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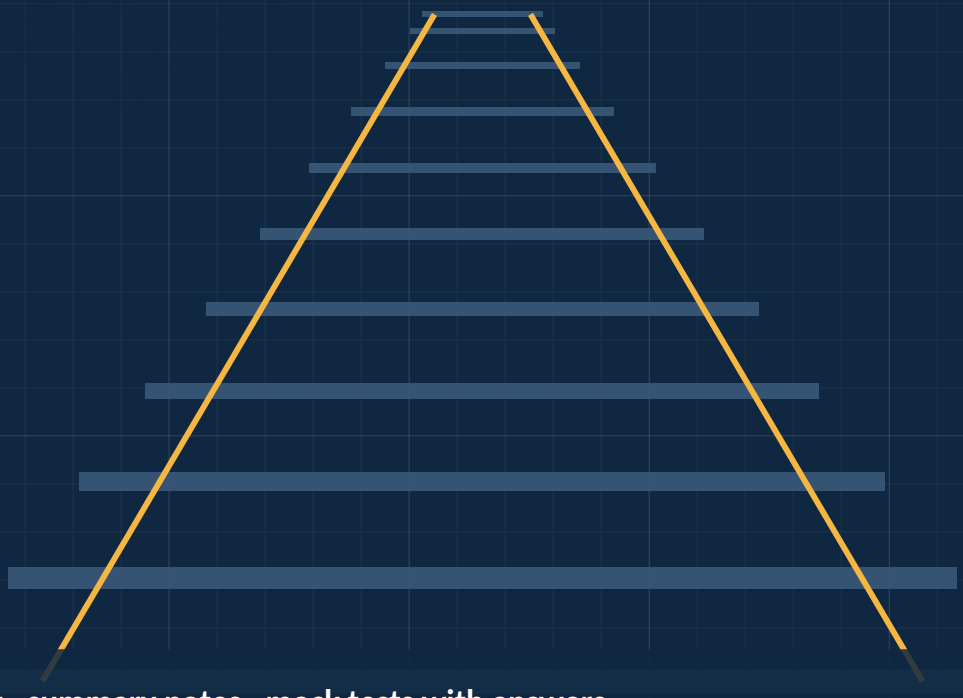
RAILPRO · VOLUME 1 OF 4

Railway Engineering

Study Notes

Railway fundamentals, track structure & curves

Chapter-wise compilation of Indian Railways training notes and circulars for engineering-department departmental & promotional exams.



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Railway fundamentals, track structure & curves

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The complete set (free)

Vol 1 — Railway fundamentals, track structure & curves (this file)
Vol 2 — IRSOD, turnouts, renewal, track machines & level crossings
Vol 3 — Works, drawings, tenders, land, finance & stores
Vol 4 — Establishment, rules, safety & reference circulars

About this compilation: the chapters reproduce Indian Railways training material — course notes of the railway training institutes for JE/SSE (P.Way, Works, Bridge and Drawing) induction programmes — and Railway Board circulars, arranged chapter-wise for revision. The original pages are kept unchanged; Nirmaanpro only adds this navigation, bookmarks and branding and does not claim authorship of the source material.

Before you rely on any value

The source documents span many years; limits, rates and rules may have been revised since. For exam answers and field work, confirm against the latest IRPWM, IRSOD, IRWM, G&SR, codes, Railway Board/RDSO letters and zonal instructions.

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PART I

Railway Fundamentals & Operating Systems

DRAWING (DESIGN ASSISTANT)

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INDUCTION COURSE FOR (SSE/JE/ DRAWING) (B-3)

DURATION: 52 WEEK

SN.	Type of Training	Place of Training	Duration	Remarks
1	Induction PH-I	Training institute	8 Weeks	Common Training for all SSE/JE drawing as per Annexure B-3 (a)
2	Induction PH-II	Training institute	4 Weeks	General Training at ZRTI as per Annexure B-3 (b)
3	Induction PH - II (a)	Training in field	13 Weeks	Field Training at the place of posting as per Annexure B-3 (c)
4	Induction PH - III	Training Institute	1 Weeks	Exam as per Annexure B-3 (d)
5		On Job Training	26 Weeks	At the place of Posting

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INDUCTION COURSE FOR PH-1 (SSE/JE/ DRAWING) (B-3a)

DURATION : 8 WEEKS

Annexure B-3 (a)

Topic	TOPIC DETAILS	PDS
1	**Joining and Introduction**	**8**
1.1	Introduction	
1.2	Basic duties and role of SSE/JE Drawing in the organisation	
2	**Basics Of Railway Track**	**120**
2.1	Track Organisation	
2.2	Basic introduction to Railway Track: Type of rails, sleepers, track structure, ballast, formation etc.	
2.3	Route Classifications, an overview of Indian Railway Network, prescribed track structure for various routes etc	
2.4	Duties of P-way Staff	
2.5	Various types of track renewal proposals. Criteria for track renewals, initiation and scrutiny of proposals for track renewals	
2.6	Estimation of quantities of materials required for track renewal. Type estimates.	
2.7	Classification of released materials , their accountal and disposal	
2.8	Relevant portions of IRPWM, Track manual	
2.9	Curves : geometry, design of curves, realignment of curves, speed on curves, grade compensation, setting out of curves	
2.10	SOD	
2.11	Points and crossings. Layout calculations. Yard Planning. S&T provisions relevant to yard planning. Preparation of Yard Plan (trainees will be made to do yard planning for one yard and draw ESP)	
2.12	Study of drawings relating to track	
2.13	Track renewal policy	
2.14	Introduction to track machines	
2.15	Level crossings including policy for elimination, interlocking etc	
2.16	Speed certification	
2.17	Provisions relating to opening of new lines	

Topic	TOPIC DETAILS	PDS
3	**Basics of Bridges**	**80**
3.1	Bridge organisation	
3.2	Introduction to Railway Bridges. Definitions of basic terms associated with Railway Bridges. Understanding GAD of a Bridge.	
3.3	Various types of Bridge loadings- only introduction	
3.4	Introduction to various bridge related codes and manuals	
3.5	Policy guidelines for construction and rehabilitation of bridges	
3.6	Preparation of roll diagram and processing. Various type of ODCs	
3.7	Processing of CRS sanctions for opening of lines, Condonation of Railway Board , Certification of track and bridges for new rolling stock etc	
3.8	Speed certification of bridges	
3.9	Preparation of GADs for Bridges. (trainees will be made to draw one GAD for a new bridge and one GAD for rehabilitation of existing bridge)	
3.10	Reading and understanding of standard RDSO drawings for Bridges and structures	
3.11	Scrutiny of proposals for Bridge rehabilitation works	
3.12	Bridge Hydraulics: Design discharge estimation- water way calcula tions including assessment of catchment properties. Fixing of span arrangement & depth of foundation.	
4	**Works and Land Matters**	**112**
4.1	Works Organisation	
4.2	Important provisions of Engineering code specially relating to surveying, estimates, execution of works, measurement of works, works programme etc	
4.3	Passenger amenity works. Latest policy guidelines	
4.4	Works manual	

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Topic	TOPIC DETAILS	PDS
4.5	Scrutiny of proposals for works programme	
4.6	Preparation of project sheets	
4.7	Land management. Protection of land	
4.8	Processing of SOR items for approval, framing of NS items, rate analysis. Collection of data for rate analysis. Escalation of rates etc	
4.9	Specification for works	
4.10	NOCs for construction of structures in vicinity of railway lines, track crossings etc, land licensing and leasing	

Topic	TOPIC DETAILS	PDS
5	**Computer Training**	**64**
5.1	MS office	
5.2	IRCEP, TMS, BMS, IRPSM	
5.3	Auto Cad (Introductory software training will be given at training institute. However, detailed computer training will be organised at their place of posting before they complete their probation).	
5.4	Zonal Railway may also decide to impart computer training in any other software being used in their office. For this purpose the services of reputed private training institutes may be obtained.	
	Total 48 DAYS X 8 PDS = 384	**384 PDS**

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INDUCTION COURSE PH-II FOR (SSE/JE/ DRAWING)(B-3b)

DURATION: 4 WEEKS

Annexure B-3 (b)

Topic	TOPIC DETAILS	PDS
1	**G & SR, SOD, CRS sanction etc**	**48**
1.1	General and Subsidiary rules: Important definitions, General rules applying to Railway servants, Signals – General provisions, Description of fixed signals, hand signals, Detonating signals, Flare signals, Defective fixed signals, various systems of working	
1.2	Classification of stations – simple layout, conditions for granting line clear, single line working on double lines, reception of trains on blocked line, starting from signalled lines, interlocking	
1.3	General rules and procedures to be followed for carrying out engineering works, protection of tracks, working of lorries, trollies, motor trollies, works of short duration and long duration, engineering indicators, safety during working on bridges, SOD, CRS sanction, Works requiring CRS sanction, Safety certificate etc.	
2	**Finance & Budget**	**16**
2.1	Revenue and works budget. Maintenance of accounts, control over expenditure, completion reports. Works programme – PWP, FWP. Allocation and heads of expenditure, CF, DF, DRF, SF etc.	
3	**Stores**	**24**
3.1	DBR, DBI, DMTR, Ledger, requisition for stock and non-stock items. Local purchase. DS-8 etc	
3.2	Scrap disposal, stock verification	
3.3	Account keeping of materials, important points from vigilance angle.	
4	**Establishment and Labour Laws**	**32**
4.1	Muster, pay sheets, pay scales, allowances, passand leave rules,	
4.2	Conduct rules, D & AR, enquiries under D & AR.	
4.3	Labour laws, HOER, Payment of wages, Workmen's compensation act, action in case of injury on duty, Minimum wages act, Factory act etc	
4.4	RTI	
5	**Disaster Management, Accidents, first aid, health and hygiene**	**16**
5.1	DM Act 2005, NDMA, ROLE of NDRF, NPDM.	
5.2	First aid, safety, health and hygiene at work sites	
6	**Official Language**	**4**
6.1	Provisions regarding use of Rajbhasha. Directives regarding implementation and promotion of Rajbhasha	
7	**Training on Soft Skills**	**12**
7.1	Communication skills, Leadership, personal development, personal management	
7.2	Meditation and Yoga	
8	**Ethics, Integrity, Gender sensitisation, Prevention of corruption**	**28**
8.1	Following ethics at work place, Moral values,integrity, Self-vigilance	
8.2	Respect for women, sexual harassment at work places, related rules and guidelines	
9	**Environment and climate change**	**12**
9.1	Pollution control, energy management including energy audit, water management including water audit. Solid waste management	
	Total Duration (phase II) 24 DAYS X 8 PDS = 192	**192**

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INDUCTION COURSE PH-II (A) FOR (SSE/JE/ DRAWING)(B-3c)
DURATION: 13 WEEKS

Annexure B-3 (c)

Topic	TOPIC DETAILS	PDS
1	**Various Topics** Field training: this training will be imparted at the place of posting. Trainees will be given exposure different sections by attaching them with different sections in Zonal or Divisional office. Detailed computer training in MS Office and Auto-Cad will be given either through departmental resources or by engaging professional agencies.	624

INDUCTION COURSE PH-III FOR (SSE/JE/ DRAWING) (B-3d)
DURATION: 1 WEEK

Annexure B-3 (d)

Topic	TOPIC DETAILS	PDS
1	**Training on ethics, Presentations and Exams**	48
1.	Panel discussion to address various doubts	
2.	Ethics at work place	
3.	Presentation by each trainee on the assigned topics	
4.	Examination to test the learning outcomes	

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INDUCTION COURSE FOR SSE / JE / DESIGN (B-4)

DURATION: 1 YEAR

SN.	Type of Training	Place of Training	Duration	Remarks
1	Induction PH-I	Training institute	8 Weeks	Common Training for all SSE/JE drawing as per Annexure B-3 (a)
2	Induction PH-II	Training institute	4 Weeks	General Training at ZRTI as per Annexure B-3 (b)
3	Induction PH - III	Training institute	1 Weeks	Exam for Ph I and II as per Annexure B-3 (d)
4	Induction PH - IV	Training Institute	5 Weeks	Technical Training – Part I as per Annexure B-4 (a)
5	Induction PH - V	Training in field	20 Weeks	Field Training (OL/ Construction) as per Annexure B-4 (b)
6	Induction PH - VI	Training Institute	7 Weeks	Technical Training – Part II as per Annexure B-4 (c)
7	Induction PH - VII	RDSO	5 Weeks	Training at RDSO as per Annexure B-4 (d)
8	Induction PH - VIII	Training Institute	2 Weeks	PSpecial Topics, Presentations and Exams as per Annexure B-4 (e)

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INDUCTION COURSE PH-IV FOR (JE/SSE/DESIGN)(B-4a)

DURATION: 5 WEEKS

Annexure B-4 (a)

Topic	TOPIC DETAILS	PDS
1	**Introductionand Duties of Design Assistants**	**4**
1.1	Introduction	
1.2.	Basic duties and role of design assistant in the organisation	
2	**Strength of material and analysis of structures**	**64**
2.1	Plain stress and strain, Hooke's law, Stress-strain diagrams, Elasticity and Plasticity. Shear stress and strain. Introduction to failure theories of materials.	
2.2	Moments of Inertia of Plane areas	
2.3	Simple bending theory, SF and BM, Stresses in Beams, Deflections of Beams, Slopes at supports.	
2.4	Concept of shear span. Cases where simple bending theory is not applicable for analysis of structural elements.	
2.5	Statically indeterminate beams and frames : simple cases	
2.6.	Torsion: basic concepts. Stress distribution due to torsion.	
3	**Hydraulics**	
	discharge estimate, water way calculations, fixing of span arrangements and foundation depth, Span arrangements.	
4	**PCC and RCC Design**	**112**
4.1	Basics of Working Stress method	
4.2	Design of gravity structures	

Topics	TOPIC DETAILS	PDS
4.3	Various practical thumb rules for proportioning of structures	
4.4	Concepts of limit State Design.	
4.5	Understanding formulae for calculation of ultimate moment resistance of sections under flexure, axial and combined loadings. Understanding design concepts for shear and torsion. Concepts of bond, bearing, development length etc.	
4.6	Design of slabs, beams, deep beams, corbels, staircases, water tanks, shallow and deep foundations, concrete pavements, design of skew slabs etc. Using design aids for quick design.	
4.7	Introduction to analysis and design by using Strut and Tie method.	
4.8	Special emphasis to be given on detailing of reinforcement.	
4.9	Design of foundations: footings, rafts, piles, pile caps and wells. Design of foundations subjected to vibratory loads.	
4.10	Design and detailing of construction and expansion joints	
4.11	Relevant IS, IRS and IRC codes for design and detailing	
4.12	Tutorials on RCC design including preparation of structural drawings	
5	**Codes and Manuals**	**40**
5.1	Study of various IS, IRS, IRC, and UIC codes relevant to design of structures. (Part1)	
	Total Duration (Phase IV) 30 Days x 8 PDS = 240	**240**

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INDUCTION COURSE PH-V FOR (JE/SSE/DESIGN) (B-4b)

DURATION: 20 WEEKS

Annexure B-4(b)

Topic	TOPIC DETAILS	PDS
6	**Various Topics**	**960**
6.1.	Trainees will be attached with design engineers working in PCE office for hands on practice on various designs being carried out / checked in PCE or CAO/c office.	
6.2	Trainees should be exposed to use of soft wares like MIDAS, STADD and Excel Sheets in use in the design office.	
6.3	Trainees will be exposed for learning: strength assessment of existing bridges, rehabilitation schemes of bridges, launching and de-launching schemes, design of various bridge components like abutments, piers, pile and shallow foundations; and design of framed buildings and steel structures etc.	
6.4	Trainees will also be deputed to sites of construction/ rehabilitation of important bridges for getting feel of actual field working conditions.	
	Total Duration (phase V) 120 DAYS X 8 PDS = 960	**960**

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INDUCTION COURSE PH-VI FOR (SSE/JE/DESIGN) (B4c)

DURATION: 5 WEEKS

Annexure B-4 (c)

Topic	TOPIC DETAILS	PDS
1	**Basic soil mechanics and Foundation Engineering**	**64**
1.1	Basics of Soil mechanics.	
1.2	Soil Classification and Soil exploration. Trial pit and bore log details.	
1.3	Soil strength parameters. Laboratory testing of soil.	
1.4	Various types of soils and their properties with respect to their suitability for foundations of structures.	
1.5	Determination of bearing capacity for shallow and deep foundations. Settlement analysis. Differential settlement and practical methods to reduce its effects on structures. Pile load testing.	
1.6	Earth pressures.	
1.7	Embankment design and Stability of slopes.	
1.8	Relevant provisions of IS, IRS and IRC codes.	
1.9	Analysis of loads and their effects for substructures and foundations	
1.10	Analysis of reinforced earth structures.	
1.11	Tunnels. Design of tunnel linings, portals etc.	
2.	**Software-STAAD PRO or/and MIDAS**	**48**
	Note : only introductory Training on these soft wares will be given at training institute. Zonal Railway will organise detailed training by engaging services of reputed training institutes when the trainees are attached with the design office for field training.	
3.	**PSC design**	**48**
3.1	Basic Concepts of PSC.	
3.2	Materials for PSC.	
3.3	Analysis of sections for flexure. Bonded and un-bonded tendons.	
3.4	Shear, bond, bearing stresses. Camber, deflections, Pre-stressing cable layouts. Partial pre-stress and non-pre-stressing reinforcement. Pre-stressing losses.	
3.5	Analysis and design of PSC slabs, I girders and Box girders. Analysis for temperature effects and designing for the same.	
3.6	Tutorials on PSC design	
4	**Steel Design**	**48**
4.1	Design of Steel Bridges, Composite bridges	
4.2	Fatigue considerations in steel bridges	
4.3	Steel buildings, including industrial buildings	
4.4	Tutorials on steel design	
5	**Dynamic Analysis**	**24**
5.1	Basics of dynamic analysis	
5.2	Earthquake design as per IS and IRS codes	
6	**Corrosion related issues**	**8**
6.1	Basic mechanism of corrosion. Carbonation of concrete. Various codal provisions for corrosion prevention	
7	**Strength assessment of existing structures and Rehabilitation of Structures**	**24**
7.1	Non-destructive testing of structures.	
7.2.	Assessment of strength form results of NDT and strength parameters obtained from destructive testing.	
7.3.	Study of various failure patterns in structures.	
7.4.	Various method of structural rehabilitation including methods using new technologies like Carbon fibre based systems. Determination of acceptance criteria for rehabilitation schemes.	
7.5.	Strength assessment of masonry arch bridges. Ring software and empirical methods like Tabulation method and modified MEXI method. Finalising dismantling schemes for structures.	
9	**Bridge Bearings**	**16**
9.1	Requirement and functions of bearings.	
9.2	Various types of bearings. Design of common type of bearings.	
10	**Temporary structures, launching schemes etc.**	**16**
10.1	Temporary structures. Load assessment and design of temporary structures. Erection loads. Crane working. Finalisation of launching and de-launching schemes. Temporary restoration of traffic at accident sites.	
11	**Codes and Manuals (Part 2)**	**40**
11.1	Study of various IS, IRS, IRC, and UIC codes relevant to design of structures.	
	Total Duration (Phase VI) 42 DAYS X 8 PDS = 336	**336**

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INDUCTION COURSE PH-VII FOR (JE/SSE/DESIGN)(B-4d)

DURATION: 5 WEEKS

Annexure B-4 (d)

Topic	TOPIC DETAILS	PDS
1	**Various topics**	**240**
1.1	Study of Standard drawings for RCC, PSC, 30 (Five weeks) Steel bridges for Railways and ROBs.	
1.2	Conversion of discrete wheel loads into EUDL	
1.3	Rail structure analysis	
1.4	Design of Railway and Highway Bridges. Trainees will be made to actually carryout designs of at least one through girder bridge for Railway, and one PSC bridge for Highway	

INDUCTION COURSE PH-VIII EXAM MODULE (JE/SSE/DESIGN)(B-4e)

DURATION: 2 WEEKS

Annexure B-4 (e)

Topic	TOPIC DETAILS	PDS
1	**Special Topics**	**16**
1.1	Rail Structure Interaction Analysis.	
1.2	Basic concepts of LWR as relevant to RSI analysis.	
1.3	Track transitions on bridge approaches	
1.4	Green building concepts	
2	**Strength assessment of existing structures and Rehabilitation of Structures**	**32**
2.1	Non-destructive testing of structures.	
2.2	Assessment of strength form results of NDT and strength parameters obtained from destructive testing.	
2.3	Study of various failure patterns in structures.	
2.4	Various method of structural rehabilitation including methods using new technologies like Carbon fibre based systems. Determination of acceptance criteria for rehabilitation schemes.	
2.5	Strength assessment of masonry arch bridges. Ring software and empirical methods like Tabulation method and modified MEXI method. Finalising dismantling schemes for structures.	
3	**Estimation of quantities** Estimation of quantities for various structures	**8**
4	**Design Reports** Preparation of Design Reports	**4**
5	**CRS sanction etc** Speed Certification of bridges, CRS sanction.	**4**
6	**Exams** Project presentation and examination	**24**
	Total Duration (Phase VIII) 12 DAYS X 8 PDS=96	**96**

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Topic-1 G& SR,SOD,CRS Sanction etc.

1.2 Classification of stations – simple layout, conditions for granting line clear, single line working on double lines, reception of trains on blocked line, starting from signalled lines, interlocking (total periods- 10)

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classification of stations

GENERAL RULES
OF
INDIAN RAILWAYS

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CLASSIFICATION OF STATIONS

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1.03 Classification of stations

(1) Stations shall, for the purpose of these rules, be divided into two categories––block stations and non-block stations.

(2) Block stations are those at which the Loco Pilot must obtain an authority to proceed under the system of working to enter the block section with his train; and under the Absolute Block System consist of three classes ––

Class 'A' stations – where Line Clear may not be given for a train unless the line on which it is intended to receive the train is clear for at least 400 metres beyond the Home signal, or up to the Starter;

Class 'B' stations – where Line Clear may be given for a train before the line has been cleared for the reception of the train within the station section; and

Class 'C' stations – block huts, where Line Clear may not be given for a train unless the whole of the last preceding train has passed complete at least 400 metres beyond the Home signal and is continuing its journey. This will also include an Intermediate Block Post.

(3) Non-block stations or Class 'D' stations are stopping places which are situated between two consecutive block stations, and do not form the boundary of any block section.

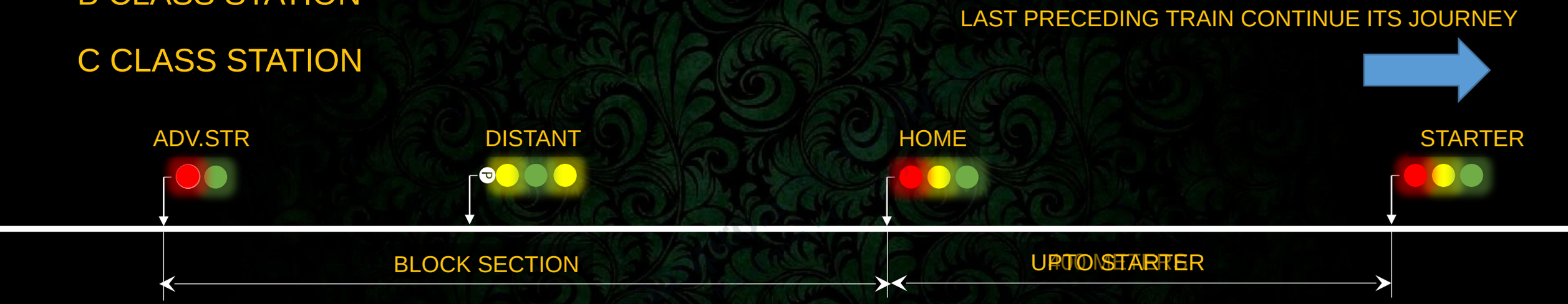
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CLASSIFICATION OF STATION

A CLASS STATION

B CLASS STATION

C CLASS STATION

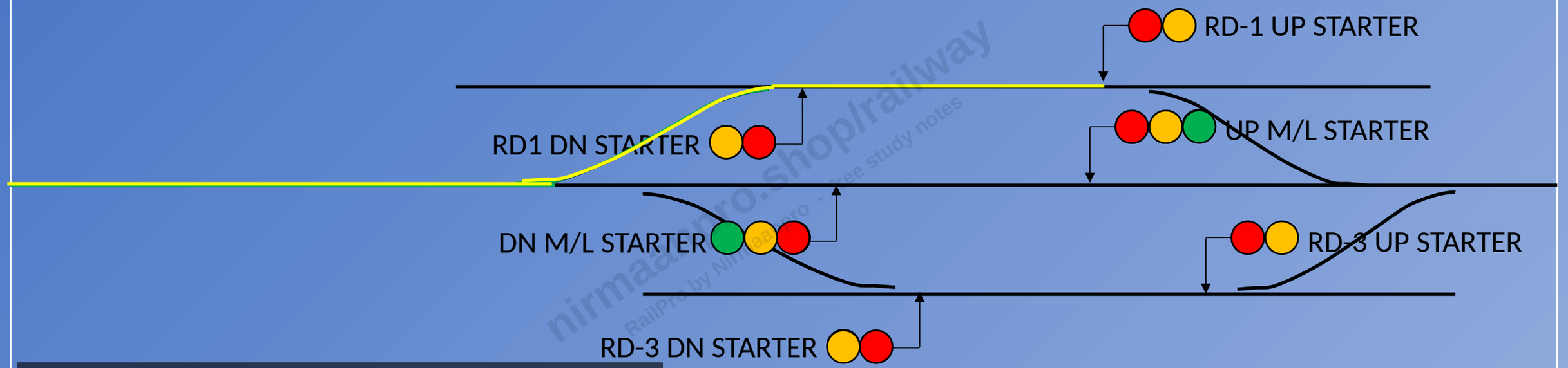


Class B Station: In such station, Line clear may be permitted if Block Section only is 400 Free

meters from Home signal is clear & the last preceding train shall continue its journey

If starter signal is provided, distance upto the starter signal shall be free.

SINGLE LINE YARD

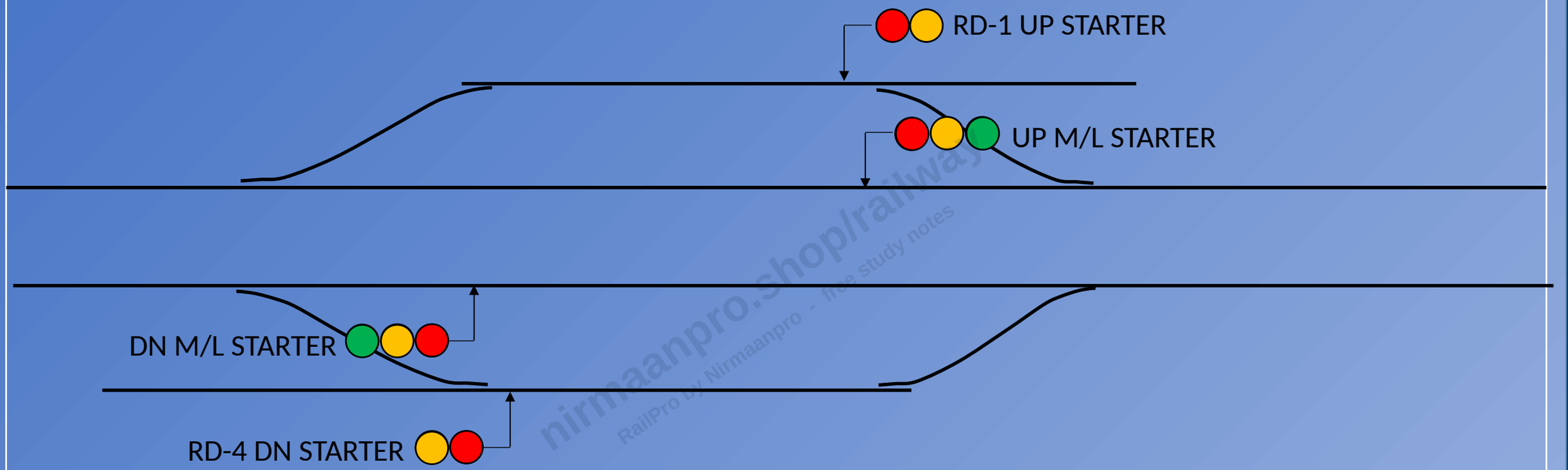


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Conditions to grant permission for Approach

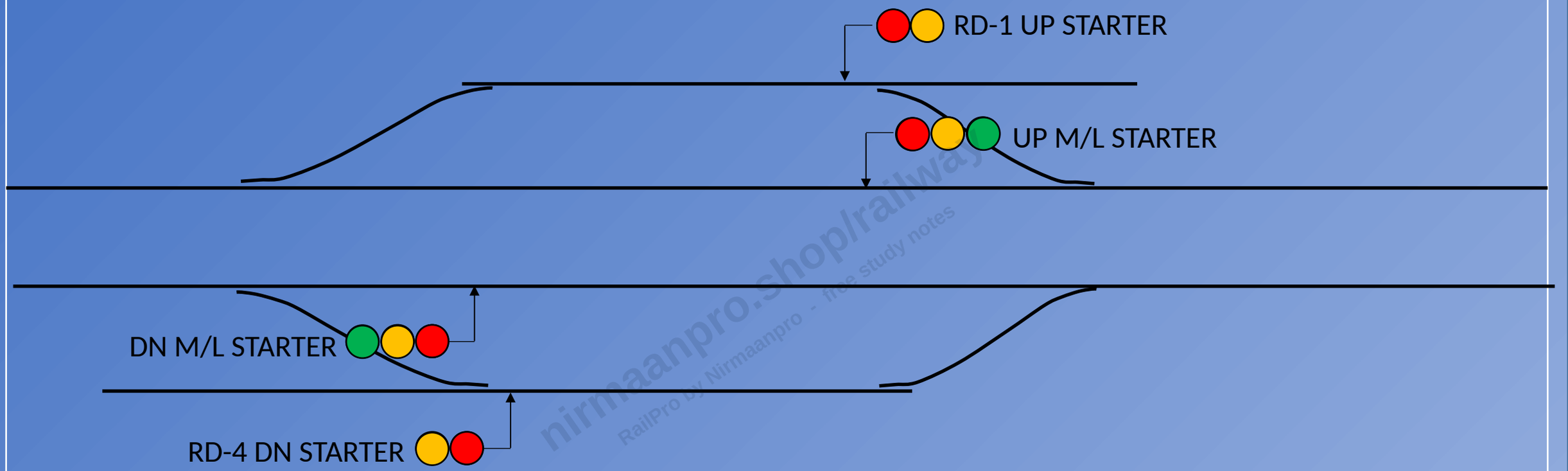
- Desired route shall be cleared of any sorts of obstruction
- Desired route shall be set and locked properly
- Level crossing gates if any shall be closed against road traffic

DOUBLE LINE YARD



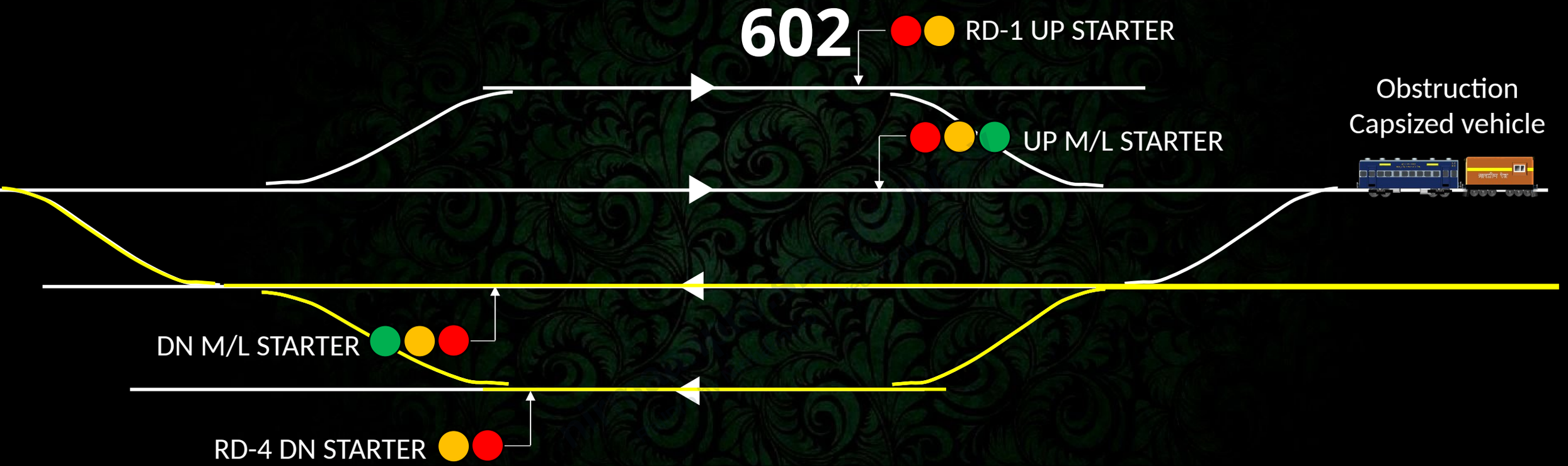
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DOUBLE LINE YARD



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SINGLE LINE WORKING IN DOUBLE LINE T/D



Temporary single line (TSL) working on double line is implemented when if any one of Up or Down line is obstructed by train or any other structure.

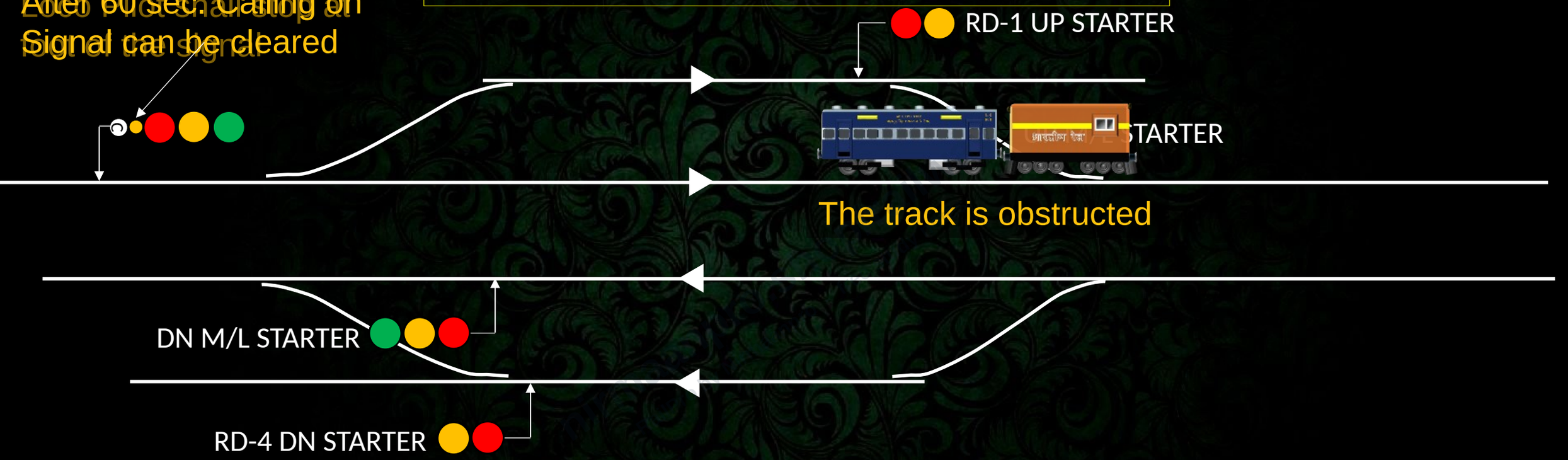
The unaffected track is used to deal trains on both the directions

An Engineering officials not below the rank of inspector shall declare the fitness of the unaffected track before commencement of such working

RECEPTION OF TRAIN ON BLOCKED LINE

Loco Pilot shall proceed cautiously and prepared to stop at any sort of obstruction ahead

After 60 sec. Calling on Signal can be cleared



All Communication Failure or Total interruption of Communication

If Line Clear cannot be obtained by Any of the following means

Block Instrument, Track Circuit or Axle Counters

Telephone attached to the block



Working of Train during Total interruption of Communication (Single Line)

STATION A

STATION B



To establish communication and to enquire line clear, a light engine shall be sent to the affected station.

Form T/B 602 shall be handed over to the Loco pilot by the duty SM before proceeding to affected station

The Loco Pilot shall move cautiously upto the affected station

The Loco Pilot shall move return back to the previous station after obtaining written consent from the affected station SM on duty regarding line clear and permitted direction of traffic

T/B 602 Authority for opening communication during total interruption of communication on Single Line Section

- Authority to proceed without Line Clear
- Authority to pass signals in Danger position
- A caution order specifying the max. speed up to which the pilot engine shall maintain
- A line clear enquiry message addressed to the Station Master of the block station
- A conditional line clear (CLC) message to the Station Master of the block station at the other end

interlocking

Interlocking is the sequential operation of signaling gears operated from lever frame or control panel so as to ensure safety.

The desired route where train is proposed to receive shall be free of any kind of obstruction and it is ensured by the Track Circuit

The route shall be set properly and locked and it is ensured by the point machine



1 2 3 4

If any interlocked Level Crossing gate exists on the route, also shall be closed against road traffic.

Finally signal will be cleared if all the sequence described above are satisfied.

Concept, Design & Animation
N.K. Meher SI/S&T-1
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Thanks
07:43

TOPIC-1 G & SR, SOD, CRS sanction etc

1.3 General rules and procedures to be followed for carrying out engineering works, protection of tracks, working of lorries, trollies, motor trollies, works of short duration and long duration, engineering indicators, safety during working on bridges, SOD,CRS sanction, Works requiring CRS sanction, Safety certificate etc. PERIOD -18

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SYSTEM OF WORKING

GR CHAPTER-1 (56) “***system of working***” means the system adopted for the time being for the working of trains on any portion of a railway;

The purpose of System of Working is to maintain adequate distance between trains

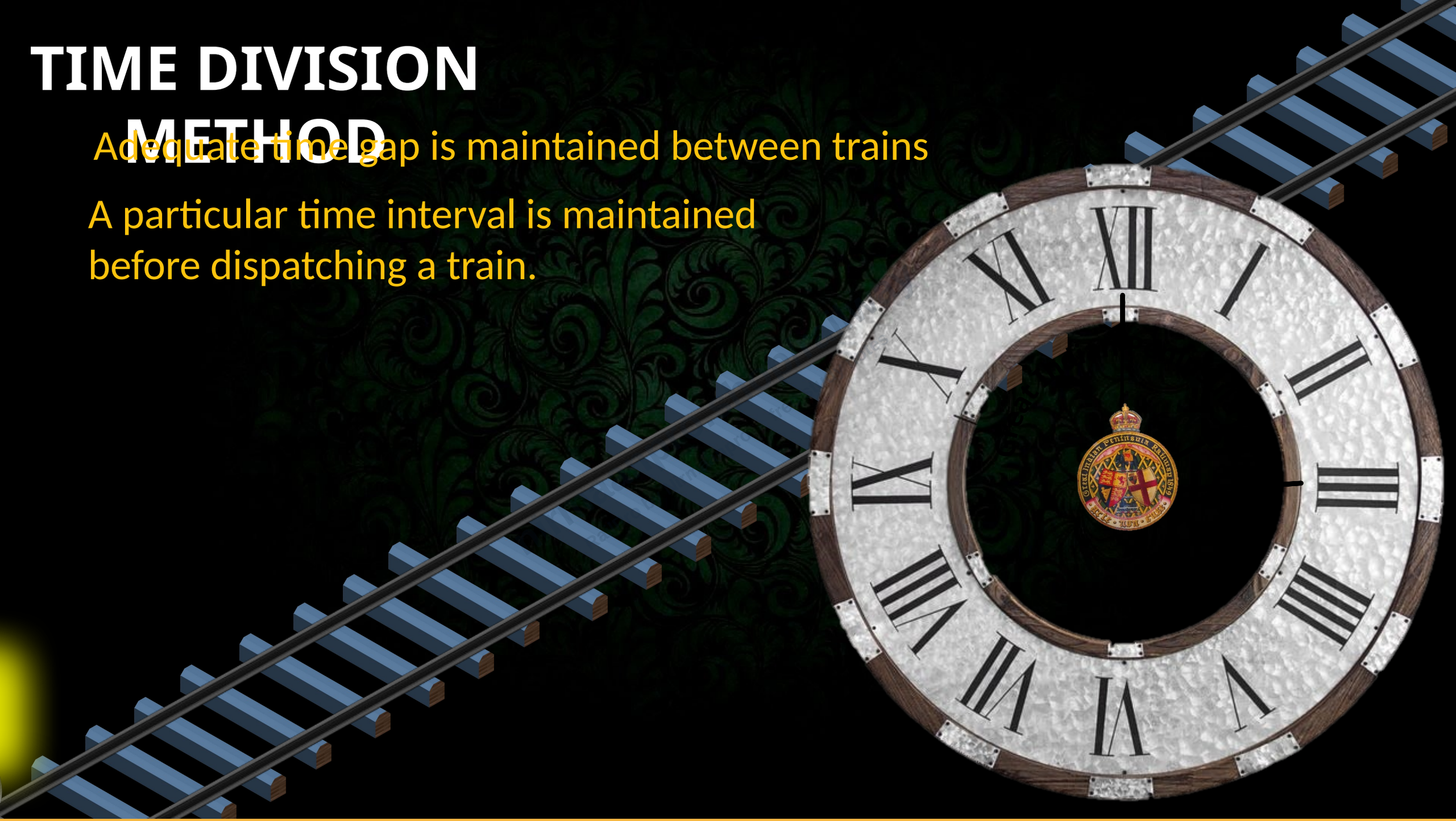
ANCILLARY WORKING

How to keep safe distance between trains ???

TIME DIVISION METHOD

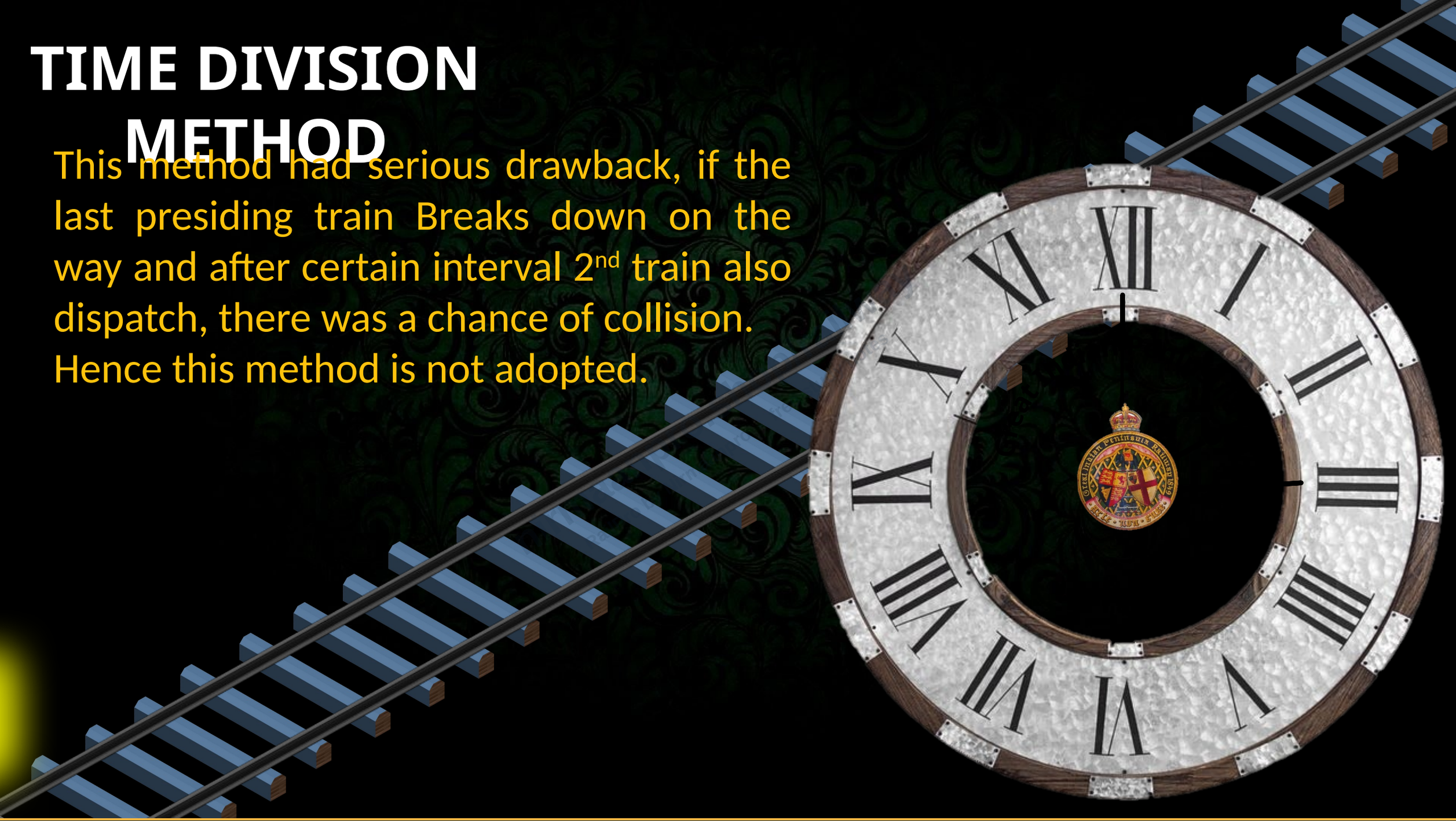
Adequate time gap is maintained between trains

A particular time interval is maintained before dispatching a train.



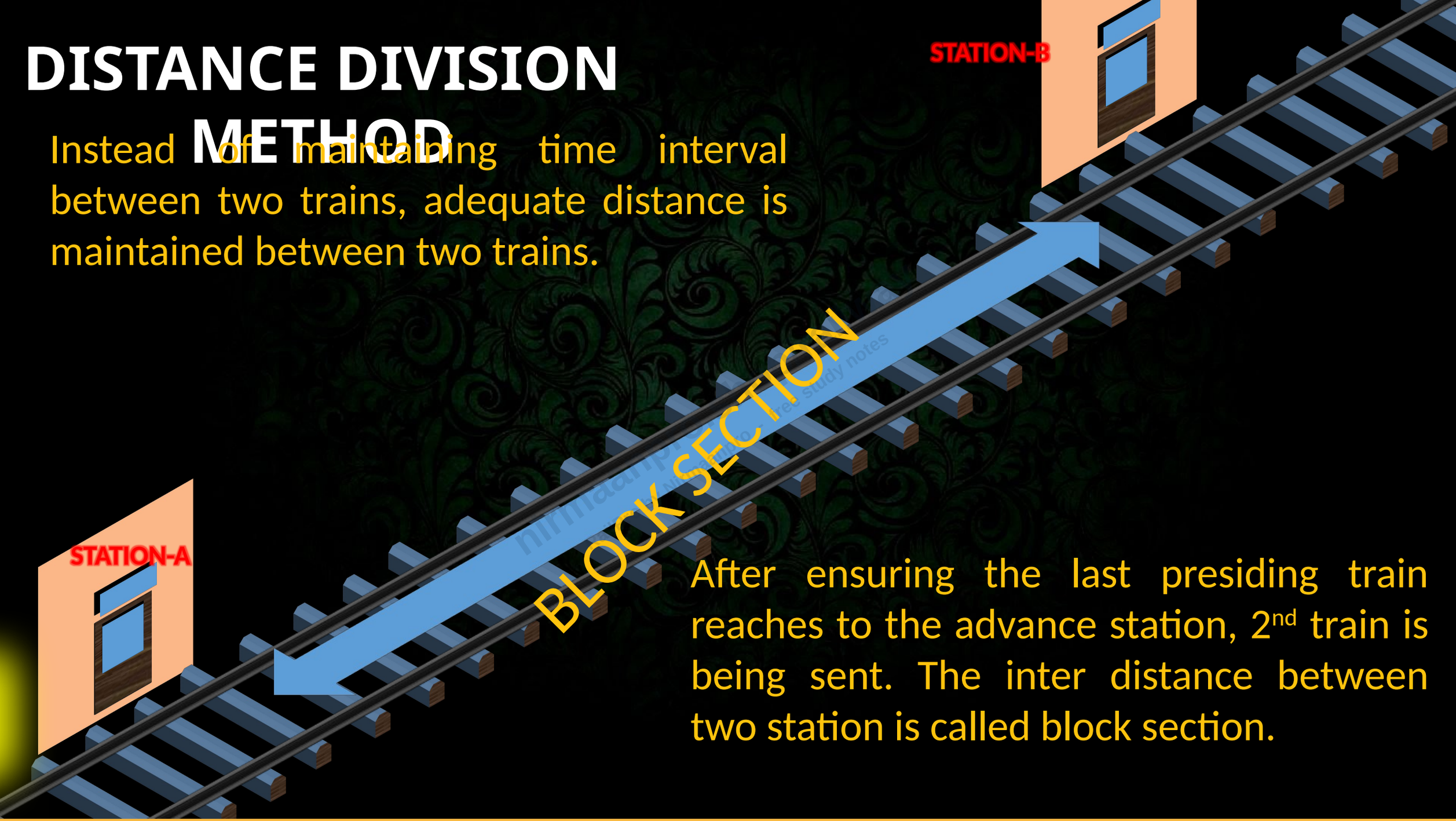
TIME DIVISION METHOD

This method had serious drawback, if the last presiding train Breaks down on the way and after certain interval 2nd train also dispatch, there was a chance of collision. Hence this method is not adopted.



DISTANCE DIVISION METHOD

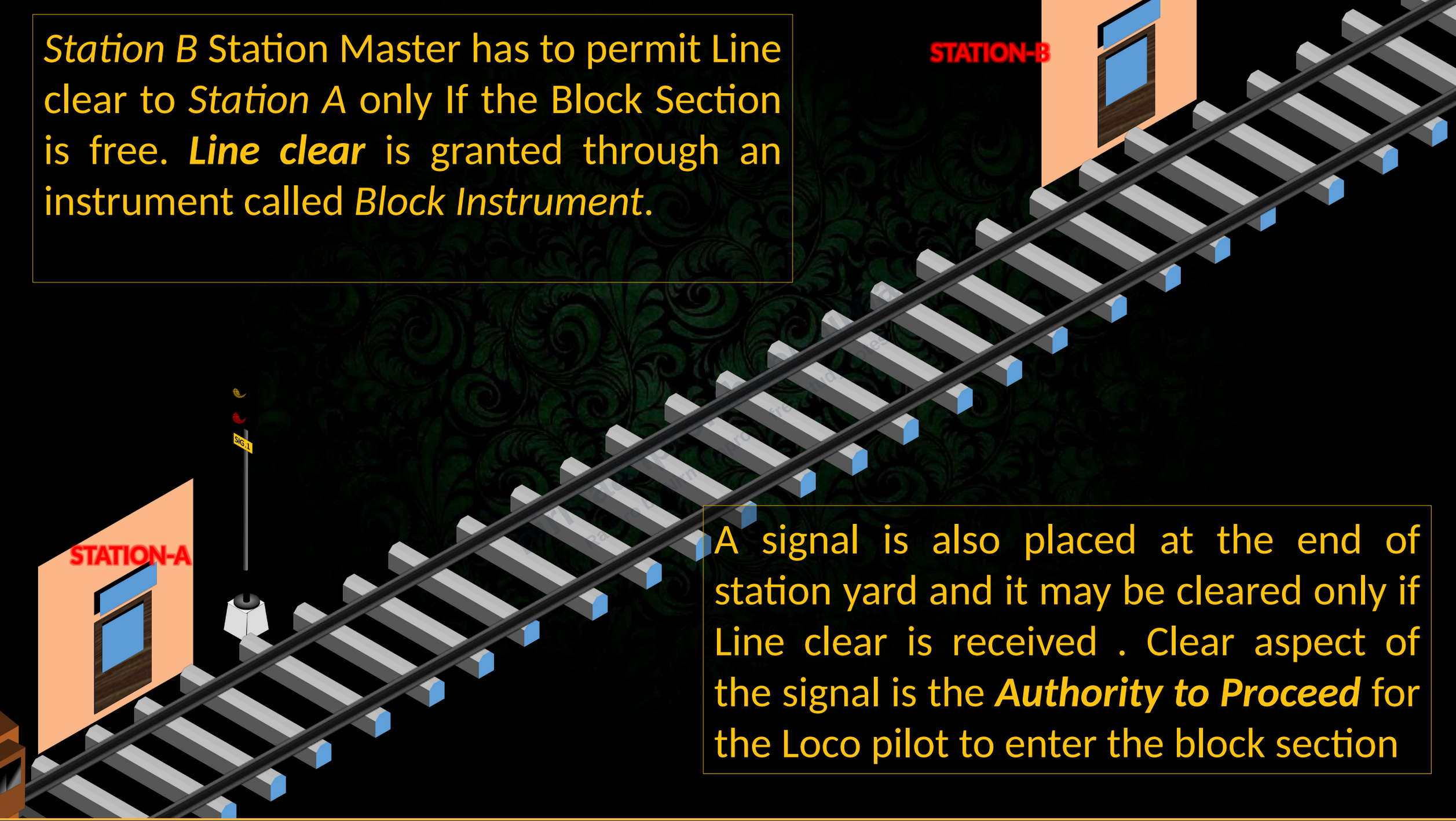
Instead of maintaining time interval between two trains, adequate distance is maintained between two trains.



After ensuring the last presiding train reaches to the advance station, 2nd train is being sent. The inter distance between two station is called block section.

Present day railway working

Station B Station Master has to permit Line clear to *Station A* only If the Block Section is free. ***Line clear*** is granted through an instrument called *Block Instrument*.



A signal is also placed at the end of station yard and it may be cleared only if Line clear is received . Clear aspect of the signal is the ***Authority to Proceed*** for the Loco pilot to enter the block section

SYSTEMS OF working gr.17.01

- Absolute Block System
- Automatic Block System
- The Following Train System
- The Pilot Guard System
- The Train-staff & Ticket System
- The One Train Only System

Automatic and Absolute block system is used in Indian Railways

Absolute Block System

Entry to the block section is restricted unless received Line Clear from the Station in advance

Station master of the rear station shall request to the advance station SM to grant line clear before allowing the Loco Pilot to enter the block section.

Block stations are required at the either end of the block section.

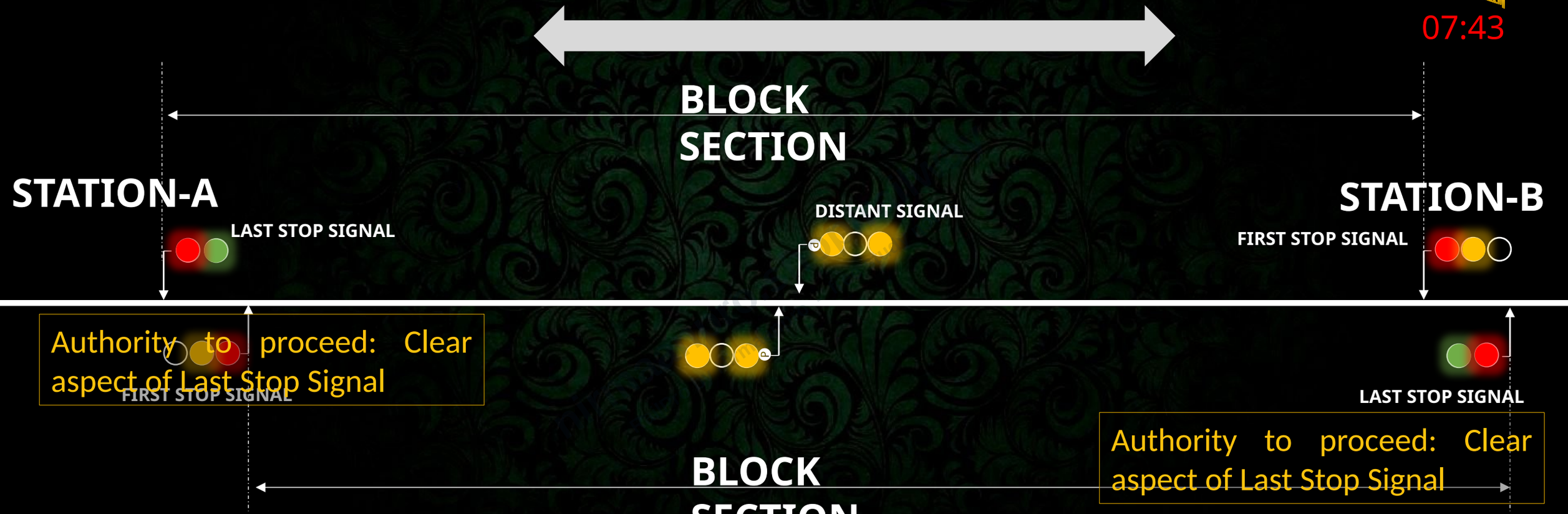
Block instruments or any other approved appliances is required to permit or grant Line clear.

Loco Pilot shall be authorised to enter the block section. Authority to proceed may be the clear aspect of the Last stop signal or a written authority from the station master on duty.

This system is used in Medium to High density traffic area

ABSOLUTE BLOCK SYSTEM

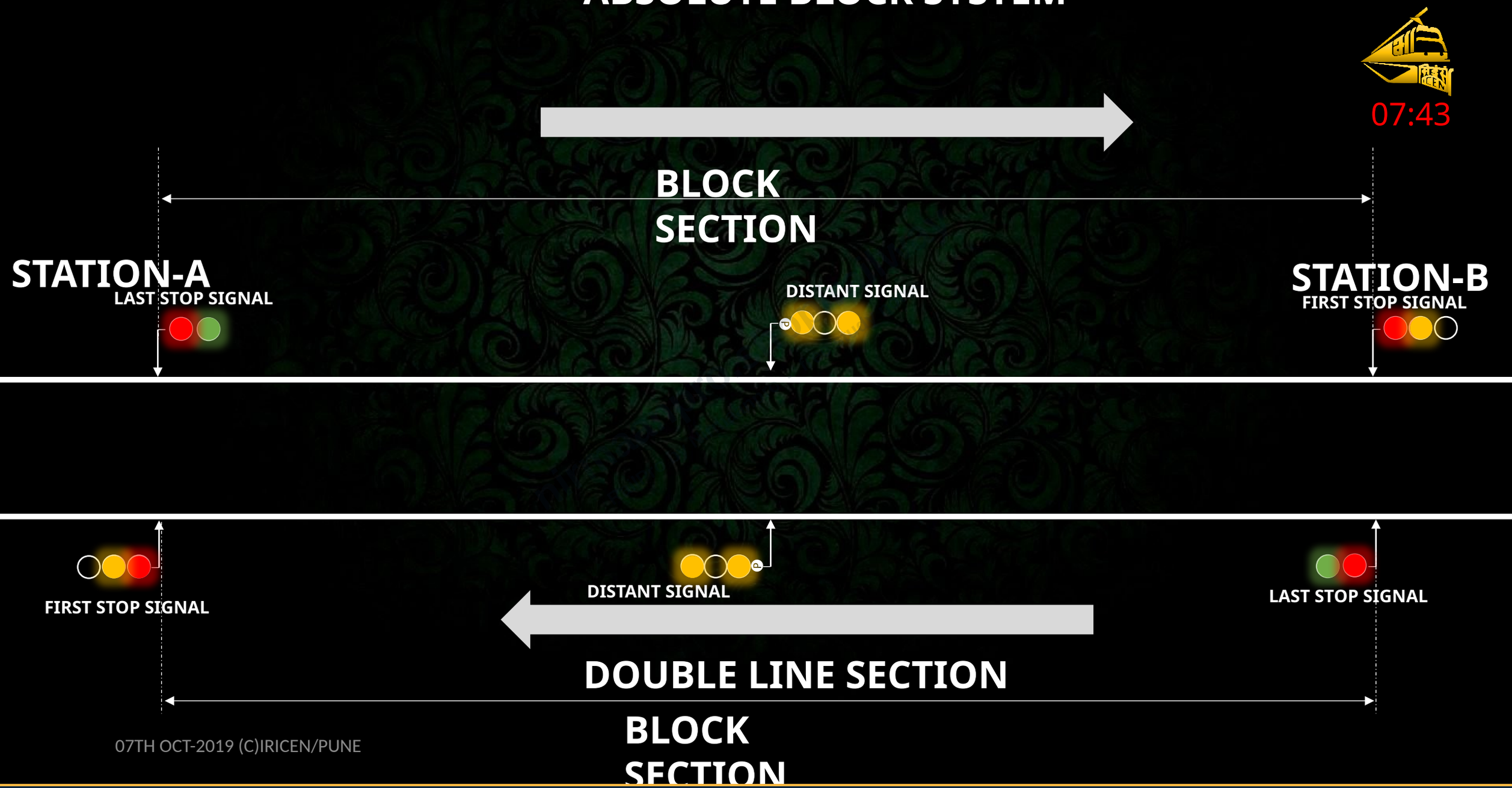
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SINGLE LINE SECTION

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ABSOLUTE BLOCK SYSTEM



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Automatic Block System

Automatic Signals are installed at each 1 km distance.

Block instruments are not required

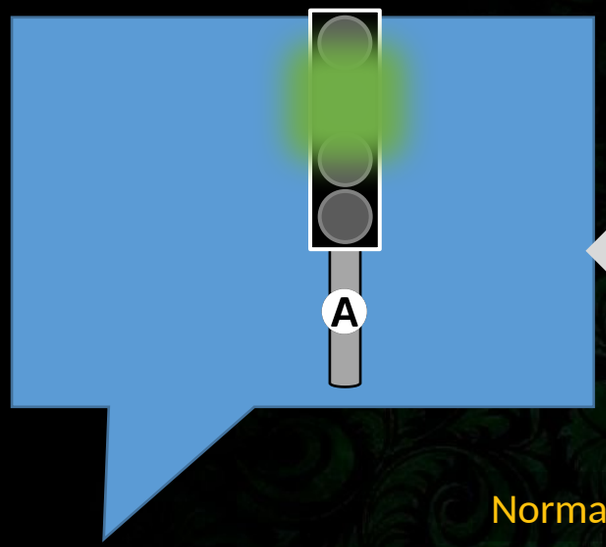
Continuous track circuits are provided in Automatic section

All signals in the Auto Section are controlled by the movement of train automatically hence no need of station masters

The Normal Aspect of an Automatic Signal is *Proceed* or *Green* and is the authority to proceed for the Loco Pilot.

This system is useful in High to Very High traffic density like Sub Urban sections.

AUTOMATIC BLOCK SYSTEM



In Single Line Automatic section, direction of traffic is established

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Normal Aspect of Signals are Green.



SINGLE LINE SECTION

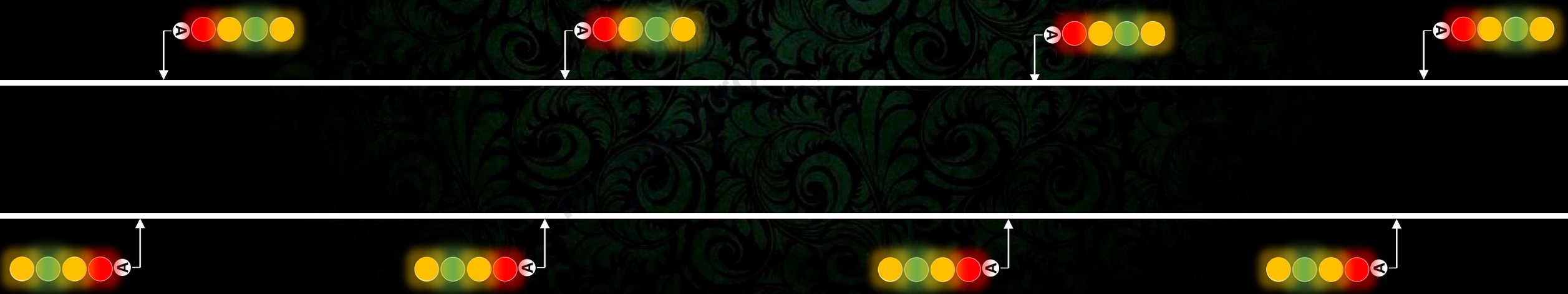
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AUTOMATIC BLOCK SYSTEM

Essential:

- Automatic Signals in every Km.
- Continuous Train Detection using train detection equipment
- Normal Aspect: Proceed
- Signal Aspects changed automatically by the movement of train

07:43



DOUBLE LINE SECTION

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- 10.02. Report to the Commissioner of Railway Safety.–– When the Following Trains System is introduced on any portion of a railway under Rule 7.01, a report shall be sent by telegram to the Commissioner of Railway Safety.
- 10.03. Conditions to be observed in working trains on the Following Trains System.–– When the Following Trains System is adopted, the following conditions shall be observed, namely:– (a) no train shall start until the Loco Pilot has been given a written authority to proceed in the form prescribed for the purpose and a written acknowledgement thereof has been obtained from him, the trains being stopped for the purpose, if not booked to stop

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Contd..

- (b) the authority to proceed shall state the station at which the train is next to stop, the speed at which it is to run and the actual time of departure of the preceding train,
- (c) the Loco Pilot and Guard of each preceding train shall have been informed of the fact that a train will follow, and of the probable period which will elapse the following train shall start,
- (d)a train shall not follow another from a station unless there has elapsed since the departure of the previous train, an interval of not less than 15 minutes, or such shorter interval as may be fixed by special instructions,

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Contd..

- (e) all the trains following the first train shall be timed to run at the same speed and such speed shall not exceed 25 kilometres an hour except under special instructions.
- (f) the actual time of the departure of each train shall at once be intimated to the block station in advance and the actual time of arrival of each train shall at once be intimated to the block station in rear, and
- (g) the number of following trains running at the same time between any two block stations shall not be more than one for each 5 kilometres of station interval; and unless permitted by special instructions, shall never exceed four, whatever may be the length of the station interval.

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Contd..

- Passenger trains shall neither follow any train nor be followed by any other train for this purpose. No passenger train shall be allowed to enter a block section on which the Following Trains System, has been introduced, unless the block section is clear of all trains. Further, no train shall be allowed to follow a passenger train until it has cleared the line between the two stations.

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THE PILOT GUARD SYSTEM

- 11.01. Essentials of the Pilot Guard System.— Where trains are worked on the Pilot Guard System,—
- (a) a railway servant (hereinafter called a Pilot Guard) shall be specially deputed to pilot trains; and
- (b) no train shall leave a station except under the personal authority of the Pilot Guard.
- S.R 11.01 (1) Pilot Guards shall be selected from Station Masters or Guards or from railway servants qualified in Station Master's or Guard's duties. In selecting Pilot Guards on the double line, Station Masters working in cabins who are acquainted with double line working and the signals and points on the section shall as far as possible be preferred.
- (2) Trains may be worked on the Pilot Guard System–
- (a) on short single line branches; or
- (b) on lines to which the application of the system is authorized by special instructions.
- (3) This system may be introduced when specially ordered by the authorized officer.

For further details chapter 11 of GR may be referred.

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THE TRAIN-STAFF AND TICKET SYSTEM (chap-12 of GR may be referred)

- 12.01. Essentials of the Train-staff and Ticket System.— Where trains are worked between two stations on the Train-staff and Ticket System, ––
- (a) a single Train-staff shall be kept at one of such stations, and
- (b) no train shall start from either of such stations to the other unless the said Train-staff is at the station from which the train starts and has either been handed to or shown to the Loco Pilot by the Station Master when giving such permission.
- 12.02. System where applicable.— Trains may be worked on the Train-staff and Ticket System only when the line is single and only between such stations as have been declared by special instructions to be Train-staff stations.

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THE ONE TRAIN ONLY SYSTEM (chapter 13 of GR may be referred)

- 13.01. Use of the One Train Only System.–– Trains may be worked on the One Train Only System, only on short terminal branches on the single line.
- 13.02. Essentials of the One Train Only System.–– Where trains are worked on the One Train Only System, only one train shall be on the section on which this system is in force, at one and the same time.
- 13.03. Authority to enter the section.–– A Loco Pilot shall not take his train into the section unless he is in possession of the authority to proceed as prescribed by special instructions.

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Thanks

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PART II

Permanent Way & Track Engineering

2.1- TRACK ORGANIZATION – Periods 2

Track Organisation

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1. 1 → TOPICS COVERED

→ OVERVIEW OF ORGANIZATION OF RAILWAYS

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Organizational Structure

Indian Railways are owned and managed by the Government of India via ministry of Railways.

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Organizational Structure on IR

.Ministry of Railways is headed by a Minister of Railway.

.Administration and Management of Indian Railways is headed by Railway Board.

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Organizational Structure ON IR

- All policies, instructions guidelines regarding administration are framed and circulated to Zones/Production Units/ Other organisations to follow including maintenance procedure and schedules.

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Organizational Structure – 3 Tier

1. Railway Board
2. Zonal Rly/ Production Unit Management/CTIs
3. Divisional Organization

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Organization: RAILWAY BOARD

- Railway Board consists of

1. A Chairman & Chief Executive Officer (CEO)
2. Four members

a)Member Infrastructure

b) Member Traction & Rolling stock

c) Member Operations & Business Development

d) Member Finance

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Organizational : Zonal Railways

Railway is divided into 18 zones for its smooth administration which are headed by respective General Managers(GM), Who reports directly to the railway board.

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Organizational Structure of Open Line

- Zone Level
- Division Level
- Sub Division Level
- Supervisor Level

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Divisional Organization

- Divisional Railway manager (DRM) heads the organization at the division level.
- Total 73 divisions on the system nationwide.

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Divisional Organization

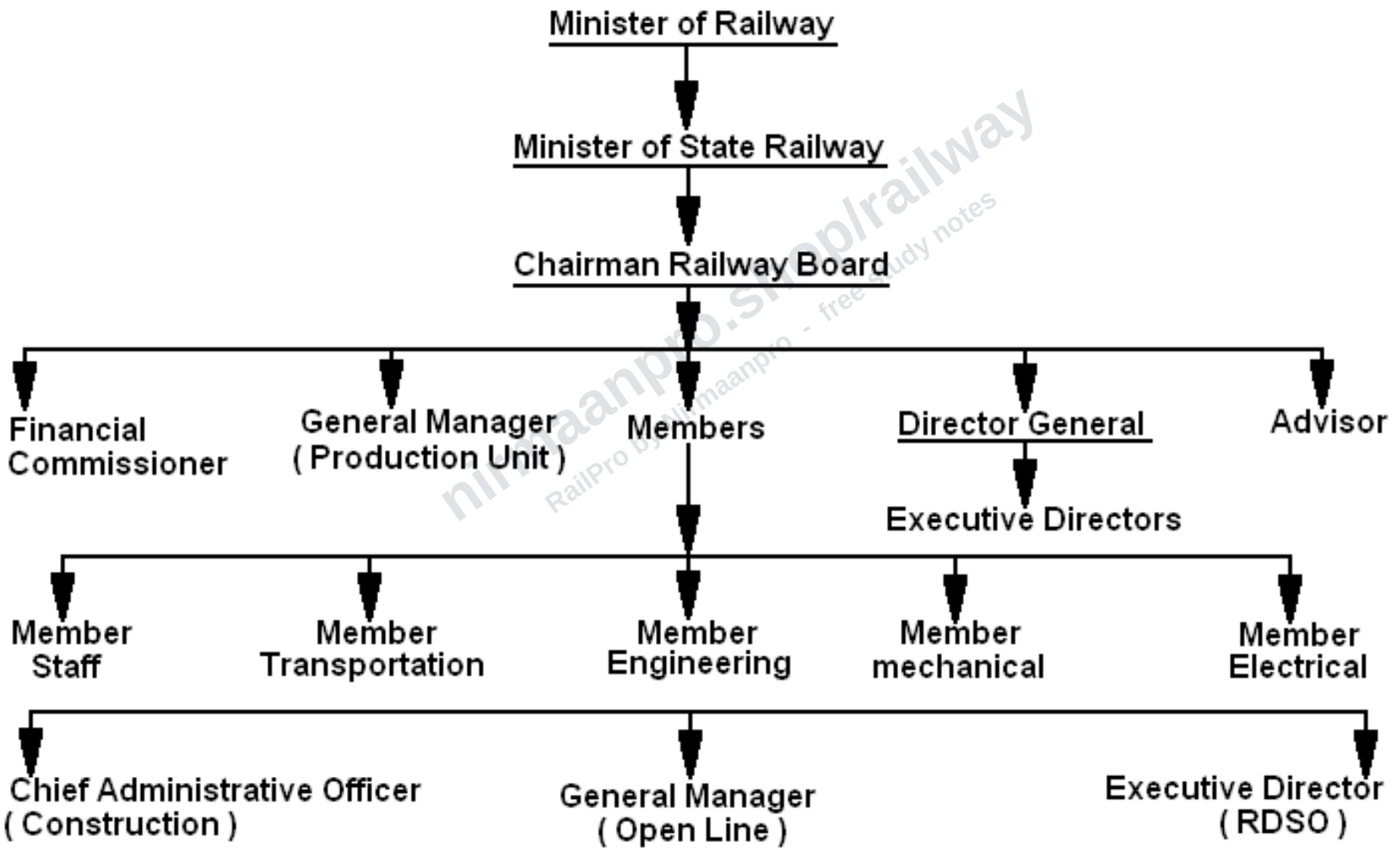
- The divisions are primarily involved with train running

- May have loco sheds (Repair shop for locomotive)
- Coaching depots (Repair home bases for passenger trains)
- Wagon depots (Repair and maintenance points for freight stock)

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Organization and Administration

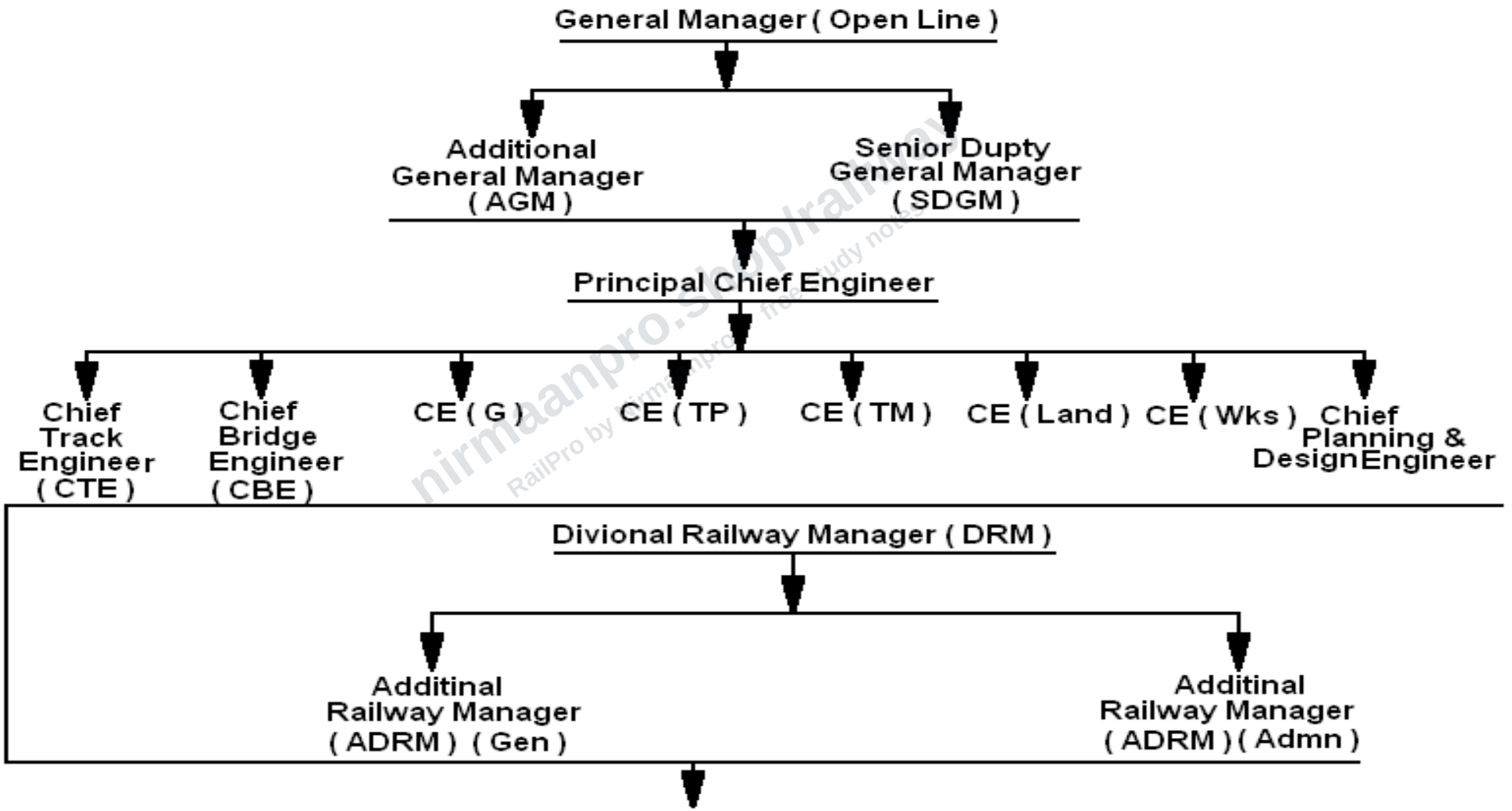
- **Railway Organization –**



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Organization and Administration

- **Structure of Open Line Organisation**



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Divisional Organization

- Each division has all the functional (or departmental) organization.
- The head of these functional groups report to the DRM for administrative purposes but rely on guidance from the railway board and the Zonal headquarters for policy guideline.

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Deptt. Heads under Divisional Railway Manager

- Engineering (Sr. DEN Co)
- Accounts (Sr. DFM)
- Commercial (Sr. DCM)
- Mechanical (Sr. DME)
- Medicals (CMS)

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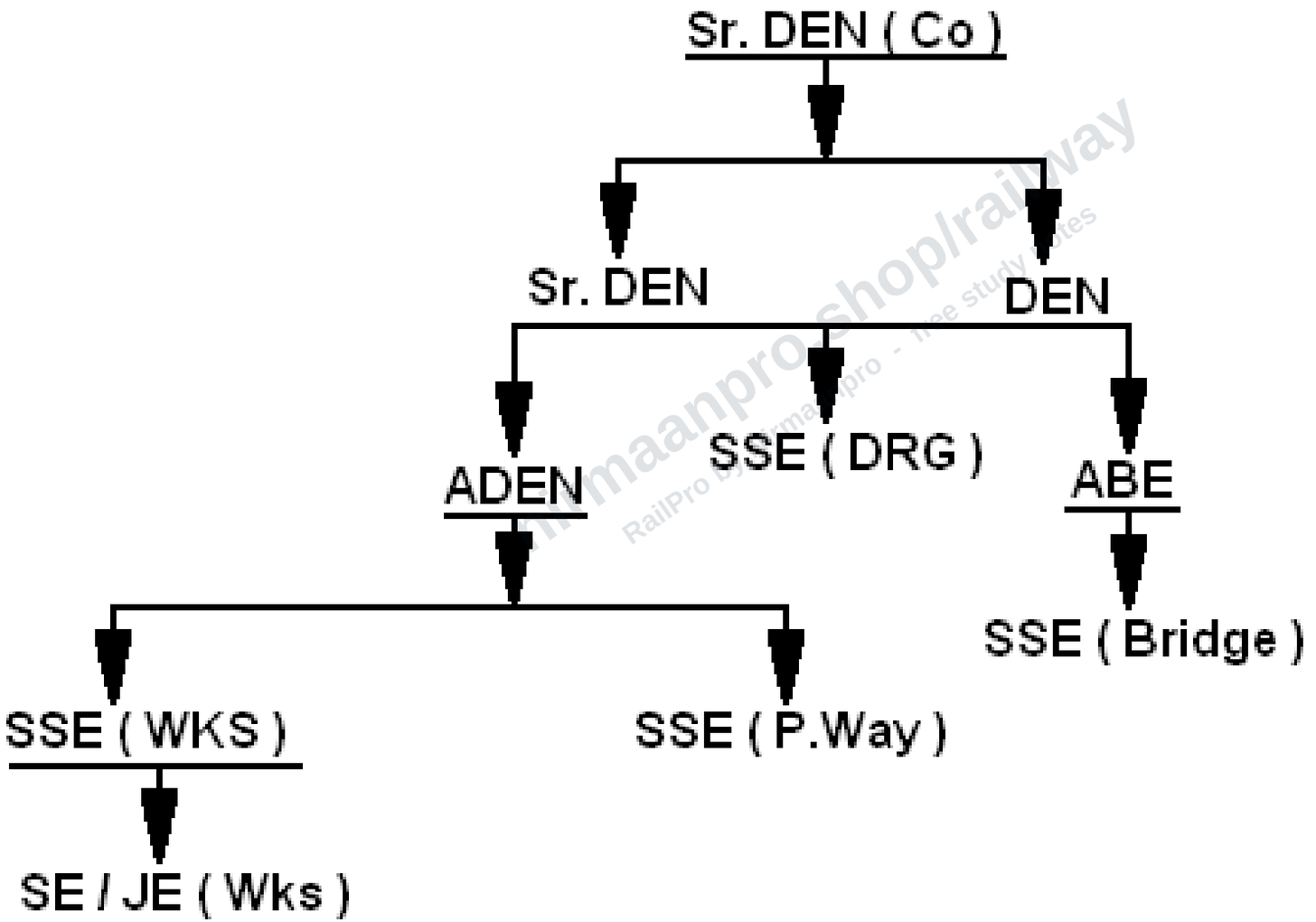
Deptt. Heads under Divisional Railway Manager

- Operating (SR. DOM)
- Personnel (Sr. DPO)
- RPF (Sr. DSC)
- Stores (Sr. DMM)
- S & T (Sr. DSTE)

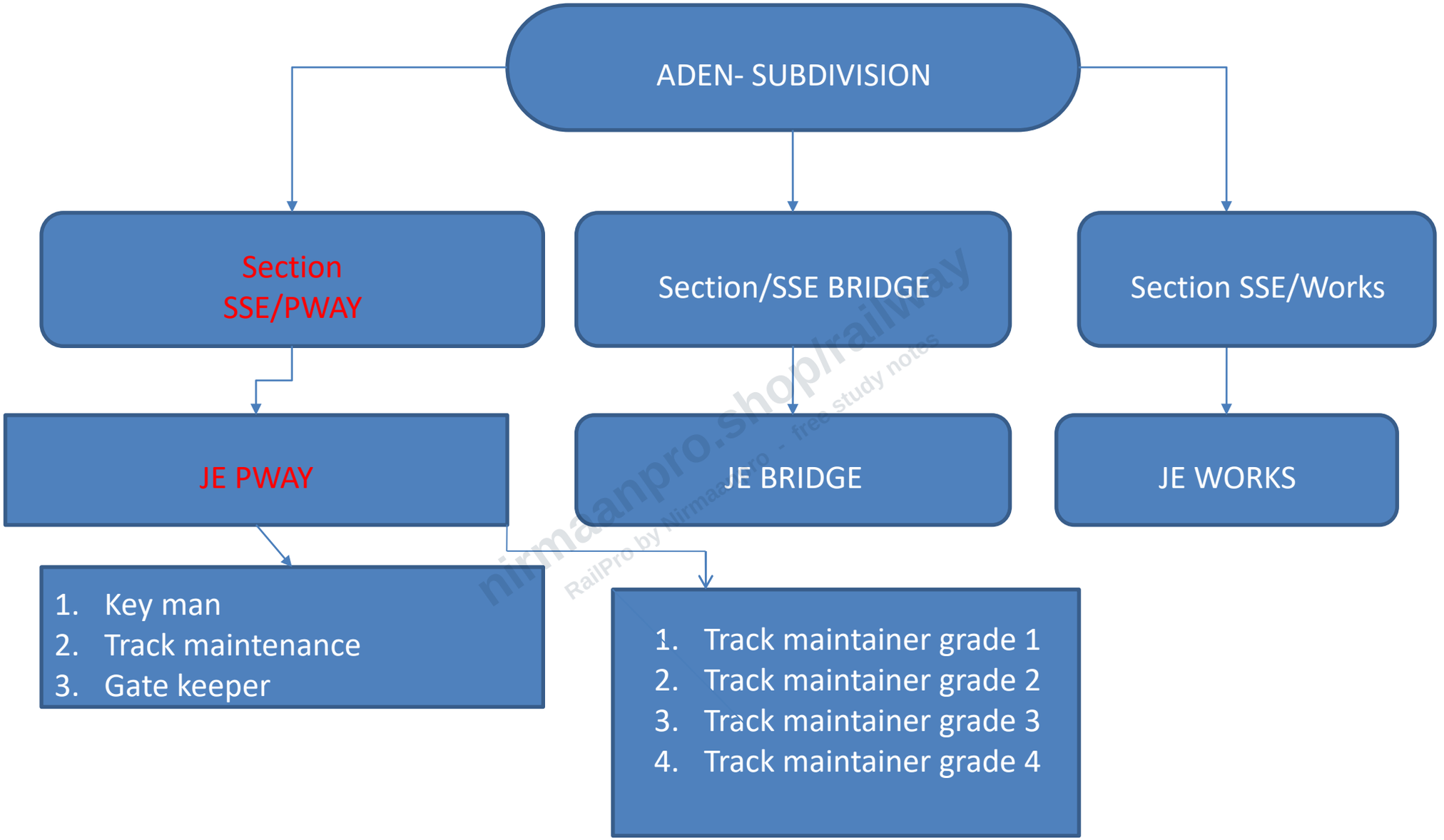
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Organization and Administration in Engg deptt.

