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Behaviour of MSE Wall with different Soil Properties and Reinforcement Length

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Abstract*: The Mechanically Stabilised Earth (MSE) retaining wall is used as an alternative designed structure for conventional cast-in-place concrete type walls and gravity walls. The MSE wall behaves as a coherent block considered as flexible, which can sustain loading types and deformations due to the interaction between the backfill and the inclusion materials. The construction of MSE walls is cost effective, requires less site preparation, and is technically more feasible. MSE wall behaviour highly depends upon type of reinforcement and backfill used in the system. However, use of backfill with high fine content and poor drainage behavior can cause excessive wall movement or even failure. In the present study, MSE wall was modelled using finite element numerical tool PLAXIS 2D, to study the effect of backfill and reinforcement on MSE wall behaviour. Wall deformations were analysed by varying soil parameters such as, soil friction angle and unit weight soil of retained and foundation soil. It was observed that, as the friction angle of the foundation soil increased, wall deformations were reduced. Also, it was seen that, length of the reinforcements has significant effect on wall deformations. Deformations were reduced as the length of reinforcements increased.

***Keywords*: MSE Retaining Wall, Finite-Element analysis, Wall Deformation, Reinforcement, Soil Friction Angle**

I. INTRODUCTION

A Mechanically Stabilized Earth (MSE) wall is an internally reinforced soil structure with a face angle of 70^0-90^0. The use of a MSE retaining wall has gained popularity as an alternative to conventional cast-in-place concrete walls. The construction of a MSE wall is cost effective, requires less site preparation, and is technically more feasible compared with a conventional concrete retaining wall [1]. The stability of the MSE wall depends on the frictional and bearing resistance between the reinforcing elements and the soil. Reinforcements are placed in layers in the backfill soil. The type of reinforcement and facing of a MSE wall are varied depending on the site condition, purpose of application, and wall height. The performance of the MSE wall strongly depends on the behavior of the backfill soil used in their construction. Therefore, knowledge of the behavior of the earthen materials and their interaction with the manufactured components of the MSE wall are of critical importance for successful wall design and performance. MSE walls require high-quality backfill for durability, good drainage, constructability, and good soil reinforcement interaction. Well-graded granular soil fulfils these criteria. However, use of backfill with high fine content as a result of poor drainage behavior can cause excessive wall movement or even failure. Mechanically stabilized earth (MSE) walls have gained significant acceptance since the 1970s because of their economic benefits compared with conventional gravity retaining wall [1][2]. MSE walls offer simple construction techniques, pleasing aesthetics, reliability, and a cost-effective solution [3]. However, design and construction should be carefully evaluated to achieve satisfactory performance of the wall [1]. Performance data on MSE walls are required in many cases and can be obtained by field instrumentation, centrifuge tests, and full-scale physical modeling. Nevertheless, field monitoring and experimental tests are costly and time-consuming [4]. As an alternative, computer-based numerical modeling can be used for the design, parametric studies, and forensic investigation of MSE walls [5].

II. NUMERICAL MODELLING OF MSE WALL

MSE wall was modelled using numerical tool PLAXIS 2D. Table I and II lists geometrical and soil properties that was used for model using Mohr Coulomb for drained condition. Figure 1 shows the geometry as it is set up for the data given in the table in PLAXIS along with the “Fine” element mesh used in the calculations. After mesh generation, the model was run for analysis. Figure 2 shows the deformed MSE wall model. It is clear from the shaded results that total displacements provide a good visualization of failure criteria.

