

Civil Engineering (Works)

Lesson-I

Design, Construction and Maintenance Organisation

1-0 Introduction

From time immemorial man has been continuously working hard for making his living conditions better and better. The role of Civil Engineers has been very important in making efforts towards achieving this. Right from the beginning, when man found himself taking shelter in caves, Civil Engineering, though not in its present form, has played its role to provide safe and comfortable places of living.

The role of Civil Engineers has increased further with the advent of modern building materials and new methods of construction. In Railways, the scope of work for a civil Engineer is vast and wide. Duties of a Civil Engineer includes construction and maintenance of structures like station buildings, residential quarters, workshop structures, sheds, railway track, water supply, drainage, bridges, towers or tanks and sewerage projects.

A Civil Engineer is required to have knowledge of various subjects related to management of his day to day duties. These subjects are briefly described in the following paragraphs.

Building Materials: Knowledge of all materials (like cement, steel, plastics, timber, stone, etc.) which are used for the construction of Civil Engineering structures such as bridges, buildings, sheds, water supply installations etc.

Strength of Materials: How various metals and other building materials behave under different loading conditions is studied under 'Strength of Materials'. This study is important for design of structures.

Surveying: Knowledge of surveying is essential for fixing the alignment of Railway tracks and location of building and roads. The problem becomes more complex if the terrain happens to be a hilly one.

Hydraulics: Study of Hydraulics covers the effect of forces of flowing water and is useful for designing of under water structures such as piers and abutments of Railway bridges. It is also helpful in designing of dams and hydraulic structures such as gates of weirs in case of water supply structures.

Geology: Study of Geology deals with the properties of natural soils which is useful in deciding the quality of earth for formation and of stone required for ballast and stone aggregate for Railway track and concrete respectively. Knowledge of Geology helps in selecting right source for these materials.

Soil Mechanics: Soil Mechanics studies the soil Characteristics and treatment and is important for designing of Railway banks and cuttings, foundations of buildings etc. Lot of

economy can be achieved by optionally designing the slopes of bank if the properties of soil used for building the bank are correctly analysed rather than by using obsolete thumb rules.

Theory of structures: Knowledge of theory of structures is required in connection with analysis of forces in various complex structures like multistoried framed structures, girder bridges, microwave towers, tank staging's and many other structures.

Design of Structures: Modern structures, like high rise buildings, bridges, water tanks etc. are constructed in steel or concrete. Detailed knowledge of design procedures is very much helpful in arriving at an efficient and economical design of structures.

Knowledge & Design of Permanent Way: Knowledge of Permanent way (Railway track) is required to ensure safe and smooth running of trains on the railway tracks. Various aspects of railway tracks include design, maintenance and construction practices and modernisation of track and other related issues.

Hydrology and River Training Works: Hydrology is the study of effect of water and its sources on structures which are subject to these forces. It also includes the study of River Training Works which are required to control flooding or to protect structures in the vicinity of water.

2.0 Construction & Maintenance Organisation on Indian Railways

Civil Engineering department is one of the major departments on Indian Railways. It is responsible for the construction and maintenance of all civil engineering assets viz. all buildings including station buildings, residential quarters, hospitals, sheds, workshop structures, goods sheds etc., railway track, sidings, water supply installations, bridges etc. The basic unit responsible for all the maintenance operations is a Division which is under the charge of a Divisional Rail Manager (DRM). There are at about 65 Divisions on Indian Railways. The Engineering department is placed under the charge of the senior most Civil Engineer designated as Senior Divisional Engineer (Co-ordination), who controls other Civil Engineers which may be other Sr. Divisional Engineers or Divisional Engineers, 4 to 5 in number on a Division. Each of the Sr. Divl. Engineers and Divisional Engineer is assisted by 2 to 3 Assistant Engineers who are normally posted in the field at important stations.