- **Structure of Open Line Organisation**



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Hierarchy Level Downward

The hierarchy level of JE in downward (Permanent Way) are mentioned below :

Junior Engineer

. Mate (TM1)

. Keyman (TM2)

. Track Maintainer 3 (TM3)

. Track Maintainer 4 (TM4)

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Zonal Railways with their head quarters

SR. NO.	Zone	Zone Full Name	H. Q.
1	C. R.	Central Railway	Mumbai (CSMT)
2	E. R.	Eastern Railway	Kolkatta
3	N. R.	Northern Railway	Delhi
4	N. E. R.	North Eastern Railway	Gorakhpur
5	N. F. R.	Northeast Frontier Railway	Guwahati (Maligaon)
6	E. C. R.	East Central Railway	Hajipur

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Zonal Railways with their head quarters

SR. NO.	Zone	Zone Full Name	H. Q.
7	E. C. O. R.	East Coast Railway	Bhubneshwar
8	N. C. R.	North Central Railway	Prayagraj
9	S. R.	Southern Railway	Chennai
10	N. W. R.	North Western Railway	Jaipur
11	S. C. R.	South Central Railway	Secunderabad
12	S. E. R.	South Eastern Railway	Kolkata

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Zonal Railways with their head quarters

SR. NO.	Zone	Zone Full Name	H. Q.
13	S. E. C. R.	South East Central Railway	Bilaspur
14	S. W. R.	South Western Railway	Hubli
15	W. C. R.	Southern Railway	Jabalpur
16	W. R.	Western Railway	Mumbai (Churchgate)
17	Metro Railway	Metro Railway	Kolkata (Park street)
18	S. Co. R.	South Coast Railway	Visakhapatnam

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2.2 BASIC INTRODUCTION TO RAILWAY TRACK

2.2	Basic Introduction to Railway Track	8
2.2.1	Types of Rails	2
2.2.2	Sleepers.	2
2.2.3	Track Structure	2
2.2.4	Ballast	1
2.2.5	Formation	1

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RAILS		
2.2.1	Rail, different types of rail section, various types of standard of loadings.	2

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FUNCTIONS OF RAIL

- Provide continuous and level surface for movement of trains.
- Provide a pathway which is smooth and has a very less friction.
- Bear the stress developed due to vertical loads transmitted to it through axles and wheels as well as breaking forces and thermal stresses.
- Carry out the functions of transmitting the load to a large area of formation through sleeper and ballast.

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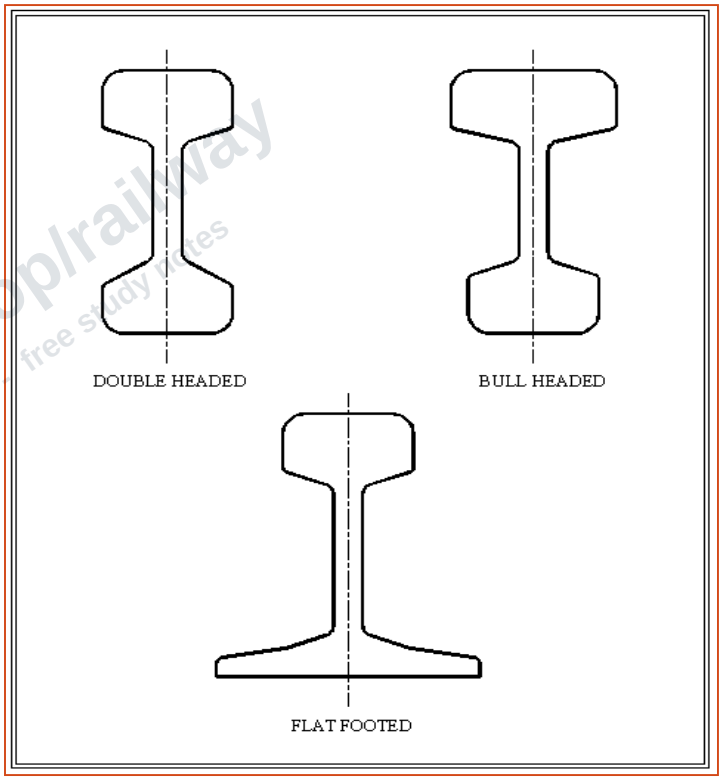
Different types of rails

- Double headed (DH)
- Bull headed (BH)
- Flat footed (FF)
- **Flat footed rails has been standardized on Indian Railway.**

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RAILS

- **Rails**
  - **Double Headed Rail**
  - **Bull Headed Rail**
  - **Flat Footed Rail**

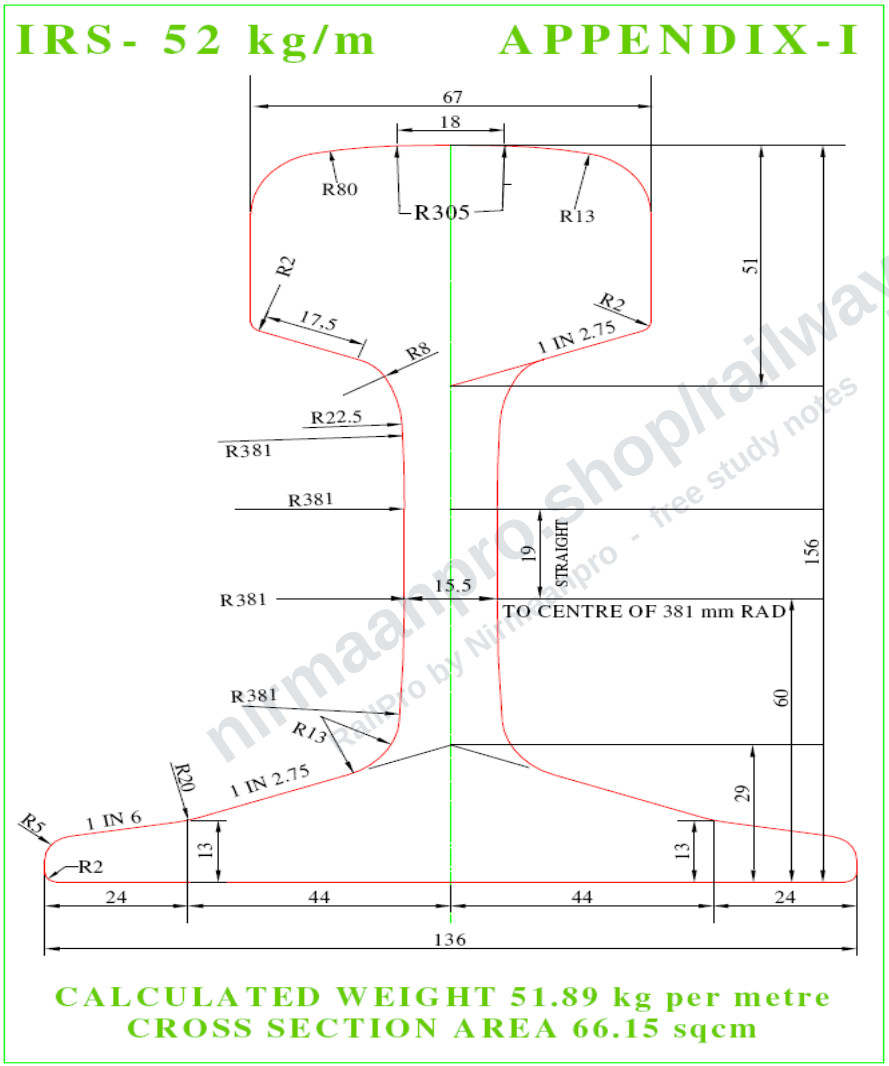


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Flat footed Rail Sections

- IRS 52 kg/m
- UIC 60kg/m
- 60E1
- R 260
- ZU 1-60 Profile (73kg/m)
- 136 RE 14 (68kg/m)

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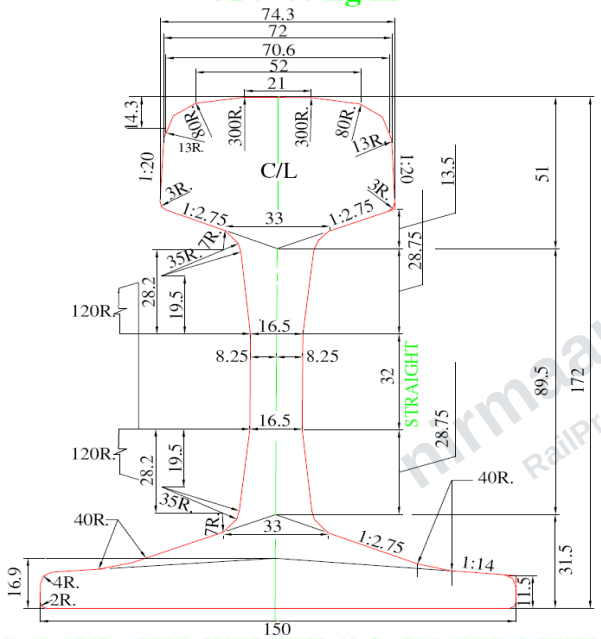
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IRS 52 Kg

Weight	= 51.89 kg/m
X-sec area	= 66.15 sqcm
Head width	= 67 mm
Foot width	= 136 mm
Height	= 156 mm

APPENDIX-II

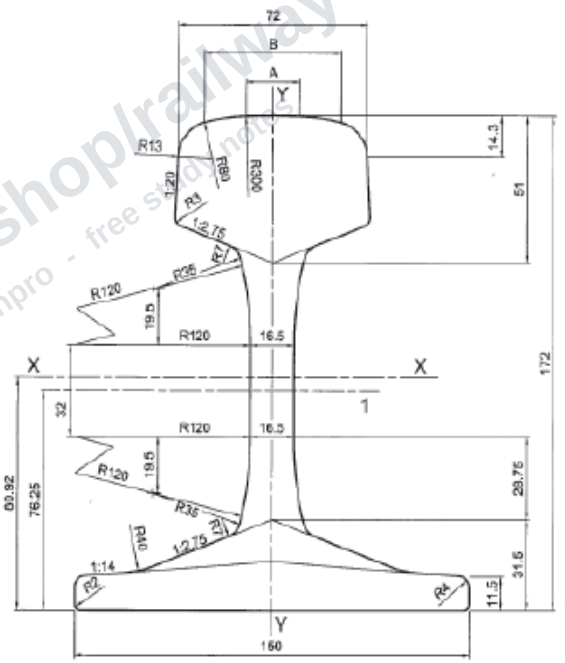
UIC 60 kg/m



CALCULATED WEIGHT 60.34 KG PER METRE
CROSS SECTION AREA 76.86 sqcm

Appendix II (Revised)

60E1 (as per EN 13674-1:2011)

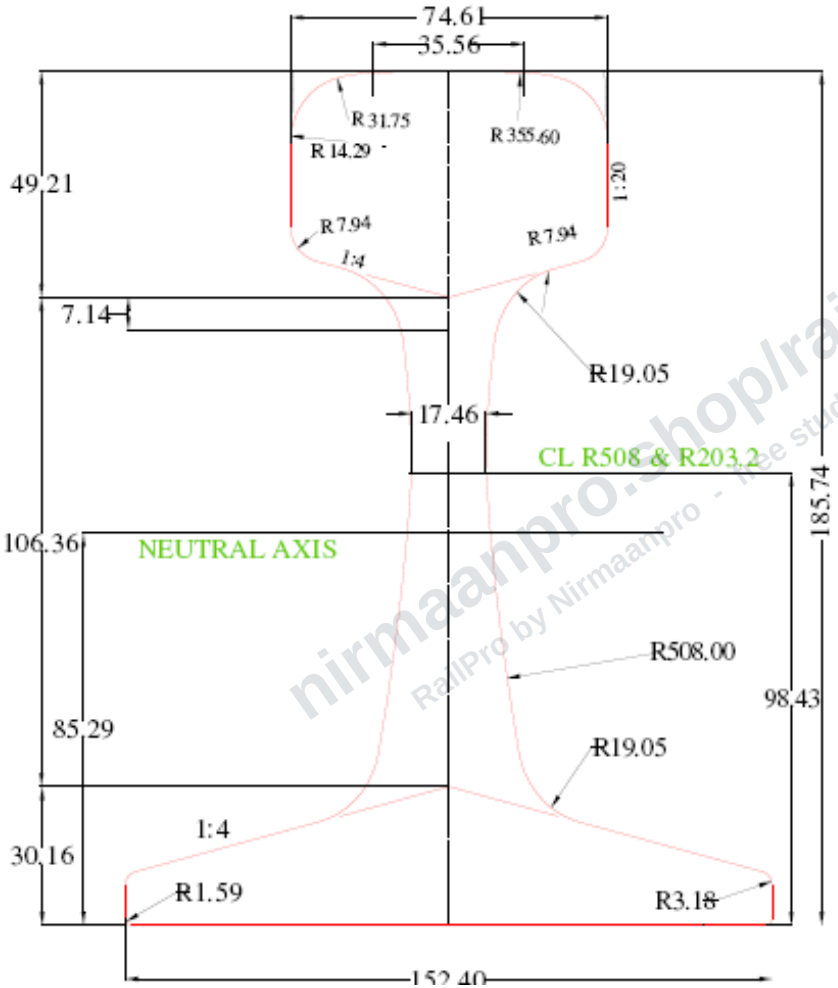


E1 60 kg

Weight = 60.34 kg/m
X-sec area = 76.86 sq cm
Head width = 72 mm
Foot width = 150 mm
Height = 172 mm

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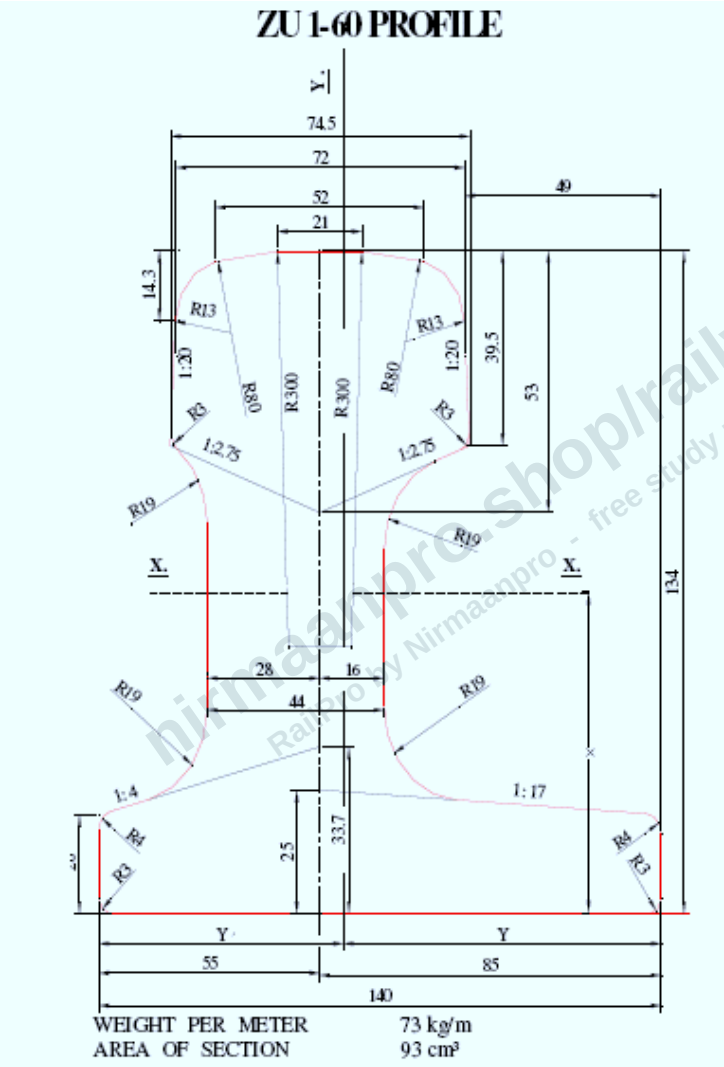
136 RE 14 (68 kg/m) APPENDIX -III



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136 RE 14

Weight = 68 kg/m
Head width = 74.61mm
Foot width = 152.4 mm
Height = 185.74 mm



ZU 1-60

Weight = 73 kg/m
Head width = 72mm
Foot width = 140 mm
Height = 134 mm

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Standard Rail Sections

- Decided on various consideration.

  (i)Heaviest axle load.

  (ii)Maximum permissible speed.

- Standard Rail Sections used in Indian railways are 60 KG, 52 KG,90R, 75R and 60R.
- The standard rail section and the standard rail length prescribed in Indian Railways are given below.

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Standard Rail Sections

- For 60 kg and 52 Kg

GAUGE	RAIL SECTION	TYPE OF SECTION	Weight (in kg/m)	Area of Cross section (in cm^2)
BG	60 kg/m	UIC	60.34	76.86
	52 kg/m	IRS	51.89	66.15

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Recommended Rail Section–

- *Main line*– Track Renewals, Doubling, New Lines and Gauge Conversions– 60kg/m rails with minimum 90 UTS
- *Note*– For Gauge Conversion works & new line works having projected traffic of less than 5 GMT, 60kg/m (SH) rails, if available with Railways, can be used depending upon future projected extension of lines etc.
- (2) *Loop Lines*–
- Renewal of loop lines is to be done with 60 kg/m (SH) or 52 kg/m (SH) rails. The new rails can also be used for these rail renewals with prior approval of Railway Board.

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Recommended Rail Section.. (Contd..)

- Private and other sidings–

(i)	Sidings taking off from DFC or feeder routes to DFC or 25t axle load routes.	60 kg/m
(ii)	Sidings other than (i) above; With permissible speed up to 50 km/h.	52 kg/m (SH); or 52 kg/m (IU)
(iii)	Sidings other than (i) above; With permissible speed more than 50 km/h.	60 kg/m

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PROPERTIES OF RAIL SECTIONS

Rail Section	Weight per metre	Area of section	Moment of inertia		Section modulus about horizontal neutral axis		Maximum distance from horizontal neutral axis	
			Horizontal axis	Vertical axis	Top	Bottom	Top	Bottom
	(kg)	(cm^2)	(cm^4)	(cm^4)	(cm^3)	(cm^3)	(mm)	(mm)
50 R	24.80	31.68	476.17	106.97	88.98	93.08	53.59	51.18
60 R	29.76	38.00	676.79	145.68	115.36	121.92	58.67	55.83
75 R	37.13	47.37	1055.56	230.18	159.28	169.44	66.29	62.30
90 R	44.61	56.95	1600.00	320.91	213.85	235.65	74.93	67.95
52 kg	51.89	66.15	2158.00	363.00	268.40	285.50	80.41	75.59
UIC 60 kg	60.34	76.86	3055.00	512.90	335.50	377.40	91.05	80.95

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GRADE OF STEEL

IRS-T-12-2009 stipulates 7 grades of rails viz.

Grade 880	880
Grade 1080 HH	1080 HH
Grade 1080 Cr	1080 CR
Grade 880 Cu - Mo	880 CM
Grade 880 Ni Cr Cu	880 NC
Grade 880 Vanadium	880 VN
Grade 880 Niobium	880 NB

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Ultimate Tensile Strength

Rail	**72 UTS**	**72 UTS**	**90 UTS**	**90 UTS**	**H/H**	**H/H**
	Rail	Weld	Rail	Weld	Rail	Weld
UTS	740-770	524-784	960-990	646-823	1240-1300	760-1130
YIELD STRESS	400-500	276-525	520-580	526-543	840-850	730-810
ELONGATION %	18-19	7-12	10-14	Lower Than parent rail	7-9	No Much ductility

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Stipulated service life(In GMT)

Rail section	72 UTS	90 UTS
60 Kg/m	550	800
52 Kg/m	350	525

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ROLLING MARKS (Brand marks)

Brand mark shall include:

- Rail section
- The Grade of steel
- Identification mark of manufacturer
- Month (using Roman numbers) and last two digits of year of manufacture
- Process of making

  (O –Basic oxygen or E- electric)

  (Brand mark will be rolled at every 3.0m . The letters should be at least 20mm in height and at least 1.0mm above surface of the web of rail.)

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ROLLING MARK

It shall be rolled in relief on one side of web of each rail

- 3 to 4 meters interval
- Size of letters - At least 20 mm
- minimum 1.5 mm above surface of the web

880 60 O SAIL XII/2002 →

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Rolling mark includes:

- 880 – Grade of steel
- 60 kg – Weight & type of section
- SAIL – Name of manufacturer
- VI 2017 – Month and year
- O.B – Process of manufacture

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60 kg RAIL SECTION

- UIC – International Union of Railway
- Actual weight – 60.34 kg
- Area of cross section – 76.86 sq.cm
- Service life – 800 GMT
- Suitable for use up to a speed of 160 kmph

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52 10 B सेल V/93


880 60. 0 सेल V/2004

Details of standard Rail sections

Rail section	Wt/ meter in kg	Area of cross section	Different dimensions in mm					
			A	B	C	D	E	F
52KG	51.89	6615	156	136	67	15.5	51	29
60 KG	60.34	7686	172	150	74.3	16.5	51	31.5
60 E1	60.21	7670	172	150	72	16.5	51	31.5

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Identification of Different Qualities of Rails in the Field–

- *(1) **Prime Quality' Rails–***
- These rails are to suitable for use in running track at all location and are classified as Class 'A' and Class 'B' rails based on tolerance in End straightness as given below.

End Straightness	TOLERANCES	
	CLASS "A" RAIL	CLASS "B" RAIL
Horizontal	Deviation of 0.5 mm Measured as maximum ordinate from the chord of 2.0 M standard straight edge.	Deviation of 0.7 mm Measured as maximum ordinate from the chord of 1.5 M standard straight edge.
Vertical (up Sweep)	Deviation of 0.4 mm measured as maximum ordinate from the chord of 2.0 M standard straight edge.	Deviation of 0.5 mm measured as maximum ordinate from the chord of 1.5 M standard straight edge.
Vertical (Down Sweep)	Nil	Nil

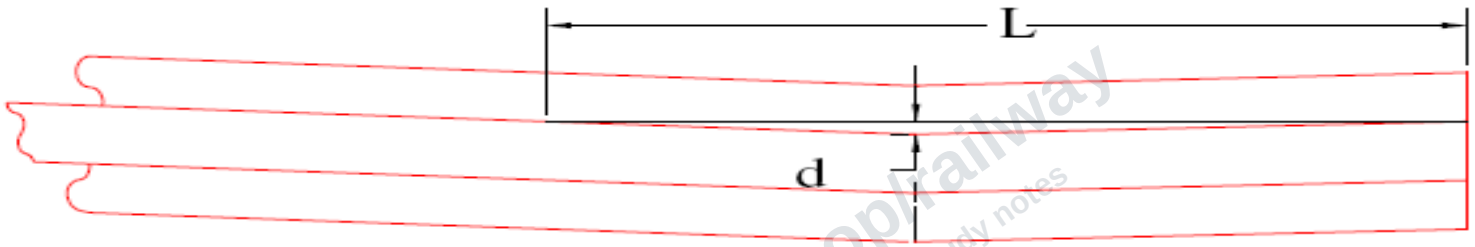
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‘Industrial Use’ Rails (IU rails)–

- There is no deviation in chemical composition or mechanical properties in ‘Industrial Use’ rails form that of ‘Prime Quality’ rails. The deviations exist only in tolerances for Parameters as mentioned in IRS-T-12.
- These rails can be used in industrial sidings with a speed restriction of **50 Kmph**. IU rails can be identified by **blue paint** on end face of flange and **both sides of flange for a distance of 500 mm from each end**. The letter **‘IU’** (Industrial Use Grade) as the case may be in **15 mm size** shall be stamped on both end faces of rails in addition to color marking.

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MEASUREMENTS



L= Length of straight edge specified in Table 2
d= Maximum tolerance specified in Table 2.

Fig.1 TOP VIEW OF HORIZONTAL TOLERANCE AT RAIL ENDS

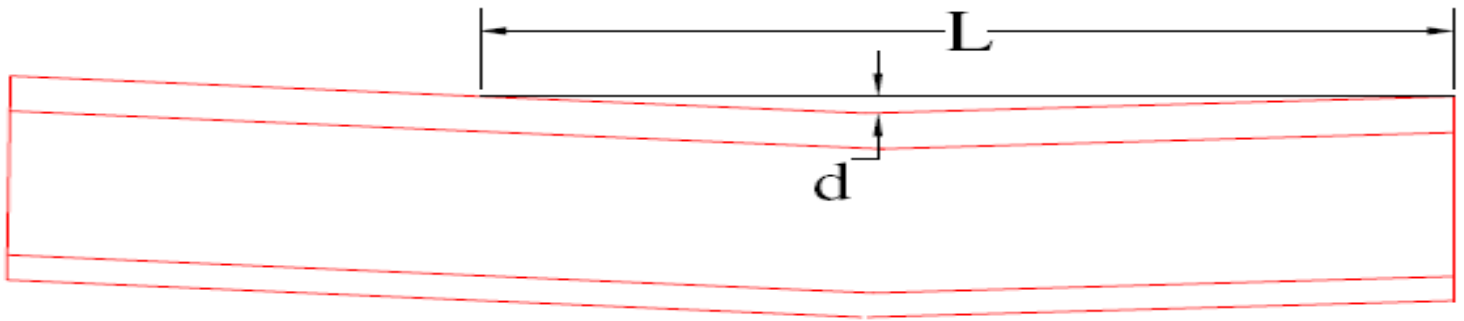


Fig.2: SIDE VIEW OF VERTICAL TOLERANCE AT RAIL ENDS

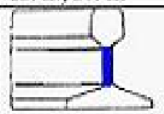
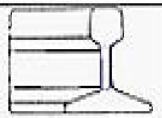
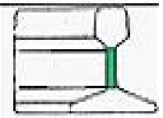
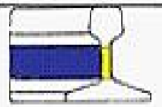
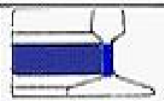
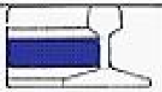
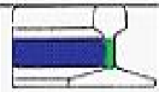
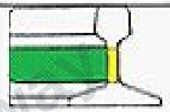
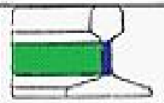
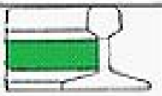
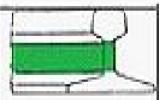
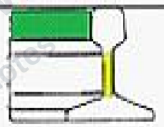
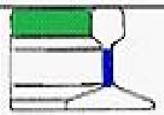
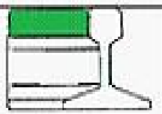
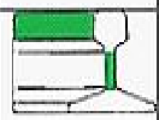
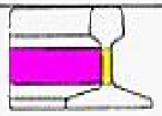
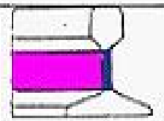
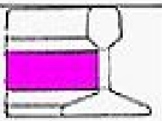
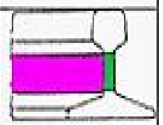
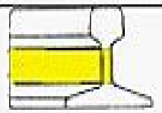
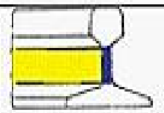
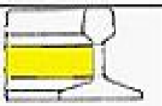
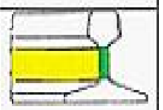
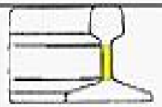
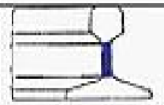
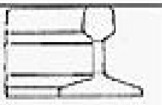
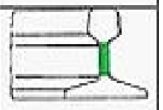
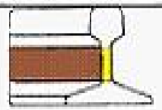
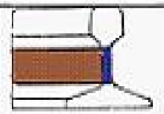
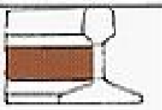
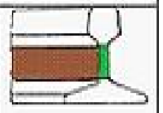
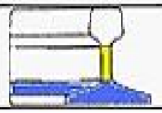
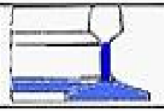
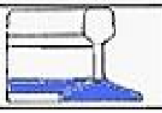
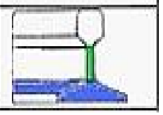
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Permissible Variations in Dimensions of Rail

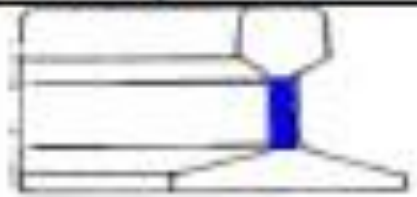
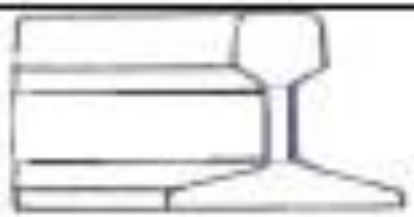
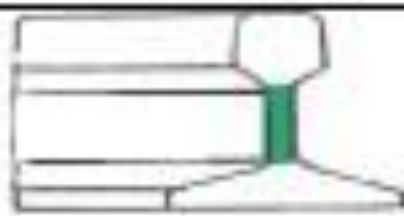
Sl no	Item		Prime Quality rails (mm)	IU rails (mm)
1	Overall height of rail		+0.8 to -0.4	+2.0 to -1.0
2	Width of head Measured 14 mm below the rail top		±0.5	±2.0
3	Width of flange	For sections less than 60 kg/m	±1.0	+1.5 to -2.0
		For sections 60 kg/m and above	+1.2 to -1.0	
4	Thickness of web Measured at the point of minimum		+1.0 to -0.5	+2.0 to -1.0

Note: Rails loaded in one wagon should not be mixed with other rails for dispatch.

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S. No.	Grade	Colour Code	13m, 26m, 130m, 260m	12m, 25m, 129m, 259m	11m, 24m	10m
1	GR. 880	Only common length wise colour code and no paint on web surface				
2	GR.1080 H.H.	In addition to common length wise colour code, **Blue** paint on both sides of web surface for a distance of 500 **mm** from each end.				
3	Gr 1080 Cr	In addition to common length wise colour code, **Green** paint on both sides of web surface for a distance of 500 **mm** from each end.				
4	CLASS 'A' RAIL	In addition to common length wise colour code, grade code as 1, 2 & 3 and **Green** paint on gauge/non gauge face for a distance of 500 mm from each end.				
5	NIOBIUM 880 NB	In addition to common length wise colour code, **Purple** paint on both sides of web surface for a distance of 500 **mm** from each end.				
6	VANADIUM 880 VN	In addition to common length wise colour code, **Yellow** paint on both sides of web surface for a distance of 500 **mm** from each end.				
7	Copper-Molybdenum 880 CM	In addition to common length wise colour code, White paint on both sides of web surface for a distance of 500 **mm** from each end.				
8	Nickel Chromium Copper 880 NC	In addition to common length wise colour code, **Brown** paint on both sides of web surface for a distance of 500 **mm** from each end.				
9	IU	In addition to common length wise colour code, **Blue** paint on end face of flange and both sides of flange for a distance of 500mm from each end.				

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13m, 26m, 130m, 260m	12m, 25m, 129m, 259m	11m, 24m	10m
			

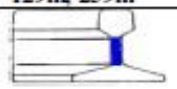
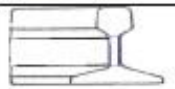
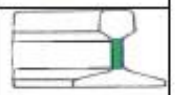
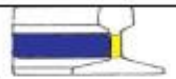
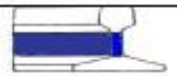
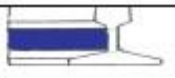
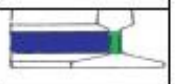
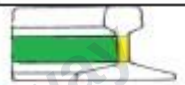
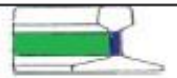
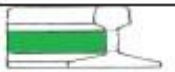
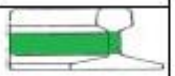
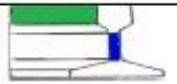
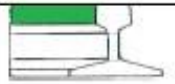
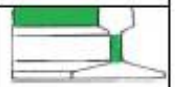
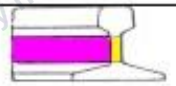
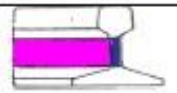
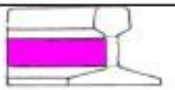
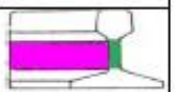
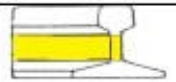
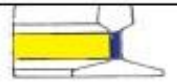
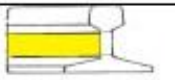
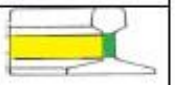
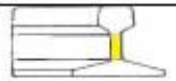
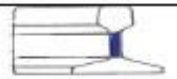
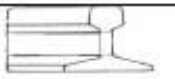
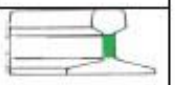
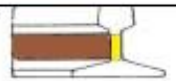
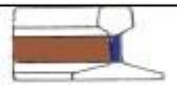
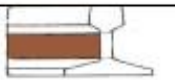
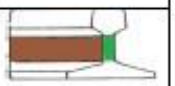
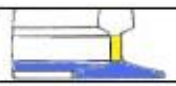
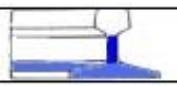
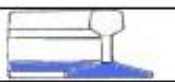
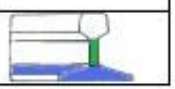
- Common lengthwise colour code
- No paint on gauge/non-gauge face indicates class B rails
- 13m, 26m, 130m, 260m - yellow paint on each end face
- 12m, 25m, 129m, 259m – blue
- 11m, 24m – white

  10m – green

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COLOUR CODE FOR RAILS

APPENDIX – IV

S. No.	Grade	Colour Code	13m, 26m, 130m, 260m	12m, 25m, 129m, 259m	11m, 24m	10m
1	GR. 880	Only common length wise colour code and no paint on web surface				
2	GR.1080 H.H.	In addition to common length wise colour code, **Blue** paint on both sides of web surface for a distance of 500 mm from each end.				
3	Gr 1080 Cr	In addition to common length wise colour code, **Green** paint on both sides of web surface for a distance of 500 mm from each end.				
4	CLASS'A' RAIL	In addition to common length wise colour code, grade code as 1, 2 & 3 and **Green** paint on gauge/non gauge face for a distance of 500 mm from each end.				
5	NIOBIUM 880 NB	In addition to common length wise colour code, **Purple** paint on both sides of web surface for a distance of 500 mm from each end.				
6	VANADIUM 880 VN	In addition to common length wise colour code, **Yellow** paint on both sides of web surface for a distance of 500 mm from each end.				
7	Copper-Molybdenum 880 CM	In addition to common length wise colour code, **White** paint on both sides of web surface for a distance of 500 mm from each end.				
8	Nickel Chromium Copper 880 NC	In addition to common length wise colour code, **Brown** paint on both sides of web surface for a distance of 500 mm from each end.				
9	IU	In addition to common length wise colour code, **Blue** paint on end face of flange and both sides of flange for a distance of 500mm from each end.				

Common lengthwise colour code

1. No paint on gauge/non-gauge face indicates class 'B' rails.
2. Yellow paint on each end face on web region indicates **13m, 26m, 130m, and 260m** length.
3. Blue paint on each end face on web region indicates **12m, 25m, 129m, and 259m** length.
4. White paint on each end face on web region indicates **11m, 24m** length.
5. Green paint on each end face on web region indicates **10m** length.

Note: - This colour code is for new rails, for second hand rails Para 321 of IRPWM-1986 may be referred to.

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Go to Setti

COLOUR CODING OF RELEASED RAILS

- Class I – No marks
- Class II

  a)Second hand rail fit to be relaid in running lines – Ends to be painted with a daub of white

  b)Second hand rail fit to be relaid in non running lines Ends to be painted with a daub of yellow
- Unserviceable rails not fit for use – Ends to be painted with a daub of red

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Color code of different type of rail

- Grade of rails colour code
- 880 grade no paint on web surface
- 1080 H.H. Rails --- Blue paint on both sides of web surface for a distance of 500 mm & from each end
- 1080 Cr.Rails --- Green paint on both sides of web surface for a distance of 500 mm & from each end

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Common lengthwise colour code

- **Yellow paint** on each end face on web region-- **13m,26m,130m and 260m**
- **Blue paint** on each end face on web region---- **12m,25m,129m and 259m**
- White paint on each end face on web region---- 11m,24m
- **Green paint** on each end face on web region

  -- 10m
- **Longer rails:**
- As per IRS-T-12, the standard length of rails is 13 m or 26 m. However, the manufacturer may also supply longer rails of 65 m, 130 m and 260 m length as required by purchaser.

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Identification of different qualities of Rails (As per T-12/09)

Class ‘A’ Rail	Green paint on gauge/non gauge face for a distance of 500mm at each end
Class ‘B’ Rail	No paint mark
‘IU’ Rail	1.Blue paint on both sides end face of flange for a distance of 500 mm from each end.
	2.The letter ‘IU’ shall be stamped in 15mm size on end faces

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2.2 Basic Introduction to Railway Track: SLEEPERS (PERIODS 2)

2.2.2 Functions of sleepers, various types of Sleepers including composite sleepers,Concrete sleepers, Mono-block PSC Sleeper, Special sleepers for L-xings, turnout, SEJ, bridges approach, slack gauge sleepers for curves (more than 4 degree), special sleepers for sharp curves (more than 8 degree), wider sleeper. Sleeper density on different routes

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SLEEPER

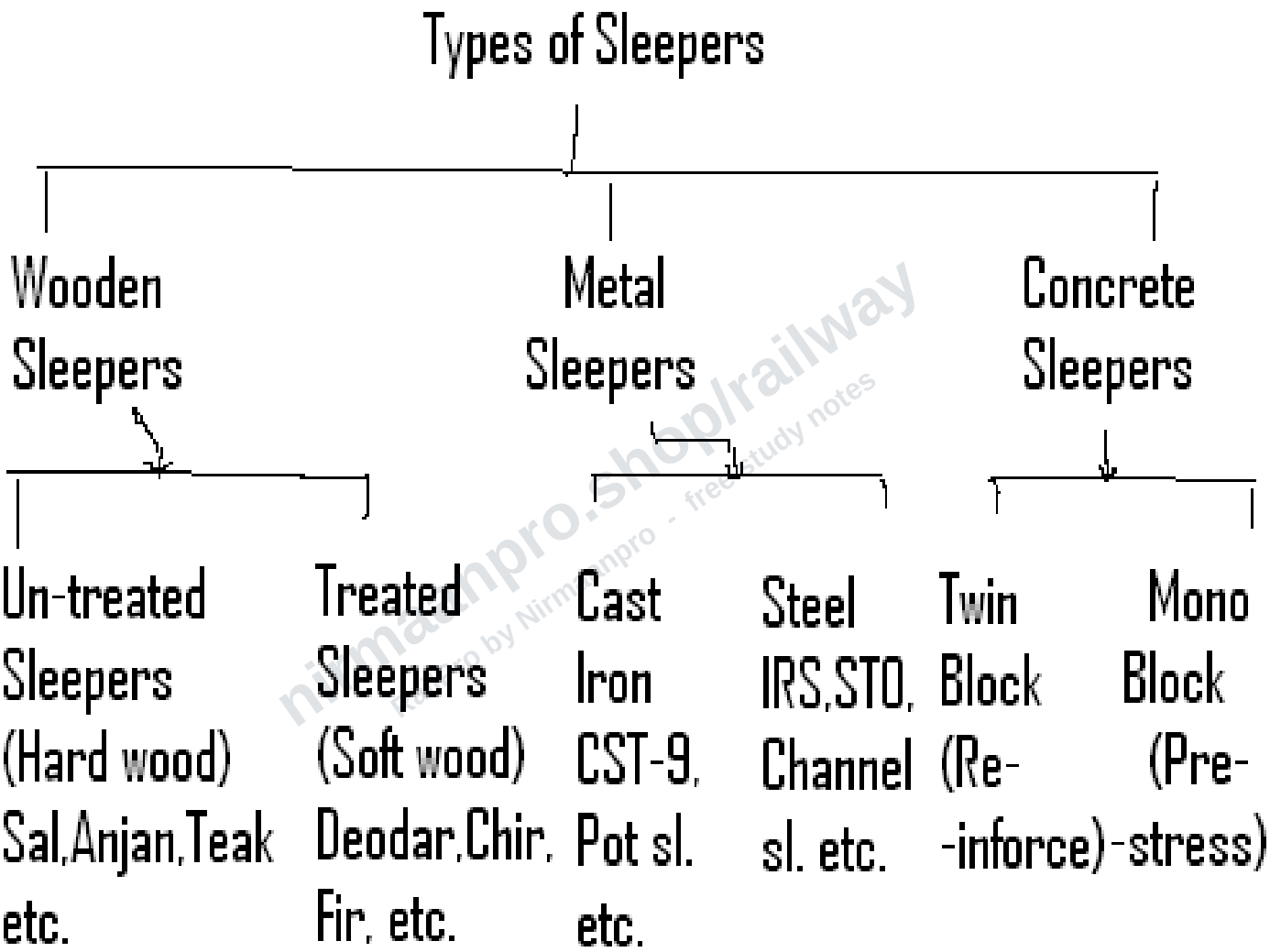
- Sleepers are members generally laid transverse to the rails on which the rails are supported and fixed, to transfer the loads from rails to the ballast and sub grade below.

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Main Functions of Sleepers

- To hold Rails in tight condition
- To maintain correct gauge & alignment
- To retain packing underneath the sleepers
- To provide firm and even support to rails
- To transfer the load from rails to the wider area of ballast
- To act as elastic medium between rails & ballast
- Providing longitudinal and lateral stability.

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CLASSIFICATION OF SLEEPERs

Sleepers can be classified according to the materials used in their construction-

1. Wooden sleepers
2. Metal sleepers
   - C S T – 9 sleepers
   - Steel trough sleepers
3. Concrete sleepers
   - Reinforced concrete sleepers
   - Pre-stressed concrete sleepers

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Wooden sleepers





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Wooden sleeper (OLD & NOW BANNED)



Wooden sleeper

Advantages of Wooden sleepers

Timber are easily available

- Fittings for wooden sleeper are few and simple in design.
- These sleepers are easy to lay, relay, pack, lift and maintain.
- These are best for





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Disadvantages of Wooden sleepers

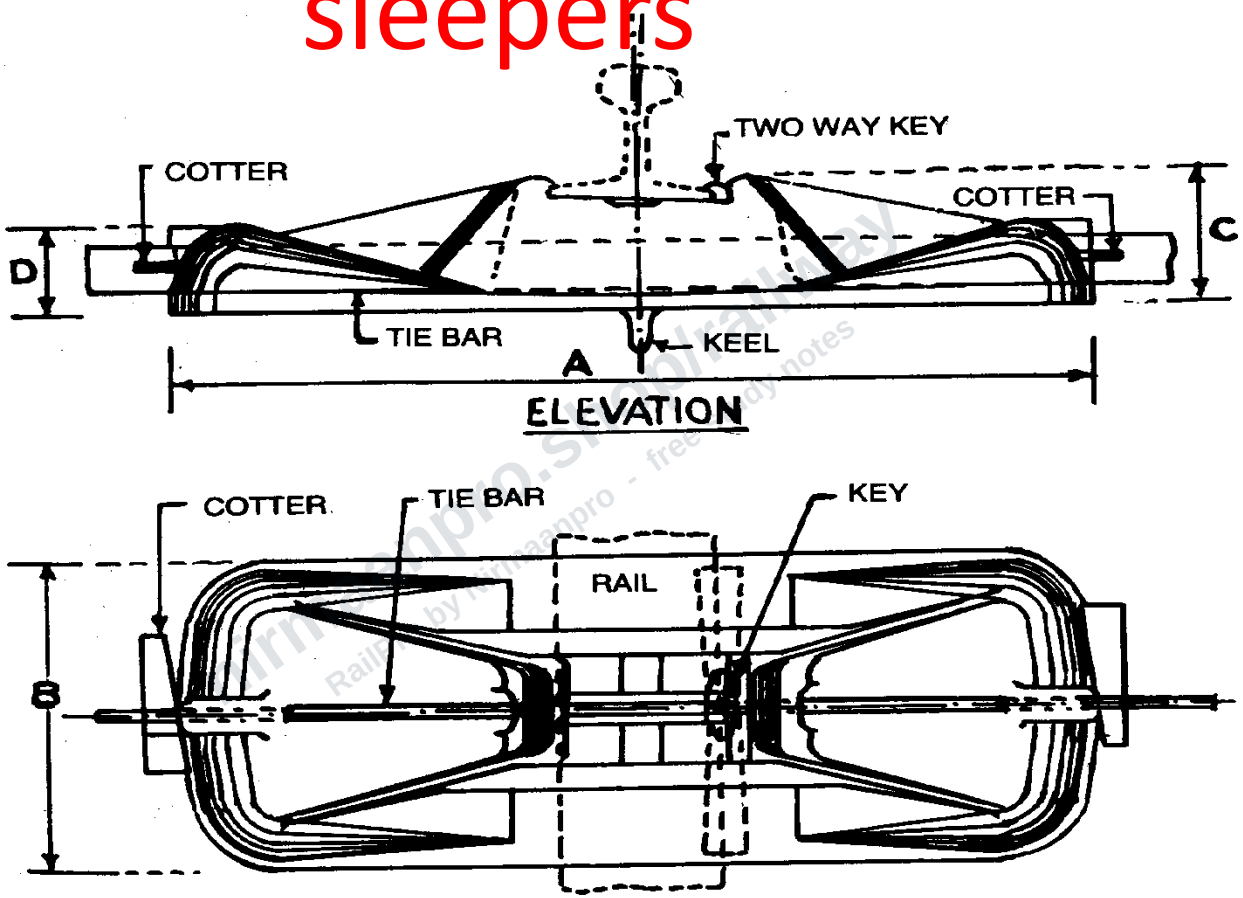




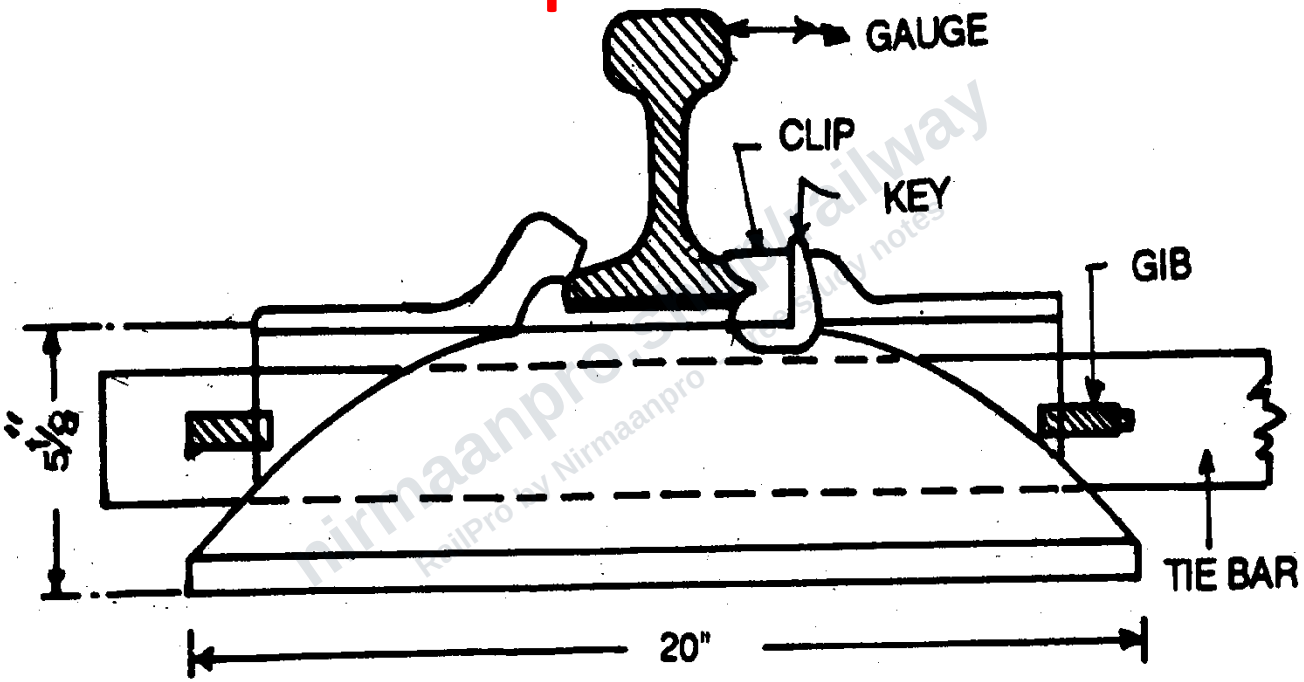
- These sleeper are subjected to wear, decay, attack by ants, spike killing etc .
- It is difficult to maintain gauge in wooden sleeper.
- Track can be easily disturbed.
- These sleeper have minimum service life around 12 to 15 years only
- Maintenance cost of wooden sleeper is very high

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C S T – 9 sleepers

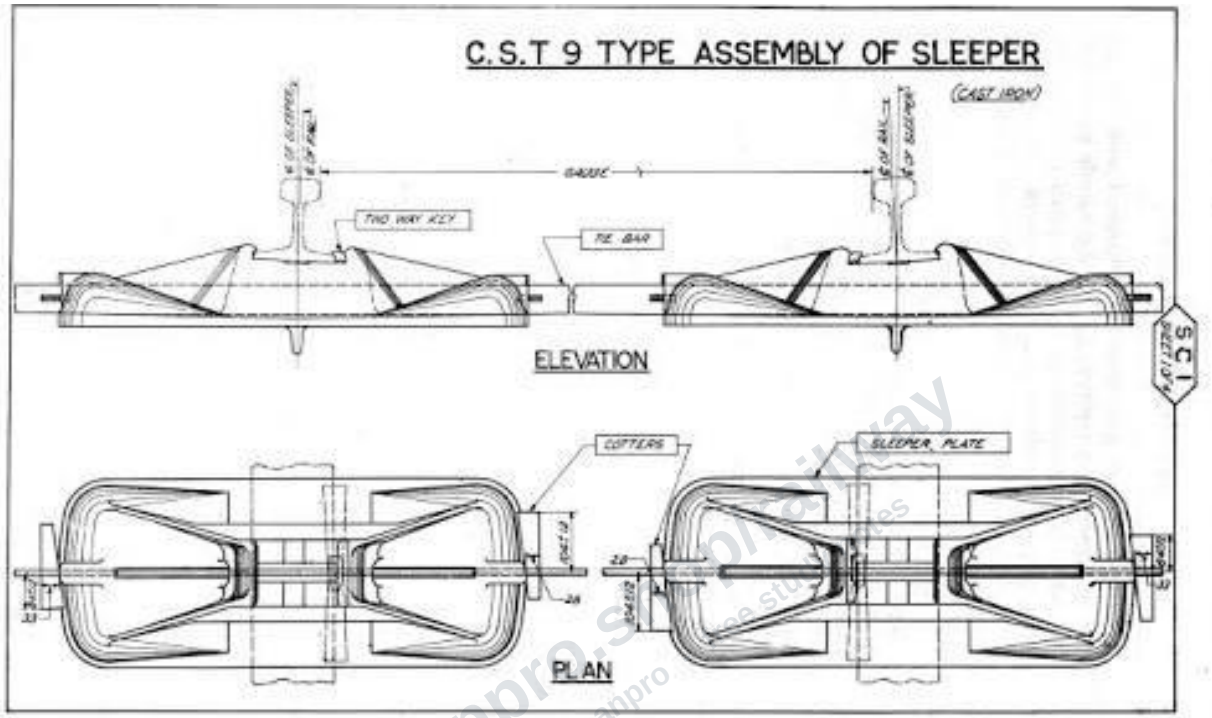


C S T – 9
sleepers



C.I. Pot Sleeper

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C.S.T 9 TYPE ASSEMBLY OF SLEEPER
(CAST IRON)
GAUGE
TWO WAY KEY
TIE BAR
ELEVATION
SCI
SECTION
COTTERS
SLEEPER PLATE
PLAN



C.S.T. – 9 or Central Standard - 9 sleeper -

These sleeper was standardized by Track Standard Committee.

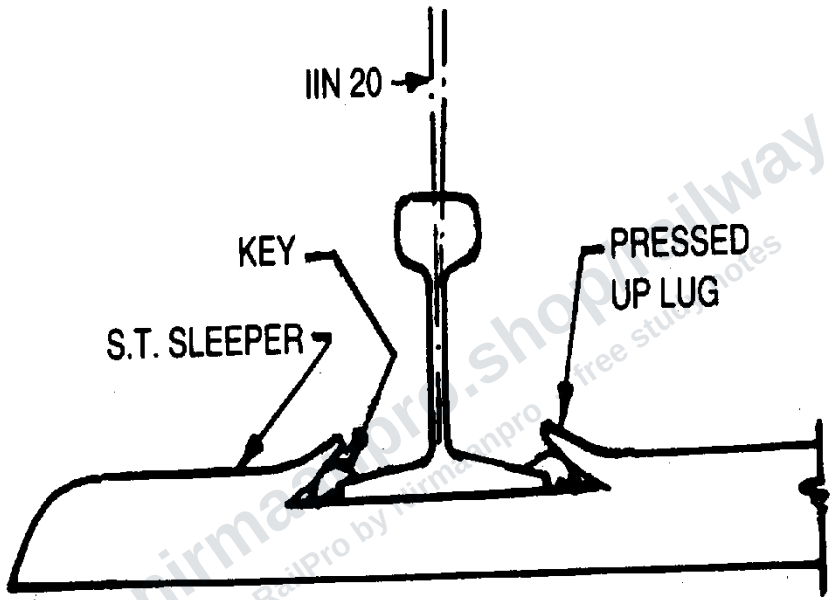
It has been extensively used on Indian Railway for last 30 years.

It has a triangular inverted pot on either side of the rail seat , a plate with the projecting rib and a box on the top of the plate. These sleeper for B.G. weighs 103 kg.

This sleeper can be easily assembled or dismantled without mechanical equipment.

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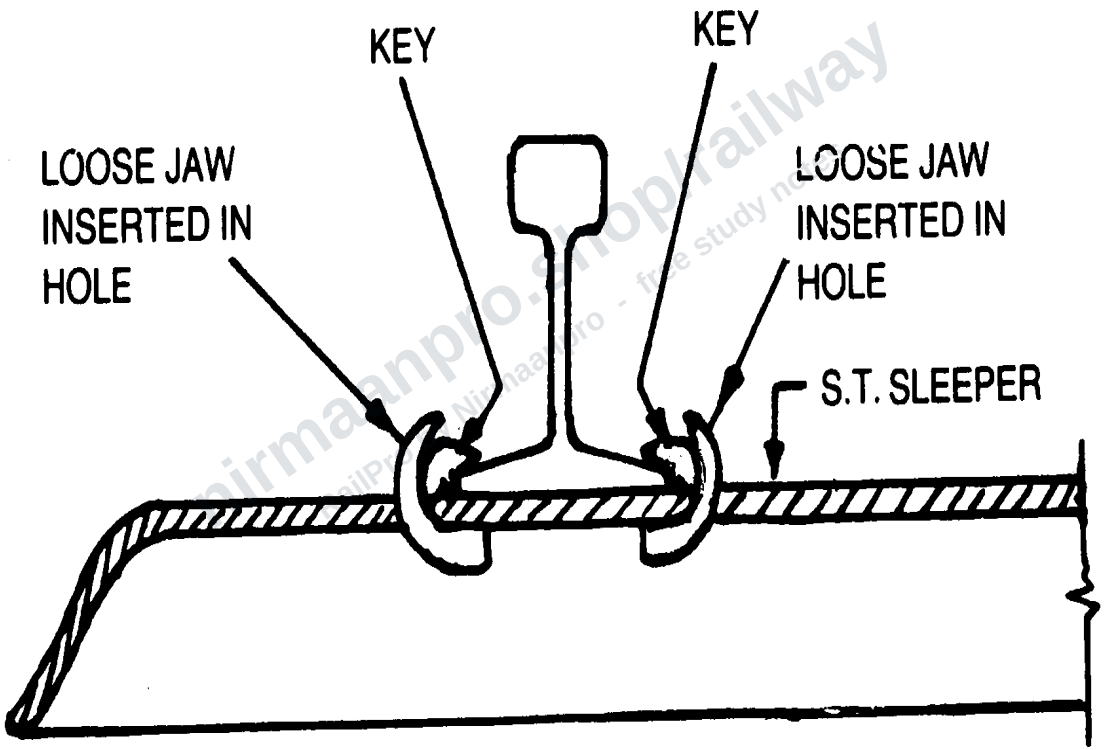
Steel trough sleepers



S.T.sleeper with pressed up lugs

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Steel trough sleepers



S.T.sleeper with loose jaws inserted inholes

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Steel sleepers :-



- These sleeper should maintain perfect gauge.
- It should be possible to fix rails easily in sleeper and without moving the sleeper longitudinally.
- The rail should have sufficient bearing area on the sleeper.
- The metal of sleeper should be strong enough as beam.
- They should be sufficiently heavy for stability.
- It can’t be used in the track circuited area.

Advantages of metal sleepers :-

- Metal sleepers are uniform in strength and durability.
- Metal sleepers are economical as life is longer and maintenance is easier.
- Gauge can be easily adjusted.
- Metal sleepers have good scrape value, easy in manufacturing and not susceptible to fire hazards.

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Disadvantages of metal sleepers

More ballast require than other type of sleepers.

- Fittings required are greater in number, and difficult to maintain and inspection.
- Metal, C. I., or steel are liable to rusting or corrosion.
- These sleepers cannot be used in track circuited areas .

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Obsolete Sleepers: Steel Trough Sleepers, Pot Sleepers

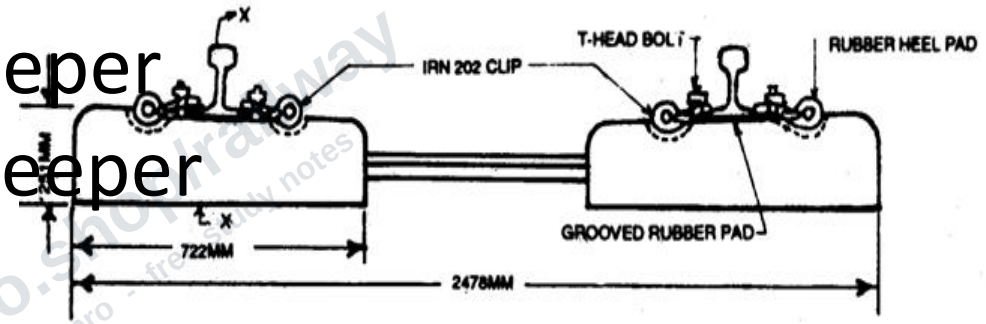
Current Sleepers : Steel Channel Sleepers, PSC sleepers, Fan Shaped T/O Sleepers



Types of concrete sleepers:

Types of concrete sleepers: 2 types

1.RCC twin block sleeper
2.PSC mono block sleeper



a) RCC twin block sleeper:

It has two blocks with inserts and connected by angle. This angle will get damaged due to hanging part of moving train if any, will get corroded quickly and also posses less stability. Hence the sleeper is not used nowadays

Types of concrete sleepers:

b) PSC mono block sleeper Design considerations:

In case of RCC the dimension of sleeper will be large. And hence prestressed con-crete is used.
It is designed for a load of 15 tonnes at each rail seat based on statical load 15 tonnes for BG and 11 tonnes for MG.
The cross section of sleeper as minimum as compared to cross section at rail seat and end face of sleeper.
The sleeper is designed for M55 grade of concrete. High tensile steel wires (H.T.S) 3x3 mm

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Concrete Sleepers - Advantages

- Freedom of design and construction
- Long service life & durability
- With elastic fastening system
  - *Maintains good track geometry for better Safety*
- Higher weight for
  - *Good longitudinal & lateral resistance*
  - *Better longitudinal & lateral stability for **LWR***
- Anti theft & Anti-sabotage
- Flat bottom – Best suited for mechanized maintenance

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Concrete Sleepers - Advantages

- Greater stability.
- Track Geometry maintained for much long duration hence economical.
- No damage by fire/corrosion.
- No possibility of theft.
- No chances of gauge widening.
- Best suited for LWR/CWR track.
- 60 Kg Sleeper can be used for 52 Kg rail.
- Best performance on P & C, S.E.J. Guard rails , Level Crossings, Check rail in curve.

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Concrete Sleepers - Disadvantages

- Less elastic then wood
- Dynamic loads and ballast stresses up-to 25% higher
- Manufacture/Transport/Laying/handling & maintenance
  - *Requires superior technology*
  - *Heavy initial investment to set-up plant*
- Not amenable to manual laying or maintenance
- Not universal – *(different type of sleepers needed)*
- Excessive damage from impact *(accidents/derailment/handling etc.)*
- Difficult to dispose
- Little scrap value etc.

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COMPARISON OF DIFFFERENT TYPES OF SLEEPERS

SN	Item	Wooden	Steel	Cast iron	Concrete
1	Weight	Moderate	Light	Moderate	Heavy
2	Service life	12-15 years	40-50 years	40-50 years	50-60 years
3	Handling	Easy , not liable to break	Easy , not liable to break	Easy, liable to break during handling	Heavy, requires mechanical means
4	Track circuit	Best	Not suitable	Not suitable	Suitable
5	Scrap value	Low	High	High	Nil
6	Maintenance cost	High	Medium	Medium	Low
7	Damage in service	May be damaged by fire or attack by white ants, termites	Susceptible to corrosion in service	Susceptible to corrosion in service	No damage by white ants or corrosion
8	Suitability	Suitable for all routes at all locations	Suitable for all routes, cannot be used in specific locations	Not suitable for high speed routes and specific locations like, GB, LC , turnouts etc	Best for high-speed routes. Cannot be used for GB

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COMPOSITE SLEEPERS

Now a day's it's difficult to use wooden sleepers over the girder bridges due to

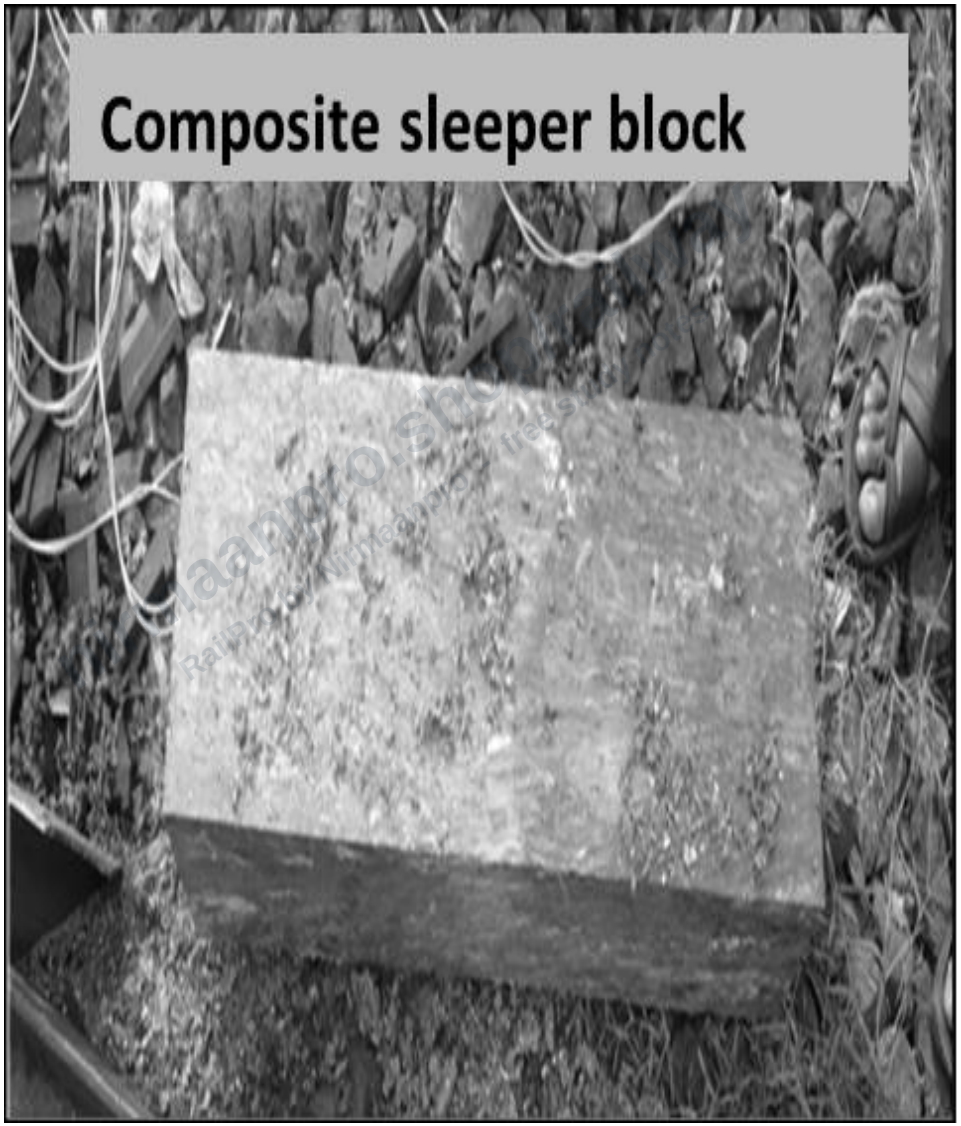
- More Cost
- Scarcity (environmental affecting issue)
- Less life

- More maintenance cost

So we have moved to an alternative resource as steel channel sleeper. It also has certain draw backs like corrosion, loose rivets are exist with so now migration towards the composite sleeper

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COMPOSITE SLEEPER BLOCK



Composite material

A composite material is a material formed using two or more discretely identified materials (e.g. a polymer binder with reinforcement in polymer composites) to obtain specific properties that are superior to the individual material.

In general, composite sleeper is a material system that incorporates reinforcement (e.g. glass fibres) and / or other property modifiers in a polymer matrix. Based on reinforcement and

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Composite sleeper block on shallow type girder .





Types of composite sleeper-

- **a) Fibre reinforced polymer composite**- polymer reinforced with fibrous glass or other fibres, including polymeric fibres. Fillers and other modifiers may also be added to enhance particular physical or mechanical properties.
- **b)Particle reinforced polymer composite**- polymer modified with dispersed small particles to enhance particulars physical and / or mechanical properties.
- **c)Hybrid composite** – a composite that incorporates two different reinforcement fibres or other structural components (e.g. a concrete steel and polymer combination).

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Requirement for a composite sleeper

- It should hold the rail with bearing plates by means of rail screw without any additional procedure to do so
- It should withstand a maximum dynamic load of 25 T and also to observe the vibration during dynamic load over the sleeper (passing of vehicle).
- It should not fail due to weather conditions such as heat/cold over the four temperature zones
- Material surface degradation due to solar ultraviolet (UV) radiation exposure shall not exceed 0.076 mm per year

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Requirement for a composite sleeper

- It would be preferable if the sleeper is grey or black in colour but shall not be red in colour.
- No visible voids on the surface of the sleeper
- Sleeper shall be fire resistant in prevailing Indian condition and shall be suitable for use in track circuited area.
- The sleeper shall be durable, so as to retain necessary strength and other structural properties during service in track.
- The sleeper shall be resistant to rot, bacteria and insects such as termites, borers etc which may reduce strength and/or integrity of sleeper.

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CONCRETE SLEEPERS



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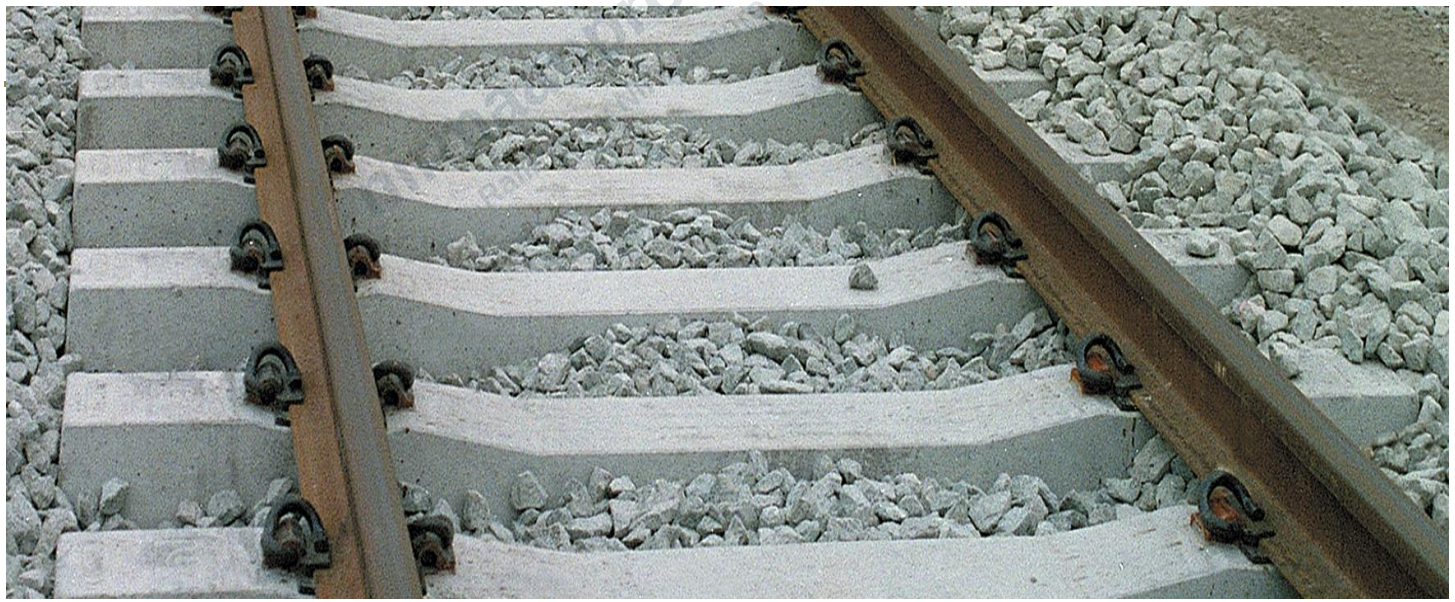
Identification of Sleepers

- Concrete sleepers can be identified by the drawing no. and code of sleeper manufacturer with year of manufacture engraved on the top end surface of sleepers.
- Permanent Way staff should take care to see that they are not obliterated during maintenance.
- All the PSC sleepers are tested for electrical resistance at the time of manufacture, and sleepers are marked by paint with “FTC” to indicate Fit for Track Circuiting and “NFTC” to indicate not fit for track Circuited location.

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Types of Concrete Sleepers

- Mono-block sleeper
  - *Enables rigid track frame, and has high flexural stiffness*
  - *Prevents rotation and buckling, and higher resistance for long. movement*



Types of Concrete Sleepers

i) Mono-Block Prestressed Concrete Sleepers.
   a) PSC – 12 for 52 Kg Rails.
   b) PSC – 14 for 60 Kg Rails.

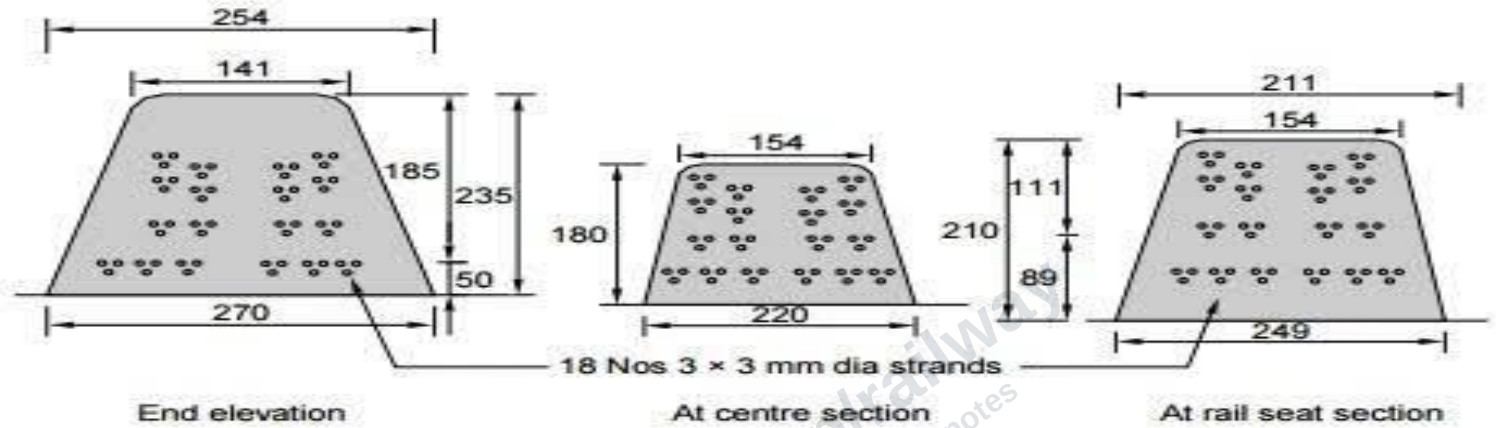
ii) Fan shape Turnout concrete sleepers.

iii) Special sleepers for Level crossing, turnout, SEJ, BR. Approach, curve

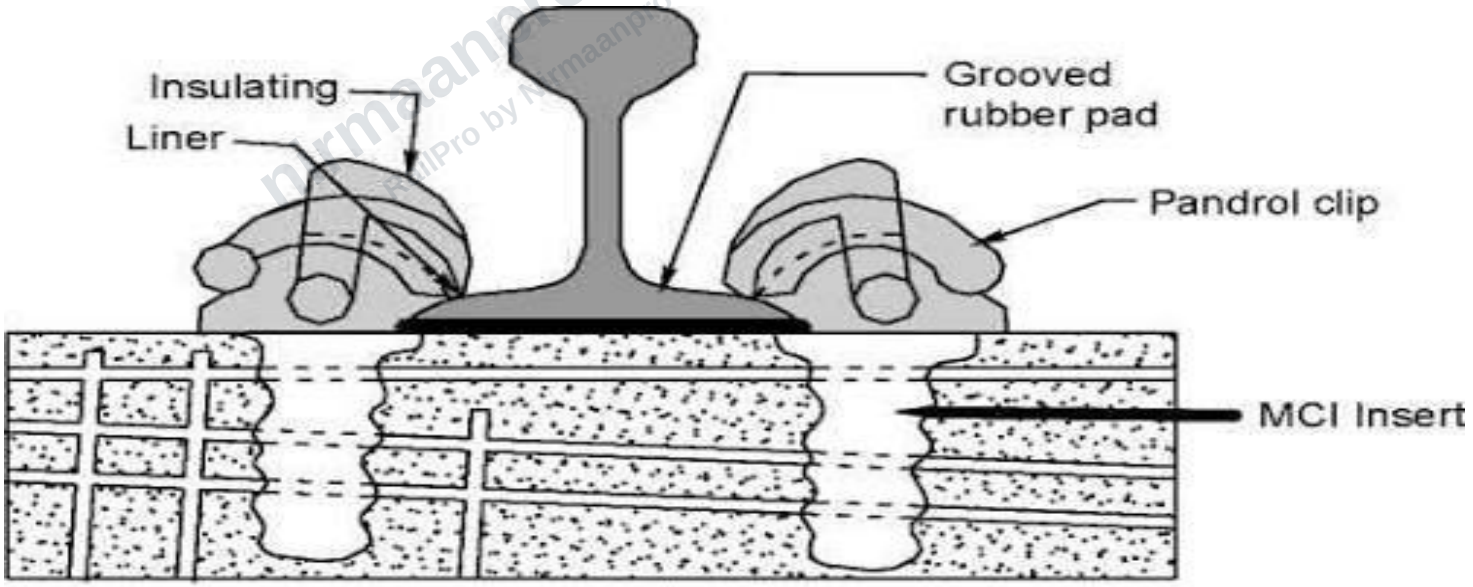
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Concrete sleepers



Dimensions of Pre Stressed Concrete sleeper



Typical cross section of Rail Seat Area

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Concrete Sleepers :-



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Concrete sleepers are made of a strong homogeneous material, impervious to affect moisture and is unaffected by the chemical attack of atmospheric gases or sub soil salts.

concrete sleepers:

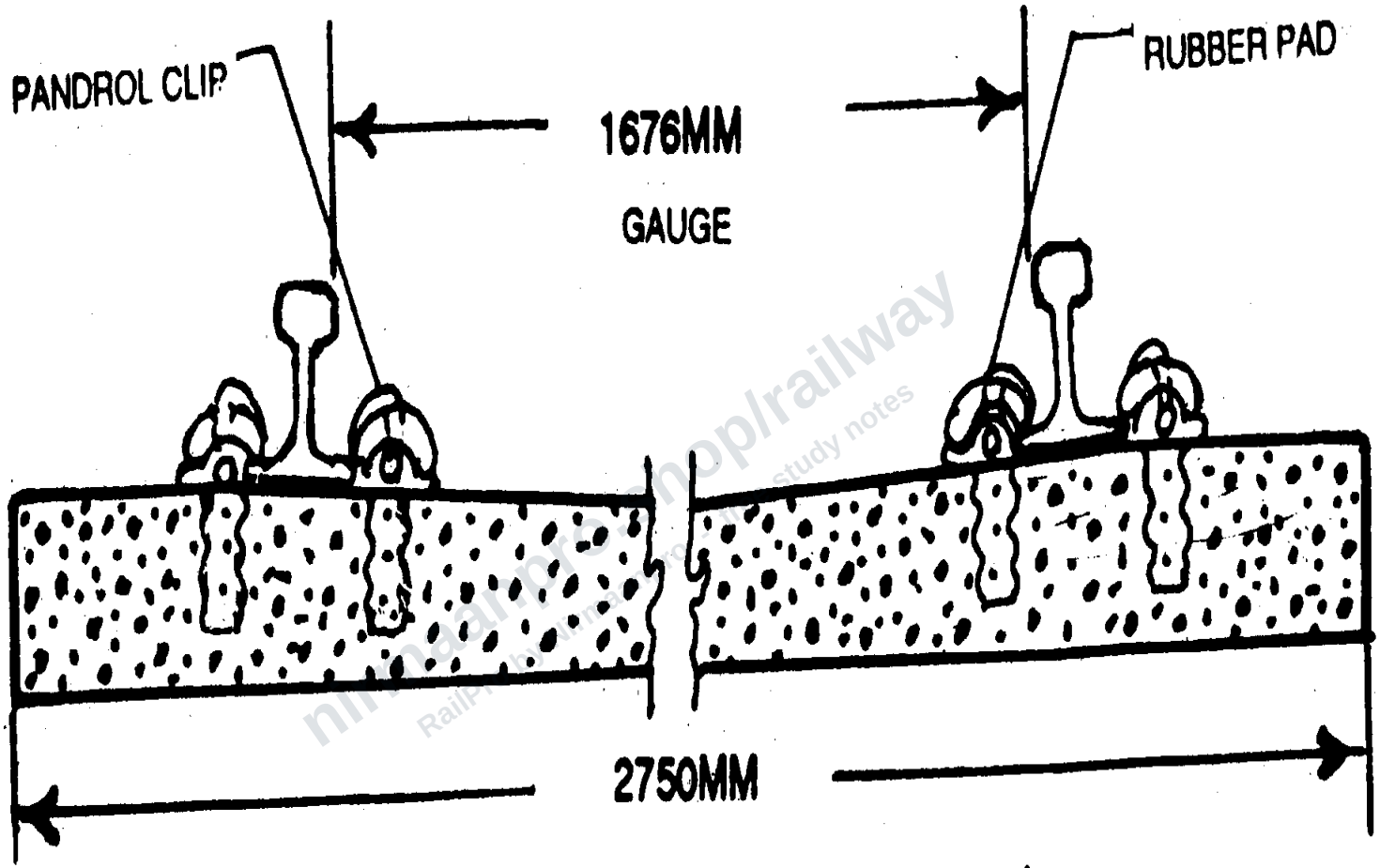
PSC mono block sleeper Design considerations:

In case of RCC the dimension of sleeper will be large. And hence prestressed con-crete is used. It is designed for a load of 15tonnes at each rail seat based on statical load 15 tonnes for BG and 11tonnes for MG.

The cross section of sleeper as minimum as compared to cross section at rail seat and end face of sleeper.

The sleeper is designed for M55 grade of concrete. High tensile steel wires (H.T.S) 3x3 mm ply

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Mono Block pre-stressed concrete sleeper

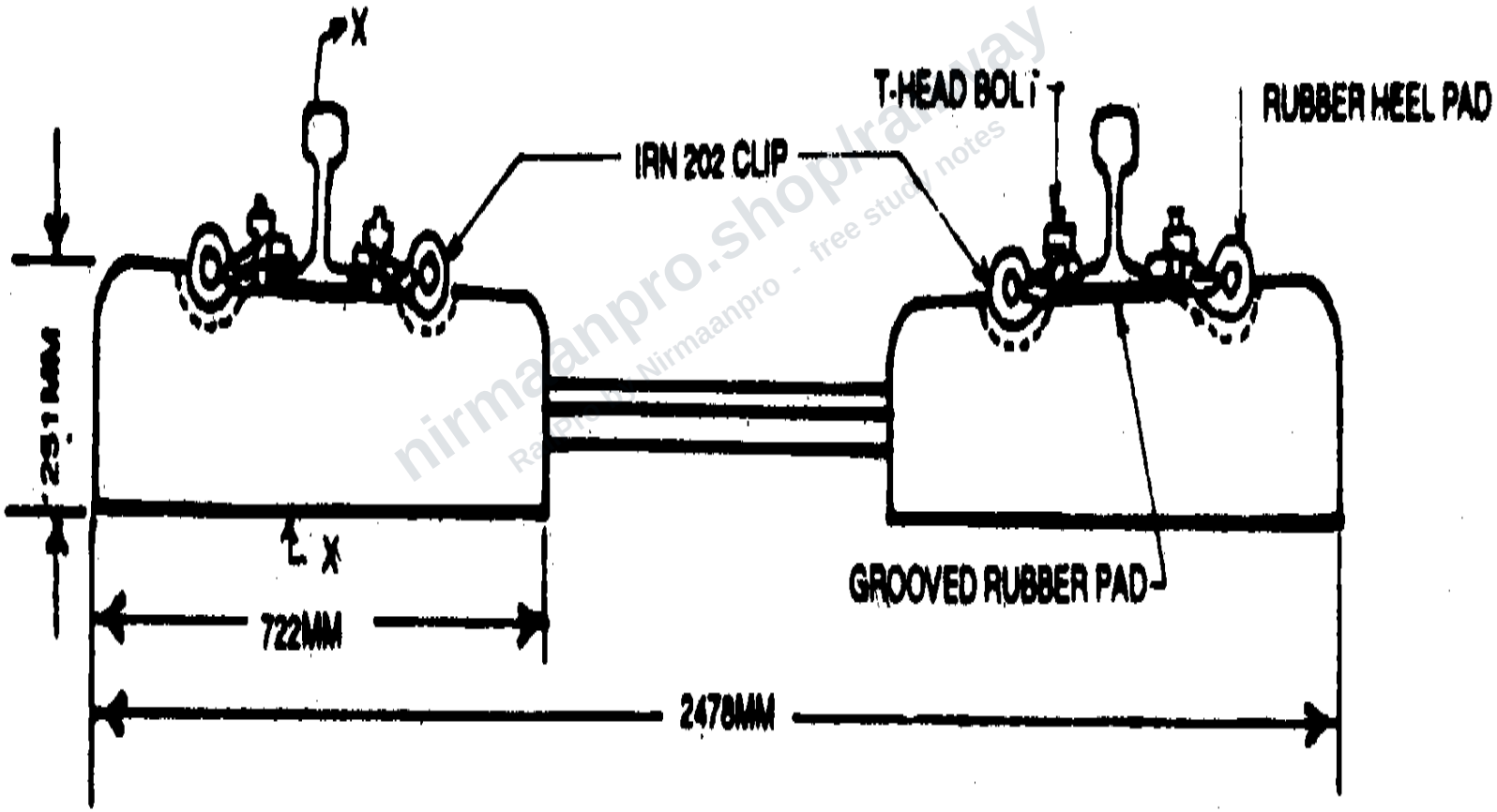
Types of Concrete Sleepers

- Twin-block sleeper
  - *Well defined bearing surface, and High lateral resistance etc.*
  - *Handling and maintenance issues*



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Twin block concrete sleeper



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Main features of PSC-12/PSC-14 Sleepers

- Length :- 2750 mm.
- Weight :- 286 Kg. (approx)
- Reinforcement :- 18 nos. 3 mm dia. HTS stands.
- Distance between Insert at rail seat :- 148mm/162mm.
- Service Life :- 50-60 years.
- Indian Railway uses the Mono-block Pre-stressed concrete sleepers predominantly. The PSC sleepers are manufactured to conform to RDSO specification No IRS: T-39 (Plain Track) and IRS: T-45 (Turnout sleepers).

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Conditions for laying Concrete Sleep

i)Track should be deep screened.

ii)Cuttings having rocky bed should have clean ballast cushion of at least 250mm.

iii)On Arch bridges formation cover minimum 1 m.

iv)On other bridges ballast cushion not less than 300 mm.

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Conditions for laying Concrete Sleepers:

v) Sleepers shall be laid square to rails on straight and radially on curve.

vi) The sleeper spacing should be marked on outer rail in case of curved track.

vii) Closer spacing should be provided at joint sleepers of fish plated joints and between joint sleeper and shoulder sleeper.

viii) Rail joints should be suspended.

