Reinforced Earth Retaining Walls with Lateritic Soil as Backfill

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ABSTRACT: The investigation as reported in this paper concerns about the suitability of lateritic soil as backfill for reinforced soil retaining walls. Since the lateritic soil has a low friction angle, a thin layer of sand on either side of the reinforcement (sandwich layer) has been provided to increase the interface friction. A series of pullout tests with lateritic soil as backfill was conducted to determine the optimum sand layer thickness, in the sandwich technique. Model studies of retaining walls with lateritic soil as backfill were also carried out using the sandwich technique. The optimum thickness of the sand layer obtained from the pullout tests was used for the model studies. Interfacial friction was found to improve substantially with the introduction of the sandwich technique. Thus reinforced soil retaining walls with lateritic soil as backfill using the sandwich technique showed better performance.

1 INTRODUCTION

Reinforced soil derives its strength from the friction developed at the soil-reinforcement interface. It has been generally considered that two main factors influence the soil-reinforcement friction. They are angle of internal friction of the backfill and surface properties of the reinforcements. For a given reinforcement, the stability of reinforced soil structures depend more on the natural friction of backfill material. Hence the use of a high friction, well draining backfill material is essential for an efficient reinforced soil structure. During construction of reinforced soil structures, very often, one finds at the site, lack of an adequate source of free draining granular backfill material available nearby. This poses practical problems in that suitable granular backfill either has to be imported at additional cost or the possible reinforced earth technique has to be abandoned for another design technique.

2 SCOPE OF THE PRESENT STUDY

Laterites and lateritic soil form the major soil deposit all along the eastern and western coasts of India. They are residual soils, resulting from the in-situ weathering of parent rock, granitic-gneiss, under intense conditions of tropical climate, high temperature and rainfall (Sreekantiah, 1987). Lateritic soils possess better drainage properties and frictional characteristics when compared to clays. But they are invariably inferior to sands. Hence reinforced soil structures with lateritic soils often have a lower stability, when compared to the high friction sand as backfill for reasons already described. It has been found from experimental investigations that the shear stress mobilized at the soil reinforcement interface decreases as the distance from the interface increases. Photo elastic pullout tests conducted by Milligan et al., (1990) also provided the same distribution. Hence it can be concluded that a thin layer of sand on either side of the reinforcement will increase the interfacial friction. This arrangement will have a beneficial effect on the performance of the structure. This technique of providing a thin layer of sand on either sides of the reinforcement is commonly known as sandwich technique (Sreedharan et al., 1991; Unnikrishnan, 1992; Sreekantiah and Unnikrishnan, 1992). In this paper, the authors describe the applications of sandwich technique to reinforced soil retaining walls, backfilled with lateritic soil.

3 EXPERIMENTAL INVESTIGATION

Inorder to arrive at the optimum thickness of the sandwich layer, pullout tests were conducted, with sandwich arrangement. The tests were conducted in a special box fabricated for the propose which has the dimensions 76mm x 305 x 102mm (height). The box has a slit at the front face to facilitate pulling out of strip reinforcement. To keep constant pullout length, a sleeve of 40 mm was provided inside the box on the rear side, using steel plates. The effective length of strip reinforcement under pullout was 265mm. Tests were conducted using geotextile reinforcement whose properties are given in table 1. The bulk backfill material used was lateritic soil whose properties are tabulated in table 2.

Table 1. Properties of the geotextile used

Geotextile type	Woven
Style (Quality No.)	PGP-I
Material	100% Polypropylene
Weight/sq. m (in grams)	225
Thickness (mm)	0.64
Wide width tensile strength (kN/m):	
Warp	36.25
Weft	28.32
Thermal Stability (Degree . C.)	0-120

Table 2. Properties of lateritic soil

Specific gravity	2.67
Angle of internal friction (Degrees)	33
Density of soil (kN/m3)	16.5

Table 3. Interfacial friction angle of the geotextile used

Soil type	Geotextile direction	Interfacial friction angle
River sand	Warp	34°
	Weft	36°
Lateritic soil	Warp	25°
	Weft	27°

To avoid the possibility of reinforcement getting stretched, and to study the interfacial friction alone, two sheets of geotextiles were placed on either sides of a thin metallic plate. This prevented the reinforcement from undergoing tension. A similar procedure was adopted by Garbulewski (1990) for the same reasons. The thickness of sandwich layer was varied over a wide range to arrive at the optimum thickness. It was found that a minimum thickness of 15mm produces interfacial friction almost equal to that of high friction sand alone condition. The value of interfacial friction for the geotextile in warp and weft directions for two different types of backfill are shown in table 3.

