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Railway Engineering

Civil Engineering

Comprehensive Theory *with* Solved Examples

Civil Services Examination

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RAILWAY ENGINEERING

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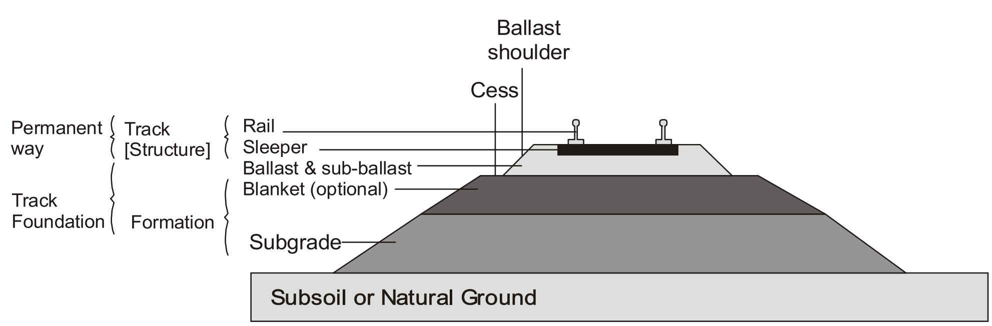
CHAPTER

Railway Track

1.1 INTRODUCTION

Railway track is a combination of rails fitted on sleepers and resting on ballast and subgrade. Essential function of railway track is to support and guide the vehicles that run over it. The conventional railway track consists of two rails located at fixed distance apart, fitted on sleepers and resting a ballast and subgrade. Railway track is also known as permanent way. The name permanent way is given to distinguish the final layout of the track from temporary track. Temporary tracks are laid for conveyance of soil and materials during construction works. In railway track, rails are joined in series by fish plates and bolt and then they are fixed to sleepers by different types of fastenings.



Typical cross-section of a permanent way on embankment

1.2 REQUIREMENT OF AN IDEAL PERMANENT WAY

Following are the basic requirements of an ideal permanent way

(i) The gauge should be uniform and correct.

(ii) Both the rails should be at the same level in a straight track.

(iii) On curves, proper superelevation should be provided to the outer rail.

(iv) Track should have enough lateral strength.

(v) Track must have certain amount of elasticity.

(vi) Radii and superelevation, provided on curves, should be properly designed.

(vii) All joints, points and crossings should be properly designed.

(viii) Drainage system should be perfect.

(ix) It should have adequate provision of easy renewals and repairs.

(x) The components of track i.e., rail, fittings, sleepers, ballast must fully satisfy requirement for which they are provided.

(xi) The track structure should be strong, low in initial cost as well as maintenance.

1.3 LOAD TRANSFER ON A RAILWAY TRACK

- All the components of a P-way are required to transfer the rolling load to the subgrade while maintaining the proper position.
- Rail acts as girders to transmit wheel load to sleeper.
- Sleeper holds the rail in correct alignment and transmit the load to ballast.
- Ballast distributes load over formation known as subgrade and finally to natural soil on ground.

1.4 GAUGES OF RAILWAY TRACK

Gauge of railway tack is the clear distance between inner or running faces of two track rails.

In India following gauges are used,

	Types of gauge	Gauge width
(i)	Broad Gauge (BG)	= 1.676 m
(ii)	Standard Gauge (SG)	= 1.435 m
(iii)	Meter Gauge (MG)	= 1.0 m
(iv)	Narrow Gauge (NG)	= 0.762 m
(v)	Feeder Gauge or Light Gauge (LG)	= 0.610 m

