Lecture Notes

Unit 1: Introduction to Railway Engineering

Introduction In the year 1832 the first Railway running on steam engine, was launched in England. Thereafter on 1st of August, 1849 the Great Indian Peninsular Railways Company was established in India. On 17th of August 1849, a contract was signed between the Great Indian Peninsular Railways Company and East India Company. As a result of the contract an experiment was made by laying a railway track between Bombay and Thane (56 Kms).

- On 16th April, 1853, the first train service was started from Bombay to Thane.
- On 15th August, 1854, the 2nd train service commenced between Howrah and Hubli.
- On the 1st July, 1856, the 3rd train service in India and first in South India commenced between Vyasarpadi and Walajah Road and on the same day the section between Vyasarpadi and Royapuram by Madras Railway Company was also opened.

Subsequently construction of this efficient transport system began simultaneously in different parts of the Country. By the end of 19th Century 24752 Kms. of rail track was laid for traffic. At this juncture the power, capital, revenue rested with the British. Revenue started flowing through passenger as well as through goods traffic. **Organizational structure Railway zones** Indian Railways is divided into several zones, which are further sub-divided into divisions. The number of zones in Indian Railways increased from six to eight in 1951, nine in 1952 and sixteen in 2003. Each zonal railway is made up of a certain number of divisions, each having a divisional headquarters. There are a total of sixty-eight divisions. Each of the sixteen zones is headed by a general manager who reports directly to the Railway Board. The zones are further divided into divisions under the control of divisional railway managers (DRM).

Zonal railways details Sl. No	**Name**	**Abbreviation**	**Date Established**	**Route km**	**Headquarters**	**Divisions**
1.	Central	CR	5 November 1951	3905	Mumbai	Mumbai, Bhusawal, Pune, Solapur, Nagpur
2.	East Central	ECR	1 October 2002	3628	Hajipur	Danapur, Dhanbad, Mughalsarai, Samastipur, Sonpur
3.	East Coast	ECoR	1 April 2003	2677	Bhubaneswar	Khurda Road, Sambalpur

						and Waltair (Visakhapatnam)
4.	Eastern	ER	April 1952	2414	Kolkata	Howrah, Sealdah, Asansol, Malda
5.	North Central	NCR	1 April 2003	3151	Allahabad	Allahabad, Agra, Jhansi
6.	North Eastern	NER	1952	3667	Gorakhpur	Izzatnagar, Lucknow, Varanasi
7.	North Western	NWR	1 October 2002	5459	Jaipur	Jaipur, Ajmer, Bikaner, Jodhpur
8.	Northeast Frontier	NFR	15 January 1958	3907	Guwahati	Alipurduar, Katihar, Rangia, Lumding, Tinsukia
9.	Northern	NR	14 April 1952	6968	Delhi	Delhi, Ambala, Firozpur, Lucknow, Moradabad
10.	South Central	SCR	2 October 1966	5803	Secunderabad	Vijayawada, Hyderabad, Guntakal, Guntur, Nanded, Secunderabad
11.	South East Central	SECR	1 April 2003	2447	Bilaspur	Bilaspur, Raipur, Nagpur
12.	South Eastern	SER	1955	2631	Kolkata	Adra, Chakradharpur, Kharagpur, Ranchi
13.	South Western	SWR	1 April 2003	3177	Hubli	Hubli, Bangalore, Mysore
14.	Southern	SR	14 April 1951	5098	Chennai	Chennai, Trichy, Madurai, Salem,[12] Palakkad,Thiruvananthapuram
15.	West Central	WCR	1 April 2003	2965	Jabalpur	Jabalpur, Bhopal, Kota
16.	Western	WR	5 November 1951	6182	Mumbai	Mumbai central, Ratlam, Ahmedabad, Rajkot, Bhavnagar, Vadodara
17.	Kolkata Metro Railway	KNR	29 December 2010		Kolkata	Kolkata

Classification of Railway Lines in India

The Railway Board has classified the railway lines in India based on the importance of the route, the traffic carried, and the maximum permissible speed on the route. The complete classification is given below.

