

# 2019

## **RANK** Improvement **WORKBOOK**



**Answer key and Hint of  
Objective & Conventional Questions**

### **Civil Engineering**

Railway, Airport, Dock,  
Harbour & Tunnelling Engg.



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Publications

# 1

## Railway Track, Rails, Sleepers, Ballast and Formation

### LEVEL 1 Objective Questions

1. (a)
2. (b)
3. (c)
4. (a)
5. (a)

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### LEVEL 2 Objective Questions

6. (a)
7. (c)
8. (d)
9. (b)
10. (d)
11. (b)
12. (c)

**LEVEL 3** Conventional Questions

**Solution : 1**

- (i) Length of track required to overcome temperature stress = 63.5 km
- (ii) To prevent creep for equilibrium, the length of welded track = 127 km

**Solution : 2**

Sleeper density is defined as number of sleepers per rail length.

**It depends on following factors:**

- (a) Axle load
- (b) Traffic volume
- (c) Speed of traffic
- (d) Type of section of Rails
- (e) Type and strength of sleepers
- (f) Type and depth of ballast cushion
- (g) Bearing capacity of the formation.

Sleeper density is expressed as  $(n + x)$ ,

Where,  $n$  = Length of rail in meters

For BG, rail length,  $L = 12.8$  m

For MG, rail length,  $L = 11.89$  m

$x$  = Varies from 4 to 7 for IR network.

**Given data:**

Type of track = BG

Length of track = 640 m

Sleeper density =  $(n + 5)$

Length of a rail for BG = 12.8 m

Number of sleeper required = ?

Sleeper density of BG =  $(n + 5)$

Length for rail BG = 12.8 m (Given)

So, take  $n = 12.8$  m

SD for BG =  $(12.8 + 5)$

Number of sleeper required for 640 m length

$$= \frac{17.8}{12.8} \times 640 = 890 \text{ sleepers}$$

**Solution : 3**

**Functions of sleeper:**

- (a) transferring the load from rails to wider area of the ballast.
- (b) act as elastic medium between rail and ballast to absorb the blows and vibrations.
- (c) keep gauge and alignment of railtrack correct.
- (d) provides firm and even support to rails.
- (e) providing lateral and longitudinal stability to permanent way.
- (f) provide means to rectify track geometry during maintenance.

**Ideal requirements of a railway sleeper:**

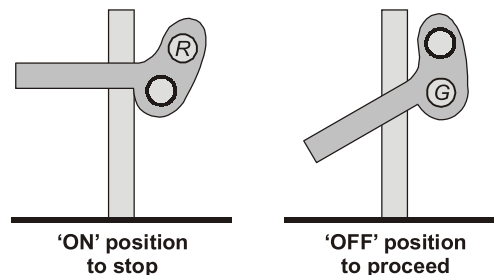
- Sleeper should have sufficient bearing area and able to resist/ absorb vibrations and shocks.
- Sleeper weight should be moderate so rails fixing and removing can easily done.
- Design of sleeper and fastening should be such that it is easily possible to maintain, adjust gauge properly.
- They should allow and not get damaged during ballast packing below them.
- They should allow track circuiting.
- Their construction and maintenance cost should be minimum.
- The sleepers should have anti-subotage and anti theft qualities.

**Solution : 4****Functions of rail in a railway track:**

- It provides continuous and even surface for smooth movements of trains with very less friction.
- Rails serve as lateral guide for running wheels.
- Rails transfer the vertical axles load to larger area of sleeper to formation and ballast.
- The rails bear the stress due to vertical axle's load as well as dragging force and thermal stresses.

**Requirements of an ideal rail section:**

- Rail should have most economical section with sufficient strength, stiffness and durability.
- Rail consists of a head, web, foot. Metal distribution in various components should be such that they are able to fulfill their requirements.
- Head should be sufficiently deep to allow for vertical wear and it should be sufficiently wide to provide wider running surface and lateral stiffness.
- Web should be sufficiently thick to withstand and transfer the vertical load.
- Foot should be sufficiently thick to bear vertical and horizontal forces. It should be sufficiently wide to protect against over turning of rail.
- Fishing angles should be such that it must ensure proper transmission of load and allow tightening of fish plate without additional stresses.

