GATE – CIVIL ENGINEERING

TRANSPORTATION ENGINEERING

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15.3 HIGHWAY MATERIALS

Previous GATE Questions

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15.3 Highway Materials

01. The Los Angeles test for stone aggregates is used to examine GATE CE 2020

a. abrasion resistance b. crushing strength c. soundness d. specific gravity

01.a

Aggregate Property	Name of the Test
Abrasion resistance	Los Angeles Abrasion test
Crushing strength	Crushing test
Soundness	Soundness test
Specific gravity	Specific gravity test

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02. Group-I gives a list of test methods for evaluation properties of aggregates. Group-II gives the list of properties to be evaluated. GATE CE 2020

Group-I: Test methods	Group-II: Properties
P. Soundness test	1. Strength
Q. Crushing test	2. Resistance to weathering
R. Los Angeles abrasion test	3. Adhesion
S. Stripping value test	4. Hardness

The correct match of test methods under Group-I to properties under Group-II, is

a. P4, Q1, R2, S3 **b.** P2, Q1, R4, S3 c. P3, Q4, R1, S2 d. P2, Q4 R3, S1

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03. A bitumen sample has been graded as *VG*30 as per IS:73-2013. The '30' in the grade means that CE1 2018

a. penetration of bitumen at 25^0C is between 20 and 40

b. viscosity of bitumen at 60^0C is between 2400 and 3600 Poise.

c. ductility of bitumen at 27^0C is more than 30 cm

d. elastic recovery of bitumen at 15^0C is more than 30%

03. b

As per IS: 73-2013, bitumen grade as VG 30

VG: Viscosity Grade

30: Viscosity of Bitumen at $60°C$ between 2400 and 3600 poise.

04. The following observations are made while testing aggregate for its suitability in pavement construction: CE1 2017

i. Mass of oven-dry aggregate in air = 1000 g

ii. Mass of saturated surface-dry aggregate in air = 1025 g

iii. Mass of saturated surface-dry aggregate under water = 625 g

Based on the above observations, the correct statement is

a. bulk specific gravity of aggregate = 2.5 and water absorption = 2.5%

b. bulk specific gravity of aggregate = 2.5 and water absorption = 2.4%

c. apparent specific gravity of aggregate = 2.5 and water absorption = 2.5%

d. apparent specific gravity of aggregate = 2.5 and water absorption = 2.4%

04. a

Mass of over dry aggregate in air, W_1 = 1000 g

Mass of saturated surface dry aggregate in air, W_2 = 1025 g

Mass of saturated surface dry aggregate in water W = 625 g

Water absorption $= \frac{w_2 - w_1}{w_1} \times 1000 = \frac{1025 - 1000}{1000} \times 100 = 2.5\%$

$W_1 - V_{ag} \cdot \gamma_w = 625$

$V_{ag} = \frac{1000 - 625}{1} = 375 \text{ cm}^3$

Volume of voids (V_V) = volume of water (V_W)

$= \frac{W_w}{\gamma_w} = \frac{25}{1} = 25 \text{ cm}^3$

Bulk density of aggregate, $\gamma = \frac{W_{ag}}{V} = \frac{1000}{375 + 25} = 2.5 \text{ g/cm}^3$

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Bulk specific gravity of aggregate, $G = \frac{\gamma}{\gamma_w} = \frac{2.5}{1} = 2.5$

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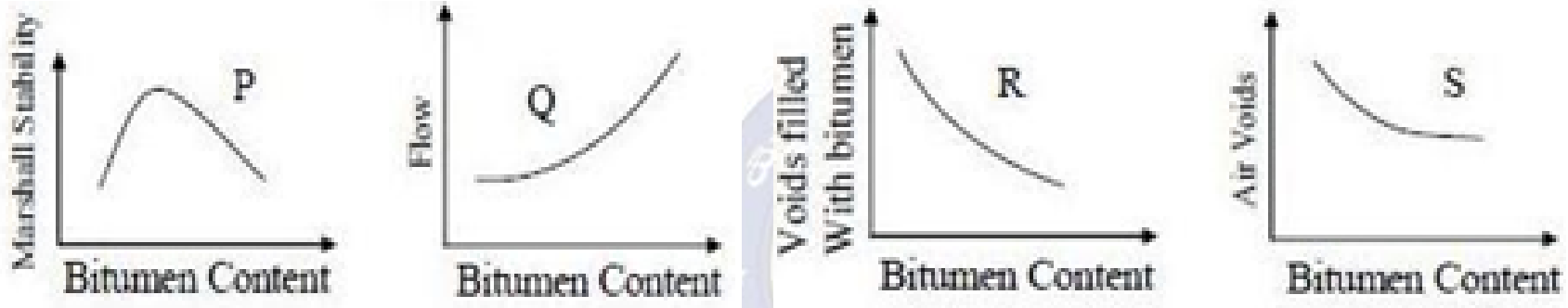
05. During a forensic investigation of pavement failure, an engineer reconstructed the graphs P, Q, R and S, using partial and damaged old reports. CE1 2016



Theoretically possible correct graphs according to the 'Marshall mixture design output' are

a. P, Q, R **b.** P, Q, S c. Q, R, S d. R, S, P

05. b

06. In Marshall Method of mix design, the coarse aggregate, fine aggregate, fines and bitumen having respective values of specific gravity 2.60, 2.70, 2.65 and 1.01, are mixed in the relative proportions (% by weight) of 55.0, 35.8, 3.7 and 5.5 respectively. The theoretical specific gravity of the mix and the effective specific gravity of the aggregates in the mix respectively are: CE2 2015

a. 2.42 and 2.63 b**.** 2.42 and 2.78 c. 2.42 and 2.93 d. 2.64 and 2.78

06. a

Specific gravity of coarse aggregate, $G_1 = 2.60$

Specific gravity of fine aggregate, $G_2 = 2.70$

Specific gravity of fines, $G_3 = 2.65$

Specific gravity of bitumen, $G_4 = 1.01$

Weight of coarse aggregate, $W_1 = 55.0\%$

Weight of fine aggregate, $W_2 = 35.8\%$

Weight of fines, $W_3 = 3.7\%$

Weight of bitumen, $W_4 = 5.5\%$

Theoretical specific gravity of the mix $G_t = \dfrac{W_1 + W_2 + W_3 + W_4}{\dfrac{W_1}{G_1} + \dfrac{W_2}{G_2} + \dfrac{W_3}{G_3} + \dfrac{W_4}{G_4}}$

$$G_t = \frac{100}{\frac{55}{2.60} + \frac{35.8}{2.70} + \frac{3.7}{2.65} + \frac{5.5}{1.01}}$$

$$= 2.424$$

Effective specific gravity of the aggregates in the mix,

$$G = \frac{W_1.G_1 + W_2.G_2}{W_1 + W_2} = \frac{55 \times 2.60 + 35.8 \times 2.70}{55 + 35.8} = 2.639$$

07. Match the information related to tests on aggregates given in Group-I with that in Group-II

CE2 2015

Group		Group-II	
P.	Resistance to impact	1.	Hardness
Q.	Resistance to wear	2.	Strength
R.	Resistance to weathering action	3.	Toughness
S.	Resistance to crushing	4.	Soundness

a. P1 Q3 R4 S2 **b.** P3 Q1 R4 S2 c. P4 Q1 R3 S2 d. P3 Q4 R2 S1

07. b

Effect on aggregate	Property
Resistance to impact	Toughness
Resistance to wear	Hardness
Resistance to weathering	Soundness
Resistance to crushing	Strength

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08. The penetration value of a bitumen sample tested at 25°C is 80. When this sample is heated to 60°C and tested again, the needle of the penetration test apparatus penetrates the bitumen sample by d mm. The value of d cannot be less than.....mm CE1 2015

08. 80

09. In a Marshall sample, the bulk specific gravity of mix and aggregates are 2.324 and 2.546 respectively. The sample includes 5% of bitumen (by total weight of mix) of specific gravity 1.10. The theoretical maximum specific gravity of mix is 2.441. The void filled with bitumen (VFB) in the Marshall sample (in %) is _____

CE2 2014

09. 68.79

Bulk specific gravity of mix, $G_m = 2.324$

Bulk specific gravity of aggregate, $G_{ma} = 2.546$

Bitumen content in sample, $W_b = 5\%$

Specific gravity of bitumen, $G_b = 1.1$

Theoretical maximum specific gravity of mix, $G_t = 2.441$

Voids filled with bitumen, $VFB = ?$

% Air voids, $V_v = \frac{G_t - G_m}{G_t} \times 100 = \frac{2.441 - 2.324}{2.441} \times 100 = 4.793\%$

% volume of bitumen, $V_b = \frac{G_m}{G_b}.W_b = \frac{2.324}{1.1} \times 5 = 10.564\%$

Voids in mineral aggregate, $VMA = V_v + V_b$

$VMA = 4.793 + 10.564 = 15.357\%$

$VFB = \frac{V_b}{VMA} \times 100 = \frac{10.564}{15.357} \times 100 = 68.79\ \%$

10. The percent voids in mineral aggregate (VMA) and percent air voids (V_V) in a compacted cylindrical bituminous mix specimen are 15 and 4.5 respectively. The percent voids filled with bitumen (VFB) for this specimen is GATE 2013

a. 24 b. 30 c. 54 **d.** 70

10. d

Percent voids in mineral aggregate, $VMA = 15$

Percent air voids, $V_V = 4.5$

Percent voids filled with bitumen, $VFB = ?$

Percent voids in mineral aggregate, $VMA = V_V + V_b$

V_V: percent volume of air voids $= 4.5$

V_b: percent volume of bitumen

$$VMA = 15\%$$

$$V_b = 15 - 4.5 = 10.5\%$$

Percent voids filled with Bitumen, $VFB = \frac{100\ V_b}{VMA} = \frac{100 \times 10.5}{15} = 70\%$

11. Two bitumen samples “X” and “Y” have softening points 45°C and 60°C, respectively. Consider the following statements: GATE 2012

I. Viscosity of “X” will be higher than of “Y” at the same temperature.

II. Penetration value of “X” will be lesser than that of “Y” under standard conditions.

The CORRECT option evaluating the above statements is

a. Both I and II are TRUE b. I is FALSE and II is TRUE

c. Both I and II are FALSE d. I is TRUE and II is FALSE

11. c

Softening point is the temperature at which the substance attains a particular degree of softening under specified condition of test.

Higher softening point indicates lower temperature susceptibility and is preferred is warm climates.

Hard grade bitumen possess higher softening point than soft grade bitumen.
Higher the softening point, higher the viscosity and lower the penetration value.

Softening point of X < Softening point of Y

Viscosity of X < Viscosity of Y

Penetration value of X > Penetration value of Y

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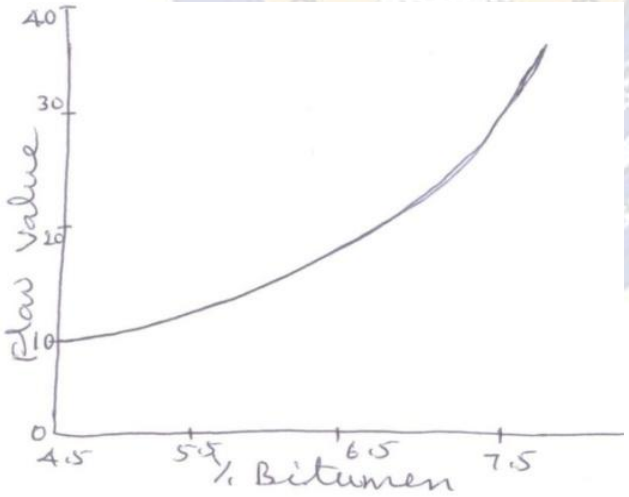
12. In Marshall testing of bituminous mixes, as the bitumen content increases the flow value GATE 2011

a. remains constant
b. decrease first and then increases
c. increases monotonically
d. increases first and then decreases

12. c

As bitumen content increases, the flow value increases monotonically.



