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Short Communication

Multiple Anchored Retaining Walls

by

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Introduction

In recent years, a bulk of jobs emplying reinforced earth technique have been completed all over the world. Reinforced earth is a construction material consisting generally of a cohesionless backfill into which reinforcing material is layered to resist the tensile stresses which the soil on its own cannot sustain. The reinforcing material is normally thin metal strips which extend horizontally into the backfill. The construction of reinforced earth structure is simple and rapid. Man has used the mixture of clay and straw for the construction of dwellings since ages. The use of bamboo mat and coconut piles for building up core walls of bunds was quite familiar in Kerala, India.

Vidal (1966) was the first to develop the principle of reinforced earth structure. Several investigators (Al-Hussaini, 1977; Al-Hussaini and Perry, 1978; Bell and Steward, 1977; Broms, 1978; Holtz, 1975, 1977, 1978; Hoshiya and Mandal, 1983; Hoshiya and Mandal, 1985; Lee *et al.*, 1975; Mandal and Char, 1985; Mandal *et al.*, 1980; Richardson and Lee, 1975; Schlosser and Long, 1974 and Schen *et al.*, 1976) have reported the model studies on reinforced earth walls. Most of the recent related work applied numerical methods wherein the soil-reinforcement system was represented by an equivalent homogeneous or a discrete finite element method, e.g. Gray and Ohashi (1983), Rave (1984) and Mandal and Char (1985).

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A study of the literature shows that till date not much attempts have been made to understand the mechanism of multiple anchored retaining walls. Therefore, the basic mechanism of multiple anchored retaining walls is the main objective of there present laboratory model studies. The rigid and flexible walls have been taken into consideration for the experimental walls. The pullout forces and displacements of multiple anchored retaining walls due to surcharge load under different tie rod lengths are discussed and reported in the paper.

Reinforced Earth Model

The model tests performed in this study were carried out on dry sand in a box of size 30×50×41.5 cm. The box was made of steel frame and transparent plastic plates so that the behaviour of the wall may be observed during experiments. The arrangement of load cells and pressure cells in reinforced wall is shown in Fig. 1. The skin elements were made of plastic plates of thickness 3 mm. The length of strips used in model tests were 100 to 450 mm. The width of the strips was 6 mm and the size of the anchor was 10 × 20 mm. The arrangement and movement of rigid and flexible walls is shown in Figs 2 and 3 respectively. The cross-section of reinforced earth wall is shown in Fig. 4. The horizontal and vertical spacing of the strips are 10 cm and 3.1 cms respectively while the height of the wall is 31 cm. The minimum and maximum dry density of the sand in the laboratory tests was 1.44 and 1.76 t/m³ respectively. The sand was rained into the tank using a raining device from a constant height to achieve an average density of 1.65 t/m³ corresponding to a relative density