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Drawings of various types of concrete sleepers

SN	Component	DRG. No	DESCRIPTION
01	Ordinary PSC sleepers	T-2495	Prestressed Concrete Sleeper for 52 kg Rail designed for 22.9 t Axle load
02		T-2496	Prestressed Concrete Sleeper for 60kg / 52 kg Rail designed for 22.9 t Axle load
03		T-8527	Prestressed Concrete Sleeper for 60kg /136 RE Rail designed for 25.0 t Axle load
04	Slack Gauge Sleeper	RT-4183-4186	PSC Sleeper for Curve with Check Rail for 60Kg Rail
05		RT-8621-8624	PSC Sleeper for Curve with Check Rail for 136RE / 60 Kg rail for 25T Axle load
06		RT-5738 – 5740	PSC Sleeper for Curve with Check Rail for 52Kg Rail
07	Sleeper for Guard rail & Bridge approaches	RT-4088-4097	PSC Sleeper for Bridge and approach
08		RT-8672-8680	PSC Sleeper for Bridge and approach for 25T axle load

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09	Sleeper for LC	RT-4148/4148A kg	PSC sleeper for LC for 60/52 kg running rail & 52 check rail
10		RT-8671 (25t)	PSC sleeper for LC for 25T axle load
11	Sleeper for SEJ	RT-4149	PSC sleeper for SEJ
12		RT-6253 60kg	PSC sleeper for SEJ (with 300 mm max: gap) (UIC) rail on bridge approaches.
13	Sleeper for P&C	RT- 4865	Sleeper Set for 1 in 8 ½ Fan shaped layout
14		RT- 4218	Sleeper Set for 1 in 12 Fan shaped layout
15		RT- 6068	Sleeper Set for Derailing switch
16	Shallow Depth Sleeper	(RT-4852)	PSC shallow sleeper (160 mm) deep
17		RT-8326	PSC shallow sleeper with Guard Rail
18	Sleeper for Re-Railing Ramp	RT-6420-6440	PSC Sleeper for Re-Railing Ramp On 52 Kg Running Rail
19		RT-8265-8291	PSC Sleeper for Re-Railing Ramp On 60 Kg Running Rail
20	Nylon Cord Reinforced GRSP	RT-7014 to 7021	6mm thick nylon cord reinforced GRSP for placing beneath crossing portion in 1 in 12 turnouts on

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DIFFERENT PSC SLEEPERS (DRAWING NO.)

ORDINARY TRACK SLEEPER

- **RDSO/ T-2495 - (52kg)**
- **RDSO/ T-2496 - (60 kg)**

(Concrete Grade - *M–40)*



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RDSO Drawings

- RDSO/ T-2495 (52kg), T-2496 (60 kg)
- Designed for 22.5 t axle load
- Declared fit for 25 t axle load upto limited speed
- A new design for 25 t axle load (for DFC) has been developed by RDSO
  - **Approved as RDSO T-7008**
  - **M – 60 concrete**

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DIFFERENT PSC SLEEPERS (DRAWING NO.)

SPECIAL SLEEPER

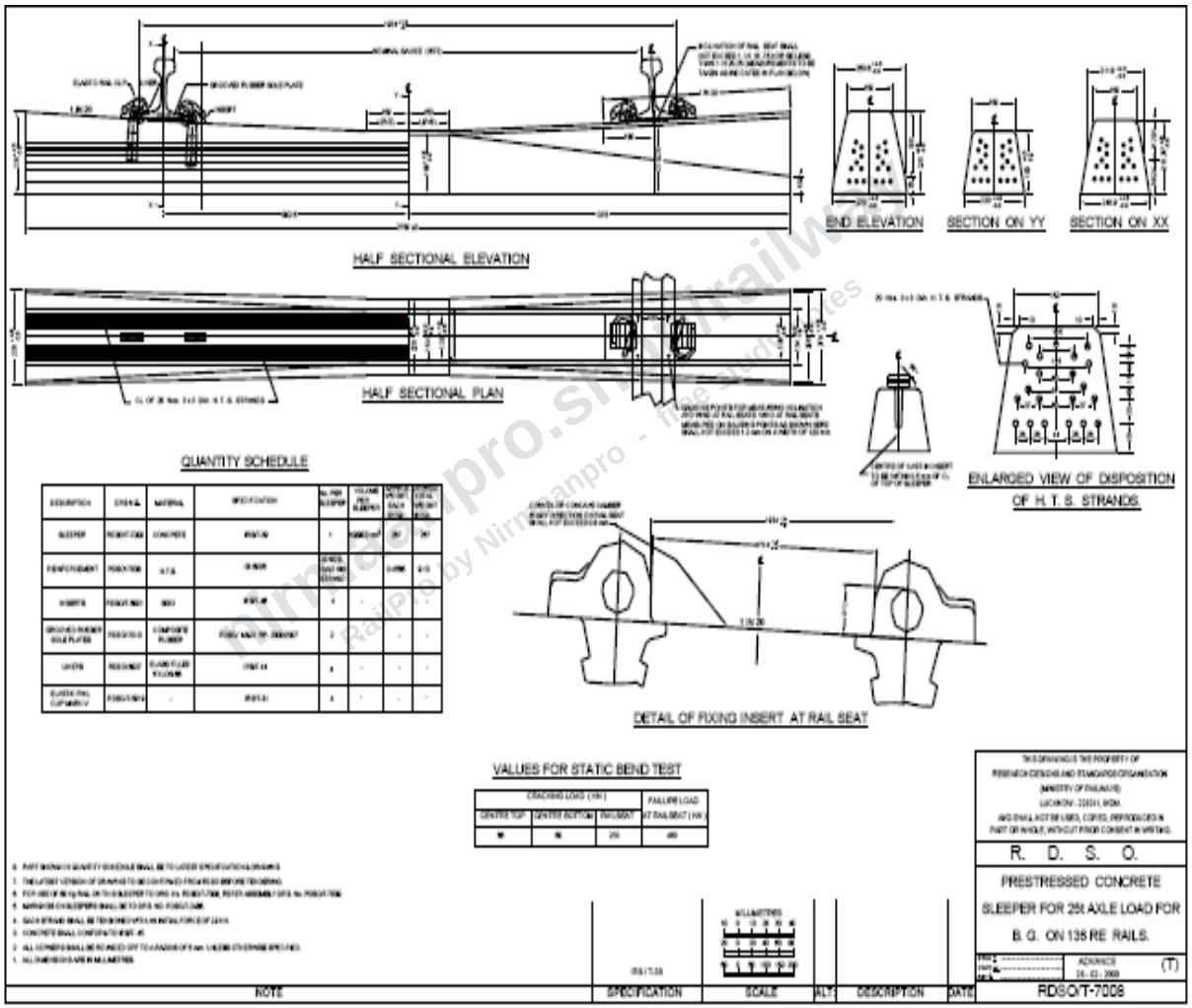
- **Shallow Prestressed Concrete Sleeper- RDSO / T-8326**

  (Height at Rail Seat is 160mm)
- **Special Sleeper For 25t Axel Load and DFC Routes - RDSO T-7008 (M – 60 concrete)**
- **Wider Sleeper For 25t Axel Load and DFC Routes RDSO / T – 8527**

  (Width at Rail Seat is 280mm)

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25 t PSC Sleeper



Special PSC Sleepers

- **Shallow Sleeper (RDSO/T-4852 Alt.-2)**
  - For restricted headroom (under ROB/FOB) in electrified area
  - Width increased and height reduced to accommodate HTS strands
  - Height at rail seat is 160 mm against 210 mm
  - Lower FoS than normal line sleeper
- **Level Crossing Sleeper (RDSO/T-4148-4148A)**
  - Steel bracket with plate screws for check rail
- **SEJ Sleeper (RDSO/T-4149)/T-6253**
- **Ballasted Deck Bridges Sleeper (RDSO/T-4088- 4097)**
  - Top surface in central portion made level *(8 Sleeper set in flared portion)*
  - GRSP under guard rail, ***to maintain rail level dowels at ends for MS Strip***

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Different PSC sleepers For Level crossing (DRAWING NO.)

- **52/60 kg Rail** - RDSO/T-4148 & T-4148A

- **60 kg Rail** - RDSO/T-8225
  (25t Axel Load) *(With 52 kg check rail)*

- **60 kg Rail** - RDSO/T-8671
  (Wider Sleeper for 25t Axel Load) *(With 52 kg check rail)*

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Different PSC sleepers (DRAWING NO.)

SEJ SLEEPER

52/60 kg Rail - RDSO / T - 4149



Different PSC sleepers



BRIDGE APPROACH

52/60 kg Running Rail

T - 4088 (With MS Plate)

RDSO / (For 90R/52 kg/60 kg Guard Rail)

T- 4089 से 4097

RDSO / (For Flare of 90R/52 kg/60 kg Guard Rail)

For 25t Axel Load

RDSO / T- 8228 (With MS Plate)

(For 60 kg Guard Rail)

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DIFFERENT PSC SLEEPERS (DRAWING NO.)

TURNOUT SLEEPER

- **PSC Sleepers for Turn out**

Kg rail 1 in 8 ½ & 1 in 12 for 52 & 60

1 in 16 & 1 in 20 for 60 Kg rail

1 in 8 ½ Diamond and Scissors Cross-over with/without slip

Derailing Switch for 60 Kg rail

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Special PSC Sleepers

- **PSC Sleepers for Turn out**
  - **1 in 8 ½ and 1 in 12 for *52 and 60 Kg/m* rail**
  - **1 in 16 and 1 in 20 for *60 Kg/m* rail**
  - **1 in 8 ½ Diamond and Scissors Cross-over with/without slip**
  - **Derailing Switch for *60 Kg/m* rail**

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Fan shaped PSC Sleepers Turnouts on BG (60/52 Kg)

(with Curved Switches and CMS Crossings)

Rail Section	Drawing No.	S E A	Switch Drg.	Crossing Drg.
52 Kg	1 in 8.5 RT-4865	0°- 46’ - 59”	RT-4866	RT-4867
60 Kg	1 in 8.5 RT-4865	0°- 46’ - 59”	RT-4966	RT-4967
60 Kg (Thick Web)	1 in 8.5 RT-6279 (Zu-1-60)	0°- 46’ - 59”	RT-6280	RT-4967
52 Kg	1 in 12 RT-4732	0°-20´-00"	RT-4733	RT-4734
52 Kg (CR-100)	1 in 12 RT-5168	0°-20´-00"	RT-5169	RT-4734
52Kg (Thick web)	1 in 12 RT-5268 (Zu-2-49)	0°-20´-00"	RT-5269	RT-4734

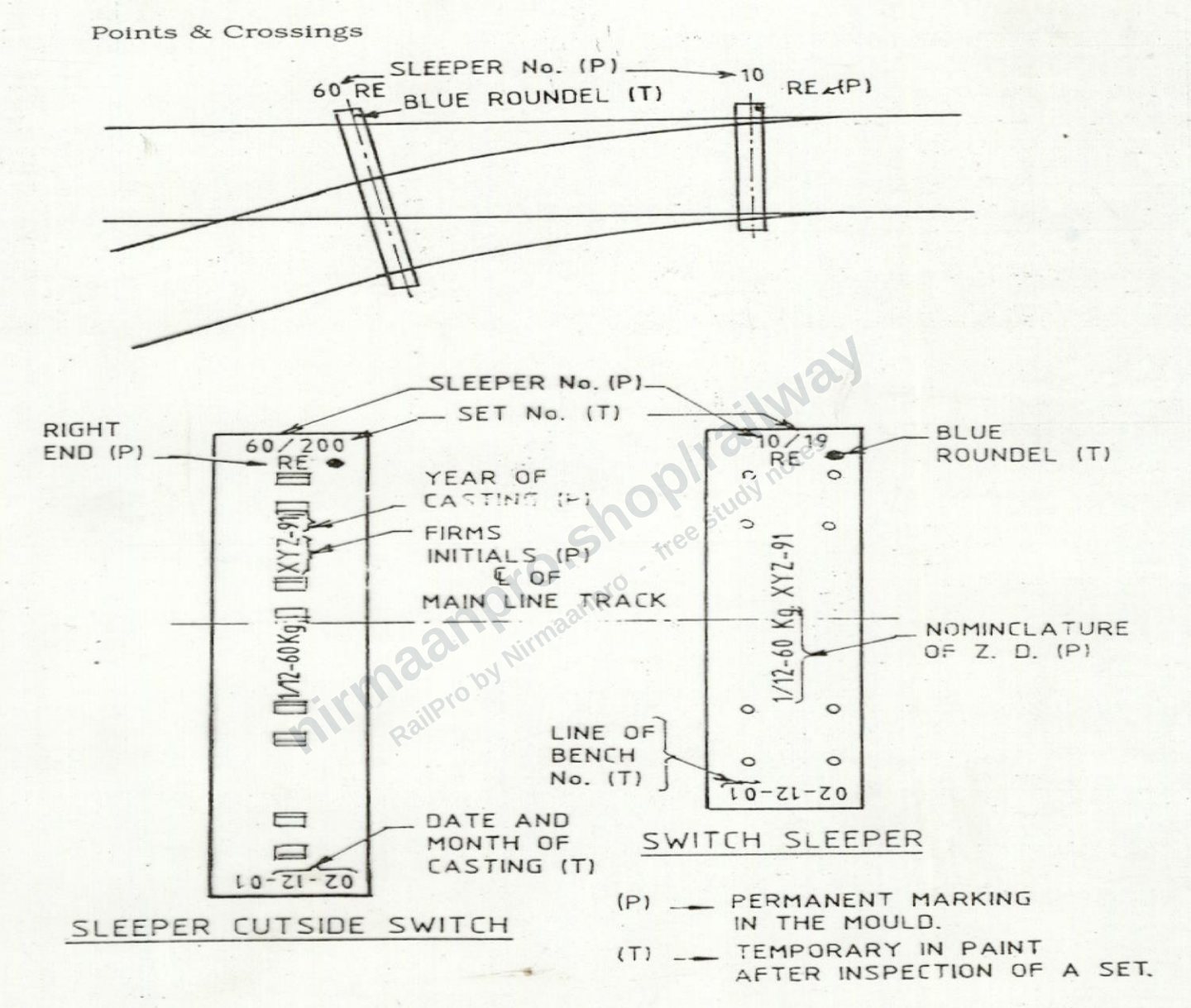
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Fan shaped PSC Sleepers Turnouts on BG (60/52 Kg)

(with Curved Switches and CMS Crossings) (Contd...)

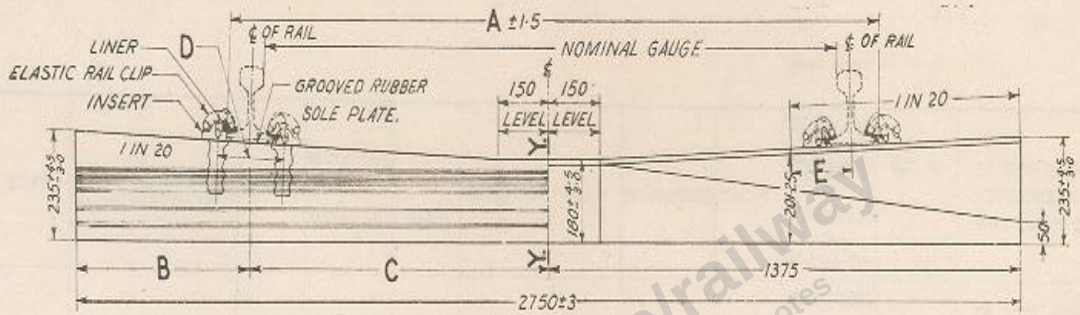
Rail Section	Drawing No.	S E A	Switch Drg.	Crossing Drg.
60Kg	1:12 RT-4218	0°-20´-00"	RT-4219	RT-4220
60Kg (Thick web)	1:12 RT-6154 (Zu-1-60)	0°-20´-00"	RT-6155	RT-4220
60Kg	1:16 RT-5691	0°-20´-00"	RT-5692	RT-5693
60Kg	1: 20 RT-5858	0°-20´-00"	RT-5859	RT-5860

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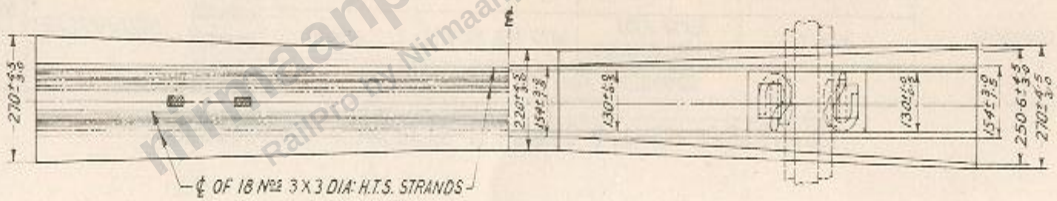


Markings on PSC Sleepers for Points and Crossings

PRESTRESSED CONCRETE SLEEPERS



HALF SECTIONAL ELEVATION



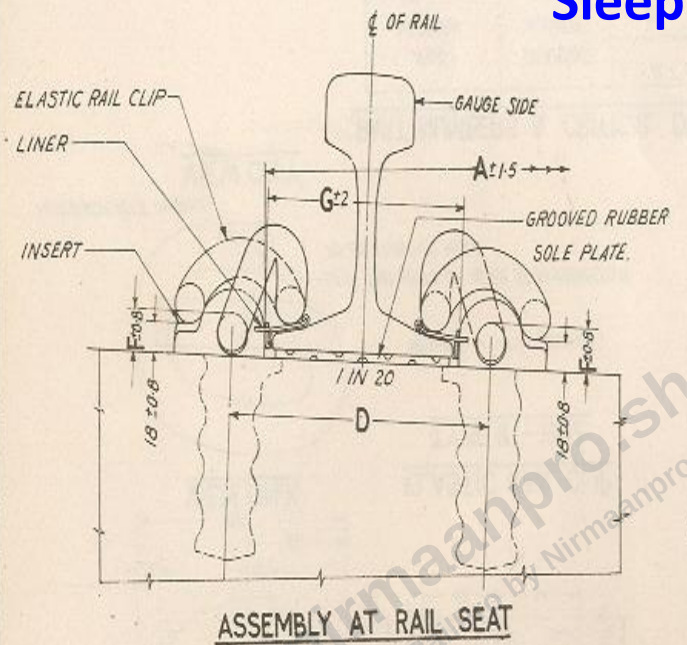
HALF SECTIONAL PLAN

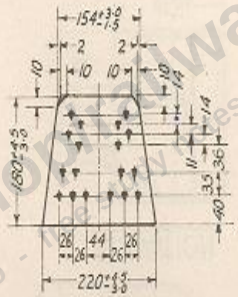
SPC 2
SHEET 1 OF 2

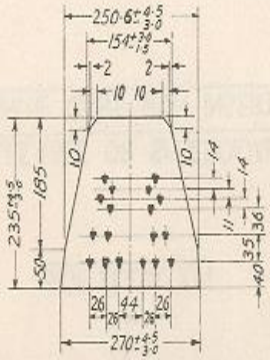
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Indian Railways Standard drawings for PRC Sleepers

Indian Railways Standard drawings for PRC Sleepers







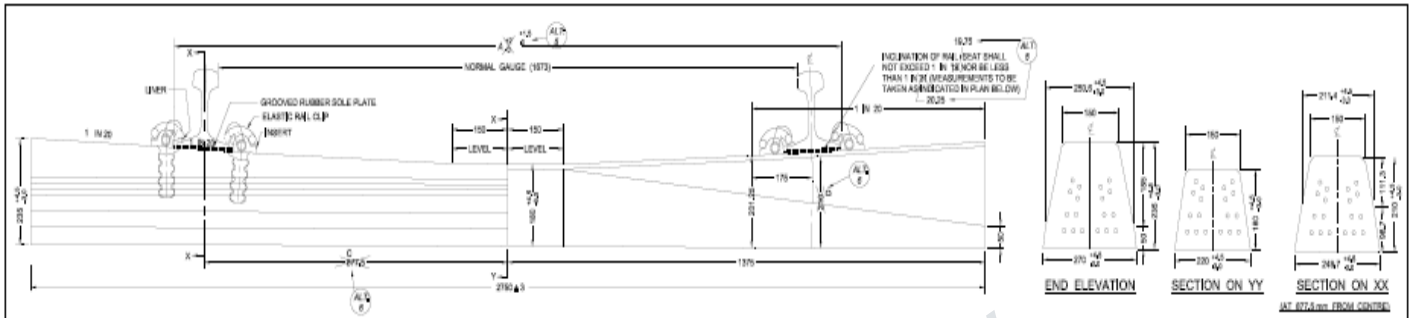
SPC 2 SHEET 2 OF 2

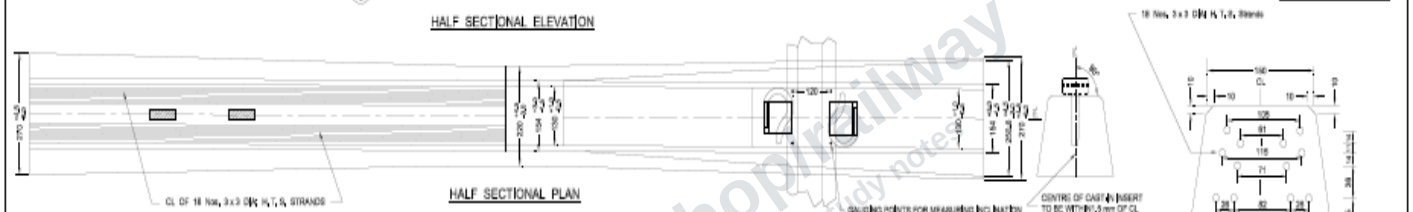
TABLE OF MAIN DIMENSIONS

RAIL SECTION	DRAWING NUMBER	TYPE OF SLEEPER	DIMENSIONS (mm) A	B	C	D	E	F	G	VOLUME OF CONCRETE PER SLEEPER (cm³)	WEIGHT PER SLEEPER EXCL: FASTENINGS (kg)
60 kg UIC	RDSO/T-2496	PCS-14	1922·5	494·5	880·5	211	178	25·75	163	108900	282
52 kg	RDSO/T-2495	PCS-12	1902·5	497·5	877·5	197	175	25	149	108900	282

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PSC Sleeper T-2495 & T-2496

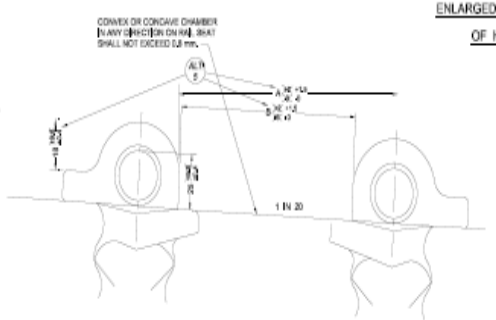




QUANTITY SCHEDULE

DESCRIPTION	RUNNING RAIL SECTION	DRG. NO.	MATERIAL	SPECIFICATION	NO. PER SLEEPER	VOLUME PER SLEEPER	WEIGHT EACH IN KG.	TOTAL WEIGHT IN KG.
SLEEPER	52 Kg.	RDSO/T-2495	CONCRETE	RSST-39	1	0.1089 CM³	267	267
	60 Kg (UIC)	RDSO/T-2496						
REINFORCEMENT	52 Kg.	RDSO/T-2495	H.T.S.	ALT-2 RDSO AMENDMENT No.3 JUNE 1999	18 Nos. 3 x 3 mm DIA STRANDS	1047 CM³	8.4869	8.217
	60 Kg (UIC)	RDSO/T-2496						
INSERT	52 Kg.	RDSO/T-381	MSE	RSST-32	4	-	1.97	8.08
	60 Kg (UIC)		SGCI	DRAFT RS SPECN. FOR SGCI RSST-33		-	1.28	5.20
ELASTIC RAIL CLIP MK III	52 Kg.	RDSO/T-3701	SI - MA SPRING STEEL	RS/T-31	4	-	-	-
	60 Kg (UIC)							
GROOVED RUBBER SOLE PLATE	52 Kg.	RDSO/T-3709	RUBBER	RS SPECN. FOR 8 mm THICK GROOVED RUBBER SOLE PLATE (PROVISIONAL - 1997)	2	-	-	-
	60 Kg (UIC)	RDSO/T-3711						
LINER	52 Kg.	RDSO/T-3702	GFN-60	RSST-34 RS SPECN. FOR GLASS FILLED NYLON 66 INSULATING LINER (PROV.)	4	-	-	-
	60 Kg (UIC)	RDSO/T-3705						
	52 Kg.	RDSO/T-3739	M.S.	RS SPECN. FOR METAL LINER FOR IS2062-75 USE WITH ELASTIC RAIL CLIP (PROV.-1999)				
	60 Kg (UIC)	RDSO/T-3740						

ALT-3



ENLARGED VIEW OF DISPOSITION OF H.T.S. STRANDS.

DETAIL FOR FIXING INSERT AT RAIL SEAT

TABLE OF DIMENSIONS

RUNNING RAIL SECTION	DRAWING NO.	MARKING ON SLEEPER	DIMENSIONS (mm) A	B	C	D
52 Kg.	RDSO/T-2495	RT-2495	1901.8	148	877.8	210
60 Kg. (UIC)	RDSO/T-2496	RT-2496	1921.5	152	880.5	210.15

ALT-5

1. FOR USE OF 52 Kg RAIL ON SLEEPER TO DRG. No. RDSO/T-2495, REFER ASSEMBLY DRG. No. RDSO/T-9751.
2. DRAWINGS TO RDSO/T-2495 ALT-2 & RDSO/T-2496 ALT-2 HAVE BEEN REVISED & REDRAWN AS RDSO/T-2495 & RDSO/T-2496 ALT-3.
3. PART SHOWN IN QUANTITY SCHEDULE SHALL BE TO LATEST SPECIFICATION & DRAWING.
4. THE LATEST VERSION OF DRAWING TO BE CONFIRMED FROM RDSO BEFORE TENDERING.
5. FOR NON-TRACK CIRCUITED LINES M.S. LINERS CAN BE USED IN LIEU OF GFN COMPOSITE INSULATING LINERS.
6. MARKINGS ON SLEEPERS SHALL BE TO DRG. NO. RDSO/T-2495.
7. EACH STRAND SHALL BE TENSIONED WITH AN INITIAL FORCE OF 27 KN.
8. CONCRETE SHALL CONFORM TO IRS:T-28.
9. ALL CORNERS SHALL BE ROUNDED OFF TO A RADIUS OF 5 mm UNLESS OTHERWISE SPECIFIED.
10. ALL DIMENSIONS ARE IN MILLIMETRE.

NOTE

IRS : T-39

SPECIFICATION

MILLIMETRES

SCALE

ALT.	DESCRIPTION	DATE
6.	DIMENSION C & D SPECIFIED	6.5.99
5.	TOLERANCES ALTERED QUANTITY SCHEDULE REVISED	24.6.98
4.	DIMENSION ALTERED, QUANTITY SCHEDULE REVISED, PCS. NUMBER DELETED,	10.8.98

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R. D. S. O.

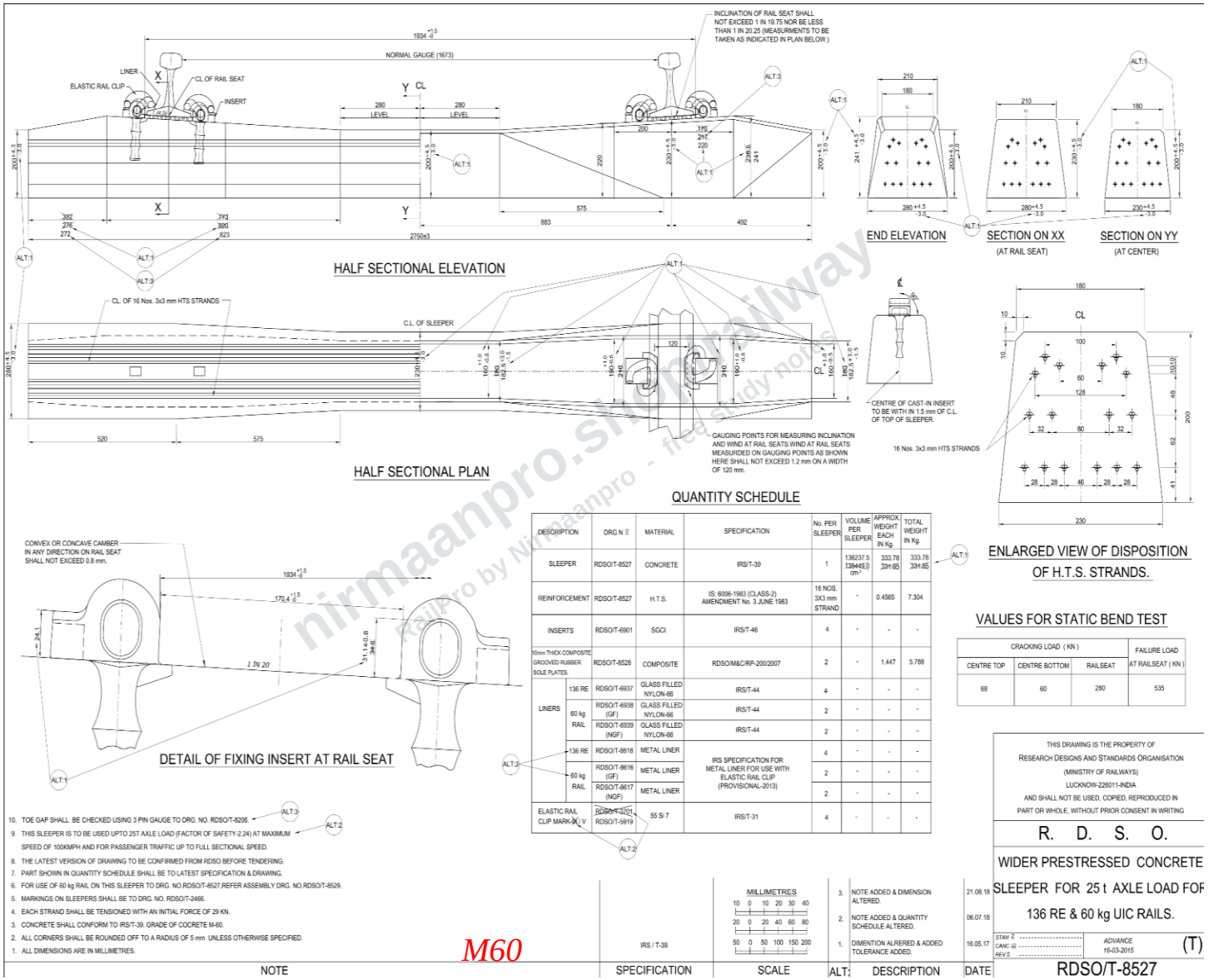
PRESTRESSED CONCRETE SLEEPER FOR 1673 mm GAUGE B. G. 52 Kg. & 60 Kg. (UIC) RAILS.

STAY A ..... ADVANCE (T)
CANC. & REVD. 4.11.78 & 18.12.79

RDSO/T-2495 & 2496

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Wider Sleeper



DESCRIPTION		DRG N.	MATERIAL	SPECIFICATION	No. PER SLEEPER	VOLUME PER SLEEPER	APPROX WEIGHT EACH IN Kg.	TOTAL WEIGHT IN Kg.
SLEEPER		RDSO/T-8527	CONCRETE	IRS/T-39	1	136237.5 cm³	333.78	333.78
REINFORCEMENT		RDSO/T-8527	H.T.S.	IS: 6006-1983 (CLASS-2) AMENDMENT No. 3 JUNE 1983	16 NOS. 3X3 mm STRAND	-	0.4565	7.304
INSERTS		RDSO/T-6901	SGCI	IRS/T-46	4	-	-	-
10mm THICK COMPOSITE GROOVED RUBBER SOLE PLATES.		RDSO/T-8528	COMPOSITE	RDSO/M&C/RP-200/2007	2	-	1.447	5.788
LINERS	136 RE	RDSO/T-6937	GLASS FILLED NYLON-66	IRS/T-44	4	-	-	-
	60 kg RAIL	RDSO/T-6938 (GF)	GLASS FILLED NYLON-66	IRS/T-44	2	-	-	-
		RDSO/T-6939 (NGF)	GLASS FILLED NYLON-66	IRS/T-44	2	-	-	-
	136 RE	RDSO/T-8618	METAL LINER	IRS SPECIFICATION FOR METAL LINER FOR USE WITH ELASTIC RAIL CLIP (PROVISIONAL-2013)	4	-	-	-
	60 kg RAIL	RDSO/T-8616 (GF)	METAL LINER		2	-	-	-
		RDSO/T-8617 (NGF)	METAL LINER		2	-	-	-
ELASTIC RAIL CLIP MARK-3(V		RDSO/T-3201 RDSO/T-5919	55 Si 7	IRS/T-31	4	-	-	-

CRACKING LOAD (KN)			FAILURE LOAD AT RAILSEAT (KN)
CENTRE TOP	CENTRE BOTTOM	RAILSEAT	
68	60	280	535

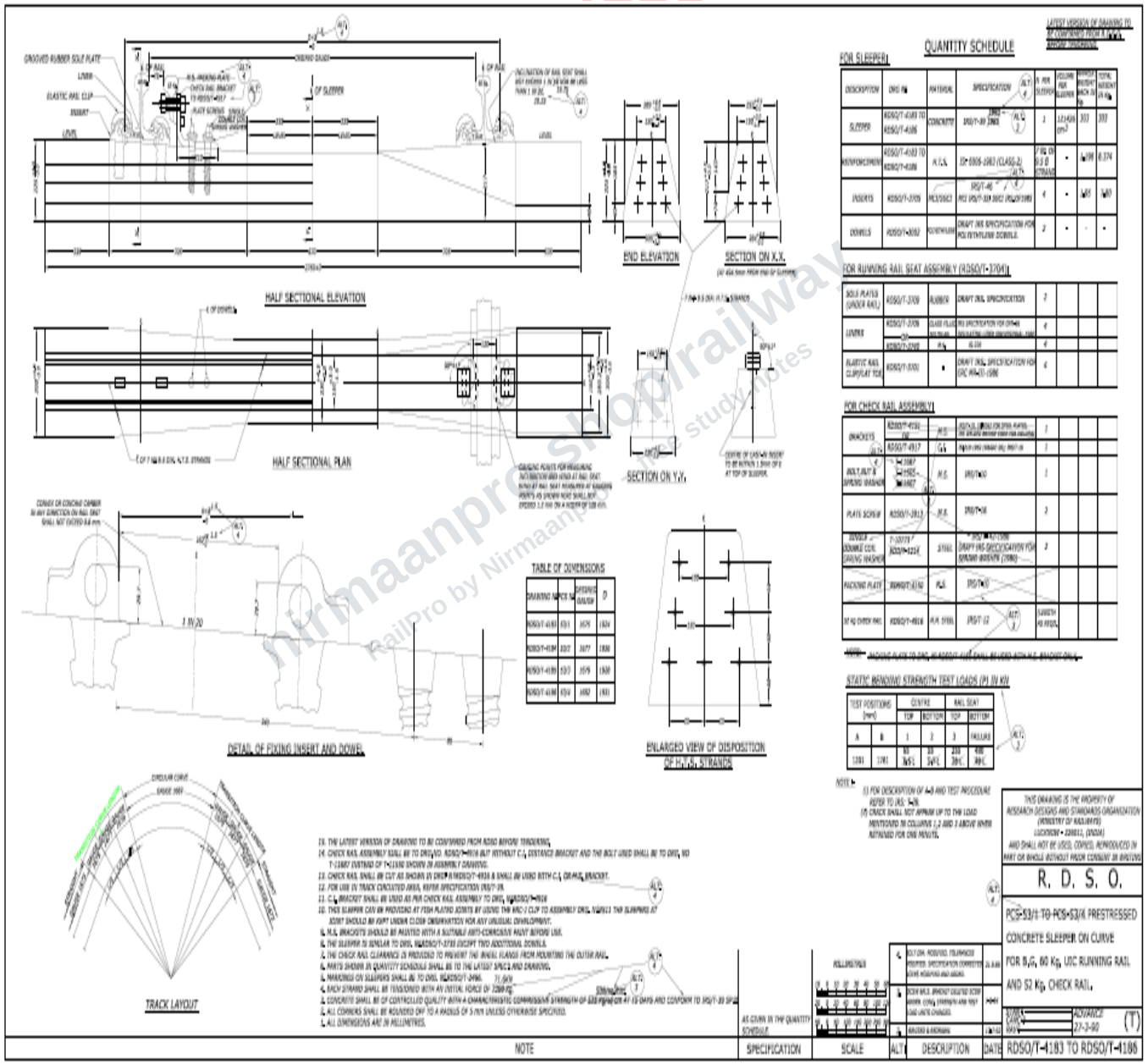
	DESCRIPTION	DATE
3.	NOTE ADDED & DIMENSION ALTERED.	21.08.18
2.	NOTE ADDED & QUANTITY SCHEDULE ALTERED.	06.07.18
1.	DIMENTION ALRERED & ADDED TOLERANCE ADDED.	16.05.17

10. TOE GAP SHALL BE CHECKED USING 3 PIN GAUGE TO DRG. NO. RDSO/T-8206.
9. THIS SLEEPER IS TO BE USED UPTO 25T AXLE LOAD (FACTOR OF SAFETY-2.24) AT MAXIMUM SPEED OF 100KMPH AND FOR PASSENGER TRAFFIC UP TO FULL SECTIONAL SPEED.
8. THE LATEST VERSION OF DRAWING TO BE CONFIRMED FROM RDSO BEFORE TENDERING.
7. PART SHOWN IN QUANTITY SCHEDULE SHALL BE TO LATEST SPECIFICATION & DRAWING.
6. FOR USE OF 60 kg RAIL ON THIS SLEEPER TO DRG. NO.RDSO/T-8527,REFER ASSEMBLY DRG. NO.RDSO/T-8529.
5. MARKINGS ON SLEEPERS SHALL BE TO DRG. NO. RDSO/T-2486.
4. EACH STRAND SHALL BE TENSIONED WITH AN INITIAL FORCE OF 29 KN.
3. CONCRETE SHALL CONFORM TO IRS/T-39. GRADE OF CONCRETE M-60.
2. ALL CORNERS SHALL BE ROUNDED OFF TO A RADIUS OF 5 mm UNLESS OTHERWISE SPECIFIED.
1. ALL DIMENSIONS ARE IN MILLIMETRES.

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PSC Sleeper T-4183 to T-4186



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Wider sleeper
Advantages of Wider sleeper

- **Increased width and weight providing higher frame resistance against buckling, chances of reducing de-stressing temperature with likely reduction in rail/weld failures**
- Increased rail seat area resulting in higher rubber pad life
- Reduced ballast pressure leading to reduction in ballast pulverization, deep screening cycle & enhanced drainage

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Wider sleeper Advantages of Wider sleeper

- Though the existing PSC sleeper RDSO/T-2496 is being used for 22.5 t axle load operation and existing PSC sleeper RDSO/T-7008 has been designed to be used for 25t axle load which has same dimensional profile but wider & heavier sleeper has been taken up for design for 25t axle load to take care of following aspects:

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Wider sleeper
Advantages of Wider sleeper

- a) Total stresses at rail seat and centre section of PSC sleeper to be brought down for improved performance and life
- b) Adequate factor of safety

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Wider sleeper
Advantages of Wider sleeper

- c) Ballast pressure to be reduced for reduction in ballast pulverization & increase in period of deep screening cycle and enhanced drainage
- d) The sleeper is sufficiently wide to increase rail seat area to accommodate wider rubber pad to reduce pressure on rubber pad for its longer life and satisfactory performance.

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Wider sleeper
Advantages of Wider sleeper

- e) A heavier sleeper is required to provide more longitudinal and lateral resistance to track to counter higher thermal forces on account of heavier rails as also the higher longitudinal forces like traction and braking, exerted by heavier trains.

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Wider sleeper
Advantages of Wider sleeper

- f) The rail seat assembly is designed to provide flexibility to adopt any of 136RE (68 kg/m) and UIC 60 kg rail section.
- g) PSC sleepers being used in other world railways are generally wider in section in comparison to IR sleepers RT-2496 & RT7008.

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Wider sleeper Advantages of Wider sleeper

- h) The depth of sleeper at rail seat has been increased to 230 mm to restrict the bending stresses generated from higher axel load. The depth of sleeper at center has also been increased to 200 mm

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Wider sleeper
Advantages of Wider sleeper

- i) The top width for the sleeper has been kept as 210mm to facilitate a larger bearing area for rubber Pad to enhance its performance and longer life.
- J) The bottom width of the sleeper has been kept as 280mm to limit the ballast pressure as well as to facilitate

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Existing 25 t & wider sleeper

Comparison of sleepers

S. No.	Parameter	BG LINE SLEEPER (22.5 T)	25 T Existing Sleeper	25 T Wider Sleeper
1.	RDSO Drawing No.	RT-2495 & 2496	RT-7008	RT-8527
2.	Grade of Concrete	M-55	M-60	M-60
3.	HTS Strands (3mm dia x 3 ply)	18 No.	20 No.	16 No.
4.	Initial Prestress	70 %	75%	75%
5.	Prestress Loss	30 %	30%	30%
6.	Axle Load	22.5 T	25T	25 T
7.	Weight	267 kg	267 kg	332 kg
	Dimensions :-			
	Length	2750 mm	2750 mm	2750 mm
	Depth at rail seat	210 mm	210 mm	230 mm

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PSC Sleepers for Curves

- **On curves (IRPWM para 403(1))**
  - For R > and upto 350m
    - **Gauge -5mm to +3mm**
  - For R < 350m
    - **Gauge upto +10mm**

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DIFFERENT PSC SLEEPERS (DRAWING NO.)

SLEEPER ON CURVES



		RDSO /T- 4174 to 4177
52 kg Running Rail (To use with different Liners)	-	RDSO /T- 3670 (Gauge Up to 1681 mm)
52 kg Running Rail	-	RDSO /T- 5738 to 5740 (For 90R Check Rail)
60 kg Running Rail	-	RDSO /T- 4170 to 4173
60 kg Running Rail	-	RDSO /T- 4183 to 4186 (For 52 kg Check Rail)
60 kg Running Rail	-	RDSO /T- 6896 to 6899 (For 65 mm Check Rail Clearance)

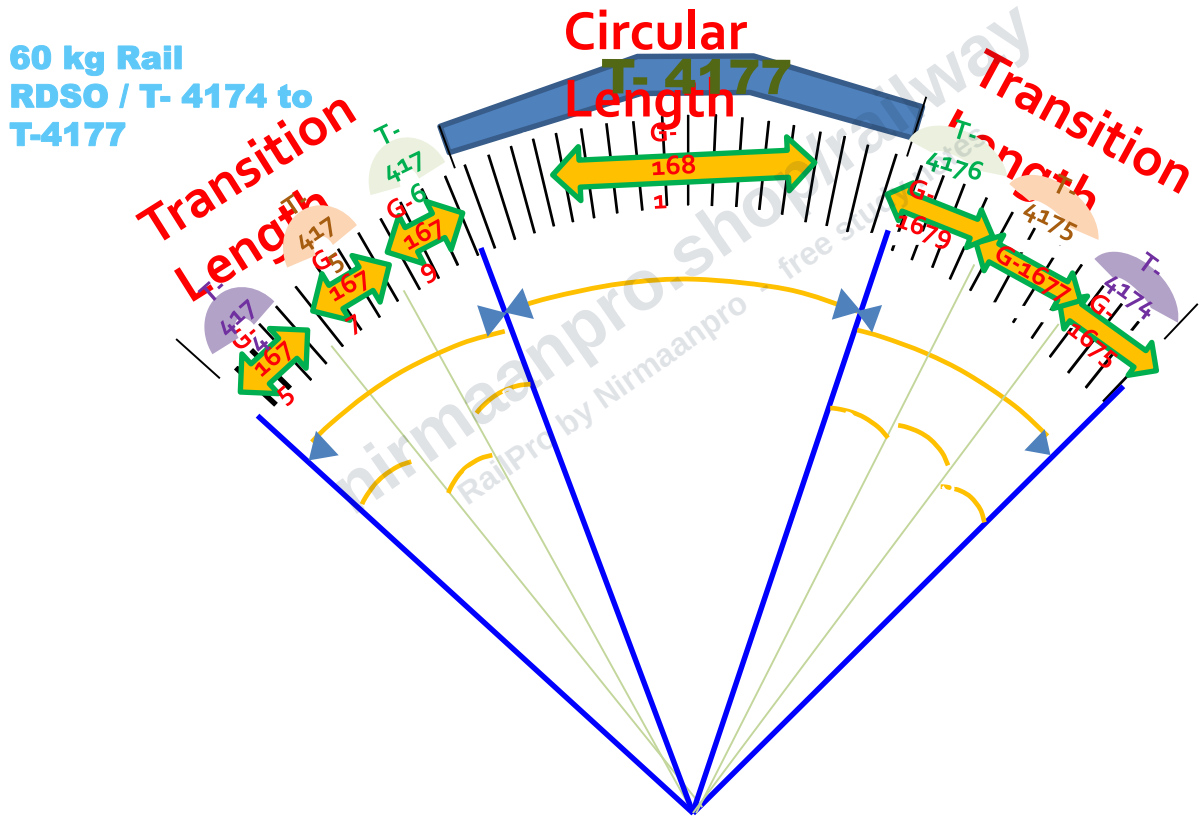
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PSC Sleepers for Curves

- **RDSO/ T-3670**
  - Gauge upto *1681 mm* using different liners
- **RDSO/ T-4170-73**
  - For 60 kg/m rail, sleepers with *1675,1677, 1679, 1681 mm* gauge
- **RDSO Drgs RDSO/ T-4183-86**
  - 60 kg/m rail with 52 kg/m Check Rail, with *75 mm* clearance, specially designed for KK line
- **RDSO Drgs RDSO/ T-6896-99**
  - 60kg with 52 kg/m Check Rail, with *65 mm* clearance

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PSC Sleepers for Curves



Average life *(in years)*

ADVANCE CORRECTION SLIP No. 62

Indian Railway Finance Code Vol.-I (Reprint Edition 1998) Para 219 :-

(i) Substitute table below Para 219 showing normal life of the various classes of railway assets with the following:-

(i) CIVIL ENGINEERING ASSETS

S.No.	Class of assets	Average life in years			
		ROUTES			
		A & B	C(Sub)	D	E
1. RAIL & FASTENTING etc.					
1.	Rail & Fastenings				
(a).	Rails	20	15	30	*30
(b).	Wooden Sleepers	10	10	10	*10
(c.1)	Metal sleepers (Cast Iron & Steel)	20	20	20	*20
(c.2)	Fittings steel trough	10	10	10	*10
(d).	Concrete sleepers	35	35	40	*40
(e).	Elastic Fastenings				
(i)	Elastic Rail clips	5-8	5-8	8-10	*8-10
(ii).	Rubber Pads/ Liners	2-4	2-4	4	*4-6
(f).	Switches	4	2/3	5	*5
(g).	Crossings	5	4/5	8	*8

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SLEEPER DENSITY

- The Sleeper Density is the number of sleeper used per rail length in SWR & fish plated track
- Described as M+4, M+5, M+6 etc where M is the length of the standard rail in mtrs.
- In case of LWR/CWR, this is expressed in number of sleeper per Km of track, ie 1340, 1540, 1660 etc.
- Sleeper Density depends upon max. permissible speed & traffic density

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Minimum Sleeper Density (Broad Gauge)

<table>
<tr><th rowspan="2">Lines</th><th colspan="6">Routes</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>‘D’ Spl.</th><th>D</th><th>E</th></tr>
<tr><td>Main lines</td><td>1660</td><td>1660</td><td>1660</td><td>1660</td><td>1660</td><td>1660</td></tr>
<tr><td rowspan="2">Loop Line</td><td rowspan="2">1540</td><td rowspan="2">1540</td><td rowspan="2">1540</td><td colspan="3">1340 for Zone I & II</td></tr>
<tr><td colspan="3">1540 for Other Zone</td></tr>
<tr><td rowspan="3">Private and Other Sidings</td><td colspan="3" rowspan="2">Sidings with permissible speed up to 50 kmph.</td><td colspan="3">1340 for Zone I & II</td></tr>
<tr><td colspan="3">1540 for Other Zone</td></tr>
<tr><td colspan="3">Sidings with permissible speed more than 50 kmph.</td><td colspan="3">1660</td></tr>
</table>

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2.2 BASICS OF RAILWAY TRACK

2.2.3BALLAST:Functions of Ballast, Ballast profile - Ballast sections for straight and curves on double lines, for BG/MG/NG with fish plated track, SWR and LWR, Specification for track ballast, measurement & testing of ballast, training out Ballast, DMT Operation, Assessment of ballast requirement

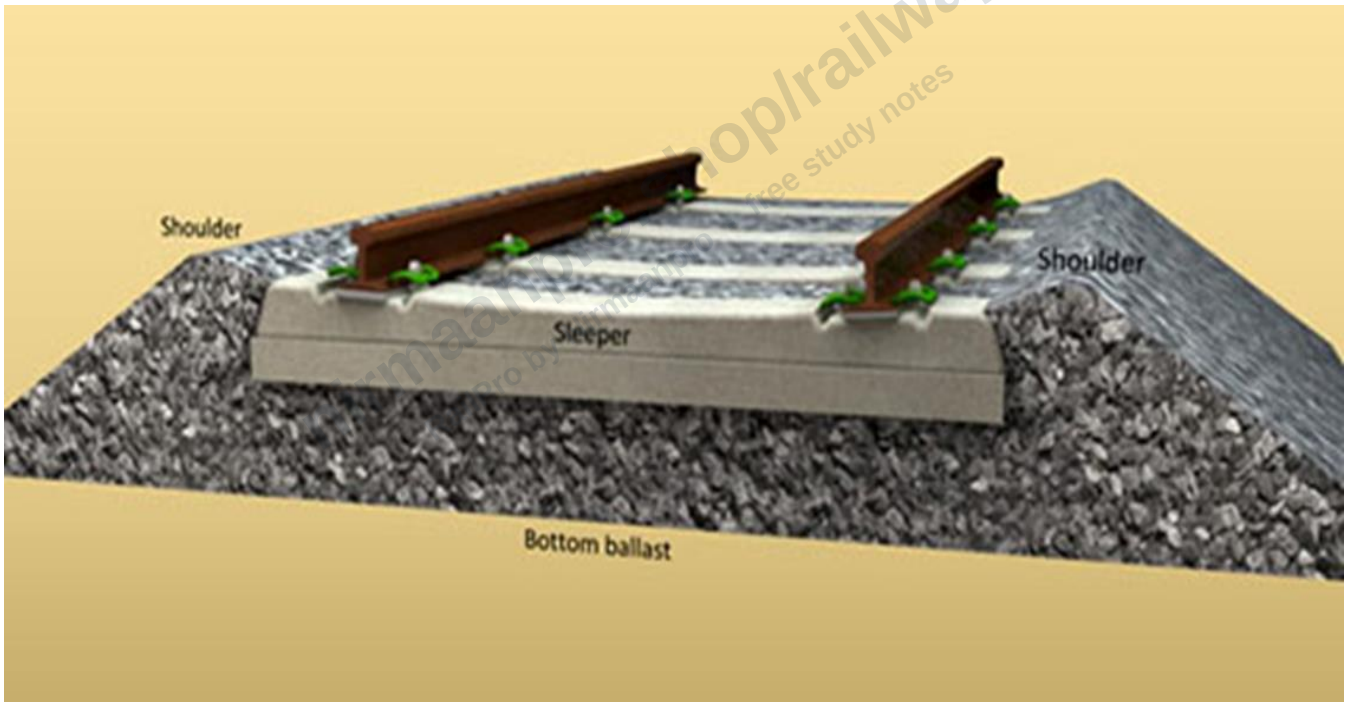
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TYPES OF BALLAST

- Sand Ballast.
- Moorum Ballast.
- Coal Ash or Cinder.
- Broken Stone Ballast.

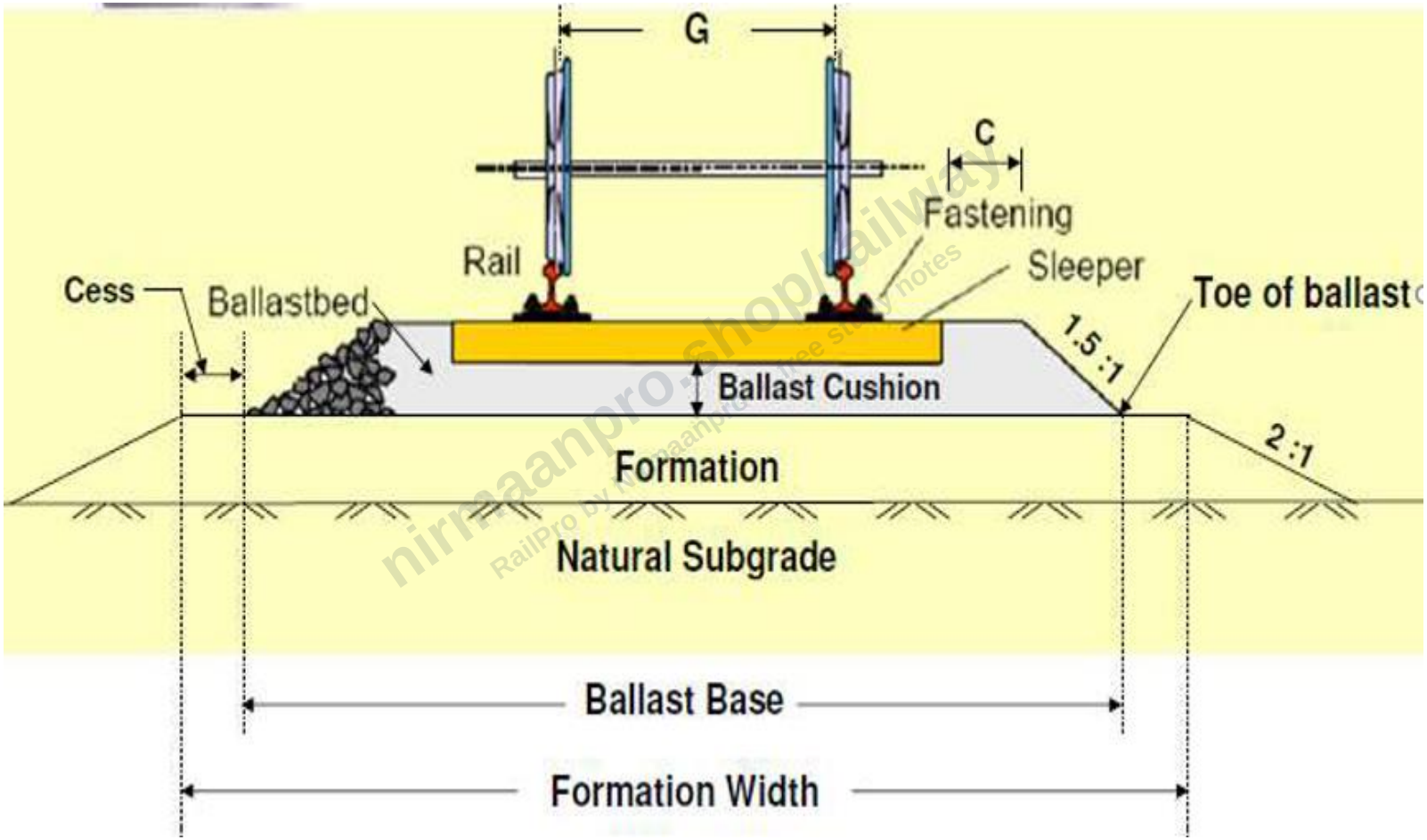
Now for uniformity 50 mm size broken stone ballast is to be adopted universally for all types of sleepers and sections.

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- Track structure



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Ballast



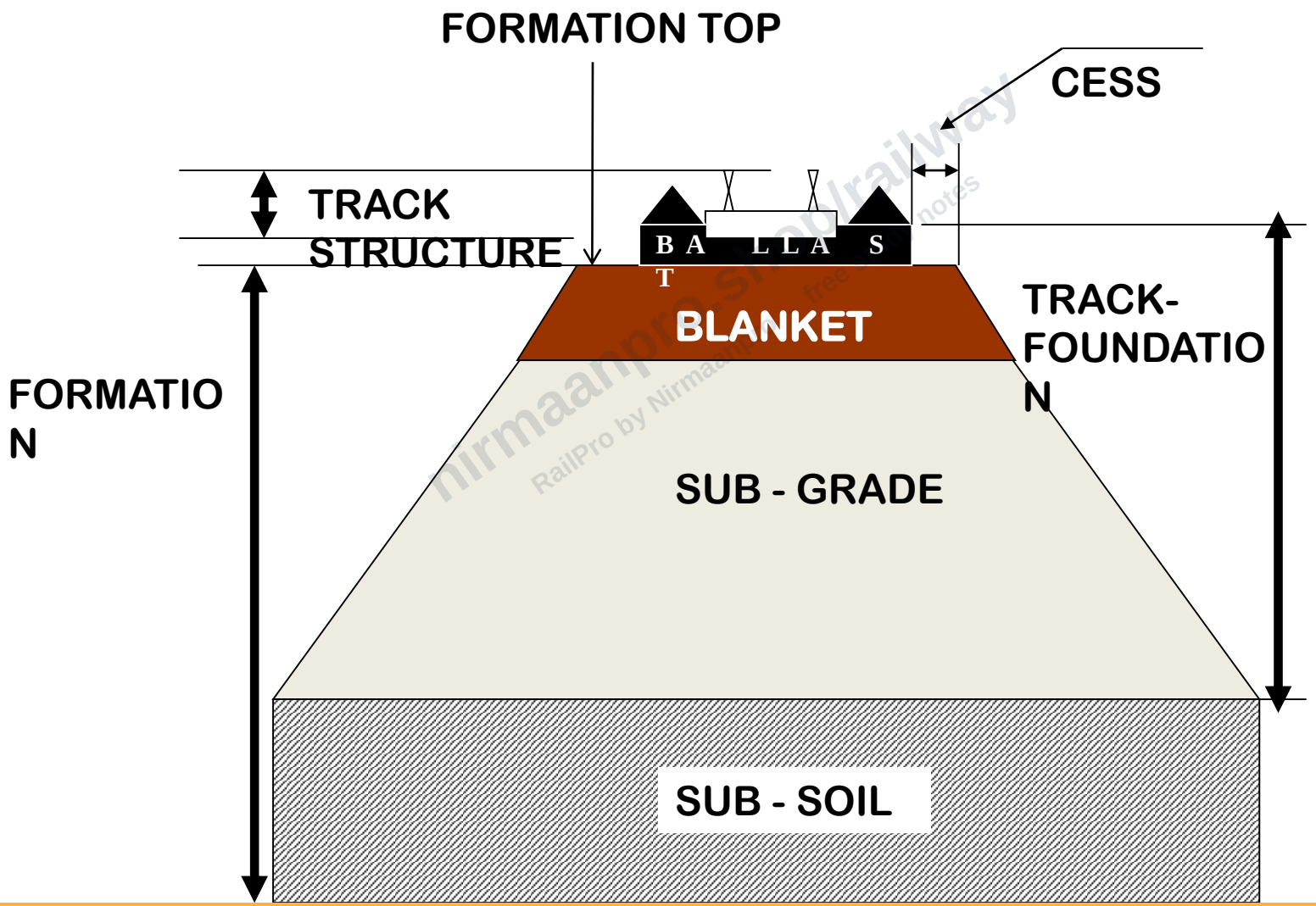
What is Ballast

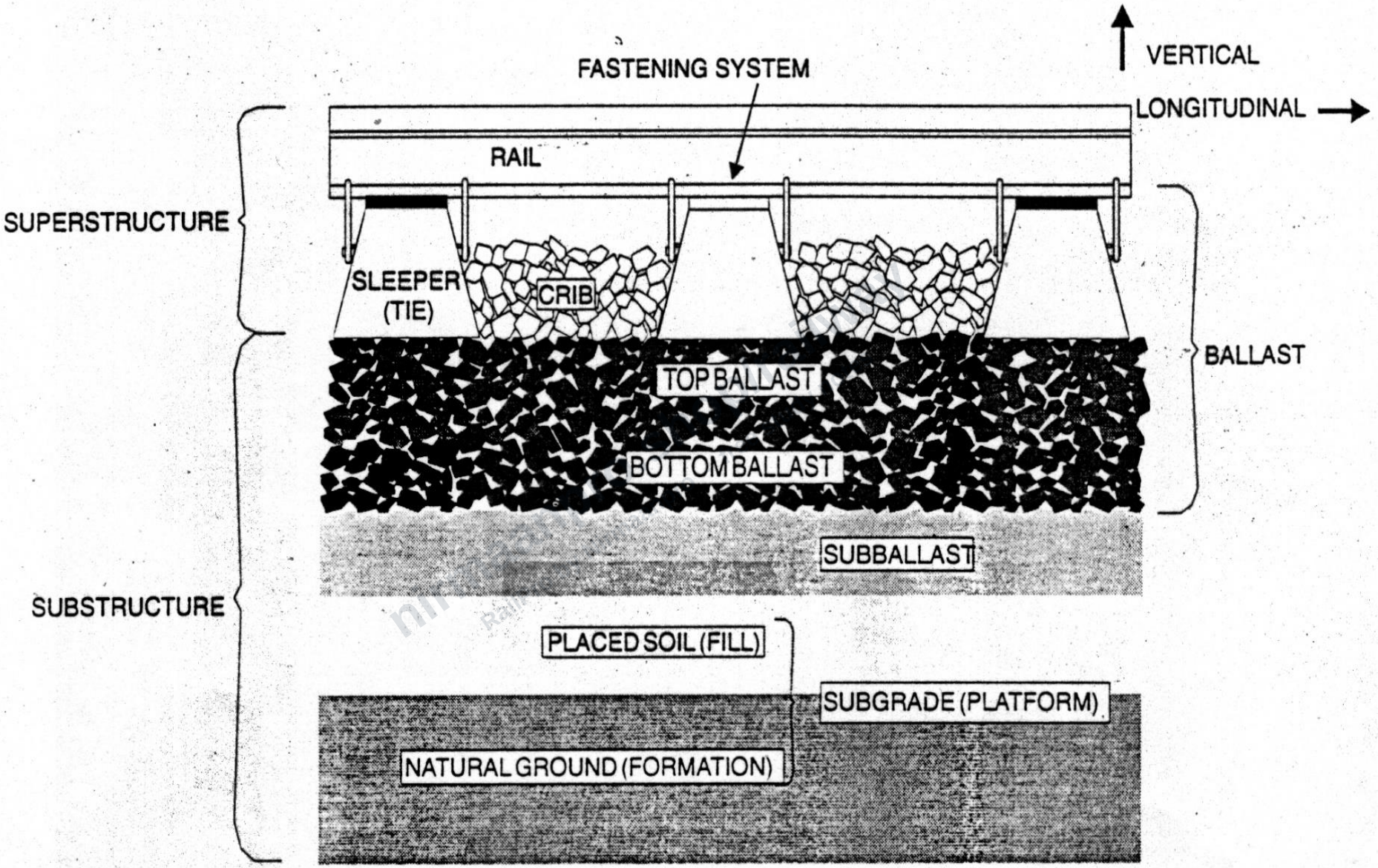
- Ballast is the select crushed granular material placed as the top layer of the substructure in which the sleepers are embedded

- **Stone ballast in Railways is used for all types of sleepers on normal track, turnouts, tunnels and deck slabs etc on all routes.**

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Ballast on formation top




VERTICAL
FASTENING SYSTEM
LONGITUDINAL
RAIL
SUPERSTRUCTURE
SLEEPER
(TIE)
CRIB
BALLAST
TOP BALLAST
BOTTOM BALLAST
SUBBALLAST
SUBSTRUCTURE
PLACED SOIL (FILL)
SUBGRADE (PLATFORM)
NATURAL GROUND (FORMATION)

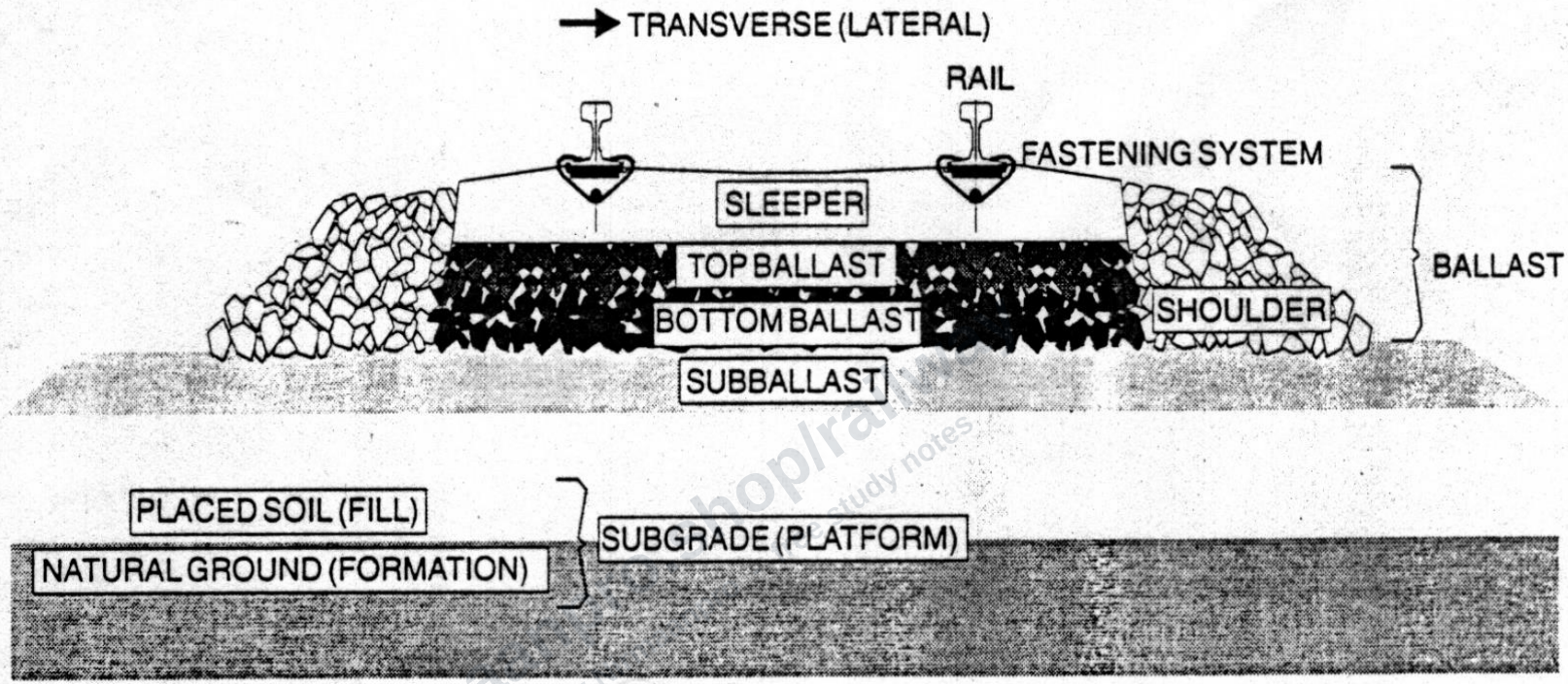


Fig. 2.1 Track structure components

Important Functions of Ballast

- Resist vertical, lateral and longitudinal forces
- Provide *Elasticity and resilience for riding comfort a*nd absorb energy
- Reduce formation pressure
- Facilitate track geometry correction
- Facilitate track drainage
- Provide voids

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Important Functions of Ballast

- **Level and hard bed for the sleepers.**
- **Sleepers in position during passage of trains.**
- **Transfer and distribute the load.**
- **Lateral and longitudinal stability.**
- **Maintain the level and alignment.**

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Additional Functions of Ballast

- Inhibit vegetation growth
- Absorb airborne noise
- Provide adequate electrical resistance

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REQUIREMENTS OF GOOD BALLAST

- It should be tough and wear resistant.
- It should be hard without getting crushed under the moving loads.
- It should be generally cubical having sharp edges.
- It should resist attrition.
- It should be durable and should not get pulverised under the weather conditions.
- It should provide good drainage of water.
- It should be cheap and economical in price.

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On Indian railway –

- Total number of divisions- 68 nos. (approx.)
- Ballast consumption in CuM – 50,000-200000 (Avg. 100000 presumed)
- Total Ballast consumption by Open line – 68 Lakh CuM
- Ballast consumption by Construction – 150 Lakh CuM
- Total ballast consumption by Indian Railways – 218 Lakh CuM
- Average cost of ballast including unloading – Rs.1000 presumed.
- Total cost of ballast for Indian
- Railways = Rs. 1000 x 218,00,000 = Rs. 2180 Crore approx.

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Ballast Profile/Section/Depth of Cushion:

- Ballast profile: -The following ballast profiles shall be provided for the various groups of track for LWR/CWR and other than LWR/CWR as given in Annexure - 2/2A, 2/2B & 2/2C of IRPWM. The approximate quantity of ballast required per metre run of track for standard ballast sections has also been indicated in the sketch.

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Note:

- (i) Minimum Formation width to be ensured for new works/alteration to existing works in embankment and in cutting (excluding side drains), as also indicated in the sketch of Annexure - 2/2A, 2/2B & 2/2C
  - For single line straight track – 7850 mm
  - For double line straight track – 13160 mm
- (ii) On curves, additional formation width over (i) above, shall have to be ensured as given below:
- (a) Increase due to extra widening of ballast shoulder on outer side of curves in both single/double line, as indicated in sketch of Annexure - 2/2A, 2/2B & 2/2C
- (b) Increase due to requirement of extra clearances on curves as stipulated in the Appendix to the IRSOD-(BG).

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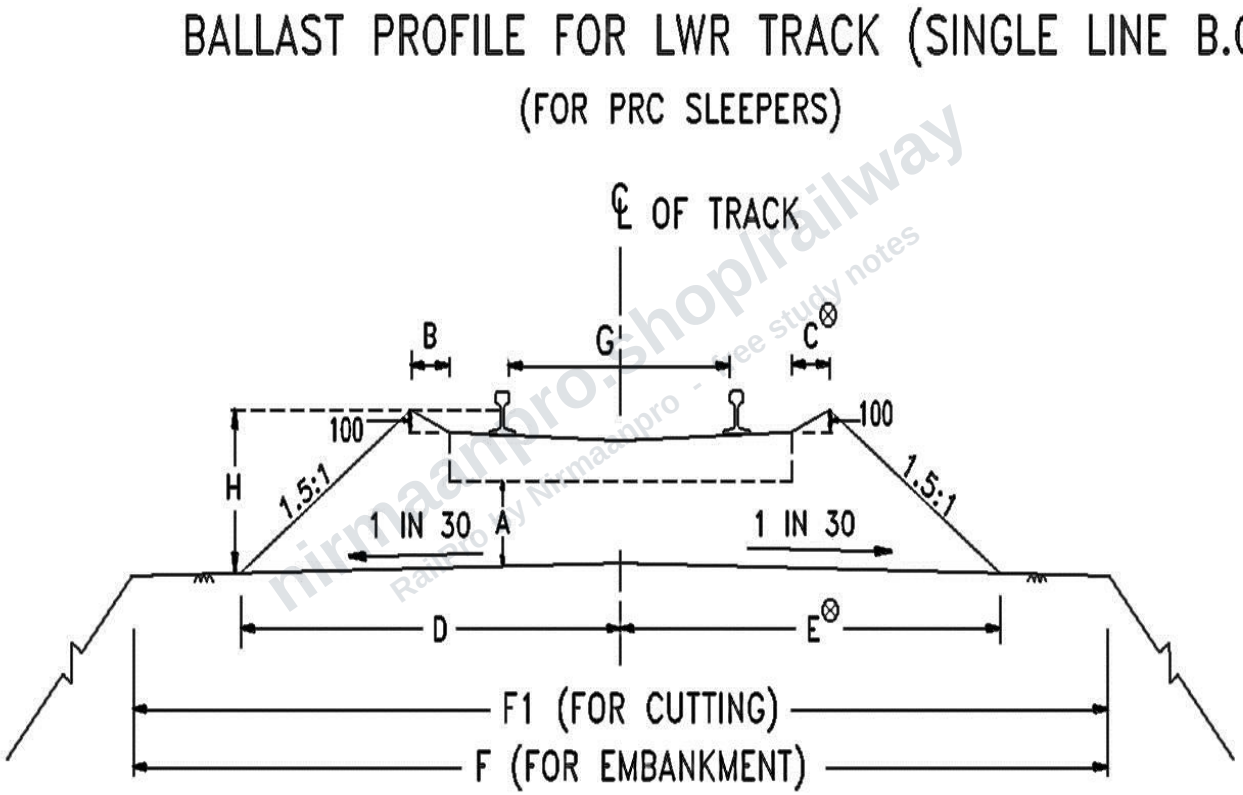
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- (iii) Increase in formation width on curves will be decided after taking into account the increase mentioned in (a) & (b) above.
- (iv) Minimum Cess width of 90 cm shall also have to be ensured for both straight track & on curves, along with ensuring minimum Formation width as specified for Single/Double line including additional formation width on curves as described above.
- (v) If even after provision of additional formation width, cess width on the outer side of curves reduces below 90 cm on account of increased ballast width due to super elevation, formation width shall be increased further, over and above additional width as stipulated in Note (ii) above, to meet the requirement of minimum cess width of 90 cm

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BALLAST PROFILE FOR LWR TRACK

(single line BG) Annexure – 2/2 A of IRPWM



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Gauge	Type of Sleeper	A	B	C*	D	E*	F	F1	H	Quantity of Ballast per meter in	
										Straight Track (M^3)	Curved Track (M^3)
1676 mm	PRC	250	350	500	2693	2851	7850	7850	646	2.030	2.120
		300	350	500	2772	2930	7850	7850	698	2.304	2.401
		350	350	500	2851	3009	7850	7850	751	2.585	2.690

Note *:*

1.Depth of ballast cushion should be provided as per ***Para 212(2)*** *of IRPWM.*

2.Cross-Slope of 1 in 30 shall be provided for New Works.

3.Minimum Formation width of 7850 mm shall be ensured for new works in both embankment and in cuttings (excluding side drains).

4.Suitable dwarf walls shall be provided in case of cuttings, if necessary for retaining ballast.

5.*On outer side of curves only.*

6.Super elevation has not been considered in calculation of ballast quantity for curved track.

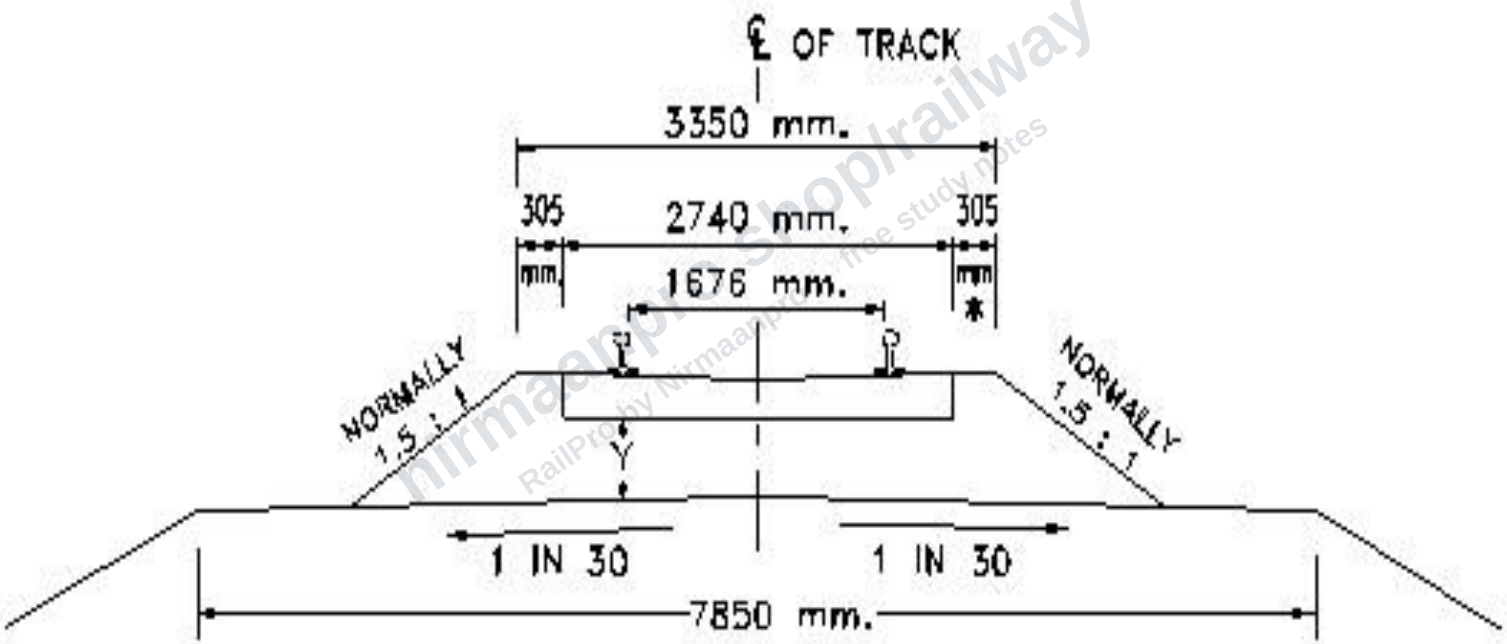
7.The cess width on existing track is to be increased on programmed basis wherever required so that minimum cess width as per side slope given above is ensured.

8.All dimensions are in mm.

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Ballast profile for BG (Other than LWR/CWR) Annexure – 2/2 B of IRPWM

STANDARD BALLAST PROFILE FOR BG (OTHER THAN LWR/CWR)



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S. No.	Depth of Ballast Cushion	Quantity of Ballast per Meter	
		On Straight and Curves of Radius flatter than 600 M	Curves of Radius sharper than 600 M
1	250 mm	1.769 M^3	1.820 M^3
2	300 mm	2.022 M^3	2.078 M^3
3	350 mm	2.282 M^3	2.344 M^3

Note :

*1.In the case of ordinary fish plated track: * To be increased on the outside of curves to 400 mm in the case of curves sharper than 600 M radius.*

2.In short welded panel Track To be increased to 400 mm on outside of all curves, flatter than 875 M radius and to 450 mm, in the case of curves sharper than 875 M radius.*

3. To be increased to 550 mm on the outside of turn in curves of turnouts in passenger yards.*

*4.Depth of Ballast cushion should be provided as per **Para 212(2)** of IRPWM.*

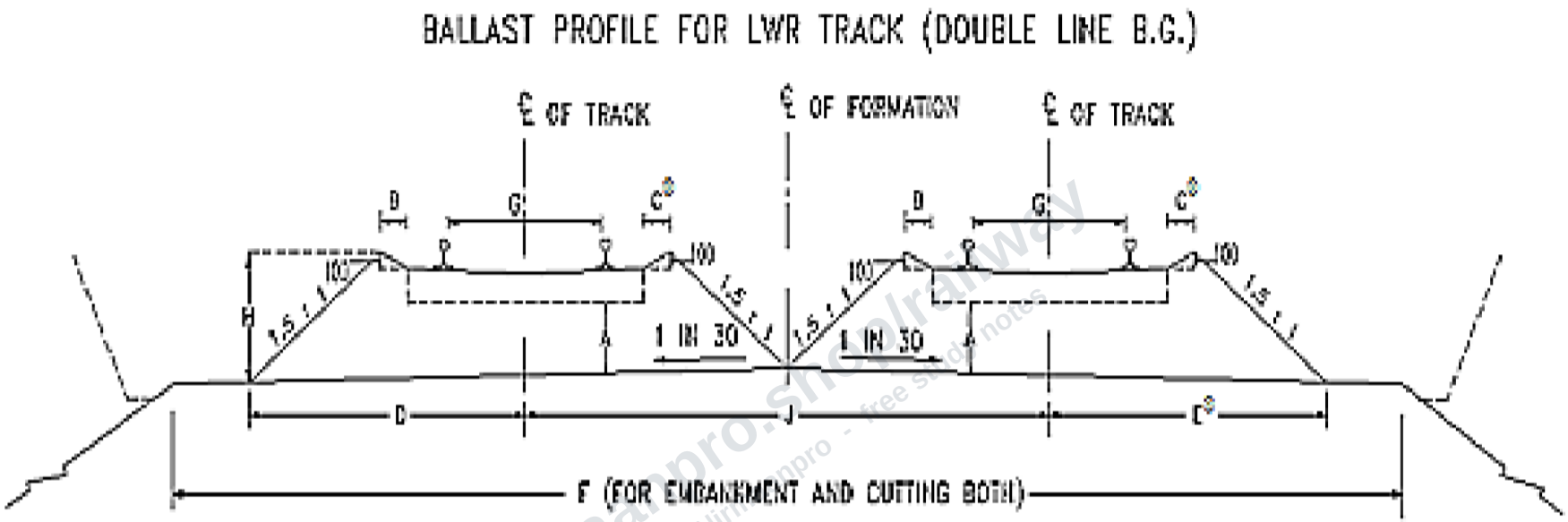
5.Minimum Formation width of 7850 mm shall be ensured for new works in both embankment and in cuttings (excluding side drains).

6.Super elevation has not been considered in calculation of ballast quantity for curved track.

7.The cess width on existing track is to be increased on programmed basis wherever required so that minimum cess width as per side slope given above is ensured.

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Ballast profile for LWR Track(Double line BG)
Annexure-2/2 C



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G Gauge	Type of Sleeper	A	B	C*	D	E*	F	H	J
1676 mm	PRC	250 300 350	350 350 350	500 500 500	2785 2864 2943	2943 3022 3101	13160 13160 13160	707 760 812	5300 5300 5300

- ***Note**:*

  *1. Depth of ballast cushion should be provided as per **Para 212(2)** of IRPWM.*

  2. Cross-Slope of 1 in 30 shall be provided for New Works.

  3. Minimum Formation width of 13160 mm shall be ensured for New works in both embankment and in cuttings (excluding side drains).

  4. In doubling work of existing lines, cross-slope of 1 in 40 in existing old formation need not be disturbed.

  However, the cross slope of 1 in 30 shall be provided in widened formation width, newly constructed for doubling.

  5. Suitable dwarf walls shall be provided in case of cuttings, if necessary, for retaining ballast.

  ***6.** *On outer side of curves only.*

  7. Super elevation has not been considered in calculating various dimensions.

  8. The cess width on existing track is to be increased on programmed basis wherever required so that minimum cess width as per side slope given above is ensured.

  9. All dimensions are in mm.

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Depths of Ballast Cushion–

The minimum depth of the ballast cushion below the bottom of the sleepers at the rail seat for BG should be as under–

In case of	Minimum depth of the ballast cushion for all routes
Track Renewals (CTR and TSR)	300 mm (Where possible 350 mm shall be provided)
All Doubling, Gauge Conversion & New Line construction works	350 mm
Loop Lines	250 mm

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Depths of Ballast Cushion–

For higher speed

Speed	Speed above 110 Kmph and up to 130 Kmph	Speed above 130 Kmph and up to 160 Kmph
Ballast Cushion in mm	Total 300 clean 150	Total 350 clean 150

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Sidings–

Private and Other Sidings	For permissible speed up to 50 Kmph.	300 mm
	For permissible speed more than 50 Kmph	350 mm

Note –

(1) Minimum depth of clean ballast cushion at all times for mechanised maintenance under the rail seat of the PSC sleepers shall not be less than 150 mm.

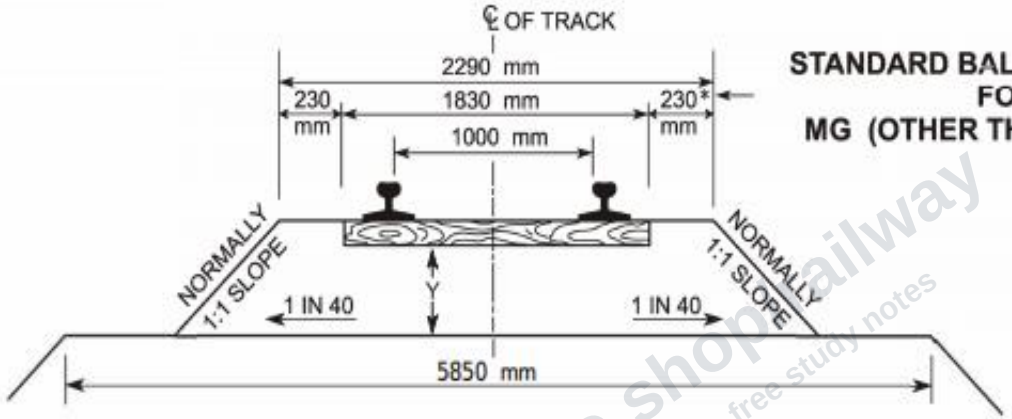
(2) Increase in ballast cushion to make up the recommended depth will be carried out during complete track renewal, through sleeper renewal or programmed deep screening of track.

(3) Special attention should be given at locations such as bridge, level crossing and tunnel approaches so as to ensure full ballast section for six rail lengths on either side.

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Ballast profile for MG(Other than LWR/CWR)

Annexure 2/14 - para 263



STANDARD BALLAST PROFILE FOR MG (OTHER THAN LWR/CWR)

RECOMMENDED DEPTHS OF BALLAST AND BALLAST REQUIREMENTS FISH-PLATED TRACK

Routes	Recommended Depth of Ballast Cushion Y	Quantity of Ballast required per Metre on	
		On Straight and Curves of Radius Flatter than 600 M	Curves of Radius Sharper than 600 M
Q Routes 100 kmph	300 mm	1.070 M^3	1.145 M^3
Q Routes of less than 100 kmph	250 mm	0.965 M^3	1.033 M^3
R-1 Routes	250 mm	0.965 M^3	1.033 M^3
R-2 Routes where LWR is contemplated	250 mm	0.965 M^3	1.033 M^3
R-2 Routes where LWR is not Contemplated.	200 mm	0.817 M^3	0.905 M^3
R-3 Routes	200 mm	0.817 M^3	0.905 M^3
S Routes	150 mm	0.673 M^3	0.725 M^3

Note-

(1) In the case of fish-plated track : * To be increased on the outside of curves to 400 mm in the case of curves sharper than 600 M radius.

