

# **MATERIALS REQUIRED FOR LAYING A TRACK**

# QUANTITY OF MATERIALS REQUIRED FOR LAYING A TRACK

- Number of rails
- Weight of rails
- Number of sleepers
- Number of fish-plates
- Number of fish-bolts
- Number of bearing plates
- Number of spikes

# PROBLEM

For 12.8m rail length of B. G. track, calculate the quantity of materials required per kilometer length of track. Assume sleeper density to be equal to  $M+4$ . Type of rail – 90R (weight = 44.7kg/m)

## SOLUTION:

1. Number of rails per km –  $(1000/12.8)*2 = 158$  number of rails
2. Weight of rails in tonnes per km –  $(158 * 12.8*44.7/1000)= 90$  tonnes
3. Number of sleepers per km – Number of rails/2 \*  $M+4 = 158/2 *(12.8+4) = 1320$  number of sleepers
4. Number of fishplates per km –  $2 * \text{number of rails per km} = 2*158 = 316$  number of fishplates.

# PROBLEM

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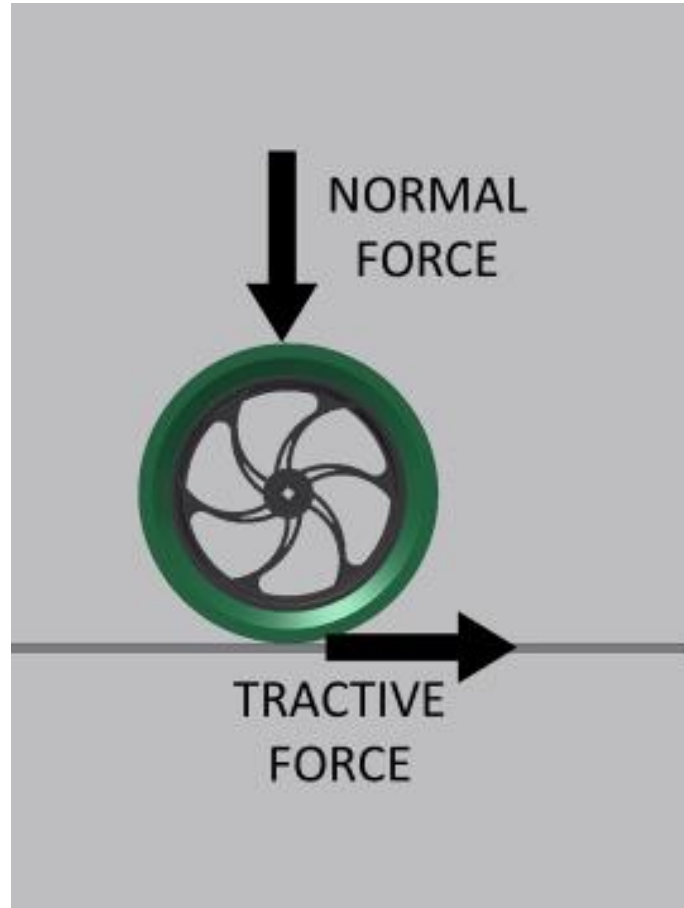
## SOLUTION:

1. Number of fish-bolts per km =  $4 * (\text{Number of fishplates}/2) = 4 * (316/2) = 632$  number of fish-bolts.
2. Number of bearing plates per km =  $2 * \text{Number of sleepers per km} = 2 * 1320 = 2640$  number of bearing plates.
3. Elastic clip –  $4 * \text{Number of sleepers per km} = 4 * 1320 = 5280$  number of elastic clips.
4. Quantity of ballast required per km =  $1000 * 1.036\text{m}^3 = 1036\text{m}^3$

# **TRACTION AND TRACTIVE RESISTANCES**

# TRACTION

Traction, or tractive force, is the force used to generate motion between a body and a tangential surface.

