Transportation Engineering

Course Code –CE-422

Contact Hours -3+3

Dr Hassan Mujtaba

Widening of Gauge on Curves

- A vehicle normally assumes the central position on straight track and the flanges of the wheel stay clear of the rails.
- However, on the curved track, the flange of the outside wheel of the leading axle continue to travel in a straight line till it rubs against the rail. Due to coning of the wheel, the outer wheel covers a longer distance as compared to the inner wheel.

Widening of Gauge on Curves (cont'd)

- This however becomes impossible for the vehicle as a whole since the rigidity of the wheel base causes the trailing axle to occupy 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 wheel slip backward and outside wheel skid forward.
- A close study of the running of vehicles on the curves indicate that the wear of the flanges eases the passage of vehicle round the curves, as it has the effect of increasing the gauge on the curves.

Widening of Gauge on Curves (cont'd)

- The widening of gauge on the curve has the same effect and tend to reduce the wear and tear both on the wheel and the track.
- The widening of gauge on the curve can be calculated using

$$w = \frac{13 \times (B + L)^2}{R}$$

$$L = 0.02(h^2 + Dh)^{\frac{1}{2}}$$

Widening of Gauge on Curves (cont'd)

- *w* is in cm
- B is the wheel base of the vehicle in meters
- R is the radius of the curve in meters
- L is the lap of the flange in meters
- h is the depth of the flange below top of the rail in cm
- D is the diameter of the wheel of the vehicle in cm