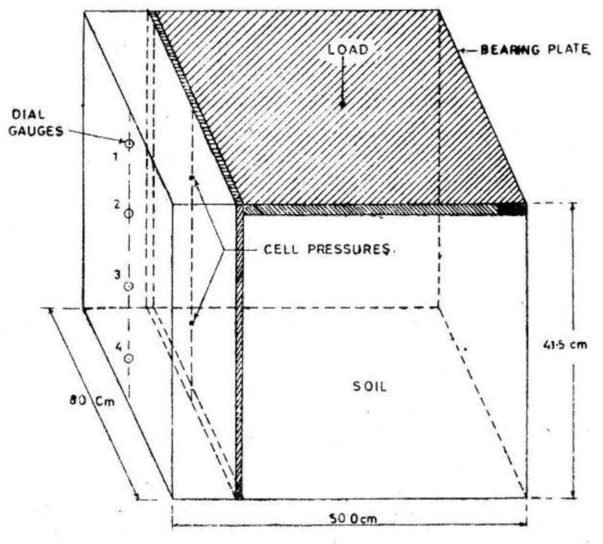

FIGURE 1 Arrangement of Earth Pressure Cells and Load Cells on the Wall

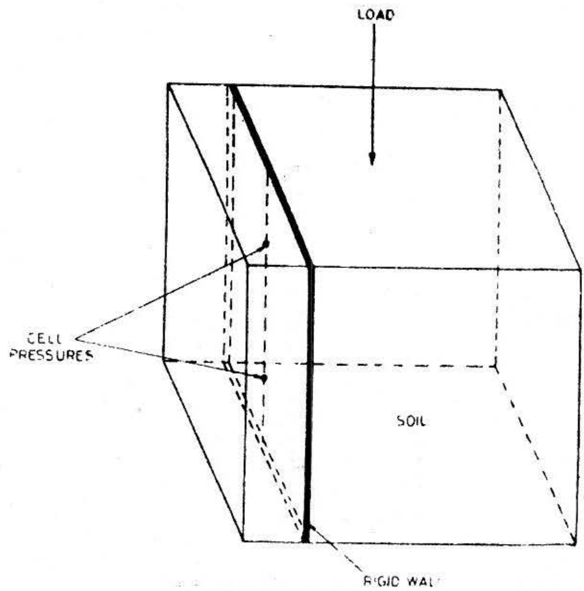

FIGURE 2 (a) Rigid Wall

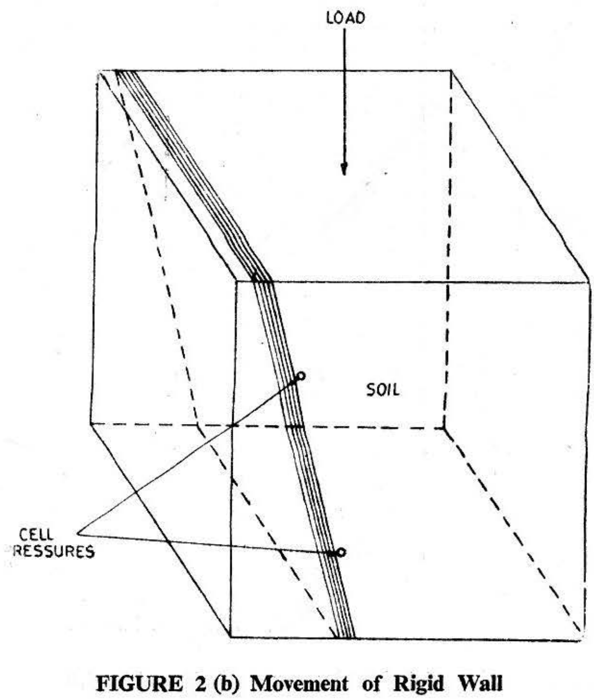

FIGURE 2 (b) Movement of Rigid Wall

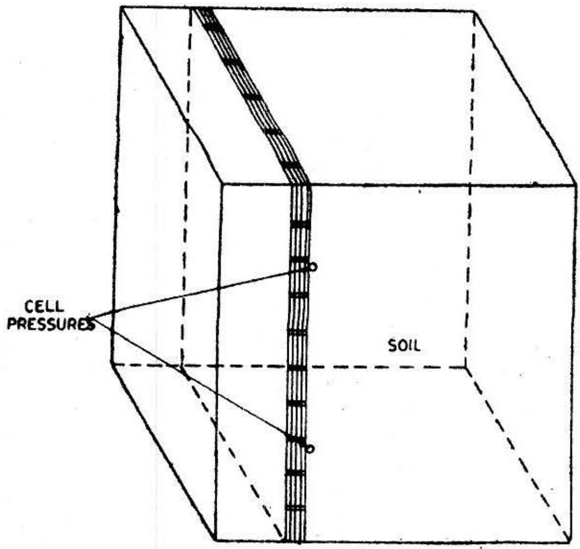

FIGURE 3 (a) Flexible Wall

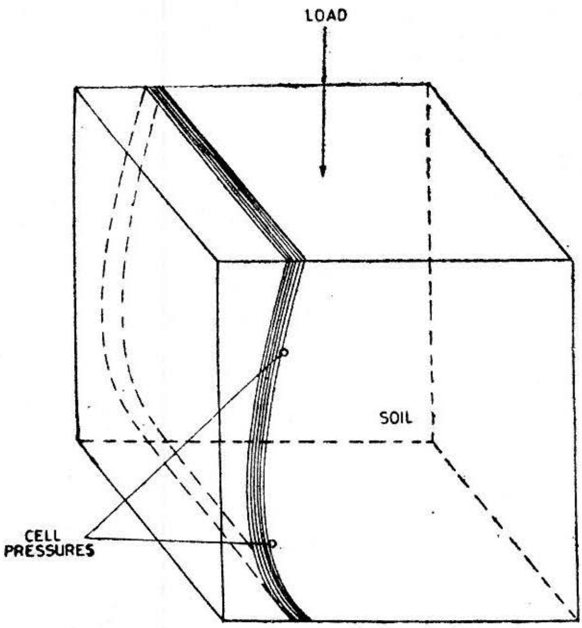

FIGURE 3 (b) Movement of Flexible Wall

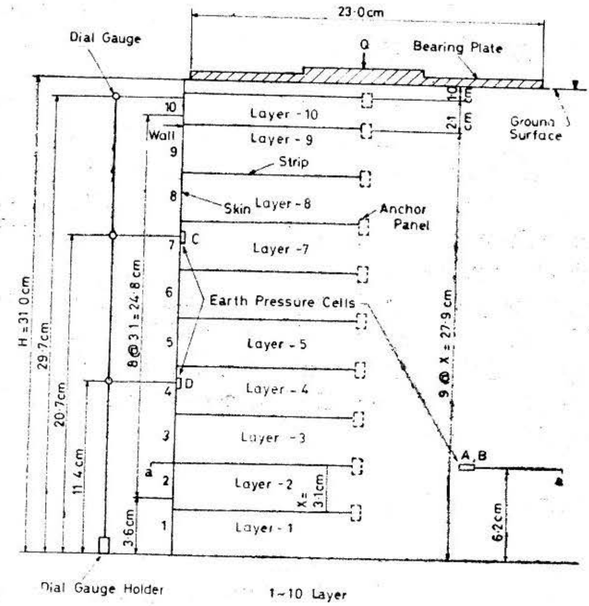

FIGURE 4 (a) Cross Section of Reinforced Earth Wall

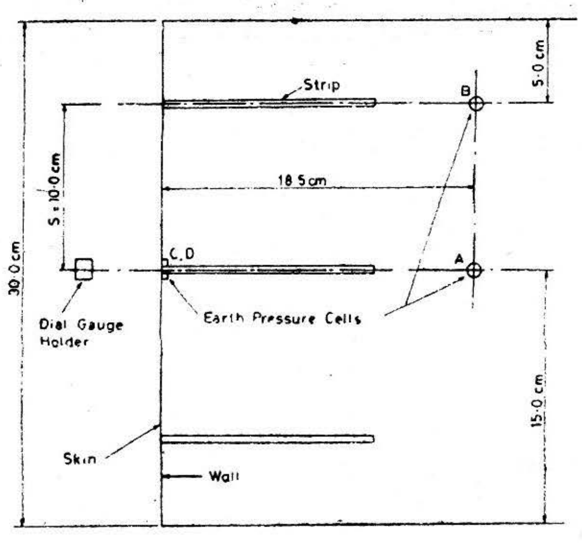

FIGURE 4 (b) Plan of Reinforced Earth Wall

Dr of 63.5 percent. At this density, the angle of internal friction of the sand was found to be approximately 39°. Water content was zero.

A load cell and pullout device were used for measurement of the pullout forces of strips and multiple anchors. The instrumentation consisted of a load cell which monitored the externally applied force to the wall. Each of the model walls was constructed by placing the sand in 31mm thick layers into the tank until the full height of that wall was reached. After laying of the final layer, the vertical load was applied through a steel ball on the bearing plate placed at the top of the wall. The model and the load cell used in this experiment was the one used by Hoshiya and Mandal (1985). The speed of the pullout tests was fixed to be 6 mm/min. for all tests. The external forces and wall displacements were monitored on an *X*—*Y* pen recorder.

