20</td>
<td>20</td>
<td>M50</td>
<td>50</td>
</tr>
<tr>
<td>M25</td>
<td>25</td>
<td>M55</td>
<td>55</td>
</tr>
<tr>
<td>M30</td>
<td>30</td>
<td>M60</td>
<td>60</td>
</tr>
<tr>
<td>M35</td>
<td>35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Maximum Water Cement Ratio

<table>
<thead>
<tr>
<th>Environment</th>
<th>Maximum Water Cement Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Concrete (PCC)</td>
<td>Reinforced Concrete (RCC)</td>
</tr>
<tr>
<td>Mild</td>
<td>0.55</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.50</td>
</tr>
<tr>
<td>Severe</td>
<td>0.50</td>
</tr>
<tr>
<td>Very Severe</td>
<td>0.50</td>
</tr>
<tr>
<td>Extreme</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Suitable plasticizer / admixture may be used to achieve workability of the order of 150 – 200 mm.

Minimum Grade of Concrete

<table>
<thead>
<tr>
<th>Environment</th>
<th>Minimum Grade of Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Concrete (PCC)</td>
<td>Reinforced Concrete (RCC)</td>
</tr>
<tr>
<td>Mild</td>
<td>M10</td>
</tr>
<tr>
<td>Moderate</td>
<td>M10</td>
</tr>
<tr>
<td>Severe</td>
<td>M15</td>
</tr>
<tr>
<td>Very Severe</td>
<td>M15</td>
</tr>
<tr>
<td>Extreme</td>
<td>M20</td>
</tr>
</tbody>
</table>

The concrete of grades M10, M15 & M20 are normally used in mass concrete work and usually mixed by volumetric batching also. The mix for this would be –

- M10 – 1 : 3 : 6
- M15 – 1 : 2 : 4
- M20 – 1 : 1½ : 3
### Minimum Cementitious Material Content

<table>
<thead>
<tr>
<th>Environment</th>
<th>Minimum Cementitious Material in Kg / M³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plain Concrete (PCC)</td>
</tr>
<tr>
<td>Mild</td>
<td>210</td>
</tr>
<tr>
<td>Moderate</td>
<td>250</td>
</tr>
<tr>
<td>Severe</td>
<td>250</td>
</tr>
<tr>
<td>Very Severe</td>
<td>300</td>
</tr>
<tr>
<td>Extreme</td>
<td>300</td>
</tr>
</tbody>
</table>

For under water concrete 10% extra cement should be added over and above the normal cement content of the concrete mix specified above.

**Spacers or Cover**
Sufficient spacers shall be provided as shall in the opinion of the Engineer be necessary to maintain specified concrete cover to the reinforcement and prevailing displacement before and during the placement of the concrete. Spacers should be of such material and designs as will be durable, will not lead to the corrosion of reinforcement and will not cause spalling of the concrete covers. Spacer block made from cement sand and small aggregates should match the mix proportion of the concrete as far as in practicable with a view to being comparable in strength durability and appearance. The use of the pieces of wood, tile or porous material will not be allowed for this purpose.

**Protective Coating**
In order to offer adequate resistance against corrosion, reinforcement bars may be provided with suitable protective coatings depending upon the environmental conditions. In aggressive environments (Severe, Very Severe and extreme) application of cement slurry coating after removal of rust and other loose material from the surface of the reinforcement bar will generally be sufficient. However specialist literature may be referred to in extreme exposure conditions.

**Workability of Concrete**

*Compactibility* - or ease with which concrete can be compacted.

*Mobility* - or ease with which concrete can flow into formwork & around reinforcement.

*Stability* - or ability of concrete to remain stable, cohesive and homogeneous mass while handling, vibrating without segregation.

**Workability of Concrete**
Despite all its importance workability is the most elusive property of concrete and is quite difficult to define and measure. In its simplest form a concrete is said to be workable if it can be easily mixed, handled, transported, placed in position and compacted. Evidently the requirement of workability varies according to the nature of job, the obstruction to the full flow of concrete caused by spacing and nature of reinforcement. The workability of concrete can be measured by one of the following three tests.

1) Slump test.
2) Compaction factor test.
3) Vee-bee test.

Normally slump test is the most popular method.

**Slump test**
Slump test is commonly adopted for ordinary concrete works. This test is performed with the help of a vessel of the shape of the frustum of a cone and open at both ends. The top and bottom diameters of the vessel should be 100 mm and 200 mm respectively and it should be 300 mm in height.

The vessel is placed in a flat non-absorbent surface and then filled with specimen concrete mix in four different layers of equal thickness. Each layer is tamped 25 times by the point of a 16 mm dia rod, 60 cm in length. The strokes are applied uniformly over the entire area with a force that the rod just penetrates the full depth of the layer being compacted. Immediately after the vessel is completely filled, it is raised...
vertically, care being taken not to disturb the filling. The concrete filling is allowed to subside or settle. The vertical settlement recorded for concrete is known as slump.

The slump test gives satisfactory results for concrete mix of medium to high workability. It however, does not give correct indication for concrete of low workability (suitable for compaction by vibration) which may give zero slump. Compaction factor test is more dependable in such cases.

**Slumps commonly adopted for various concrete mixes**

<table>
<thead>
<tr>
<th>Type of work</th>
<th>Slump</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>When vibrators are used</td>
</tr>
<tr>
<td>1. Mass concrete in foundations, footing retaining walls and pavements.</td>
<td>1.0 to 2.5 cm.</td>
</tr>
<tr>
<td>2. Thin sections of flooring of less than 75 mm thickness.</td>
<td>2.5 to 4.0 cm.</td>
</tr>
<tr>
<td>3. Reinforced cement concrete work in foundation, footing and retaining walls.</td>
<td>1.0 to 2.5 cm.</td>
</tr>
<tr>
<td>4. RCC in Beams, slab and column.</td>
<td>2.5 to 4.0 cm.</td>
</tr>
<tr>
<td>5. Thin RCC section</td>
<td>4.0 to 5.0 cm.</td>
</tr>
</tbody>
</table>

**Compaction Factor Test**

Here workability is the amount of work required to place concrete and to compact it thoroughly. Two hoppers are one above the other and cylindrical mould 30 cm. high, 15 cm dia at bottom to collect concrete. Wt. Of concrete collected in cylinder divided by theoretical wt. of concrete gives CF.

**Vee Bee Test**

i. Vibrating table 36 x 26 cm, with fixed cylindrical container & a transparent disc.

ii. Ordinary slump test done by putting cone into the cylinder. Slump measured with plastic disc.

iii. Then vibration started with disc resting on concrete.

iv. Time required for the concrete to take horizontal surface in sec. is Vee Bee degree.
Factors affecting Workability -

i. Water.
ii. Size of particles.
iii. CA / FA ratio.
iv. Particle interference – gap grading helps.
v. Shape of aggregates.
vi. Admixtures – Air entraining agents, pozzolanas.

Effect of inadequate workability -

i. Honey combing.
ii. Less strength.
iii. Less durability.

Controlled Concrete :-
Controlled Concrete may be specified for large works where facilities for its manufacture on scientific basis and testing are available and where considerable economy in the cost of cement can be achieved by adopting concrete of a specified strength, Controlled Concrete for use in plain and reinforced structures are normally in grades M10, M15, M20, M25 and M30 in the maximum total quantity of aggregate by weight per 50 kg. of cement should not exceed 450 kg. except in special circumstances.

The following points need to be emphasised in designing for concrete mixes.

i. Agree gate Cement ratio determines cost of the mix.
ii. Water Cement ratio determines strength of concrete.
iii. Water Agree gate ratio determines the workability of concrete.

Plum Concrete –
To economies cost of concreting rubble stones used where section of concreting is more for this rough rubble stone free from skin and large as can be conveniently handled by one shall be used. They shall be thrown on the concrete from a height by which to bed them selves. The concrete shall be shoveled around the stone. Minimum distance between two stones shall be 150 mm & not more than 20% of the volume shall be plums stones shall be wetted before use & placed in such way that half height in one layer & remaining half in next upper layer to create bond other specification remains similar to general concreting.

Water Cement Ratio –
The ratio of the volume of water to volume of cement used in concrete mix is termed as water cement ratio. As a result of experiments it is observed that for a given proportion of ingredients in a concrete mix, there is almost a fixed amount of water, which gives maximum strength of concrete. In case the water used is less, the resultant concrete will be comparatively dry, difficult to place in position and may pose problems in compaction. Moreover with less water complete setting of cement can not be ensured and hence the strength of concrete get reduced appreciably. On the other hand, in case the water is more it
would result in formation of excessive voids and honey combing in the set concrete, thereby reducing its density, strength and durability. Thus water cement ratio serves as a yardstick for obtaining concrete of desired strength. The lower the ratio, the greater is the strength of the mix. A rich mix of concrete gives higher strength than a lean mix, not because of more cement but it is on account of the fact that concrete can be used with a lower water cement ratio.

**Prestressed Concrete –**

With the introduction of prestressing it has become possible to avoid the formation of cracks in tension concrete and to use high strength steel most economical.

The essence of prestressing a concrete member in the induction of sufficient compressive stress in concrete prior to the member being subjected to loads in the zones, which will be tensile when the loads are applied. Thus when the prestressed concrete member is subjected to external loads. The already induced compressive stress in concrete will neutralize the tensile stress developed in the member on loading. Hence the resultant stresses in concrete in tensile zone will be eliminated altogether or get reduced to a great extent. Thus in a prestressed concrete member the entire cross section of the member becomes effective for resisting bending and at the same time the danger of cracking when the member is loaded is minimized or even avoided.

**Advantage of Prestressed Concrete –**

i. By the method of prestressing it is possible to take full advantage of high compressive strength of concrete and high tensile strength of the steel used. Hence the combination of the two materials results in most economical sections.

ii. On account of its higher strength it can be safely recommended for structures having longer spans and subjected to heavy loads and those subjected to impact and vibration.

iii. Since it is possible to eliminate the formation of cracks in prestressed concrete members, they have increased resistance to atmospheric and other chemical action and hence they prove more durable.

iv. Prestressed concrete members are thinner in section and hence these are a great reduction of the self weight of the structure, which ultimately affects economy in the cost of foundation.

**Cover in RCC –**

Reinforcement shall have concrete cover as follows:

i. For each end of a reinforcing bar, not less than 25 mm, nor less than twice the diameter of the bar.

ii. For a longitudinal reinforcing bar in a column, not less than 40 mm, nor less than the diameter of the bar.

iii. For a longitudinal reinforcing bar in a beam, not less than 20 mm, nor less than the diameter of the bar.

iv. For tensile, compressive, shear or other reinforcement in a slab, not less than 12 mm, nor less than the diameter of the reinforcement.

v. For any other reinforcement, not less than 12 mm, nor less than the diameter of such reinforcement.

**Removal of Shuttering –**

The minimum period that should elapse after the concrete has been laid before easing and removal of centering and shuttering is undertaken should be as under –

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Part of structure (ordinary Portland cement) with temperature at about 16°C</th>
<th>Mini. Period for easing and removal of centering or shuttering</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Sides of foundations, beams, columns and walls.</td>
<td>2 days.</td>
</tr>
<tr>
<td>02.</td>
<td>Under sides of slabs up to 4.5 meters span.</td>
<td>7 days.</td>
</tr>
<tr>
<td>03.</td>
<td>Under sides of slabs above 4.5 meters span, and under sides of beams and arches up to 6 meters span.</td>
<td>14 days.</td>
</tr>
</tbody>
</table>
04. Under sides of beams and arches over 6 meters span and up to 8 meters span. 21 days.

05. Under sides of beams and arches over 8 meters span. 28 days.

**Design mix**

1. Test data for aggregates :-
   a) Specific gravity of :-
      - Cement = ………………………….
      - F.A. = ………………………….
      - C.A. = ………………………….
   b) Water absorption by :-
      - F.A. = ………………………….
      - C.A. = ………………………….
   c) Moisture Content of :-
      - F.A. = ………………………….
      - C.A. = ………………………….
   d) Sieve analysis :- (As per table)

2. Degree of Quality Control = ………………………….

3. Grade of Concrete for which mix is designed = …………………………………………………….

4. Standard deviation (s) = ………………………..

**Value of standard Deviation**

<table>
<thead>
<tr>
<th>Grade of Concrete</th>
<th>Standard deviation for different degree of control (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Good</td>
</tr>
<tr>
<td>M 10</td>
<td>2.0</td>
</tr>
<tr>
<td>M 15</td>
<td>2.5</td>
</tr>
<tr>
<td>M 20</td>
<td>3.6</td>
</tr>
<tr>
<td>M 25</td>
<td>4.3</td>
</tr>
<tr>
<td>M 30</td>
<td>5.0</td>
</tr>
<tr>
<td>M 35</td>
<td>5.3</td>
</tr>
<tr>
<td>M 40</td>
<td>5.6</td>
</tr>
<tr>
<td>M 45</td>
<td>6.0</td>
</tr>
<tr>
<td>M 50</td>
<td>6.4</td>
</tr>
<tr>
<td>M 55</td>
<td>6.7</td>
</tr>
<tr>
<td>M 60</td>
<td>6.8</td>
</tr>
</tbody>
</table>

**Degree of Quality Control**

**Very Good**
Fresh cement from single source and regular tests, weigh batching of all materials, aggregates supplied in single sizes, control of aggregate grading and moisture content, control of water added, frequent supervision, regular workability and strength tests, field laboratory facilities.

**Good**
Carefully stored cement and periodic tests, weigh batching of all materials, controlled water, graded aggregate supplied, occasional grading and moisture tests, periodic check of workability and strength, intermittent supervision, experienced workers.

**Fair**
Proper storage of cement, volume batching of all aggregates allowing for bulking of sand, weigh batching of cement, water content controlled by inspection of mix, occasional supervision and tests.

**Sieve analysis**

<table>
<thead>
<tr>
<th>I.S.Sieves</th>
<th>F.A.</th>
</tr>
</thead>
</table>
### Sieve analysis

<table>
<thead>
<tr>
<th>I.S. Sieves</th>
<th>C.A. - I</th>
<th>C.A. - II</th>
<th>Coarse aggregates: Combination of CA – I &amp; CA – II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wt. Retained gms</td>
<td>Cum. Wt. Retained gms.</td>
<td>Cum. % Wt. retained</td>
</tr>
<tr>
<td>80mm</td>
<td>40mm</td>
<td>20mm</td>
<td>10mm</td>
</tr>
</tbody>
</table>
MSA = ............ Mm.

**Fine aggregates :-**

<table>
<thead>
<tr>
<th>I. S. SIEVES</th>
<th>F.A. % Passing</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.36 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.18 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600 µ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300 µ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 µ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Target mean strength :
   \[ f' = f + (1.65 \times S) \]
   \[ f' = \text{.........................} \]

6. Grade of Cement used :- 

7. Water Cement ratio corresponding to target mean strength & type of cement = 

8. Exposure condition = 

9. Maximum W / C ratio for exposure condition = 

10. Adopted W / C (lower of 7 & 9) = 

11. Entrapped air = 

12. Degree of workability = 
   
   C. F. = 

13. Minimum Cement content = 
   
   Adjustment in min cement content = 
   
   Adjusted min. cement content = 

14. (a) Water content W = 
   (b) Percentage of F. A . Þ =
   
15. Adjustment in W & Þ

<table>
<thead>
<tr>
<th>Change in condition</th>
<th>Adjustment</th>
<th>W</th>
<th>Þ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase / decrease in C.F.</td>
<td>-----------</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>Increase / decrease in W / C ratio.</td>
<td>Nil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>φ F.A. for Zone :-</td>
<td>--</td>
<td>Nil</td>
<td></td>
</tr>
</tbody>
</table>

16. Cement Content (Kg/m³ of Concrete)
   \[ = \frac{W}{W/C} \text{ ratio} = \text{.................} \text{ Kg.} \]

17. Check for min⁰⁰ cement 

18. Aggregate cal :- In one m³ concrete :
   (a) \[ V = \left[ \frac{W}{C} + \frac{1}{1 - \phi} \times \frac{F_a}{S_{fa}} \right] \times 1 \times 1000 \]
   \[ \phi F_a = \text{..........................kgs.} \]
   (b) \[ V = \left[ \frac{W}{C} + \frac{1}{1 - \phi} \times \frac{F_a}{S_{fa}} \right] \times 1 \times 1000 \]
   \[ \phi C_a = \text{..........................kgs.} \]

Some modern compounds commonly used for improving quality of Concrete

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of compound</th>
<th>Name of firm</th>
<th>Nature of compound</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Pidi proof LW</td>
<td>Pidlite Industries.</td>
<td>Integral water proofing mixture.</td>
<td>For water tightness of concrete. Also acts as a plasticizer and saves water by 10%.</td>
</tr>
<tr>
<td>03.</td>
<td>Pidicrete CR</td>
<td>Pidlite Industries.</td>
<td>Chloride free concrete</td>
<td>Used where slower setting</td>
</tr>
<tr>
<td>No.</td>
<td>Product Name</td>
<td>Supplier</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>----------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>04.</td>
<td>Poly proof-I Greenboro Industries (Delhi)</td>
<td>Water proofing concrete additive. Mix 2 to 3% by weight of dry cement.</td>
<td>For water proofing of concrete, mortar.</td>
<td></td>
</tr>
<tr>
<td>05.</td>
<td>Conplast NC Forsoc Industries</td>
<td>Accelerates the initial setting of concrete and helps early strength gain of concrete.</td>
<td>Used for pre cast sections, concrete placed in cold weather and concrete repair works.</td>
<td></td>
</tr>
<tr>
<td>06.</td>
<td>CICO Structural water system (Noida, UP)</td>
<td>Integral water proofing admixture, available both in powder and liquid form.</td>
<td>For water proofing of concrete, mortar.</td>
<td></td>
</tr>
<tr>
<td>07.</td>
<td>Chemicrete integral water proofing mixture. Chemisol Agencies (Bombay)</td>
<td>Chloride free water proofing agent, liquid admixture based on synthetic rubber and complex chemicals, mix 2% by weight of cement.</td>
<td>For water proofing of concrete. Also reduces W / C ratio making concrete more strong and dense increases workability.</td>
<td></td>
</tr>
<tr>
<td>08.</td>
<td>Nitobond AR (Bonding and repairing material) Forsoc Industries</td>
<td>Acrylic emulsion cement modifier.</td>
<td>For bonding new materials to old one and for improving the properties of cement. Can also be used as curing agent.</td>
<td></td>
</tr>
<tr>
<td>09.</td>
<td>Nitobond PVA (Bonding and repairing material) Forsoc Industries</td>
<td>Multipurpose adhesive based on polymerized resins.</td>
<td>Bonding agent used for bonding &amp; repairing.</td>
<td></td>
</tr>
</tbody>
</table>

**Do's and Don't's for Concrete**

1. **Handling and Storage of Cement -**

   **Do's –**
   1. Check weight of cement bags periodically.
   2. Stack different types and grades of cement separately in water tight shed.
   3. Use placards displaying type, grade, name of manufacturer, date of arrival at different cement stacks.
   4. Restock if stored for more than six months. Use cement on “First in First” basis.
   5. Stack cement bags close together to restrict circulation of air.
   6. Keep stack minimum 500 mm clear of wall.
   7. Stack bags on pallets or on dry board platform minimum 150 mm clear of the ground.
   8. Enclose the stack completely in polythene (700 gauge) sheets in monsoon.
   9. For temporary storage at site, keeping one week’s consumption with adequate precautions in monsoon.

   **Don't's –**
   1. Do not use more than six months old cement unless retested with successful results.
   2. Do not exceed 7 bags stack height if storage period is likely to exceed two months. However never exceed 12 bags stack height.
   3. Do not store cement in newly constructed warehouse unless interior is thoroughly dried.
   4. Do not use set cement.

2. **Fine and Coarse Aggregates -**
Do's –
1. Stack aggregates in bins with dividers. Use distinct stacks or battle dividers.
2. Provide adequate slope in bin bottom to allow effective drainage.
3. Plan out storage of aggregates, placing of mixer etc. for convenience in mixing and leading of concrete.
4. Explain implication of existence of water in aggregates to workers.
5. Wash the aggregates before use in case they contain dirt / clay or organic matter.

Dont's –
1. Do not mix different types of aggregates.
2. Do not make conical heaps.
3. Do not use bottom 300 mm layer of fine aggregates without ascertaining moisture content.
4. Do not exceed height of stack more than that resulting from one lorry load.

3. Reinforcing Steel -
Do's –
1. Ensure effective drainage of stacking site.
2. Prevent distortion, deterioration and corrosion.
3. Provide anti corrosive treatment in conformity with procedure laid down by CECRI, Karaikudi while working in corrosive environment.
4. Stack bars clear of ground, properly under cover.
5. Stack prestressing steel in water proof sheds, protect it against ground dampness and preferably keep anti rust powder in shed.
6. Test prestressing steel stored for long time before use.

Dont's –
1. Do not stack steel on unleveled ground.
2. Do not allow water to accumulate near steel.
3. Do not keep grease, oil, paint near steel to avoid even occasional conduct.
4. Do not use bars with mud and dirt sticking to them.

4. Form work or shuttering material -
Do's –
1. Formwork should be strong enough so as not to deform under weight of concrete or force of vibration.
2. Ensure even surface of form work.
3. Wet the form surface immediately before placing concrete so that water from concrete in not absorbed by the form work.
4. Use form release agents of good quality before placing the reinforcement.
5. Provide adequate base supports and liberal diagonal / lateral bracing. Use wedges which help in de-shuttering. All wedges to be held in position with nails.
6. Take hot weather concrete precautions when working above 40°C ambient temperature and high winds. Normally, no placement of concrete be done if ambient temperature is more than 40°C.
7. Seal joints in forms to prevent leakage of cement slurry.
8. Design the form work in such away that these can be reused. This will save time and cost.
9. Observe stripping time of form work as given in IS : 456. (Clause 10.3) / relevant specification.

Dont's –
1. Do not use Black oil as form release agent.
2. Do not use polythene sheets to make form work watertight as these sheets cause wrinkles on concrete surface.
3. Avoid jerks while removing form work.

5. Assembly of Reinforcement -
Do's –
1. Use full scale drawings for difficult locations before cutting bars.
2. Use correct placement methods. Use chairs and cement mortar / synthetic cover blocks.
3. Reduce wastage to minimum by planning cut lengths.
4. Store all cut length at raised level having proper drainage.
5. Join bars securely at crossings with soft iron wires of 18 / 20 SWG or by spot welding.
6. Do detailing of overlaps and intersections in advance.

**Dont’s –**
1. Do not store steel in contact with grass / ground leading to corrosion.
2. Do not use stone chips or similar pieces to maintain cover during concreting.
3. Do not use steel after prolonged storage without cleaning and applying anti-corrosive coating.

**6. Mixing of Concrete -**

**Do’s –**
1. Proportion the aggregates either by weight or in steel boxes if by volume.
2. Always use concrete mixers. For very small jobs, manually operated mixers should be used.
3. Put cement in between aggregate layers in mixer hopper to avoid flying off of cement.
4. Ensure correct mixing time depending upon type of mixer ( normally 90 to 120 seconds ).
5. Maintain correct gap between drum and blade for efficiency of mixer.
6. After mixing concrete should have uniform consistency ( By pressing and throwing up in hands it should be possible to roll it in balls ).
7. Use only clean water, free from materials such as silt, clay, organic matters, acids, alkalis and chemical salts etc. Water good enough for drinking is generally suitable for concrete.
8. Use appropriate brand of chloride free plasticizers for proper workability in thin / narrow section.

**Dont’s –**
1. Do not allow hand mixing even for small jobs.
2. Do not mix the left out concrete in which initial set has started with the fresh concrete.
3. Do not add excess water to make mix workable as it would result in porous concrete.

**7. Placing and Compaction of Concrete -**

**Do’s –**
1. Place concrete in position before initial set occurs i.e. normally within about 30 minutes of mixing.
2. Place concrete in position gently rather than throwing it.
3. In deep falls of 1.5 – 2.0 meter, ensure that the concrete falls on soft bed of mortar or wet concrete.
   Use chutes if placed from more than 1.5 m. height.
4. Avoid cold joints. If joint is unavoidable treat it to obtain good adhesion. Place fresh layer before the previous layer has hardened.
5. Provide walkway away from reinforcement.
6. Use vibrator for compaction of concrete.
7. Select vibrator needle according to aggregate size, reinforcement spacing etc.

**Dont’s –**
1. Do not allow concrete to fall more than 1.5 m in open to avoid segregation.
2. Do not allow more than 30 cm thick layer of concrete to avoid formation of cold joint or improper consolidation.
3. Do not distribute heaped concrete with vibrator.
4. Do not disturb reinforcement and cover blocks by walking / moving / vibrations.
5. Do not leave concrete un vibrated or under vibrated.
6. Avoid over vibration.
7. Do not place concrete during rains unless proper cover is provided.

**8. Finishing of concrete work -**

**Do’s –**
1. Carry out concrete finishing with worked up slurry. Do not use mortar.
2. Use back form, if necessary, or adjust water / cement ratio to get stiffer mix in slope with repeated working.
3. Use vacuum dewatering techniques for floors in workshops / platforms etc. to achieve hard wear resistant surface. Use power trowel for leveling.
4. Use concrete mix of such consistency which gives float of mix rather than flowing slurry.

**Dont’s –**
1. Do not spray dry mortar or dry cement for finishing.
9. Curing of Concrete -
**Do's** –
1. Explain the importance of curing to workers.
2. Ensure 100% humidity around concrete for at least 7 days to prevent evaporation of water from concrete.
4. Use potable water for curing.
5. Do water flooding on flat surfaces.
6. At isolated locations or where there is shortage of water use curing compound of approved quality.

**Don'ts** –
1. Never resort to alternate wetting and drying. It adversely affects concrete strength.
2. Do not use leaky forms which will lead to loss or water from concrete.
3. Do not wait for 24 hours final set in hot weather. Start spraying water when concrete becomes so hard that thumb impression is not marked.
4. Do not neglect curing. It is better to over cure than to under cure. Under curing results in loss of strength which can not be improved.

10. Testing of Concrete -
**Do's** –
1. Use cube moulds of correct dimensions and finishing.
2. Monitor date of testing religiously.
3. Cure test samples along with parent concrete.
4. Make adequate number of cubes for intermediate result and for stripping of forms etc.
5. Make at least 3 cubes for testing at each stage and not just one or two.
6. Make concrete cubes by taking samples from concrete, being used in the work at random covering entire concreting.
7. Calibrate testing machines periodically to avoid wrong results. Rate of loading for cube testing should be 40 ton per minute.

**Don'ts** –
1. Do not make concrete specially for cubes. Take samples at random from concreting site.
2. Do not cure cubes more than parent concrete laid at site to get reliable result.
Sanitation

Definitions -
Sanitary engineering - The branch of public health engineering which deals with the removal and disposal of the liquid waste order to maintain healthful living conditions is called sanitary engineering.

Soil waste: the discharge from water closets. Urinals, sinks, cattle sheds. Gullies etc.,
Sullage –Used water from bath, kitchen, wash basin , & sink.
Sewage – The liquid waste from the entire area of the city is called sewage.
Scum–Greasy and other substances which floats at the surface of the sewage when retained in sewage treatment plant.
Sludge –The solid matter deposited at the bottom of the tank during treatment of the sewage, in a semi solid condition.
Influent –Raw or partly treated sewage flowing into a sewage treatment tank.
Effluent –Partly or completely treated sewage flowing out of a sewage treatment plant.
Refuse –Solids organic waste excluding body waste e. g. garbage , Rubbish, ash, solid waste of Market and Industry.
Garbage - Organic waste resulting from consumption of food products.
Rubbish – Organic waste excluding ash e. g. Paper, can, glass, wood scrap metal.

Influent –Raw or partly treated sewage flowing into a sewage treatment tank.
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Soil Pipe –Pipe which carries night soil or sewage.
Ventilating Pipe - The pipe which provides an outlet for the foul gases in a sewer line.
Vent Pipe - The pipe which provides an outlet for the foul gases from the drainage system of building.
Anti Syphonage - Pipe to preserve the water seal of the trap through proper ventilation
Stack –Vertical line of drainage.
Cleaning Eye or Rodding Eye - An access opening having a removable cover to enable removal of deposits, obstructing the flow.
Baffle –Deflector, placed in flowing liquid to divert or guide the flow of liquid.
Benching –Sloped floor of man hole on both sides and above the top of the channel.
Invert - The lowest of the interior of the sewer.
Service Pipe -Pipe taking out of the water main and used for feeding from the main to the building.
Supply Pipe -Pipe which extends from the stop cock to the entrance of the storage tank.
House Drain - That part of horizontal piping which receives the discharge from soil, waste and other drainage pipes within the house of building
House Sewer -That part of horizontal piping that extends from the end of house drain to the public sewer or other outlet.
Cowl – A ventilating top of a sewage.
Storage Tank -Tank for storage of water , connected to the water main Supply pipe .It includes domestic storage tank and flushing Storage tank.
Flushing Cistern - Cistern with discharge arrangement for flushing a water closet , urinal, sink or drain.
Trap - Fitting constructed with water seal to prevent the passage of foul air through the drainage pipe.
Water Seal - Vertical distance between the dip and crown wear of a trap.
Gully Trap - Trap provided in drainage system to collect sullage and rain water.
Channel - Open water way through which sewage storm water etc. flow at the invert of man hole or inspection chamber.
Drain – A channel or pipe which carries waste water in a building drainage system.
Inspection Chamber – Water tight chamber constructed in house drainage system which takes waste from gully trap and disposes off to man hole with access for inspection & maintenance.
Outfall - An out let of the main sewer, at the point of disposal.
Cess Pool - Pit with open joint towards the bottom in which effluent is discharged and from which the liquid leaches.
Drop Man Hole - Man hole incorporating a vertical drop for the purpose of connecting a sewer at a higher level to one at a lower level.
Dry Weather Flow - The normal flow in a sewer during dry weather is called dry weather flow.
Sewer - Closed drain which carry the sewage to a point of disposal.
Sewerage: A system for the collection and conveying sewage to the point of disposal.
Manhole: An opening by which a man may enter and leave a drain, a sewer or other closed structure for inspection, cleaning and other maintenance operations fitted with a suitable cover.
Soak Pit - Pit dug in permeable ground to which the soil water is led so as to leach into the surrounding soil.
Sump Well - A well constructed for collecting sewage from which it can be pumped for further disposal.
Infiltration - The water which has leaked into sewers from the ground is termed as infiltration.
Storm water: Quantity storm run off is dependent on the intensity and duration of rain fall.
Storm water flow for this purpose may determined by hydrographic methods or empirical formulae.

************************************************

Various Types of Sanitary Fittings -

Trap –
It prevents the passage of foul gases through water seal. Depth of water seal varies from 25mm to 75mm. Generally it is 50mm.

Classification of Trap -

i. P. – Trap
ii. Q. – Trap
iii. S. - Trap
iv. Floor Trap
v. Gully Trap
vi. Intercepting Trap

P Trap –
Trap is a depressed or bent sanitary fittings which always remains full of water it is water seal. Its functions are to prevent passage of foul air or gases but at the same time allows flow of sewage through it.
Effectiveness of trap depends on depth of water seal (Varies from 25 to 50 mm)

Requirement of a good trap as under –

i. It should be capable of being easily cleaned.
ii. It should be easily fixed with drain.
iii. Simple.
iv. Passes adequate water seal.
v. Surface should have smooth finish.

According to shape the traps are of the following three type –


P. & Q. Trap is used in water closet and S. Trap is generally used in Urinal, sink, washbasins and Bath – tub etc.
Floor Trap --Floor trap is provided in the bath room and kitchen for the disposal of sullage. Grating is necessary at the top of floor trap to retain the Large particles like hairs, threads etc. to prevent from entering into the pipe through the trap. It may be Cast iron or PVC.  
Gully Trap: - Gully trap is provided at the ground floor level of the building. Sullage from the top grating and rain water from side opening flow through this trap.  
Intercepting Trap: - Intercepting trap is provided at the junction of house drain and house sewer. It prevents the entry of foul gases entering from public sewer in to house drain through the house sewer.

Water Closet:-
W. C. are three types:-
1. Indian type- (a) Long Pan Pattern - Size - 580mm, 630mm, 680mm.  
(b) Orissa Pattern - Size - 580mm X 440mm.  
630mm X 450mm.  
680mm X 470mm.  
(c) Rural Pattern - Size - 450mm.  
Squatting pan should be smooth & water tight & have minimum Water seal 50mm depth. Minimum height from top to the bottom of Trap is 45 cm.  
2. Western Type :-
In western type squatting pan and trap are manufactured in one piece. Minimum depth of water seal is 50mm. Height of pan top from floor level is 400 to 410mm.  
3. Anglo Indian Type :-
This type W. C. with integral foot rest specially designed for use in European as well as Indian type.

Flushing Cistern :-
These are three types :-
1. Automatic :- Capacity - 5 liter & Used in public urinal.  
2. Bell type flushing cistern or High level flushing cistern :- Capacity – 10, 12.5, 15 liters & Used in Indian type W.C., Minimum height from top of Indian type w. c. is 1.2 M.  
3. Low level flushing cistern :- Capacity - 10, 12.5, 15 liter. Used in western type or European type w. c. Minimum height from top of western type W.C. is 30 cms.

Urinals :-
These are three types :-
1. Bowl type:- Size - 430 x 370 x 340 mm. Minimum height from floor level is 65cms. Minimum clear space between two partition wall is 60 cms. 5 nos. urinals can be connected in one out let.  
2. Stall type:- Size - 1140x 460x 400 mm. &600x 460x 400mm.  
3. Squatting type :- Size - 600x 350mm. & 450x 350 mm.  
These urinals is generally provided in ladies Urinals & bottom is kept below the floor level.

Bath Tub :- Size - 170x 70x 43 cm. & 185x 75x 45 cm.

Sink :-
These are used in Kitchen, Hotel, Laboratory,  
Minimum height from floor to top edge is 90 cm.  
Size - 600x 450 x 200 mm., 750 x 450 x 250 mm., 400 x 250 x 150 mm., 450 x 300 x 150 mm., 450 x 300 x 150 mm., 600 x 400 x 200 mm.,

Wash Basin :-
These are placed either on pedestal or on bracket. Minimum height from floor is 78.5 cm.
Clearance between two wash basin should not be less than 10 cm. C/C Distance of two wash basin are 70 cm. Wash basin center distance from wall in corner is 40 cm. Size - 630 x 450 mm., 550 x 400 mm., 450 x 300 mm.

Shower :-
Used in bath rooms at a height of 2 M. from floor level.
****************************************************

Inspection Chamber and Manhole -
An opening in any drainage system in the form of inspection chamber, man Hole, drop man hole, is for quick inspection & maintenance of drainage system. These are provided in sewer line at every junction, Bend, Change of grade and Change of diameter, Change of alignment.

Inspection Chambers :-
Inspection chamber is water tight chamber constructed in any house drainage system Which takes waste from gully trap etc. and disposes off to manhole.

Man Hole :-
Man hole is an opening through the surface of the ground to the sewer. Spacing of man holes is designed with reference to sewer diameter as given below:

<table>
<thead>
<tr>
<th>Sewer diameter in mm.</th>
<th>Up to 300</th>
<th>301 to 500</th>
<th>501 to 900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spacing in meters.</td>
<td>45</td>
<td>75</td>
<td>90</td>
</tr>
</tbody>
</table>

When silt and grit loads are heavy catch pits may be provided at suitable intervals Depending on local conditions and as approved the DEN. Man hole should not be less then 75 cm x 75 cm in size for depth up to 80 cm And 1.2 m. x 0.90 m. in size for depth between 80 cm to 2.10 m. for greater Depth circular man hole having diameter not less then 1.4 m.

