Example 5.2. *The effective span of a plate girder through type bridge for a single broad gauge track is 30 m. The dead load, live load and impact load reaction is 1200 kN. The vertical reaction due to overturning effect of wind at each end of the girder is 80 kN. The lateral load due to wind at each bearing is 34 kN. Design the rocker bearing.*

Design :

Step 1. Dead load, live load and impact load reaction = 1200 kN

Vertical reaction due to wind = 80 kN

Longitudinal load from Bridge Rule, for 30 m span, for broad gauge per track.

Tractive effort = 476 kN, Braking force = 457 kN

Longitudinal load per girder = $\frac{1}{6}$ x 476 = 238.0 kN

Allowable stress in cement concrete = 4 N/mm^2

Area of bed plate required = $\left(\frac{1200 \times 1000}{4}\right) = 3000 \times 100$ mm^2

Provide 700 mm x 700 mm bed plate as shown in Fig. 5.11. A large bed plate is provided, since, it will also be subjected to lateral load and longitudinal force.

Step 2. Design of Rocker bearing

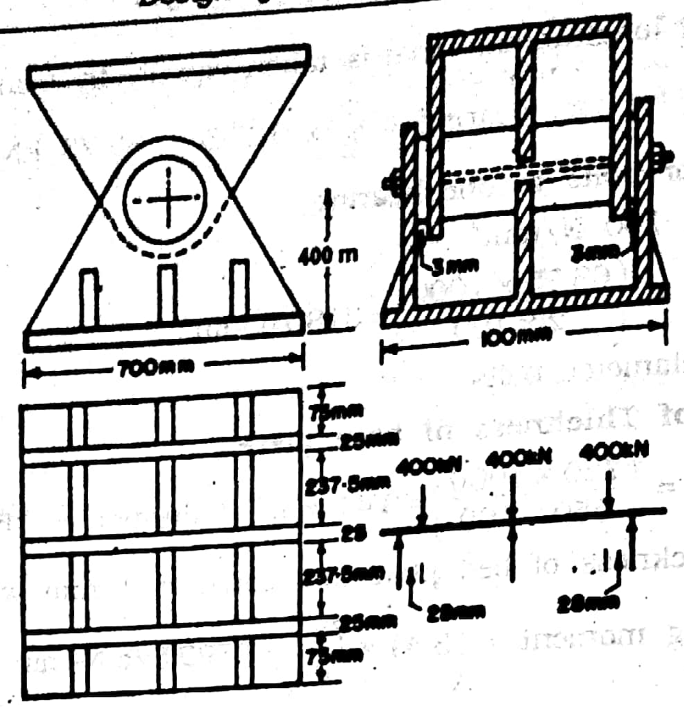

Fig. 5.11

As per IS : 800-1984, Allowable stress in bearing on projected area = 0.75 f_y

Allowable stress on mild steel pins

In shear = 100 N/mm^2

In bearing = 300 N/mm^2

In bending = 0.66 f_y

Provide 150 mm diameter pin

Thickness of rib plates required = $\left(\dfrac{1200 \times 1000}{0.750 \times 250 \times 150}\right)$ = 42.66 mm

Provide 25 mm thick, 3 rib plates

Total thickness = 75.0 mm

Load shared by each plate = (1/3 x 1200) = 400 kN

Let the gap between two outer plates of top casting and bottom casting be 3 mm.

Distance between centre to centre of two outer plates, = (25 + 3) = 28 mm

Maximum bending moment in pin = 400.0 x 28/10^3 = 11.2 kN-m

Maximum bending stress in the extreme fibre of pin.

$$\sigma_b = \left(\frac{11.2 \times 10^6}{\frac{\pi}{32} \times 150^3}\right) = 32.82 \text{ N/mm}^2. \text{ Hence safe.}$$

Maximum shear stress, $\tau_{v.cal} = \dfrac{4}{3} \times \left(\dfrac{400.0 \times 1000}{\frac{\pi}{4} \times 150^2}\right)$ = 30.2 N/mm^2 . Hence , safe