**Sketch of semaphore signal:****Solution : 5****Important elements of a modern railway track:**

- |               |                             |
|---------------|-----------------------------|
| (a) Rails     | (b) Fixtures and fastenings |
| (c) Sleepers  | (d) Ballast                 |
| (e) Formation | (f) Sub-grade               |

**Function of ballast in a railway track:**

- to transfer distribute the load from sleeper to a larger area of formation.
- to provide longitudinal and lateral stability to rails of track.

- (c) to provide elasticity and resilience to track for better comfortable ride.
- (d) to keep track above soil and better drainage
- (e) to provide flexibility to maintain evenness and alignment of track.

**Maintenance of ballast in high speed track:**

- (a) maintenance of ballast in high speed track should be mechanical process as it is more efficient and effective.
- (b) for time to time packing of ballast, tamping machine should be used to provide stability to track and maintain its geometry.
- (c) Ballast cleaning is need be done by on track machine unit to clean fouled ballast and to maintain their drainage property. In this process ballast at track shoulder is cut up to right depth, it is cleaned and replaced by different sections of machine.
- (d) renewal of ballast is done by dumper and undercut machine time to time after several time cleaning ballast is detoriated to such a level that it cannot be cleaned and placed again. In case, new ballast is just dumped over the track, then track is lifted to desired level and old ballast is cut by under cut machine.



# 2

## Station Yard Layout and Equipment Train Resistance and Power of a Locomotive, Signals and Interlocking

### LEVEL 1 Objective Questions

1. (c)

2. (c)

3. (a)

4. (a)

5. (b)

9. (a)

7. (c)

8. (b)

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### LEVEL 2 Objective Questions

9. (d)

10. (b)

11. (b)

12. (b)

13. (c)

14. (b)

15. (d)

16. (b)

17. (c)

**LEVEL 3** Conventional Questions

**Solution : 1**

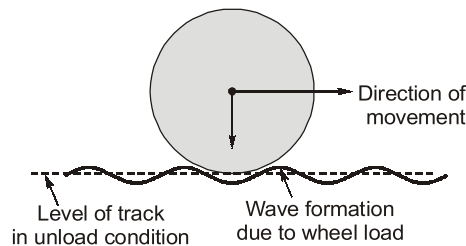
Steepest gradient permissible is 1 in 60.

**Solution : 2**

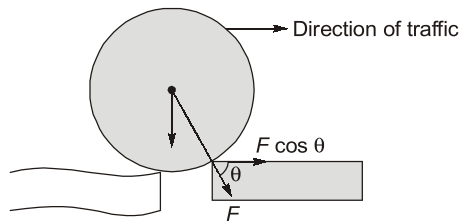
Creep is defined as longitudinal movement of the rail with respect to sleepers, due to movement of traffic over a period of time.

**Reason of creep:**

- (a) **Wave motion theory:** due to wheel load a wave in rail is created in direction of traffic, resulting in creep.



- (b) **Percussion theory:** Due to horizontal component of (load + kinetic) force  $F$ , at expansion joint, creep is observed.



- (c) **Dragging Theory:** Due to friction force between wheel & rail a drag force generate opposite to movement of train, resulting in creep.  
 (d) Due to braking & acceleration (skidding + slipping).

**Following are some of avoidable causes of creep:**

- (a) Rail are not property fastened with sleepers.
- (b) Loose packing of ballast around sleepers.
- (c) Improper expansion gaps.
- (d) Too light rail for heavy traffic
- (e) Sharp gradients and sharp curves.
- (f) uneven spacing of sleepers etc.

**Preventive and remedial measures of creep:**

- (a) rails should be firmly held to sleepers.
- (b) bearing load fastenings should always be slightly more than the ballast resistance.
- (c) ballast should be properly packed specially around sleepers and shoulders.
- (d) use of creep anchors at adequate interval.

