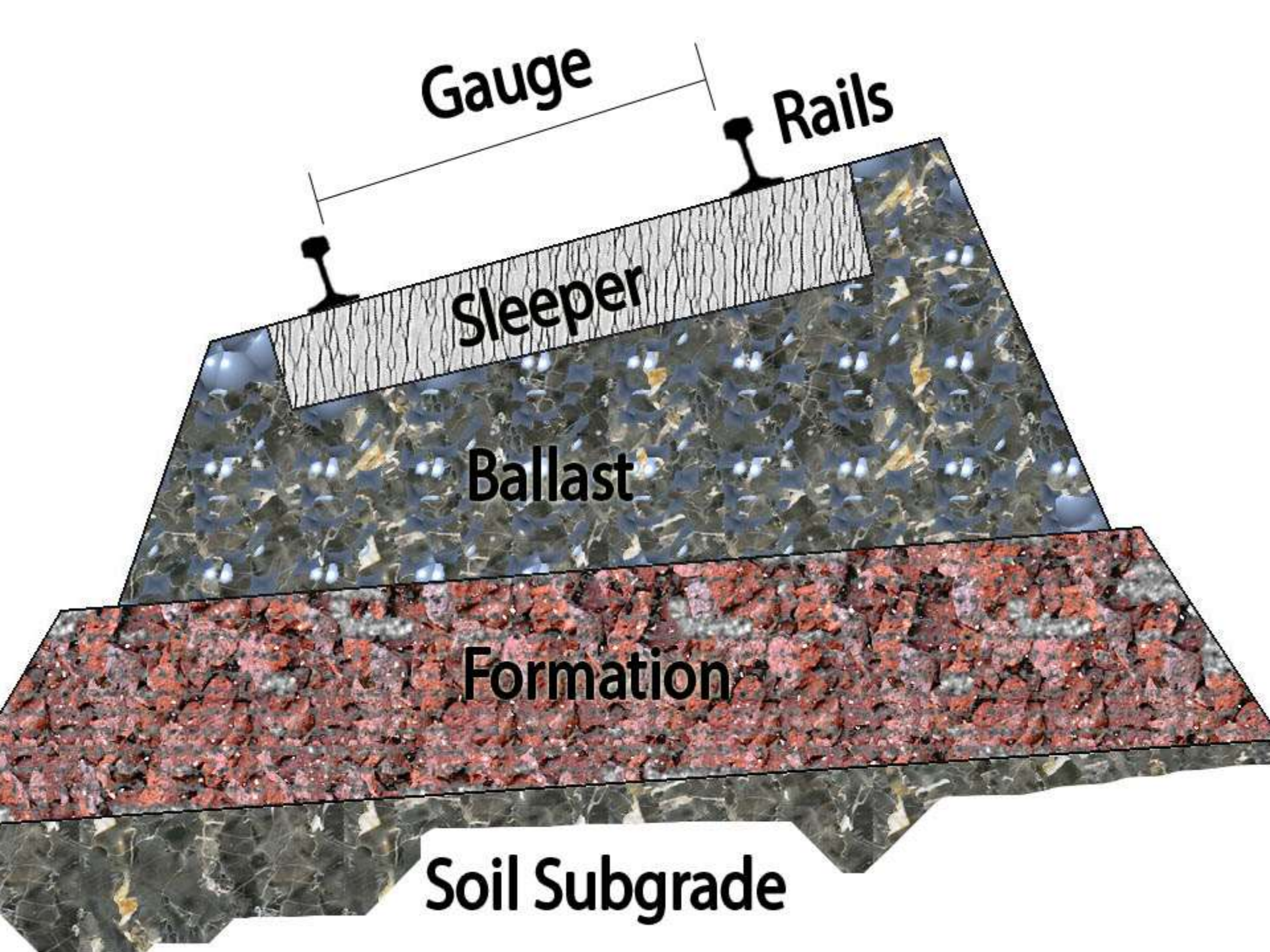
# CE8702
# RAILWAYS, AIRPORTS,DOCKS & HARBOUR ENGINEERING

# UNIT I

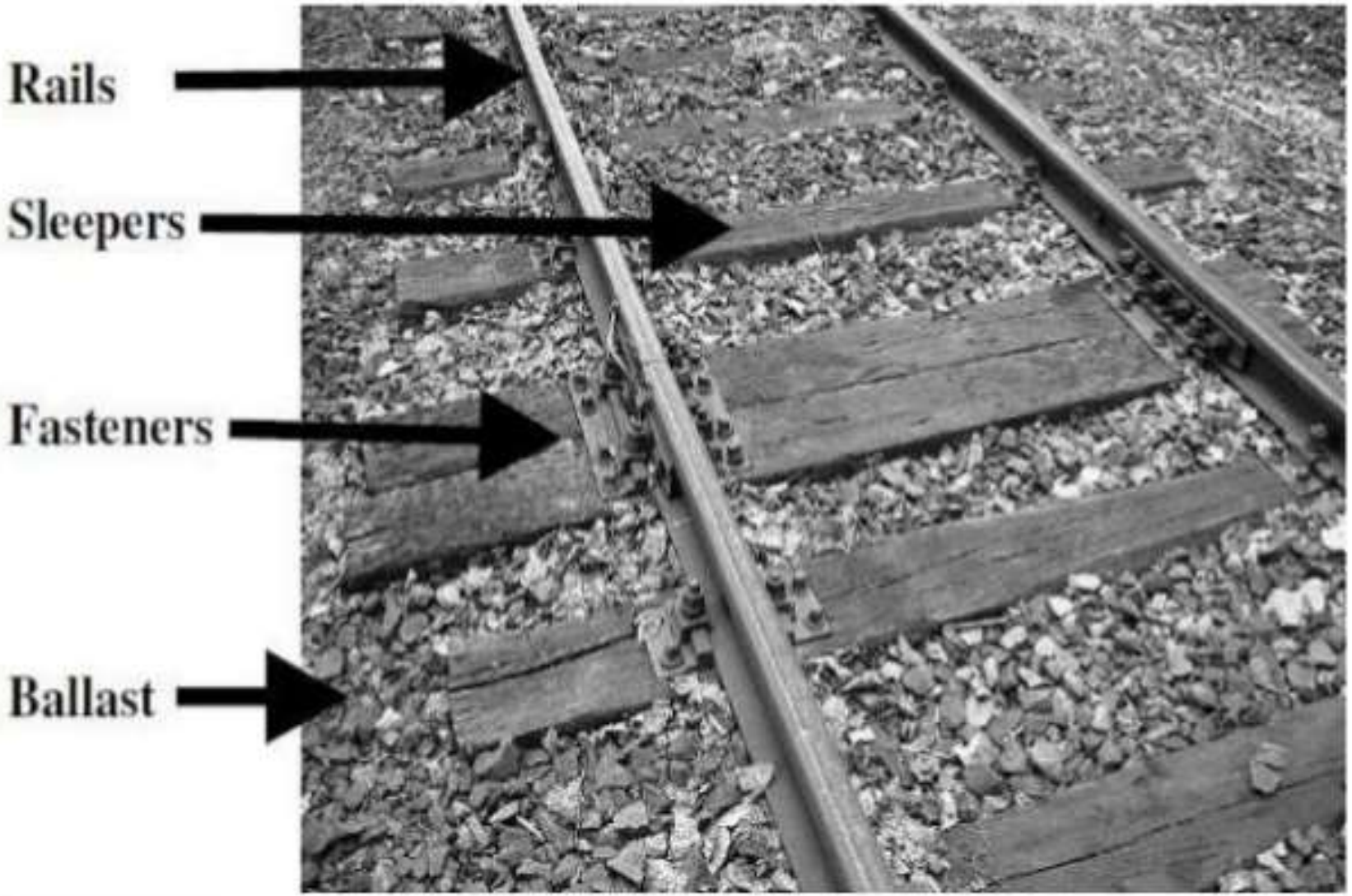
# RAILWAY PLANNING

# *RAILWAY ENGINEERING*

The branch of Civil Engineering which deals with the design, construction and maintenance of the railway tracks for safe and efficient movements of trains is called Railway Engineering

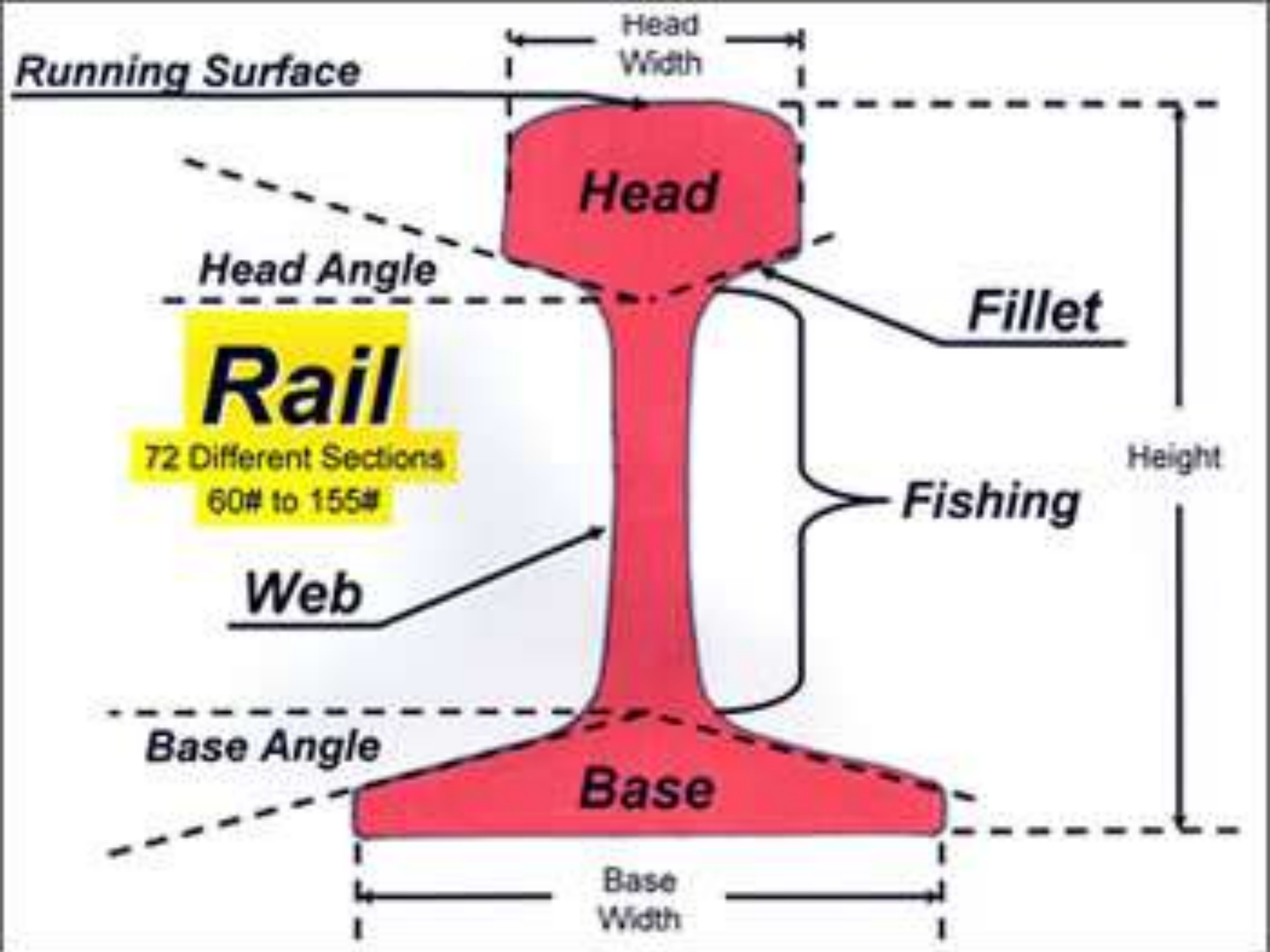

Gauge
Rails
Sleeper
Ballast
Formation
Soil Subgrade

# Track components



# RAILS

The rolled steel sections laid end to end in two parallel lines over sleepers to form a railway track are known as **RAILS.**


Head
Width
Running Surface
Head
Head Angle
Fillet
Rail
72 Different Sections
60# to 155#
Height
Fishing
Web
Base Angle
Base
Base
Width

# TYPES OF RAILS :-

The rails used in the construction of railway track can be divided into the following three types :

(1) Double Headed Rails (D.H. Rail)

(2) Flat Footed Rails (F.F. Rail)

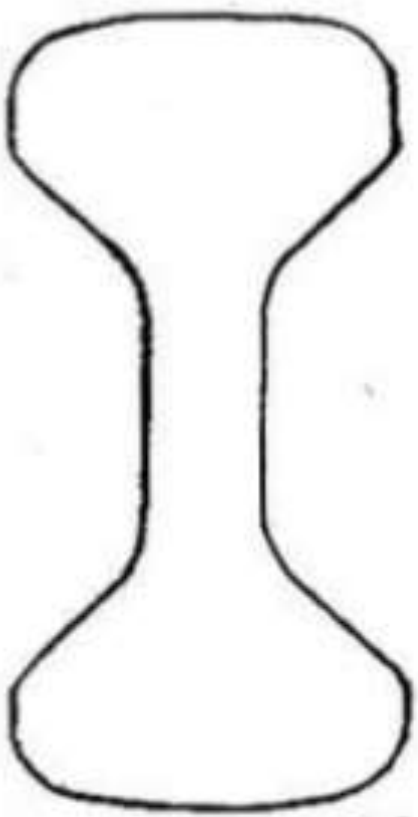
(3) Bull Headed Rails (B.H. Rail)

# 1. DOUBLE HEADED RAIL :-

The rails having their head and foot of same dimensions are known as **double headed rail (D.H.).**

# Double headed Rails

- Now practically out of use
- Length varies from 610 to 732cm
- Wrought iron was used to manufacture these rails



# 3. BULL HEADED RAIL :

The rails sections having their head of more dimension then that of their foot are known as **bull headed rails (B.H.).**

# Bull Headed Rails

- The foot is designed only to properly hold the wooden keys with which the rails are secured to chairs.
- Only to provide necessary strength to the rail
- 2 cast iron chairs are required for each sleeper.


BULL HEAD RAIL

# 2. FLAT FOOTED RAILS :-

The rail section having their foot rolled to a flat are known as **flat footed rails.**