Each Assistant Engineer is in charge of about 100 Km of double line section or 150 to 200 Km of single line section and is in charge of maintenance of track, bridges and all structures on his section. Assistant Engineers are assisted by Permanent Way Inspectors (P.W.I.) now called Senior Section Engineer Way (SSE Way) for the maintenance of track and Inspector of works (I.O.W) now called Senior Section Engineer Works (SSE Works) for the maintenance of all other structures such as station buildings, water supply structures, roads, drainage etc. The maintenance of masonry structure of bridges is also with the SSE/JE except that of major steel girders for which there are Bridge Inspectors in each Division who are either controlled by Sr. Divisional Engineer or work under a separate bridge maintenance unit of the Head Quarters Office. A chart showing the pattern of administrative set up on a Division is shown in fig. 1.1 (For Engineering Department)

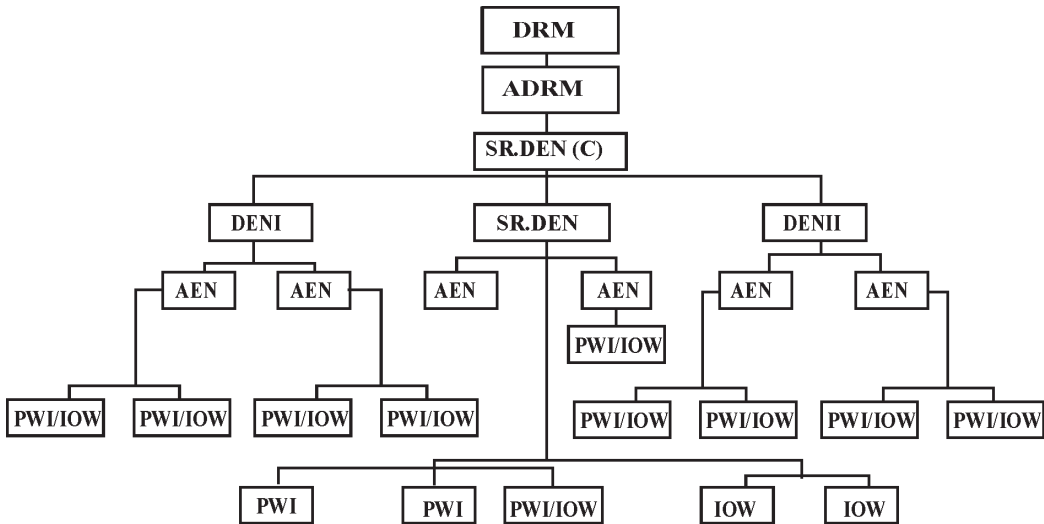


FIG. 1.1 DIVISIONAL ORGANISATION-CHART OF ENGG. DEPARTMENT

There is a General Manager for each Zonal Railway. He heads the Railway Zone. In the Headquarters Office, under the General Manager, there are Heads of Departments who control their respective departments. Principal Chief Engineer is the Head of Department who is in charge of the Civil Engineering Department. The Principal Chief Engineer is assisted by a number of functional and territorial Chief Engineers and Deputy Chief Engineers in the Hd. Qtrs. The Hd. Qtrs. has specialized units for the maintenance of bridges (including a section for designs of bridges), water supply, track modernisation activities, track supply, land management, track planning (maintenance and renewals) and a design office for buildings and structures, is also responsible for the annual Works Programme. The construction works on the zone are under the charge of CAO (Construction) who is assisted by Chief Engineer (Construction), Deputy Chief Engineer (Construction) and their officers and staff. A chart showing the administrative arrangement in the Head Quarters Office is in fig. 1.2 (For Engineering Department)