(2) In short welded panel : * To be increased to 330 mm in the case of all curves flatter than 600 M radius, and to 380 mm in the case of curves sharper than 600 M radius.

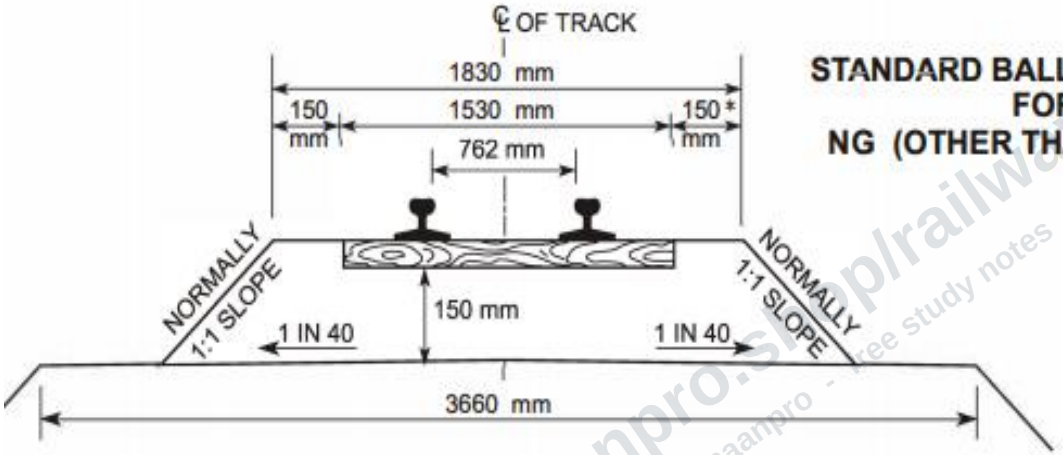
(3) *To be increased to 550 mm on the outside of turn in curves of turn-outs in passenger yards.

(4) In the case of SWR track, the minimum depth of cushion shall be 200 mm.

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Ballast profile for NG(Other than LWR/CWR)

Annexure 2/15 - para 263



STANDARD BALLAST PROFILE FOR NG (OTHER THAN LWR/CWR)

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Recommended Depth of Ballast Cushion	Quantity of Ballast required per Metre of Track	
	On Straight	Curves of Track Sharper than 300 m Radius.
150 mm	0.543 M^3	0.584 M^3

Note-

(1) *To be increased on the outside of curves, to 300 mm in the case of curves sharper than 300 M radius.

(2) * To be increase to 450 mm in the case of turn in curves of turn-outs in passenger yards.

Requirements of Track Ballast

- Tough and wear resistant
- Hard without getting crushed under moving loads
- Generally cubical having sharp edge (Angular)
- Non-porous and non-absorbent of water

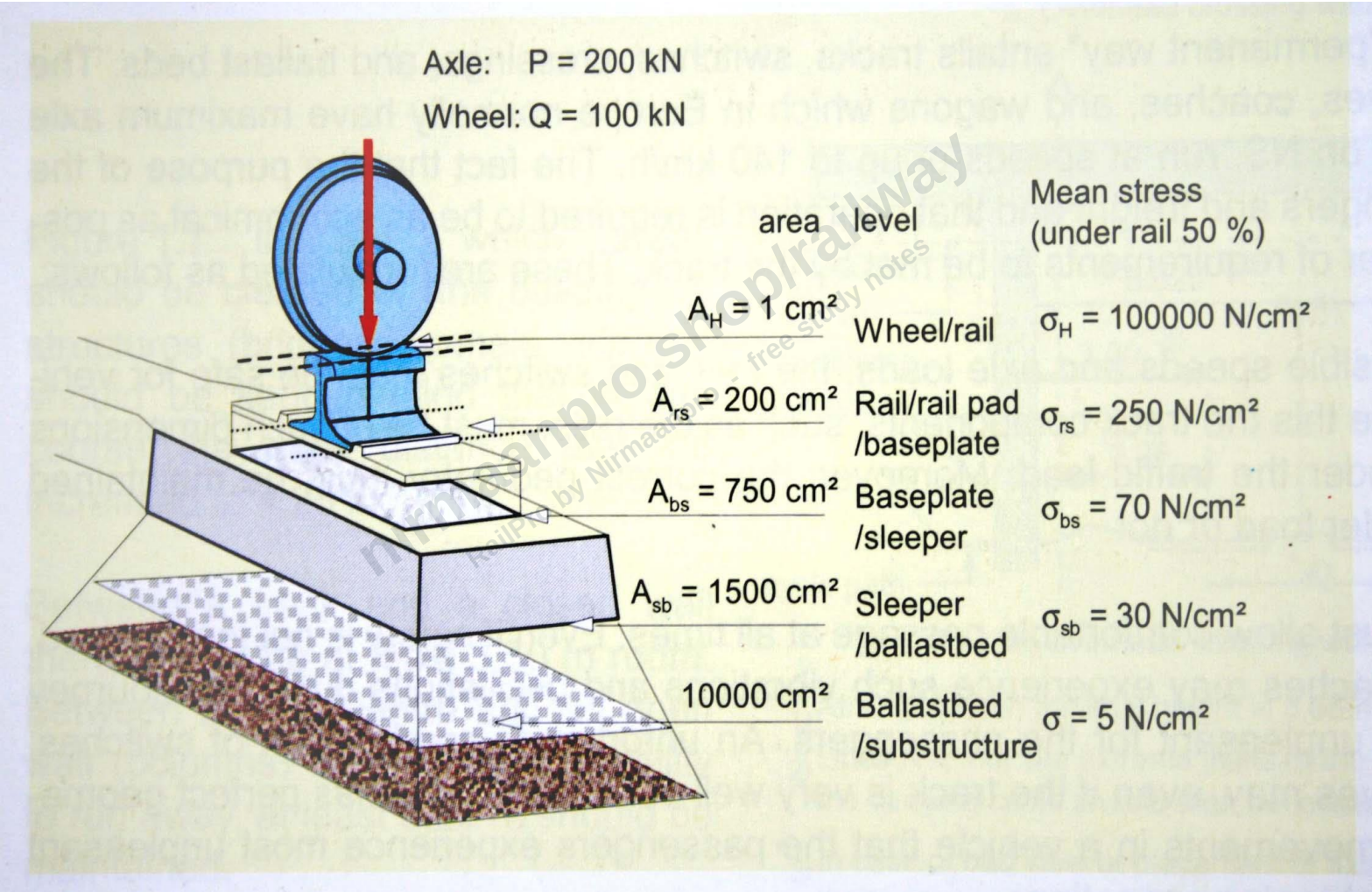
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Requirements of Track Ballast

- Resist Attrition
- Durable and should not get pulverized under weather condition
- Good drainage of water
- Economical in cost

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Stress Distribution



Ballast Fouling

Potential sources are

- **Ballast breakdown**
  1. Handling
  2. Tamping/packing
  3. Traffic
  4. Weathering

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CONTD..

Ballast Fouling

- **Fines from subgrade**
  1. Mud pumping
  2. Seepage

- **Fines from surface**
  1. Droppings from trains
  2. Wind or water transported
  3. Open defectation and garbage dumping in city limits by adjoining slum area.

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Effects of Fouling

- **Impedes drainage**
- **Affects elasticity of ballast & track modulus**
- **Tamping/ packing becomes difficult**
- **Increases dynamic loads (impact factor)**
- **Reduces electrical resistance**

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Remedial measures - fouling

- **Shoulder screening : Preventive maintenance – Once in 3 yrs.**

- **Deep Screening : Breakdown maintenance – Once in 10 yrs.**
- **Deep Screening of track shall be done after 500GMT or 10 years, whichever is earlier, or if clean cushion is less than 150mm.(ACS132)**

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Track Ballast

Ballast may be subdivided into following zones:

1. Crib
2. Shoulder
3. Top Ballast
4. Bottom Ballast

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Parameters for determination of Standard of Ballast

Physical parameters	General Requirement	Functional Requirement
i) Specific Gravity	More mass	More mass helps in resisting lateral forces.
ii) Structure	Cubical shape	i. For compaction, interlocking & internal friction ii. Round ballast cannot be compacted iii. Helps enhanced retentivity
a) Shape		
b) Grading	Uniformly graded	i) Optimum voids for resilience and drainage ii) Longevity is controlled by the voids available to accommodate fines.

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Parameters for determination of Standard of Ballast

Physical parameters	General Requirement	Functional Requirement
c) Size	Larger size (>50mm)	Small percentage is tolerable; otherwise settlement properties gets adversely affected.
	Smaller size (<40mm)	Small percentage is required for correcting track geometry defects during maintenance.
	Optimum size (40 to 50mm)	This range of particle size gives least settlement.
iii) Texture	a)Elongation Index b) Flakiness Index	As low as possible; flaky and elongated ballast is unstable and lacks locking properties.

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Parameters for determination of Standard of Ballast

Mechanical parameters

i)	Hardness	Resistance to abrasion/attrition, required for least damage / breakage during maintenance. This is measured by Los Angels Abrasion value.
ii)	Toughness	Resistance to fracture under impact loads. This is measured by Impact Value.
iii)	Water absorption	This should be checked to ensure higher resistance to weathering during adverse weather conditions.

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Parameters for determination of Standard of Ballast

Chemical parameters:

i)	Inertness	This should be checked to ensure that ballast is chemically inert and inactive from decomposition.

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Flakiness Index

- The flakiness index of an aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths(60%) of their mean dimension

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Elongation Index

- The elongation index of an aggregate is the percentage by weight of particles in it whose greatest dimension (length) is greater than one and four-fifth times (1.8 times) their mean dimension

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DETAILED SPECIFICATIONS
IRS GE – 1 JULY 2016

- **Basic Quality:** **Ballast should be hard, durable and as far as possible angular along edges/corners, free from weathered portions of parent rock, organic impurities and inorganic residues.**

- **Particle Shape:** **Ballast should be cubical in shape as far as possible. Individual pieces should not be flaky and should have generally flat faces with not more than two rounded/sub rounded faces.**

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DETAILED SPECIFICATIONS

- **Mode of Manufacture:**

1. All BG main lines and running lines, except on 'E' routes but including 'E' special routes: **machine crushed**
2. Other BG lines and MG/NG routes planned/sanctioned for conversion: **preferably machine crushed. Hand broken ballast can be used in exceptional cases** with prior approval of Chief Track Engineer/CAO/C.
3. Other MG & NG routes not planned/sanctioned for conversion: **hand broken ballast,** no approval shall be required.

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DETAILED SPECIFICATIONS

- **Physical Properties**

Ballast sample should satisfy the following physical properties in accordance with IS:2386 Pt.IV-1963 when tested as per the procedure given in Annexure 1&2

	BG, MG & NG (Planned/sanctioned for conversion)	NG&MG(Other than those planned for conversion)
Aggregate abrasion value	**30% Max***	**35% Max**
Aggregate Impact Value	**20% Max***	**30% Max**

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DETAILED SPECIFICATIONS

* **In exceptional cases, on technical and/or economic grounds relaxable upto 35% & 25% respectively by CTE in open line and CAO/C for construction projects. The relaxation in Abrasion and Impact Values shall be given prior to invitation of tender and should be incorporated in the tender document.**

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DETAILED SPECIFICATIONS

- **The "Water Absorption" tested as per IS:2386 Pt-III – 1963 following the procedure given in Annexure 3 should not be more than 1%. This test however, to be prescribed at the discretion of CE/CTE in open line and CAO/Con for construction projects.**
- **As per correction slip No 3 a new para 2.2.2.1 is added. Now CAO/CTE can permit relaxation upto 2.5% in water absorption for specified areas**

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DETAILED SPECIFICATIONS

- SIZE AND GRADATION: FULL RATE PAYMENT

– **Retained on 65mm sq. mesh sieve** - 5% Maximum

– **Retained 40mm sq.mesh sieve**

- **For machine crushed ballast :** 40% to 60%
- ***For hand broken ballast :*** *Not required, but the executive must ensure that the ballast is well graded between 65 mm and 20 mm sieve.*

– **Retained on 20mm sq.mesh sieve**

- Not less than 98% for machine crushed
- Not less than 95% for hand broken

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DETAILED SPECIFICATIONS

OVERSIZE BALLAST - Reduced Rate Payments

i) Retention on 65mm square mesh sieve

- A Maximum of 5% ballast retained on 65mm sieve shall be allowed without deduction in payment.
- In case ballast retained on 65mm sieve exceeds 5% but does not exceed 10%, payment at 5% reduction in contracted rate shall be made for the full stack.

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DETAILED SPECIFICATIONS

OVERSIZE BALLAST- Reduced Rate Payments

- **If ballast retained on 40mm square mesh sieve (machine crushed case only) > 60%, payment at the reduced rates shall be made for the full stack in addition to the reduction worked out above.**
    - **5% reduction in contracted rates if retention on 40mm sq. mesh sieve is between 60% (excluding) and 65% (including)**
    - **10% reduction in contracted rates if retention on 40mm sq. mesh sieve is between 65% (excluding) and 70% (including).**

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DETAILED SPECIFICATIONS

REJECTION OF BALLAST ON GRADATION ACCOUNT

- **OVERSIZE:**
  - When the ballast retained on 65 mm sieve > 10 %.
  - When the ballast retained on 40 mm sieve > 70 %.
- **UNDERSIZE:**
  - When the ballast retained on 40 mm sieve < 40 %.
  - **Machine Crushed Ballast:** When the ballast retained on 20 mm sieve < 98%.
  - **Hand Broken Ballast:** When the ballast retained on 20 mm sieve < 95%.

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DETAILED SPECIFICATIONS

METHOD OF SIEVE ANALYSIS

- **Sieve sizes are nominal sizes.**
- **The following tolerances shall be permitted:**

  65mm square mesh sieve Plus minus 1.5mm

  40mm Square Mesh Sieve Plus Minus 1.5mm

  20mm Square Mesh Sieve Plus Minus 1.0mm
- **Mesh size of the sieves should be checked before actual measurement.**
- **The screen shall not be less than 100cm in length, 70cm in breadth and 10cm in height on sides.**

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- Plate Thickness
  - 65 mm = 3 mm (+1.0 mm, -0.5mm)
  - 40 mm = 2 mm (± 0.5 mm)
  - 20 mm = 2 mm (± 0.5 mm)

- Pitch of Square Holes of the Sieve
  - 65 mm = 80 mm (+12 mm, -8.0 mm)
  - 40 mm = 50 mm (+7.5 mm, -5.0 mm)
  - 20 mm = 25 mm (+4.0 mm, -2.5 mm)

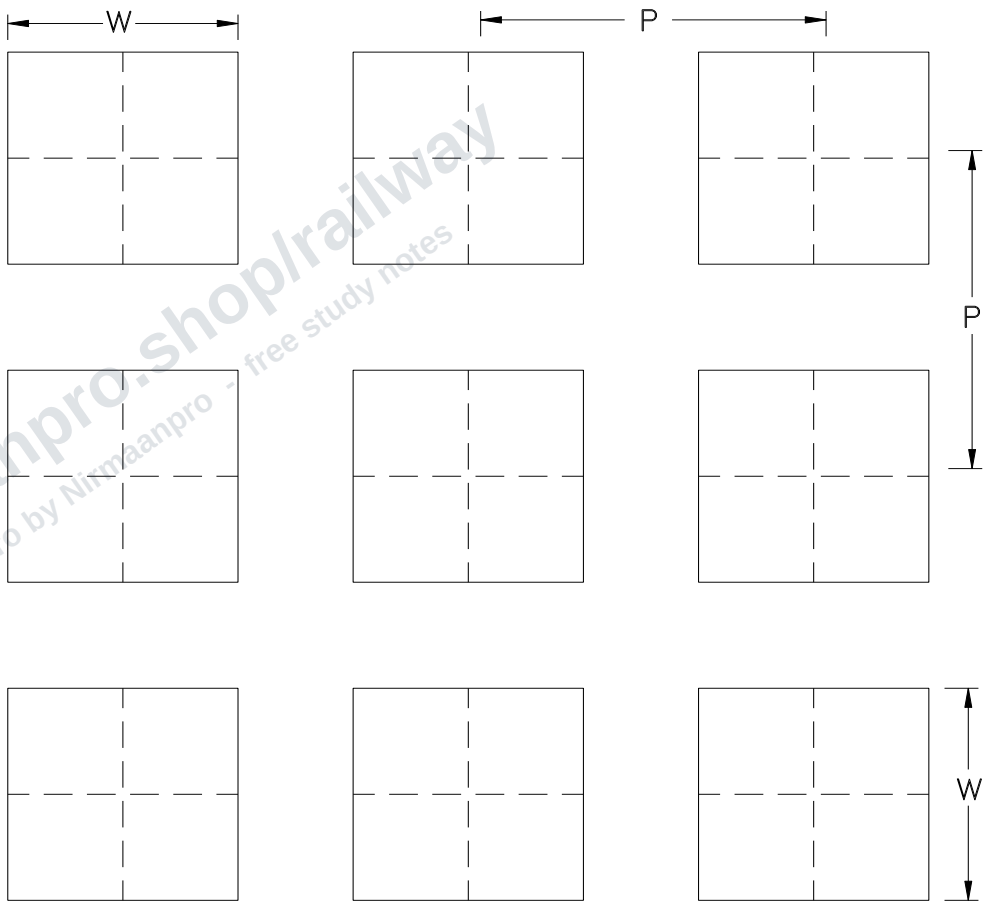
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Test Sieve



Sieve Analysis of Ballast- Specification of Test Sieve

- ✓ **Arrangement of Holes/Apertures** : The square holes/ apertures of size “W” in the perforated plate shall be arranged at Pitch “P” as per the sketch given below:



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Specification of Test Sieves (ANNEXURE-IV)

Sieve opening size, Pitch of openings and tolerances

Test Sieve of Square Mesh Size	W		P	
	Nominal Size	Tolerance	Distance	Tolerance
65 mm	65 mm	(±) 1.5 mm	80 mm	(+) 12.0 mm (-) 8.0 mm
40 mm	40 mm	(±) 1.5 mm	50 mm	(+) 7.5 mm (-) 5.0 mm
20 mm	20 mm	(±) 1.0 mm	25 mm	(+) 4.0 mm (-) 2.5 mm

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Specification of Test Sieves (ANNEXURE-IV)

Marking on test sieves: A label with following information:

(i) Nominal Aperture Size,

(ii) Material of perforated plate,

(iii) Material of sieve frame,

(iv) Maker's Name or Trademark, and

(v) An Identification Number for the sieve.

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DETAILED SPECIFICATIONS

METHOD OF SIEVE ANALYSIS

- **While carrying out sieve analysis, the screen shall not be kept inclined, but held horizontally and shaken vigorously.**

- **The pieces of ballast retained on the screen can be turned with hand to see if they pass through but should not be pushed through the sieve.**

- **The percentage passing through or retained on the sieve shall be determined by weight. Least count of weighing equipment shall not be > 100 gm.**

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DETAILED SPECIFICATIONS

CONDITIONS FOR SUBMISSION OF TENDER

- Each tenderer at the time of tendering shall submit **the test report of Impact Value, "Abrasion Value, Water Absorption Value from approved laboratories** and the list of these Laboratories shall be mentioned in the tender documents.

- The tenderer shall also furnish an undertaking as incorporated in the tender document that the ballast supply at all times will conform to Specifications for Track Ballast as specified by Railway.

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DETAILED SPECIFICATIONS

STACK MEASUREMENT

- **Stacking on a neat, plain, firm and well drained ground (to be done by railway)**
- **The height of stack shall not be less than 1 m (hilly areas - 0.5 m) but not more than 2.0 m.**
- **Top width shall not be less than 1 m.**
- **Top of stack shall be kept parallel to the ground plane.**
- **The side slopes should not be flatter than 1.5:1 (H : V).**
- **Cubical content of each stack shall normally be not less than 30 cum in plain areas and 15 cum in hilly areas.**

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DETAILED SPECIFICATIONS

WAGON MEASUREMENT

- A continuous white line should be painted inside the wagon
- The cubical content in cubic meter corresponding to white line should also be painted on both sides outside the wagon.
- In addition, short pieces of flats **with cubical contents punched** shall be welded at the centre of all the four sides as permanent reference.
- **In case the supply is taken in general service wagons, actual measurements will be taken.**

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DETAILED SPECIFICATIONS

SHRINKAGE ALLOWANCE

- **Payment shall be made for the gross measurements either in stacks or in wagons without any deduction for shrinkage/voids.**

- **When ballast supply is taken in wagons, shrinkage upto 8% shall be permitted at destination while verifying the booked quantities by the consignee.**

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SAMPLING AND TESTING

- CL-5.1.1 The samples shall be drawn with due diligence and adequate precaution so that they represent the true nature and condition of the ballast.
- 5.1.2 Being a heterogeneous material, the gradation of ballast loaded in wagons and/or dumped/inserted in the track may not remain same as that initially checked in stacks. Similarly in case of direct loading into wagons, the gradation at destination may not remain same as that at source, Therefore, the samples from wagons and track are not representative samples as far as gradation is concerned. Even in the same stack, results of two checks may not be same.
- 5.1.3 The samples from a stack taken after lapse of a long period of stacking are not representative samples of the ballast initially supplied in the stack, due to settling down of smaller size particles in voids underneath, dirt/dust getting accumulated in the stack, rains etc.

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SAMPLING AND TESTING

- 5.2 **Sampling Frequency**
- In order to ensure supply of uniform quality of ballast, the following norms shall be followed in respect of sampling, testing and acceptance:

- 5.2.1 On supply of the first 100 cum, the tests for Size & Gradation, Abrasion Value, Impact Value and Water Absorption (if prescribed) shall be carried out by Railway. Further supply shall be accepted only after this ballast satisfies the specifications for these tests. Railway reserves the right to terminate the contract as per GCC at this stage itself in case the ballast supply fails to conform with any of these specifications.

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SAMPLING AND TESTING

- CL-5.2.2 Subsequent test shall be carried out as follows:

- **Type of Tests**
- **Supply in Stacks**
- **Supply in Wagons**
- (a) Size and Gradation Tests
- One for each 100 cum or part thereof in any stack
- One for each 100 cum or part thereof for quantity to be loaded in wagons
- (b) Abrasion Value, Impact Value and Water Absorption Value (*)
- One Test for every 2000 cum
- (*) These tests shall be done for the purpose of monitoring quality during supply. In case of the test results not being as per the prescribed specifications at any stage, further supplies shall be suspended till suitable corrective action is taken and supplies ensured as per specifications.

- The above tests may be carried out more frequently, at the discretion of Railway.
- 5.2.3 All tests for Abrasion Value, Impact Value and Water Absorption should be got done through approved laboratories or Railway's own laboratories (list of these laboratories shall be mentioned in the tender document). These tests, subsequent to award of contract, shall be done at Railway's cost.
-

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CL-5.3 Supply of ballast in Stacks

CL-5.3.1 Sampling Procedure

- (i) Stack shall be kept in such a way that every part of the stack is accessible to the JCB or Power Equipment

- (ii) Ballast supply in stacks:

Three “Samples” each of 0.3-0.5 cum

one sample each from two sides and one sample from top after removing outer layer (150-200 mm) should be collected for every 100 cum or part thereof, by JCB/suitable Power Equipment.

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5.3 Supply of ballast in Stacks

(iii) The location (in plan) and depths of sampling points shall be varied for different "Samples" and different stacks in a lot.

(iv)"Gross Sample" should be prepared by thoroughly mixing the three "Samples"

- Note: For specific constraints, approval of Competent Authority (Engineer-in-charge) shall be taken prior to invitation of tender, for using manual means for collection and mixing of "Samples", and this should be incorporated in the Tender Document.

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5.3 Supply of ballast in Stacks

- (v) A “Test Sample” of volume 0.027 cum shall be taken

- (vi) Method for drawing “Test Sample”:The ballast in “Gross Sample” shall be scooped into a cone shaped pile by taking care to drop each scoopful exactly over the same spot.

- After the cone is formed, it shall be flattened by pressing the top of cone with a smooth surface. Then it is cut into quarters by two lines which intersect at right angles at the centre of the cone.

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5.3 Supply of ballast in Stacks

- The bulk of the sample is reduced by rejecting any two diagonally opposite quarters. The remaining ballast shall be mixed and “test sample” shall be drawn for testing. After drawing“ test sample”, the left over ballast of “Gross Sample” shall be dumped back in the stack.

- (vii)Use tarpaulin or any other suitable sheet may be used on a flat surface for mixing, drawing and sieve analysis of samples.

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5.3 Supply of ballast in Stacks

- 5.3.2 In case of stacks of volume more than 100 cum, more than one “Test Samples” will be tested for Gradation.
- The full payment/reduced payment for the whole stack, as given in Para 2.3 of the “Specifications for Track Ballast (IRS-GE-1, June-2004), shall be decided based on the average of the sieve analysis results of all the “Test Samples” for a stack.

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Sampling of ballast in Heaps for loading directly in Wagons

- Samples of ballast shall be collected from heaps of ballast proposed to be loaded into the wagons.
- ADEN in-charge shall decide the location of heaps from which sampling is to be done, judiciously covering the entire quantity of ballast to be loaded in the rake.
- Based on the approx. quantity of ballast to be loaded in the rake, methodology for sampling of ballast to be followed shall be the same as in Para-5.3.1and 5.3.2 above.

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Sampling Procedure

- Sufficient space around the stack to facilitated movement of JCB/other ballast handling equipment.
- Total 3 samples each of 0.3-0.5 CuM for each 100 CuM or part thereof. (sample collection by JCB / other ballast handling equipment.)
- One sample from top (after removing outer layer of 150-200 mm) &
- Two samples one each from sides

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- Location (in plan) & depth of sampling shall be varied for different samples & different stacks.
- Gross sample is prepared by thoroughly mixing the three samples collected as above, using JCB.
- Test sample of 0.027 CuM is drawn from each gross sample for carrying out size and gradation analysis.

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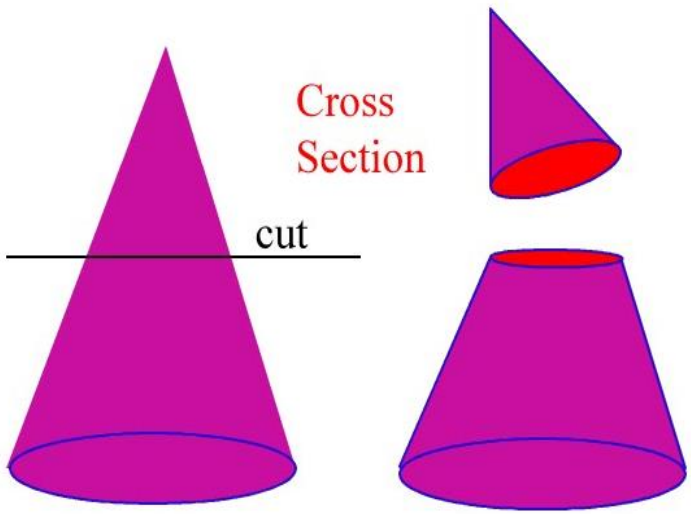
Preparation of test sample.



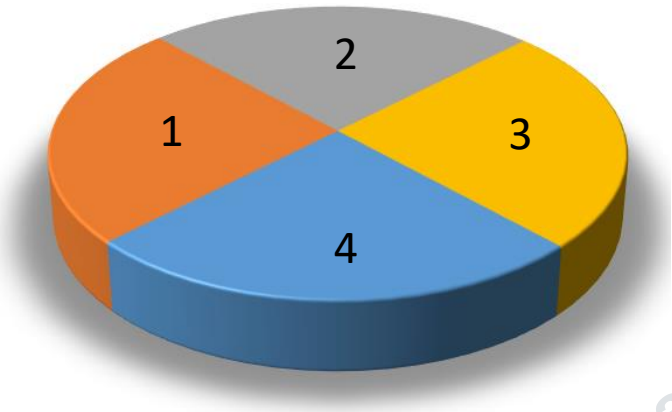
- Ballast from gross sample is scooped into cone shaped pyramid.
- After formation of cone, it is flattened by pressing the top with a smooth surface.

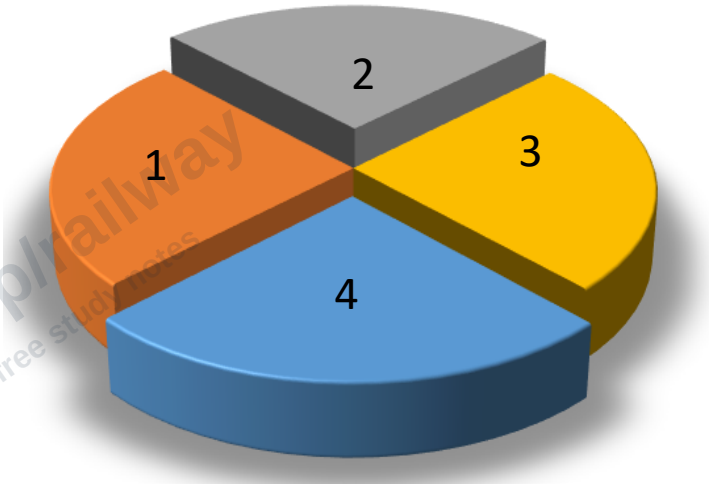
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- The heap is cut into quarter
- by two lines at right angles
- at the center of cone.



- Out of 4 quarter samples, any two diagonally opposite samples are removed away and remaining two qtr samples are mixed which is treated as test sample for
further carrying out size and gradation test





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- After drawing test sample, left over ballast is dumped back into the stack.

DETAILED SPECIFICATIONS

- Subsequent tests :

	Supply in stack		Supply in wagons
	For stack of volume less than 100cum	For stack volume more than 100cum	
a) Size and Gradation Tests			
- No of Tests	One for each stack	One for each stack	Every 100 cum
- Size of one sample	** 0.027 cum	**<u>** 0.027 cum for every 100cum or part thereof</u>	** 0.027 cum
b) Abrasion Value Impact Value & Water Absorption test @	<u>One test for every 2000 cum</u>		

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DETAILED SPECIFICATIONS

** Sample should be collected using a wooden box 0.3mx0.3mx0.3m from different parts of the stack/wagon.

@ These tests shall be done for the purpose of monitoring quality during supply – further supply can be suspended in case of non-conformation.

- The above tests may be carried out more frequently, if warranted at the discretion of Railway
- All tests for abrasion value Impact value and water absorption conducted subsequently to award of contract **shall be done at Railways' cost.**

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Qty of Ballast required for B.G. Single line LWR track

Type of Sleeper	Depth of Ballast cushion In mm	Approx Qty of Ballast in cum/meter (Straight track)	Approx Qty of Ballast in cum/meter (Curved track)
PSC	250	2.030	2.120
PSC	300	2.304	2.401
PSC	350	2.585	2.690

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Qty of Ballast required for B.G. Single line other than LWR

Type of Sleeper	Depth of Ballast cushion In mm	Approx Qty of Ballast in cum/meter (Straight track)	Approx Qty of Ballast in cum/meter (Curved track)
PSC	250	1.769	1.820
PSC	300	2.022	2.078
PSC	350	2.282	2.344

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App. Qty of Ballast required for P & C (B.G.)

Sr. No	Angle of crossing	Type of sleepers	Ballast cushion	Qty of ballast in cum
1	1 in 8-1/2	PSC	300 mm	79.14
2	1 in 12	PSC	300 mm	113.97

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Minimum depth of Ballast Cushion on B.G.

Track Renewal i.e. CTR and TSR	300 mm *
Doubling , Gauge conversion and New Line construction	350 mm
Loop Lines	250 mm
* Where possible, a depth of 350 mm depth may be provided	

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Assessment of Ballast Requirements–

1. The requirement of ballast shall be assessed separately for
   - Making good the deficiencies as existing in track,
   - Making good deficiencies arising out of overhauling, through packing/tamping and deep screening,
   - For providing adequate cushion in the case of mechanical tamping,
   - For providing extra cushion/profile for converting into LWR or up-gradation of track structure for higher axle load.

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Assessment of Ballast Requirements–

2. The ballast required for maintenance purposes shall be estimated by assessing the quantity approximately if necessary, by a survey, over a rail length in every 1 km. Care should be taken that the cores under the sleepers are not disturbed.

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Assessment of Ballast Requirements–

3. In case of deep screening, assessment of ballast required for recoupment and providing standard section should be made by deep screening the ballast section to the full depth in a rail length for two to three sleepers at every 0.5 to 1 km. In this case screening is done under the sleepers as well.

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Assessment of Ballast Requirements–

- The quantities assessed vide *Sub-Para* above will be the net quantities of ballast required to recoup the deficiencies to provide required profile / sections. The above net quantities may be enhanced suitably (say 8%) to arrive at gross quantities of ballast for the purpose of procurement action in case measurements are proposed to be taken in stacks or in wagons at originating station.

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Formation profile for bank and cutting including side and catch water drains

Periods 2

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FORMATION









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Formation

- The prepared flat surface or platform, which is ready to receive the ballast, sleepers, and rails, is called the formation.
- It is important constituent of the track as it supports the entire track structure.
- Formation consists of the layers comprising blanket, sub-grade , and embankment fill.

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General Description of formation

- Prepared either by doing additional earth work over the existing ground or by excavating existing surface and making cutting.
- Can be either in the shape of embankment or a cutting.
- Height of formation depends upon the ground contours and the gradient adopted.
- The side slopes depends upon the shearing strength of soil.
- The width of the formation depends upon the number of tracks to be laid & gauge of track.

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Types of Formation

- Embankment
- Cutting

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EMBANKMENT

- That part of the Railway land where originally ground is low, subsequently raised by earth work to give the adjacent level which was decided during the survey.
- Side slope of the embankment is 2:1 (Horizontal : Vertical)

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CUTTING

- That part of the Railway land where originally ground is high, subsequently lowered by earth cutting to give the adjacent level which was decided during the survey.
- Side slope of the cutting is 2:1 or even steeper in case of rock.
- Catch water drain to be provided in the top cutting wall and Side drain to be provided to the side of the track to ensure smooth flow of water.

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Functions of Formation

- To provide a smooth and uniform bed for laying the track.
- To bear the load transmitted to it from the moving load through the ballast.
- To facilitate drainage.
- To provide stability to the track.

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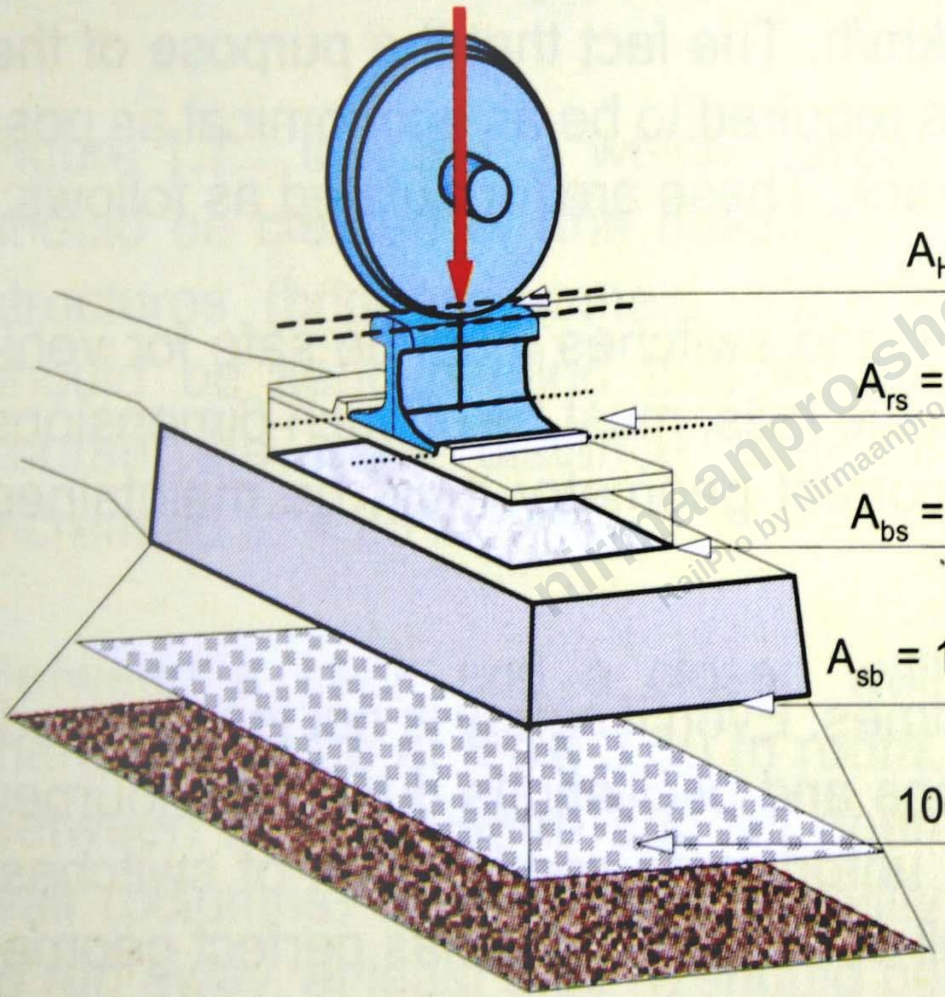
DISTRIBUTION OF STRESSES

- From Rail wheel contact stresses of the order of 10,000 Kg/cm^2 to Ballast blanket contact stresses of the order of 0.5 Kg/cm^2 i.e. at the top of the formation

- AIM – To have a formation which is able to take repetitive load without distress

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Stress Distribution



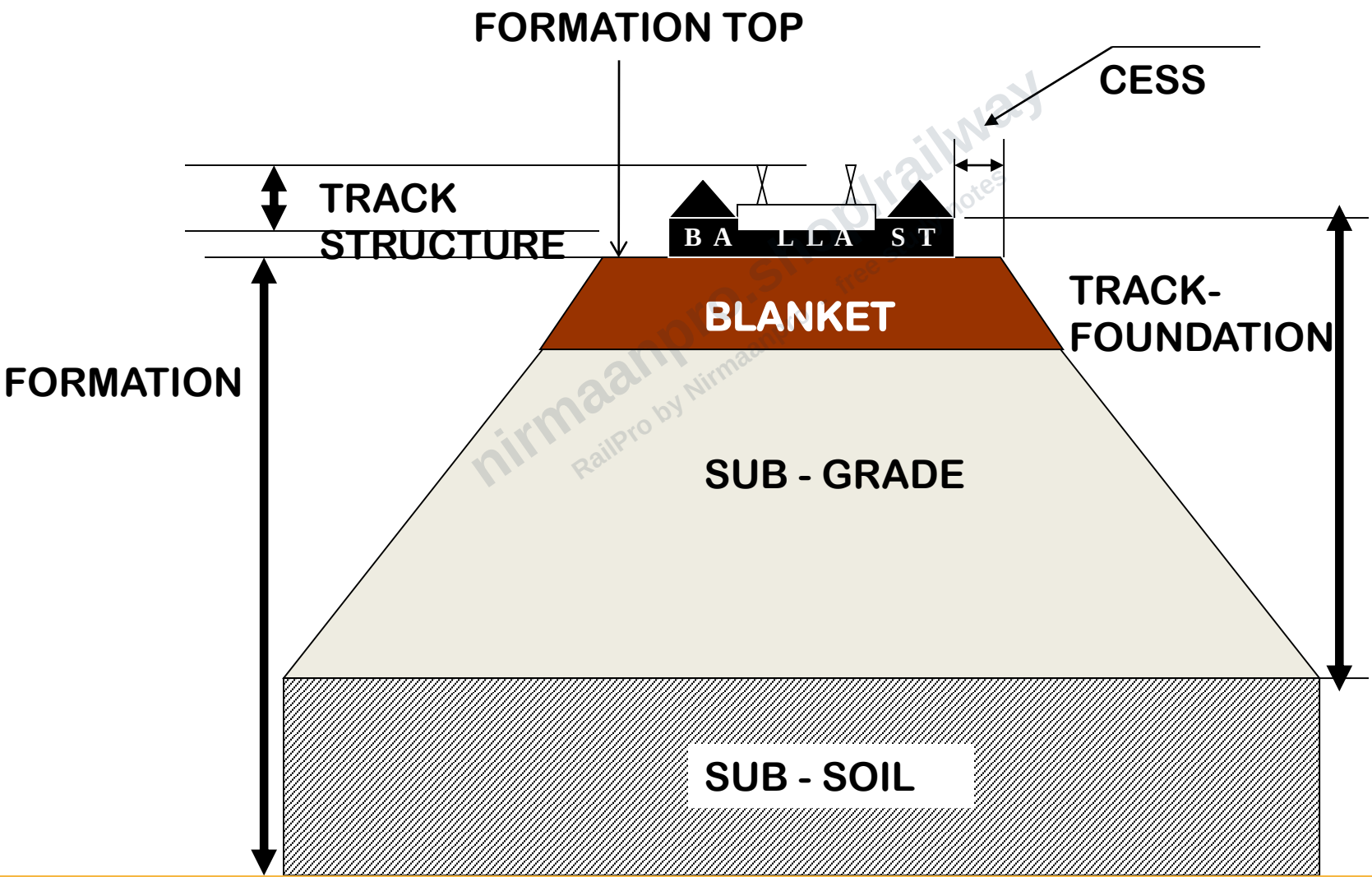
Axle: P = 200 kN

Wheel: Q = 100 kN

area	level	Mean stress (under rail 50 %)
A_H = 1 cm²	Wheel/rail	σ_H = 100000 N/cm²
A_{rs} = 200 cm²	Rail/rail pad /baseplate	σ_{rs} = 250 N/cm²
A_{bs} = 750 cm²	Baseplate /sleeper	σ_{bs} = 70 N/cm²
A_{sb} = 1500 cm²	Sleeper /ballastbed	σ_{sb} = 30 N/cm²
10000 cm²	Ballastbed /substructure	σ = 5 N/cm²

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Components of formation



- **Track Foundation**

  Constitutes ballast, sub-ballast, blanket and sub-grade, which is placed / exist below track structure to transmit load to subsoil.
- **Formation Top**

  Boundary (interface) between ballast and top of blanket or sub-grade (where blanket layer is not provided).
- **Formation-Width**

  It is the distance between the edges of the prepared surface.
- **Cess**

  Portion at top of formation level, extends from toe of ballast to edge of formation.
- **Ballast**

  Crushed stones with desired specifications placed directly below the sleepers.

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- **Sub-Soil**

  It is the soil immediately under the natural ground level.
- **Sub-Grade**

  It is the upper part of embankment/cutting provided above subsoil by borrowed soil of suitable quality up to bottom of blanket/ballast.

  For embankment, sub-grade may be of imported soil whereas in cuttings it is the naturally occurring soil of sufficient strength.
- **Prepared Sub-grade**

  The upper part of the sub-grade is formed into a prepared Sub-grade layer, which normally has a cross-fall.
- **Side-Slope**

  It is the inclined surface of an embankment on cutting.

- **Sub-ballast**

  Sub-ballast is a layer of coarse-grained material provided between blanket/sub-grade and ballast and confined to width of ballast section only.
- To reduce the effect of loads transmitted to formation through ballast and
- To guard against the possibility of ballast penetration into the formation.
- It is desirable to provide a sub-ballast of 15cm depth below the ballast layer.
- The need to provide this sub-ballast may be decided by Chief Engineer (Const.) in-charge of the project".

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- **Blanket**

  Blanket is a layer of specified coarse, granular material of designed thickness provided over full width of formation between sub-grade and ballast.
- Blanket may be required over the formation where
- The soil is of poor quality,
- Rainfall is heavy and
- Traffic density is high.
- The absence of blanket in such cases can lead to problems in service, such as swelling or heaving of formation.

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- **Blanket**

  Whether the blanket should be provided in a particular length and if so, its thickness (which should not be less than 30cm) should be decided by the Chief Engineer (Const.), in-charge of the project, duly taking into account the type of soil, rainfall and density of traffic and other factors relevant to the site conditions.

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- **Functions :** A blanket/sub-ballast layer fulfil following important functions :
- **Primary Function :**

  Stress Reduction Function - It reduces the traffic induced stresses on top of sub-grade to a tolerable limit. This function must be fulfilled to avoid track foundation failures.
- **Secondary Function :**
- **Separation Function :** It prevents penetration of ballast into sub-grade and also prevents upward migration of fine particles from sub-grade into ballast.

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- **Drainage Function :** It should intercept water coming from ballast away from sub-grade and at the same time, prevent drainage of water that is flowing upward from the sub-grade.
- **Prevention of Mud Pumping :** It prevents mud pumping by checking attrition of sub-grade particles by ballast.

  The quality of blanket material should be such that it is able to carry out the above functions satisfactorily

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Action for Smooth and uniform bed and to bear the load transmitted

Preparation of Natural ground

Compaction of filled up material

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Action for Smooth and uniform bed and to bear the load transmitted

Preparation of Natural ground

Site should be cleared properly for full formation width at Ground level plus one metre.
Then dressed and leveled. Depressions be filled with suitable soil duly compacted.
Benching should be provided on ground having steep slope.
In conversion/doubling, suitable benching of existing slope should be done to provide proper bonding between old and new earthworks.

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Action for Smooth and uniform bed and to bear the load transmitted

Compaction

To produce a soil mass with controlled or improved engineering properties.

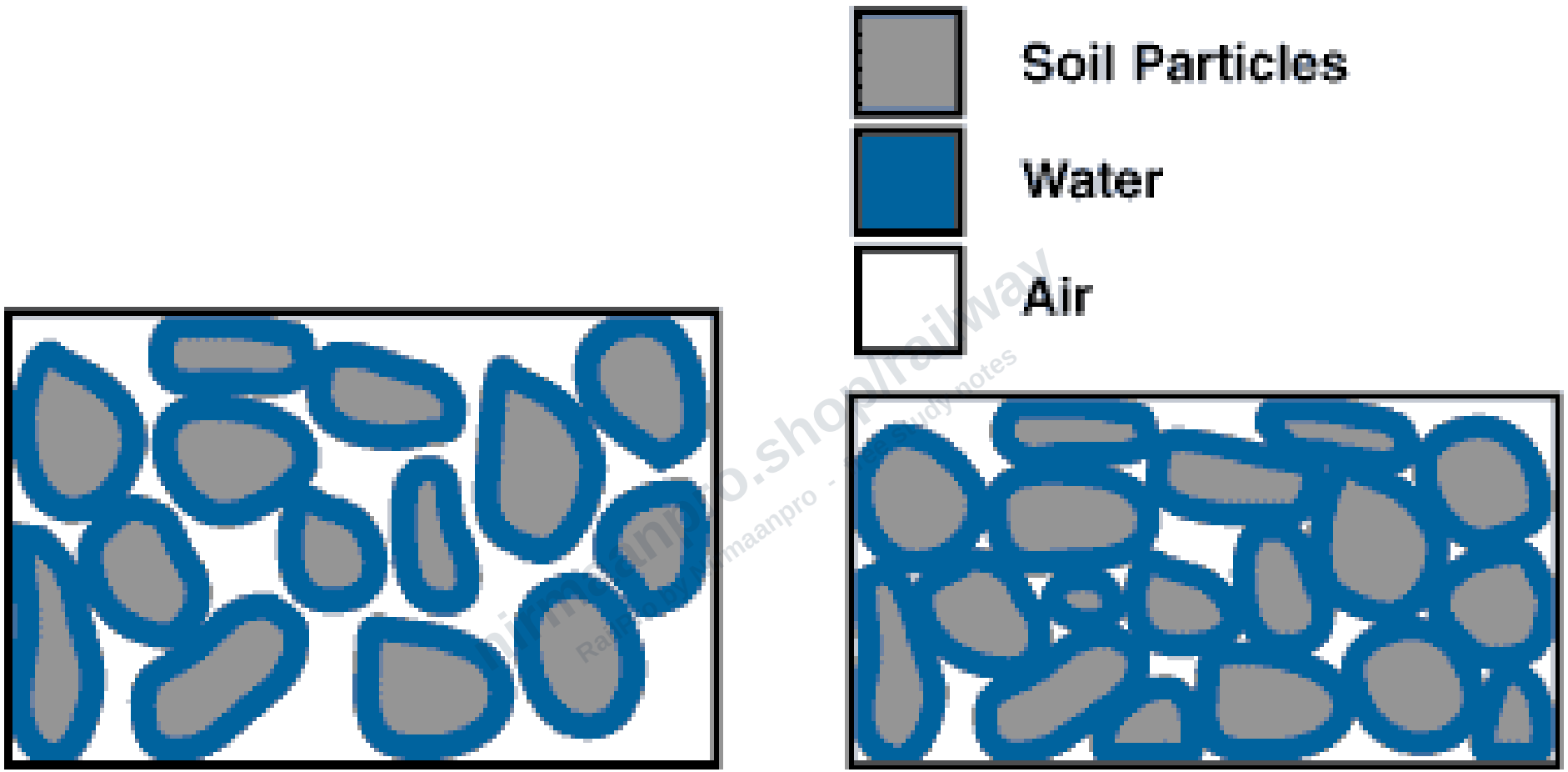
The water acts as lubricant and a closer packing of soil grains is obtained by the expulsion of air from the voids.

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Compaction of filled up material

- **Process of increasing "Density of Soil" by mechanical means, by packing the soil particles closer together (by expelling air from the voids) to obtain a homogeneous soil mass having improved soil properties .**

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Factors affecting Compaction in Field

- Compacting effort
- Moisture control
- Soil type
- Thickness of layer
- Number of passes
- Compaction equipments

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Compacting Effort

- Types of machinery required are decided based on type of soil to be compacted.
- Compaction is primarily of four types:
  - Static compaction,
  - Dynamic or Impact compaction
  - Vibratory compaction and,
  - Kneading compaction.

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Moisture Control

Maximum density with minimum compacting effort can be achieved by compaction of soil near its OMC (Optimum Moisture Content).

Soil Type

- Normally, clays and silts (fine grained soils) offer higher resistance to compaction.
- Sandy soils or Gravelly soils (coarse grained soils) are amenable for easy compaction.
- Coarse grained soils yield higher densities in comparison to clay.
- A well-graded soil can be compacted to higher density.

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Thickness of Layer

- Depends upon type of soil involved and type of roller, its weight and contact pressure of its drums.
- Decided on the basis of Field Compaction Trials. Normally, 200 – 300 mm is optimum in field for achieving homogenous compaction.

Number of Roller Passes

- Density of soil increases with the number of passes but after optimum number of passes, further increase in density is insignificant for additional number of passes.
- Determined by Field Compaction Trials. **Keep moisture content near OMC(OMC±2%) at the time of compaction.**

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Moisture control

Keep moisture content near OMC (OMC ± 2%) at the time of compaction.

Compaction Equipments

For Suitable type of Compaction Equipment, Number of Passes and Maximum thickness of Layers

For different Type of Soils
Refer to Annexure-4 of RDSO Guidelines GE:G-1 (July'2003)

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Smooth Wheeled Rollers

- Self-propelled or Towed, Weight 2 – 20 T.
- Suitable for: Well Graded Sands and Gravels, Silts and Clays of low plasticity.
- Unsuitable for: Uniform Sands, Silty Sands and Soft Clay.





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Vibratory Roller

- Range from “Hand guided” to “Larger roller”.
- Suitable for: Most soils with low to moderate fines content.
- Unsuitable for: Large volume of work and wet clayey soil.



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Pneumatic Tyred Roller

- Usually a container on two axles.
- Wheels aligned to give a full-width rolled surface.
- Dead loads added to give masses of 12-40 T.
- Suitable for: most coarse and fine soils.
- Unsuitable for: very soft clay & highly variable soil.





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Sheep Foot Roller

- Also known as a 'tamping roller'.
- Self propelled or towed units, with hollow drum fitted with projecting club-shaped 'feet'.
- Weight: 5-8 T.
- Suitable for: fine grained soils/sands/gravels, with >20% fines.
- Unsuitable for: very coarse soils & uniform gravels.





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Impact Roller

- Introduces energy to ground surface in quick succession, around two impacts per second.
- By doing this in a rolling action at around 10 kmph, large areas can be treated quickly.
- Useful for Bulk earthworks. Compacting in 1m lifts up to 2 to 3 m depth at 10 kmph.



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Grid Roller

- Towed units with rolls of 30-50 mm bars, with spaces between of 90-100 mm.
- Weight: 5-12 T.
- Suitable for: well-graded sands; soft rocks; stony soils with fine fractions.
- Unsuitable for: uniform sands; silty sands; very soft clays.



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Vibrating Plate for Slope Compaction

- Range from “hand-guided” to “large machine” .
- Suitable for: most soils with low to moderate fines content.
- Unsuitable for: large volume work; wet clayey soils.





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Slope Vibratory Roller





- Available in weight of 5.5 T to 17.0 T
- Drum width: 900 to 1300 mm
- Vibrations: 1300 to 2000 vib/min

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STABLE RAILWAY FORMATION

- Stable formation – Should retain the track geometry under anticipated traffic densities and axle loads during service under most adverse conditions of operations and weather.

- Should be structurally sound and the settlements should be within limits.

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Function of effective Drainage

- Rain water during monsoon is main enemy in damaging banks / cuttings So effective drainage is most important to safeguard formations from failure.
- Flow of water contaminate ballast, also erodes formations. It should not be allowed along the track .
- Drainage system should be efficient enough to prevent stagnation and allow quick disposal of water.
- Effectiveness depends on size of drain, permeability.

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REFERENCE FOR MORE INFORMATION

- RDSO Guidelines for Earthwork in Railway Projects Guideline No: GE-1 July- 2003.
- RDSO Guidelines and Specifications for Design of Formation for Heavy Axle Load No.GE : 0014 Nov - 2009
- RDSO Specification No: RDSO/2018/GE:IRS-004(D) Part-IV " Rationalization of Formation layer thickness on Indian Railway Track – Issued on 25.07.2019.
- RDSO Specification No: RDSO/2018/GE: IRS-004(D) Part-I " Specification of Non Woven Geo-textile to be issued as Separator/filtration in Railway Formation" – Issued on March 2019.

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REFERENCE FOR MORE INFORMATION

RDSO Specification No: RDSO/2018/GE: IRS-004(D) Part-II Issued on - March 2019. “Specification of Geo-composite Drain to be used at the base of Embankment” for Railway Formation.

RDSO Specification No: RDSO/2018/GE:IRS-006 Issued on - March 2019. “Specification of Geo-composite Drain to be used behind Bridge abutment/Retaining wall”.

RDSO Specification No: RDSO/2018/GE:IRS-004(D) Part-III Issued on - February 2020. “Specification for Geo-grid to be used as Reinforcement/Stabilization for Railway Formation”.

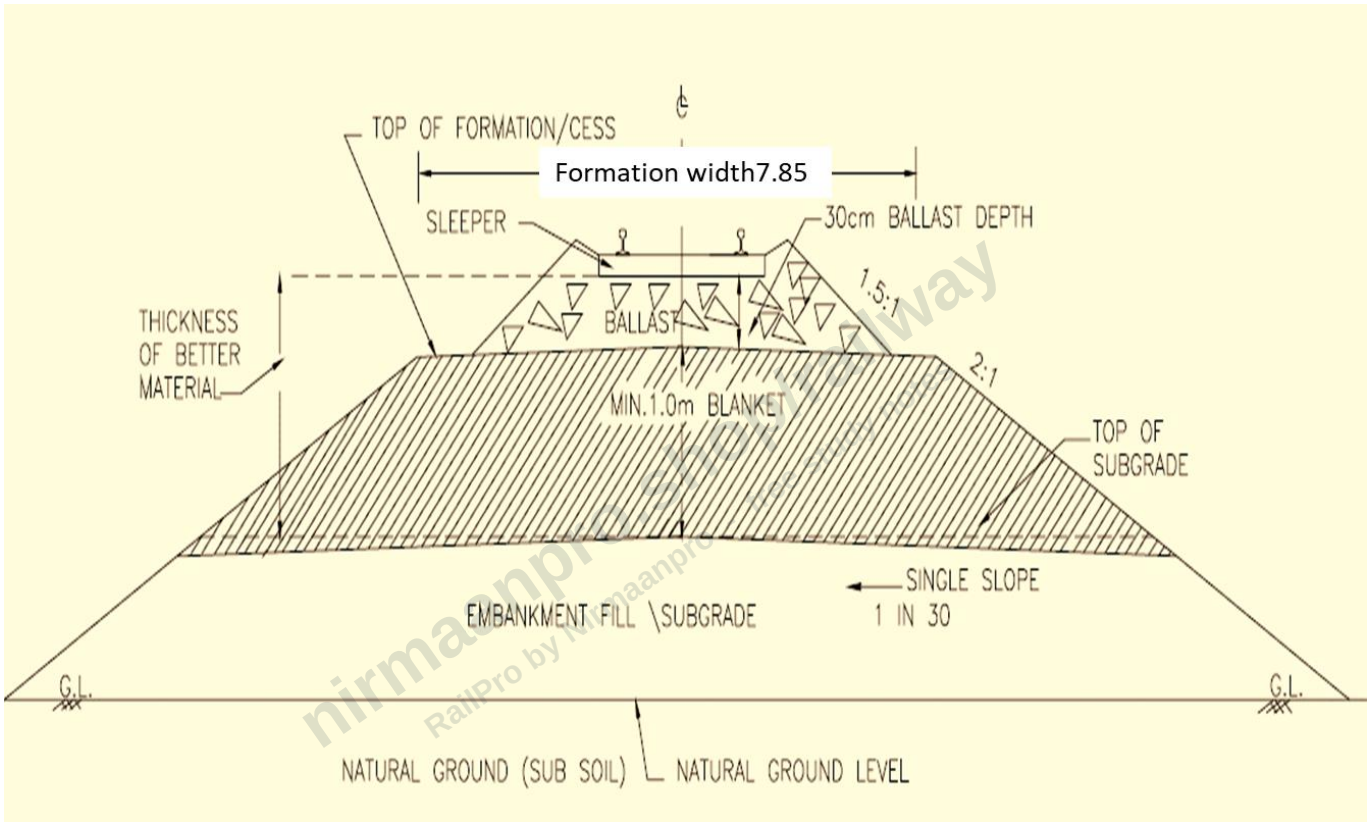
RDSO Specification No: RDSO/2007/GE:G-0008 Issued on - February 2007. “ Guidelines for application of Jute Geo-textile in Railway Embankments and Hill slopes ”.

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6.2 Formation profile for bank and cutting including side and catch water drains

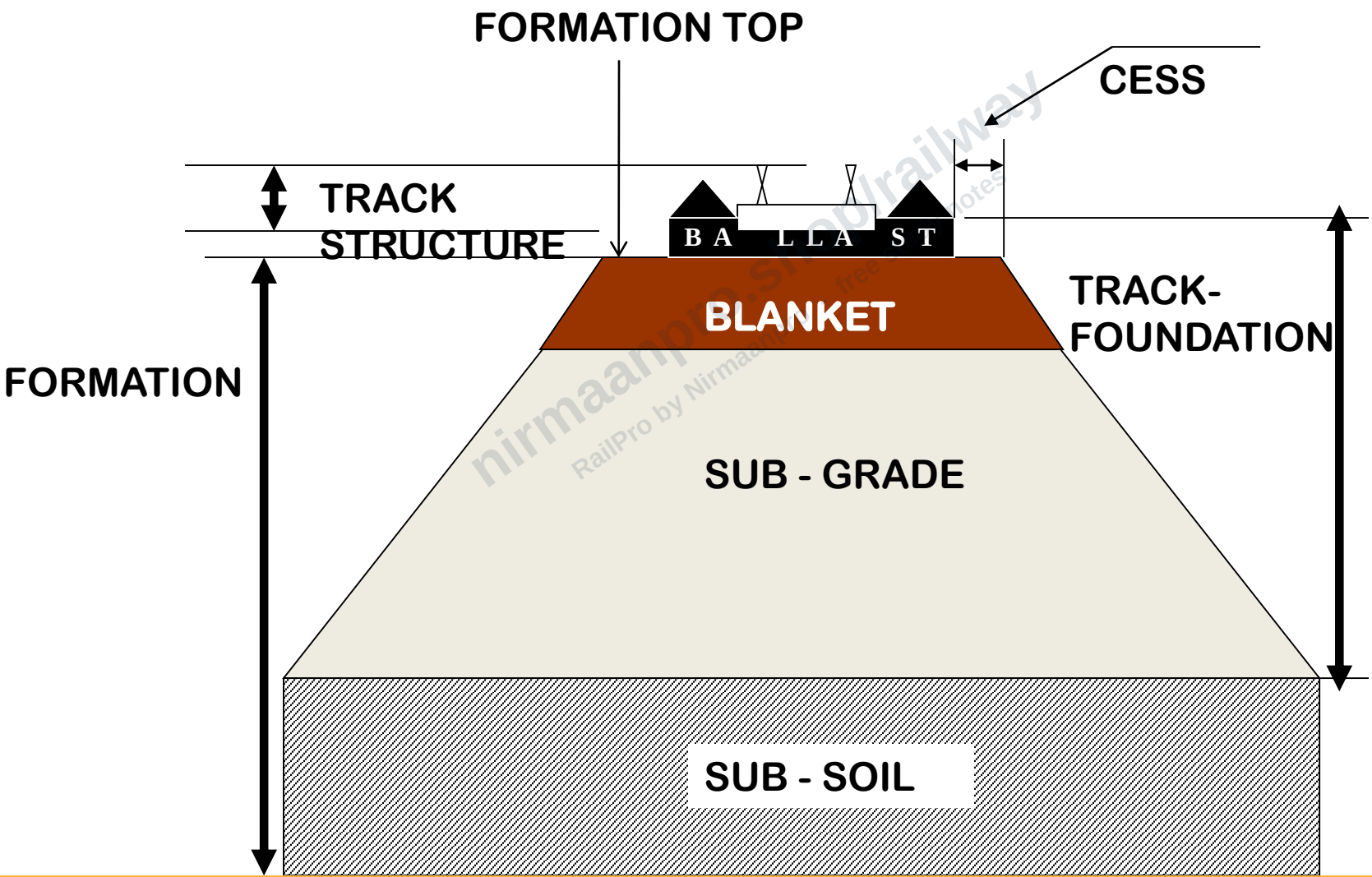
Periods 2

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BG TRACK SHOWING NOMENCLATURE OF DIFFERENT ITEMS GE G1 AND IRPWM

Formation profile



- **Formation component**

  Formation Top

  Boundary (interface) between ballast and top of blanket or sub-grade (where blanket layer is not provided).

- **Formation-Width**

  It is the distance between the edges of the prepared surface.

- **Cess**

  Portion at top of formation level, extends from toe of ballast to edge of formation.

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- **Sub-Soil**

  It is the soil immediately under the natural ground level.
- **Sub-Grade**

  It is the upper part of embankment/cutting provided above subsoil by borrowed soil of suitable quality up to bottom of blanket/ballast.

  For embankment, sub-grade may be of imported soil whereas in cuttings it is the naturally occurring soil of sufficient strength.
- **Prepared Sub-grade**

  The upper part of the sub-grade is formed into a prepared Sub-grade layer, which normally has a cross-fall.
- **Side-Slope**

  It is the inclined surface of an embankment on cutting.

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Top Width of Formation

It should be adequate enough to accommodate track laid with concrete sleepers and standard ballast section and have minimum 900mm cess width on either side.

- **Factors Governing Formation Width**
- Length of Sleeper , Cess Width, Side Slope of Ballast

  Angle of Repose –45^0 for Crushed Stone

  During service-Flatter (1:5 to 1:75)

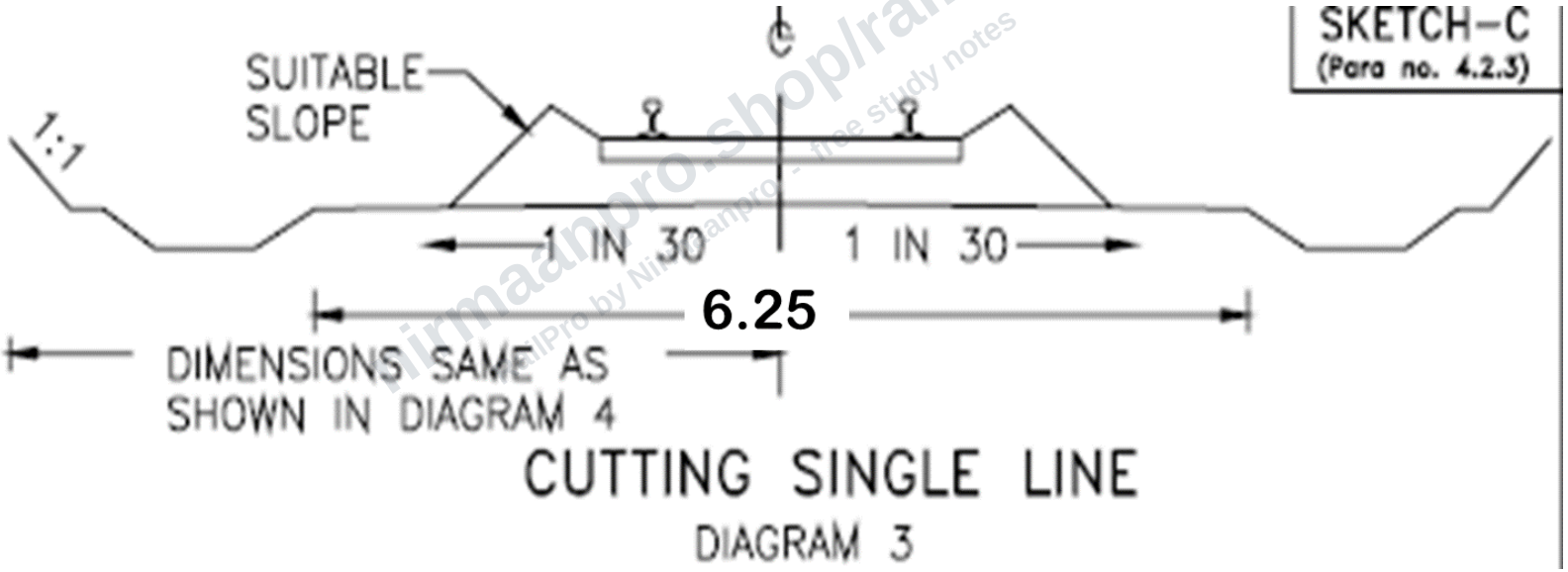
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Formation top width	Single line		Double line	
	Embankment	Cutting	Embankment	Cutting
Earlier width	6.85	6.25	12.16	11.55
Current width	7.85		13.16	

- **Additional Width** of formation will have to be provided to cater for increase in extra ballast on out side of curves and extra clearance required on double line on account of super-elevation etc.
- As per GE-14 recommended formation top width for Heavy Axle Load Track is 8.5 m for single line and 8.5 m plus distance between track centers for double line section, and for DFC shall be minimum 13.5 m.

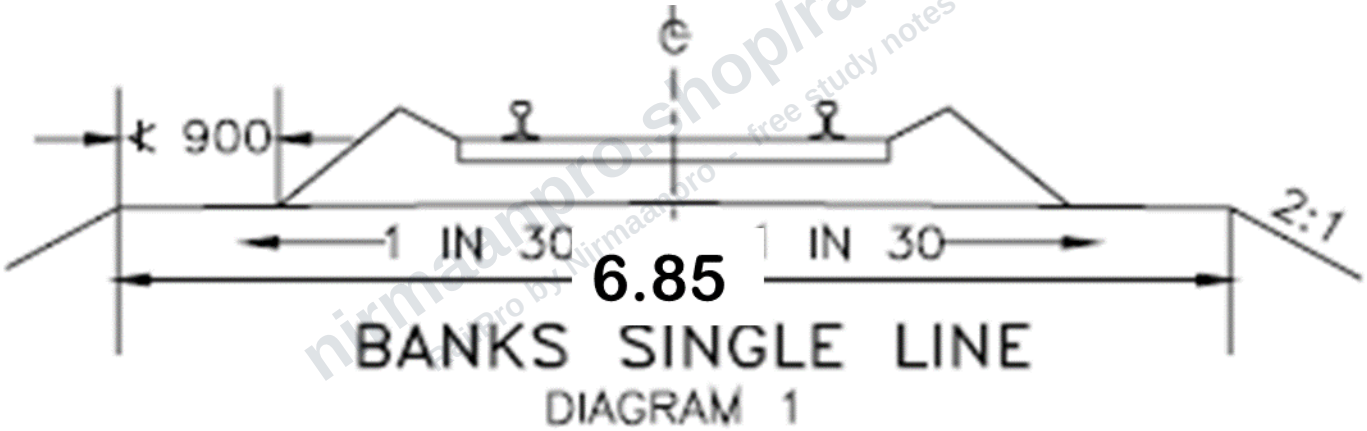
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Min Recommended Formation Width For Concrete Sleeper Track as per GE-1 (single line in cutting)



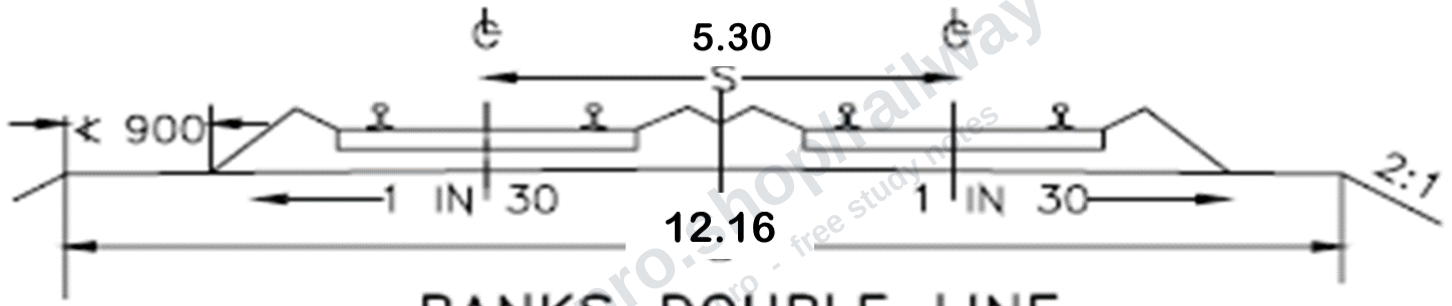
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Min Recommended Formation Width For Concrete Sleeper Track as per GE-1 (single line track in embankment)



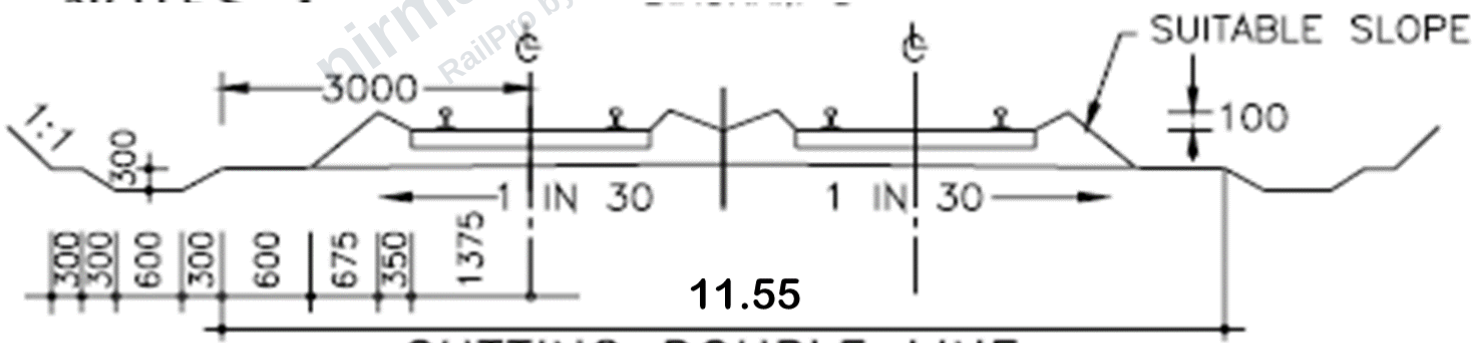
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Min Recommended Formation Width For Concrete Sleeper Track as per GE-1 (Double line track)



BANKS DOUBLE LINE

DIAGRAM 2

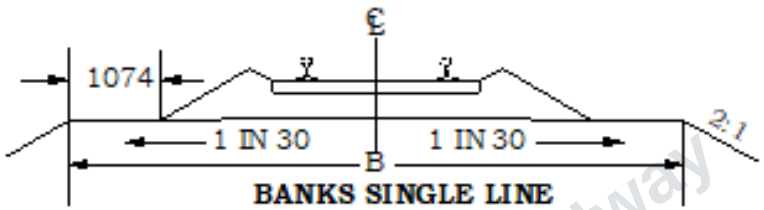


CUTTING DOUBLE LINE

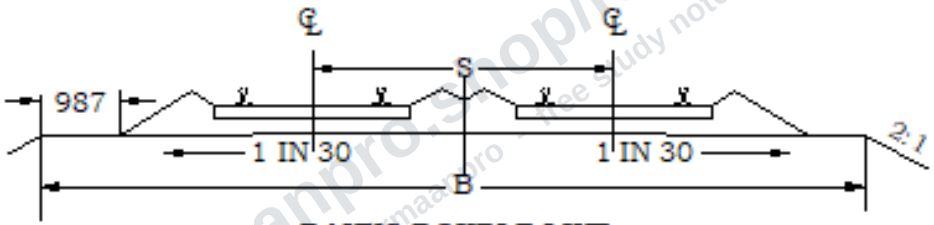
DIAGRAM 4

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Formation width for concrete sleepers as per GE-14



BANKS SINGLE LINE
DIAGRAM 1

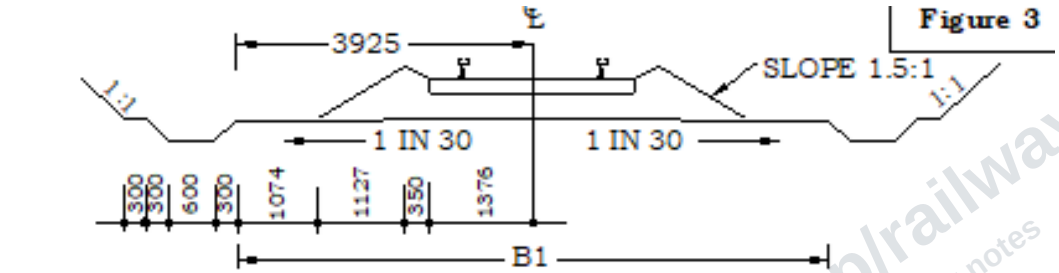


BANKS DOUBLE LINE
DIAGRAM 2

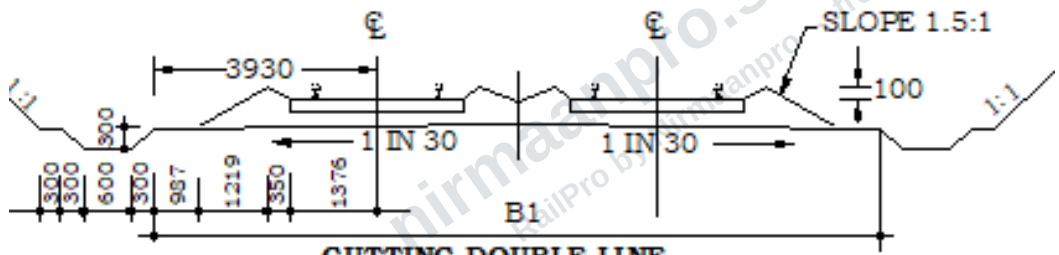
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GAUGE	MINIMUM FORMATION WIDTHS			
	IN BANKS (B)		(B1)	
	SINGLE LINE	DOUBLE LINE	SINGLE LINE	DOUBLE LINE
BG 1676 (for existing lines)	6.85m	12.16m	6.25m	11.55m
BG 1676 (for all doublings, gauge conversions & new lines)	7.85m	13.16m	7.85m	13.16m
MG 1000	5.85m	9.81m	5.25m	9.21m

Formation width for concrete sleepers as per GE-14



CUTTING SINGLE LINE
DIAGRAM 3



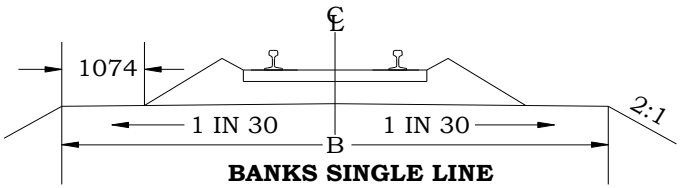
CUTTING DOUBLE LINE
DIAGRAM 4

GAUGE	MINIMUM FORMATION WIDTHS			
	IN BANKS (B)		(B1)	
	SINGLE LINE	DOUBLE LINE	SINGLE LINE	DOUBLE LINE
BG 1676 (for existing lines)	6.85m	12.16m	6.25m	11.55m
BG 1676 (for all doublings, gauge conversions & new lines)	7.85m	13.16m	7.85m	13.16m
MG 1000	5.85m	9.81m	5.25m	9.21m

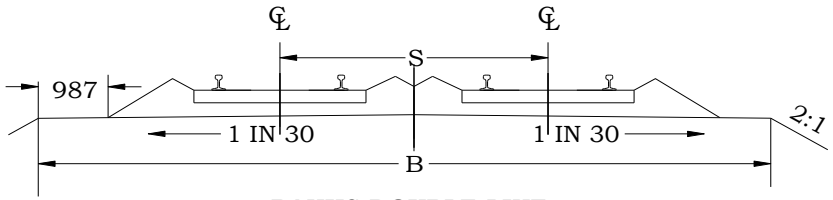
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Formation width as per GE-14

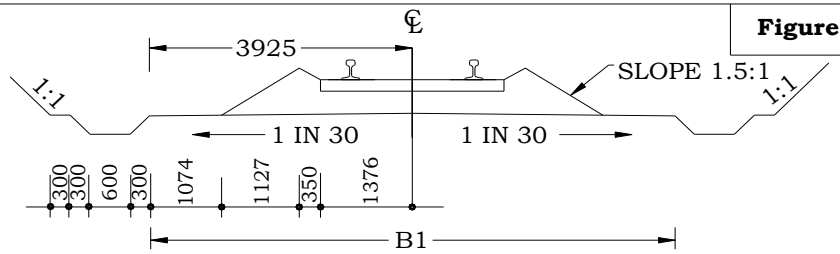
Figure 3



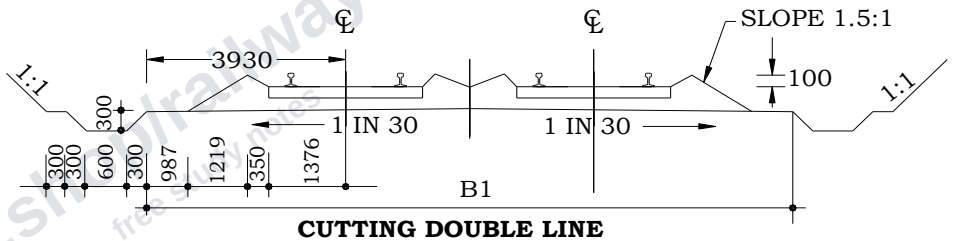
BANKS SINGLE LINE
DIAGRAM 1



BANKS DOUBLE LINE
DIAGRAM 2



CUTTING SINGLE LINE
DIAGRAM 3



CUTTING DOUBLE LINE
DIAGRAM 4

NOTES:

1. ALL DIMENSIONS SHOWN IN THE DIAGRAMS ARE IN mm.
2. ON BG AND MG DOUBLE LINES, THE MINIMUM FORMATION WIDTH IS BASED ON DISTANCE (S) BETWEEN TRACK CENTRES OF 5.30m AND 3.96m RESPECTIVELY.
3. IN FLAT TERRAINS THE HEIGHT OF BANK/DEPTH OF CUTTINGS SHOULD PREFERABLY BE NOT LESS THAN 1m FOR ENSURING GOOD DRAINAGE, FORMATION STABILITY AND TO AVOID TRESSPASSING.
4. THESE DIMENSIONS ARE BASED ON A BALLAST CUSHION OF 35cm.
5. THESE DIMENSIONS ARE ALSO APPLICABLE IN CASE OF ALL NEW LINES BECAUSE OF THE POSSIBILITY OF USE OF CONCRETE SLEEPER AT A LATER DATE.
6. ON CURVES THE FOLLOWING INCREASE IN FORMATION WIDTHS SHALL BE MADE:-
   (1) FOR EXTRA BALLAST CUSHION ON OUTERSIDE OF THE CURVE 0.15m ON SINGLE LINE AND 0.30m ON DOUBLE LINE (INCLUDING 0.15m INCREASE IN TRACK CENTRES).
   (2) FOR EXTRA CLEARANCE REQUIRED ON DOUBLE LINE DUE TO EFFECT OF SUPER-ELEVATION ETC. AS STIPULATED IN APPENDIX TO THE SCHEDULE OF DIMENSIONS FOR BG./MG.
7. FORMATION WIDTH HAS BEEN CALCULATED ASSUMING A BALLAST SIDE SLOPE OF 1.5:1.
8. WIDTH OF CUTTING WILL HAVE TO BE ADEQUATELY INCREASED TO ACCOMODATE DESIGNED FILL OF BLANKET MATERIAL.

GAUGE	MINIMUM FORMATION WIDTHS			
	IN BANKS (B)		(B1)	
	SINGLE LINE	DOUBLE LINE	SINGLE LINE	DOUBLE LINE
BG 1676 (for existing lines)	6.85m	12.16m	6.25m	11.55m
BG 1676 (for all doublings, gauge conversions & new lines)	7.85m	13.16m	7.85m	13.16m
MG 1000	5.85m	9.81m	5.25m	9.21m

NOT TO SCALE

Research Designs & Standards Organisation

GUIDELINES FOR EARTHWORK IN RLY. PROJECTS

MINIMUM RECOMMENDED FORMATION WIDTHS FOR BANKS/CUTTINGS FOR CONCRETE SLEEPER TRACK

DRG.NO: GE/SK/GL/128/Rev.2/2015

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Side Slope of Formation

- Characteristics of Fill Material and Sub-soil – Design Aspect
- Side slopes of High Embankment and Cuttings should be analyzed & designed in detail with realistic soil parameters and drainage conditions, using standard method of slope stability analysis/ software.
- Not to be Steeper than 2H:1V
  - Semi-mechanized System of Maintenance
  - Surface Water Run off – Erosion
- Slopes of 2:1 of embankment up to height of 6.0 mts would be safe for most of the soils.
- Sub bank to be provided after every 6mts height of bank and side slope to be not less than 2.3H:1V

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SKETCH-G
(para no.6.7.7)

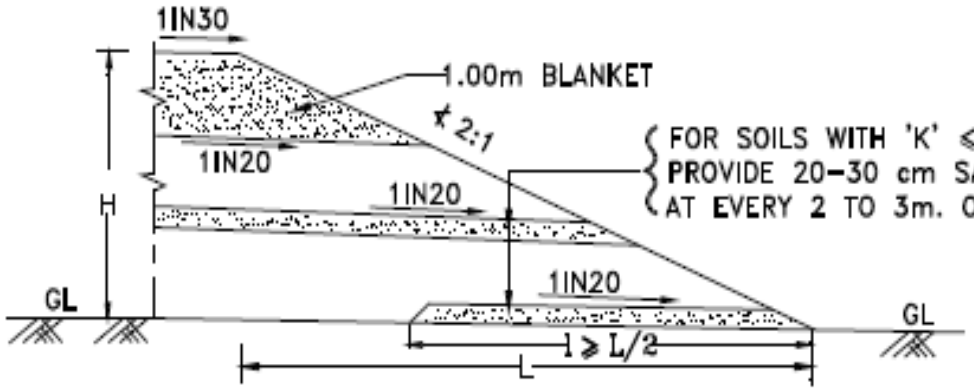


FIG. (a) H ≤ 6m

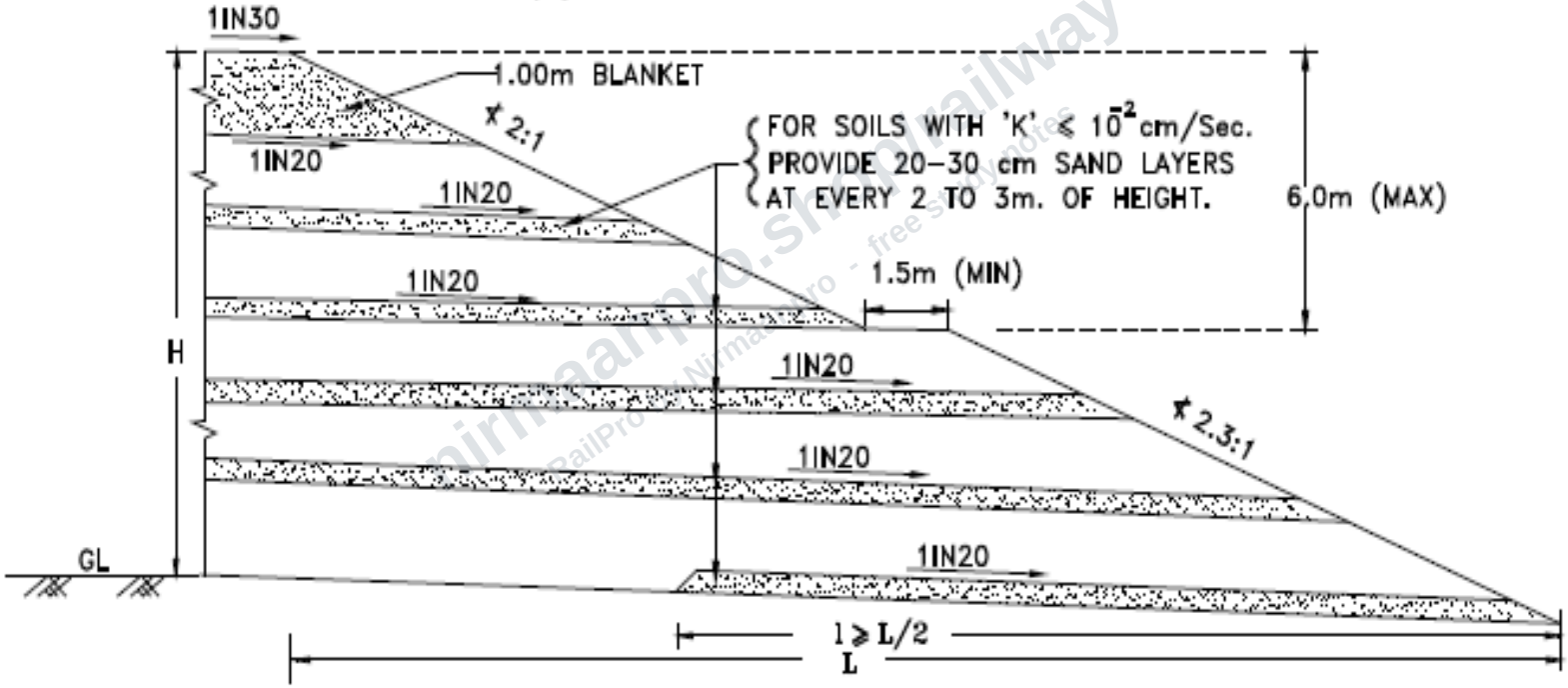


FIG. (b) H – 6m TO 12m

NOTES:

1. FOR BANK OF HEIGHT MORE THAN 12m PROPER COMPUTATION FOR FAILURES AGAINST SLIPS, SETTLEMENT, ETC. SHOULD BE CARRIED OUT.
2. COEFFICIENT OF UNIFORMITY (Cu), OF SAND TO BE USED FOR SANDWICH CONSTRUCTION SHOULD BE GREATER THAN 2.