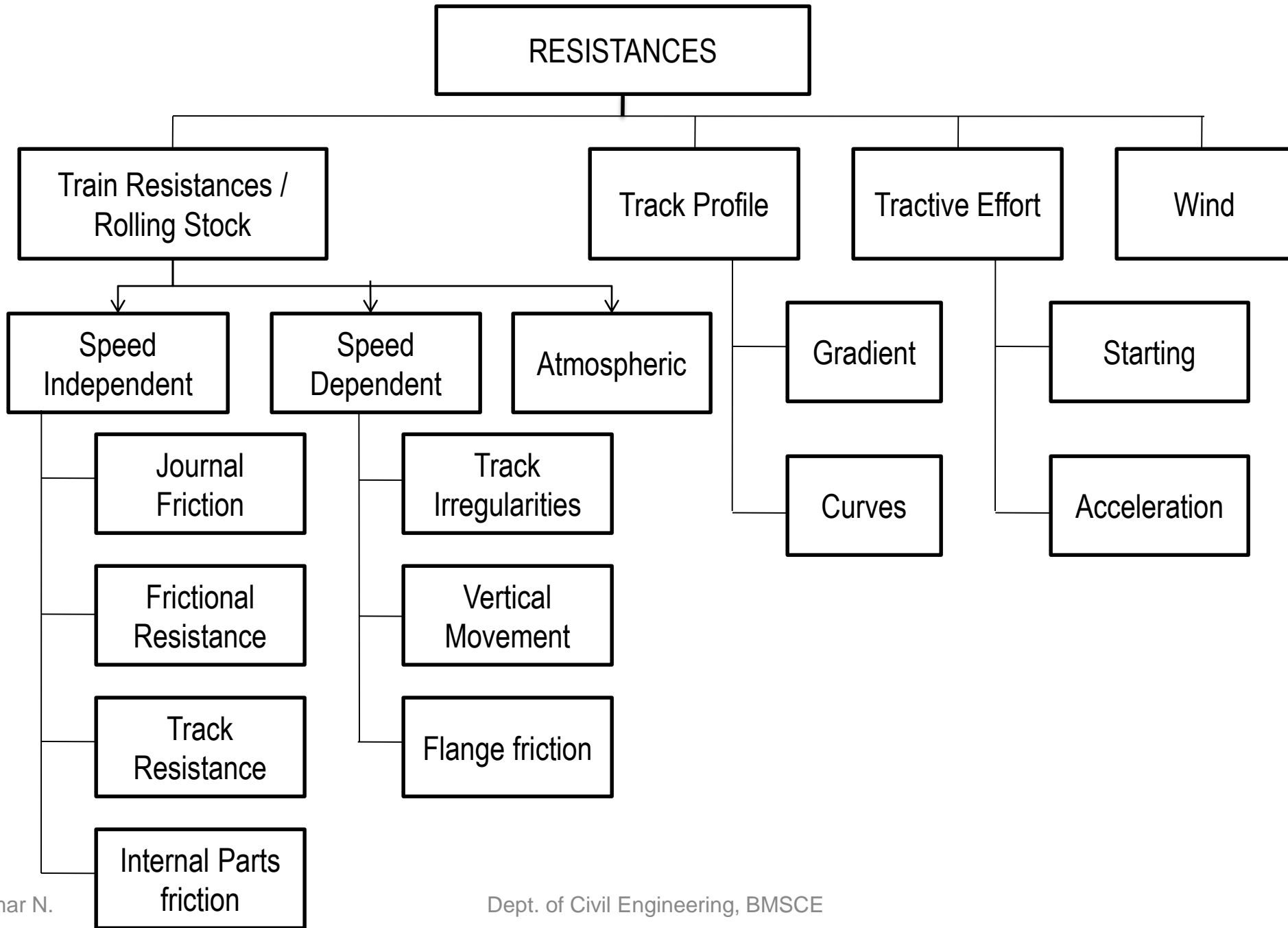


# TRACTION

- The train consists of two units the locomotive which provides power for propulsion and the trailing unit which consists of passenger compartments or goods wagons.
- The source through which the locomotive drives power is called traction.
- Sources
  - Steam
  - Diesel fuel
  - Electric supply (AC/DC)

# TRACTION

- Traction / Power depends on –
  - Load carrying capacity
  - Speed
  - Economy
  - Efficiency of service



# TRACTIVE RESISTANCES

- The various resisting forces which a locomotive has to encounter before starting a train and to keep it in motion can be classified in following four categories:-
  - Train resistances ( $RT_1$ )
  - Resistances due to track profile ( $RT_2$ )
  - Resistances due to starting and acceleration ( $R_{SA}$ )
  - Wind resistance ( $R_W$ )

# TRACTIVE RESISTANCES

## ➤ Train Resistances ( $RT_1$ )

Further it can be classified into following categories:

### ➤ Resistances independent of speed: ( $Rt_1$ )

#### ➤ Rolling Resistances -

The resistance to the motion of a train, running at a constant speed, is offered by the friction between the metal surface of rails and the wheels. It consists of the following:-

Journal Friction

Frictional Resistance

Track Resistance

Resistance due to Internal Parts

# TRACTIVE RESISTANCES

## ➤ Rolling Resistances

➤ Journal Friction – Friction imposed due to locomotives, wagons and compartments. Dependent upon :-

- Type of bearing
- Lubricant used
- The temperature of atmosphere

# TRACTIVE RESISTANCES

- Rolling Resistances
  - Frictional Resistance – It is the rolling friction due to the resistance offered to the movement of steel wheels on steel rails.
  - Track Resistance – Caused due to wave action of rails.