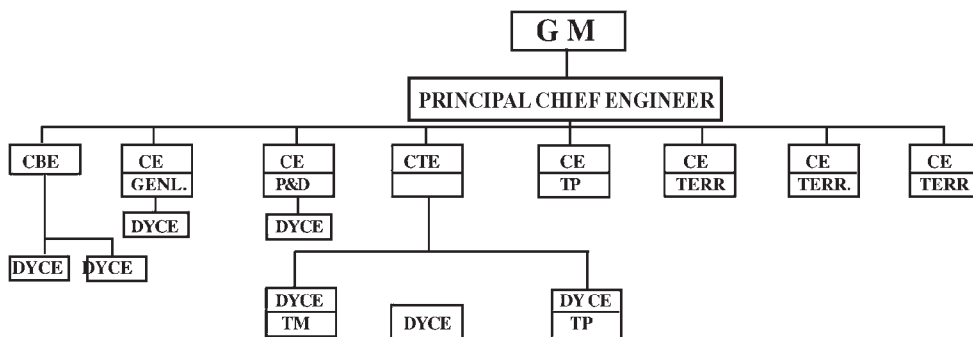


FIG. 1.2 ORGANISATION CHART OF ENGG. DEPARTMENT IN HQRS OFFICE

The Zonal Railways are under control of Railway Board, which is also the Ministry of Railways, situated in New Delhi. Member Engineering (ME) is the head of Engineering department, who is responsible for all policy decisions, technical in nature. Any decision involving financial implications are taken in consultation with the Financial Commissioner (FC). Decision on issues involving more than one Department are taken by the Railway Board which is headed by Chairman Railway Board (CRB) and consists of 6 other members viz. Member Engineering, Member Traffic, Member Traction, Member Rolling Stock, Member staff and Financial Commissioner (Railways). Member Engineering is assisted by Additional Members, Advisors, Executive Directors, Directors and Joint Directors, who are responsible for Planning, Sanctions, implementation and monitoring of different functions.

3.0 Functions of Civil Engineering Department

The functions of Civil Engineering Department are briefly given below:

- (i) Construction and Maintenance of railway track or permanent way which includes embankment, ballast, sleepers, rails and all fittings. This includes renewal of track and its components both casual renewals and regular renewals on age-cum-condition basis.
- (ii) Construction and Maintenance of all Railway and Road bridges, including Road Over and Road Under bridges.
- (iii) Survey and Investigations in reference to construction of new Lines and realignment of existing track.
- (iv) Investigation of soil including deep level investigations required to design foundations of bridges and other structures.
- (v) Construction and Maintenance of water supply plants including source development, storage, treatment facilities and distribution for domestic use and for workshops, sick lines, yards and offices, colonies.
- (vi) Construction and maintenance of all residential and non-residential buildings, station buildings, hospitals, sheds and workshops, foot over bridges, fences required to protect

Railway property etc.

- (vii) Construction and maintenance of all roads within Railway premises.
- (viii) Regular inspections of main line track, bridges, sidings, yards, water supply installations, all buildings and structures including station buildings, sheds, workshops, towers with a view to ensure efficient maintenance for optimum use.
- (ix) Maintenance and operation of all types of track machines being used on Indian Railways for maintenance and new construction of track.
- (x) Maintenance of all land records to ensure efficient use of the land and to prevent unauthorized encroachment thereupon.
 - (xi) Procurement of track material including rails, sleepers, fittings, certain building materials, spare parts of track machines, required for efficient maintenance of the same.
- (x) Maintenance of all land records to ensure efficient use of the land and to prevent unauthorized encroachment thereupon.
 - (xi) Procurement of track material including rails, sleepers, fittings, certain building materials, spare parts of track machines, required for efficient maintenance of the same.
- (xii) Measurement of water levels and course of major rivers in connection with maintaining hydrological records required for design of waterway of new bridges and review of existing ones.
- (xiii) Joint inspections of Railway affecting works with State/Central/Pvt. authorities.
- (xiv) Submission of proposals for inclusion in works programmes & revenue budget.
- (xv) Execution & Measurement of works.
- (xvi) Preparation of plans & estimates.

3.1 Duties of SeniorSection Engineer Works

SeniorSection Engineer (Works) or Works Inspector is directly responsible for inspection, maintenance, surveying and execution of civil engineering works. He is also responsible for land management, afforestation and other horticulture works under his jurisdiction. His responsibility also covers correct accountal of stores, tools and plants.

Duties: The essential duties of the SSE (Works) are as given below:

- (i) Inspection and maintenance of services buildings staff quarters and other structures including water supply, drainage and sewerage systems, approach roads, etc.,
- (ii) Inspection of bridge works, as assigned.
- (iii) Execution of all new building/structural works
- (iv) Accountal and periodical verification of stores and tools in his charge:
- (v) Maintenance of land boundaries, as specified.
- (vi) Removal of encroachment at his headquarters and at other places, in his jurisdiction as specified.
- (vii) Afforestation and other horticulture works.
- (viii) Ensuring required training to his staffas prescribed in the training module.

