BHUBANANANDA ODISHA SCHOOL OF ENGINEERING, CUTTACK

DEPARTMENT OF CIVIL ENGINEERING

LECTURE NOTE ON: RAILWAY AND BRIDGE ENGINEERING

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PREPARED BY: RASHMI REKHA ROY

GUEST FACULTY IN CIVIL ENGINEERING DEPT

BOSE, CUTTACK

Chapter-1

INTRODUCTION

Transportation is regarded as an index of economic, social and commercial progress of a country. The transport industry, which undertakes nothing more than mere movement of persons and things from one place to another has constituted one of the most important activities of men in every stage of advanced civilization. No country can ever flourish if it lacks adequate transport facilities.

The first public railway in the world was opened to traffic on 27 September 1825 between Stockton and Darlington in the UK. The first railway in Germany was opened from Nuremberg to Furth in 1835. The USA opened its first railway line between Mohawk and Hudson in 1833.

The first railway line in India was opened in 1853. The first train, consisting of one steam engine and four coaches, made its maiden trip on 16 April 1853, when it traversed a 21-mile stretch between Bombay (now Mumbai) and Thane in 1.25 hours. Starting from this humble beginning, Indian Railways has grown today into a giant network consisting of 63,221 route km and crisscrossing this great country from the Himalayan foothills in the north to Cape Comorin (Kanyakumari) in the south and from Dibrugarh in the east to Dwarka in the west.

1.1: RAILWAY TERMINOLOGY:

The commonly used terms in Railway Engineering includes:-

Railway Engineering: Railway Engineering is that branch of civil engineering which deals with the construction and maintenance of the railway tracks for safe and efficient movement of trains on it.

Rails: Rails are steel girders which provide the hard and smooth surface for movement of wheels of a locomotive and railway vehicles.

Sleepers: Sleepers are the members laid transversely under the rails which are meant to support the rails over them and transfer the load from rails to ballast.

Gauge: The gauge of a track is the minimum distance between the inner running faces of the two rails.

Metre Gauge: The gauge of a track in which distance between the running faces of two track rails is one metre is called Metre Gauge.

Broad Gauge: The gauge of a track in which distance between the inner running faces of the two rails is 1.676 metres is termed as Broad Gauge.

Narrow Gauge: The gauge of track in which the distance between the running faces of two rails is 0.762 metre is known as Narrow Gauge.

Railway Track: Railway track is the structure provided by rails fitted on sleepers, resting on ballast and subgrade for passage of wheels.

Bearing Plates: To reduce the intensity of pressure, particularly on soft variety of sleepers, a rectangular plate of mild steel or cast iron is introduced between the rails and sleepers. This plate is known as Bearing Plate. This plate distribute the loads on large area.

Ballast: Ballast is the granular material packed under and around the sleepers to transfer loads from sleepers to ballast. It helps in providing elasticity to the track.

Coning of wheels: The wheels are coned at a slope of 1 in 20 to prevent from rubbing the inside face of the rail head and to prevent lateral movement of the axle with its wheels. This is known as coning of wheels.

Creep of rails: Creep is the longitudinal movement of rails in a track. The effect of creep tends to drag the track if the ballast are insufficient to hold the rails.

Guard rails: Guard rails are extra rails provided over bridges to prevent damage and danger in case of derailment occurring on the bridge.

Embankments: The raised structure above the ground level for carrying the railway track is called embankment. When the height of the embankment is more, the side slopes are stepped for better stability of slopes.

Hogged rails: Those rails which get battered due to impact of wheels over the end of the rails are called hogged rails. These rails are get bent down and deflected at the ends.

Gradient: Any departure of the railway track from

The level is known as grade or gradient. It is called up gradient when the track rises in the direction of motion, and a down gradient when track falls in the direction of motion.

Fish plates: These plates resembling in shape to a fish, are used to provide the continuity between the two rails at the rail-joints. They also provide the required gap for expansion and contraction of rails due to temperature variations.

Locomotive: It is a machine which transfers chemical energy of fuel in mechanical energy of motion. Fuel may be water and coal or diesel or electricity.

Level crossing: When the railway line and a road cross each other at the same level, it is called level crossing.

Momentum Gradient: It is rising gradient, which takes advantages of falling gradient in developing the momentum and kinetic energy, tp negotiate this rising gradient.