13. Aggregate impact value indicates the following property of aggregates

a. Durability **b**. Toughness c. Hardness d. Strength

GATE 2010

13. b

Soundness test	Durability
Aggregate impact value	Toughness
Abrasion value	Hardness
Aggregate crushing value	Strength

15. During a CBR test, the load sustained by a remolded soil specimen at 5.0mm penetration is 50kg. The CBR value of the soil will be GATE 2009

a. 10.0% b. 5.0% c. 3.6% **d.** 2.4%

15. d

Load sustained by a soil specimen at 5 mm penetration, $P = 50$ kg

Load sustained by a standard aggregate at 5 mm penetration, $P_s = 2055$ kg

$$\text{CBR value (\%)} = \frac{P}{P_s} \times 100 = \frac{50}{2055} \times 100 = 2.43\ \%$$

14. A combined value of flakiness and elongation index is to be determined for a sample of aggregates. The sequence in which the two tests are conducted is

a. elongation index test followed by flakiness index test on the whole sample

b. flakiness index test followed by elongation index test on the whole sample

c. flakiness index test followed by elongation index test on the non-flaky aggregates

d. elongation index test followed by flakiness index test on non-elongated aggregates

GATE 2008

14. b

The flakiness index of aggregate is the percentage by weight of aggregate particles whose least dimension / thickness is less than three fifths or 0.6 of their mean dimension. The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension or length is greater than one and four fifths or 1.8 times their mean dimension.

If a combined value of flakiness and elongation index is to be determined for a sample of aggregates, then flakiness index test followed by elongation index test on the whole sample is to be conducted since there is no change in flakiness index due to breaking down of aggregate during the elongation index test.

15. The specific gravity of paving bitumen as per IS : 73-1992 lies between

a. 1.10 and 1.06 b. 1.06 and 1.02 **c.** 1.02 and 0.97 d. 0.97 and 0.92

GATE 2008

15. c

As per IS : 73-1992, the specific gravity of bitumen lies between 1.02 and 0.97.

16. Match the following tests on aggregate and its properties GATE 2007

Test	**Property**
P. Crushing test	1. Hardness
Q. Los Angeles abrasion test	2. Weathering
R. Soundness test	3. Shape
S. Angularity test	4. Strength

a. P2 Q1 R4 S3 b. P4 Q2 R3 S1 c. P3 Q2 R1 S4 **d.** P4 Q1 R2 S2

16. d

Test on aggregate	Property
Crushing test	Strength
Los Angles abrasion test	Hardness
Soundness test	Weathering
Angularity test	Shape

17. The consistency and flow resistance of bitumen can be determined from the following GATE 2007

a. Ductility test
b. Penetration test
c. Softening point test
d. Viscosity test

17. d

Test on Bitumen	Parameter tested
Ductility test	Property of the binder and ability to stretch
Penetration test	Hardness or softness
Softening point test	Softening point
Viscosity test	Consistency and flow resistance.

18. If aggregate size of 50-40 mm is to be tested for finding out the portion of elongated aggregates using length gauge, the slot length of the gauge should be

a. 81 mm b. 45 mm c. 53 mm d. 90 mm GATE 2006

18. a

Slot length for enlarged aggregate = $1.8 \times$ Mean dimension

$$= 1.8 \times \frac{50 + 40}{2}$$

$$= 81 \text{ mm}$$

19. Bituminous concrete is a mix comprising to GATE 2005

a. fine aggregate, filter and bitumen

b. fine aggregate and bitumen

c. coarse aggregate, fine aggregate, filter and bitumen

d. coarse aggregate, filter and bitumen

19. c

Bituminous concrete is mixture comprising of coarse aggregate, fine aggregate, filter and Bitumen.

20. Group I contains some properties of Bitumen. Group II gives a list of Laboratory Tests conducted on Bitumen to determine the properties. Match the property with the corresponding test GATE 2005

Group I	**Group II**
P. Resistance to flow	1. Ductility test
Q. Ability to deform under load	2. Penetration test
R. Safety	3. Flash and Fire point test

a. P2 Q1 R3 b. P2 Q3 R1 c. P1 Q2 R3 d. P3 Q1 R2

20.a

Properties of Bitumen	Test
Resistance to flow	Penetration test
Ability to deform under load	Ductility test
Safety	Flash and fire point test

21. A Marshall specimen is prepared for bituminous concrete with a bitumen content of 5 percent by weight of total mix. The theoretical and the measured unit weights of the mix are 2.442 g/cm^3 and 2.345 g/cm^3 respectively. The bitumen has a specific gravity of 1.02. The percent voids in mineral aggregate filled with bitumen (VFB) are GATE 2004

a. 34.55 b. 35.9 c. 73.55 **d.** 74.3

21. c

Weight of bitumen, W_b = 5% of total mix

Theoretical unit weight of mix, γ_t = 2.442 g/cm^3 $G_t = 2.442$

The measured unit weight of mix, γ = 2.345 g/cm^3 $G = 2.345$

Specific gravity of bitumen, G_b = 1.02

Percent air voids, $V_v = \frac{G_t - G}{G_t} \times 100 = \frac{2.442 - 2.345}{2.442} \times 100 = 3.97\ \%$

Volume filled with bitumen, $V_b = G.\frac{W_b}{G_b}$ $V_b = 2.345 \times \frac{5}{1.02} \times 100 = 11.5\%$

Voids in the mineral aggregate, $VMA = V_v + V_b = 3.97 + 11.5 = 15.47\ \%$

Percent voids filled with bitumen, $VFB = \frac{100V_b}{VMA} = \frac{100 \times 11.5}{15.47} = 74.34\ \%$

22. Column I below gives a list of physical properties of aggregates which should be determined to judge their suitability in road construction. Column II gives a list of laboratory tests which are conduced to determine these properties.

Column I	**Column II**
P. Hardness	1. Water adsorption
Q. Porosity	2. Impact test
R. Toughness	3. Soundness test
S. Durability	4. Abrasion test

Which of the following matches is correct ? GATE 2003

a. P1 Q2 R3 S4 **b.** P4 Q1 R2 S3 c. P3 Q4 R1 S2 d. P2 Q3 R4 S1

22. b

Physical properties of aggregate	Laboratory test
Hardness	Abrasion test
Porosity	Water adsorption
Toughness	Impact test
Durability	Soundness test

23. In the Marshall method of mix design, the coarse aggregates, fine aggregates, filler and bitumen, having respective specific gravities of 2.62, 2.72, 2.70 and 1.02 are mixed in the ratio of 55, 34.6, 4.8. Specific gravity of the mix would be

a. 2.36 b. 2.40 **c.** 2.44 d. 2.50 GATE 2003

23. c

The theoretical specific gravity of the mix is given by

$$G_t = \frac{100}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_4}{G_4}}$$

Percentage by weight of coarse aggregate in total mix, W_1 = 55%

Percentage by weight of fine aggregate in total mix, W_2 = 34.6%

Percentage by weight of filler in total mix, W_3 = 4.8%

Percentage by weight of bitumen in total mix, W_4 =5.6%

Apparent specific gravity of coarse aggregate, G_1 = 2.62

Apparent specific gravity of fine aggregate, G_2 = 2.72

Apparent specific gravity of filler, G_3 = 2.70

Apparent specific gravity of bitumen, G_4 = 1.02

$$G_t = \frac{100}{\frac{55}{2.62} + \frac{34.6}{2.72} + \frac{4.8}{2.70} + \frac{5.6}{1.02}} = 2.44$$

24. Bitumen is derived from GATE 2002

a. destructive distillation of coal tar **b.** destructive distillation of petroleum

c. fractional distillation of petroleum d. naturally occurring ores

24. b

Bitumen is a complex organic material occurs either naturally or artificially derived from destructive distillation of petroleum.

25. Bituminous materials are commonly used in highway construction because of their good GATE 2000

a. tensile and compression properties **b.** binding and water proofing properties

c. shear strength and tensile properties d. bond and tensile properties

25. b

Bituminous materials are commonly used in highway construction because of their good binding and waterproofing properties.

26. Rapid curing cutback bitumen is produced by lending bitumen with
a. Kerosene b. Benzene d. Diesel **d.** Petrol GATE 1999

26. d

Rapid curing cutback bitumen: Bitumen blending with petroleum distillate such as naphtha or gasoline.

Medium curing cutback bitumen: Bitumen blending with kerosene or light diesel.

Slow curing cutback bitumen: Bitumen blending with high boiling point gas oil, or by controlling the rate of flow and temperature of the crude.

27. The penetration test for bitumen is conducted at a temperature of GATE 1997

a. 60°C b. 37°C **c.** 25°C d. 50°C

27. c

The penetration test for bitumen is conducted at a temperature of 25^0 C

28. Bituminous materials are used in highway construction primarily because of their
a. cementing and waterproofing properties
b. load bearing capacity
c. high specific gravity
d. black colour which facilitates road markings GATE 1996

28. a
Bituminous materials are used in highway construction primarily because of their binding and water proofing properties.

29. The following general statement may be made about the penetration value and softening point of bitumen GATE 1996

a. higher the penetration value, higher is the softening point

b. higher the penetration value, lower is the softening point

c. for very high and very low penetration value, the softening point is very low

d. absolutely no correlation can be drawn between penetration value and softening point of bitumen

29. b

The penetration of test determines the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in five seconds. In hot climates, a lower penetration grade bitumen like 30/40 bitumen is preferred.

Generally higher softening point indicates lower temperature susceptibility and is preferred in warm climates.

For bitumen, higher the penetration value lower is the softening point.

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30. The temperature to be maintained for the determination of the penetration value of bitumen is GATE 1992

a.15^0 C **b.**25^0 C c.40^0 C d.60^0 C

30. b

In penetration test, the sample is maintained at a temperature of $25^0 C$.

Penetration test is used to determine the hardness or softness of bitumen.

51. California Bearing Ratio (CBR) GATE 1991

a. is a measure of soil strength

b. is a procedure for designing flexible pavements

c. is a method of soil identification

d. is a measure to indicate the relative strengths of paving materials

51. d

California bearing ratio (CBR) test is a simple strength test that compares the bearing capacity of a material with that of a well-graded crushed stone. CBR is a measure to indicate the relative strength of paving materials.

31. The maximum possible value of Group Index for a soil is…… GATE 1991

32. 20

Group index, $GI = 0.2a + 0.005a.c + 0.01b.d$

a : Portion of material passing $0.075\,mm$ sieve greater than 35 and not exceeding 75% . $(0\,to\,45\%)$

b : Portion of material passing $0.075\,mm$ sieve greater than 15 and not exceeding 35%. $(0\,to\,20)$

c : Value of liquid limit in excess of 40 and less than 60. $(0\,to\,20)$

d : Value of plasticity index exceeding 10 and not more than 30. $(0\,to\,20)$

GI varies in the range of $0\,to\,20$. $0 \le GI \le 20$

The maximum value of Group Index $= 20$

33. The result of ring and ball softening point test on asphalts is given in terms of

a. viscosityb. time c. flow **d.** temperature GATE 1991

33. d

Softening point is the temperature at which the substance attains a particular degree of the softening under specified condition of test. Softening point is determined by ring and ball test.

