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Comparative Study on the Strengthening of Cellular Lightweight Concrete Block (CLC) Masonry

Irfanullah[1], Salman Hamad[2], Lalzaman[3], Inayat Ullah Khan[4*], Khalid Khan[5]
[1,4,5]*M.Sc. Student, Department of Civil Engineering, University of Engineering and Technology Peshawar, Peshawar, Pakistan*
[2,3]*B.Sc. Student, Department of Civil Engineering, University of Engineering and Technology Peshawar, Peshawar, Pakistan*

***Abstract*: Cellular Lightweight Concrete Block Masonry is a new and emerging construction material, spreading at a high rate in developing countries. This material requires proper laboratory testing at a material level before commercialization. This paper elaborates the stress-strain behavior of strengthened and un-strengthened prisms under compressive loading, tested according to requirements of ASTM standard. Six prisms, three of which were strengthened and three un-strengthened, having dimensions of 8″ x 24″ x 24″ were casted. Experimental results show that there is very little improvement happened in the strengthened samples as compared to that of un-strengthened. This is because during the test, due to the low compressive strength, screws were pulled out and hence did not play their role in strengthening.**

***Keywords*: Strengthening, Cellular lightweight concrete block masonry, Masonry compressive strength.**

1. Introduction

Today's world is moving toward sustainability. For making the construction sector sustainable, choosing a sustainable material, both in terms of environment and in terms of economy, is the need of the day. CLC is lightweight material, having faster construction and reduce the overall sizes of different structural members. Brick is mainly used as a building block for most masonry structures around the world. Thus, the brick production sector is constantly aiding Global warming due to its high CO2 production rate [1]. As compared to clay bricks, a very less amount of energy is required for the production of CLC block masonry and has minimum environmental effects [2]. The main constituent of CLC blocks are cement, sand, fly ash, water and foaming agent. Unreinforced masonries have showed poor performance in past earthquakes, like in 2005 Kashmir earthquake, and failed in various failure modes [3]. Thousands of houses were either completely destroyed or were not serviceable anymore. This vast amount of destruction cost Pakistan for billions of dollars [3]. It was found that if in that time locally available strength improvement techniques for masonries were available, then much of the cost for construction of new masonries could have been saved [4]. Different strengthening techniques are available but the most economical and which requires less skilled workers is the application of ferrocement overlay [5]. Cellular Lightweight Concrete (CLC) block is a new construction material, prepared from locally available constituent materials, therefore it needs proper laboratory testing at material level to find its basic material properties before commercialization and use. Moreover, the overall response of full-scale structure depends on the material properties.

This study aimed to find different engineering properties of prisms tested under compression. For this purpose, direct compression tests on three strengthened and three un-strengthened prisms were performed though universal testing machine (UTM). The strengthening was done with ferrocement overlay and then after analysis, its comparison is done with control specimen.

2. Methodology

The CLC block, used in this study, is made of locally available materials like cement, fly ash, sand, water, and foaming agent. Blocks were prepared and tested under UTM using monotonic axial compression loading following the recommendation of ASTM C1314 [6].

A. Material Properties

The strength of CLC block is totally affected by density. The blocks were prepared as per the density of 770 kg/m^3 as a codal requirement (ASTM C796-97) [7]. The mix design, which was followed for the block construction is shown in the Table 1. Each block has size of 24" in length, 6" in height and 8" in width. Typical block is shown in Figure 1. Before performing

Table 1
Ingredients of foam concrete

Ingredients	Density (Kg/m^3)	Weight (Kg)	Unit Weight (kN/ m^3)
Cement	1440	100	3.14
Fly Ash	1350	200	2.44
Fine Aggregate	1500	50	3.19
Water	1000	180	1.00
Foaming agent	70	240	1.39

*Corresponding author: 16pwciv4553@uetpeshawar.edu.pk

Table 2
Basic mechanical and physical properties

Tests	No. of samples	Sample Type	Sample Size	ASTM	Average Values	COV (%)
Thermal conductivity (W/mxK)	3	Cylinder	1″ x 1.25″	ASTM-C177	0.37	2.70
Water absorption (%)	3	Blocks	12″x 8″x6″	ASTM-C140	16.1	3.50
Comp. Strength of Block (psi)	3	Cubes	4″x 4″x4″	ASTM-C495	201	4.75
Flexural Strength of Block (psi)	3	Blocks	24″x 8″x6″	ASTM-C293	67	5.78
Mortar Comp. Strength	3	Cubes	2″x 2″x2″	ASTM-C109	1345	5.00

compression tests on both samples, basic material properties were found, and listed in Table 2.