3.2 Schedule of Inspection by SeniorSection Engineer (Works)

Type of Inspection	Details of Inspection
1. Inspection of buildings and structures	<ul style="list-style-type: none"> (i) Systematically inspect once a year all buildings and structures in his charge and record brief details of repairs to be carried out. (ii) He will maintain petty repair books at all station buildings and other important buildings, and check them during his inspections and ensure prompt action/repairs. (iii) He will be also inspect bridge foundations and substructures as assigned from time to time.
2. Inspection of water supply arrangements	<p>Keep proper records 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.</p> <ul style="list-style-type: none"> (ii) He will have complete history and data of tube wells, and ensure testing of yield of tube wells and other sources of water, once every year in coordination with Electrical staff at the time when the sub-soil water is at the lowest.

<p>3. Inspection of sewerage and drainage system</p> <p>4. Land and land boundaries</p>	<p>(iii) He will ensure cleaning of over-head/ underground storage tanks periodically. He will be responsible for the disinfection of water supply, wherever required.</p> <p>Periodically inspect sewerage and drainage systems and ensure their efficient performance.</p> <p>Periodically inspect land and land boundaries in his jurisdiction and furnish necessary certificates to Assistant Engineer.</p>
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3.3 Other Duties of SeniorSection Engineer (Work)

- (i) **Execution of Works:** The SeniorSection Engineer (Works) is personally responsible for the accurate setting out and execution of all works according to approved drawings and specifications.

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.

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 competent authority.

- (ii) **Measurement of works:** Every SSE(Works) is responsible for proper measurement of contractual worksas per power delegated. He should ensure timely billing and maintain movement register of MB and standard measurement register for works.
- (iii) **Imprest of tools and materials:** The SSE(Works)should examine all tools and plant with the artisans once a month and replace the unserviceable or defective onesor arrange repairs. He should also 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 requirements. Recoupment of shortage should be effected without delay.
- (iv) **Accompanying important inspections:** When the SSE(Works)accompanies a periodical or special inspection, such as that of the General Manager, Chief Engineer and other senior railway officials, he should be in possession of the following, besides the Works Manual, Schedule of rates and thestandard specifications for materials and works, etc.
1. Plans and details of all important works, recently completed, on hand or contemplated.
 2. Progress report of works and any other papers and plans that are likely to be required

for discussion.

3. Contract files of works in progress.
 4. Tape (15m and 2m), plumb bob, and other tools and surveying equipment, required during inspection.
- (v) **Correspondence & Records:** SSE(Works) shall keep his correspondence upto date & see that all office records , registers & store ledgers are maintained properly & posted regularly.
- (vi) **Work affecting moving dimensions:** The SSE(Works) shall refer to Assistant Engineer for instruction regarding works likely to affect moving dimensions.
- (vii) **Witnessing payment to staff:** Payment to both permanent and temporary staff will generally be made through checks, however in case of cash payments is made by the Pay Clerk in the presence of the SSE(Works) who is responsible for correct identification of the payee and to satisfy himself that the correct amount is paid.
- (viii) **Journal of daily duties:** The SSE(Works) should enter the works performed daily in the T.A. Journal showing there in his movements by train, trolley or road-vehicle and submit the same to the Assistant Engineer every month.
- (ix) **Medical examination:** The SSE(Works) should ensure that all Group D staff working under him are sent for medical examination for fitness for service.
- (x) **Service Books:** Service books for Group D staff should be prepared by the SSE(Works) on the prescribed form as soon as appointment in temporary/permanent vacancies are made and submitted to the Assistant Engineer for verification and signature. All increments & promotions should be noted in service book.
- (xi) **Provisions in the Payment of wages Act, the Workmen's Compensation Act and other regulations:** The SSE (Works) should ensure that the rule laid down in the Acts and Regulations, as modified from time to time, are strictly complied with.
- (xii) **Promotion to higher grades:** SSE (Works) should maintain in manuscript form of records of staff working under him in which he shall enter awards or penalties of each staff as and when such entries are justified.
- (xiii) **Relinquishment of charge:** On relinquishing charge of section the SSE (Works) should 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.

Which handing over and taking over charge, both the Works Inspectors (relieving as well as relieved) should together visit the whole section, inspect each work in progress, check staff, tools, plant and materials.

The relieving SSE(Works) should 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.

4.0 Code and Manuals For Engineering Department

A number of Codes and Manuals have been written for ensuring working of the Department as per rules and having uniform procedure throughout the length and breadth of the country. These codes and Manuals are described briefly in the following paragraphs.