Depth of man hole :-

<table>
<thead>
<tr>
<th>up to 80 cm</th>
<th>81 cm to 2.1 m.</th>
<th>greater then 2.1 m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of bed concrete -</td>
<td>15cm</td>
<td>25cm</td>
</tr>
</tbody>
</table>

Minimum thickness of wall is 23 cm up to 1.5 m. depth and 34.5 cm for greater Depth. Rings shall be provided in all man holes of depth more than 80 cm and Shall preferably be of C.I. rings. These rings may be staggered in two vertical run, Which may be 38 cm set apart horizontally. The top ring shall be 45 cm below The top of man hole and the lowest not more than 30 cm. Above the benching. The diameter of circular M. H, cover should not be less than 55cm. The thickness of pre cast R. C. C. cover should not be less than 8cm. No man hole or I. C. shall be permitted in side a building or in any passage.

Drop Man Hole: -
The term drop man hole is used to indicate the M. H. on sewer line which is constructed to provide a connection between the high level branch Sewer to low level main sewer with a minimum amount of disturbance.

Drop man hole serves two purposes:

1. The branch sewer is generally situated the ground level and the main sewer is laid at a greater depth below ground level. D. M. H. avoid UN necessary step gradient of branch sewer and it thus reduces the quantity of earthwork.
2. If D.M.H. is constructed the discharge of branch sewer appears at the bottom of the manhole. It thus avoids the possibility of sewage being thrown on person entering the chamber of M.H.

*******************************

Septic Tanks

Modern septic tank system is on a site disposal method which uses standard flushing. The septic tank acts as sedimentation cum digestion tank, anaerobic digestion of the settled sludge occurs in its bottom zone and the supernatant liquid has to undergo treatment in a soak pit / filter bed. Use of septic tank with out follow up treatment is not permitted, as the effluent from the septic tank is hazardous from the point of view of health and pollution, since it is usually not possible to provide soak pit / filter bed in built up urban areas, Septic tank system would not be appropriate in such areas.

The capacity of the septic tank should be such as to take care of the variations in the flow. A detention period of 24 to 48 hrs for tanks serving less than 50 persons and a period of 10 18 hrs for tanks serving more than 50 persons are generally adopted.

The size and shape of the septic tank shall be generally in agreement with the minimum dimension given in the table below:

<table>
<thead>
<tr>
<th>No of user</th>
<th>Domestic Tank</th>
<th>Length in M</th>
<th>Width in M</th>
<th>Liquid depth in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td>1.5</td>
<td>0.75</td>
<td>1.0</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>2.0</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>2.0</td>
<td>0.9</td>
<td>1.3</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>2.3</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>4.0</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Tanks for housing colonies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>8.0</td>
<td>2.6</td>
<td>1.0</td>
</tr>
<tr>
<td>150</td>
<td></td>
<td>10.6</td>
<td>2.7</td>
<td>1.0</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td>12.4</td>
<td>3.1</td>
<td>1.0</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td>14.6</td>
<td>3.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Tanks for hostels and Boarding Schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>5.0</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>5.7</td>
<td>2.1</td>
<td>1.4</td>
</tr>
<tr>
<td>150</td>
<td></td>
<td>7.7</td>
<td>2.4</td>
<td>1.4</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td>8.9</td>
<td>2.7</td>
<td>1.4</td>
</tr>
<tr>
<td>300</td>
<td></td>
<td>10.7</td>
<td>3.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

The septic tank should be constructed in 2 compartments to facilitate cleaning of one while the other is in use. A bottom slope of 5 to 10% to wards in le t is recommended.

Septic tanks should be cleaned when a large quantity of sludge has collected in the bottom of the tank, the interval of cleaning should not normally exceed 12 months. No disinfectants should be used in Latrines attached to septic tanks as they kill the organism which digest sewage.

For providing any soak pit / filter bed with septic tanks the water table must be well below their depth and the rain water from surface also should not interfere with their functioning. Hence these are not usually suitable where water tables are high or where ground slopes are flat.

Functioning of a ‘Septic tank’–

A septic tank is a masonry or concrete tank usually built under ground in which bacteria are specially cultured to hasten the putrefaction of the organic matter in sewage under controlled conditions. The bacteria are of the anaerobic type i.e. those which flounce in the absence of air. The action of a septic tank is not to purify the solid organic matter in human excreta as is
popularly and erroneously often believed but to liquefy it and incidentally to reduce its bulk. This it does by setting purification in it.

Septic tank system is on a site disposal method which uses standard flushing. The septic tank acts as sedimentation cum digestion tank, Anaerobic digestion of the settled sludge occurs in its bottom zone and the supernatant liquid has to undergo treatment in a soak pit / filter bed. Use of septic tank without follow up treatment is not permitted, as the effluent from the septic tank is hazardous from the point of view of health and pollution, since it is usually not possible to provide soak pit / filter bed in built up urban areas, Septic tank system would not be appropriate in such areas.

Septic tank shall be air tight, the light and oxygen should be totally excluded. In order to create favorable atmosphere for anaerobic bacteria to develop the lighter part of the suspended matter in sewage floats on water collected scum, the scum should not be disturbed for this purpose. In and out let are provided. Scum board also may be provided at times to prevent scum being disturbed. Velocity of the sewage is reduced by allowing water to pass through opening at the bottom. The detention period of sewage is 10 to 12 hours.

Design Factor :

The Volume of sewage per head may be taken as follows –

- Up to 100 Users - 0.086 M$^3$ (3 Cft)
- 101 to 500 Users - 0.071 M$^3$ (2.5 Cft)
- 501 to 2000 Users - 0.057 M$^3$ (2 Cft)

Depth of Septic Tank - 1.2 m to 2.7 m.
Length of Septic Tank shall be minimum twice the width, it should vary between 2 to 4 times.
Volume of Sludge Chamber shall be \(1/3\) of volume of septic tank.
Digestion Chamber shall be \(1/3\) of total length of septic tank.
Aeration Chamber shall be \(2/3\) of total length of septic tank.
Depth of Sludge Chamber = 0.45 + Depth of septic tank.
Bottom Slop = 5 to 10%

Location of Septic Tanks:
1. It should be 20m away from the building.
2. It should not be located in water logged area.
3. Should be fixed so as to avoid excessive sewer length.
4. While deciding the location of septic tank, wind direction should be ascertained
5. Should be located that foul gasses coming out of septic tank.
6. Should not foul residential and working area by wind.

Aerobic and anaerobic Action:-
The action which takes place in the presence of oxygen is called aerobic action.
The action which takes place in the absence of oxygen is called anaerobic action.

Self Cleaning velocity:-
Is the velocity which causes all salvage both floating and heavy transported easily with flow.
It is essential that all sullage drains have Self Cleaning velocity as far as possible so that there are no accumulations in the sewers and the sewage does not become septic.
Self-cleaning velocity is determined by considering the particle size and specific weight of the suspended solids in sewage. A minimum velocity of 0.8 mps at design peak flow in the sewers is recommended subject to a minimum velocity of 0.6 mps for present peak flow.

Size of sewers: - minimum diameter 200 mm except for hilly areas where steep slopes are available in those areas minimum size may be 100mm

Egg shaped’ sewer lines are superior in comparison with ‘Circular’ sewer lines because the egg shaped sewer which for low discharges, maintains the hydraulic depth nearly uniform and gives 25 to 30 per cent higher velocities, when running less than half full is more suitable.

Designing of sewers:
- Sanitary sewer system and storm water drainage system should be designed separately.
- Size of sanitary sewer depends on quantity of sanitary sewage, variation in peak and average flows, limiting velocities of flow, topography of the area, construction material etc.,
- The size of the storm sewer depends on storm water run off, self cleaning velocity construction material etc.,
- sanitary sewers are not expected to receive storm water. It should be ensured that proper design and construction of sewers and manholes are provided.
- the sewer should be designed for the maximum flow rate.

Quantity of sewage:
- The factors which influence the quantity of sewage are population and per capita sewage.
- population estimates should cater for future requirements. Generally 80% of the water supplied may be considered.
the lean and peak flows of sewage will be 50 to 150 percent. of average respectively

**Materials used for sewers :-**

i. Stone ware pipes,

ii. Cast-iron pipes

iii. Cement concrete pipes >150 mm

iv. Asbestos cement pipes

v. PVC pipes may be used for drainage purpose only.

**Lay out of Drain :-**

lay out of drain such that –

i. Joints of sewer should be water tight, and should be properly checked so. Any leaking joint,

ii. Especially when the pipe is buried in the wall or floor, will later on pose serious problems, needing dismantling of walls and floors.

iii. The drainage system should as far as possible, be such as to permit easy cleaning in case of blockade, or repair in case of leakages, or additions if additional sanitary fittings are provided on a future date.


v. High quality sewer pipes should be used in the system.

vi. Rain water from roofs or open courtyards should not be allowed to mix with house sewage or sullage

vii. The lay out should be simple, direct as practicable and laid in straight lines as far as possible in both the vertical and horizontal planes.

viii. Drains may be laid under the buildings only when unavoidable. it laid so sufficient fall should be given.

ix. It is desirable that drains should not be taken through living room or kitchen and shall be preferably be under stair case room or passage.

x. Size and shape of drain should be decided considering the following factors:

xi. ground slope of nearby area.

xii. Catchment's area in which drain is proposed.

xiii. size of drainage should be such that they will not overflow at the time of maximum discharge.

xiv. drainage system to be properly ventilated.

xv. Given slope can develop self cleaning velocity in the drainage. The following slopes are usually sufficient:

   1 in 40 for 10 cm pipe.
   1 in 60 for 15 cm pipe
   1 in 90 for 23 cm pipe.

xvi. This ensures their safety in future.

**Type of sludge –**

**Sewage Sludge** – The settled solid matters removed from the bottom of sewage sedimentation tanks is called sewage sludge.

**Raw, Fresh or Un digested Sludge** – The sludge if removed quickly from the sedimentation tanks after collection is called raw or fresh or Un digested Sludge.

**Stale or Septic Sludge** – The Sludge if allowed to remain for a longer period in the tank before removal is called Stale or Septic Sludge.
**Partially digested sludge** – If the sludge is drawn too early from the digestion tank then it is called Partially digested sludge.

**Activated Sludge** – The sludge obtained by settling sewage in presence of sufficient oxygen is referred as Activated sludge.

**Flow diagram of Activated Sludge System**

**Activated Sludge process** –

The term Activated Sludge is used to indicate the sludge which is obtained by settling sewage in presence of abundant oxygen. The Activated Sludge is biologically active and it contains a large number of aerobic bacteria and other micro organisms which have got an unusual property to oxidise organic matter.

Activated Sludge is mixed with raw or partially treated sewage. When Activated Sludge is mixed properly with sewage containing ample or sufficient quantity of oxygen, micro organisms present in Activated Sludge multiply rapidly as result of this.

a) Organic solids present in sewage are rapidly oxidised.

b) Suspended and colloidal matters coagulate and they from a readily settle able precipitate.

After such precipitate settles down the effluent which is obtained is clear and sparking. The effluent contains very low amount of organic matter. A portion of settled sludge is sent for recirculation and the remaining part is sent to sludge digestion tanks. The digested sludge is harmless.

**Advantage** –

i. It requires small area for construction of the entire unit.

ii. It is free from fly nuisance as there is no foul smell.

iii. It is not costly process.

iv. It removes BOD bacteria’s and suspended solids by 90%.

v. It produces effluent which is clear and free from odour.

vi. It has high fertilizing value than the sludge obtained from other processes.

**Disadvantage** –

i. Its operational cost is high.

ii. It produces more quantity of sludge.

iii. It needs skilled supervision.

**Secondary Clarifier / Final Clarifier** –

The sedimentation tank located after the units of secondary treatments such as filters of activated sludge process units are called secondary clarifiers.
**Aeration Tank**
The tank in which air is supplied for agitating the mixed liquor containing activated sludge and effluent is called aeration tank.

**Sludge Treatment**
The process of treating sludge before disposing off finally is known as sludge treatment. Sludge treatment is mainly done –
- To stabilize the organic matter.
- To destroy the pathogenic bacteria’s.
- To reduce the water content for facilitating ultimate disposal.
The method employed for sludge treatment include –
- Sludge digestion.
- Sludge drying.

**Sludge digestion.** – The process in which the solid organic matter deposited by sedimentation is liquefied and gasified by biological action is referred as sludge digestion.

**Sludge Drying** – The process for final disposal is referred as sludge drying.

**Sludge Disposal** – The method of disposing off the sludge is referred as sludge disposal.
The following ways are used for the disposal –
- Sludge can be disposed off on land either by ploughing.
- Disposed off by conveying it through a pipe line to the near by farm for using it as a fertilizer.
- Disposed off by pumping into the sea.
- Disposed off by burning in incinerators.
- Disposed off by drying on drying bed.

**Oxidation Pond**
The pond used for oxidizing the organic matter by oxygen absorbed from the air are called oxidation ponds or stabilization ponds or lagoons. Generally number of ponds are placed in series. Sewage flows progressively from one to another till it is finally discharge. The depth of pond should not exceed 2 m. It should be minimum 1 m. to discharge growth of aquatic vegetation. The sewage is detained for 3 to 6 weeks. It has been observed that BOD removal is about 90%. This method required more land. The banks of the ponds must be kept clean in order to avoid mosquito breeding.

**Advantage**
- These are successful in the disposal of sewage.
- These help in the evaporation of same liquid and percolation of the remaining portion.
- These provide suitable content for industrial use.
- These are more effective in adjusting to the rapid fluctuation in the quantity and quality of waste.

**Disadvantage**
- These create nuisance as they become the breeding place.
- These are costly to maintain.
- These tend to pollute the under ground water and adjacent surface water due to flooding of lagoons.

**Aqua Privy Latrine**
There are a sort of latrines also called septic tank latrines. These are constructed over septic tanks & flushing is also provided. The excreta together with flush water falls into the septic tank where it under goes anaerobic decomposition. The effluent flows to filters and then to soak pits. These tanks are designed for a capacity of 70 Liter / head / day and for a population even up to several thousands. A raw of water closets may be constructed over single septic tank. A grit chamber is necessarily provided at the inlet end of the septic tank which detains hard solid
masses of faces which would otherwise pass undigested at the other end. The grit chamber is made by erecting a wall at 1/6th the length of tank from inlet side. This wall has an opening at the bottom so that excreta pieces are held on the surface in grit chamber till they are decomposed and digested while the main flow passes down through the opening at the bottom.

***********************
WATER SUPPLY

Necessity - Water is the basic need of human life with out water no life can exist. Hence it is necessary that arrangements for water supply made at every location where people live.

Sources of Water Supply -

<table>
<thead>
<tr>
<th>Surface Water</th>
<th>Underground Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>River</td>
<td>Infiltration gallery</td>
</tr>
<tr>
<td>Lakes and natural pond</td>
<td>Infiltration wells</td>
</tr>
<tr>
<td>Stored rainwater</td>
<td>Porous pipe gallery</td>
</tr>
<tr>
<td>Impounding reservoir</td>
<td>Radial Collector wells</td>
</tr>
<tr>
<td>Streams</td>
<td>Wells &amp; Springs</td>
</tr>
</tbody>
</table>

Rivers : The quantity of river water is maximum of all the surface sources. The water is easily available for water supply purposes. Due to this reason most of cities have developed along the river banks.

Lakes and natural pond : The quantity of water in lakes and ponds is very small, It depends mainly on the intensity of rain fall, its distribution and the capacity of the depression. They are not considered as the principal source of supply due to there in efficiency to meet the public demand.

Impounding reservoir : The storage reservoir is created by the construction of a solid dam across a flowing stream, Run off is accumulated in the lake and stored which is supplied after wards for water supply purposes.

The catchment area, its characteristics and the rainfall decide how much water would be available for storage. A contour plan of the neighborhood of proposed dam facilitates the decision of the height of the dam and decides whether or not there is sufficient storage capacity for the amount of water needed. Losses by evaporation and absorption should be assessed. Expert agencies should be consulted where necessary.

The storage capacity depends on the height of the dam and contours of catchment behind.

Streams : Streams are formed by run off. The water is Streams flows only during rainy season. The quantity of water available in streams is small. Stream water is generally supplied to places which are situated hilly areas.

Infiltration Galleries : The horizontal wells constructed at shallow depths up to 6 meter along the banks of the river To intercept ground water table are called as infiltration galleries.

These are constructed in water bearing strata. The gallery obtains its water from water bearing strata by various porous drain pipes. A collecting well at the downstream end of the gallery serves as the sump from where the infiltrated supply is pumped out. The gallery laid perpendicular to the flow of sub surface water yields maximum quantity. Quality of water is normally reasonably good and only disinfection may be required.
Infiltration Wells: - The wells [vertical] provided along the banks of a river to draw ground water in dry season and percolated water in the remaining season are called infiltration wells.

Porous Pipe Galleries: - Porous pipes are laid horizontally below the river bed. Porous pipes are provided length wise in the river bed so as to draw water from as large an area as required. These are laid in a grid system and slopes to collect water at one point. From this point the collected water is pumped to the purification plant.

Radial Collector wells: - Radial collector well consists of a cylindrical well of RCC construction, 4-5 meter in diameter going into the water bearing medium to as great depth of the substrata as possible. In the collector well the radial pipes which are slotted steel pipes normally 200mm to 300mm diameter are driven horizontally at about 7 meter below the water table in the well. The radial collector wells have higher efficiency of drawing the ground water compared to ordinary wells. This type of wells are able to obtain high yields of water depending on the strata and depth of submergence. This is normally provided in alluvial beds of major rivers.

Springs: - The quantity of water obtained from springs is very small. Therefore these are not suitable for water supply schemes. If locally available then these can fulfill the water requirements of few houses.

Springs are of the following types:-
1. Surface Spring. 2. Shallow Spring. 3. Artesian Spring. 4. Spring due to fault in a rock

Wells: - The vertical hole dug out or drilled into the ground to get sub surface water is termed as well.
6. Driven Wells.

Shallow Wells: - Wells to a depth of 7.5 m to 12 m which are left in a pervious strata and do not meet any impervious layer below water table are called shallow wells.

Artisan wells: - When an aquifer is enclosed between two impervious strata making cup shot. The well is called artisan well.

Deep wells: - Wells which rest on the impervious soil and get the supply from the under laying previous layer through a small hole bored in the impervious layer are called deep wells.

Gravity wells: - When in the pervious strata the surface of water surrounding the well is at atmospheric pressure the well is termed as a gravity well.

Tube wells: - A pipe sunk into the ground and fitted at the bottom with a filter to tap the under ground water is called tube well.

Driven wells: - These are shallow wells and are also called percussion wells. In this case casing pipe a strainer is provided in order to allow the clear water to enter into the well.

Checking Verticality of tube wells: - Tube wells must be perfectly vertical. A simple method is to use plumb disk. Two disks made out of 3mm thick steel plate are connected together by a rod of 25mm diameter and 3 meter long tightened with the help of nuts at the ends. Some holes are punched in plates to facilitate immersion in water. A knob is fixed on the top nut to which a thin steel wire is attached. The disk is suspended into the tube by the wire passing over a pulley on a try pod.
When the disk is lowered into the pipe the wire is exactly in the center of pipe. When the disks are further lowered down and if the well pipe is not truly vertical, the wire will deviate from the center and that shall be indicated at the top of pipe. Absolute verticality is ideal but a deviation of 100 mm per 30 meters of boring is generally acceptable where submersible pumps are not to be installed.

**Failure of wells and the Remedial Measures**

The clogging of wells by sand or by corrosion or encrustation of the screen may reduce the yield substantially. The wells may be readily cleaned of sand by means of a sand pump or bucket but if the strainers are corroded, they must be pulled out cleaned or renewed or replaced.

*Well Clogging Problems and its suggested Treatments*

1. Clogging due to fine sand, clay and silts: -
   
   Sodium hexameta phosphate 50 gm / liters depending on the capacity of well bore be left therein for 24 hrs. the same should be followed by surging, jetting with chemical mix or normal development till well is freed from clogging.

2. Chemical clogging: -
   Hydrochloric acid or sulphuric acid with inhibitor are added to the well.

3. Bacterial clogging: -
   Chlorine has been found to be effective in loosening this type of clogging calcium hypo chloride should be used to form solution which is introduced in well in a small polythene pipe 200gms of hypo chloride is required at 70 % concentration for 1000 liters of water.

*Capacity of Source:*
Ordinarily, in the summer season sources should be able to supply in eight hours the quantity of water normally consumed in a day.

*Yield of well:*

The rate of which water percolates into well under safe maximum critical depression Head is termed as yield of well. The yield of well is measured in cum / hour or liters / hours.

There are two ways of testing the yield: -

1. Pumping test.
2. Recuperation test.

**Pumping Test:**

Water level is dropped in the well by pumping. The water from the well at a particular level then speed of the pump is so adjusted that the rate of water entering the well is kept equal to the rate of pumping which is yield of the well.

\[
Yield = \frac{Q}{T_1 + T_2} \text{ Liter per hour.}
\]

Where \( Q = \) Quantity of water in liters pumped out in \( T_1 \) hours.

\( T_2 = \) Time in hours taken for the water level to come to original level.

**Recuperation Test:**

In this case initially water is pumped out from the well and then it is allowed to recuperate.

The yield of the well is calculated by using the following equation: -

\[
Q = \frac{2.303}{h_1} \log_{10} \left( \frac{A}{h_2} \right) \text{ cum. Per hour}
\]

Where- \( Q = \) Yield of the well. \( h_1 = \) Initial draw down in m.
T = Time required to recuperate from h1 to h2 in hours.
H2 = Final draw down in m.  H = Average draw down in m.
A = Area of the well in sq m.

The yield can also find by V notch as per chart given below:-

<table>
<thead>
<tr>
<th>Inches</th>
<th>Gallon / Hrs.</th>
<th>Lit. /Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1”</td>
<td>135</td>
<td>596.05</td>
</tr>
<tr>
<td>1.25”</td>
<td>230</td>
<td>1046.5</td>
</tr>
<tr>
<td>1.5”</td>
<td>363</td>
<td>1651.65</td>
</tr>
<tr>
<td>1.75”</td>
<td>533</td>
<td>2425</td>
</tr>
<tr>
<td>2”</td>
<td>744</td>
<td>3385</td>
</tr>
<tr>
<td>2.25”</td>
<td>1002</td>
<td>4559</td>
</tr>
<tr>
<td>2.5”</td>
<td>1302</td>
<td>5924</td>
</tr>
<tr>
<td>2.75”</td>
<td>1650</td>
<td>7507</td>
</tr>
<tr>
<td>3”</td>
<td>2052</td>
<td>9336</td>
</tr>
<tr>
<td>3.25”</td>
<td>2508</td>
<td>11411</td>
</tr>
<tr>
<td>3.5”</td>
<td>3052</td>
<td>13486</td>
</tr>
<tr>
<td>4”</td>
<td>4212</td>
<td>19164</td>
</tr>
</tbody>
</table>

Improving Yield in Open wells :-

A – In sandy soil –
If the yield with a drop of 2meters is insufficient, then a larger diameter well is needed. Alternatively a tube well may be sunk in the open well to supplement the yield. Any increase in the drop will increase the critical velocity and blowing of the sandy soil and subsidence of staining may occur.

B – In moorum and porous rock –
If the yield is insufficient, it may be improved by deepening provided the lower strata is porous. This can only be ascertained by making a bore. Driving ad its into sides of the well and providing a greater number of weep holes would increase the yield.

In porous rock the inflow may be slightly increase by holding up surface flow of the rainfall in the vicinity of the well. This may be effected by building a bund on the upstream side of the well.

Requirement of Water

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Particulers</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Officers &amp; Staff Qrt. *</td>
<td>200 Lit./Head/Day</td>
</tr>
<tr>
<td>2.</td>
<td>Offices</td>
<td>45 Lit./Head/Day</td>
</tr>
<tr>
<td>3.</td>
<td>School</td>
<td>25 Lit./Head/Day</td>
</tr>
<tr>
<td>4.</td>
<td>Workshop</td>
<td>30 Lit./Head/Day</td>
</tr>
<tr>
<td>5.</td>
<td>Hospital</td>
<td>450 Lit./Bed/Day</td>
</tr>
<tr>
<td>6.</td>
<td>Hostel</td>
<td>135 Lit./Bed/Day</td>
</tr>
<tr>
<td>7.</td>
<td>Institute</td>
<td>15 Lit./Seat/Day</td>
</tr>
<tr>
<td>8.</td>
<td>Retiring Room &amp; Rest House</td>
<td>180 Lit./Bed/Day</td>
</tr>
<tr>
<td>9.</td>
<td>Apron Washing</td>
<td>10 Lit./Sq. M.</td>
</tr>
<tr>
<td>10.</td>
<td>Plate Forme Washing</td>
<td>5 Lit./Sq. M.</td>
</tr>
<tr>
<td>11.</td>
<td>Running Room</td>
<td>250 Lit./Bed/Day</td>
</tr>
<tr>
<td>12.</td>
<td>Carriage Washing - [A] On Washing Line</td>
<td>3600 Lit./Carriage For [BG]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2600 Lit./Carriage For[MG]</td>
</tr>
<tr>
<td></td>
<td>[ B ] On Plate Form</td>
<td>500 LIT./CARRIAGE</td>
</tr>
<tr>
<td>13.</td>
<td>Passenger on Plate Form **</td>
<td>25 Lit./Passenger</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>14.</td>
<td>Carriage watering ***</td>
<td>As per actual requirement</td>
</tr>
<tr>
<td>15.</td>
<td>Gardens &amp; Lawn</td>
<td>22500 Lit./ Hector</td>
</tr>
<tr>
<td>16.</td>
<td>Road watering</td>
<td>2800 Lit./Km./ Day</td>
</tr>
<tr>
<td>17.</td>
<td>Fire Service</td>
<td>5% To 10%</td>
</tr>
<tr>
<td>18.</td>
<td>Wastage</td>
<td>10% To 15%</td>
</tr>
</tbody>
</table>

- Number of persons considered in a quarter shall be taken 5.
- ** Number of passengers considered on a station shall be equal to passenger entraining at the station plus half of the passengers detraining.
- *** Quantity of water required for a train originating station shall be equal to the full capacity of tank for all the coaches for trains scheduled for watering on other stations only 75% capacity filling may be considered.

Tank capacity – 225 lit [in BEML coach] & 275 lit [in ICF coach] each four tanks in a carriage i.e. – 900 lit / carriage & 1100 lit / carriage.

Actual Fire demand may be calculated by following formula:

1. Buston’s formula \[ Q = 5663 \sqrt{P} \]
2. Freeman’s formula \[ Q = 1136.5 \left[ \frac{P}{5} + 10 \right] \]
3. Kuichling’s formula \[ Q = 3182 \sqrt{P} \]
4. National Board of fire under writers formula \[ Q = 4637 \sqrt{P} [1 - 0.01 \sqrt{P}] \]

Where \( Q \) = quantity of water required in liter / min.
\( P \) = Population in thousands.

**Design The Water Supply System**

1. Requirement:- Actual requirement + 10% Wastage + 20% Future demand
2. Capacity of Source and Pumping -
   Capacity of Pumping.
   
   [1] In 12 hours or less the normal quantity required in 24 hours,
   [2] In 16 hours or less the present maximum quantity required in 24 hours.
   [3] In about 20 hours the estimated maximum future requirement in 24 hours.
3. Discharge -
   \[ Q = \frac{\text{Liter}}{1000 \times 16 \times 60 \times 60} = \ldots \ldots \text{cu. m./sec.} \]
   Peak hourly demand = \( 2.5 \times \text{Discharge} = \ldots \ldots \text{Cu. m. /sec.} \)

   [The per capita rate of water supply indicates only the average consumption of water per day. To take into account fluctuation in consumption due to season, month, day, and hour, the average demand should be multiplied by a peak factor for the purpose of designing a distribution system. A peak factor of 2.5 is recommended.]
4. Diameter of Pipe Line -
   [A] Economical diameter of pumping main –
   \[ D = 0.97 \sqrt{Q} = \ldots \ldots \text{Meter.} \]
   [B] \[ Q = AV, \quad A = \pi D^2 / 4, \quad D = \sqrt{4 \frac{Q}{\pi V}} \]
   \[ V = 0.80 \text{ m / sec} \text{ to } 1.35 \text{ m / sec.} \]
5. Storage Capacity -
   (A) 1/4 The maximum water consumption in 24 hours.
   (B) 1/3 The normal water consumption in 24 hours.
   (A) 1/3 The maximum water consumption in 24 hours.
   (B) 1/2 The normal water consumption in 24 hours.
6. Pump Horse Power :-
   \[ P.H.P. = \ldots \ldots = \ldots \ldots \text{H.P.} \]
Break horse power :-

\[ \text{B.H.P.} = \frac{WQH}{75 E} = \ldots \] H.P.

Where-
- \( Q \) = Discharge in cu. m. / sec.
- \( W \) = Specific weight of water = 1000
- \( E \) = Efficiency of pump i.e. 60% = 0.60
- \( H \) = Total Head = \( H_s + H_d + H_f + H_v \)
- \( H_s \) = Suction Head
- \( H_d \) = Delivery Head

Head loss due to friction = \( H_f = \frac{Q^2}{4fLv^2} \)

Velocity Head = \( H_v = \frac{2g}{v^2} \)

Where-
- \( f \) = Friction coefficient = 0.01
- \( L \) = Length of pipe line.
- \( G \) = 9.81 m./sec./sec.
- \( H_s + H_d \) = Static Head

\[ f = 0.005 \left[1 + \frac{1}{40d}\right] \quad \text{[For new pipe]} \]
\[ f = 0.01 \left[1 + \frac{1}{40d}\right] \quad \text{[For old pipe]} \]

\[ L[ H+h ] \]

Where-
- \( L \) = Liter of water/min.

\[ \text{P. H. P.} = \frac{75}{4560} \]

Water Samples

Following procedure should be followed –

**Improvement of Water supply at Station**

When considering schemes for improving water supply at a station or a colony it is necessary that the present and future requirements both for normal and maximum operating conditions should be taken into account:

1. Capacity of source.
2. Capacity of Pumping.
3. Storage Capacity.
4. Distribution: - The distribution system should be designed for the following minimum residual pressures at ferrule point –
   - Single story building - 7 m
   - Two story building - 12 m
   - Three story building - 17 m
   Distribution system should not ordinarily be designed for residual pressures exceeding 22 m. Multi – storied buildings needing higher pressure should be provided with boosters.

**Water Samples**

Following procedure should be followed –
Sterilized glass stoppered bottles available with the Divn medical officer should be obtained on application mentioning whether bacteriological or chemical examination is intended or both. The paper cover of the stopper should be removed just before taking the sample. The stopper be removed just before filling the bottle and replaced immediately after. The top should hold the stopper while the bottle is being filled contamination while filling the bottle must be avoided. There should be no contact with the mouth of the bottle or the part of the stopper that goes into it.

The bottle should be filled to about 25 mm below its neck.

When samples of water are taken from a tap, the mouth of the tap should be heated by a sprit lamp for 3 minutes. Water should then be allowed to flow for 5 minutes before the sampling bottle is filled.

If the sample is to be obtained from a tank or reservoir or a river the unopened bottle is to be held in the water about 300 mm below the surface and away from the edge with out disturbing the bed.

Well water should be collected by lowering the bottle (weighted with a piece of lead ) into the well by a string attached to the neck the stopper should be removed by another string tied to it and the bottle filled in with water not from the surface but from a point a meter or two meter above the bottom of the well . If collected from a tube well with a pump the water should be allowed to flow for about 20 minutes.

Bottles containing samples of water should be properly labeled packed around with ice and saw dust and sent with out any delay to reach the DMO. The packing should be at least up to the water level in the bottle satisfactory, packing and expeditious dispatch is essential for a proper bacteriological examination.

**Impurities in water .**

**Suspended Impurities :-**
The solid particles which are dispersed in water are referred as suspended Impurities. These are microscopic as under-

(a) Bacteria  
(b) Algae; Protozoa; Fungi; Silt; clay; mineral matter; organic matter

**Colloidal Impurities :-**
The finely divided particles of soil such that their small quantities are not Visible to the naked eye are referred as colloidal impurities.

**Dissolved Impurities :-**
The impurities which are caused by the action of water and water forming Acids with organic matter and carbon dioxide from air during its flow over mineral Salts present in the soil are called dissolved impurities.

These include following :-

(a) Salts :-  
(i) Calcium and magnesium salts ( Carbonates; Bicarbonates; Chlorides; Sulfates.)

(ii) Sodium salts- Carbonates; Bicarbonates; Chlorides; Sulphates; fluorides.

(b) Metals:- Iron; Lead; Manganese; Arsenic.

(c) Gases ;- Oxgyen; chlorine; Hydrogen; Sulphide; Carbon dioxide; Ammonia.

(d) Vegetable and Animal matter.

**Examination of Water**

1. **Physical Examination :-**

(a) Temperature :- Beyond 80 degree F. the water becomes unpalatable

(b) Color :- Maximum 20 PPM on platinum cobalt scale.

(c) Turbidity :-  5 PPM To 10 PPM.

(d) Odors & Tastes :- Unobjectionable.

2. **Chemical Examination :-**
Total solids; Hardness; Chlorides; Chlorine; Iron; Magnese; P. H. Value; Arsenic; Lead; Dissolved gases; Copper; Fluorine; Cadmium; Mineral oil; Zinc; Calcium; Nitrates; Fluorides; etc.

3. Bacteriological Examination :
Bacteriological impurities are caused by the presence in the water of the Pathogenic bacteria making water dangerous for the health.  

Bacteriological test results are indicated as under:

<table>
<thead>
<tr>
<th>Class</th>
<th>Result</th>
<th>Count of cloakroom bacteria in 100 ml by the Presumptive test.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excellent</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Satisfactory</td>
<td>1 To 3</td>
</tr>
<tr>
<td>3</td>
<td>suspicious</td>
<td>4 To 10</td>
</tr>
<tr>
<td>4</td>
<td>Un Satisfactory</td>
<td>Greater than 10</td>
</tr>
</tbody>
</table>

P H Value :
It is a symbol for hydrogen ion concentration and indicates acidity or alkalinity. When P H Value more than 7 water is alkaline and less than 7 water is acidity. When it is 7 water is natural water for public water supply it should be between 7 to 8.5. Lower value may indicate sediment deposit and difficulty in chlorination.