Vertical load due to dead load, live load, impact load and wind load

= (1200 + 80) = 1280 kN

Let the height of pin centre line of pin above base = 400 mm

Half diameter of pin = 150/2 mm

Lateral load due to wind at each bearing = 34 kN

Moment due to wind at the base = 34.0 x 0.30 = 10.2 kN-m

Moment due to longitudinal force = (238 x 0.30) = 71.4 kN-m

Maximum pressure below the base

$$= \left(\frac{1280 \times 1000}{700 \times 700}\right) + \left(\frac{10.2 \times 10^6}{\frac{1}{6} \times 700 \times (700)^2}\right) + \left(\frac{71.43 \times 10^6}{\frac{1}{6} \times 700 \times (700)^2}\right)$$

$= 4.04 \text{ N/mm}^2 < 1.25 \times 4 \text{ N/mm}^2$. Hence, safe.

Allowable stress for occasional loads is 1.25 x allowable stress for normal loads.

Step 3. Design of base plate

Let base plate be = 25 mm

Height of pin above base = (400 − 75 − 25) = 300 mm

Therefore, design pressure for base $= \left(\frac{4.04}{1.25}\right) = 3.23 \text{ N/mm}^2$

Let the projection of the base = 75 mm

Maximum bending moment per mm strip, $= \left(\frac{3.23 \times (75)^2}{2}\right) = 9084.38$ mm

Let t be the thickness of base plate.

Then, $\frac{1}{6} \times 1 \times t^2 \times 185 = 9084.38$, t = 17.16 mm

Provided 25 mm thick base plate.

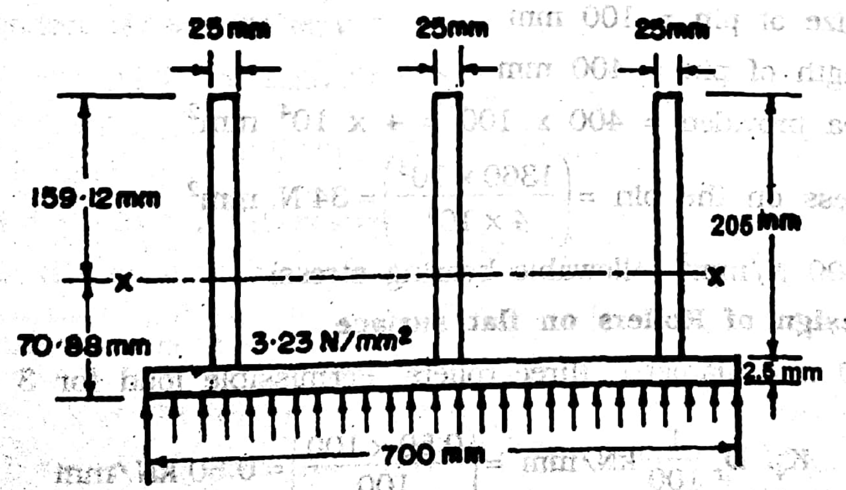

Fig. 5.12

The base plate is tested at section XX as shown in Fig. 5.12.

Maximum bending moment $= \left[\dfrac{3.23 \times 700 \times (350)^2}{2 \times 100}\right] = 138.486$ kN–m

Let the distance of XX-section from the base be y,

$$\bar{y} = \left[\frac{700 \times 20 \times 10 + 3 \times 205 \times 25 \times \left(\frac{210}{2} + 20\right)}{700 \times 20 + 3 \times 205 \times 25}\right] = 70.88 \text{ mm}$$

The moment of inertia of base block

$$I = \left[\frac{1}{12} \times 70 \times 2^3 + 70 \times 2 \times (6.088)^2 + \frac{3 \times 2.5 \times (21)^2}{12} + 3 \times 2.5 \times 21 \times (5.412)^2\right]$$

$$\times\ 10^4 \text{ mm}^4 = 15636.85 \times 10^4 \text{ mm}^4$$

Bending stress, $\sigma_b = \left[\dfrac{138.486 \times 10^6 \times (230 - 70.88)}{15636.85 \times 10^4}\right] = 140.92 \text{ N/mm}^2$

Hence, safe.

