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COMPARATIVE HORIZONTAL RETAINING FORCE OF CONVENTIONAL AND INTERLOCKING CONCRETE BLOCK RETAINING WALL

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ABSTRACT

Comparative horizontal retaining force tests were conducted between regular and interlocking concrete block free standing retaining wall sections 1.63 m (64") high and 2.44 m (96") wide. The centrally loaded horizontal force was applied using the 793 Series MTS linear Actuator. The force and corresponding wall deflection was logged at one second intervals until structural wall failure. Experimental results indicated that the free standing interlocking block retaining wall section resisted a higher horizontal force ranging from 32.5% to 66.3% when compared with the regular concrete block wall section. The interlocking block wall section showed an average of 46.5% higher horizontal retaining force then the regular block wall. There were no significant difference in the wall deflection at which structural failure occurred for the regular concrete block wall and the interlocking concrete block wall.

KEYWORDS – Retaining wall, Interlocking blocks, Concrete blocks, Horizontal force.

1. INTRODUCTION

In general landscaping retaining walls are structures designed and constructed to resist the lateral pressure of soil and keep it in place when there is a desired change in ground elevation that exceeds the angle of repose of the soil [1]. There are different designs of retaining walls suited for respective applications [2]. However, the most important consideration in proper design and installation of retaining walls is to ensure that the wall counteract the tendency of the retained material to move downslope due to gravity. The downslope movement of the retained material creates lateral earth pressure behind the wall [3]. The magnitude of this pressure depends on the angle of internal friction, the cohesive strength of the retained material, as well as the direction and magnitude of movement the retaining structure undergoes [4].

Some special purpose walls are designed to retain water, however, in general it is important to have proper drainage behind the wall in order to limit the pressure due to water retention. Accommodation of drainage materials or design consideration will reduce or eliminate the hydrostatic pressure and improve the stability of the material behind the wall [5]. Without a pressure-relief system, the weight of the water in the soil could crack, or even buckle, the wall. Drystone retaining walls are normally self-draining. Weep holes incorporated in the wall along the top of the first course can channel some of the water out. Other designs include a plastic drainpipe covered with gravel [6].

Concrete blocks are commonly available material that are ideal for building small scale retaining walls to hold back the soil after digging into a slope for a pathway, patio, or other small projects. Retaining walls constructed from standard blocks are generally the same as freestanding block walls. However, since the retaining wall has a horizontal force to resist it must be stronger than freestanding walls [7]. To improve the wall strength a rebar is insert in the footing of the wall which is accommodated in the core of the blocks. Usually at every three blocks high intervals the cores around the rebar are filled with mortar from the bottom to top [8]. The conventional concrete blocks has a square edge and during wall construction the blocks are placed together with a layer of mortar between to hold it in place [9]. In this study, an interlocking concrete block design that do not require mortar between consecutive horizontal blocks was used to construct a retaining wall section. The horizontal retaining wall force was tested and compared to a conventional block retaining wall section under similar test conditions.

2. EXPERIMENTAL PROCEDURE

Two retaining wall sections with different concrete block designs were constructed for comparative testing. The first wall design was constructed with the regular commercial concrete block of dimensions 152 mm x 203 mm x 406 mm (6”x8”x16”) as shown in Figure 1.

