Lateral Resistance of Interlocking Stabilised Soil Block Walls with Different Geometrical Wall Configurations

Furqan Qamar[1] and Terence Thomas[2]

1. Corresponding Author. Research student, University of Warwick UK.
   Email: furqan.qamar@warwick.ac.uk

2. Engineering Dept. University of Warwick CV47AL UK

Abstract

Interlocking masonry walls exposed to lateral loads have reduced lateral resistance due to lack of its tensile strength, as reported in the literature. Different techniques have been used to enhance the lateral resistance of such structure which include use of reinforcement, grout within interlock, plastering and rendering etc. In this study 1500 mm high interlocked masonry walls mostly used in poor developing countries are experimentally tested. The research focus was to evaluate the structural parameters like stiffness, load at first crack and toughness by changing the geometrical plan of walls. Two walls of 3000 mm length were tested which include straight wall and non-straight wall. It was noted that first crack lateral stiffness of non-straight wall as compared to straight wall was improved by 800%. Non-straight wall also undertook twice the load than straight wall failure load without occurring failure.

Keywords: Interlocking stabilised soil wall, mortar-less, non-straight wall, lateral load, lateral stiffness.

1. INTRODUCTION:

One of the oldest construction materials is masonry. It is still being widely used with some improvements. Different types of the unit developed over the time from simple block to interlocking blocks have led to mortar-less construction. The types of the blocks used in the mortar-less construction around the globe include Haenar system, Mecano system (Vargas 1988), Putra Block (Thanoon et al. 2004), Bamba system, Tanzanian interlock block (TIB) system (Kintingu 2009) etc. Among these block systems, mostly have similarity with conventional units with the differences in projections and keys which provide interlocking mechanism for mortar-less construction (Safiee et.al, 2011). The performance of masonry interlocking walls is being widely explored (Velazquez and Ehsani 2000, Baqi et al. 1999, Rodriguez et al. 1998). Wind and earthquake loadings are typical examples of lateral loading, which is required to resist by masonry walls. Various research works were conducted to study the behavior of masonry walls exposed to lateral loads (Sokairge et al. 2017, Griffith et al. 2004, Uzoegbo 2001, Velazquez and Ehsani 2000 and Drysdale and Essawy 1988). In the research work by Uzoegbo 2001, experimental work is performed for mortar-less wall due to lateral loading and also plastering of walls are considered. The result indicated that the addition of plaster affected the lateral capacity of interlocked walls and it was noted that load capacity increased by 20%. In another study by Safiee et al. 2011, interlocking system was used and the behaviour of masonry wall under lateral load was experimentally investigated. It was concluded that the lateral behaviour was mainly controlled by large displacement and opening of block joint. In another research work by Sokairge et al. 2017, mortar-less blocks were used and tested for lateral loading. It was discussed that this system has some disadvantages like low bending capacity and also interlocking units had to settle down to balance uneven surfaces which could result in low strength of the walls. Therefore, some other mechanism or methods are required to overcome these deficiencies. In this study, Interlocking soil stabilized blocks (ISSBs) system was used to build the wall and was subjected to lateral load. In order to enhance the lateral resistance of these walls, technique of changing the geometric plan of the walls was explored. Comparison of structural parameters of both walls system was carried out which include peak load, lateral stiffness, energy absorption and toughness. This study will enable to explore the technique of enhancing the strength of the masonry wall by changing the geometry with similar material cost.

2. EXPERIMENTAL PROCEDURES:

2.1 Wall preparation and specifications:

The dimensions of interlocked stabilised soil block (ISSB) are shown in the Figure 1. These blocks were prepared in a machine with manual compression. Two walls (3000 mm long x 150 mm wide x 1500 mm high) were built with ISSB without any mortar. 600 mm block returns at the ends were given to avoid wall instability. Both walls tested against monotonic lateral load. Sample labelling is shown in Table 1. Sample A represents the straight wall whereas sample B has got return in the middle and classified as non-straight wall.

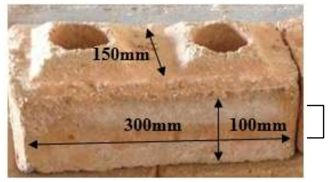


Figure 1: ISSB with dimensions

Table 1: Sample Labelling

Specimens	Straight wall	Non-straight wall
Label	A	B

2.2 Testing Procedure:

The straight and non-straight wall testing are shown in Figures 2 and 3, respectively. The application of lateral loading by using pulley at 1000 mm height is also demonstrated. Displacements at the top of wall are measured with non-digital theodolite. Smaller loads were chosen initially to get the smaller displacement. Load was then applied in increments of 40 N so as to observe first crack and peak load resistance.