- (e) When creep became excessive ( $> 150$  mm) causing maintenance problems. The same should be adjusted by pulling back manually or mechanically. During pulling back operation survey of expansion joint, gaps and rail to rail joint with sleepers should be carried out properly.

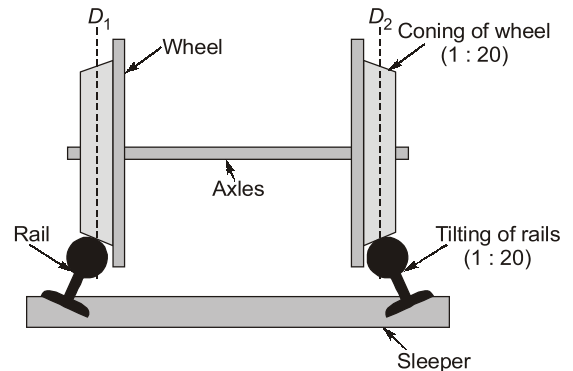
**Solution : 3**

**Coning of wheels:** The surface (tread) of the wheels of a railway are not made flat instead they are sloped at 1:20 in cone shape. This is called coning of wheels.

**Tilting of Rails:** The rails in track are tilted inward at an angle of 1 in 20 (same as coning of wheels) to reduce wear tear of rails as well as wheels.

Necessity and effects of coning of wheel and tilting of rails.

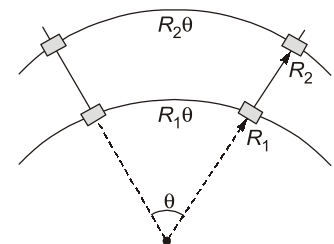
Coning helps in movement of train on a straight track as well as on a curved track.

**1. On a straight track:**

- On straight and level track coning helps to keep train in central position. The wheel assembly axle is forced to move just in central position, such that diameters of wheel on both rails are exactly same ( $D_1 = D_2$ ).
- If the train moves sideways in any direction, dia of wheel on one rail will increase and decrease on other rail, due to which the axle will start moving on a circular path, forcing axle to come back in its original central position.

**2. On the curved track:**

- On curved track due to centrifugal force the train will move sideways thus the diameter of wheel on outer rail will increase.
- On a curved track the distance required to be travelled on outer rail ( $R_2 \theta$ ) is more than that on inner rail ( $R_1 \theta$ ).
- The distance is partly adjusted by coning and the train starts moving on circular track as required due to difference of dia on two rails.

**Solution : 4**

**Function of a Marshalling yard :** Important functions of a marshalling yard are,

- Reception
- Sorting
- Departure

In marshalling yard trains are received in reception siding then they are sorted out in sorting siding and new trains are formed, which are kept in departure siding to be dispatched on wards to their destinations.

For efficiency working of marshalling yard, the following factors must be considered.

- Marshalling yard should be located in a such a way that shunting operation don't disturb the time table of the regular trains.
- Design of marshalling yard should be such that maximum number of wagons, may be sorted and dispatched in given time.

3. Movement of wagons should be in only one direction in marshalling yard.
4. Marshalling yard should be kept parallel to running lines.
5. Marshalling yards should be properly lighted, transship platforms for exchange of goods, should be provided on one or more siding of the marshalling yards.
6. In designing marshalling yard, its future extension for increased good traffic should be kept for provision.

**Solution : 5**

Following are the various type of railway yard:

1. **Passenger yards:** The main functions of passenger yards is to provide facilities for safe movement of passengers and passenger wagons. Passenger platform are used as passenger yard. At terminal stations and station junction, separate siding are provided to accommodates passenger trains during their idle period and also for washing, cleaning and storing the vehicle.
2. **Goods yards:** The yards which are provides for receiving, loading and unloading of the goods and for the movement of goods vehicles, are called goods yards. Goods platforms are treated as goods yards. Separate goods siding are generally provided for storing and delivery of goods at important stations.
3. **Marshalling yards:** The arrangement made with an elaborate set of sidings for reception, sorting and dispatching wagons (Both goods and passenger) at important station according to traffic requirement, is called Marshalling yards. It is classified into flat, gravitations and hump yard.
4. **Locomotive yards:** The yards in which locomotive are housed for surviving and also for coaling, watering, rearing, cleaning, fueling etc are called locomotive yards.