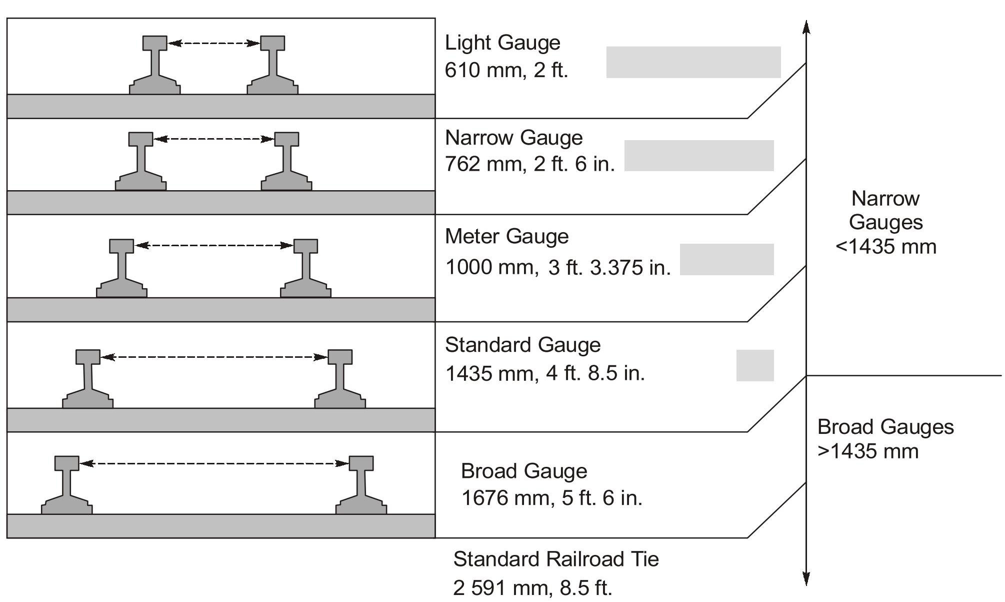
NOTE

(i) A larger gauge has the advantage of greater traffic capacity, speed and safety.

(ii) Small lengths of standard gauge are used in India for individual projects and short line lengths. For example: Delhi Metro

(iii) *Wheel Gauge:* The distance between the inner faces of a pair of wheel is called the "wheel gauge".

(iv) *Dynamic Gauge:* The centre to centre distance of two track rails is called the "Dynamic Gauge".



1.5 SELECTION OF GAUGE

Following factors are considered for selection of gauge:

(i) ***Traffic condition:*** If the intensity of traffic on the track is likely to be more, a gauge wider than standard gauge is suitable.

(ii) ***Development of poor areas:*** The narrow gauges are laid in certain parts of the world to develop a poor area and thus link the poor area with the outside developed world.

(iii) ***Cost of track:*** The cost of railway track is directly proportional to the width of its gauge. Hence if the fund available is not sufficient to constructed a standard gauge, a meter gauge or a narrow gauge is preferred rather than to have no railways at all. In India, the approximate costs of M.G. track and B.G. track per kilometer lengths are about Rs. 50 lakhs and Rs. 1 crore respectively. However there is no appreciable increase in cost of track, if a wider gauge is adopted initially because of the following facts:

(a) There is only proportional increase in the costs of ballast, sleepers, rails etc. for different gauges.

(b) The cost of acquisition of land for the permanent track is not much affected by the change of gauge width.

(c) The cost of culverts, bridges, tunnels, signals staff quarters, level crossings and other works associated with the permanent track are more or less same for all the gauges.

(d) The cost of rolling stock is independent of the gauge of track for carrying the same volume of traffic.

(iv) ***Speed of movement:*** The speed of a train is a function of the diameter of wheel which in turn is limited by the gauge. The wheel diameter is usually about 0.75 times the gauge width and thus the speed of a train is almost proportional to the gauge. If higher speeds are to be attained, the B.G. track is preferred to the M.G. or N.G. track.

(v) ***Nature of country:*** In mountainous country, it is advisable to have a narrow gauge of the track since it is more flexible and can be laid to a smaller radius on the curves. This is the main reason why some important railways, covering thousands of kilometers, are laid with a gauge as narrow as 610 mm.

1.6 UNIFORMITY OF GAUGES

Gauge to be used in a particular country should be uniform throughout as far as possible, because it will avoid many difficulties experienced in a non-uniform system.

Following are the advantages of uniformity of gauges:

(i) ***No transport bottlenecks:*** In a unigauge system there is no transport bottlenecks. It gives improved operational efficiency and fast movement of goods and passengers.

(ii) ***No transshipment hazards:*** In unigauge system there is no need of changing trains, hence no damage to goods and no inconvenience to the passengers.

(iii) ***Improved utilization of track:*** In unigauge system the track can be used to the full capacity, resulting in reduction of working expenses of the railway.

(iv) ***Provision of alternate routs:*** The unigauge system provides alternate routs for free movement of traffic, resulting in reduced pressure on the track.

(v) ***Better turn round:*** The unigauge system provides better turn round of wagons and locomotives resulting in improved operating ratio of the railway system. This will result in immense benefits to the nation.

(vi) ***Balanced economic growth:*** Due to the unigauge system the development of all areas will be uniform resulting in balanced economic growth.