Table 4. Dimensions of model retaining walls

	Retaining wall 1	Retaining wall 2
No. of layers	3	2
Length (mm)	1000	1000
Width (mm)	1100	1100
Height (mm)	840	840
Thickness of layers (mm)	280	420

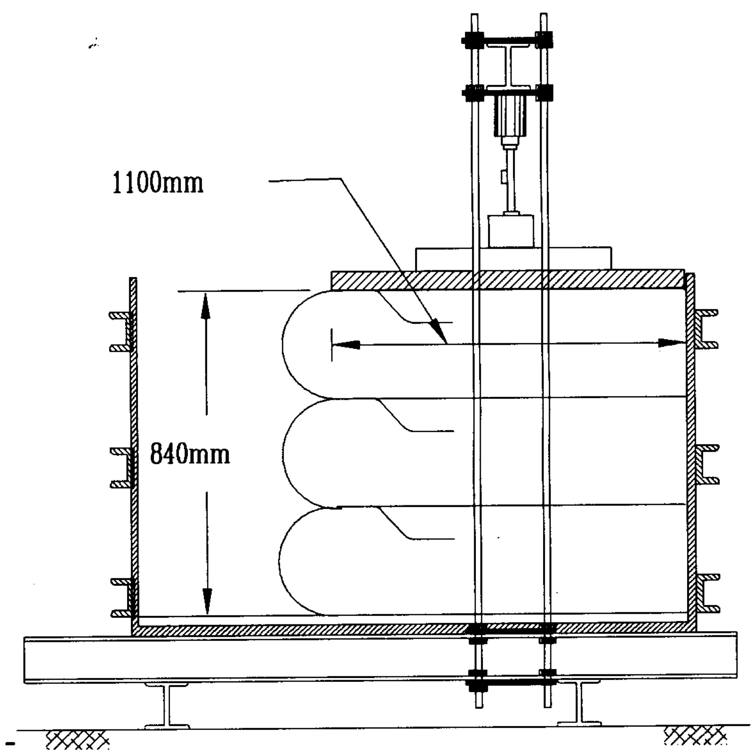

Figure 1. Experimental setup

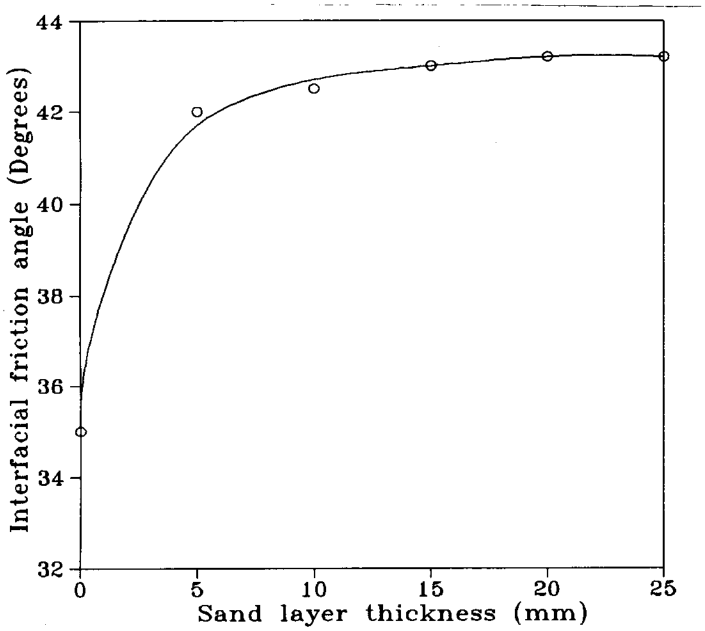

Figure 2. Effect of sand layer thickness on interfacial friction angle

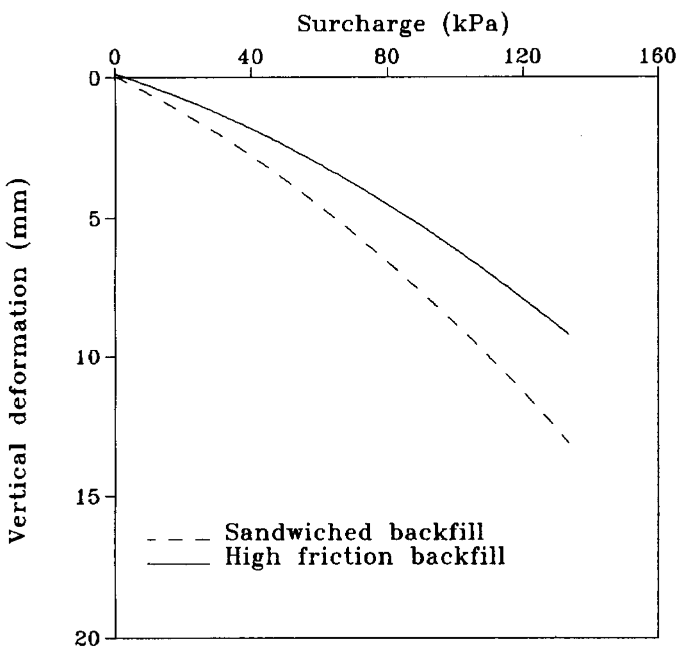

Figure 3. Vertical deformation of retaining wall 1

Model retaining walls were constructed and tested using lateritic soil as backfill with a sandwich layer thickness of 15mm. Tests were carried out in a model tank of size 1m x 1.5m x 1m (height). Retaining wall models with three layers of reinforcement (retaining wall 1)and two layers of reinforcement (retaining wall 2) were tested. The dimensions were as shown in table 4. Also experiments were conducted on retaining walls of same dimensions, but with high friction sand alone as the backfill, for comparison. The tests were conducted on a 50 tonne loading frame (Fig 1).