Devices and equipment used in station yards

1. Booking, enquiry office, luggage room, cloak room, waiting room for passengers.
2. Washing line, sick line facilities
3. Facilities like footover bridge to passing a through train.
4. Plateform, siding for shunting operation.
5. Cart weighing machine in goods yards
6. Cranes for loading and unloading of cargo
7. Vaccum testing machine.
8. Hydrauling jack for lifting operation in locomotive yard.
9. Turn table
10. Ash pit etc.

**Solution : 6**

Gradient of BG track is 1 ub 170.45.



# 3

## Geometric Design

### LEVEL 1 Objective Questions

1. (d)
2. (b)
3. (c)
4. (b)
5. (c)

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### LEVEL 2 Objective Questions

6. (357)
7. (c)
8. (c)
9. (a)
10. (c)
11. (a)
12. (d)

**LEVEL 3** Conventional Questions**Solution : 1**

The restricted speed on main track = 67.4 kmph say 65 kmph.

**Solution : 2**

Permissible speed,  $V_{\max} = 55.78 \text{ km/hr}$

**Solution : 3**

Maximum permissible speed is given as 96 kmph.

**Solution : 4**

Maximum permissible value of cant deficiency is 7.6 cm.

**Solution : 5**

Length of transition curve = 47.52 m

**Solution : 6****Part-1:** For first part function of sleeper:**Functions of sleeper:**

- (a) transferring the load from rails to wider area of the ballast.
- (b) act as elastic medium between rail and ballast to absorb the blows vibrations.
- (c) keep gauge and alignment railtrack correct.
- (d) provides firm and even support to rails.
- (e) providing lateral and longitudinal stability to permanent way
- (f) provide means to rectify track geometry during maintenance.

**Material used for sleepers:**

- (a) concrete
- (b) Steel
- (c) Cast iron
- (d) Wood

**PART-2**

- (i) Radius of curvaure = 595.5 m
- (ii) Degree of curvature = 2.88
- (iii) Super-elevation = 14.6 cm
- (iv) Length of transition = 106.38 m

**Solution : 7**

Transition curve is varying radius curve introduced between a straight portion and curved portion of a track.

**Transition curve is provided to serve following purpose:**

1. to increase the radius of curvature gradually from infinite at straight curve to that of circular curve so vehicle can negotiate curve smoothly.
2. to provide superelevation in a gradual manner with in the length of transition curve.
3. to increase/ decrease centrifugal force  $mv^2/R$  in gradual manner to avoid sudden jerk.

**Requirement of ideal transition curve:**

- Transition curve should be perfectly tangential to its junction points.  
at straight junction radius of curve =  $\infty$   
at curved junction radius of curve =  $R$
- Rate of change of curvature ( $1/R$ ) should be same as rate of change of superelevation so full SE can be provided within the length of transition curve.

**Date given:**

$$R = 500 \text{ m};$$

1.

$$\begin{aligned} V_{\max} &= 4.35\sqrt{R-67} \\ &= 4.35\sqrt{500-67} \\ &= 90.52 \text{ km/hr} \end{aligned}$$

2.  $\therefore$ 

$$e_{\text{th}} = \frac{GV_{\max}^2}{127R} = \frac{1.676 \times 90.52^2}{127 \times 500} = 21.6 \text{ cm}$$