(vii) ***No multiple tracking works:*** the unigauge system eliminates the duplicate traffic facilities and tracking works, resulting in saving of resources.

1.7 CAPACITY OF RAILWAY TRACK

- Maximum number of trains that can be run safely on any given lengths of the track during a calendar day of 24 hours, is called the capacity of railway track.
- Scott's formula is used to assess the capacity of a given section,

Line capacity, $$\text{'c'} = \frac{24 \times 60}{T_{rb} + T_0} \times \eta$$

where, T_{rb} = The highest time in minutes taken by the slowest train to pass over the ruling block section.

T_0 = The average time in minutes required for signalling and block operations.

η = Efficiency factor.

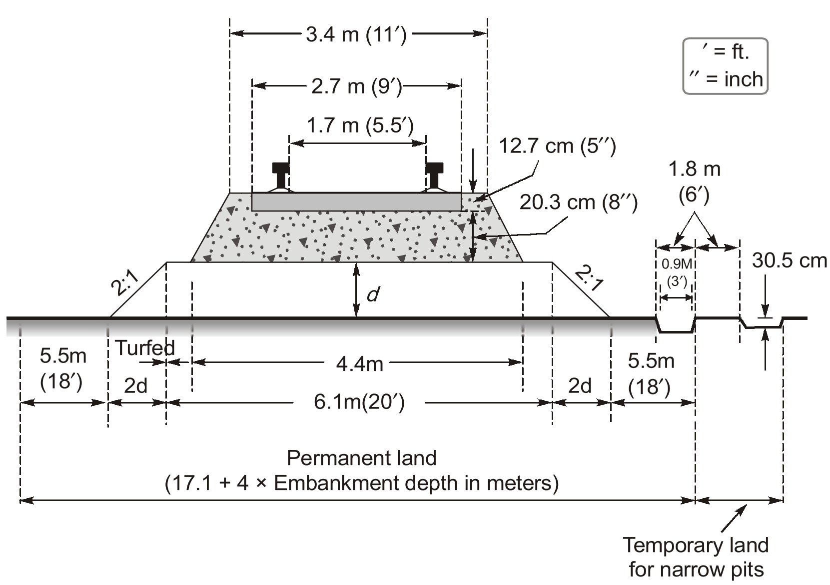
- The track capacity can be increased by
  (i) Achieving faster movement of trains on a track and
  (ii) By decreasing the distance between successive trains.

Some general measures adopted to increase track-capacity are:

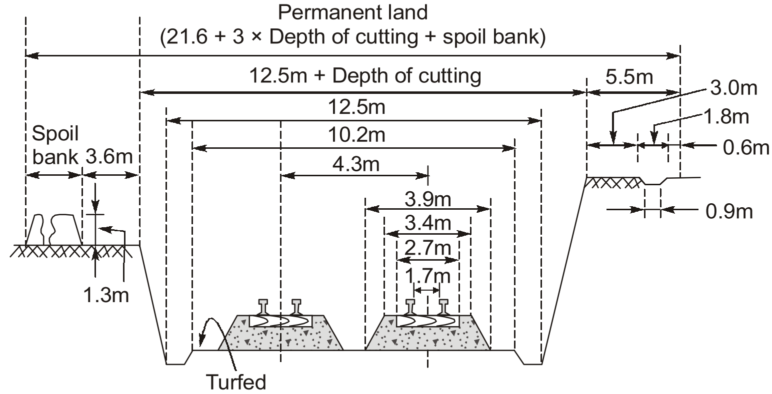
(a) The speed of trains can be increased by adopting electric traction.
(b) A reduction in the time of stoppages of trains.
(c) Centralized traffic control on B.G. and M.G. track.
(d) New lines should be constructed for operational and industrial purposes.
(e) The sections with increased traffic and all important yards should be interlocked and interlocking standard should be revised to permit higher speeds on main trunk routes.
(f) Maintaining rolling stock, control and signalling equipment to a high standard of efficiency (η)

