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Analysis of Multi-Tier Retaining Wall

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ABSTRACT: Retaining Walls are the structures which with stand the lateral earth pressure exerted by water pressure, surcharge loads and self-weight of the wall. Retaining walls are constructed to support almost vertical (steeper than 70 degrees) or vertical slopes of earth masses. In recent years, with the rapid development of highways, instability of retaining walls to cause embankment landslides has become common. When the height of retaining wall is greater than the 20 ft (6m) they are employed into the critical application these types of walls are built in multi-tire retaining wall. As the heavy traffic demands have lead to widening of existing roadways to indulge the increased traffic volume. However additional right of way is uneconomical and limited space is available at the site location; construction of earth retaining walls is often done under a constrained space. The use of tired walls will become necessary when the height of wall is greater than 6m. This study represents the results of the GEO5of a series of tiered walls with various offset distance.

KEYWORDS: Retaining wall, Multi-tier retaining wall, offset distance, GEO5.

I. INTRODUCTION

However in daily life usage of vehicles has been increased which leads to increase in the traffic volume, for such conditions additional right of way is necessary. Additional right of way is uneconomical and limited space is available at the site locations; Construction of earth retaining walls is often done under a constrained space.

Retaining wall is a structure which supports the vertical soil mass. And designed for the effects of surcharge and its self weight, it prevents the soil falling, sliding, external loads are transmitted to the foundation. The failure occurs suddenly due to external forces, due to moving loads the wall may get cracks due these cracks the wall may fail. To overcome this problem we are providing the reinforcement to soil to take the loads directly

Geosynthetics are provided as a reinforcement material for retaining wall, which decreases the intensity of load and surcharges to lower level of soil mass. Length and vertical spacing depends upon the loads and ultimate tensile strength of reinforcement.

The use of multi-tier retaining wall is applicable when the height of wall is greater than 6m. In tiered retaining wall the lower tier wall height should be greater than upper tier. The load intensity of upper tier to the lower tier depends upon the offset distances between the walls.

My present study is about the two-tier wall of 4 soils by using the GEO5 software and considering the various offset distances (2m,3m,5m). Here the wall is considered as skew wall at 8° inclination.

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II. STABILITY ANALYSIS

Stability analysis can be classified into following

- (i) External stability
- (ii) Internal stability

External stability:

- It may overturn about its toe fig.1
- It may slide along its base fig.2
- It may fail due to loss of bearing capacity fig.3