Standards of quality of Drinking water

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Characteristics</th>
<th>Requirement</th>
<th>Permissible limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Turbidity</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>2.</td>
<td>Colour</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>3.</td>
<td>Taste &amp; Odour</td>
<td>Unobjectionable</td>
<td>-</td>
</tr>
<tr>
<td>4.</td>
<td>P. H. Value</td>
<td>6.5 TO 8.</td>
<td>No Relaxation</td>
</tr>
<tr>
<td>5.</td>
<td>Total Dissolved Solids</td>
<td>500 mg/l</td>
<td>2000</td>
</tr>
<tr>
<td>6.</td>
<td>Total Hardness</td>
<td>300 mg/l</td>
<td>600</td>
</tr>
<tr>
<td>7.</td>
<td>Chlorides</td>
<td>1000 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>8.</td>
<td>Sulphates</td>
<td>200 mg/l</td>
<td>400</td>
</tr>
<tr>
<td>9.</td>
<td>Fluorides</td>
<td>1.0 mg/l</td>
<td>1.5</td>
</tr>
<tr>
<td>10.</td>
<td>Nitrates</td>
<td>45 mg/l</td>
<td>100 mg/l</td>
</tr>
<tr>
<td>11.</td>
<td>Calcium</td>
<td>75 mg/l</td>
<td>200 mg/l</td>
</tr>
<tr>
<td>12.</td>
<td>Iron</td>
<td>1.0 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>13.</td>
<td>Zinc</td>
<td>15 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>14.</td>
<td>Minral Oil</td>
<td>0.03 mg/l</td>
<td>-</td>
</tr>
<tr>
<td>15.</td>
<td>Copper</td>
<td>0.05 mg/l</td>
<td>1.5 mg/l</td>
</tr>
<tr>
<td>16.</td>
<td>Arsenic</td>
<td>0.05 mg/l</td>
<td>No Relaxation</td>
</tr>
<tr>
<td>17.</td>
<td>Cadmium</td>
<td>0.01 mg/l</td>
<td>- do -</td>
</tr>
<tr>
<td>18.</td>
<td>Lead</td>
<td>- do -</td>
<td>-</td>
</tr>
<tr>
<td>19.</td>
<td>Residual Free Chlorine</td>
<td>0.02 mg/l</td>
<td>-</td>
</tr>
</tbody>
</table>

Distribution System –
The distribution system is important in a water supply scheme for wholesome and adequate supply of water at required pressures in sufficient quantity. The distribution accounts for 40 to 70 % of the outlay of the water supply scheme. Proper provision of configuration of pipes, pumping arrangements, and location of valves and pipe specials are very important and adequate attention should be paid to the functional and hydraulic purposes to be served by the system.

Methods of distribution

1. By Gravity System ;
Water is distributed from the higher to consumers at lower level without pumping.

2. **By Pumping System** :-
   Water is pumped directly to consumers.

3. **BY Combined Gravity and Pumping System or Dual System** :-
   Water is pumped in to the main and reservoirs or high level storage tank simultaneously than supplied to the consumers by gravity.

   **Lay Outs of Distribution system** –

1. **Dead end System / Tree System** ;- 
   Adopted for unplanned colony. The tree system of distribution will be adequate only in small water supply distribution system on way side stations.

2. **Grid Iron / Interlaced / Reticulation System** ;- 
   In a planned city colony roads are developed in a grid iron pattern. For general convenience of distribution, a grid where different mains are interconnected is recommended. This system facilitates supply of water to any point from two directions.

3. **Ring System** ;- 
   A close ring of the water main is formed either rectangular or circular around the area to be served.

4. **Radial System** ;- 
   The area to be served in large than it is divided in to suitable zone and each zone is provided with a tank.

Distribution systems should be laid out in the form best suited to conditions at site. The economical diameter of a pipeline is based on considerations of head losses and velocities under conditions of maximum flow including fire demand. The design of the distribution system should be based on the maximum estimated daily consumption being supplied in 10 to 16 hours as may be prescribed.

A diagram of main, branch mains and distributaries should be prepared and on it the points of supply, the lengths of pipes and the reduced levels of all junctions noted. Starting at the end farthest from the points of supply, the supply in liters per minute that each pipe must be able to accommodate, is worked out for its length and noted on the diagram. From the heads and longitudinal sections, the diameters are arrived at a reserve of at least 3 meters head should be ensured at the tail end of every service line under conditions of maximum discharge. Raising Mains not to be used for Distribution –

The tapping of a rising main for purposes of distribution shall be strictly prohibited. Where for engineering construction purposes such a course may be justified as a temporary expedient in order to save long lengths of service pipelines, a control valve must be fitted on the connection.

*Separate Supplies for Drinking and Other Purposes* –
Where there are separate mains for drinking water and water for other purposes, it should be ensured that when any junctions or branches are laid, the two supplies may not get connected.

*Service Pipes from Mains* –
The number and size of service pipes that can be supplied from properly designed distribution main may be assumed as shown below exceptional cases will depend however on actual conditions:

<table>
<thead>
<tr>
<th>Distribution Main</th>
<th>Diameter of service pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15mm</td>
</tr>
<tr>
<td>Number of service pipes</td>
<td></td>
</tr>
<tr>
<td>40mm</td>
<td>12</td>
</tr>
<tr>
<td>50mm</td>
<td>20</td>
</tr>
</tbody>
</table>
To avoid dead ends, the main shall be arranged in a grid formation or in a network.

**High Level Storage**

**Inspection and Maintenance and Cleaning of Storage Tanks** -
IOW & AEN should be inspected each tank in half every year on a programme basis before and after monsoon.

The IOW recorded results in ink in the tank inspection register and submit the same by the prescribed date to the AEN who should scrutinize the entries issue such orders as deemed necessary and return the register. Prompt action shall be taken to carry out repairs required.

The conditions of which warrant special attention should be inspected more frequently.

A defect once mentioned should not be omitted in future years it has been eliminated through repair in which case a note should be made to that effect.

During inspection the following points should receive attention.

1. Condition of Paint.
2. Whether any corrosion in steel.
3. Condition of rivets, bolts, and tie rods, C I Tank plates should be examined for any cracks.

**Painting** - Painting should normally be done once in 5 to 7 years unless local conditions warrant otherwise.

**Cleaning** - Tanks used for the storage of drinking water should be rubbed and cleaned at such intervals as specified by the divisional Engineer. The cleaning of water tank and disinfection should be carried out as per recommended procedure. Tanks used for the storage of water for locomotive and carriage washing purposes should be scrubbed and cleaned at least once in six months.

Reports on cleaning of tanks should be submitted to the AEN by the section engineer (works) who shall maintain a register with complete particulars for the purpose. The periodical reports should include information regarding the condition of external and internal painting and corrosion if any.

The dates of cleaning and of both external and internal painting should be painted on one side of the staging in such a manner that these are readily visible.

**Float Gauges and Scouring Sluices** -
Every high level storage tank should be provided on the outside with a float gauge with a scale marked in meters divided into 5 parts to indicate the water level in the tank.

Every storage tank whether at high level or at ground level should be provided with a sluice at its sill level to facilitate the cleaning of the tank.

**Protection Against Pollution** -
High service storage tanks, for drinking water in particular, should be locked and provided with gauze wire to obviate pollution by birds and growth of algae.

**Purification of Water**

**Screening** - For removing of large size of particles with the help of Screen.

**Aeration** - For removing objectionable dissolved gases and oxidising other soluble compounds.

Methods –

1. By water flow over weirs & water falls.
2. By dropping water through the perforated plats.
3. By forcing it through the spray nozzles.
4. By diffusing air through water.
5. Filtering through perforated trays.

**Sedimentation** - Suspended particles settle by action of gravity & force.

1. Plain Sedimentation
2. Sedimentation with coagulants or Chemical Sedimentation.

**Detention Period** – 6 to 8 hrs for Plain Sedimentation

1.5 to 3 hrs for Chemical Sedimentation.

- **Depth of flow** - 3 to 6 meters.
- **Velocity of flow** - 30 cm / min.
- **Length of tank** = 3 to 4 time of width of tank.
- **Bottom slope** - 1 : 100

In case of circular tank dia less than 60m.

**Type of Sedimentation Tank** –

1. Horizontal flow Sedimentation Tank
2. Upward flow Sedimentation Tank
3. Circular Sedimentation Tank

**Coagulation** – The addition of coagulant before sedimentation. The process is called coagulation.

**Flocculation** – A coagulant is a chemical compound which when added to water forms a heavier flocculate precipitate, known as floc. The process is called Flocculation.


**Dose of Coagulant** – Depends upon – Turbidity, Colour, P H Value.

Dose can be fixed as per Jar test – [0.03 to 0.13 gm coagulant per jar]

Turbidity may be determine by –

i. Turbidity Rod,
ii. Jackson’s Turbidimeter,
iii. Baylis Turbidimeter.

**Filtration** - Filtration consists of passing the water through a thick layer of sand which acts as a strainer.

**Types of filter** –

i. **Slow sand filter**
ii. Rapid sand filter
iii. Pressure filter
iv. Sujala filter

Slow sand filter

<table>
<thead>
<tr>
<th>Plan Area</th>
<th>50 to 2000m$^2$ or more</th>
<th>10 to 80 m$^2$, 6x 8m, 8 x 10m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>2.5 to 3 m.</td>
<td>3 to 3.5 m.</td>
</tr>
<tr>
<td>Bottom slop</td>
<td>1: 100 to 1: 200</td>
<td>-</td>
</tr>
<tr>
<td>Filter media</td>
<td>0.3 to 0.35 mm</td>
<td>0.35 to 0.5 mm</td>
</tr>
<tr>
<td>Sand</td>
<td>[0.6 to 0.9 m]</td>
<td>[0.6 to 0.75]</td>
</tr>
<tr>
<td>Base material</td>
<td>30 to 75 mm</td>
<td>10 to 50 mm</td>
</tr>
<tr>
<td>Gravel</td>
<td>[0.6 to 0.9 m]</td>
<td>[0.45 m in 5 to 6 layer]</td>
</tr>
<tr>
<td>Under drainage</td>
<td>2.5 to 3.5 m apart</td>
<td>C I manifold with Strainers &amp; Lateral.</td>
</tr>
<tr>
<td>On the bottom of floor</td>
<td></td>
<td>On the bottom of floor</td>
</tr>
<tr>
<td>Filter Head</td>
<td>0.75 to 1.2 m</td>
<td>1.2 m. Mini.</td>
</tr>
</tbody>
</table>

[Mini. Equal to depth of sand]
Pressure filters:

These are just like small rapid sand filters placed in closed vessels. Water passed under pressure such filters are located in airtight vessels. Water from the sedimentation tanks is pumped into the filter by means of pumps. The pressure varies from 3 to 7 kg pressure. Filters are classified as:

1) Horizontal pressure filter.
2) Vertical Pressure filter.

The diameter varies from 0.30 m to 2.75 m and height varies from 2 m to 2.5 m in case of vertical pressure filter. In case of horizontal pressure filters the diameter varies from 2 to 3 m and length up to 9 m. The rate of filtration is 6000 to 15000 Lit. / hr / m² of filter area. The cleaning is done in a similar way as in case of rapid sand filter. In order to increase the rate of filtration air pressure is generally maintained on the water surface.

These are less efficient than rapid sand filters in removing turbidities and bacteria’s. The quality of water is not good. These are preferred for treating smaller quantities of water and are best suited for swimming pools, railway stations, private estates, individual industries etc.

Advantage of pressure filter –

The advantage of pressure filters can be enumerated as follows –

1) These are compact units and the modern automatic pressure filter unit is designed in such a way that it does not require manual operation or supervision.
2) These filters are flexible in operation because the rate of filtration can be altered by changing the compressed air pressure.
3) They do not require further pumping as the filtered water comes out under pressure.
4) They prove to be ideal for small estates.
5) They require less number of fittings.
6) They require very small space for their installation.
7) When these filters are employed the sedimentation and coagulant tanks are not required.

Disadvantage of pressure filter –

The pressure filters possess the following disadvantages –

<table>
<thead>
<tr>
<th>Rate of filtration</th>
<th>Rate of back wash</th>
<th>Cleaning Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 to 200 Lit / hr / m²</td>
<td>3000 to 6000 Lit / hr / m²</td>
<td>1 to 3 days</td>
</tr>
<tr>
<td>300 to 900 Lit / min / m²</td>
<td>[By top layer 15 to 30 mm scrap]</td>
<td>By back wash</td>
</tr>
</tbody>
</table>
1) It becomes difficult to keep close watch on the performance of these filters because the process of filtration and back washing are done in the closed tank.
2) It is difficult to repair these filters.
3) The overall capacity of these filters is small.
4) They are costly and hence they cannot be recommended for treating large quantity of water.
5) They possess poor efficiency in the removal of bacteria and turbidity.
6) They require additional pumps for pumping the water in then.

**Sujala Filter –**
The central Railway design of Sujala module consists of depth of sand of 40 cm layer of coconut shell granules on top both these layers are supported by a 45 cm layer of graded gravel resting on the manifold at the bottom. Standing water of 1.4 meters is required over the filter bed. The Plant has been designed at a rate of filtration of 7000 Lit. / m² / hr or 154 M³ / m² / day capacity as a minimum during highly turbid condition of raw water and this Plant is capable of 200 M³ / m² / day in normal condition.

It is recommended that after laying the gravel over the manifold give one backwash so as to ensure a clean bed for coconut shell granule layer. The coconut shell granules should be cleaned manually tow or three times thoroughly drying the same there after before placing the granules in the filter Plant. Then minimum 3 backwashes should be given for removal of silt and odour before commissioning the filter Plant.

In Sujala the back wash can be done when head loss in 1.2 m max against the normal of 1.8 m and have maintained a tank cap of 2000 liter Sintex tank against a normally required cap of 3000 liter.

- **C S =** Crushed Coconut shell granules 1.2 mm size [0.30 m.]
- **F S =** Fine Sand 0.5 mm. [0.40 m.]
- **G =** Gravel – 2 to 5 mm = 70mm
  5 to 10 mm = 80 mm
  10 to 20 mm = 100 mm
  20 to 40 mm = 100 mm
  40 to 50 mm = 100 mm

Alum required 50 mg / lit [Alum solution 5 %]
Chlorination 10 gm / 1000 lit [solution 10 %]

**Disinfect ion** - The process of killing bacteria’s from water is called disinfection. Disinfect ion is carried out by chlorination.

Other minor methods –
1. Boiling method – 10 to 15 minutes to be boiled.
2. Light method - Sun light, Ultra violent rays.
3. Chemical method – Iodine, Bromine, Potassium per magnate, Silver ions, copper ions, lime.

**Chlorination** –
The process of applying small quantities of chlorine to water is called chlorination. Chlorine can be applied may be any one of the following –

Chlorination should be done generally using chlorine Gas or other similar methods by Engineering department. At other places chlorination has to be done by mixing good quality
bleaching powder solution at a particular rate with raw water in the pumping main at the pump house itself or at the high level storage Tanks by the IOW.

**Type of chlorination** –

1. Plain chlorination
2. Pre chlorination
3. Post chlorination
4. Double chlorination
5. Break point chlorination
6. Super chlorination
7. De chlorination

**Plain chlorination** -
When only chlorine treatment is given to raw water the process is termed as Plain chlorination.

**Pre chlorination** –
When chlorine is added to raw water before any treatment, the process is termed as Pre chlorination.

**Post Chlorination** –
When chlorine is applied after all the treatment, the process is termed as Post chlorination.

**Double chlorination** –
When chlorine is added to raw water at more than one point, the process is termed as Double chlorination.

**Break point chlorination** –
The process of adding chlorine beyond the Break point is called Break point chlorination.

**Super chlorination** –
The application of excess amount (residual chlorine 0.5 PPM To 2 PPM) of chlorine thus removes high concentration of Taste Odour & Bacteria. The type of treatment is termed as Super chlorination.

**De chlorination** –
The process of removing excess chlorine from water is called De chlorination Following chemicals are used for this purpose – Sodium bisulphate, Sodium thiosulphate, Sodium sulphate, Potassium per magnate, sulphur dioxide, activated carbon.

**Residual chlorine** –
The amount of chlorine remaining at the end in treated water after chlorine used in killing bacteria’s called as Residual chlorine. The dose should be such that a residual chlorine of about 0.2 PPM appears in water after a contact period of 20 minutes.

The minimum recommended of free residual chlorine is 0.2 ppm at tail end.
Free or Residual chlorine available in the water can be very easily found out using chlorotex apparatus (chloroscopes) such apparatus should be available with all engineering staff in charge of chlorination at filtration Plants.

Chlorine demand –

The difference between the amount of chlorine added and the amount of chlorine remaining at the end of a contact period of 10 to 20 minutes.

**Pumps**

Selection of pumps-
Pumping units should be so selected that they could be operated continuously at rated load as the units are operated most efficiently at the rated load. Pumping capacity should not exceed the yield of the source, so as not to damage the strata through which water filtrates into the source.

Types of Pumps -
The types of pumps in general uses are –

i. Reciprocating Pump
ii. Centrifugal Pump
iii. Airlift Pump
iv. Vertical spindle deep well turbine Pump
v. Submersible Pump
vi. Hydraulic rams

**Reciprocating Pump** –
Reciprocating Pumps have nearly a uniform efficiency over a large range and therefore greater flexibility in operation. Reciprocating Pumps may be duplex, triplex or quadruplex accordingly to the number of water cylinders and are suitable for pumping from open wells. They are however not suitable for tube well operation as the intermittent suction has a damaging effect on the strainers.

**Centrifugal Pump** –
Centrifugal Pumps are efficient economical and require little attention. The suction lift is however limited as in the case of reciprocating pumps.

Centrifugal Pumps are of two types –

i. Rotary type or Volute Type
ii. Turbine type or Diffuser type

**Airlift Pump** –
In tube wells where centrifugal pumps cannot be installed sufficiently close to the water table, Airlift Pumps may be used. Their efficiency is however low and should not normally be used for capacities in excess of 35000 liters per hour.

**Vertical spindle deep well turbine Pump** -
Vertical spindle deep well turbine Pumps are suitable for tube wells of large size they are easy to operate and have a high efficiency. They should be used in tube wells, which are free from grit and where competent supervisory staffs are available, as adjustments during repairs require skilled attention.

**Submersible Pump** –
Submersible Pump is suitable for comparatively smaller installations. It consists of an electric motor and pump both submerged in water the vertical spinning shaft is dispensed with the water being pumped through a vertical pipe.

**Pump Installation** –
While installing a pump, the following points should be paid attention –
1. The foundation should be sufficiently strong to absorb vibrations and to form a permanent, right support for the base plate. The foundations shall be designed for the loads as per IS: 2974.
2. The suction lift, which should be made as low as possible, the greatest suction lift that may be expected at sea level is about 7 meters.
3. The suction pipe should be air tight laid with as few bends as possible and equipped with foot valve.
4. Near the pump a non-return valve and a delivery valve should be provided. The non-return valve should be between the pump and delivery valve. The size of the valve should match the size of pipe.
5. The delivery pipe shall be of such size that the velocity of water is about 2.5 m/s.
6. A dismantling joint must be provided between the pump and the valves. The design of the dismantling joint should be such that no pull or push is transmitted to the pump.
7. Sufficient space for generating sets should be available in the pump house. The minimum space between two adjoining pumps or motors should be 0.6 m for the small or medium units and 1.0 m for large units.
8. Space for control panels should be planned as per the Indian Electricity Rules.

**Driving Units**
The driving unit may be an electric motor or an oil engine. Where power is available:
1. The prime mover should preferably be an electric motor, being economical.
2. Where power is not available oil engines may be used.
3. The standby provided may be an electric generator so that in case of failure of electric supply pumping is assured.
4. Non-return valve at the discharge pipe supplement by a sluice valve shall not be closed while the is running.

**Water distribution**
The process of supplying water to the consumer at the desired pressure through the pipes, valves, service reservoirs etc is referred as water distribution.

**Pipe**
The conduct through which water flows is called a pipe.

**Conveyance of water from source**

i. Gravity conduits – should be accurately set out to the necessary gradient and covered to prevent contamination they should be provided at the lowest point with a scour sluice and with manholes not farther apart than 250 meters and at all bends and changes of gradient.

ii. For pressure mains.

**Various types of Pipes**

**Cast Iron Pipes** – (C.I. Pipes)
These pipes are used for pressure main pipes over 80 mm diameters. These are classified into four categories [Class A, Class B, Class C, Class D]. The material cast iron is highly resistant to corrosion and life is more than 100 years. Available length up to 5.55 m and diameter 80 mm to 750 mm &more up to 1.2 m.

These pipes are two types Socket & Spigot type and Flanged type. Pipes are jointed either by socket & spigot or flanged joints or by expansion joint.

First and Second class cast iron pipes in stock when used should be treated with a solution in order to reduce corrosion and encrustation. Owing to liability to tuberculation and encrustation it is not economical to use cast iron pipes of 80 mm diameter or less. When arriving at the diameter of accost iron pipe calculations should be based on data for old pipes unless it is positively known that the pipes will not be required to serve for more than two years.

**Ductile Iron Pipes** – (D.I. Pipes)
At present these pipes are substitute of cast iron pipe

**Steel Pipes** –
Steel pipes can be adopted conveniently where changes in relative ground levels are there and are very suitable for lying in ground liable to subsidence. Where high dynamic loading is expected pipes are joined by flexible joint.
Judicious method of laying and joining may be used either flexible joint made of white lead and spun yarn or welding the plain ended pipes. These pipes are generally used for pipes having diameter greater than 1.2 m to 6 m or more.

**Hume Steel Pipes** –
If steel pipes coated from in side as well as out side with cement mortar (1: 2) are used. These steel pipes are called Hume steel pipes.

**Asbestos Cement Pipes** – ( A. C. Pipes )
It is casting by asbestos, cement and silica. The size of pipe varies from 0.1 m to 0.90 m in diameter in a length of 3 m to 4 m. pressures varies from 3.5 kg / cm$^2$ to 14 kg / cm$^2$ . These pipes are used to convey under very low pressure as per relevant BIS specification.

**Concrete pipes** –
Concrete pipes are best suited where pressure is low and danger of shock small. These are not to be used for pressures above 50 meters head of water. For greater pressures hume / steel pipes are to be used.

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Traffic Survey & Engineering Survey

Various Types of Surveys for Construction of new Railway Lines & Railway Project-
Whenever there is a demand for the provision of a new line Railway has to analyse the problem to see whether the demand is justified or not. For this preliminary investigation is done on the basis of existing maps, published figures of existing railway in similar country.

If on the basis of preliminary investigations, it is seen that the line is justified, estimate are prepared for proposed surveys & sanction of the board is obtained. Following surveys are carried out before taking of construction of the line in hand.

1. Traffic Survey
2. Engineering Survey
   i. Reconnaissance Survey
   ii. Preliminary Survey
   iii. Final Location Survey

(I) Traffic Survey-
This is detailed study of Traffic conditions of the area to be determined-
   i. Promising Route
   ii. Probable Traffic
   iii. Standard of Construction Required

The Survey is carried out by Commercial Department either independently or with Engineering Department. All possible data should be collected in the beginning only to avoid repetitions of the survey. The officer In charge of Survey should be supplied with the terms of references which include the following points-

Terms of References-
1. Tentative alignment plotted on topographic sheet.
2. Particulars of existing railway in the area.
3. Interests involve in the Proposal & Scope and Nature of Investigation to be done.
4. Estimated cost of Survey with its details.
5. Time limit for Completion of Survey work & Submission of Project Reports.
7. Instructions to visit Main-Line headquarters for discussion & guidance.

Field Work - The Traffic Survey team should also work in close collaboration with the Engineering Survey Party, if there is one in the field at the same time, and while collecting information should visit all trade centers in the area, consult local authorities and prominent citizens freely, both as regards trade and industry and the most suitable alignment for the proposed Railway line.

Estimates- Calculation should be done for expected Coaching & Goods earnings and compared with data of existing lines in similar country. Working expenses should be worked out and financial prospects of the proposed line should be examined.

Report- A report should be submitted summarizing the information collected dividing it in the different parts such as General description of the country, alternative routes & possible extensions, population, existing imports, exports, station-sides, goods & coaching earnings, Train Services etc.

Covering Note- Report with statement showing information collected about population, imports & exports of commodities etc. should be submitted to the Railway Board under a covering note giving gross earnings & working expenses in the sixth year after opening, length of line & gauge etc.

(ii) Engineering Survey-
Reconnaissance Survey-
Rough & Rapid Survey with or without instruments of one or more routes for proposed line is called Reconnaissance Survey. Approximate height & distances are collected instruments such as Prismatic Compass, Clinometers, Hand-Level & Range Finder etc.

Terms of Reference-
1. Tentative alignment plotted on tope sheet.
2. Particulars of existing railway in the area.
3. Interests involve in the Proposal & Scope and Nature of Investigation to be done.
4. Estimated cost of Survey with its details.
5. Time limit for Completion of Survey work & Submission of Project Reports.
7. Instructions to visit Main-Line headquarters for discussion & guidance.
8. Instruction regarding ruling gradient & max. degree of Curvature etc.

Field Work- In carrying out a Reconnaissance Survey particular attention should be paid to ascertaining the waterway required, and the best sites for stations, crossings of streams, bridges and roads. The nature of foundation which would be required for large bridges should be investigated and recorded. Materials and labour available in the area covered by the Survey should be taken note of.

Maps- The reports and estimate should be accompanied by a map of the area on a scale of 25 Km. to 1 cm, an index map on a scale of 2.5 Km to 1 cm., and by an index plan and section on a scale of 0.5 Km. to 1 cm. horizontal and 10 m. to 1 cm. vertical the proposed route or routes being marked on them in red, and all towns and places referred to in the report clearly shown therein.

Estimate- Approximate of Abstract Estimate of the Proposed line & Junction arrangements with detailed estimates for 1 km of P. Way should be submitted.

Report- It should be divide in following chapters stating whether Line is Financially justified or not-
1) History & geography
2) Gauge, Length, Fixed Points, Levels, Gradients & Curves
3) Location
4) Alternate Routes & Possible entrances
5) Relation with Public, Military & other Govt. Deptt.
6) Construction & Engg.
7) Conclusion & Recommendations

Covering Note- The Report, Plans & Estimates should be submitted to Rly. Board under a covering note with the following information stating whether the estimates are accepted or not or any change is necessary.

1. Length of the Line.
2. Gauge.
3. Cost including Junction arrangement & Interest during construction.
4. Cost of the Line per km including Junction arrangement & Rolling Stock.

Detailed Plans & Sanction- The plan show all features of the country within a distance of 100 m. on each side of the center line showing position of masonry pillars along with the center lines & position of Bench-Mark. In addition to this show following details within a distance of 300 m. on either sides of center line.
1. Important roads with their Bridges, Culverts & km marks.
2. Rivers requiring water-way 12 m. & above.
4. The out lines of all towns, villages, important streets.
5. Boundaries of states and Districts etc.
6. Hills, Peaks & important features, Camping Ground, Rifle-Range etc.
All proposed works should be shown on plan, at Junction show existing line for a distance of 1 km. The section show formation level in RED, existing ground line in BLACK. It should be preferably continuous i.e. without changes of datum. Show Bed-Levels, HFL of all rivers & stream position of bridges, Level-Crossing etc. should be shown.

**Plan & Cross-Section for Rivers** - It should be drawn for all rivers requiring water way 110 sq. m. & above.

**Plan** - Draw to scale 1cm = 50m. & showing all details within a minimum distance of 2 km from the center line of proposed Railway.

**Cross-Sections** - Three cross-sections are plotted selecting points at about 2 km interval to a scale of 1 cm = 5 m. or other convenient scale. Show ordinary water level, ordinary flood level, HFL & trial pit details. It may be plotted on same sheet as the plan or on separate sheet.

**Plan for Station Yards & Junction Arrangements** - These are drawn to a scale 1 cm = 10 m. All lines sidings, platform, Bridges, Buildings, Wells, Tanks, ash pits, Weigh-Bridges, Turn-Tables etc. should be shown.

**Detailed drawings of structures etc** - Drawing of all schemes should be prepared but need not to be submitted to Rly Board. Following drawings are usually required by Board. Type Drawings of Banks, Cutting Tunnels where proposals involves infringements skeleton outlined Drawings to small scale of all Bridges.

**Estimate** - Detailed estimates are prepared for all jobs to be done & collectively called as construction estimate. It should show cost of construction of proposed line & Junction Arrangements. Detailed Estimates of preliminary expenses, Land, Earthwork, Tunnels, Bridges etc. with general charges along with Abstract cost of project & Junction Arrangement should be attached with tabulated details for-

- Curve Abstract
- Gradient Abstract
- Bridge Abstract
- Important Bridges
- Station Machinery
- Stations & Station Sides

**Preliminary Survey** - A detailed instrumental examination of the route or routes selected as a result of reconnaissance survey in order to obtain a close estimate of the line is called preliminary survey.

**Terms of references** - Same as for Reconnaissance survey.

**Field Work** - It includes Compass Traverse along one or more routes longitudinal & Transverse Levels are taken at required locations. Alignment needs not to be fully staked out with Theodolite stone pillars or permanent mark are provided on ground.

**Maps & Plans** - Following Drawings should be submitted-

- General Map
- Index Map
- Index Plans & Section on scale 1 cm = 0.1 km horizontal, 1 cm = 10 m vertical.

Detailed plans and Sections & other drawings should be prepared with maximum details but need not be submitted unless called for by the railway Board.

**Estimate** - It should be sufficiently accurate to enable to decide whether sanction to be accorded or not. An abstract estimate of the cost of the line, abstract estimate of junction arrangements with detailed estimates for Land, Tunnels, bridges & 1 km of P.Way etc should be submitted.

**Report** - The report should be divided into the same chapter as for reconnaissance survey submitting following information required.

(a) **History & Geography** - State how the proposal has originated & Give an object. General description of the country, physical, Geological & Botanical features, Cost of construction,
working expenses and future prospects of the railway with details of survey party work done by them etc also should be given.

( b ) Gauge, Length, Fixed Points, Levels, Gradients & Curves- In this Chapter give important features against each item.

( c ) Location- Divide this into sections corresponding to convenient sections in which line has been divided. Give data about general description of location obligatory points, station sides, calculations regarding cost of distance curvature, Rise-fall & minor deviations etc.

( d ) Alternate route & Possible Extensions- Give advantages & Disadvantages of each route & reasons why alignment finally selected is preferred. Similarly give opinion about possibility of providing branches & Extension in future.

( e ) Relation with public, military & other Govt. Department- Give in this chapter specifying the points discussed with these authorities.


Covering-Note- Details same as for reconnaissance survey. The documents should be bound in following order-
1. Covering-Note
2. Index
3. Abstract estimate of the cost of the line
4. Detailed Cost of 1 km of P.way
5. Report
6. Annexure
7. Map & Diagrams

Final Location Survey-
If the line is justified on the basis of data collected in Traffic & preliminary survey report taking construction of the line in hand. An other survey is carried out in detail. This is called final location survey.

Terms of References- Same as for Reconnaissance survey.

Field-Work- It is restricted to alignment, finally selected. Center line is completely staked out by theodolite or Tacheometer fining pegs at 20 m. intervals. A large peg stamping number on it are fixed 100 m. Interval pegs at every 300 m interval should be of hard wood. Masonary pillar should be built at tangent point of curves at 500 m interval along center line. Compass bearings of each tangent should be taken. Maximum possible data should be collected to enable to prepare fairly accurate estimate & drawings.

Map & Plans- The project drawings consist of-
1. General Map to a scale of 1 cm = 25 km
2. Index Map to a scale of 1 cm = 2.5 km
3. Index Plan & Section to a scale of 1 cm = 0.5 km horizontal, 1 cm = 10 m vertical.
4. Detailed Plan & Section to a scale of - 1 cm = 50 m horizontal, 1 cm = 5 m Vertical
5. Plans & Cross-Sections
6. Plans of Stations Yards
7. Detailed Drawings of Structures
8. Plan of Junction arrangements

Index plan & Section- It should be on tracing cloth. Project sheet size is 840 x 1020 mm.

Index Plan- Show all towns, roads, canals, rivers, hills, boundaries states & districts within a distance of 10 km on either side of the line. Proposed alignment and stations should be shown in RED. Draw plan above section.

Index Section- Show formation level by RED line, indicate height of formation above mean sea level, gradients, position of important bridges, level crossing & their clause with km from fix point.
Reports- Details same as for preliminary survey.
Covering-Note- Details same as for reconnaissance survey. If any estimate has been submitted previously, show the comparison.
Arrangements of Documents- The documents are arranged in following order-
1. Covering-Note
2. Index
3. Report followed by least of Drags accompanying the report.
4. Appendices to the report-
   i. Historical & Geographical
   ii. Location Report
   iii. Rate for construction
5. Tabulated details for curves, gradients, bridges, important bridges, station machinery, Stations & Station Sites
6. Detailed Estimates
7. Abstract Cost of Project
8. Abstract Estimate for junction Arrangements
9. Index Map & General Map

Cost of Engineering Surveys may be taken as under
   i. Reconnaissance Survey- 0.2 to 0.25 % of total cost of construction
   ii. Preliminary Survey- 0.3 to 0.4 % of total cost of construction
   iii. Final Location- 0.4 to 0.5 % of total cost of construction

Short Notes on Survey-
Traffic Surveys: - This is a detailed study to make the forecast of the Traffic prospects to facilitate the projection of the most promising route & category of line to be constructed in the case of new lines & to assess the quantum of Traffic to determine the Traffic facilities to be provided on existing line. These surveys are to be undertaken with reconnaissance or preliminary Engineering Surveys so that the technical feasibility & cases of the alternative proposals can be taken into account while formulating the recommendation.
Reconnaissance survey: This term should apply to all rough and rapid investigation of an area with a view to determine feasibility and approximate cost of one or more routes for a projected railway line from a general and same what and same what hasty examination with the help of countered survey of India maps and other available material without a more careful investigation in the field and with the use of only these instruments that will rapidly give approximate distances and heights such as prismatic compass dimometer or hand level, range finder and similar instruments.
Preliminary survey; This consists of a detailed instrumental examination of the route or routed selected as a result of “Reconnaissance” in order to obtain a close estimate of the probable cost of the projected line under this survey however staking out of alignment with a theodolite is not required. Whether the line is to be built or not will usually be decided on the basis of this survey considered jointly with Traffic Survey. The railway board however may require the submission of an estimate based on a final location survey before sanctioning the commencement of construction.
Final Location Survey: This survey will generally be a post investment decision, investigation to prepare working details & to make accurate costing in certain cases. The principal differences between the work required in Final Location Survey & that in a Preliminary Survey is that the alignment finally selected during a Final Location Survey should be fully staked on the ground with a theodolite or Tacheometer, the report should be full & detailed plans & sections should be submitted.

******************************
Station & Yard

Platforms –
As per Minimum Essential Amenities at each Category of stations.
( a ) On all new lines, Gauge conversion & Doubling projects, minimum level of platforms shall be medium level.
( b ) Wherever platform height gets reduced on account of track works the same should be restored.
( c ) Platform should be high level irrespective of category, wherever EMU trains dealt with.

Length of Plat Forms –
The length should be adequate to accommodate the longest train received at the station.

Width of Plat forms –
The width should be determined on the basis of the specified in the schedule of dimensions.
The capacity of station platforms in discharging passengers per meter width of un-obstructed passage for movement in both directions can be taken as:
Suburban Passengers : 60 per minute.
Non-Suburban Passengers : 40 per minute.

Height of Plat forms –
High Level - 760 mm above rail level (840 mm above rail level in case of Suburban stations & stations in cutting.) For BG
405 mm above rail level For M G.
Medium Level - 455 mm above rail level for B G &
305 mm above rail level For M G.