# Flat footed rail

# RAIL JOINTS

1.FISH PLATE JOINT

2.FASTENERS JOINT

3.SLIDE CHAIARS JOINT

4. JUNCTION PLATE JOINT

5.BEARING PLATE JOINT

6.CHAIRS

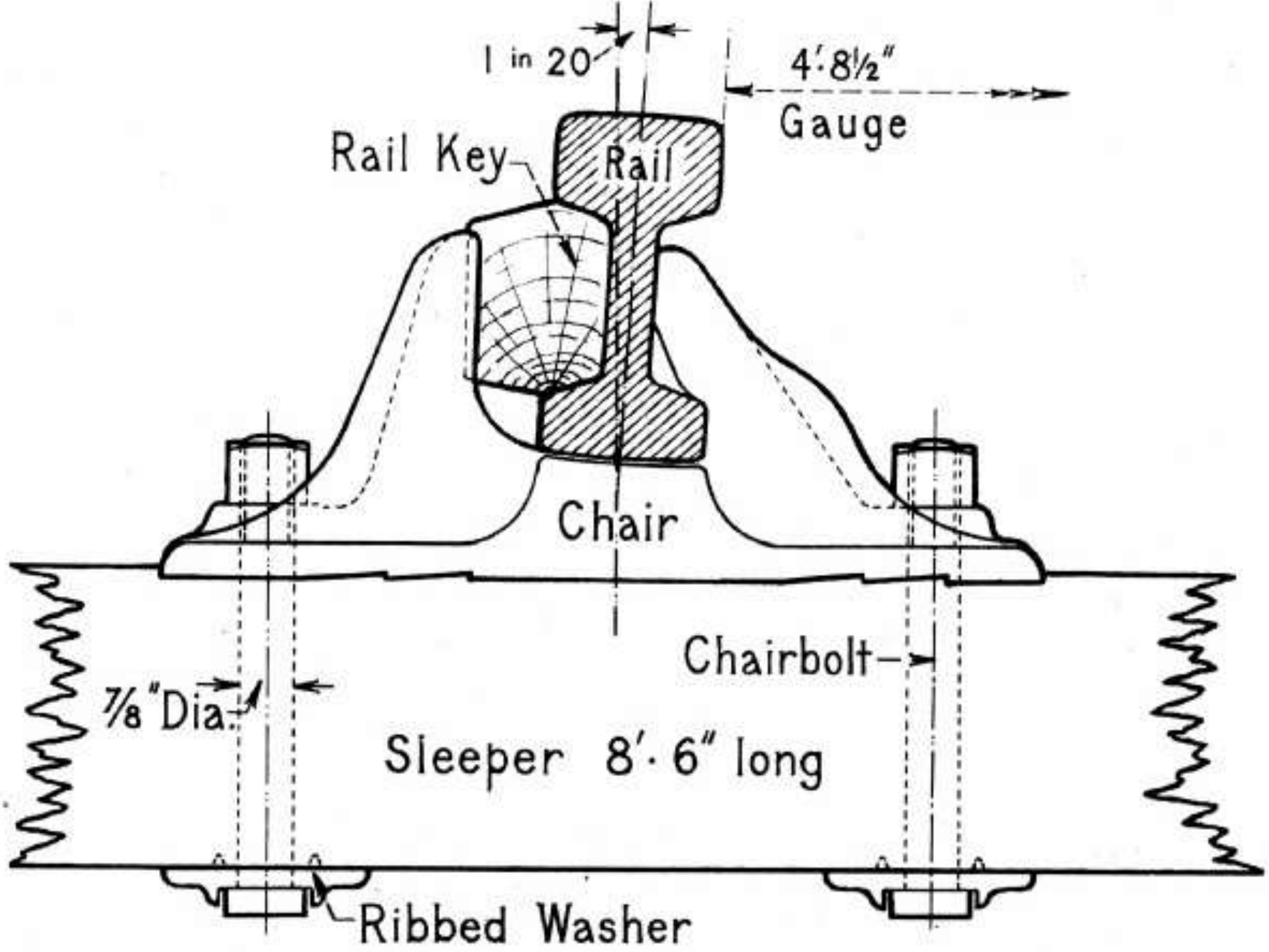
# FISH PLATE JOINT

# FASTENERS JOINT

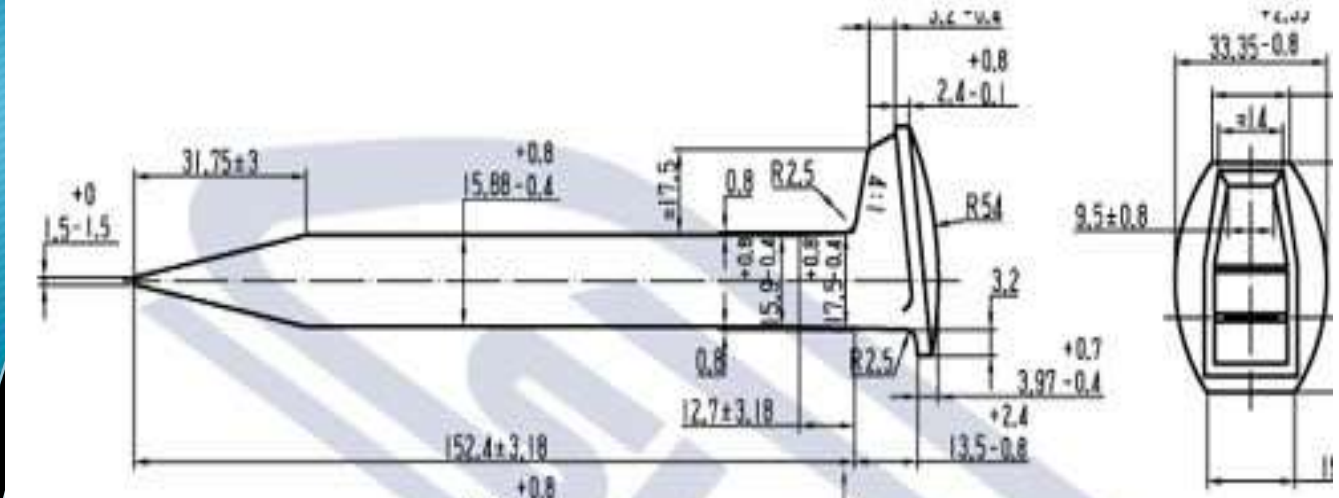
# SLIDE CHAIARS JOINT

# JUNCTION PLATE


SORA
15


1 in 20
4'·8½"
Gauge
Rail Key
Rail
Chair
Chairbolt
⅞" Dia
Sleeper 8'·6" long
Ribbed Washer


TBS
1905



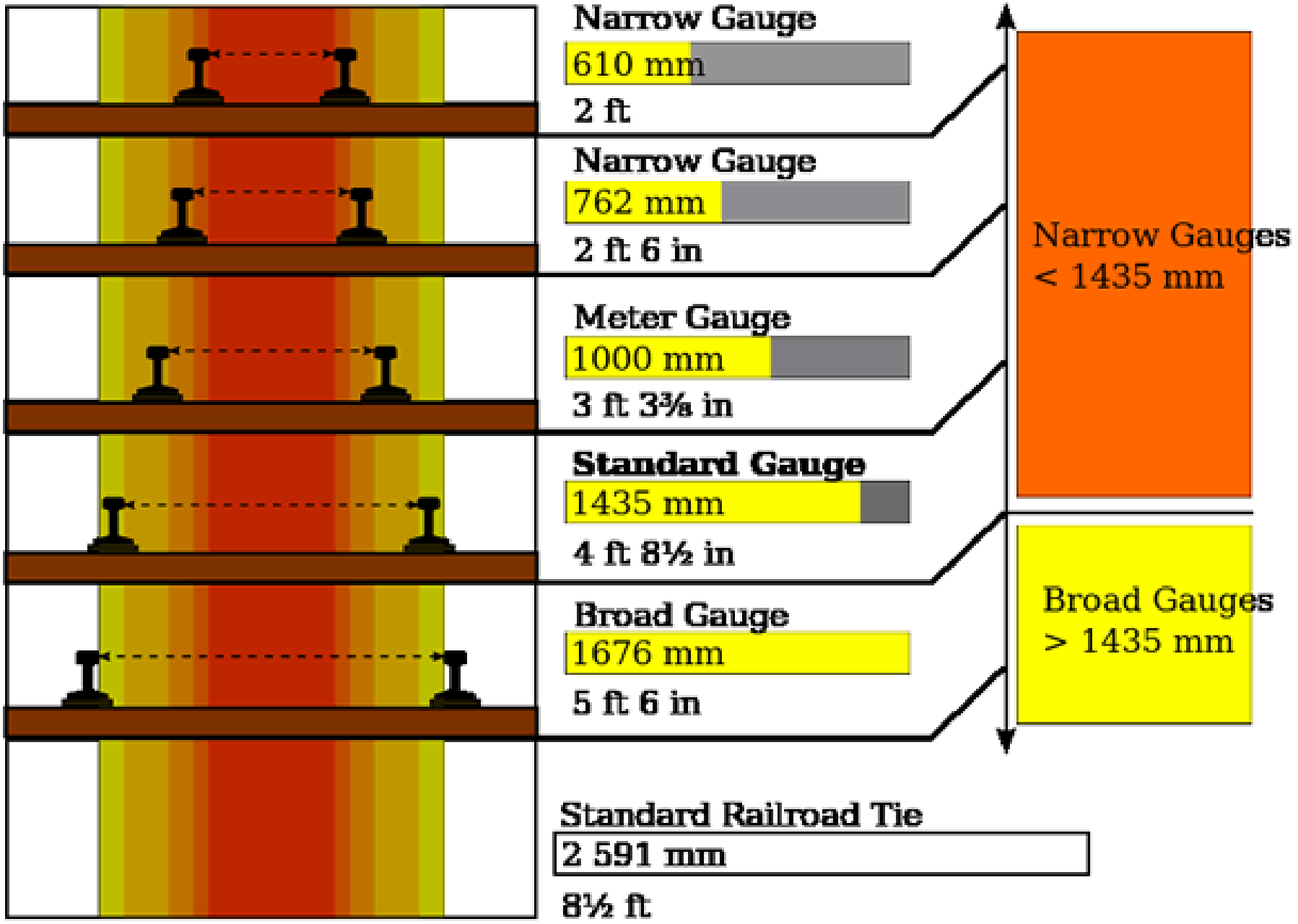

rade:4.8
ensile Strength:≥420Mpa
ield Point:≥320Mpa
rface: Plain (Oiled)

# 螺纹道钉
# Screw Spike

昆山艾力克斯铁路紧固件有限公司
KUNSHAN ALEX RAILWAY FASTENING CO., LTD.

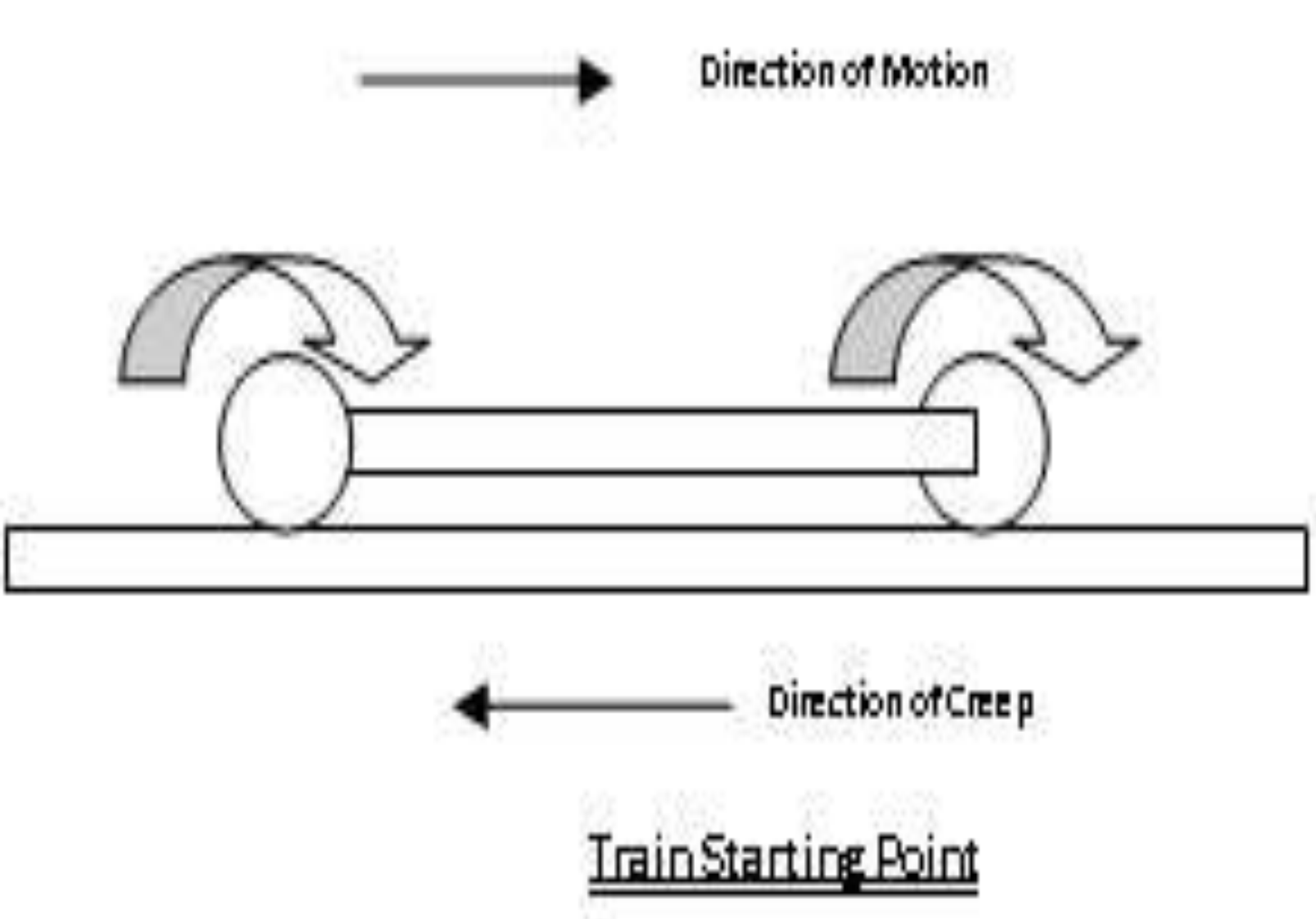
TÜVRheinland®
Precisely Right.

# GAUGES


Narrow Gauge
610 mm
2 ft
Narrow Gauge
762 mm
2 ft 6 in
Meter Gauge
1000 mm
3 ft 3⅜ in
Standard Gauge
1435 mm
4 ft 8½ in
Broad Gauge
1676 mm
5 ft 6 in
Narrow Gauges
< 1435 mm
Broad Gauges
> 1435 mm
Standard Railroad Tie
2 591 mm
8½ ft

# Creep in Rails

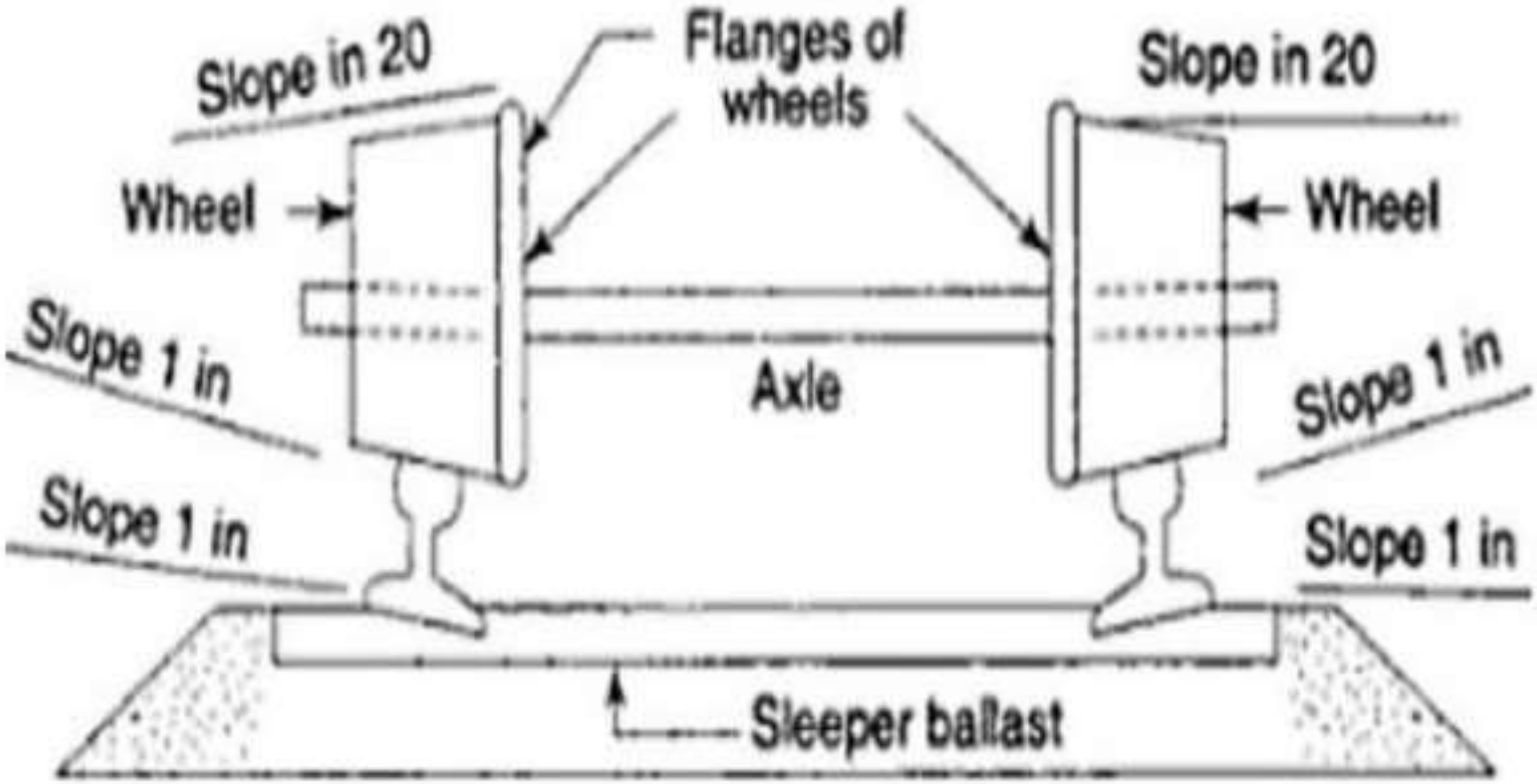
- It is defined as the longitudinal movement of rails wrt sleepers in a track.
- **Causes of creep:**
  - Closing of successive expansion spaces at rail joints in the direction of creep and opening out of joints at the point from where the creep starts.
  - Marks on flanges and webs of rails made by scratching as the rails slide.


Direction of Motion
Direction of Creep
Train Starting Point

# Effects of Creep

- Sleepers move out of position leading to *change in gauge* and alignment of the track.
- **Rail joints are opened** *out of their limit* & stresses are developed in fish plates and bolts which leads to the breakage of the bolts.
- **Points and crossings** get disturbed.
- Maintenance and replacement of tracks becomes difficult.
- Smashing of fish plates and bolts, bending of bars, kinks at joints are other effects of creep.