R. D. S. O.

GUIDELINES FOR EARTHWORK IN RLY. PROJECTS

TYPICAL EMBANKMENT PROFILE FOR SANDWICH CONSTRUCTION WITH COHESIVE SOILS

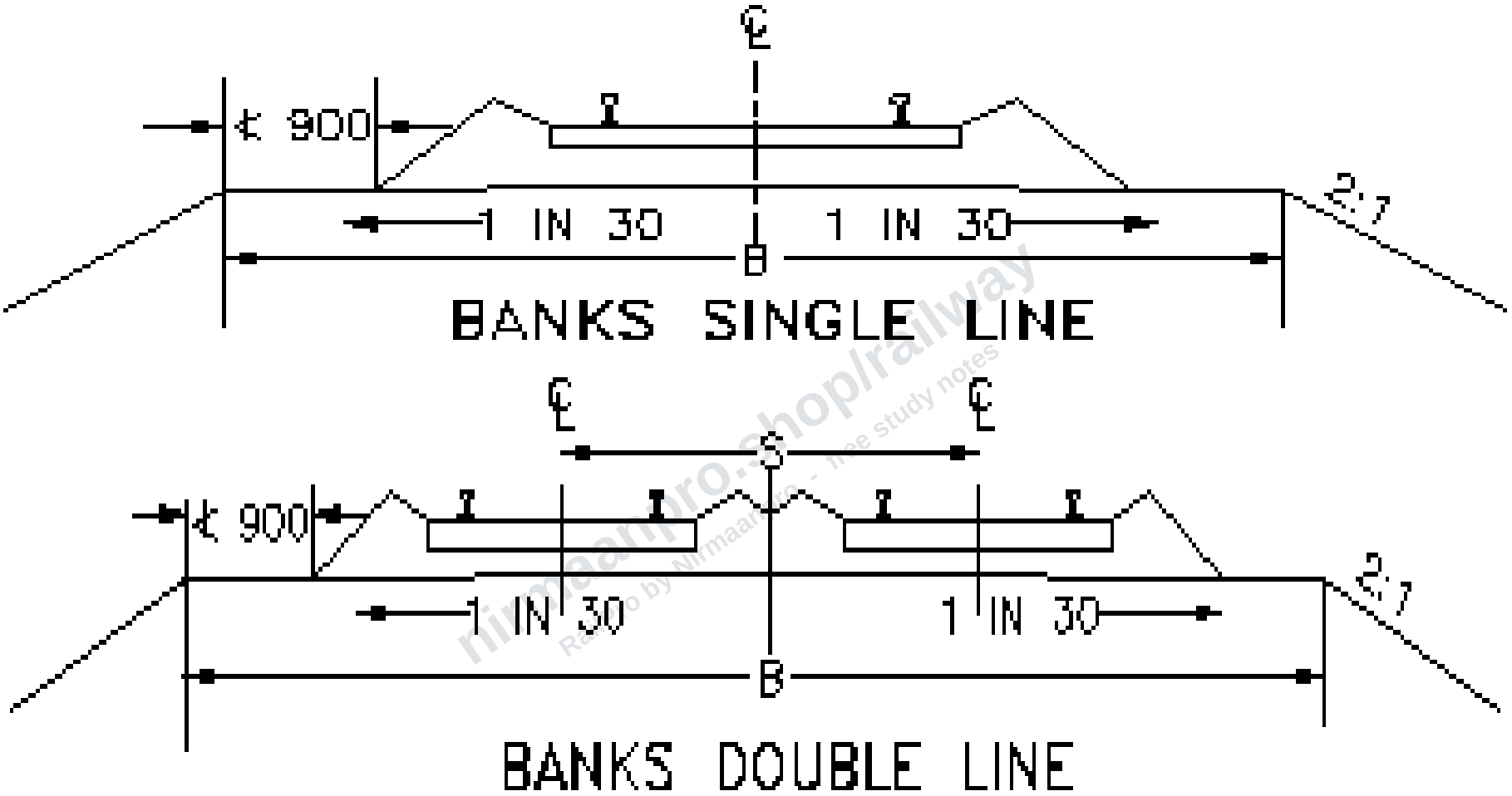
DRG.NO: GE/SD/0019/Rev.0/2003

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- **Cross Slope on top of formation**
- **Adequate drainage must be ensured for the worst service conditions to drain out surface water.**
- **The top of formation should have a cross slope of 1 in 30 from centre of track towards both sides in single line.**
- **Top of the formation should be finished to cross slope of 1 in 30 from one end to other towards cess/drain in multiple lines.**
- **Alternatively, separate cross slope for individual tracks can be also provided with suitable longitudinal drain provided between the tracks at toe of the cross slopes, with suitable cross drain system.**

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Cross Slope



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- For drainage of Surface Water
- Design Value 1 in 30
- Tolerance (1 in 28 to 1 in 32)

- **Height of formation above GL**
- **Rationalization of formation layer thickness**
- **In case of all new construction, minimum height of embankment should not be less than one meter above GL or HFL to ensure proper drainage, effective stress dispersal, and uniform riding qualities.**
- **If the ground soil satisfies the specifications of prepared sub-grade soil, further excavation of ground soil not required.**
- **Total thickness of formation layer of 1.5 mts minimum should be provided of blanket prepared sub-grade and sub-grade / embankment fill uniformly in embankment / cutting for effective stress dispersal**

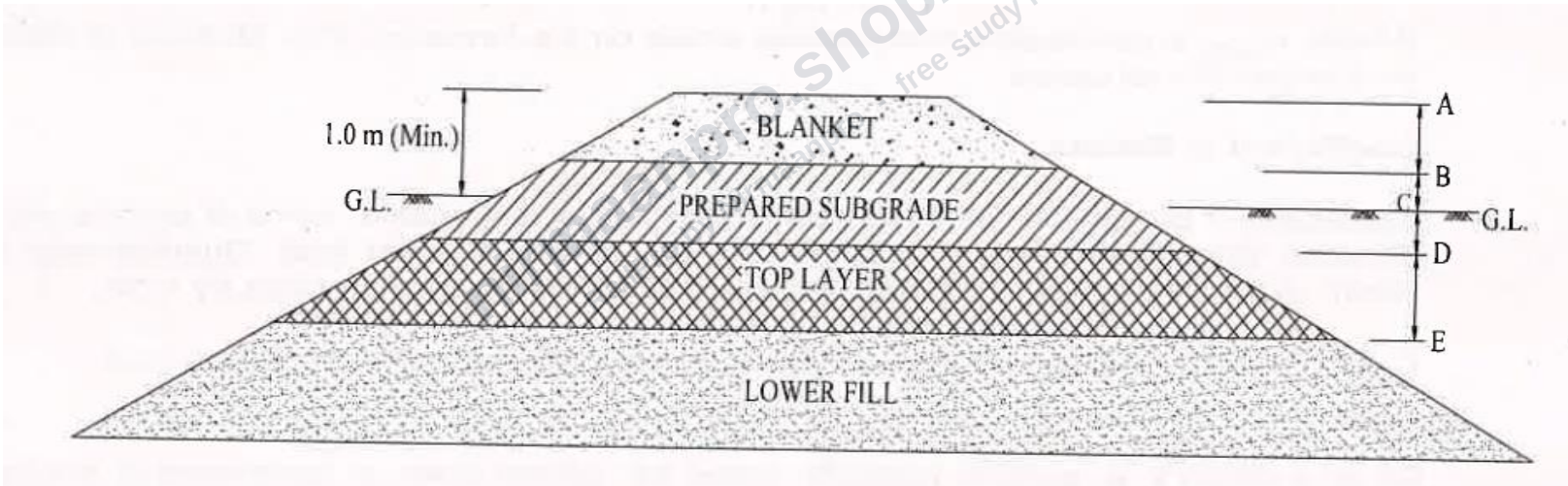
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- For providing uniform total thickness of formation layers of 1.5 Mts in
- For Embankment
- If the specification of sub soil meets specification of prepared sub grade up to required depth and
- If the specification of sub soil meets specification of sub grade up to required depth then
- In that case there is no need for excavation else excavation will be done as per requirement.
- The specification of soil strata below GL must be decided from the results of soil exploration.

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Min Formation layer thickness in embankment

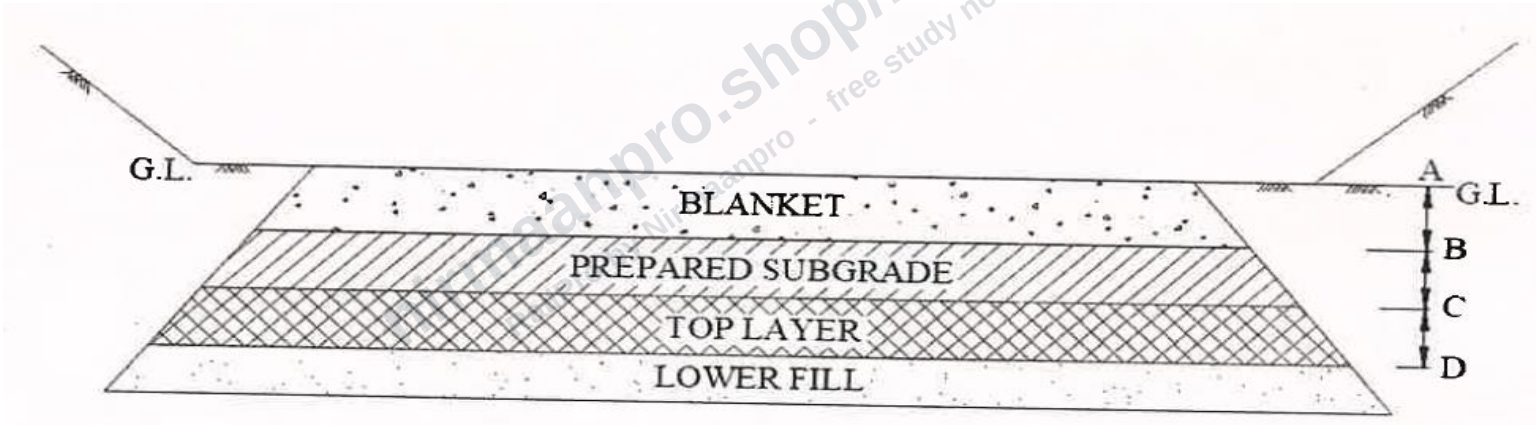
Blanket + Prepared sub grade + Sub grade/Embankment fill = 1.5M



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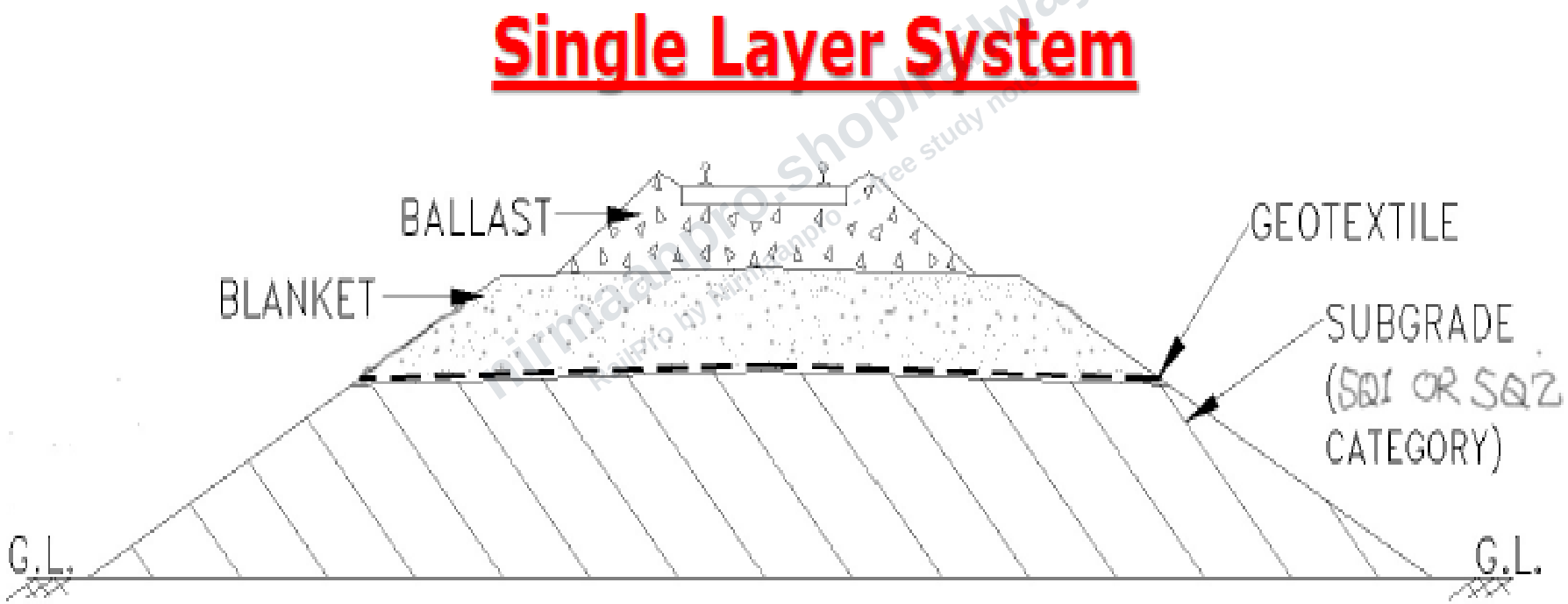
Min Formation layer thickness in cutting

Blanket + Prepared sub grade + (Top layer + lower layer)Sub grade = 1.5M

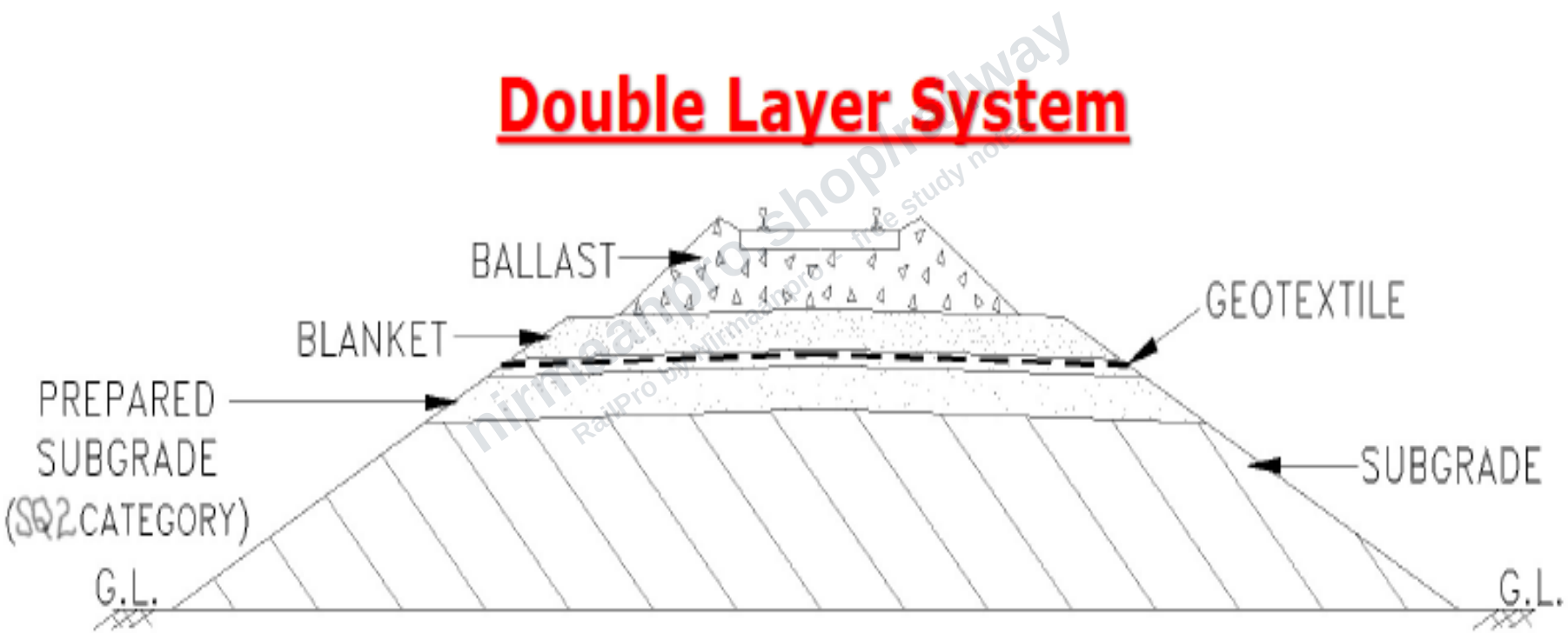


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Blanketing layer system



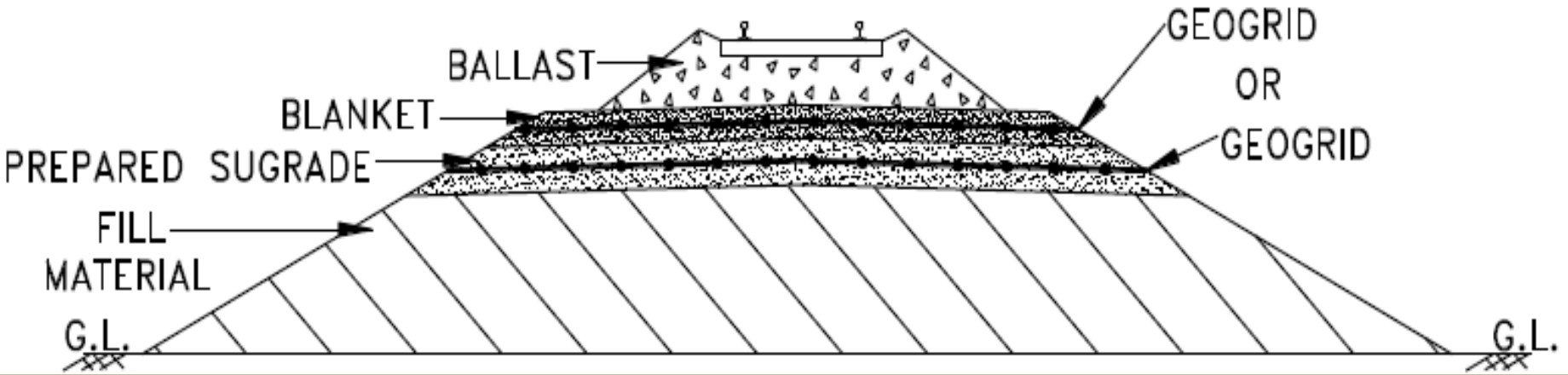
Blanketing layer system



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Reduction in thickness of blanket layer.

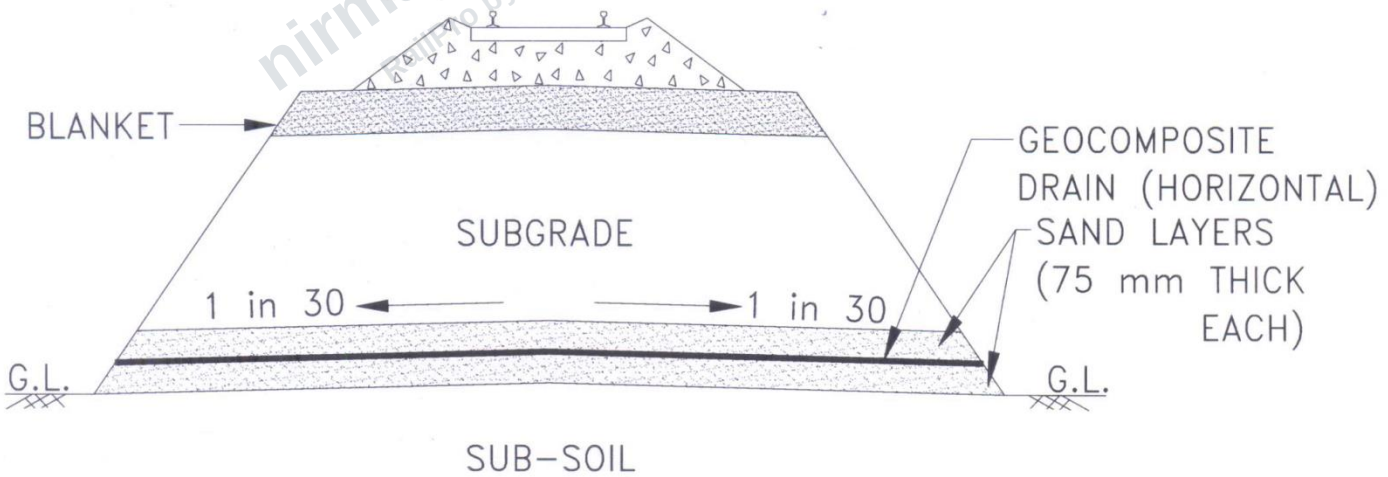
- In case of new constructions on techno- economic grounds To reduce the thickness of blanket layer (which is costly granular material by quarrying or mining) and to reduce impact on environment due to quarrying and mining,
- Geo-grid can be used as stabilization element to form a mechanically stabilized layer.



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Use of Geo composite drain in bank over soft sub-soil.

- In case of fine grained sub-soil and sub-grades, where water table is also at higher level, it is a good practice to provide a "separator-cum-drainage layer" of sand (about 1.0m thick) at the ground level.
- In areas with scarcity of sand, thickness of the sand layer can be reduced by laying a Geo-composite drain layer, sandwiched between two layers of sand of lesser thickness (about75mm).



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DRAINAGE

- Rain water during monsoon is main enemy in damaging banks / cuttings. So effective drainage is most important to safeguard formations from failure.
- Flow of water contaminate ballast, also erodes formations.
- It should not be allowed along the track .
- Drainage system should be efficient enough to prevent stagnation and allow quick disposal of water.
- Effectiveness depends on size of drain, permeability.

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TYPES OF DRAINS

- Conventional Drains
- Surface Drains
- Sub Surface Drains
- Side Drains
- Catch Water Drains
- French Drains
- Geo Net Drains
- Edge Drains
- Bored Drains
- PVC Vinyl Pipe Drains
- Latest JGT (Jute Geo-textile Drains)

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General points for effective drainage

- For effective drainage following point to be ensured Top of formation should have a cross slope of 1 in 30 from centre of track towards both sides in single line.
- Top of the formation should be finished to cross slope of 1 in 30 from one end to other towards cess/drain in multiple lines.

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General points for effective drainage

- Separate cross slope for individual tracks can be also provided if the distance between adjacent tracks is large enough with suitable longitudinal drain provided between the tracks at toe of the cross slopes, to make rain water flow in natural manner.
- In case of double line central drain to be avoided since it is not only difficult to construct but also difficult to maintain due to continuous vibrations caused by traffic.

General points for effective drainage

- Once top of formation is prepared to proper slope and level movement of material vehicle to be avoided which may cause development of un-eveness which will accumulate water and weaken formation.
- Blanket material should confirm to specifications.
- In case of all new constructions minimum height of embankment should not be less than 1 mts.

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General points for effective drainage

- In cuttings designed side drains and catch water drains of adequate capacity to be provided.
- In yards surface drains should generally be open for cleaning and inspection.
- Overhauling and deep screening of ballast should be carried out at prescribed intervals.
- Drains should be cleaned and repaired regularly preferably before monsoon.

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SIDE DRAINS

- In case of cuttings, properly designed side drains of required water carrying capacity are to be provided.
- Side drains along the track shall be provided in all cuttings and also in fillings if height of bank less than the depth of blanket or the depth of ballast pocket.
- If depth of cutting is upto 4 m. Only side drains are sufficient.
- If depth of cutting is more than 4 m. Side drain along with catch water drain are made.

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SIDE DRAINS

- Top of side drains should be little below bottom of blanket layer, to allow flow of track water in the side drain.
- The section of the side drains shall be adequate to carry required discharge.
- Longitudinal slopes of the drain shall ensure development of self-cleaning velocity.
- Side drains shall have of-side berm of 300mm width to prevent materials rolling down the slope into the drain and also provide space to keep the muck during their cleaning.

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SIDE DRAINS

- Side drains shall have proper outfall which may fall into (adjacent) culvert/bridge or low ground. Care should be taken to arrest the tail end erosion.
- Kutcha drains if deeper than 0.6m shall be filled with locally available granular materials with coarser material in middle to provide inverted filter effect.

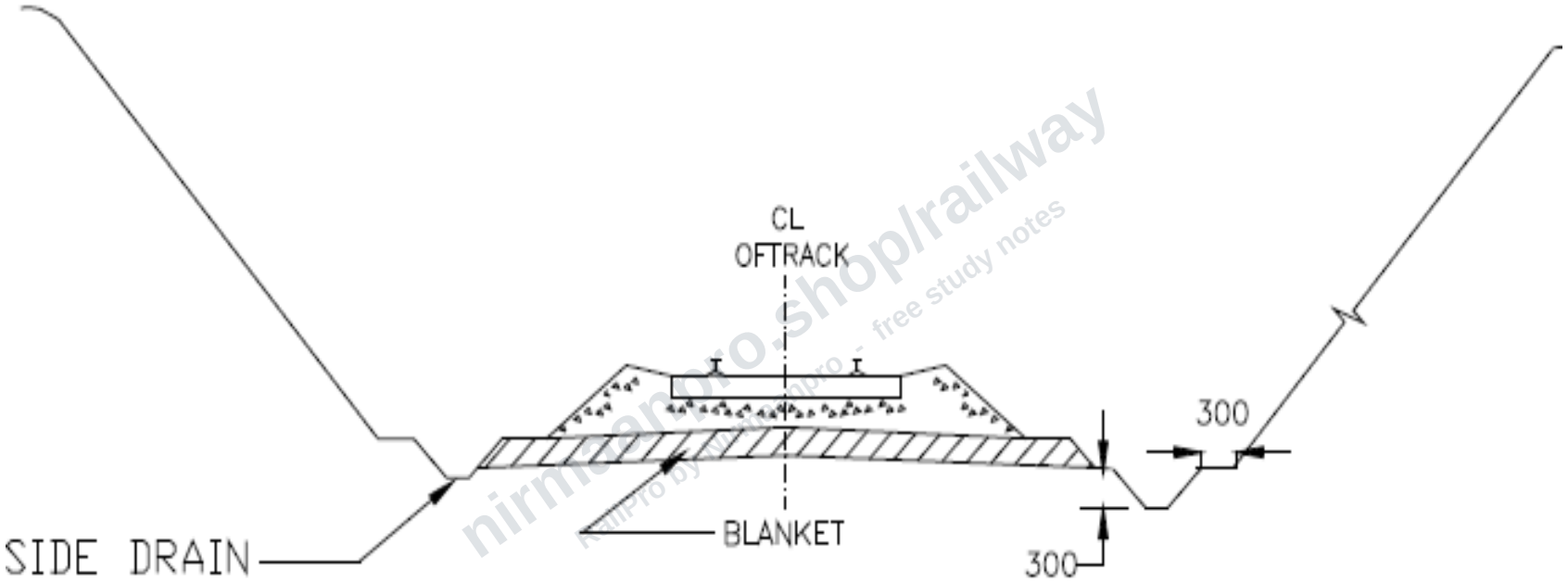
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SIDE DRAINS

- Pucca side drains must have weep hole, of 75mm Dia at 30m centers at 75mm above bed level. Coarse grained materials shall be placed behind weep holes for effective drainage.
- Side drains shall be lined except where the drains are cut in hard soil strata.
- To take the full flow of side drains, adequate openings should be provided under level crossings, trolley refuges and OHE masts where these exist in cuttings.
- The minimum depth of side drain should be 300 mm

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SIDE DRAINS



DRAINAGE ARRANGEMENT IN A CUTTING

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SIDE DRAINS

- The parabolic (saucer type) side drain section is hydraulically the best and most erosion resistant.
- The trapezoidal/rectangular section is more generally used as it is easier to construct.
- The min depth of drain shall be as under,
  a) 30 cm below cess level
  b) 15 cm below the bottom of blanket
  c) 30 cm below the bottom of ballast pocket

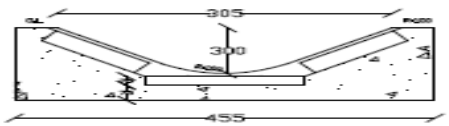
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TYPICAL SECTION OF STANDARD OPEN DRAINS IN YARDS.

EXTRACTED FROM TYPE PLAN NO: Q-14
NRHQE PLAN NO- HQ/8/03-78-Q

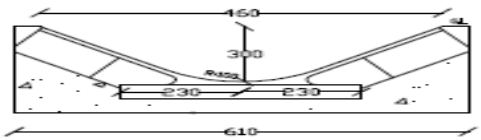
NOTES:-
1. ALL DIMWENSIONS ARE IN MILLIMETRES
2. THE DRAINS MAY ALSO BE MADE WITH PRECAST SECTIONS LAID ON SUITABLE FOUNDATIONS.

TYPE- 'A'

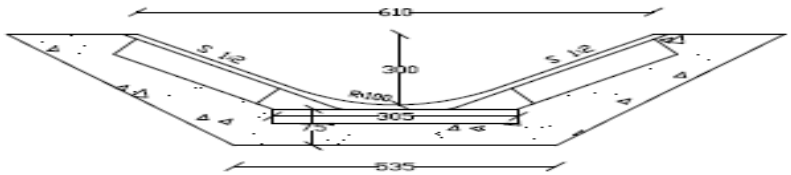


GRADE: 1 IN 400 TO 1 IN 300
DISCHARGE: 0.0028 TO 0.0025 CUMECS

TYPE- B'

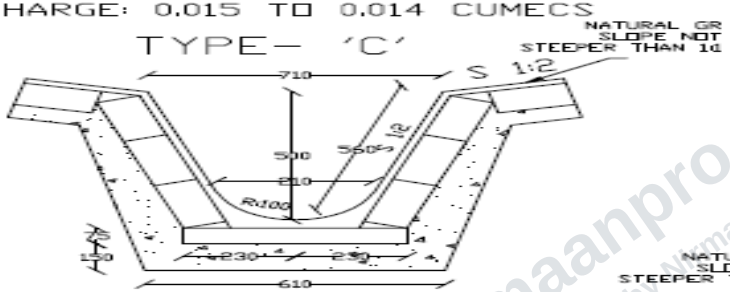


GRADE: 1 IN 400 TO 1 IN 600
DISCHARGE: 0.00846 TO 0.007 CUMECS



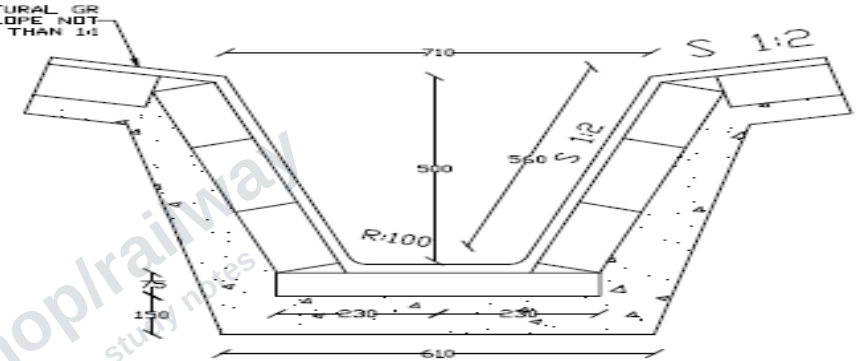
GRADE: 1 IN 600 TO 1 IN 700
DISCHARGE: 0.015 TO 0.014 CUMECS

TYPE- 'C'



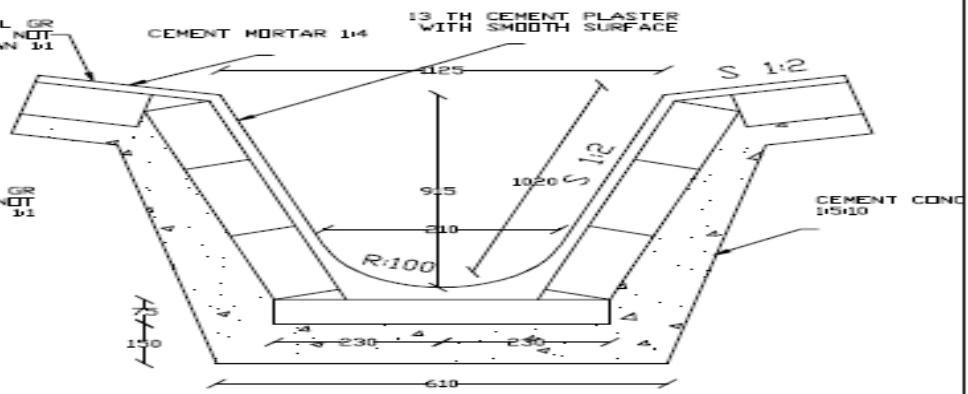
GRADE: 1 IN 800 TO 1 IN 900
DISCHARGE: 0.056 TO 0.053 CUMECS

TYPE- 'E'



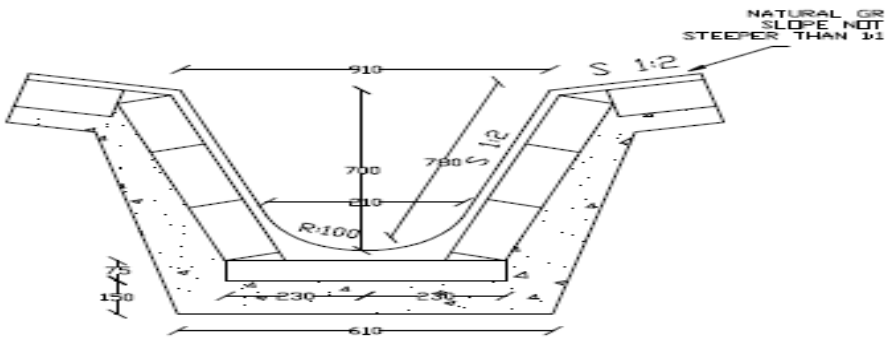
GRADE: 1 IN 700 TO 1 IN 800
DISCHARGE: 0.04 TO 0.036 CUMECS

TYPE- 'D'



GRADE: 1 IN 1000 TO 1 IN 1200
DISCHARGE: 0.0163 TO 0.149 CUMECS

TYPE- 'G'

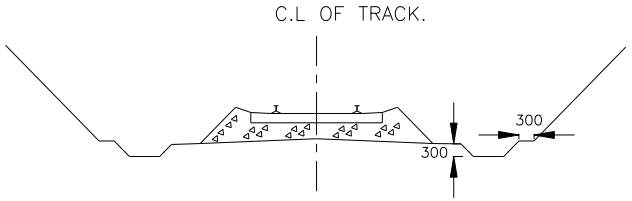


GRADE: 1 IN 900 TO 1 IN 1000
DISCHARGE: 0.101 TO 0.095 CUMECS

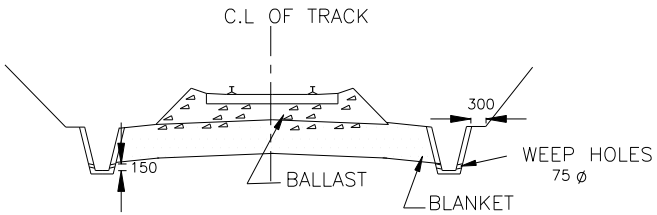
TYPE- 'F'

FIG:NO:- 4

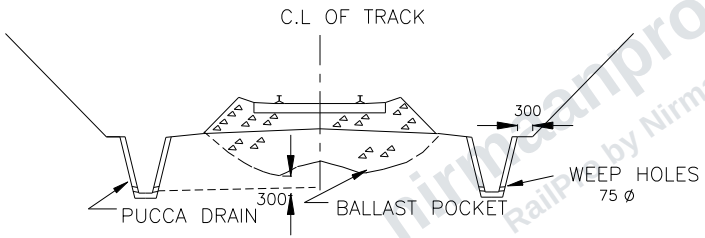
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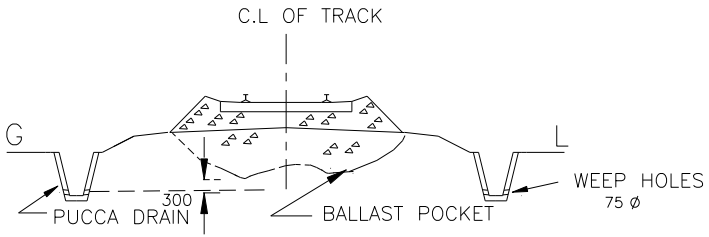
SIDE DRAIN IN CUTTING



SIDE DRAIN WHERE BLANKET PROVIDED



SIDE DRAIN IN CUTTING OF HEAVY BALLAST PENETRATION



SIDE DRAIN IN FILLING

NOTES:–

1. SIDE DRAINS SHALL BE PROVIDED IN ALL CUTTINGS AND ALSO IN FILLINGS IF HEIGHT OF BANK IS LESS THAN THE DEPTH OF BLANKET OR THE DEPTH OF BALLAST POCKET.
2. THE MINIMUM DEPTH OF DRAINS SHALL BE AS UNDER
   a) 30 cm. BELOW CESS LEVEL
   b) 15 cm. BELOW THE BOTTOM OF BLANKET
   c) 30 cm. BELOW THE BOTTOM OF BALLAST POCKET .
3. SECTION OF THE SIDE DRAINS SHALL BE ADEQUATE TO CARRY REQUIRED DISCHARGE
4. LONGITUDINAL SLOPES OF THE DRAIN SHALL ENSURE DEVELOP–MENT OF SELF CLEANSING VELOCITY
5. SIDE DRAINS SHALL HAVE OFF–SIDE BERM OF 300 mm. WIDTH TO PREVENT MATERIALS ROLLING DOWN THE SLOPES INTO THE DRAIN AND ALSO PROVIDE SPACE TO KEEP THE MUCK DURING THEIR CLEANING
6. KUTCHA DRAINS ARE DESIRABLE FOR EFFECTIVE DRAINAGE OF FORMATION. PUCCA SIDE DRAINS WITH BASE AND SIDES CONSTRUCTED MONOLITHICALLY , PROVIDE CONFINEMENT TO FORMATION INCREASING ITS BEARING CAPACITY.
7. PUCCA SIDE DRAINS MUST HAVE WEEP HOLES OF 75 mm. DIA. AT 3.0 m c/c. WITHOUT ANY OBSTRUCTION AT 75 mm. ABOVE BED LEVEL.
8. SIDE DRAINS SHALL HAVE PROPER OUT–FALL WHICH MAY FALL INTO ADJACENT CULVERT/BRIDGE OR LOW GROUND. CARE SHALL BE TAKEN TO ARREST THE TAIL END EROSION
9. KUTCHA DRAINS IF DEEPER THAN 0.6m SHALL BE FILLED BY LOCALLY AVAILABLE GRANULAR MATERIALS WITH COARSER MATERIAL IN MIDDLE TO PROVIDE INVERTED FILTER EFFECT.
10. COARSE GRAINED MATERIAL SHALL BE PLACED BEHIND WEEP HOLES FOR EFFECTIVE DRAINAGE.
11. ALL DIMENSIONS ARE IN MILLIMETRES.

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PROVISION OF SIDE DRAINS

DRG. NO. GE/SD/0004/Rev.0/1994

Catch-Water Drains

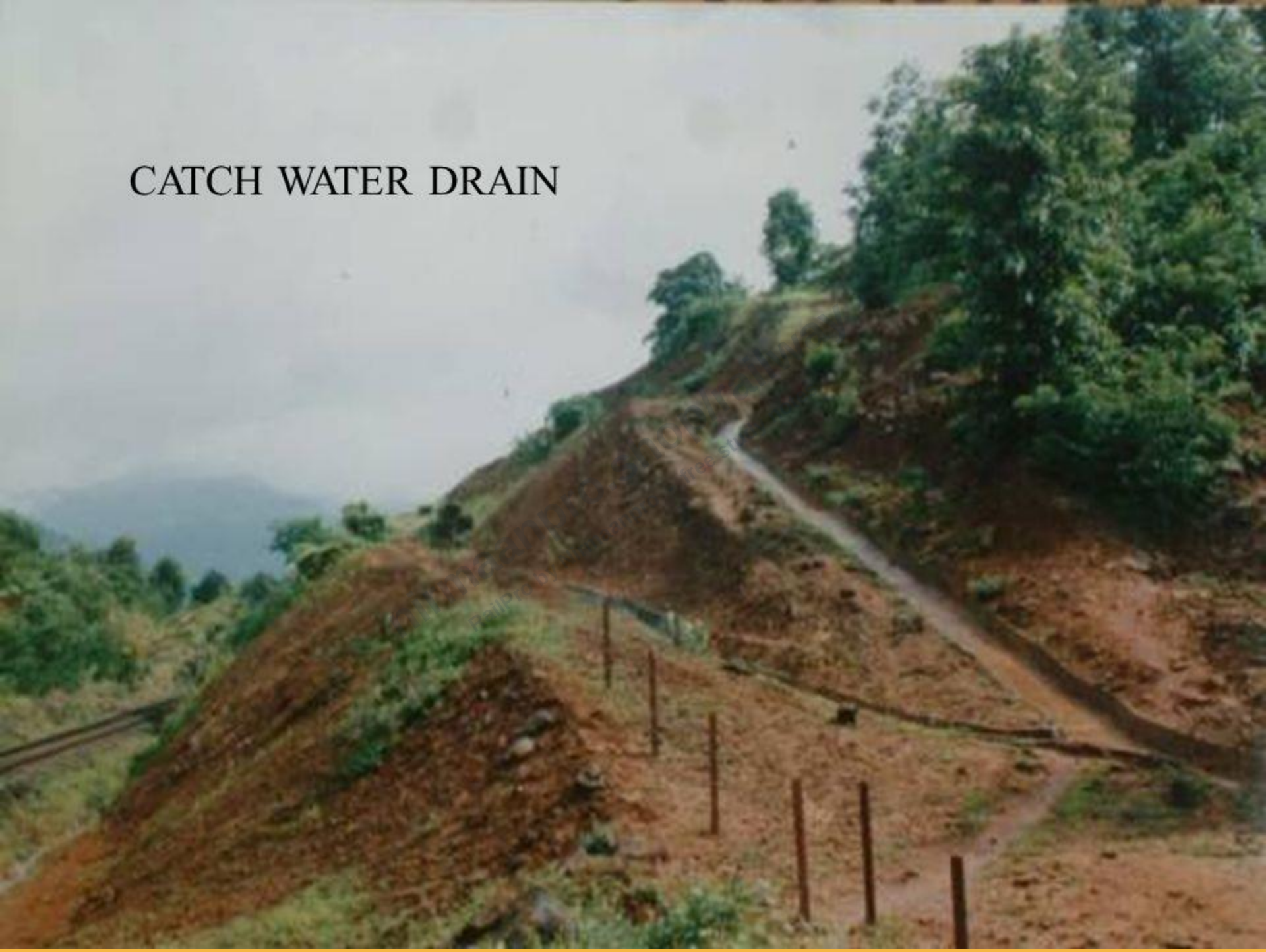
- Surface water flowing from top of hill slope towards the track in huge quantity needs to be controlled on safety considerations.
- It is also not possible to allow water from the hillside to flow into the side drains, which are not designed for carrying a huge quantity of water.
- It is therefore essential to intercept and divert the water accordingly coming from the hill slopes.

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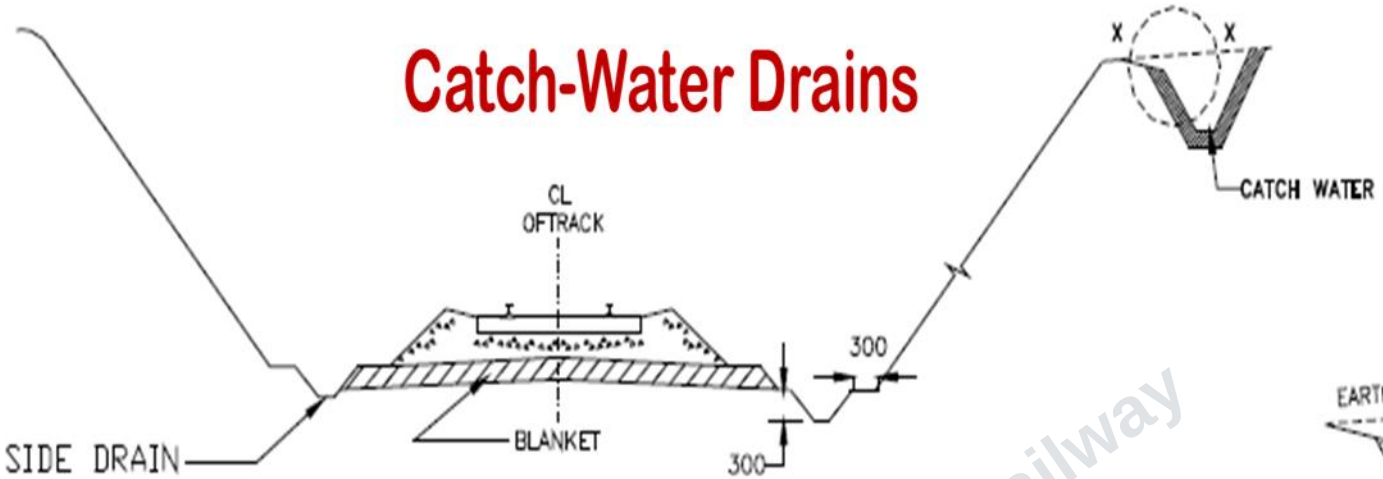
Catch-Water Drains

- **Accordingly catch-water drains are provided running almost parallel to the track.**
- **Catch-water drains should be pucca lined with impervious locally available flexible material.**
- **Catch-water drains should be located slightly away (as per site conditions) from the top edge of the cutting, and water flow should be led into the nearby culvert or natural low ground.**

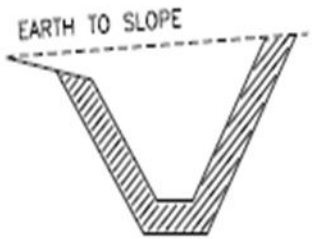
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CATCH WATER DRAIN

Catch-Water Drains



DRAINAGE ARRANGEMENT IN A CUTTING



DETAILS AT X–X

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NOTES:

1. CATCH WATER DRAINS SHALL BE PROVIDED ON THE NATURAL GROUND IF FORMATION IN CUTTING IS LIKELY TO GET FLOODED FROM SURFACE WATER FLOWING ACROSS THE CUTTING OR WHEN DEPTH OF CUTTING IS MORE THAN 4m.
2. ALL CATCH WATER DRAINS SHALL BE PUCCA. THE EXPANSION JOINTS SHALL BE SEALED WITH BITUMENOUS CONCRETE.
3. THE CATCH WATER DRAINS SHALL HAVE SECTION ENOUGH TO CARRY 50% MORE THAN THE REQUIRED DISCHARGE TO CATER FOR ANY BLOCKADE OR SILTING.
4. CATCH WATER DRAIN SHALL HAVE ADEQUATE SLOPE TO ENSURE DEVELOPMENT OF SELF CLEANSING VELOCITY.
5. CATCH WATER DRAIN SHALL HAVE WELL DESIGNED OUTFALL WITH PROTECTION AGAINST TAIL-END EROSION.
6. CATCH WATER DRAIN SHALL NOT HAVE ANY WEEP HOLE.
7. SIZE OF SIDE DRAINS OF ADEQUATE CAPACITY SHOULD BE PROPERLY DESIGNED KEEPING IT'S BOTTOM LEVEL AT 300mm BELOW BOTTOM OF BLANKET LAYER.

NOT TO SCALE

R. D. S. O.
GUIDELINES FOR EARTHWORK IN RLY. PROJECTS
TYPICAL CROSS SECTION OF CUTTING SHOWING SIDE AND CATCH WATER DRAINS
DRG.NO. GT/SD/0005/Rev.1/2002

DESIGN CONSIDERATIONS OF CATCH WATER DRAINS

- Catch water drains should be properly designed, lined and maintained.
- In kutcha catch water drains water percolates through resulting cracks and instability in cuttings.
- Catch water drains should be located slightly away from the top edge of cutting.
- Water flow in the catch water drain should be led into the near by culvert or natural low ground.
- It should not have any weep hole.
- It should have well designed out fall with protection against erosion.

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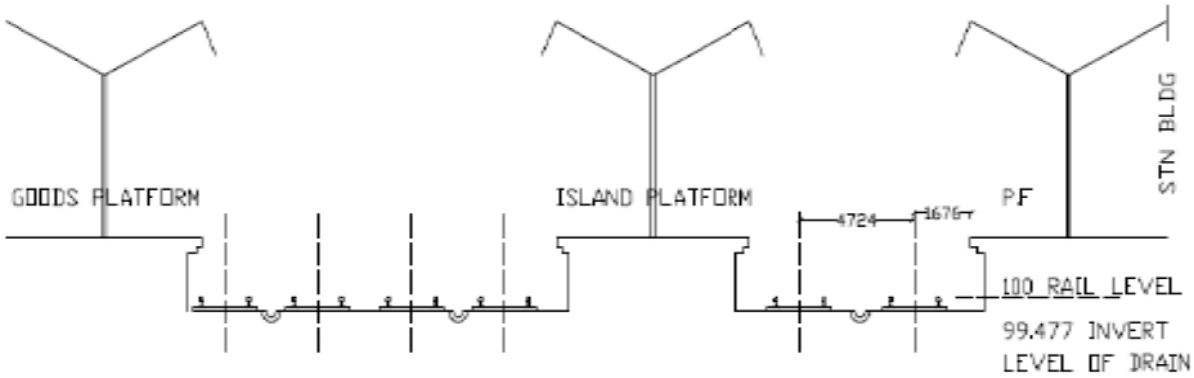
- It should not have any weep hole.
- It should have well designed out fall with protection against erosion.
- The minimum gradient should be in the range of 1 in 400 to 1 in 700.
- Catch water drains should have trapezoidal cross section.
- Regular inspection and maintenance work before monsoon should be carried out to plug seepage of water.
- Intensity and duration of rainfall are important for design of catch water drains.

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Drainage in Yards

- Ballast section in station yards must be the same as on main line
- Every station yard shall have network of cross and longitudinal drains, whether earthen or masonry, such that the storm water is led away in the least possible time.
- Arrangements for surface drainage at carriage watering points and washing hydrants shall be efficiently maintained. The water must be adequately trapped and led away in a pipe or line drain.
- The yards must be kept clear of all of all loose materials, heaps of earth or cinder which will interface with drainage.
- Every yard must have a Master Plan For Drainage.

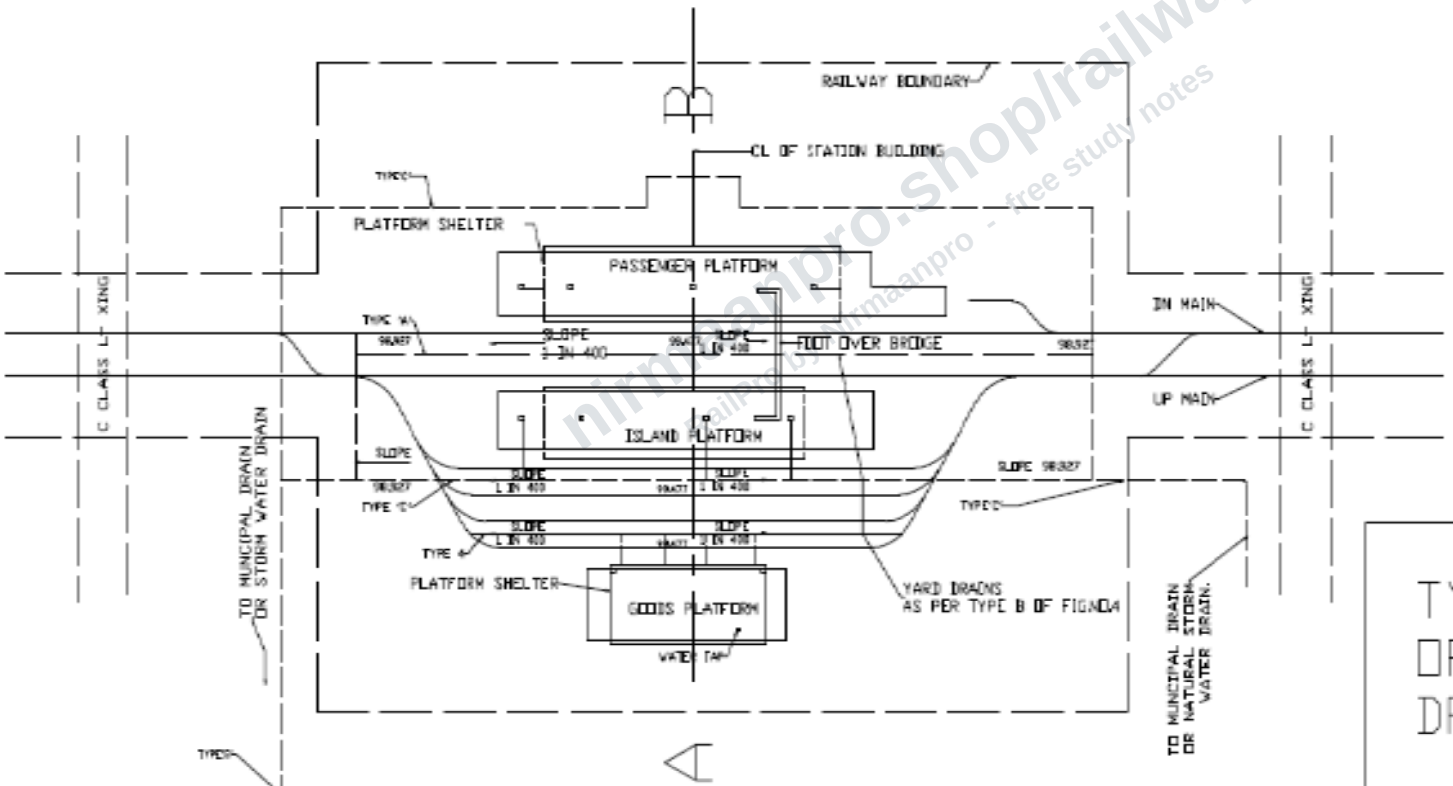
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SECTION ON A - B



NOTES.
1. DRAINS SHOWN THUS
2. ALL DIMENSION ARE IN MM
3. FOR TYPE OF DRAINS SEE FIG.NO.4



PLAN OF YARD

NOTE:
LONGITUDINAL SLOPE OF DRAIN MAY BE VARIED DEPENDING UPON SITE CONDITION

TYPICAL PLAN OF YARD DRAINAGE

FIG. NO. 3

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Planning of yard drainage

- While planning yard drainage, the following guidelines shall be kept in view:
- Drainage shall generally be open for ease of cleaning and inspection.
- While designing drains in yard, velocity range of 0.5-1.0 M/sec, for kutcha drains and 1.0-2.0 M/sec, for Pucca drains may be adopted.
- Longitudinal drains between two tracks should be saucer shaped. However, drains with vertical sides may be provided wherever saucer drains are not practicable.
- In the case of large size drains and in some particular situations in yard drains, covers may have to be provided.
- The drain top shall not be above the cess level for effective drainage of ballast bed.

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Planning of yard drainage

- If a drain with higher top level has to be provided to retain ballast, weep-holes shall be provided at the assumed cess level and the drain designed so as not to flow above bottom level weep-holes.
- Weep-holes generally get choked. A preferable alternative is to provide 4 cm wide vertical weep-slits at about one meter intervals, right from the top level of the drain down up to the cess level.
- Wherever outfall is available at either end of yard, longitudinal drain shall be provided with slope in opposite direction from the middle of the yard. This will ensure minimum size and depth of the drains.

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Drainage on Platform

- All end platforms shall normally be slopped away from the track.
- All drains from platform shelters, tea stalls, toilets, water taps or other sullage generation points shall be in pipes and normally discharged on the non track side of the end platform. If necessary longitudinal covered drains may be provided on the platform.
- In the case of island platforms, all drains shall discharge on the less important track and not towards the run through line. Wherever situation exists to the contrary, the drainage shall be modified to conform.

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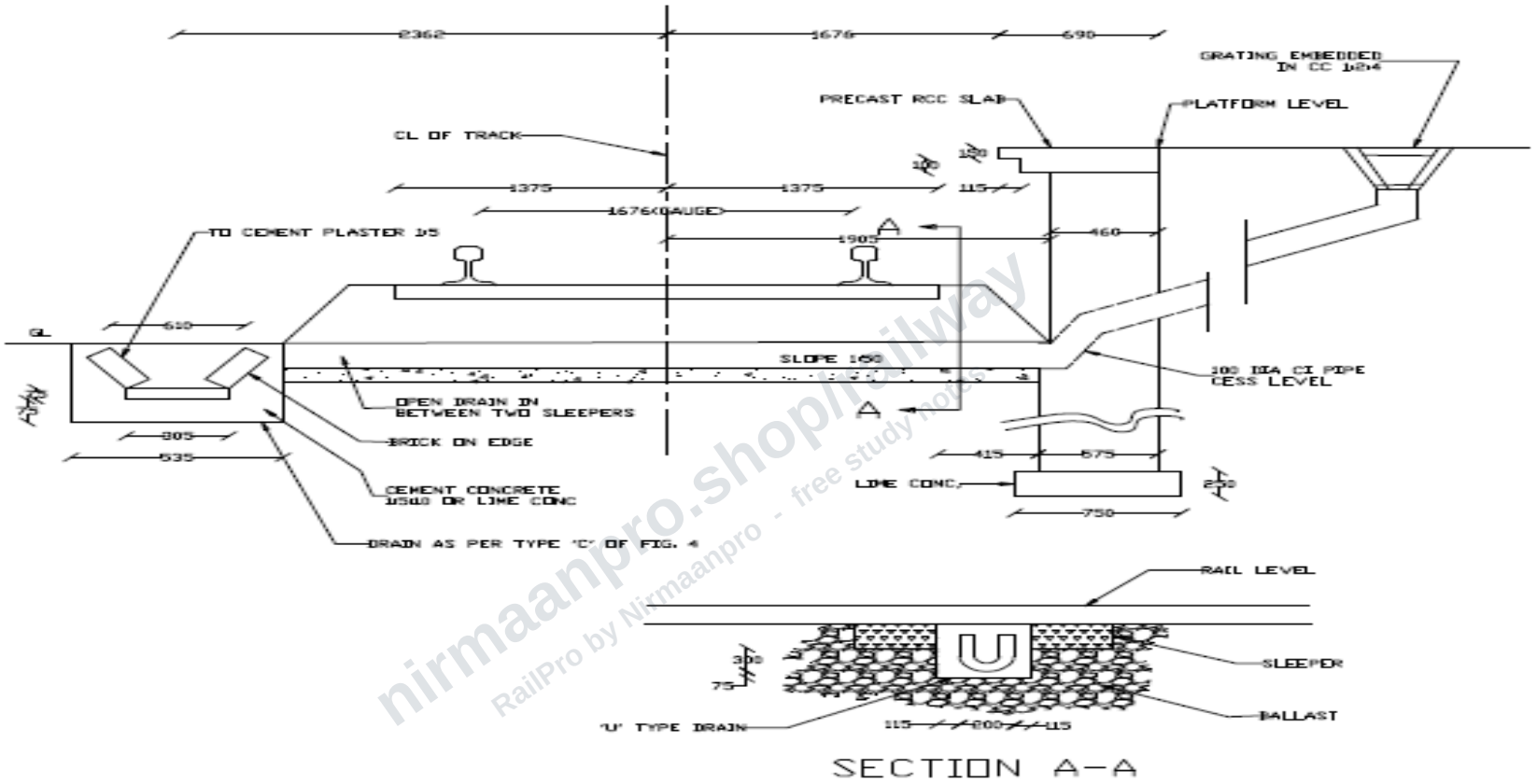
Drainage on Platform

- If an island platform has run through lines on both the sides a longitudinal covered drain should run on the platform taking the affluent from all the points on the platform. It should cross the track at only one point at the end of the platform by a suitable arrangement.
- Whenever a cross drain discharges towards a track, it should be in a pipe discharging directly in to the drain between the track.
- All drains emanating from the platform must be provided with suitable grating, well fixed in position so that any material likely to clog the drain is retained on the grating.

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DRAINAGE PLATFORM

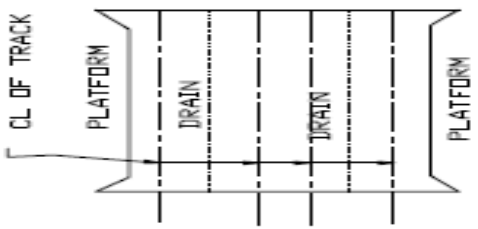
NOTE: ALL DIMENSIONS ARE IN MILLIMETRES



SECTION A-A

KEY PLAN

STATION WITH 4 LINES



STATION WITH 3 LINES



FIG.NO. 7

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Drainage of Embankment

- In bank cross slope is provided from center towards end to drain out surface water. Therefore, normally there is no need of side drains in case of embankment.
- In situations where height of bank is such that blanket layer goes below normal ground level. In such cases, side drains may require to be constructed along the track at suitable distance so that track alignment does not become channel for flow of ground surface water.
- In double line, central drain between the tracks should be avoided to extent possible as it is not only difficult to construct but also difficult to maintain for continuous vibrations caused by moving traffic, problem in proper curing of concrete etc

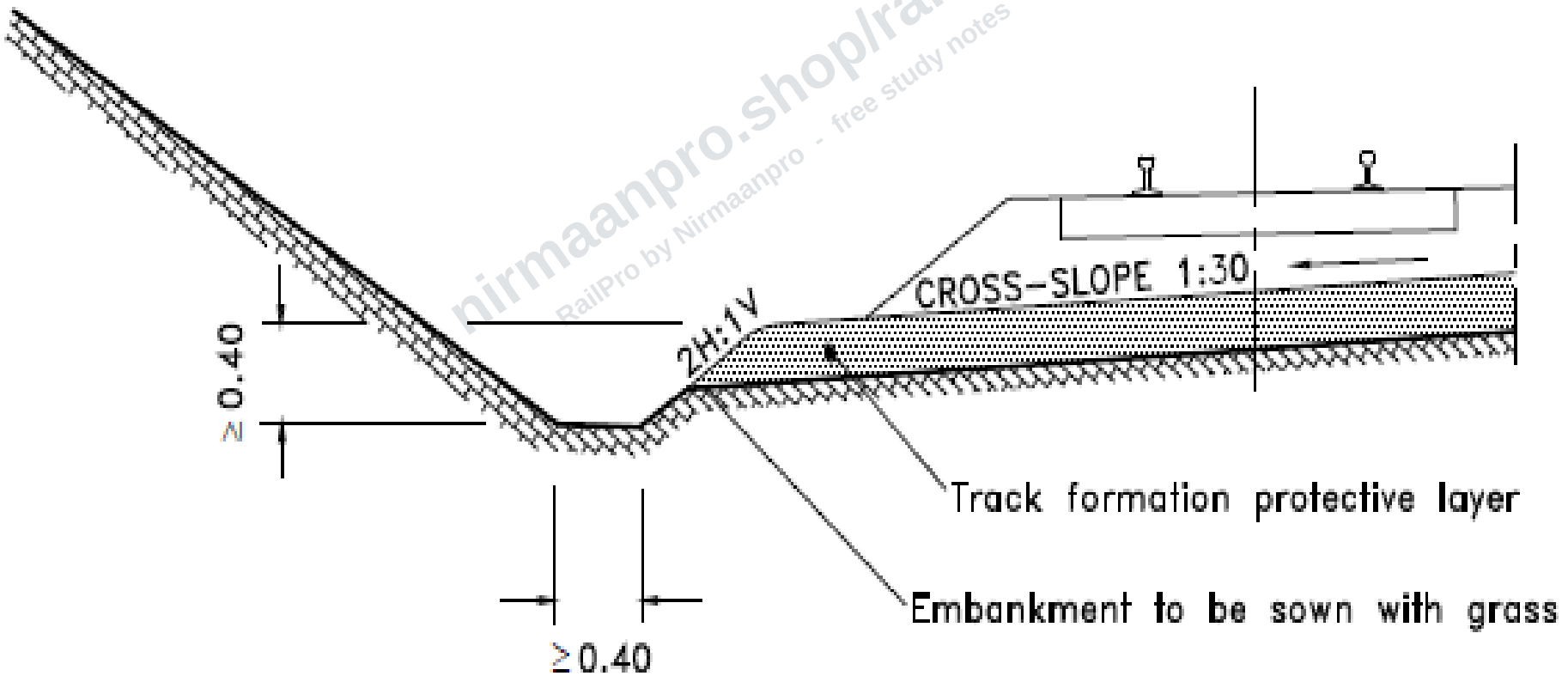
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Drainage of Embankment

- In double line in situations, when drainage of water is not possible without construction of drain, suitable arrangements for construction of drain with pre-cast concrete channel/ subsoil drains along with proper outfall should be provided.
- If distance between adjacent tracks is large enough, suitable slope should be provided in ground to make rain water flow in natural manner.
- Wherever, there is level difference between two adjacent tracks, suitable non-load bearing dwarf wall may be constructed to retain earth.

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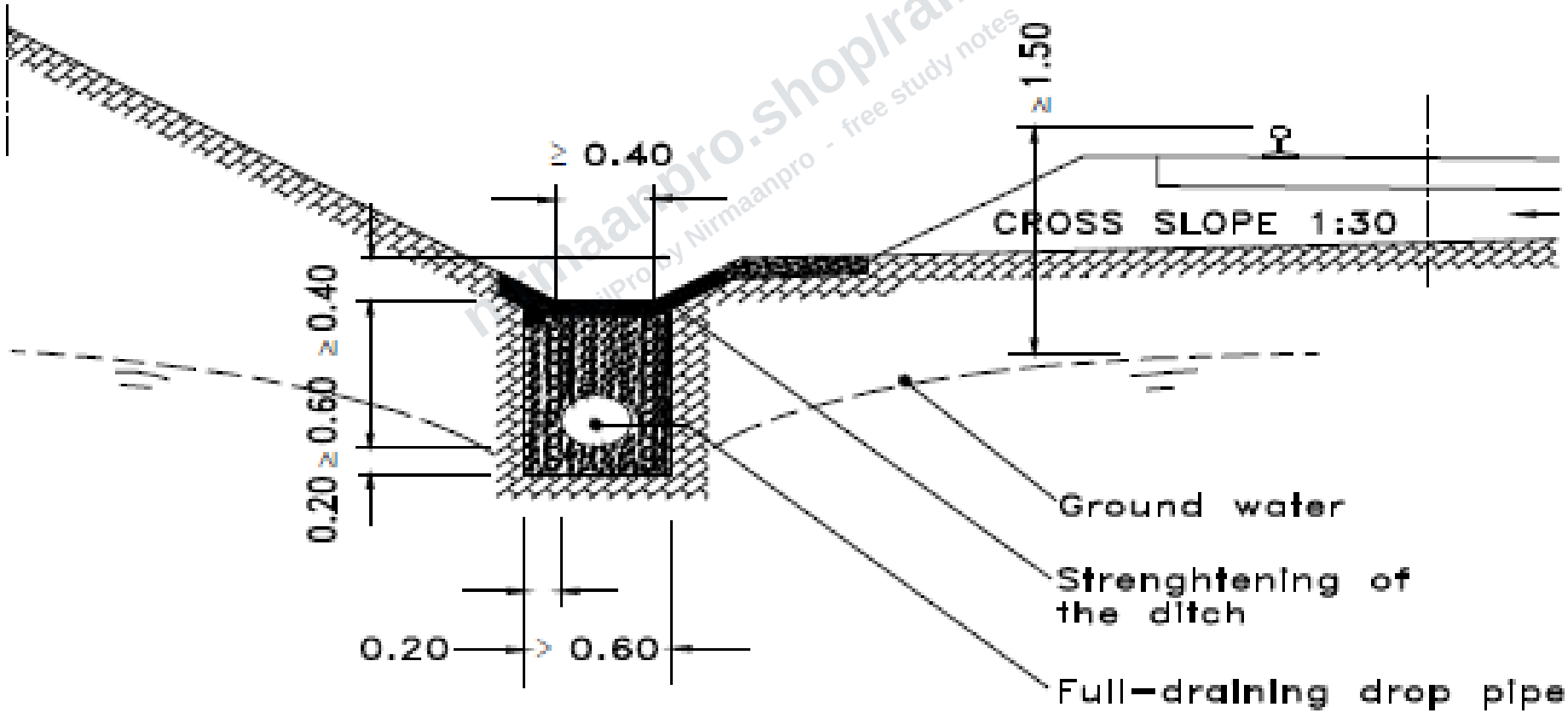
1. Open Drainage System, typical facilitates collection of rainwater from embankment, cuttings and side of cuttings and lead it away.
2. Similar arrangement can be also provided longitudinally at the lowest point between cross slopes of formation of two track



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Sub-soil Drain System are installed where the ground water level has to be lowered (depth < 1.5 m below the rail top), where

1. **the soil surrounding the track formation has to be drained or**
2. **where percolating and layer water has to be drained.**



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Inspection: Para no 103, 640, 1124 of IRPWM

- The permanent way staff shall keep all side drains and catch water drain clear.
- Ensure that the outlets of the drains and the water-ways of all Bridges and Culverts are kept free from obstruction.
- Spoils from cleaning drains or cuttings should not be deposited at a place from where it is likely to be washed back into the drains.
- JE/P.Way shall inspect all side drains, catch water drains, bridge waterways **at least once in a year in the month of April prior to monsoon.**
- SSE/P.Way (In-charge)shall inspect all side drains, catch water drains, bridge waterways **at least once in a year prior to monsoon.**

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Thank you

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2.3- ROUTE CLASSIFICATION– Periods 2

An Overview of Indian Railway Network.
Prescribed track structure for various Routes.

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2.3→ TOPICS COVERED

→ AN OVERVIEW OF INDIAN RAILWAY NETWORK

→ PRESCRIBED TRACK STRUCTURE FOR VARIOUS ROUTES ETC.

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DIFFERENT GAUGES

- INTRODUCTION
- Gauge : Clear minimum distance between the running faces of the two Rails.

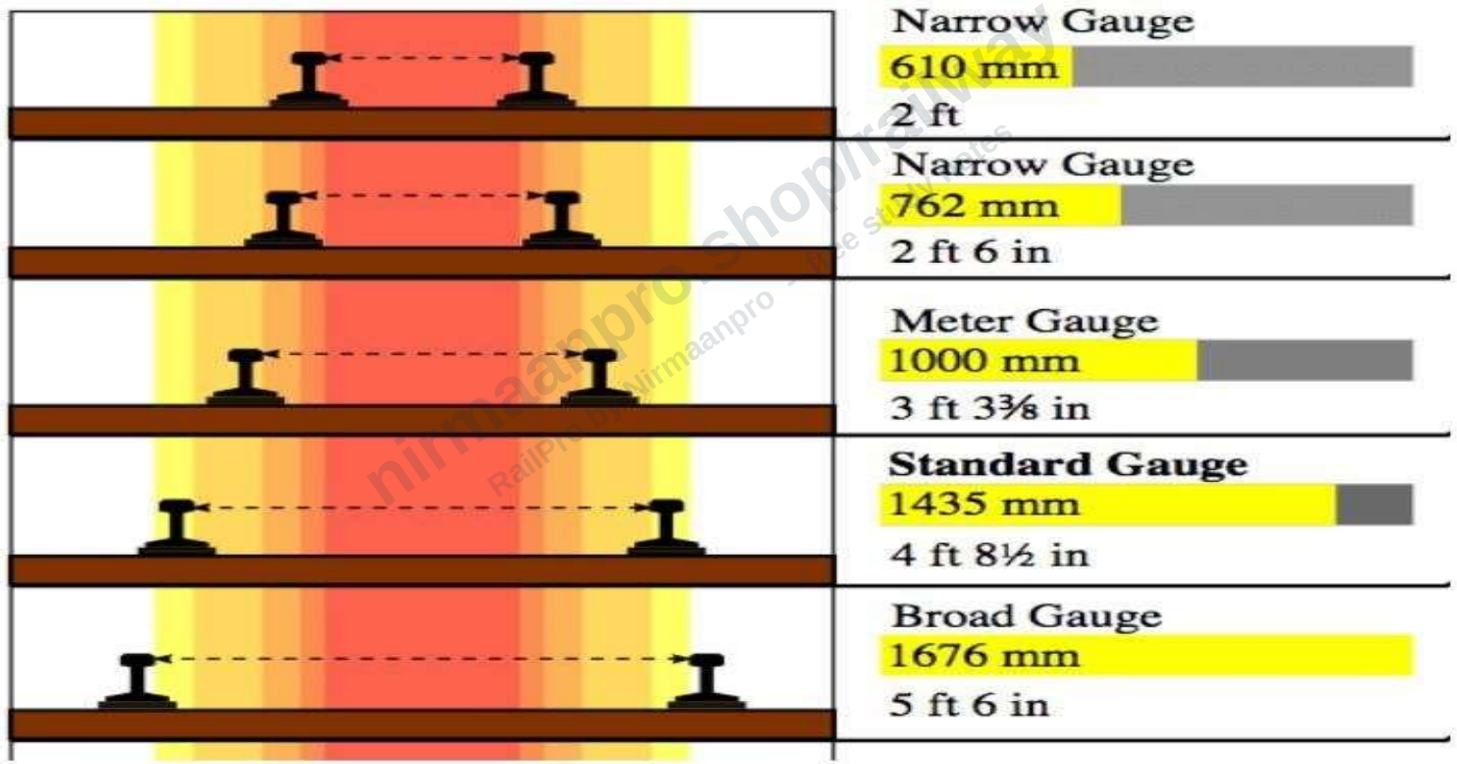
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VARIOUS GAUGES IN INDIAN RAILWAYS

Name of gauge	*Width (mm)*	*Width (feet)*	*Route kilometres*	*% of route kilometres*
Broad gauge (BG)	1676	5′6″	39,612	63.2
Metre gauge (MG)	1000	3′3.37″	19,210	30.7
Narrow gauge (NG)	762	2′6″	3838	6.1
	610	2′0″		
Total	–	–	62,660	100

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VARIOUS GAUGES IN INDIAN RAILWAYS



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Different Types of Gauges

Gauge[2]	2020 (Apr) Route km	2020 (Apr) Route share	1947 Route km[3]	1947 Route share
Broad gauge (1,676 mm (5 ft 6 in))	62,891	93.29%	25,170	46.0%
Metre gauge (MG) (1,000 mm (3 ft $3\frac{3}{8}$ in))	2,839	4.21%	24,153	44.2%
Narrow gauges (NG) (762 mm (2 ft 6 in) and 610 mm (2 ft))	1,685	2.50%	5,370	9.8%
Total	67,415	100%	54,693	100%

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WHY BROAD GAUGE AS INDIAN STANDARD GAUGE?

- BALANCED ECONOMIC GROWTH
- BETTER TRANSPORTING INFRASTRUCTURE
- BETTER LOADING GAUGE
- IMPROVED UTILIZATION OF TRACK
- FASTER MOVEMENT

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Gauge	*Maximum height of rolling stock*	*Maximum width of rolling stock*
BG	4140 mm (13′7″)	3250 mm (10′8″)
MG	3455 mm (11′4″)	2745 mm (9′0″)

CLASSIFICATION OF ROUTES

Broad Gauge– The BG lines have been classified into six group 'A' to 'E' on the basis of the future Maximum permissible speeds and traffic load .

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Group ‘A’ – Speeds up to 160 kmph

(i) New Delhi to Howrah–Rajdhani Route (via the Grand Chord and Howrah–Burdhwan Chord).

(ii) New Delhi to Mumbai Central (Frontier/ Mail Route).

(iii) New Delhi to Chennai Central (Grand Trunk Route).

(iv) Howrah–Nagpur–Mumbai CST.

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Group ‘B’ – Speeds upto 130 kmph

(i) Allahabad–Katni–Jabalpur–Itarsi-Bhusaval.

(ii) Kalyan–Pune–Daund–Wadi–Secunderabad–Kazipet.

(iii) Kharagpur–Waltair–Vijayawada.

(iv) Wadi–Raichur–Arakkonam–Chennai-Central.

(v) Howrah–Bandel–Barddhaman.

(vi) Khanna–Barharwa–Farakka Bridge–Malda Town.

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Group ‘B’ – Speeds upto 130 kmph

(vii) Sitarampur–Madhupur–Kiul–Patna–Mughal Sarai.

(viii) Kiul–Bhagalpur–Sahibganj–Barharwa.

(ix) Delhi–Panipet–Ambala Cantt. Kalka.

(x) Ambala Cantt.–Ludhiana–Jallandhar–Pathankot.

(xi) Ambala Cantt.–Moradabad–Lucknow–Pratapgarh–Mughul Sarai.

(xii) Arakkonam–Jolarpettai–Salem–Erode–Coimbatore–Ernakulam.

(xiii) Vadodara–Ahmedabad.

(xiv) Jolarpettai–Bangalore.

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Group ‘B’ – Speeds upto 130 kmph

(xv) Ahmedabad–Ajmer–Jaipur–Bandikui–Rewari–Delhi.

(xvi) Malda Town–Barsoi–New Jalpaiguri.

(xvii) Chennai Beach–Dindigul.

(xviii) Bangalore–Dharmavaram–Gooty.

(xix) Ghaziabad–Saharanpur.

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Group ‘B’ – Speeds upto 130 kmph

(xx) Chennai Beach–Chennai Egmore 3rd line

(xxi) Bandikui–Agra Fort

(xxii) Sawaimadhopur–Jaipur

(xxiii) Bellary–Guntkal

(xxiv) Gudur–Renigunta

(xxv) Pagadipalli–Nadikudi–Guntur–Tenali

(xxvi) Vijaywada–Guduwada–Bhimavaram–Nidadavolu

(xxvii) Guntkal–Guntur & Guntur–Krishna canal

(xxviii) Manmad–Mudkhed–Secundrabad

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Group ‘B’ – Speeds upto 130 kmph

(xxix) Secundrabad–Dhone

(xxx) Renigunta–Tirupati–Pakala–katpadi

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Group ‘C’

- Suburban Sections of Mumbai,
- Delhi, Chennai and Kolkatta as listed below.

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Group ‘C’

(i) CSTM–Ravli–Kurla–Panvel

(ii) Ravali–Mahim–Andheri

(iii) Churchgate–Mumbai Central–Borivali–Virar

(iv) Chennai Central–Basin Bridge–Veysarpadi–Arakonam

(v) Chennai Central–Basin Bridge–Washermanpet–Chennai Breach–Tambaram

(vi) Chennai–Central–Basin Bridge–Korukkupet–Tondiarpet–Tiruvottiyar–Gummidipundi

(vii) Chennai Beach-Tiruvanmiyar–Velachery

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Group ‘C’

(viii) Sealdah–Dumdum–Naihti–Kalyani–Ranaghat–Krishnanagar

(ix) Sealdah–Sonarpur–Baruipur–Lakshmikantapur–Namkhana

(x) Ballygunj–Budge Budge

(xi) Seoraphul–Tarakeshwar

(xii) Dum Dum Jn–Barasat Jn–Bangaon Jn

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Group ‘C’

(xiii) Howrah–Panskura–Kharagpur

(xiv) Ranaghat–Bangaon

(xv) Kalyani–Kalyani Simanta

(xvi) Ranaghat–Gede

(xvii) Kankurgachi–Ballygunge

(xviii) Kalinarayanpur–Shantipur

(xix) Barasat–Hasnabad

(xx) Sonarpur–Canning

(xxi) Baruipur–Diamond–Harbour

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Group ‘C’

(xxii) Dum Dum Jn–Princep Ghat–Majerhat

(xxiii) Dum Dum–Dankuni

(xxiv) Dum Dum Jn–Chitpur

(xxv) Bandel–Naihati

(xxvi) Bandel–Katwa

(xxvii) Liluah–Belur Math

(xxviii) Palval–Okhla–Tilak Bridge

(xxix) Okhla–LPNR–DBSI, DLI–DKZ–DBSI–NDAZ

(xxx) SBB–DSA–DLI

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Group ‘D’ Spl.

- **Speeds upto 110 kmph and the**
- **annual traffic density is 20 GMT or more.**

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Group ‘D’

- **Speeds upto 110 kmph and the**
- **annual traffic density is less than 20 GMT.**

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Group ‘D’

- *Note* – While classifying route, in case of double and multiple lines, annual traffic density on each line shall be considered separately. The route shall be classified based on the highest GMT on any one line.

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Group ‘D’

- List of routes either in group ‘D’Spl. or group D are as under, (They shall be reclassified in ‘D’Spl. or D routes based on note mentioned above).

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Group ‘D’

(i) Bina–Katni–Annupur–Bilaspur

(ii) Bhopal–Ujjain–Nagda

(iii) Udhna–Jalgoan

(iv) Ahemdabad–Viramgoan

(v) Bellary–Hospet

(vi) Champa–Gevra Road

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Group ‘D’

(vii) Anara–Sini
(viii) Kharagpur–Adra
(ix) Jharsuguda–Titlagarh–Vijaynagaram
(x) Titlagarh–Raipur
(xi) Barabanki–Gorakhpur Cantt–Chapra-Kacheri
(xii) Burhwal–Sitapur
(xiii) Delhi–Ghaziabad–Hapur–Moradabad
(xiv) Kanpur–Lucknow
(xv) Varanasi–Zafarabad–Sultanpur–Utartia–Lucknow
(xvi) Hajipur–Chapra

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Group ‘D’

(xvii) Hajipur Mujjafarpur–Samastipur–Barauni
(xviii) Hajipur–Bachawara
(xix) Barauni–Katihar
(xx) Gomoh–Chandrapura
(xxi) Barakakhana–Gevraroad–Sonenagar
(xxii) Gevraroad–Chopan
(xxiii) Kota–Chittorgarh–Neemuch–Ratlam
(xxiv) Kota–Ruthiyai–Bina
(xxv) Bayan–Agra–Tundla

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Group ‘D’

(xxvi) Ujjain–Indore
(xxvii) Viramgoan–Okha
(xxviii) Kanalus–Porbandar
(xxix) Surendranagar–Dhola–Dhasa
(xxx) Dhola–Pipavav
(xxxi) Rajkot–Junagarh
(xxxii) Dhola–Bhavnagar
(xxxiii) Palanpur–Samakhali–Gandhidham
(xxxiv) Ghandhidham–Kalol
(xxxv) Banglore–Ariskere–Hubli

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Group ‘D’

(xxxvi) Banglore–Maysore–Hasan–Ariskere

(xxxvii)Hasan–Manglore

(xxxviii) Hospet–Hubli–Londa–Miraj–Pune

(xxxix) Baiyappanahalli–Omlur

(xl) Vikarabad–Parlivaijnath–Parbani

(xli) Nadikuide–Macherla

(xlii) Samalkot–Kakinada Port

(xliii) Gooty–Pendekallu

(xliv) Karur – Dindigal – Madurai –Vanchchimaniyachchi

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Group ‘D’

(xlv) Ernakulam–Thiruvananthapuram
(xlvi) Ernakulam–Alappuzha–Kayanlwlam
(xlvii) Thoke–Manglore–Shoranur
(xlviii) Mayipaduturai–Kumbakonam–Thanjavur–Trichchirapalli
(xlix) Jodhpur–Marwar
(l) Udaipur–Chittorgarh–Ajmer
(li) New Jalpaiguri–Lumbding–Tinsukia
(lii) NJP–Alipurdwar–Samukhala Road
(liii) Kumedpur–Katihar
(liv) Bhatni–Varanasi–Allahabad

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Group ’E’

- All other Sections and branch lines with speed up to 100 kmph.