Platform Surfaces:-
i. The platform surfaces should be of such material that it is dust free in dry weather and mud free in rains. At important stations, surface of main platforms should be paved with Kota stone or interlocking pavers. To keep platform surface smooth and clean, all trollies plying at the station be provided with rubber tyred wheels.
ii. In the case of single face platforms, the platform surface should have a slope of 1 in 60 away from the coping up to the edge of the berm, with the berm and the slope of the platform filling being protected by turfing or pitching as considered adequate.
iii. In the case of two face (island) platforms the platform surface should have a slope of 1 in 60 away from the centre of the platform up to the coping on either side.
iv. The ends of the platforms should be provided with ramps at a slope not steeper than 1 in 6.
v. A demarcation line should be drawn 1.8 m from the edge of platform. In the area so demarcated, trollleys shall not be allowed to enable free movement of passengers in that area.

Platform Fencing –
All single face plat forms should be provided with a suitable fencing or hedging of a height 1.8 m with a berm.
Whenever plat forms are extended washable aprons if already existing shall also extended simultaneously.

Shady trees on plat forms –
i. The planting protection and upkeep of the trees will be the responsibility of the Engineering Department. Traffic Department should associate in watering of plants at wayside stations wherever feasible.
ii. The species and spacing of the trees should be properly decided.
iii. The trees should be so planted that they do not obstruct the visibility of signals or infringe Schedule of Dimensions or infringe the overhead electric wires or obscure the platform lights or signs.
iv. If the trees are already in existence, the positioning of the new equipment should be so adjusted as to avoid cutting of trees as distinct from trimming their branches.
v. It would be advantageous to provide suitable raised masonry platforms around the fully grown trees as an additional seating accommodation for the passengers.

Plate form walls –
   i. The length and width of plate forms shall be to the Railway Board’s specifications.
   ii. All plate form walls should be built to approved drawings and in conformity with the dimensions prescribed in the schedules of standard dimensions.
   iii. Where rail level platform are provided face adjacent to the track should be suitably defined by a raw of dressed stone or brick masonry or RCC curb or wooden sleepers at the standard distance from the center of the track.
   iv. Track adjacent to plate forms may be provided with distance pieces made of unserviceable timber fixed at intervals of about 30 m to obviate the possibility of horizontal distance between center of track and face of plate form coping being infringed.

Platform Covers –
Covering of platforms should be confined to –
   i. Junction stations.
   ii. Stations at civil District Headquarters.
   iii. Stations at cities and towns with a population of more than 1 lakh.
   iv. Stations in heavy rainfall areas.
   v. Suburban Stations.
At important and Suburban Stations, the whole platform should be covered.
The Platform Covers should be provided in term of standard bays.
Platform shelters should be extended up to the landing of the foot- over bridge.

Signages -
   i. Standard signages shall be provided at the stations.
   ii. For location of signages, a plan should be made for each station.

Platform Sign-Boards -
Indication sign boards - For larger stations, the following colour scheme should be adopted:-
   i. Bright red letters on white background for important offices such as Station Superintendent, Deputy Station Superintendent, Enquiry, Telegraph and Railway Mail Service etc.
   ii. Blue letters on white background for passenger amenities such as refreshment rooms, waiting rooms, retiring rooms and platform lavatories etc.
   iii. Black letters on white background for other offices.
   iv. Blue arrows should be painted at 1.5 meters above platform level or 300mm above the dado level on the walls directing passengers to Waiting, Refreshment and Retiring Rooms. Red arrows should be painted to direct passengers to Station Superintendent, Deputy Station Superintendent, Enquiry and Telegraph offices.
   v. Every sign-board is painted on one side with the name of the office in Hindi and on the other in English and the regional language. The board should be erected at right angles to the building and immediately over the door of the office or room to which it refers.
   vi. The wording on sign-boards, the direction of arrows and platform numbers should be decided by Divisional Officers of the Engineering, Operating and Commercial Departments.
   vii. All notice boards shall be erected and maintained by the Engineering Department.
   viii. For smaller stations, black lettering on white background may be used for all kinds of sign boards which may be painted on one side only and fixed to the wall.

Platform number signs - These may be on enamel plates to the following specifications:-
   Size of board .. 600 mm square
   Size of letter .. 300 mm
   Colour - white figure on blue background.
Soil Mechanics

The branch of physical science which deals with the properties, nature and performance of soil as a construction and foundation material is called soil mechanics.

**Soil Properties –**

**Porosity –**

The ratio of the volume of voids to the volume of soil mass is called porosity.

\[
\eta = \frac{V_v}{V} \times 100, \quad \eta = \frac{V_v}{V_s + V_v} \times 100 = \frac{V - V_s}{V} \times 100, \quad \eta = (1 - \frac{V_s}{V}) \times 100,
\]

**Void ratio –**

Void ratio \(e\) of a given soil sample is the ratio of the volume of voids to the volume of soil solids in the given soil mass.

\[
\text{Thus } \quad e = \frac{V_v}{V_s}, \quad V = V_s + V_v, \quad V_v = V - V_s, \quad e = \frac{V - V_s}{V_s} = \frac{V_v}{V_s} - 1,
\]

\(V_v\) = Volume of voids. \(V_s\) = Volume of soil solids.

**Degree of Saturation –**

The ratio of volume of water in a given soil mass to the volume of voids is called degree of saturation.

\[
S = \frac{V_w}{V_v} \times 100,
\]

**Water Content –**

The water content \(w\) also called the moisture content is defined as the ratio of weight of water \(W_w\) to the weight of solids \(W_s\) in a given mass of soil.

\[
W = \frac{W_w}{W_s} \times 100
\]

The water content is generally expressed as a percentage.

The free water may be in any one of the following forms –

1. **Gravitation Water** – It is the water which is in excess of the amount of moisture the soil can retain.
2. **Capillary Water** – It is the water which is present due to the capillary action of the soil mass.
3. **Absorbed Water** – It is the water which is present in a dense state. It is also referred as contact moisture or hygroscopic moisture. It is not affected by gravity.

This moisture is removed by drying the soil particles at \(105^0\) C to \(110^0\) C.

Gravitational and Capillary water is removed by drying the soil sample in the air. Water content is determined in the laboratory by drying the soil sample in an electric oven at \(105^0\) C to \(110^0\) C for 24 hrs.

**Specific Gravity –**

The ratio of unit weight of material to the weight of some reference material is called specific Gravity of the material.

\[
\gamma_s = \frac{W}{V}, \quad \text{Where } \gamma_s = \text{Unit weight of the material, } \gamma_w = \text{Unit weight of water.}
\]

**Unit Weight / Density –**

The weight of soil per unit volume is called unit weight or density.

It is denoted by \(\gamma\) and is expressed as gm / cc.

\[
The \text{ weight of soil per unit volume is called unit weight or density. It is denoted by } \gamma \text{ and is expressed as gm / cc. }
\]

\[
\gamma = \frac{W}{V}, \quad \text{Where } W = W_w + W_s \quad V = V_a + V_u + V_s
\]

Unit weight is further classified as –

1. **Bulk Unit Weight** – The total weight of a soil mass per unit of its total volume is called bulk unit weight or bulk density or mass unit weight.
2. **Dry unit Weight** – The weight of solids per unit of total volume of a soil mass is called dry unit weight or dry density.

\[
\gamma_d = \frac{W_s}{V}
\]
The dry density \( \gamma_d \) or the dry unit weight is the weight of solids per unit of total volume (prior to drying) of the soil mass. 

\[
\frac{W_s}{V} = \gamma_d \quad \text{gm/cc.} \quad \text{or} \quad \frac{\gamma}{1 + W} = \frac{\gamma_d}{\text{gm/cc.}}
\]

**Example** - If wet density of a soil is 1.9 gm per cm at a moisture content of 24%, what will be its dry density?

**Solution**: Given - Wet density of a soil \( \gamma = 1.9 \text{ gm/cm}^2 \)

Moisture content \( w = 24\% = 0.24 \)

Dry density \( \gamma_d = \gamma / (1 + w) = 1.9 / 1 + 0.24 = 1.9 / 1.24 = 1.53 \text{ gm/cm}^2 \) \( \text{Ans.} \)

**Example** - The field density of a compacted fill is determined by means of a core cutter whose empty weight is 1000 g and volume is 1000 cm\(^3\). The cutter full of soil weighs 2890 g. If the water content is 11%, what is the dry density?

**Solution**: Weight of empty core cutter – 1000 g.

Volume of core cutter – 1000 cm\(^3\).

Weight of core cutter with full of soil – 2890 g.

Weight of soil in core cutter = 2890 – 1000 = 1890 g.

Field density of soil = Weight of soil / Volume of Soil = 1890 / 1000 = 1.89 g./ cm\(^3\).

Water content in soil – 11%.

Weight of water in soil = 11 \times 100 \times 1890 = 207.90 g.

Weight of dry soil = 1890 – 207.90 = 1682.10 g.

Dry density of soil = Weight of dry soil / Volume of Soil = 1682.10 / 1000 = 1.68 g./ cm\(^3\).

**Ans.**

3. **Saturated Unit** – The bulk density of a soil mass when fully saturated is called a saturated unit weight or saturated density.

4. **Submerged unit weight** – The submerged weight of solids per unit of total volume of a soil mass is called submerged density or buoyant unit weight or effective unit weight.

5. **Unit weight of solids** – The weight of solids per unit volume of solids is called Unit weight of solids or density of solids.

**Soil Consistency** –

The property of the material which is evident by its resistance to flow is called consistency.

A fine grained soil can exist in any one of the following states –

1. **Liquid State** – A fine grained soil mixed thoroughly with large quantity of water is said to be in liquid state. In this state the soil dose not offer any resistance to deformation.

2. **Plastic State** – When the water content is reduced to such an extent that the shape of soil can be changed with out producing surface cracks then the state of soil is said to be in plastic state. In this state the soil offers resistance to deformation.

3. **Semi Solid State** – When the moisture content is further reduced to such an extent that cracks start forming then the soil is said to be in semi solid state. In this state the soil loses plasticity.

4. **Solid State** – When the moisture content is further reduced to such an extent that no further change in volume takes place in the clay soil mass no shrinking takes place the soil is said to be in solid state. The colour of the soils change in this state and the clay takes on a lighter shade.

**Consistency Limits** –

The percentage moisture contents at which the soil passes from one state to another are called consistency limits.

1. **Liquid Limit** – The minimum moisture content at which the soil is still in liquid state but has a small shear strength against Plastic Limit & shrinkage limit is called liquid limit.

Soil having liquid limit more then 35 is not good and soil having 50 liquid limit is not at all stable.

2. **Plastic limit** – The minimum moisture content at which the soil can be rolled into 3 mm threads with out showing any sign of cracks is called Plastic limit.

3. **Shrinkage Limit** – The moisture content at which reduction in water content will not cause a decrease in volume.
4. Plasticity Index – It indicates the Plastic range of the soil and is the numerical difference between liquid limit and Plastic limit. ∴ PI = LL – PL.

This index depends on the Plasticity of soil –

<table>
<thead>
<tr>
<th>Plasticity Index</th>
<th>Degree of Plasticity</th>
<th>Plasticity Index</th>
<th>Degree of Plasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>Non Plastic.</td>
<td>15 – 40</td>
<td>Plastic.</td>
</tr>
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</table>

Soil Classification By Plasticity Index

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Types of Soil</th>
<th>Degree of Plasticity</th>
<th>Consistency limits</th>
<th>Limit of Plasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Liquid Limit</td>
<td>Plastic Limit</td>
</tr>
<tr>
<td>01.</td>
<td>Sand</td>
<td>Nil</td>
<td>20</td>
<td>20</td>
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<tr>
<td>02.</td>
<td>Silt</td>
<td>Low</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>03.</td>
<td>Silty Clay</td>
<td>Medium</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>04.</td>
<td>Clay</td>
<td>High</td>
<td>70</td>
<td>40</td>
</tr>
</tbody>
</table>

5. Liquidity Index – The ratio of the difference between natural water content (W) of the soil and its plastic limit.

\[ \text{L.L.} = \frac{W - W_p}{P.I.} \]

Capillarity – It is the ability of the soil to transmit moisture in all directions regardless of any gravitational force.

Compressibility –
Gravels, sands and silts are incompressible if a moist mass of these materials is subjected to compression, moisture and or expulsion of air resulting in a reduction in volume which is not immediately recovered when the compression load is withdrawn. The decrease in volume per lunette increase of pressure is defined as the Compressibility of the soil.

Compression of soil – The phenomenon of the gradual reduction in volume of soil due to expulsion of water from its voids is called compression.

Elasticity – A soil is said to be elastic when it suffers a reduction in volume or change in the shape and bulk while the load is applied recovers its initial volume immediately when the load is removed.

Optimum moisture content – The maximum moisture content in the soil after which the addition of water creates hindrance in bringing the particles closer, is called Optimum moisture content (OMC).

It may be clearly noted if the moisture content of the soil is more than the Optimum moisture content no compaction of the soil is possible because of too wetness.

Permeability – Permeability may be defined as a property of soil which permits the flow of water through its interconnecting voids.

Resiliency – It is graded as extreme limit to which material can repeatedly be strained without fracture or permanent change of space.
Shear Strength – The shear strength of soil may be defined as the property of the soil which enables it to maintain equilibrium on a sloping surface. It plays an important role while designing earth, dams, canals.

Constituents of soils – Soils contain three constituents’ air, water and solids. The solids are a mixture of mineral matters with particles differing in size, shape and structure and varying in chemical composition.

Density index – The term density index \( I_d \) or relative density or degree of density is used to express the relative compactness of a natural soil deposit. The density index is defined as the ratio of the difference between the void ratio of the soil in its loosest state \( e_{\text{max}} \) and its natural void ratio \( e \) to the difference between the voids ratios in the loosest and densest state –

\[
I_d = \frac{e_{\text{max}} - e}{e_{\text{max}} - e_{\text{min}}}
\]

Where - \( e_{\text{max}} = \) voids ratio in the loosest state. \( e_{\text{min}} = \) voids ratio in the densest state.

This term is used for cohesion less soils only.

Classification of soils – In view of the wide diversity of the soil types, these have been classified into groups or classes according to their particle size and cohesive properties-

1. Fine grained Soil – The soil that consists of fine grains is called fine grained soil or cohesive soil. Silt is a fine grained soil with little or no plasticity. Clay is formed from the disintegration and decomposition of rock constituents.

The cohesion in a soil mass increases with the increase of fine particles. Clay is more cohesive than silt. The particles of fine grained soil are not visible to the naked eye. The size of clay particles is less than 0.075 mm (75 microns.)

2. Course Grained Soil – The soil that consists of coarse grains is called coarse grained soil. It is also known as cohesion less soil or granular soil. Sand and Gravels fall in this category. There is no cohesion between coarse particles.

Coarse grained soils are unsuitable for the construction of embankments as these soils are more permeable.

3. Organic soil – The soils that contain organic matter are called organic soils. The organic matter generally consists of decomposed remains of plants and animal organism.

This type of soil is unsuitable for civil engineering construction.

Characteristics of soils – Characteristics of a soil are important in predicting the performance of the soil under load, which depends upon the grain size, shape. Surface texture and chemical composition. The property having most influence on the physical characteristics is that of particle size distribution, and therefore it is essential to determine the extent with which each is present.

There is wide variation the characteristics of different soils and the performance of each individual soil is affected by its moister content and density. In general the properties of soils composed largely of clays and colloids, the properties are primarily controlled by the moisture content. Behavior of soils containing 30% or more clay depends solely on the Characteristics of the soil.

Important Properties of soils – The following properties of soil are generally to be specially studies as these have important bearing on design of structures.

i. Particles size of soils.
ii. Porosity and void ratio.
iii. Degree of saturation.
iv. Unit weight and water weight.
v. Specific gravity.

Compaction and consolidation of soil –

Compaction - The process of increasing the dry density of soil by artificial methods and packing the soil particles together into a dense mass to sustain a dynamic load, is termed as compaction.

Consolidation – A gradual expulsion of water from the pores of a saturated clay by a continuous pressure due to the load of the structure takes place and thus the volume of soil mass decreases. On the other hand, compaction is a quick process for reducing the volume of soil mass by applying dynamic loads.

Effect of compaction on soil properties –

Compaction is resorted to get the following main effect on soil properties –

i. To increase the density as well as bearing capacity of soil.
ii. To increase the shearing strength of the soil.
iii. To decrease the changes of settlement under repeated loads and also to retard the permeability of soil.

Determination of Index Properties –

Water Content – The water content of a soil sample can be determined by the following methods –

1) Oven drying method.
2) Sand bath method.
3) Alcohol method.
4) Calcium carbide method.
5) Pycnometer method.

Oven drying method is the most accurate method of determining the water content. A clean non-corrodible container is taken and its mass is found with its lid, on a balance accurate to 0.01 g. A specimen of the moist soil is placed in the container and the lid is replaced. The mass of the container and the contents is determined. With the lid removed the container is then placed in the oven for drying at the temperature between 105°C to 110°C. After drying the container is removed from the oven and allowed to cool in a desiccator. The lid is then replaced and the mass of container and the dry soil is found. The water content is calculated from the following expression –

\[ w = \frac{M_2 - M_3}{M_1} \times 100 \text{ (percent) } \]

Where – 
- \( M_1 \) = mass of container with lid.
- \( M_2 \) = mass of container with lid and wet soil.
- \( M_3 \) = mass of container with lid and dry soil.

Sand bath method. – This is a field method of determining rough value of the water content. The container with the soil is placed on a sand bath. The sand bath is heated over a kerosene stove. The soil becomes dry within \( \frac{1}{2} \) to 1 hour.

Alcohol method – This also crude field method. The wet soil sample is kept in an evaporating dish and mixed with sufficient quantity of methylated sprit. The dish is then properly covered and the mixture is ignited. The mixture is kept stirred by a wire during ignition. The water content is calculated from the following expression –

\[ w = \frac{M_2 - M_3}{M_1} \times 100 \text{ (percent) } \]

Where – 
- \( M_1 \) = mass of empty dish.
- \( M_2 \) = mass of dish + wet soil.
- \( M_3 \) = mass of dish + dry soil.

Calcium carbide method – In this method 6 g of the wet soil sample is placed in an air tight container called moisture tester and is mixed with sufficient quantity of fresh calcium carbide powder. The mixture is shaken vigorously. The acetylene gas produced by the reaction of the moisture of the soil and the calcium carbide, exerts pressure on a sensitive diaphragm placed at the end of the container. The dial gauge located at the diaphragm reads the water content directly. The method is very quick the result can be obtained in 5 to 10 minutes. This method is specially suited to a circumstance where water content is to be quickly determined for the purpose of proper field control such as in the compaction of an embankment.

Pycnometer method – This id also a quick method of determining the water content of those soils whose specific gravity is accurately known. Pycnometer is a large size density bottle of about 900 ml capacity. A conical brass cap having a 6 mm diameter hole at its top is screwed to the open end of the pycnometer. A rubber washer is placed between conical cap and the rim of the bottle so that there is no leakage of water.

**Producer** – Take a clean dry pycnometer and find its mass with its cap and washer ( \( M_1 \) ). Put about 200 g to 400 g of wet soil sample in the pycnometer and find its mass with its cap and washer ( \( M_2 \) ). Fill the pycnometer to half its height and mix it thoroughly with the glass rod. Add more water and stir it. Replace the screw top and fill the pycnometer flush with the hole in the conical cap. Dry the pycnometer from outside and find its mass ( \( M_3 \) ). Empty the pycnometer clean it thoroughly and fill it with clean water to the hole of the conical cap and find its mass ( \( M_4 \) ). The water content is then calculated from the following expression –

\[ w = \frac{[(M_2 - M_1) \times (G - 1)]}{M_3 - M_4} \times 100 \]

Determination of Density -

The field density of a natural soil deposit or of a compacted soil can be determined by the following methods –
1) Sand replacement method.
2) Core cutter method.
3) Water displacement method.
4) Rubber balloon method.

**Sand replacement method** – The equipment in the sand replacement method consists of (i) sand pouring cylinder mounted above a pouring cone and separated by a valve or shutter. (ii) Calibrating container. (iii) Tray with central circular hole. (iv) Chisel, scoop, balance.

**Calibration of the cylinder** - This consists of the determination of the weight of sand required to fill the pouring cone of the cylinder and the determination of the bulk density of sand. The cylinder is filled up to a height 1 cm below the top with 300 micron sand and its initial mass \( M_1 \) is taken. The sand is run out of cylinder, equal in volume to that of the calibrating container. The cylinder is then placed over a plane surface and the sand is allowed to run out to fill the cone below. When no further sand runs out the valve is closed. The sand filled in the cone is collected and its mass \( M_2 \) is found. All the sand is then refilled in the cylinder so that the total mass of sand and cylinder is equal to the original mass \( M_1 \). The cylinder is then put centrally above the calibrating container and the sand is allowed to run into the calibrating container. The valve is closed when there is no further movement of sand. The mass of cylinder with sand is found \( M_3 \). The mass \( M \) of the sand required to fill the calibrating container will be equal to \( M_1 - M_3 - M_2 \). The mass \( M \) divided by volume of the calibrating container gives the bulk density of the sand. All the sand is than refilled in the cylinder.

**Measurement of soil density** – A test hole approximately of a depth equal to that of the calibrating container is excavated in the ground and the soil is collected in the tray. The mass \( M \) of the excavated soil is found. The cylinder is centrally placed over the hole and the sand is allowed to run it. The valve is closed when no further moment of sand takes place. The mass \( M_4 \) of the cylinder and the remaining sand in it is measured. The mass \( M \) run into the hole up to level ground surface will evidently be equal to \( M_1 - M_2 - M_4 \). Dividing \( M \) by the bulk density of sand the volume of the hole and hence the volume \( V \) of the excavated soil is known. Dividing the mass \( M \) by the volume \( V \), the bulk density \( \rho \) of the soil excavated is known.

**Dry density** – A suitable sample of the excavated soil is kept for water content \( (w) \) determination. The dry density \( \rho_d \) of the soil will be equal to the bulk density divided by \( (1 + w) \).

**Core cutter method.** – A Core cutter consisting of a steel cutter 10 cm in diameter and about 13 cm high and a 2.5 cm high dolly is driven in the cleaned surface with the help of a suitable rammer till about 1 cm of the dolly protrudes above the surface. The cutter containing the soil is dug out of the ground the dolly is removed and the excess soil is trimmed off. The mass of the soil in the cutter is found. Measure the inside dimensions of the core cutter and calculate its volume. By dividing it by the volume of the cutter the bulk density is determined. The water content of the excavated soil is found in the laboratory and the dry density is computed.

**Water displacement method** – A small specimen is trimmed to a more or less regular shape from a larger sample and its mass \( M_1 \), is found. The specimen is covered with a thin layer of paraffin wax and the mass \( M_2 \) of the coated specimen is taken. A metal container is filled above the overflow level and excess water is allowed to run off through the overflow outlet. The coated specimen is then slowly immersed in the container and the overflow water is collected in a measuring jar. The volume \( V_w \) of the displaced water is thus known. The volume \( V \) of the uncoated specimen is then calculated from the relation:

\[
V = V_w \frac{M_2 - M_1}{G_p} \]

Where - \( G_p \) = density of paraffin wax (g/ml)

**Rubber balloon method** – In this method the volume of the excavated hole is measured with the help of an inflated rubber balloon. The apparatus consists of a graduated glass or Lucite cylinder enclosed in an air tight aluminium case, with an opening in the bottom and a tray with central circular hole of 10 cm diameter. The cylinder is partially filled with water. Pressure or vacuum can be applied to the bottom of the cylinder with the help of a double acting rubber bulb. The ground surface is cleaned and leveled and tray is placed over it. The cylinder is then placed centrally over the tray. The air valve is opened and air is pumped into the cylinder until the balloon is completely inflated against the surface of the soil in the opening of the tray. The water level is read in the cylinder and removed and a hole is excavated in the ground. The excavated soil is weighed and a sample is kept for water content determination. The cylinder is then placed over the opening in the tray, air valve is opened and air is forced in the cylinder to inflate the bottom until the base of the instrument is raised off.
the tray at least by 1 cm. The air valve is closed and both feet are placed firmly on the base plate so that the balloon is forced into any irregularities in the hole. The water level is read in the cylinder and volume of the hole is found from the difference between the initial and final water level in the glass cylinder. Knowing the mass, volume and water content, the bulk density and dry density can be computed.

**Determination of Consistency Limits –**

1. **Liquid Limit –** It is determined in the Laboratory with the help of standard liquid limit apparatus consisting of a hard rubber base over which a brass cup drops through a desired height. The brass cup can be raised and lowered to fall on the rubber base. Before starting the test the height of fall of the cup is adjusted to 1 cm. Two types of grooving tools are used – (i) Casagrande tool cuts a groove of size 2 mm wide at the bottom 11 mm wide at the top and 8 mm high. (ii) ASTM tool cuts a groove of size 2 mm wide at the bottom 13.6 mm wide at the top and 10 mm deep used for sandy soils.

About 120 g of the specimen passing through 425 micron sieve is mixed thoroughly to form a uniform paste. Paste is placed in the cup and the groove is cut in the soil paste. The handle is rotated at a rate about 2 revolutions per second and the number of blows are counted until the two parts of the soil sample come into contact at the bottom of the groove along a distance of 10 mm.

Liquid limit is the percentage moisture content at which the soil has such a shear strength that it flows to close a groove of standard width of 1.25 cm under the impact of 25 blows is a standard liquid limit. Attempts have been made to determine the liquid limit by taking only one reading of water content and its corresponding number of blows. The liquid limit is than estimated from the following equation –

\[ w_L = w \left( \frac{n}{52} \right)^E \]

Where – \( w \) = water content corresponding to \( n \) number of bellows. \( w_L \) = water content at liquid limit. \( E \) = index the value of which varies from 0.068 to 0.121

**Specification for Back – fill behind the abutments of bridges**

**Dry Rubble** - At the bank of all bridge abutments and wing walls, the space next to the masonry is to be filled in by a hand-packed dry rubble backing, to the thickness shown on the plans, or as directed by the Engineer.

**Filling** - Behind this dry rubble, the space up to the back of the excavation is to be filled with moorum, good granular yellow soil or other sound granular materials. Under no circumstances is black cotton or any clayey or silty soil to be used. This filling will be watered and rammed in layer thickness. Each layer should have a slope of 45° towards ground level, the slope to commence from immediately behind the abutment.

**Rehabilitation of weak Formation**

With introduction of high speed heavier axle loads and an increase in traffic density the necessity of rehabilitating the existing poor formation has assumed greater importance. Poor formation on central Railway has been in two categories –

1. **Very bad** – Where either speed restriction are necessary or instances of maintenance is very high even for existing speed.

2. **Bad** – Where existence of maintenance is high and introduction of high speed is only possible only after rehabilitation.

**Pre requisites of a stable formation –**

i. The bank should not be prone to structural failure.

ii. The formation should be able to withstand load with out excessive settlement.

iii. The formation should be such that the ballast dose not puncture in to it even during the worst condition when the soil is fully saturated.

iv. No mud pumping should take place so that the ballast under sleepers remain clean and elastic.

v. It should be possible to maintain the track to the stipulated standard with normal maintenance.

**Design of Railway Formation**

i. A stable formation should be able to sustain the track geometry under anticipated traffic densities and axle loads during service under most adverse conditions of weather & maintenance of track structure, which are likely to be encountered.

ii. The formation should be structurally sound and the settlements should be within limits.

**Types of Failure of Formations –**
1. Structural Failure or Constructional Failure - It is caused due to unstable bank and will depend upon the nature of strata below ground, shear strength of the bank soil, height of bank and the external forces to which the bank is subjected. Such failures can either be -

(i) Base failure of foundations –
If the sheer failure caused below the ground level. It is known as base failure and it is generally associated with unheaval of nature of ground beyond the toe of bank. Such failure normally occurs either during the construction period or even after a short period after the full dead or live load is induced over the ground. This may also occur sometime at a later stage if soil is removed due to excavation closes to the toe of bank.

(ii) slope failure or Slip circle in embankment failure –
If the failure takes place within the body of the embankment, due to inadequate section of the bank profile, it is known as slope failure or Slip circle in embankment failure.

2. Settlement Failure -
If the Railway embankment are constructed with adequate compaction, consolidation during construction, such trouble can be avoided.
If the strata over which the embankment is constructed consists of high compressible clay, the settlement of the bank takes place even if the new embankment is compacted due to consolidation.

3. Formation Failure -
This can occur in following three ways –
i. Local shear failure.
ii. Mud pumping.
iii. Formation of Ballast pockets.

4. Development of cracks in formation -
This type of cracks are always seen during monsoon in the banks which are constructed out black cotton soil. Such black cotton soil has high shrinkage when dry and high swelling capacity under the wet condition. Cracks are found during summer.
The condition gets worst during rains as water finds access inside the formation to the cracks, resulting in swelling.

Investigations –
History of the bank – The past history of the bank such as –
i. Speed restriction.
ii. Slip of the bank.
iii. Settlement.
iv. Heaving of cess etc.
v. Other troubles such as drainage.
vi. Maintenance problem.
vii. Depth of ballast penetration.
Collect detail information on the above items.

Various types of remedial measures –
The nature of the measures will depend upon the trouble experienced. The measures will depend upon the trouble experienced. The measures adopted for these types of troubles are given below –

1. Structural Failure or Constructional failure - If the bank profile is inadequate here by causing either slope or base failure, such failure can be checked by adopting one of the following measures -
i. Provision of flater slope.
ii. Provision of Sub banks.

iii. Provision of vertical piles.

2. Settlement Failure - The troubles due to settlement failure can be avoided only if care is taken during the construction for an expediting consolidation of the strata below the ground level and eliminating settlement due to consolidation in the bank soil. It will be very difficult to eliminate the trouble due to settlement in an existing embankment. Therefore the following methods are adopted -

Blanket

- The layer between the ballast & the sub grade is the blanket

- Functions:
  1. Reduce stress to sub grade
  2. Keep sub grade & ballast separate
  3. Prevent upward sub grade fines migration
  4. Prevent sub grade attrition by ballast
  5. shed water from above
  6. Drain water from below

- Ballast fulfills function (1) only
- Blanket fulfills all functions and including function (1), it reduces the otherwise required greater thickness of the ballast.
- In the absence of a blanket layer a high maintenance effort can be expected
- In addition, blanket dampens vibration.

Properties of Blanket Material

- Reduce stress to sub-grade:
- To serve as a structural material, it must have a
  - High enough resilient modulus
  - Stable plastic strain accumulation characteristic under repeated wheel load
- To achieve these properties
  - The material must be permeable enough to avoid significant positive pore pressure build up under repeated load
  - Must consist of durable particles
  - Must not be sensitive to changes in moisture content
- Such a material is represented by mixtures of sand & gravel particles composed of crushing and abrasion resistant materials.
- Particle Separation: - Must Prevent
  - Intermixing of ballast & sub-grade
  - Upward migration of sub-grade particles into the ballast

These properties can be achieved by proper gradation.

Separation Criteria

- D15(filter)<5D85 (protected soil) ……. (i)
- D50(filter)<25 D50 (protected soil) ……. (ii)

The criterion in (i) Causes the particles at the coarsest end of the protected soil (D85) to be blocked by the particles at the finest end of the filter (D15).

The criterion in (ii) helps to avoid gap graded filters and create a filter gradation that is somewhat parallel to that of the protected soil.

- % Fines (Passing 75µ) up to 5% plastic fines & upto12% non-plastic fines
- No skip grading, coarse granular & well graded & more or less within enveloping curve.

- The material –well graded with Cu & Cc as below:
  - uniformity coefficient, Cu = D60 /D10 > 4(preferably >7)
  - coefficient of curvature, Cc = (D30)²/D60 /D10 within 1 & 3

Required Ballast/Blanket Depth

- A min. ballast layer thickness is needed to provide for maintenance tamping & for void storage space
- A min. sub-ballast layer thickness is required for performing the functions of a separation/filter layer
- In addition, the combined ballast/blanket thickness must be sufficient to prevent progressive
shear sub-grade failure, and excessive rate of settlement through plastic strain accumulation in the sub-grade
• As per RDSO guidelines, thickness of blanket required is 0 to one meter as per soil used in top one meter of sub-grade & Axle load.

**Depth of Blanket Layer**
• For axle load up to 22.5 t for different types of sub-grade soils (in top one meter)
  – No need of blanket for soils
  • Rocky beds except shales & other soft rock, which are susceptible to weathering or becomes muddy on contact with water
  • GW – well graded gravel
  • Soil confirming to blanket material
  • Soil having grain size distribution curve lying on right side of enveloping curve of blanket material in consultation with RDSO
• 45 cm thick blanket for soils
  – 1.GP having Cu > 2, 2.SP having Cu > 2,
  – 3.GM, 4.GM-GC
• 60 cm thick blanket for soils
  – 1.GC, 2.SM, 3.SC, 4.SM-SC
  – 5.Should increase to one meter if PI > 7
• 100 cm thick blanket from soils
  – 1.ML, 2.ML-CL, 3.CL, 4.MI, 5.CI
  – Rocks which are very susceptible to weathering
• Soils having fines between 5 to 12% having dual symbol e.g. GP-GC, SW-SM etc. provide thickness as per second symbol
• Geo – synthetics can be used in consultation with RDSO as it reduced requirement of thickness of blanket.
• Blanket should be provided in new construction on all lines (even with light passenger traffic)
  – In cohesive sub-grade even 100 cycles of repeated load in excess of threshold strength will cause failure of formation.
• In case more than one type of soil in top one sub-grade, soil requiring higher thickness of blanket will govern.
• For other types of soils not covered above, RDSO may be consulted for deciding thickness of blanket
• For higher axle loads
  – Above 22.5 t up to 25 t
    • Add 30 cm thickness over & above as given for 22.5 t
  – Above 25 t up to 30t
    • Add 45 cm thickness over & above the given for 22.5t

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**INSPECTION & MAINTENANCE OF BUILDINGS**

**Plinth Area For Various Types Of quarters –**
Board Letter No. 17020 (4) / w . 2  dt. 14 – 8 – 75
Revised scale of Plinth area

<table>
<thead>
<tr>
<th>Type</th>
<th>Area of unit m²</th>
<th>Stair cash m²</th>
<th>Balcony m²</th>
<th>Cycle shed / scooter garage</th>
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</thead>
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<td>34.00</td>
<td>5.00</td>
<td>7.45</td>
<td>2.50</td>
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<tr>
<td>II</td>
<td>45.00</td>
<td>5.00</td>
<td>7.45</td>
<td>2.50</td>
</tr>
<tr>
<td>III</td>
<td>55.75</td>
<td>5.00</td>
<td>7.45</td>
<td>4.20</td>
</tr>
<tr>
<td>IV</td>
<td>83.60</td>
<td>5.50</td>
<td>7.80</td>
<td>4.20</td>
</tr>
<tr>
<td>V</td>
<td>139.35</td>
<td>6.00</td>
<td>9.85</td>
<td>18.00</td>
</tr>
<tr>
<td>Servant Qr. attached</td>
<td>18.60</td>
<td>4.50</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1. These plinth area standards shall be applicable to the construction of residential accommodation in all places in India.
2. Plinth areas proposed above are based on the wall thickness achieved by using standard bricks size 9" x 45" x 3" (nominal). Where wall thickness has to be more for technical reasons. Plinth area may be suitably increased.
3. Sleeping out balconies shall be provided in regions of hot & dry climate and for construction, which is, more than two storied.
4. The area of sitting out balconies in Bombay & Calcutta will be 1.5m² for type I 2.5m² for type II 3.5m² for type III 4.5m² for type IV 5.50 m² for type V.
5. Areas of sleeping and sitting out balconies may vary with the type design depending on the architectural and structural considerations.
6. In hot and dry regions sitting out balconies must be provided for two-storied construction.
7. In the case of type I, II, and III qrs. The standard plinth area may be exceed up to 2% when found necessary on architectural considerations.
8. In type II qrs car garages will be provided for 75% of the number of units to be constructed out of this ¼ ′th of the garages will be partitioned temporarily so as to provide scooter sheds for remaining 50% of the allottees.
9. In case of double stori ed qrs. cycle or scooter sheds shall not be provided. Also no scooter/cycle sheds will be provided in Bombay & Calcutta.
10. Stair case/Circulation area is based on a stair width of 3′-6″.

