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Parametric Study of Reinforced Soil Walls with the Finite Element Method

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Abstract: Traditionally, the design of geosynthetic reinforced soil walls is performed using the simplified classical analysis or empirical methods. Unfortunately, the applications of these methods render various degrees of approximations in determination of major designing factors. In this paper, the behavior of geosynthetic reinforced soil walls is studied by the numerical method (FEM) with PLAXIS 2-D software. The results showed that in designing of reinforced soil walls of both the short reinforcement and long reinforcement can be used, so that at the top of wall of long reinforcement and at the bottom of wall of short reinforcement were be put . Another way, the reinforcements with a distance less in top of the wall be use . with this method, displacements and deformations reaches to their lowest. Can be also design an optimal and economical in terms of consumption is achieved reinforcements. Also an optimal design and economic in use of the reinforcements achieved.

Key words: Reinforced soil wall, Angle of the internal friction, Cohesion, PLAXIS software.

INTRODUCTION

The technique of reinforced soil has been widely used in construction of retaining walls and levee foundations. A wide range of reinforcement elements of different materials are produced and developed for use in such structures. Most important elements of reinforcements are metal strips, steel bars and various geosynthetics. Soils are materials that have good resistance against pressure and cutting, but are weak in tension. Numerous efforts are performed to overcome the weakness of the soil stretching process. Polymer or synthetic fabrics such as geosynthetics are compatible with the soil in deformability. Moreover, they are resistant to corrosion and acid attacks. Nowadays geosynthetic reinforced soil walls are one of the important options in the design of retaining walls due to their superiority than other reinforcements.

Many investigators have studied the reinforced soil walls, i.e., Hausman and Lee (1978), Pinto and Cousens (1996), Jewell (1985), Lawson *et al*. (2004), Juran and Christopher (1989), Palmeira and Lanz (1994), Wong *et al* (1994), Rowe and Ho (1997), Pinto and Cousens (1999), Filippo *et al*. (2000), Simonini *et al*. (2003), Hatami and Bathurst (2004), Ma and Wu (2004), Desai and Hoseing (2005), Bathurst *et al*. (1992), and Kapurapu and Bathurst (1995), Madhav and Poorooshasb (1988), Poorooshasb (1989, 1991), Ghosh and Madhav (1994), Shukla and Chandra (1994, 1995), Yin (1997a, b, 2000), Maheshwari *et al*. (2004), Nogami and Yong (2003), Deb *et al*. (2005), Love *et al*. (1987), Poran *et al*. (1989).

MATERIALS AND METHODS

In this paper, the behavior of geosynthetic reinforced soil walls is studied by the numerical method (FEM) with PLAXIS 2-D software. In a study conducted by Abioghli (2010), five of geosynthetic reinforced soil walls were modeled with the use of Plaxis software. Then, numerical models are calibrated by using instrumented model results or experimental model and the ability of PLAXIS software in prediction of wall displacement, facing deformation and tension of reinforcement layers is assessed. Here, one of the models is selected and the parametric study is performed. The effect of factors such as: property of soil and stiffness of reinforcements on reinforced soil wall behavior will be investigated.

Figure 1 shows the geometry of the reinforced soil wall. Properties of various materials used in the model reinforced soil wall is presented in study conducted by Abioghli (2010). The numerical model simulates the panel with beam elements, the reinforced layers with geogrid elements and the soil-structure contact area with interface elements. Furthermore, the Mohr-Coulomb plastic model is used for the soil. The wall construction is modeled with staged construction.

RESULTS AND DISCUSSION

Here results of the sensitivity of the numerical model to the calibrated model are presented. Angle of the internal friction of the backfill (φ) than the calibrated model to the amount of 5,10 percent reduction and to the amount of 5,10 percent have increased. Table 1 shows the effect of changes angle of the internal friction of the backfill on maximum displacement of the wall and on maximum deformation of the facing. Figure 2 shows the effect of changes angle of the internal friction of the backfill on deformation of the facing. Cohesion of the

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backfill (C) than the calibrated model to the amount of 5,10 percent reduction and to the amount of 5,10 percent have increased. Table 2 shows the effect of changes cohesion of the backfill on maximum displacement of the wall and on maximum deformation of the facing. Figure 3 shows the effect of changes cohesion of the backfill on deformation of the facing.