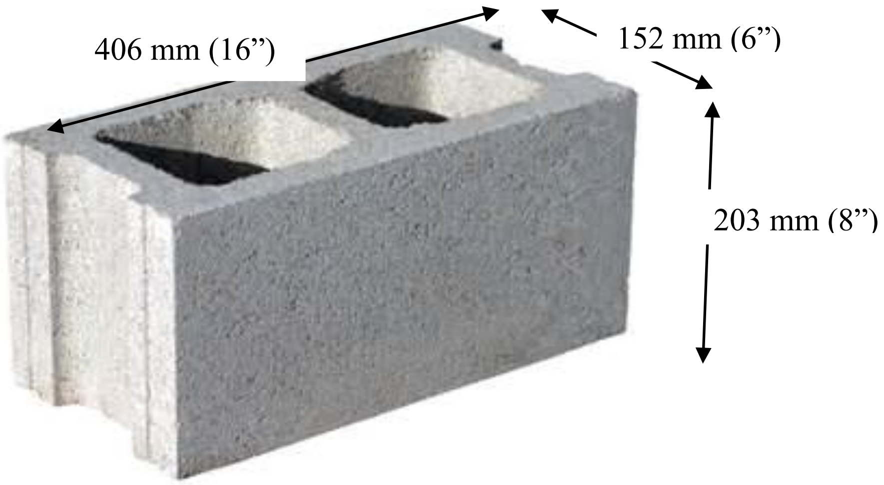

Figure 1. Regular conctete block

A 13 mm (½”) steel rod was centrally installed in the vertically core of each block. The Cores of the blocks wall were filled with pliable concrete at three block height intervals. During the core filling process the concrete was prodded to ensure proper and complete filling of the cores. Figure 2 shows a wall section under construction. Three test wall sections 1.63 m (64”) high and 2.44 m (96”) wide was constructed. Each test wall section was allowed to cure for seven days before testing.

Figure 2. Regular concrete test wall under construction

The second wall design was constructed with the interlocking concrete block of dimensions 152 mm x 203 mm x 406 mm (6”x8”x16”) as shown in Figure 3.

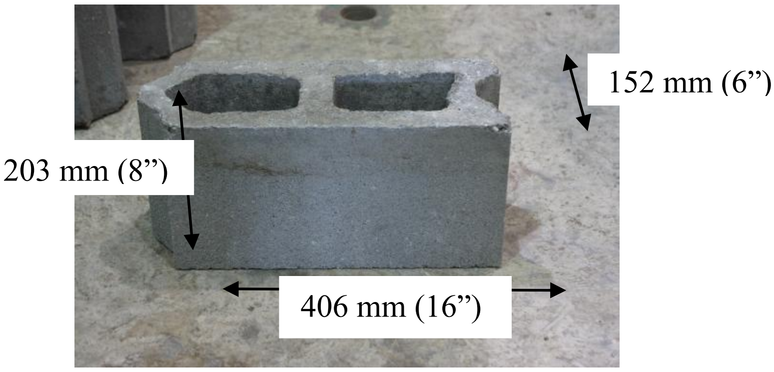

Figure 3. Interlocking conctete block

A 13 mm (½”) steel rod was centrally installed in the vertically core of each interlocking block. The Cores of the interlocking blocks wall were filled with pliable concrete at three block height intervals. During the core filling process the concrete was prodded to ensure proper and complete filling of the cores. Three test wall sections 1.63 m (64”) high and 2.44 m (96”) wide was constructed. Figure 4 shows a completed interlocking block wall section after construction. Each test wall section was allowed to cure for seven days before testing.

Figure 4. Completed interlocking block wall section with rebar

The retaining wall sections were ‘simply-supported’ vertically at both ends. The distance between the vertical restraining bars was 2 m. The base of the walls rested freely on a smooth 18mm thick steel plate to simulate a free standing wall section. To simulate the force exerted from the backfill material a centrally placed horizontal force was applied to the wall section. Figure 5 shows a schematic of the test set-up.

