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PLANNING AND ESTIMATION OF A PEDESTRIAN SUBWAY SYSTEM

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ABSTRACT

The proposal of the pedestrian subway system in V.R.S.E.C across the extending canal road thorough the project site. Survey is done for measurements of land primarily. Then a plan is prepared for the selected site considering two entry zones on each side of the passing zone. Design is done manually for various components considering the code provisions of IRC: 6-2000, IS: 456-2000. Estimate is made to know the cost of the project. Here the subway is normally an underpass for pedestrians or cyclists beneath a road or a railway line allowing them to reach the other side safely. So, the estimation of the project is done in detail.

Keywords: Pedestrian, Subway, System, canal, road, Estimation, Project.

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1. INTRODUCTION

Underpass are the structures that are used for the passage of water, traffic and cattle. When there is an intersection of two roads in which one is of heavy traffic such as a state highway and other is slow pedestrian traffic there is a need of provision of some medium for transportation from one side to another side. This can be achieved either by constructing a foot over bridge or an underpass to cross the road at the intersection. Keeping in view that the foot over bridge is less suitable and preferable at the selected location and also to introduce the emerging infrastructure to the public. This is an underpass that is meant for only pedestrian traffic and not for the vehicles. In this the risk for accidents is also less when compared to the other means of transport.

2. OBJECTIVES

- To determine the lateral earth pressure in the wall of the subway
- To determine the impact of live load against overturning, sliding, pressure on wall.
- To determine the cost estimation of the project

The abstraction focus is mainly on the involvement of several design considerations and calculations of box culvert, subway staircase and retaining wall. The design of the whole structure includes various components. Design standards adopted in the project are in accordance with the guidelines from Indian codes IS 456-2000, IRC 6-2000 and IS 21-2000.

3. METHODOLOGY

For Lateral Earth Pressure on wall

A length of one metre of the wall is considered for design. From Rankin's theory of earth pressure

$$P = \frac{WH^2}{2}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)$$

p = total pressure on wall acting at H/3 from the base

3.1. Stability Requirements

Following the conditions must be satisfied for stability of wall.

- It should not overturn
- It should not slide
- It should not sub side, that is max pressure at the toe should not exceed the safe bearing capacity of the soil under working condition

3.2. Analysis of design of subway system

Check against overturning:

Factor of safety against overturning = $\frac{MR}{MO} \geq 1.55$ (= 1.4/0.9)

MR = Stabilising moment or restoring moment

MO = Over turning moment

As per IS: 456-2000,

MR>1.2 MO, $_{\text{ch DL}}$ + 1.4 MO, $_{\text{ch IL}}$

0.9 MR ≥ 1.4 MO, $_{\text{ch IL}}$

Check against Sliding:

FOS = Resisting force to sliding / Horizontal force causing sliding

$= \mu = \sum \frac{W}{Pa} \geq 1.55 \left(= \frac{1.4}{0.9}\right)$

As per IS: 456:2000

$1.4 = \mu(0.9 \sum W)/Pa$

Pressure below the wall:

$X = \sum M / \sum W$, $\sum M$ = Sum of all moments about toe

Eccentricity of the load = $e = \left(\frac{b}{2-x}\right)$

Minimum pressure at heel

$$P_{min} = \sum \frac{W}{B}\left[1 - \frac{6e}{b}\right]$$

This should not be less than zero to avoid tension at the base. From this e=b/6, resultant should cut the base within the middle third. Otherwise the wall tends to separate from the base due to tension.

Maximum pressure at toe

$$P_{max} = \sum \frac{W}{b}\left[1 + \frac{6e}{b}\right]$$

This should not be greater than SBC of soil to avoid the subsidence of wall.

Depth of Foundation:

Rankin's formula - $D_f = \frac{SBC}{\gamma}\left[\frac{1-\sin\phi}{1+\sin\phi}\right]x^2 = \frac{SBC}{\gamma}k_a^2$

Stem Design

M_u = partial safety factor x (Ka γH $3/6$)

All the three elements namely stem, toe and heel act as a cantilever slab and hence the design and detailing principles are same as that of conventional cantilever slabs.