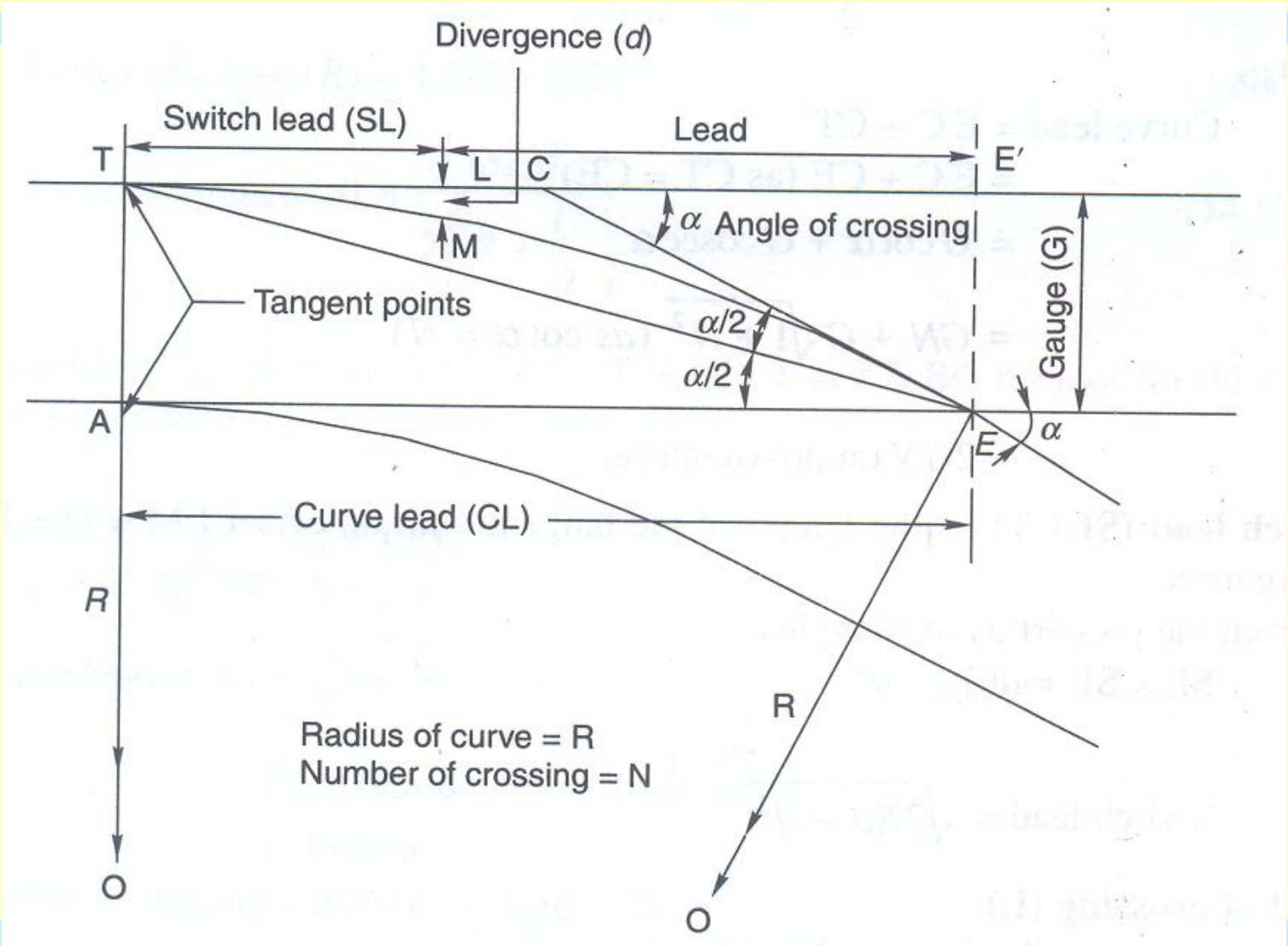
Problem

- The wheel base of the vehicle moving on a broad gauge track is 6 m. The diameter of the wheel is 1524 mm and the flange project 32 mm below the top of the rail. Determine the extra width of the gauge required if the radius of the curve is 168 m.

Layout of Turnout using Cole's Method

- The curvature begins from a point on a straight main track ahead of the toe of the switch at the theoretical toe of the switch (TTS) and ends at theoretical nose of crossing (TNC).
- The heel of the switch is located at the point where the offset of the curve is equal to heel divergence.

Turnout from Straight track



Notations used in the Figure

- Curve lead (CL)
- Switch Lead (SL)
- Lead of crossing (L)
- Gauge of the track (G)
- Angle of crossing (a)
- Heel divergence (d)
- Number of crossing (N)
- Radius of outer rail of turnout curve (R)

Formulae to calculate various lengths of turnout

- Curve Lead (CL) = 2GN
- Switch lead (SL) = $(2Rd-d^2)^{1/2}$
- Lead of crossing = $2GN-(2Rd-d^2)^{1/2}$
- Radius of curve (R) = $1.5G+2GN^2$
- Heel divergence, $d = \dfrac{(SL)^2}{2\left(R+\dfrac{G}{2}\right)}$

Problem

- Calculate the lead and radius of a 1 in 8.5 BG turnout using Cole's Method. Heel divergence is 120 mm.

- Calculate the lead and radius of a 1 in 10.5 BG turnout using Cole's Method. Heel divergence is 100 mm.

Maintenance Organization

- General Manager (GM)
- Divisional Superintendent (DS for each division)
- Divisional Executive Engineer (DEN)
- Assistant Executive Engineer (AEN)
- Work Manager (WM)
- Assistant Work Manager (AWM)

Gang Length and Gangmen

- Gang length is the basic organization unit for track maintenance and is under the charge of gang mate
- An average gang length on a single track is 3 miles.
- The number of gangmen for each gang depends on
  - Soil formation
  - Age and condition of track material
  - Intensity of traffic
  - Speed, curves and grades

Duties of Various Staff

- Mate - is the incharge of the railway property in a section. He is responsible for ordinary work of maintenance and safety of track. Controls the gang-men, sees the cleanliless and tidiness of track and yards.
- Keyman