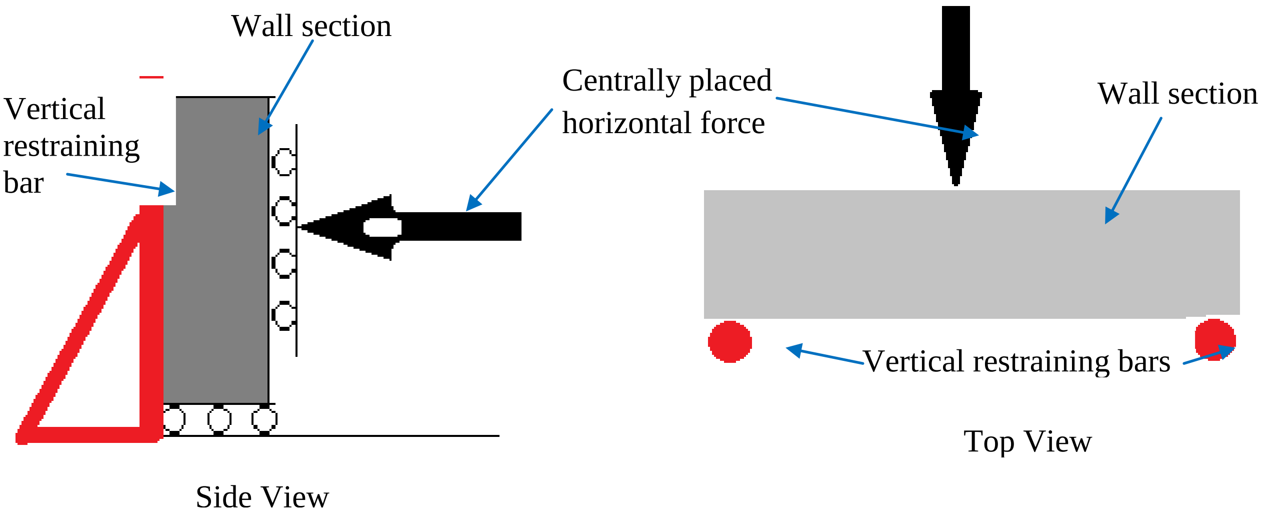

Figure 5. Schematic of wall section test set-up.

Comparative retaining force tests were conducted on the six cured retaining wall sections. The apparatus used to apply the horizontal force was the 793 Series MTS Actuator. This linear actuator measured simultaneously the horizontal force (N) (± 0.1N) and the respective wall deflection (mm) (±0.01 mm). Once the test started the apparatus was automatically controlled by a computer that recorded the force and corresponding wall deflection data at one second intervals. Each test proceeded until the wall failed.

3. RESULTS

Each cured specimen of the free standing retaining wall sections, simply-supported vertically at both ends, was tested to determine the horizontal retaining force. The specimens were subjected to a centrally located horizontal force using the 793 Series MTS Actuator apparatus and the variation of horizontal force with horizontal wall displacement was recorded automatically by the computer at one second intervals until the wall section was broken. The test results for the three wall sections constructed with the regular concrete blocks with 13 mm vertical rebar in the core filled with concrete are shown below in Figures 6 to 8. The maximum retaining force and corresponding displacement for each test are noted.

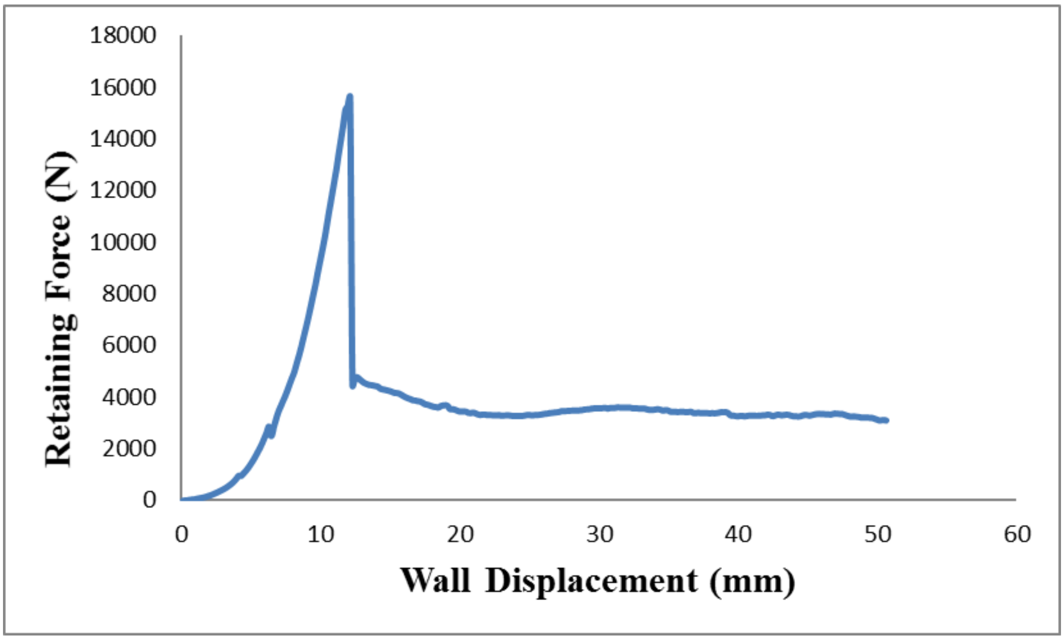

Figure 6. Regular Concrete Block Wall with Vertical Steel rebar concrete filled core – Sample 1.