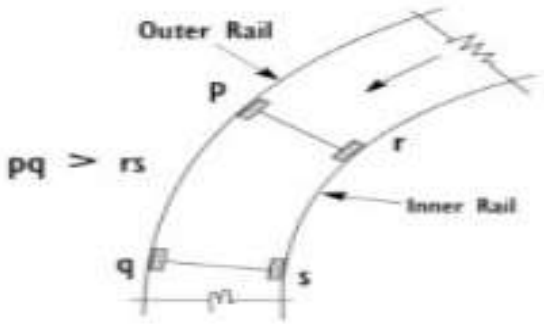
# Coning of wheel:-

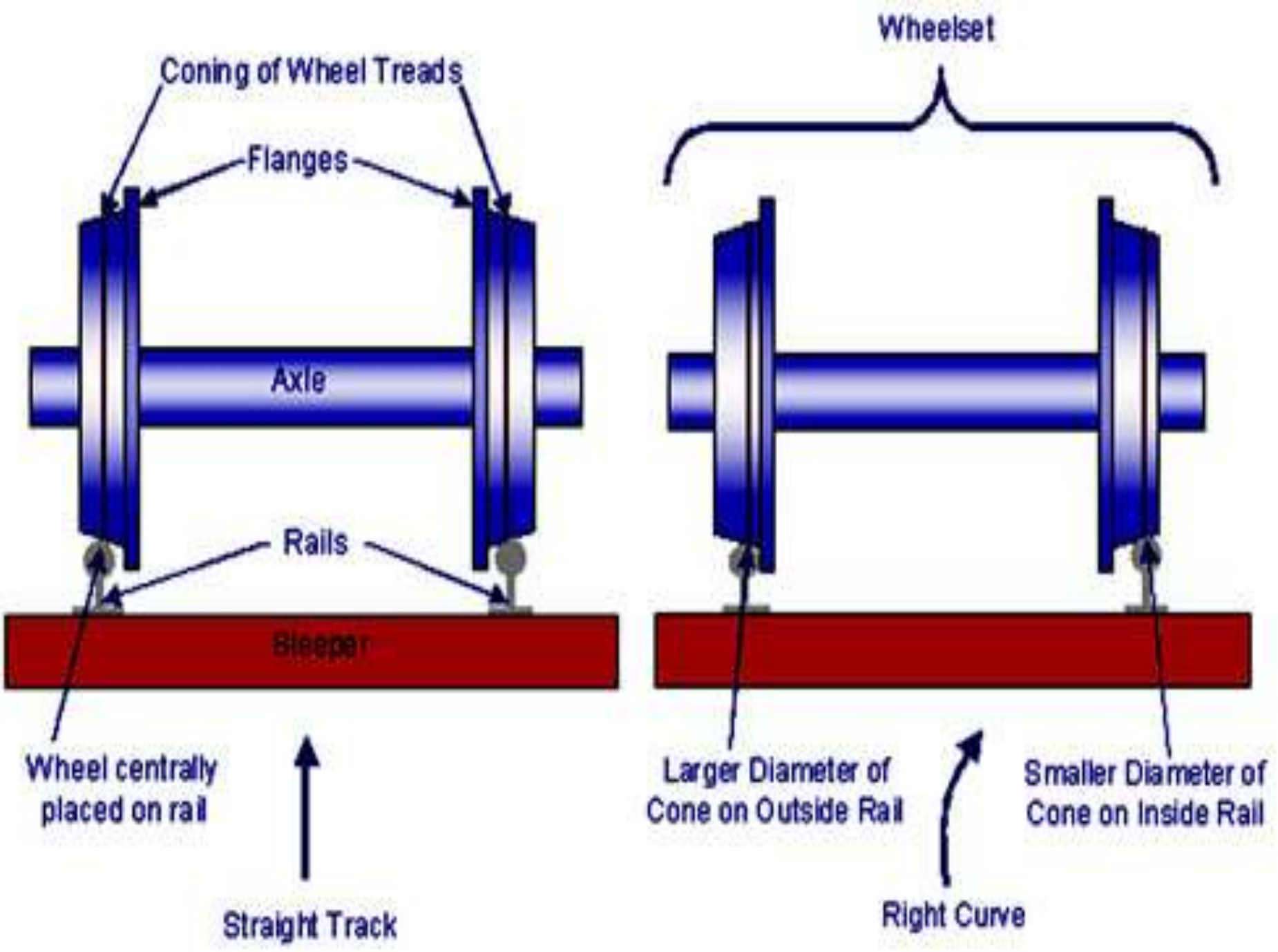



Coning of Rails.

# Coning of Wheels

- Tread of wheels of a railway vehicle is not made flat, but sloped like a cone in order to enable the vehicle to move smoothly on curves & straight tracks.
- On **Straight & level** surface: Circumference of treads of inner & outer wheels are equal.
- On **curves,** problem arises when outer wheel has to negotiate more distance on the curve as compared to inner wheels.




Coning of Wheel Treads
Flanges
Axle
Rails
Sleeper
Wheel centrally placed on rail
Straight Track
Wheelset
Larger Diameter of Cone on Outside Rail
Smaller Diameter of Cone on Inside Rail
Right Curve

# Kinks In Rails

When the ends of adjoining rails move slightly out of position, "shoulders" or "kinks" are formed.

Measures taken to rectify kinks in rails:

1. By correcting alignment at joints and at curved locations.
2. Proper packing of joints.
3. Proper maintenance of the track periodically in repect of cross levels, gauge, alignment, welding of worn out portions etc.

# Sleepers

Sleepers are members generally laid transverse to the rails, on which the rails are fixed to transfer the loads from the rails to the ballast and the subgrade.

# Function of Sleepers

- Holds rails in their correct gauge & alignment.
- Giving rails a firm & even support
- Transfers the load evenly from the rails to a wider area of the ballast.

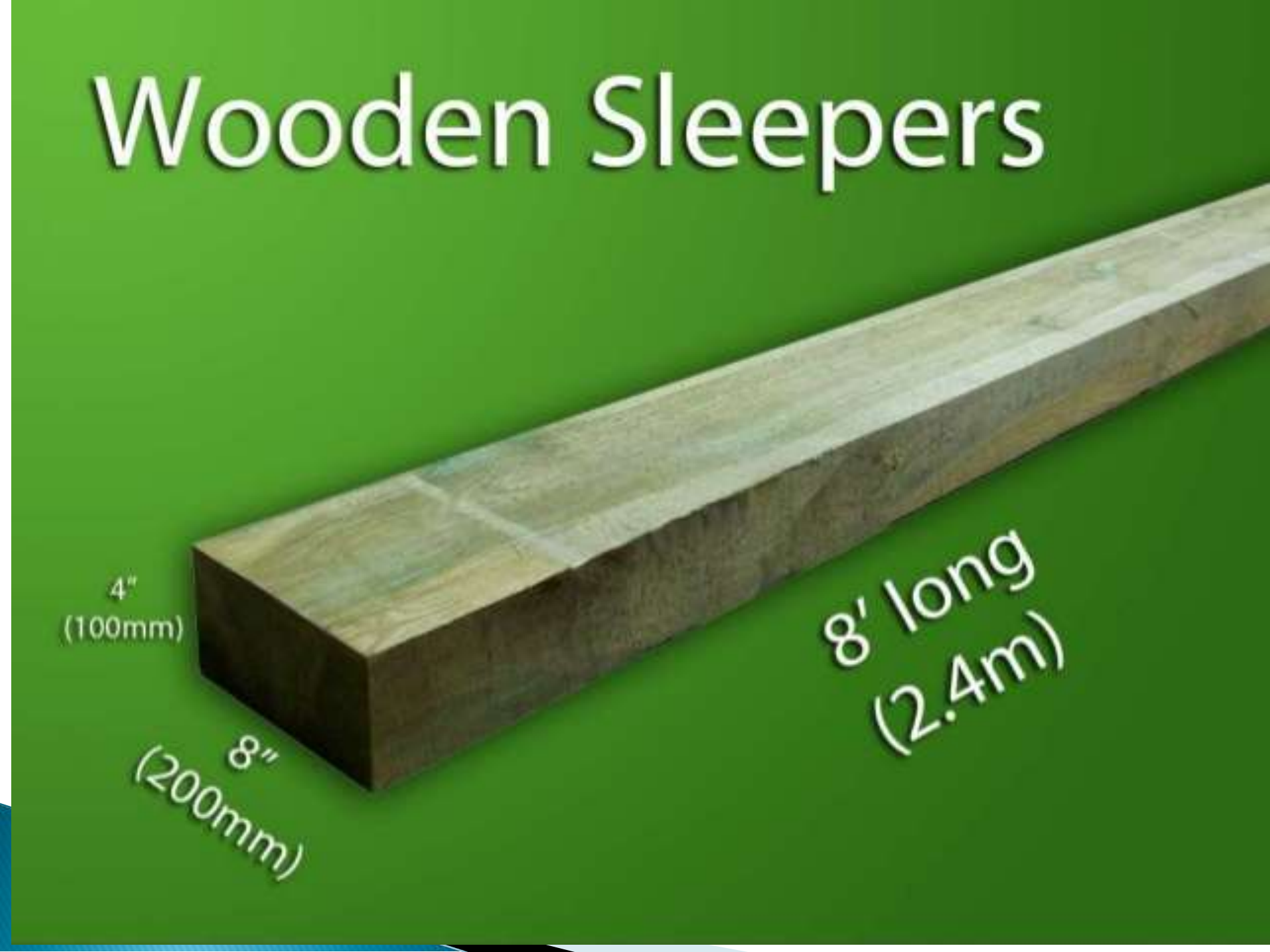
# Function of Sleepers

- Acts as an *elastic medium between rails & ballast* to absorb blows & vibrations caused by moving loads
- Providing longitudinal & lateral stability to the permanent way.
- Providing the means to rectify the track geometry during their service life.

# TYPES OF SLEEPERS

- Wooden Sleepers
- Metal Sleepers
- Concrete Sleepers

# Wooden Sleepers



# Timber Sleepers - Advantages

- Less no of fittings
- Simplistic design
- Suitable for all types of ballast
- Easy to lay, relay, pack, lift and maintain
- Less noisy track
- Economical overall
- Obtained in different sized and lengths for easy adoptability at certain locations viz., bridges, crossings etc

- Permits track circuiting
- Damage during derailments is less
- Can be placed on yielding formations because of more bearing area
- Possible to widen the gauge easily with wooden sleepers

# Timber Sleepers - Disadvantages

- Difficult to maintain gauge
- High maintenance cost
- Less useful period
- Easily disturbed from their positions
- Easily subjected to wear and decay due to various forces and causes
- Require special treatment for protection
- Possess less scrap value

# METAL SLEEPER


LIVERPOOL
LONDON

# Steel Sleepers - Advantages

- Less fastenings, simple in nature
- Maintenance and adjustment of gauge are easy with steel sleepers
- Manufacturing process of steel sleepers is simple in design and operation
- Are available in one piece
- Possess good scrap value
- Light in weight, easy handling
- Meets requirement of long welded track in cases
- Good anti creep sleeper
- Behaves better in the case of yielding formation.

# Steel Sleepers - Disadvantages

- Cost of steel sleepers is high
- Cracks develop at rail seat
- Rounded ends of sleepers prevent lateral shift
- Liable to corrosion
- Are not good insulators
- Excess damage during derailment
- Steel sleepers are difficult to pack at the rail joints because of their close spacing.
- Leads to battering of rails

# CONCRETE SLEEPERS

Typical arrangement of concrete sleepers with flat bottomed rail and pandrol clips. Note how the sleepers are shaped to provide a degree of natural drainage.

# Concrete sleepers - Advantages

- High electrical resistance
- Good resistance to abrasion
- Increased bond resulting in shorter transmission length.
- Increased impermeability
- Reduction in loss of pre-stress due to reduction in shrinkage, creep and elastic shortening
- Very high fatigue strength.

# Concrete sleepers - Drawbacks

- The damage during derailment is excessive
- Possess no scrap value
- Require complete machanisation in handling
- Requires use of superior and costly technology for manufacture.

# Sleeper Density

- No of sleepers present in a given length of rail
- Spacing of sleepers is indicated by formula n+x
  - n = length of rail
  - x = no of sleepers more than n.
- Sleepers density depends on several factors:
  - Lateral thrust of locomotives to which the track is subjected
  - Axle –load which the track is expected to carry
- Sleepers density cannot be increased indefinitely – minimum spacing is required for packing ballast and maintenance.
  - Wooden sleepers 300mm (for BG), 250mm (for MG)
  - Metal sleepers 380mm (for BG), 330mm (for MG)

# BALLAST

Ballast is the granular material usually broken stone or bricks single and kanker, gravel and sand placed and packed and around the sleeper to transmit Load from sleeper to formation Layer.

Size = 20mm – 65mm

# Function of Ballast

- Provides a level & hard bed for sleepers to rest on.
- Holds the sleepers in position during the passage of trains.
- Transfers & distributes load from sleepers to a larger area of the formation.
- Provides elasticity & resilience to the track for proper riding comfort.
- Provides resistance to the track for longitudinal & lateral stability.
- Provides effective drainage to the track.
- Maintains the level & alignment of the track.

# Requirement of Ballast

- Tough & wear resistant
- HARD: not get crushed under the moving loads.
- SHAPE: generally cubical with sharp edges.
- Non-porous & should not absorb water.

# Requirement of Ballast

- Resist both attrition & abrasion.
- Durable & should not get pulverised or disintegrated under adverse weather conditions.
- Allow for good drainage.
- Cheap & economical.

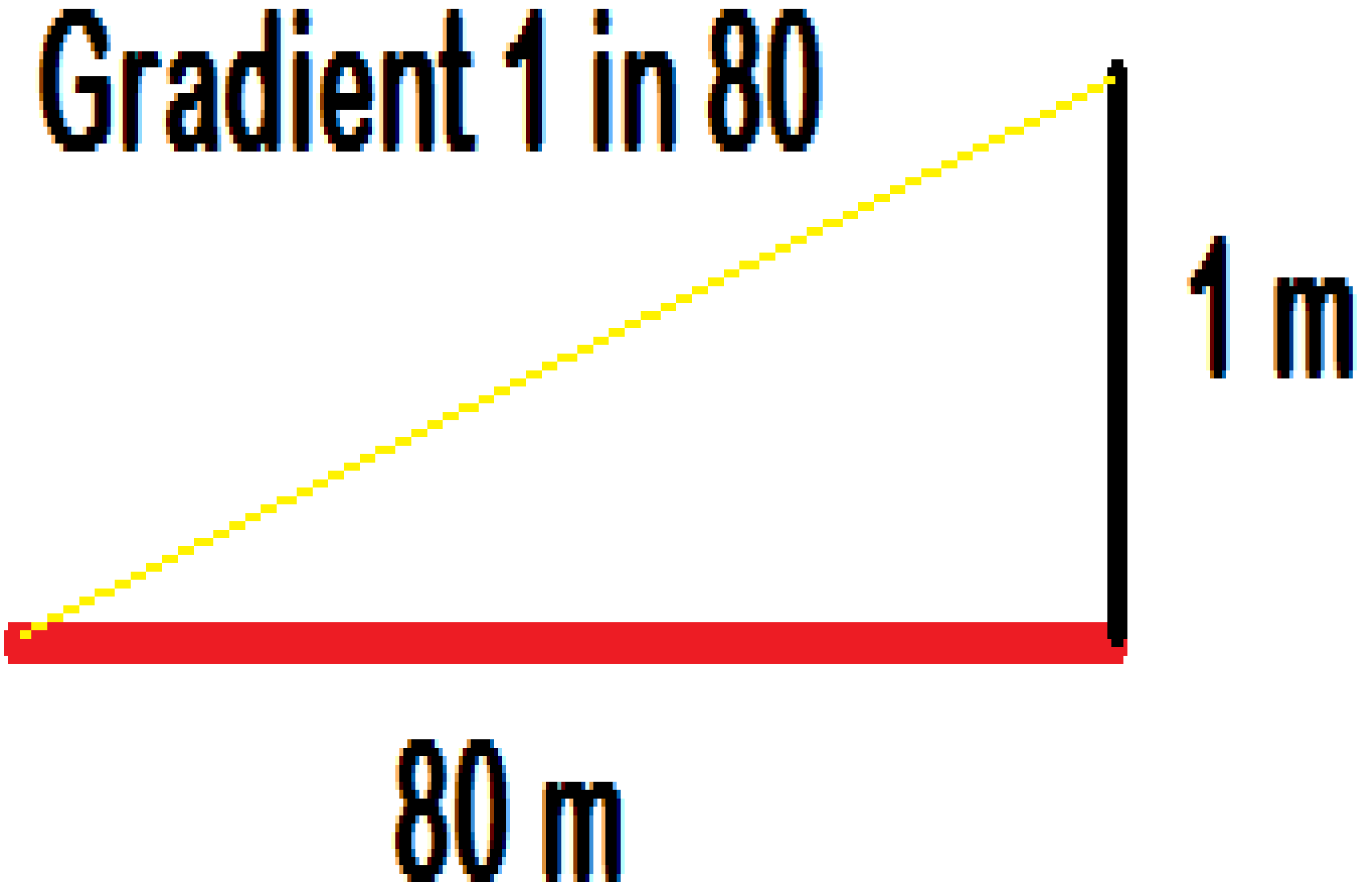
# Ballast Materials

- Broken stone
- Gravel
- Ashes or cinders
- Sand
- Kankar
- Moorum
- Brickbats
- Selected earth