1.8 RAILWAY TRACK CROSS-SECTION

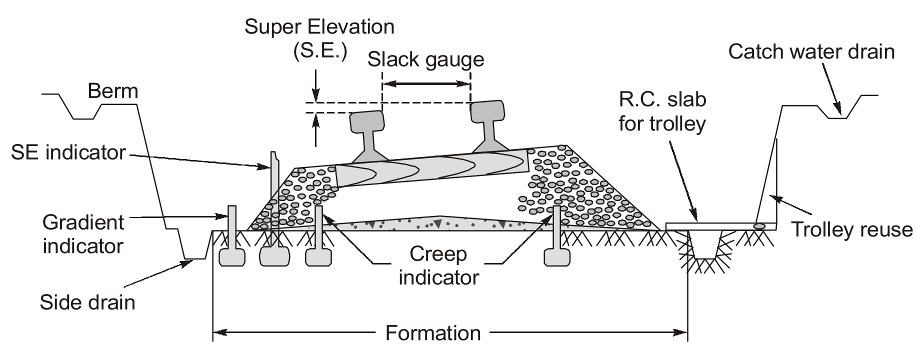
The typical cross-section of a railway track have been shown in the figure given below:



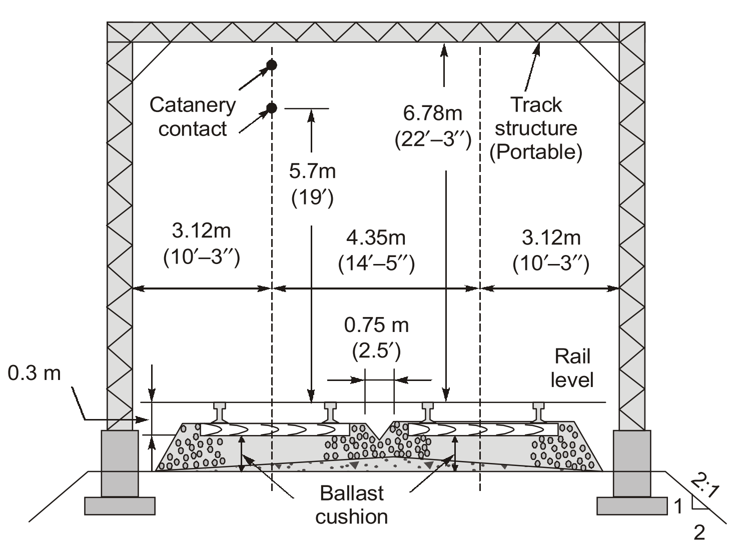
The cross-section of a B.G. Track in Embankment (On straight track)



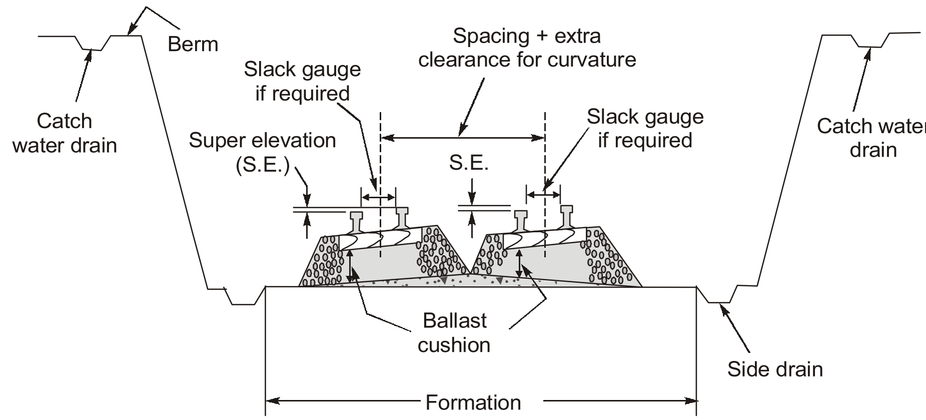
The cross-section of a B.G. Track in cutting for double line (On straight track)