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2 – BASICS OF RAILWAY TRACK

2.4. DUTIES OF P.WAY STAFF- (4 Periods)

2.4.1 Duties of Track maintainer (1 Period)

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Duties of Track maintainer:

- Track maintainers are responsible for maintenance of track as shown in the video

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Video

(by Ministry of Railways)

- Track maintainers perform various duties like
  - Relieving Gateman



Relieving Keyman



- Track maintainers perform various duties like patrolling of track



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- Track maintainers perform various duties like material leading/ loading/ unloading etc. as instructed by Gangmate and controlling supervisor, in order to ensure safety of track.



2 – BASICS OF RAILWAY TRACK

2.4. DUTIES OF P.WAY STAFF-(4 Periods)

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1.2 Duties of Keyman (1 Period)

Responsibilities of a Keyman:

(A) General:

i. The Keyman shall inspect the entire beat once a day on foot, both the tracks and bridges, and return along the opposite rail to that taken on outward journey in case of single line.

ii. On double line, Keyman will carry out one round of inspection in morning hours by going along up line and then returning along down line or vice-versa.

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iii. On the days of Gang holidays and rest, the Keyman shall perform the usual duties and get a day's rest in the week as per the roster duties in force.

iv. On rest days or during absence or leave or sickness, a competent Track Maintainer should be deputed in place of the regular Keyman.

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(2) **Roster duty hours of Keyman–**

- The roster duty hours of Keyman for winter months should be so adjusted as to ensure one round of track inspection in early morning to enable detection of any rail or weld fractures that might have occurred during the night or early morning.
- DEN/Sr.DEN of the section shall decide and notify the exact timings and the period of each section.

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(3) **Equipment of Keyman–**

Keyman shall carry two red flags, and one green flag, ten detonators, a keying hammer, Alloy Spanner D/E, Spanner Tubular, Tapered Gauge, Tapered Pin, Keyman Diary, spare fittings and a rail closure of 30 mm size.

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(3) **Equipment of Keyman–**



Rain coat with cap/ hood and separate waterproof trousers: Waterproof coat and trousers with full slvees and cap/hood

Winter jacket: Jacket with inner lining with/without cap, orange colour Superior quality

Safety shoes: As per IS 15298 standard-reputed brands Bata, Action

Safety helmet with detachable miner's light- Miner's helmet with detachable headlight having flexbility for rotation with straps

Luminous vest : Retro reflective orange colour

Tool kit bag: matte nylon bag

Tricolour LED torch

In addition to this, UD transmitter device, that alerts the trackman with vibration on the train operation will also be provided.

Important Duties of Keyman–

(1) While walking the Keyman should look for defects, such as loose fish bolts, loose bolts on joggled fish plates, SEJ, fittings in switches and crossings, fittings on girder bridges and open top culverts, broken or notched sleepers, broken plates or tie bars and attend to them as necessary.

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Important Duties of Keyman–

If the Keyman finds that fittings are consistently working loose even after repeated attention, he should report the matter to the Gang Mate, JE/SSE/P.Way. If the defects are serious, it should be informed at once to the Gang Mate of the gang, duly protecting the line in the meantime, if necessary, according to rules.

(2) The Keyman shall keep a special watch on the rails and welds marked for observation by the USFD team.

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(3) If the Keyman notices any condition of danger, such as broken rail, broken weld or wash away of ballast, theft of fittings in large numbers etc., the line shall be protected at once as per rules, and the Keyman shall take such action as is possible and report the matter to the Gang Mate, the nearest Station Master and JE/SSE/P.Way.

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(4) Keyman, in addition to the normal round of the entire beat inspection and tightening of loose fittings, should attend one OHE mast /hectometre post on one line thoroughly on every day and carryout other works assigned by Mate. This thorough attention should consist of checking of each bolt and fittings including fittings of fishplates, joggled fishplates, & PRC/ other sleepers in these OHE mast /hectometre post of the beat during that particular day and tightening them, wherever required. Missing ERCs, liners, keys and other missing fittings will be recouped by Keyman, who would also ensure correct driving of fittings in this stretch.

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(5) Keyman with the assistance of Track Maintainer(s) will also carry out rail end examination, lubrication of fish plated joints as per direction of JE/SSE/P.Way.

(6) For imposing of caution after stopping the train or otherwise, wherever required for safety, the Keyman will be provided pre-printed paper slips by JE/SSE/P.Way. The Keyman, after filling location and speed, will hand over the paper slip to Driver or ASM and obtain acknowledgement.

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(7) The following are the additional duties and responsibilities of the Keyman in LWR/CWR territories:-

(a) Periodical (fortnightly) oiling and greasing of SEJ, checking and retightening of fastenings at SEJ and other sleepers, if necessary.

(b) Tighten loose fittings and replacement of missing fastenings not requiring lifting or slewing of track in accordance with ***Para 345(5) (a) of IRPWM***.

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(7) The following are the additional duties and responsibilities of the Keyman in LWR/CWR territories:-

(c) To watch for sun kinks, loose or missing fastening which may result in buckling or any damage to LWR/CWR and SEJ. On noticing any buckling or damage to track, the Keyman shall take necessary action to protect the track and report the same immediately to JE/SSE/P.Way (sectional), SSE/P.Way (In-charge), and Station Master. However, the Keyman will continue to perform duties of daily inspection.

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(7) The following are the additional duties and responsibilities of the Keyman in LWR/CWR territories:-

(d) To keep a sharp vigil in cold mornings, especially during winters to detect any fractures which may occur, in case of rail/weld fracture, the Keyman shall take prompt action to protect the track and carry out emergency repairs to permit the restoration of traffic promptly and report to SSE/P.Way (In-charge), JE/SSE/P.Way (Sectional) and nearest Station Master.

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(8) The Keyman shall promptly report to Mate/SSE/JE (P.Way) any encroachment or unauthorised structures as and when they take place in the Railway land.

(9) After completing inspection of the beat, the Keyman should assist the Gang Mate in the day's work being done.

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(10) When materials, such as dynamo-belts, engine parts and personal articles of passengers, are found on line, the Keyman should collect them and arrange for handing them over to the nearest Station Master.

(11) The Keyman will remain in-charge of the gang in absence of the Gang Mate once a week. On that day, the Gang Mate is required to carry out the work and duties of Keyman.

(12) Whenever directed the Keyman will supervise rail dolly working. However, the Keyman must have competency certificate for the same.

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(13) The Keyman shall watch height gauges for any damage. In case of any such damage, the Keyman shall also look for any damage/shifting of girder, infringement to track or damage to overhead electrical installations and shall report the matter to the Gang Mate, the nearest Station Master and JE/SSE/P.Way and also protect the line as the situation warrants.

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(14) The Keyman shall maintain the Keyman's book supplied to them up to date wherein-

(a) All special work done, missing fittings and their recoupment with location and date are to be entered.

(b) Special locations to be watched by the Keyman should be entered.

(c) The special fittings like joggled fishplates and other material provided in the section, which are vital for safety and for restoration of traffic should also be mentioned in the book.

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2 – BASICS OF RAILWAY TRACK

2.4. DUTIES OF P.WAY STAFF-(4 Periods)

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2.4.3 Duties of Mate (1 Period)

General: Every Gang Mate shall be responsible for maintenance and safety of track in every situation. They shall follow the instructions of their concerned higher authorities.

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Knowledge of Rules and Signals– Every Gang Mate shall have the correct knowledge of hand and detonating signals and shall be conversant with the following rules:

(1) "Safety first" rules.



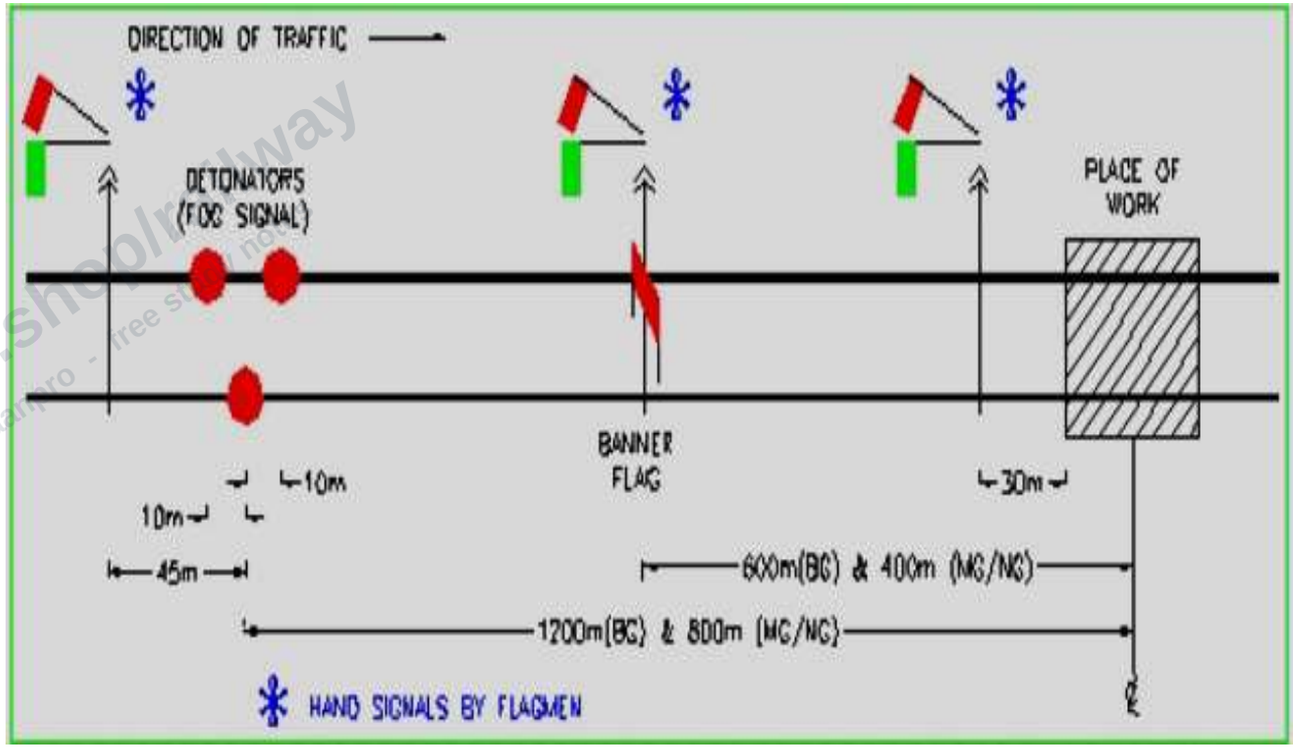
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Knowledge of Rules and Signals–

Every Gang Mate shall have the correct knowledge of hand and detonating signals and shall be conversant with the following rules:

(2) Method of fixing and safety range of detonators.

(3) Protecting the line in an emergency and during work(s) affecting the track/safety.



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Knowledge of Rules and Signals– Every Gang Mate shall have the correct knowledge of hand and detonating signals and shall be conversant with the following rules:

(4) Action to be taken when a train is noticed to have parted, having hot axle or any other unusual(s).

(5) Action to be taken where sabotage is suspected and patrolling in emergencies.

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Important Duties of Gang Mate:

(1) **Safety of the Line**– Every Gang Mate shall see that the line is kept safe for the passage of trains. All locations needing urgent attention shall be attended to without waiting for orders from the JE/SSE/P.Way.

(2) **Knowledge of track maintainer** - Gang Mate shall ensure that every track maintainer is having knowledge of safety rules before deploying them on track.

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Important Duties of Gang Mate:

Gang Mate shall ensure that the safety equipment and signals supplied to the Gangs are kept in good order and ready for use and that every person in the Gang has correct knowledge of all these safety equipment and signals.

(3) **Equipment at Site of Work**–Gang Mate shall ensure that all the requisite tools and equipment as prescribed with gang are with the trackmen at the site of work.

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(3) **Equipment at Site of Work–**



(4) **Musters and Gang Charts/Diary Books–**

(a) The muster and Gang chart /diary shall be in the possession of each Gang Mate. The Gang chart should be carefully kept in a container provided for the purpose.

(b) The muster should normally be marked by the Gang Mate. However, literate Track Maintainer may be allowed to sign muster, which should be checked by Gang Mate.

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(4) **Musters and Gang Charts/Diary Books–**

(c) The Gang Mate shall see that the prescribed system of track maintenance is adhered to and the tasks allotted, according to verbal instructions or entries made in his Gang chart / diary, and explained to him, are efficiently carried out including lubrication of rail joints, attention to bad spots and isolated renewed of sleepers, If capable of entering details of work done in Gang diary, the Gang Mate should do so.

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(5) **Observance of Sleeper Packing During Passage of Train–** During the passage of the first and last trains in working hours, the Gang Mate and the Trackmen should stand on the cess, each about one rail length apart, and observe the effect on the sleepers. Loose sleepers should then be marked and adequately packed. On double line, the Gangs shall invariably stand on the cess side and not in between the tracks.

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(6) Precautions when View is Obstructed–

When working at a place from which an approaching train cannot be seen, at least 600 metres away a Track Maintainer with hand signals should be sent out by the Gang Mate:

(a) On double line in the direction of approaching trains,

(b) On a single line in the direction the view is obstructed (in both directions if view is obstructed on both sides).

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(6) Precautions when View is Obstructed–

It will be the duty of such Flagman to warn the Gang Mate by means of signals when a train is approaching.

The Gang Mate will be responsible for warning the Gang in good time to enable them to get clear off the track. It may be deemed expedient, as an additional precaution, to issue portable whistle boards of the type indicated in to the Gang Mates, who should fix them at least 600 metres from the work-site, in the direction the view obstructed to less than this distance.

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(7) **Tidiness of Section–** Gang Mate shall see that the entire Gang length is kept neat and tidy and that all loose materials are collected and brought to stations, gang's quarters or gate lodges.

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(8) **Safe Custody of Tools–** Gang Mate shall be responsible for the safe custody of tools used by himself, the Keymen and all Track Maintainers. Gang Mate should see that Track Maintainers on work remove their tools clear of the track on the approach of a train. After the day's work the Gang Mate should secure the tools in the toolbox. In no case should Track Maintainers be permitted to take tools home. Before Track Maintainers break for mid-day meals the Gang Mate should see that the tools are kept away from track.

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(9) **Action when Line is Unsafe or in the Event of Accident–**

(a) If a Gang Mate or his Keyman considers that the line is likely to be rendered unsafe, or that any train is likely to be endangered in consequence of any defect in the permanent way or works, or due to abnormal rain or flood or any other occurrence, Gang Mate shall take immediate steps to secure the safety of trains by using the prescribed signals to “Proceed with Caution” or to “Stop” as necessity may require, vide ***Para 806/812 of IRPWM***, and shall, as soon as possible, report the circumstances to the nearest Station Master and the JE/SSE/P.Way.

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(9) **Action when Line is Unsafe or in the Event of Accident–**

(b) In the event of an accident, the Gang Mate, Keymen and Track Maintainers should lookout for broken fittings of wagons and track components and see that these are not disturbed until these have been seen and recorded by a responsible official.

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(10) **Patrolling during Abnormal Rainfall–** During abnormal rainfall, the Gang Mate should organise patrolling on the gang-length, whether or not Patrolmen are on duty. In the event of damage being detected, action should be taken to safeguard traffic by protecting the line in accordance with ***Para 812.***

(11) **Weekly Inspection of Gang Length by Gang Mate–** Gang Mate shall inspect the entire Gang length once a week. On that day Gang Mate will carry out the Keyman's duties; and the Keyman will remain in-charge of the Gang.

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(12) **Commencing Work Affecting Safety of Trains–** No work, which may involve danger to trains, should be under taken by the Gang Mate except under the personal supervision of the JE/SSE/P.Way, a competent Railway servant authorised by special instructions, unless it is an emergency where the requirements of safety warrant the commencement of the work. In such cases the Gang Mate shall ensure that Engineering Signals are exhibited at the specified distances according to rules and Flagmen are posted with necessary equipment to man them before commencing the work.

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(13) **Preventing Trespass and Theft of P.Way Fittings–** Every Gang Mate and the trackmen shall endeavour to prevent trespass in Railway limits by persons or cattle on the gang length, of line, and report any attempts at encroachment or unauthorised structures when noticed. Gang Mate along with Gang, should also attempt to prevent theft of P.Way fittings and report any attempt to steal, to JE/SSE/P.Way.

(14) **Relief arrangement in Emergencies–** Gang Mate shall arrange immediate relief for Keymen, Gatemen, Patrolmen and Watchmen when, due to sickness, they are unable to perform their duties.

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(15) **Assistance in protection of Trains–**Gang Mate and the trackmen should render assistance to Guards and Drivers of the trains for the protection of the trains in the event of an accident between stations, when called upon to do so.

(16) **Assistance in Placing Fog Signals–** On requisition from the Station Master, the Gang Mate of a yard gang may depute, if available, two Track Maintainers for placing of detonators, during time of poor visibility, in the rear of approach signals of the station.

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(17) **Responsibilities of the Gang Mate in LWR Track–** The specific duties and responsibilities of the Gang Mate in LWR sections are as under:

(a) To carry out maintenance work under personal supervision, only if in possession of valid competency certificate issued by Zonal/Divisional Training Centre to work on LWR/CWR section.

(b) To undertake only those works of track maintenance for which Gang Mate is authorised.

(c) To maintain additional/special equipment issued in good condition and bring to the notice of JE/SSE/P.Way, if any defective equipment need repairs.

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(17) **Responsibilities of the Gang Mate in LWR Track–** The specific duties and responsibilities of the Gang Mate in LWR sections are as under:

(d) To introduce hot/cold weather patrolling when instructed by the Supervisors and ensure that hot/cold weather patrolmen turn out on duty during the specified patrol period and carry out the patrolling duties correctly.

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(e) To be vigilant during hot weather and order patrol if the temperature is likely to reach td+20°C and report to the supervisors any unusual occurrences that take place on the LWR/CWR in his beat.

(f) To take prompt action to protect the track in case of rail/weld fractures and carry out emergency repairs to permit the restoration of traffic promptly and report to nearest Station Master /SSE/JE/P.Way.

(g) To take immediate steps to secure the safety of the trains as per ***Para 806/812 of IRPWM,*** if they consider that track is likely to be rendered unsafe.

(h) To report any ballast deficiency or disturbance of track to the JE/SSE/P.Way.

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(i) To inspect SEJ and LWR/CWR under his jurisdiction frequently, especially during the hottest part of the afternoons in summer and report any unusual occurrence on LWR/CWR to JE/SSE/P.Way to obtain further order.

(j) The Gangmate shall note down the details of missing fittings and fastenings on plain track, turn-outs, SEJs, Glued Joints, bridges etc. and recoup them as soon as possible. He will also note down the details of cracked/ broken/ notched sleepers in the track and advise the same to JE/SSE/P.Way.

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(k) On receipt of advice of a danger of buckle,

i. The Gangmate should proceed to the site quickly with all available men/resources and ensure protection of affected portion at site.

ii. Thereafter the Gangmate should inspect the condition of track 100 m on either side of this suspected zone and commence heaping of surplus ballast, if available, on the shoulders and up to the rail head and keep on compacting the ballast with available tool.

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(k) On receipt of advice of a danger of buckle,

iii. No attempt should be made to slew or align the track or disturb the existing ballast section. The Gangmate should continue to remain at site till the arrival of JE/SSE/P Way.

iv. The rail temperature will also be noted by one of these officials at the place of apprehended/actual buckle. The rail facing the sun will be covered up to the level of rail-head on the outside by ballast or leaves etc. to bring down the temperature of the rail.

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2 – BASICS OF RAILWAY TRACK

2.4. DUTIES OF P.WAY STAFF- (4 Periods)

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2.4.1 Duties of JE/SSE(P.Way) (1 Period)

DUTIES OF JUNIOR ENGINEER /SENIOR SECTION ENGINEER/P.WAY/(SECTIONAL)

General responsibilities– The Junior Engineer/Senior Section Engineer (P.Way), working as sectional and abbreviated as JE/SSE /P.Way (Sectional) is generally responsible for:

(1) Inspection and maintenance of track in the sub-section in a safe and satisfactory condition for traffic, lorrying out of material, including execution of all works incidental to track maintenance.

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DUTIES OF JUNIOR ENGINEER /SENIOR SECTION ENGINEER/P.WAY/(SECTIONAL)

General responsibilities– The Junior Engineer/Senior Section Engineer (P.Way), working as sectional and abbreviated as JE/SSE /P.Way (Sectional) is generally responsible for:

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(2) Efficient execution of Special Works, such as Renewals, Spot attention, Curve realignment and deep Screening, as per approved plans and specifications.

DUTIES OF JUNIOR ENGINEER /SENIOR SECTION ENGINEER/P.WAY/(SECTIONAL)

General responsibilities– The Junior Engineer/Senior Section Engineer (P.Way), working as sectional and abbreviated as JE/SSE /P.Way (Sectional) is generally responsible for:

(3) Making a date wise schedule and record in the Keyman's book indicating the Kms/TPs that the Keyman has to attend on each day of the month to complete the task required to be done as per his duties.JE /SSE /P.Way (Sectional) during their inspections should check to ensure that such locations have really been thoroughly attended to and initial against the entries.

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Knowledge of Rules and Regulations –

- 1) Every SSE/P.Way (Sectional) shall have in his possession up-to-date copies of the codes and manuals etc. with all correction slips up-to-date as per Para 102 of IRPWM.
- 2) SSE/P.Way (In-charge) shall be well acquainted with the rules, regulations and procedures concerning the work and duties as enjoined in these codes, manuals etc. He shall keep himself in touch with the instructions and circulars issued by higher authorities from time to time and efficiently act upon them.
- 3) SSE/P.Way (In-charge) shall ensure that all the staff are well acquainted with the relevant rules and working methods and efficiently perform assigned duties.
- 4) SSE/P.Way (In-charge) shall be well conversant with the various modules of the Track Management System

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Duties of JE /SSE /P.Way (Sectional) are detailed as below:

(1) Inspection and maintenance of track in a satisfactory and safe condition.

JE /SSE/P.Way (Sectional) shall conduct inspection as per the Schedules laid down by the Administration *(**Table**)*; enter the inspections data in TMS, and attend to the deficiencies noticed at the earliest possible.

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Duties of JE /SSE /P.Way (Sectional) are detailed as below:

JE /SSE /P.Way (Sectional) being directly responsible for the safety of the track; shall

(a) Devote sustained attention to Permanent way as regards safety, smooth running, economy and neatness.

(b) Be vigilant to locate faults/irregularities in the Permanent Way and ensure prompt remedy.

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Duties of JE /SSE /P.Way (Sectional) are detailed as below:

JE /SSE /P.Way (Sectional) being directly responsible for the safety of the track; shall

(c) Observe the behaviour of track under passing trains to detect inadequate packing during routine inspections.

(d) Travel on the footplate of Engine /Rear brake-van/last Vehicle of fast trains, take down notes of bad running locations, and get them rectified.

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(e) Immediately bring the defects, which are beyond powers of remedy, to the notice of SSE/P.Way (In-charge) and obtain advice.

(f) Ensure timely removal / cutting of trees in proximity to and liable to foul the track during a storm.

(g) During his routine inspections, independent of detailed periodical inspections, should watch for any signs of weakness in bridges and structures affecting track and promptly report any matter demanding the attention of higher authority.

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(2) JE/SSE/P.Way (Sectional) should have a thorough knowledge of important pre-requisites for proper functioning of LWR/CWR and the limitations and precautions laid down for work on LWR/CWR and ensure that the maintenance instructions are strictly followed by all the staff dealing with maintenance of LWR/CWR.JE/SSE/P.Way (Sectional) shall be responsible for the duties as mentioned in ***Para 106(2) (a) of IRPWM.***

(3) Inspection and maintenance of track at Bridges/Tunnels/cuttings: As per provisions contained in ***Para-106 (3) of IRPWM.*** (Relating to track only)

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(4) Track Machines- while deputed on machine JE /SSE /P.Way (Sectional) shall be the in-charge of the supervision of the work of track machine and responsible for following duties:

(a) Ensuring safe movement of machine from siding to block section and back as per the provisions given in IRTMM and G&SR.

(b) Undertaking & ensuring all prerequisites, pre-block, during block and post-block activities according to track machine and for quality output.

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(c) Arranging adequate precautionary measures for the protection of the site of work and adjoining track wherever necessary along with the safety of staff working with machine in the block section against danger of trains on the adjoining line(s).

(d) Ensuring various important Parameters of track machines like tamping depth, squeezing pressure, wear and tear of tamping tools, squeezing time, condition of cutter bars etc. as per the type of machine and provisions of IRTMM in order to ensure quality and output of machine during block.

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(e) Checking of the track Parameters and condition of track, during working of track machines, and ensuring that the track Parameters are well within the tolerances.

(f) Ensuring that track is free of obstructions and infringements for safe passage of traffic before clearing the traffic block. As required or stipulated JE/SSE/P.Way (Sectional) shall allow traffic at suitable speed restriction based on the condition of track after machine working.

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(g) To investigate and take suitable remedial measures in coordination with JE/SSE/ (Track Machine), in case the quality of work done by the machine is not satisfactory.

(h) To issue of all necessary caution orders for machine working.

(i) For ensuring that the machine(s) are stabled in suitable sidings and at such stations as to minimize idle run of the machines as well as wastage of block hours in entering and clearing of the block section.

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(j) Co-ordinate with other departments like Traffic, OHE and S&T in the field to facilitate working.

(k) Take all possible actions to clear the block section expeditiously, in the eventuality of breakdown of machine, once it is known that it cannot be repaired during the block.

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(5) Execution and monitoring track works– As per provisions contained in ***Para -106(6) of IRPWM,*** JE/SSE /P.Way (Sectional) shall carry out maintenance works as assigned to him by SSE/ P.Way (In-charge).

(6) Co-ordination with Works, Bridge and Staff of other Departments– JE/SSE/P.Way (Sectional) should keep close co-ordination with the Works, Bridge, Operating, Signalling and Electrical Staff, whenever they are required to work jointly.

(7) JE/SSE/P.Way (Sectional) should work in the SSE/P.Way (In-charge) office and assist the SSE/P.Way (In-charge) as required.

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(8) Training of P.Way officials–JE /SSE /P.Way (Sectional) shall be responsible for counselling of Trackmen, Gateman, Keyman, Patrolman and Stationary Watchman for their specific duties, safety and protection rules at the appropriate stage, better maintenance practices, and also examine/check at frequent interval during routine trolley and other inspections.

(9) Action in case of Emergencies– As per the provisions contained in ***Para -106(16) of IRPWM.***

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(10) Action during extreme weather condition: As per the provisions contained in ***Para -106(17) of IRPWM***.

(11) Inspection of on-going works of construction and other organization (like RVNL, RITES, DFCCIL etc.) or authorized agencies in the section as much as possible during Foot plate/Trolley inspection to check quality of work and ensuring safety of the running trains.

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(12) Upkeep of Station Yards–JE/SSE/P.Way (Sectional) shall be responsible for cleanliness of station yards. The materials should be stacked methodically in a tidy manner.

(13) JE /SSE/P.Way (Sectional) shall observe the track movement in yards especially at turnouts, SEJs, glued joints and other fish plated joints during passing of trains and shall take corrective measures to rectify the defects observed.

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DUTIES OF SENIOR SECTION ENGINEER / P.WAY IN OVERALL CHARGE

- General –
- The Senior Section Engineer/P.Way in overall charge, abbreviated as SSE/P.Way (In-charge), is generally responsible for:
- (1) Maintenance and inspection of track in a satisfactory and safe condition for traffic.
- (2) Efficient execution of all works incidental to track maintenance, including track relaying works.
- (3) Accountal and periodical verification of stores and tools.
- (4) Maintenance of land boundaries between stations and at unimportant stations as may be specified by the administration.
- (5) Compliance of Inspection notes of higher officers in reasonable time

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Knowledge of Rules and Regulations

- 1) Every SSE/P.Way (In-charge) shall have in his possession up-to-date copies of the codes and manuals etc. with all correction slips up-to-date as per Para 102 of IRPWM.
- 2) SSE/P.Way (In-charge) shall be well acquainted with the rules, regulations and procedures concerning the work and duties as enjoined in these codes, manuals etc. He shall keep himself in touch with the instructions and circulars issued by higher authorities from time to time and efficiently act upon them.
- 3) SSE/P.Way (In-charge) shall ensure that all the staff are well acquainted with the relevant rules and working methods and efficiently perform assigned duties.
- 4) SSE/P.Way (In-charge) shall be well conversant with the various modules of the Track Management System.

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Duties of SSE / P.Way (In-charge) are detailed as below:

- (1) Inspection and maintenance of track in a satisfactory and safe condition. SSE/P.Way (In-charge) shall conduct inspection in his jurisdiction as per the Schedules laid down (Table-1B) of IRPWM by the Administration from time to time,
- Enter the inspections details in TMS, and ensure compliance within a reasonable time as per the guidelines.
- SSE/P.Way (In-charge) being directly responsible for the safety of the track, shall
- (a) Devote sustained attention to Permanent way as regards safety, smooth running, economy and neatness.
- (b) Be vigilant to locate all faults/irregularities in the Permanent Way and ensure prompt remedy.

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- (c) Observe the behaviour of track under passing trains to detect inadequate packing during routine inspections.
- (d) Travel on the footplate of Engine / Rear brake-van/last Vehicle of fast trains, take down notes of bad running locations, and get them rectified.
- (e) Immediately bring the defects, which are beyond powers to remedy, to the notice of Assistant Divisional Engineer and obtain advice.
- (f) Ensure timely removal / cutting of trees in proximity to and liable to foul the track during a storm.

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- (g) During routine inspections, independent of detailed periodical inspections, watch for any signs of weakness in bridges and structures affecting track and promptly report any matter demanding the attention of Assistant Divisional Engineer.
- (2) SSE/P.Way (In-charge) of section should have a thorough knowledge of important pre-requisites for proper functioning of LWR/CWR and the limitations and precautions laid down for work on LWR/CWR and ensure that the maintenance instructions are strictly followed by all the staff dealing with maintenance of LWR/CWR

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- (a) The SSE/P.Way (In-charge) of section shall-
- (i) Supervise all track maintenance work for which they are responsible and authorised.
- (ii) Make arrangements for patrolling of track in hot and cold weather and post mobile watchmen as and when required and ensure that patrolmen and mobile watchmen are issued proper equipment for carrying out patrolling.
- (iii) Responsible for repairs and restoration of traffic in case of accident, derailment, buckling, wash-away, rail fracture etc.
- (iv) Responsible for greasing of ERCs, effectiveness of all fittings, soundness and squareness of sleepers, track drainage etc.

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- (v) Responsible for carrying out de-stressing, welding and other maintenance operation correctly and complete them within the block period for which block has been taken.
- (vi) Record rail temperatures, de-stressing temperature, minimum and maximum rail temperatures and also periodically check the rail thermometers used for recording rail temperature with reference to standard thermometer.
- (vii) Ensure imposition of necessary speed restriction, in case the temperature exceeds td + 20°C after the maintenance work has been completed on LWR/ CWR for the period of consolidation.
- (viii) Ensure proper ballast section of the track and shall arrange to recoup the ballast, as per standard ballast profile, before the onset of summer

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- (b) SSE/P.Way (In-charge) of section shall be responsible for:
- (i) The procurement of the permanent way materials and the equipment required for the maintenance of LWR/ CWR for all the staff working under him.
- (ii) Maintenance of a permanent record of each LWR/CWR as per the proforma and shall be responsible for keeping the records up-to-date.

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(3) Inspection and maintenance of Bridges:

- SSE/P.Way (In-charge) shall;
- (a) Inspect the track and approaches of all the bridges including footpath (and runoff frame if any) once a year during the prescribed months prior to monsoon (Para1101 of IRBM).
- (b) Inspect the track and approaches at every tunnel and cutting before monsoon or as specified, and take the remedial action if required for safety of track. The SSE/P.Way (In-charge) shall be responsible for clearing the drains before monsoons in tunnels and cuttings.
- c) Follow instructions given in relevant manuals and the local instructions of higher authority while maintaining the track in Ghat section, in cuttings, on high banks or any other vulnerable section.

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4) Track Machines-

- (SSE/P.Way (In-charge) shall monitor and ensure progress and quality output of various track machines working in the section, and shall;
- (a) Ensure all prerequisites, pre-block, during block and post-block activities according to track machine and for quality output.
- (b) Be responsible for temporary storage and timely arrangement and transportation of HSD oil from the depots to various machines working in his jurisdiction.
- (c) Be responsible for making lighting arrangement during night working.
- (d) Ensure transportation of tamping tools to be reconditioned and bringing back reconditioned tamping tools to the machine.
- (e) Be responsible for protection of the site of work and adjoining track wherever necessary.

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- (f) Be responsible for arranging adequate precautionary measures for the protection of the site of work and adjoining track wherever necessary along with the safety of staff working with machine in the block section against danger of trains on the adjoining line(s).
- (g) Arrange for track protection and provide look out men for safety at site.
- (h) Be responsible to ensure that the machine(s) are stabled in suitable sidings and at such stations as to minimize idle run of the machines as well as wastage of block hours in entering and clearing of the block section.

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- i) Arrange for protecting and watching of stabled machines and also ensure that no sick vehicles etc. are pushed into the same siding affecting the taking out of the machines to avail blocks.
- (j) Co-ordinate with other departments like Traffic, OHE and S&T in the field to facilitate smooth working.
- (k) Take all possible actions to clear the block section expeditiously, in the eventuality of breakdown of machine, once it is known that it cannot be repaired during block.
- (l) Inspect the track machines as per the prescribed schedule (Table-1B of IRPWM) and items / check lists as per IRTMM;

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- (5) Preparation of plans and estimates of various track works and submission of proposals to ADEN for further action.
- (6) Execution and monitoring track works as per the tender conditions and approved plan &schedule of the work.
- SSE/P.Way (In-charge) shall ensure timely measurement and bill preparation with proper test check and ensuring quality.
- (a) Special works: Before commencing any work, SSE/P.Way (In-charge) shall ensure that all necessary materials and tools are in possession.
- (b) SSE/P.Way (In-charge) should programme the works by organizing the labour in an efficient manner; and maintain detailed accounts of materials received and issued to the work.

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- (c) SSE/P.Way (In-charge) shall ensure that Engineering Signals are exhibited at the specified distances according to rules and Flagmen are posted with necessary equipment; and should exercise as much as possible checks but minimum once in a month on quality and quantum of work and submit progress reports on works periodically as may be prescribed.
- (d) Quality of welding and avoidable fractures– The direct responsibility for quality of AT welding being done in the section shall rest on the SSE/P.Way (In-charge) of the section. He will ensure that the equipment available with the welding team are complete and are in good condition.
- (e) The responsibility for avoidable fractures taking place in the section shall also rest with the SSE/P.Way (In-charge) of the section, except in cases where the USFD testing was done and found good up to three months before the fractures.

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- (f) SSE/P.Way (In-charge) shall ensure to arrange for the repairs and maintenance of small track machines available with him.
- (g) Other P-Way maintenance works: SSE/P.Way (In-charge) shall ensure that all the P.Way maintenance works like casual sleeper / rail /fittings renewal, de-stressing, bad spot attention, overhauling at level crossings, oiling and greasing of joints and ERCs, fracture attention, glued joint / SEJs/ Switches / Crossings replacement, rails / sleepers transportation through rail dolly, handling of material trans like ballast / rails/ sleepers unloading in block etc. are being done as per the stipulated provisions of IRPWM / G&SR and with proper safety of running trains and working staff

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- (7) Material Under Trial: SSE/P.Way (In-charge) shall be responsible for monitoring performance of ‘material under trial’ in his section and ensure that the required details for the same are collected as per the trial scheme and submitted to ADEN through TMS.
- (8) Measurement of Ballast: SSE/P.Way (In-charge) will measure the ballast, if so directed by the Assistant Divisional Engineer, and record measurements. SSE/P.Way (In-charge) will also keep proper records of training out and spreading of ballast in the track.
- (9) Co-ordination with Works, Bridge and Staff of other Departments– SSE/P.Way (Incharge) should keep close co-ordination with the Works, Bridge, Operating, Signalling and Electrical Staff, when they are required to work jointly.

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- (10) Inspection and test check of USFD- SSE/P.Way (In-charge) shall check the work of SSE/P.Way/USFD at least once in each round of testing or as specified by higher authority. SSE/P.Way (In-charge) shall also ensure the USFD testing of AT welds within the earliest possible time and as per the specified period/frequency.
- (11) Dealing with store: SSE/P.Way (In-charge) is the in-charge of store depot and shall be accountable of each item of P.Way in the jurisdiction. The SSE/P.Way (In-charge) shall;
- (a) See to the security of rails, sleepers, fastenings and other materials and ensure that unused materials are stacked properly clear off the line, so as not to interfere with the safe running of trains.

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- (b) Be responsible for submitting the requisition/indent for the procurement of various materials as per the need well in advance to avoid critical situation especially of safety items like fittings, gang tools and other safety equipment etc.
- (c) Be responsible for ensuring availability of various materials like Imprest rails, CMS crossings, switches, SEJs, Glued joints, etc. at nominated locations in the section in order to avoid the delay in attention of emergency repairs/replacement.
- (d) Be responsible for offering the scrap and unused materials for their timely disposal.
- (e) Keep the records of every transaction of each material from and to the store.
- (f) Keep his store in neat and tidy condition and will cooperate in verification of stores with stock verifier

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(12) Accompanying Inspection by Higher Officials.

- In addition to above; SSE/P.Way (In-charge) shall arrange to carry the following measuring devices/equipment for these inspections–
- (a) Gauge-cum-level. (b) Flange way gauge.
- (c) Fishing cord. (d) Tape.
- (e) Metric steel scale (30 cm). (f) Tapered gauge& Feeler gauge.
- (g) Magnifying glass and mirror. (h) Versine measuring equipment.
- (i) Inspection hammer etc. (j) Rail Thermometer.

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- (13) SSE/P.Way (In-charge) shall accompany Track Recording / OMS / Oscillograph Car runs in the jurisdiction and take down notes regarding the spots needing attention, and take appropriate actions to rectify the defects/irregularities.
- (14) Training of P.Way officials – SSE/P.Way (In-charge) should take interest in all P.Way officials sent to him for training and see that the training is given according to the specified programme. SSE/P.Way(In-charge) should also ensure that all the P.Way supervisors and staff are undergoing refresher courses / mandatory and other trainings as per the schedules laid down; and instructions of higher authorities. SSE/P.Way (In-charge) shall also be responsible for counselling of Trackmen, Gateman, Keyman, Patrolman and Stationary Watchman for their specific duties, safety and protection rules at the appropriate stage, better maintenance practices, and also examine/check at frequent interval during routine trolley and other inspections.

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(15) Dealing with staff matter:.

- SSE/P.Way (In-charge) shall ensure that:
- (a) Strict discipline is maintained within the frame work of the rules;
- (b) Service and leave records of staff are maintained correctly and up-to-date;
- (c) All staff are sent for medical examination and are fit for the medical standards, as per the relevant instructions in force, before appointment or promotion.
- (d) Ensure that the staff under him are sent for periodical medical examination as laid down in the relevant rules.
- (e) Supply of uniform, winter jackets, safety shoes, torches etc. to the staff are made timely as per the stipulated criteria.

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- (f) The relevant provisions of the Payment of Wages Act, Workmen's Compensation Act, Hours of Employment Regulations etc., as amended from time to time are followed and complied with.
- (g) Issue of passes, preparation of pay bills etc., as may be allotted by the administration is being done promptly.
- (h) Selection of proper Gatemen and Patrolmen are carried out from the existing Track Maintainers and train them in their duties.
- (i) Prompt processing for filling up of the vacancies of Keyman, Gang Mate and artisans etc.
- (j) Appeals and representations are dealt with promptly;

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(16) Action in case of Emergencies– I

- In the case of an accident, including a breach, affecting the running of trains, SSE/P.Way (In-charge) should proceed to the site by the quickest available means.
- On the way, SSE/P.Way (In-charge) should ascertain the requirements of materials and men at site and arrange for the same.
- SSE/P.Way (In-charge) should also order for the Accident Relief Equipment as necessary and take all possible measures to restore the traffic quickly.

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(17) Ensuring preparedness for action during extreme weather condition:

- SSE/P.Way (Incharge) shall-
- (a) Keep the List of Railway affecting Works with brief history and List of vulnerable locations, where stationary watchmen are to be posted.
- (b) Ensure that preparatory works have been completed and due precautions have been taken well before the onset of monsoon, summer and winter.
- (c) Ensure proper watch at vulnerable locations as per the requirements;

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- (d) Arrange for patrolling (hot weather, cold weather and monsoon) of track as per the instruction and patrol chart issued from division.
- SSE/P.Way (In-charge) shall ensure availability of patrol book and required equipment with them.
- Before deploying trackmen for patrolling, proper training / counselling of patrolmen should be done.
- Stationary watchmen at vulnerable locations according to the extreme weather should be deployed with necessary equipment to ensure safety of track.

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- (18) Inspection of on-going works of construction and other organization like RVNL, DFCCIL etc., SSE/P.Way (In-charge) should inspect the ongoing works in the section as much as possible during Foot plate/Trolley inspection to check quality and safety of the running trains.
- (19) Upkeep of Station Yards– SSE/P.Way (In-charge) shall ensure cleanliness of station yards. Under- growth should be cleared every year, usually in the month, before the seeds has ripened. At stations where it is proposed to stack engineering or contractor's materials, the stacking area should be carefully selected and clearly demarcated. The materials should be stacked methodically in a tidy manner.
- (20) SSE/P.Way (In-charge) shall be responsible for maintaining the land boundaries intact and free from encroachment by outsiders in his jurisdiction. SSE/P.Way (Incharge) should keep watch and take immediate necessary action for removal of any type of encroachment, if noticed.

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- (21) Maintenance and up keep of Correspondence and records- SSE/P.Way(In-charge) shall keep all correspondences up-to-date and see that the TMS records, office records, registers and stores ledgers are maintained systematically and posted regularly and as required. SSE/P.Way (In-charge) shall update the data in TMS timely in appropriate fields relating to all types' inspections, all kinds maintenance works and all casual/scattered/planned renewal activities etc. for all the assets.
- (22) Relinquishment of charge– SSE/P.Way (In-charge) shall follow the Instructions on "Transfer-of-charge" contained in Para 143 to 147 of the Indian Railway Code for the Engineering Department

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2.6 General requirement of P-Way Materials for 1 Km track

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Quantity of P Way Material for 1 Km Track (for 60 kg rail & 60 kg PSC Sleeper LWR track)

- 1. Rails – if we use 130 m rail panels to lay 1 Km LWR Track then – (60 Kg 90 UTS rail)
- No. of Panels Required for both sides = 1000X2/130
  = 15.38 = 16 panels





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Quantity of P Way Material for 1 Km Track (for 60 kg rail & 60 kg PSC Sleeper LWR track)

- 2. Sleepers – No. of sleepers for 1660 sleeper density = 1660 nos.(RT-2496)





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Quantity of P Way Material for 1 Km Track (for 60 kg rail & 60 kg PSC Sleeper LWR track)

- 3. ERC - 4 ERCs are required for 1 sleeper (Mk III – RT-3701)
- No. of ERC = 1660 x4 = 6640 no.







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Quantity of P Way Material for 1 Km Track

- 4. GRSP – 2 GRSP are reqd. per sleeper (RT- 3711)
- No. of GRSP required = 1660X2 = 3320 no.





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Quantity of P Way Material for 1 Km Track

- 5. Liners – 4 liners are reqd. per sleeper (Metal – RT-3740, GFN – RT-3706)
- No. of Liners required = 1660X4 = 6640 nos.





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Quantity of P Way Material for 1 Km Track

- 6. Ballast – for LWR track on single line BG on 300 mm ballast cushion Total Ballast Quantity Required for 1 Km Track = 2.304 X 1000 = 2304 M^3







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Quantity of P Way Material for 1 Km Track

- 7. SEJ – 2 sets of SEJ required at both the ends to lay 1 Km LWR track.(RT- 6902 SG/6922 DG)



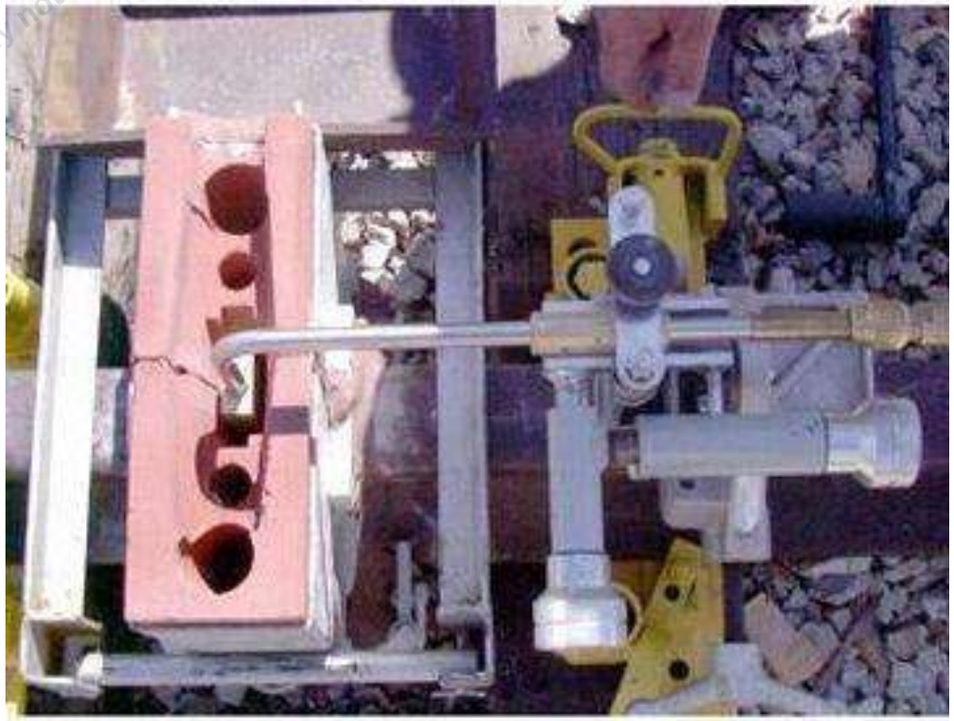




Quantity of P Way Material for 1 Km Track

- 8. AT welding Portion – 7(LH)+ 7(RH)+ 4(SEJ)+ 12(T/O) = 30 portions (for 60 Kg 90 UTS rail)

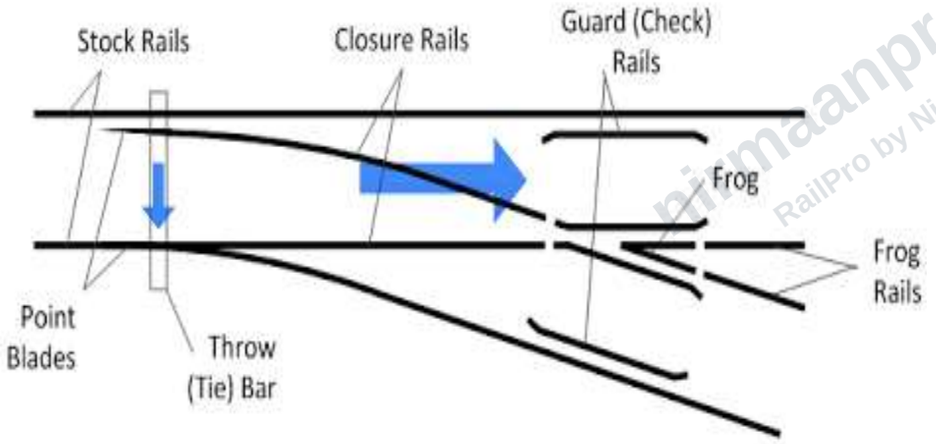




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Quantity of P Way Material for 1 Km Track

- 9. Turnouts – generally 2 no. 1 in 12 turnouts(for Loop Line) with all fittings, T/R & S/R, CMS Xing & Sleepers are required for one main line on a single line section. (RT- 4165)





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PART IX – CURVES

Part 1
HORIZONTAL CURVES
(TOTAL PERIODS – 20)

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2.9 Types of Curves, Degree of Curve, Relation between degree & Radius, Chord and Versine, Standard chords for measuring Versine.

Total periods - 20

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INTRODUCTION

- It is desirable to follow the straight alignment but to be changed by introduction of curve(s)for some unavoidable reasons -
- Connectivity to sources of traffic.
- Obstructions like hills, water bodies etc.
- Unstable geological formations etc.
- Technical and economical considerations when river alignment, length of bridge, need for climbing steep hills.

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- Due to the forces on a curved track, it has been estimated that the maintenance effort on curves is about 25% extra over that on a straight track.
- Therefore the forces and their effect on track, vehicle and passengers are required to be systematically studied so that curves are properly designed and easily maintained.
- Better understanding the vehicle movement on curves and proper laying, maintenance, realignment of curves etc track engineers will be in better position to maintain

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Types of curves

Different types of curves in the track are:

- Simple curves
- Compound curves
- Reverse Curves

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IDENTIFICATION OF CURVE

- Curve is a line of which no part is straight and which changes direction without angles.
- A railway curve is a track which changes alignment without any sharp corners in rails.
- This change of alignment through curves is best attained through circular curve.
- A circular curve has the advantage of uniform curvature means uniform change of direction.
- Identification: R- radius, D- degree, direction of curve : LH/RH

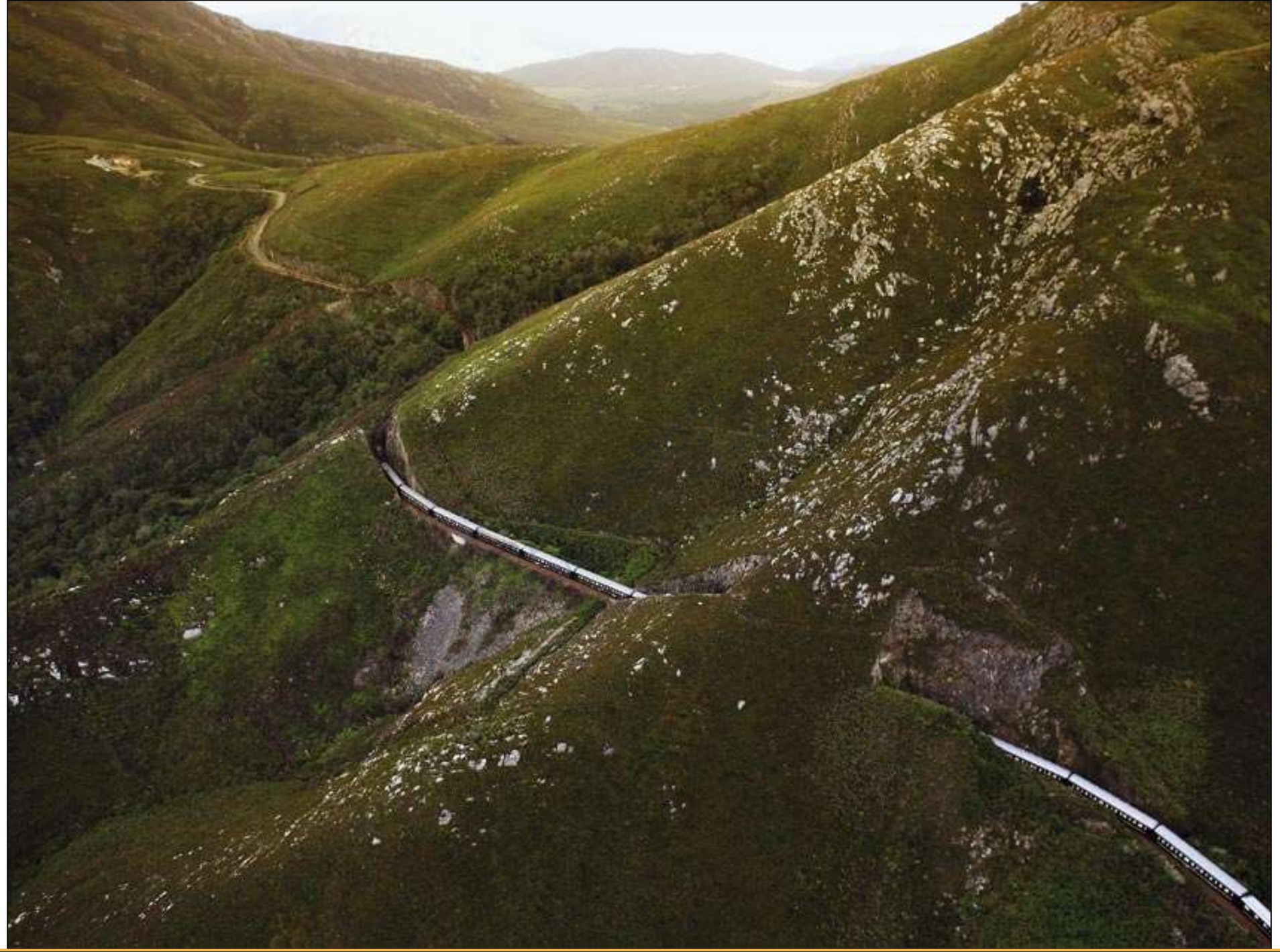
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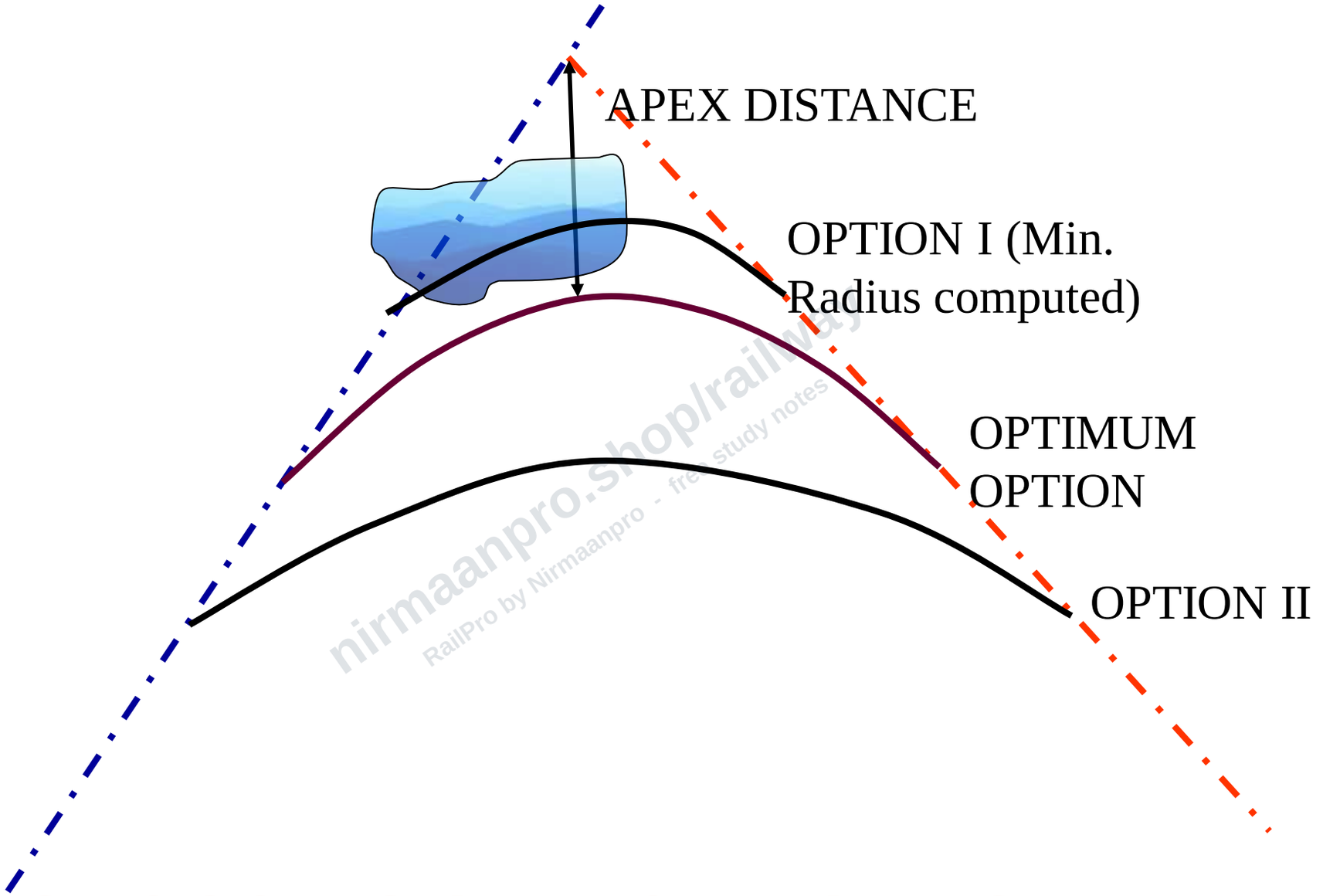
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10



CHOOSING APPROPRIATE CURVE

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How does the train move on rails?

- Vehicle shall be Self centering/ self stabilising
- Coning is the main mechanism
- SINUSOIDAL MOTION.

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Movement of wheels on a straight track

- Coning of wheels helps to keep the vehicle centrally aligned on a straight and level track also.
- Slight irregularities in the track do occur as a result of moving loads and the wheels, therefore, move from side to side and the vehicles sway. Due to the coning of wheels, this side movement results in the tread circumference of one wheel increasing over the other.

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Movement of wheels on a straight track

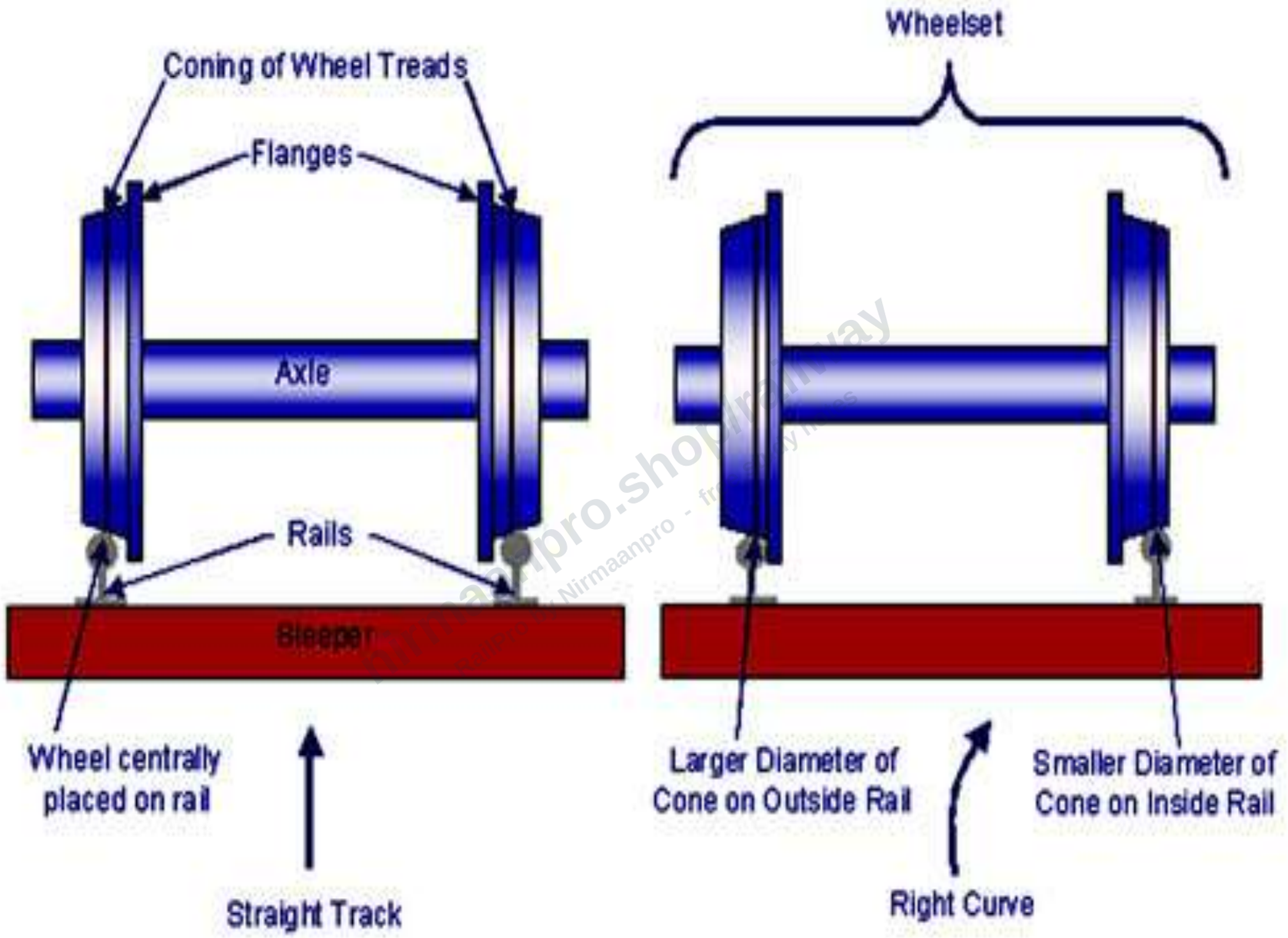
- As both the wheels have to traverse the same distance, this causes one wheel to slide. Due to the resistance caused by the sliding, any further side movement is prevented.
- If there was no coning, the side movement would have continued and the flange of the wheel would have come in contact with the side of the rail, causing jerks and making the ride uncomfortable.

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Behavior of coned wheel in curved track

- On Outer rails wheel has to cover great distance than inner rail
- Vehicle has tendency to move sideways towards outer rail
- Circumference of flange of outer wheel will be greater than that of inner wheel
- Helps the outer wheel to cover longer distance than inner rail

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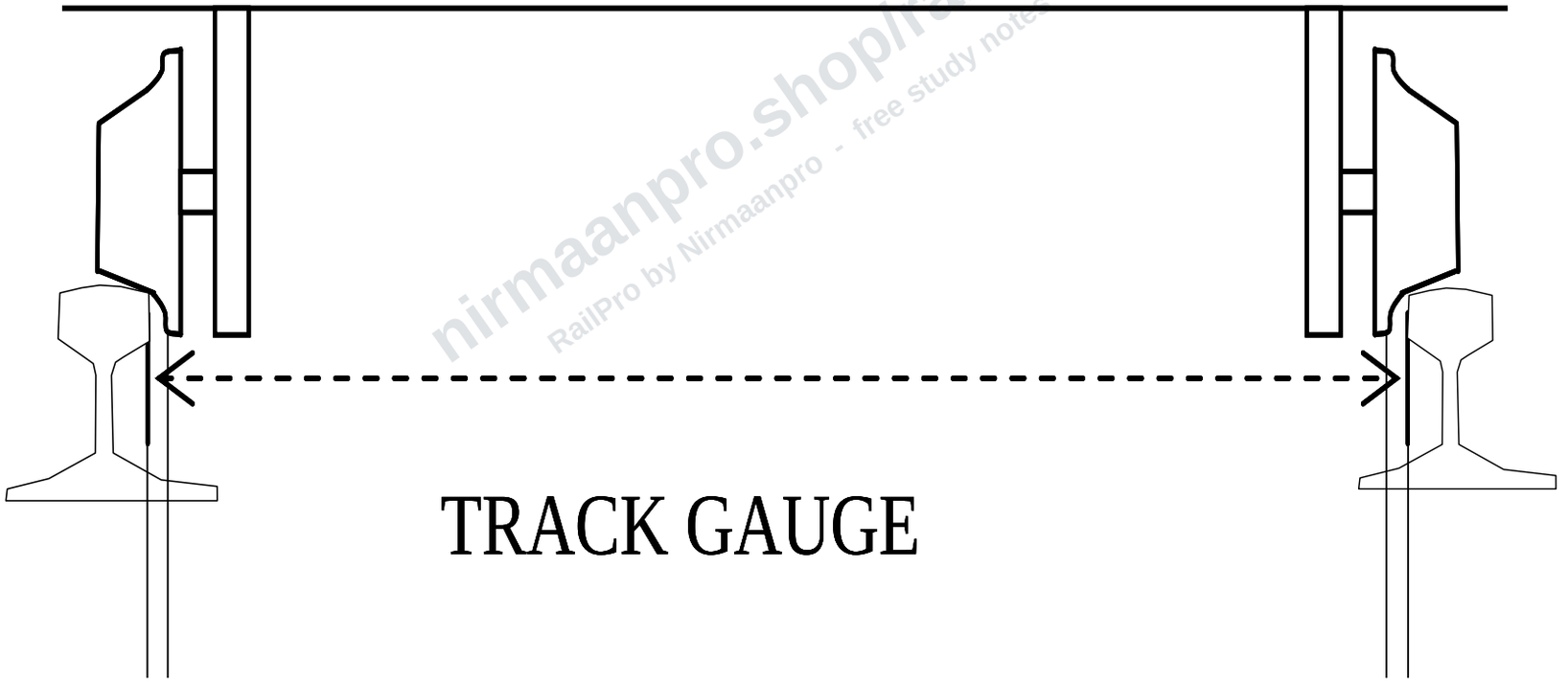

Coning of Wheel Treads
Flanges
Axle
Rails
Sleeper
Wheel centrally placed on rail
Straight Track
Wheelset
Larger Diameter of Cone on Outside Rail
Smaller Diameter of Cone on Inside Rail
Right Curve

ADVANTAGES OF CONING THE WHEELS

- Helps in reducing wear & tear of the wheel flanges and rails, which is due to rubbing action of flanges with gauge face of the rail head
- Provides possibility of lateral movement of the axle with its wheels
- Prevent the wheels from slipping to some extent

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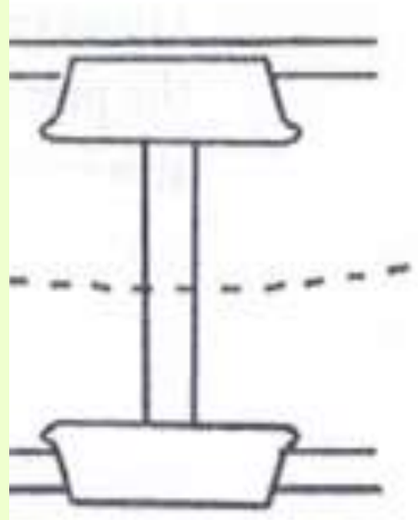
Wheel set on track: play helps wheel movement



σ_s= Standard Play

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Sinusoidal motion of wheel set on straight



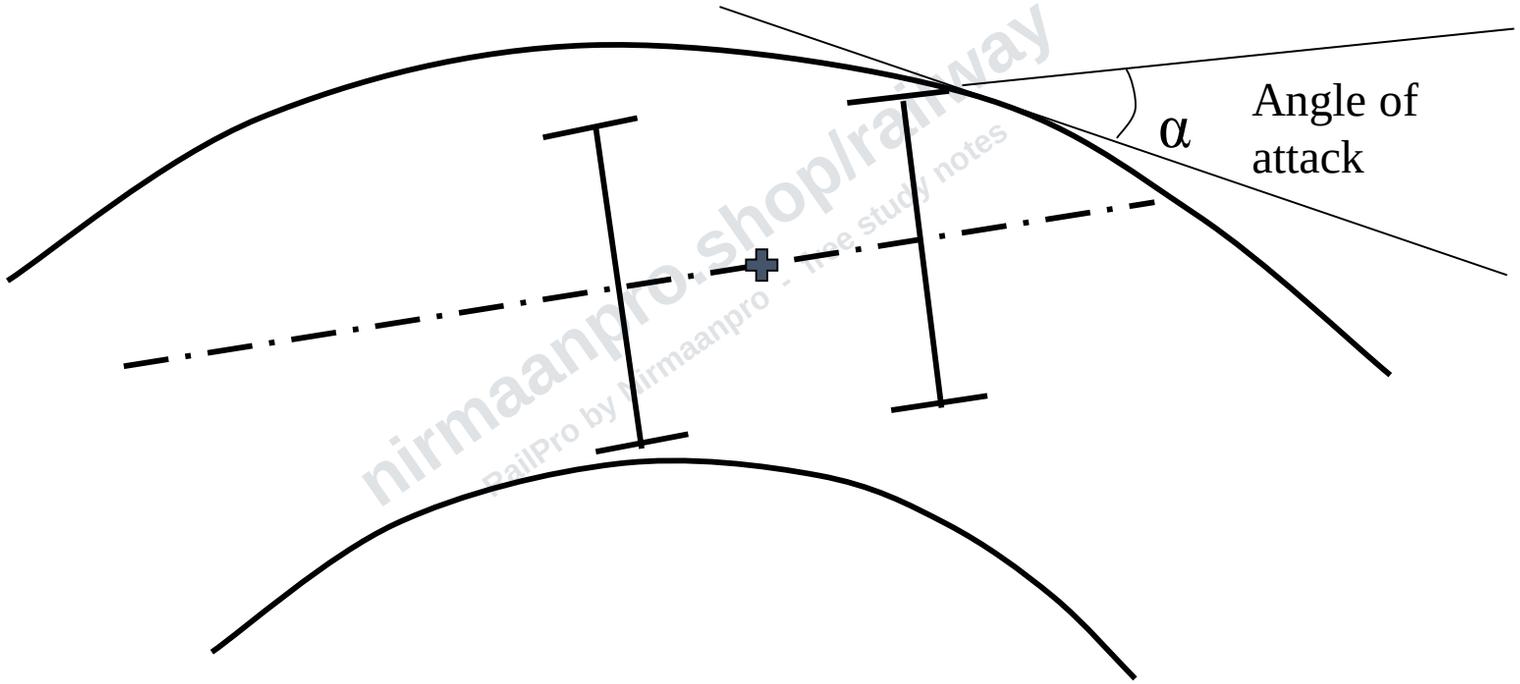
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Guidance of wheel on track

- Straight track
  - Sinusoidal motion
- Curved track
  - Shifting of center of gravity of wheel set
  - Actual guidance of the wheel flange by the outer rail in sharper curves
    - Slipping/skidding of wheels on sharp curves

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Angularity of axle while negotiating a curve



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Curve designation

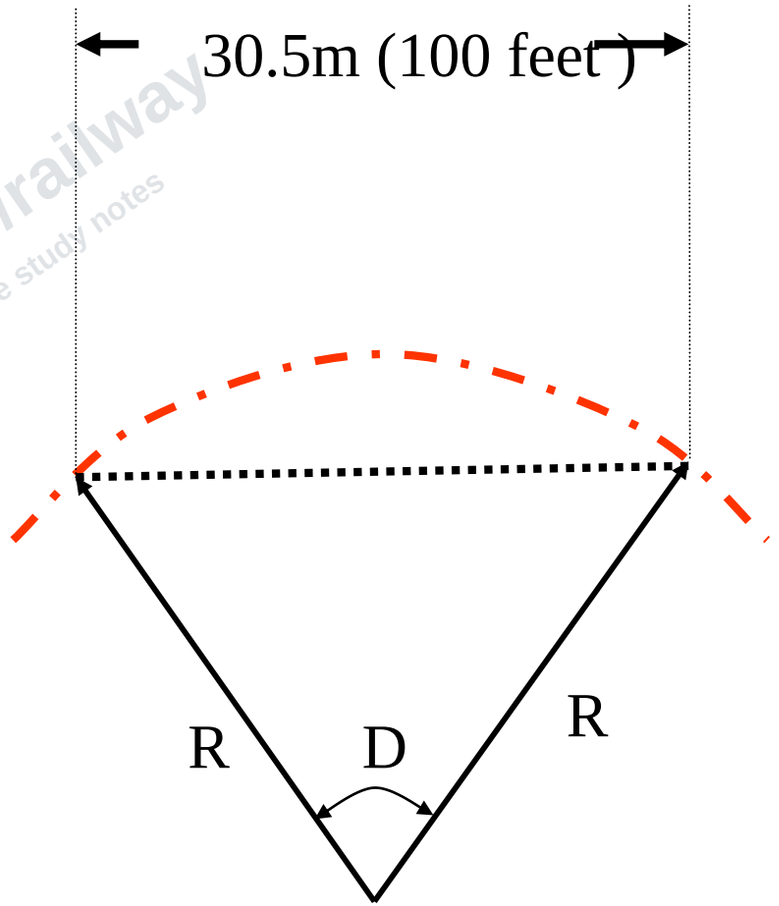
- Curves are Designated By Their Radii, Except On IR & US rail roads where

degree of curve is used for designation and

- Radii For Calculation.
- Limiting radii (item-2 chapter I of SOD)
- BG : 175 M
- MG :109 M
- NG : 44 M

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DEGREE OF CURVE IS THE ANGLE SUBTENDED BY 30.5m CHORD AT THE CENTRE



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RELATION BETWEEN DEGREE AND RADIUS OF THE CURVE

- The value of degree can be found out, as indicated below-
- Angle subtended by $2\pi R$m Length i.e; circumference=360°.
- Angle (D) subtended by 1 m Length i.e; circumference i.e $D = 360° \times 1 / 2\pi R$.
- Angle (D)subtended by an arc of 30.5m length

  $D = 360° \times 30.5 / 2\pi R = 1746.81 / R$

  Say **$D = 1750 / R$**

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Degree of Curve - Exercise

Find Radius-

If Degree of Curve is

- **0.50° - 3500 m**
- **2° - 875 m**
- **4° - 437.5 m**
- **5° - 350 m**

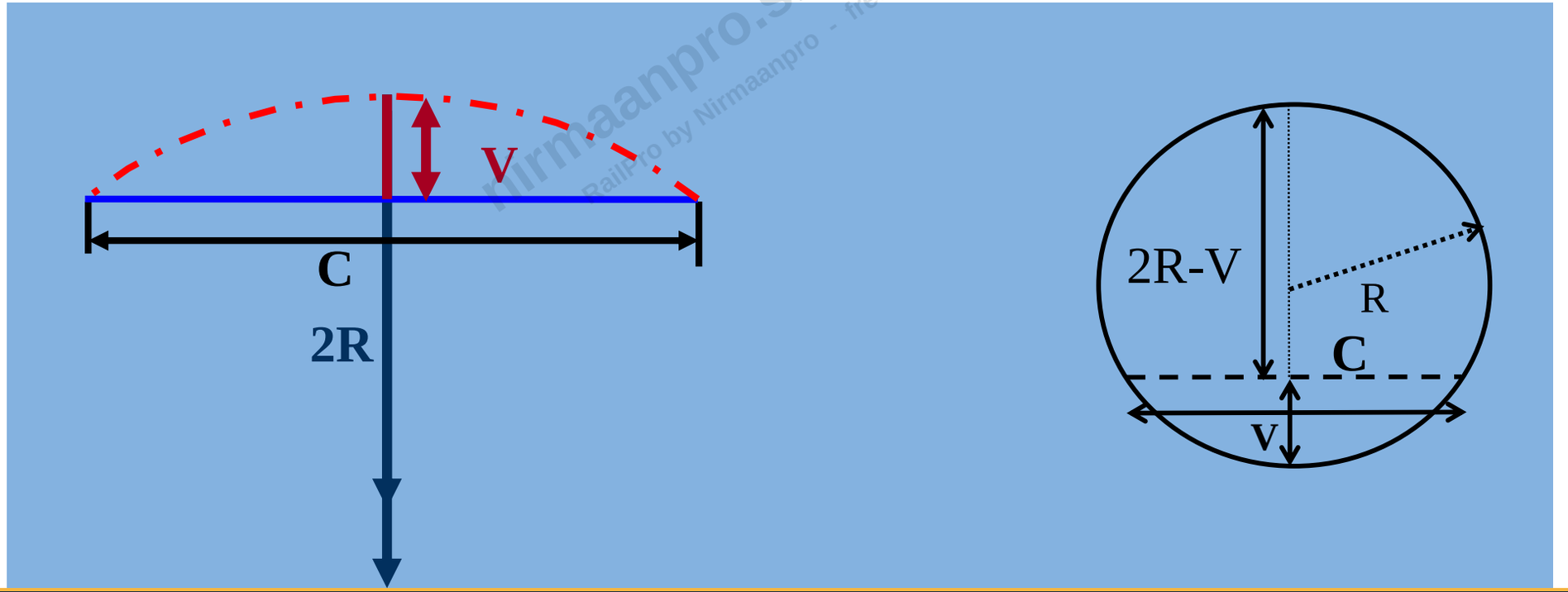
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CURVE MEASUREMENT: BY VERSINE
(MID CHORD OFFSET ON 20m CHORD)

By Property Of Circle, V*(2R-V) = C/2*C/2

i.e. $2RV=C^2/4$ [NEGLECTING V^2]

i.e. Versine, $V = C^2/8R$



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Versine - Exercise

Find Versine on 20m Chord –

If Degree of Curve is

- **0.50° - 14.28 mm**
- **1° - 28.57 mm**
- **4° - 114.28 mm**
- **5° - 142.80 mm**

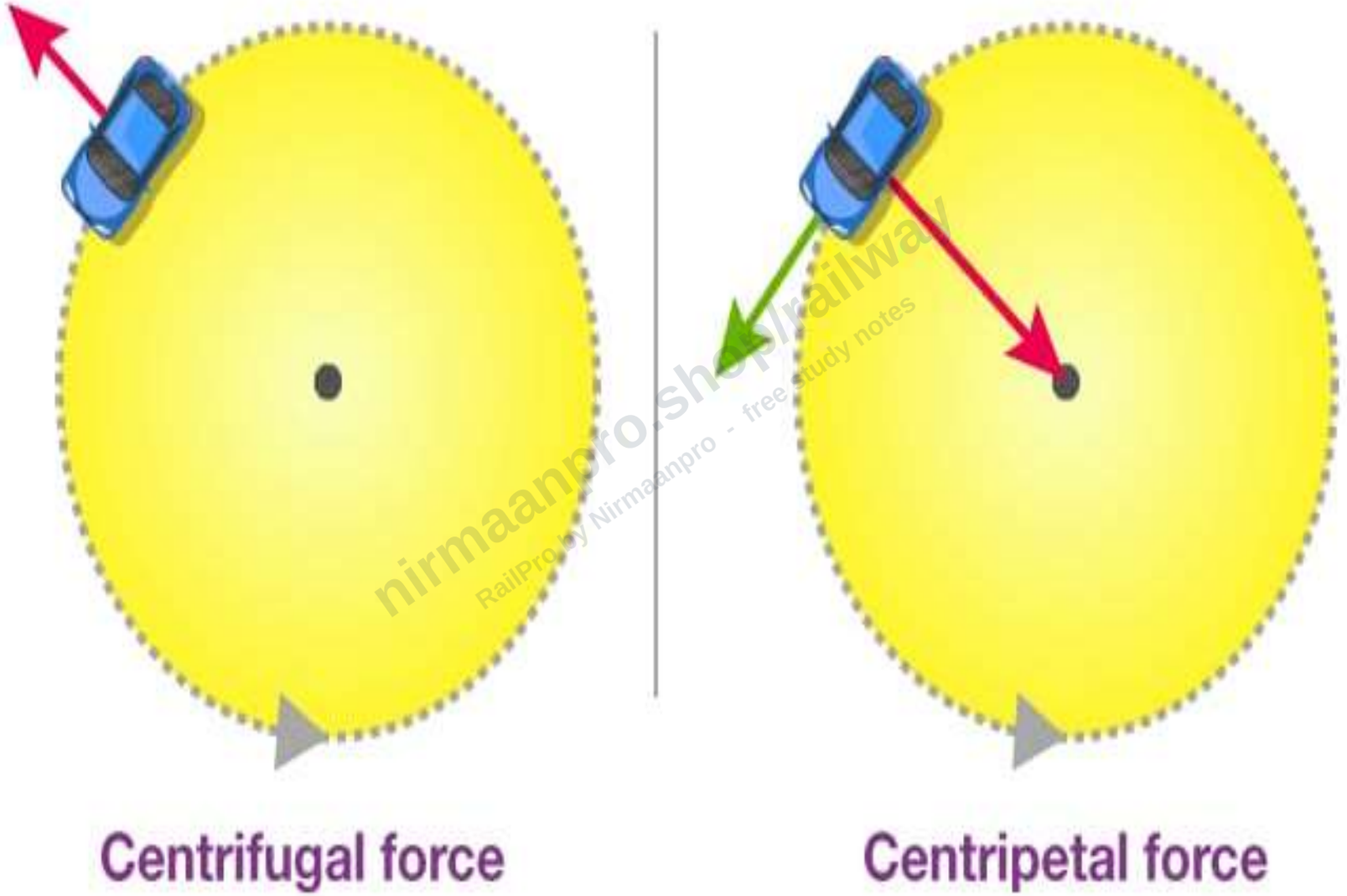
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PARAMETERS OF CURVES

- RADIUS, R AND DEGREE OF CURVE, D
- ACTUAL CANT C_a
- CANT DEFICIENCY C_d
- CANT EXCESS C_{ex}
- EQUILIBRIUM CANT C_e / EQUILIBRIUM SPEED V_e
- RATE OF CHANGE OF ACTUAL CANT rc_a
- RATE OF CHANGE OF CANT DEFICIENCY rc_d
- CANT GRADIENT, i
- LENGTH OF TRANSITION, L

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Centrifugal & Centripetal Force



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Effects of curve: Centrifugal force

- Vehicle Running at a Speed of V In a Curve of Radius R experiences **Centrifugal Force = MV^2/R**
- UNDESIRABLE EFFECTS
  - Possible passenger discomfort
  - Possible displacement of loads
  - Risk of vehicle overturning

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Effects of curve: Centrifugal force

- Risk of derailment
- High lateral force resulting in maintenance problems
  - Wear of rail & wheel flange
  - Lateral force on track structure

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Thanks

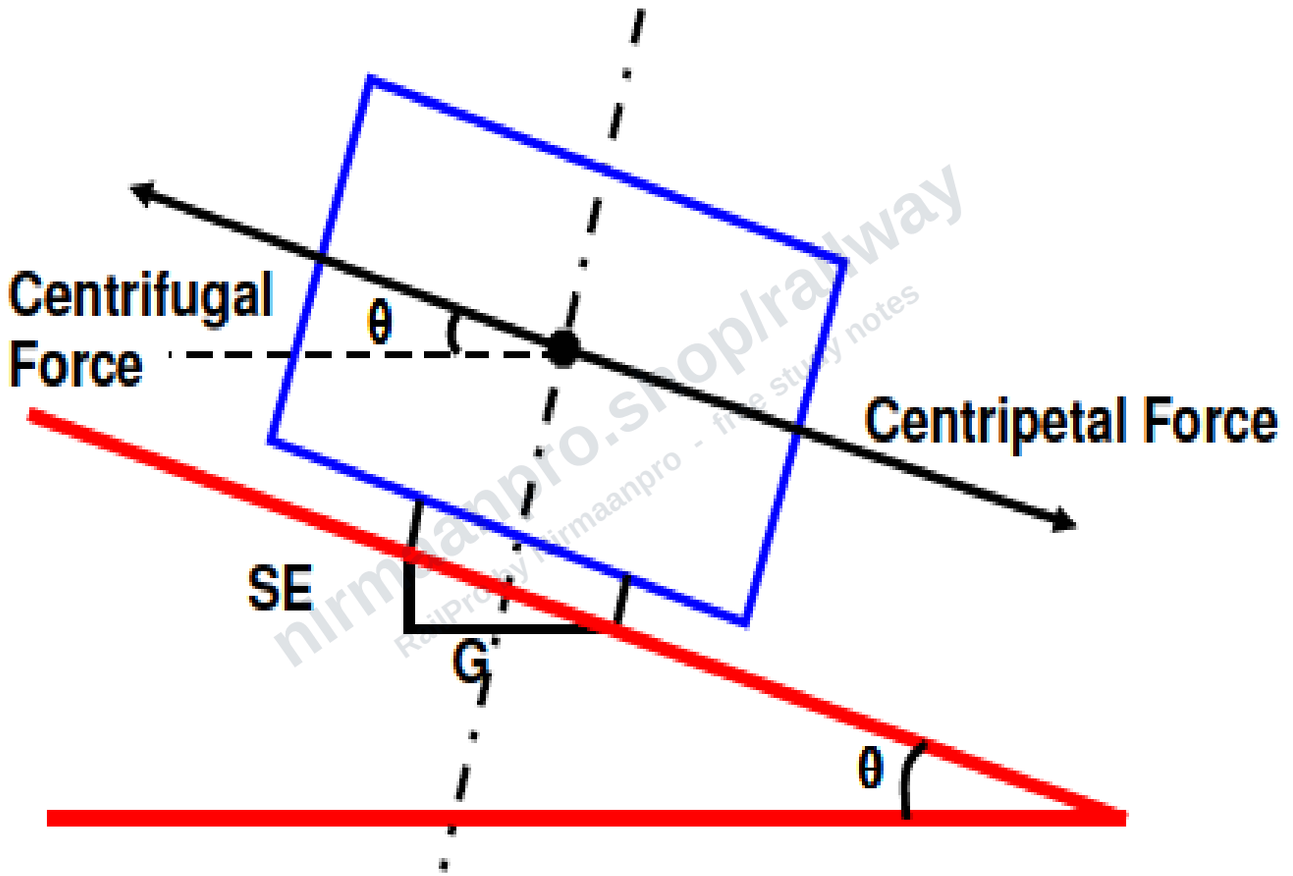
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1.3 Super elevation / equilibrium cant, Maximum cant for normal and high speed trains, Cant deficiency and cant excess, Formula for safe speed on curves, Equilibrium speed, Calculation of cant to be provided and permissible speed, Transition length, Maximum cant gradient, Rates of running out of cant and cant deficiency,
grade compensation