****************************

**Lesson 1**

**Basic Amenities in staff quarter –**
All Staff quarters should be provided with the following basic amenities -
2. Individual Bathroom.
3. Individual sanitised Latrines – Where ever individual Latrines are not feasible due to space constraints as in the case of back to back Qrs sanitised community Latrines should be provided.
4. Basic Ventilation arrangements – The above amenities may be provided on a Programme basis where ever these are not available.

**************************
Type of Flooring, Wall surface in Staff Qrs.–

The following standards should be generally observed unless otherwise directed by the CE -

   a) Officer Quarters -
      i. Flooring – Mosaic flooring
      ii. Wall Surface – Dado & Floor of Bath room – Ceramic Tiles.

   c) Other than officer’s Quarters –
      i. Flooring – Cement Concrete.
      ii. Wall Surface – Dado in Bathrooms with same material as flooring skirting in other rooms.

Type of Flooring, Wall surface and colour of wood and steel work in Service Buildings –

   c) Hospitals and Dispensaries –
      1. Important rooms & Bathrooms -
         ii. Flooring – Mosaic or Terrazzo or non-slippery ceramic tile.
      iii. Wall Surface – 1.2 m. height dado Mosaic or terrazzo. Wall – distemper or ceramic tiles and ceiling distempered.
      iv. Woodwork & steel work - White Paint.
   2. Un important rooms –
      i. Flooring – Cement concrete and mosaic floor only for Bathrooms.
      ii. Wall Surface – Cement dado 1.2 m. height wall ceiling white wash.
      iii. Wood work & steel work - Buff or Brown Paint.

   d) Staff canteens -
      i. Flooring – Marble chip flooring or anti slippery ceramic tile.
      ii. Dado - 1.2 m. Height mosaic or ceramic.
      iii. Wall - white washed.
      iv. Glazed Tiles – serving counter, dishwashing place & 1.2 m. high dado on walls above the kitchen counter slab.

Use of new material-
New material available in market may be used if found suitable from the consideration of cost contractibility and aesthetic with the approval of concerned SAG officer.

************************************************************************

Lesson 1 Sub Lesson 4

Colour For timber , steel Work and Walls in Staff Qrs.-

Colour for painting of walls, timber work and steel work of staff Qrs. may be as follow as directed by the Chief Engineer -

1.   Doors, Window and structural wood work of officer’s and senior Group c Staff Quarters –
   Frames of doors & windows & structural Woodwork – White, cream, buff or brown.
   Venation & panels – Cream or light brown.
   Doors & Windows of Officer’s quarters – Polished or varnished, doors & Windows likely to come in contact with water may be painted with epoxy Paint.
2. All woodwork of C & D Quarters - dark battle ship gray or buff.
3. All Steel Work in Residential Quarters – Aluminum or Dark battleship gray.
4. Exterior Plastered - Pale Cream.
5. Interior Plastered - White, pale Cream, Pale Green, Pale Blue.

All exposed steel work should be provided with a primer coat of red lead and appropriate final coats.
C.I. & G.I. sheets should not be painted unless they are in corrosion prone areas.

Colour For timber, steel Work and Walls –

6. All Wood Work in offices –
   Oiled / polished or Varnished or Painted with approved paints.
7. Doors, Window and structural wood work of officer’s and senior
   Group c Staff Quarters –
   Frames of doors & windows & structural Woodwork – White, cream, buff or brown.
   Venation & panels – Cream or light brown.
   Doors & Windows of Officer’s quarters – Polished or varnished, doors &
   Windows likely to come in contact with water may be painted with epoxy Paint.
8. All woodwork of Building & structure other than 1 & 2-station Building and C & D Quarters -
   dark battle ship gray or buff.
9. All Steel Work in Station buildings, Offices and Residential Quarters – Aluminum or Dark
   battleship gray.
10. Steel Work on P.F. - Grey, Aluminum or red.
11. Steel Work in FOB, Bridges, Signal gantries, Goods shed and small work shop - Grey,
   Aluminum or red.
12. Steel Work in Power House & Large Work Shop – Grey or Aluminum.
13. Steel work in Water Tank & Staging – Grey or Red or aluminum or black.
15. Exterior Plastered - Pale Cream.
16. Interior Plastered - White, pale Cream, Pale Green, Pale Blue.
17. Buffer Stops - Black & buffer beam red.

Rest Houses –
Officer’s rest house should be separated from the subordinate rest house. Provision should be
made for Dormitory accommodation for Group D staff.

Railway institute –
Railway institute with its ancillaries should be considered as a club provided and maintained
rent free for the benefit of railway employees.

RMS Building in Railway –
The RMS building and maintenance works will be carried out by the Railway after mutual
discussion between the Railway administration and the Postal authorities. Funds will be
provided by Postal department.

Building for Railway Police –
   i. Provision of barracks – railway will continue to provide barracks for GRP.
   ii. Provision of Quarters -
Leasing of railway land for quarters – 
The responsibility of provision of quarters to the GRP primarily rests with the state Governments.

Provision of quarters – 
Construction of Quarters for GRP on the land so leased is to be done by the state Government out of their own funds.

Ownership / maintenance of Quarters – 
The ownership of these quarters will vest with the state government concerned. The railway shall maintain the Quarters and the maintenance charges for the same will be born by the state Government concerned.

Provision of Chicks and venetion blinds – 
1. Hospital
2. Rest House.
3. Running Rooms.
4. Offices at Railway head quarters.
5. Officer’s bungalows and Qrs of senior class III staff.

Additions and Alteration to Quarters – 
1. Additions and Alteration to staff Quarters only of a temporary nature may be permitted.
2. Additions and Alterations of permanent nature shall not be carried out without competent sanction.
3. Additions & alteration to standard type Quarters should not be carried out without the prior approval of the chief Engineer.

Building Registers – 
Building registers in chief engineer’s office and Divisional Engineer’s offices shall be maintained unto date and show complete details of each structure.

Transfer of Buildings – 
1. Each department is responsible for the allotment of staff Quarters under its control.
2. In the case of transfer of staff Qrs from one department to another, the department concerned will carry out the transfer.
3. In the case of occupation of Quarters by a new occupant the SE (wks) will be contacted by the allottee with the allotment order for obtaining the key of the Quarters.
4. In the case of new service buildings the assistant Engineer will fix a date for handing over of the building for use to the department.
5. In the case of buildings constructed by the construction department the open line will take over the same after joint inspection.

Block Numbering of Buildings and structures – 
Every building or structure in a station, yard, railway colony and between stations should be numbered.

Vacant railway Buildings – 
1. As far as possible no railway Quarters should be allowed to remain unoccupied.
2. A return of vacant buildings should be sent by the Divisional Engineer's office to the accounts Department / allotment authority at the end of every month.
Additions and Alteration to Quarters –

1. Additions and Alteration to staff Quarters only of a temporary nature may be permitted to be done by occupant with the prior approval of the Sr DEN and on the specific understanding that the occupant will dismantle the same at the time of vacation of the Quarters.
2. Additions and Alterations of permanent nature shall not be carried out without competent sanction when an existing building is to be enlarged or extended the external architectural features of the old structures should be adhered to as far as possible.
3. Additions & alteration to standard type Quarters should not be carried out without the prior approval of the chief Engineer.

Responsibilities of staff occupying Quarters –

1. All staff is under obligation to keep their Quarters and compounds in a clean and tidy state and to obey all sanitary rules that are in force.
2. Before occupying railway Qrs the occupant should satisfy himself of their condition and sign the prescribed from.
3. Cooking except in kitchen or places specially provided is forbidden.
4. The occupant is responsible for notifying the vacation of his Qrs and for giving reasonable notice to the works, Electrical and telecom staff for inspecting it in his presence.
5. The works and electrical supervisor in charge should inspect the Qrs and submit an estimate of damages attributable to the occupant to enable the department concerned to recover the cost.
6. If there is interval of time from date of vacation of quarters to next occupation the SE ( Wks ) should make necessary arrangements for its safe custody.
7. If is the responsibility of the Engineering staff or special staff where appointed to see that the occupants adhere to instructions laid down. Any breach of instruction should be reported to the occupants immediate superior.

Inspection and maintenance of Building –

Inspection and repairs –

1. All buildings shall be systematically inspected by the section engineer (works) and particulars for repairs submitted to the ADEN repairs requiring urgent attention should be carried out expeditiously.
2. The inspection will be recorded in the inspection register. One page will be allotted for each building.

Performa for inspection register

<p>| Sr. No. | Date of | Official | Condition of | Condition of | Condition of |</p>
<table>
<thead>
<tr>
<th>Initial of inspecting officials</th>
<th>Nature of repairs to be attended</th>
<th>Details of repairs done with date</th>
<th>Initial of occupant</th>
<th>Initial of IOW</th>
<th>Remark of inspecting officials</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>8.</td>
<td>9.</td>
<td>10.</td>
<td>11.</td>
<td>12.</td>
</tr>
</tbody>
</table>

3. The insides of staff quarters should be inspected in the presence of or with prior consent of the occupants.

4. The assistant engineer should inspect as many buildings as possible particularly those requiring heavy repairs and arrange for all repairs to be carried out in good time.

5. S.E. (wks) should inspect all the buildings, water supply installation, sewerage installations and drainage once a year.

6. Advertisement hoardings situated along side the running lines particularly in the Suburban sections should be thoroughly inspected by S.E. (wks)/ J.E. (Wks) once in 6 months by rotation in order to ensure the integrity of their components with special reference to fitments like corrugated iron sheets which are likely to get loose and be impelled towards the adjacent track by gusts of wind or by the aerodynamic force generated by the passage of fast trains in their proximity.

7. In monsoon period repairs or renovation works should not be carried out except pointing and work considered being urgent.

8. Requisition for repairs and renovation works should specify the dates of previous such works without which work orders should not be issued.

9. Planning of repairs should be based on the inspections carried out should be completed well in time to enable the repairs being done under the annual zonal contract which commences from 1st July of each year.

******************************************
Lesson 1

Sub Lesson 8

**Monitoring Maintenance**

1. Petty repair books at station – At each station a ‘Petty repair book’ shall be maintained by station master as per proforma given below –

<table>
<thead>
<tr>
<th>Date</th>
<th>S. No.</th>
<th>Qr. No.</th>
<th>Name of occupant &amp; Designation</th>
<th>Nature of complaint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>2.</td>
<td>3.</td>
<td>4.</td>
<td>5.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Repairs attended on</th>
<th>Remarks for not doing repairs</th>
<th>Sig. Of S.E. (wks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>7.</td>
<td>8.</td>
</tr>
</tbody>
</table>

The section engineer (works) should inspect the books frequently and attend to the repair.

2. (i) In major stations and colonies a complaint book may be kept in SE (Wks) office.
   (ii) Colony committees should be formed in big colonies having more than one thousand Qrs.

   The following persons shall constitute the colony committee ADEN (Chairman), ADMO, HI, SE (Wks), EF (M) one representative of each two recognised unions.

   This colony committee will hold meetings once every two months by 7 days notice to the member.

   The following items will fall under the purview of the colony committee.
   i. Upkeep of the colony including cleanliness of Qrs, their maintenance, roads, drains, water supply, sanitation, boundary wall, street lighting, repairs to outside doors & windows, structural integrity, leaky roof etc.
   ii. Improvement to sub standard Qrs.
   iii. Disposal of waste from colony.
   iv. Prevention of encroachments.
   v. Eviction of encroachments.
   vi. Prevention of cattle nuisance.
   vii. Subletting of Qrs.

3. A list of passenger amenities provided at each station is kept with the station master. The SE (Wks) inspecting the same will verify.

4. Service improvements Groups inspection of stations (SIG) SIG shall be formed at various levels for inspecting all the improvement stations. Representative of Engineering, Medical, Operating and electrical departments shall be the member of the SIG. The SE (Wks) being a member of this Group has a part to play in this scheme by attending to the following item –
   i. Checking up the water taps.
   ii. Water stagnation around the taps on the Platform.
   iii. Clearing up of Platform.
   iv. Walls if defected by pasting of unauthorised posters.
   v. Repairs of Platform drains & washable aprons and side drains.
   vi. Maintenance of toilet in waiting halls, waiting rooms, retiring rooms.
   vii. Availability of water.
   viii. Arresting wastage of water.

***********************************************************
Lesson 1

**Sub Lesson 9**

**Periodical maintenance Works -**
1. Plastering to exterior of Brick masonry should be avoided.
2. No colour washing should be done to the out side of rubble stone masonry.
3. Painting of wood /steel work should normally be done once in 5 to 7 years.
4. Doors , windows and ventilators of kitchens and pantries may be painted once every two year.
5. Valley gutters , down take pipes of service buildings and platform covers should be attended before monsoon.

***********************

Lesson 1

**Sub Lesson 10**

**Periodical Inspection –**

Every structure on the section / sub division shall be inspected in detail by the Section Engineer ( Wks ) / ADEN as indicated below.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Name of Structure</th>
<th>By SE ( Wks )</th>
<th>By ADEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Structure such as Workshop, running sheds , Platform cover and FOB.</td>
<td>One a year during the prescribed month</td>
<td>One fifth every year on a Programme basis</td>
</tr>
<tr>
<td>2.</td>
<td>CI , WI , Pressed steel plate , Water tanks and stagings whether of steel sections or rails.</td>
<td>One a year on a Programme basis</td>
<td>As required</td>
</tr>
<tr>
<td>3.</td>
<td>Structure with roof trusses</td>
<td>Once a year during the prescribed month</td>
<td>10% to 20% test check inspection of structures under each group</td>
</tr>
<tr>
<td>4.</td>
<td>Other structures in which timber , rail or steel work is used to support any part of the structure</td>
<td>- Do -</td>
<td>- Do -</td>
</tr>
<tr>
<td>5.</td>
<td>Tie rods of arched roofs excluding jack arches</td>
<td>- Do -</td>
<td>-</td>
</tr>
<tr>
<td>6.</td>
<td>WI or MS Tanks on sleeper cribs at temporary watering Kilometreages</td>
<td>- Do -</td>
<td>-</td>
</tr>
</tbody>
</table>

The SE (Wks ) shall record results in ink in the structural steel & timber work inspection register and submit the same by the prescribed date to the ADEN who should scrutinise the entries issue such orders as deemed necessary and return the register. Prompt action shall be taken to carry out repairs required.

The SE ( WKS ) shall accompany the ADEN on the letter’s inspection of structures carried out during the prescribed period.

ADEN shall record results of his inspection in ink in the register maintained by SE ( WKS ) and ensure expeditious compliance of notes recorded.

Structures the condition of which warrant special attention should be inspected more frequently.

A defect once mentioned should not be omitted in future years unless it has been eliminated through repair in which care a note should be made to that effect.

When during inspection of building the SE ( Wks ) notices the building to be unsafe for occupation he shall forth with advise the occupant of the fact and also advise the ADEN to get a notice issued to the
occupant for vacation of the premises and to apprise the controlling officer of the occupant of the premises.

**Details of Inspection –**
During inspection the following points should receive attention –

i. The condition of paint.

ii. Whether any corrosion in steel or decay in timber is taking place.

iii. In the case of steel work connected to masonry such as tie rods of arched building and trusses, whether any corrosion is apparent near the masonry.

iv. The condition of welds, rivets, bolts and tie rods particularly of water storage tanks CI Tank plates should be examined for any cracks.

v. Whether any deformation of the structure has occurred.

vi. Foundations and bearing with particular reference to tightness of anchor bolts.

vii. The inspecting official shall make a thorough examination of every part of a structure in all respects.

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**Lesson 1**

**Sub Lesson 11 & 12**

**Schedule of distempering, colour washing and white washing –**

<table>
<thead>
<tr>
<th>Name of building</th>
<th>Colour washing</th>
<th>White washing</th>
<th>W.W. kitchen &amp; pantry</th>
<th>Distempering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rainfall more than 1500 mm</td>
<td>Rainfall less than 1500 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) Service Building</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Hospitals.</td>
<td>Once a year</td>
<td>Once in 2 year</td>
<td>Once a year</td>
<td>Once in 2 year</td>
</tr>
<tr>
<td></td>
<td>-Do-</td>
<td>-Do-</td>
<td>-Do-</td>
<td>-Do-</td>
</tr>
<tr>
<td>2. Refreshment Room.</td>
<td>-Do-</td>
<td>-Do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Rest House.</td>
<td>-Do-</td>
<td>-Do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Running Room.</td>
<td>-Do-</td>
<td>-Do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Station Buildings-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) W / hall, W / room &amp; Bath room</td>
<td>-Do-</td>
<td>-Do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Other rooms.</td>
<td>-Do-</td>
<td>-Do-</td>
<td>-Do-</td>
<td></td>
</tr>
<tr>
<td>6. Offices.</td>
<td>-Do-</td>
<td>-Do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. W. shop &amp; Running shed.</td>
<td>-Do-</td>
<td>-Do-</td>
<td></td>
<td>-Do-</td>
</tr>
<tr>
<td>8. Goods, T.P., Repacking shed.</td>
<td>-Do-</td>
<td>-Do-</td>
<td>-Do-</td>
<td>-Do-</td>
</tr>
<tr>
<td>9. Gate lodges &amp; cabins.</td>
<td>-Do-</td>
<td>-Do-</td>
<td>-Do-</td>
<td>-Do-</td>
</tr>
<tr>
<td>10. Schools.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Lesson 1

**Sub Lesson 13 & 14**

**Schedule of Inspection**

(as per C. E. circular No. 153)

Schedule of Inspection in connection with maintenance of station and important Service building and structures as per C. E. Circular No. 153 are as under –

<table>
<thead>
<tr>
<th>Category of building to be inspected</th>
<th>IOW</th>
<th>AEN</th>
<th>DEN/ Sr DEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Staff Quarters- (a) Staff quarters at wayside stations. (b) Staff quarters in major colonies. 2. Other important Structures and Service buildings- (A) Station buildings:</td>
<td>Once in 6 months.</td>
<td>Once in 2 years.</td>
<td>Once in 3 years or earlier as considered necessary.</td>
</tr>
<tr>
<td></td>
<td>Once in a years.</td>
<td>Once in a years.</td>
<td>Once in 3 years or earlier as considered necessary.</td>
</tr>
<tr>
<td>(i) Station with waiting rooms &amp; refreshment rooms. Way side stations.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(ii) Junction and important Stations.</td>
<td>Monthly</td>
<td>Quarterly</td>
<td>Half Yearly</td>
</tr>
<tr>
<td>Important Service Building –</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(i) Rest house/ Retiring room.</td>
<td>Monthly</td>
<td>Quarterly</td>
<td>Half Yearly</td>
</tr>
<tr>
<td>(ii) Running room.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(iii) Cabins.</td>
<td>Monthly</td>
<td>Quarterly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(iv) Dispensaries.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(v) Hospitals.</td>
<td>Monthly</td>
<td>Quarterly</td>
<td>Half Yearly</td>
</tr>
<tr>
<td>(iv) Administrative offices.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(vii) All sheds (Loco, Goods, IRS type cover over.</td>
<td>Monthly</td>
<td>Quarterly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(viii) Roads, Platforms surface.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(ix) FOB, ROB, RUB.</td>
<td>Monthly</td>
<td>Quarterly</td>
<td>Yearly</td>
</tr>
<tr>
<td>3. Water Supply –</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(a) High Service tanks &amp; Under ground tanks.</td>
<td>Monthly</td>
<td>Quarterly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(b) Filter Plants and Chlorination plants.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(c) open well and tube wells.</td>
<td>Monthly</td>
<td>Quarterly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(d) Reservoirs Dams Infiltration galleries.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>4. Drainage –</td>
<td>Once a year.</td>
<td>Once in 6 months.</td>
<td>At least 5 systems in 2 years.</td>
</tr>
<tr>
<td>(a) Under ground drainage system.</td>
<td>Once in 2 years.</td>
<td>- do -</td>
<td>At least 5 Nos. in 2 years.</td>
</tr>
<tr>
<td>(b) Oxidation ponds.</td>
<td>Once in 2 years.</td>
<td>- do -</td>
<td>At his discretion.</td>
</tr>
<tr>
<td>(c) Septic tanks.</td>
<td>Once in 2 years.</td>
<td>- do -</td>
<td>At his discretion.</td>
</tr>
<tr>
<td>(d) Manholes.</td>
<td>Once in 2 years.</td>
<td>- do -</td>
<td>At his discretion.</td>
</tr>
<tr>
<td>(e) Aqua type chambers.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>5. Gardening –</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(a) Lawn –</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(b) Nursery.</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>6. Land –</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(a) Verification of land boundary in station yard (where IOW is stationed)</td>
<td>Quarterly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
<tr>
<td>(b) Checking encroachments.</td>
<td>Yearly</td>
<td>Half Yearly</td>
<td>Yearly</td>
</tr>
</tbody>
</table>
Lesson 1

Sub Lesson 15

C. E. Circular No 153


(a) Inspection on & maintenance of:
   i. Service buildings, structures and stall quarters.
   ii. Approach roads –
   iii. Foundations & sub structures & Bridges including road & FOB and Protective Works may be specified.
   iv. Water supply, drainage & sewerage system.

(b) Accountal and periodical verification of stores and tools in charge.

(c) Maintenance of land boundaries as may be specified.

Inspection & Maintenance –

1. Residential Building – All Residential building shall be systematically inspected by IOW and his inspection notes recorded in register maintained for the purpose. The details of repairs arising out such inspections should be recorded in the demand register maintained by IOWs.

   AEN will inspect residential buildings particularly those requiring heavy repairs and which are structurally in sound.

   Other important structures and service building should be inspected as per schedule of inspection.

2. Petty repair Registers – should be maintained by station master for all such service buildings and stations and should be scrutinized by section engineer (works) and AEN as frequently as possible and follow up action should be recorded. There in periodical renovation works should be carried out as per IRWW manual.

3. Inspection of structural steel & timberwork – As sub Lesson 10.

4. Water Supply – The water supply arrangements include storage tanks, reservoirs, wells pipelines and accessories such as different type of valves, HS Tank, water purification plants, tube well and water distribution system, meter etc.

   AEN & IOW should frequently inspection all water supply installations and pipe lines and ensure their maintenance in efficient conditions.

   Once ½ year in April & Oct all tanks will be cleaned out and AEN must test check while they are empty and attention given to be stays, bolts, and staging if any. The dates of cleaning should be recorded in the register.

   Sample of raw water, filter water & sterilized water from filter plant should be sent for testing as may be prescribed by DMO and samples from colonies and stations every fortnight flow up action should be taken.

5. Drainage and Sewerage – The AEN & IOW should frequently (but not less then once a year) inspect all drainage system in their change and ensure that maintenance is in efficient condition.

   Sewers line gangs of under the Engg department should attend to cleaning and flushing of all sewers at least twice every month.
Open sullage drains should be maintained in satisfactory condition cleaning and flushing should be done at least once a month.

6. **Roads** – All roads should be inspected by IOW at least twice a year and maintained in good condition. Pot holes if any must be attended. Goods shed approach roads and circulating area near station should receive special attention.

7. **Land boundaries** - The IOW shall inspect at least once a year and maintain the railway boundary at important station and staff colonies.

   PWI / IOW is responsible for maintaining railway boundaries and for reporting any encroachments.

8. IOW will maintain the following registers –
   i. Register for inspection of Staff Qrs.
   ii. Register for inspection of Service Buildings.
   iii. Register for inspection of sheds.
   iv. Tank register.
   v. Encroachment register.
   vi. Progress register.
   vii. Site Order Book.
   viii. PNM register.
   ix. Planning register.
   x. Handing over / Taking over notes.

***************

**Lesson 1**  
**Sub Lesson 16**

**C.E. Circular No. 160**

**Directed Maintenance of Building**

To improve the productivity of staff available for maintenance of colonies and to improve the level of satisfaction of the occupants, it is proposed to introduce Directed Maintenance of Buildings with effect from 01-4-1995 in all Divisions of this Railway.

The directed building maintenance in the section of each AEN should be started as per the order to be decided in consultation with recognised unions. Once a colony is identified for starting the work the work should be taken up from one end of the colony and systematically proceeded towards the other end.

The principle of Directed Maintenance would involve the following steps:-

The Directed Maintenance will be carried out jointly by civil Engg. Electrical Engg. And Medical departments.

Inspection of one or two blocks ( depending upon the size of blocks ) by inspections / supervisors of the three departments a few days in advance and preparation of quarter-wise list of items to be attended.

Calculation of material and man-power required for those blocks will be done by the supervisors. They will maintain the record in a register.

Identification of the order in which various blocks are required to be attended.

On the day of attention full complement of staff requirement and the material to be used are taken from the store to the work site. Work is done by staff of all the three departments under direct supervision of one Inspector / supervisor of each department.

Based upon quantities, the actual execution of work can be done for 1, 2, or 3 days, as per requirement.

In major colonies, 50 to 60% of the maintenance staff can be put into direct maintenance gang, and the rest of the staff can be left for attending the day-to-day complaints.
In smaller colonies, as number of staff available for maintenance is small they can attend to day-to-day complaints for 3 days in a week and do directed maintenance for rest of the days.

Generally each directed maintenance team will have minimum of the following staff -

( a ) Civil Engg : - J. E. (works) Gr. II - One
- Mason - Two
- Carpenter - One
- Fitter - One
- Khalasi - Five

( b ) Electrical : - Charge man - One (Partial)
- Wireman - One
- Helper - Two

( c ) Medical : - Health Insp. - One (Partial)
- Zamadar - One
- Safaiwala - Two

Directed system of maintenance would also increase the productivity of staff as follows apart improving the conducting of the worst maintained colonies in the section of the AEN.

Time spent by Artisan staff at present to inspect, report back, get the material issued etc. is used.

As all work is done under the supervision of an inspector better quality and quantity of work is achieved.

As three departments are working jointly the instances of work not getting done due to non-receipt of assistance from other departments dose not occur.

For taking assistance from other departments, joint instructions may be issued by Sr. DEN (Co) with Sr. DEE and M.S. of the division and with the approval of DRM, where necessary.

In the beginning there may be some difficulty in meeting with day-to-day complaints will drastically come down and satisfaction of the residents of the colony would increase.

The Assistant and the divisional Officers should closely monitor the system followed by the staff for this maintenance, including timely supply of material and site supervision to ensure its success.

The number of quarters attended by directed Building Maintenance must be reported by each Sr. DEN in their covering letter of MCDO every month.

Advantages of DBM

1. Efficient & Close Supervision.
2. Better Quality & Increased Productivity Saving of time loss in material transportation. No disturbance to occupant again & again.
3. More satisfaction to occupant.
4. Proper maintenance of colony in systematic way.

Planning and General instructions

Sitting of Building –

a) Provide for the right to erect buildings on their own land by railways without having to obtain sanction of municipal or cantonment authorities.
b) Inside curves should be avoided, building should be at boundary and not to interfere with the visibility of Drivers of trains or road vehicles at level crossing.
c) Multi storied quarters shall only be constructed on consideration of land cost.
d) Type I & II single storied quarters are to be constructed at least in 2 unit blocks.

Planning of Railway Staff Colonies –

a) Orientation of building –
The following climatic factors influence the optimum orientation of the building –
   1. Natural light and temperature.
   2. Prevailing winds.
   3. Relative humidity.

b) Water Supply and Drainage –
Adequate water supply and sullage and storm water drains should be provided.
c) Dust bins.
d) Shady trees.
e) Play ground for children.
f) Venders stall / shops.

general Design Requirement of Building –

1. Plinth level should be adequately higher than Road level.
2. Antitermite treatment should be done at the time of construction.
3. Floor level of bathrooms should be suitably designed.
4. Location of sanitary fittings, inspection holes, plumbing and other sanitary installations should be pre determined.
5. Mosquito proof shutters should be provided in Type IV and higher type quarters.
6. The position of conduits for concealed wiring and other service installations should be pre determined.
7. Design of important building should be finalised in consultation with an architect.
8. No additions /alterations should be carried out without the prior approval of chief engineer.

Scale of fitments for water supply sanitation and drainage –

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Fitment</th>
<th>For Male</th>
<th>For Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Water Closets /</td>
<td>1 For every 25 persons</td>
<td>1 For every 15 persons</td>
</tr>
<tr>
<td></td>
<td>European-</td>
<td>1 in each w. c.</td>
<td>1 in each w. c.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 water tap for every 50 Persons near w.c. &amp; Urinal</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Ablution Tap-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Urinals-</td>
<td>Up to 6 Person - Nil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 to 20 Person - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>21 to 45 Person - 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>46 to 70 Person - 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>71 to 100 Person - 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 to 200 Person - 2.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 200 Person - Add 3%</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Wash basin -</td>
<td>1 for 25 Persons</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Drinking water</td>
<td>1 for every 100 Persons with minimum one on each floor.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Sink -</td>
<td>One per floor</td>
<td></td>
</tr>
</tbody>
</table>

For Office Building –

For Factories –
<table>
<thead>
<tr>
<th></th>
<th>Water Closets / European-</th>
<th></th>
<th>Ablution Tap -</th>
<th></th>
<th>Urinals-</th>
<th></th>
<th>Wash basin -</th>
<th></th>
<th>Drinking water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 to 15 Person - 1</td>
<td>1</td>
<td>1 to 12 - 1</td>
<td></td>
<td>As office Building</td>
<td></td>
<td>1 for 25 Persons</td>
<td></td>
<td>As office Building</td>
</tr>
<tr>
<td></td>
<td>16 to 35 Person - 2</td>
<td></td>
<td>13 to 25 - 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36 to 65 Person - 3</td>
<td></td>
<td>26 to 40 - 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>66 to 100 Person - 4</td>
<td></td>
<td>41 to 57 - 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>101 to 200 Person - Add 3%</td>
<td></td>
<td>58 to 77 - 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Above 200 Person - Add 2.5%</td>
<td></td>
<td>78 to 100 - 6</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>101 to 200 - Add 5%</td>
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<td></td>
<td></td>
<td></td>
<td>Above 200 - Add 4%</td>
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Lightweight Concrete

Lightweight concrete, weighing from 35 to 115 pound per cubic foot, has been used in the United States for more than 50 years. The compressive strength is not as great as ordinary concrete, but it weathers just as well. Among its advantages are less need for structural steel reinforcement, smaller foundation requirements, better fire resistance and most importantly, the fact that it can serve as an insulation material! It can cost more that sand and gravel concrete, and it may shrink more upon drying.

Concrete may be made by using lightweight aggregates, or by the use of foaming agents, such as aluminum powder, which generates gas while the concrete is still plastic. Natural lightweight aggregates include pumice, scoria, volcanic cinders, tuff, and diatomite. Lightweight aggregate can also be produced by heating clay, shale, slate, diatomaceous shale, perlite, obsidian, and vermiculite. Industrial cinders and blast-furnace slag that has been specially cooled can also be used.

Pumice and scoria are the most widely used of the natural lightweight aggregates. They are porous, froth-like volcanic glass which come in various colors and are found in the Western United States. Concrete made with pumice and scoria aggregate weighs from 90 to 100 pounds per cubic foot.

Rock from which perlite is manufactured has a structure resembling tiny pearls and when it is heated it expands and breaks into small expanded particles the size of sand. Concrete made with expanded perlite weighs between 50 to 80 pounds per cubic foot and is a very good insulating material.

Vermiculite comes from biotite and other micas. It is found in California, Colorado, Montana, and North and South Carolina. When heated, vermiculite expands and becomes a fluffy mass, which may be 30 times the size of the material before heating! It is a very good insulating material and is used extensively for that purpose. Concrete made with expanded vermiculite aggregate weighs from 35 to 75 pounds per cubic foot.

Concrete made with expanded shale and clay is about as strong as ordinary concrete, but its insulation value is about four times better. Pumice, scoria, and some expanded slags produce a concrete of intermediate strength, but with even more impressive value as insulation. Perlite, vermiculite, and diatomite produce a concrete of very low strength, but with superior insulation properties; however these are subject to greater shrinkage. All of these kinds of lightweight concretes can be sawn to some extent, and they will hold fasteners, especially screws.

Lightweight aggregate should be wetted 24 hours before use. It is generally necessary to mix lightweight concrete for longer periods than conventional concrete to assure proper mixing and it should be cured by covering it with damp sand or by using a soaker hose.

Pumicecrete

Pumicecrete has been used in constructing buildings for many years. It is simply concrete that uses crushed volcanic rock as an aggregate rather than conventional sand and gravel. Both pumice and scoria, when used in this fashion, render a product that is much lighter than concrete. It also transforms what is usually considered a thermal mass material into something that is much more of an insulator (about R-1.5 per inch), because of all the trapped air. This is very useful, because it makes it possible to actually build a load-bearing structure with an insulating material, as with earth bags filled with the same crushed volcanic rock. When mixing pumicecrete, the idea is to use just enough wet cement to coat the aggregate so it will adhere to the surrounding particles. Too much cement will defeat the purpose of maintaining all of that trapped air; about three bags of portland cement per cubic yard of aggregate is recommended. Once the material has set up a bit, the surface can be washed to expose the natural color of the stone. The rough texture of pumicecrete is ideal for adhering to further plasters that might be used.
Pumiccrete is best placed on an ordinary concrete foundation, and most applications require a cement bond beam at the top of the wall, for structural strength and to tie the roof structure to. Entire domes of pumiccrete have been successfully constructed. A wall thickness of at least 14 inches is advised, with thicker walls providing more stability and insulation.

**Cellular Lightweight Concrete (CLC)**

Extensive research has been undertaken in the use of industrial waste consisting of fly ash from power plants as a raw material for manufacturing building materials. The large volume of waste has become one of the most significant problems of environmental protection, as its disposal is expensive and non-productive. Experiments show that this waste material can be used for the production of high quality bricks, blocks and other building elements which are less energy intensive than their conventional counterparts. This research has yielded patented technology for the production of concrete-like blocks based on oil-shale and coal fly-ash, cured under normal atmospheric conditions.

A particularly interesting material that has been developed is ash-based cellular concrete, which in addition to being based on industrial waste, is also manufactured through a low-energy process. The manufacture of conventional cellular concrete of comparable properties requires very high energy input.

This material has been used in over 40 countries over the past 25 years to build residential and commercial buildings. It is an air-cured lightweight concrete that can be produced at the project site, using standard concrete equipment and molds. A typical mix for making blocks is:

- Portland Cement...........190 kg
- Sand..........................430 kg
- Fly Ash.........................309 kg
- Water..........................250 kg

plus a foaming agent

**Perlite and Vermiculite Concrete**

This type of lightweight concrete has a long history of industrial and construction uses; it can be highly insulating, and is especially useful where its light weight is an advantage, such as on roof structures.