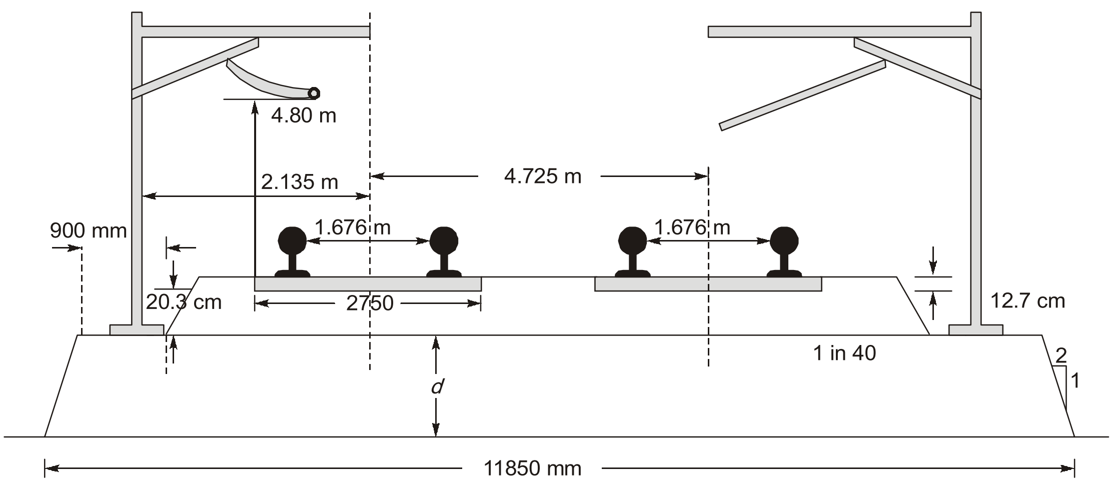
The cross-section of a B.G. track for a single Line (curved track)



The cross-section of a B.G. Track for double line with electric-traction



The cross-section of a B.G. Track for double line in Cutting (On Curved Track)



Cross-section broad gauge double line with OHE

1.9 TRACK ALIGNMENT

- The direction and position given to the centre line of the railway track on the ground is called the track alignment.
- The horizontal alignment includes the straight path, its width, deviations in width and horizontal curves.
- The vertical alignment of railway track includes changes in gradients and vertical curves.
- A new railway track should be aligned very carefully as improper alignment would result either in capital loss in initial cost of construction or recurring loss in maintenance and vehicle operation cost or both.

1.9.1 Surveys for Track Alignment

Following surveys are carefully conducted to choose a best possible alignment,

(i) Traffic survey

(ii) Reconnaissance survey

(iii) Preliminary survey or survey for initial location

(iv) Detailed survey or survey for final location *(i) Traffic survey*

Objective of this survey is to make accurate determination of both passenger and goods traffic at present and its future potential. This is essential for determining the feasibility of a new line proposed, to assure reasonable return on the large investments likely to be involved.

(ii) Reconnaissance survey

This is a rough and rapid inspection, both visual and instrumental, of various physical characteristics of the area to determine the suitability of different alignments marked on the available map during map study or paper location.

(iii) Preliminary survey or survey for initial location

The objective of this survey is to determine the details of different alternative routes as found and drawn in reconnaissance survey and at the same time economics of different routes are studied. Preliminary survey should be conducted with great precision as the selection of final alignment is based on this survey.

(iv) Detailed survey or survey for final location

The objective of final location survey is to transfer or refix the final location of alignment from paper to ground, in order to carry out the ground survey of this alignment in detail.

This survey gives all the required data to the construction engineer such as levels, benchmark, reference pillars, physical features, their measurements, etc. for construction of the track.

1.9.2 Requirements of Good Alignment

Followings are the requirements of good alignment:

(i) Purpose of track: The alignment of the track should be done keeping in view the basic purpose or purposes, it is going to serve. Generally railways serve purpose like,

(a) Transportation services

(b) Political and strategic purposes

(c) Linking important centres of country

(d) To open up new tracks for the land, whose resources are not yet tapped.

(e) Shortening existing track when the existing alignment is zig-zag or uneconomical.

(ii) Feasibility: For aligning a railway line, it is necessary to carryout feasibility study so that the proposed track alignment meets all technical requirements and also fits in well with the general planning of the country.

(iii) Economy: The track alignment should be economical, like initial construction cost should be minimum, maintenance cost should be minimum and operating expenses or transportation cost should be minimum.

(iv) Safety: The track should be so aligned that the passengers and goods traffic can be transported without any chance of accident or derailment.

(v) Aesthetic aspects: Aesthetic aspect of a railway line should be kept in view for comfortable and pleasant railway journey.

1.9.3 Factors Affecting in Selection of Good Alignment

For satisfying most of the requirements, the following factors require due consideration in selection of good alignment.

(i) Obligatory or controlling points: These are the points which govern the alignment of a railway track. These points are classified into two categories.

(a) Points through which a track must pass like important towns and cities, existing hill passes, existing tunnels, existing major bridges etc, so that purpose of the track can be fulfilled economically.

(b) Points through which a track should not pass. Example religious places like temple, church, mosque, tomb, etc, as they are protected by law areas liable to flooding, marsky area, cutting in snowfall area should be avoided.

