Abutments :- It is the substructure which supports the end of the superstructure of a bridge and laterally supports the embankment which serves as an approach to the bridge.

Types :- Masonary, Plain concrete and reinforced concrete.

Components :- i) the breast wall : to support D.L & L.L

ii) the wing walls,: as extension of breast wall only to retain the fill.

iii) the back wall (the dirt wall) : to prevent the flow of material from the fill on to the bridge seat.

Forces :-

1) D.L due to superstructure
2) L.L on the superstructure
3) Self wt. of the abutment.
4) Longitudinal forces due to tractive effort braking, temperature variation and concrete shrinkage.
5) Thrust on the abutment due to retained earth. (Bridge Code, clause 714.4 requires all abutments to be designed for Live load surcharge of 1.2m ht of earth fill).

Methodology / Objectives :-

- Design based on assumption of preliminary dimensions, depending upon superstructure, substructure & foundation.
- Check for stability against overturning, base pressures and sliding
- Factor of safety against overturning > 2.0.
- Eccentricity of the resultant of all forces on the abutment

should lie within one sixth of the base width, so that there is no tension at the base.

- Max. stress should be less than safe bearing capacity of the soil.
- Factor of Safety against sliding > 1.5.

<u>Example</u>:-

I) Data.

Superstructure:

T-beam two lane bridge of effective Span = 16.1 m

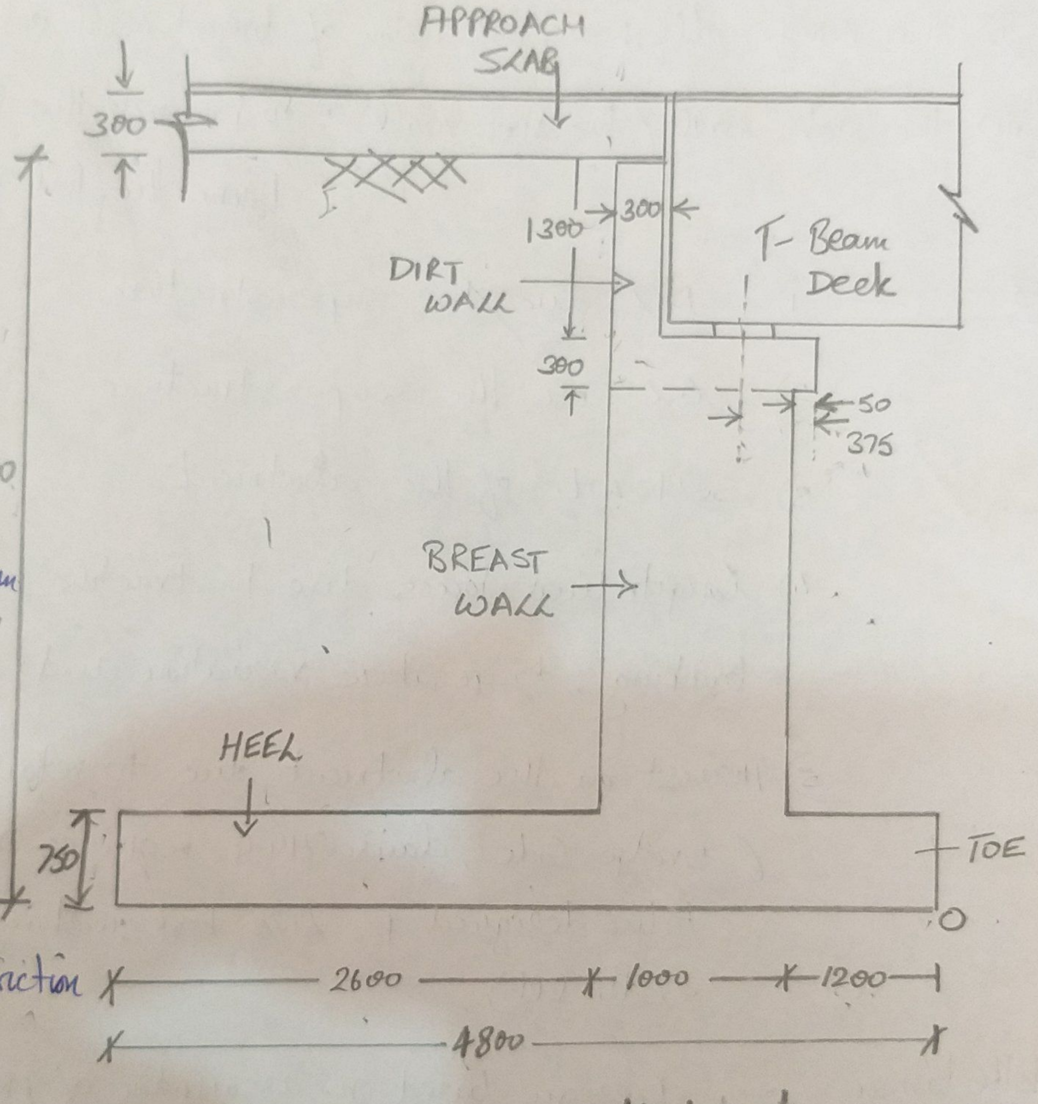
Overall length = 17.26 m

Back fill = Gravel ($\phi = 35^\circ$)