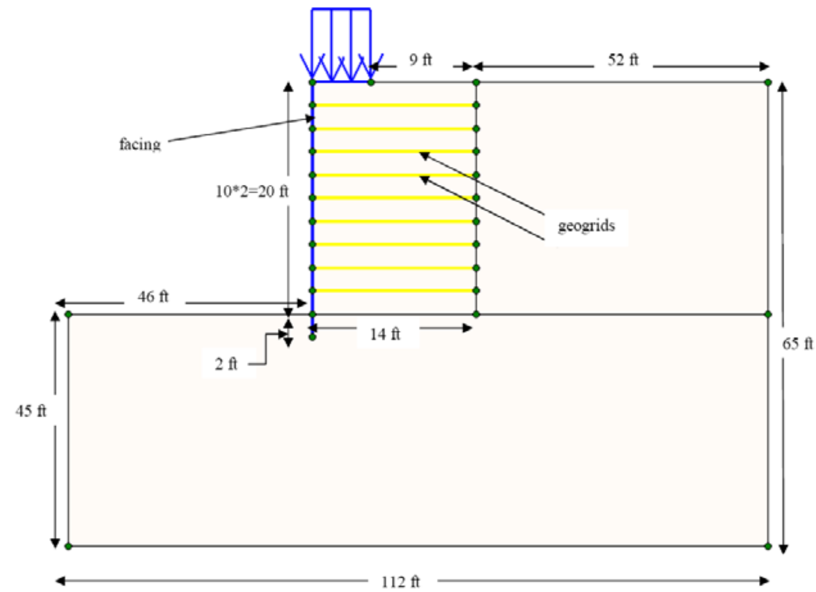

Fig. 1: Geometry of the model reinforced soil wall.

Table 1: Effect of changes angle of the internal friction of the backfill on maximum displacement of the wall and on maximum deformation of the facing.

Maximum deformation of the facing (mm)	Maximum displacement of the wall (mm)	Angle of the internal friction
13.2	63.5	0.9φ
13.6	49	0.95φ
13.8	70.3	φ(calibrated model)
15.2	59.2	1.05φ
14.1	60.3	1.1φ

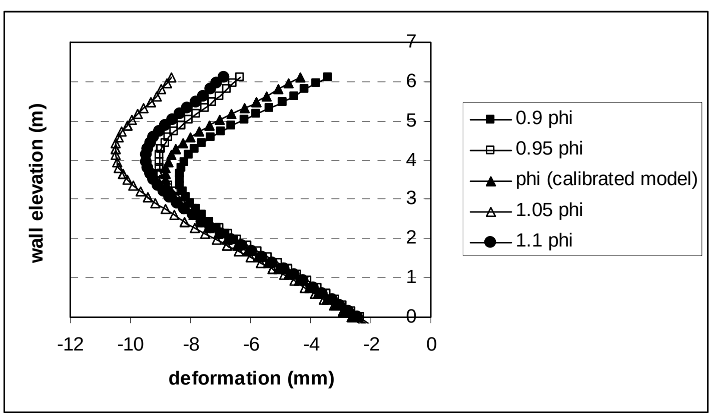

Fig. 2: Effect of changes angle of the internal friction of the backfill on deformation of the facing.