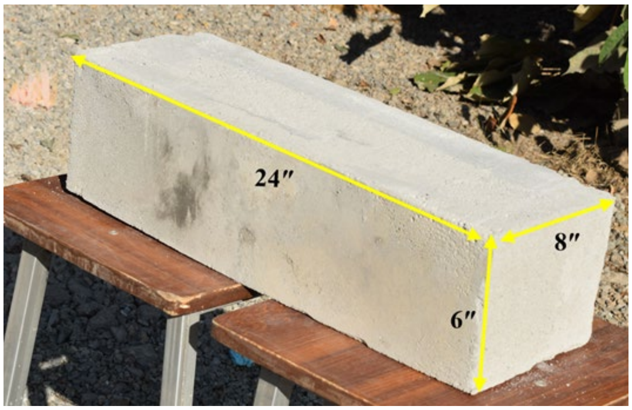

Fig. 1. Lightweight CLC block

B. Fabrication of Samples

Six samples having dimensions i.e., height, h_p and thickness t_p, were casted in structure testing lab. Control samples (Without strengthening) was applied with just plaster of cement-sand ratio of 1:4 and tested as per guidelines of ASTM C-1314. h_p/t_p values were taken within the range, recommended by ASTM C-1314 [6] and shown in Figure 3. Three were strengthened with Ferrocement overlay and rest were only plastered. All the samples were moist cured for seven days and then tested. The results of control samples were compared with that of strengthened samples to quantify the beneficial effect of the strengthening technique.

To construct strengthened samples, first mesh was connected to wall through nails. The spacing of nails (nail's density) was calculated analytically using compatibility and mechanics of materials approach. It was found that 3.45 screws per sq. foot were required for strengthening. But practically 4 screws per sq. foot were provided in order to hold the mesh over the masonry prims surface. Figure 4a and Figure 4b shows strengthened and un-strengthened samples respectively. Figure 4c shows the failure of samples tested through UTM. Figure 2 shows items used in strengthening of prisms while Table 3 gives specification of items.

Fig. 2. Washer, Plug, Screw

Table 3
Specifications of stationary

Item	Dimension
Steel Wire Mesh	50 ft by 6 ft
Screws	Average diameter = 6 mm
Washers	Interior Diameter = 6mm, Exterior Diameter = 1.375 ″

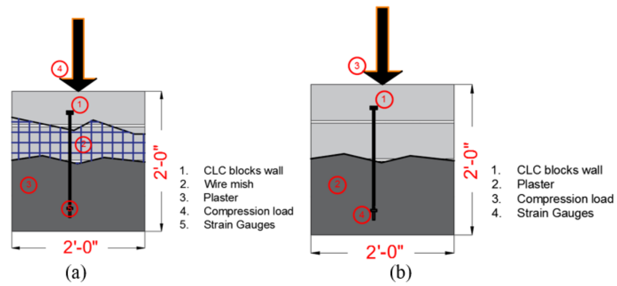

Fig. 3. Samples (a) Strengthened (b) Without strengthening

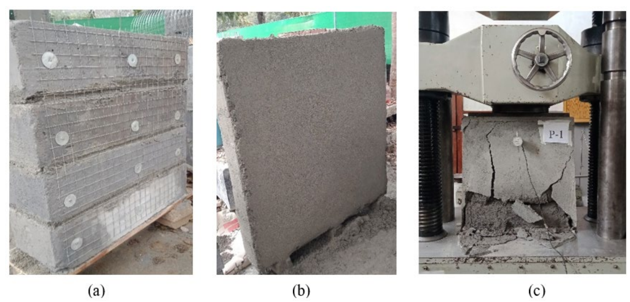

Fig. 4. Samples (a) Strengthened (b) Without strengthening (c) Testing

3. Results and Discussion

Initially the behavior of prism is very stiff which shows the confinement effect produced by plaster and ferrocement. After 0.001, the slope of the stress-strain decreases which shows the crack produced in the plaster leading to masonry.

Another reason for low stiffness at the start (strain of 0.003) is due to loose materials on the top. Beyond this range the stiffness is increased because masonry took load until the strain of 0.002. Beyond this strain level, micro hair line cracks get started and the stiffness of the sample get decreased dramatically. This effect can be seen in the graph, given in Figure 5, as it is flattened. The strengthened sample took peak compressive stress of approximately 63 psi at strain of 0.0013. After the peak, the plaster spalling started and hence the resistance was decreased slowly until failure of the sample at 0.0027 strain. Failure pattern and mode of failure was the same in both type of samples as it is clear from the graph. Moreover, it shows that the value of material properties is quite low than the competitive masonries [8]-[10]. The material properties of both control and strengthened samples is shown in Table 4 and 5.