11. If the load carried by a CBR specimen at 2.5 mm penetration is 14 kg/cm^2, the CBR of the soil is

a.10% **b.** 20% c. 30% d. 50%

Ans. b

Pressure carried by a specimen at 2.5m penetration = 14 kg/ cm^2

The standard load value at 2.5m penetration = 70 kg/ cm^2

$$\text{CBR\%} = \frac{\text{pressure sustained by specimen at 2.5mm or 5mm penetration}}{\text{pressure sustained by standard aggregates at 2.5mm or 5mm penetration}}$$

$$= \frac{14}{70} \times 100 = 20\%$$

12. If the pressure carried by a CBR specimen at 2.5 mm penetration is 3.5 N/mm^2. The CBR of the soil is

a. 10% b. 35% **c.** 50% d. 70%

Ans. c

Pressure carried by a specimen at 2.5m penetration = 3.5 N/mm^2

The standard load value at 2.5m penetration = 7.0 N/mm^2

$$\text{CBR\%} = \frac{\text{pressure sustained by specimen at 2.5mm or 5mm penetration}}{\text{pressure sustained by standard aggregates at 2.5mm or 5mm penetration}}$$

$$= \frac{3.5}{7.0} \times 100 = 50\%$$

27. Match List I with List II and select the correct answer using the code given below the lists : IES 2007

List-I (Type of Construction)		**List-II** (Binder content generally specified)	
A.	Bituminous macadam	1.	8-15%
B.	Dense bituminous macadam	2.	3-3.5%
C.	Bituminous concrete	3.	4-4.5%
D.	Bitumen mastic	4.	4.5-6.0%

a. A2 B1 C4 D3 b. A4 B3 C2 D1 **c.** A2 B3 C4 D1 d. A4 B1 C2 D3

Ans. c

01. In the Loss Angeles Abrasion test on aggregate, if the speed of the drum is increased to 50 rpm, then the abrasion value will IES 1995

a. increase b. decrease c. remain unchanged d. be unpredictable

Ans. a

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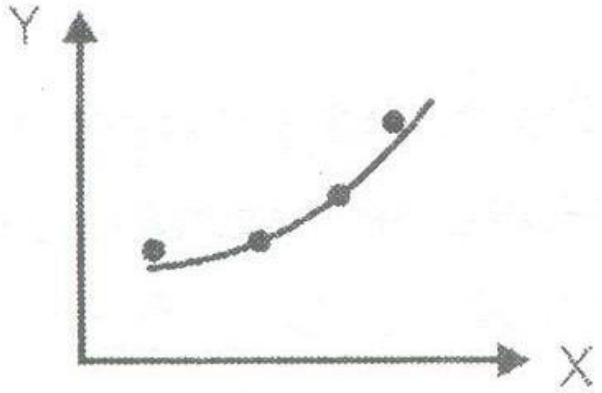
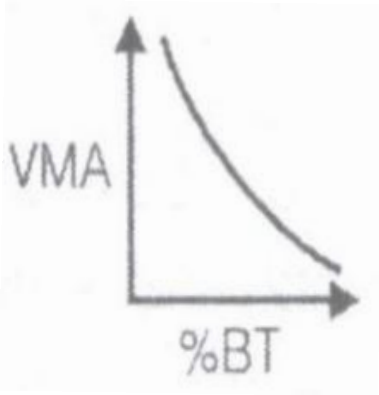
02. A typical Marshall test graph is shown in the given figure. The variable on the X-axis is % binder content by weight of total mix. The variable on the Y-axis for the given graph will be IES 1995



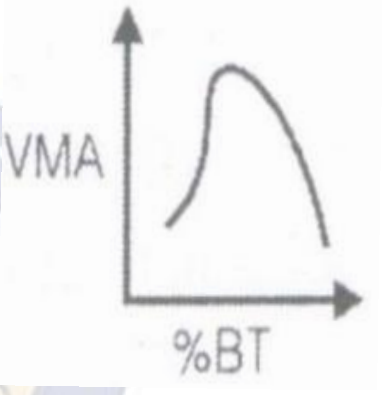
a. stability value **b.** flow value c. percentage of voids d. unit weight

Ans. b

04. Which one of the following diagrams illustrates the relationship between VMA and % bitumen content (BT) in Marshall test? IES 1996

a. 

b. 

c. 

d. 

Ans. b

06. The amount of mechanical energy imposed on the aggregate during the aggregate impact test is of the order of IES 1998

a. 5320 kg-cm b. 6750 kg-cm **c.** 7980 kg-cm d. 11400 kg-cm

Ans. c

12. Bitumen grade 80/100 indicates that under the standard test conditions, penetration value of bitumen would vary from IES 2000

a. 0.8 mm to 1 mm

b. 8 mm to 10 mm

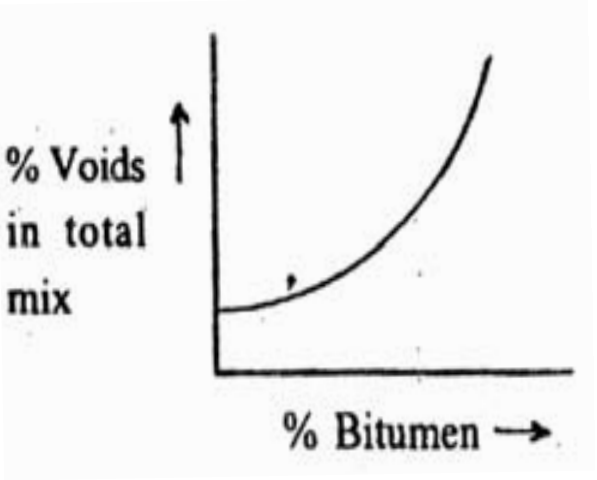
c. 8 cm to 10 cm

d. 0.08 mm to 0.1 mm

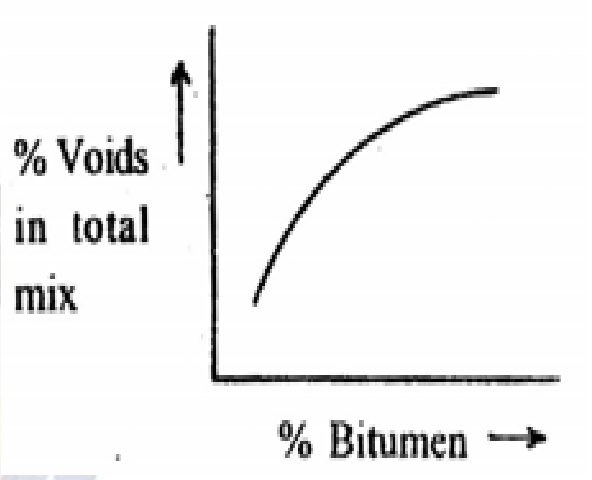
Ans. b

13. Which one of the following curves illustrates the correct relation between % voids in total mix and % bitumen ? IES 2000

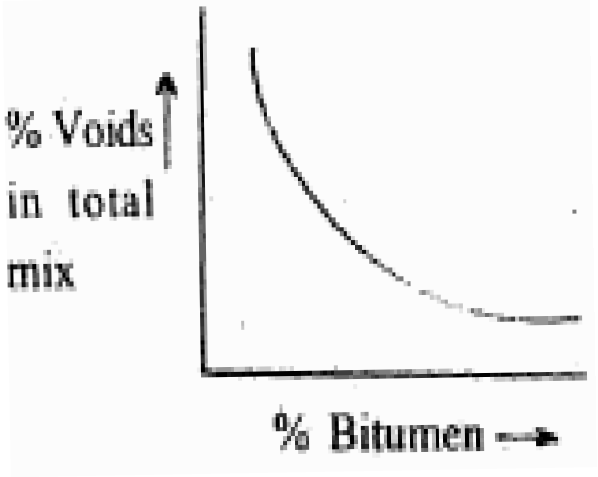
a.



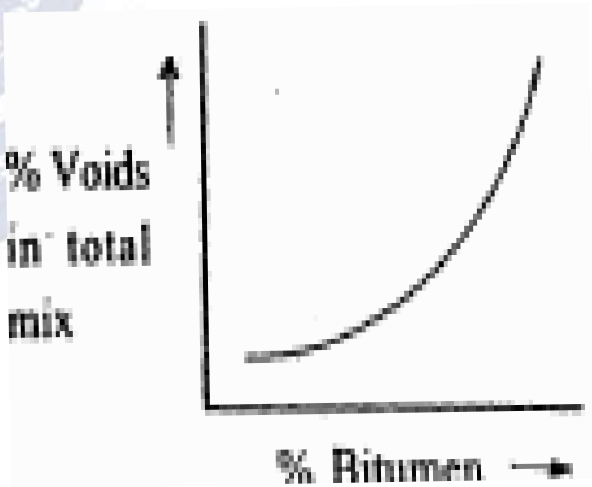
b.



c.



d.



Ans. c

15. Match list I(Type of construction) with List II (% Bitumen content) and select the correct answer : IES 2002

List I	**List II**
A. Bituminous macadam	1. 3 –3.5%
B. Dense bituminous macadam	2. < 4%
C. Bituminous concrete	3. 14–17%
D. Bituminous mastic	4. Min. 4.5%

a. A4 B2 C1 D3 **b.** A1 B2 C4 D3 c. A4 B3 C1 D2 d. A1 B3 C4 D2

Ans. b

16. Match List I with List II and select the correct answer using the codes: IES 2004

List I (Test)	**List II (Purpose)**
A. Impact test	1. Bitumen adhesion
B. Los Angeles abrasion test	2. Toughness
C. Crushing test	3. Hardness
D. Stripping test	4. Strength

a. A2 B3 C4 D1 b. A4 B1 C2 D3 c. A4 B3 C2 D1 d. A2 B1 C4 D3

Ans. a

17. In 500 gm sample of coarse aggregate, there are 100 gm flaky particles and 80 gm elongates particles. What are the flakiness and elongation indices (total) as per I.S?

IES 2004

a. 40% **b**. 36% c. 18% d. 4%

Ans. b

Weight of coarse aggregate sample, w = 500g

Weight of flaky particles, $w1$ = 100g

Weight of elongated particles, $w2$ = 80g

$$\text{Flakiness index} = \frac{w_1}{w} \times 100 = \frac{100}{500} \times 100 = 20\%$$

$$\text{Elongation index} = \frac{w_2}{w} \times 100 = \frac{80}{500} \times 100 = 16\%$$

Total = 20+16 = 36%

18. In a shape test of aggregate, which one of the following gives the correct slot for flakiness index for a material passing 50 mm IES 2005

a. 25mm b. 27 mm c. 81 mm **d.** 30 mm

Ans. d

Flakiness index of aggregate is the percentage by weight of aggregate whose least dimensional thickness is less than 0.6 times of their mean dimension.

Slot for flakiness index for 50 mm = 0.6 × 50 = 30 mm

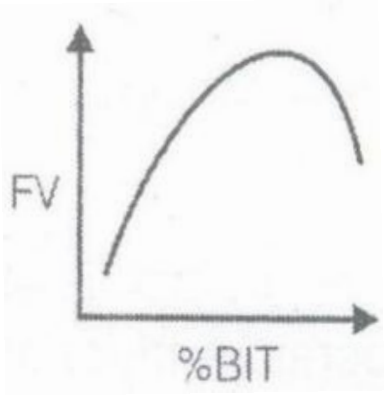
21. What are the standards for testing of road macadam in Aggregate impact Test?

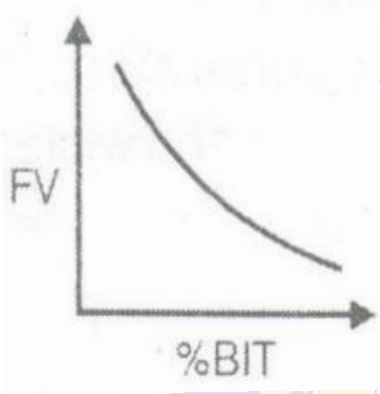
IES 2006

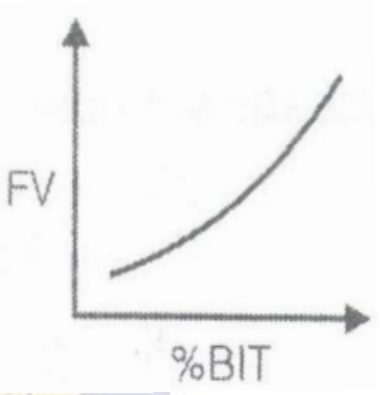
a. 14 kg weight, 38 cm drop, 15 blows
b. 14 kg weight, 35 cm drop, 20 blows
c. 18 kg weight, 35 cm drop, 15 blows
d. 18 kg weight, 30 cm drop, 20 blows

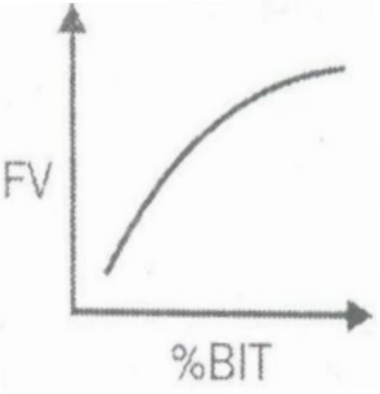
Ans. a

23. Which one of the following diagrams illustrates the relationship between flow value (FV) and percentage bitumen (% BIT)? IES 2006

a. 

b. 

c. 

d. 

Ans. c

26. The weight of aggregate having specific gravity 2.65, completely filled into a cylinder of volume 0.003 m^3 is 5.2 kg. What is the value of the angularity index of aggregate (approximately) as given by Murdock? IES 2007

a. 1 b. 0.34 c. 0.15 d. 0.05

Ans. *

Specific gravity of aggregate, $G = 2.65$

Volume of cylinder, $V = 0.003\ m^3$

Weight of aggregate, $W = 5.2$ kg

Angularity of index of aggregate = ?