Unit wt of Backfill, $w_1 = 18\ KN/m^3$

Angle of internal friction $z_1 = 17.5^\circ$

Approach slab = 300 mm thick



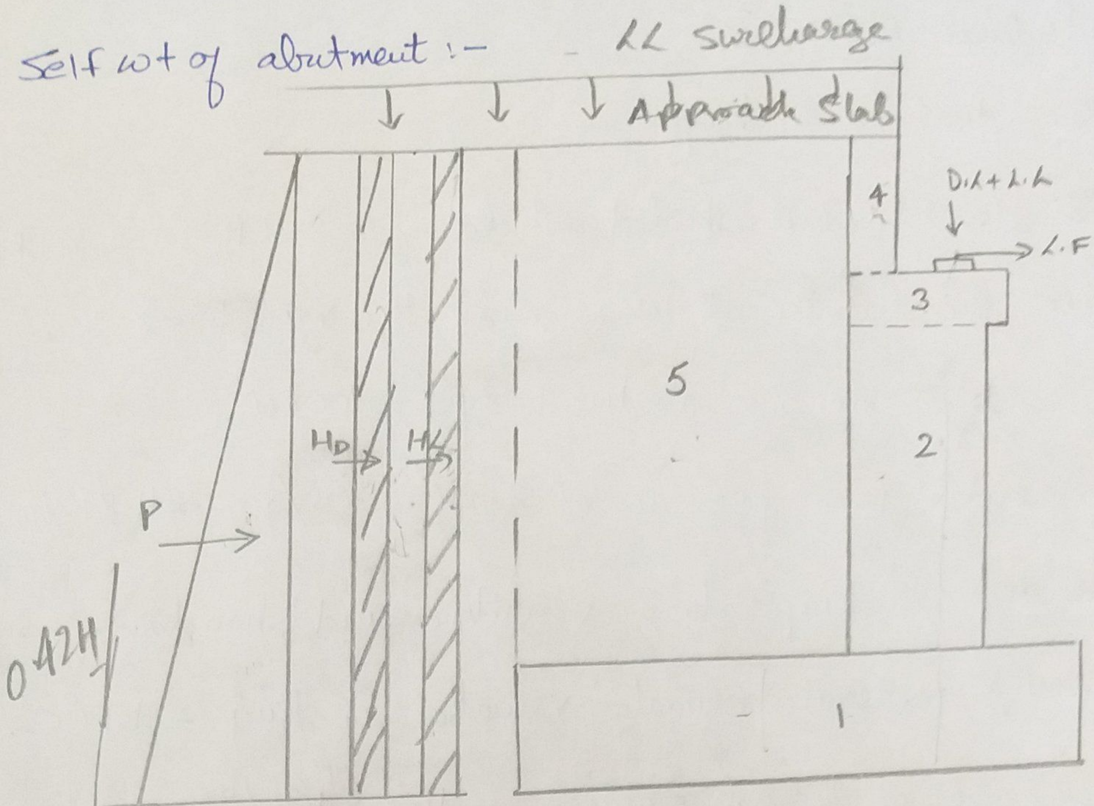
<u>Dimensions of Abutment</u>

Load from superstructure per running foot of abutment wall:-

Dead Load = 119 KN/m
Live load = 85 KN/m
] For a width of 8.5 m

Bearings: Neoprene [320 × 500 × 65 mm] embedded 5 plates (3 mm thick) and 6 mm clearance in plan, $G = 1\ KN/mm^2$

II Self wt of abutment :-



S.No.	Details	Force KN V	Force KN H	Arm (m)	Moment about O KN m M_V	Moment about O KN m M_H
01	D.L from Superstructure	119.0	–	1.595	178.5	–
02	Horizontal force due to temp & shrinkage	–	4.0	4.30	–	17.2
03	Active Earth pr.	–	140.0	2.35 ~~1.87~~	–	329.0 ~~261.80~~
04	Horizontal force due to LL surcharge and approach slab	–	80.83	2.80	–	226.324
05	Vertical load due to LL surcharge & approach slab	75.66	–	(1.3+1.0 +1.2) = 3.5	264.81	~~264.81~~ –
06	Self wt - part I 4.8 × 0.75 × 25	90	–	2.4	216	–
07	II, 3.25 × 1.0 × 25	81.25	–	0.5+1.2 = 1.7	138.125	
08	III, 0.3 × 1.05 × 25	7.88	–	0.525+1.15 = 1.68	13.23	
09	IV, 0.3 × 1.3 × 25	9.75	–	0.15+0.7+1.2 = 2.05	20.00	
10	Wt of earth on heel slab	227	–	1.3+1.0+1.2 = 3.5	794.50	–
	span unloaded	610.54	224.83		1625.17	~~505.324~~ 572.524
11	LL From 70R loading	85	–	1.50	127.50	–