**Hempcrete**

Hempcrete is a mixture of chopped hemp, hydrated lime and a small amount of either Portland cement or quick-set gypsum, and possibly includes sand or pozzolans. A reaction between the lime and the hemp results in a very lightweight material that still has reasonable compressive strength. The advantage of hempcrete over regular cement is that the hempcrete is both structural and insulative, so both ends are achieved in the same pour. It is also lower in embodied energy. The disadvantages are a longer set time (2-4 weeks) and lower strengths. It is easier to work than traditional lime mixes and acts as a moisture regulator. It lacks the strength and brittleness of cement and consequently does not need expansion joints. It is less dense than concrete and is marketed under names like Hemcrete, Canobiote, Canosmose, and Isochanvre. Where the high ultimate strength of concrete is not necessary, this option works well.

**Lightweight Composite Concrete**

The majority of regular concrete produced is in the density range of 150 pounds per cubic foot (pcf). The last decade has seen great strides in the realm of dense concrete and fantastic compressive strengths (up to 20,000 psi) which mix designers have achieved. Yet regular concrete has some drawbacks. It is heavy, hard to work with, and after it sets, one cannot cut or nail into it without some difficulty or use of special tools. Some complaints about it include the perception that it is cold and damp. Still, it is a remarkable building material - fluid, strong, relatively cheap, and environmentally innocuous. And, it is available in almost every part of the world.
Regular concrete with microscopic air bubbles added up to 7% is called air entrained concrete. It is generally used for increasing the workability of wet concrete and reducing the freeze-thaw damage by making it less permeable to water absorption. Conventional air entrainment admixtures, while providing relatively stable air in small quantities, have a limited range of application and aren't well suited for specialty lightweight mix designs.

Lightweight concrete begins in the density range of less than 120 pcf. It has traditionally been made using such aggregates as expanded shale, clay, vermiculite, pumice, and scoria among others. Each have their peculiarities in handling, especially the volcanic aggregates which need careful moisture monitoring and are difficult to pump. Decreasing the weight and density produces significant changes which improves many properties of concrete, both in placement and application. Although this has been accomplished primarily through the use of lightweight aggregates, since 1928 various preformed foams have been added to mixes, further reducing weight. The very lightest mixes (from 20 to 60 pcf) are often made using only foam as the aggregate, and are referred to as cellular concrete. The entrapped air takes the form of small, macroscopic, spherically shaped bubbles uniformly dispersed in the concrete mix. Today foams are available which have a high degree of compatibility with many of the admixtures currently used in modern concrete mix designs. Gecko Stone of Hawaii is currently experimenting with one such foam.

Foam used with either lightweight aggregates and/or admixtures such as fly ash, silica fume, synthetic fiber reinforcement, and high range water reducers (aka superplasticizers), has produced a new hybrid of concrete called lightweight composite concrete, or LWC.

Implementing LWC Design
For the most part, implementation of Lightweight Composite design and construction utilizes existing technology. Its uniqueness, however, is the novel combination drawing from several fields at once: architecture, mix design chemistry, structural engineering, and concrete placement.

Given the hoops that any new material or method must go through, implementation of LWC construction can be much at the mercy of any number of bureaucratic standards (licenses, approvals, etc.) including fire ratings, material test data, environmental impacts, as well as opposition from labor unions and existing suppliers supporting the lumber industry. Bureaucratic standards are sometimes easy enough to achieve, but only if one has deep pockets. But these costs are pretty much out of range for the average entrepreneurs in this field. These individuals also have found reluctance within the ready mix industry to take the initiative for R&D... their natural conservatism and relative success in the last four decades only has reinforced their will to keep things the same without added risk. They wait for the entrepreneur's homework. Other technologies, such as synthetic fiber manufacturers, also wait for the entrepreneur. It seems leadership, unfortunately, is not likely to come from the industries with the most available resources, but from those individuals who not only have a vision for the future, but a persistent mission to make it a reality.

LWC construction can be a partial solution for several environmental problems. Deforestation could be substantially reduced by relinquishing the demand for timber used in residential construction. Wood can be used for decorative trim rather than structural elements. Steel can be used for what it does best - strength. Plastics can be recycled and used as secondary reinforcement. Used glass and other waste materials such as expanded polystyrene (EPS) can be converted to lightweight aggregate. Structural lumber requires treatment with poisons; steel is a dirty - albeit necessary - industry. The use of structural steel with concrete may be curtailed in the future by the development of high strength plastic-ceramics such as glass, basalt, carbon, and other fibers.

Considering all the positive characteristics of LWC, it is surprising so little attention has been given to its possibilities. This may be due to an uniformed public, a tradition to use wood for construction, and a bad rep for a previously cold, stoney product. Yet homes and other buildings
can achieve and maintain a higher degree of function and permanence, resulting in greater intrinsic value. The only limitations are the restraint of our imaginations, the reluctance of humanity to try anything new, and the resistance of unions to efficient construction. The latter may influence inordinate restrictions imposed by local, state, and federal building codes. But recent large natural disasters, such as fires and hurricanes, are now prompting people to take a closer look at shelter permanency being of greater value than consumer construction. The potential for the five hundred year house is here.
New Building Materials

i. Fly Ash Bricks.
ii. Lightweight autoclaved unreinforced Blocks.
iii. USE OF Fly Ash in Embankment.
iv. Recycled Aggregate in Concrete.
v. Ceramic and Vitrified Tiles.
vi. Concrete Paver Blocks.

Fly Ash -

i. Fairly divided residue from combustion of coal or sub-bituminous coal
ii. More than 70 Thermal Power Plants in country
iii. On burning nearly 30% of coal is converted into Ash, 75% of which is fine fly ash and the rest is coarse bottom ash
iv. Yearly Production of fly ash is app 110MT

Disposal of this -

i. **Dry system** - carried away pneumatically into overhead silos or a bunker then moved using mechanical means.
ii. **Wet system** - fly ash is mixed with water and sluiced to the settling ponds. This is cheaper if water is available.
iii. Only approximately 40% of this is being used at present.
iv. Rest is fly ash land fill covering an area of 40,000 acres.

Use, a must -

Fly ash is an alumino silicate glass consisting of oxides of silicon, aluminium, iron and calcium, with magnesium, potassium, zinc, sulphur and other trace elements which can leach into the environment and contaminate ground and surface water. Thus, disposing it off in ash ponds and landfills is risky. This wastes lots of water and land. If this ash is used in construction, it would help reduce a substantial amount of carbon dioxide (co2) produced in making cement; such manufacturing accounts for six to seven per cent of the co2 produced by human activities, globally.

Fly Ash – A Resource Material -

i. Cement Application - Pozzolanic Characteristics
ii. Geotechnical Applications - Engineering Properties
iii. Filling Applications - Near Inert Material
iv. Ceramic Application
v. Agricultural Applications - Physical & Chemical Properties

Indian Scenario - Fly Ash Generation and Utilisation

1994 -

i. FA Generation --- 40 Million Tonne
ii. FA Utilisation --- 3% (1.2 Million Tonne)

March 2005

i. FA Generation --- 112 Million Tonne
ii. FA Utilisation --- 38% (42 Million Tonne)

Thrust Areas Utilisation -

i. Roads & Embankments
ii. Building Components
iii. Hydraulic Structures
iv. Agriculture Related Studies & Applications
v. Minefills

Safe Management -

i. Ash Pond Management
ii. Reclamation of Abandoned Ash Ponds

Fly Ash Bricks -

i. There is good demand for fly ash bricks.
ii. The technologies are eco friendly.
iii. Reduces solid waste and dust in the nature.
iv. Compared to clay brick the cost is reasonable.
Manufacturing Process -
   i. Requires raw material like Fly ash, Gypsum, alum, stone crushing dust and small quantity of cement to be mixed as per the ratio.
   ii. This is to be kept in moulds for manufacturing of automatic locking fly ash bricks.
   iii. After the processing the bricks have to be dried after applying required water for curing on the bricks. This is normally for 14 days

Brick Pressing Machine -

Specifications as per IS3495(Part I &II) -
   i. Compressive Strength - 3 to 5 MPa (actual up to 8MPa).
   ii. Water absorption shall be less than 20% (actual about 5%).
   iii. Commercial size 230*150*80mm.

Technical Advantages -

Bricks & Blocks -
   i. Better finish
   ii. High strength
   iii. Less water absorption
   iv. No efflorescence
   v. Lower unit weight, less load on foundation

Economic Savings -
   i. Reduced Energy Consumption
   ii. Reduces excavation of clay
   iii. Lower cost of brick as compared to clay brick of same quality.
   iv. Number of blocks required per unit volume of construction is less.
   v. Less consumption of mortar.
   vi. Less number of joints in case of blocks.
   vii. Plastering may be avoided or if it is to be done, the thickness of plaster required is less.

Fly Ash Bricks –

Lightweight autoclaved unreinforced Blocks -
   i. Manufactured in India since 1972, in collaboration with International Siporex AB of Sweden. The unique flexibility, structural and physical properties of Siporex (ALC - “Aerated Light Weight
Concrete) are appreciated the world over and is the preferred building material. It is ideal for all types of climatic and seismic zones.

ii. Siporex is structural material, steam cured, cellular (aerated) concrete. It is available as blocks, floor and roof slabs and wall panels, for all types of buildings Specially for multi-storeyed buildings

Building Blocks –

i. Available Sizes: - 200 x 240 x 600 mm, 150 x 240 x 600 mm, 125 x 240 x 600 mm, 100 x 240 x 600 mm

ii. Light Weight: Oven dry density of SIPOREX is 450 to 650 kg/m³ i.e. just one fourth the weight of dense concrete, thus ensuring economic design.

iii. It also makes these ideal for low bearing soils, for seismic zones and for adding storeys to existing buildings.

iv. It is easy to handle, hoist and transport.

v. It is the ideal material for use in existing buildings where additional FSI/TDR is available.

vi. Highly Insulating: Cuts the peaks of heat and cold to provide economy in the working of air conditioning and central heating. K value 0.122 Kcal/ Hr/ M° C makes it suitable as insulation material for boilers, heat exchangers, furnaces, ovens, forges, steel works, galvanising kettle linings, etc. saves 25% cost of installations as well as recurring costs of electricity.

vii. High strength to weight ratio- It is 18 to 22 against 16 for concrete of M 150 grade

viii. Water Penetration - SIPOREX structure being of closed cells, there is less capillary action and high surface activity allows for last evaporation of moisture.

ix. Comfortably worked - SIPOREX is versatile. It can be drilled, chased or nailed using simple carpentry tools. Thus, it simplifies plumbing, electric work, fixing joinery, etc. preventing wastages at site. It is workable like wood and endures like stone.

x. Environment Friendly - It eliminates the use of bricks which consume valuable fertile soil required to grow food for our vast population.

BIS Specifications -

i. Bis-2185-Part 3: Specifications for Autoclaved Cellular Concrete Blocks

ii. BIS-6041: Construction of autoclaved cellular concrete block masonry

iii. BIS-6072: Specifications for autoclaved reinforced cellular concrete wall slabs.

iv. BIS-6441: Methods of test for autoclaved Cellular Concrete products (Determination of unit weight or bulk Density & Moisture Content) Part 1,2,4,5,6&8

v. BIS-6073: Autoclaved Reinforced Cellular Concrete floor and roof slabs

vi. BIS-3809 : Fire resistance Test of Structure

IMPORTANT SPECIFICATIONS -

i. Oven Dry Density for slabs will be 640 kg/Cum

ii. Bending compression: 15kg/cm²

iii. Shear strength: 1kg/cm²

iv. Modulas of elasticity: 2.1x104kg/cm²

v. Coefficient of liner expansion: 0.000008 per °C

USE OF FLY ASH IN EMBANKMENT -

i. National Highway Authority of India (NHAI) is utilising Fly ash in its major highway construction projects, Implementing the latest amendment to MOEF’s notification on Fly ash utilisation.

ii. Ministry of Road Transport and Highways (MoRT&H), has directed all its agencies to use fly ash for all Road and Embankment construction work within a radius of 100 km from the thermal power plant, as per Indian Road Congress specifications SP 58-2001.

iii. National Highway Authority of India (NHAI), and Delhi Metro in the country, are utilising fly ash on a massive scale.

iv. 60 lac cum of fly ash is being used in its ongoing projects in Delhi, UP and West Bengal, and its New NH-2 project would use more than 67 lac cum of fly ash.
Technical Advantages -
  i. • Good compaction
  ii. • High range of OMC
  iii. • High internal angle of friction
  iv. • No large lumps to be broken (easy to spread)
  v. • Light in weight (can be used on weak sub-grades)

Economics Savings -
  i. No royalty to be paid as excavation of soil is eliminated
  ii. Reduces excavation cost of borrow material
  iii. Normally reduces transportation cost
  iv. Easy and faster construction leads to reduction in construction cost
  v. Saving in ash management expenditure of thermal power plants
  vi. Additional agricultural produce from the land which would otherwise have been—Excavated for getting soil or Used for fly ash disposal

Government Regulations -
The government promotes the use of fly ash in construction work. Ex. President A P J Abdul Kalam had called for raising its utilisation from the current 40 per cent to 100 per cent. The Bureau of Indian Standards (BIS) now allows blending 35 per cent fly ash with cement, against the earlier 25 per cent. The government has also made the use of 25 per cent fly ash mandatory in the manufacture of clay bricks/tiles/blocks by units located within 100 kilometres of coal- or lignite-based thermal power plants (TPP).
Recycled Aggregate in Concrete -
  i. Recycled conc. is suitable for a wide range of structural applications
  ii. RC is being considered more extensively in international and national standards in order to exploit its potential.
  iii. This is an important prerequisite towards a sustainable material flow.
  iv. Fine grained residues form the production of recycled aggregates show a positive effect on mechanical properties of mortar/concrete
  v. Strength properties show similar behaviour as CC: - compressive strength & flexural strength
  vi. Properties being influenced by porous aggregates is requirement of extra water for attaining desired W/C ratio

Present Use -
  i. Landfills are being used to dispose concrete
  ii. Scarcity of natural aggregate sources makes RC cost effective
  iii. Recycled Materials have been used in the past for recycled asphalt pavement, reclaimed concrete pavement

Ordinary and recycled concrete -
Recycled Aggregate in Concrete -
  i. RCAC has slightly lower strength
  ii. Shrinkage of RCAC is greater at 28-days
  iii. w/o mix design needs adjustments
  iv. Addition of FIBERS results in controlling shrinkage cracks

INTELOCKING CONCRETE PAVING BLOCKS -
APPLICATION -
  i. Railway Platforms
  ii. Building Premises
  iii. Landscapes, Garden, Parks
  iv. Parking areas
  v. Office drive ways
  vi. Residential colony roads

SHAPES -
  i. Type A – Plain vertical faces : Do not key into each other
  ii. Type B – Alternating plain and curved vertical faces which key into each other
  iii. Type C – All faces are curved which key into each other along all vertical faces
  iv. Type D – L and X shaped blocks which key into each other along all vertical faces.

THICKNESS OF BLOCKS -
i. Cycle tracks, pedestrian footpath : 60 mm
ii. Light commercial traffic, residential street : 60 – 80 mm
iii. Medium commercial traffic, Bus/Truck Parking Area : 80 – 100 mm

**Sequence of Operations** -

i. Installation of sub-surface drainage structures.
ii. Levelling and compaction of subgrade.
iii. Provision and compaction of sub-base (if required).
iv. Provision and compaction of base course and checking for correctness of profile.
v. Installation of edge restraints (to resist rotation or displacement of blocks).
vi. Provision and compaction of coarse bedding sand.
vii. Laying of blocks and interlocking.
viii. Application of joint sealing sand.
ix. Cleaning of surface and compaction (using vibratory plate compactor).
x. Filling remaining portions near edges with in-situ concrete/cement mortar (1:6).
xii. Cleaning of surface.

**Construction of Subgrade** -

i. Water table should be at least 600 mm below the subgrade.
ii. Subgrade to be compacted in layers of 150 mm/100mm.
iii. The prepared subgrade surface should be within tolerance of ± 20 mm of design levels.

**Bedding Layer** -

i. Thickness after compaction 20-40 mm. (Preferably 20 – 25 mm)
ii. Thickness should be uniform.
iii. Material sand as per specified gradation.

**Base Material** -

*Base Material* :- Crushed rock, Water-bound macadam, wet mix macadam, cement bound granular material, lean concrete.

Sub Base :- Essential if commercial traffic is expected.

**Joint Filling Sand** -

i. To conform to specified gradation.
ii. Fines to be restricted to 10 per cent.
iii. Cement should not be mixed with sand.
iv. Sand should be dry.
Gradation of Bedding and Joint Filling Sand –

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.52 MM</td>
<td>100</td>
<td>--</td>
<td>600 Micron</td>
<td>25-60</td>
<td>60-90</td>
</tr>
<tr>
<td>4.75 MM</td>
<td>95-100</td>
<td>--</td>
<td>300 Micron</td>
<td>10-30</td>
<td>30-60</td>
</tr>
<tr>
<td>2.36 MM</td>
<td>80-100</td>
<td>100</td>
<td>150 Micron</td>
<td>0-15</td>
<td>15-30</td>
</tr>
<tr>
<td>1.18 MM</td>
<td>50-95</td>
<td>90-100</td>
<td>75 Micron</td>
<td>0-10</td>
<td>0-10</td>
</tr>
</tbody>
</table>

Laying of Block -

i. Laying to start from edge strip
ii. Laying to proceed in one direction only along the entire width
iii. On sloping site laying should start from lowest point to avoid down-slope creep.

CORRECTION SLIPS OF IRBM

ADVANCE CORRECTION SLIP NO. 1 DATED 01.09.1999

(Issued under Railway Board’s letter no. 99/CE-I/Misc/23(IRBM) Dated 01.09.1999)

1. Existing Para no. 1007 of Chapter X of IRBM, 1998 be modified to read as “1007 (A)”
2. A new Para no. 1007 (B) may be added between Para 1007 (A) and Para 1008 to chapter 10 of IRBM, 1998 as under:

   “1007 (B). Ventilation of Tunnels

I. General:
Ventilation of tunnel is one of the important aspect related to passenger and crew comfort during passage of train inside the tunnel. It is also important for workmen working inside the tunnel from their health point of view. Movement of trains inside tunnel, transforms its environmental features. Some of the pollutant gases emitted from locomotives, may be potential hazards to the health, physiological and psychological comfort of human being. For safe operation, it is necessary that these hazardous features especially gases emitted from locomotives, should not cause discomfort to crew, passenger and workman inside the tunnel. Concentration of pollutant gases (i.e. NO, NO2, CO, CO2, SO2 and hydrocarbons etc.) and rise in temperature of air inside tunnel depends upon effectiveness of ventilation in tunnel. Thus, it is necessary
that tunnels are provided with adequate ventilation, so that concentration of hazardous gases and rise in
temperature of air inside tunnel remain within permissible limits.

II. EFFECT OF MOVEMENT OF TRAIN INSIDE TUNNEL:
The passage of a train in a tunnel transform environmental features and create the following
environmental hazards:

a) Air Quality Deterioration:
Emission from diesel locomotive contains potentially hazardous gases such as oxides of nitrogen (NO,
NO2), oxides of carbon (CO, CO2) Sulpherdioxide and hydrocarbons. These gases are emitted from top
d of locomotive and get mixed up with the air available inside tunnel and pollutes it. Part of polluted air
descends, to the lower part of the tunnel. High concentration of carbon monoxide gases causes
headache and discomfort and may be fatal if stay is prolonged. Nitrogen Oxides (NO, NO2) have toxic
effects. Sulpherdioxide is bronchial and nasal irritant. In short, pollutant gases emitted by locomotive may
prove to be hazardous, if their concentration exceeds permissible value.

b) Thermal Environment Hazards
As a locomotive traverses through a tunnel, heat from exhaust gases and other part of locomotive, is
emitted. The air inside the tunnel gets heated up due to heat emitted from exhaust gasses / locomotive
surface. For safe operation of the trains in the tunnel, the thermal environment is to be controlled within a
safe range for efficient functioning of locomotive and comfort of passengers, crew and workman.

c) Pressure Transient Hazards
When a train passes through a tunnel, aerodynamic effects come into play. Due to this, the drag and
propulsion power increases and the pressure environment around the train gets changed. The change of
pressure environment around the moving vehicle may cause severe discomfort to passengers.

III. PERMISSIBLE VALUES OF POLLUTANTS:
Limits are required to be set for the various pollutants inside tunnel to ensure safety and health of
passengers, crew and workmen. The permissible values for the concentration of pollutants in tunnels
depend upon the time of exposure. These values shall be different for workers who are supposed to work
for 8 hours inside tunnel and for passengers and crew who are supposed to pass the tunnel within few
minutes, depending upon the length of the tunnel and speed of the train. Threshold level for various
pollutants are given in Table-10.01. As workers are required to remain in tunnel for 8 hours, values for 8
hours exposure need to be considered for the design of ventilation system. Maximum temperature of air
inside tunnel needs to be limited to 50°C considering passengers and workmen comfort.

TABLE 10.01
THRESHOLD LEVELS FOR POLLUTANTS INSIDE TUNNELS

<table>
<thead>
<tr>
<th>Pollutant Gas</th>
<th>8 hours exposure values</th>
<th>15 minutes exposure values</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>50 ppm</td>
<td>400 ppm</td>
</tr>
<tr>
<td>NO</td>
<td>25 ppm</td>
<td>35 ppm</td>
</tr>
<tr>
<td>NO2</td>
<td>5 ppm</td>
<td>5 ppm</td>
</tr>
<tr>
<td>CO2</td>
<td>5000 ppm</td>
<td>18000 ppm</td>
</tr>
<tr>
<td>SO2</td>
<td>5 ppm</td>
<td>5 ppm</td>
</tr>
</tbody>
</table>

* These values are from the consideration of passengers comfort and shall depend upon the length of the
tunnel and speed of the train.

IV. TYPES OF VENTILATION SYSTEMS:
The ventilation in a tunnel can be achieved by:-

(a) Natural Ventilation:
When a train traverses inside tunnel at a relatively high speed and ratio of train frontal area to tunnel
cross section is of the order of 0.5 to 0.6, it induces considerable air flow inside tunnel. This type of
ventilation is called as natural ventilation. The amount of induced air flow will depend upon orientation of
tunnel and atmospheric pressure difference between inside and outside the tunnel. Quantum of induced
air flow will be more in tunnels laid parallel to prevailing wind and having exposed approaches as
compared to tunnels sheltered from prevailing wind. Thus this aspect needs to be considered at the time
of deciding orientation of tunnel. However limitation imposed by terrain and track geometry parameters
may not make it feasible in every case. If length of tunnel is small, the induced air flow may be sufficient
to keep the pollutants concentration and rise in temperature inside tunnel, within permissible limits. In
such case there may not be any necessity for provision of artificial ventilation.

(b) Artificial Ventilation:
In long tunnels induced air flow due to train movement is not sufficient to keep concentration of pollutant gases under permissible limit inside tunnel. In such cases artificial ventilation may have to be provided by means of provision of ventilation shafts with or without provision of electric fans, with suction and delivery arrangement. Where provision of shaft is not feasible, longitudinal ventilation with the help of an axial blower fan at the portal supplemented by auxiliary fan of smaller capacity, spaced at suitable intervals along the length of tunnel may be considered.

**V. DESIGN OF VENTILATION SYSTEM OF TUNNELS**

V(i) The essential requirement of a ventilation system of tunnel are as under:

(a) It should ensure, sufficient airflow relative to moving train, to keep the concentration of pollutant gases inside tunnel within permissible limits.

(b) It should ensure sufficient air flow to prevent locomotives from over-heating and to keep thermal effects within desirable limits.

(c) It should ensure that pressure transient are within acceptable limits.

V(ii) The amount of air flow and type of ventilation arrangements required depend upon the level of concentration of pollutants and maximum temperature likely to be attained inside tunnel due to movement of trains. Level of concentration of pollutants and maximum temperature likely to be attained inside tunnel depends upon the following factors:

i) Type of locos. ii) Gradient inside tunnel ii) Length of train iv) Speed of the train v) Time interval between two trains vi) Ambient temperature vii) Length of tunnel viii) Cross section of tunnel ix) Direction of prevailing winds etc.

V(iii) As large no. of factors are involved, it may be difficult to estimate pollutants concentration & maximum temperature likely to be attained analytically. Thus mathematical modeling and simulation studies are necessary for design of ventilation system. As factors governing designs of ventilation system vary considerably from site to site, therefore design for ventilation of each tunnel has to be developed separately.

V(iv) Normally on single line sections, tunnels having length up to 2 kms, may not require provision of artificial ventilation but it should be ensured that levels of concentration of pollutants during passage of trains are not likely to exceed threshold levels. Tunnels having length more than 2 kms may require provisions of artificial ventilation, by means of shaft with or without provision of fans, depending upon results of simulation studies.”

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**ADVANCE CORRECTION SLIP NO. 2 DATED 21.07.2000**


I. Insert a new sub Para 16 under Para 1107 of Chapter 11 - Inspection of Bridges

“16. Health Monitoring of Very Important Bridges :- Health monitoring of very important bridge should be done periodically by an independent agency. Health monitoring will include corrosion monitoring, deterioration of material, system damage, retrofitting, etc. The periodicity of health monitoring is recommended as given below.

<table>
<thead>
<tr>
<th></th>
<th>Aggressive environment (Extreme, Very severe &amp; Severe)</th>
<th>Other than Aggressive environment (Mild and Moderate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Survey</td>
<td>5th year</td>
<td>5th year</td>
</tr>
<tr>
<td>Subsequent surveys</td>
<td>At 5 years interval</td>
<td>At 10 years interval</td>
</tr>
</tbody>
</table>

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**ADVANCE CORRECTION SLIP NO. 3 DATED 21.07.2000**


I. Delete existing Para no. 513 (b) of Chapter - V and insert as under:

“(b) Where the existing structure is fairly sound and does not show any sign of distress but is of inadequate section or has extensive surface weathering, jacketting with cement concrete with minimum thickness of 150mm, suitably dowelled into the old masonry/concrete may be done. The jacketting, to be effective, must be taken right up to the foundation and integrated at foundation level with the foundations. The dowel bars consisting of 20mm diameter MS deformed bar (HYSD bars) hooked at the exposed end or MS tie bar flats (45 x 10mm size) with the ends split, may be fixed into old masonry/ concrete. These dowels should be taken down to a depth of not less than 200mm inside the masonry/concrete. The spacing of dowels should not be more than 450mm horizontally and vertically. Dowels should be provided in staggered manner. (Annexure-5/3a)”
Before jacketting is taken up, existing cracks should be thoroughly grouted. It should also be ensured that the resulting reduction of waterway due to jacketting is within permissible limit. The face of the existing masonry or the concrete should be thoroughly cleaned free of all dirt. In case of concrete, the smooth surface should first be made rough. Before laying the new concrete, neat cement grout should be applied uniformly over the face of the old masonry/concrete. The new concrete layer should be of 1:2:4 mix although the maximum size of the aggregate may go up to 40mm. A mat of steel reinforcement with a minimum of 10mm bars spaced at 200mm horizontally and vertically may be provided as distribution reinforcement. The following precautions should be taken while carrying out the jacketing works:

i) Foundation shall be exposed for only limited width at a time so as to avoid endangering the safety of the structure.

ii) Pumping of water from foundation should be avoided as far as possible, as it may endanger the safety of the structure.

iii) Holes for dowels should be drilled and not made by pavement breakers.

iv) The work of jacketting should be done under suitable speed restriction. Depending upon location, extent of exposure, type of soil etc., speed restriction may be as under:

- Jacketting below bed level 15 km/h to 30 km/h depending on the extent of exposure, type of soil etc.
- Jacketting from bed level 30 km/h to 50 km/h depending on top of sub-structure on condition of masonry. The above speed restrictions may be relaxed after the completion of work as per the following guidelines, if jacketting is carried out using ordinary Portland cement conforming to IS: 269:
  i) 50 km/h after 7 days of last concreting;
  ii) 75 km/h after 14 days of last concreting; and
  iii) Normal sectional speed after 28 days of last concreting.

To reduce the duration of speed restriction, rapid hardening cement to IS: 8041 may be used.

ADVANCE CORRECTION SLIP NO. 4 DATED 21.07.2000

I. Delete existing Para no. 515 of Chapter - V and insert as under:

“515. Distressed arch bridges:

1) In case of cracks in arches, pressure grouting with cement mortar at a pressure 4 to 6 kg/cm² is generally quite effective.

2) If pressure grouting is not effective, one of the following alternative methods may be adopted:
   a) Construction of a suitably designed box culvert under the arch and filling the intermediate space between the arch and the box with lean cement concrete (Annexure 5/5a). This method may be adopted when the HFL is not high.
   b) Construction of a box culvert abutting one of the abutment dismantling the other abutment, when the HFL is high or the waterway is inadequate (Annexure-5/5b).
   c) Closed ring jacketing, where a slight reduction in waterway is permissible (Annexure 5/5c). Specially designed folded plate design can be successfully adopted in the above case (Annexure 5/5f).
   d) Jacketting below intrados: For strengthening of distressed arches, jacketting below intrados is preferable, if the resultant reduction in waterway is permissible. In such cases, new arches should be designed as under:
      i) to take the entire load by itself where the existing arch has transverse crack(s).
      ii) to take the entire load by composite action with the existing arch ring, where the existing crack(s) are all longitudinal or there are no signs of distress in the existing arch and if effective bond could be ensured between the new and old arch ring.
   e) Jacketting above extrados: In some special cases, external (extrados) jacketting of the arch is resorted to, after relieving the arch by temporary girders. In such cases, the new arch ring should be designed to take the entire loads i.e. dead and live loads etc.
   f) Where the HFL is high, it may be advantageous to convert the arch bridge into a slab top by suitable raising and strengthening the masonry of the piers/abutments and using pre-cast reinforced cement concrete/prestressed concrete slabs over them. Alternatively arch relieving girders may be used. The arches can be retained where there is adequate cushion above them. In other cases, the arch may be dismantled, either during a line block or under temporary relieving arrangement but before placing of the slab/girder. (Annexure 5/5d and e).

3) In the case of strengthening (i.e. by jacketting) of abutments and piers of arch bridges, the design should always be on the basis of composite action of the new material acting along with the existing one.
It should, however, be ensured that a proper bond is established between the existing masonry and new material by suitable means such as dowels and post grouting through grout holes to be left while casting the jacket.

4) In all cases of cracked masonry, whether in arches or in abutments and piers, all the cracks should be plugged by pressure grouting before the additional material (jacket) is provided.

5) In all cases of jacketting, precautions mentioned in Para 513 (b) should be followed. In cases of jacketting below intrados, the space in between the new arch ring and the existing arch ring should be pressure grouted, for which hole should be provided in new arch ring.

6) Jacketting works should be done under suitable speed restriction. Depending upon location, extent of exposure, type of soil etc., speed restriction may be as under:

| 1. | Jacketting below bed level. | 15 km/h to 30 km/h depending on the extent of exposure, type of soil etc. |
| 2. | Jacketting from bed level to spring level. | 30 km/h to 50 km/h depending on condition of masonry. |
| 3. | Jacketting of arch ring full design load | 30 km/h to 50 km/h depending on the condition of arch ring and cushion. |
| 4. | Jacketting of arch ring when designed by taking composite action with existing arch. | 15 km/h. |

The above speed restrictions may be relaxed after the completion of work as per the following guidelines, if jacketting is carried out using ordinary Portland cement conforming to IS:269:

i) 50 km/h after 7 days of last concreting;
ii) 75 km/h after 14 days of last concreting; and
iii) Normal sectional speed after 28 days of last concreting.

To reduce the duration of speed restriction, rapid hardening cement to IS : 8041 may be used.

ADVANCE CORRECTION SLIP NO. 5 DATED 21.07.2000

I. Delete existing Para no. 603 of Chapter-VI and insert as under: “603 Material of Construction:

1) For stone masonry, the proportion of cement mortar used should be minimum 1:4.

2) When mass cement concrete is used, the concrete mix shall be minimum M-20 grade. It shall be preferably design mix, using 40mm aggregate.

3) Reinforced cement concrete, used in the form of thin pier or as a framed structure, can be adopted for viaducts, fly over and road over bridges. Cellular piers are suitable if the heights are considerable. For reinforced cement concrete structure, the mix concrete shall be minimum M-25 grade.

4) Prestressed cement concrete can be used for all piers of viaducts. The mix to be adopted should be according to the design requirements.”

ADVANCE CORRECTION SLIP NO. 6 DATED 21.07.2000

I. Delete the existing Para No. 222(1b) of Chapter II and insert as under:

“b) Rocker and Roller bearing (Annexure 2/11), with or without oil bath, permitting rotation and translation respectively. Oil bath bearings are generally provided for new girders of spans above 76.2m and for other open web girders, whether new or existing, in case it is considered difficult to lift the girders for periodic greasing.”

II. Delete the existing Para No. 222(2f) of Chapter II and insert as under:

“f) In the case of roller bearings with oil bath, dust covers should invariably be provided to keep the oil free from dirt. Wherever oil bath bearings are provided, inspection of the bearings, after removal of the casings to the extent necessary, should be carried out at least once in 5 years. Checking of oil level, draining out as necessary to detect and remove any water collected at the bottom and replenishing the oil, should be done annually.”

ADVANCE CORRECTION SLIP NO. 7 DATED 21.07.2000

I. Delete the existing Para No. 618 of Chapter VI and insert as under:

“618: Painting of New Girders
The schedule of painting as detailed in IRS B-1 Specification shall be adopted.”
ADVANCE CORRECTION SLIP NO. 8 DATED 21.07.2000
(Issued under Railway Board’s letter no. 99/CE-I/Misc/23(IRBM) Dated 25.07.2000)
(i) Add new para-521 in Chapter V:
521. Replacement of Meter Gauge Bridges: Whenever MG bridges are rebuilt the substructure and super structure shall be built to BG standards.
(ii) Replace Para 504(4) of Chapter V as under:-
4. The bridge may then be classified as “Distressed” by the Senior Divisional Engineer/Divisional Engineer after a personal inspection. A detailed report should be sent to Headquarters office & RDSO with complete data about the bridge including its completion drawings.
(iii) Add new sub Para 5 under Para 616 of Chapter VI:
5. Adoption of riveted fabrication for plate/composite girders should not be done without prior approval of Board.
(iv) Add new sub Para 5 under Para 210 of Chapter II:
5. Water on deck bridges should not be allowed to stagnate or retained in the ballast. Cleaning of ballast and drainage arrangements to be ensured annually before monsoons.

ADVANCE CORRECTION SLIP NO. 9 DATED 27.07.2000
(Issued under Railway Board’s letter no. 99/CE-I/Misc/23(IRBM) Dated 27.07.2000)
Add new sub Para 317 of Chapter III:
317. Approval of drawings for new lines, doublings and Gauge Conversion:
In case of doublings/gauge conversion, General Arrangement Drawings for all major bridges, bridges where linear water way is being reduced or vertical clearances are inadequate and where construction is likely to affect any of the existing bridges, shall be approved by Chief Bridge Engineer. Besides this, General Arrangement Drawings for bridge constructed on new lines, which affect the existing bridges, shall also require the approval of Chief Bridge Engineer.