Permanent Track: It is the track which is permanent nature and handles the normal commercial traffic for which it is meant. It is also called permanent way.

Points and crossings: Points, crossings, cross-overs and turnouts, etc. are arrangements by which different routes either parallel or diverging are connected to afford for the train to move from one track to another.

Pusher Gradient: The gradient which requires one or more additional locomotives for hauling the load over the rising gradient is called a pusher gradient.

Ruling Gradient: It is the maximum rising gradient which is provided keeping in view the power of the locomotives.

Railway Track: Railway track is the structure provided by rails fitted on sleepers, resting on ballast and subgrade for passage of wheels.

Sleeper Density: Sleeper density represents the number of sleepers per rail length in meters.

Track circuit: The length of track, which is connected by electric circuit to signal cabin, block telegraph apparatus, etc. required for indication of light or bell, is called a track circuit.

Turnouts: A complete set of points and crossing with the intervening lead rails is called a Turnout.

Derailment: Derailment occurs when moving wheels of a train or bogie get out of the rails. It causes by an accident and often results in loss of lives of property damages.

Super elevation or cant: On curves, to counter act the effect of centrifugal force, the level of outer rail is raised above the inner rail by a certain amount. This raising of outer rail over the inner rail is called super elevation or cant.

Cant deficiency: The equilibrium cant is provided on the basis of the average speed of different trains on the track. This equilibrium will fall short of that required for speeds higher than average speed. This shortage of can is called cant deficiency.

Buckling of rails: The railway track gets out of the original position due to buckling if the expansion of rails due to rise in temperature is prevented during hot weather. This is known as buckling due to rise in temperature.

Packing: The process of ramming the ballast underneath the sleeper is known as packing.

Wear of rails: Due to movement of very heavy loads at high speeds, the concentrated stresses often exceed the elastic limit of metal, resulting the metal flow. This flowed materials of rails is chipped off by the striking of wheels. The rail is them called worn out rail and this happening is called wear of rails.

1.2: ADVANTAGES OF RAILWAYS:

Railways have brought about many political, social and economic changes in the life of Indian people.

(a) Political advantages:

(i) Railways have united the people of different castes, religions customs and traditions.

(ii) With the adequate network of railways, the central administration has become more easy and effective.

(iii) Railways have contributed towards development of a national mentality in the minds of people.

(iv) The role of railways during emergencies in mobilizing troops and war equipment has been very significant.

(v) Railways has helped in the mass migration of the population.

(b) Social advantages:

(i) The feeling of isolation has been removed from the inhabitants of the Indian people.

(ii) By travelling together into the compartment without any restriction of caste, the feeling of caste difference has disappeared considerably.

(iii) The social outlook of the masses has been broadened through railway journeys.

(iv) Railway has made it easier to reach places of religious importance.

(v) Railways provide a convenient and safe mode of transport for the country.

(c) Economic Advantages:

(i) Mobility of people has increased, there by congested areas can be relieved of congestion and the sparsely populated areas can be developed.

(ii) Mobility of labour has contributed to industrial development.

(iii) During famines, railways has played the vital role in transporting food and clothing to the affected people.

(iv) Growth of industries has been promoted due to transportation of raw materials through railways.

(v) Railways provide employment to millions of people and thus solving the problem of unemployment in the country.

(vi) Trade developed due to railways thereby has increased the earnings and standard living of Indian people.

(vii) Due to mobility of products through railways, the price stabilization of commodities could be possible.

(d) Techno-Economic Advantages:

(i) Cost saving in transportation of long haul bulk traffic.

(ii) Energy-efficiency (iii) Environment friendliness.

(iv) Higher safety.

(v) Efficient land use and ease in capacity expansion.

1.3: Classification of Indian Railways:

(A) Classification based on importance of route, traffic carried and maximum permissible speed on the routes.

1. Trunk routes
2. Main lines
3. Branch lines

1. Trunk routes: The standards of trunk routes includes:-

ITEMS	B.G	M.G
Maximum permissible speed	120 km.p.h	80 km.p.h
Rail section	52 kg/m	37.5 kg/m
Sleeper density	n+7	n+7
Ballast cushion	25 cm below sleeper	25 cm below sleeper
Design speed for new track	160 km.p.h	100 km.p.h
Example	1. Delhi-MughsaraiHowrah	1. LucknowGorakhpur-Guwahati
	2. Delhi-kotaMumbai 3. Delhi-Jhansi-Nagpur-Chennai 4. Howrah-BagpurMumbai 5. MumbaiGuntakul-Chennai 6. Howrah-VijayawadaChennai	2. DelhiJaipur-Ahmedabad 3. ChennaiMaduraiTrivandrrum

2. Main lines: All lines other than trunk routes carrying 10 Gross Million Tonnes (GMT) per annum or more for B.G and 2.5 G.M.T or more for M.G. or where maximum permissible speed allowed is 100 km.p.h for B.G and 75 km.p.h for M.G. are classified as main lines.

