Inter Operability on Trans-Asian Rail Networks

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Flow of the presentation

- History of the evolution of the track structure.
- Important issues concerning inter operability and seamless flow of international containers.
- Present day world scenario of railway lines – heavy speed lines, heavy haul routes, miscellaneous traffic lines, suburban lines and metro lines.
- Tailoring track to traffic needs.
- Modern machinery for track construction and maintenance.
- Cost effective track maintenance systems.
- Rehabilitation and strengthening of bridges.
- Conclusion and Recommendations

History of Evolution of Track Structure

Stockton and Darlington Railway – First railway line of the world : year 1825.

Track consisted of T-shaped wrought iron rails, weighing 28 pounds per yard, 15 feet long, carried in chairs on stone sleeper blocks at 3 feet spacing. Track gauge : 5 feet between centre to centre of wheels.

Dimensions between the running edges of the rails, was 4 feet and 8 ½ inches (1435 mm).

Gauges commonly adopted by the world railways are 1000 mm, 1067 mm, 1435 mm and 1676 mm.

Development of Rails

- 1850 – 60-85 pound per yard rails.
- 1857 – The first steel rail.
- Early rails were of T-section, or flat bottom rails.
- 1835 – Double headed rails.
- 1848 – Bull headed rails.
- Europe and North America always used flat bottom rails

Present Day Rails

- Flat bottom rails are the standard all over the world.
- Rail weight mostly varies from 37 kg/m to 75 kg/m.
- Most popular section – 60 kg UIC
- Rail steel is usually of 3 grades:

I. Normal grade – UTS 72 kg/mm^2

II. Wear resisting grade – UTS 90 kg/mm^2

III. Special wear resisting grade – UTS 110 kg/mm^2 and above.

Welding of Rails

I. ALUMINO-THERMIC WELDED JOINTS

II. FLASH BUTT RAIL WELD

III. GAS PRESSURE WELDING

Sleepers

- Wooden sleepers.
- Steel sleepers.
- Cast iron sleepers.
- Concrete sleepers.
  a) Monoblock pre-stressed concrete sleepers
  b) Two block RCC sleepers

Rail to Sleeper Fastenings

Conventional Rigid Fastenings and their inherent drawbacks.

1. Tend to get loose on account of high frequency rail vibrations.
2. Unable to maintain track geometry for long.
3. Require continuous attention.

Rail to Sleeper Elastic Fastening systems

Ideal fastening system satisfies the following requirements:

- Safe guards track parameters for long periods of time.
- Resistance to longitudinal forces.
- Few components.
- Fit and forget.
- Safe guards theft and sabotage.
- Retains adequate toe load during service.

Rail to Sleeper Fastenings

Main Elastic Fastening Systems in use over world railways

(i) British Pandrol clip.

(ii) German Vossloh fastening system.

(iii) French Nabla fastening system.

(iv) Japanese KOWA clip fastening system

Ballast and Formation

Functional requirements of ballast:

I. Carries the load and distributes it safely on to the formation.

II. Provides a firm, level and resilient bed for the sleeper.

III. Facilitates easy drainage.

IV. Fills inequalities on the formation.

V. Provides lateral and longitudinal stability to track.

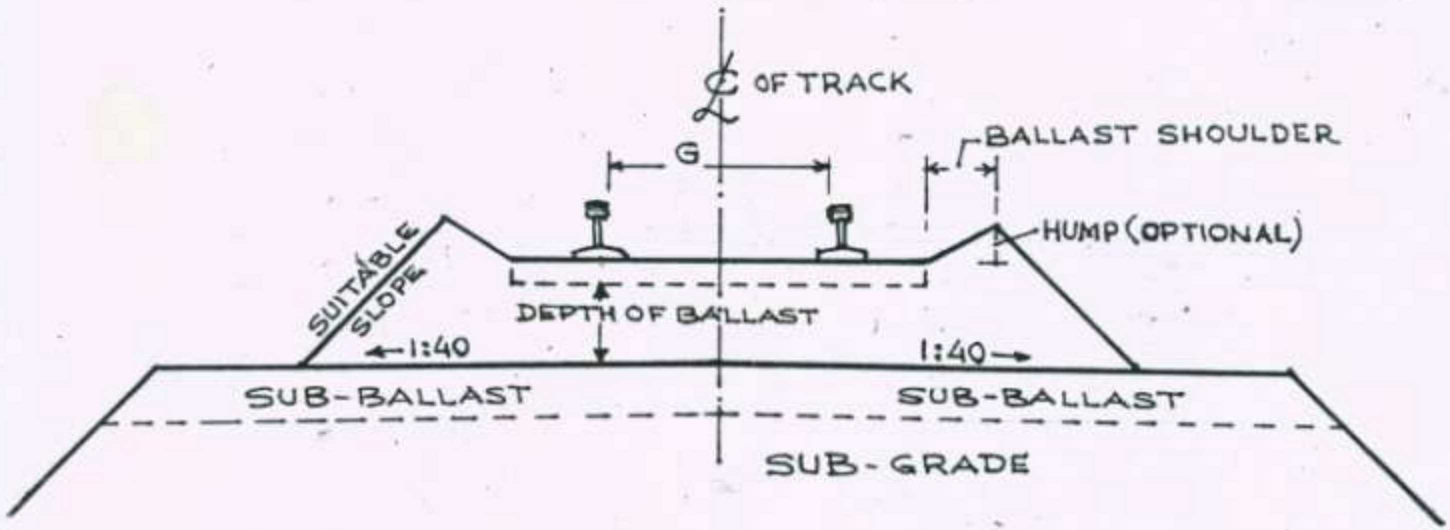
VI. Projects formation against weathering action, rains and winds.