The position of keyman is next to mate and generally take up the duties in the absence of mate. His duty is to go along the whole section walking on one side and returning on the other side and checking any discrepancies in the track. Responsible for inspection of all the fastenings and joints. His tools are keying hammer, bolt hammer, hand signals flag etc. The most important task is greasing the fish plates and oiling of fish bolts

Maintenance of Permanent Way

- Perception to determine bad running spots
- Facility to ascertain the cause of these defects
- Regularity of detailed inspection of track, to note these defects and to rectify them
- Overhauling of the track in-accordance with the instruction laid down
- Maintenance of Track consists of
  - Ballasting and surfacing
  - Aligning the track
  - Proper drainage
  - Careful attention to track constituents

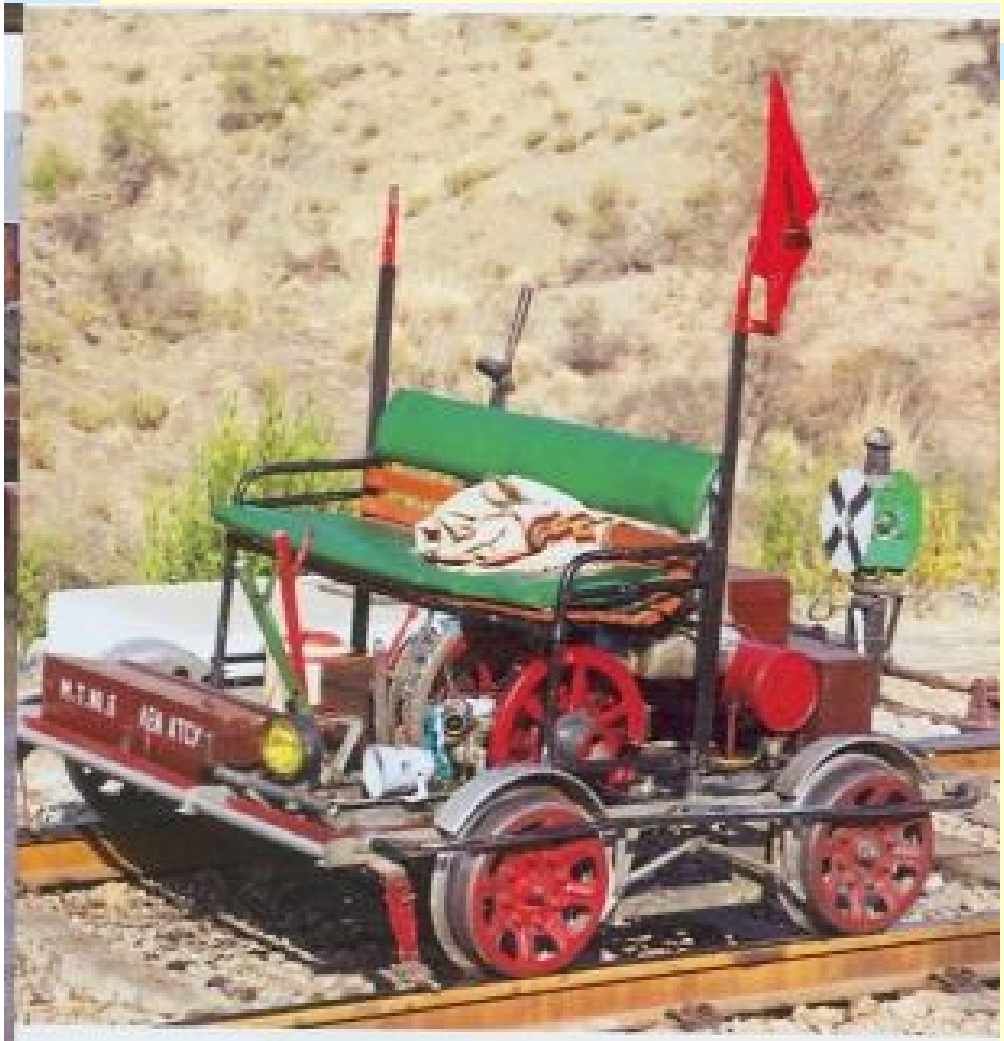
Ballasting and Surfacing

- Ballast under the sleeper get loose and depression appear in the plane of rails
- The joints, which are subjected to constant blows from passing wheel are particularly affected.
- On soft formations, the whole rail length get depressed.
- The frequency of ballast depends upon condition of ballast, riding quality of track, traffic density and train speed over section.