12	Vertical force due to braking	4.1	–	1.50	6.20	
13	Horizontal force due to braking	–	11.80	4.3	–	50.7
14	span loaded	699.54	236.63		1758.87	~~556.024~~ 623.224

III Longitudinal Forces :-

i) Force due to braking :-

Force due to 70R wheeled vehicle $= 0.2 \times 1000 = 200 KN$

This force acts at 1.2 m above the road level

Force on one abutment wall $= 100 KN$

Horizontal force per m of wall $= 100/8.5 = 11.8 KN/m$

ii) Force due to temperature variation and shrinkage

Assuming moderate climate, variation in temp $= \pm 17°C$.

Coefficient of thermal expansion $= 11.7 \times 10^{-6}/°C$

Strain due to temp variation $= 17 \times 11.7 \times 10^{-6} = 1.989 \times 10^{-4}$

Strain due to concrete shrinkage $= 2.0 \times 10^{-4}$ (Clause 220.3)

Total strain $= (1.989 + 2.0) \times 10^{-4} = 3.989 \times 10^{-4}$

Horizontal deformation of one abutment $= \dfrac{3.989 \times 10^{-4} \times 17260}{2}$

$= 3.44 mm$

Strain in bearing $= \dfrac{\text{Deformation}}{\text{Elastomer thickness}}$

$= \dfrac{3.44}{65-(5\times3)} = 0.069$

Horizontal force due to strain in longitudinal direction at bearing level $= \dfrac{1.10 \times \text{Strain} \times G \times \text{area of plates in bearing} \times \text{No. of Bearings}}{1000 \times \text{width}}$