Example 5.3. *The dead load, live load and impact load reaction at the end of a bridge girder as 1300 kN. The vertical reaction of each end of the girder due to overturning effect of wind is 60 kN. Design the roller bearing. The least allowable perpendicular distance between the faces of adjacent rollers after their revolved position may be taken as 6 mm. The centre of roller travels 25 mm.*

Design :

The maximum end reaction at the support due to dead load, live load, impact load, and vertical reaction at each end of the girder due to overturning

= (1300 + 60) = 1360 kN.

Step 1. Design of Pin

The pin bearing is provided with continuous seating

Minimum size of pin = 100 mm

Assume length of pin = 400 mm

Bearing area provided = 400 x 100 = 4 x 10^4 mm^2

Bearing stress on the pin $= \left(\dfrac{1360 \times 10^3}{4 \times 10^4}\right) = 34 \text{ N/mm}^2$

< 1.33 x 300 N/mm^2 (Allowable bearing stress)

Step 2. Design of Rollers on flat surface

Provide 100 mm diameter, three rollers. Permissible load for 3 or more rollers

$$K_4 .\ D_r \frac{1}{100} \text{ kN/mm} = \left(\frac{0.50 \times 100}{100}\right) = 0.50 \text{ kN/mm}$$

Total length of rollers required, $\left(\frac{1360}{0.50}\right) = 2720$ mm

Length of each roller = $\left(\frac{2720}{3}\right) = 906.66$ mm

Provide 100 mm diameter, 3 rollers each 0.950 m long.

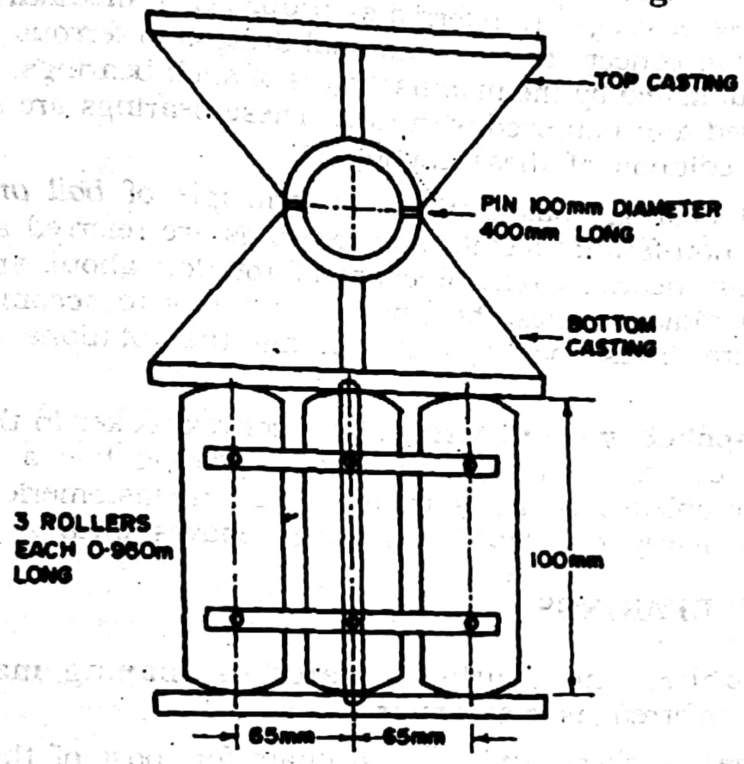

Fig. 5.13

Least allowable perpendicular distance between the faces or adjacent rollers after their revolved position, b = 6 mm

Horizontal travel, B = 25 mm

Diameter of rollers, D = 100 mm

From Eq. 5.1, the width of segmental rollers

$$d = D \sin\left(\frac{114.6 \times B}{D}\right) = 100 \sin\left(\frac{114.6 \times 2.5}{10}\right) \text{mm} = (100 \times 0.48) = 48\text{mm}$$

Provide 50 mm width for the rollers

From Eq. 5.2, the spacing between adjacent rollers

$$a = b \sec\theta + d(\sec\theta - 1), \quad \theta = \left(\frac{114.6\,B}{D}\right) = 28.65$$

$$\therefore a = 6 \times \sec(28.66)^\circ + 50\ (\sec 26.65^\circ - 1) = 13.7 \text{ mm}$$

The spacing between adjacent rollers is kept equal to 15.0 mm.

The bearing designed is shown in Fig. 5.13.