4.1 Engineering Code

This is the basic code book for the Engineering Department which deals with the following subjects:

- (i) Organizational structure of Engineering Department for maintenance and construction activities.
- (ii) Surveys and investigations required for preparation of Project Reports
- (iii) Investment planning and Works Budget.
- (iv) Different types of Estimates.
- (v) Acquisition, Custody, management and disposal of Railway land.
- (vi) Tenders and contracts for efficient executions of works.
- (vii) Basic records and method of measurement of items of works and supplies.
- (viii) Accounting of revenue (maintenance) and works expenditure and Budgetary control.
- (ix) Commissioning of new lines.
- (x) Management of buildings and working out rent.

4.2 Indian Railway Permanent Way Manual

This book deals with the detailed procedures for day to day working for efficient maintenance of track and related structures. It contains the following subjects:

- (i) Duties of various Permanent way (track) officials.
- (ii) Procedure for the general maintenance of track and its components.
- (iii) Track structure on bridges.

- (iv) Special instructions for maintenance of track in electrified sections.
- (v) Treatment of formation.
- (vi) Renewal of track.
- (vii) Curve maintenance including realignment of curves.
- (viii) Laying and maintenance of short welded, and continuous welded rails.
- (ix) Track recording and analysis of results.
- (x) Management of accidents.
- (xi) Precautions to be taken with reference to rainy season and dealing with floods and breaches.
- (xii) Speed restrictions for carrying out maintenance works, use of indicators, detonators and flare signals.
- (xiii) Inspection and maintenance of level crossings.
- (xiv) Patrolling of Railway track during rainy season and safety patrolling.
- (xv) Working of material trains, track machines and trolleys.
- (xvi) Laying and maintenance of concrete sleepers.
- (xvii) Training of Staff.

4.3 Track Manual

This book specifies in detail various track components i.e. rails, sleepers, fish plates, bearing plates, keys and cotters, spikes, anchors etc. It also gives details of various layouts such as turn outs, diamonds with single slip and double slips and dimensioned drawings of various types of switches and crossings.

4.4 Indian Railways Works Manual

The works manual covers the following:

1. Duties of Engineering officials.
2. Planning and general instructions
3. Inspection and maintenance of buildings
4. Inspection of Structural steel and Timber work .
5. Maintenance of Sanitary & Hygienic conditions in Station Buildings, Yards & Railway colonies.
6. Passenger Amenities, Stations & Yards
7. Water Supply

8. Open Wells & Deep Tube Wells, Impounding Reservoirs, Infiltration Galleries, & Wells
9. Pumps, Aqueducts & Pipelines, Water treatment, High level storage, Distribution of water, maintenance & operation water supply installations.
10. Drainage & Sewerage
11. Water-Borne Sewerage
12. Maintenance of Sewerage & Drainage
13. Gardens & Plantation , Disposal of Grass & Other Natural Products, Felling of trees.
14. Acquisition , Management & Disposal of Land/
15. Land Records, Demarcation & Verification of Railway Boundries.
16. Management of Land.
17. Preparation of Plans
18. Storage & Use of Explosives
19. Police Jurisdiction & Security of Railway Materials.

Indian Railway Bridge Manual

This manual deals with the various aspects of bridge in following chapters:

1. Duties of bridgeofficials.
2. Maintenance of bridges.
3. Investigations and survey for construction of bridges
4. Construction of foundations of bridges.
5. Rehabilitation of bridges.
6. Construction of substructure and super structure including erection of girders.
7. Rivers and Floods.
8. River training and protection works.
9. Fabrication, erection, inspection and maintenance of other steel structures.
10. Inspection and maintenance of tunnels and deep cuttings.
11. Inspection of bridges.
12. Plant and machinery of engineering department.

13. Training for the bridge staff.

14. Books of references.

4.5 General Conditions of Contract (GCC)

This book deals with standard conditions of contract and includes standard provisions dealing with various aspects of works contracts including arbitration Clauses. If certain provisions require modifications to suit special situation, the same can be done by providing special conditions superseding the standard conditions.

4.6 Schedule of Dimensions

This book deals with the minimum/maximum moving dimensions required to be observed for safe working of Railways. The book also prescribes dimensions which are recommended as good practice. While the recommended dimensions can be altered to achieve economy in specific cases with specific approval of competent authorities, the minimum prescribed dimensions can only be altered in very rare cases with specific approval of Railway Board.