$= \dfrac{1.10 \times 0.069 \times 1.0 \times (308 \times 488) \times 3}{1000 \times 8.5}$

$= 4.0 KN/m$

(iii) Vertical reaction due to braking

Vertical reaction at one abutment $= \frac{200(1.2 + 1.3 + 0.3)}{16.10 \times 8.5}$

$= 4.1$ KN/m

(iv) Earth pressure

Active earth pressure, $P = 0.5 K_a w h^2$

$\theta = 90°$, $\phi = 35°$, $z = 17.5°$, $\delta = 0°$

$K_a =$ ~~0.0.49~~ 0.496

Ht. of back fill below approach slab = 5.6m

Active Earth pressure $= 0.5 \times 0.496 \times 18 \times 5.6^2 = 140.0$ KN/m

Ht. above the base of centre of pressure $= \frac{1}{3}$ 0.42 $\times 5.6 =$ ~~1.87~~ 2.35m

Passive pressure in front of toe slab is neglected.

(v) Live load surcharge and approach slab.

Equivalent ht. of earth for live load surcharge is 1.20m.

Horizontal force due to LL surcharge $= 1.20 \times 18 \times 0.496 \times 5.6$

$= 60.0$ KN/m.

Horizontal force due to approach slab $= 0.3 \times 25 \times 0.496 \times 5.6$

$= 20.83$ KN/m

These forces act at 2.8m above the base.

Vertical load due to LL surcharge and approach slab.

$= (1.2 \times 18 + 0.3 \times 25) \times 2.6 = 75.66$ KN/m

(vi) Wt. of earth on heel slab

Vertical load $= 18(5.6 - 0.75) 2.6 = 227$ KN/m

(vii) Check for stability – overturning

i) Span loaded condition

Overturning moment about toe = ~~556.024~~ 623.224 kNm

Resisting moment " = 1758.87 kNm

$$FOS = \frac{1758.87}{~~556.024~~\ 623.224} = 2.82 > 2.0 \text{ Safe}$$

Location of Resultant from O.

$$x_0 = \frac{M_V - M_H}{V} = \frac{1758.87 - ~~556.024~~\ 623.224}{699.54} = 1.62\,m$$

Ecc. of resultant

$$e_{max} = B/6 = \frac{480}{6} = 80\,cm = 0.80\,m.$$

$$e = \frac{B}{2} - x_0 = \frac{4.8}{2} - 1.62 = 0.78 < 0.80\,m.$$

ii) Span unloaded condition

Over turning moment = ~~505.324~~ 572.524 kNm

Resisting moment = 1625.17 kNm

$$FOS = \frac{1625.17}{~~505.324~~\ 572.524} = 2.83 > 2.0 \text{ Safe.}$$

$$x_0 = \frac{M_V - M_H}{V} = \frac{1625.17 - ~~505.324~~\ 572.524}{610.54} = 1.72$$

$$e = \frac{B}{2} - x_0 = \frac{4.8}{2} - 1.72 = 0.68 < 0.80\,m$$

(viii) Check for stresses at base

For span loaded condition :-

Total downward forces = 699.54 kN = P

$$\text{Stresses} = \frac{P}{b}\left(1 \pm \frac{6e}{b}\right)$$

$$= \frac{699.54}{4.8 \times 1.0}\left[1.0 \pm \frac{6 \times 0.78}{4.8}\right]$$

$$= 287.85 \ \& \ 3.64 \ kN/m^2$$

Max. pressure = 287.85 kN/m² < 350 kN/m²

Min. pressure = 3.64 kN/m² > 0 (No tension).

(ix) Check for sliding

Sliding force = 236.63 kN

Force resisting sliding = 0.6 × 699.54 = 419.72 kN

$$FOS = \frac{419.72}{236.63} = 1.77 > 1.5 \text{ (Safe)}.$$

The section of abutment is adequate.