(ii) ***Traffic-its position, nature and potential:*** Position of traffic decides control points of the alignment, and nature of traffic (passenger or good) and potential volume of traffic govern the type of construction to justify the revenues.

(iii) ***Gauge of track:*** Gauge of track decides the cost and carrying capacity of the alignment.

(iv) ***Geometric elements:*** Geometric elements should be so designed, which would give economical combination of construction and operation costs.

(v) ***Topography of country:*** Alignment should be done considering the topography of country to justify both construction and operation cost. Example: Unavoidable steep gradient.

(vi) ***Economic considerations:*** The best alignment would be one, which gives the maximum annual return (r) given by the formula

$$r = \frac{\text{Gross revenue (R)} - \text{Annual running expenses (F)}}{\text{Investment } (I)}$$

$$r = \frac{R - E}{I}$$

(vii) ***Other considerations:*** While aligning the track, geological formation should be studied. The effect of flood and climate on alignment is important.

1.10 TRACK STRUCTURE FOR ROUTES ON INDIAN RAILWAY

1.10.1 Track classification of B.G. routes

B.G. routes are classified into 7 categories, these are:

(i) ***A class:*** Lines in this class are BG section rated for speeds upto 160 km/hr.

(ii) ***B class:*** This class allows speeds upto 130 km/hr.

(iii) ***C class:*** This is not a speed rated class, but is the classification used for suburban sections of metropolitan areas.

(iv) ***D special class:*** BG lines rated up to 100 kmph, with high traffic density or high expected growth in traffic.

(v) ***D class:*** BG lines rated upto 100 km/hr.

(vi) ***E special class:*** BG lines with sanctioned speeds below 100 kmph, with high traffic destiny or high expected growth in traffic.

(vii) ***F class:*** This class includes all other BG lines with sectioned speeds below 100 kmph.

1.10.2 Track classification of M.G. routes

M.G. routes are broadly classified into 3 categories:

(i) ***Q class:*** These are MG lines rated for speeds above 75 kmph and traffic generally above 2.5 Gross Million Tonnes (GMT)/year.

(ii) ***R class:*** These are MG lines rated at upto 75 kmph. This category is further broken down into three classes based on traffic density, i.e.,

(a) *R-1:* Routes having traffic above 5 GMT/year.

(b) *R-2:* Routes having traffic 2.5-5.0 GMT/year.

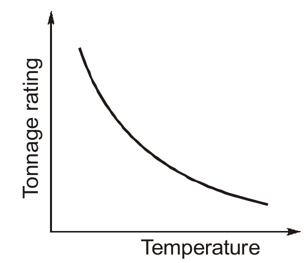
(c) *R-3:* Routes having traffic 1.5-2.5 GMT/year.

(iii) S class: These are all the remaining MG lines rated for below 75 kmph and/or with low traffic densities, below 1.5 GMT/year.

1.11 TONNAGE RATING OF A LOCOMOTIVE

The tonnage rating of a locomotive is that tonnage which can be hauled at a specified minimum speed over a given territory. A tonnage rating must be separately established for each class of motive power or consist of each type of traffic and desired minimum speed.

Effect of temperature on tonnage rating.



PRACTICE QUESTIONS

Question : 1

What are the requirement of an ideal permanent way? Draw a dimension cross-section of a BG track in cutting on a straight track and mark the details.

[15 Marks]

Solution:

Permanent track is regarded to be semi-elastic in nature. There is possibility of track getting disturbed by the moving wheel loads. The track should, therefore, be constructed and maintained keeping the requirement of a permanent way, in view, so as to achieve higher speed and better riding qualities with less future maintenance.

Following are some of the basic requirements of a permanent way :

(i) The gauge should be correct and uniform.

(ii) The rail should be proper level. Thus, in a straight track, two rails must be at the same level on curves, the outer rail should have proper super-elevation and there should be proper transition at the junction of a straight and a curve.

(iii) The alignment should be correct, i.e., it should be free from kinks or irregularities.

(iv) The gradient should be uniform and as gentle as possible.

(v) The track should be resilient and elastic in order to absorb shocks and vibration of running track.

(vi) The track should have enough lateral strength so that alignment is maintained even due to effects of side thrust on tangent length and centrifugal forces on curves.

(vii) The radii and super-elevation on curve should be properly designed and maintained.

(viii) Drainage system must be perfect for enhancing safety and durability of track.