The test results shown on Figure 6 indicated a Maximum retaining force 15600.59 N at a wall deflection of 12.1681 mm. Structural failure occurred beyond this point.

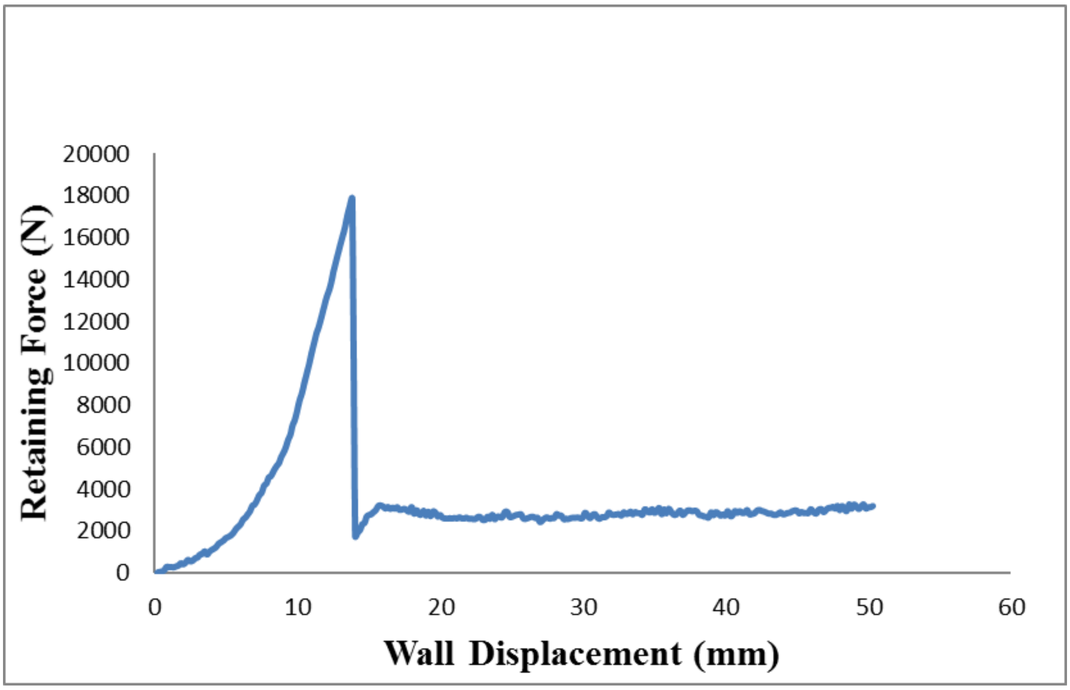

Figure 7. Regular Concrete Block Wall with Vertical Steel rebar concrete filled core – Sample 2.

The test results shown on Figure 7 indicated a Maximum retaining force 17835.47 N at a wall deflection of 13.8286 mm. Structural failure occurred beyond this point.