VII. Protects the sleepers from capillary moisture of formation.

VIII. Does not allow free vegetation growth.

IX. Provides a media for energy absorption of all impact forces coming from rolling stock by undergoing a temporary change in its contact relationship. The ballast particles can be lifted back to their normal level by manual packing or mechanical tamping. This is one of the most vital functions that the ballast performs in the track.

Ballast and Formation



BALLAST & FORMATION

Blanket, Sub-Ballast

A layer of specified coarse grade material interposed between ballast and formation to serve the following objectives:

I. To spread the load on formation.

II. To eliminate mud-pumping.

Formation

I. Main requirements are:

II. Well compacted and stable – least settlement during service.

III. Minimum ballast puncturing.

IV. Well drained.

V. Adequate strength against slip failures.

Switches and Crossings

Conventional Turnouts :

I. Low speed potential, 10 – 15 kmph on turnout tracks

II. Poor structural strength, mainly fabricated from normal rail sections

III. Poor maintainability on account of poor geometry and inefficient structural support.

IV. Have a large number of fishplated joints.

V. Require frequent maintenance.

VI. Modern Turnouts

Switches and Crossings

Modern Turnouts -Important features

I. Have a high speed potential even up to 220 kmph on turnout tracks.

  a. Made possible by small entry angle, smaller angle of crossing, adoption of transition curves etc.

II. Easy to maintain due to improved structural strength. Measures taken are:

  a. Use of high strength thick web tongue rails.

  b. CMS/welded crossings, concrete sleepers, elastic fastenings, improved bearing plates, stronger hold on stock rail, continuously welded, etc.

  c. Use of movable crossings.

  d. Designed for machine laying and machine maintenance to close tolerances. Latest development in the field is installation of computerized turnout monitoring systems.

Slab Track (Rails directly fixed to concrete slab)

British design – PACT system

a. Japanese design – top adjustable track slab supported on concrete foundation with an intermediate layer of cement-maxphalt mix.

b. Channel tunnel type track using two block RCC sleepers resting in rubber boots.

c. German high speed slab track, different designs (Japanese type, individual elastic rail seat, monoblock sleeper type) under trials.

d. Conventional wooden block ballast-less track for metros.

e. Floating track – Similar to Japanese Shin-Kan-Sen design but metallic spring or elastomeric pads provided for track elasticity.

Important Issues Concerning Inter Operability and Seamless Flow of International Containers

- Track Gauge

  Fortunately most of the countries in South East Asia have meter gauge (1000 mm) railway system. For inter operation to adjoining countries problem in respect to change of gauge shall have to be solved. Such as:

  - Track gauge in China – Standard gauge (1435 mm)
  - Bangladesh and India – broad gauge (1676 mm)

- Other technical requirements are:

  a. Loading gauge – Its effect on over-bridges, station platforms, through girder bridges, tunnels will have to be examined.

  b. Axle load – its effect on track structure and bridges will have to be studied.

  c. Speed – Curves and grades in track alignment, hauling power of the locomotives and signaling system have relevance to the speed of operation.

  d. Type of couplers for joining different types of rolling stock.

  e. Length of trains will influence the station yards in respect to stabling and passing routes.

In addition, the soft aspects of freight movement across the borders including tariff-related issue custom checks and other institutional frame work.