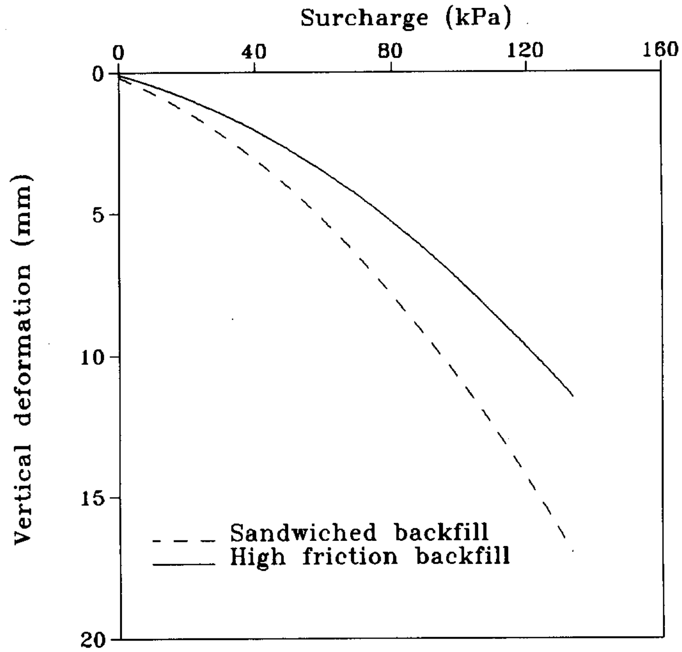

Figure 4. Vertical Deformation of retaining wall 2

4 RESULTS AND DISCUSSIONS

Pullout tests using sandwich technique proved that a minimum thickness of 15mm produces an interfacial friction angle comparable to that of sand alone condition. However a sandwich layer thickness equal to the maximum particle size of the backfill was preferred. It was noticed that at higher normal stresses, thin sand layers will be sufficient. The rate of increase of pullout resistance in the case of tests with lateritic soil alone was very much lower than the tests involving sandwich technique. This indicates that at higher normal stresses, the low friction soil cannot provide sufficient high friction as the sandwiched case does. Figure 2 shows the effect of sand layer thickness on the interfacial friction angle.

