Design of ABUTMENT

Name Of Work :- Construction of Submersible Bridge on ON KHERWARA - JAWAS - SUVERI ROAD IN KM 9/000, ACROSS RIVER SOM

(a) Data

Preliminary dimensions	: Assumed as in Fig. **TYPABUT-01**	
Superstructure	: RCC Slab Bridge Total Width of Slab =	8.40 M
	overall length = 8.80 m	
Type of abutment	: Reinforced concrete	
Loading	: As for National Highway	
Back fill	: Gravel with angle of repose Φ =	35^{o}
	Unit weight of back fill, w =	18 kN/m3
	Angle of internal friction of soil on wall, z =	17.5^{o}
Approach slab	: R.C. slab 300 mm thick, adequately reinforced	

Load from superstructure per running foot of abutment wall:

Dead load = 177.85 kN/m

Live load = 93.84 kN/m

(Refer Stability Analysis for sub structure. The above two values are obtained from the calculations for superstructure, and are taken to act over a width of 15 m).

Bearing : Tar Paper Bearings

(C) Self weight of abutment

Treating the section as composed of 6 elements as shown in Fig. 1the weight of each element and moment about the point O on the front toe are computed as in Table 1

(d) Longitudinal forces

(i) Force due to braking

Force due to 70 R wheeled vehicle = 0.2 x 1000 = 200 kN

This force acts at 1.2 m above the road level(Clause 214.3).

Force on one abutment wall = 200 / 2 = 100 kN

Horizontal force per m of wall = 100 / 8.40 = 11.91 kN/ m

(ii) Force due to temperature variation and shrinkage

Assuming moderate climate, variation in temperature is taken as + 17 oC as per Clause 218.5 of Bridge Code.

Coefficient of Thermal expansion = 1.17E-05 $/^{o}C$

Strain due to temperature variation = 17 x 1.17E-05 = 1.99E-04

From Clause 220.3, strain due to concrete shrinkage = 2.00E-04

Total strain due to temperature and shrinkage = 1.99E-04 + 2.00E-04 = 3.99E-04

Horizontal deformation of deck due to temperature and shrinkage affecting one abutment = $3.99E-04 \times 8800 /2 = 1.76E+00$ mm

Modulus of Elasticity Ec = $5000 \times fck^{1/2}$ = 31220.19 N/mm2

Horizontal Stress due to strain in longitudinal direction at bearing level = $3.99E-04 \times 31220.19 =$ 12.45 N/mm2

Horizontal Force due to strain in longitudinal direction at bearing level (For 1 m width of Slab) =

$1.25E+01 \times 750 =$ 9340.30 N/m

= 9.34 kN/m

(iii) Vertical reaction due to braking

$$\text{Vertical reaction at one abutment} = \frac{200(1.2 + 0.975)}{11.10 \times 15} = 2.61 \text{ kN/m}$$

(d)Earth pressure

Active earth pressure $P = 0.5\, wh^2 K_a$

where K_a is obtained from Equation (3.5)

$K_a = \sec\Theta \sin(\Theta-\Phi)/[(\sin(\Theta+z))^{1/2} + \{\sin(\Phi+z) \sin(\Phi-\delta)/\sin(\Theta-\delta)\}^{1/2]}$

Where P= Total active pressure, acting at a height of 0.42 h inclined at z to the normal to the wall on the earth side

w = unit weight of earth fill

h = height of wall

Θ = Angle subtended by the earthside wall with thw horizontal on the earth side

Φ = Angle of internal friction of the earthfill

z = angle of friction of the earthside wall with the earth

δ = Inclination of earthfill surface with the horizontal

$\Theta = 90^0$ $\Phi = 35^0$

$z = 17.5^0$ $\delta = 0^0$

Substituting values in Equation (3.5), we get K_a = 0.496 Coefficient

Height of backfill below approach slab = 4.83 m

Active earth pressure =

$0.5 \times 18 \times 4.83^2 \times 0.496$

= 104.15 kN/m

Height above base of centre of pressure = $0.42 \times 4.83 =$ 2.03 m

Passive pressure in front of toe slab is neglected.

(e) Live load surcharge and approach slab

Equivalent height of earth for live load surcharge as per clause 714.4 is 1.20 m

Horizontal force due to L.L. surcharge =1.2 x 18 x 0.496 x 9.20 = 51.75 kN/m

Horizontal force due to approach slab = 0.3 x 24 x 0.496 x 9.20 = 17.25 kN/m

Total 69 kN/m

The above two forces act at **2.415 m above the base.**

Vertical load due to L.L. surcharge and approach slab

= (1.2 x 18 + 0.3 x 24) x 4.5 = 129.6 kN/m

(f) Weight of earth on heel slab

Vertical load = 18 x4.5x (4.8300000000 = 34.48 kN/m

(g) Check for stability - overturning

The forces and their position are as shown in Fig. 1

The forces and moments about the point O at toe on the base are tabulated as in

Table 1 Two cases of lading condition are examined (i) Span loaded condition and (ii) Span unloaded condition.