Alignment of Track

- Due to side movement of vehicle over the track, the wheel flanges exerts a side thrust on the side of rails.
- When this thrust is of fair magnitude, the track is pulled out of alignment.
- If this defect is not rectified and alignment is permitted to become irregular, the quality get badly affected.
- The maintenance on curve is either repacking or re-alignment

Alignment of Track



A motorized trolley for the use of the Assistant Executive Engineer for inspecting tracks.

A motorized trolley for the use of the Assistant Executive Engineer for inspecting track

Maintenance on Bridges

- Special care is required for maintenance of track fastening on bridges.
- At the junction of the bridge girder with the bank, there is a considerable change in the resiliency of track.
- Sleepers on the bridges are spaced so that derailed wheel cannot fall through.
- The bearing of the girder is coated with oil from time to time

Removal of Weeds and Bush

- Presence of weed and bush is a constant source of trouble to the maintenance staff.
- For proper functioning, it is to be kept clean of weeds because there presence stop drainage, collects and retains dust and with subsequent decay fills the ballast voids and clogs them.

Process of Over hauling

- Opening of track
- Conditions of sleepers, fastening and other fittings
- Re-gauging
- Packing
- Straightening
- Drainage
- Final straightening and packing
- Boxing
- Making up of formation

Tools for Maintenance

- Beater cum pickaxe to pack the ballast under the sleeper
- Rail gauge for checking the gauge
- Cant board to provide super elevation
- Spirit level and height board for testing cant
- Spanners for tightening and loosening fish bolts
- Auger for drilling spike hole
- Jim crow for bending of rails
- Ballast screen
- Keying Hammers
- Fog Signals

Railway Track Drainage

- A slight increase in the moisture content would considerably reduce the bearing power of the subgrade.
- This may even cause the subgrade to become unstable.
- The ingress of water in case of roads is checked by bituminous treatment on the surface where as for railways it is not possible

Need for Proper Track Drainage

- Settlement of embankment
  - Excess water may cause the embankment to settle. An unequal settlement may lead to variation in cross levels as well as longitudinal levels thereby affecting the safety and riding quality of track.
- Reduction in bearing capacity of soil
- Failure of embankment
  - Percolation of water increases the weight of soil on one hand and on the other hand reduces its shear resistance

Need for Proper Track Drainage

- Formation of ballast pockets
  - Excess moisture leads to puncture in the formation. The constant hammering action of running trains causing the sleepers to move up and down resulting in ballast pockets, pumping sleepers and other such problems.
- Shrinkage and cracking of banks
  - The embankment soil cracks and shrinks once excess water dries up. This problem become acute in case of poor soils resulting in loss of ballast in the cracks and uneven settlement.

Ingress of Water

- Water from rain
- Capillary action from subsoil
- Water seeped below the track from adjoining area
- Water retained by the soil mass due to hydroscopic action

<u>Drainage System</u>

- Surface Drainage
- Sub-surface Drainage

Surface Drainage

- By providing side drains
- By provision of cross drainage works e.g bridges and culverts