# TRACTIVE RESISTANCES

- Rolling Resistances
  - Resistance due to Internal Parts – It consists of the resistance between cylinder and rim of driving wheels, resistance of other moving parts and resistance of locomotive and wagons.



Source: <https://en.wikipedia.org/>

# TRACTIVE RESISTANCES

- The total train resistance independent of the speed ( $R_{t_1}$ ) can be obtained by the following expression:

$$R_{t_1} = 0.0016w$$

Where,  $w$  is weight in tonnes

# TRACTIVE RESISTANCES

- **Resistances dependent on speed: ( $Rt_2$ )**
  - Track Irregularities – When the track is not properly maintained due to irregularities, this additional resistance has to be overcome.
  - Due to vertical movement of wheels on Rails – Due to improper joints and poor maintenance of track, vertical movement of wheels on rails occurs creating resistance to traction.

# TRACTIVE RESISTANCES

- **Resistances dependent on speed: ( $Rt_2$ )**

- Due to Flange Friction, Oscillations, Swaying, etc.

- On railway track, the locomotives moves in zig-zag manner within the limits of wheel gauge tolerance. This is called “nosing action”.

- The total train resistance depends on the speed ( $Rt_2$ )

$$Rt_2 = 0.00008wv$$

Where,  $w$  = weight in tonnes

$v$  = speed in km/h

# TRACTIVE RESISTANCES

➤ **Atmospheric resistances: ( $Rt_3$ )**

- Resistance which is developed on the ends and sides of the train when wind velocity is considered to be zero.

$$Rt_3 = 0.0000006wv^2$$

Where,  $w$  = weight in tonnes

$v$  = speed in km/h

Therefore, the total train resistance ( $RT_1$ ) will be given by:

$$RT_1 = Rt_1 + Rt_2 + Rt_3$$

$$RT_1 = 0.0016w + 0.00008wv + 0.0000006wv^2$$

Where,  $w$  is weight in tonnes and  $v$  is speed in km/h

# TRACTIVE RESISTANCES

- **Resistance due to Track Profile ( $RT_2$ )**

Further classified into two categories:

- Resistance due to gradients ( $R_g$ )
- Resistance due to curves ( $R_c$ )

# TRACTIVE RESISTANCES

## ➤ Resistance due to gradients ( $R_g$ )

- When train has to move along a rising gradient, it first has to overcome the resistance which it experiences due to rising gradient.

$R_g$  = weight of train x percent slope

$$R_g = w \times g$$

# TRACTIVE RESISTANCES

- Resistance due to Track Profile ( $RT_2$ )
  - **Resistance due to curves ( $R_c$ )**
    - When train moves on the curvilinear path, resistance comes into consideration.
      - Resistance increases with increase of the gauge.
      - Resistance increases with increase in degrees of curvature.

$$\text{For B.G - } R_c = 0.0004w \times D$$

$$\text{For M.G - } R_c = 0.0003w \times D$$

$$\text{For N.G - } R_c = 0.0002w \times D$$

Where D is the degree of curve.

# TRACTIVE RESISTANCES

- **Resistance due to Starting and Accelerating ( $R_{SA}$ )**
  - Resistances are experienced by a train at the stations while starting, accelerating and decelerating.
    - Resistance due to Starting ( $R_s$ )
    - Resistance due to Accelerating ( $R_a$ )

# TRACTIVE RESISTANCES

## ➤ Resistance due to Starting ( $R_s$ )

For locomotives,  $R_{s1} = 0.15w_1$

For vehicles,  $R_{s2} = 0.005w_2$

Where ,  $w_1$  = weight of a locomotive in tonnes

$w_2$  = weight of a vehicle in tonnes.

$$R_s = 0.15w_1 + 0.005w_2$$

# TRACTIVE RESISTANCES

## ➤ Resistance due to Accelerating ( $R_a$ )

➤ Caused due to change in speed with respect to time

➤  $R_A = 0.028w \frac{(v_2 - v_1)}{t}$

Where  $v_1$  = velocity at the beginning of acceleration (kmph)

$v_2$  = velocity at the end of acceleration (kmph)

$t$  = Time taken in seconds for achieving the speed  $v_2$  from  $v_1$

$w$  = total weight of train in tonnes

# TRACTIVE RESISTANCES

- **Resistances due to Wind ( $R_w$ )**
  - Depends up on –
    - Direction of wind w.r.t movement of train
    - Wind velocity
    - Sectional area exposed to wind

# TRACTIVE RESISTANCES

## ➤ Resistances due to Wind ( $R_w$ )

$$\text{➤ } R_w = 0.000017 \cdot a \cdot V^2$$

Where  $a$  = exposed area of train in sq.m

$V$  = Speed of wind in kmph

## ➤ Total Resistance to Traction ( $R_T$ )

$$\text{➤ } R_T = R_{T_1} + R_{T_2} + R_{SA} + R_w$$

# HAULING CAPACITY

- Defined as the load that can be handled by the locomotive. It is an indicative of power available to locomotive.
- It can be computed as a product of coefficient of friction and weight on the driving wheels.