ADVANCE CORRECTION SLIP NO. 10 DATED 31.08.2000
(Issued under Railway Board’s letter no. 99/CE-I/Misc/23(IRBM) Dated 06.09.2000)
Replace Para 604 of Chapter - VI as under:-
604. Piers, abutments, wing walls and approach slabs
1. Piers, abutments, and wing walls:
   a) The size of piers and abutments depends on the construction materials used.
   b) Masonry piers are provided with a batter varying from 1 in 24 to 1 in 12. Their width at the top is determined keeping the minimum space required for seating of the bearings of girders as also to provide sufficient distance on the outside of the bearings to resist diagonal shearing.
   c) For masonry abutments, a front batter of 1 in 16 to 1 in 10 is used: a flatter slope or steepings are provided in the rear as per design requirements.
   d) When piers are reinforced cement concrete, typical sections used are shown in Annexure 6/1.
2. Wing Walls
   a) The abutments can either be of the conventional type with the front face exposed or of the buried type when waterway requirement is not the main consideration.
   b) In the former case, wing walls are necessary to retain the slopes of the approach banks. Wing walls can be of the splayed, straight, square or ‘box’ type (Annexure 6/2). Butt joints should be provided between wing walls and abutment, wing walls and return walls and for the various tracks, when the bridge is for more than one track to cater for differential settlement in case of poor soils.
   c) Wing and return walls also require provisions of weep holes as in abutments.
3. Approach Slabs:
   In order to reduce impact effect and to obtain improved running, properly designed approach slabs may be provided on both the approaches of nonballasted deck bridges having spans of 12.2 m or more. One end of the approach slab may be supported on the abutment and other end on the formation. Length of the approach slab shall be minimum 4 m.

ADVANCE CORRECTION SLIP NO. 11 DATED 14.01.2003
(Issued under Railway Board’s letter no. CBS/PSBC Dated 14.01.2003)
I. Following paragraph is inserted before Chapter 1 of the Indian Railway Bridge Manual:

“Scope:
The scope of Indian Railways Bridge Manual is to bring out the practices and procedures for maintenance of bridges on Indian Railways. For design and construction purposes, the provisions of relevant IRS Codes will override those provided in this manual wherever the two contravene each other.”

ADVANCE CORRECTION SLIP NO. 12 DATED 18.12.2007
(Issued under Railway Board’s letter no. CBS/PSBC Dated 18.12.2007)

1. Para No. 217.2 ( a ) ( i ) :-
“Delete one heavy coat of ready-mixed paint red lead priming to IS : 102”
And
Read Para No. 217.2 ( a ) ( i ) as under :-
“Priming Coat :- One coat of ready mixed paint Zinc chromate priming to IS : 104 followed by one coat of ready mixed paint red oxide, Zinc Chrome priming paint to IS : 2074.
Or
‘Two coats of zinc chromate, red oxide primer to IRS – P – 31.”

2. Para No. 217.2 ( b ) ( i ) :-
“Delete two coats of ready-mixed paint red lead priming to IS : 102”
And
Read Para No. 217.2 ( b ) ( i ) as under :-
“Priming Coat :- One coat of ready mixed paint Zinc chromate priming to IS : 104 followed by one coat of Zinc Chrome red oxide priming to IS : 2074.

ADVANCE CORRECTION SLIP NO. 13 DATED 22.01.2008
(Issued under Railway Board’s letter no. CBS/PSBC Dated 22.01.2008)

Existing Para No. 317 may be replaced as under:
317: Approval of bridge drawings for doublings, gauge conversions, new lines and other bridge works:
(i) In case of doublings/ gauge conversions, General Arrangement Drawings for all major bridges, bridges where linear waterway is being reduced or vertical clearance are inadequate and where construction is likely to affect any of the existing bridges, shall be approved by Chief Bridge Engineer.
(ii) General Arrangement Drawings for bridges constructed on new lines, which affect the existing bridges, shall require the approval of Chief Bridge Engineer.
(iii) General Arrangement Drawings for all bridge works on open line shall require approval of Divisional Railway Manager and Chief Bridge Engineer.

ADVANCE CORRECTION SLIP NO. 14 DATED 20.03.2008
(Issued under Railway Board’s letter no. CBS/PSBC Dated 20.03.2008)

i) Delete the existing Para No. 310 of Chapter III and insert as under :-
310. Design Discharge for Foundations ( Qf )
To provide for an adequate margin of safety against any abnormal flood exceeding the design discharge ( Q ) the foundations, protection works and training works except free board, shall be designed for a higher flood discharge. This shall be computed by increasing the design discharge ( Q ) estimated according to Para 309, by the percentage indicated below :-

| i ) | Catchment up to 500 Sq. km. | 30% |
| ii ) | Catchment more than 500 Sq. km. and up to 5,000 Sq. km. | 30% to 20% ( decreasing with increase in area ) |
| iii ) | Catchment more than 5000 Sq. km. and up to 25,000 Sq. km. | 20% to 10% ( decreasing with increase in area ) |
| iv ) | Catchment more than 25000 Sq. km. | Less than 10% ( at the discretion of the Chief Engineer ). |

ii ) Delete the existing Para No 312 ( 4 ) of Chapter III and insert as under :-
312. 4. While rebuilding bridges on existing lines or building new bridges on parallel doublings, the clearance stipulated above can be relaxed by Principal Chief Engineer / Chief Bridge Engineer with the consideration to the past history, to the extent shown provided:
(a ) adoption of the prescribed values of clearance would result in heavy expenditure and / or serious difficulties in construction, and
(b) the clearance can be safely reduced from those stipulated under sub Para 1 above.

<table>
<thead>
<tr>
<th>Discharge (Cumecs)</th>
<th>Reduced Clearance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 3</td>
<td>300</td>
</tr>
<tr>
<td>3 to 30</td>
<td>300 – 400 (Pro – rata)</td>
</tr>
<tr>
<td>31 to 300</td>
<td>400 – 1200 (Pro – rata)</td>
</tr>
</tbody>
</table>

This is in accordance with Para 4.8.3 of IRS Bridge Sub Structure & Foundation Code.

iii) Delete the existing Para No 313(2) and 313(3) of Chapter III and insert as under:

313. 2. In special circumstances where the free board can be safely reduced and where adoption of the prescribed values would result in heavy expenditure and/or serious difficulties in construction, the free board may be relaxed at the discretion of the Principal Chief Engineer/Chief Bridge Engineer as indicated below:

<table>
<thead>
<tr>
<th>Discharge (Cumecs)</th>
<th>Minimum free board (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 3</td>
<td>600</td>
</tr>
<tr>
<td>3 to 30</td>
<td>750</td>
</tr>
<tr>
<td>More Than 30</td>
<td>No relaxation is permissible</td>
</tr>
</tbody>
</table>

3. While executing works other than rebuilding a bridge or extending it for doubling purpose, the existing free board may be retained after taking measures for safety as considered necessary by Principal Chief Engineer/Chief Bridge Engineer.

ADVANCE CORRECTION SLIP NO. 15 DATED 05.08.2008
(Is issued under Railway Board’s letter no. CBS/PSBC Dated 05.08.2008)

1.0 Para 410 (2)(b): Para 410 (2)(b) is replaced as below:

"The minimum factor of safety with static or dynamic formula shall be 2.5. The value to be selected for the factor of safety shall, however, take into account, the allowable total settlement and differential settlement of the structure as a whole. The ultimate load capacity should be obtained, whenever practicable, from a load test (initial) (as per IS: 2911 (Part 4) – 1985). Factor of safety for assessing safe load on piles from load test data should be increased in unfavorable conditions where:

(I) settlement is to be limited or unequal settlement avoided as in the case of accurately aligned machinery or a superstructure with fragile finishing.

(ii) large impact or vibrating loads are expected.

(iii) the properties of the soil may be expected to deteriorate with time, and

(iv) the live load on a structure carried by friction piles is a considerable portion of the total load and approximates to the dead load in its duration.

2.0 Para 418 (5) : ‘300 mm’ is replaced by 300 mm or of appropriate’.

3.0 Para 430: Para 430 is replaced as below:

" Construction of the top plug: The Construction of the top plug should be started only after the sand filling has settled thoroughly and tested by ramming."

4.0 Para 3(ii) of 606 is proposed for deletion and Para 3(1) be renumbered as 3.

ADVANCE CORRECTION SLIP NO. 16 DATED 13.08.2008
(Is issued under Railway Board’s letter no. CBS/PSBC Dated 13.08.2008)

Existing Para 317 (iii) may be replaced as under:

317: (iii) General Arrangement Drawings for all bridge works on open line shall require approval of Chief Bridge Engineer.

ADVANCE CORRECTION SLIP NO. 17 DATED 15.09.2008
(Is issued under Railway Board’s letter no. CBS/PSBC Dated 15.09.2008)

Para 318 may be inserted as below:

Para 318: Approval of bridge drawings for Dedicated Freight Corridor lines:

"General Arrangement Drawings for all major bridges on Dedicated Freight Corridor lines, bridges where linear water way is being reduced or vertical clearance are inadequate and where construction is likely to affect any of existing bridges, shall be approved by Chief Bridge Engineer."
Add new para 224 in IRBM as below :-

224 – Dismantling of arch bridges :-

1. In case of running lines prior CRS sanction for methodology / safety precautions, drawings etc. shall be obtained for dismantling work of the arch bridge.

2. Arch is a structure, which transmits heavy horizontal thrust to abutments and piers. In case of abutments, this load is resisted by heavy section of abutment and soil fill behind it. At piers, in case of multi span arches, horizontal thrust due to dead load is balanced. If both spans are loaded, horizontal thrust due to live load also gets balanced, but in case of only single span being loaded, pier has to bear unbalanced horizontal thrust. Piers are therefore designed to take up only unbalanced horizontal thrust which is quite less as compared to total thrust at abutment.

3. Whenever in multi span arches, if one span is dismantled, large unbalanced horizontal thrust comes on pier and there can be collapse of pier along with other spans. Following procedure, suitable for both single and multi span arches, can be followed to safely dismantle arch bridges :-

   (a) Dismantling with explosives – Explosives can be used to bring down all spans of an arch bridge at one go. This will require cordoning off the area likely to be affected by the explosion and long time to remove the debris thereafter. This method can only be used if the arch is not near habituated area and experts can be engaged to take up such work.

   (b) Dismantling with machinery – Special type of machinery with long jib can be used to dismantle one span of arch on one go. As unbalanced horizontal thrust may cause collapse of all or few other spans of the bridge, whole work should be planned in a single block and all the spans should be dismantled in one block. It must be ensured that work is completed in the block and no portion of the arch is left with unbalanced horizontal thrust in the block. This procedure will require cordoning off the whole area and engaging suitable machinery.

   (c) Part by part dismantling – The above two methods, though safe may not be possible under many circumstances. In part by part dismantling method, dismantling is done in such a systematic manner that at no point, there is excessive unbalanced horizontal thrust on piers.

Step by step procedure shall be as under :-

(i) Divide the depth of soil into two parts, i.e. Part ‘A’ from top of soil to the depth up to level of crown of arch. Part ‘B’ is from crown level to the top of abutment / pier as shown in fig. 1 (a).

(ii) Divide the width (W) of bridge into equal parts each about 50 cm wide for the width of each span as shown in Fig. 1 (b). (Fig. 1 (b) shows bridge divided into seven parts, it will be more for wider bridges). No. of divisions should be odd number.
Engage four parties to remove soil. First party will start removing soil from the Section “A1”. It means start removing soil in the section – 1 from top level and depth up to the level of crown of arch i.e. Part ‘A’ as shown in the sketch. Second party will simultaneously remove the soil from Section – 2 Part ‘A’ i.e., A2. It means soil from top level to the depth up to the crown. Third and four parties shall work in section A3 & A4.

After completing A1, A2, A3, & A4 follow the sequence Section A5, A6, A7, A8 and A9, A10, A11 & A12 and then A13 & A14. After this exercise Section A is cleared. This procedure ensures that there are no unbalanced lateral forces.

Similarly follow the same sequence for removing soil of Part – B.

Provide thick nylon netting supported on piers so as to arrest any falling debris as shown in Fig 1 (c).

Now each of four parties should break spandrel wall S1, S2, S3 & S4 simultaneously under block, as some debris can fall on track.

After breaking spandrel wall, arch barrel of section 1, 2, 3 & 4 shall be broken under protection by each of four parties. In next block section 5, 6, 7 & 8 shall be broken and so on.

At the end last middle section 13 & 14 will remain (since arch has been divided in to odd numbers of parts), which should be dismantled by pulling it down with the help of ropes or some long jib machinery while dismantling last section, no person should be on top of the arch.

After wards piers can be dismantled in systematic manner from top to bottom.

In case of 3 span arches, no. of parties required shall be 6, in case of 4 span arches, no. of parties required shall be 8 and so on.

**4. General –**

The dismantling of arches should be done under proper supervision and as per approved scheme of dismantling.
(b) At major dismantling sites, minimum level of supervision shall be senior section Engineer (in charge), who should be nominated by Dy. Chief Engineer / Sr. DEN in writing.

c) Dismantling plan should be approved by Chief Bridge Engineer in case of open line organization or H.O.D. In case of Construction Organization. Dismantling plan should invariably mention the sequence of dismantling operations, equipments to be used for dismantling, area likely to be affected by debris, any adjacent buildings likely to be affected and action to be taken there of.

d) Proper barricading should be done to stop access of unauthorized personnel near the dismantling area. Wherever necessary, assistance of RPF should be taken to prevent people from coming close to dismantling area. Signages warning people not to enter the danger zone should also be displayed.

e) Proper announcement through Public Address System should be done at regular intervals to keep the onlookers away from the major dismantling affected zone.

f) The adjacent buildings likely to be affected by dismantling should also be evacuated.

g) In area where law and order is likely to be affected, assistance of local police should be taken to keep people away from dismantling area.

h) Dismantling would be done under rail and road traffic diversions / blocks.

ADVANCE CORRECTION SLIP NO. 19 DATED 11.1.2010
(Issued under Railway Board’s letter no. CBS/PSBC Dated 11.1.2010)

New para 318 inserted vide correction slip No. 17 dt. 15 – 9 – 08 is modified as under :-

Para 318 :- Approval of bridge drawings for Dedicated Freight Corridor lines :-

(i) “General Arrangement Drawings for bridges on Dedicated Freight Corridor lines where alignment is on de-tour, far off from the existing track, where linear waterway is being reduced or vertical clearances are inadequate and where new bridge (during construction or during service) is likely to affect any of existing bridges, shall be approved by Chief Bridge Engineer.

(ii) “General Arrangement Drawings for bridges on Dedicated Freight Corridor lines where alignment is near the existing track, all major bridges and bridges where linear waterway is being reduced or vertical clearances are inadequate and where new bridge (during construction or during service) is likely to affect any of existing bridges, shall be approved by Chief Bridge Engineer.

ADVANCE CORRECTION SLIP NO. 20 DATED 7.6.2010
(Issued under Railway Board’s letter no. CBS/PSBC Dated 7.6.2010)

Para 1104 (5) vide correction slip No.20 dt.7.6.10 is replaced as below:

“Scrutiny by Territorial HOD & CBE and action thereon :-
The registers should then be forwarded by the Divisional Engineer to the Territorial HOD by a specified date, who will examine each register, issue orders regarding matters referred to him duly endorsing the registers to the effect. In cases where bridge matters are referred by divisional engineer to HQ’s office, then those bridge registers should also be seen by CBE after scrutiny by THOD. The registers should then be returned to the Divisional Engineer latest by a specified date. Subsequent action taken on the Territorial HOD’s and CBE’s orders should be entered in the register by the Assistant Engineers.”

ADVANCE CORRECTION SLIP NO. 21 DATED 2.7.2010
(Issued under Railway Board’s letter no. CBS/PSBC Dated 2.7.2010)

(i) “Para 1107 (d) to be modified as below :

Underwater sub-structure inspection :
The sub-structure of the bridges which are normally under water should be inspected by adopting suitable methods which may include engaging of divers and special equipments:

(i) Routine/swim by inspection should be done once a year

(ii) Detailed inspection should be done once in five years.

(iii) Special inspection- as considered necessary”

(ii) “Add new Para 1107(15) (i) in IRBM as below :

1107 (15) (i) In case of PSC girders, measurement of loss of deflection should be done. Deflection measurement should be at centre up to 20m span and at centre & quarter points for spans more than 20m. Deflection measurements would be entered in column 8 of Annexure 11/9.”

ADVANCE CORRECTION SLIP NO. 22 DATED 28.3.2011
(Issued under Railway Board’s letter no. CBS/PSBC Dated 28.3.2011)
Replace existing Para 1107 (15) (i) in IRBN with following and renumber it as 1107 (15) (b) (i):

1107 (15) (b) (i) – In case of PSC girders, assessment of loss of camber should be done. Camber measurement should be at center up to 20 m span and at center & quarter points for span more than 20 m. Camber measurements would be entered in column 8 of Annexure 11 / 9.

(ii) Existing Para 1107 (15) (b) is renumbered as 1107 (15) (b) (ii).

ADVANCE CORRECTION SLIP NO. 23 DATED 23.8.2011
(Issued under Railway Board’s letter no. CBS/PSBC Dated 23.8.2011)
Replace existing Chapter-VIII (River Training and Protection Works) by Revised Chapter-VIII (River Training and Protection Works) as appended below:

CHAPTER-VIII
RIVER TRAINING AND PROTECTION WORKS

801. Training/protection of rivers - The objective of river training/protection works is to prevent the river from damaging Railway formation, bridges and other structures. The training/protection works will have to be decided depending on the reach in which the river is situated namely:

a) Upper reaches (Mountainous)
b) Submontane reaches (Foot hills)
c) Quasi-alluvial reaches (Trough)
d) Alluvial reaches, and
e) Tidal reaches

802. Upper Reaches (Mountainous Rivers)
1. Characteristics: - These streams have narrow and deep cross section with very steep bed slopes. The gorge is often deep and narrow with formation of rapids. The discharge is extremely variable and their beds are interspersed with large size bed material consisting of rock, boulders, shingle and gravel. The rise of flood in them is very sudden and flashy. The water is heavily sediment laden, with high concentration of suspended load.

2. Suggested protective measures: - The following protective measures are suggested/recommended for adoption:

a) Suitable protective fenders of concrete, rolled steel or rails may be provided upstream of the bridge to reduce the impact on piers and abutments due to rolling boulders down steep slopes.
b) Measures for controlling soil erosion and landslips, improving stability of side slopes and arresting bed load in boulder bedded hilly terrains should be undertaken.
c) The formation of gullies by the water coming down the hills can be prevented by afforestation, construction of gully/check dams, contour bunding, debris basins, chambers or wells. These should be cleaned as frequently as necessary.
d) Stability of side slopes can be improved by provision of adequate drains, breast and toe walls etc.
e) Properly designed chutes with paved apron at the entrance with adequate free board may be used in Railway cutting for leading the water of mountainous streams down the hill slopes. Alternatively, suitably designed catch water drains on water-shed side may be constructed.

803. Submontane Reaches (Foot Hills)
1. Characteristics: - The rivers in these regions have a flatter bed slopes generally from 1 in 50 to 1 in 500. The velocity and its sediment transporting capacity get reduced encouraging deposition of excess sediment load. Medium size boulders, gravel and coarse sand are generally found in the beds. The floods are of flashy nature. These streams are highly erosive and the erosion proceeds through grinding of bed material during transport, formation of deep holes through whirlpools and plunging action along with cliffs forming the banks, in the higher reaches. These actions go on widening the bed and deepening the channel. The flow in the channel, except during highest stages, is insufficient to transport the detritus which gets deposited blocking the original channel; another channel may then be formed and in course of time the river bed may become a network of such channels with islands in between. Such streams are called “Braided” stream (Annexure 8/1). All these channels normally overflow during high floods and the river acquires very wide and shallow cross section. The rivers in this reach are prone to progressively raise their beds by sediment deposition. Such rivers are known as “Aggrading” type. In these cases, the over bank spills increase year after year, until occurrence of abnormal floods in a year, when sudden change of course may take place.
2. **Suggested protective measures**: It is not desirable to locate bridge in such reaches. However, if a bridge is to be provided, training measures in the form of marginal bunds, extending right up to the high ground in the hills are required to shift the point of aggradation downstream. To reduce the erosive action on the marginal bund:
   a) Suitable slope protection with boulders or concrete slabs,
   b) Adequate toe protection in the form of two rows of in-situ concrete blocks or boulders in wire crates and,
   c) Boulders in wire crates forming flexible type apron may be provided.

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**804. Quasi-Alluvial Reaches (Trough)**

1. **Characteristics**: In this reach, the bed slope varies from 1 in 500 to 1 in 2,500. The bed consists of small size gravel and medium sand. The channel has generally a well defined course.

2. **Suggested protective Measures**: Bridging such rivers normally involves constriction in width and provision of guide bunds. Assistance of specialised agency, undertaking hydraulic model studies may be availed of, as considered necessary.

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**805. Alluvial Reaches**

1. **Characteristics**: In this reach, the river bed slope varies from 1 in 2,500 to 1 in 25,000. The river flows on an almost flat bed built by its alluvium. The alluvial river meanders as a whole within its “Khadir” (a strip of low land within which a river meanders and its flood rises. In terms of river hydrology, khadir is used to define extent or width of the river bed within which the river is likely to flow either during lean or flood season. Khadirs are generally bound by high and firm banks. Khadirs can be very wide say 6 to 8 km and are particular to rivers in alluvium terrain ). (Annexure 8/2).

   The main difference between the alluvial and quasi-alluvial rivers is that the former meanders as a whole within its “Khadir” while the later has well defined banks and it is only during periods of low water that the channels meander. Rivers in alluvial reaches are normally stable with no perceptible lowering or raising of the river bed in the course of the years. Shape, size and mobility are the most important characteristics of a meander for design and maintenance of railway bridges. They are described below (Annexure 8/2):

   \[ LR = \text{Length along maximum depth} \]
   \[ LR / LV = \text{Tortuosity ratio} \]
   \[ LV = \text{Valley length} \]
   \[ W = \text{Width of the channel} \]
   \[ R = \text{Radius of bend} \]
   \[ ML = \text{Meander length} \]
   \[ MB = \text{Meander Belt} \]
   \[ Q = \text{Angle of bend} \]

   Meander shape can be circular/sinusoidal or parabolic and is defined by tortuosity ratio. A tortuosity ratio of 1 describes a straight channel. A ratio of 5.5 is a limiting value when consecutive bends are likely to cut into one another. The meander size is defined by the ratio of the radius of center line of bend or a meander and surface width of the channel.

   \[ \text{Meander Size} = R / W \text{ or } MB / W \]

   Meander shape is the most efficient hydraulic flow under the given flow conditions. If the present channel flow condition becomes hydraulically less efficient, river is able to find a more efficient path i.e. an alternative channel known as cut-off. This can be a natural development by the river itself. Alternatively, it can be artificially developed by cutting a pilot channel. Depending upon the location of cut-off, it can be either a neck/loop cut-off or chute cut-off. Neck / loop cut-off occurs due to progressive bank erosion at the bend of acute bends, as shown in Annexure 8/2. This is more commonly occurring natural case of cut-off. A chute cut-off occurs at the flat of a meander and is less common as compared to neck cut-off. Immediately after a cut-off takes place, there are number of changes in the flow pattern both up and down stream of the cut-off. There is heavy erosion of banks and the new channel readjusts itself to the new alignment. There can be local deposits on the downstream side, where the cut-off channel meets the main channel. This however is removed in a season or two during succeeding floods.

2. **Suggested protective Measures**: The training of alluvial rivers is generally on the same lines with guide bund system as described for quasi-alluvial rivers. The meanders do not remain fixed but usually travel downstream. Every effort should be made to keep the river to its original course near the bridge. In some cases it is observed that the main current of the river starts flowing along the railway bank on the upstream side due to the meander travel downstream. The building of spurs along the railway embankment is not a good remedy, as it perpetuates the main channel along the Railway alignment. In such cases every effort should be made to divert the river to its original course. In some cases the construction of a second control point consisting of a spur about 0.4 times the meander length has been found to be satisfactory. The exact length and location of such works however, should be determined through model studies in a hydraulic laboratory.
806. Tidal Reaches - A river, whose flow changes periodically due to tides, is called tidal. Before joining the sea and before becoming a tidal river, it may branch off into several streams forming a delta. The last portion is called a delta river. Constriction of the water way is to be avoided in these reaches and tidal regime is to be kept in view, while designing bridges.

807. South Indian Rivers - The river system in south India is geologically older and stable. Tendency for shifting of the river bed course and aggradation / degradation is insignificant. Problems of river training and protection normally do not arise except in the deltaic region/tidal reaches.

808. Important considerations for hydraulic structures - For hydraulic design, most important parameters are discharge, gauge Level / HFL, scour and physical layout of the channel. Parameters like discharge and bed slopes can vary and estimation of them is largely empirical. For important rivers, data required for computing flood discharge are generally available. The data may require proper interpolation or extrapolation. Discharge is also worked out on the basis of Gauge-Discharge curve. This is also a fairly reliable estimate. All bridges shall be designed with adequate waterway for design discharge. This shall normally be the computed flood with a probable recurrence interval of 50 years. However, at the discretion of Principal Chief Engineer / Chief Bridge Engineer, bridges, damage to which is likely to have severe consequences may be designed for floods with a probable recurrence interval of more than 50 years.

The discharge should be known for design of pier as well as protection works. Discharge should also be known for the lean period, when construction will be undertaken. This will decide how temporary works should be designed to enable construction activities. It is for the lower discharge, when pitching of bank slopes fail. This is because of high surface velocity at lower discharge, when scour has not fully developed.

Scour data can be had from the evidence left behind the river for past discharge gauge. This requires careful survey and enquiry made from local people. Known water holes or sounding of some structures upstream can give very useful information. This needs to be verified by calculations either made by some empirical methods or by hydraulic model studies. Scour depth likely to be there for lower discharge during construction is very important data. This is necessary for designing temporary works required during construction.

809. River Training Works - The necessity and suitability of River Training Works should be carefully assessed. For effective design of river training works, following useful details are to be collected:

i) History of flow / channel - Change of river course happens mainly due to meandering effect of the river. In case of meander, it is possible to know the maximum radius of curvature from which it should be possible to estimate the likely area of effect. Adequate studies and data keeping results in easier, cost effective and simpler designs of protection measures.

ii) Addition of any hydraulic structure on the regime of the flow should be taken note of, both on upstream as well as on downstream. On downstream side, effects are rarely beyond 5 kms. Such changes may be in the form of additional spans/works provided by highways on upstream side. This may also be due to construction of barrage/dam/water storage structures. These are considered as Railway Affecting Works and may have significant impact on Railway bridge.

iii) Shift in flow channel because of meander: This should be studied particularly with reference to acuteness of the meander given by tortuosity ratio.

iv) Any large scale deforestation on upstream will cause heavy sediment load leading to change in flow pattern.

The following types of river training work sand bank protection measures are generally adopted on the Indian Railways:
1. Guide Bunds;
2. Spurs (Groynes);
3. Marginal Bunds;
4. Closure Bunds;
5. Assisted Cut-offs;
6. Boulder Crates and
7. Sausage Crates.

810. Guide Bunds

1. Necessity :- Guide bunds are meant to confine and guide the river flow through the structure without causing damage to it and its approaches. They also prevent the out flanking of the structure.

2. Shape and Design Features :
a) The guide bund can either be divergent upstream or parallel. In the case of divergent guide bund, there is possibility of formation of a shoal at the center. Parallel guide bunds minimise obliquity and separation of flow along the flanks. According to geometrical shape, the guide bunds may be straight or elliptical. In the case of certain type of alluvial rivers with sandy bed and meandering pattern, elliptical shape appears preferable to minimise obliquity and separation of flow. Various types of guide bunds are shown in Annexure 8/3.
b) Normally the upstream shank of the guide bund is between 1.0 to 1.5 times the length of the bridge, while the downstream shank is between 0.25 to 0.4 times the length of the bridge.
c) The tail bund on the downstream side is provided to afford an easy exit to the water and to prevent formation of vertical whirlpools or rollers which give rise to scour. These tail bunds are also curved at their ends and should be properly armoured.
d) The guide bund is provided with a mole head on its upstream side. The mole head bears the brunt of the attack and should be provided with adequate protection in the form of slope pitching and properly designed launching apron. The shank i.e. the portion behind the curved mole head of the guide bund should also be similarly protected on the river side. The slope in the rear of the guide bund need not necessarily be provided with pitching and may be protected by planting grass or shrubs as found suitable.
e) Radius of curved upstream mole head may be taken as 0.45L (L is water way width determined from Lacey’s formula subject to minimum of 150m and maximum of 600m). The radius of downstream curved tail may be kept as 0.3 to 0.5 times the radius of upstream curved head. The angle of sweep of curved head may range from 1200 to 1450 according to river curvature and that of the tail head may be kept as 450 to 600. For smaller rivers, one single radius is good enough. For important rivers, multi radii may be selected generally after model studies for smoother flows.
f) Top width of the shank of the guide bund should be wide enough to permit plying of trucks and keeping reserve boulders for maintenance. From this consideration top width may be taken between 6m to 9m, and side slopes may be taken as 2:1.
g) Side slopes of guide bund needs protection on following counts:-
i) Wave action on the upstream side
ii) Water current along the slopes
iii) Wind action
iv) Rain cuts/Rain water
Most common method is to provide stone pitching. It is necessary to provide 20cm to 30cm thick graded filter below the pitching. Stone used for pitching is generally man size boulder of 35 to 55kg so that they cannot be easily displaced by the current. For small works, one stone thick pitching (25 to 30cm) should suffice. Gaps in between could be filled up by smaller pieces.
In case of guide bund, the pitching should continue right up to the top of the formation for the river side, including the curved head on both sides and tail head. For important rivers or in case of large ponding etc., the pitching should be done on the rear side of the guide bund also. For approach embankment, on the upstream side, the pitching should continue up to the free board level which should be determined not only on HFL but also to take care of velocity head (V^2/2g), wave action etc. For the downstream side, pitching may be done up to the water level based on hydraulic model study or general water level observed. A good drainage is key for protection of slopes from rain cuts, particularly on high banks of over 6m height. For this, longitudinal and cross drains should be provided.
Guide bunds and approach embankments particularly in khadir of the river must be constructed in one go in one season. In case this is not possible, at least, a wedge size equal to angle of internal friction of the old construction should be removed and the next construction should be done with proper benching. For slope protection and apron, an overlap may be provided.
h) No spurs projecting from the guide bunds should, in any case, be provided.
k) A typical lay out of a guide bund is shown in Annexure 8/4.3. Apron Protection for guide bunds:
a) Apron is provided beyond the toe of the slope of the guide bund, so that when bed is scoured, the scoured face will be protected by launching of the apron stone or wire crate containing stone.
b) Following are the important details for design of apron:
i) **Thickness of apron** - Thickness of apron is governed by thickness of pitching on the slopes of the guide bund (T). In case of straight portion of guide bund, the thickness of apron through its width is...
generally kept as 1.5T. In case of curved portion of guide bund, the thickness of apron is generally kept as 1.5T at the junction of apron with pitching on the slope and the same is increased through its width to 2.25T at the end of apron.

ii) Level at which the apron is to be laid: Normally apron should be laid on dry bed, as low as possible.

iii) Width of apron: Width of apron is determined by depth of scour and is generally kept as 1.5 times the difference between the deepest known scour level and low water level.

4. Maintenance:
   a) Substantial reserve of pitching stone should be maintained on the guide bund for use during emergency. This should be stacked at the top of the guide bund. Quantity of reserve stock to be maintained at guide bund should also be specified by Principal Chief Engineer/Chief Bridge Engineer as per provisions of Para 709(1).
   b) The track on the guide bund, where provided, should be maintained in a satisfactory condition and should be capable of taking boulder trains at any time. The Permanent Way Inspector and the Assistant Engineer should inspect the track soon after the monsoon every year and carry out necessary repairs well before the next monsoon.
   c) Every effort should be made to ascertain whether the apron is launching to the intended position and this should be done by probing after the flood season is over. Plotting of the levels will indicate the efficacy of the launching.
   d) Disturbance of pitching stone on the slope indicates dangerous condition and additional stones should be placed in position immediately as necessary.

5. Failures and remedial measures: The conditions under which an apron of the guide bund can fail and remedial measures to be adopted are stated below:
   a) If the launching takes place beyond the capacity of the stone in the apron and results in leaving the bank material exposed to the current and wave action, more stone will have to be added to the apron.
   b) If stones are carried away by high velocity current from the launching apron and the toe of the bund, the apron should be strengthened against severe attack by laying large sized stones at the outer edge of the apron.
   c) If slips and blow-outs in the bund occur due to a steep sub soil water gradient resulting from a rapidly falling flood in the river, the bank should be widened to reduce the hydraulic gradient. This equally applies to marginal bunds.
   d) Wherever disturbance is noticed in rear of guide bund due to wave lash or other causes, the slope pitching should be adopted as a remedial measure.
   e) An apron can launch satisfactorily only if the material scour easily and evenly and the angle of repose of the underlying material is not steeper than that of the stone.

In all these cases action should be taken to dump the boulders on the toe of the bank and make up irregular surface.

811. Spurs (Groynes)

1. A spur/groyne is a structure constructed transverse to the river flow and is projected from the bank into the river.

2. Type of spurs/groynes:
   i) They may be either “Permeable” or “Impermeable”. Permeable spurs are constructed by driving wooden bullies or bamboos, filled in with brush wood, with sarkanda mattresses or other suitable material. These are helpful in causing quick siltation due to damping of velocity. They are useful when flood velocities are relatively lower and concentration of suspended sediment load is heavy. They allow water to pass through. Permeable structures are discussed in detail in Para 811(5). Impermeable spurs are made of solid core, constructed of stones or earth and stones with exposed faces protected by pitching. These spurs can withstand severe attack better than permeable spurs.
   ii) Spurs may be classified as (a) repelling (deflecting) (b) attracting and (c) normal (sedimenting). Repelling (deflecting) spurs are those which incline upstream at an angle of 60 degree to 70 degree to the river course and deflect the current towards the opposite bank. They cause sitting in still water on the upstream pocket. Attracting spurs incline downstream and make the deep channel flow continuously along their noses. They cause scour just on the downstream side of the head due to turbulence. The river flow is attracted towards the spur. Normal (sedimenting) spurs are those which are built at right angles to the bank to keep the stream in a particular position and promote silting between the spurs. They have practically no effect on the diversion of the current and are mostly used for training of rivers for navigational purposes.
iii) Spurs are also classified as full height spurs and part height spurs. Where top level is higher than HFL, it is called a full height spur.

iv) Spurs are also constructed extending into the stream with a “T” head or hockey stick shaped head, properly armoured to hold the river at a distance. A series of such spurs / groynes correctly positioned can hold the river at a position away from the point intended to be protected. The edge of the “T” head should be curved somewhat in the manner of a guide bund to avoid swirls. Sketches of the various types of spurs may be seen in Annexure 8/5.

3. Location and salient features of a spur / groyne :-

i) The space between spurs or groynes generally bears a definite ratio to their length. The common practice is to keep the spacing at about 2 to 2.5 times the length so as to effectively protect the bank.

ii) If designed as a full height spur, care should be taken to see that spurs are built sufficiently high so that they are not overtopped and out flanked by the current during high floods. Free board of 1 meter is provided.

iii) The side slopes of spurs are generally 2:1.

iv) The spurs should be anchored on to high ground.

v) The head of the spur is most vulnerable point for scour and should be well protected on slopes by pitching and at toe by an apron designed for scour depth of 2.5 to 2.75 times D Lacey at the mole head. For computation of D Lacey, Clause 4.6 of ‘IRS Code of Practice for the Design of Substructures and Foundations of Bridges’ may be referred.

vi) Spurs should never be constructed at a point where severe attack is taking place but at some distance upstream.

vii) Spurs / groynes should be used only insituation where they are absolutely necessary.

viii) The design of spurs may be finalised preferably through hydraulic model studies.

ix) For design and construction of groynes (spurs)/launching aprons reference may be made to IS:8408-1994 (Planning and Design of Groynes in Alluvial Rivers – Guidelines) and IRC:89-1997 (Guidelines for Design and Construction of River Training and Control Works for Road Bridges).