Results and Discussion

The displacement versus the height of the wall using strips of 150 × 6 mm are shown in Fig. 5 under different surcharge loads and consequently, the inclusion of anchor plates with the strips are also shown in Fig. 6. It can be found from the experimental results that the inclusion of anchor plate in the strip decreases the displacement of wall. This is due to the sliding resistance between the strip and surrounding soil. Besides the resisting force from the anchor may prevent the wall displacement. Fig. 7 shows the wall displacement versus surcharge load. The results indicate that surcharge load and wall displacement are almost linear with panel or without panel. However, the miltiple anchor plates show a smaller displacement than the strip under different

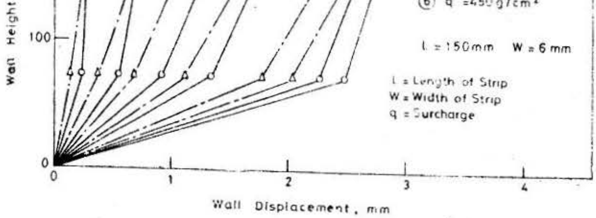

FIGURE 5 Relationship between Wall Displacement and Surcharge with and without Strips

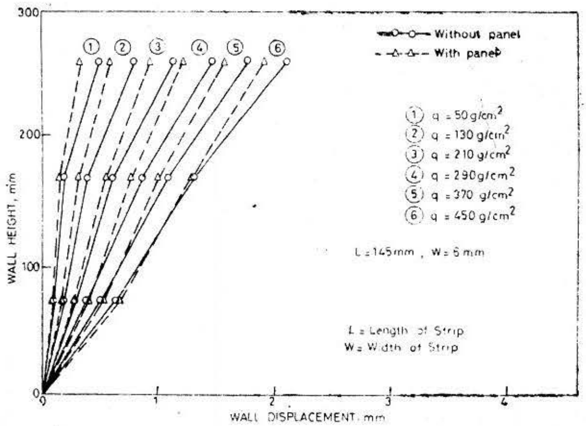

FIGURE 6 Relationship between Wall Displacement and surcharge with and Without Panel