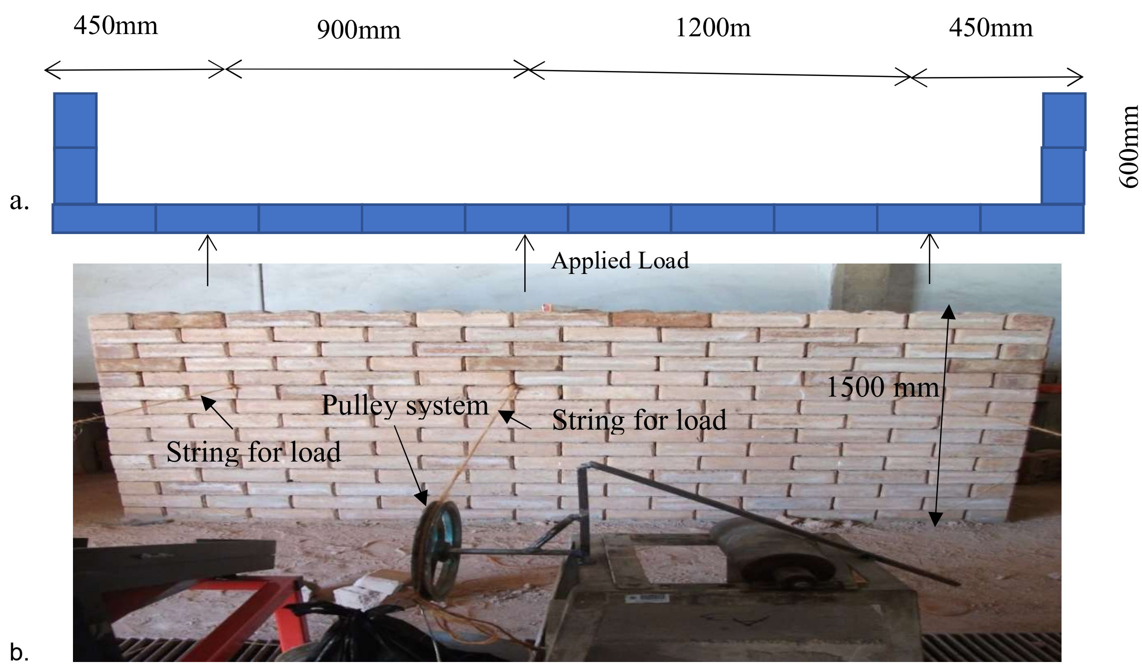
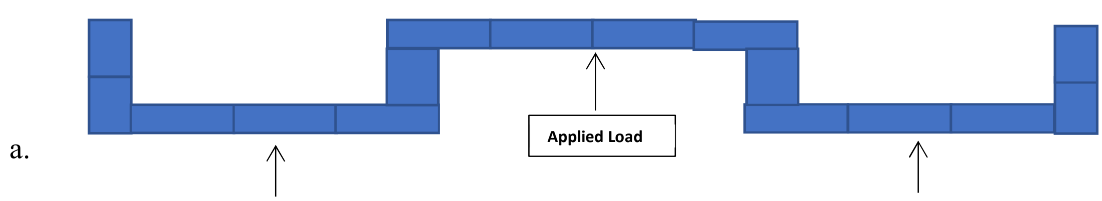


Figure. 2: Straight wall testing: (a) Schematic figure and (b) Test setup displaying system for lateral load



b.

Figure. 3: Non-straight wall testing: (a) Schematic figure and (b) Test setup displaying system for lateral load

3. RESULTS:

3.1 Behaviour against lateral load

The load displacement plot of each wall is detailed in Figure 4. It may be noted that around 5 mm displacement is observed against a load of 100 N for straight wall whereas loads for non-straight walls are much higher for the similar displacement. Non-straight wall showed very high stiffness. The highest load was found much higher for non-straight wall as compared to straight wall and increased to 617 N. This showed that by changing the geometric plan of th