Weight of water in cylinder, $C = 0.003 \times 1000 = 3$kg

$$\text{Murdock formula for angularity index} = 67 - \frac{100W}{C.G} = 67 - \frac{100 \times 5.2}{3 \times 2.65} = 1.59$$

27. Which one of the following tests is performed in the laboratory to determine the extent of weathering of aggregates for road works? IES 2009

a. Soundness test b. Crushing test c. Impact test d. Abrasion test

Ans. a

28. Which one of the following is not a desirable property of the sub-grade soil as a highway material? IES 2009

a. Stability b. Ease of compaction c. Good drainage **d.** Bitumen adhesion

Ans. d

54. If aggregate size of 50 – 40 mm is to be tested for determining the proportion of elongated aggregates, the slot length of the gauge should be IES 2014

a. 45 mm b. 53 mm **c.** 81 mm d. 90 mm

Ans. c

Aggregate size : 50 – 40 mm

$$\text{Average size of aggregate} = \frac{50+40}{2} = 45\,mm$$

The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension or length is greater than 1.8 times their mean dimension.

Slot length of the gauge = 1.8 × 45 = 81 mm

55. Absorption capacity of an aggregate refers to the difference expressed in appropriate proportion in water content between IES 2014

a. a wet aggregate and a dry aggregate.

b. a dry aggregate and an over-dry aggregate

c. a saturated surface-dry aggregate and dry aggregate

d. a saturated surface-dry aggregate and an over-dry aggregate

Ans. d

56. The consistency and flow resistance of a sample of bitumen can be determined through which of the following tests? IES 2016

a. Viscosity test b. Penetration test c. Ductility test d. Softening point test

Ans. a

57. Flexible concrete is a mix comprising of IES 2016

a. Gravel, filler and 30/40 bitumen

b. Sand, filler and 30/40 bitumen only

c. Gravel, sand, filler and 60/70 bitumen

d. Sand, filler and 60/70 bitumen only

Ans. c

58. Consider a soil sample, for which tests yield the following results:

Passing 75 micron sieve 62%

Liquid limit 35%

Plasticity Index 14%

As per the group index classification of soil, what is the soil condition of the above soil sample? IES 2016

a. Poor b. Fair c. Good d. Excellent

Ans. a

Percent passing 75μm sieve = 62%

Liquid limit, LL = 35%

Plasticity index, I_P = 14%

Group index of soil, GI = 0.2a + 0.005ac + 0.01 bd

a: portion of material passing 75μm sieve, greater than 35 and not exceeding 75% (0 to 40) = 62-35 = 27

b: portion of material passing 75μm sieve, greater than 15 and not exceeding 55% (0 to 40) = 62-15 = 47 $\Rightarrow$ b = 40

c: value of liquid limit in excess of 40 and less than 60 (0 to 20) = 35 – 40 = 0
d: value of plasticity index exceeding 10 and less than 30 (0 to 20) = 14-10 = 4

GI= (0.2 × 27) + (0.005 × 27 × 0) + (0.01 × 40 × 4) = 5.4 + 0 + 1.6 = 7.0

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60. A collapsible soil sub-grade sample was tested using Standard California Bearing Ratio apparatus; and the observations are given below:

S. No.	Load	Penetration
1	60.55 kg	2.5 mm
2	80.55 kg	5.0 mm

Taking the standard assumptions regarding the load penetration curve, CBR value of the sample will be taken as IES 2016

a. 3.9% b. 4.0% **c.** 4.4% d. 5.5%

Ans. c

Load carried at 2.5 mm penetration, $P_{2.5}$ = 60.55 kg

Load carried at 5.0 mm penetration, $P_{5.0}$ = 80.55 kg

CBR value of the sample = ?

$$\text{CBR} = \frac{\text{Load sustained by the specimen at 2.5 mm or 5.0 mm penetration}}{\text{load sustained by standard aggregates at the corresponding penetration level}}$$

$$(CBR)_{2.5} = \frac{60.55}{1370} \times 100 = 4.49\%$$

$$(CBR)_{5.0} = \frac{80.55}{2055} \times 100 = 3.92\%$$

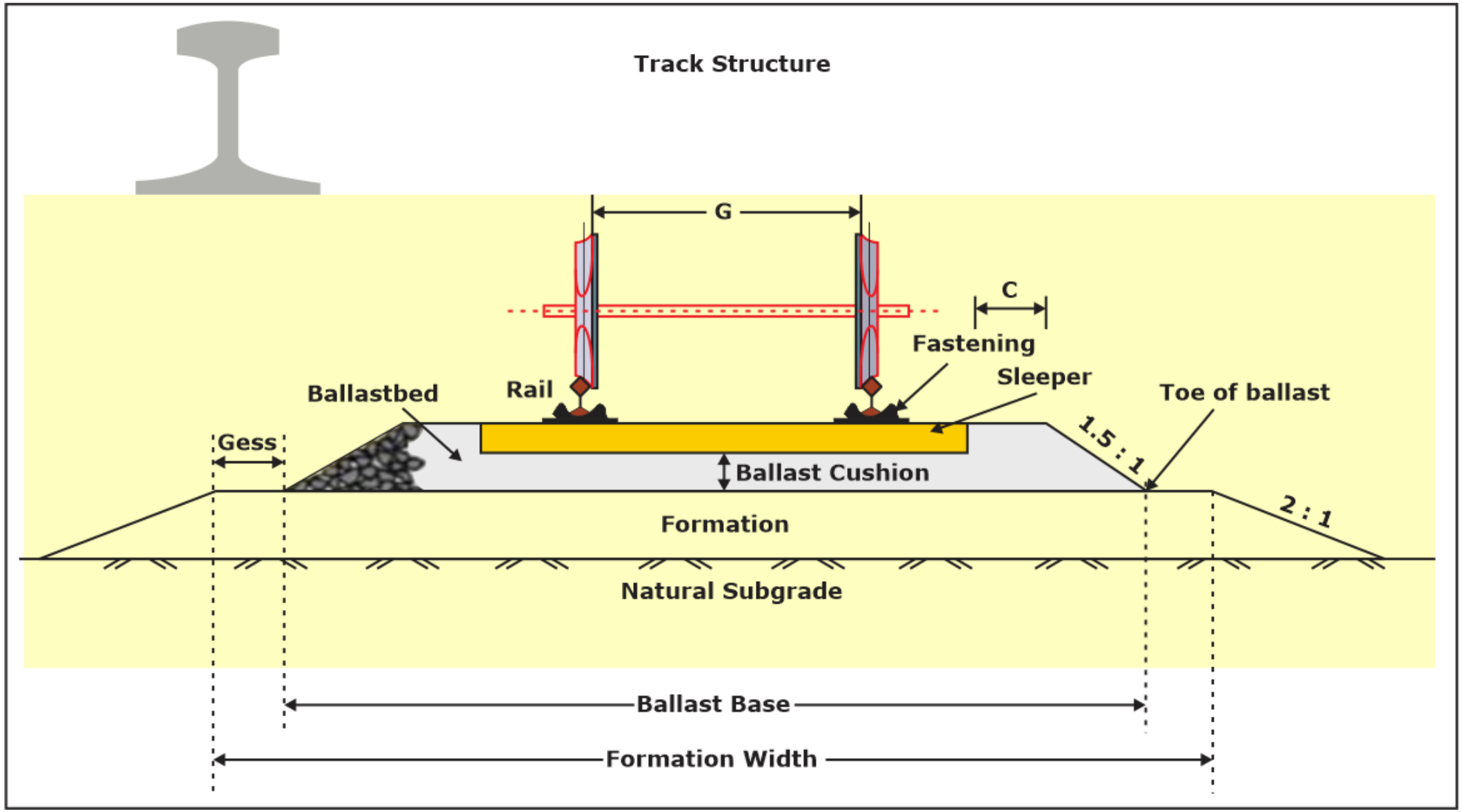
CBR: maximum of the above two values = 4.49%

RAILWAY ENGINEERING

Prof. B. Jayarami Reddy

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.
- The pressure exerted over by the rails is in turn transmitted to the formation with the help of sleepers and ballast.
- Railway track is also known as permanent way. In a permanent way, rails are joined in series by fish plates and bolts and then they are fixed to sleepers by different types of fastenings.
- The sleepers properly spaced, resting on ballast, are suitably packed and fixed with ballast.
- The layer of ballast rests on the prepared subgrade called as the formation.



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COMPONENTS OF RAIL SECTION

Formation

- The formation (also called subgrade level) is the ground surface prepared to support the track surface.
- It is the top layer of the extended subsoil.
- A subgrade protection layer applied to the formation is an integral part of track construction.

Formation protective layer:

- The fine-grained formation protective layer is applied on the formation, possibly on an additional layer of geosynthetics (geotextiles).
- It is also called "track bed layer", because it is intended to increase the load-bearing capacity of the soil and can be used for soil improvement with a lime-cement mixture.

Ballast

- Ballast is composed of hard rocks with sharp edges and a particle size of between 32 and 65 mm. It is broken in special ballast plants.
- It is important that the particles have sharp edges so that the ballast bed can provide a secure location in the ballast bed.
- The materials used are granite, or basalt.
- The quantity of ballast required per metre of track is 3.5 to 4 tonnes on average, which is slightly more than 2 m^3.
- After about 30 to 50 years, the ballast needs to be completely renewed.

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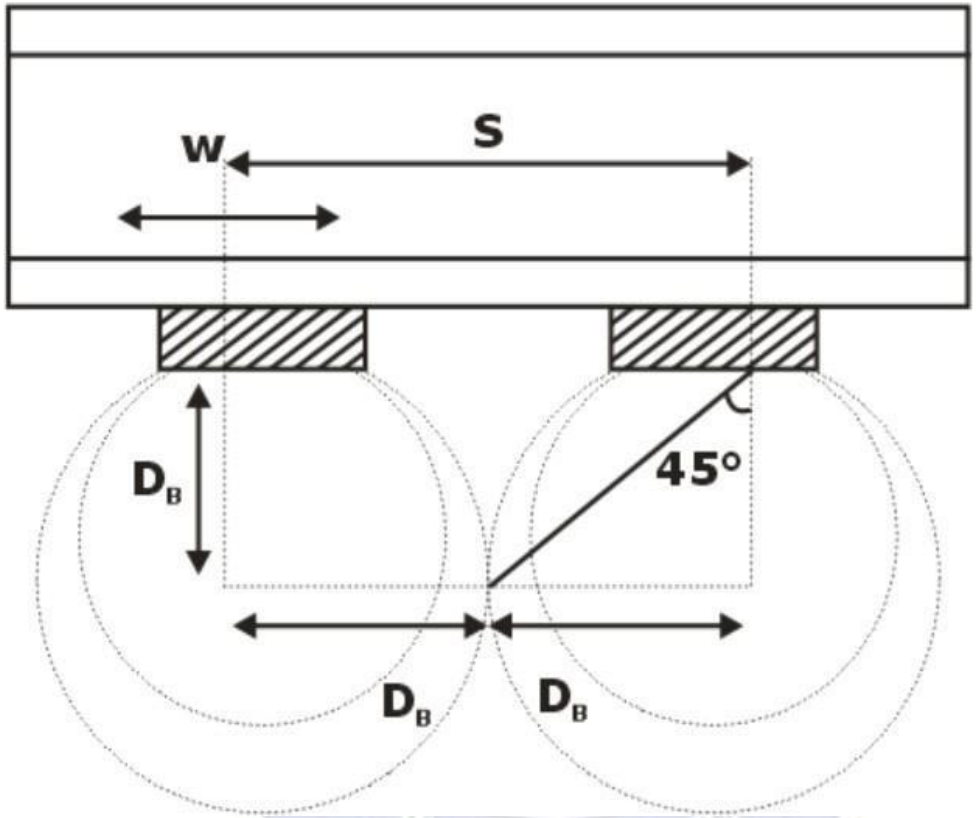
Ballast bed:

- The ballast bed carries the track grid and ensures that it is retained in a stable position, but at the same time must be elastic and enables a certain amount of track deflection under load.
- In addition, the ballast bed must allow rain water to drain away effectively.
- Regular maintenance of the ballast bed ensures that it retains its properties.
- At longer time intervals, depending on load and ambient conditions, the ballast bed must be cleaned partially by machines or completely replaced.
- Inadequate maintenance reduces the carrying capacity of the track bed, leading to the introduction of speed restrictions and finally up to the destruction of the ballast.
- Minimum size ensures drainage conditions whereas maximum size ensures shear strength.