 $\therefore$ 

$$e_{\text{th}} = e_{\text{act}} + \text{CD}$$

Assume

$$\text{CD} = 7.6 \text{ cm}$$

$$\begin{aligned} e_{\text{act}} &= e_{\text{th}} - \text{CD} \\ &= 21.6 - 7.6 \end{aligned}$$

$$e_{\text{act}} = 14 \text{ cm}$$

Maximum permissible  $e_{\text{act}} \not\geq 16.5 \text{ cm}$ 

Provide

$$e_{\text{act}} = 14 \text{ cm}$$

length of transition curve

$$L = 7.2 e = 7.2 \times 14 = 100.8 \text{ m}$$

$$\begin{aligned} L &= 0.073 e U_{\max} \\ &= 0.073 \times 14 \times 90.52 = 92.5 \text{ m} \end{aligned}$$

$$\begin{aligned} L &= 0.073 \text{CD} V_{\max} \\ &= 0.073 \times 7.6 \times 90.52 = 50.22 \text{ m} \end{aligned}$$

Length of transition curve should be maximum that is = 100.8 m

Shift of the curve,

$$S = \frac{L^2}{24R} = \frac{100.8^2}{24 \times 500} = 84.6 \text{ cm}$$

Setting out of curve,

$$y = \frac{x^3}{6RL}$$

$$y = \frac{x^3}{6 \times 500 \times 100.8} = \frac{x^3}{302400}$$

$x(\text{m})$	0	30	60	90	100.8
$y(\text{hr})$	0	0.09	0.71	2.41	3.39

**Solution : 8**

- (a) (i) **Cant deficiency:** When actual cant is provided for an average or equilibrium speed, then the cant required for a high speed train will be more than provided one.

Cant difference between maximum cant required for high speed train and actual provided is called cant deficiency. When trains speed is more at curve than cant provided there, situation of cant deficiency for that will occur.

- (ii) **Negative superelevation:** When outer rail of a curved track is provided at relatively lower elevation as compared to inner rail, this is called a negative superelevation.

If a curved branch track is diverting from main track in opposite direction, then situation of negative superelevation occur because +ve SE for main track became -ve SE for branch track.

**(b)**

- (i) Super-elevation = 7.4 cm  
(ii) Speed on the branch = 43.8 km/hr



# 4

## Track Fastening, Points and Crossing

### LEVEL 1 Objective Questions

1. (d)
2. (b)
3. (a)
4. (c)

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### LEVEL 2 Objective Questions

5. (d)
6. (a)
7. (b)
8. (a)
9. (b)

**LEVEL 3** Conventional Questions

**Solution : 1**

1. Curve lead = 28.49 m
2. Radius = 243.85 m
3. Switch lead = 7.45 m
4. Lead = 21.04 m

**Solution : 2**

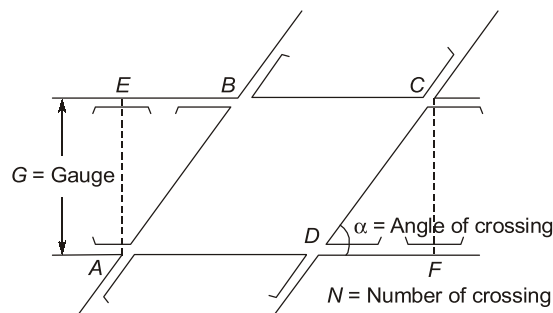
- (i) The intermediate straight distance = 13.91 m
- (ii) The overall length of cross-over = 70.894 m

**Solution : 3**

- (i) Number of sleeper required for 1 km of railway track = 1385
- (ii) Number of rail required = 153.84 say 154 rails  
 Number of pandrol/Elastic rail clip required = 5540 nos. clips  
 Number of fish plates required = 304 plates.  
 Number of nut and bolts = 608 nos.