4.7 Standard Specifications

This book lays down standard specifications for different items of works and indicates detailed procedure for carrying out various items of Civil Works. Each Railway frames its own detailed specifications depending upon the local prevailing conditions.

4.8 Standard Schedule of Rates (USSOR 2010)

This book prescribes standard rates for carrying out various works. The rates of items depends on prevailing market rates of different components of material and labour used in the work and has time reference mark. The rates are based on the provisions of “Standard Specifications”. Where a particular item of works does not conform to the Standard Specifications, nonstandard rates are prepared and got

4.9 A.T. Welding Manual

It includes execution precautions and steps to be taken before, during and after welding in field. It also includes specifications giving destructive and Non- destructive (ultrasonic) tests with acceptance requirements. It also gives information about Portions manufacturing agencies approved by RDSO/ Lucknow. Latest A.T. welding techniques are also available in this manual.

4.10 Long Welded Rails Manual,

This book prescribes standards for laying and maintenance of Long welded Rail and continuous welded rails (LWRs & CWRs), action in case of buckling etc. and provides information/ calculations for various temperature zones.

4.11 Manual for Reconditioning of Points & Crossings

This book prescribes various methods of reconditioning of points & crossing which get worn out during service. It also provides information about type of electrodes to be used for

resurfacing, method of resurfacing CMS Xings, procedures for various test and methods for depot/ in Situ welding.

4.12 Chief Engineer's Circulars

These Circulars are issued by Chief Engineers of various Zonal Railways and contain detailed instructions about various Civil Engineering matters suiting local conditions within the overall policy laid by Railway Board.

4.13 Commissioner of Railway Safety

There is a 'Commission of Railway Safety' headed by a Chief Commissioner of Railway Safety, headquartered at Lucknow, under the Ministry of Civil Aviation. The Commissioner of Railway Safety looks after the safety aspects and other statutory functions concerning various Zonal Railways. There are nine Commissioners of Railway Safety who are headquartered at various locations such as Lucknow, Mumbai, Delhi, Kolkata, Chennai, Bangalore, Secunderabad, Gorakhpur and Guwahati.

The responsibility for safety in the working and operation of Railways rests solely with the Railway Board and the Zonal Railway administrations. The main task of the Commissioner of Railway Safety, however, is to direct, advise and caution the Railway executives with a view to ensure that all reasonable precautions are taken with regard to soundness of rail construction and safety of train operation

Functions of Commissioner of Railway Safety

- (i) Inspection of new Railway lines prior to authorization for passenger traffic.
- (ii) Periodical inspection of open lines.
- (iii) Approval of works and renewals affecting passenger carrying lines.
- (iv) Investigation into accidents, including enquiries into such accidents of passenger trains as are considered to be of a serious nature.
- (v) General advice on matters concerning safety of train operation; The Commissioners of Railway Safety have Statutory powers under section 4, 5 and 6 of Indian Railway Act to inspect the railway systems, conduct in place of inquiries in the causes of accidents and sanction execution of all works affecting the safety of running lines.

4.14 Safety at Work Site

Construction sites at times are quite remote, with difficult working conditions and the construction activities have to be performed systematically so that safety is ensured at all times.

The following tips are recommended for preventing accidents during construction stage.

- (i) Suitable warning boards and men with banner flags must be provided at the prescribed locations for the precaution of work site.
- (ii) Proper caution order must be given to the stations on either side of the work site so that

the driver is suitably advised of work on the track and he should look out for men at work and drive cautiously in the area where work is going on.

- (iii) Look out for moving train on the adjacent track and keeping lookout men with proper Equipments.
- (iv) Equipments and tools should be in good working condition.
- (v) Adjacent track should be safeguarded by providing fencing.
- (vi) Good lighting and providing non-slipping plate ways helps in safe working.
- (vii) Remove extra debris from the vicinity of the track so that it does not foul the line and ensure proper drainage to prevent slush and injuries due to slipping.
- (viii) Provide fire fighting equipments at all key points.
- (ix) All workers should be medically fit to work and they should be periodically examined. Doctors and First aid facilities should be available at site.
- (x) Wearing of helmets and safety reflective jackets by all workers should be made mandatory.