# HAULING CAPACITY

- The factors controlling the capacity are:
  - Weight coming on the driving wheels, and
  - Coefficient of friction
    - It largely depends up on:
      - Condition of rail surface, and
      - Speed of the locomotive

# HAULING CAPACITY

- Coefficient of friction – value

- Condition of rail surface:

Very wet / very dry	0.25
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Greasy	0.03
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Average dampness	0.166
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In tunnels / frosty condition	0.125
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- With respect to speed it varies between 0.1 at high speeds to 0.3 at low speeds

# HAULING CAPACITY

➤ Hauling Capacity =  $\mu \times w \times n = \mu \times W$

Where,  $\mu$  = coefficient of friction

$w$  = weight exerted on driving wheels

$n$  = number of pairs of driving wheels

$W$  = Total load on driving wheels

➤ Maximum axle load in India

➤ BG = 28.56 tonnes

➤ MG = 17.34 tonnes

➤ NG = 13.26 tonnes

# HAULING CAPACITY

- The locomotive should possess power or tractive effort, a little in excess of the hauling capacity.
- The total load, which a locomotive can haul, is worked out by the following equation:

**Hauling capacity = Sum of various train resistances**

# PROBLEMS

1. Find out the hauling capacity of a locomotive with 3 pairs of driving wheels and an axle load of 20 tonnes. Use 0.2 as co-efficient of friction.

Solution: - Hauling capacity of locomotive =  $\mu \times w \times n = 0.2 * 3 * 20 = 12$  tonnes.

# PROBLEMS

2. What would be the gradient for a B. G. track when the grade resistance together with curve resistance due to a curve of  $3^\circ$  shall be equal to the resistance due to a ruling gradient of 1 in 200?

Solution:-

Let 'w' be the weight of the train and 1 in x be the required gradient.

Resistance due to required gradient =  $1/x * w$

Resistance due to ruling gradient =  $1/200 * w$

Resistance due to curve  $3^\circ$  on B. G. Track =  $0.0004w \times D$

Therefore, under given condition =  $1/x*w + 0.0004 *w*3 = 1/200*w$

Therefore, Required ruling gradient,  $x = 263$ , 1 in 263

# PROBLEMS

3. Calculate the maximum permissible train load that can be pulled by a locomotive having four pairs of driving wheels carrying an axle load of 24 tonnes each. The train has to run at a speed of 80 kmph on a straight level B. G. track.

Also calculate the reduction in speed, if train has to climb a gradient of 1 in 200.

If train climbs the gradient with a  $2^\circ$  curve, then what would be reduction in speed.

# PROBLEMS

Solution: - Assuming the hauling capacity of the locomotive is equal to  $1/6^{\text{th}}$  times the load on driving wheels.

Hauling capacity = 16 tonnes.

On a straight level track, train resistances are  $RT_1 = Rt_1 + Rt_2 + Rt_3$

$$RT_1 = 0.0016w + 0.00008wv + 0.0000006wv^2$$

**Hauling capacity = Sum of various train resistances**

$$16 = 0.0016w + 0.00008w*80 + 0.0000006w*80^2$$

$$w = 1351 \text{ tonnes.}$$

Now, train has to move up gradient of 1 in 200,  $RT_1 = Rt_1 + Rt_2 + Rt_3 + Rg$   
( $w*g$ )

# PROBLEMS

**Hauling capacity = Sum of various train resistances**

$$16 = 0.0016w + 0.00008w*80 + 0.0000006w*80^2$$

$$w = 1351 \text{ tonnes.}$$

Now, train has to move up gradient of 1 in 200,  $RT_1 = Rt_1 + Rt_2 + Rt_3 + Rg$   
( $w*g$ ) +  $Rc$

$$16 = 0.0016*1351 + 0.00008*1351*v + 0.0000006*1351*v^2 + (1351 * 0.5/100)$$

Speed,  $v = 48$  kmph

Reduction in speed =  $80 - 48 = 32$  kmph