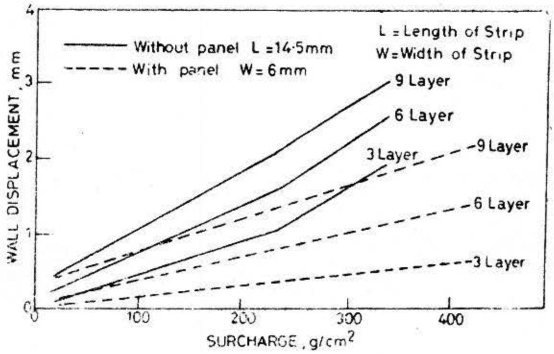

FIGURE 7 Relationship between Surcharge and Wall Displacement

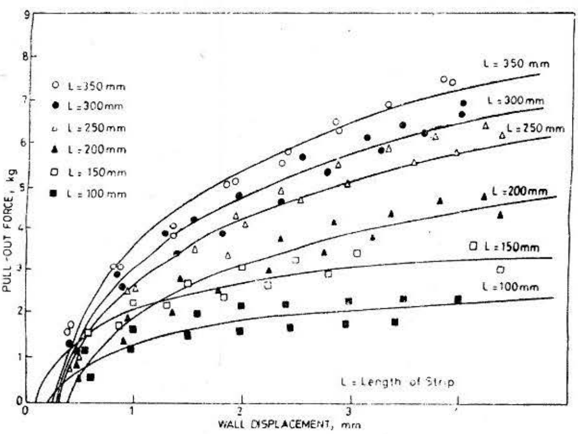

FIGURE 8 Pullout Force Vs Wall Displacement Curves

surcharge pressures. The relationship between pullout force and wall displacement is shown in Fig. 8. The pullout force does not vary linearly with the wall displacement under different tie lengths. Fig. 9 shows the relationship between wall displacement and surcharge load. The curve is linear in both rigid as well as flexible type of retaining walls. The variation between the pullout force and tie road lengths is shown in Fig. 10. The result shows that the pullout force is increasing with the increase of tie rod length. The compensated and observed surcharge load under different tie rod lengths is given Fig. 11. A plate has been placed on the top of the sand sample as a surcharge load. It has been observed that the tie rod lengths are directly proportional to the surcharge load upto the length of 150 mm, then the surcharge loads are either decreasing or increasing depending on the length of the ties. The resisting force (R_E), active earth pressure (P_A) and the wall displacement with respect to height of the wall are shown in Figs 12 and 13 respectively, as a rigid and flexible wall. From the figures, it can be stated that the nature of active earth pressure on the flexible wall are slightly different from the nature of active earth pressure on the rigid