Depth of ballast = $DB = \frac{SS - WS}{2}$

Here, SS = spacing between sleepers WS = Width of sleeper

DB = Depth of ballast

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Sleepers:

- The sleeper laid transverse to the direction of travel in general keeps both rails parallel to each other, distributes the load and ensures the correct track gauge.

Types of Sleepers:

- Typical forms are the classic wooden sleeper, RCC sleeper, PSC sleeper and steel sleeper, as well as Y-steel sleeper.
- Bi-block- sleeper: two concrete elements are connected under the rails by steel rods.
- Sleepers lying under both rails along the direction of travel, which require additional tie rods or other elements to maintain the correct distance apart, are also designated as Long sleepers.
- Sleeper provides elasticity on the railway track.

i. Wooden sleepers:

- Dog spikes were used for wooden sleeper.
- Composite sleeper index is an index to check the suitability of a particular timber to be used as a sleeper.

$$CSI = \frac{S + 10H}{20}$$

S: Strength of timber

H: Hardness of timber

ii. Steel sleepers: Steel sleeper provides maximum rigidity to the rail movement

iii. Concrete sleeper: Pandrol clip is used for concrete sleeper

Sleeper density:

- Number of sleepers used for one rail length are denoted by M + *x*, where M = length of rail in meter.
- Sleeper density for B.G. should lie between (M + 4) to (M + 7).

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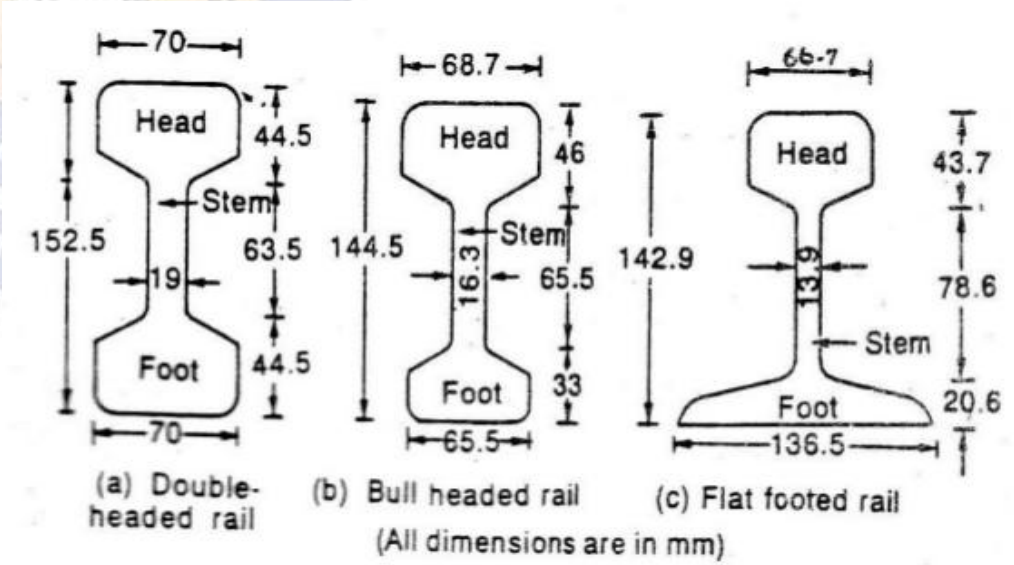
Rails

- There would be no railway without rails. There is a variety of different rail sections, some of which have limited use (eg. crane rails).
- Each rail is a rolled, long steel beam.
- The widest part is always the rail foot and above it there is the rail web and at the top of this there is the rail head.
- The rail foot is located next to the sleeper. Where appropriate, it is separated by an elastic rail pad.



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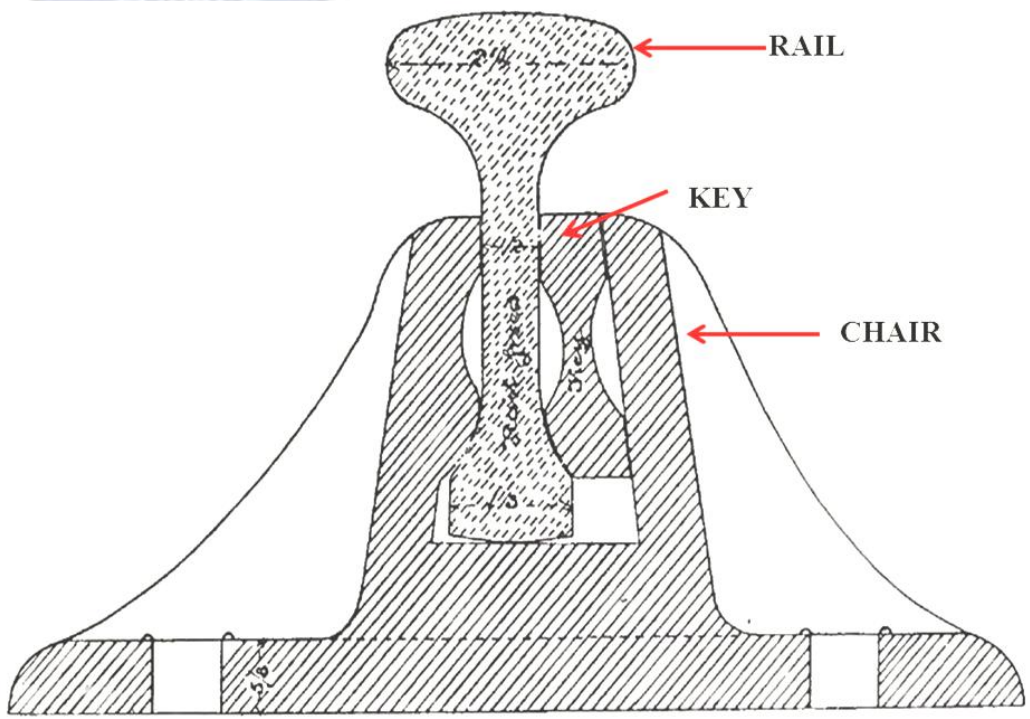
- If rails are connected by bolted joints, holes are provided in the rail web and the rail ends are connected by steel bolts in the "fishplate surface", which connect the fishplates.
- Normally, rails are continuously welded today.
- The track is formed of two rails with sleepers and ballast or slab track.
- In special cases such as the integration of narrow-gauge railways, the track can have three or even four rails.
- Routes with just one central, paved guide rail have been laid for rubber tyre vehicles similar to bus and coach lanes especially in French cities.

Fixtures and Fastenings:

- Fixtures and fastenings are those fittings which are required for connecting the rails end to end and for fixing the rails to the sleepers in a track.

Fixtures and fastenings are

- Fish plates
- Spikes
- Bolts
- Chairs
- Keys
- Blocks
- Bearing plates



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The different functions of fittings are:

- To keep the rails in the proper positions
- Connection of rail to rail.
- To set points and crossings properly
- To allow for expansion and contraction of rails.

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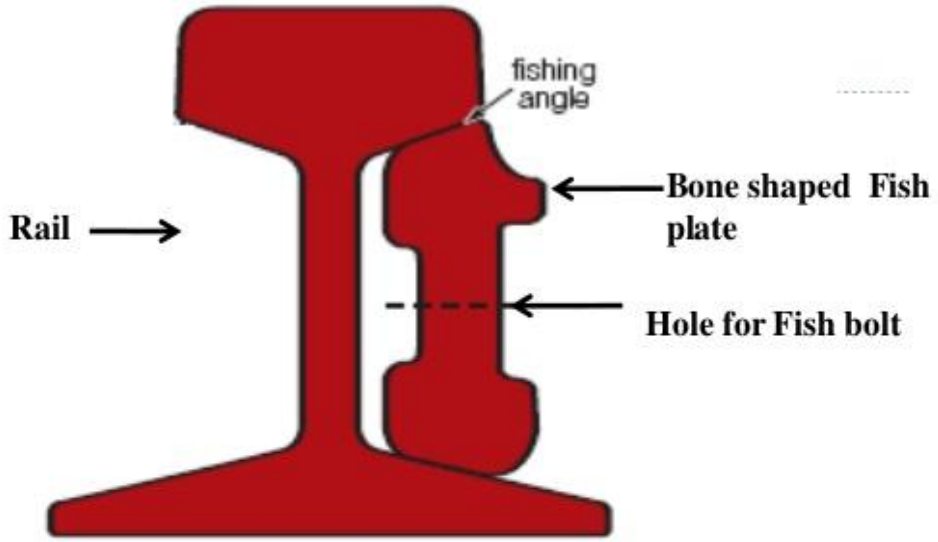
Fish Plates:

- used to maintain proper alignment of the rail line.
- to maintain the continuity of the rails and also allow expansion or contraction of rails caused due to temperature variations.
- Fish plates are made of mild steel and 20 mm in thickness.
- They are 45.6 cm long and provided with 4 numbers of 32 mm diameter holes at 11.4 centre to centre.

Fish plates

Indian railways generally adopt following two types of fish plates:

- Bone shaped fish plate
- Increased depth fish plate



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Spikes:

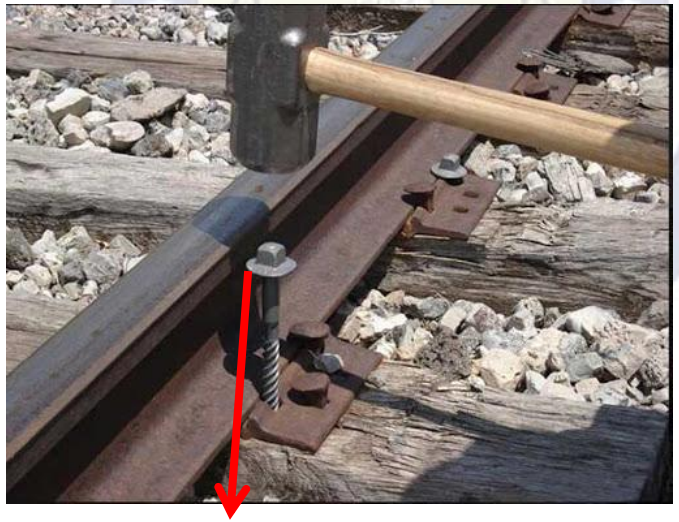
- Spikes are used to hold the rails to the wooden sleeper.

A good spike should have following qualities:

- It should have sufficient strength to hold the rail in position.
- It should help in maintaining proper gauge.
- It should be easy to fix and replace from the sleepers.

Indian Railways use following types of spikes:

- Dog spikes
- Screw spikes
- Round spikes
- Standard spikes
- Elastic spikes



Spikes

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Bolts:

Bolts are used for connecting

- Fish plates to the rails at each rail joint.
- Chairs or bearing plates to timber sleepers.
- Sleepers to bridge girders, etc.

The different types of bolts used in Indian Railways are:

- Hook bolts
- Fish bolts
- Fang bolts
- Rag bolts

Bolts

Chairs:

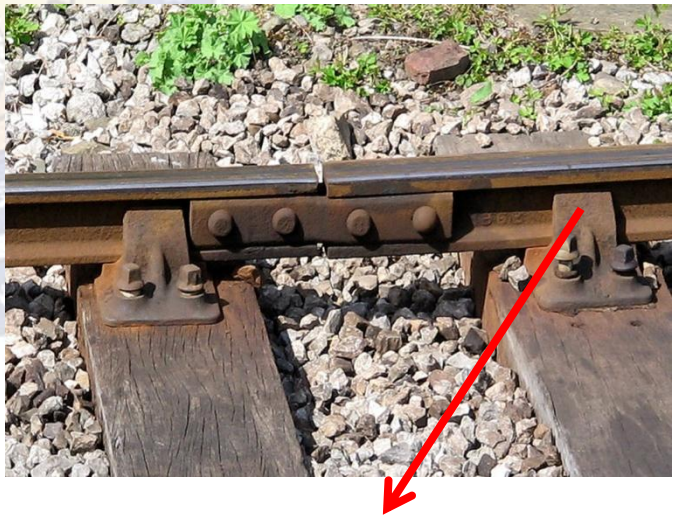
- Chairs are used to hold the double headed and bull headed rails in required position.
- Chairs are made of cast iron having two jaws and a rail seat.
- In order to fix the double headed or bull headed rail to a chair, the rail is placed between the two jaws of the chair.

Keys:

- Keys are small tapered pieces of timber or steel to connect rails to chairs on metal sleepers.

Types of keys generally used are:

- Timber keys
- Metal keys
- Stuart's keys
- Morgan keys



Chairs

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Blocks:

- Blocks are inserted in between the two rails running close to each other and bolted to maintain the required distance.
- They may touch either the webs or the finishing faces or both.