ITEMS	B.G	M.G
GMT/annum	≥ 10	≥ 2.5
Maximum permissible speed	100 km.p.h	75 km.p.h
Rail section	52 kg/m	37.5 kg/m
Design speed for new track	120 km.p.h	75 km.p.h

3. Branch lines: These are classified on the basis of following criteria:

   All those B.G lines which carry less than 10 GMT per annum and have max. Permissible speed of less than 100 km.p.h are classified as Branch lines.

   For M.G tracks, all those lines which carry less than 2.5 GMT per annum and have max. Permissible speeds less than 75 km.p.h are classified as Branch lines.

(B) Classification based on speed criteria:

According to this B.G railway lines are classified into 5 groups:-

1. ***Group 'A' lines*****:** They consists of those trunk routes on which the trains are running or are meant for running the trains at a speed of 160 km.p.h or more.

   Example-i. New delhi-howrah by Rajdhani route

ii. New Delhi-Mumbai central iii.

New Delhi-Chennai central iv.

Howrah- Mumbai V.T.

2. ***Group 'B' lines:*** They consists of those routes on which the trains with a maximum sanctioned speed of 130 km.p.h are running or are intended to run. At present nearly 13 routes come under this category e.g., Allahabad to Bhusaval, Kalyan to Chennai, Kharagpur to Vijayawada, Howrah to New jalpariguri, Sitarampur to Mughalsarai, Kiuli to Barharwa, Delhi to Kolkata, Ambala to Pathankot, Ambala to Mughalsarai, Arkonam to Coimbatore, Vadodara to Ahmedabad and Jalanpet to Bangalore.
3. ***Group 'C' lines:*** They consists of all suburban routes of Mumbai, Kolkata and Delhi.
4. ***Group 'D' lines:*** All other routes in the country where maximum permissible speed at present is 100 km.p.h.
5. ***Group 'E' lines:*** The other routes and branch lines where the permissible speed limits are less than 100 km.p.h.

2.1 **Definition and components of a permanent way**

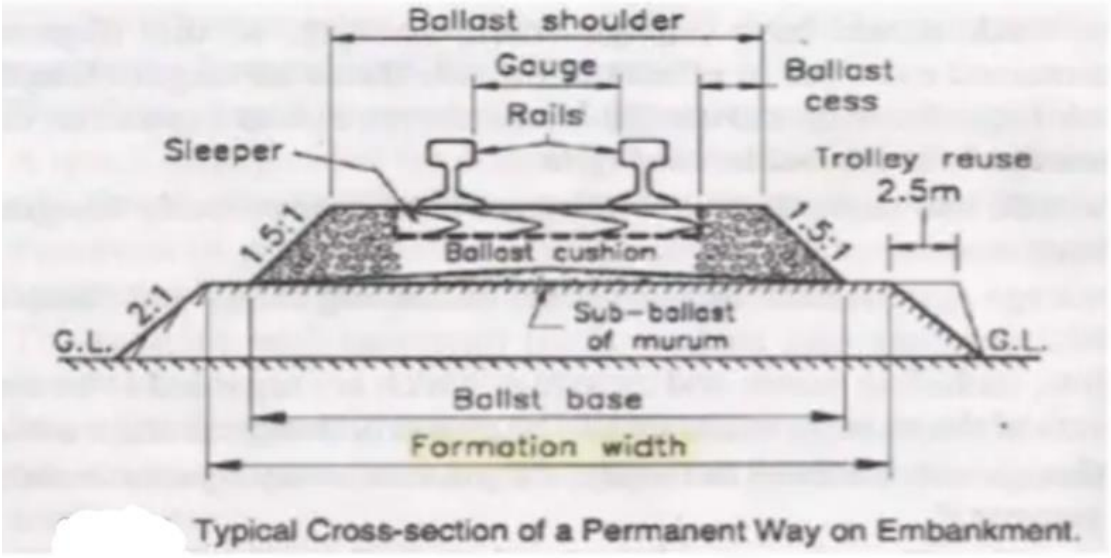
The combination of rails, fitted on sleepers with the help of fixtures and fastenings and resting on ballast and subgrade is called the railway track or permanent way.