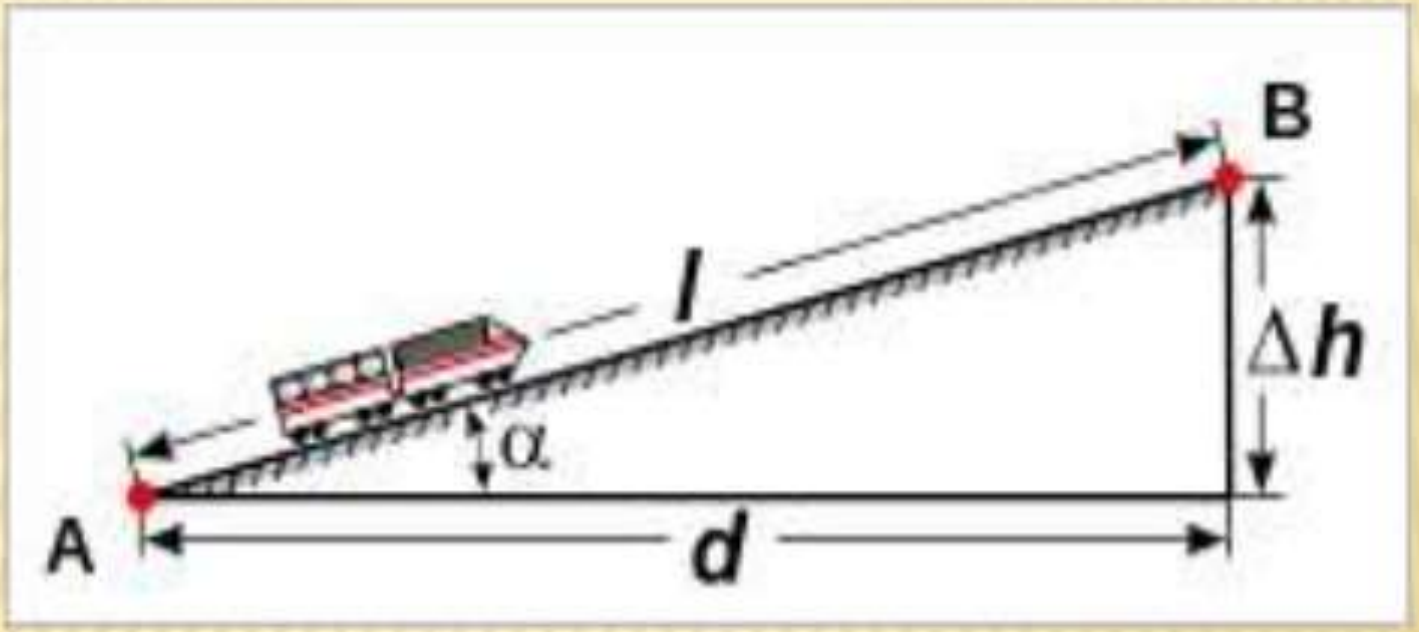

Nilgiri Mountain Railway
Route Map
Ooty
7200 ft
Fern Hill
7300 ft
Ketti
Lovedale
7000 ft
Aruvakkadu
Wellington
Coonoor
5500 ft
3500 ft
2000 ft
Kateri
4500 ft
Hill Grove
Adderely
Kallar
1250 ft
Coonoor River
Runnymede
INDICA.CO.IN
Broad Gauge
Meter Gauge
Meter Gauge ( with Rack & Pinion )
Mattupalayam
1071
Bhavani River
to Coimbatore

# GEOMETRIC DESIGN OF RAILWAY TRACK

- GRADIENTS
- CURVES
- SUPER ELEVATION
- WIDENING OF GAUGE ON CURVES


Gradient 1 in 80
1 m
80 m

# RAILWAY TRACK GRADIENTS




**d = distance traveled horizontally**

**Δh = rise**

**l = slope length**

**α = angle of inclination**

## Objective of Gradients

- To reach various stations at different elevations
- To follow the natural contours of the ground to the extent possible
- To reduce the cost of earthwork.


WDG4
12638

# RAILWAY TRACK GRADIENTS

1) Ruling gradient

2) Momentum Gradient

3) Pusher gradient

4) Gradient at stations

# Ruling Gradients

- It is the steepest gradient that exists in a section.
- It determines the maximum load that can be hauled by a locomotive on that section.
- Factors for deciding the RG
  - Severity of G
  - Length & position wrt G on both sides.
  - Power of locomotive
- In Plain terrain: 1 in 150 to 1 in 250
- In Hilly Terrain: 1 in 100 to 1 in 150
- All other G in that section should be flatter than the RG.

# 1) RULING GRADIENT

# Momentum Gradient

- MG is also steeper than RG.
- In valleys, a falling gradient is followed by a rising gradient.
- During falling G, train gathers good speed or momentum which gives additional kinetic energy to the train & allows it to negotiate G steeper than RG.

# 2) MOMENTUM GRADIENT

# Pusher of Helper Gradient

- When the gradient of ensuing section (in hilly terrain) is so steep as to necessitate the use of an extra engine for pushing the train, it is known as P/H G.
- Here gradients steeper than RG are provided to reduce the overall cost (length of railway line).

# 3) PUSHER GRADIENT

# Gradient in Station Yards

- These are quite flat due to following reasons:
  - It prevents the standing vehicles from rolling & moving away from the yard due to combined effect of gravity & strong winds.
  - It reduces the additional resistive forces required to start a locomotive.
  - Max G: 1 in 400; Recommended G: 1 in 1000

# 4) GRADIENT AT STATIONS

# CURVES

- Horizontal Curve – *(change in alignment direction)*
  - Simple Curve
  - Compound curve
  - Reverse Curve
  - Transition curve
- Vertical Curve – *(change in gradient)*
  - Summit Curve
  - Valley Curve

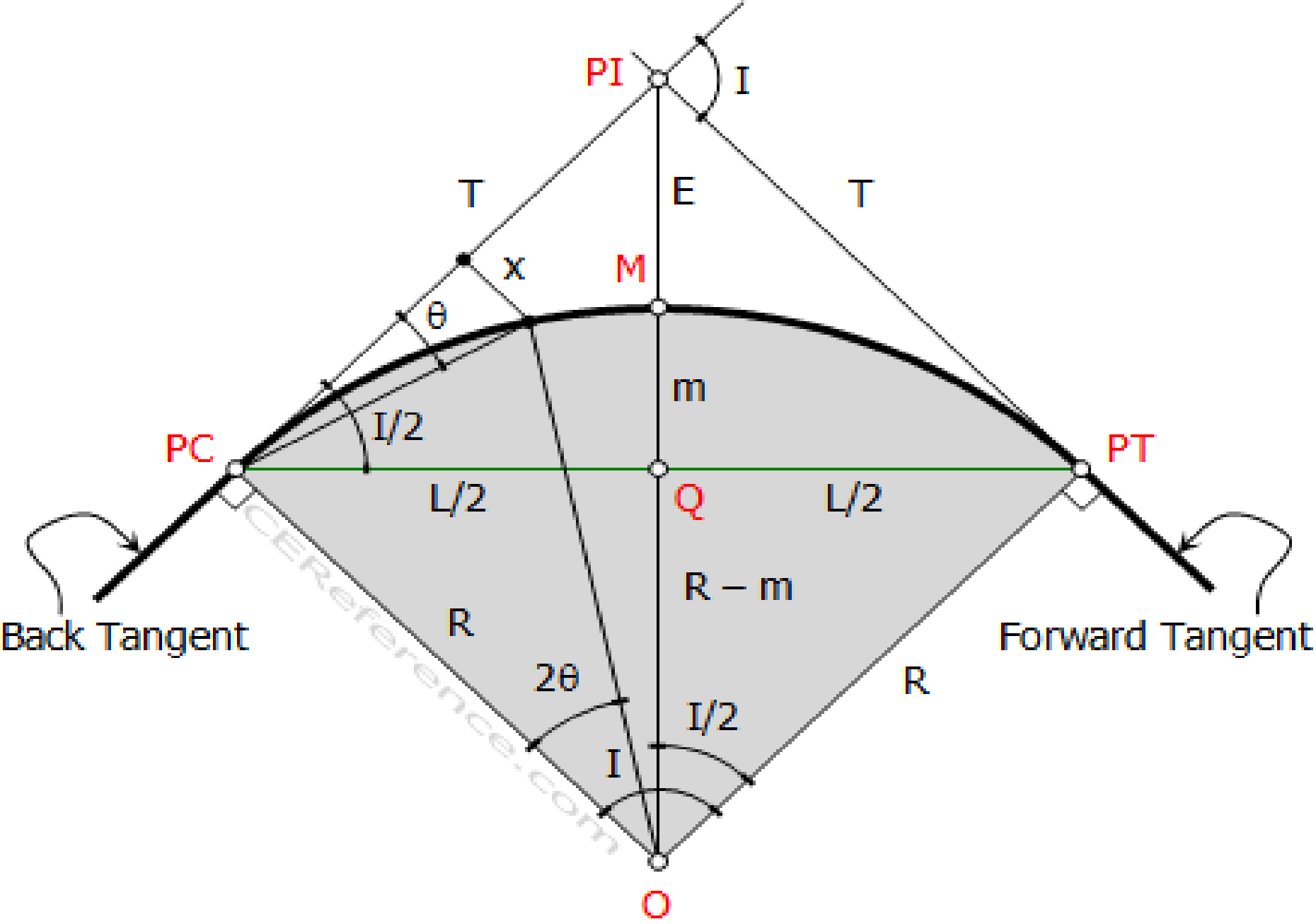
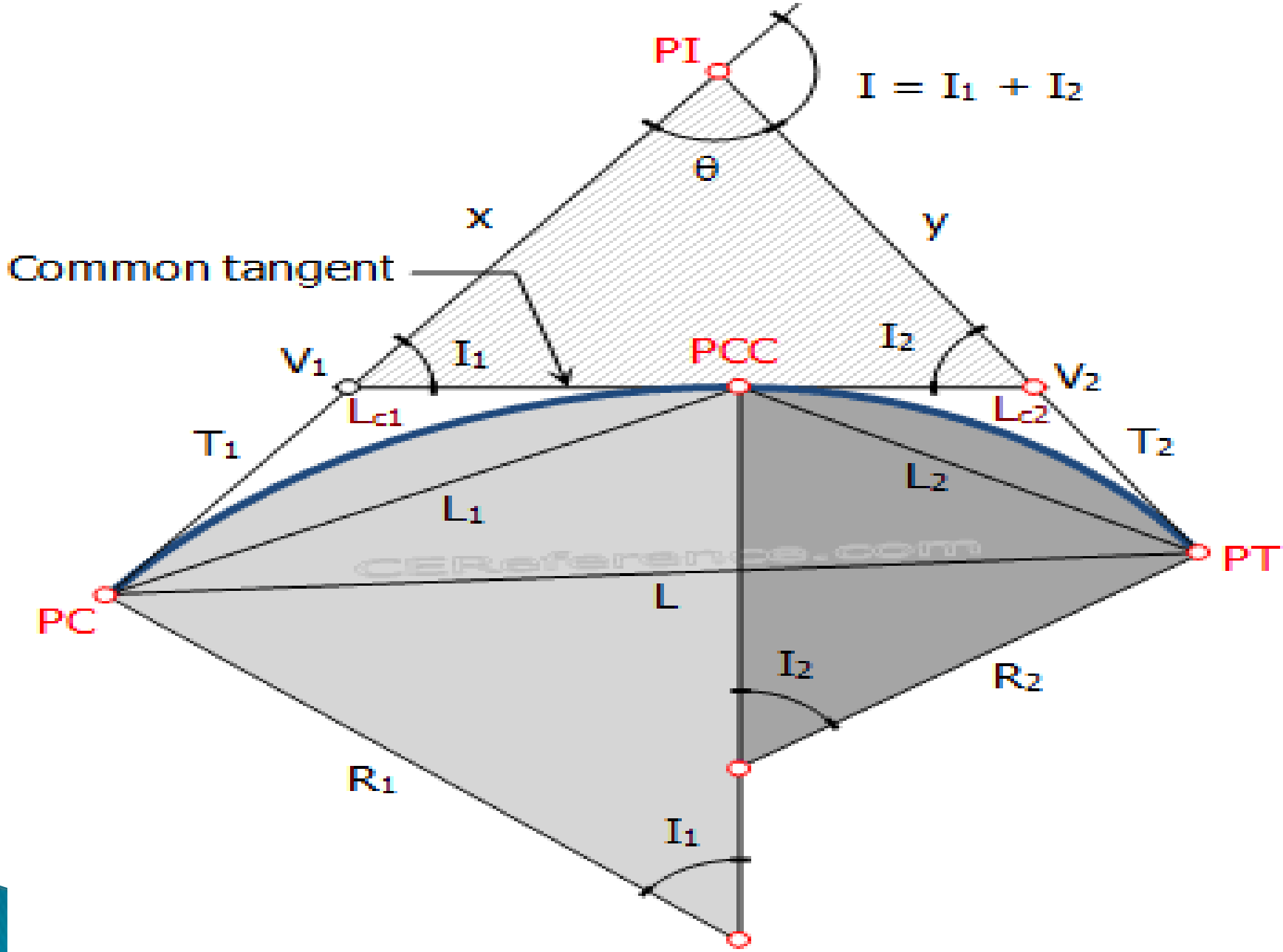
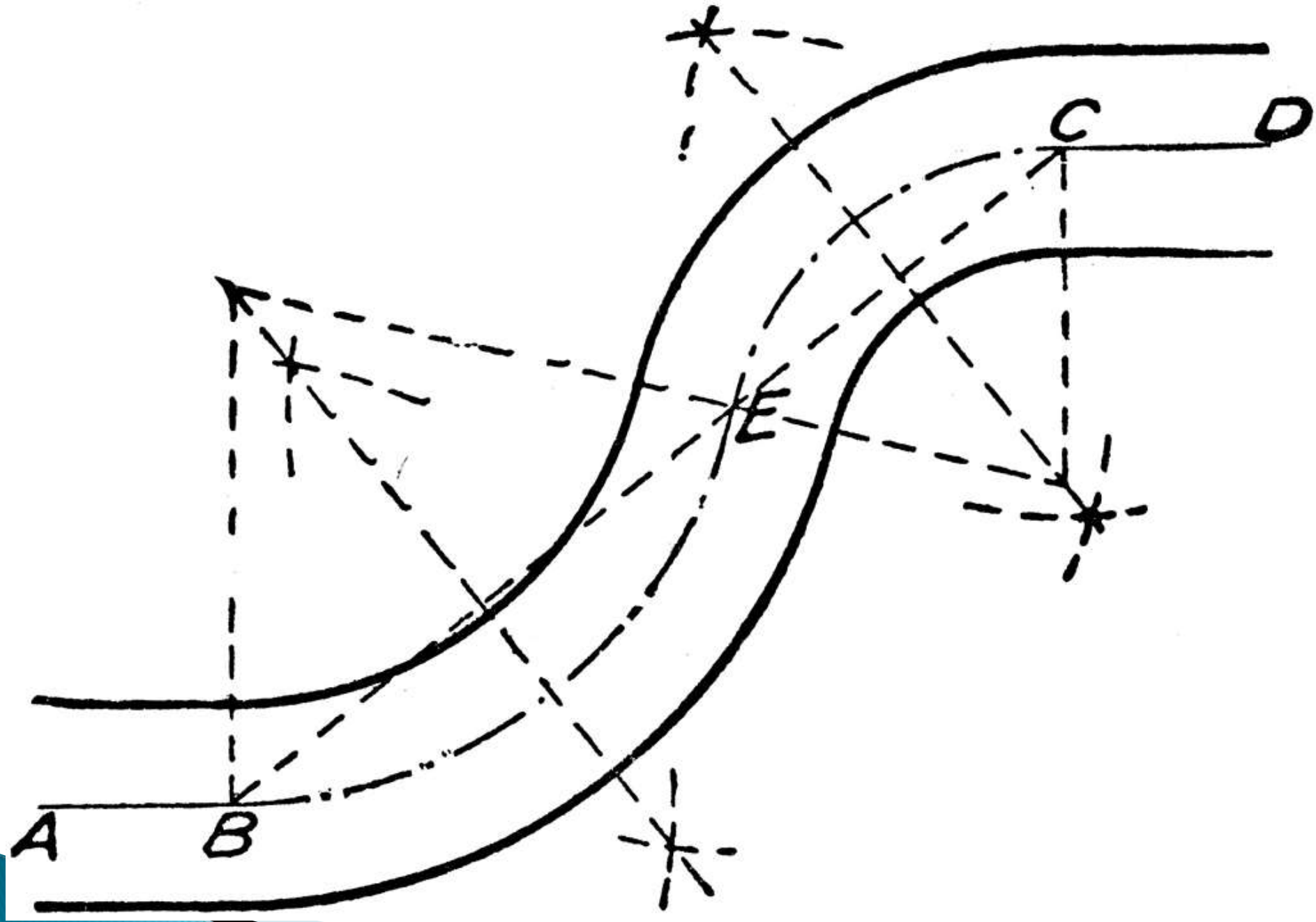
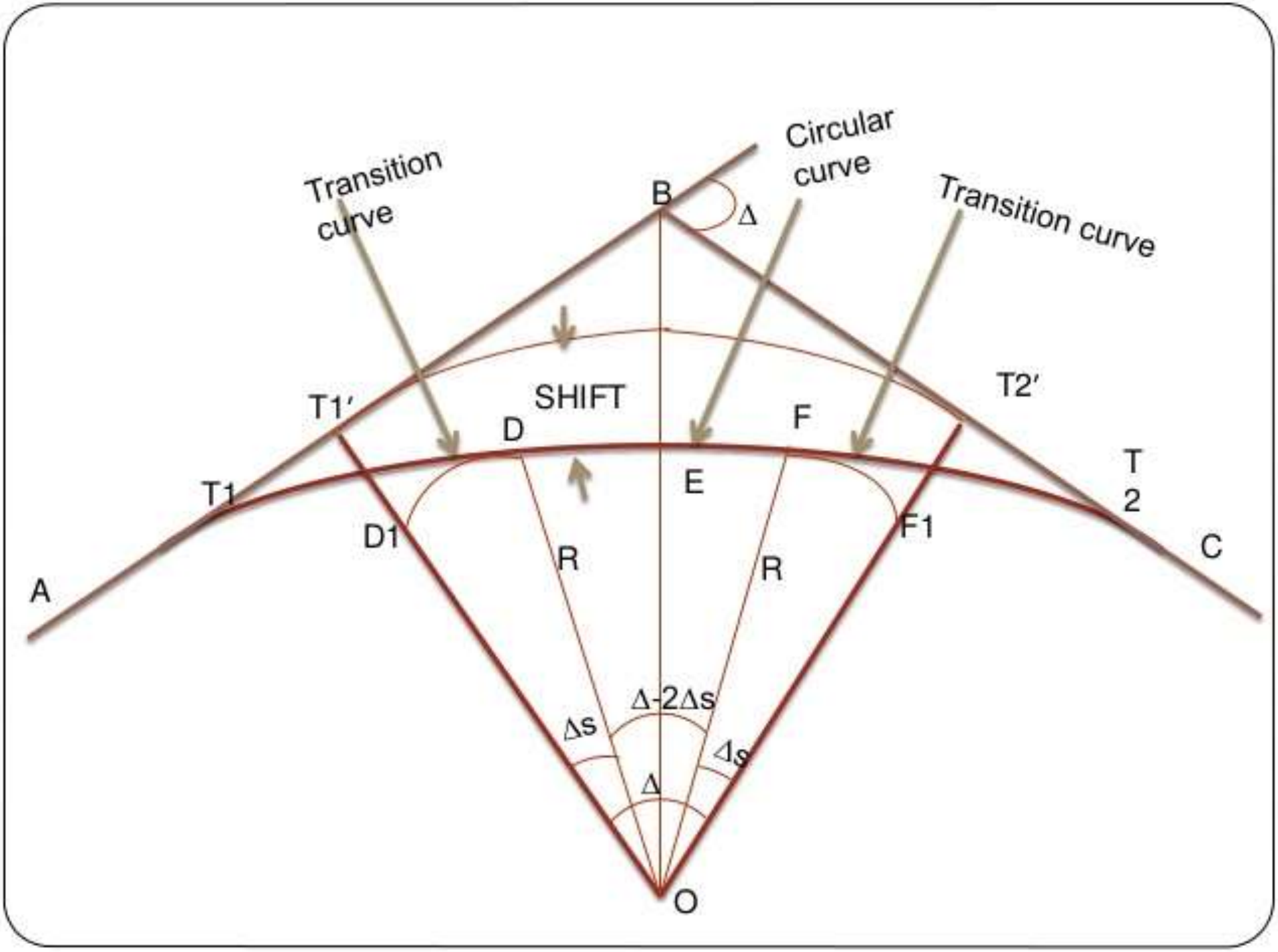