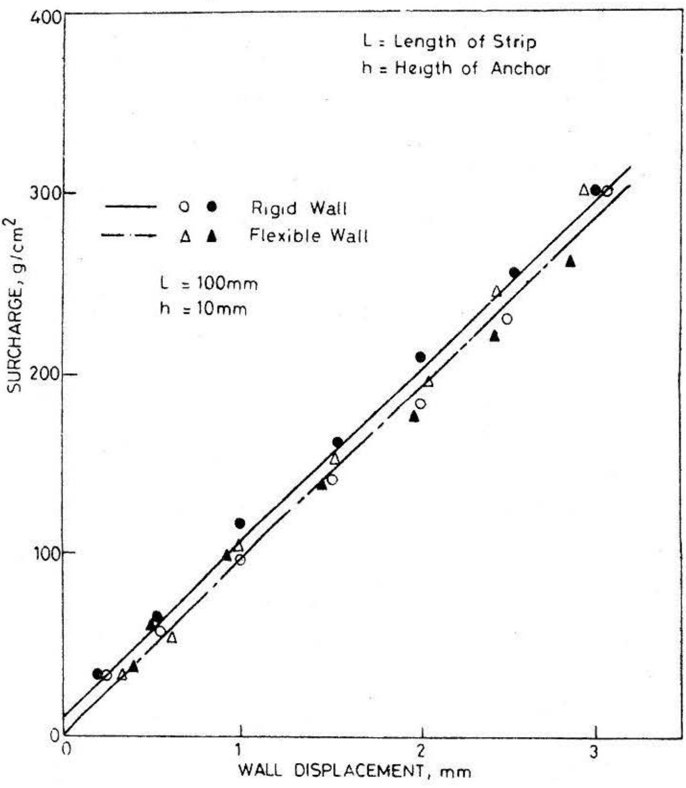

FIGURE 9 Relationship Between Wall Displacement and Surcharge

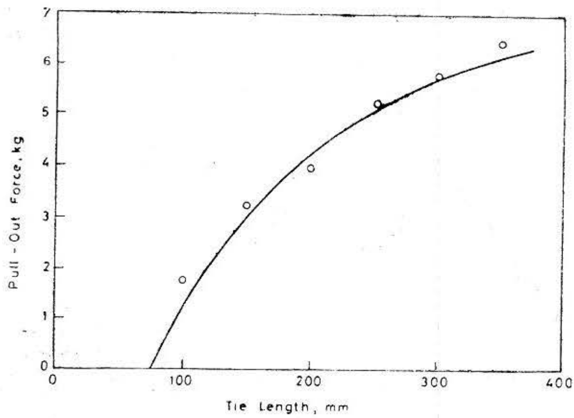

FIGURE 10 Relationship between Pullout Force and Tie Length

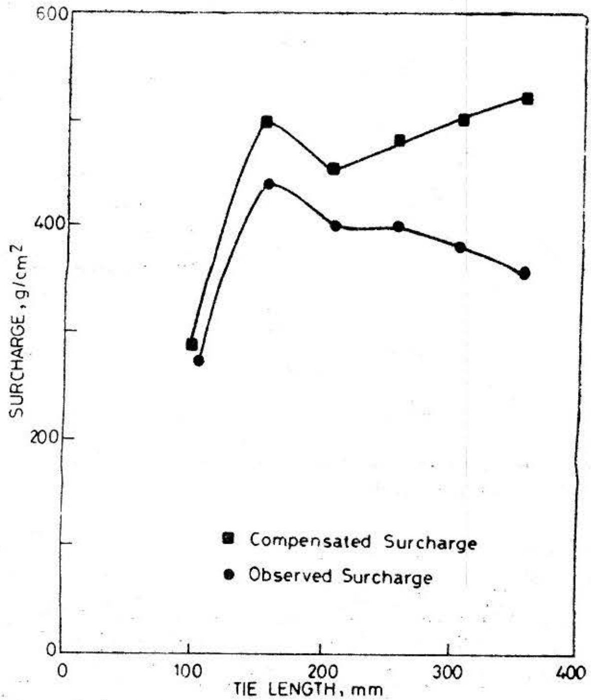

FIGURE 11 Relationships between Surcharge and Tie Length

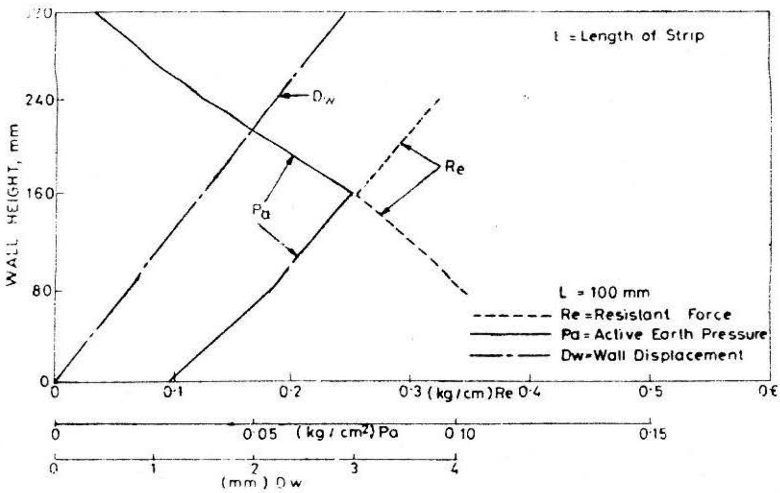

FIGURE 12 Relationship between Resistant Force, Active Earth Pressure and Displacement in Rigid Wall

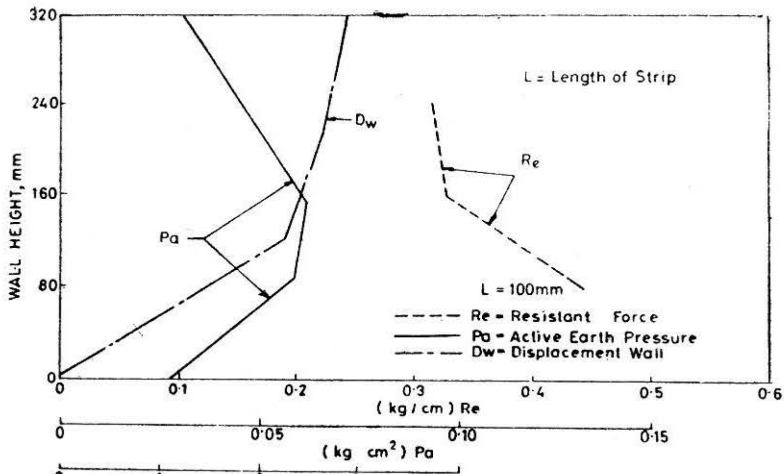

FIGURE 13 Relationship between Resistant Force, Active Earth Pressure and Displacement in Flexible Wall

wall. There is a variation of displacement on the top of the walls. No systematic variation of displacement in the flexible wall have been observed as in the case of rigid wall. The variation of resisting forces is also shown in the same figure. The resisting force, tie rod length and surcharge loads are given in Figs 14 and 15 for the rigid and flexible walls respectively. From both the figures it can be noticed that the resisting force increases with the increase of tie lengths upto 150 mm approximately and then suddenly