Basically a track consists of two parallel rails having a specified distance between them, known as gauge and fastened to the sleepers. These sleepers are embedded in a layer of ballast of specified thickness, spread over the formation. The rails are joined to each other by fish plates and bolts and the rails are fastened to the sleepers with the help of various fittings such as spikes and keys. The sleepers are spaced at a specified distance and are held in position by embedding in ballast.

A track or permanent way is consisted of the following components:

- Rails
- Sleepers
- Fittings and fastenings
- Ballast
- Formation

Track Cross-section



Typical Cross-section of a Permanent Way on Embankment.

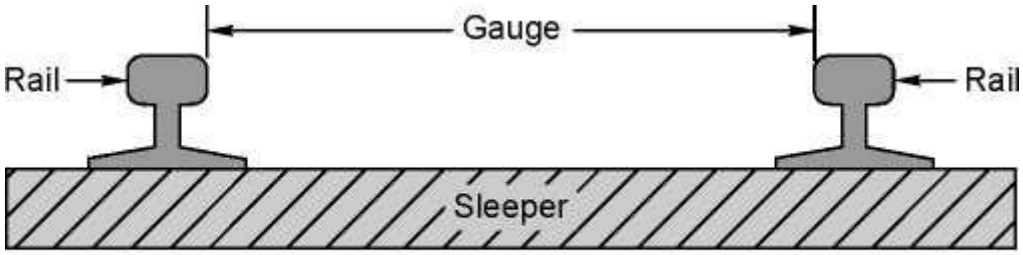
Functions of track components :

- *Rails:* rails are steel girders over which the train moves and transmit the wheel loads of trains to the sleepers below.
- *Sleepers:* The sleepers hold the rails in proper position amd provide a correct gauge with the help of fittings and fastenings and transfer the train load to the ballast below.
- *Ballast:* Ballast holds the sleepers in position and provides a uniform level surface. They also provide drainage to the track and transfer the train load to a larger area of formation below.

- *Fittings and fastenings:* They provide a grip between rails and sleepers. The rails are fastened with the sleepers by fittings and fastenings.
- *Formation:* Formation is the base of the track. It gives a level surface where the ballast rests. It takes the total load of track and the trains move on it.

2.2 Concept of gauge :

The clear horizontal distance between the running inner faces of the two rails forming a track is known as gauge.



Gauge

Different gauges prevalent in India and suitability of these gauges under different conditions:

The different gauges prevalent in India are of the following 3 types:

1. Broad Gauge
2. Metre Gauge
3. Narrow Gauge

Broad Gauge :

When the clear horizontal distance between the inner faces of two parallel rails forming a track is 1676mm (5' -6"), the gauge is called Broad gauge (B.G)

This gauge is also known as standard gauge of India and is the broadest gauge of the world.

Suitability: BG is suitable under the following conditions:

- When sufficient funds are available for the railway project
- When the prospects of revenue are very bright

This gauge therefore was adopted for main cities and routes of maximum traffic intensities.

Metre Gauge :

When the clear horizontal distance between the inner faces of two parallel rails forming a track is 1000mm , the gauge is known as metre gauge.

Suitability : MG is suitable under the following conditions:

- When the funds available for the railway project are inadequate
- When the prospects of revenue are not very bright.

This gauge , therefore, was used for undeveloped areas and in interior areas where trafbrigis very small and development of future prospects aren't very bright.

Narrow Gauge :

When the clear horizontal distance between the inner faces of 2 parallel rails forming a track is either 762mm (2'-6") or 610mm (2'), the gauge is known as narrow gauge.

The gauge of 610mm(2') is also sometimes called feeder gauge

Suitability : NG is suitable under the following conditions :

- When the construction of a track with wider gauge is prohibited due to provision of sharp curves, steep gradients, narrow bridges and tunnels etc.
- When the prospects of revenue aren't very bright.

In hilly regions , where broad and metre gauges aren't possible due to steep gradients & sharp curves & to develop the thinly populated are as by joining the under develop areas with developed / urbanised areas narrow gauges are used.