**Solution : 4**

Diamond crossing:



Diamond crossing design:

Data given:

- Crossing and angle or crossing number = 1 in 10 Blood gauge track  
 $G = 1.676 \text{ m}$
- Crossing number,  
 $N = 10$
- Crossing angle,  
 $\alpha = \cot^{-1}(N)$   
 $= \cot^{-1}(10) = 5.71^\circ$
- Crossing,  
 $AB = BC = CD = DA$   
 $= G \operatorname{cosec} \alpha$   
 $= 1.676 \times \operatorname{cosec} (5.71^\circ)$   
 $= 16.845 \text{ m}$
- Distance,  
 $DF = BE = G \cot \alpha$   
 $= 1.676 \times \cot(5.71^\circ)$   
 $= 16.762 \text{ m}$

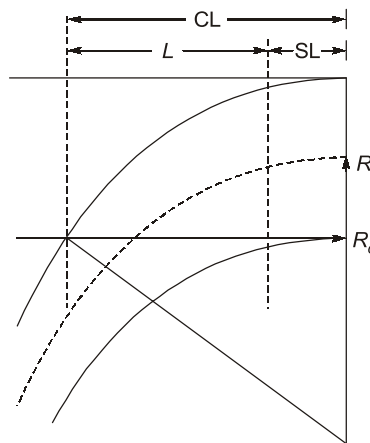
Diagonal,  $AC = G \operatorname{cosec} \frac{\alpha}{2} = 1.676 \times \operatorname{cosec} \left( \frac{5.71}{2} \right) = 33.649 \text{ m}$

Diagonal,  $BD = G \sec \frac{\alpha}{2} = 1.676 \times \sec \left( \frac{5.71}{2} \right) = 1.678 \text{ m}$

**Solution : 5**

Straight distance of track/crossover,  $S = 19.71 \text{ m}$

Total length of crossover,  $L = 100.16 \text{ m}$

**Solution : 6**

Date given,  $BG$ :

$\Rightarrow G = 1.676 \text{ m}$

1 in 12 crossing:

$\Rightarrow N = 12$   
 $\alpha = \cot^{-1}(N)$   
 $= 4^\circ 45' 49.11''$  or  $4.76^\circ$

Heel divergence,

$h = 11.4 \text{ cm}$

1.

Curve load,  $CL = 2 GN$   
 $= 2 \times 1.676 \times 12 = 40.224 \text{ m}$

2.

Radius,  $R_0 = 1.5 G + 2 GN^2$   
 $= 1.5 \times 1.676 + 2 \times 1.676 \times 12^2 = 485.202 \text{ m}$

$R = R_0 - \frac{G}{2} = 485.202 - \frac{1.676}{2} = 484.364 \text{ m}$

3.

$\delta L = \sqrt{2R_0 h} = \sqrt{2 \times 484.364 \times 0.114} = 10.51 \text{ m}$

4.

Lead,  $L = CL - SL = 40.224 - 10.51 = 29.715 \text{ m}$



**LEVEL 1** Objective Questions

1. (a)
2. (d)
3. (c)
4. (a)
5. (a)
6. (a)
7. (d)
8. (b)
9. (d)
10. (a)
11. (d)
12. (c)
13. (c)
14. (c)
15. (d)

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**LEVEL 2** Objective Questions

16. (d)
17. (d)
18. (c)
19. (a)
20. (c)
21. (a)
22. (b)
23. (a)
24. (d)
25. (a)
26. (d)
27. (b)
28. (b)
29. (b)

**LEVEL 3** Conventional Questions**Solution : 1**

Corrected runway length is 2150 m.

**Solution : 2**

Effective gradient of runway = 0.35 percent

**Solution : 3**

The design runway length = 2870 m

**Solution : 4**

Turning radius,  $R = 62.66$  m

The turning radius to be actually provided = 120 m.



# 6

## Port, Harbour, Dock and Tunnel

### LEVEL 1 Objective Questions

1. (d)
2. (a)
3. (c)
4. (b)
5. (d)
6. (a)
7. (a)
8. (a)
9. (d)
10. (d)
11. (d)
12. (a)
13. (a)

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### LEVEL 2 Objective Questions

14. (b)
15. (c)
16. (c)
17. (a)
18. (d)
19. (d)
20. (b)
21. (b)
22. (b)
23. (d)
24. (b)
25. (a)