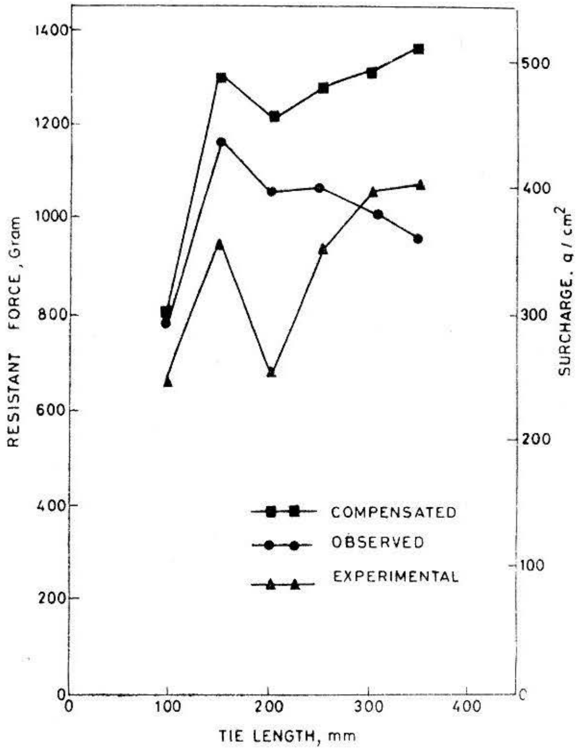

FIGURE 14 Relationship between Tie Length, Surcharge and Pullout Force in Rigid Wall

decreases. The resisting force is showing an increasing tendency after a length of 200 mm. The nature of the curves are almost same in both the cases.

It was found that in all the cases, the strip was strong enough not to repture during the experiments. For all failures, a failure wedge was clearly identified by means of placing very thin layers of coloured sand during backfilling.

Conclusions

A series of model tests were carried out using rigid and flexible wall, with and without reinforcing strips and anchors being attatched to the wall in the backfill. The exact pattern and cause of failure are not known since the failure was catastrophic. The pressure distribution should be linear, but with the introduction of reinforcing materials it can be pointed out that the pressure distribution is not linear with depth along the face of the wall. It can be concluded that the multiple anchored retaining walls contribute significantly more to the wall stability than the retaining wall with thin strips. Moreover, the displacement of retaining walls with multiple anchors

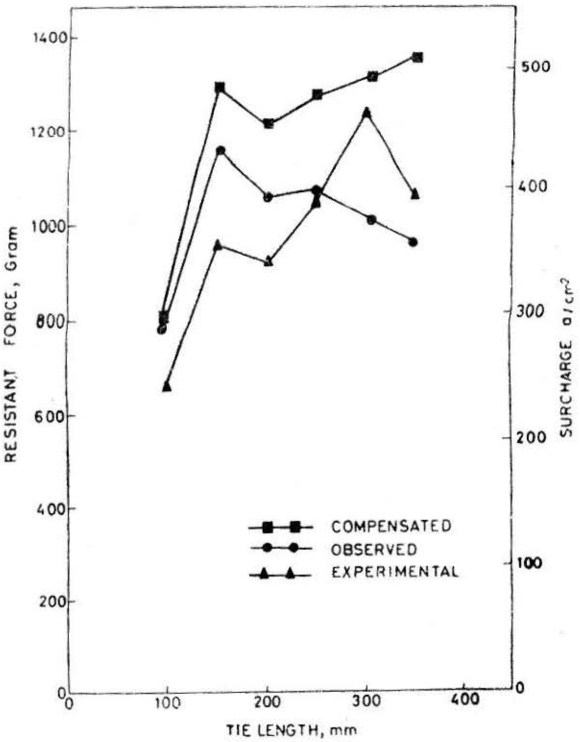

FIGURE 15 Relationship between Tie Length, Surcharge and Pullout Force in Flexible Wall

are less than that corresponding to the retaining walls with strips. The rigid and flexible retaining walls contribute to the understanding of the behaviour of reinforced earth structure.

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