X-Section of Side Drain

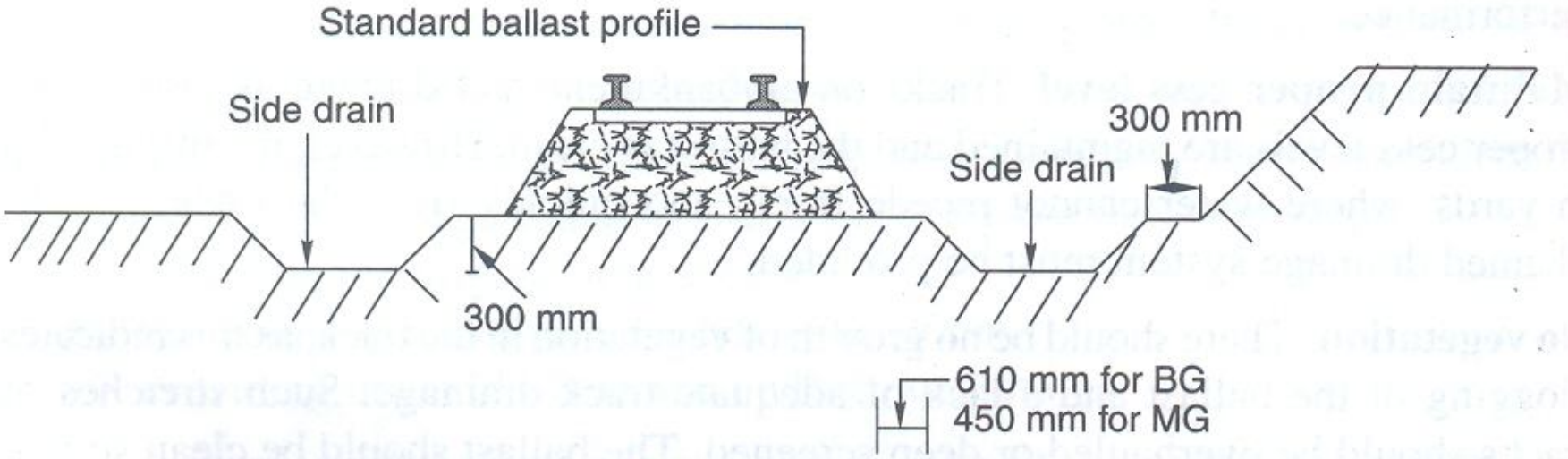


Fig. 19.1 Typical cross section of side drain

Open Drain Between Tracks

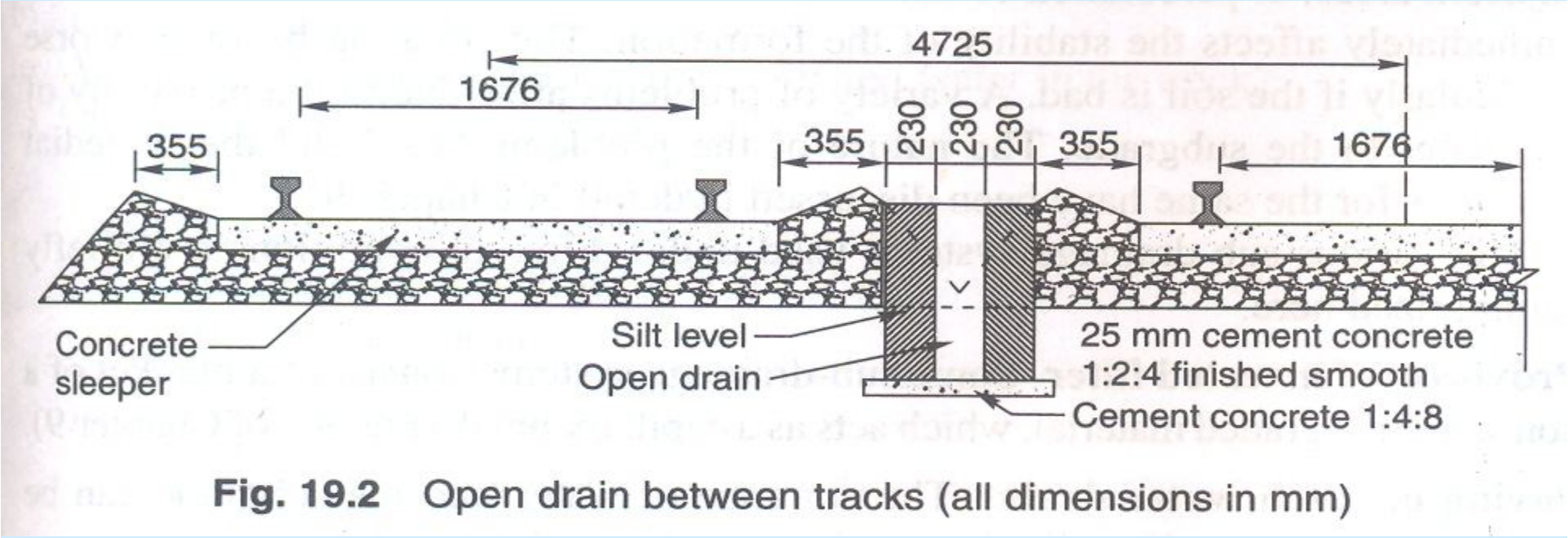


Fig. 19.2 Open drain between tracks (all dimensions in mm)

Sub-Surface Drainage

- Seepage water from adjoining area
  - By lowering GWT
  - By using catch drain at the top of cutting
- Due to capillary action
  - By providing pervious layer in the embankment
  - By providing inverted filter
- Provision of inverted filter
  - It consists of a blanket of a non-cohesive graded material, which acts as a capillary break.