**Figure 001.** Circular Curve

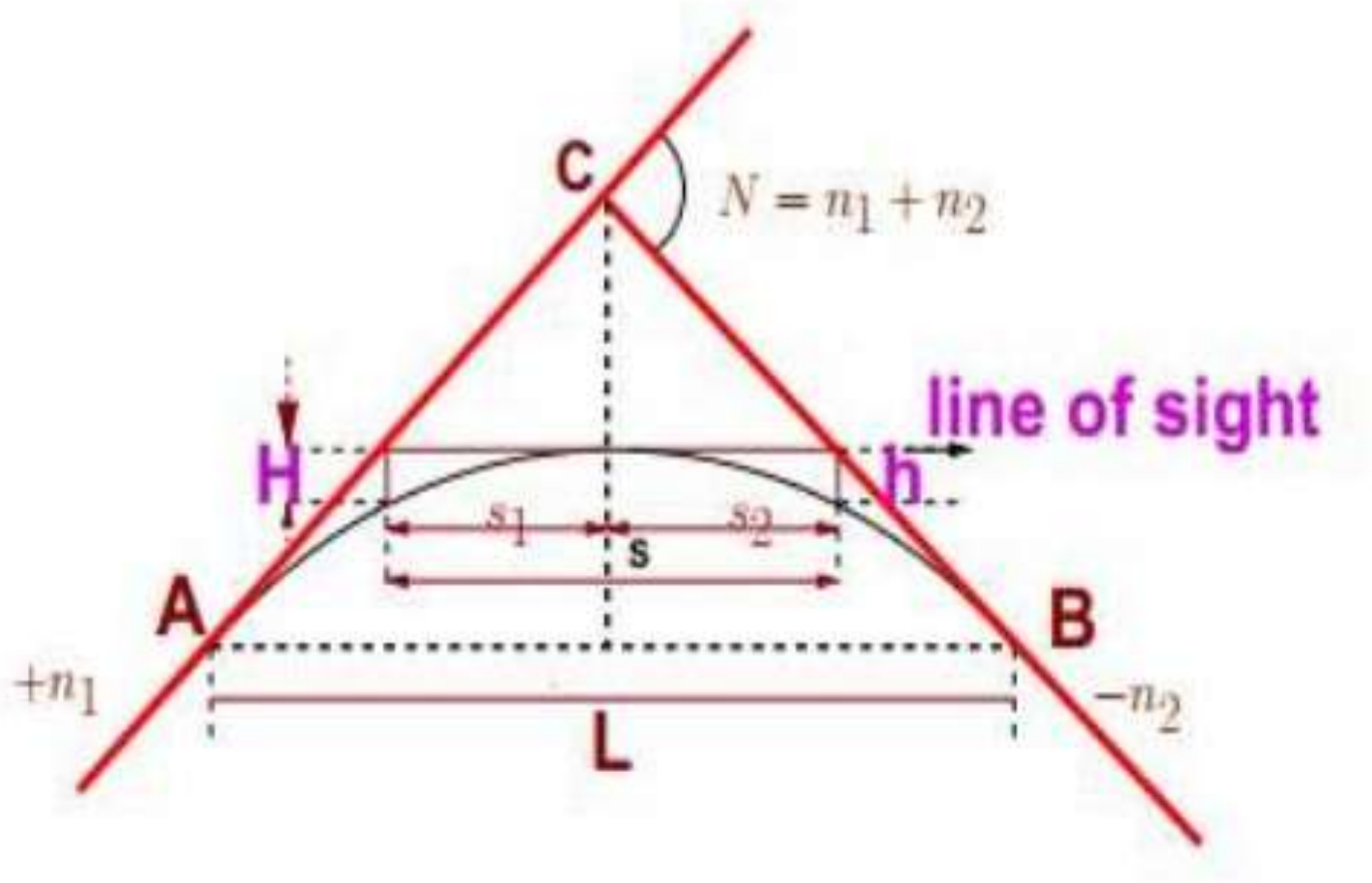


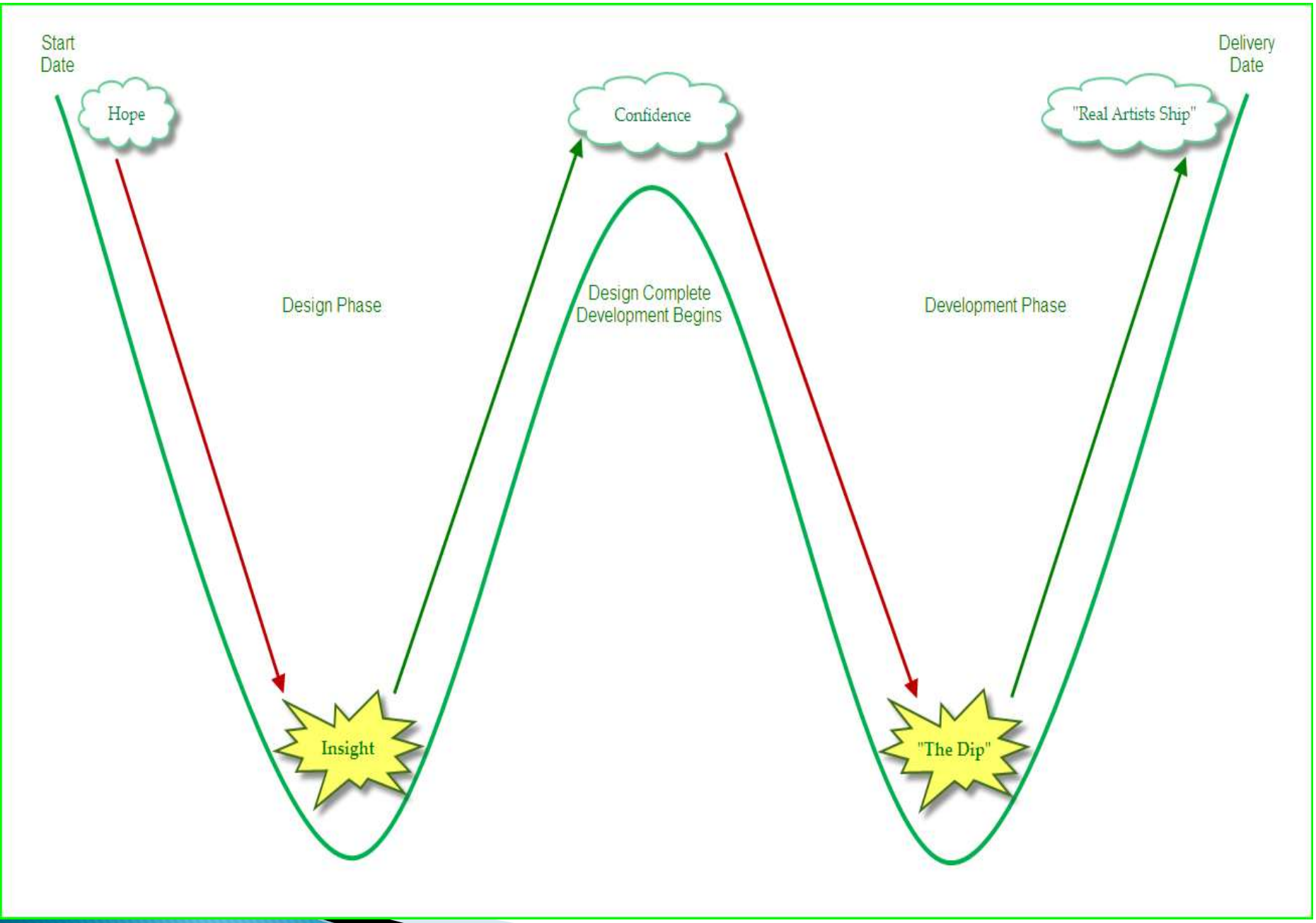

**Compound Curves**


C
D
E
A
B


Transition curve
Circular curve
Transition curve
B
Δ
T1′
SHIFT
T2′
D
F
T1
E
T 2
D1
F1
C
A
R
R
Δ-2Δs
Δs
Δs
Δ
O

# Summit Curve – S < L




Start Date
Hope
Design Phase
Insight
Confidence
Design Complete
Development Begins
"The Dip"
Development Phase
"Real Artists Ship"
Delivery Date

# Super elevation

- Super elevation or Cant ($C_a$): is the **difference in height** between the OUTER & INNER rail of the curve.
- It is provided by gradually lifting the outer rail above the level of the inner rail.
- Functions
  - To ensure a better distribution of load on both rails.
  - To reduce wear & tear of the rails & rolling stock
  - To neutralize the effect of lateral forces
  - To provide comfort to passengers.


Superelevation between the inside and outside rails

Curve with superelevation

# Super elevation

- **Equilibrium Speed:** When speed of a vehicle negotiating a curved track is such that the resultant force of WEIGHT of vehicle & RADIAL acceleration is **perpendicular** to the plane of rails, the vehicle is not subjected to any unbalanced radial acceleration & is said to be in equilibrium.
- **Maximum Permissible Speed:** is the highest speed permitted to a train on a curve taking into consideration – Radius of Curvature, Actual Cant, Cant Deficiency, Cant Excess & Length of Transition.

# Super elevation

- **Cant Deficiency ($C_d$):** It occurs when a train travels around a curve at a HIGHER than equilibrium speed. It is the difference between the **theoretical cant** required for such HIGH speeds & actual cant provided.
- **Cant Excess ($C_e$):** It occurs when a train travels around a curve at a LOWER than equilibrium speed. It is the difference between the **actual cant** provided & theoretical cant required for such LOW speeds.

# POINT OF CROSSING

Point , crossing , turnout , cross-overs and such related terms are arrangement by which different routes either parallel are connected and offered the means for terms to move from one route to another route is called POINT OF CROSSING .


Switches In Railways
BY: Sagar Pokharel

# Definition

- A railroad switch or turnout is a mechanical installation which enables railway trains to be guided from one track to another, such as at a railway junction.

- Combination of stock rail and tongue rail form a switch.
- A set of switches is known as points.
- The combination of points and crossing is called a Turn out
- A turnout generally has a straight "through" track (such as the main-line) and a diverging route.

- *Right-hand switches* have a diverging path to the right of the straight track, when coming from the narrow end, and a *left-handed switch* has the diverging track to the left of the straight track.

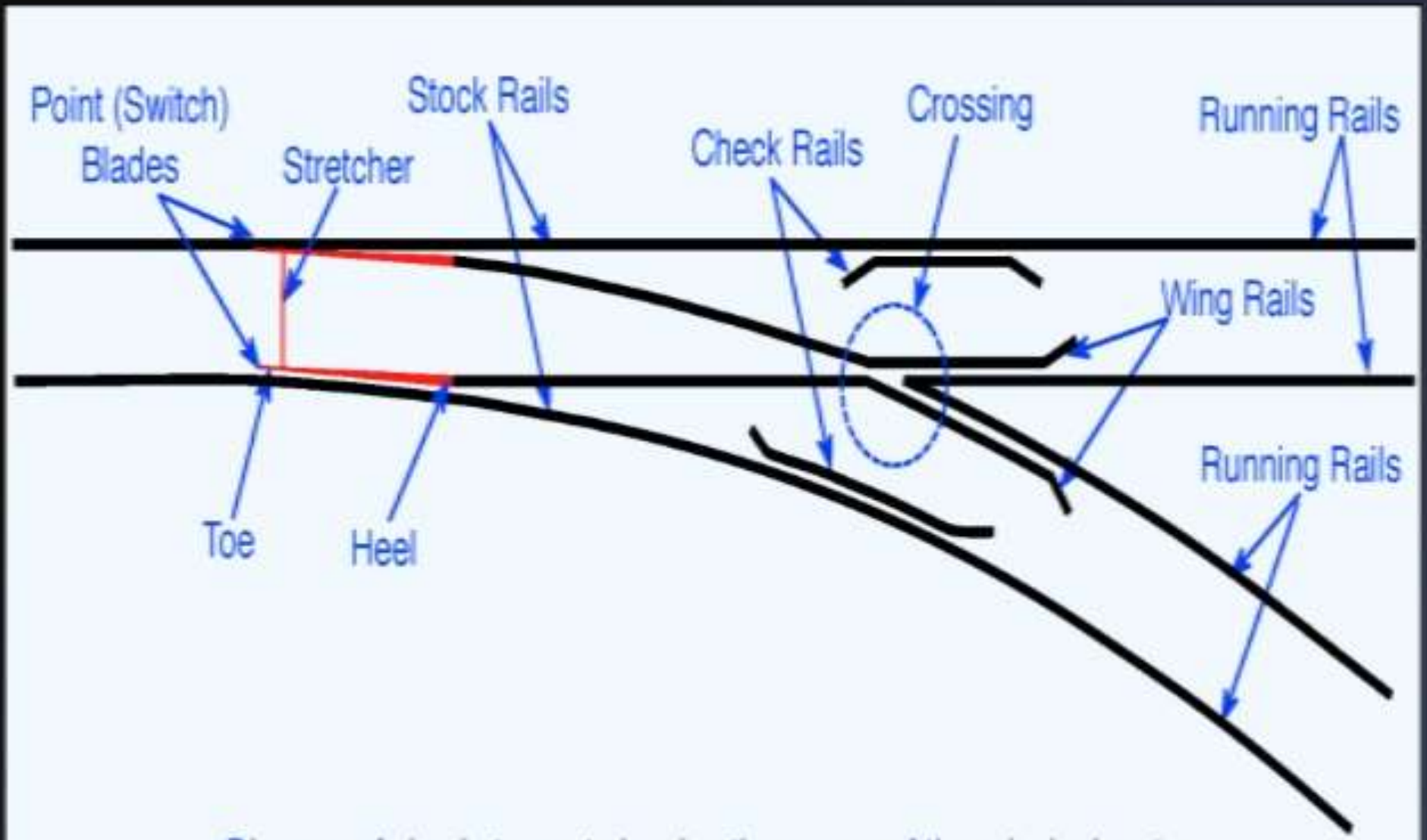



Diagram of simple turnout showing the names of the principal parts.
Moving switch blades shown in red.