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TABLE I
GEOMETRY OF WALL AND REINFORCEMENT

Sl no	Properties	Values	Units
1	Height of the wall	4	meter
2	Type of facing panels	Single facing panel	-
4	Thickness of facing panels	0.15	meter
5	EA	3625.950	kN/m
6	EI	6.799	kNm^2/m
7	Weight, w	7.3	kN/m/m
8	Poison's Ratio, µ	0.2	-
9	Type of reinforcement	Geogrid	
10	Length of reinforcement	7	m

TABLE II
PROPERTIES OF SOIL USED IN THE MODEL

Sl no	Properties	Retained soil	Reinforced soil	Foundation soil	Units
1	Unit weight	18	18	18	kN/m^3
2	Cohesion	0	0	10	kPa
3	Angle of internal friction	30^o	34^o	30^o	degrees
4	Saturated unit weight	18	18	18	kN/m^3
5	SPT N-value	4	10	4	-
6	Modulus of Elasticity(E)	1.07×10^4	1.55×10^4	1.07×10^4	kN/m^2
7	Poisson's ratio ϑ	0.3	0.3	0.3	-
8	Dilation angle ψ	0	4^o	0	degrees

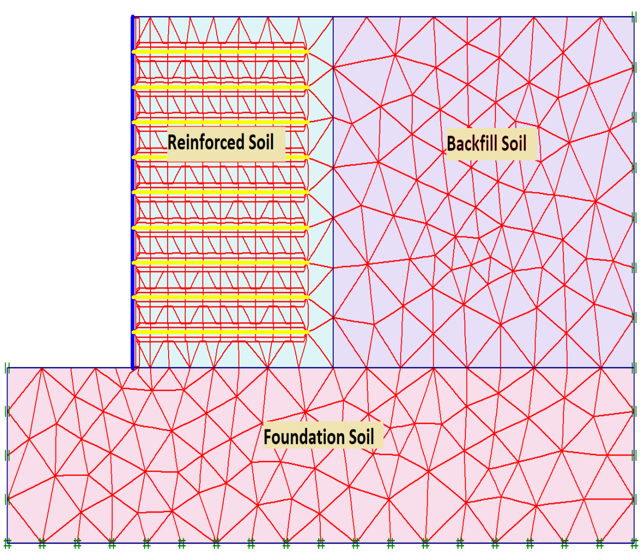

Fig. 1 MSE Wall model with mesh generation

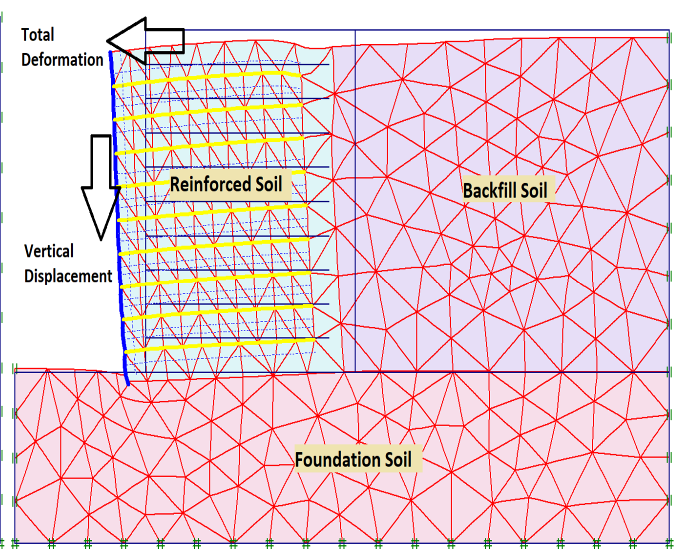

Fig. 2 Deformed mesh with total displacement

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A. Effect of Length of Reinforcement on Wall Deformations

Codal provisions like FHWA and some of the builders restricted for reinforcement of length 0.7 times the height of wall. However, in some restricted areas and space constraints it may not be adopted. Hence, this analysis was carried out, to study the deformations of MSE wall for various reinforcement lengths.