Inverted Filter and Underground Drainage

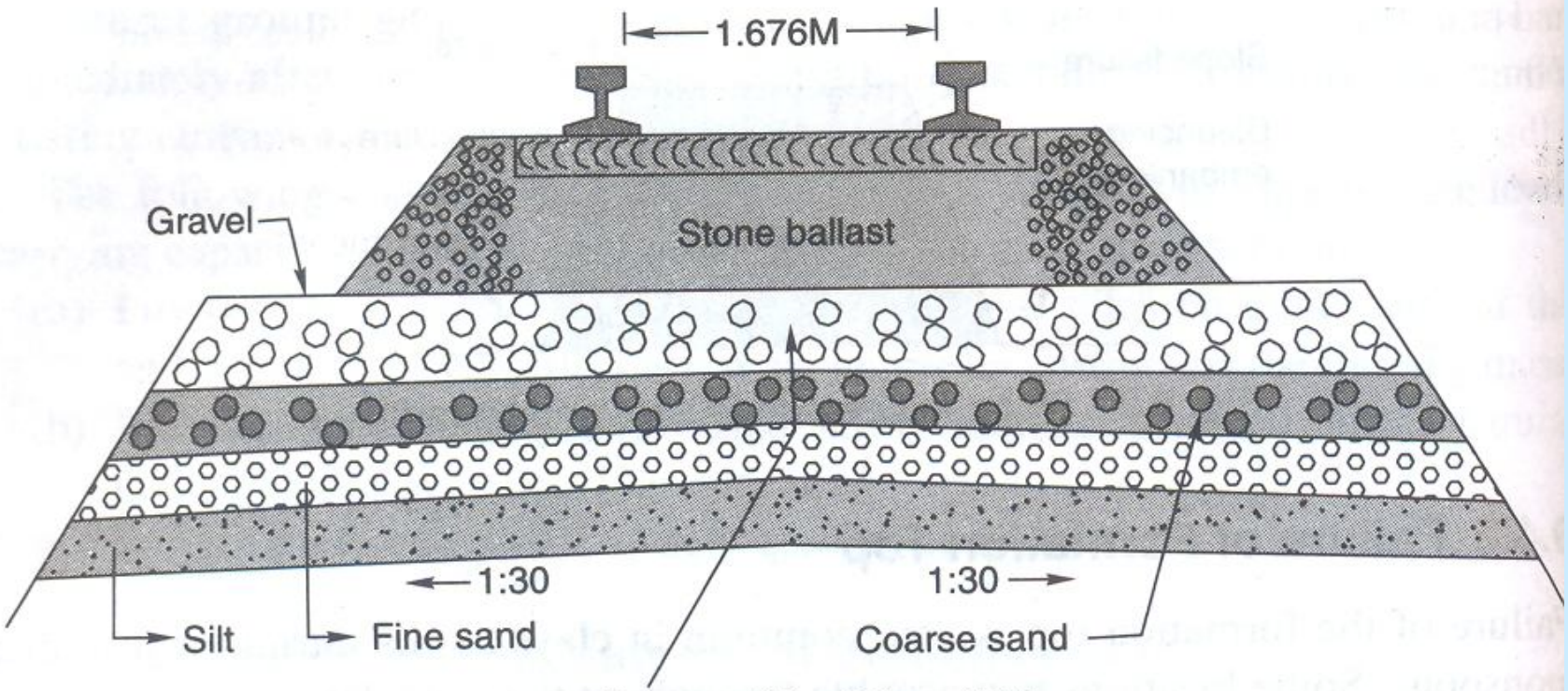


Fig. 9.3 Inverted filter and underground drainage

Sub surface drainage (cont'd)

- Paving of catch water drains
  - The entrance of water into subgrade can be checked by constructing effective catch water drains that are duly paved.
- Provision of sand piling
  - Some drainage systems are provided with an adequate number of sand piles of diameter about 20 cm. This improves sub surface drainage