Case (i) Span loaded condition

See Row 15 of Table 12.3

Overturning moment about toe = 471.35 kN-m

Restoring moment about toe = 4132.47 kN-m

Factor of safety against overturning = 4132.47 / 471.35 = **8.77**

Location of Resultant from O **> 1.5 Hence Safe**

$X_0 = (M_V - M_H) / V = (1740.9 - 623.1) / 691.4 = 1.62$ m

=(4132.472 - 471.349) / 1004.041) = 3.65 m

Eccentricity of resultant

$e_{max} = B/6 =$ 8.05 /6 = 1.34 m

$e = (B/2 - X_{0)} = 0.78$ m < 0.80 m 4.03 - 3.65 = 0.38 m

< 1.34 m

Case (ii) Span unloaded condition

See Row 11 of Table 12.3

Overturning moment about toe = 419.06 kN-m

Restoring moment about toe = 3855.15 kN-m

Factor of safety against overturning = 3855.15 / 419.06 = **9.2**

Location of Resultant from O **> 1.5 Hence Safe**

$X_0 = (M_V - M_H) / V =$

=(3855.154 - 419.064) / 907.587) = 3.79 m

(h)Check for stresses at base

For Span loaded condition

Total downward forces = 1004.04 kN

1004.04 6 x 0.78

Extreme stresses at base =

Maximum Stress = 1004.041/(8.05x1)(1 +(6x0.38/8.05)) = 160.06 kN/m2

Minimum Stress = 1004.041/(8.05x1)(1 -(6x0.38/8.05)) = 89.4 kN/m2

Table 1 Forces and Moments About Base for Abutment.

Sl. No.	Details	Force, kN		Moment about O, kn-m		
		V	H	Arm m	Mv	M_H
1.	D.L. from superstructure	177.85	-	2.88	512.200	-
2.	Horizontal force due to temperatre and shrinkage	0	9.34	4.39	-	41.004
3.	Active earth pressure	0	104.15	2.03	-	211.425
4.	Horizontal force due to L.L surcharge and approach slab	0	69.00	2.415	-	166.635
5.	Vertical load due to L.L. surcharge and approach slab	129.60	-	5.8	751.68	-
6.	Self weight - part 1 8.05x1x 24 =	193.20	-	4.025	777.63	-
7.	Self weight - part 2 2.18000000000001x1.05x 24 =	54.94	-	3.03	166.468	-
8.	Self weight - part 3 1.2x1.05x 24 =	30.24	-	1.68	50.8032	-
9.	Self weight - part 4 0.3x0.45x 24 =	3.24	-	2.05	6.642	-
9.	Self weight - part 5 Triangular River Side 1/2x2x2.63000000000001x24=	63.12	-	1.83	115.72	-
9.	Self weight - part 5 Triangular Earth Fill Side 1/2x4x2.83000000000001x24=	126.24	-	4.88	616.472	-
10.	Weight of earth on heel slab part 1 Rectangular Portion 0.5 x 3.83000000000001 x 18=	34.48	-	7.8	268.944	-
10.	Weight of earth on heel slab part 2 Triangular Portion	94.68	-	6.22	588.594	-

	1/2x4x3.83000000000001x18=					
11.	**Items 1 to 10** **(Span unloaded condition)**	**907.59**			**3855.15**	**419.06**
12.	L.L. from Superstructure Class 70 R wheeled vehicle	93.84	-	2.875	269.794	-
13.	Vertical force due to braking	2.61	-	2.88	7.524	-
14.	Horizontal force due to braking	0.00	11.91	4.39		52.2849
15.	**Items 11 to 14** **(Span loaded condition)**	**1004.04**	**194.40**	**-**	**4132.47**	**471.35**

NET LONGITUDINAL MOMENT 4132.47 - 471.35 = 3661.12

Maximum pressure = 160.06 kN/m2 < 200.00 kN/m2 permissible HENCE OK.

Minimum pressure = 89.4 kN/m2 >0 (No tension) HENCE OK.

(i) Check for sliding

See Row 15 of Table 1

Sliding force = 194.40 kN

Force resisting sliding = 0.6 x 1004.04 = 602.43 kN

Factor of Safety against sliding = 602.43 / 194.40 = **3.1**

(j) Summary **> 1.5 Hence Safe**

The assumed section of the abutment is adequate.