Box Culvert – Central Passage

Retaining wall – Side earth retaining

Staircase - Approach zones

Moment Distribution Table

Joint	D		A	
Member	DC	DA	AD	AB
Distribution Factor	1/3	2/3	2/3	1/3
Fixed end moments	80.105	-24.72	25.53	-59.32
Balance	-18.42	-36.85	22.52	11.26
Carry Over	11.26		-18.425	
Balance	-3.75	-7.506	12.28	6.14
Carry Over	6.14		-3.753	
Balance	-2.046	-4.09	2.502	1.25
Carry over	1.251		-2.045	
Balance	-0.417	-0.834	1.36	0.681
Carry Over	0.681		-0.417	
Balance	-0.227	-0.454	0.278	0.139
Carry Over	0.139		-0.227	
Balance	-0.046	-0.092	0.151	0.075
Carry Over	0.0755		-0.046	
Balance	-0.025	-0.05	0.03	0.05
Final end moments	55.17	-55.1	39.75	-39.76

3.3. Cost Estimation of the project

3.3.1. Concrete

- Total Volume of box culver (Central span) = 4 (3.8x0.3x8.5) = 38.76m^3
- Top Volume of slab on both sides of culvert = 2(11.58x3.6x0.3) = 28.0128m^3
- Volume of retaining wall along the staircase = ((0.02+0.3)/2)+(2.5x0.35))x11.58 = 41.39 m^3
- Inclined slab for staircase on 4 approaches = 4(7.0x3.0x0.3) = 25.2m^3
- Retaining wall along stair case = 4(1.78x3.74) = 26.6m^3
- Base slab beyond box culvert at the junction = 2(4.4x3.6x0.3) = 9.504m^3

Total volume of concrete = 38.76 + 25.0128 + 41.39 + 25.2 + 26.6 + 9.504 = 166.4m^3

Concrete Cost (Rs. 3500 / m^3) = 166.4 x 3500 = Rs. 5,82,400/-

3.3.2. Earth Work (Excavation)

- Earth work for central box culvert including the extension at the junction

= 14.8 x 4.4 x 5

= 325.6 m^3

- Volume of earth work for the triangular portions for the staircases (Approach zones)

= 4(3x0.5x3.5x5.0)

= 105 m^3

Total Volume of Earth = 325.6 +105

= 430.6 m^3

Cost of earth work excavation (Rs 100 / m^3) = 430.6 x 100

= Rs. 43,060/-

3.3.3. Steel (Reinforcement)

- Reinforcement in box culvert = 2% of concrete volume

= 2x 38.76/100

= **0.7752m^3**

- Reinforcement in retaining wall = 1.5% concrete volume

= 1.5 x (41.39 + 26.6) / 100

= **1.01 m^3**

- Reinforcement in stair case slab = 1% of concrete volume

= 1x25.2/100

= **0.252 m^3**

Total Volume of Steel = 0.775 + 1.01 + 0.252 = **2.03 m^3**

1 m^3 = 7850 kg

2.03m^3 = 2.03x7850/1 = 15992 kg

Reinforcement steel cost (Rs.65/- per kg) = 15992 x65 = Rs. 10,39,481/-

3.3.4. Brick Work

Volume of brick work for the steps (stair case) for each flight = 22x (0.5x0.27x0.18x2.5)

$= 1.3365\ m^3$

Total no. of flights = 4

Total Volume of Brick work = $4(1.3365) = 5.346m^3$

Brick work cost (Rs. 2000/- per m^3) = 5.346 x 2000

= Rs.10692/-

3.3.5. Other and Miscellaneous Cost

This includes drainage, lightning cost and other changes = Rs. 300000/-

Total Cost = 582400 + 43060 + 1039481 + 10692 + 300000 = Rs. 19,75,633/-

Contractor and work charge establishment = 10% of total cost

= 0.1 x 1975633

= 1,97,563.3 /-

TOTAL COST OF THE PROJECT = Rs. 21,73,196.30 /-

4. RESULTS & DISCUSSIONS

The proposed subway will serve the public in such a way that, crossing of the highway can be done in very convenient and safe way. Also, these underpasses are best suited than foot over bridges in all aspects such as economical point of view and also the free fearless usage. Sometimes theses subways provide a clear access for pedestrians to pass through underground rather than passing by bridge stairs. So, we can recommend these widely for future construction especially in developing places.