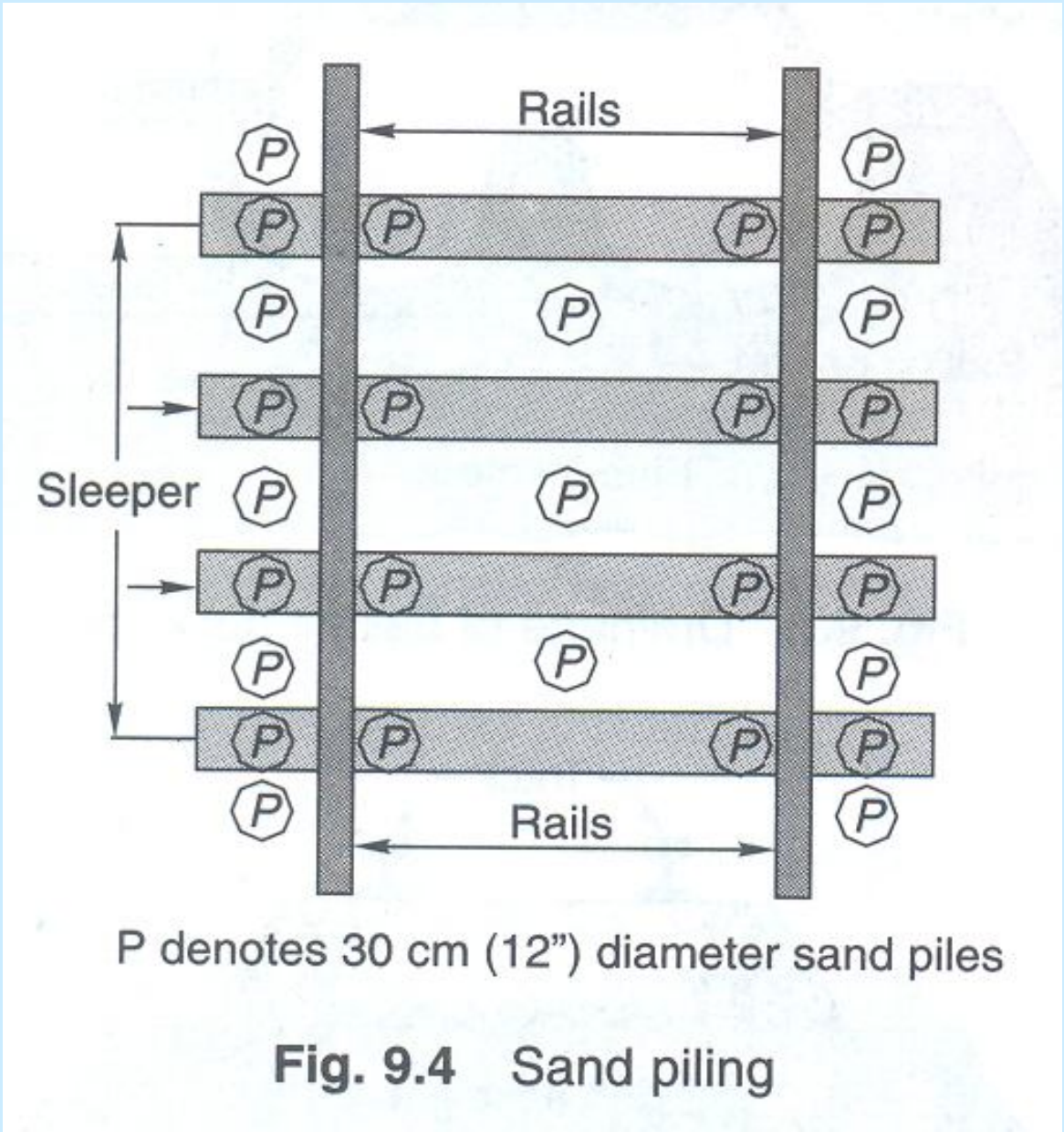


Fig. 9.4 Sand piling

Sub surface drainage (cont'd)

- Drainage of water pockets by perforated pipes
  - Perforated pipes having diameter of about 30 cm are provided at appropriate places to drain off water pockets.
- Drainage of water pockets by puncturing holes