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Superelevation/ Cant

How to manage the centrifugal force



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EQUILIBRIUM CANT

When on circular motion , if the resultant of weight & centrifugal force is perpendicular to the plane of rail & passes through the centre of track, the corresponding speed is called **EQUILIBRIUM SPEED** & the cant is called **EQUILIBRIUM CANT**

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EQUILIBRIUM CANT

Centripetal Force=W*sinθ

Centrifugal Force Comp. = $M*(V^2/R)*\cos\theta$

i.e. $W*\sin\theta = M*(V^2/R)*\cos\theta$

i.e. $W*\tan\theta = M*(V^2/R)$

i.e. $M*g*SE/G = M*V^2/R$

i.e. Equilibrium Cant, $SE=G*V^2/(g*R)$

$SE=G*V^2/(127*R)$

Para 406(a) of IRPWM

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SUPERELEVATION / CANT

- The effect of centrifugal force is eliminated/reduced by raising the outer rail by a specified amount. This raising of outer rail over inner rail is called SUPERELEVATION/ CANT
- The force due to the raising of the outer rail is exerted inwards and is called CENTRIPETAL FORCE

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LIMITS OF ACTUAL CANT C_a

- Maintenance criteria
  - High cant will cause rolling of ballast & flattening of inner rail
- Overturning at inner rail
  - Not very sensitive to wind force
- Safety against derailment
  - Empty wagon stopped & started
- Comfort criteria
  - No appreciable discomfort upto 180 mm
- Limited to 1/8 to 1/10 of dynamic gauge

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IRPWM PROVISIONS

- MAXIMUM CANT
- 165 MM for group A, B and C routes
    - 185 MM for structures
- 140 MM for group D and E routes

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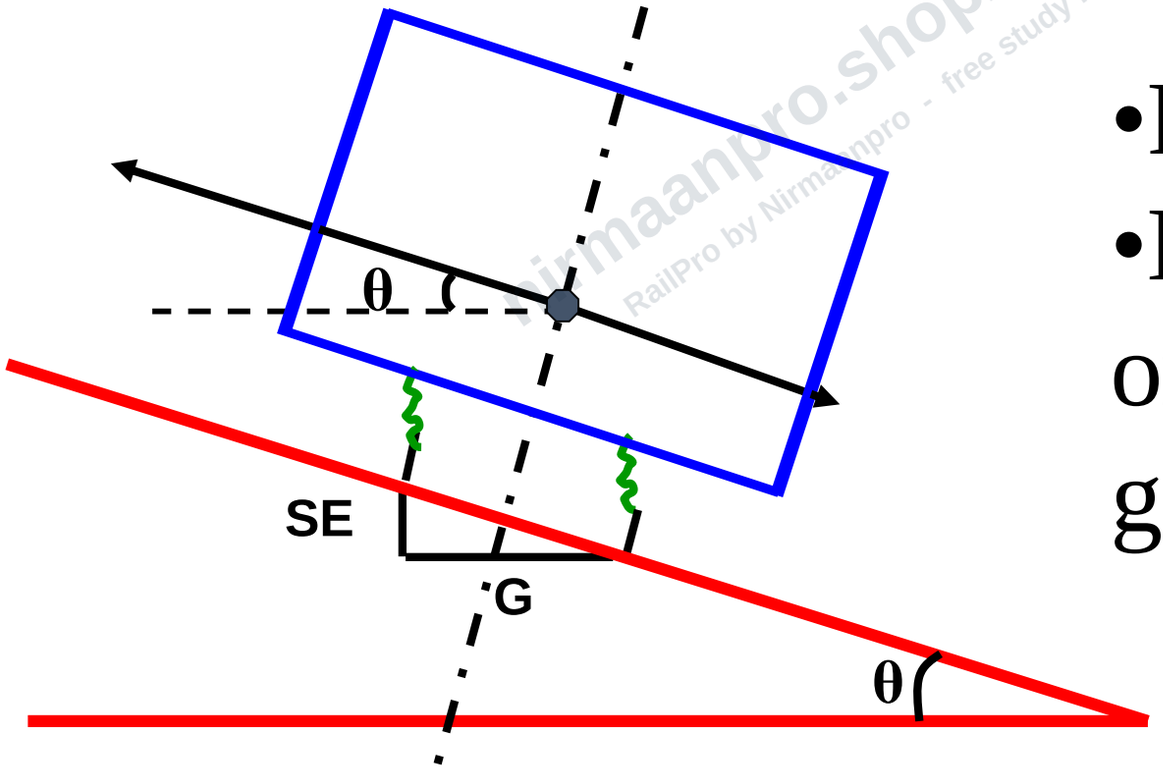
Cant Deficiency: fast trains



EFFECTS OF VEHICLE WITH CANT DEFICIENCY

Speed more than equilibrium speed

Centrifugal force > Centripetal Force



- Ro>Ri
- More wear on outer rail gauge face

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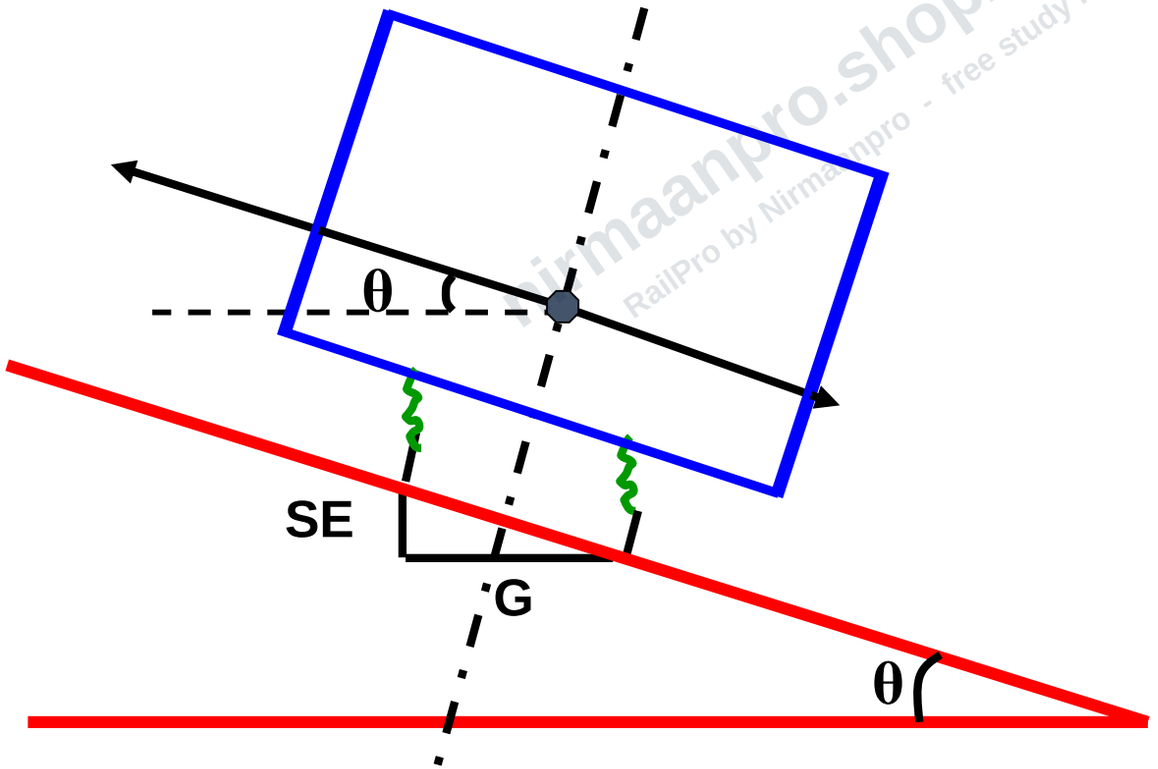
CANT DEFICIENCY C_d

- Safety
  - Upto 175 mm safe with critical wind velocity
- Comfort criteria
  - Discomfort if **U**nbalanced **L**ateral **A**cceleration is greater than **0.1g**
    - Cant deficiency should be less than **0.1G**
- Observed value of **ULA** is more than the theoretical value

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VEHICLE WITH CANT DEFICIENCY

Centrifugal force > Centripetal Force

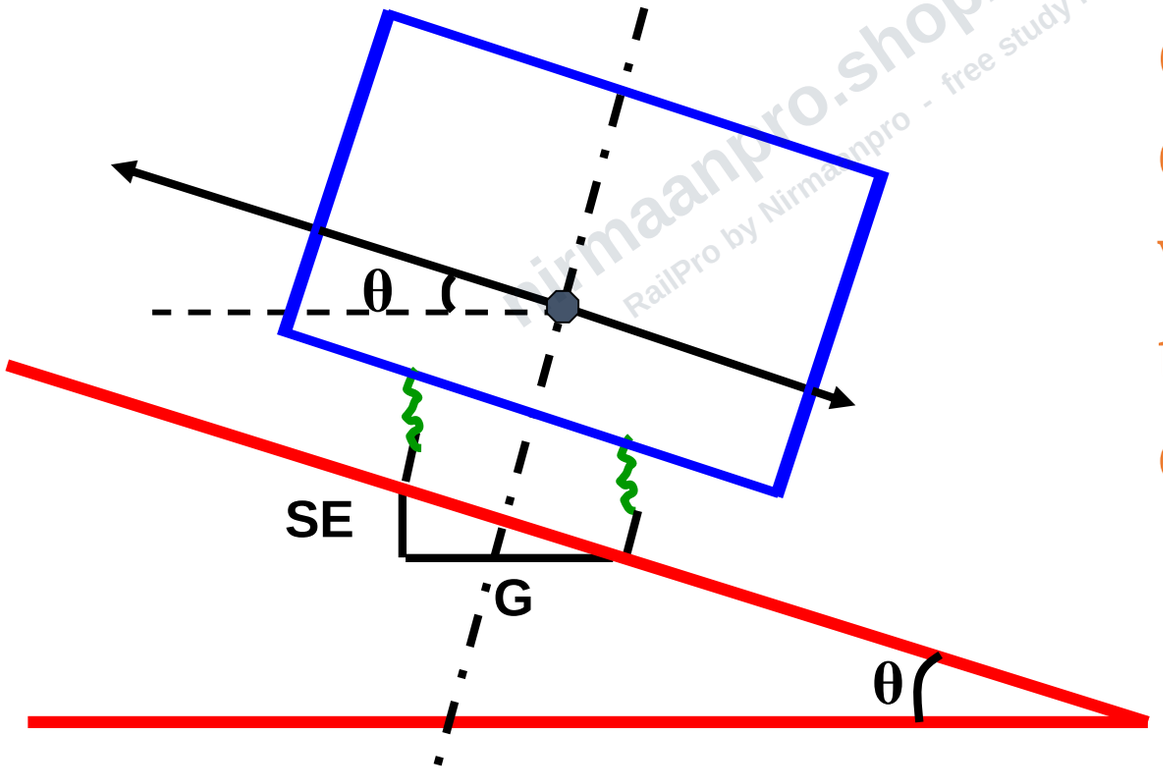


Reaction On Outer Rail Is More Than Inner Rail, So Outer Spring Deflects More Than Inner Spring

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VEHICLE WITH CANT DEFICIENCY

Centrifugal force > Centripetal Force



Actual cant deficiency experienced by vehicle is more than the calculated value

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IRPWM PROVISIONS

- MAX. CANT DEFICIENCY
- On routes with speed more than 100 kmph for Nominated Stock With Permission Of PCE : 100 MM
  - For Others : 75 MM

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Cant Excess: slow trains



CANT EXCESS C_{ex}

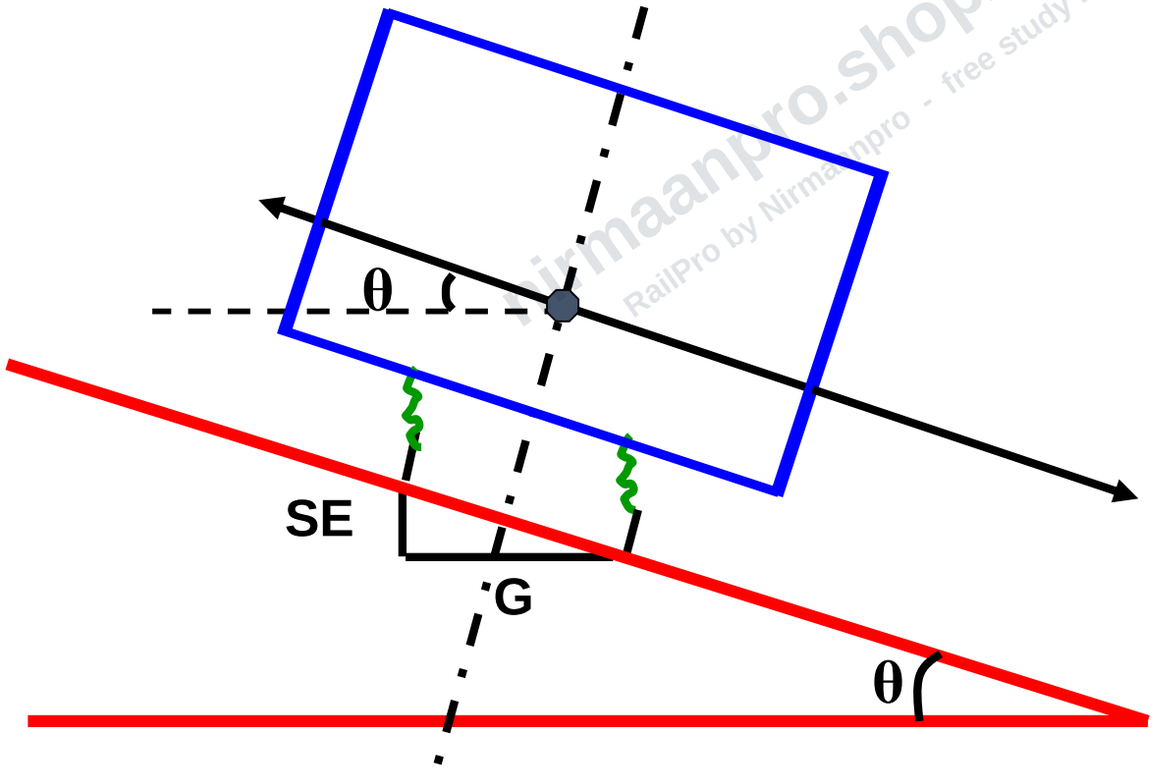
- No Comfort Consideration
- Min speed = 0, already taken in max. Cant actual considerations
- Maintenance consideration
  - Excess wear on inner rail

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EFFECTS OF VEHICLE WITH CANT EXCESS

Speed less than equilibrium speed

Centrifugal force < Centripetal Force



- Ri>Ro
- More wear on inner rail top table

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IRPWM PROVISIONS

- CANT EXCESS
  - Max. 75 mm
  - Sections carrying predominantly goods traffic shall have less cant to reduce wear on inner rail
  - Worked out for booked speed of goods trains.

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CONSIDERATIONS OF MIXED TRAFFIC

- For which speed, cant shall be provided?
  - Maximum speed?
  - Minimum Speed?
  - Average Speed?

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EQUILIBRIUM CANT

- IRPWM STIPULATION
  - **Equilibrium speed** is to be decided by **CE** considering
    - Max. Speeds of fast & slow moving trains
    - Permanent speed restriction
    - Junctions
    - Stopping places
    - Gradient affecting speed of goods train

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Equilibrium Speed

- Russian Formula:

$$V_{eq} = \sqrt{\frac{\sum_{i}^{m} n_i W_i V_i^2}{\sum_{i}^{m} n_i W_i}}$$

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- n_i: No of trains of type i,
- W_i: Weight of such train,
- V_i: Speed of such train,
- m: Total types of trains

Transition Curves

DEFINITION

REQUIREMENT OF CURVE

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TRANSITION CURVE

Transition curve is an easement curve introduced between straight & curved track to facilitate gradual change of versines & superelevation

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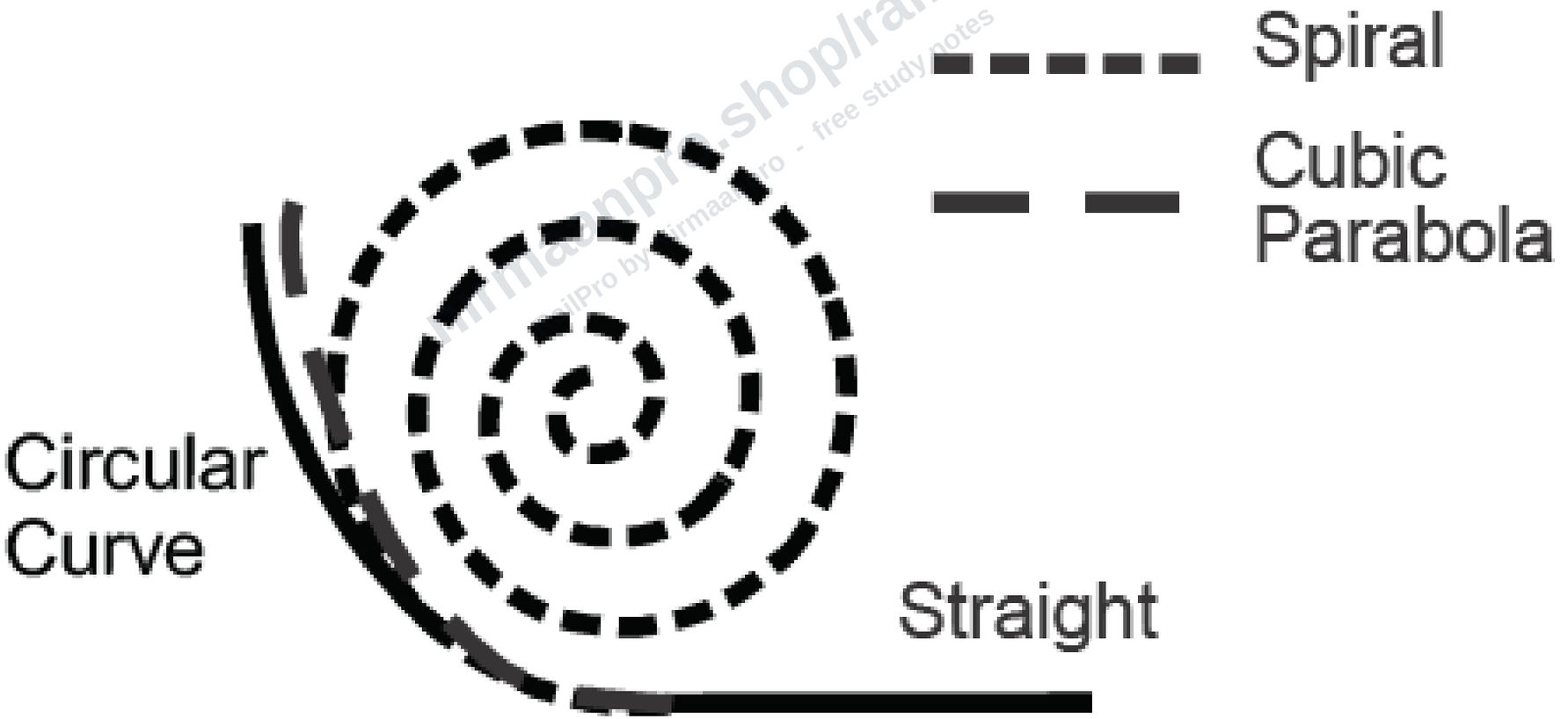
REQUIREMENT FROM TRANSITION CURVES

- Curvature shall vary uniformly with distance
  - Curvature = 1/R
  - Versines shall vary uniformly
- Cant shall vary uniformly
- Transition shall be tangential to the straight as well as circular curve
  - Radius infinity at junction with straight
  - Radius R at junction with circular curve

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Cubic Parabola as transition

- There is not much difference in the layout of a spiral and cubic parabola until the deflection from straight is approximately **4 M** and deflection angle upto **12°**

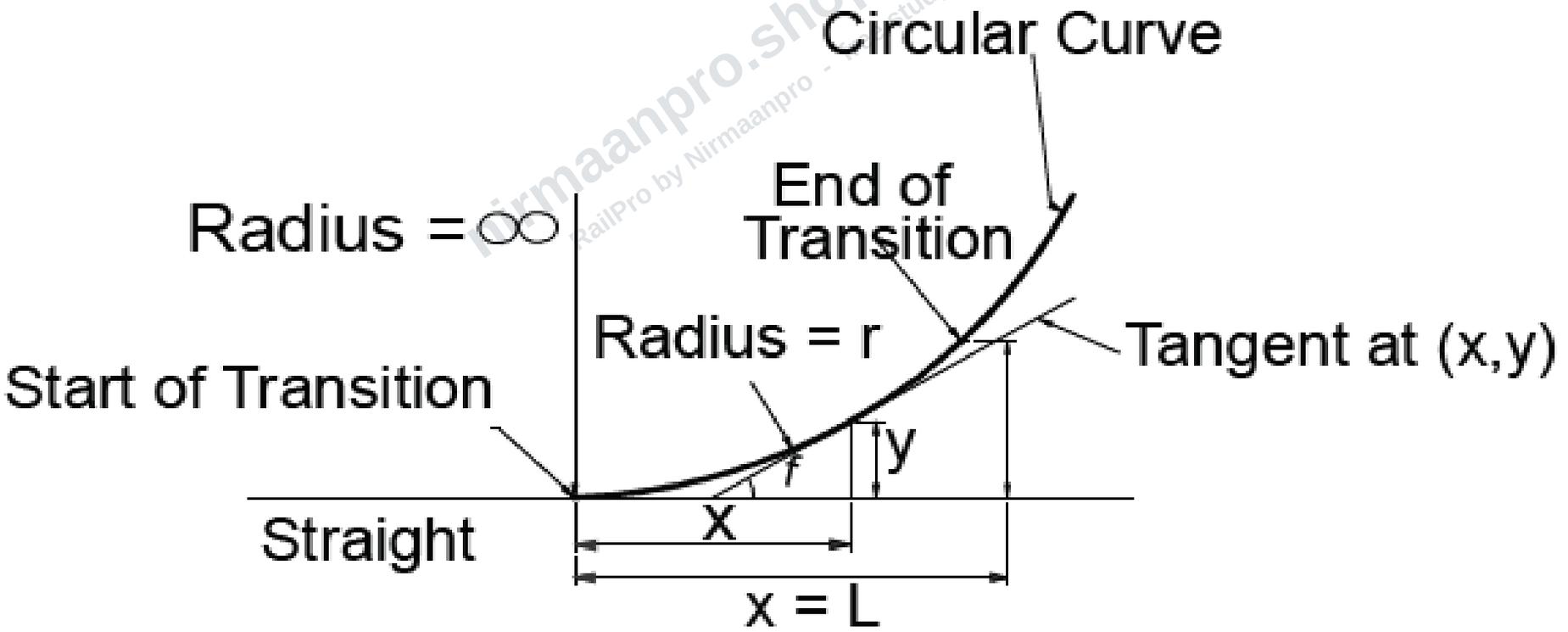


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Cubic Parabola as transition

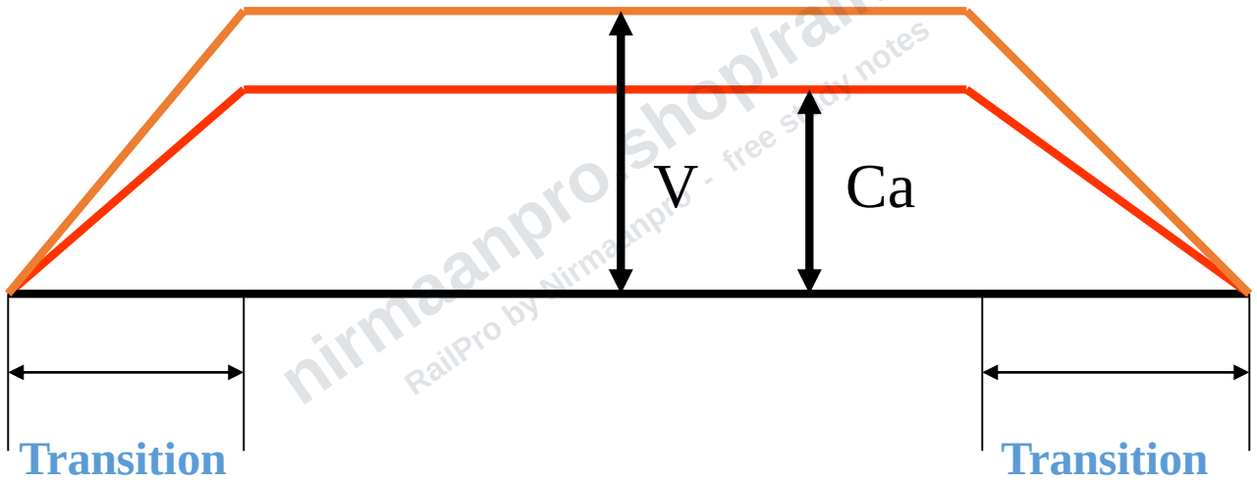
- **Let us draw the transition curve, keeping the tangent track horizontal**
- **On Indian Railways for Transition Curves, it is cubical parabola with the equation:**

$Y = KX^3$ ➔ $(Y = X^3/6RL)$

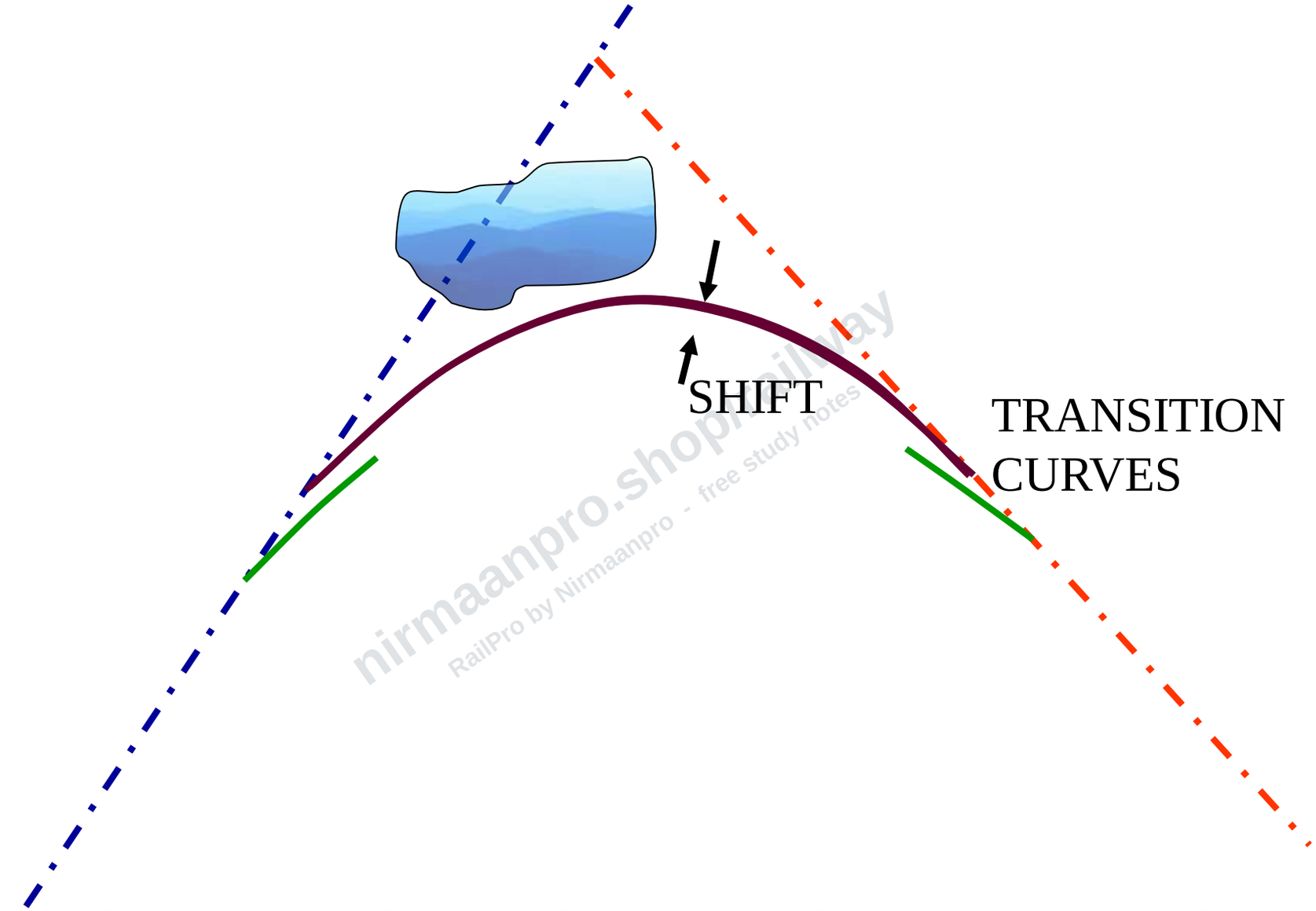


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DESIRABLE VERSINE AND CANT DIAGRAM OF A CURVE



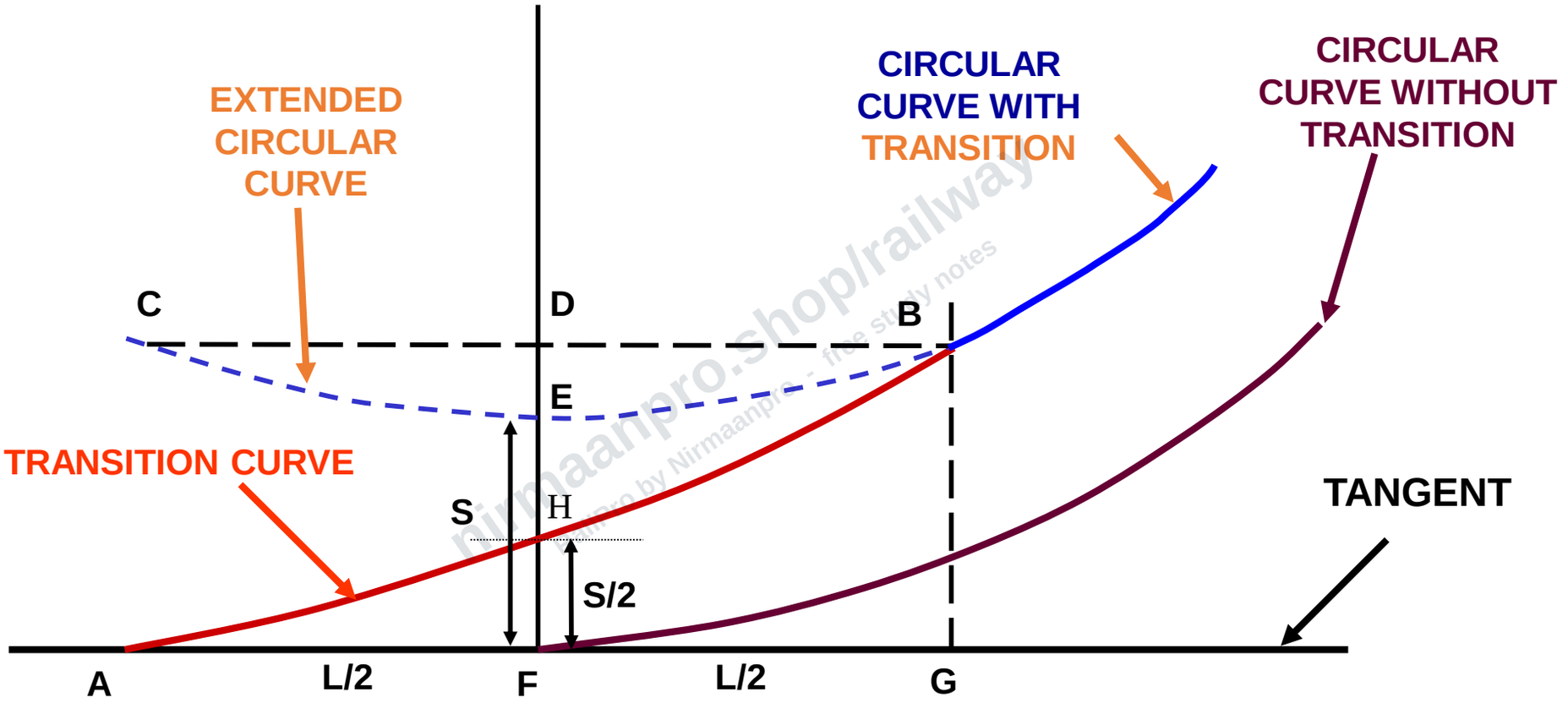
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INSERTING TRANSITION CURVES

SHIFT ON TRANSITION CURVE



SHIFT, $S = L^2/24R$

$DE = L^2/8R$ $BG = L^2/6R$

SHIFT ON TRANSITION CURVE

- The circular curve originally chosen is starting at F.
- Due to introduction of the transition curve, AB, the ordinate at B is BG.
- The circular curve shifts inwards to meet the transition curve at B.
- In order that the transition curve and circular curve meet, the circular curve is shifted inwards by an amount EF.
- Shift is measured between the original circular curve without transition and the circular curve after the transition has been provided, and not between the straight and the circular curve i.e. shift is EF and not BG

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LENGTH OF TRANSITION

- **COMFORT CRITERIA**
  - RATE OF CHANGE OF **ULA** LESS THAN 0.03g
  - RATE OF CHANGE OF C_d <0.03g
  - HOWEVER, NORMALLY SHALL NOT EXCEED 35 mm /sec
  - UNDER EXCEPTIONAL CIRCUMSTANCES IT CAN BE INCREASED TO 55 mm /sec

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LENGTH OF TRANSITION

- **COMFORT CRITERIA**
  - For slower speeds, the actual cant causes similar comfort problems
  - Rate of change of C_a is just noticeable at 65 TO 75mm/sec but normally shall not exceed 35 mm /sec
  - Under Exceptional Circumstances It Can Be Increased To 55 mm /sec

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LENGTH OF TRANSITION

- **TWIST CRITERIA**
  - Cant gradient causes twist in track
  - Limited to **1.4 mm/m** or cant gradient – **1 in 720**
  - In **Exceptional** Cases It Can Be **2.8 mm/M** OR **1 in 360**
  - Future Layouts With 1 in 1200

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LENGTH OF TRANSITION

- Length of transition will be max. of
  - **$L_1 = 0.008\ C_a * V_m$**
  - **$L_2 = 0.008\ C_d * V_m$**
  - **$L_3 = 0.72\ C_a$**

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LENGTH OF TRANSITION

- In exceptional circumstances, minimum length of transition will be max of
  - **2/3RD OF L_1**
  - **2/3RD OF L_2**
  - **½ OF L_3**

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PROCEDURE TO FIND OUT SPEED ON CURVE

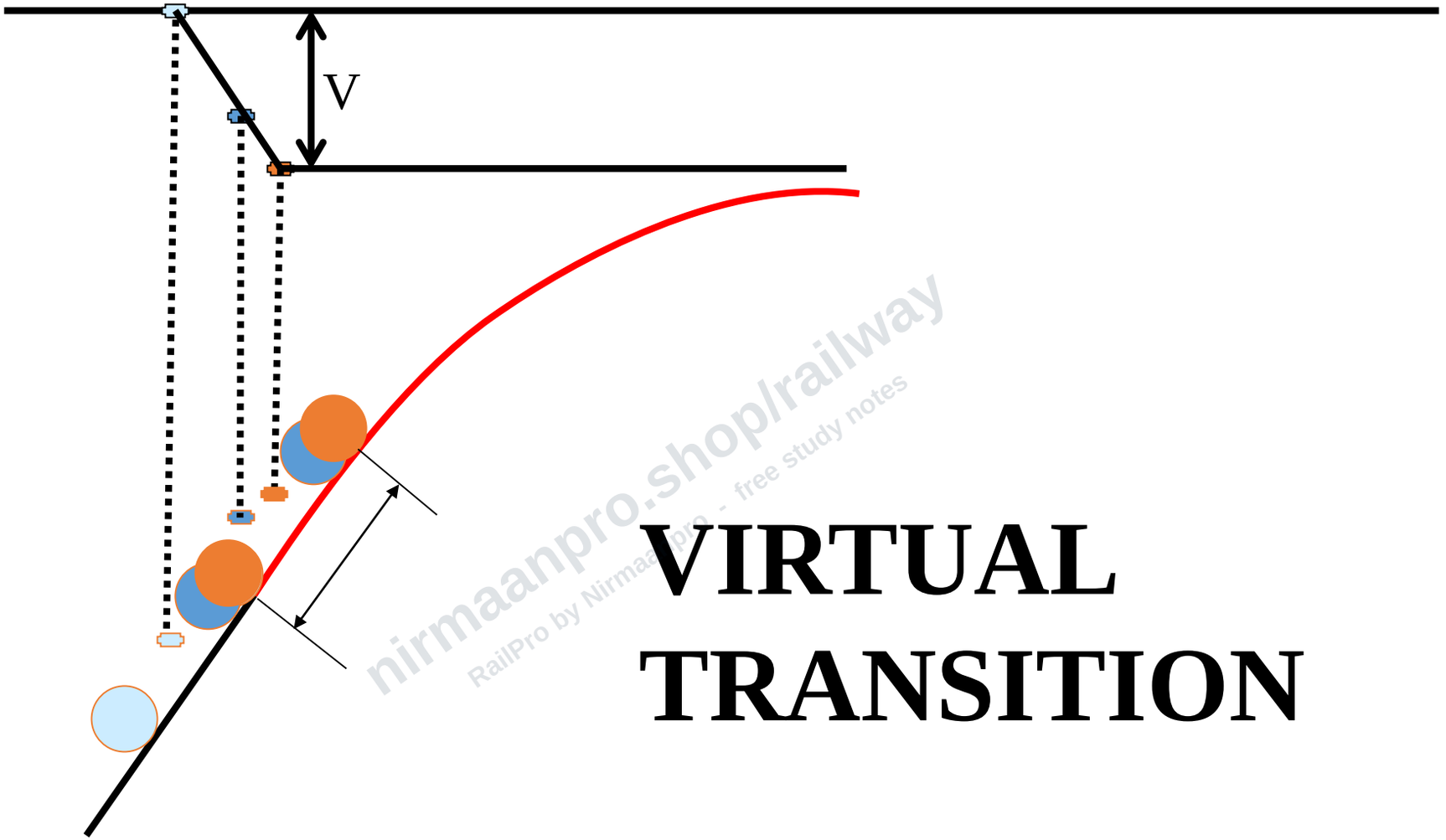
- Find out the equilibrium cant for the maximum speed
  - Find out the minimum cant required by deducting the cant deficiency from above
- Find out the cant required for booked speed of goods trains.
  - Add cant excess and find out the maximum cant permissible
- The cant to be provided shall be between the two values computed above

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PROCEDURE TO FIND OUT SPEED ON CURVE

- Cant To Be Provided Shall Also Be Less Than The Maximum Permissible As Per IRPWM
- Corresponding to actual cant provided, find out maximum speed
- Find out the desirable/ minimum transition length
- If shift is not possible, restrict length of transition and work out cant and speed permissible corresponding to the reduced length available

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VIRTUAL TRANSITION

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VIRTUAL TRANSITION

- If there is no space for transition, circular curve immediately follows the straight but the distance between pivots of bogie becomes the transition virtually
  - For BG- 14.785 M
  - For MG-13.7 M
- Cant is provided in virtual transition length
  - half in straight and half in circular curve
  - @1 in 360 (max cant gradient), max cant = 14.7 * 2.8 = 40 mm(approx.)

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Types of curves

Different types of curves in the track are:

- Simple curves
- Compound curves
- Reverse Curves

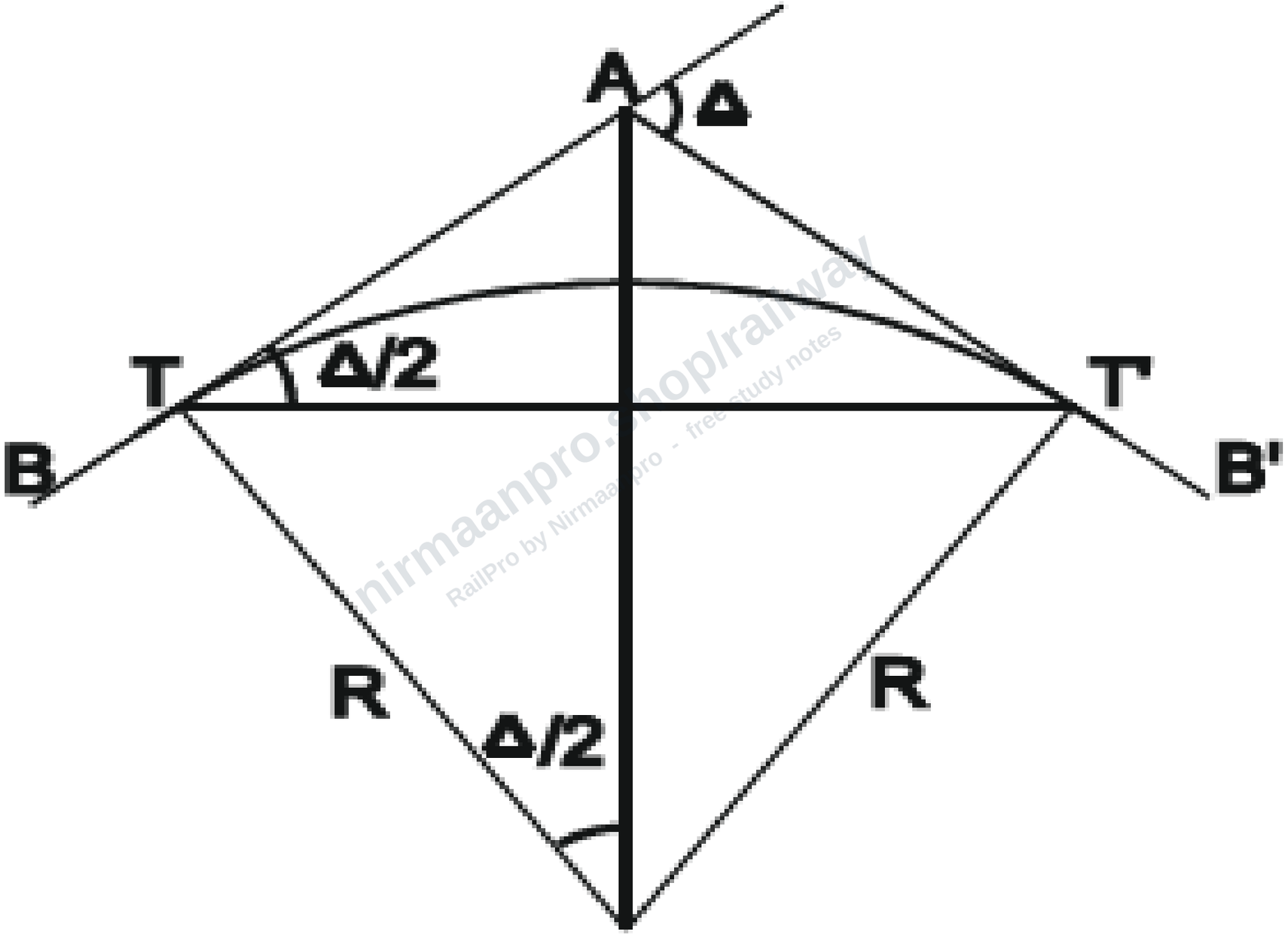
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Simple curve

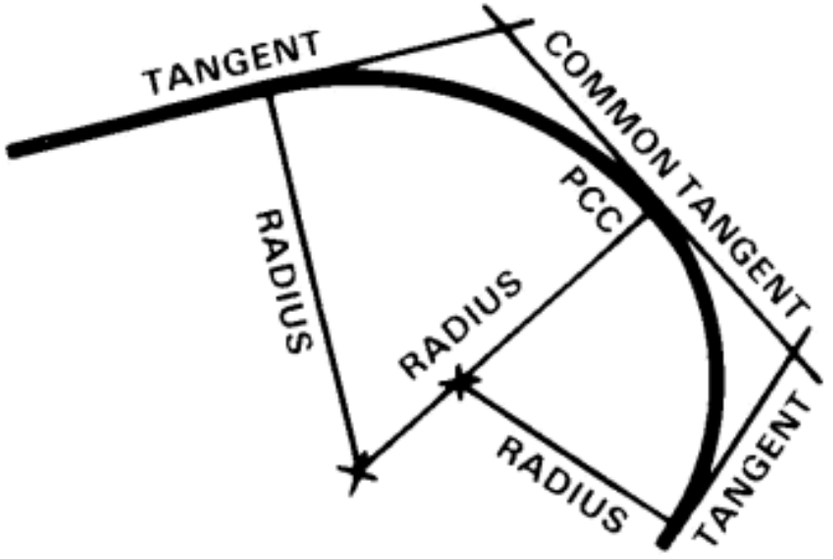
- A simple curve is a single circular curve with uniform radius throughout the length, joining two tangent tracks .
- Transition curve may be there at either end junction of the curve with tangent track.
- If we measure any curve in service, there will always be some variation in the versines from station to station and therefore, the simple curve will have some variations in radius at various points on the curve.
- Such slightly disturbed curve will still be called a simple curve.

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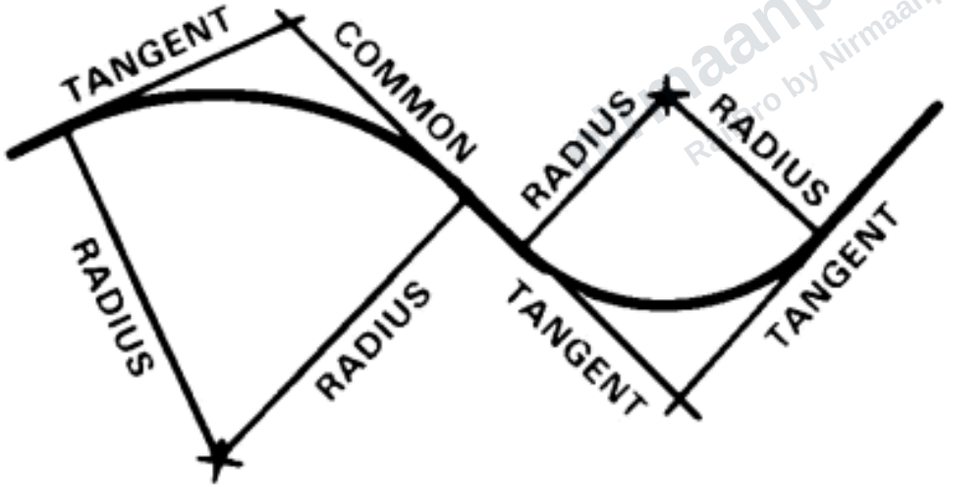
Simple curve



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COMPOUND CURVE



REVERSE CURVE

Reverse and compound Curves

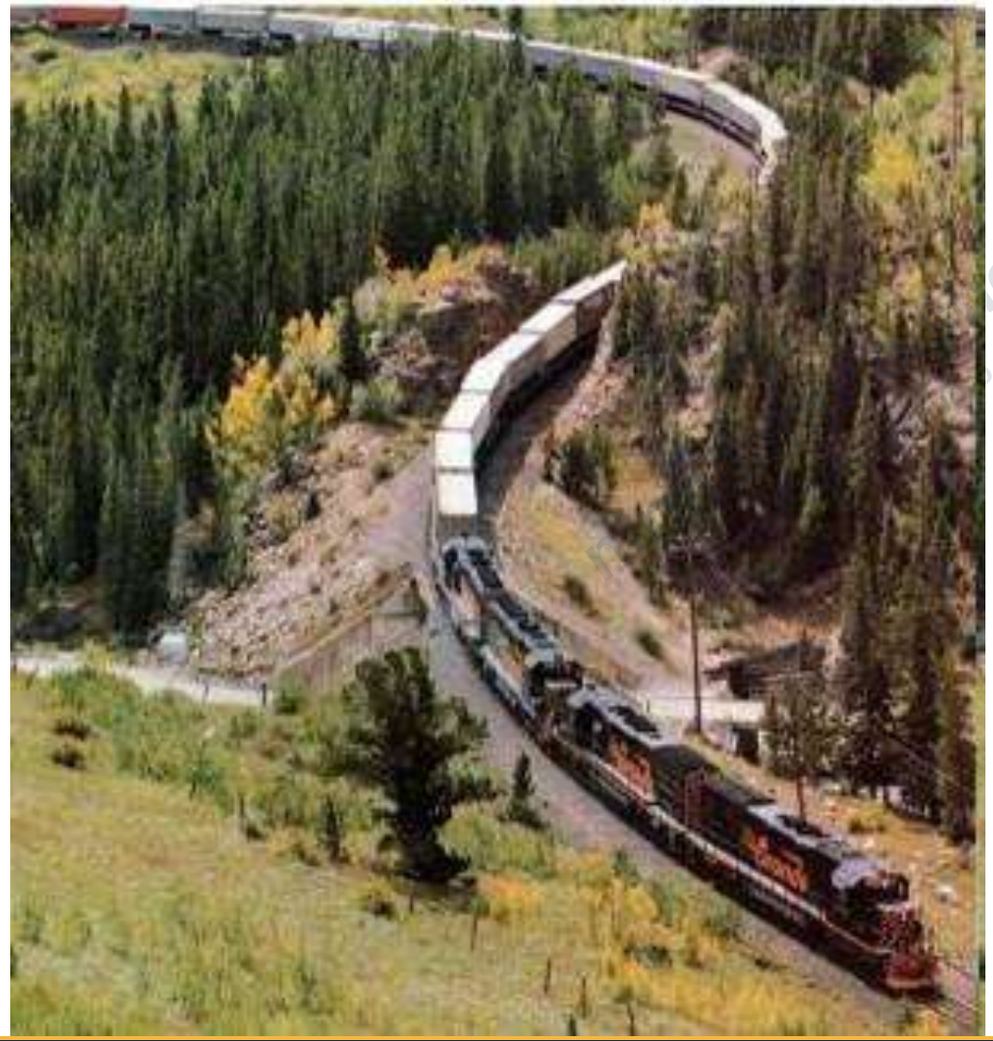
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Reverse curve

- A reverse curve is a combination of two circular curves of contrary flexure (i.e. having opposite direction of radius from the centre).
- Two curves of opposite flexure, separated by small tangent or straight length in between will still be called a reverse curve.
- Reverse curves are introduced in track when the track alignment is to be shifted laterally, by and large parallel to the original direction.
- Such shifting is required at difficult layout locations where there is some obstruction in the form of any structure, water body hill etc.

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REVERSE CURVES



Length of transition will be MAX. of

$L_1 = 0.008*(Ca_1+Ca_2)*Vm$

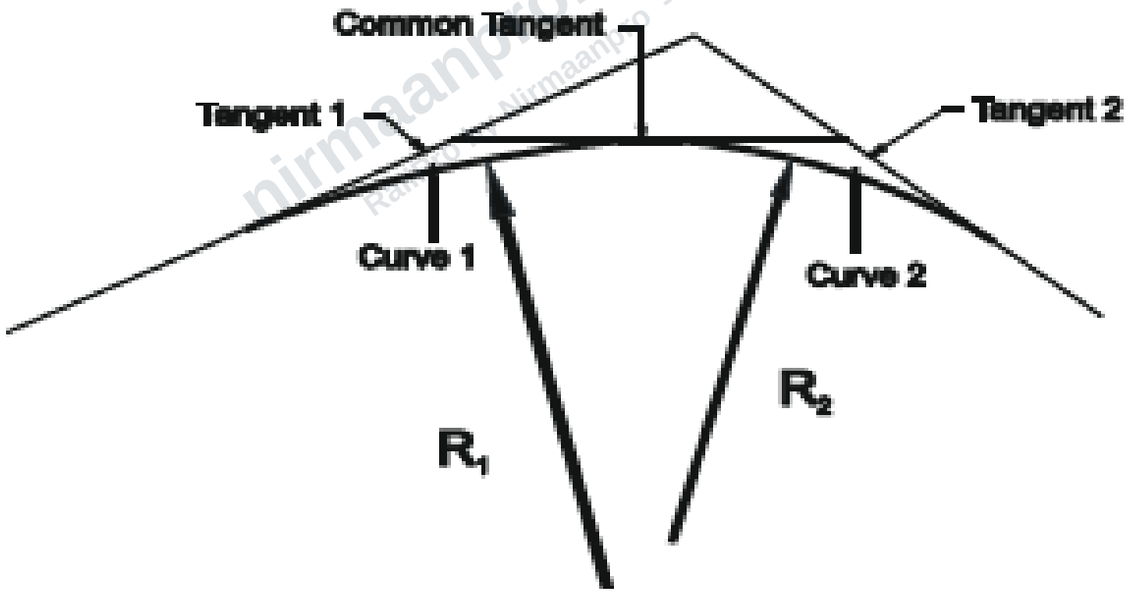
$L_2 = 0.008\ (Cd_1+Cd_2)*Vm$

$L_3 = 0.72\ (Ca_1+Ca_2)$

This is not applicable if the reverse curves separated by straight in between

Compound curve

- A compound curve is a combination of two or more circular curves of different radii in similar flexure (i.e. having same direction of radius from centre).
- Between the curves of different radii, transition curve may be provided.

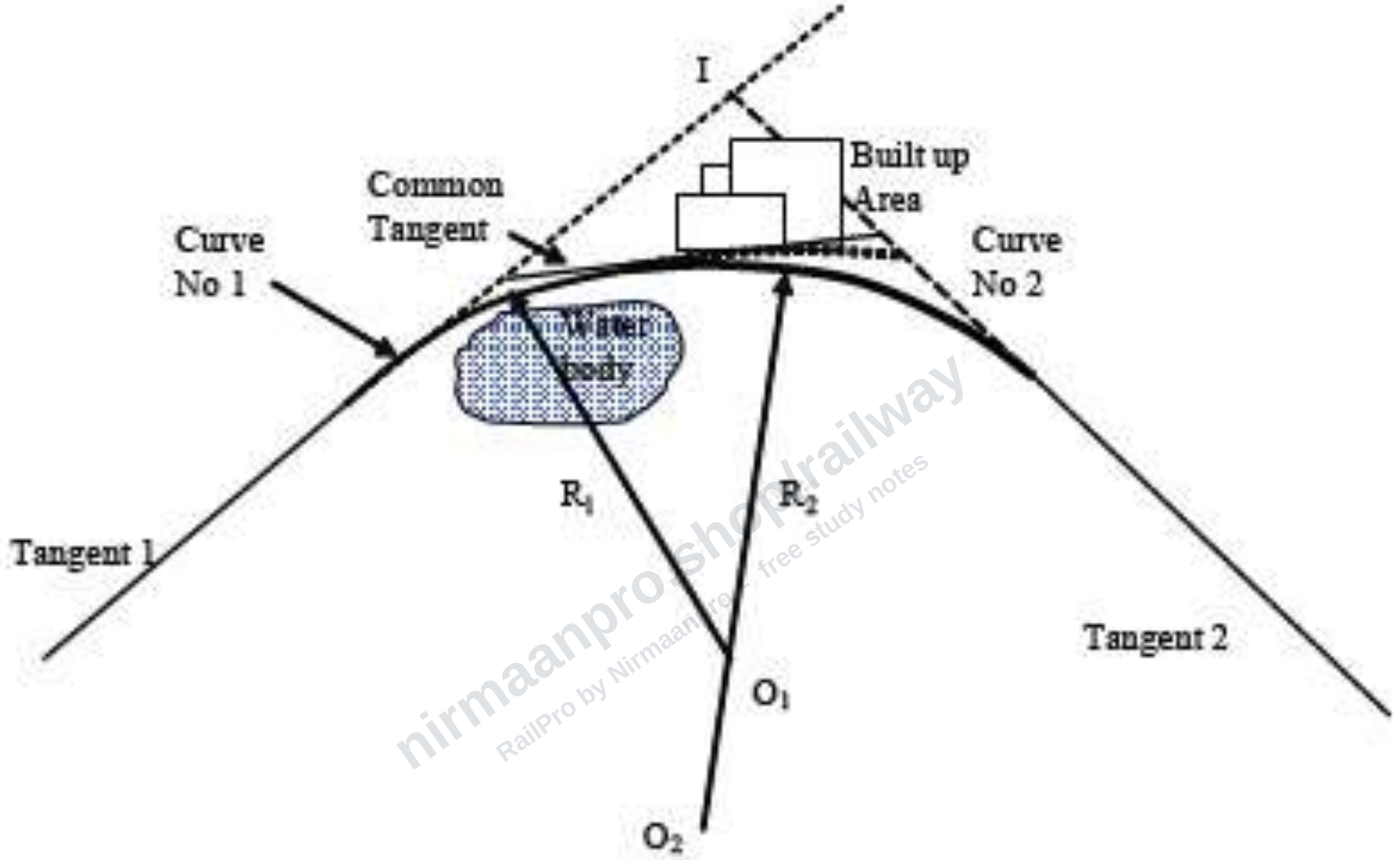


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Compound curve

- Normally, compound curves are introduced in the alignment in the following circumstances:
- When the track alignment is to pass through a restricted space due to multiple obstructions on either side of the proposed track, the simple curve might not be feasible and compound curves are the only alternative.
- Where the length of transition is not available at one end, the larger radius curve may be introduced at that end, and compounding may be done to get the full speed potential on the curve.

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- **Compound curve (R1 and R2 are in same direction) set out in a very congested area between a water body and built up area.**

Compound Curves



COMPOUND CURVES

- For **Compound Curves:**

Length of transition shall be MAX. of

- **L1 =0.008 $(Ca_1-Ca_2)*V_m$**
- **L2 =0.008 $(Cd_1-Cd_2)*V_m$**
- **L3 =0.72 (Ca_1-Ca_2)**

  If length is coming less than virtual transition then common transition is deleted and the cant is run out on the length of virtual transition

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Effect of Curve: Curve Resistance



Compensation for curvature on gradient

- Called Grade Compensation
  - Reduction in ruling gradient to allow for the effect of curve OR
  - Increase in actual gradient to get “Compensated Gradient” to get combined effect of curve + gradient
  - 70/R % OR
  - 0.04% PER DEGREE

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Thanks

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1.5 Miscellaneous - Running out cant on transitioned curves, laying of rails on curves, Mid stagger joints on sharp curves, Rail posts and Curve boards, Lubrication of outer Rails on curves, Check rails on sharp curves.

Total periods - 8

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RUNNING OUT OF SUPERELEVATION

1. On transitioned curves, cant should be run up or run out on the transition, not on the straight or on the circular curve, increasing or decreasing uniformly throughout its length.
2. On non-transitioned curves, cant should be run up or run out on the ‘virtual transition’.
3. Longitudinal profile of transition on the reverse curve may be in one of the following two alternatives:
   - In case no. 1, the level of one of the rails is maintained and the superelevation is run out on the other rail by lowering it over half the transition length and raising it to the required amount of cant over the remaining half portion of the transition.

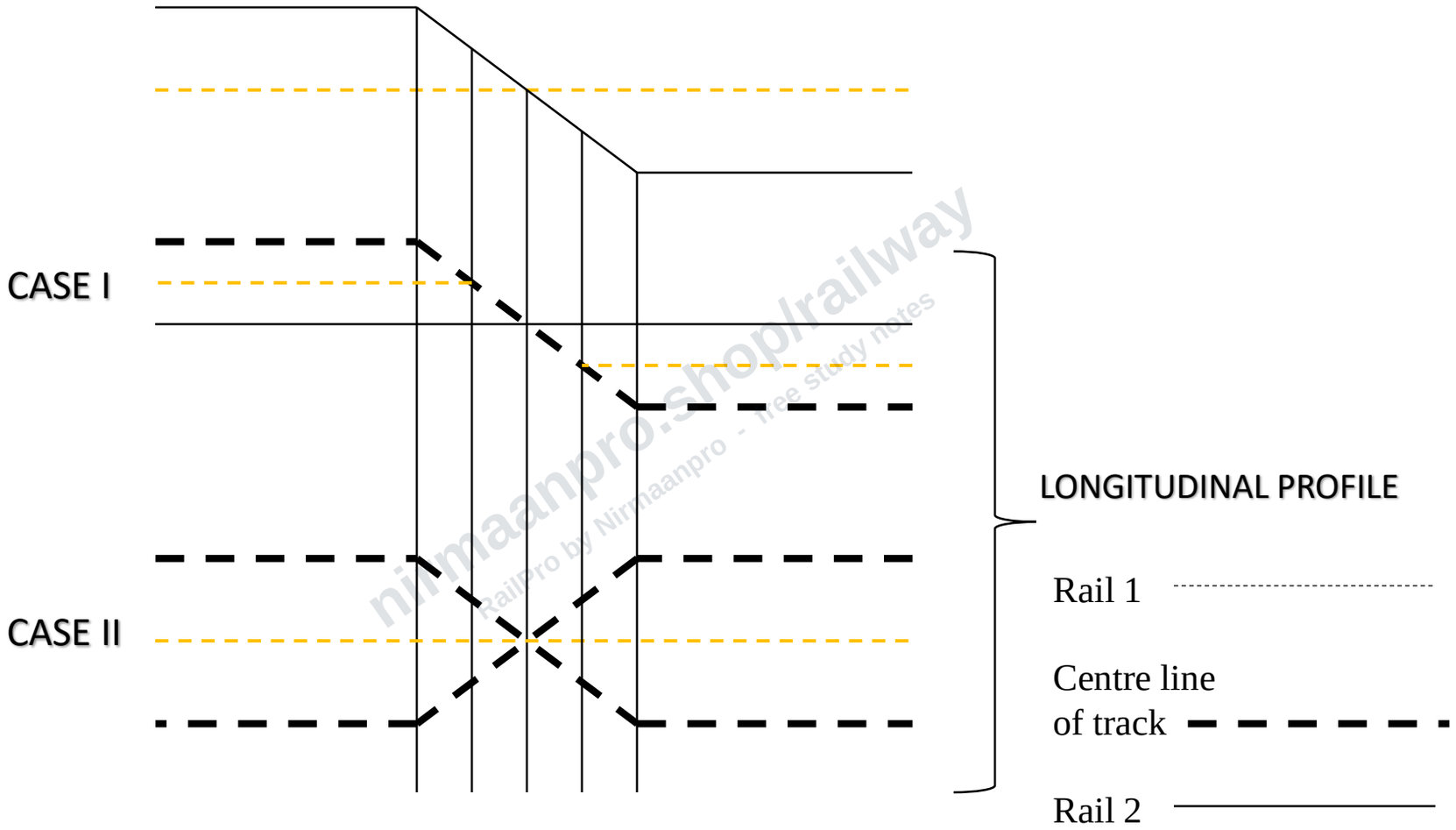
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RUNNING OUT OF SUPERELEVATION

- In case no. 2, the level of the centre line of the track is maintained the same throughout and the cant is provided by raising one rail by half the amount of cant and lowering the other rail by the equal amount. Cant is run out or gained over the length of the transition by raising and lowering both the rails by equal amount symmetrically, with respect to the level of the centre line track.

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In case of no. 1, the level of the centre of the track gets disturbed whereas in case no. 2,it is maintained the same throughout.



VERSINE OR CANT DIAGRAM

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RUNNING OUT OF SUPERELEVATION

- If running out of super-elevation is done as per above then;

- Special cases of Super-elevation run out may be approved by the Chief Track Engineer.

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Cutting of Rails on Curves:- (contd..)

- Rails are usually laid with square fish plated joints on curve.
- On curved track the inner rail fish plated joints gradually lead over the outer rail joints.
- When the inner rail of the curve is ahead of the outer rail by an amount equal to half the pitch of boltholes, cut rails should be provided to obtain square joints.
- Cut rail is a rail, which is shorter than the standard length of rail by an amount equal to the pitch of the boltholes.

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Cutting of Rails on Curves:-

The excess length ‘d’ by which the inner rail gains over the outer rail is calculated by the formula

$$d = \frac{L \times G}{R}$$

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- where, ‘d’ is the length in mm by which the inner rail joint is ahead of the outer rail joint over the entire length of the curve, if cut rails are not provided.
- L = length of the curve in metre
- R = radius of the curve in metre G = the gauge + width of the rail head in mm

Joints on Curves:-

- As para 422 of IRPWM ;
- (1) It must be ensured that fish plated rail joints are square at beginning and at the end of the curve.
- (2) On the sharp curves less than 400 metres the rail joints may be staggered, where elbows/kinks are likely to develop if rail joints are laid square.

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IRPWM PROVISIONS

AT THE TIME OF LAYING/ RELAYING :

- VERSINE VARIATION OVER THEORETICAL
  - 600 M RADIUS AND MORE: 5 MM
  - LESS THAN 600 M RADIUS: 10 MM
- GAUGE IN TRACK ON CURVES
  - MORE THAN 350 M RADIUS: -5 MM TO + 3 MM
  - LESS THAN 350 M RADIUS: +10 MM

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IRPWM PROVISIONS

- CURVE BOARDS
  - CURVE BOARD SHALL BE PROVIDED AT TANGENT POINT ON OUTSIDE OF THE CURVE
- CURVE POSTS
  - RAIL POSTS INDICATING BEGINNING AND END OF TRANSITION, PAINTED RED AND WHITE SHALL BE PROVIDED

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IRPWM PROVISIONS

- RADIUS OF CURVE
  - $R = 125C^2/V$ WHERE V IN mm other in metre.
- FOR MEASURING VERSINES
  - NORMAL: 20 M CHORD OVERLAPPING WITH STATIONS AT 10 M
  - TURN IN CURVE : 6 M CHORD OVERLAPPING WITH STATIONS AT 3.0 M
- INNER RAIL IS TAKEN AS REFERENCE AND OUTER RAIL IS RAISED BY AMOUNT OF SUPERELEVATION

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IRPWM PROVISIONS

- SAFE SPEED ON A CURVE
  - $V = 0.27 \sqrt{R} (C_a + C_d)$
- NON TRANSITIONED CURVE
  - LENGTH OF TRANSITION : 14.785 M
- ON OUTSIDE OF CURVES, EXTRA WIDTH OF BALLAST TO BE PROVIDED
  - 150 MM: FOR LWR TRACK
  - 95 MM: ON FISH PLATED TRACK, RADIUS LESS THAN 400 M

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IRPWM PROVISIONS

- SUPERELEVATION MARKING ON RAILS
  - VALUE OF SUPERELEVATION SHALL BE MARKED ON THE WEB OF INSIDE RAIL AT VERSINE STATIONS IN TRANSITION PORTION
  - VALUE AS ABOVE SHALL BE MARKED AT THE BEGINNING AND END OF THE CIRCULAR CURVE
  - FOR LONGER CURVES, THE VALUE OF SUPERELEVATION SHALL BE REPEATED AS ABOVE AT INTERVALS NOT EXCEEDING 250 M

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IRPWM PROVISIONS

- INSPECTIONS :
- ADEN : to inspect those bad curves as per TRC/OMS/ Foot plate results and on the basis of inspections of SSE/JE (P Way)
- SSE/PWAY (I/C) and Sectional JE/SSE :
- For curves > 2 deg : once in 6 months by rotation
- For curves <= 2 deg :

(i) Sectional JE/SSE – once in a year

(ii) SSE(I/C) – based on TRC/OMS / Foot plate results or inspections of Sectional SSE/JE

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Lubrication of Outer rails on Curves

- LATERAL WEAR ON RAILS IN CURVES
  - GROUP A AND B : 8 MM
  - GROUP C AND D : 10 MM
- MINIMISING WEAR ON OUTER RAIL
  - RAIL FLANGE LUBRICATORS SHALL BE PROVIDED IN CURVES LESS THAN 600 M RADIUS. FIRST ONE SHALL BE AHEAD OF THE CURVE

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Track mounted auotomatic Gauge face lubrications on curves

- To be provided on curves sharper than 2 degree on BG.
- On routes where rail grinding in practice on 1.25 degree and sharp.
- LOCATION:- on tangent track at the beginning of transition of curve where wheel flanging just occur. On single line direction of heaviest traffic.
- NOT TO LOCATE: switches, crossing or area where discontinuity in LWR exists.

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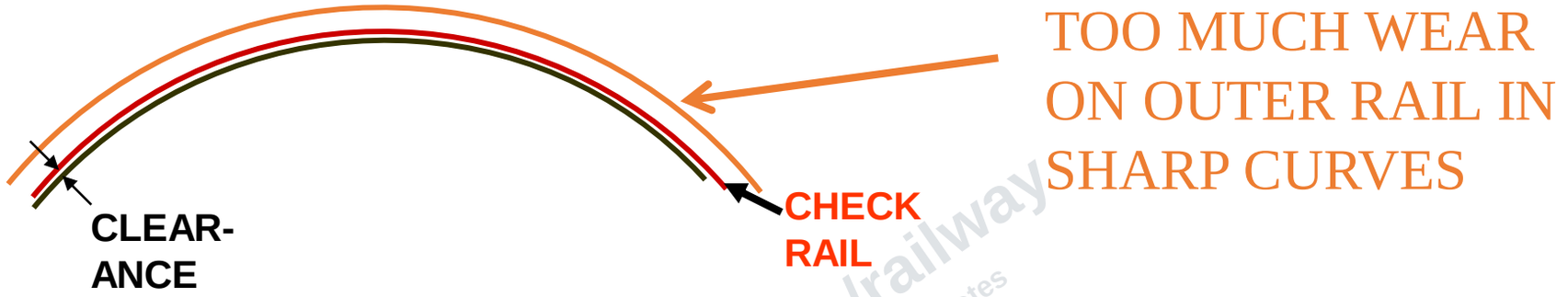
Automatic curve lubricator



CHECK RAILS ON CURVES



CHECK RAILS ON CURVES



- CHAPTER 1, BG SOD

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- ON CURVES OF 8 DEGREES & ABOVE
- MIN. CLEARANCE = 44 mm
- CLEARANCE = 44 + (G*-1676)/2
- G*: Actual gauge on the curve. (wide gauge sleeper)

CHECK RAILS ON CURVES

- Check rail reduces the risk of derailment on the sharp curves.
- (1) Check rail should be provided on the inside of the inner rail of the curve, with appropriate clearances between the checkrail and the running rail, as stipulated in the “Schedule of Dimensions”.
- (2) Locations where checkrail should be provided shall be decided by the Divisional Engineer taking into consideration the negotiability of the rolling stock and the curve geometry

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Wear on Outer Rail of Curves:-

- (1) The wear on the outer rail on the curve can be reduced effectively by-
- (a) Lubricating the gauge face of outer rails on the curves.
- (b) Maintaining correct curve geometry and Super-elevation.
- (c) Provision of suitable checkrail.
- (d) Adopting slack gauge PSC sleeper as per RDSO drawings depending on curvature of track.

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Wear on Outer Rail of Curves:-

- (2) Track mounted automatic Gauge Face Lubricators should be provided on curves of radius 875 m (2°) and sharper to reduce rail gauge face wear.
- On routes where rail grinding is in practice, track mounted automatic Gauge Face lubricators should be provided on curves of radius 1400 m (1.25°) and sharper.
- Lubrication should be done on new rails or on old rails, which do not have Gauge Corner Cracking or head checks.

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Wear on Outer Rail of Curves:- (contd..)

- While deciding the location of lubricators, following should be considered:-
- (a) It is located on tangent track at the beginning of transition curve where wheel flanging is just beginning to occur.
- (b) On single lines, the lubricator shall be located in the direction of heaviest traffic.
- (c) Lubricators should be located away from switches, crossings and other areas where discontinuity in LWR track may exist.

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Measurement of Rail Wear on Sharp Curves:

- The wear of rails of curves having radius of 600 m or less shall be recorded periodically as specified by the zonal railway.
- The lateral wear, vertical wear and total loss of section should be recorded and proper record of measurements maintained.

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Thanks

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1.6 - Widening of gauge on curves, Extra clearance on curves, Minimum length of straight between Reverse Curves.

Total periods - 4

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Gauge Widening on curves

- The minimum clearance required to permit the vehicles to negotiate a curve with free curving motion depends on the Maximum rigid wheel base and the Degree of curve for a particular track gauge.
- For minimum clearance, it is desirable to have 3 to 5 mm additional clearance to cater to the angularity assumed by the wheel set while negotiating the curve.

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Gauge in curves

- On new lines and on lines where complete renewal or through sleeper renewal is carried out, the track should be laid to the following standards

Radius in Mts	Gauge
B.G (1676 mm)	
Straight including curves of radius upto 350m. and more	-5mm. to +3mm. (1671 to 1679 mm)
For curves of radius less than 350m	Upto +10mm. (1686 mm)

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Gauge in Curves

- While it is desirable to maintain correct gauge, it may not be possible to maintain correct gauge due to age and condition of the sleeper.
- It is good practice to work within the following tolerances of gauge, provided generally uniform gauge can be maintained over long lengths:

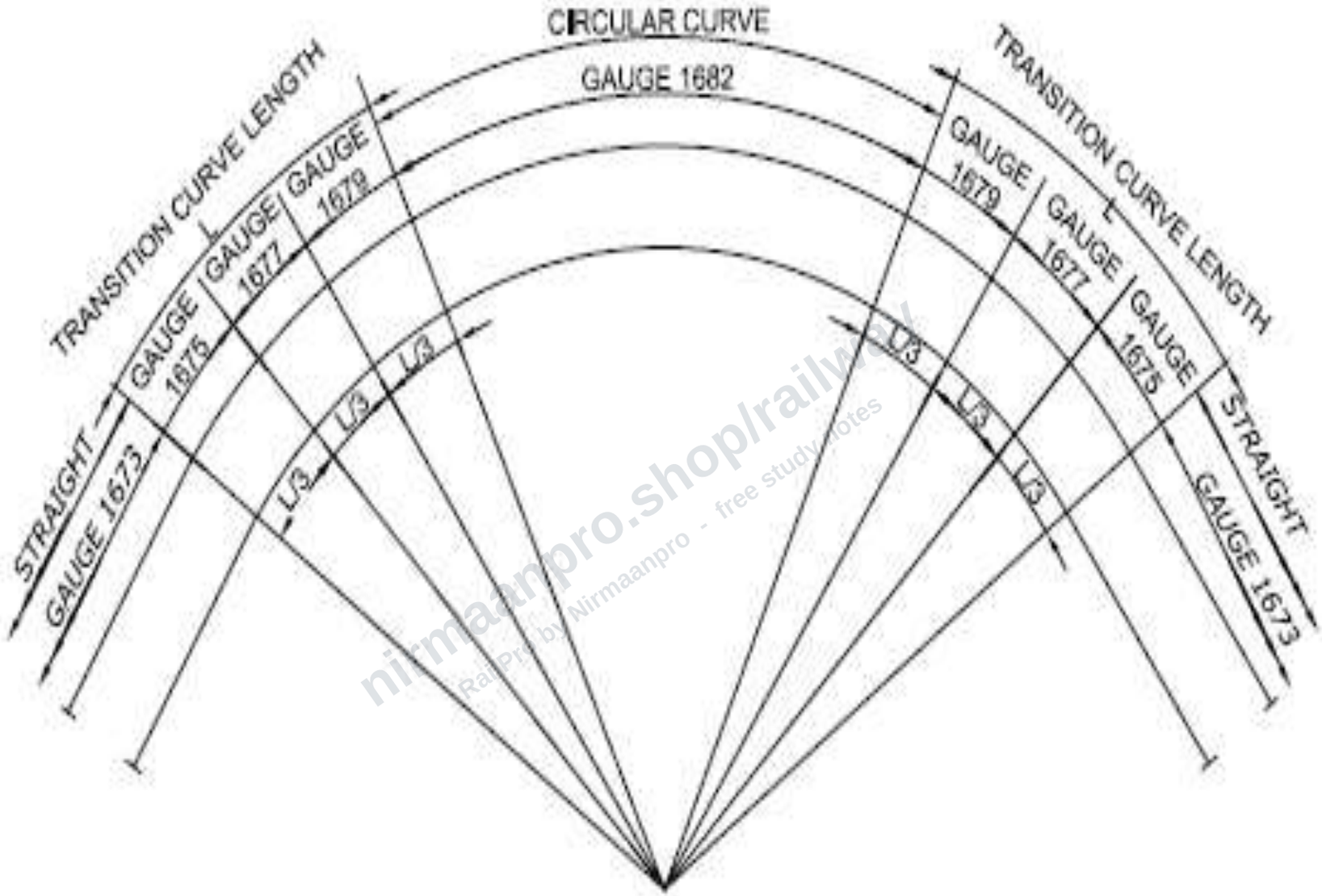
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Radius in Mts	Gauge
B.G (1676 mm)	
On Straight	- 6mm. to +6mm. (1670 to 1682 mm)
On curves with radius 440 m or more	- 6mm to +15mm. (1670 to 1691 mm)
On curves with radius less than 440 m	upto +20mm. (1696 mm)

Providing wide gauge sleepers

- The normal PRC sleepers used in the straight have nominal gauge of 1673 mm.
- Where the wider gauge is to be provided, special sleepers having wider nominal gauge shall be provided.
- The extra widening of the gauge has to be introduced in the transition portion of the curve, and sleepers are also to be provided accordingly.
- The gauge shall be changed from normal to the wider gauge in curve at the rate of 1/3rd widening in each 1/ 3rd length of transition. (PSC sleepers on curves RDSO T-4183 to T-4186)

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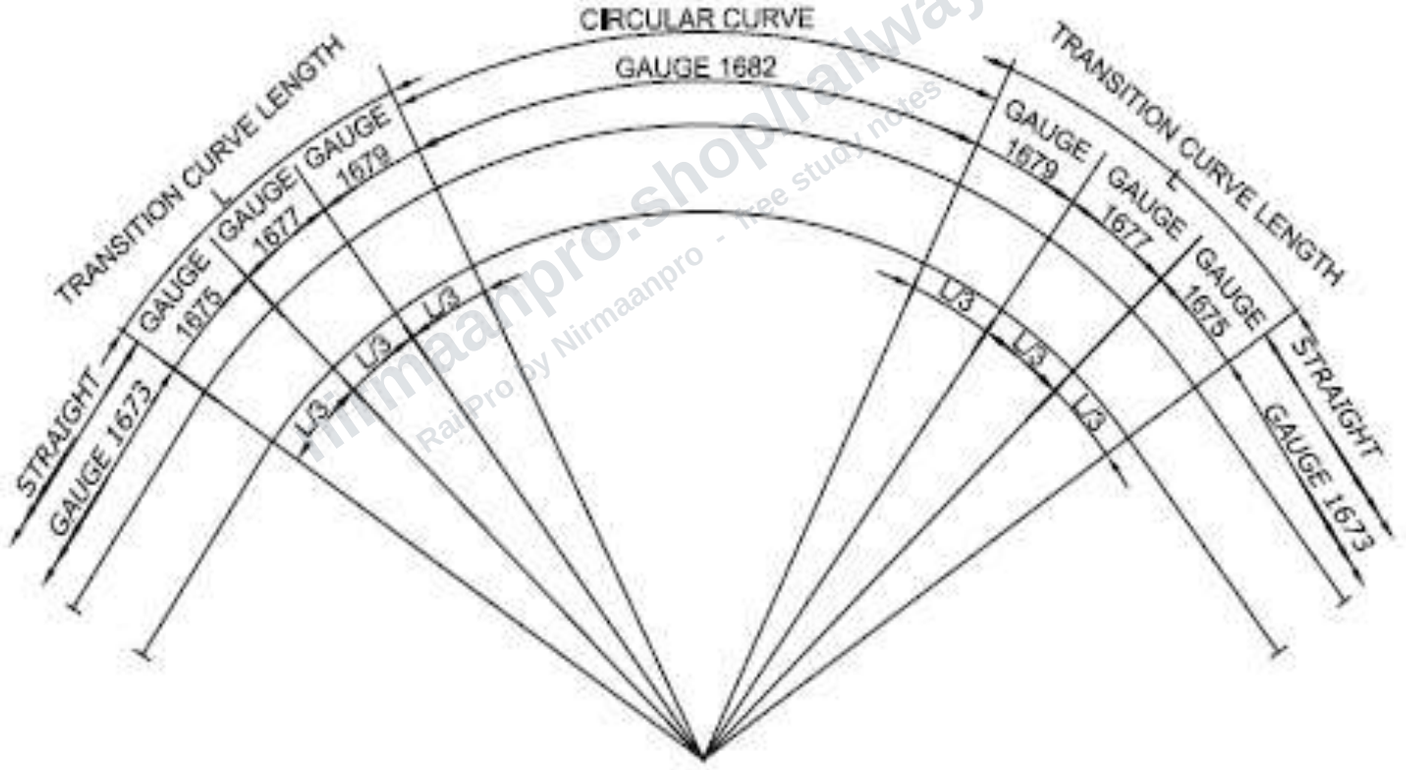


TRACK LAYOUT

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- **TABLE OF DIMENSIONS**

DRAWING N O..	PCS NO..	DESIRED GAUGE
RDSO/T-4183	53/1	1675 (+ 2)
RDSO/T-4184	53/2	1677 (+ 4)
RDSO/T-4185	53/3	1679 (+ 6)
RDSO/T-4186	53/4	1682 (+ 9)

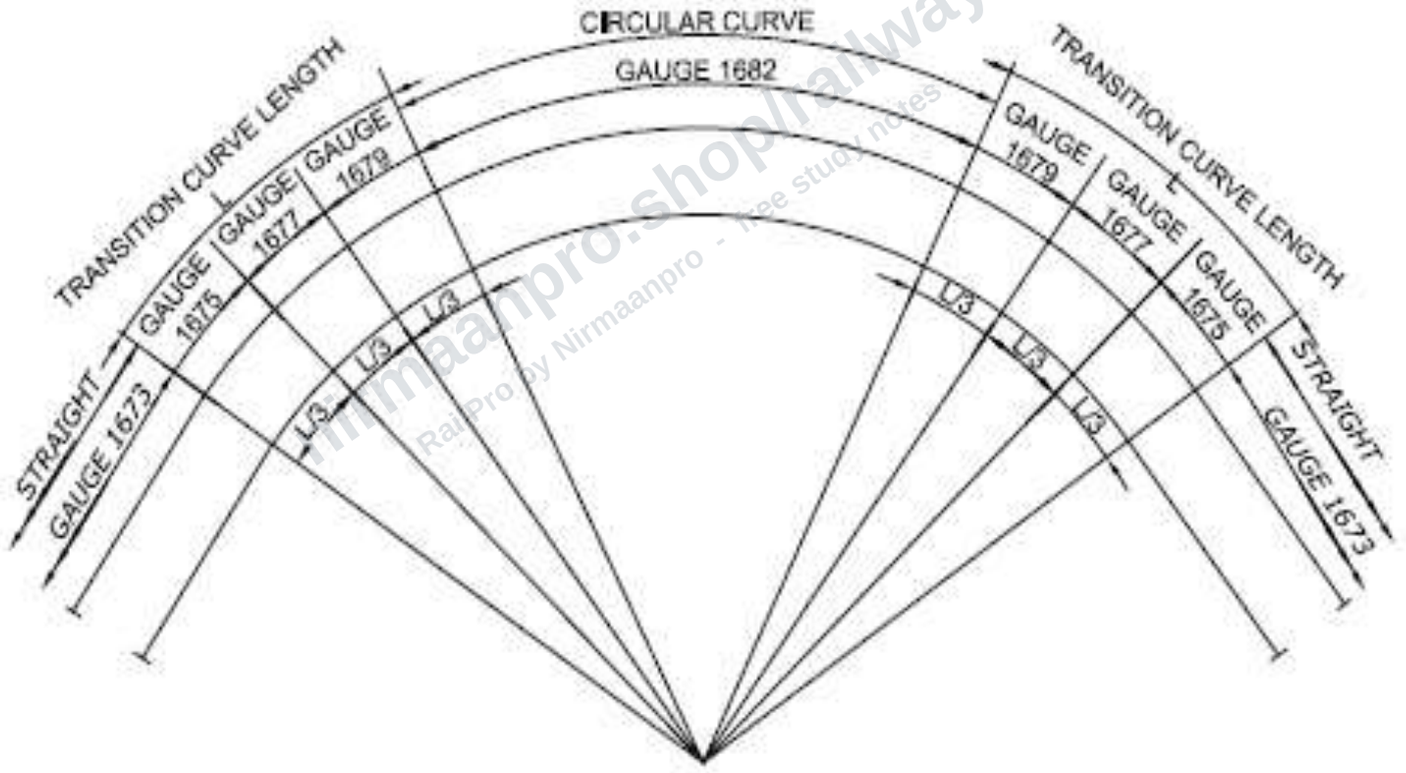


TRACK LAYOUT

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RDSO/T-4184	53/2	1677 (+ 4)
RDSO/T-4185	53/3	1679 (+ 6)
RDSO/T-4186	53/4	1682 (+ 9)



TRACK LAYOUT

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- **TABLE OF DIMENSIONS for check rail clearance of 75 mm with 60 kg Running rail and 52 kg check rail**

DRAWING NO..	PCS NO..	DESIRED GAUGE
RDSO/T-4183	53/1	1675 (+ 2)
RDSO/T-4184	53/2	1677 (+ 4)
RDSO/T-4185	53/3	1679 (+ 6)
RDSO/T-4186	53/4	1682 (+ 9)

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Laying Sleepers in curves

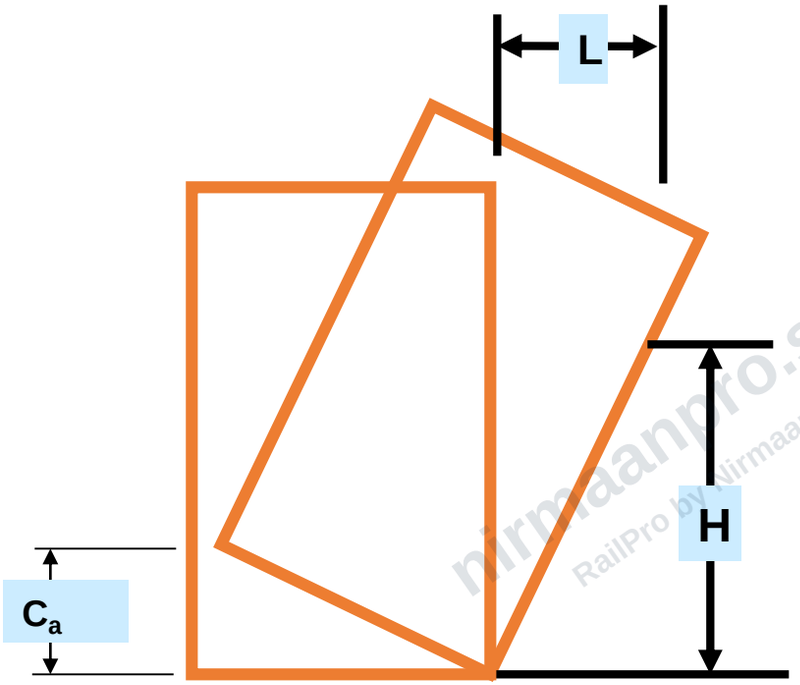
- On curved track, the sleepers are required to be laid radial to the curve.
- To ensure this, the spacing should be correctly marked on outer rail and then the position can be transferred on the inner rail with the help of a ‘T’ square.