Broad Gauge Routes

All the broad gauge (BG) routes of Indian Railways have been classified into five different groups based on speed criteria as given below.

Group A lines

These lines are meant for a sanctioned speed of 160 km/h:

- New Delhi to Howrah by Rajdhani route
- New Delhi to Mumbai Central by Frontier Mail/Rajdhani route
- New Delhi to Chennai Central by Grand Trunk route
- Howrah to Mumbai VT via Nagpur

Group B lines

These lines are meant for a sanctioned speed of 130 kmph:

- Allahabad-Itarsi-Bhusaval
- Kalyan-Wadi Raichur-Madras
- Kharagpur-Waltair-Vijayawada
- Wadi-Secunderabad-Kazipet
- Howrah-Bandel-Burdwan-Barharwa over Farakka-Malda town
- Barsoi-New Jalpaiguri
- Sitarampur-Kiul-Patna-Mughalsarai
- Kiul-Sahibganj-Barharwa
- Delhi-Ambala Cantt-Kalka
- Ambala Cantt-Ludhiana-Pathankot
- Ambala Cantt-Moradabad-Lucknow-Paratapgarh-Mughalsarai
- Arkonam-Erode-Coimbatore
- Vadodara-Ahemdabad
- Jalapet-Bangalore

Group C lines

These lines are meant for suburban sections of Mumbai, Kolkata, and Delhi.

Group D and D Special lines

These lines are meant for sections where the maximum sanctioned speed is 100 km/h.

Group E and E Spl lines

These lines are meant for other sections and branch lines.

D Spl and E Spl routes based on the importance of routes, it has been decided that few selected routes presently falling under D and E routes will be classified as D special and E special routes. This has been done for the purpose of track renewal and priority allotment of funds. The track standards for these routes will be 60-kg 90 ultimate tensile strength (UTS) rails and prestressed concrete (PSC) sleepers with sleeper density of 1660 per km.

Metre Gauge Routes

Depending upon the importance of routes, traffic carried, and maximum permissible speed, the metre gauge (MG) tracks of Indian Railways were earlier classified into three main categories, namely, trunk routes, main lines, and branch lines. These track standards have since been revised and now the MG routes have been classified as Q, R1, R2, R3, and S routes as discussed below.

Review of track standard for MG Routes

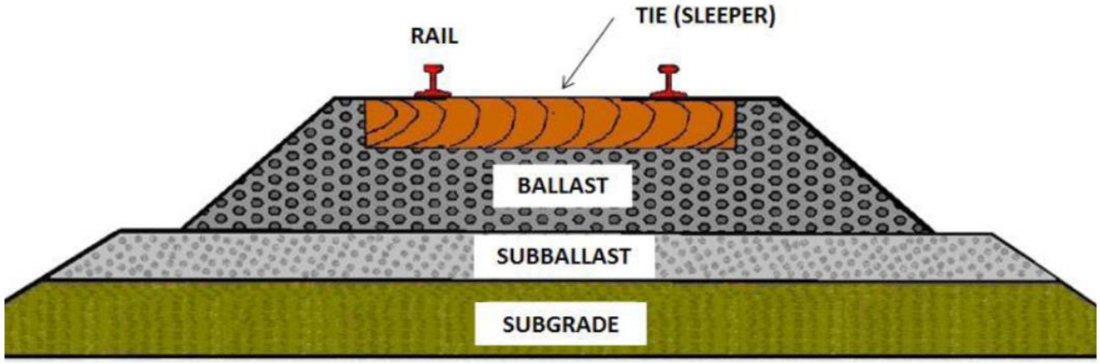
A committee of directors, chief engineers, and additional commissioner of railway safety (ACRS) was formed in 1977 to review the track standards for MG routes.
The committee submitted its report in December 1981, in which it recommended that MG routes be classified into four categories, namely, P, Q, R, and S routes, based on speed criteria. The committee's recommendations were accepted by the Railway Board after certain modifications. The final categories are as follows.
Q routes -Routes with a maximum permissible speed of more than 75 kmph. The traffic density is generally more than 2.5 GMT [gross million tonne(s) per km/ annum].
R routes -Routes with a speed potential of 75 kmph and a traffic density of more than 1.5 GMT. R routes have further been classified into three categories depending upon the volume of traffic:

(i) R1-traffic density more than 5 GMT
(ii) R2-traffic density between 2.5 and 5 GMT
(iii) R3-traffic density between 1.5 and 2.5 GMT

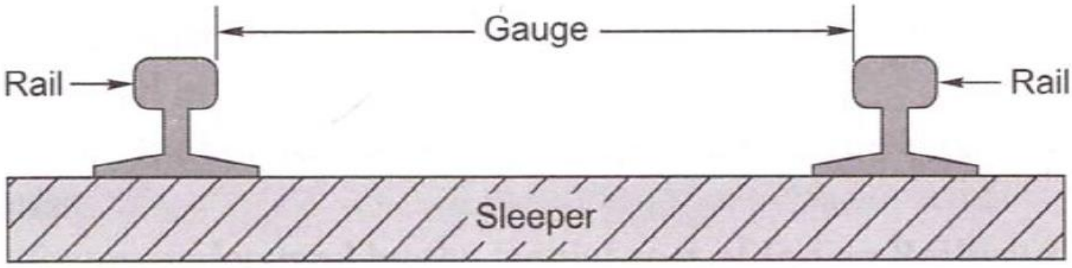
S routes -Routes with a speed potential of less than 75 kmph and a traffic density of less than 1.5 GMT. These consist of routes that are not covered in Q, R1, R2, and R3 routes. S routes have been further sub classified into three routes, namely, S1, S2, and S3. S1 routes are used for the through movement of freight traffic, S3 routes are uneconomical branch lines, and S2 routes are those which are neither S1 nor S3 routes.

Component parts of railway track

The Typical components are – Rails, – Sleepers (or ties), – Fasteners, – Ballast (or slab track), – Subgrade



GAUGE The clear minimum horizontal distance between the inner (running) faces of the two rails forming a track is known as Gauge. Indian railway followed this practice. In European countries, the gauge is measured between the inner faces of two rails at a point 14 mm below the top of the rail.



GAUGES ON WORLD RAILWAYS Various gauges have been adopted by different railways in the world due to historical and other considerations. Initially British Railways had adopted a gauge of 1525 mm (5 feet), but the wheel flanges at that time were on the outside of the rails. Subsequently, in order to guide the wheels better, the flanges were made inside the rails. The gauge then became 1435 mm (4'8.5"), as at that time the width of the rail at the top was 45 mm (1.75 "). The 1435 mm gauge became the standard on most European Railways. The various gauges on world railways are given in below Table

Various gauges on world railways

Type of gauge	Gauge (mm)	Gauge (feet)	% of total length	Countries
Standard gauge	1435	4'8.5"	62	England, USA, Canada, Turkey, Persia, and China
Broad gauge	1676	5 '6"	6	India, Pakistan, Sri Lanka, Brazil, Argentina
Broad gauge	1524	5'0"	9	Russia, Finland
Cape gauge	1067	3 '6"	8	Africa, Japan, Java, Australia, and New Zealand
Metre gauge	1000	3 '3.5"	9	India, France, Switzerland, and Argentina
23 various other gauges	Different gauges	Different gauges	6	Various countries

DIFFERENT GAUGES ON INDIAN RAILWAYS The East India Company intended to adopt the standard gauge of 1435 mm in India also. This proposal was, however, challenged by W. Simms, Consulting Engineer to the Government of India, who recommended a wider gauge of 1676 mm (5 '6 "). The Court of Directors of the East India Company decided to adopt Simms's recommendation and 5'6 " finally became the Indian standard gauge. In 1871, the Government of India wanted to construct cheaper railways for the development of the country and 1000 mm metre gauge was introduced. In due course of time, two more gauges of widths 762 mm (2 '6 ") and 610 mm (2 '0 ") were introduced for thinly populated areas, mountain railways, and other miscellaneous purposes. The details of the various gauges existing on Indian Railways are given in below.