Present Day World Scenario of Railway Lines

–Heavy Speed Lines, Heavy Haul Routes, Miscellaneous Traffic Lines, Suburban Lines and Metro Lines

- High Speed Lines

  Criteria: Minimum end to end average speed of 200 kmph.

  High speed lines may be classified under two categories:

  - High speed on existing lines.
  - Newly constructed, dedicated high speed lines

- High speed on existing lines

  - Track structure

  Generally standard track structure with improved turnouts, superior signalling system, track maintained to closer tolerances

  - Rolling Stock:
  - Superior suspension system, reduced braking distances.
  - Motive Power:

  Generally loco hauled but EMU system preferred.

  Tilting Train Technology : Being progressively introduced in Europe, Japan and U.S.A. to increase speed potential by 20-30% on sharp curves.

Newly constructed, dedicated high speed lines

Track structure

France, Germany, Italy, Spain	**-**	**Conventional ballasted track structure**
Japan	-	Slab track
Germany	-	New lines, a number of new

designs of slab track under trial

Speeds – 200 kmph and above

Top speed – Over 300 kmph in France, Spain and Japan

Track maintained to very close tolerances.

Track maintenance requirements considerably reduced on slab track

Rolling stock:

Very superior suspension stock used.

Dedicated High Speed Lines
(Axle Loads Generally Limited to 16-18 Tonnes)

	SHINKANSEN JAPAN	TGV FRANCE	BELGIUM	GERMANY	SOUTH KOREA
Top Speed (kmph)	300	300	280	280	300
Minimum Horizontal Radius (M)	4000	10000	3280	3280	7000
Gradient (Max %)	3.0	3.0	4.0	4.0	3.0
Rails (Kg/m)	60	60	60	60	60
Sleepers (Concrete)	Monoblock Ballastless	Twin block	Monoblock	Monoblock	Monoblock
Fastenings	Kowa	Nable	Vassloh	Vassloh	Pandrol
Ballas	25-30 cm + sub ballast	32 cm + sub ballast	32 cm + sub ballast	25-30 cm + sub ballast	25-30 cm + sub ballast
Maintenance System	2- Tier	2- Tier	2- Tier	2- Tier	……..

Dedicated Heavy Haul Routes

Heavy haul railways are those, which have a minimum of

i. 25.5 tonne axle load.

ii. 7000 tonne unit trains.

iii. 20 GMT per annum per track.

They usually carry iron ore, minerals, coal, heavy container traffic etc.

Sturdy track structure is a sine-qua-non for these lines as described below:

Rails

i. 60 – 75 kg/m rails, 90 – 110 UTS.

ii. Re-profiled to match rolling stock.

iii. Rail grinding, rail re-profiling and lubrication, quite common to get longer rail life.

iv. Stronger concrete sleepers and good ballast.

Track closely monitored with ultrasonic rail flaw detecting car, rail profile measuring car and track geometry recording car.

Turnouts

Strong turnouts: usually cast manganese movable crossings and high strength switch rails.

Mixed Traffic Lines

I. Passenger train speed – up to 200 kmph.

II. Goods train speed – about 100 to 130 kmph

Track structure

I. Rail:- *49 – 60 kg depending upon axle loads and speeds.*

II. Sleepers:- *Wooden/steel/concrete sleepers with density 1350 to 1660 number per km.*

Track monitored and maintained to the tolerances laid for a particular speed.

Suburban Lines

I. Medium to high train density.

II. Low top speeds but rapid acceleration and braking.

III. Track is also used by higher speed through passenger trains.

IV. Turnouts negotiated at higher speeds.

V. Tracks usually have wear resistance rails particularly on curves

- Rails – 52 to 60 kg/m.
- Sleeper – wooden/concrete .