The load deformation characteristics of the model retaining walls are shown in figures 3, 4, 5 and 6. It can be seen that the horizontal and vertical deformations of retaining walls with lateritic soil as backfill were slightly greater than the retaining walls using sand alone backfill. This is due to the fact that the strength of backfill itself plays an important role, in addition to the interfacial friction. Since the bulk backfill used is of low shear strength, the retaining wall yielded more. But it can be seen that the retaining walls with lateritic soil as backfill can be used with sandwich technique, at places where slightly more deformations are acceptable. The advantage of cost reduction by the use of local material as the bulk backfill material is often the more important criteria.

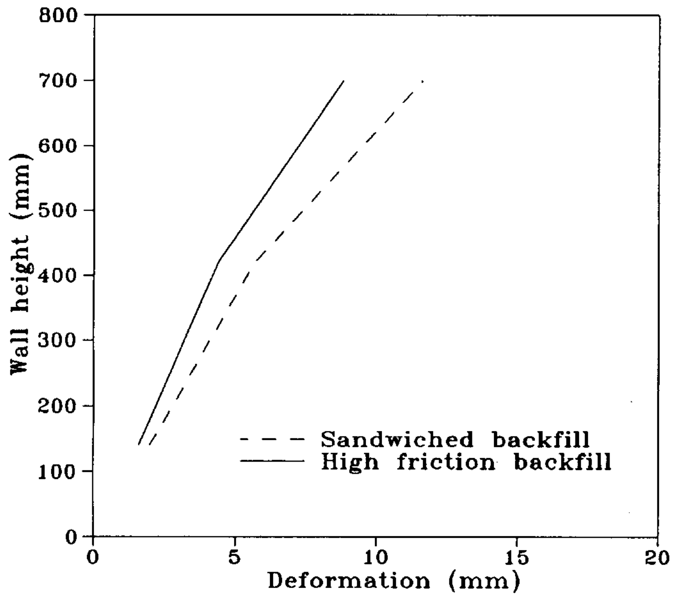

Figure 5. Horizontal deformation of retaining wall 1

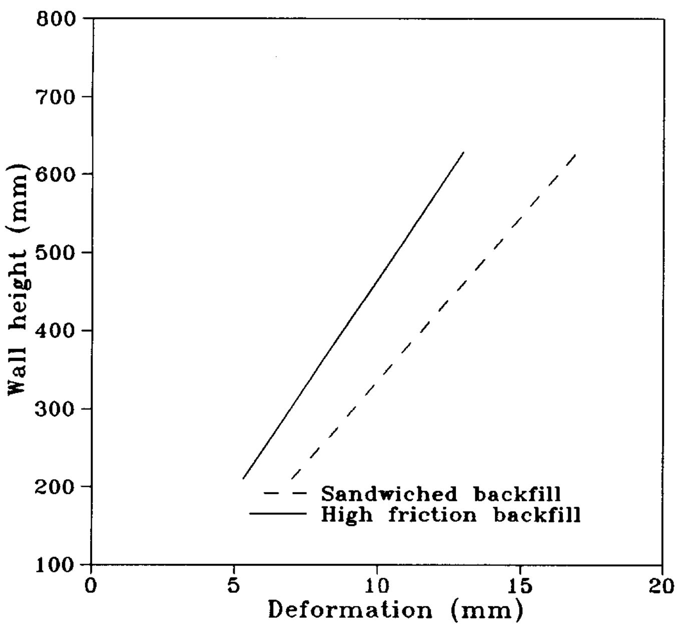

Figure 6. Horizontal deformations of the retaining wall 2

5 CONCLUSIONS

1. Lateritic soil can be used in geotextile reinforced soil retaining walls, with sandwich technique, for greater advantage.
2. The strength of the bulk backfill material plays an important role in the stability of retaining walls.
3. In the sandwich technique with lateritic soil, a minimum sand layer thickness equal to the maximum particle size of the bulk backfill may be adopted.
4. Because of the increased horizontal deformations, the earth pressures reduce much below the Ko condition. At high enough lateral deformation, the state of stress may approach the active state.

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