Various gauges on Indian Railways as on 31.03.2011

Name of gauge	*Width (mm)*	*Route (km)*	*% of route (km)*
Broad gauge (BG)	1676	55,188	85.6
Metre gauge (MG)	1000	6809	10.6
Narrow gauge (NG) 610	762	2463	3.8
Total all gauges		64,460	100

Broad Gauge: - When the clear horizontal distance between the inner faces of two parallel rails forming a track is 1676mm 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. The Other countries using the Broad Gauge are Pakistan, Bangladesh, SriLanka, Brazil, Argentine, etc.50% India's railway tracks have been laid to this gauge.

Suitability: - Broad gauge is suitable under the following Conditions:- (i) When sufficient funds are available for the railway project. (ii) When the prospects of revenue are very bright. This gauge is, therefore, used for tracks in plain areas which are densely populated i.e. for routes of maximum traffic, intensities and at places which are centers of industry and commerce. 2. **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 (M.G) The other countries using Metre gauge are France, Switzerland, Argentine, etc. 40% of India's railway tracks have been laid to this gauge. ***Suitability:-*** Metre Gauge is suitable under the following conditions:- (i) When the funds available for the railway project are inadequate. (ii) When the prospects of revenue are not very bright. This gauge is, therefore, used for tracks in under-developed areas and in interior areas, where traffic intensity is small and prospects for future development are not very bright.

3. **Narrow Gauge**:- When the clear horizontal distance between the inner faces of two parallel rails forming a track is either 762mm or 610mm, the gauge is known as Narrow gauge (N.G) The other countries using narrow gauge are Britain, South Africa, etc. 10% of India's railway tracks have been laid to this gauge. ***Suitability: -*** Narrow gauge is suitable under the following conditions:- (i) When the construction of a track with wider gauge is prohibited due to the provision of sharp curves, steep gradients, narrow bridges and tunnels etc. (ii) When the prospects of revenue are not very bright. This gauge is, therefore, used in hilly and very thinly populated areas. The feeder gauge is commonly used for feeding raw materials to big government manufacturing concerns as well as to private factories such as steel plants, oil refineries, sugar factories, etc.

CHOICE OF GAUGE The choice of gauge is very limited, as each country has a fixed gauge and all new railway lines are constructed to adhere to the standard gauge. However, the following factors theoretically influence the choice of the gauge:

Cost *considerations* there is only a marginal increase in the cost of the track if a wider gauge is adopted. In this connection, the following points are important

(a) There is a proportional increase in the cost of acquisition of land, earthwork, rails, sleepers, ballast, and other track items when constructing a wider gauge.
(b) The cost of building bridges, culverts, and runnels increases only marginally due to a wider gauge.
(c) The cost of constructing station buildings, platforms, staff quarters, level crossings, signals, etc., associated with the railway network is more or less the same for all gauges.
(d) The cost of rolling stock is independent of the gauge of the track for carrying the same volume of traffic.

Traffic considerations the volume of traffic depends upon the size of wagons and the speed and hauling capacity of the train. Thus, the following points need to be considered.
(a) As a wider gauge can carry larger wagons and coaches, it can theoretically carry more traffic.
(b) A wider gauge has a greater potential at higher speeds, because speed is a function of the diameter of the wheel, which in turn is limited by the width of the gauge. As a thumb rule, diameter of the wheel is kept 75 per cent of gauge width.
(c) The type of traction and signalling equipment required are independent of the gauge.

Physical features of the country It is possible to adopt steeper gradients and sharper curves for a narrow gauge as compared to a wider gauge.

***Uniformity of* gauge** The existence of a uniform gauge in a country enables smooth, speedy, and efficient operation of trains. Therefore, a single gauge should be adopted irrespective of the minor advantages of a wider gauge and the few limitations of a narrower gauge.