  - In special situations holes are punctured in the impervious layer to drain away the water.

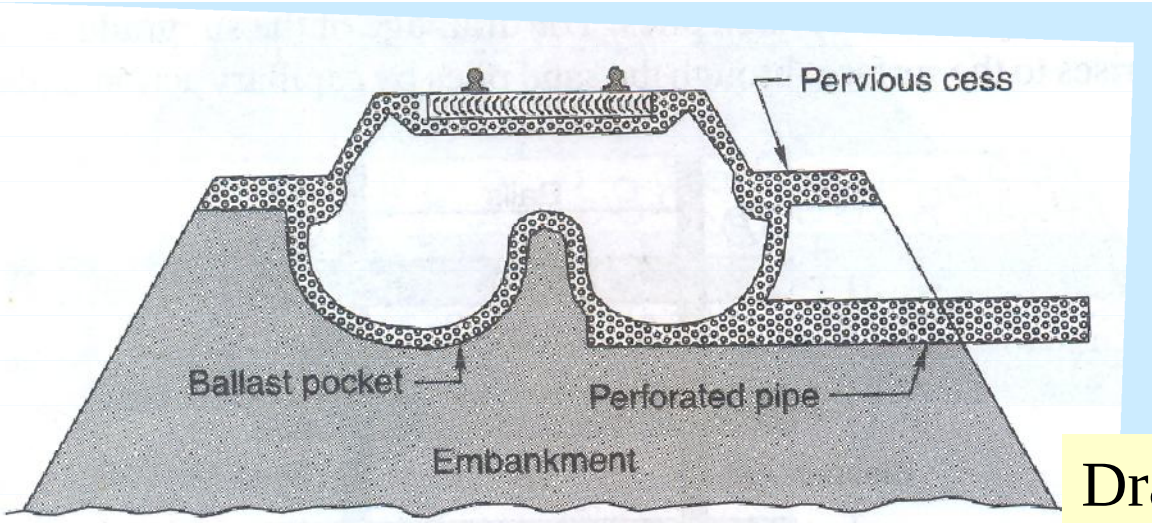


Fig. 9.5 Drainage of ballast pockets

Drainage of Ballast Pockets by Puncturing Holes

Drainage of Ballast Pockets by Perforated Pipes