Blocks

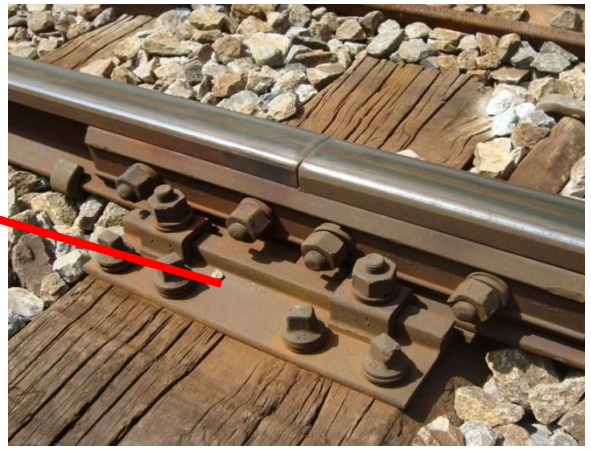
Bearing Plates:

- Bearing Plates are the plates placed in between the flat footed rails and timber sleepers on a track.
- They serve as chairs for flat footed rails. They are made of cast iron, wrought iron or steel.

Types of Bearing Plates:

1. Flat bearing plates: Flat bearing plates are used at locations where rails are laid flat.
   - Also they are used in turn out tracks under points and crossings.
2. Canted bearing plates: Canted Bearing plates are used on soft timber sleepers beneath outside rail on curves, on sleepers placed on either side of rail joints, bridges etc. where rails laid at an inward tilt of 1 in 20.

Bearing plates



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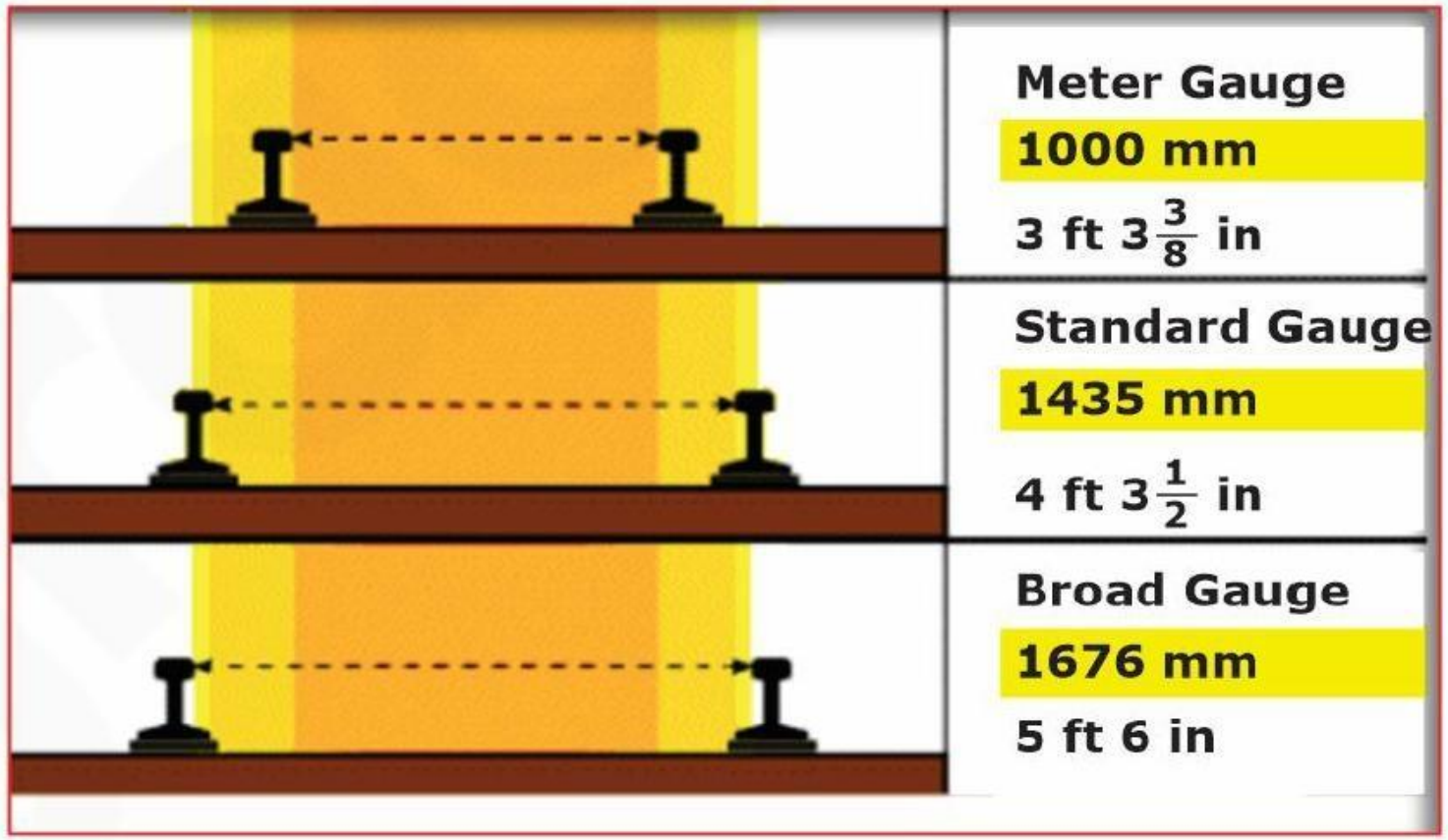
Gauge distance:

- It is the distance between inner faces of rails or running faces of rail section.

Type of Gauges:

- Broad Gauge: 1.676 m
- Standard Gauge: 1.435 m
- Meter Gauge: 1.00 m
- Narrow Gauge: 0.762 m
- Feder Gauge: 0.610 m



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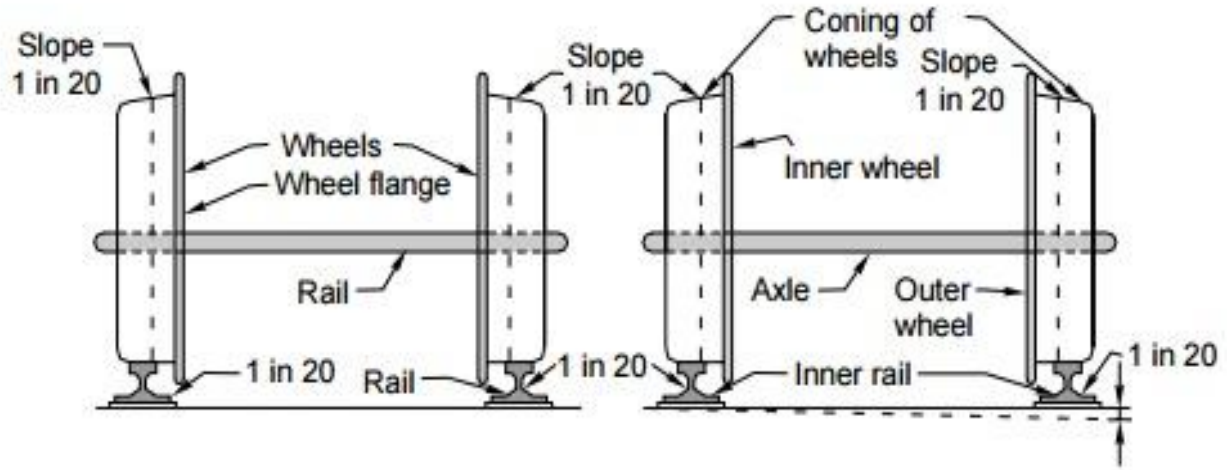
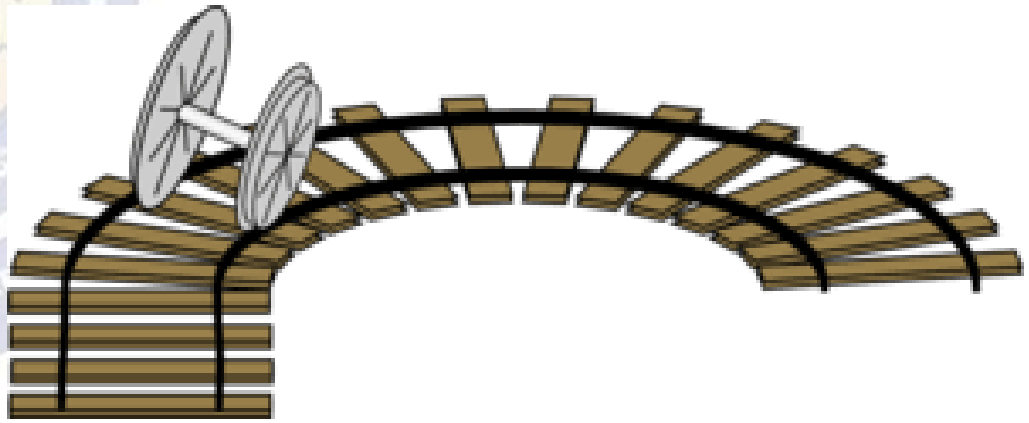
Coning of wheels:

- The wheels are made cone shaped having different diameters at different cross sections.
- Diameter near flange is more than the diameter near other ends.
- The rails are laid at a slope of l in 20 ie. Same slope as that of wheel.
- Coning of wheels is the slope of wheel face.





Purpose of coning

- On a straight track, to keep the wheel assembly in central position to avoid derailment.
- To reduce wear and tear due to centrifugal force, the wheel assembly is moving in outward direction so that diameter on outer rail will increase. Hence the distance travelled on outer rail will become more as required. Due to difference of diameter on two rails, the trains will be moving on a circular track and distance travelled on two tracks will be adjusted as required.
- Only some part of difference is adjusted due to coning. Remaining part is covered by slip or skid on the surface. Due to cone shaped wheels, diameter of wheel is not same at each section.
- On straight track, the wheel will always move in central position in such a way that diameter at contact point with rail is same on the two rails. If the train or axle of wheel tries to move in any direction, diameter of wheel on one rail will increase. So the axle will start moving on a circular track. Thus the wheel assembly will be automatically returned back in its central position.

Welding of Rails

Welding methods:

- Gas pressure welding
- Electric arc welding / Metal arc welding
- Flash butt welding
- Thermite welding

Geometric Design of Railway Track

1. Maximum speed on a railway track:

It is the minimum of,

- Speed decided by Railway board
- Speed decided by Martin's formula
- Speed calculated by superelevation formula
- Speed calculated by length of transition curve formula

Martin's formula:

a. On a Transition Curve

i. For BG/MG

$$V_{max} = 4.35\sqrt{(R-67)}$$

ii. For NG

$$V_{max} = 3.6\sqrt{(R-61)}$$

b. On a Non- Transition Curve

$$V_{max} = 0.8\ (V_{max} \text{ of transition curve})$$

c. For High Speed Trains

$$V_{max} = 4.58\sqrt{(R)}$$

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Super elevation:

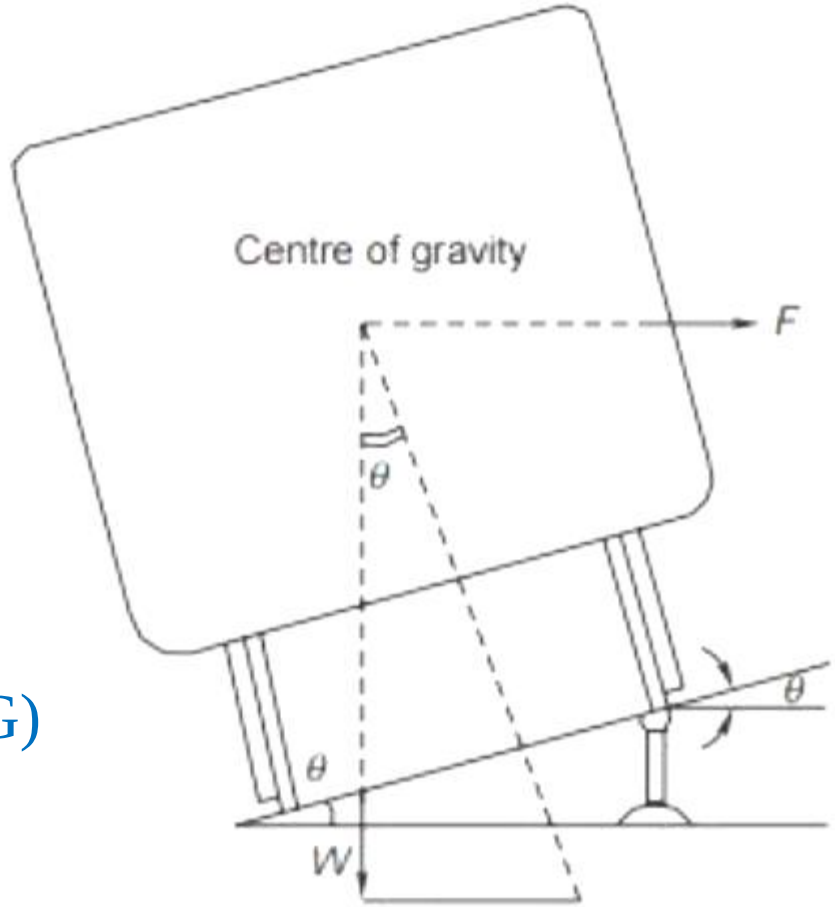
If θ is the angle that the inclined plane makes with the horizontal line, then

$$\tan\theta = \frac{\text{Superelevation}}{\text{Gauge}} = \frac{e}{G}$$

$$\text{Also, } \tan\theta = \frac{\text{Centrifugal Force}}{\text{Weight}} = \frac{F}{W}$$

$$\text{From these equations, } \frac{e}{G} = \frac{F}{W} \Rightarrow e = F.\frac{G}{W}$$

$$e = \frac{W}{g}.\frac{v^2}{R}.\frac{G}{W} = \frac{Gv^2}{gR} \qquad e = \frac{Gv^2}{gR} \qquad e = \frac{GV^2}{127R}$$



e: Equilibrium superelevation,

G: Gauge(G: 1750 mm for BG and 1058 mm for MG)

V: Speed, km/h

g: Acceleration due to gravity

R: Radius of the curve.

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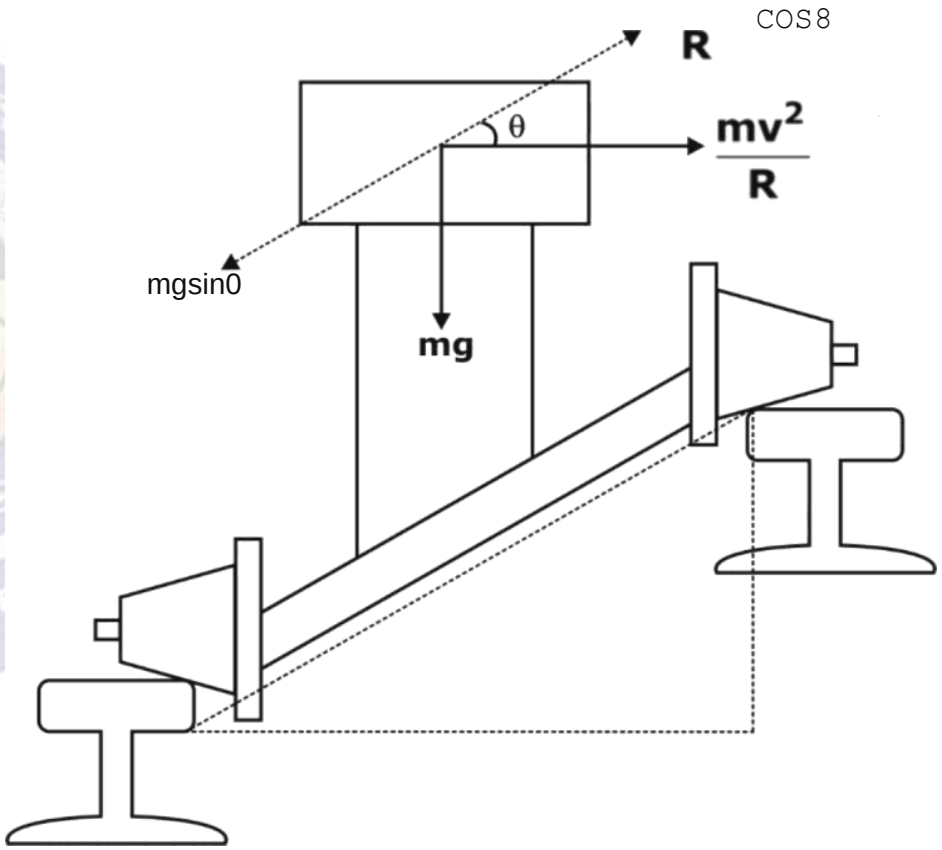
Permissible value of actual cant

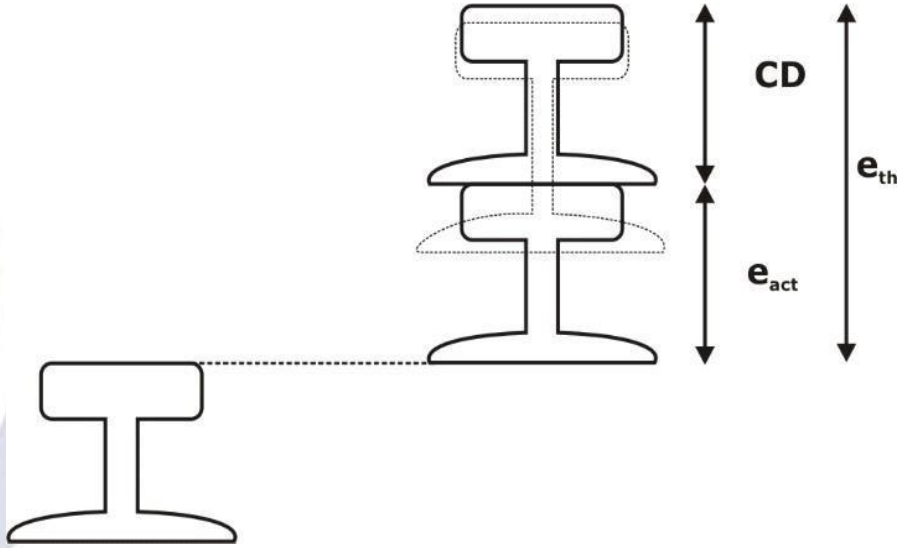
Gauge	Speed ≤ 120 km/h	Speed > 120 km/h
BG	16.5 cm	18.5 cm
MG	10.0 cm	—
NG	7.6 cm	—



Cant Deficiency

For high speed train, cant requirement will be more than the actual cant provided so the train will be forced to move on a lower value of cant. This deficiency of cant for high speed train movement is called cant deficiency.

$$e_{theoretical} = e_{actual} + \text{cant deficiency}$$



Limits of cant deficiency

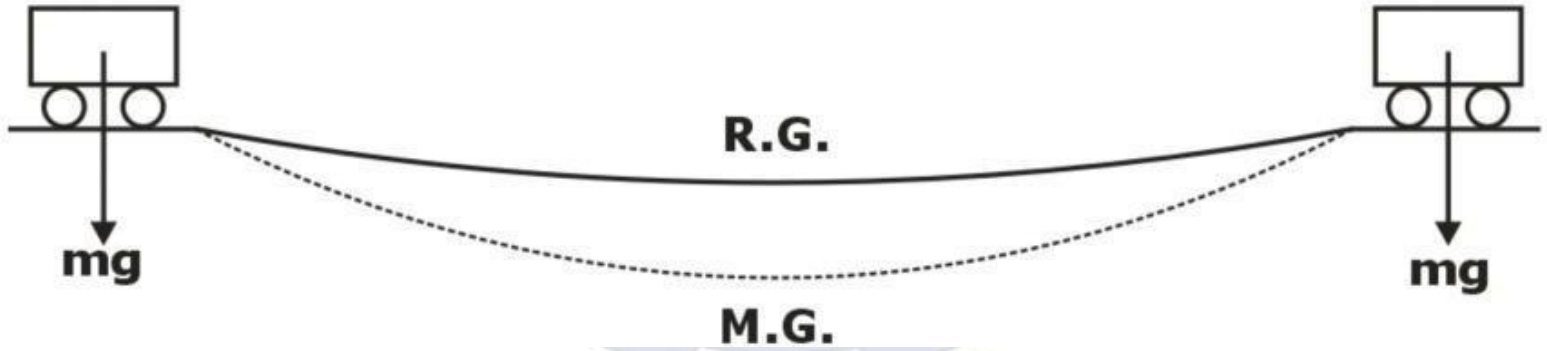
Cm	Speed ≤ 100 km/hr	Speed > 100 km/hr
BG	7.6	10
MG	5.1	—
NG	3.8	—

Vertical Curves

Types of gradients

a. Ruling Gradient: It is the maximum gradient that can be provided in the most general condition and that determines maximum load that a locomotive can carry on that particular section.

b. Momentum gradient: For a practical situation as shown in figure, gradient may be increased more than ruling gradient (with no stoppage)



c. Pulling/helper/pusher gradient: When gradient is greater than ruling gradient, then extra locomotive is provided for that particular section.

- Greater gradient reduce the cutting cost
- Minimum gradient at station yard: 1/100
- Maximum gradient at station yard: 1/400

Grade compensation: If the gradient is provided on a curved location then gradient value is reduced to compensate curve resistance. Reduction in gradient for broad gauge is 0.04% per degree of the curve.

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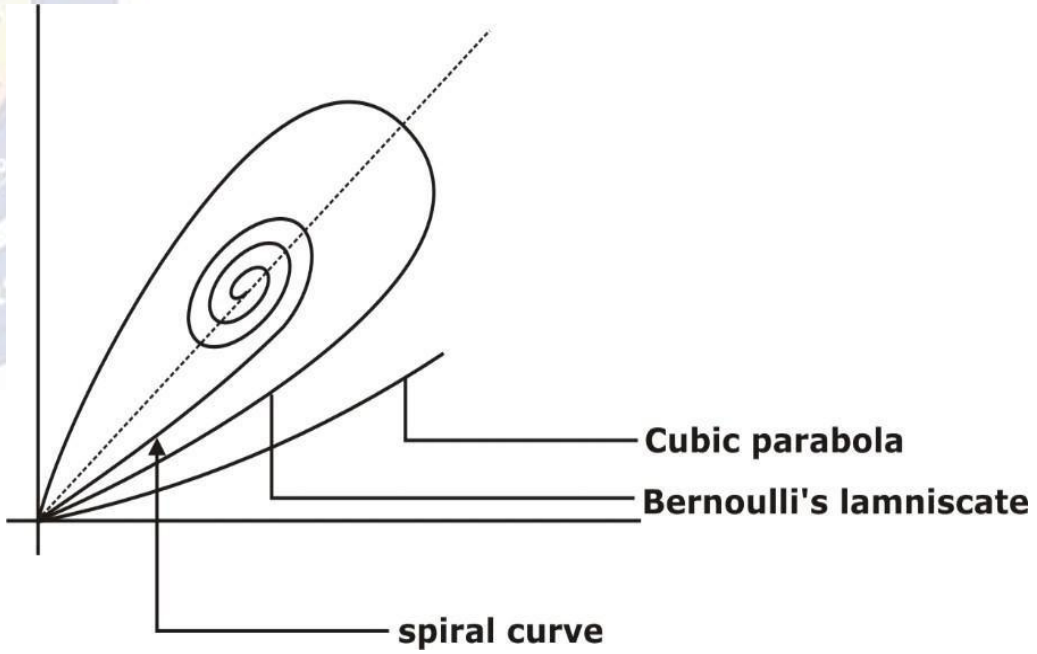
Transition Curve

It is required for

- Introduction the superelevation in a gradual manner within the length of transition curve in outer railway track.
- Reducing the radius of the curve from infinite to some value
- Curve should be perfectly tangential at joining points
- If the centrifugal force is to be increased at a constant rate, centrifugal force must vary with time.



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The ideal condition for transition curve is Parabola.