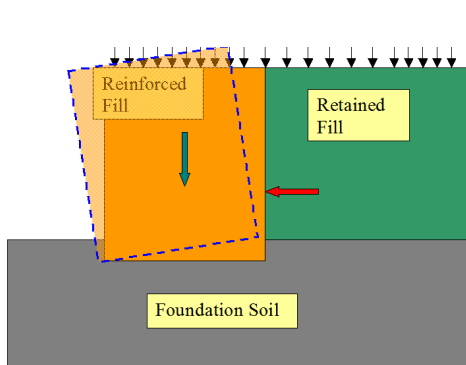


Fig.1: Overturning failure

The overturning failure which occurs at the toe

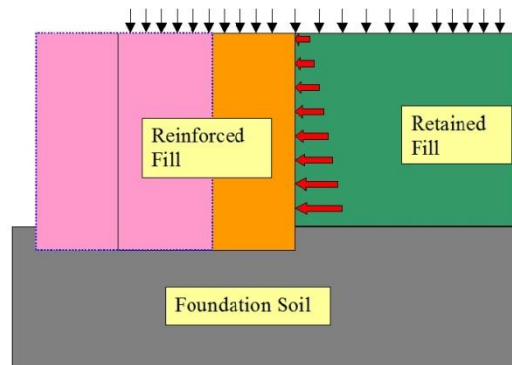


Fig.2: Sliding failure

Sliding failure occurs along its base

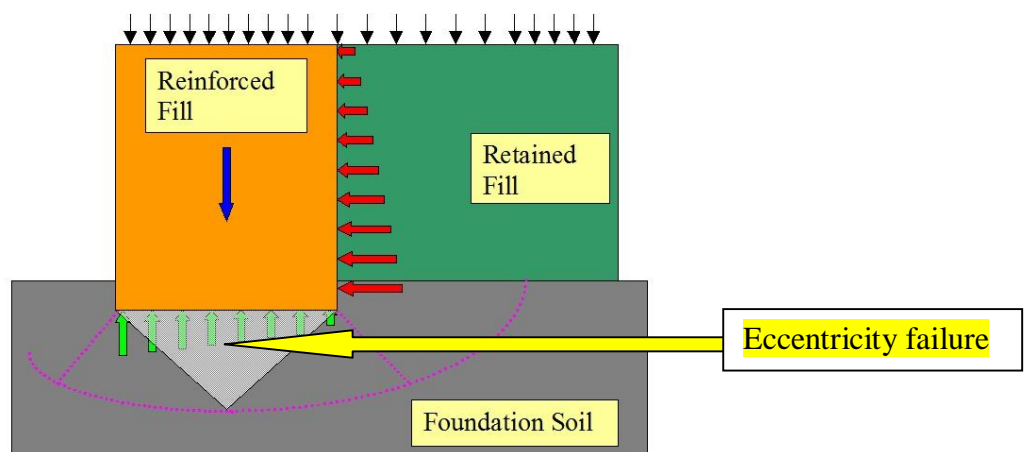


Fig.3: Bearing capacity failure & Eccentricity failure

It may fail due to the loss of bearing capacity of soil supporting at the base

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Factor of safety for overturning:

$$FS_{(\text{overturning})} = \frac{\sum M_r}{\sum M_o} > 1.5$$

$\sum M_r$ = sum of moment of force tending to resist
 $\sum M_o$ = sum of moments of force tending to overturning

Factor of safety for sliding:

$$FS_{(\text{sliding})} = \frac{\sum F_r}{\sum F_d} > 1.5$$

$\sum F_r$ = sum of horizontal resting forces
 $\sum F_d$ = sum of horizontal driving forces

Factor of safety for bearing capacity:

$$FS_{(\text{bearing capacity})} = \frac{\sum q_u}{\sum q_{\max}} > 2.0$$

$\sum q_u$ = ultimate bearing capacity

$\sum q_{\max \text{ or } \min}$ = maximum or minimum pressures $\left\{ \frac{\sum V (1 \pm \frac{6e}{B})}{B} \right\}$

Eccentricity $e = \left\{ \frac{B}{2} - x \right\}$

Internal stability:

Verification of reinforcement fig.4

Factor of safety for tensile strength:

$$FS_{(\text{tensile strength})} = \frac{\text{tensile strength}}{\text{georeinforcement force}} > 1.5$$

Factor of safety for pullout:

$$FS_{(\text{pullout})} = \frac{\text{pullout resistance}}{\text{georeinforcement force}} > 1.5$$

Global stability:

Global stability is analysed by Bishop's simplified method of analyses which considers the forces on the side of each slice fig.5. So factor of safety is defined as ratio of max. Shear strength to mobilised shear resistance

Factor of safety for global stability:

$$FS_{(\text{global stability})} = \frac{\text{shear strength}}{\text{mobilised shear resistance}} > 1.5$$

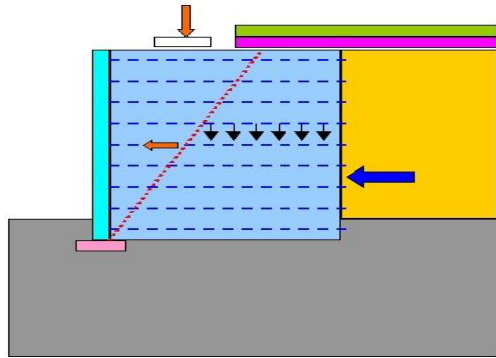


Fig.4: Internal stability
Internal stability is analysed by taking active earth pressure and tensile strength of reinforcement.