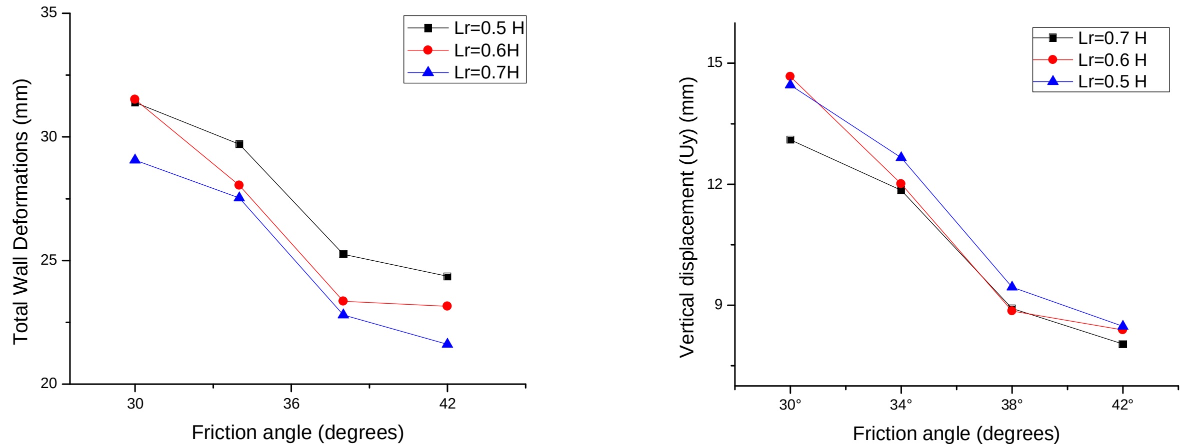

Fig. 3 Total Wall Deformations and Vertical Displacements of MSE Wall for Different Lengths of Reinforcement

The graphs show that displacements are highly influenced by the length of reinforcement, as the length of reinforcements are increased, there is an observation of decrease in total wall deformations and vertical displacements of wall.

B. Effect of Unit Weight of Reinforced soil on Wall Deformations

The effect of unit weight of reinforced soil on total wall deformations and displacements are put in graph with respect to variation of reinforcement length. Increment of soil unit weight ranges from 16 kN/m^3 to 20 kN/m^3. However, soil with higher unit weight shows higher deformations as shown in Figure 4. Unit weight also affects the friction between reinforcement and soil. Therefore, in case of smaller reinforcement length, lesser friction force of interface exerted between reinforcement and mass soil due to presence of lighter reinforced soil results in higher displacements compared with higher unit weights.