Not to scale

# COMPONENTS OF SWITCH

1. A pair of stock rail.
2. A Pair of tongue rail.
3. Heel Block.
4. Stretcher bar.
5. Slide Chair.

# A PAIR OF STOCK RAIL

# A PAIR OF TONGUE RAIL

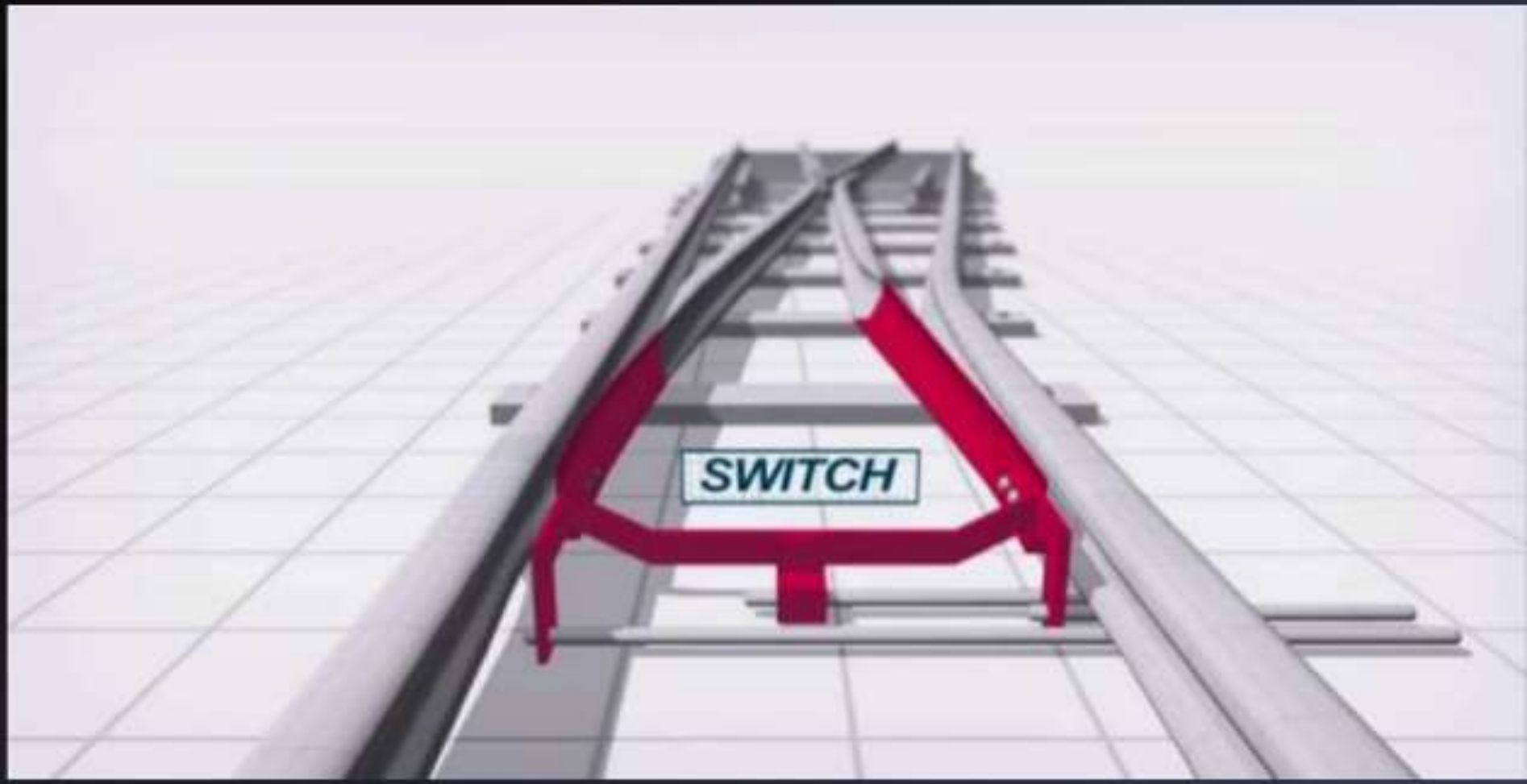
# HEEL BLOCK

# STRETCHER BAR

# Various component parts of switches

- Stock rail
  - They are the main rails of the track to which the tongue rails are fit closely
  - They are the outer rail in the turnout.

- Tongue rail (Switch rail)
  - Rails which lie between the 2 stock rails
  - End portion of the tongue rail is called toe and is connected by stretcher bar .
  - It is the moving part of the switch which diverts the train from one track to the other.

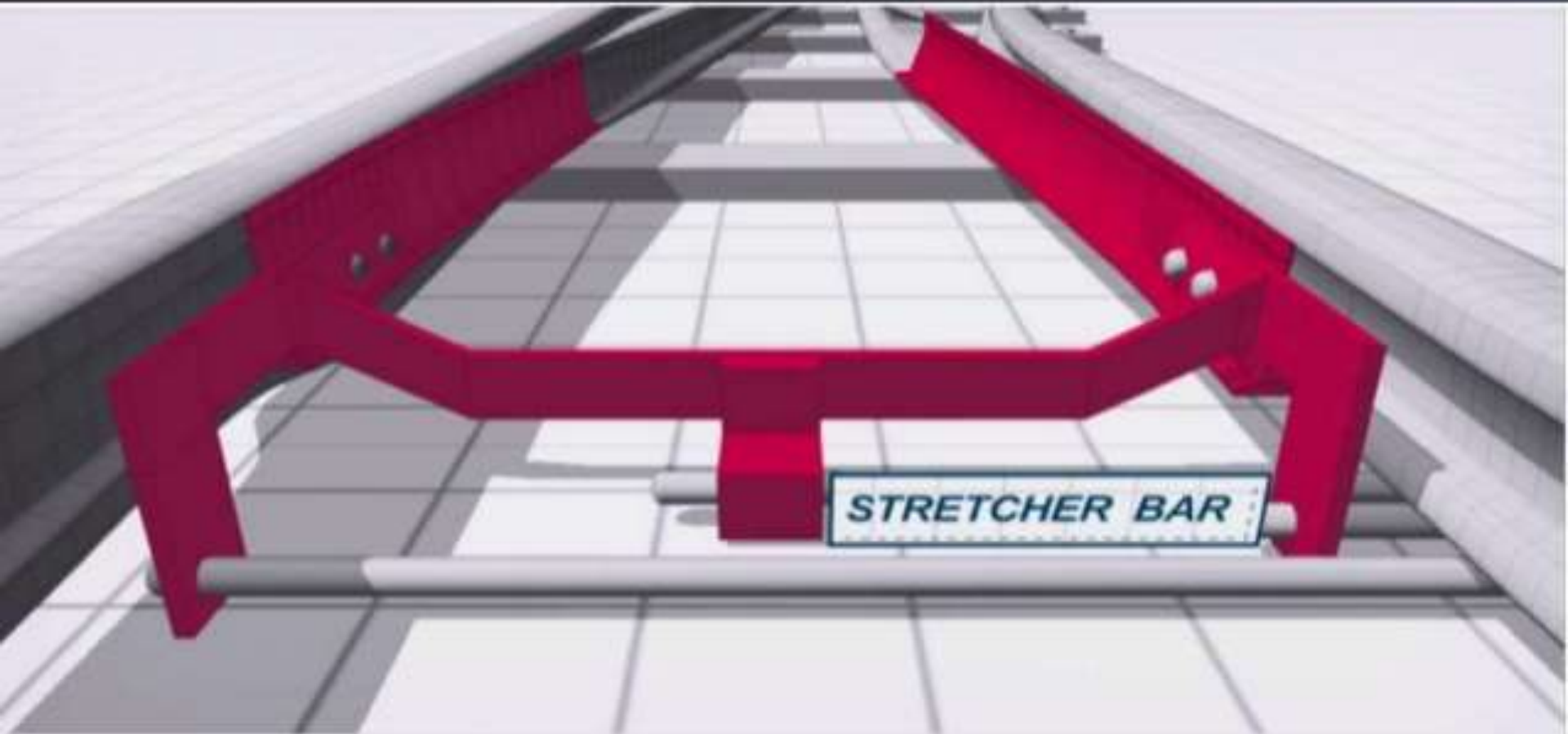

SWITCH

## Requirements of tongue rails

- Top and side of the tongue rail is tapered in such a way that they do not bear any load
- Tongue rail is higher than stock rail by 6mm
- Half thickness of the tongue rail at the toe should be closely fitted within the stock rail

## Stretcher bar

- Used to connect the toe of the tongue rails so that both the tongues moves through the same distance or gap
- Generally 2 or 3 bars are used near and behind the toe



## Sliding plate

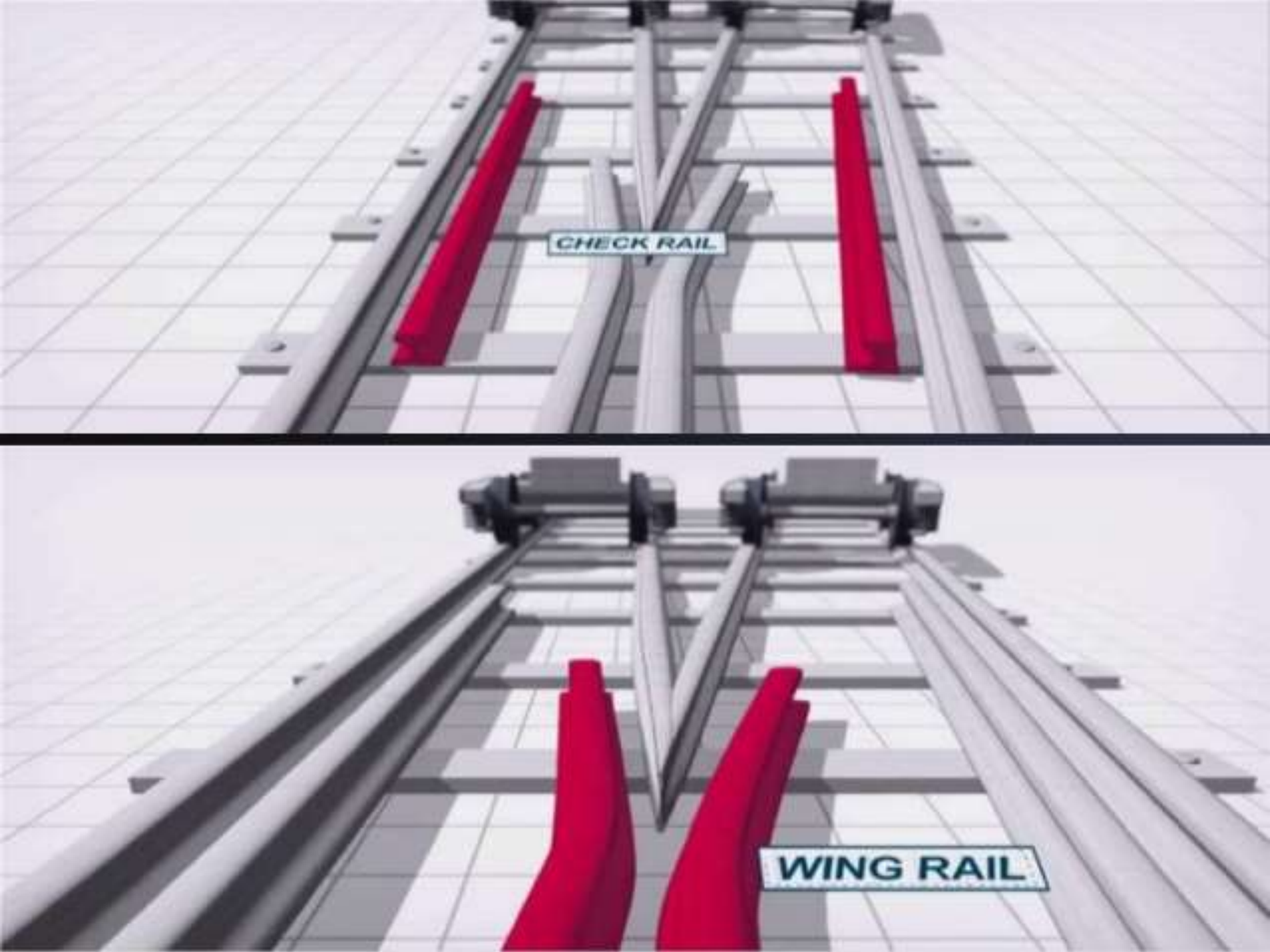
- These are the special plates which are provided for supporting and sliding the tongue rails.
- It is essential because it helps the tongue rail to move toward and away from stock rails and tongue rails are able to slide.

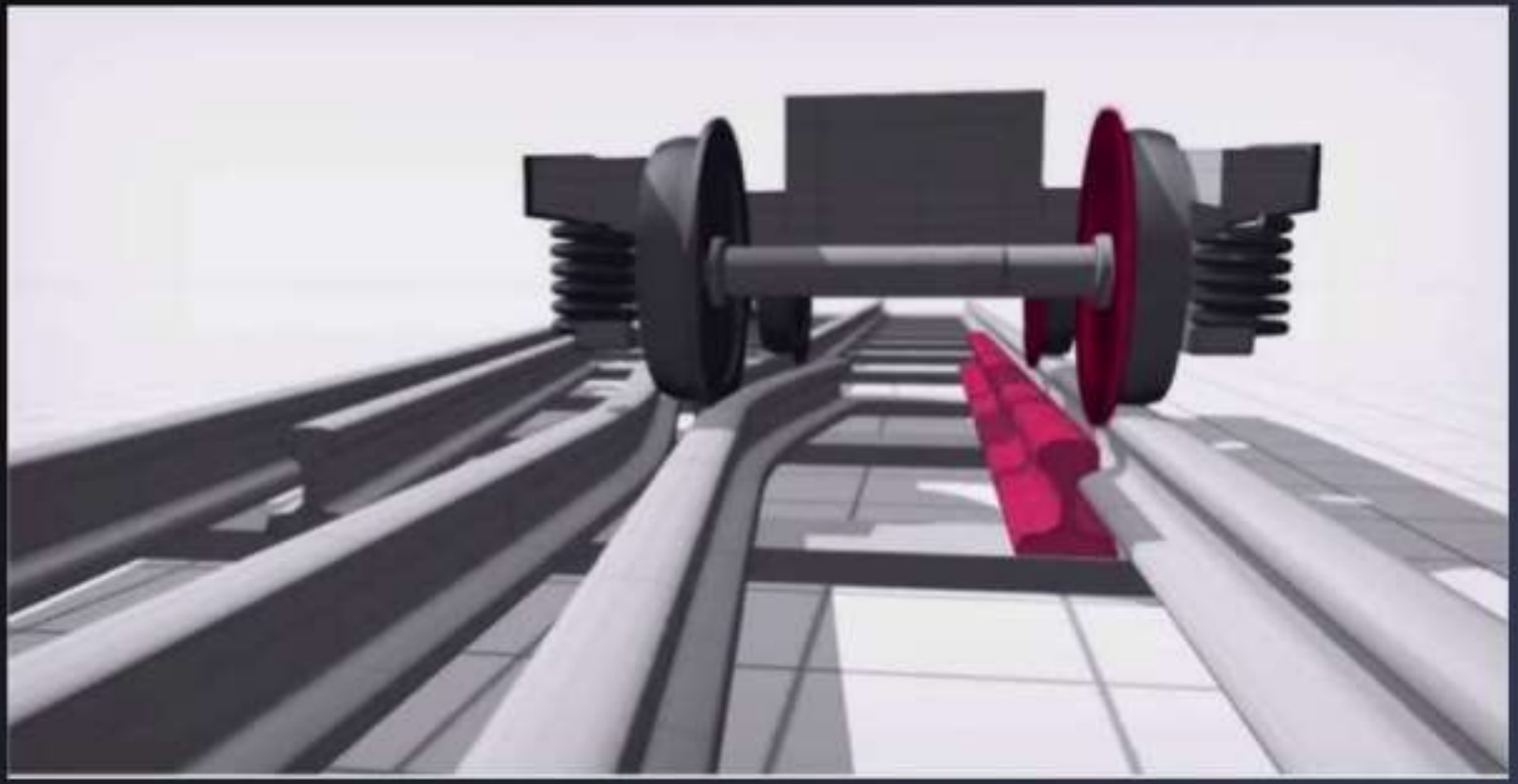
## Check rails

- They are the rails which are used guide the outer wheel flange of the train.
- To ensure that the train does not derail.

## Wing rail

- Rails which are used to guide the inner wheel flange of the train.


CHECK RAIL
WING RAIL



- Crossing
  - It is a arrangement of rails introduced at the junction where two rails cross to permit the wheel flange of a railway vehicle to pass from one track to another track.

# *Types of Switches*

## 1. Stub switch

- First developed for steam railways, was one in which the straight and diverging tracks were completely separate and side by side.
- The *throw* of the switch was about 5 inches.
- No separate tongue rail was provided.
- This type is no more in use and has been replaced by Split Switch.