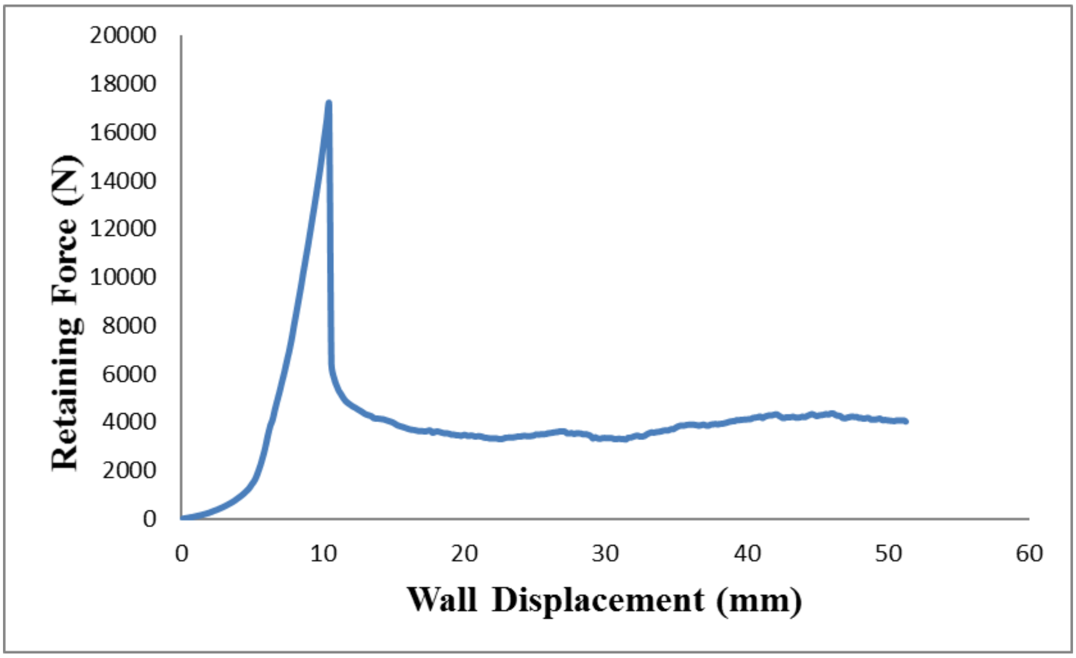

Figure 8. Regular Concrete Block Wall with Vertical Steel rebar concrete filled core – Sample 3.

The test results shown on Figure 8 indicated a Maximum retaining force 17149.73 N at a wall deflection of 10.4950 mm. Structural failure occurred beyond this point.

The average retaining force for the regular concrete block wall with vertical steel rebar and concrete filled core was calculated as 16862 N at an average wall deflection of 12.2 mm.

The test results for the three wall sections constructed with the interlocking concrete blocks with 13 mm vertical rebar in the core filled with concrete are shown below in Figures 9 to 11. The maximum retaining force and corresponding displacement for each test are noted.