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Extra Clearances on curves: Lean and Sway



CLEARANCE ON CURVES- LEAN



$$L = H*C_a/G$$

H is the height of the structure or maximum height of vehicle whichever is less.

G is track gauge as per SOD

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ADDITIONAL ALLOWANCE DUE TO SWAY

- Inside
  - ¼ of lean due to superelevation
- Outside
  - Not to be considered if lean is there
    - **We do not take advantage of the extra clearance given by lean away from outer side structures**

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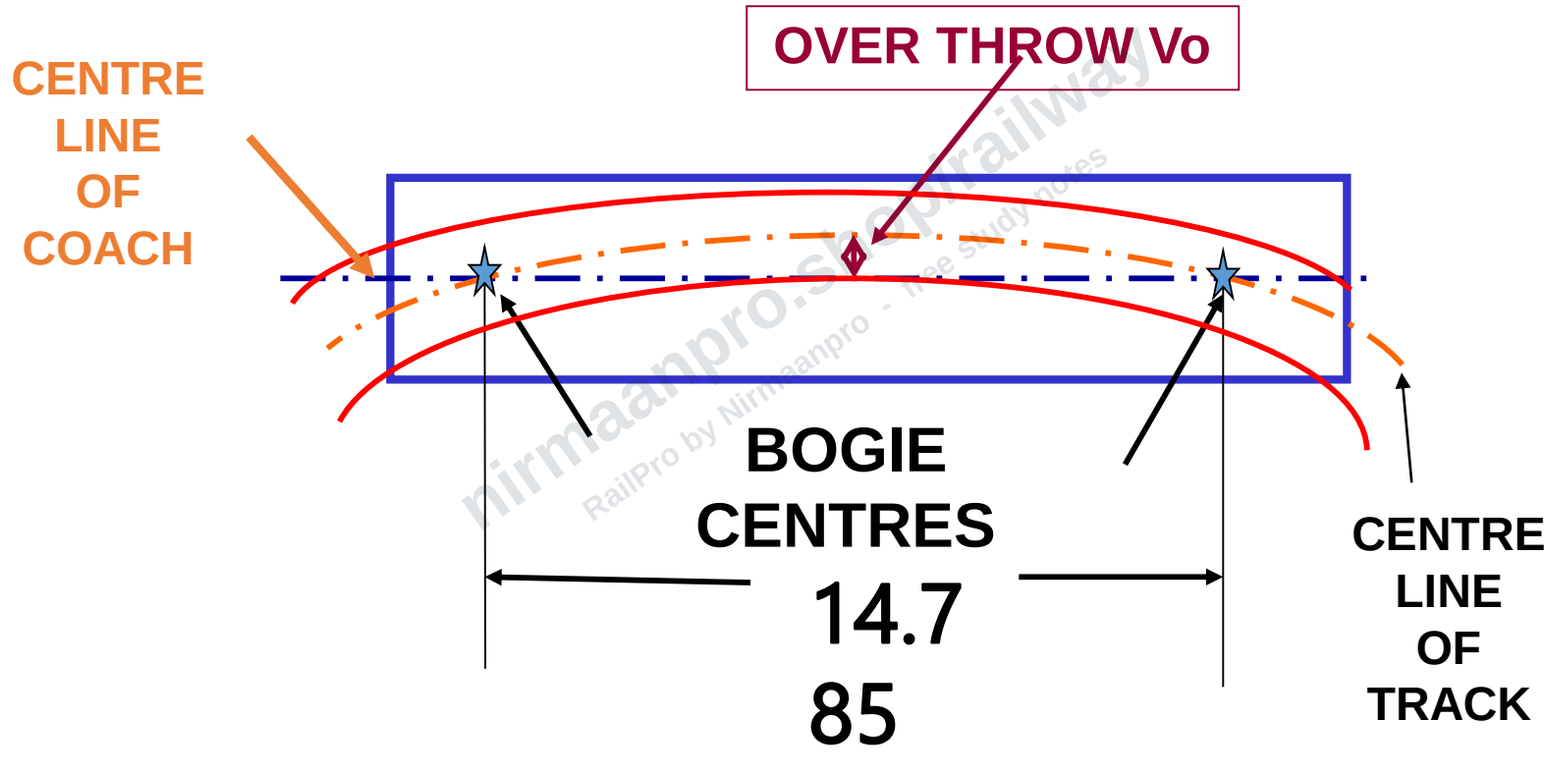
Extra Clearances on Curves: Platforms and structures



Clearance On Curves- Effect of Chords

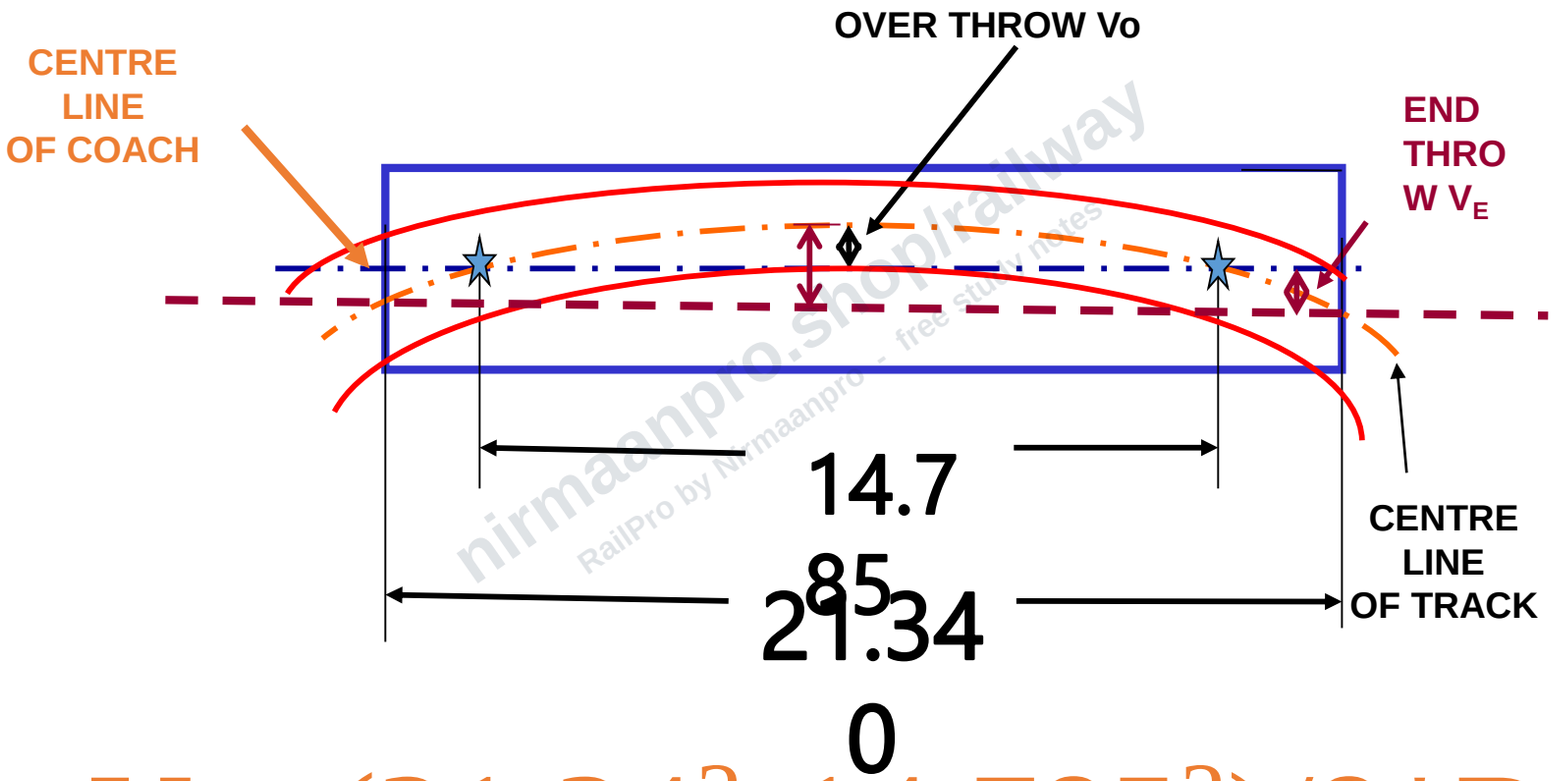


ADDITIONAL CLEARANCES ON CURVES



$$V_o = 14.785^2/8*R$$

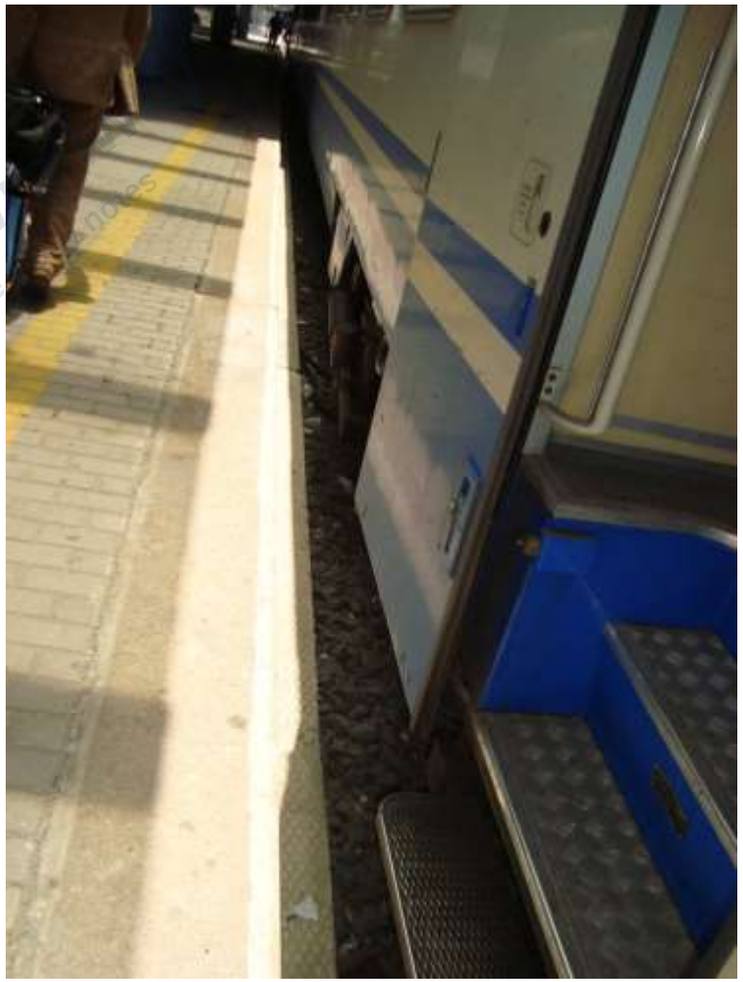
ADDITIONAL CLEARANCES ON CURVES



$$V_E=(21.34^2-14.785^2)/8*R$$

EXTRA CLEARANCE DUE TO CURVATURE

- Platforms/ structures
- Inside of curve
  - $(V_O+L+S-51)$
- Outside of curve
  - (V_E-25)mm



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Extra Clearances due to Curvatures

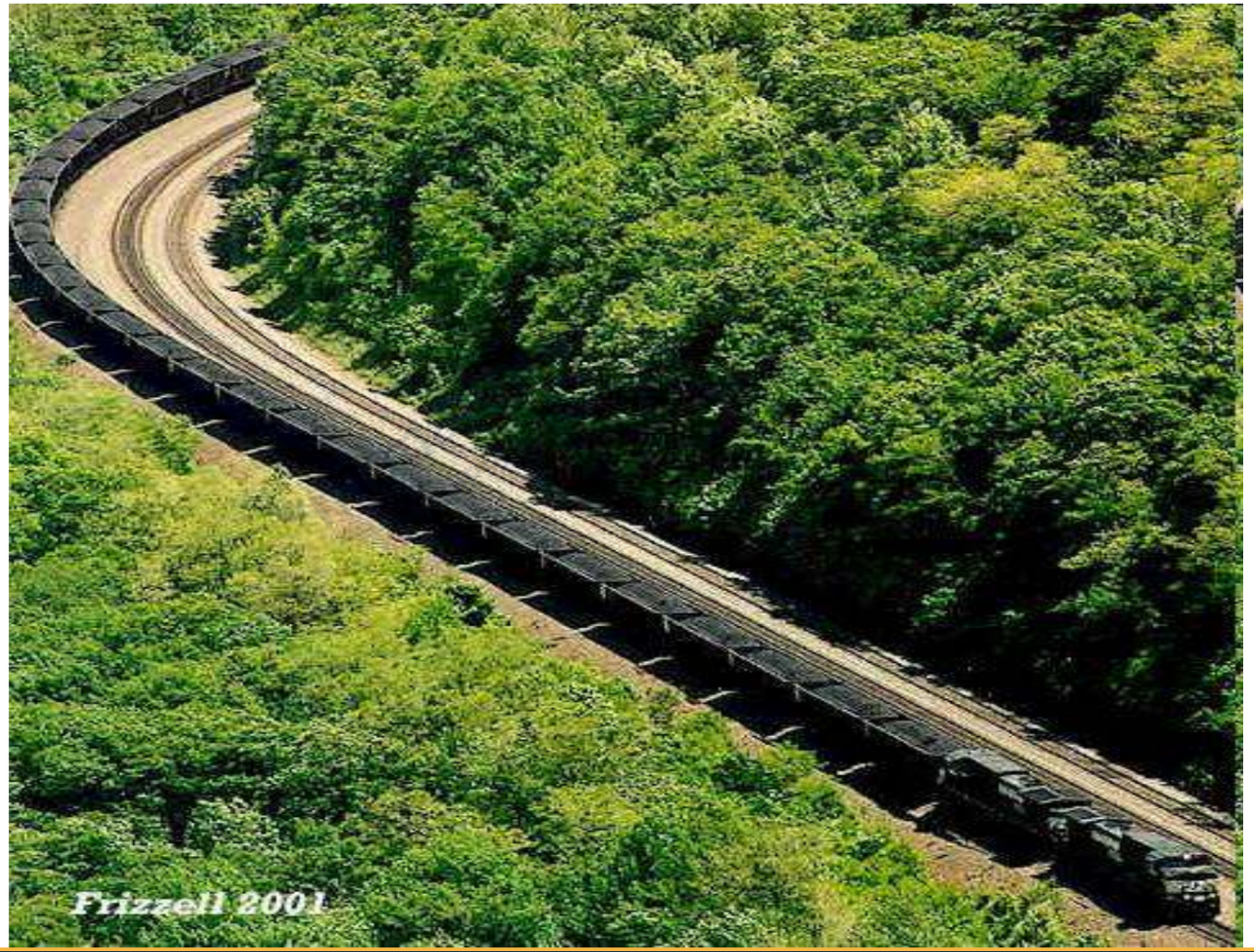
- Between Adjacent Tracks

  $$V_O + V_E + 2 * (L/4)$$

  - In new works, if c/c track is 5300 mm, extra clearance is to be provided for curves beyond 5° only.

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Extra Clearances on parallel curved tracks



Min. length of straight in REVERSE CURVES

- For high speeds, in Group ‘A’ and ‘B’ routes, a straight with a minimum length of 50 m shall be kept between two transitions of reverse curves.
- (i) On groups ‘A’ and ‘B’ routes on straights less than 50 metres between reverse curves should be eliminated by suitably extending the transition lengths.
- In doing so, it should be ensured that the rate of change of cant and versine along the two transitions so extended is kept the same.
- (ii) Whenever such straights between reverse curves can neither be eliminated nor the straight length increased to over 50 metres, speed in excess of 130 Kmph should not be permitted.

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Example

- Instructor to give an example to trainees to work out the extra clearances on Platform and ask them to workout themselves for different degree of curvature.

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Thanks

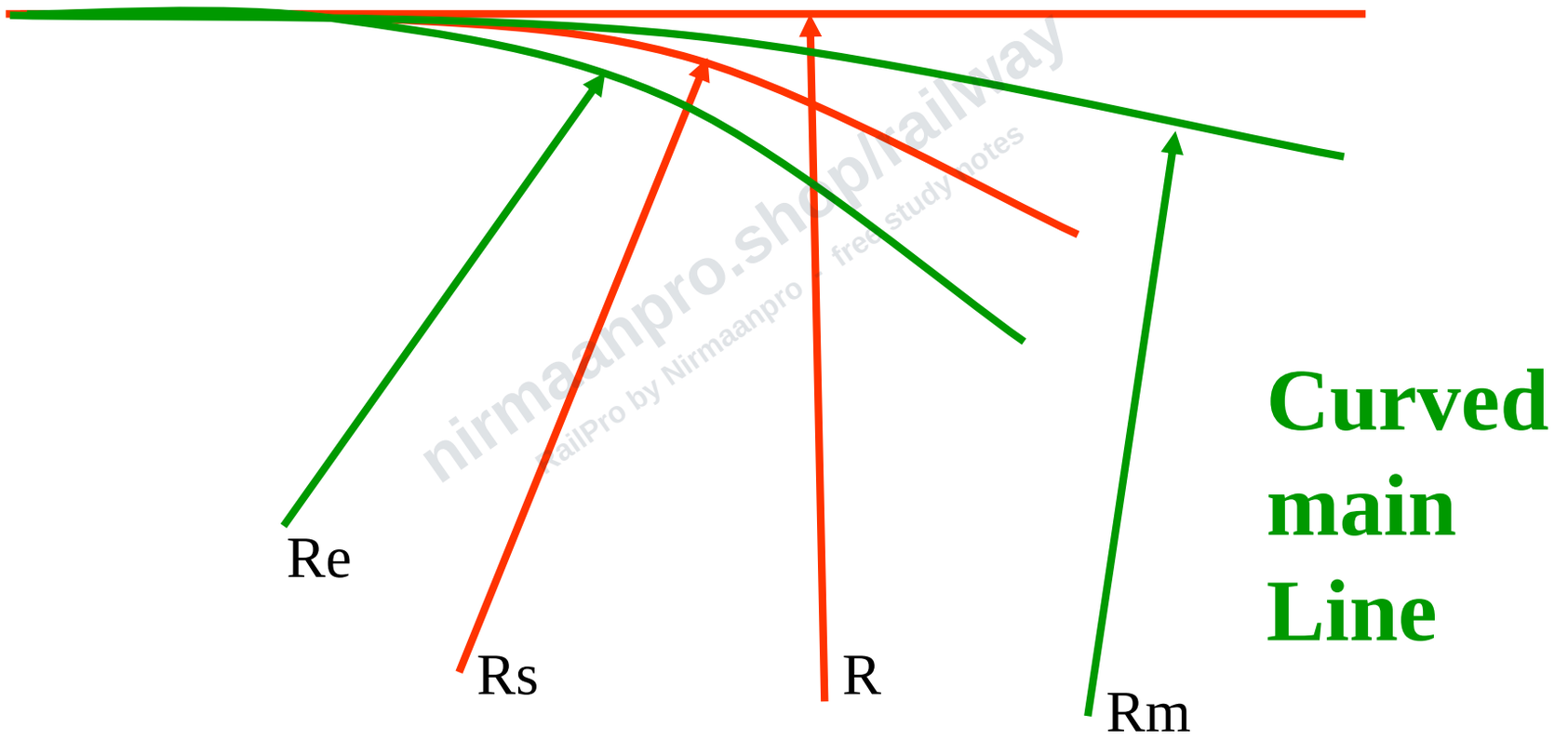
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1.7 Curves with similar and contrary flexure, Calculation of cant to be provided and permissible speed, Curve with X-over and diamonds

periods - 6

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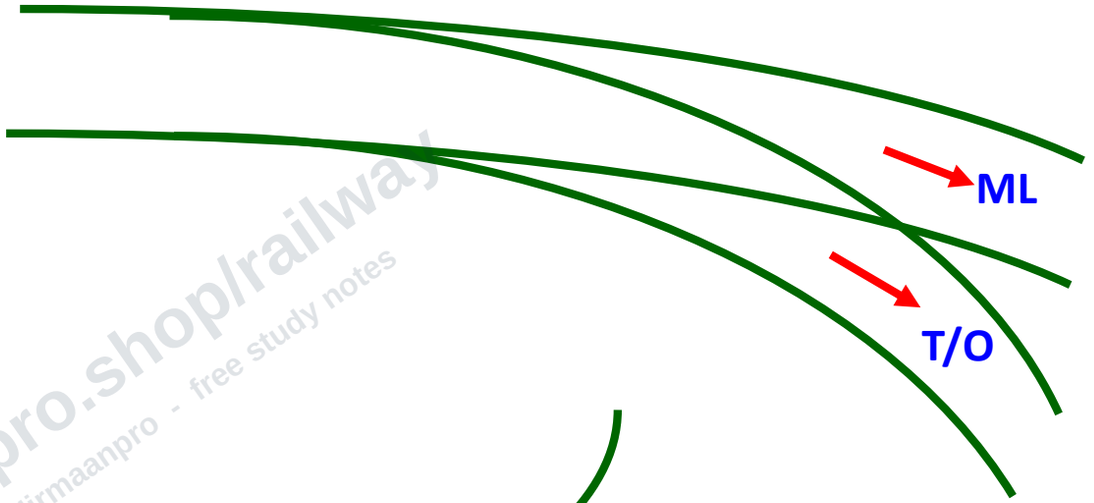
Turnouts taking off from curve



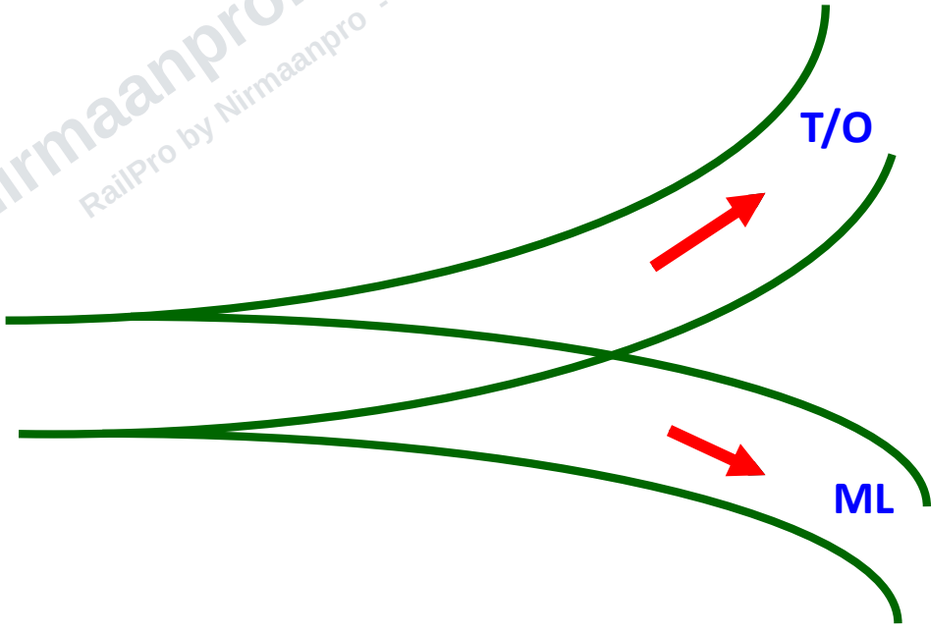
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Turnouts on Curves

Similar Flexure



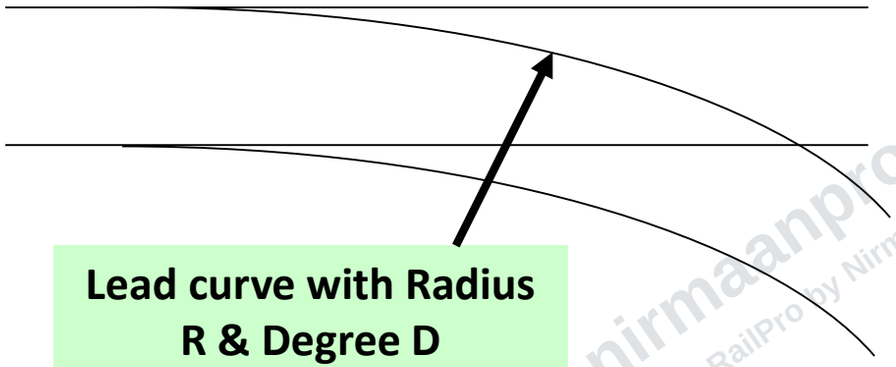
Contrary Flexure



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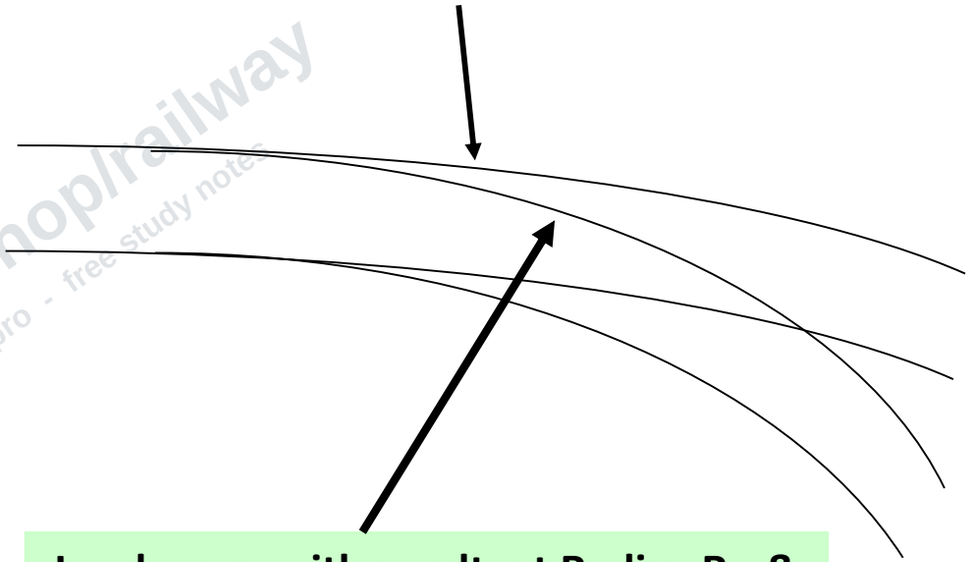
Resultant Lead Radius in Similar Flexure Turnouts

Turnout Laid on Straight



Lead curve with Radius R & Degree D

Main line with Radius R_1 and Degree D_1



Lead curve with resultant Radius R_2 & resultant Degree D_2

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For similar flexure,

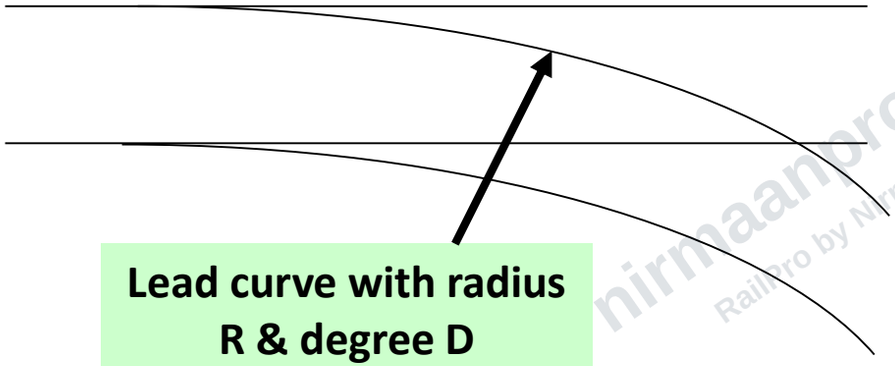
D2 = D1 + D

1750/R2 = 1750/R1 + 1750/R

1/R2= 1/R1 + 1/R

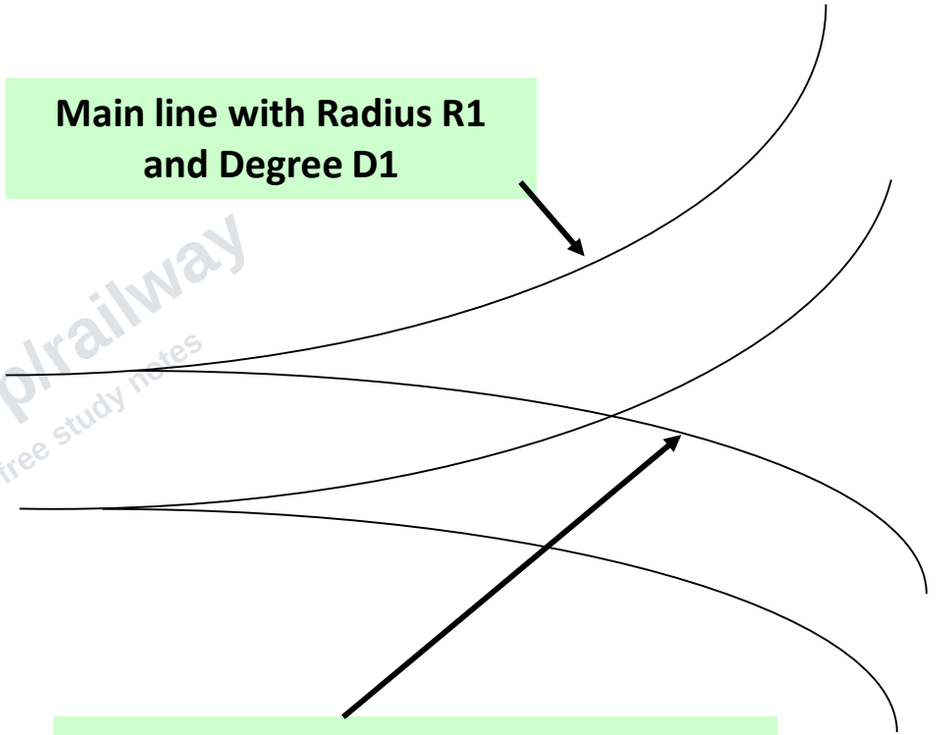
Resultant Lead Radius in Contrary Flexure Turnouts

Turnout Laid on Straight



Lead curve with radius R & degree D

Main line with Radius R1 and Degree D1



Lead curve with resultant Radius R2 & resultant Degree D2

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For contrary flexure,

$$D2 = D1 - D,$$

$$1750/R2 = 1750/R1 - 1750/R,$$

$$1/R2 = 1/R1 - 1/R$$



Equivalent Curvature

- The train moving on the turnout side experiences dual curvature
    - Due to the main line curve
    - Due to the turnout itself
- The curvatures get added up
    - Curvature=1/Radius

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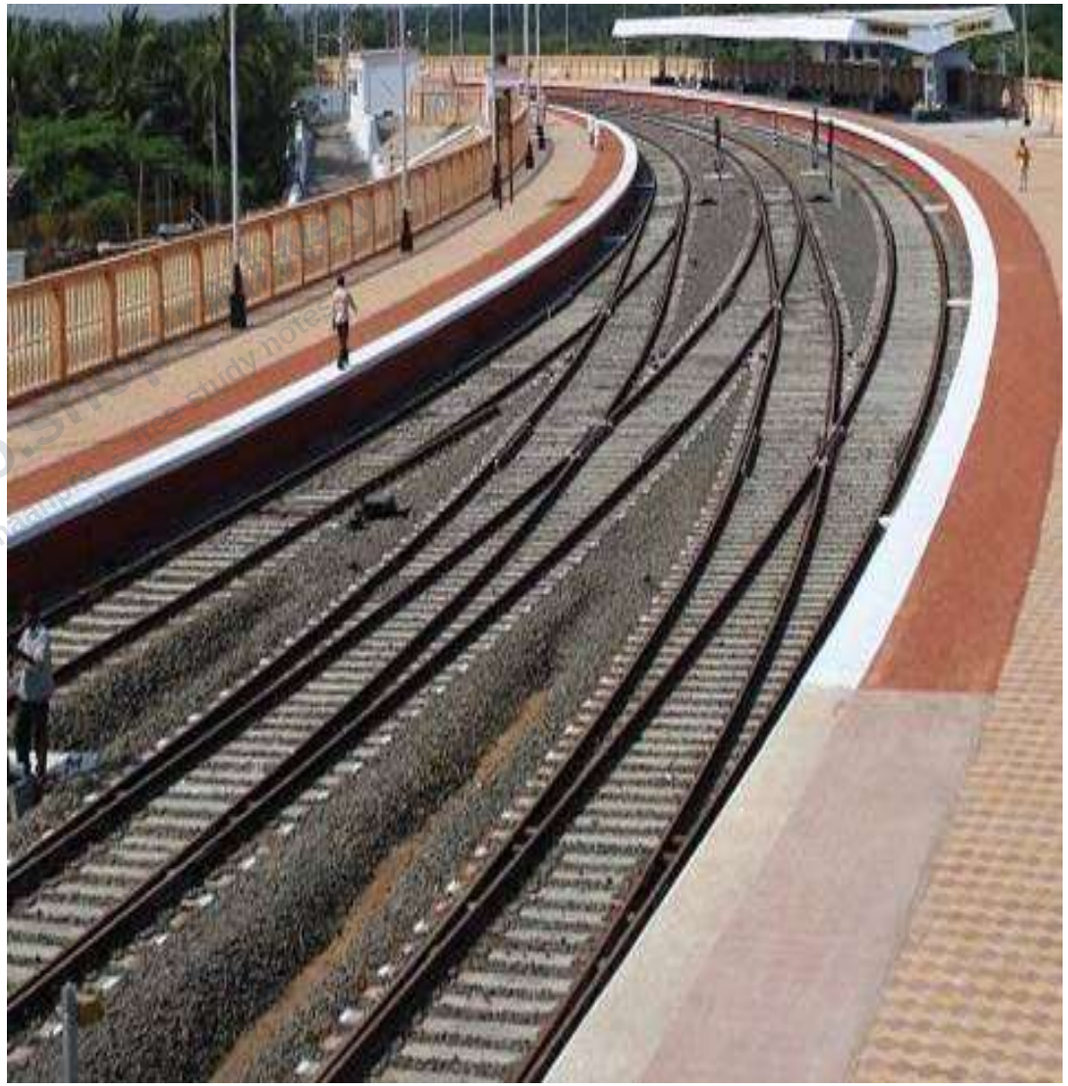
Turnouts in Similar Flexure

$$R_e = R_m * R_s / (R_m + R_s)$$

R_e: Equivalent Radius

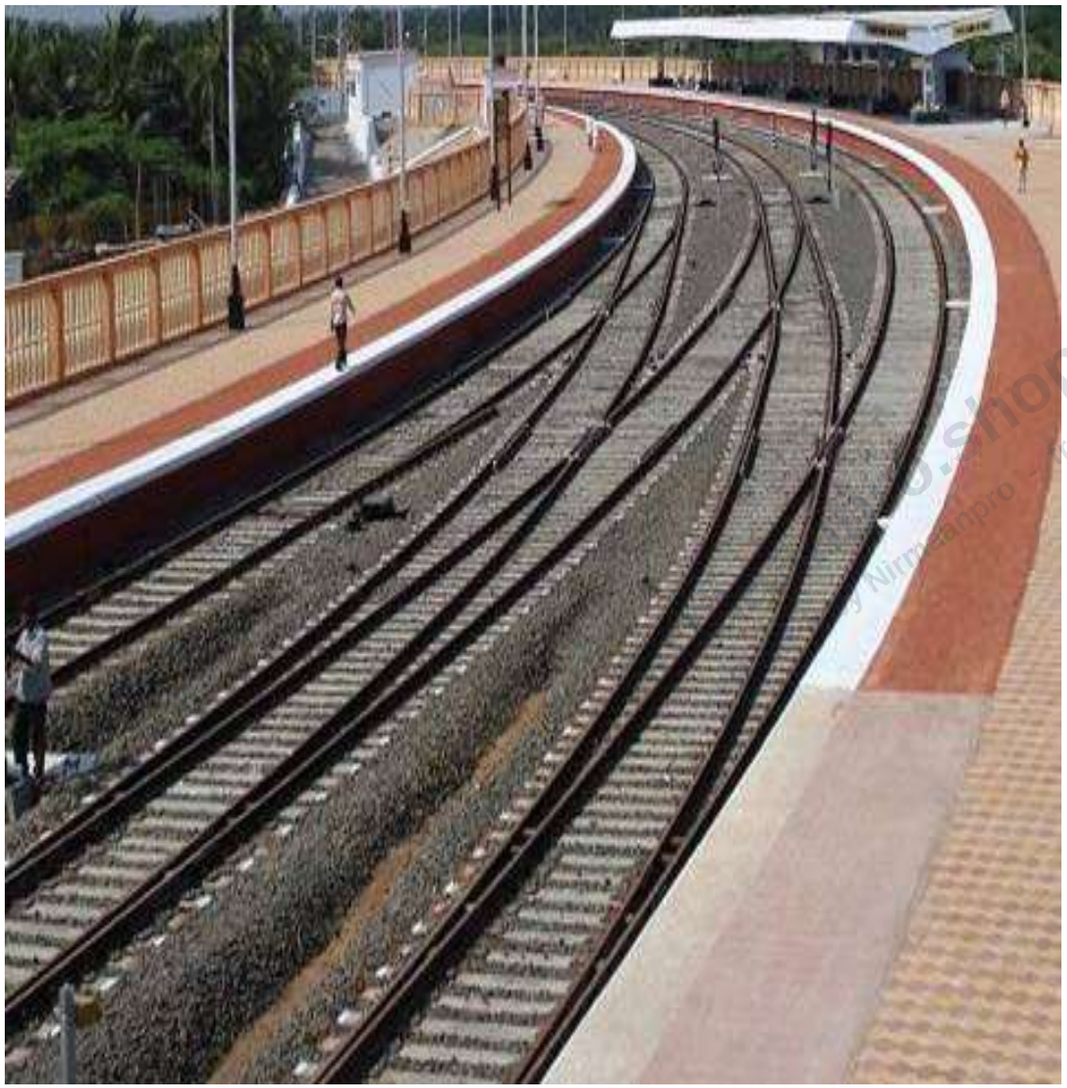
R_m: Main Line Radius

R_s: Switch Radius



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Turnouts in Contrary Flexure



$$R_e = R_m * R_s / (R_m - R_s)$$

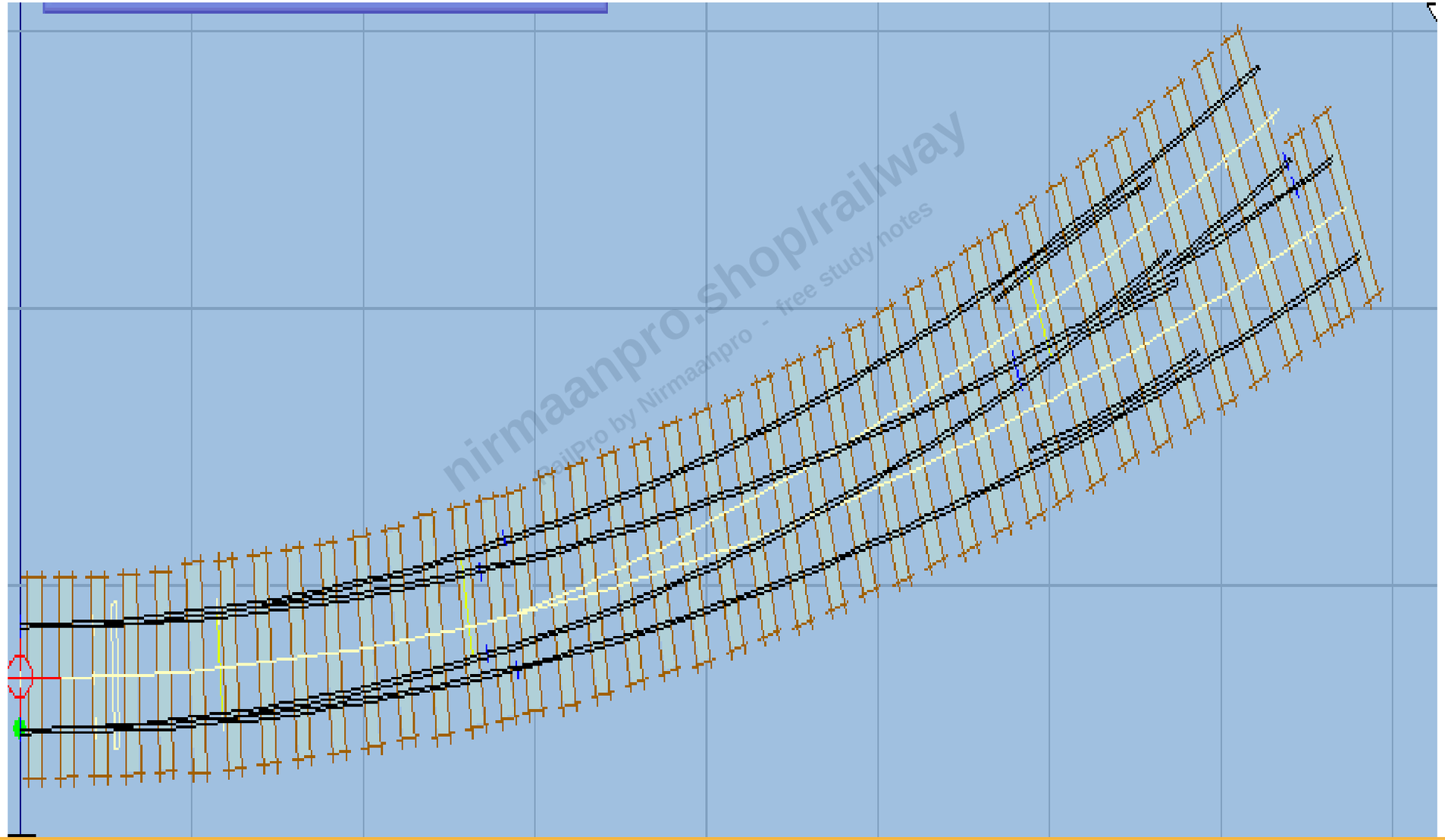
R_e: Equivalent Radius

R_m: Main Line Radius

R_s: Switch Radius

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Similar flexure



Equivalent curvature

- The train moving on the turnout side experiences dual curvature
  - Due to the main line curve
  - Due to the turnout itself
- The curvatures get added up
  - Curvature=1/Radius

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Speed on Curve having Turnouts

- Trains move on main line as well as the turnout side
  - Allowable cant to be found after checking for both the tracks
    - **Similar flexure:** turnout side train moves with slower speed and more cant is there on main line so **check for cant excess**
    - **Contrary flexure:** Turnout side train with Negative cant. **Check for cant deficiency**

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Calculation of Cant



- **Similar flexure Turnout:**
  - Calculate equilibrium super elevation for turnout side as per maximum speed permitted on turnout side (i.e. C_{eqto})

    $C_{eqto} = GV^2/127R_{to}$

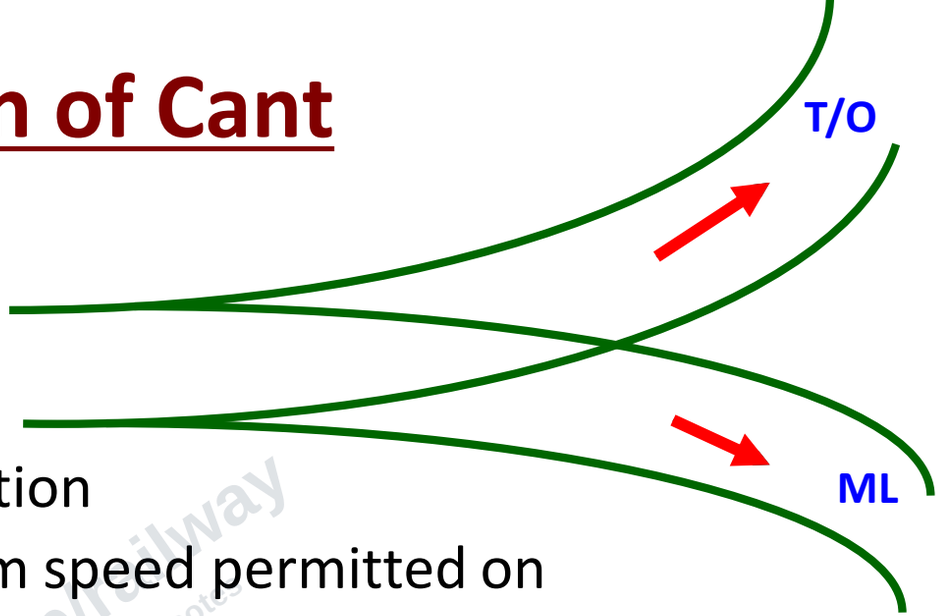
    (R_{to} is the resultant radius of Lead curve)
  - Add 75mm of cant excess, this is the super elevation which can be provided on turnout side (i.e. C_a).

    $C_a = C_{eqto} + 75mm$
  - Speed for main line can be calculated by taking C_a as calculated above and taking C_d as 75mm.

    $C_a + C_d = GV^2/127R_m$

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Calculation of Cant



- **Contrary flexure-**
  - Calculate equilibrium super elevation

    for turnout side as per maximum speed permitted on turnout side (i.e. C_{eqto})

    $C_{eqto} = GV^2/127R_{to}$

    (R_{to} is the resultant radius of Lead curve)
  - Deduct it from 75mm i.e. cant deficiency, this is the super elevation which can be provided on main line (i.e. C_a)

    $C_a = 75mm - C_{eqto}$
  - Speed for main line can be calculated by taking C_a as calculated above and taking C_d as 75mm.

    $C_a + C_d = GV^2/127R_m$

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Turnouts in Contrary Flexure

- Curves of contrary flexure
  - Equilibrium super elevation for turnout side

    $C = G * V^2 / (127\ R)$ [$]

    V: Speed in KPMH for Turnout,

    R: Metres,

    C: mm,

    G: mm
  - Super-elevation For Main Line

    (Negative Super-elevation For Turnout) is 75 - C

([$] The old formula in SOD has been revised in CS No. 3)

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CROSS-OVERS ON CURVES

In case of cross-over located in curves, the points and crossing in the inner curve takes off from the outside of the curve and the points and crossing in the outer curve takes off from the inside of the curve.

The super-elevation computed for the inner track having contrary flexure is less than that for the outer track having similar flexure. However, if we provide these different super-elevations, twist will be there in the straight portion between the two crossings. Since the compound curvature of the crossover track is already very sharp and the length is very small, this twist will be beyond permissible limits.

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CROSS-OVERS ON CURVES

- **Therefore, in case of cross-over in curve, the complete cross-over shall be in the same plane of inclination and the superelevation calculated for the inner track shall be provided for the complete cross-over. Thus speed restriction worked out for the inner track will be applicable for the outer track also.**

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CURVES WITH DIAMOND CROSSING

Normally straight diamond crossings should not be provided in curves as these produce kinks in the curve and uniform structure cannot be obtained. However, where provisions of such diamonds cannot be avoided or in case where such diamonds already exists in the track, the approach curves of these diamonds should be laid without cant for a distance of at least 20mtrs on either side of the diamond crossings.

Cant should be uniformly runout at the specfied rate beyond 20mtrs. The speed restrictions on the approach curve shall be decided in each case by the Chief Engineer taking into consideration the curvature, cant deficiency and lack of transition but shall in no case be more than 65kmph in BG, 50kmph for MG and 40kmph for NG(762mm).

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CURVES WITH DIAMOND CROSSING

- In the case of diamond crossing on a straight track located in the approach of a curve, a straight length of minimum 50m between the curve and the heel of acute crossing of diamond is necessary for permitting unrestricted speed over the diamond, subject to maximum permissible speed over the curve from considerations of cant deficiency, transition length etc.

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Working Example

- Instructor to give problems of working out speed for different situation on curve where point is taking off from outside or inside of curve.
- One problem may be asked for cross over laid on curve.
- total duration – 3 to 4 hrs.

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THANK YOU



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PART IX – CURVES

Part 3
REALIGNMENT OF CURVES
(TOTAL PERIODS – 2)

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3.1 Realignment of Curves, String Lining of Curves, Need for Curve Realignment:

total - 2 periods

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WHY SLEW REQUIRED ?

- Because curve geometry gets disturbed under passage of traffic as;
  - Trains are not moving at equilibrium speed
  - Large horizontal forces on the rails due to slight variations in curvature and due to vehicle imperfections

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WHAT IS MEANT BY ROC ?

- Bringing the curve back to proper alignment
- Doesn’t necessarily mean restoring to original alignment
- Infinite number of curves are possible between same set of tangents

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OBJECTIVES OF ROC

- No abrupt variation of curvature or superelevation
- Superelevation should be in proportion to the curvature
- Solution shall be practical
  - Least slews and subject to obligatory points

NOTE: In electrified territory, there is severe restriction of the maximum amount of slews which can be permitted

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REQUIREMENTS OF REALIGNMENT

- **Local adjustments**
- **Realignments of transitions**
- **Complete realignment**
  - **During laying**
  - **During up-gradation**
  - **During remodelling**
  - **During service**

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String lining Operations:-

- (1) The work of realigning and transitioning curves consists of the following three main operations–
- (a) Survey of the existing curve by measurement of versines.
- (b) Determination of the revised alignment and computation of slews, including provision of correct Super-elevation.
- (c) Slewing of the curve to the revised alignment.

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Versine survey of curve–

- (a) Versine readings shall be taken along the gauge face of the outer rail.
- (b) To ensure inclusion of the point of commencement of the curve, a mark is made on the gauge face of the outer rail at a distance of at-least 30 m (three stations) behind the beginning of curve, and at the end of curve as indicated by station markings on the rails. i.e., station number zero/last station (or apparent tangent point, if no such markings exist on track).

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Versine survey (contd..)

- (c) If station markings at every 10 m interval are not available on track, it shall be marked at every 10 m (half-chord distance) interval beginning from the marking made before beginning of the curve (vide Sub-Para (b) above) till the marking beyond end of the curve (vide Sub-Para (b) above),
- (d) These “stations” should be marked and numbered in white paint on the rail.

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Versine survey (contd..)

- (e) With a fishing cord or wire stretched out over the full length of the cord, the versines are measured to 1 mm accuracy serially at each station from one end of the curve to the other with the rule held normal to the line and recorded.
- (f) Certain features, which restricts slewing of the track either inwards or outwards should also be recorded, indicating the maximum extent inwards or outwards to which slewing is possible-
- (i) under existing circumstances; and
- (ii) if a moderate expenditure could be incurred in removing the “restriction”

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Versine survey (contd..)

- (g) The existing Super-elevation should also be measured and recorded against each “Station”.
- (h) The record obtained would be in the following form:
- Curve from km.....to .....km.....
  Between station.....and station.....
  Date of survey .....

Jurisdiction of JE/SSE/P.Way (In-Charge) / (Sectional) .....

Station	versine	Existing cant	Remarks regarding restrictions to slew

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Versine Survey (contd..)

- (i) In the case of reverse curves, the versine survey should be continuous, but transferred to the outer rail at points where the curvature changes sign.
- It is probable that the exact point will not be definite; it is therefore, desirable to keep the original rail face as the base until the change is certain to enable plus or minus versines to be read from the same rail, it is only necessary to hold the fishing cord or wire 20 mm clear of the rail edge at each end by using special gadget and subtracting 20 mm from the reading at the centre.
- (j) Where there are two or more lines, track centres should also be recorded at every station. After the versine-survey, the curve alignment shall not be disturbed until the realignment is commenced.

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Thanks

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3.2 Criteria for Curve Realignment (Total periods -2)

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CRITERIA FOR ROC

- **Unsatisfactory Running;**
- **Based on results of curve inspection**
  - **Station to station variation is the primary consideration**
  - **Service limits laid down in IRPWM**
  - **If values go beyond service limits at more than 20% stations—realign within a month**
  - **If the variation is only at few stations, local adjustments shall be done.**

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SERVICE LIMITS FOR STATION TO STATION VARIATION OF VERSINE

Speed Range	Permissible Versine Variation :
BELOW 160 KMPH AND UP TO 110 KMPH	10mm (15 mm for 110 kmph) or 20% of average versine on circular portion, whichever is more
Below 110 kmph and upto 50 kmph	20mm or 20% of average versine on circular portion, whichever is more
Below 50 kmph	40mm or 20% of average versine on circular portion, whichever is more

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Checking the actual curve for realignment criterian:

- Check weather following curve requires realignment or not,

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Station number	Existing versines in mm or 20 M chord
(1)	(2)
0	2
1	0
2	14
3	28
4	30
5	36
6	36
7	24

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8	32
9	28
10	36
11	34
12	32
13	34
14	36
15	24
16	24
17	28
18	0
19	6
20	0
	484

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Checking the actual curve for realignment criterian

- Another curve can be given curve by instructor from TMS record for a actual curve to check the requirement of realignment by trainees.
    - (1 period)

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Thanks

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2.9 Calculation of slews by Second Summation method

2.9 Steps involved in Curve Realignment

(total periods - 2)

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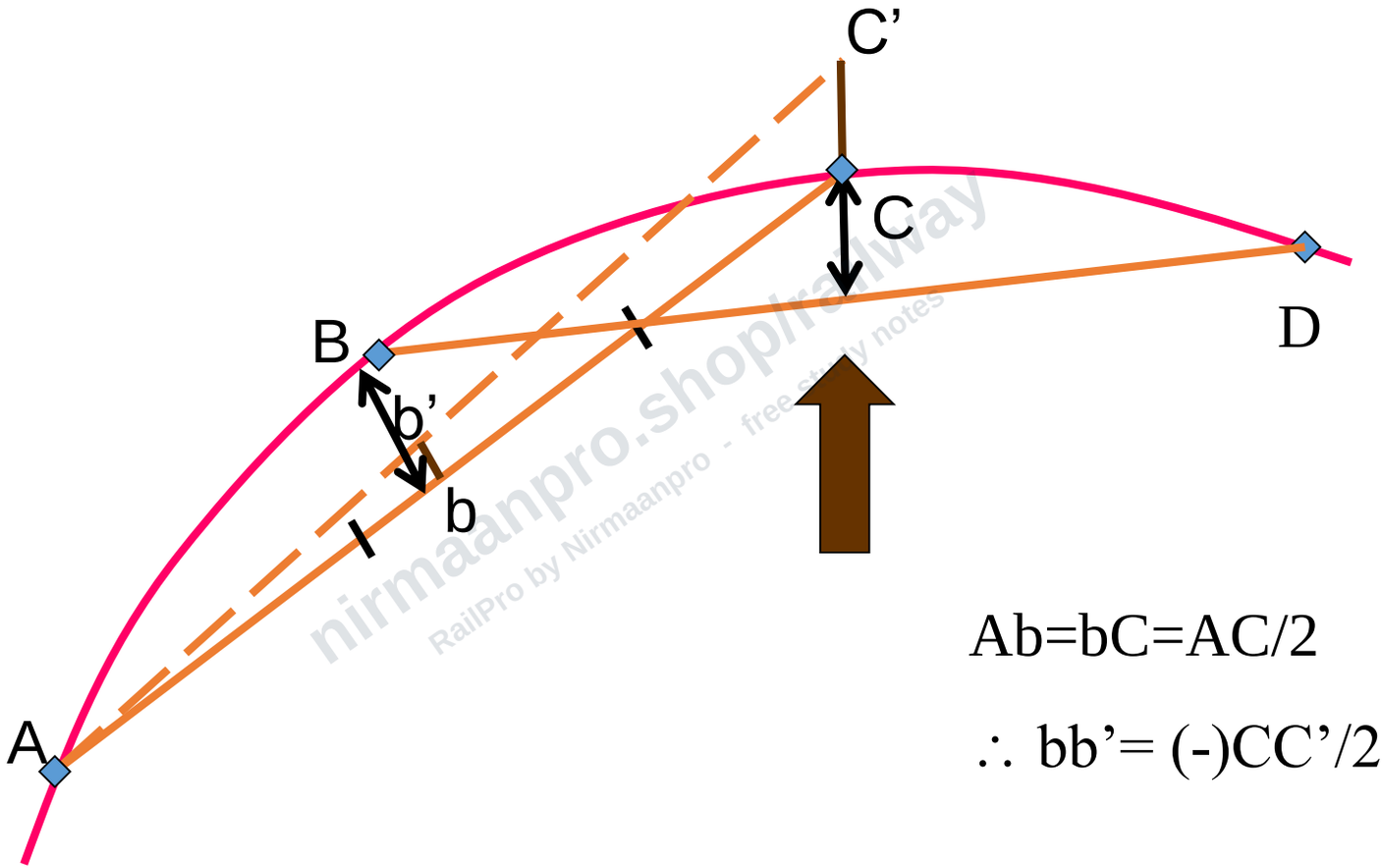
STRING LINING METHOD
BASIC PRINCIPLES

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1st PRINCIPLE

- Also known as 1st property of versine of any curve.
- “The slewing a station on curve affects the versines at the adjoining two stations by half the amount in opposite direction .”

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$Ab = bC = AC/2$

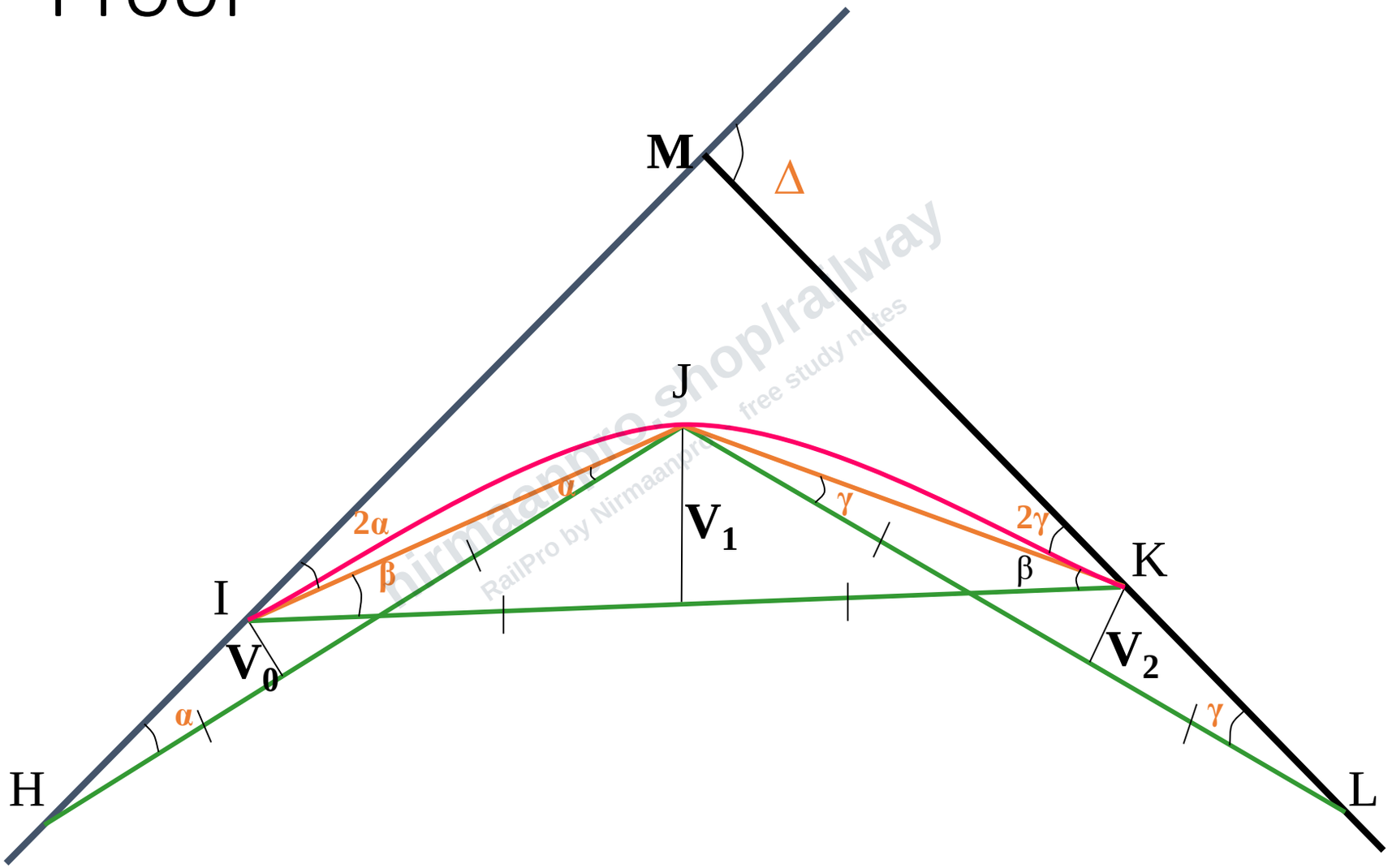
$\therefore\ bb' = (-)CC'/2$

2nd PRINCIPLE

- “The sum total of versines on equal chords of any number of curves between the same tangents are equal.”

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Proof



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Proof

- $V_0=\alpha*(c/2)$
- $V_1=\beta*(c/2)$
- $V_2=\gamma*(c/2)$
- $\Sigma V=V_0+V_1+V_2= (\alpha+ \beta+ \gamma)*(c/2)$
- In ΔIMK, <MIK+<MKI=Deflection Angle
- i.e. $\Delta= (2\alpha+ \beta) + (2\gamma+ \beta)=2(\alpha+ \beta+ \gamma)$
- i.e. $\Delta=2(\Sigma V)*(2/c)$, $\Sigma V=\Delta*c/4$
- i.e. If station units are constant and Δ does not change, the sum of all versines will be constant

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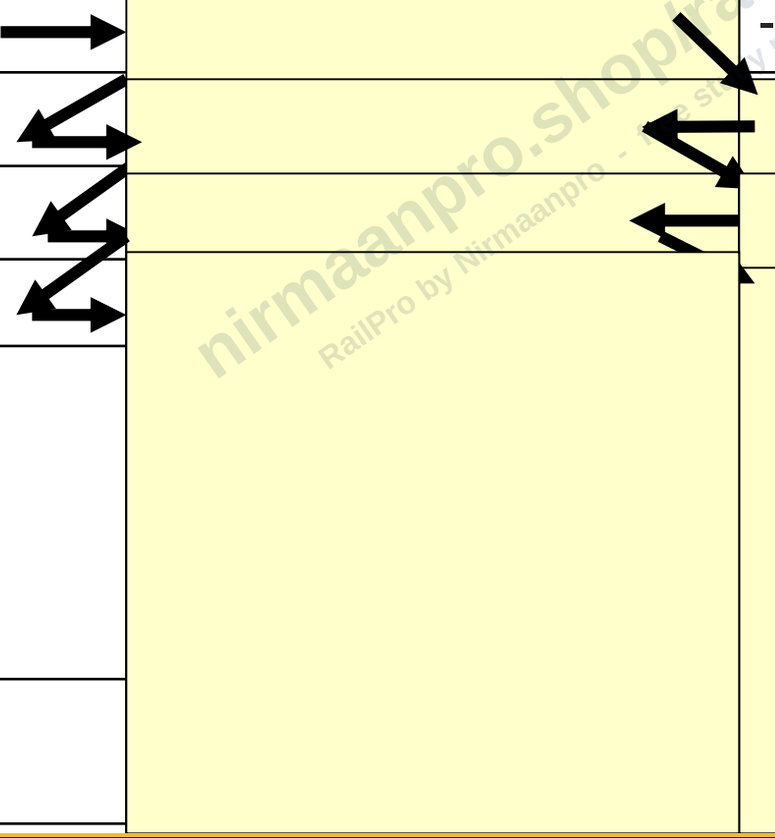
COROLLARY TO 2nd PRINCIPLE

- "The chord length being equal, the sum total of the existing versines should be equal to the sum total of the proposed versines."

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First and Second summations

Station No	Versine	FSV	SSV
0	V_0		-
1	V_1		
2	V_2		
3	V_3		
. . . . .	. . . . .		
n	V_n		

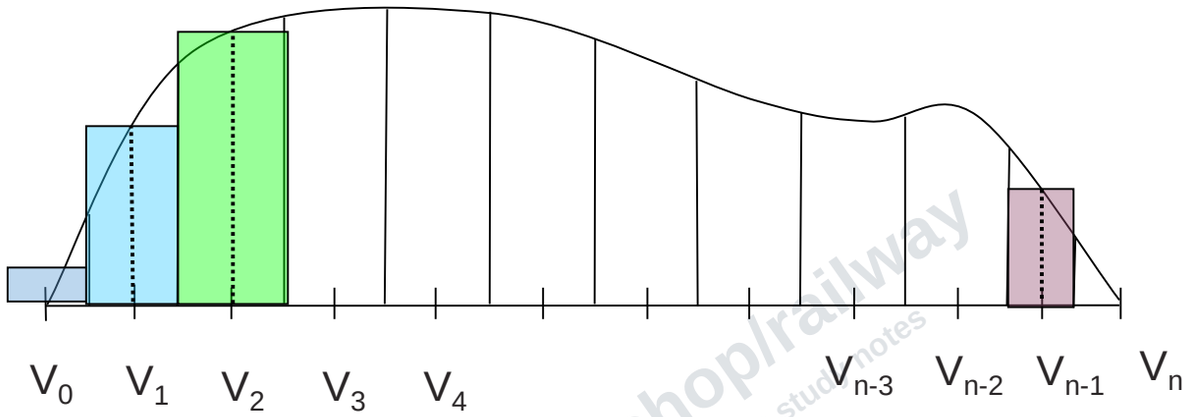


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3rd PRINCIPLE

- "First summation of versines represents the area of versine diagram (in station distance units)
  - *Summation means the sum of all the items above a certain station in the table*

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If station to station distance is taken as unit,

Area of each histogram segment= Ordinate at center i.e., V_0, V_1, V_2, …., V_{n-1} etc

Total Area of the versine diagram= Sum of areas of each histogram segment

$$= V_0 + V_1 + V_2 + \ldots + V_{n-1}$$

Lever Arm for each histogram segment= n-station number

$\therefore$ Moment of versine diagram about station n= n* V0+(n-1)* V1+

(n-2)V2+ ….. + 2* Vn-2+ Vn-1

4th PRINCIPLE

- “Second summation of versines represents the moment of versine diagram about the last station (in station distance units).”

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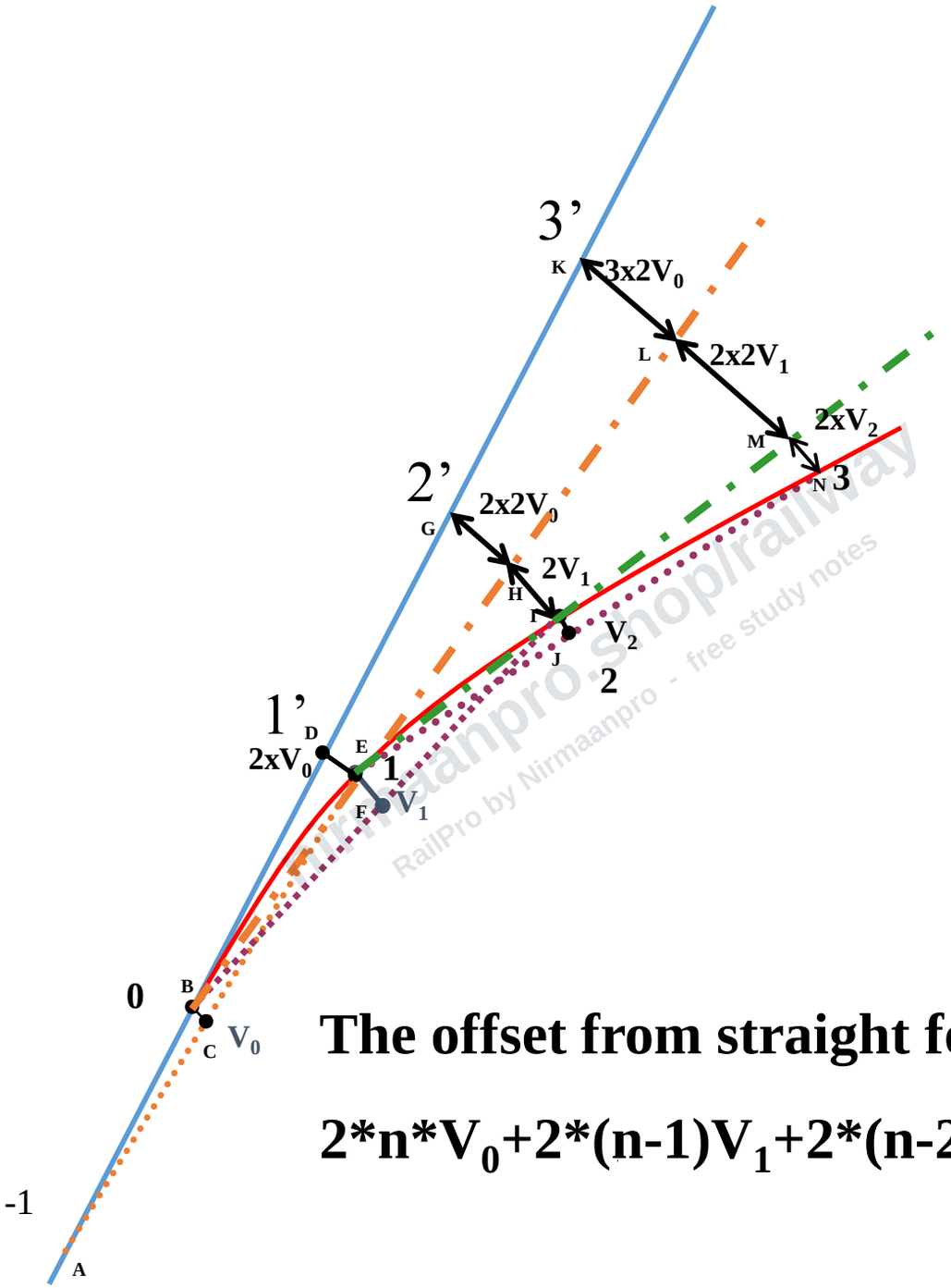
5th PRINCIPLE

- Twice the second summation of the difference of proposed and existing versines up to a point gives the slew at a station.

OR

- "The second summation of versine difference represents half the slew at any station"

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The offset from straight for the station no n:

$$2*n*V_0+2*(n-1)V_1+2*(n-2)V_2+ \ldots + 2*V_{n-1}$$

COROLLARY TO 5TH PRINCIPLE

- The second summation of the difference of proposed and existing versines at first and last stations shall be zero.
- Means there should not be any residual slew value if any than should be distributed through correcting couple .

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PRINCIPLES APPLIED IN ROC

- Existing versines are available from measurements and the solution has to be ‘proposed’
- Take the difference between the existing and proposed versines and then work out first and second summation
  - The second summation of versine difference at the first and the last station should be zero. [Slew at the first and last stations shall be zero]
  - The first summation of versine difference shall be zero at last station
- ROC AS DONE IN FIELD IS ALSO CALLED “STRING LINING OPERATIONS”

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3.5 Steps involved in Curve Realignment

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Steps involved in Curve Realignment

- Survey existing versines
- Find sum of existing versines and get an idea of the average versines
- Propose new versines for the curve according to the principles :
  - Sum of existing versines = Sum of proposed versines
  - Uniform rate of change of versine in transition portion
  - Uniform versine over circular portion

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Steps involved in Curve Realignment

- Workout Versine Difference (v_p-v_e)
- Workout First Summation of Versine Difference
  - FS at last station shall be zero
- Workout Second Summation of Versine Difference
  - Value at first and last station shall be zero

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Station number	Existing versines in mm or 20 M chord
(1)	(2)
0	2
1	0
2	14
3	28
4	30
5	36
6	36
7	24

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8	32
9	28
10	36
11	34
12	32
13	34
14	36
15	24
16	24
17	28
18	0
19	6
20	0
	484

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(1)	(2)	(3)
0	2	2
1	0	8
2	14	16
3	28	24
4	30	32
5	36	32
6	36	32
7	24	32
8	32	32
9	28	32
10	36	32
11	34	32
12	32	32
13	34	32
14	36	32
15	24	32
16	24	24
17	28	16
18	0	8
19	6	2
20	0	0

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Station number	Existing versines in mm or 20 M chord	Proposed versine in mm	Versine difference (3) - (2)	1st summation of versine difference	2nd summation of versine difference or half throw in mm
(1)	(2)	(3)	(4)	(5)	(6)
0	2	2	0	0	0
1	0	8	+8	+8	0
2	14	16	+2	+10	+8
3	28	24	-4	+6	+18
4	30	32	+2	+8	+24
5	36	32	-4	+4	+32
6	36	32	-4	0	+36
7	24	32	+8	+8	+36
8	32	32	0	+8	+44
9	28	32	+4	+12	+52
10	36	32	-4	+8	+64
11	34	32	-2	+6	+72
12	32	32	0	+6	+78
13	34	32	-2	+4	+84
14	36	32	-4	0	+88
15	24	32	+8	+8	+88
16	24	24	0	+8	+96
17	28	16	-12	-4	+104
18	0	8	+8	+4	+100
19	6	2	-4	0	+104
20	0	0	0	0	+104

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STEPS IN STRING LINING OPERATIONS

- If SS at last station is non-zero, apply correcting couple so that SS at last station becomes zero
  - Workout FS,SS for CC
  - Add the SS for original versine difference and the SS for the correcting couple.
  - Workout Resultant Slew (These slews are to be actually applied in field) (when we calculate as per procedure in IRPWM table1 +slew inside, - Slew outside)
  - Workout Resultant Versines, for checking the slews (=v_p+CC)

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Station number	Existing versines in mm or 20 M chord	Proposed versine in mm	Versine difference (3) - (2)	1st summation of versine difference	2nd summation of versine difference or half throw in mm	Correcting couple: Correcting versine in mm	Correcting couple: 1st summation of correcting versine	Correcting couple: 2nd summation of correcting versine
(1)	(2)	(3)	(4)	(5)	(6)	(7)	98)	(9)
0	2	2	0	0	0			
1	0	8	+8	+8	0			
2	14	16	+2	+10	+8			
3	28	24	-4	+6	+18			
4	30	32	+2	+8	+24			
5	36	32	-4	+4	+32			
6	36	32	-4	0	+36			
7	24	32	+8	+8	+36			
8	32	32	0	+8	+44			
9	28	32	+4	+12	+52			
10	36	32	-4	+8	+64			
11	34	32	-2	+6	+72			
12	32	32	0	+6	+78			
13	34	32	-2	+4	+84			
14	36	32	-4	0	+88			
15	24	32	+8	+8	+88			
16	24	24	0	+8	+96			
17	28	16	-12	-4	+104			
18	0	8	+8	+4	+100			
19	6	2	-4	0	+104			
20	0	0	0	0	+104			

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Use of correcting couple

- There is a residual second summation of versine difference is +104 at the last station, it means that the second summation of existing and proposed versines are not equal.
- This also means that centre of gravity of existing versine diagram does not coinside with the proposed versines.
- The correcting couple which is small correction in the proposed versine diagram.

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Principles of choosing correcting couple.

- These are equal and opposite.
- If the residual second summation of versine difference at the last station is positive, a negative correction is applied at the initial stations of the curve and positive correction is applied at the later station of the curve. So SS will be negative. Similarly vice versa for negative residual value.

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Principle contd..

- The correcting couple disturbed trapezoidal distribution of the proposed versines , and consequently correction shall be as small as possible in value.
- If the correction are applied farther apart , the second summation of the correcting couple will be higher.

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Correcting couple

Correcting

Station number	Existing versines in mm or 20 M chord	Proposed versine in mm	Versine difference (3) - (2)	1st summation of versine difference	2nd summation of versine difference or half throw in mm	versine in mm	1st summation of correcting versine	2nd summation of correcting versine
(1)	(2)	(3)	(4)	(5)	(6)	(7)	98)	(9)
0	2	2	0	0	0	-1	-1	
1	0	8	+8	+8	0	-1	-2	-1
2	14	16	+2	+10	+8	-1	-3	-3
3	28	24	-4	+6	+18	-1	-4	-6
4	30	32	+2	+8	+24	-1	-5	-10
5	36	32	-4	+4	+32	-1	-6	-15
6	36	32	-4	0	+36	-1	-7	-21
7	24	32	+8	+8	+36	-1	-8	-28
8	32	32	0	+8	+44		-8	-36
9	28	32	+4	+12	+52		-8	-44
10	36	32	-4	+8	+64		-8	-52
11	34	32	-2	+6	+72		-8	-60
12	32	32	0	+6	+78		-8	-68
13	34	32	-2	+4	+84	+1	-7	-76
14	36	32	-4	0	+88	+1	-6	-83
15	24	32	+8	+8	+88	+1	-5	-89
16	24	24	0	+8	+96	+1	-4	-94
17	28	16	-12	-4	+104	+1	-3	-98
18	0	8	+8	+4	+100	+1	-2	-101
19	6	2	-4	0	+104	+1	-1	-103
20	0	0	0	0	+104	+1	0	-104

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Station number	Existing versines in mm or 20 M chord	Proposed versine in mm	Versine difference (3) - (2)			Correcting couple					
				1st summation of versine difference	2nd summation of versine difference or half throw in mm	Correcting versine in mm	1st summation of correcting versine	2nd summation of correcting versine	Resultant half slew (9) + (6)	Resultant full slew inmm	Resultant versine in mm (3) + (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	98)	(9)	(10)	(11)	(12)
0	2	2	0	0	0	-1	-1		0	0	1
1	0	8	+8	+8	0	-1	-2	-1	-1	-2	7
2	14	16	+2	+10	+8	-1	-3	-3	+5	+10	15
3	28	24	-4	+6	+18	-1	-4	-6	+12	+24	23
4	30	32	+2	+8	+24	-1	-5	-10	+14	+28	31
5	36	32	-4	+4	+32	-1	-6	-15	+17	+34	31
6	36	32	-4	0	+36	-1	-7	-21	+15	+30	31
7	24	32	+8	+8	+36	-1	-8	-28	+8	+16	31
8	32	32	0	+8	+44		-8	-36	+8	+16	32
9	28	32	+4	+12	+52		-8	-44	+8	+16	32
10	36	32	-4	+8	+64		-8	-52	+12	+24	32
11	34	32	-2	+6	+72		-8	-60	+12	+24	32
12	32	32	0	+6	+78		-8	-68	+10	+20	32
13	34	32	-2	+4	+84	+1	-7	-76	+8	+16	33
14	36	32	-4	0	+88	+1	-6	-83	+5	+10	33
15	24	32	+8	+8	+88	+1	-5	-89	-1	-2	33
16	24	24	0	+8	+96	+1	-4	-94	+2	+4	25
17	28	16	-12	-4	+104	+1	-3	-98	+6	+12	17
18	0	8	+8	+4	+100	+1	-2	-101	-1	-2	9
19	6	2	-4	0	+104	+1	-1	-103	+1	+2	3
20	0	0	0	0	+104	+1	0	-104	0	0	1

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SHORTCOMINGS IN METHOD

- Difficult to decide proposed versines, especially when the stations are more.
- There is no way to know if the length of existing curve was ok
  - Curve may increase or decrease in length during service
  - affects assumed proposed versines
- Correct beginning of curve is not known

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OPTIMISATION METHOD

- Optimization
  - By finding out the
    - correct beginning and end of the curve
    - Correct length of curve
- Control by keeping slew at centre of curve as zero.
- Used in computer programs as calculations tedious by hand.

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OPTIMISATION PROCEDURE

- Workout FS and SS of existing versine (v_e)
- Find out chainage of CC, x =(N-SS up to N) / (FS up to N)
- Find out offset at x from table of SS by interpolation. (As per third principle offset of a station from the tangent is given by second summation of versine up to that station.)
- Assume length of transition L & Find out V by solving equation:

Actual Offset at CC for existing curve= SS of versine up to cc of curve.

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FORMULA FOR OPTIMISATION

Actual Offset at CC proposed curve = Offset in equivalent circular curve at CC + shift

$= Oc + S = T^2/2R + L^2/24R;$

(Now, $T = N/2$; And $V=C^2/8R$; C=2 stn units; i.e. $V=1/2R$)

$= V*N^2/4 + V*L^2/12$

$=(VN)^2/4V + VL^2/12$ (Note V*N = FSVe and transition length is modified equation above)

Due to correction near the ends of transitions: Actual Offset at CC= ~ $(FSVe)^2/4V + V(L^2-4)/12$

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OPTIMISATION COMPUTATIONS

- Length of Equivalent Curve = FS of v_e / V
- (Equivalent length of curve the proposed curve if there where no Transitions)
- (Total Length L'= Length of Equivalent Curve + Transition Length)
- BC = Chainage of CC – L'/2
- EC = Chainage of CC + L'/2
- Decide values of v_p
- Proceed as per String Lining Method

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Realignment of Curve								
Station No.	Existing Versine	1st summation of existing versine	2nd summation of existing versine	Proposed versine in mm	Versine difference Column 5 - 2	1st summation of versine difference	2nd summation of versine difference or half throw in mm	Resultant full slew in mm
1	2	3	4	5	6	7	8	9
0	0	0	0					
1	3	3	0					
2	8	11	3					
3	7	18	14					
4	9	27	32					
5	15	42	59					
6	6	48	101					
7	2	50	149					
8	5	55	199					
9	-4	51	254					
10	15	66	305					
11	16	82	371					
12	18	100	453					
13	20	120	553					
14	8	128	673					
15	7	135	801					
16	3	138	936					
17	0	138	1074					
	138	138	1074					

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Realignment of Curve

Proposed versine in mm	Versine difference Column 5 - 2	1st summation of versine difference	2nd summation of versine difference or half throw in mm	Correcting Couple in mm	FS for CC	SS for CC	Combi-ned SS Col(8)+ Col (11)	Resul-tant Slew in min 2 x Col. 11	Resul-tant Ver-sine in mm Col.5 + Col. 9
(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	1	0		0	0	0	0	1
4	1	2	1	-1	-1	0	1	2	3
6	-2	0	3	-1	-2	-1	2	4	5
8	1	1	3		-2	-3	0	0	8
9	0	1	4		-2	-5	-1	-2	9
9	6	-5	5		-2	-7	-2	-4	9
9	3	-2	0		-2	-9	-3	-6	9
9	7	5	-2		-2	-11	-13	-26	9
9	4	9	3		-2	-13	-10	-20	9
9	13	22	12		-2	-15	-3	-6	9
9	-6	16	34		-2	-17	17	34	9
9	-7	9	50		-2	-19	31	62	9
9	-9	0	59		-2	-21	38	76	9
10	-10	-10	59		-2	-23	36	72	10
9	1	-9	49	+1	-1	-25	24	48	10
8	1	-8	40	+1	0	-26	14	28	9
6	3	-5	32		0	-26	6	12	6
4	4	-1	27		0	-26	1	2	4
1	1	0	26		0	-26	0	0	1
0	0	0	26		0	-26	0	0	0

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PROCEDURE TO PASS CURVE THROUGH NOMINATED POINT ON CIRCULAR CURVE

Actual Offset at X= Offset in equivalent circular curve at X + shift = Ox + S

$= T^2/2R + L^2/24R;$

$T = N/2 + X - CC;\ V=1/2R$

$= V(FSVe/2V+(X-CC))^2 + VL^2/12$

$\sim V(FSVe/2V+(X-CC))^2 + V\,(L^2-4)/12$

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REALIGNMENT PROGRAMS AVAILABLE

- RECUR 100 or RC100 or RC 101 (Not suitable for reverse curve)
- Program by Mr Sheshagiri Rao (Least slews)
- Program by Sh M S Ekbote
- Program by Sh Venkateshwara Rao (By iterations, only simple curves)
- Program in MX Rail
- Program with 3X machine

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REALIGNMENT PROGRAMS AVAILABLE

Program by Sh M S Ekbote

- Available in IRICEN website Member's Download Area
- Has modules for ROC of simple curves by
  - Pure trapezoidal solution
  - Realignment in segments
  - Averaging method
  - Limited maximum slews
  - Incorporates obligatory points
  - Check need for complete realignment required
  - Attention to transitions only if required Contd…

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REALIGNMENT PROGRAMS AVAILABLE

Program by Sh M S Ekbote

- Has modules for ROC of
  - Reverse curves
  - Only transitions
  - Vertical curves
- Algorithm based on equating the maximum inward and outward slews (Shifts the curve inwards or outwards to equalize the maximum values of slews)

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THANK YOU



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