Figure 1 Map showing the alignment of subway

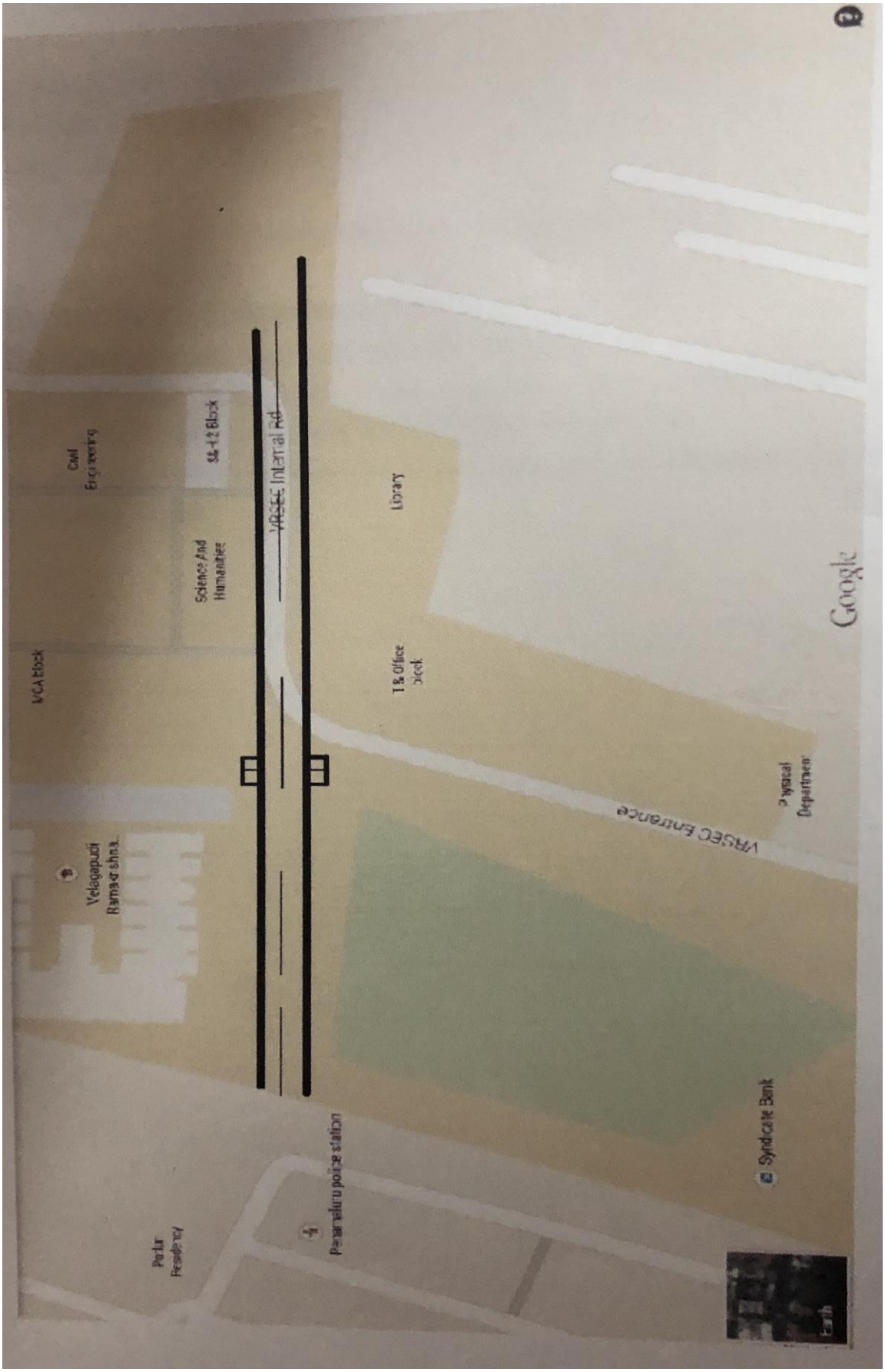

Figure 2 Map showing the alignment of subway

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