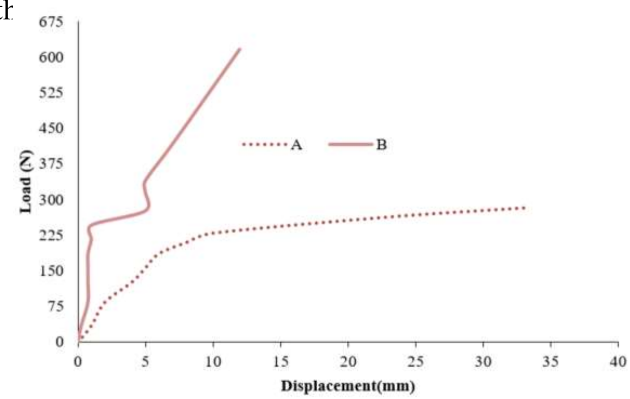
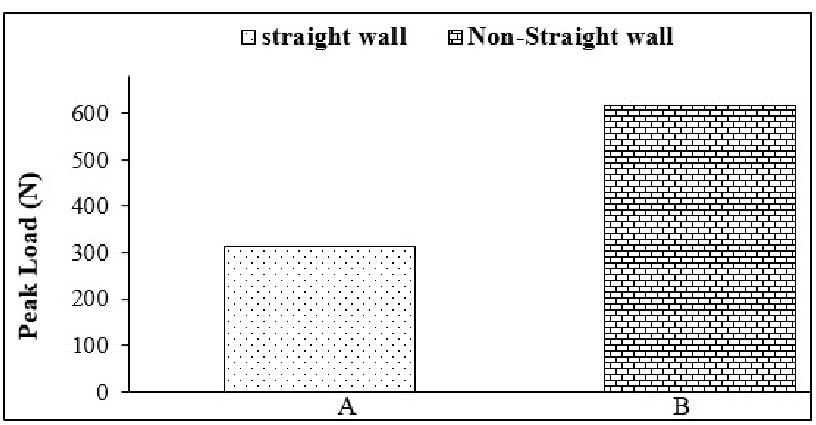


Figure 4: Load displacement curves for straight and non-straight walls

Figure 5 explains the highest loads for the straight and non-straight wall. There is an increase in failure load from 314 N for straight wall to 617 N for non-straight wall. Around two times increase in lateral resistance is observed.



3.2 Load, Stiffness and Energy Absorption Properties

The investigated parameters of both walls are presented in Table 2. These are load at first crack, peak load, first crack stiffness and energy absorption related to before and after crack. The load-displacement slope up to load at first crack is taken as the first crack stiffness. First crack and after crack energy absorbed are calculated as the areas of load displacement plots up to initial crack load and from initial crack to highest load, respectively. Overall energy absorbed was obtained by adding before and after crack energy. The fraction of overall energy to first crack energy is considered as toughness. It is noted that the first crack stiffness is enhanced from 8.48 N/mm for straight wall to 68 N/mm for non-straight wall. This is around eight times increase. It can be noted that the significant increase in first crack stiffness is achieved by changing the geometry of the wall. The before crack energy absorbed for non-straight wall is showing less value as compared to straight wall. This is due to limitation of loading as non-straight wall could not reached to failure load. However non-straight wall showed after crack energy absorbed and toughness index of 2.05. This showed ductile behaviour of non-straight wall as compared to straight wall after first crack. The straight wall showed value of toughness index 1.0, indicating brittle failure. The non-straight wall showed higher failure load but a lower strain, this is due to the fact that stiffness of the non-straight wall enhanced by changing the geometry of the wall.

Table 2: Investigated parameters of straight and non-straight walls

Specimen	**First crack load (N)**	**Peak load (N)**	**Frist crack stiffness (N/mm)**	**Before crack energy absorbed (N-mm)**	**After crack energy absorbed (N-mm)**	**Overall energy absorbed (N-mm)**	**Toughness (-)**
A	284	314	8.48	7526	0	7526	1.00
B	340	617	68	1888	1987	3875	2.05

4. CONCLUSIONS:

Experimental work was conducted to find the improvement in structural parameters by the changing the geometry of ISSB walling system. Two walls with different geometry were considered for lateral loading. The conclusions are found as below:

- First crack stiffness of non-straight wall as compared to straight wall was improved by 800%.
- Non-straight wall undertook twice the load than straight wall failure load without occurring failure.
- Non-straight wall showed ductile behavior after first crack as compared to straight wall with toughness index of 2.05.

From the results, it can be concluded that non-straight wall enhanced the lateral stiffness and lateral load as compared to straight wall. Further investigation required to observe the effect on strength of non-straight wall by inclusion of plastering and fibrous plaster. Thus, cement content can be reduced with reduction in plaster thickness by utilizing the strength gain due to different geometry for economical solution.

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