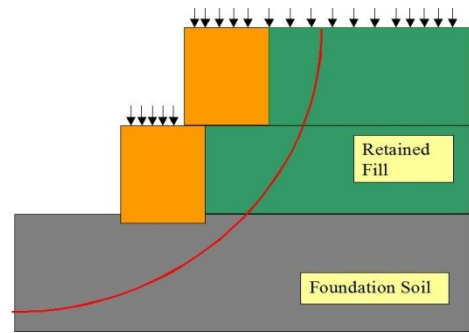


Fig.5: Global stability
Global stability is analysed by using bishop method

III. MATERIALS

Soil properties:

soil-1	
well graded gravel (WG) ,medium dense	
unit weight (γ)=	21.00KN/m ³
internal friction of soil ϕ =	38.5
cohesion,C	0
viod ratio e=	0.3
specific gravity,G=	2.52
saturated unit weight , γ_{sat} =	21.69
coefficient of active earth pressure Ka=	0.23

Table -1: Input parameters for soil-1

soil-2	
poorly graded sand(SP) ,medium dense	
unit weight (γ)=	18.50KN/m ³
internal friction of soil ϕ =	33.5
cohesion,C	0
viod ratio e=	0.3
specific gravity,G=	2.65
saturated unit weight , γ_{sat} =	22.69KN/m ³
coefficient of active earth pressure Ka=	0.28

Table-2: Input parameters for soil-2

Soil properties are considered as backfill material for retaining wall and analysed for various offset distances.table.1&2 are input parameters of soil in backfill.Table3&4 are the model input parameters. Total height of wall is 10m which is two-tier in combination of 7m +3m.

Properties of reinforcement material: High long-term design strengths (LTDS).Miragrid geogrids have more than 0100,000 hours of tension creep testing performed at an independent test laboratory. Credible, dependable long term strength assured. Cost effective, Creep resistant polyester fibers provide higher allowable tensile strength, minimizing the required number of geogrid layers. Miragrid geogrids provide the widest Strength range, and are the highest strength geogrid material in the market today. Miragrid geogrids can be used in most MSE applications for soil reinforcement including internally reinforced soil walls, segmental retaining wall reinforcement, steep reinforced slopes, and reinforcement in a variety of landfill applications including potential voids bridging and veneer stability. When a project specifies for long-term design strength for structural stability Miragrid is used.

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Types of reinforcement used:

- (i) Miragrid 18XT
- (ii) Miragrid 20XT
- (iii) Miragrid 22XT

Embankment height	Spacing	No. of reinforcement	offset distance (m)	embankment length (m)	reinforcement group	T_{ult} (KN/m)	length of reinforcement (m)
upper-3m Lower-7m	spacing of reinforcement (hr)=0.5m , length of first reinforcement h=0.5m	upper -5 Lower -13	2	0.42	Miragrid 18XT	138.6	7
				0.98	Miragrid 18XT	138.6	7
			3	0.42	Miragrid 18XT	138.6	7
				0.98	Miragrid 22XT	259.1	9.5
			5	0.42	Miragrid 18XT	138.6	5
				0.98	Miragrid 18XT	138.6	8

Table-3: Model input parameters of soil-1

Embankment height	Spacing	No. of reinforcement	offset distance (m)	embankment length (m)	reinforcement group	T_{ult} (KN/m)	length of reinforcement (m)
upper-3m Lower-7m	spacing of reinforcement (hr)=0.5m , length of first reinforcement h=0.5m	upper -5 Lower -13	2	0.42	Miragrid 20XT	259.1	8.5
				0.98	Miragrid 20XT	259.1	8.5
			3	0.42	Miragrid 18XT	138.6	7
				0.98	Miragrid 22XT	259.1	10.5
			5	0.42	Miragrid 18XT	138.6	5
				0.98	Miragrid 20XT	259.1	8.5

Table-4: Model input parameters of soil-2

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Table 3 and 4 represents the input parameters of GEO5 such as embankment length, embankment height, offset distances, spacing, length of reinforcement, type of reinforcement, ultimate tensile strength of reinforcement

IV. RESULTS AND DISCUSSIONS

The following figure explains about the geometry of two-tier retaining wall which includes surcharge and offset distance and skew of a wall.