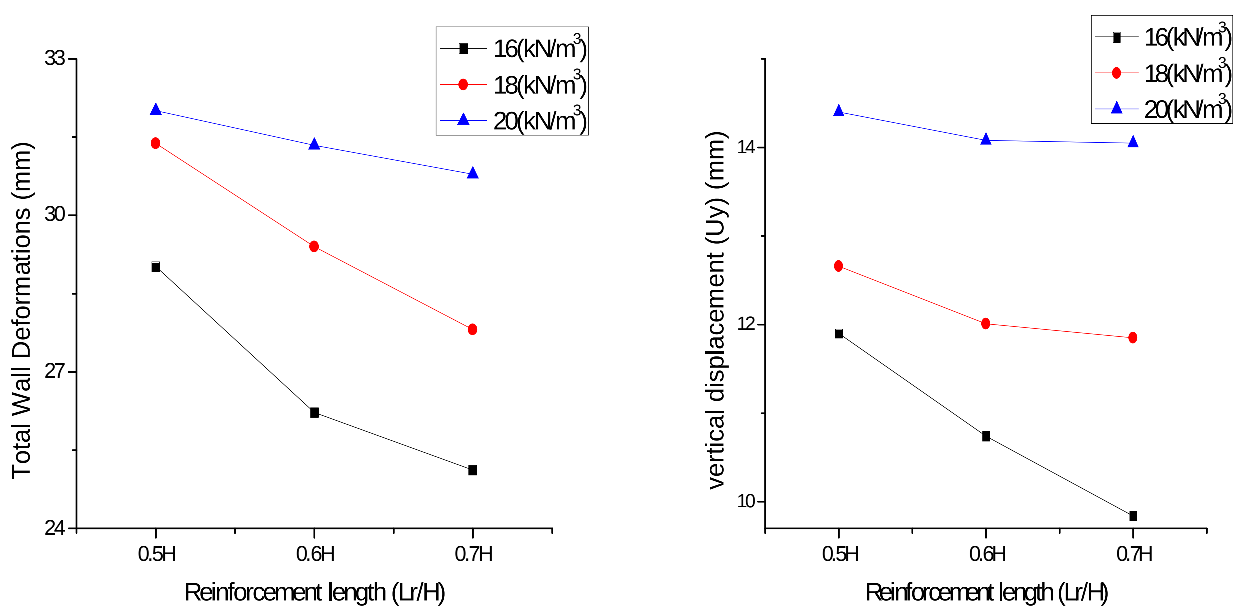

Fig. 4 Total Wall Deformations and Vertical Displacements of MSE Wall for Different unit weights of retained soil

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C. Effect of Friction Angle of Foundation Soil on Wall Deformations

The effect of internal friction angle is ranging from 30° to 42°. The total wall deformations, vertical displacements are obtained for MSE wall as shown in Figure 5. The graphs show that deformations are highly influenced by the soil friction angle, as the friction angles are increased with increase in reinforcement length there is an observation of decrease in total wall deformations.

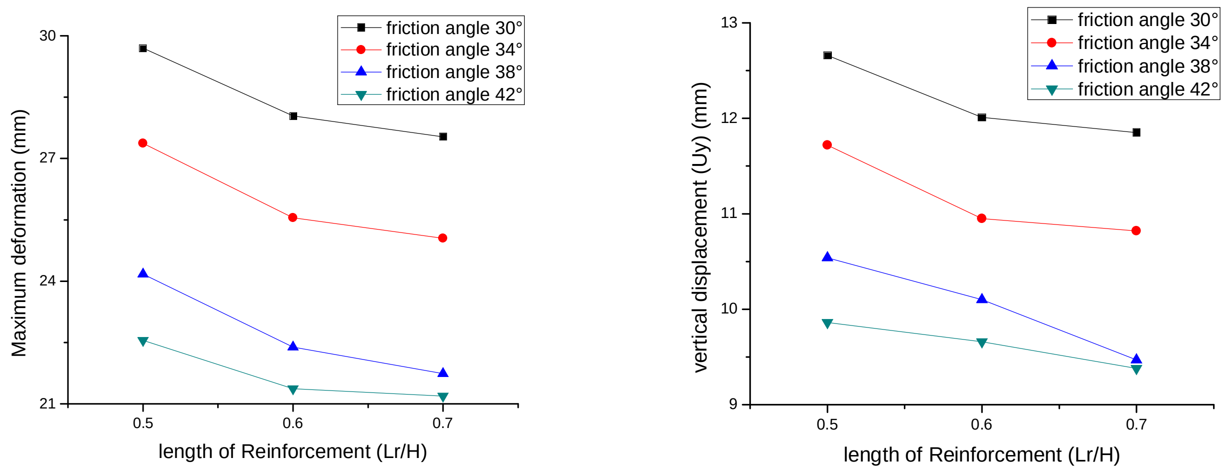

Fig. 5 Total Wall Deformations and Vertical Displacements of MSE Wall for Different Friction angles of foundation soil

III.CONCLUSIONS

Present design practice explains MSE walls require inclusion lengths of 70% of height of wall. The effect of soil parameters on retained, reinforced and foundation soil are discussed with different reinforcement lengths. Total wall deformation and vertical displacements are investigated in this paper. Results obtained by modeling conclude some of the parametric variations of soil and reinforcements:

A. As the length of reinforcements increased, wall deformations and vertical displacements decreased.

B. As the unit weight of retained soil increases, there was increase in wall deformations, because there will be more active earth pressure acting on MSE wall resulting in more deformations.

C. As the friction angle of the reinforced and foundation soil increased, wall deformations were reduced with increase in reinforcement length.