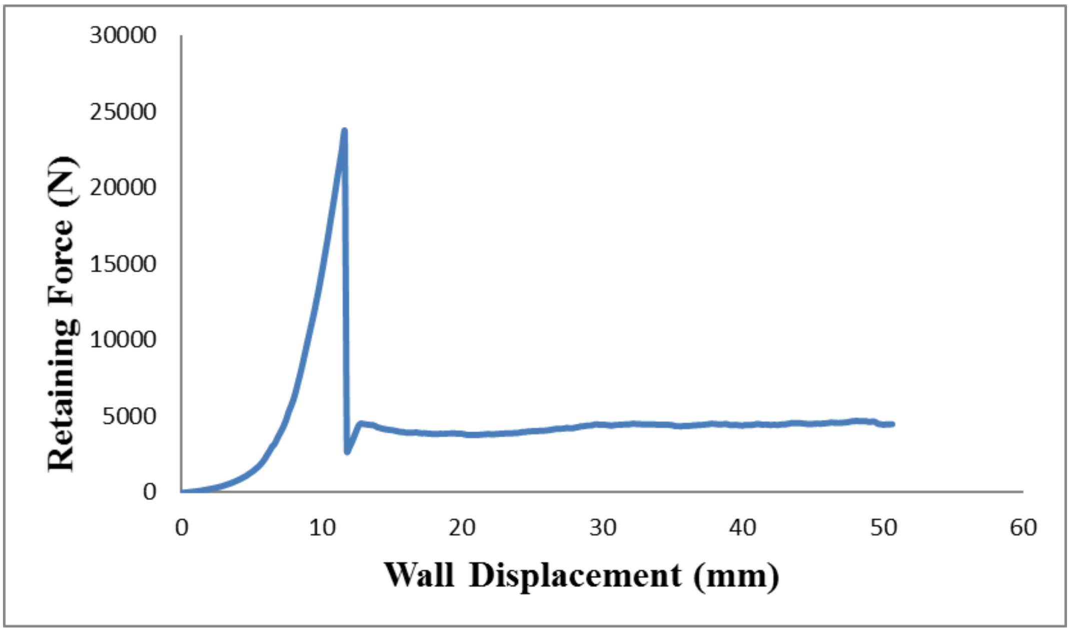

Figure 9. Interlocking Concrete Block Wall with Vertical Steel rebar concrete filled core – Sample 1.

The test results shown on Figure 9 indicated a Maximum retaining force 23637.81 N at a wall deflection of 11.6664 mm. Structural failure occurred beyond this point.

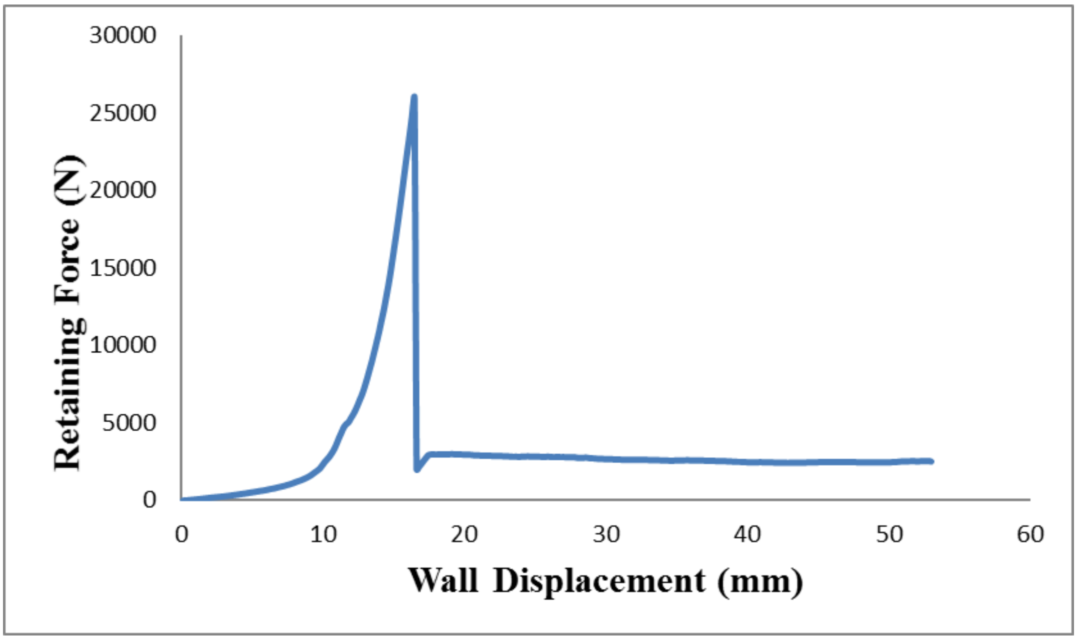

Figure 10. Interlocking Concrete Block Wall with Vertical Steel rebar concrete filled core – Sample 2.

The test results shown on Figure 10 indicated a Maximum retaining force 25942.31 N at a wall deflection of 16.5014 mm. Structural failure occurred beyond this point.