Table 2: Effect of changes cohesion of the backfill on maximum displacement of the wall and on maximum deformation of the facing

Maximum deformation of the facing (mm)	Maximum displacement of the wall (mm)	Cohesion
12.3	98.7	0.9 C
13.6	74.7	0.95 C
13.8	70.3	C (calibrated model)
13.7	71.6	1.05 C
14.1	68.9	1.1 C

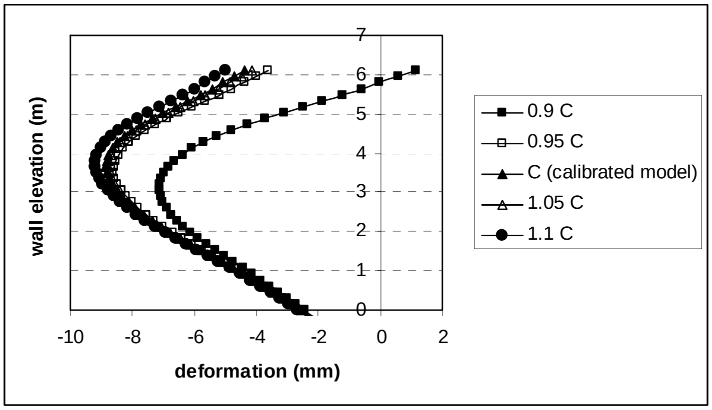

Fig. 3: Effect of changes cohesion of the backfill on deformation of the facing.

Stiffness of reinforcements (EA) than the calibrated model to the amount of 25,50 percent reduction and to the amount of 25,50 percent have increased. Table 3 shows the effect of changes stiffness of reinforcements on maximum displacement of the wall and on maximum deformation of the facing. Figure 4 shows the effect of changes stiffness of reinforcements on deformation of the facing.

Table 3: Effect of changes stiffness of reinforcements on maximum displacement of the wall and on maximum deformation of the facing

Maximum deformation of the facing (mm)	Maximum displacement of the wall (mm)	stiffness of reinforcements
13.2	109.8	0.5 EA
14	74.7	0.75 EA
13.8	70.3	EA (calibrated model)
13.8	67.1	1.25 EA
14.1	52.1	1.5 EA

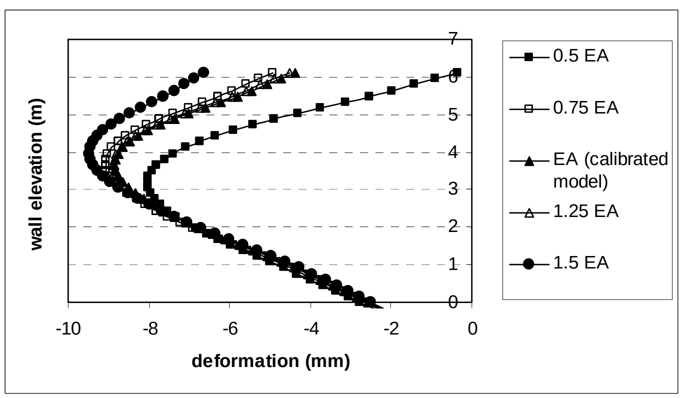

Fig. 4: Effect of changes stiffness of reinforcements on deformation of the facing.

Changes in reinforced soil parameters, including the angle of the internal friction and Cohesion of the backfill, have negligible impacts on the maximum deformation of the facing, but changes in cohesion of the backfill on the maximum displacement of the wall is greater. Changes in reinforced soil parameters on deformation of the facing, at the bottom of the wall is negligible and at the top of wall significantly.

When the stiffness of reinforcements have reduced or increased, maximum displacement of the wall than the calibrated model respectively increased or decreased, but changes in stiffness of reinforcements on the maximum deformation of the facing is less. Changes in stiffness of reinforcements on deformation of the facing, at the bottom of the wall is negligible and at the top of wall significantly.

Conclusion:

Note that the reinforced soil wall failure occurs with a slope of $(45+\varphi/2)$ degrees and accuracy in the numerical analysis results can be seen that displacements and deformations in this area have their maximum value. Thus it can noted that in designing of reinforced soil walls of both the short reinforcement and long reinforcement can be used, so that at the top of wall of long reinforcement and at the bottom of wall of short reinforcement were be put . Another way, the reinforcements with a distance less in top of the wall be use . with this method, displacements and deformations reaches to their lowest. Can be also design an optimal and economical in terms of consumption is achieved reinforcements. Also an optimal design and economic in use of the reinforcements achieved.

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