4. Maintenance of spurs / Groynes :- In all cases, satisfactory arrangement should be made for the maintenance of spurs / groynes by providing access to them during all seasons of the year and keeping boulders as reserve. The maintenance procedures specified for guide bunds apply equally to spurs / groynes also.

5. Permeable Structures :-

a) Permeable structures can be used either independently or with the support of other impermeable stone structures or river training and bank protection measures. These structures are easy to construct, use low cost locally available material and require limited skill in construction. These are very handy in antierosion works during emergencies in floods. These structures can also be used in areas where good quality stones are costly and/or not available. Thus permeable structures are cost effective alternative to the river training or antierosion works with impermeable spurs. Depending upon the purpose to serve, the permeable structures are constructed transverse or parallel to the direction of flow. Permeable structures serve one or more of the following functions:

i) Training the river along a desired course.
ii) Reducing the intensity of flow at the point of river attack.

iii) Creating a slack flow to induce siltation in the vicinity of the permeable structures and in the downstream reach.
iv) Providing protection to the bank by dampening the velocity of flow along the bank.

b) The permeable structures can be classified as follows :-

i) According to function served, namely, diverting and dampening, sedimenting.
ii) According to the method and material of construction, namely, bally, bamboo, tree and willow structures.

iii) According to the conditions encountered, namely, submerged and non submerged.
iv) According to the type of structure provided, namely, spur type, screen type or dampeners (revetment) type.

c) The permeable structures are made up of different types of smaller units called elements. Many elements, made up of bamboos, ballies, RCC poles etc. are arranged in specific pattern and linked together to form a permeable structure. Different types of elements used for making permeable structures are as following:
i) Porcupines – Porcupines are typically made up of bamboos / ballies, have cubical/prism shaped box at the central portion with their legs extending in all directions. The overall size is 2m to 3m. The central box is filled with stones for stability of individual unit during floods. (Annexure-8 / 6 (a & b).

ii) Cribs – This is a pyramid type of structure made up of bamboos / ballies with a box at the bottom for holding stones for stability during floods. Size of the box is generally square of size 2m to 2.5m at the bottom. Total height of the structure is 3m to 4m. (Annexure – 8 / 6 (c).

iii) Bally frames - Permeable bally structures are made up of main skeleton of large bamboos or ballies. Cross ballies are used for stability of the structure.

iv) Tree branches – Branches of trees or trees of short height are hanged from a wire rope duly weighted with stones and are aligned as a spur projecting into the river. The wire rope is duly anchored on the bank and in the riverbed.

d) The main criteria for the selection of the material are cost and easy/local availability. Standard, commercially available bamboos of girth 20cm to 30cm are used for the porcupines and cribs. Smaller girth of 20cm to 25cm is used for bracings. Standard, commercially available ballies of girth 15cm to 25cm are used for the bally structures. Normally, the larger girth of 20cm to 25cm is used for the main members, whereas, the smaller girth of 15cm to 20cm is used for bracings. Generally, 4 to 5 strands of 4mm GI wire are used for interconnecting porcupines, cribs, and anchor them to the ground.

Ballies driven into the ground up to a depth of 2m are treated as anchor. Concrete anchors have an anchor rod of size 32-36mm, well embedded in concrete cube. Wire crate anchors are of size 1.5m x 1.5m x 1.5m, made up of thick wires and filled with stones or bricks. A concrete block is casted with bolt and is included in the wire crate anchor. In case of emergencies, tie wires are joined directly to the wires of the crates.

e) In case of shallow water flows and up to maximum depth of flow 3m to 4m, porcupines are used for both spurs and screens. For maximum depths of flow from 4m to 6m, cribs are preferred. For the depths beyond these limits, bally spurs are preferred.

f) Permeable structures commonly used are spurs, dampeners and screens.

i) Spurs are generally made up of 3 to 4 rows of porcupines or 4 to 6 rows of cribs. Schematic sketch of typical permeable spur is shown in Annexure-8/6(d). On a straight reach, permeable spurs are normally spaced at 3 to 4 times its length. On a curved channel, depending upon the obliquity of flow, the spurs are normally spaced at 2 to 3 times the length. Projection of the spurs into the river channel is normally 11% to 15% of width of channel. Three spurs are normally provided for a specific reach to be protected. A single permeable spur is generally not found effective. Alignment of spurs is kept pointing towards upstream.

ii) For depth of flow up to 3m, two rows of porcupines are laid along the banks on either side at the toe as dampeners. For more depth, numbers of rows are increased.

iii) Permeable screens are used for choking the secondary channels. 4 to 6 rows of porcupines or 6 to 9 rows of cribs are normally used in a permeable screen. One screen is normally provided at the entrance of the bypass or secondary channel. The second screen is provided at a distance of 1 to 1.5 times width of the screen and is extended on both the banks for a length one third of the channel width.

g) Due to inherent weakness of the elements, the counter weights are provided in the central box of the porcupines or in the bottom tray of the cribs. Due care is necessary to tie the weights to the main body of the elements. The elements are tied to each other by wire ropes. The tie ropes are duly anchored to the bank and at the nose with the help of suitable anchor or anchor blocks. Intermediate anchors are also provided at an interval of 15m to 20m along the length of the structures on the upstream side.

h) No bed protection is needed for the structures made up of porcupines and cribs. Sinking of these structures into riverbed is a welcome feature, which adds up to the stability during floods resulting in better performance.

812. Marginal Bunds - Marginal bunds are provided to contain the spread of the river when the river in flood spills over its banks upstream of the bridge site over wide area and likely to spill in the neighbouring water courses or cause other damages. The marginal bund should normally be built well away from the active area of the river. The slope should be well protected by turfing. Where a marginal bund has to be built in the active area of the river, it should be protected with pitching and apron. The earth for the construction of marginal bund should preferably be obtained from the river side. The upper end of the marginal bund should be anchored into high ground well above HFL. Marginal bunds should be inspected every year along with the annual bridge inspection and necessary repairs should be carried out before the
onset of monsoon. Cattle crossing and rodent holes across the marginal bund should be specially watched and deficiencies made good.

813. Closure Bunds - Sometimes it may be necessary to entirely block one or more channels of the river in order to prevent the discharge of such channels developing into a main river channel after the construction of the bridge. This is done by providing a closure bund. The bund is designed as an earthen dam. The same is generally constructed at some distance from the Railway line. Special care should be exercised to guard it against its failure. It should be inspected every year after the monsoon and necessary repairs carried out.

814. Assisted / Artificial Cut-Offs - Sometimes when very heavy meandering develops near bridges and there is a danger of its encroaching too heavily into the still water area or otherwise dangerously approaching the Railway embankment, it becomes necessary to dig a cut-off channel which will ultimately develop and help in the diversion of water through it. To effect economy, a pilot channel cut is usually made when there is low flow in the river and full development of the channel takes place during the flood. This cut-off channel should preferably have (i) at least three times the river’s straight regime slope and (ii) the upstream end should take off from where the bed load of main channel has less than the average amount of coarse material i.e. from the active part of the channel where the velocity is more. The entrance to the pilot cut should be bell shaped to facilitate entry of water. The chord loop ratio should normally be greater than 1 to 5 if a successful channel is to develop. Cut off should be planned with care taking all relevant factors into account (Annexure 8/2).

815. Boulder Crates - Boulder crates are formed by filling boulders in a crate made of hot dip galvanized wire. Wires of 4 SWG and 6 SWG are generally used in important and ordinary works respectively. The size of crate is dependent on the discharge and should be such that crate is not lifted by water flow. In case of apron, the size of stone required to resist mean design velocity (average velocity) is assessed by the following formula as per IRC: 89-1997:

\[ V = 4.893d^{1/2} \]

Where, \( V \) = mean design velocity in meter/sec. \( d \) = equivalent diameter of stone in meter.

The weight of stone can be determined by assuming spherical stones having a specific gravity of 2.65 (average). Where requirement of weight is more on account of higher mean velocity, crated boulder provides practically feasible option. Size of crates can be determined based on above considerations.

816. Sausage Crates - These are crated boulder of circular cross section of diameter varying from 600mm to 900mm. They are usually very good for protecting slope of an embankment.

817. Protection of Approach Banks

1. Approach banks of bridges may be subjected to severe attack under the following conditions:
   i) When the HFL at the bridge is very high and there is spill beyond the normal flow channel.
   ii) When the stream meets a main river just downstream of the bridge.
   iii) In the case of bridges with insufficient water way.
   iv) The wave action on the approach bank of bridges situated in a lake/large tank bed may have a detrimental effect. In all the above cases the pitching of the approach bank up to HFL with sufficient free board is an effective solution. Provision of toe wall and narrow apron in some cases will also be useful.

2. If deep borrow pits are dug near the toe of approach banks, the water flows through these pits and forms a gradually deepening water course which may eventually threaten the safety of the approach bank. In this case it will be useful to put rubble “T” spurs across the flow to reduce the velocity and expedite silting of the course.

3. Whenever the water level on either side of an approach bank is different, there may be seepage of water and to ease the hydraulic gradient, widening of banks, provision of sub banks and toe filters etc may be resorted to.

4. At locations with standing water against the embankment, special watch should be kept when the water level recedes rapidly and when slips are likely to occur.

818. Design for Protection Works

Minor Bridges :- Most of minor bridges are on open foundation. They have to be properly protected by a well designed flooring system. This will include floor, curtain and drop wall. Length of floor and depth of drop wall will be on the basis of scour depth. This can be determined either by local observation or by using empirical value of D Lacey based on design discharge. Depth of drop wall should be 1.25times D Lacey. Floor should cover the entire width and length of abutment including wing wall. The slope of floor should match the bed slope and also the top of drop wall should match the slope. It is essential to do
proper protection of the box culvert which relies on uniform ground support for its designed structural behavior. If the underside is scoured, the box culvert gets unevenly supported. For this purpose, properly designed floor system as described above should be provided. Sometimes, instead of splayed wing wall, straight return wall is provided particularly on high bank or in case of a box, another box is provided to function like a wing wall. Similar protection work is called for in such cases.

**Major/Important Bridges** :- As far as bridges on open foundations are concerned, it is generally on rocky / in-erodible bed and not requiring any particular protection. In other cases, flooring with drop walls as in minor bridges may have to be provided. Since well and pile foundations are designed for the scour, hence no protection is necessary even in case of a local scour. However, bridge may need a well designed guide bund with proper protection on the approach embankments.

**River training works through model studies** :- In case of large alluvial river, where training / protection works involve a heavy financial outlay, model studies should be resorted to, to arrive at the most economical and effective solution.
Shape of a Meander

1. Divergent Up Stream
2. Parallel
3. Straight Guide Bund

Cut-Off

Annexure 8/3
Para 810.2
4. Elliptical Guide Bund
Different Forms of Guide Bund

Annexure 8 / 4
Para 810.2

D Max = Maximum Anticipated Scour Depth Below Low Water Level

Typical Layout of Guide Bank

Annexure 8 / 5
Para 811.2

Attracting Spur
Repelling Spur
Sedimenting Spur (Normal)
Types of Spurs or Groynes

Annexure 8 / 6 Para 811.5

(a) Sketch of Typical Procupine
Annexure 8 / 6 Para 811.5

(b) Elevation of Typical Porcupine (Cubical Shape)

(c) Sketch of Typical Crib

Not to Scale

Annexure 8 / 6 Para 811.5

Typical Porcupine Spur

Note: - For clarity in drawing porcupine are drawn with spacing more than the actual.

(d) Sketch of Typical Layout of Porcupine Spur

Not to Scale
Advance Correction Slip No. 24 Dated 14 – 9 – 2011
(Issued under Railway Board’s letter no. CBS/PSBC Dated 14.9.2011)

( I ) “Para 714 (2) to be modified as below:
The Assistant Engineer shall submit the register to the Divisional Engineer by a prescribed date, indicating the point on which the orders of the Divisional Engineer are required.
The Divisional Engineer shall carefully scrutinize the register, examine such works as called for his inspection, record his orders regarding the points referred to him and initial against every bridge or kilometerage in token of his scrutiny. Points on which the Chief Bridge Engineer’s decision is required shall be clearly indicated.
The register should then be sent to the Assistant Engineer for noting the Divisional Engineer’s orders with instructions to return it within 15 days. The Assistant Engineer should extract the orders issued by Divisional Engineer and arrange expeditious compliance.
The register should then be forwarded by a prescribed date to Chief Bridge Engineer who will scrutinize the entries, issue orders regarding matter referred to him endorsing the register to that effect, and return it to the Divisional Engineer. Subsequent action taken on Chief Bridge Engineer’s notes should be entered in the register by the Assistant Engineer.

( II ) “Para 1005 (1) to be modified as below:
The Divisional / Sr. Divisional Engineers shall carefully scrutinize the Assistant Engineer tunnel Inspection register and inspect such tunnels as called for his inspection. He shall record his orders regarding the points which require a decision by him and initial against every entry of tunnel in the register in token of scrutiny. He should endorse on each register, below the Assistant Engineer certificate, as follows:
“I have personally scrutinized this register and have issued orders regarding all essential points requiring a decision by me. The following points are submitted to the Chief Bridge Engineer at Headquarters for orders.”

( III ) “Para 1005 (3) to be modified as below:
The register should be forwarded to the Chief Bridge Engineer at Headquarters who will examine each register, issue orders regarding matter referred to him endorsing the register to the effect, and return them to the Divisional / Sr. Divisional Engineer. Subsequent action taken on the notes should be entered in the registers by the Assistant Engineer.

( IV ) “Para 1104 Heading to be modified as below:
By Divisional Engineers and Chief Bridge Engineer / nominated SAG officer in Headquarters.

( V ) “Para 1104 (2) to be modified as below:
Certificate by Divisional Engineer.
He should endorse on each register, below the assistant Engineer’s certificate as follows:
“I have personally scrutinized this register and inspected all important bridge and bridges referred to me and have issued orders regarding all essential points requiring a decision by me. The following points are submitted to Headquarters for orders.

Bridge No. (s) – require rehabilitation.
Bridge No. (s) – have ORN 1 or 2
Bridge No. (s) – have one or more CRN as 0 for more than one consecutive inspection.”

( VI ) “Para 1104 (5) to be modified as below:
Scrutiny by Chief Bridge Engineer / Nominated SAG officer in Headquarters and action thereon.
The registers should then be forwarded by the Divisional Engineer to Bridge Branch in Headquarters by a specified date. All the registers of major and important bridges sent by divisions should be examined by CBE. The minor bridge registers sent by a division may be examined by a SAG officer in Headquarters nominated by PCE for this purpose. Chief Bridge Engineer / Nominated SAG officer in Headquarters will issue orders regarding matters referred to them duly endorsing the registers to the effect. However, observations of inspecting officers in respect of minor bridges which have been assigned ORN as 1, 2 or 3 and cases where bridge matters are referred by DEN / Sr. DEN to Headquarters should also be seen by CBE after examination by nominated SAG officer. The registers should then be returned to the Divisional Engineer latest by a specified date. Subsequent action taken on the nominated SAG officer’s and Chief Bridge Engineer’s orders should be entered in the register by the Assistant Engineers.

( VII ) “Para 1108 (2) to be modified as below:
Details of in section:
He shall inspect the steel work of such bridges,
a) As called for his inspection after scrutiny of the registers.
b) As directed by the Chief Bridge Engineer and enter his notes and ensure prompt action thereon.  
"He will list out the defects considered sufficiently important and bring them to the notice of the Chief 
Bridge Engineer."

( VIII ) Page No. XI ( Index ) 1104 to be modified as below :  
1104. By Divisional Engineers and Chief Bridge Engineer / Nominated SAG officer in Headquarters.

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Advance Correction Slip No. 25 Dated 17 – 12 – 2012  
( Issued under Railway Board’s letter no. CBS/PSBC Dated 17.12.2012 )
New Sub Para 3 may be added to existing Para 311 in IRBM as under :-
‘3. Minimum clear span of 1 m should be provided in new bridges and rebuilding of bridges on existing 
lines. Minimum headroom of 1.2 m should be provided in new bridges for proper inspection and 
maintenance. However, while constructing / rebuilding new bridges on existing lines, efforts should be
made to provide minimum headroom of 1.2 m duly exploring the possibility of lowering of bed level etc. 
Principal Chief Engineer / Chief Bridge Engineer may permit relaxation in minimum headroom provisions 
in cases where adoption of 1.2 m height results in heavy expenditure, heavy regarding of track and 
difficulties in construction.”

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Advance Correction Slip No. 26 Dated 23 – 08– 2013  
( Issued under Railway Board’s letter no. CBS/PSBC Dated 23.08.2013 )
(I ) Existing Para 217.2 9(a ) ( ii ) is to be replaced as below :
217.2 ( a ) ( ii ) Finishing Coat :
Two cover coats of paint to IS:13607 with colour / shade to be specified by Zonal Railway or any other
approved paint applied over the primer coats.
Note : ( I ) The colour / shade of finishing cot should be generally matching with the Smoke Grey colour / 
shade No. ISC 692 mentioned in IS:5-2004.
( ii ) The colour / shade can be changed by CBE as per the local requirements.
(ii ) Existing Para 217.2 ( c ) is to be replaced as below :
Para 217.2 ( c )
In case where the priming coat is in good condition the steel work is painted with two coats of paint to 
IS:13607 with colour / shade to be specified by Zonal Railway or paint aluminium to IS:2339 depending 
on the severity of corrosion.
Note : ( I ) The colour / shade of finishing cot should be generally matching with the Smoke Grey colour / 
shade No. ISC 692 mentioned in IS:5-2004.
( ii ) The colour / shade can be changed by CBE as per the local requirements.
( iii ) Existing Para 217.4 ( c ) is to be replaced as below :
Para 217.4 ( c ) – Para deleted
( iv ) Existing Para 217.4 ( d ) is to be replaced as below :
Para 217.4 ( d )
While painting with IS : 13607 a little quantity of same paint of other shade shall be added to the paint 
while doing the first coat to distinguish it from the second coat. Similarly in the case of aluminium paint a 
little blue paint can be added for 1st coat.
( v ) Existing Para 217.4 ( e ) is to be replaced as below :
Para 217.4 ( e )
Paints should be used within the prescribed shelf life from the date of manufacture. The quantity of paint 
procured should be such that it is fully utilized before the period prescribed for its use. The shelf life of 
various paints used in the railways are as follows :
( I ) Paint Ready mixed Zinc Chrome Primer ( IS : 104 ) : 1 Year.
( ii ) Paint to IS : 13607 with colour / shade to be specified by Zonal Railways : 1 Year.
( iii ) Paint aluminium :
When paste and oil are not mixed : 1 Year.
When paste and oil are mixed : 4 months.
( iv ) Oil linseed boiled : 2 years.
( v ) Paint ready mixed Red oxide Zinc Chrome ( IS : 2074 ) : 1 Year
(vi) Red Oxide Zinc Chromate Primer (IRS – P – 31): 1 Year
(vii) Existing Para 217.4 (I) is to be replaced as below:
Para 217.4 (I)
Each coat of paint shall be left to dry till it sufficiently hardens before the subsequent coat is applied.
(vii) Existing Para 615 is to be replaced as below:
Para 615
Preparation of surface:
The surface of steel work should be carefully prepared by removing mill scales, rust, grease etc, using wire brushes, sand or grit blasting as required.
The surface and locations which will be in permanent contact after assembly by riveting should be given a heavy coat of red oxide zinc chrome priming to IS : 2074.

Advance Correction Slip No. 27 Dated 03 – 01– 2014
(Issued under Railway Board’s letter no. CBS/PSBC Dated 03.01.2014)
New Para 1107. 5 (I) may be added as follows
(I) In case of girders having High Strength Friction Grip (HSFG) Bolts:
(1) Inspection: The inspection of HSFG Bolts shall be done visually for broken and loose bolts. Hitting HSFG bolts to check looseness is not allowed. Looseness of bolts shall be seen by rust appearing beneath the bolt head / washer / nut etc or marks left by water or apparent relative movement between the steel parts joined by the HSFG bolts. The broken / loose bolts if any, shall be marked by a round circle all around and shall be replaced expeditiously by new HSFG bolts of same specifications properly tightened. Retightening of loose bolts found during inspection is not allowed in any case.
(2) Use of HSFG bolts for repair / rehabilitation works: Where any girder component / joint is to be replaced, HSFG bolts shall be used as follows:
(a) Complete joint shall have HSFG bolts. HSFG bolts cannot be used for replacement of isolated loose rivets.
(b) Proper surface preparation shall be done and joint design shall be done based on design provisions as per Para 7.12 of Steel Bridge Code. Particular care shall be taken regarding use of appropriate slip factor for the surface preparation done.

New Para 215 A may be added as follows:
215 A Maintenance of HSFG Bolts–
(I) Painting in service: HSFG bolts shall be painted as per normal painting schedules and painting methodologies as specified in the Indian Railway Bridge Manual for the girder as a whole.
(II) Anti-theft and Anti-sabotage measures: Here it is apprehended that theft / sabotage might take place, the bolt threads may be destroyed by applying welding tack to the bolt projection beyond the nut after final tightening and inspection. The tack shall not be more than 5 mm long and not more than 3 mm in size. It shall be especially ensured that too much heat is not imparted to the bolt so as to alter its metallurgical properties. Alternatively proven bounding agent may be applied to the threads projecting beyond the nut to seize or lock the bolt in position.

Following may be added below existing Para 615
Where HSFG bolts are to be provided the surface preparation shall be done as assumed by designer based on slip factor chosen.

Advance Correction Slip No. 28 Dated 20 – 03– 2014
(Issued under Railway Board’s letter no. CBS/PSBC Dated 20.03.2014)
Chapter –X, PART B – Title of “DEEP CUTTINGS” replaced by “CUTTINGS” and Para 1010 to 1015 & Annexure 10/2 replaced by Para 1010 to 1017 (as below) and Annexure 10/2 (attached) respectively.
1010. General
A register for inspection of cuttings should be maintained in the proforma in Annexure 10/2. Separate page will be maintained for each cutting. This register should be sent to CBE for his perusal every year.
1011. SCHEDULE Of Inspection of Cuttings.
1. Immediately after the monsoon, the SSE / JE P.Way should inspect each cutting and record his observation in the register which should be sent to the ADEN for his examination well before the next monsoon to enable planning of remedial measures that he may like to take in the intervening period.

2. Each cutting should be inspected before the onset of rain by the ADEN concerned and he should record his remark in the register which then be sent to the SSE / JE P. Way for taking appropriate action. Action taken by the SSE / JE P. Way should be recorded in the register and the same returned to the ADEN for his perusal before the onset of the monsoon. Date by which these registers should be returned to the ADEN for his perusal to ascertain that adequate action has been taken should be specified by the Sr. DEN / Co-ordination depending upon the time when the monsoon starts in a particular section.

3. Divisional Engineer / Sr. Divisional Engineer should inspect the cuttings referred to him by ADEN and by CBE if referred by Divisional Engineer / Sr. Divisional Engineer.

4. During spell of heavy rains, the ADEN & SSE / JE P.Way should inspect by trolley, foot-plate of the engine or other means the cuttings and allied works as frequently as possible.

1012. Vulnerable Cuttings – Identification and special precaution

1. Divisional Engineer / Sr. Divisional Engineer should review and identify the Vulnerable Cuttings in his jurisdiction at least once in every three years. If required, an experienced geologist from reputed institute / organization may be associated for joint inspection.

2. Vulnerability of Cuttings is to be established after careful evaluation of risk potential that the cuttings pose to traffic and workmen from critical study of relevant factors. ( Refer : RDSO Guidelines for cuttings in Railway Formations; Guideline No. GE : G-2, August 2005 : Chapter VIII, Part B, Para 5.0 ).

3. Stationary watchmen should be posted round the clock at nominated Vulnerable Cuttings during the monsoon period in accordance with Para 1014 of Indian Railway Permanent Way Manual 2004.

4. During monsoon, frequent inspection of Vulnerable Cuttings may be carried out as required keeping in view the past history and the Vulnerability of the Cuttings.

1013. Points to be noted during inspection of cuttings

1. Method of inspection, procedure for identification of loose mass and its removal for different heights of cuttings shall be as given below –

- i) Cutting which are of height less than 5 m.
   These cuttings should be inspected thoroughly by walking over them. The loose soil, susceptible boulders shall be identified and marked with paint. Removal of loose boulders shall be planned and executed well before monsoon in a systematic manner, observing adequate safety precautions.

- ii) Cutting with height 5 to 10 m.
   These cuttngs should be inspected using binoculars and integrity of cutting judiciously examined. Particular attention should be given to locations having mixed type of strata ( like boulders and soil ) and to cracks, fractures and joints in rock cuttings. If there seems any chance of separation of boulders / rock mass during monsoon, it should be immediately attended before onset of monsoon.

- iii) Cutting more than 10 m height.
   The specially trained persons normally designated as hill gang shall be recruited for climbing by using harnesses, rope and other accessories as required for rock climbing. The doubtful locations shall be judiciously identified by inspecting persons and necessary action for felling of loose boulders etc. shall be taken using “Boulder Special”.

2. The inspecting official should carefully examine:

   - i) Signs of upheaval in the regular slope surface of cuttings.
   - ii) Whether catch water drains have been provided to intercept water from running down the hill side and getting into the cuttings. He should see that the catch water drains are clear of all obstructions and ensure that there are no depressions in the longitudinal level of these drains which could collect storm water and may cause slips. He should check that the catch water drains have a good longitudinal slope towards the outfall.
   - iii) The condition of side drains and see that they are not choked up.
   - iv) Any loose boulders and perched trees on top of cuttings and side slopes which are likely to fall and are in precarious position.
   - v) The condition of pitching on the slopes, if any.
   - vi) The condition of retaining walls, weep holes and other protection / strengthening measures. Instructions as given in Para 1014 and 1015 shall be followed for inspection of Boulder nets and Rock Bolts respectively.
vii) Availability and condition of warning systems / boards and trolley refuges.

1014. Inspection of Boulder nets provided in cutting:
1. Boulder nets, joints, fixtures and other accessories should be inspected for signs of corrosion.
2. PVC coating on the boulder nets should be inspected to detect any loss that might have taken place.
3. Top, bottom and intermediate anchoring of boulder nets should be inspected for their adequacy and effectiveness.
4. Interfacing of boulder nets should be inspected and corrected if required.
5. Boulder nets shall be inspected for any loose / trapped boulder / rock mass and necessary action for their removal shall be taken as per requirement.
6. Boulder nets shall be inspected for any damages / bulging.
7. If boulder nets show any signs of distress, suitable remedial / strengthening measures should be taken to ensure effectiveness of boulder nets. In case of suspected loss of strength of boulder nets, a sample piece should be sent to a reputed laboratory for confirmatory tests as per applicable specifications and necessary remedial / strengthening action shall accordingly be taken.

Comments / Observations on above items shall be recorded in cutting Inspection Register.

1015. Inspection of Rock bolts provided in cuttings / Tunnels.
1. The inspection of rock bolts provided in cuttings / tunnels shall be carried out along with respective cuttings / tunnel inspection and it should be entered specifically in the respective registers.
2. The schedule of inspection of rock bolts will be same as that of the inspection schedule of cuttings / tunnel.
3. Rock bolt shall be numbered serially in the order of increasing KM.
4. Rock bolts ( including accessories ) shall be inspected for signs of corrosion and looseness. The surroundings of bolts should be closely inspected for any sign of distress.
5. Any dampness observed around the rock bolt should be recorded.
6. If rock bolt shows any signs of distress, sounding of the location should be done for 10 m on either side and pull out tests ( as per IS : 11309 – 1985 ) in distressed stretch. Based on the results of sounding and pull out tests ( if conducted ), suitable remedial / strengthening measures should be taken.

1016. Action to be taken in the case of boulder fall.
1. In the case of boulder fall, the boulder may be removed by jacking. If the boulder can not be moved by jacks or levers, blasting will be necessary.
2. SSE / JE who will handle blasting equipment should be conversant with the methods of blasting and should be familiar with all safety precautions to be observed for the custody and use of explosives.
3. The following equipments should be kept at the Headquarters of each SSE / JE in whose section such vulnerable cuttings exist:
   i) Adequate capacity Jacks in good working condition.
   ii) Jumping steel bars 1” dia and 5’ long.
   iii) Charging rods and
   iv) Suitable stock of explosives, fuses and detonators at specified places.
4. In case of report of boulder fall at any location, immediate action should be taken to loose-scale the cutting covering a length of about 50 meter on either side of the location. Till such time the loose scaling is completed, the location should be treated as “VULNERABLE”.

1017. Action to be taken for maintenance of cuttings:
1. Cleaning, repairing and improving drainage.
2. Weeding, trimming and felling of plants, trees and shrubs and managing vegetation to reduce any deleterious effects.
3. Provision of protection and strengthening measures as necessary.
4. Repairing local slips and settlement or erosion channels.
5. Scaling.
8. Following safety equipments / gear shall be used by the officials / workmen during inspection and maintenance of cuttings; for which adequate stock shall be maintained by SSE / Pway in-charge.
   i. Helmets
   ii. Safety Belts.
   iii. Sun Glasses, to protect from bright light and small debris.
   iv. Good quality trekking and climbing shoes.
   v. Chalk required to keep hands dry and marking loose boulders.
   vi. Gloves.
   vii. Binoculars.
   viii. Good quality harness and holds.

Note: 
   a) The inspecting person should be well trained in rock climbing, preferably from any Mountaineering institute.
   b) The health and fitness of inspecting person should be sound with good agility and judgment.

Annexure – 10 / 2
Para 1010

CUTTING INSPECTION REGISTER

General Information (last updated on ………….. )
Division……………………

1. Section : …………………
2. Between Station : …………………
3. Cutting No.: …………….
4. Chainage : …………………
5. Length : …………………
6. Maximum Height : UP…… DN……
7. Type of cutting : …………
8. Vulnerable : Yes / No
9. Stationary Watchman Posted : Yes / No
10. Authority for nominating as Vulnerable ………
11. Year of last review for Vulnerability: …………

12. Unusual Occurrences and remedial measures adopted:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Month / year</th>
<th>Details of unusual occurrence</th>
<th>Strengthening / Remedial measures / Action Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

13. Details of Drainage, Preventive and Protective Measures:

<table>
<thead>
<tr>
<th>Items / Works</th>
<th>Line</th>
<th>Chainage</th>
<th>Details</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From</td>
<td>To</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side Drain</td>
<td>UP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catch Water Drain</td>
<td>UP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boulder Nets</td>
<td>UP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitching</td>
<td>UP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warning Boards</td>
<td>UP</td>
<td></td>
<td>At Chainage :</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN</td>
<td></td>
<td>At Chainage :</td>
<td></td>
</tr>
<tr>
<td>Trolley Refuge</td>
<td>UP</td>
<td></td>
<td>At Chainage :</td>
<td></td>
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<tr>
<td></td>
<td>DN</td>
<td></td>
<td>At Chainage :</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

14. Other Geotechnical Information:

CUTTING INSPECTION REGISTER
Proforma of Inspection Form for AEN / SSE / JE P.Way Register:
Date of Inspection ………………… Name & Designation of Inspection Official ……………………………

1. Drainage:

<table>
<thead>
<tr>
<th></th>
<th>Satisfactory</th>
<th>Unsatisfactory</th>
<th>Remarks</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Drain Adequacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catch Water Drain Adequacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Condition of Slopes:

<table>
<thead>
<tr>
<th></th>
<th>Line</th>
<th>Remarks</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Sign of surface cracks, bulging, upheaval of beams, sliding etc.</td>
<td>UP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DN</td>
</tr>
<tr>
<td>II</td>
<td>Sign of separation of boulders from soil.</td>
<td>UP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DN</td>
</tr>
<tr>
<td>III</td>
<td>Observation on cracks / fracture / joints of cuttings.</td>
<td>UP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DN</td>
</tr>
<tr>
<td>IV</td>
<td>No. ( or stretch ) of loose boulder / rocks Identified for removal.</td>
<td>UP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DN</td>
</tr>
<tr>
<td>V</td>
<td>No. of trees identified to be felled.</td>
<td>UP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DN</td>
</tr>
</tbody>
</table>

3. Preventive and protective measures:

<table>
<thead>
<tr>
<th>Retaining walls / Breast walls</th>
<th>Line</th>
<th>Satisfactory</th>
<th>Unsatisfactory</th>
<th>Specific Observation / Remarks</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Condition</td>
<td>UP</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>DN</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Condition / Cleanliness of weep holes</td>
<td>UP</td>
<td></td>
<td></td>
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<td></td>
<td>DN</td>
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<tr>
<td>Pitching</td>
<td>UP</td>
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<td></td>
<td>DN</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Boulder nets</td>
<td>UP</td>
<td></td>
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<tr>
<td></td>
<td>DN</td>
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<td></td>
</tr>
<tr>
<td>Rock Bolts</td>
<td>UP</td>
<td></td>
<td></td>
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<td></td>
<td>DN</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Warning Boards</td>
<td>UP</td>
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<td></td>
<td>DN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trolley refuges</td>
<td>UP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DN</td>
<td></td>
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</tr>
</tbody>
</table>

4. Proposed Remedial / Strengthening measures

Remarks and Signature of inspecting Official ……………………………………………………
*****************************************************************************
1. Replace existing Para 312 (2) as under:
   2. In the case of arch bridges, minimum clearance measured to the crown of the intrados of the arch shall be as under:

<table>
<thead>
<tr>
<th>Span of arch</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 4 m.</td>
<td>Rise or 1200 mm whichever is more.</td>
</tr>
<tr>
<td>4.0m to 7.0 m.</td>
<td>2/3 rise or 1500 mm whichever is more.</td>
</tr>
<tr>
<td>7.1 m to 20.0 m.</td>
<td>2/3 rise or 1800 mm whichever is more.</td>
</tr>
<tr>
<td>Above 20.0 m.</td>
<td>2/3 rise.</td>
</tr>
</tbody>
</table>

2. Replace existing Para 312 (2) as under:
   4. While rebuilding bridges on existing line or building new bridges on these or new lines, the clearance stipulated above can be relaxed by Principal Chief Engineer / Chief Bridge Engineer with the consideration to the past history, to the extent shown below provided:
      a) adoption of the prescribed values of clearance would result in heavy expenditure and/or serious difficulties in construction, and
      b) the clearance can be safely reduced from the stipulated in sub Para 1 above.

<table>
<thead>
<tr>
<th>Discharge (Cumecs)</th>
<th>Reduced clearance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 3</td>
<td>300</td>
</tr>
<tr>
<td>3 to 30</td>
<td>300 – 400 (Pro-rata)</td>
</tr>
<tr>
<td>31 to 300</td>
<td>400 – 1200 (Pro-rata)</td>
</tr>
</tbody>
</table>

3. Add new Para 313 (4) as under:
   4. However in case of siphon bridges the provision for free board as per Para 313 (1) need not be considered where a spillway is provided on one bank of the channel at a suitable point upstream within or outside the Railway boundary so that as and when the channel rises over the danger mark, the water from the channel will flow out. A small drain also has to be provided from the point of spillway to the nearest bridge to lead the water from the channel in case of overflow from the spillway.

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