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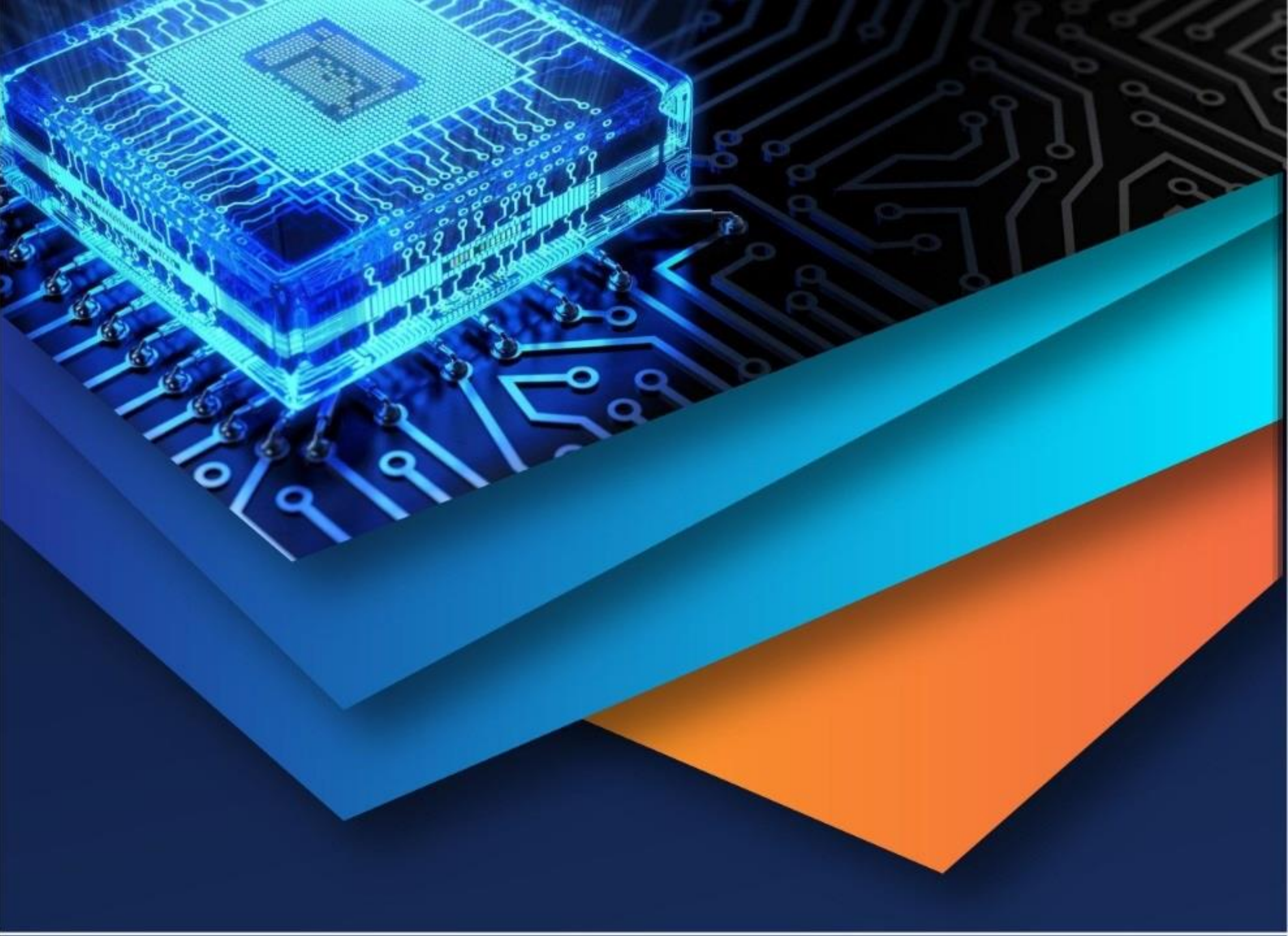

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