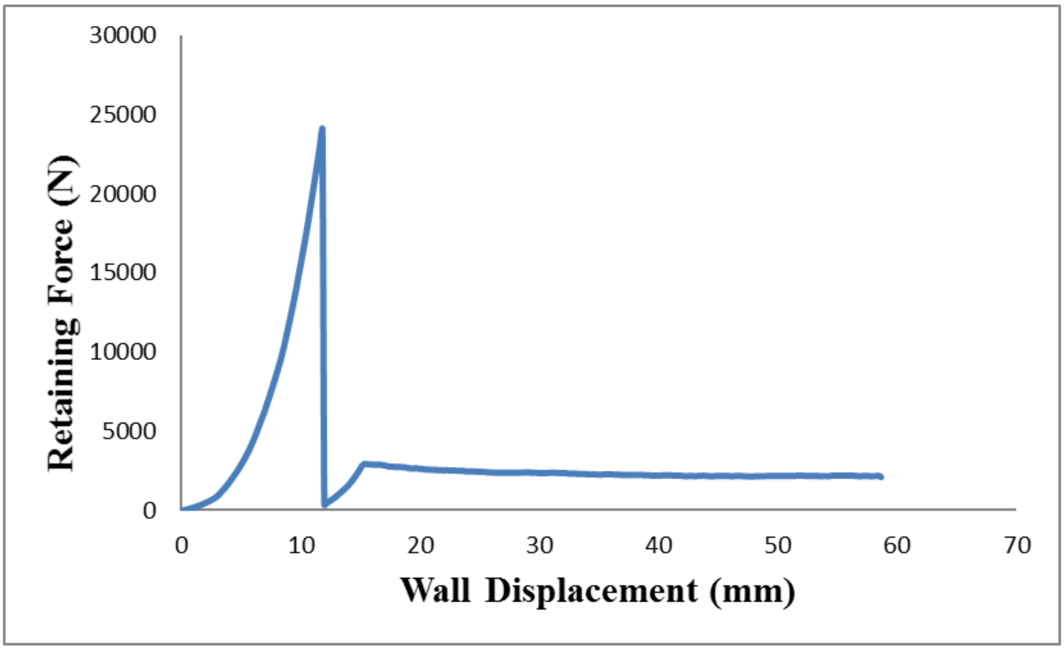

Figure 11. Interlocking Concrete Block Wall with Vertical Steel rebar concrete filled core – Sample 3.

The test results shown on Figure 11 indicated a Maximum retaining force 24059.28 N at a wall deflection of 11.8328 mm. Structural failure occurred beyond this point.

The average retaining force for the interlocking concrete block wall with vertical steel rebar and concrete filled core was calculated as 24546 N at an average wall deflection of 13.3 mm.

4. DISCUSSION

Regular concrete blocks are convenient and easily available for the construction of retaining wall structures. The practice of using vertical rebar with concrete filled core are the norm for concrete block retaining walls. The use of mortar during construction is to hold the blocks in place and ensure proper alignment. The mortar joining is not a structural force bearing attachment. The interlocking block design accommodated for load bearing joint where the blocks interlocked. At this junction the adjacent pre-cast concrete blocks make direct contact which would resist horizontal force loading.

The experiments were designed to simulate a horizontal force loading on a free standing retaining wall section as shown in Figure 5. The test results for the three regular concrete block wall sections ranged between 15600 N to 17835 N with an average horizontal retaining force of 16862 N at a mean wall deflection of 12.2 mm at the center of the wall. The test results for the three interlocking concrete block wall sections ranged between 23637 N to

25942 N with an average horizontal retaining force of 24546 N at a mean wall deflection of 13.3 mm at the center of the wall.

All three interlocking retaining wall section showed a higher horizontal retaining force than the three regular retaining wall sections. From the test results the minimum difference in horizontal retaining force between the regular and interlocking block walls was 5802 N or 32.5%. The maximum difference in horizontal retaining force between the regular and interlocking block walls was 10342 N or 66.3%. The difference between the mean horizontal retaining force between the regular and interlocking block walls was 7684 N or 45.6%. Structural failure on the average for all the walls was 12.7 mm. There were no significant difference in the structural failure deflection between the regular concrete block wall and the interlocking concrete block wall.

5. CONCLUSIONS

The interlocking concrete block design forms a horizontal retaining force load bearing joint between adjacent blocks. The free standing interlocking block retaining wall section showed a higher horizontal retaining wall force ranging from 32.5% to 66.3% when compared with the regular concrete block wall section. On the average, the interlocking block wall section showed a 46.5% higher horizontal retaining force then the regular block wall. On the average, structural failure under horizontal force loading occurred at about 12.7 mm deflection for both the interlocking and regular concrete block wall sections.

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