VI. Track drainage and cleanliness are special problems

Branch Lines

I. Train speeds, train density are comparatively low.

II. Rails: 37 to 54 kg, released re-profiled rails are often used.

III. Sleeper density: M + 3 to M + 7, 70 to 60 cm centre to centre.

Metro Lines

I. Dedicated passenger train lines in large cities, which may be below surface/elevated in parts.

II. Train density is very high with rapid acceleration and braking .

III. Maximum speed limited to 80 to 100 kmph.

IV. Traffic is unidirectional and turnout few and far between.

V. Track structure to be almost maintenance free.

VI. Ballast-less track of various types, quite common in tunnels and on viaducts.

VII. Rails : wear resistant on account of high percentage of curved tracks.

VIII. Track designed to absorbs noise and vibrations to the maximum extent.

Tailoring Track to Traffic Needs

Important Railway Construction Parameters

I. Gauge.

II. Grades.

III. Loading and construction gauge.

IV. Curves/transitions.

V. Track structure.

VI. Turnouts.

VII. Loop length at stations.

VIII. Limitations in the design of bridge structures, viaducts etc.

IX. Signalling requirements.

Normally Accepted construction Parameters for Medium Speeds

I. Grades not steeper than 1 in 100, 1 in 150 preferred.

II. Curves not sharper that 5° (up to 3°, desirable).

III. Vertical curves minimum radius 3000- 4000 m.

IV. Maximum super elevation 185 mm.

V. Maximum cant deficiency – 100 mm.

VI. Maximum cant excess 75 mm.

VII. Maximum cant grade 1 in 720.

Optimization of Track Structure

Principal Components:

- Rails
- Sleepers
- Fastening System
- Sleeper Density
- Ballast and Formation
- Switches & Crossings

Factors Influencing Choice of Track Structure

- Traffic density.
- Axle loads.
- Wheel diameter.
- Permissible speed of passenger and goods train.
- Traffic mix pattern.
- Level of comfort of traveling public, particularly for the design of turnouts.
- System of track maintenance, especially the extent of track mechanization.

Rails

Choice to be made of:

- Type of rail.
- Weight of rail.
- Ultimate Tensile Strength (UTS).
- Rail hardness.
- Length of the rail (single rail/LWR).
- Method of welding.

Factors influencing the choice of rails

- Traffic density
- Axle loads
- Wheel diameter
- Possible wear on curves
- Traffic blocks for mechanized maintenance

Quantification of Advantages of Heavier and Stronger Rails

I. Lifetime GMT carried proportional to:

$(UTS)^2$.
$(\text{Section Weight})^3$.

$\left\{\frac{1}{\text{Axle load}}\right\}^3$.

I. Track geometry deterioration:
Proportional to (axle load)2.

II. Weight of rail:
Each additional kg in the weight of the rail saves 3% maintenance cost.

III. Hardness ratio:
Ideal rail/wheel hardness ratio: 1.

IV. LWR/CWR:
Reduces fuel cost by more than 5%.

V. Heavier track structure:
Reduces soil pressure, thereby saving track maintenance cost.

Sleepers

Commonly Used Sleepers:

- Wooden
- Concrete
- Steel
- Cast iron

Types of Concrete Sleepers:

- Pre-stressed mono block
- RCC two block

Choice of depends upon:

- Technical consideration
- Easy availability
- Manpower for track maintenance
- Level of traffic
- Quality of sub grade
- Environmental considerations

Rail to Sleeper Fastening

Type of Fastenings:

- Rigid Fastenings
- Elastic Fastening

Elastic Fastening are grouped under:

- Self tensioning fastenings needing no adjustment
- Affords tensioning at appropriate level

Choice Depends upon:

- Track geometry tolerances
- Track maintenance efforts
- Traffic density
- Level of skill of track men

Sleeper Density

Sleeper Density Depends upon:

- Strength of the rail
- Type and design of sleeper
- Depth of ballast cushion/sub ballast
- Formation behavior
- Axle loads, volume and speed of traffic

Ballast and Formation

- Need for high quality clean ballast of adequate depth
- Advantages of blanket/sub ballast
- Minimum ballast cushion recommended is 300 mm for trunk routes and 200 mm for other lines
- Ballast – Generally the most cost-effective constituent of track structure and yet the most neglected one.

Switches & Crossings

Choice depends upon:

a) Speed on the St. & Turnout track

b) Volume & Tonnage of traffic

"a" decides Xing angle & design of S & C

"b" decides Structural strength of turnouts.

Normal Crossing angle : 1 in 8 to 1 in 20

Permitted Speed :20-220 kmph on turnout track

Types of Switch and Crossing Assemblies

Types of crossing assemblies:

- Fabricated bolted
- Fabricated welded
- Cast steel crossing

Types of Switch Assemblies:

- Standard Rail Section
- Special Thick Web Rail

Types of Turnout Sleepers:

- Wooden
- Steel
- Concrete

Modern machinery for Track Construction and Maintenance

Modern track construction and maintenance is now available in large varieties for performing various operations and to meet the requirement of budget. They are:

Track construction machinery – Machinery for soil compaction, ballast distribution, sleepers placement, rails placement, welding of rails, ballast regulation and profiling, track tamping, track stabilizing, monitoring of track construction tolerances.

Assembling of turnouts, their transport and placement in position

Machinery for track maintenance - Tamping machines for various type of track and levels of output.