Parabola equation for transition curve:

$$y = \frac{x^3}{6R_c L}$$

$$\left.\begin{aligned} h &= 7.2e \\ h &= 0.073 e.V_{\max} \\ h &= 0.073 CD.V_{\max} \end{aligned}\right\}_{\max}$$

h = in m

e = actual cant in cm

$V_{\max}$ = in km/hr

CD = in cm

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Spiral and Deflection Angles:

ϕ = spiral angle

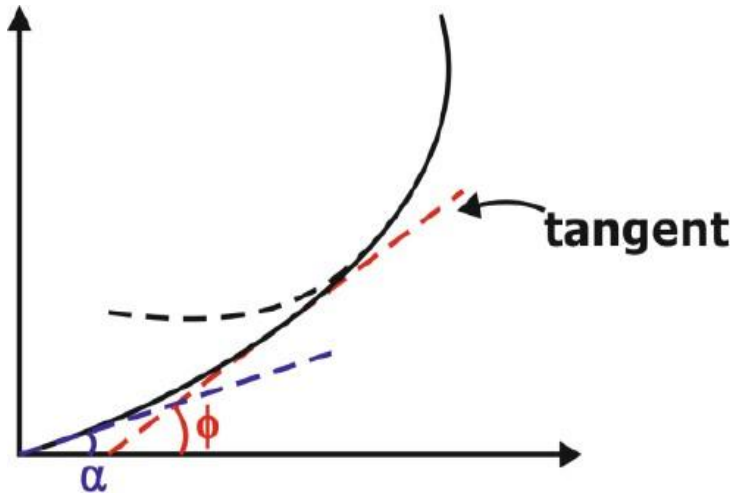
$$\tan\phi = \frac{dy}{dx} = \frac{d}{dx}\left(\frac{x^3}{6RL}\right) \Rightarrow \tan\phi = \frac{3x^2}{6RL}$$

$$\phi_{max} = \frac{L}{2R} \qquad \{x = L\}$$

α = deflection angle

$$\tan\alpha = \frac{y}{x} = \frac{x^3/6RL}{x} = \frac{x^2}{6RL}$$

$$\alpha = \tan^{-1}\left(\frac{x^2}{6RL}\right)$$



Shift → because of transition curve, the path shifted w.r.t. circular curve $S = \frac{L^2}{24R}$

L = length of transition curve

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Left Hand Turnout

It is an arrangement on railway track to direct the trains from one track to another track.

a. Tongue rail: They are provided on sliding plate and each plate of tongue rail is connected by structure bars.

b. Flare: It is provided to guide the wheel such that range of wheel enter and leave the turnout smoothly.

c. Heel Block

- **Flangeway clearance:**
  It is the distance between adjacent faces of stock rail and tongue rail
- **Flange way depth:**
  It is the vertical distance from top of the rail surface to top of the heel block.
- **Heel divergence:**
  It is the distance between the running faces of stock rail and tongue rail

Cross Over

- It is the combination of 2 turnouts with intermediate portion as straight portion or curved portion i.e., used to drive the trains from one track to another track.

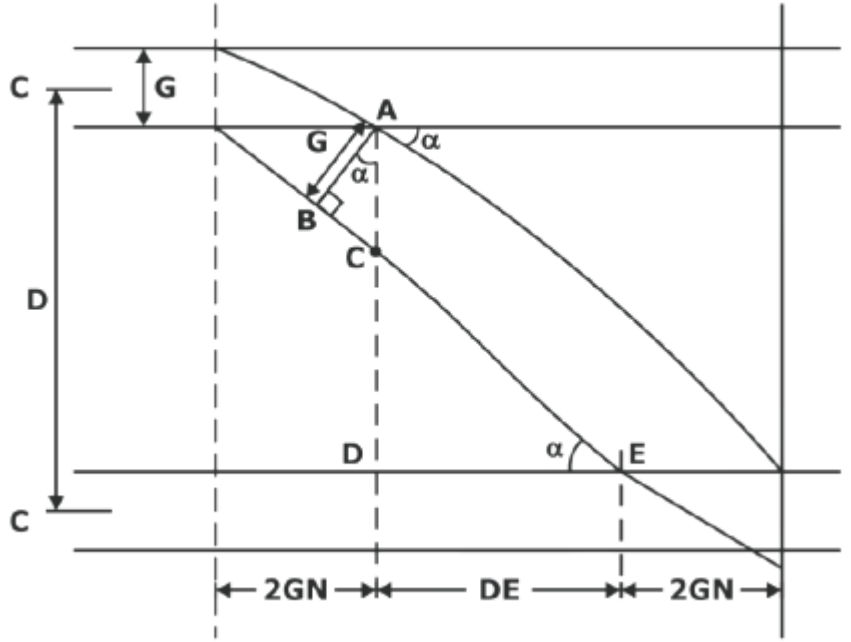
From ΔABC,

$$\cos\alpha = \frac{G}{AC} \Rightarrow AC = G\sec\alpha$$

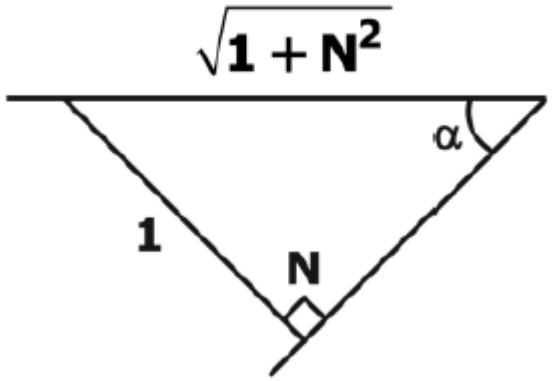
$$CD = \left(D - \frac{G}{2} - \frac{G}{2} - AC \right)$$

From ΔCDE,

$$\tan\alpha = \frac{CD}{DE} \Rightarrow DE = CD\cot\alpha$$



Also, we know



$$\tan\alpha = \frac{1}{N}$$

$$\cos\alpha = \frac{N}{\sqrt{1+N^2}} \qquad \sec\alpha = \frac{\sqrt{1+N^2}}{N}$$

$$\text{So } DE = \left(D - G - \frac{G\sqrt{1+N^2}}{N} \right).N$$

So total cross over length = 2GN + 2GN + DE

$$= 4GN + (D-G)N - G\sqrt{1+N^2}$$

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Hauling effect

Maximum functional force that can be generated between rail surface and driving wheels.

Hauling capacity = μWN

μ: Functional co-efficient

W: Load on each driving axle (in tonnes)

N: Number of pairs of driving wheel

Creep of Rail

Longitudinal movement of rails with respect to sleeper is called as creep of rails.

Drag , $P = AE \propto T$,

L: Length of rail in one direction, $L = (n - 1)s$

T : Temperature variation

$\propto$: Thermal coefficient

n: Number of sleepers required. {Ro: resistance offered by one single sleeper}

s: Spacing between two sleepers

Widening of Gauge on Curves

- A vehicle normally assumes the central position on a straight track and the flanges of the wheels stay clear of the rails.
- As soon as the vehicle moves onto a curve, the flange of the outside wheel of the leading axle continues to travel in a straight line till it rubs against the rail.
- Due to the coning of wheels, the outside wheel travels a longer distance compared to the inner wheel. This becomes axle to occupy a different position.
- In an effort to make up for the difference in the distance travelled by the outer wheel and the inner wheel, the inside wheels slip backward and the outer wheels skid forward.
- A close study of the running of vehicles on curves indicates that the wear of flanges eases the passage of the vehicle round curves, as it has the effect of increasing the gauge.

- The widening of the gauge on a curve has the same effect and tends to decrease the wear and tear on both the wheel and the track.

The widening of the gauge on curves can be calculated using the formula:

Extra width on curves, $w = \frac{13\,(B+L)^2}{R}$

B: wheel base of the vehicle, m

R: Radius of the curve, m

L: Lap of the flange, m

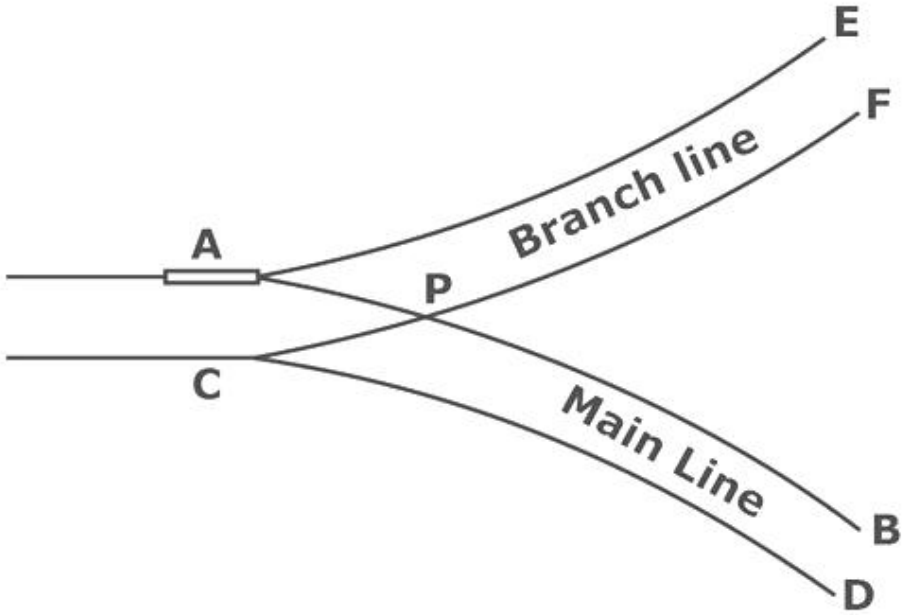
$$L = 0.02\,(h^2 + D.h)^{0.5}$$

h: Depth of flange below top of the rail

D: Diameter of the wheel of the vehicle.

Negative Superelevation

- When the main line lies on a curve and has a turnout of contrary flexure leading to a branch line, the superelevation necessary for the average speed of trains running over the main line curve cannot be provided.
- In the figure below, AB, which is the outer rail of the main line curve, must be higher than CD.
- For the branch line, CF should be higher than AE or point C should be higher than point A.
- These two contradictory conditions cannot be met within one layout.
- In such cases, the branch line curve has a negative super elevation and, therefore, speeds on both tracks must be restricted, particularly on the branch line.



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The provision of negative superelevation for the branch line and the reduction in speed over the main line can be calculated as follows:

i. The equilibrium super elevation for the branch line curve is first calculated using the formula:

$$e = \frac{GV^2}{127R}$$

ii. The equilibrium super elevation e is reduced by the permissible cant deficiency CD and the resultant super elevation to be provided is

$$x = e - CD$$

x: Superelevation e: Equilibrium superelevation

CD is 75 mm for BG and 50 mm for MG.

The value of CD is generally higher than that of *e* and hence *x* is normally negative. The branch line thus has a negative super elevation of *x*.

iii. The maximum permissible speed on the main line, which has a super elevation of *x*, is then calculated by adding the allowable cant deficiency *(x + CD)*. The safe speed is also calculated and smaller of the two values is taken as the maximum permissible speed on the main line curve.

- Railways are modernized with the objective of allowing heavier trains to run safely and economically at faster speeds and providing better customer service to rail users.
- It consists of upgrading the track, use of better designed rolling stock, adopting a superior form of traction, better signalling and telecommunication arrangements, and using other modern techniques in the various operations of a railways system.

A railway track is modernized by incorporating the following features in the track:

- Use of heavier rail sections such as 52 kg/m and 60 kg/m and the use of wear-resistant rails for heavily used sections so as to increase the life of the rails.
- Use of curved switches of 1 in 16 and 1 in 20 type for smoother arrival at yards.
- Use of prestressed concrete sleepers and elastic fastenings such as Pandrol clips to provide resilience to the track and ensure the smooth movement of trains at high speeds.
- Use of long welded rails and switch expansion joints to ensure a smooth and fast rail journey.
- Modernization of track maintenance methods to include mechanized maintenance, measured shovel packings, etc., in order to ensure better track geometry, to facilitate high speeds and smooth travel.
- Track monitoring using the Amsler car, portable accelerometer, Hallade track recorder, etc. to assess the standards of track maintenance and plan for better maintenance, if required.

Other aspects of modernization of the railways generally include making the following provisions:

- Use of better designed all-coiled, anti-telescope ICF coaches with better spring arrangements and better braking systems for safe and smoother rail travel.
- Provisions of universal couples to ensure uniformity in the coupling of the coaches.
- Introduction of diesel and electric traction in order to haul heavier loads at faster speeds.
- Introduction of modern signalling techniques to enable trains to move at high speeds without any risks.
- Setting up of a management information system for monitoring and moving freight traffic in order to avoid idle time and increase productivity.
- Computerization of the train reservation system to avoid human error and provide better customer service for reservation of berths.
- Use of computers and other modern management techniques to design and maintain railway assets more efficiently and economically, to ensure efficient human resource development (HRD), to increase productivity, and to provide better customer service.