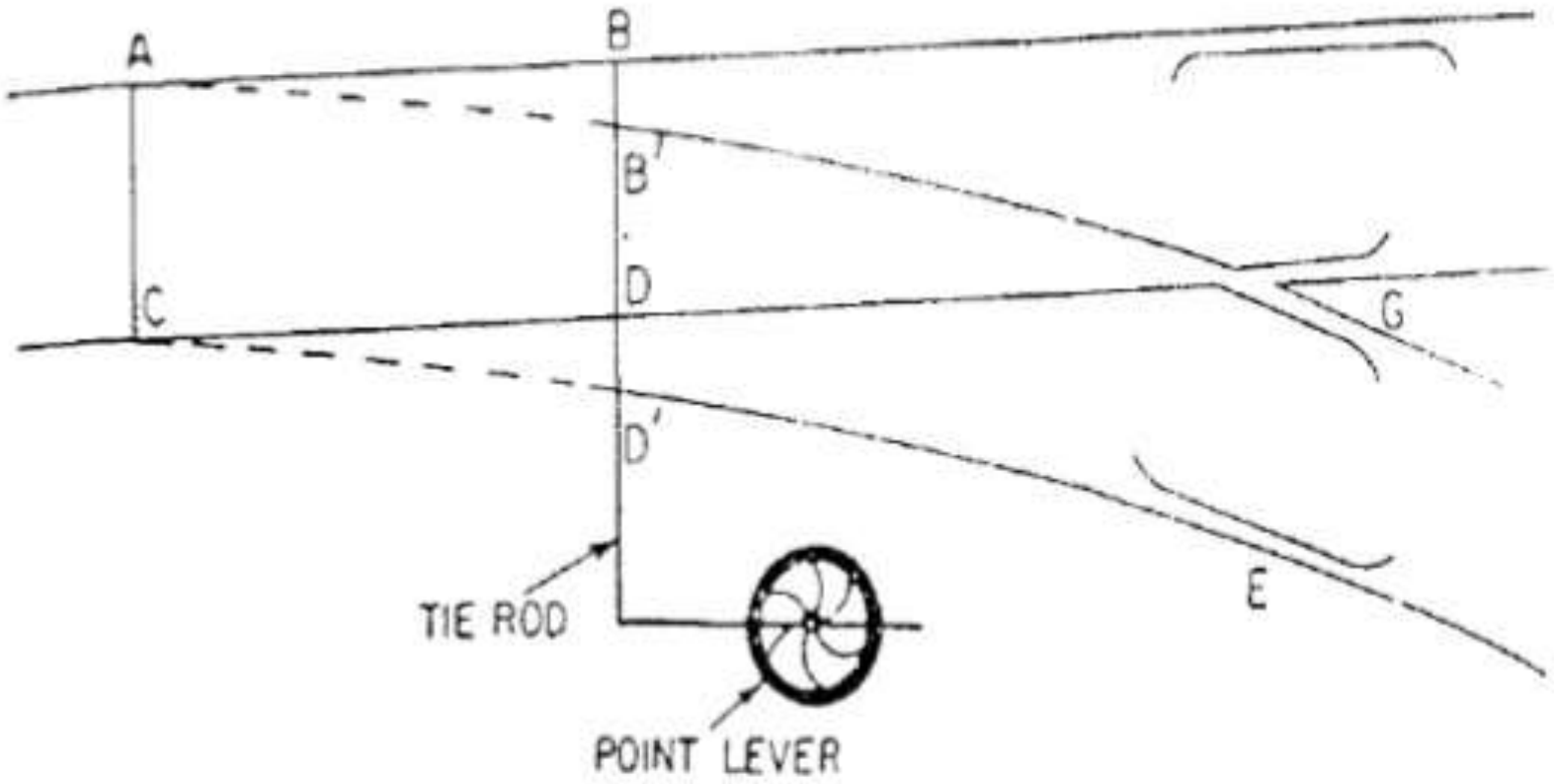



Figure 9.6. A stub switch

## 2. Split Switch

In this type of switch a tongue rail is combined with the stock rail.

Split Switches are classified as:

### A) On the basis of fixation at heel:

#### (i) Loose Heel Type

- In this type, tongue rails are joined to lead rails by means of fish plates.
- Two front bolts are kept loose to allow the throw of the switch and these bolts are kept tight when the tongue is open
- This is suitable for short length switches.

# INTRODUCTION TO SIGNALING

## What is Signaling in Railways?

- Signaling is Mechanism by which the station master conveys information to the Loco driver to Stop, Go with Caution or Proceed

# What are the Types of Signaling Systems in Railways

- Time Interval Method
- Space Interval Method

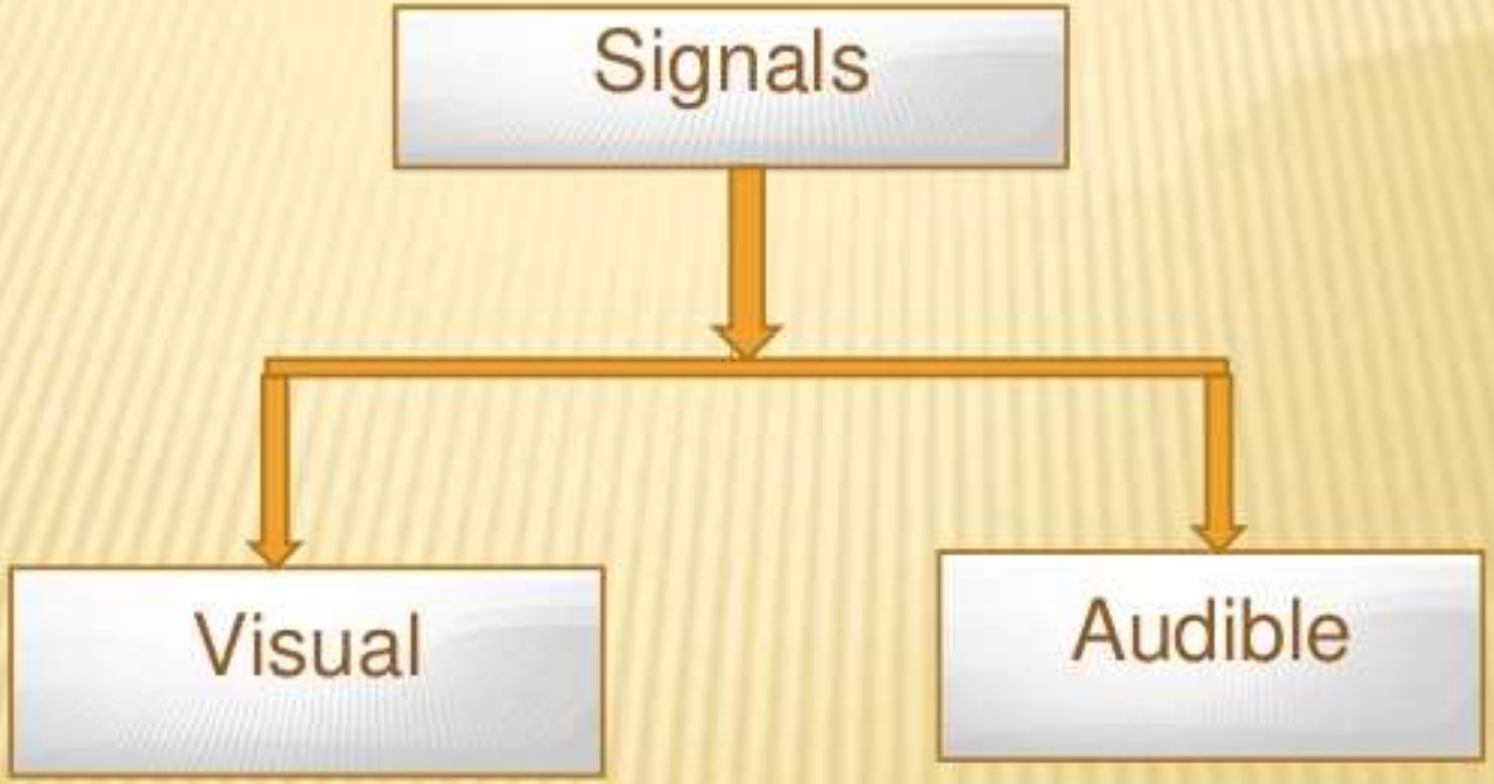
# TIME INTERVAL METHOD

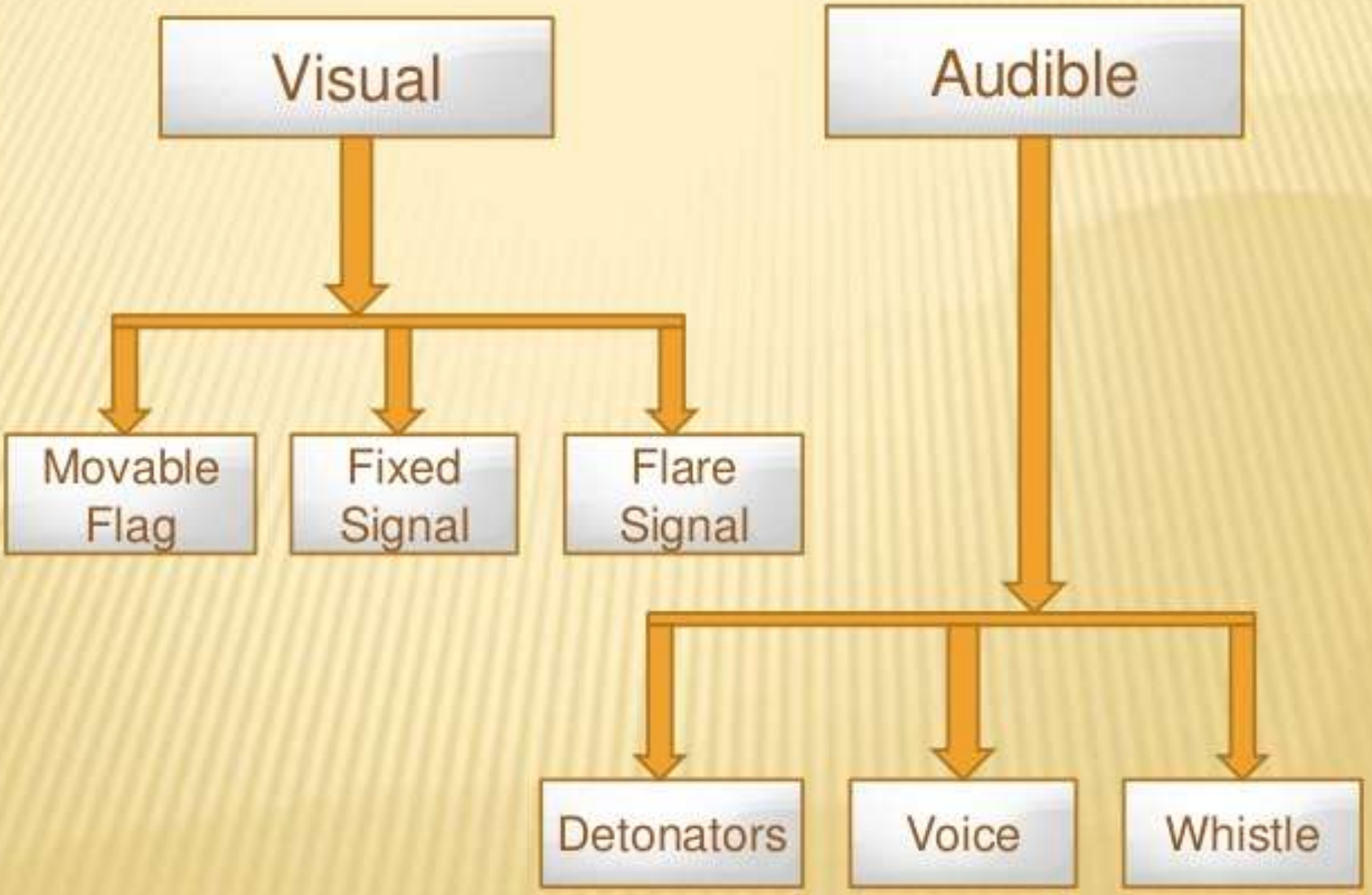
- Trains are Spaced Over an length of a track in such a way that , if the first train stops, the following train driver should be able to stop the train in sufficient distance without colliding with the first one.
- This type is used where traffic is less and weight of the trains are less, e.g: Trams
- This Type of System cannot be used in Passenger rails since weight and traffic is High

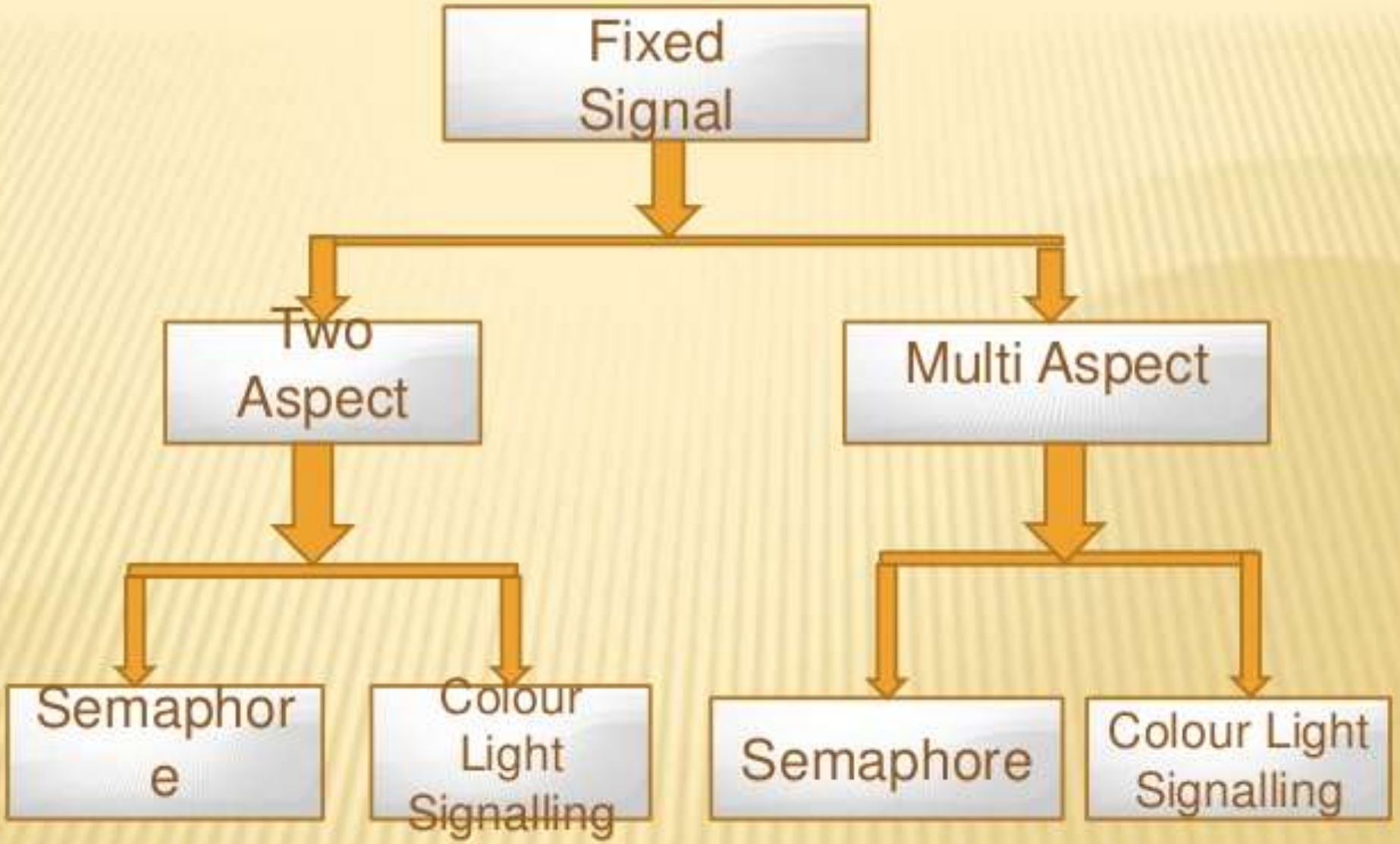
# SPACE INTERVAL METHOD

- In this method of “Control Over Movement”, the length of the track is divided in to sections called Blocks. The Entry of a train in to the ‘Block’ is controlled in such a way that only when it is free, a train can be allowed to enter it. This means that between two consecutive trains , there is definite space interval.