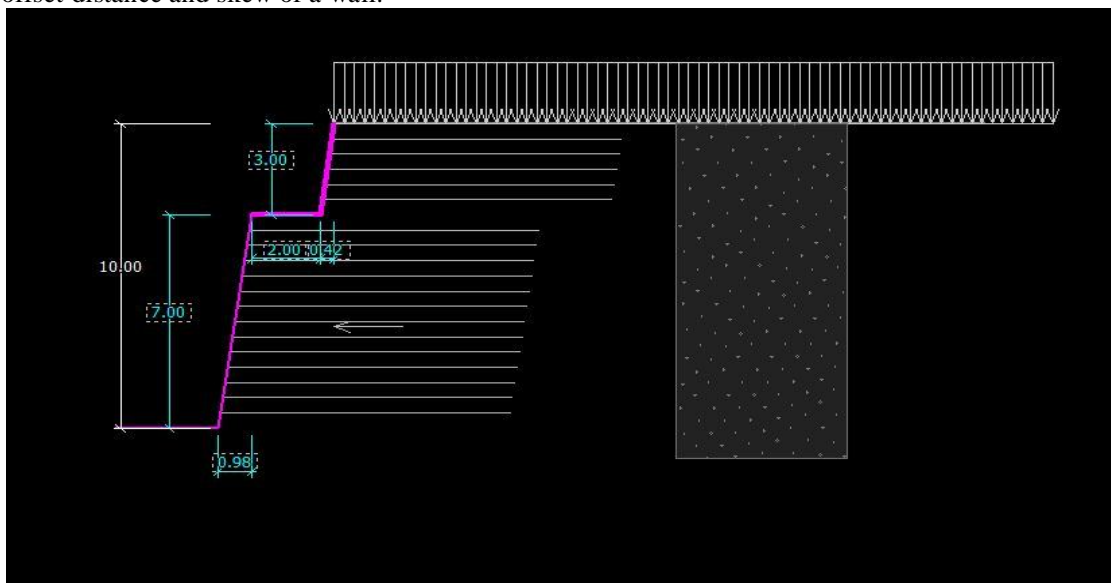


Fig.6: Model for two tier wall with 2m offset distance
Fig.6 shows model of multi-tire retaining wall @ 2m offset distance

OFFSET DISTANCES	2m		3m		5m	
	soil -1	soil-2	soil-1	soil-2	soil-1	soil-2
Verification of complete wall:						
FS _{overturning}	10.99	8.39	9.11	8.58	8.24	7.46
FS _{sliding}	5.77	3.17	4.06	3.35	3.74	2.68
Verification of reinforcement:						
FS _{tensile strength}	2.02	2.06	4.72	3.85	4.55	3.8
FS _{pullout}	9.24	6.23	12.17	7.07	10.36	3.32
Verification of bearing capacity:						
FS _{bc}	2.23	2.51	2.6	2.77	2.66	3.03
Verification of global stability:						
FS _{gs}	1.52	1.51	1.92	1.82	1.64	1.52

Table.5: Factor of safeties for Retaining wall.

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At respective offset distance the factor of safety's are evaluated by using the GEO5 software It has been observed that for various offset distances with respect to the soils there is a much variation in factor of safety values. At the offset distance 3m the factor of safety for pullout, factor of safety for global stability gives more values compared to 2m and 5m offset distance.

V. CONCLUSION

From the findings has been concluded that the intensity of surcharge of upper tier to the lower tier as been calculated by using GEO5 software, according to the results it is observed that to increase in the pullout resistance there should be minimum length of reinforcement. A model is developed in the study to analyse the MSE walls and founded for well graded gravel and poorly graded sand, overturning behaviour depends upon the geometry of the wall and it's skew. Load intensity depends upon the offset distance between the walls. In this model global stability analysis has been verified by Bishop's method.

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BIOGRAPHY



K Jagadeesh completed my B.TECH degree in Civil Engineering from ACE Engineering College, Ghatkesar, Rangareddy (Dist), affiliated to JNTUH. Am currently pursuing M.Tech Geotechnical engineering in VNR Vignana Jyothi College of Engineering and Technology (Autonomous), Bachupally, Rangareddy (Dist), affiliated to JNTUH.



K.Suresh, his M.E degree from Osmania University, Hyderabad in Civil Engineering. He has 4 years of teaching experience, working as Assistant professor and coordinator in the department of Civil Engineering in VNR Vignana Jyothi College of Engineering and Technology (Autonomous), Bachupally, Rangareddy (Dist), affiliated to JNTUH.