- Ballast regulating and profiling machine
- Ballast crib and shoulder consolidators.
- Dynamic track stabilizers.
- Ballast renewal equipment and track renewal trains.
- Formation rehabilitation machinery
- Off-track tampers.
- Small track machines
- Gang lories
- Rail cutting, drilling equipment and other small track machines for transport of track materials, welding distressing rail grinding equipment.
- Track recording cars.

Cost Effective Track Maintenance System

Pre-Requisite for a Cost Effective Mechanized Maintenance System

Track structure requirements

- Stable Formation
- Adequate Ballast
- Robust Track Structure
- LWR/CWR
- Level & Line Accuracy
- Ballasted Deck Bridge to the Extent Possible
- Flatter Curves
- Efficient Drainage
- Grade Separation for Road Crossings
- Less Vulnerability to Natural Hazards

Requirements for deployment of track machines

- Assured track possession for efficient deployment.
- An efficient operating and maintenance organization.
- Adequate logistic support; timely availability of fuel, lubricants, consumable stores, repair, welding facilities etc.
- Stabling facilities at nominated stations.
- Maintenance and over hauling facilities, easy availability of spare parts.

Cost effective mechanized track maintenance system
. for Konkan Railway 760 km on West Coast of India

Design parameters

- Maximum permissible speed – 160 kmph for passenger trains, 100 kmph for goods train.
- Axle loads – Maximum 22.5 tonne for goods traffic, 20 tonne for present day traffic.
- Traffic forecast – Mixed traffic, 15 GMT on single line in the next three years, expected to increase further.
- Track substructure – Compacted, well treated formation.

Track Structure provided

Main Line

Ballast	: 30 cm hard deccan trap ballast, blanketing material provided where necessary.
Sleepers	: Monoblock concrete sleeper spacing 60 cm centre to centre. Ballast-less track in tunnels.
Elastic fastening	: Pandrol clip type fastening for concrete sleepers.
Rails	: 52 kg/m rail in general, 60 m/kg in tunnels.
Turnouts	: Thick web switch rails and CMS crossings: 1 in 12, speed potential – 15 kmph on turnout tracks, concrete sleepers.
Welding	: Continuously welded rails, gas pressure welding technique used.

Broad frame work of the new system

A three tier system was adopted

I. Top Tier

- Ballast regulator
- 09 type continuous tamping machines
- Ballast reprofiler, and
- Dynamic stabilizer (09 – dynamic may be used if becomes available which will be able to perform all the functions)

II. Middle Tier

Middle tier of track maintenance consists of:

- A tamper of picking up of isolated spots.
- A multipurpose gang lorry

iii. Base Tier

These will be sectional gangs having a jurisdiction of seven to nine km. Each gans will consist of the following persons:

- Mate/gang chief
- Key man (Patrol man)
- Track man

Casual labour/contractors will be employed to assist maintenance gangs, if required.

Rehabilitation and Strengthening of Bridges

Bridges have two main components

- Sub Structure
- Super structure

Sub structure should have

f) Adequate waterway

g) Stable formation

h) Ability to carry static and dynamic load from super structure

Super structure slabs, beams, girders etc, are designed to carry train loads.

Every railway system decides the bridge loading standards for the design of bridges

Loading standards adopted by Indian Railways for design of bridges

Rehabilitation and Strengthening of Bridges

	Axle Load	*Train Loading Density*	*Tractive force*
1. Broad Gauge (BG)			
BGML Loading	**22.9 tonnes**	**7.67 t/m**	**47.6 tonnes**
RBG Loading	**22.9 tonnes**	**7.67 t/m**	**75 tonnes**
MBG Loading 87	**25 tonnes**	**8.25 t/m**	**100 tonnes**
HML Loading	**30 tonnes**	**8.5 t/m**	**135 tonnes**
2. Meter Gauge (MG)			
Axle Load	***Locomotive loading density***	***Train Loading density***	***Tractive Force***
MMG 16 tonnes	**6.312 t/m**	**5.5 t/m**	**64 tonnes**

For determining the inter operability, the bridges shall have to be examined for the intensity of loading they are likely to be subjected to.

Conclusion and Recommendations

- **Railway transport system with its many sided advantages is now being increasingly favored for long distance, high volume traffic.**
- **Present day track technology provides ample scope for tailoring track structure to traffic needs.**
- **Track structure can be upgraded as the situation demands.**
- **Track maintenance systems need to be design to meet the traffic requirements and also according to the prevailing social-economic conditions.**
- **For inter operability issues, in respect to loading gauge, safety of the track structure and bridges, are required to be addressed**

Thank you