Table 4
Results of Un-strengthened Prism

S.No.	Sample length (in)	Sample Thickness (in)	Maximum Load (lbs)	f_{mt} (psi)	E_m (psi)
1	24	8	12717	65.23	19348
2	24	8	11557	59.34	18578
3	24	8	12232	58.34	19002

Table 5
Results of strengthened Prisms

S.No.	Sample length (in)	Sample Thickness (in)	Maximum Load (lbs)	f_{mt} (psi)	E_m (psi)
1	24	8	12803	66.68	19431
2	24	8	11713	61.01	18456
3	24	8	11995	62.47	18991

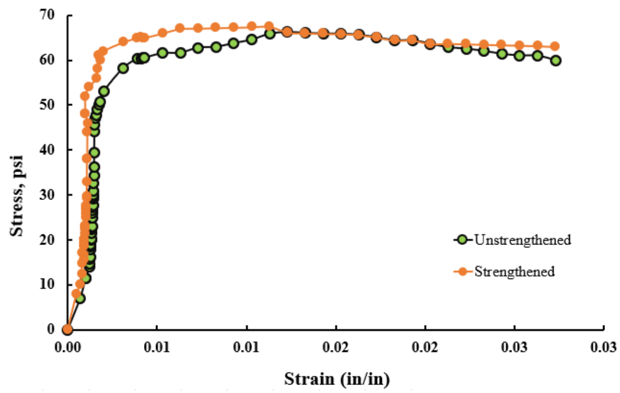

Fig. 5. Stress-strain curve from prism testing

4. Conclusions

In this work, a compressive test was performed on control and strengthened samples, constructed from CLC block masonry, and tested through universal testing machine. The results were analyzed and some conclusions are drawn as under.

The value of compressive strength was found nearly same for both samples. Moreover, the value of elastic modulus is found in the range of 19000 psi, which is quite similar for both samples.

From the results, it is cleared that there is negligible improvement in overall parameters of the prism after testing. This is because of pulling out of screws during the test. The reason for pulling out of screws was the weakness of masonry unit in compression.

Though the capacity wasn't improved but initial cracks in the plaster during test is important indicator of the warning before further crushing of the masonry.

References

[1] V. Ramalingam and S. Ramanagopal, "Compression Behaviour of Polypropylene Fibre Reinforced Cellular Light Weight Concrete Masonry Prism," in *Civ. Environ. Eng. Rep*., vol. 30, pp. 145–160, Mar. 2020.

[2] K.-H. Yang and K.-H. Lee, "Tests on high-performance aerated concrete with a lower density," in *Constr. Build. Mater*., vol. 74, pp. 109–117, Jan. 2015.

[3] M. Javed, A. Khan, A. Penna, and G. Magenes, "Behaviour of masonry structures during the Kashmir 2005 earthquake," in *First Eur. Conf. Earthq. Eng. Seismol. 1st ECEES Geneva Switz. Pap*., vol. 1077, Jan. 2006.

[4] K. Shahzada, "Improvement of Masonry Structures Against Seismic Force," *Bulletin of the International Institute of Seismology and Earthquake Engineering*, p. 43, 2007.

[5] M. ElGawady, P. Lestuzzi, and M. Badoux, "A Review of Conventional Seismic Retrofitting Techniques for URM," in *Proceedings of 13th International Brick/Block Masonry conference*, p. 10, 2004.

[6] ASTM C1314-21, "Standard Test Method for Compressive Strength of Masonry Prisms." ASTM international, 2021. Accessed: Aug. 19, 2022. [Online]. Available: https://www.astm.org/c1314-21.html

[7] K. Khan, I. Khan, M. Khan, M. Shakeel, and A. Khan, "Mechanical and Physical Properties of Cellular Lightweight Concrete (CLC) Blocks," 2022.

[8] A. Gul, K. Khan, A. Khan, K. Shahzada, and I. Khan, "Mechanical Properties of Dry Stack Masonry using Hydraform Blocks," in *1st International Conference on Advances in Civil & Environmental Engineering, UET TAXILA (1st ICACEE-2022)*, UET Taxila, Pakistan, Mar. 2022.

[9] B. Alam, K. Shahzada, I. U. Khan, and A. Gul, "Experimental assessment of diagonal shear parameters of dry stacked block masonry built with self-interlocking compressed earth blocks," in *Int. J. Mason. Res. Innov*., vol. 1, no. 1, p. 1, 2022.

[10] S. Ali, A. Gul, I. Khan, and K. Shahzada, "Effect on the Mechanical Properties of Brick Masonry by Replacing the Cement Sand Mortar with Marble Waste Tile Bond Mortar," in *1st International Conference on Advances in Civil & Environmental Engineering, UET TAXILA (1st ICACEE-2022),* UET Taxila, Pakistan, Mar. 2022.