The Space Interval Method is further divided in two types as follows:

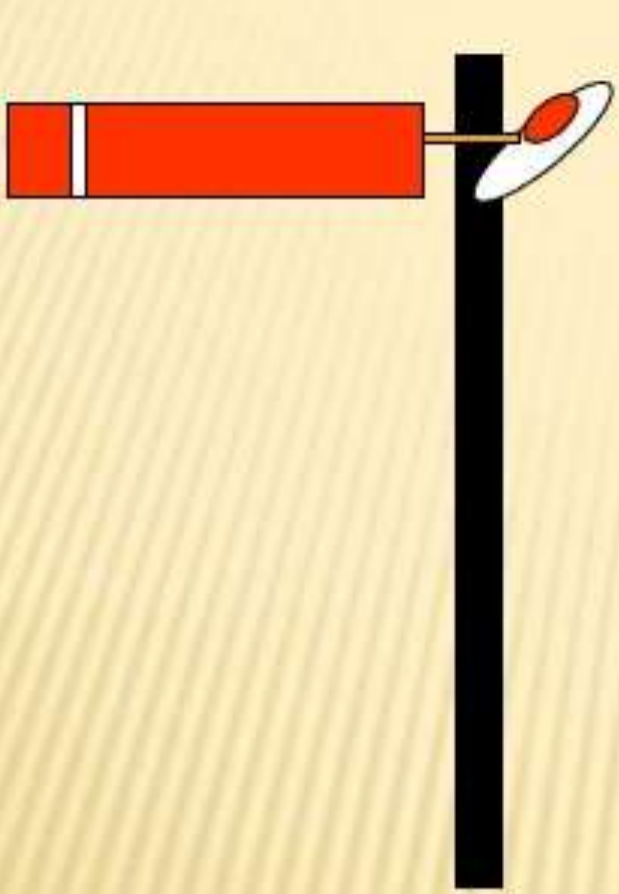



Visual
Audible
Movable Flag
Fixed Signal
Flare Signal
Detonators
Voice
Whistle

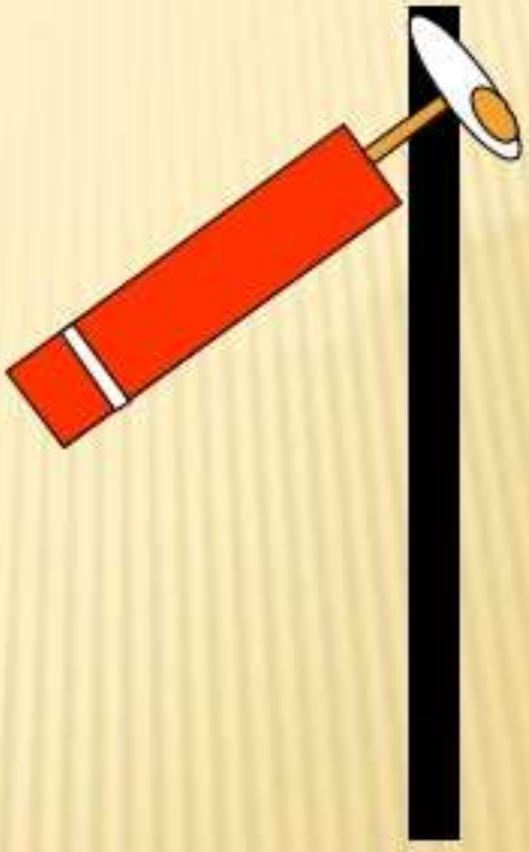

Fixed Signal
Two Aspect
Multi Aspect
Semaphor e
Colour Light Signalling
Semaphore
Colour Light Signalling

# SEMAPHORE SIGNALING

- Semaphore signals are rectangular or fish tailed arm fixed to a vertical Post.
- The arm is rotated in different angles to convey information to the Loco driver.



Stop Dead Aspect



Proceed Aspect

# COLOUR LIGHT SIGNALS

- In This type of signaling colour lights are used to convey information to the Loco driver. This has many advantages over semaphore signals. They may be elaborated as follows:

1. The day and Night aspects are the same, so no confusion to the driver.

2. Visibility can be available for Longer ranges, so it is easier for the driver to apply brakes in time.

3. The Signals are Placed at drivers Eye Level.

4. No Mechanical Transmission and no moving parts.



# CONTROLLING SIGNALS

Which are mandatory to observe for train movement .

# INDICATING SIGNALS

Correspond to the traffic signs of highways
Also mandatory to observe.



# WARNING SIGNALS

They provide a pre-hand warning to the driver about the controlling signals ahead. These only enhance the efficiency and provide a further safety caution

# STOP SIGNAL

The normal position of the signal is horizontal & it can be lowered at an angle of 45” to 60” with horizontal by pulling the wire from the signal cabin. In the horizontal position, the signal indicates the “**Danger Stop**“,& it is said “**On Position**”when the arm is in inclined position it indicates “**Clear Proceed**“ & is said in ”**Off Position**“.

# STOP SIGNAL

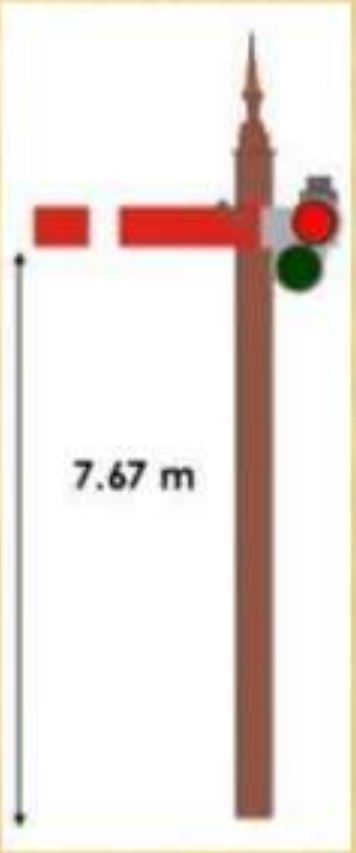
- The length and width of arm vary from 120-167 cm and 23-25 cm respectively.

- The outer end of the arm is about 2.45 cm broader than that of the hinged end .

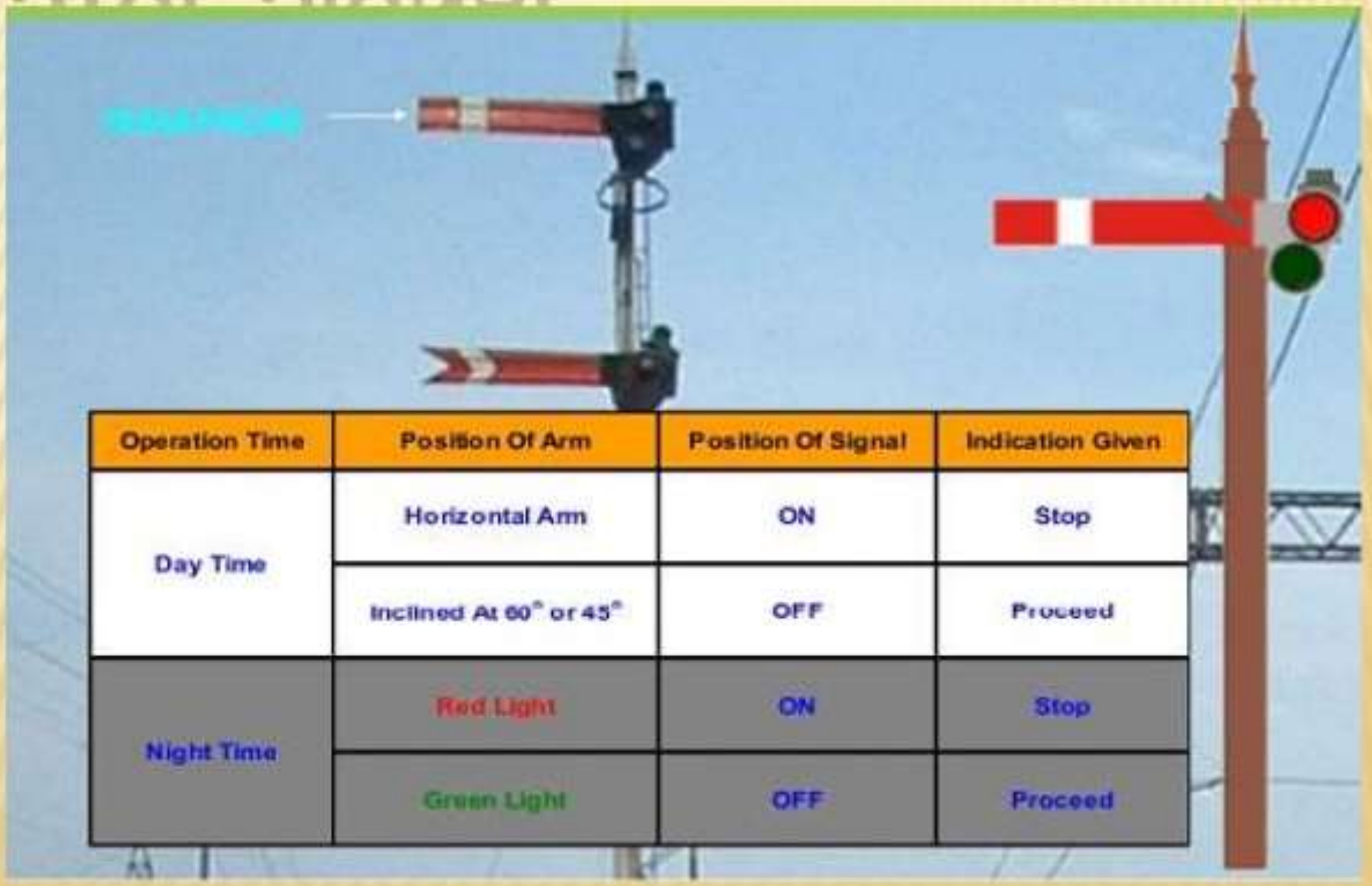
- It is placed on the left hand side of the direction of movement of train.

- The side of the arm facing the driver is painted red with white band near the end.

- The other side is painted white with black bands.



# STOP SIGNAL



| Operation Time | Position Of Arm | Position Of Signal | Indication Given |
|---|---|---|---|
| Day Time | Horizontal Arm | ON | Stop |
| | Inclined At 60° or 45° | OFF | Proceed |
| Night Time | Red Light | ON | Stop |
| | Green Light | OFF | Proceed |

# WARNER SIGNAL

- Signals place ahead of the stop signals to warn driver before entering the station.
- These signals are similar to stop signals with the exception that at their free end V notch is cut to distinguish it from stop signals.
- Warner signals are placed generally at about 540 m away from the stop signals.

# SIGNAL INDICATIONS

**Inclined Position**

Track is clear and driver can proceed with confidence.

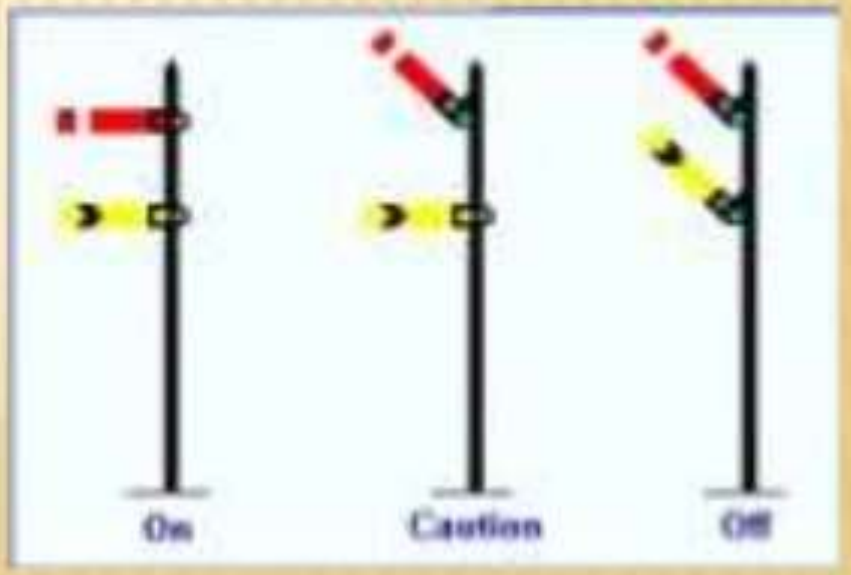
**Horizontal position**

Driver can take his train up to stop signal cautionsly.

# SEMAPHORE AND WARNER SIGNAL

- Semaphore and Warner signals can be placed on same the pole .


- Semaphore is placed on top and the Warner at about 2m below it.

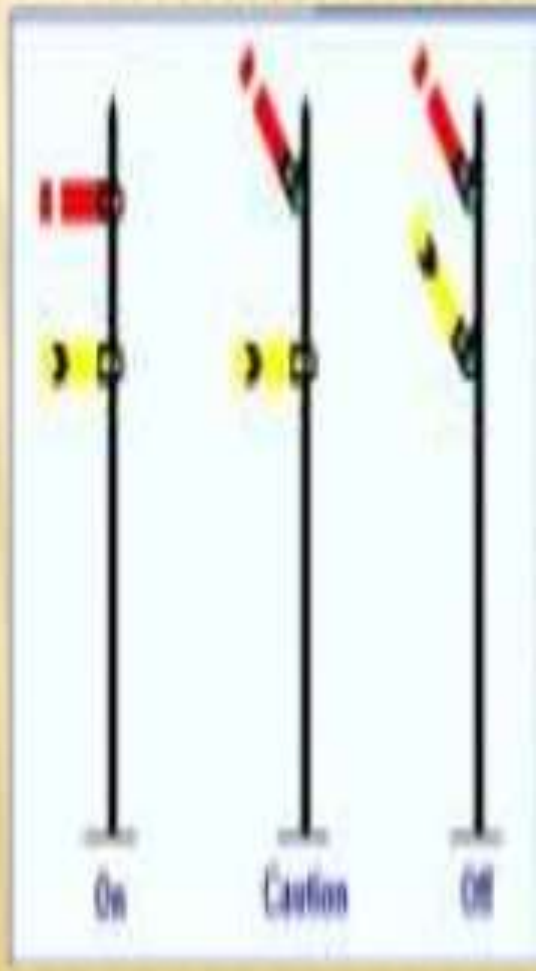


# SIGNAL INDICATIONS

**Both in Horizontal position**

Neither approaching section nor next block is clear

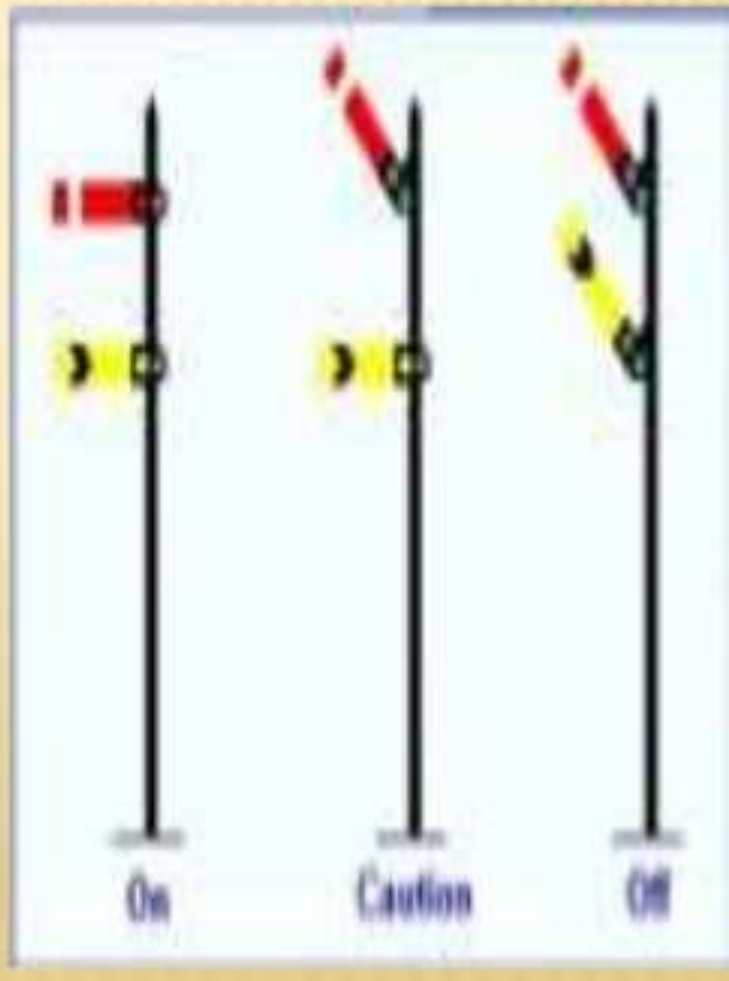
When Semaphore is inclined and warner is horizontal proceed with precaution i.e section up to station is clear but not the block beyond.



# SIGNAL INDICATIONS

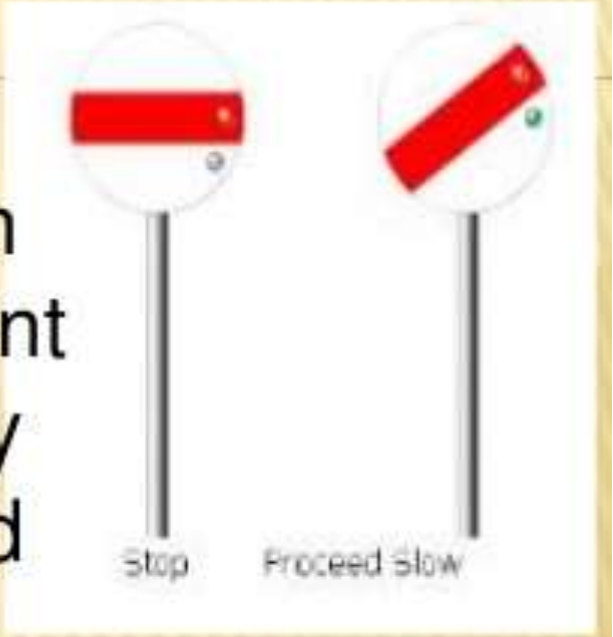
**Both in Inclined position**

Track is clear and proceed with confidence.



# DISC SIGNAL

These are shunting signals which are used for low speed movement during shunting operations. They consists of circular discs with red bands on white background.




# COLOURED LIGHT SIGNAL

- These are automatic signals & give indications by electric light both during the day as well as in light.

- These signals are provided with special lenses & hoods to emits beam of light which can be visible from a long distance even during the day