APPLICATION OF COCONUT FIBER IN CEMENT BLOCK INDUSTRY

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Abstract: In the recent times, seismic effects have become major governing factor in analysis, design and construction of structures in Papua New Guinea. This is mainly due to the occurrence of severe earthquakes in the region. As to the current construction practices, most of the earthquake resistive structures are designed with cement hollow block providing require reinforcements. However, this construction method is very expensive and not affordable for middle class families. Therefore, an experiment was carried out by author to find out the suitability of coconut fiber application in cement hollow block work. The experimental study was focused to apply coir fiber to enhance the shear strength of cement hollow block as a cost effective and sustainable practical solution.

The results presented in this paper on the basis of the results of the testing about 40 cement hollow blocks carried out by the author for various percentages of coir fiber by cement weight . It can be seen from the experimental result that shear strength of cement hollow block can be increased by 40 % with addition of 3 % coconut fiber by cement weight to cement hollow blocks mixture. Therefore using coir fiber reinforced cement hollow block instead of normal cement hollow block; required steel quantity can be reduced. Hence overall construction cost of earthquake resistive walls can be reduced.

Keywords: Cement hollow block, Coir fiber, Earthquake, Seismic effects, Sustainable

I. INTRODUCTION

Earthquakes of considerable magnitudes are occurring frequently in the recent years, and causing mass destruction of buildings because of exceeding the designed limit of resistivity to earthquake load. This ultimately in loss of life and property. To significantly improve life quality, new techniques for economical and safe housing are required [1].

Natural fibers reinforced cement based material has gain increasing application in residential components. The use of natural fiber such as Coir, Oil palm, Bamboo, Coca offer advantages such as availability, renewability, low cost and the established technology to extract the fibers [2]. However addition of high natural fiber content to cement block mixture reduced the compressive strength and self weight of the blocks, the resulting blocks could be classified as lightweight cement blocks suitable to be used as lightweight walling materials [2-3]. In the recent studies on various natural fibers shown that Coir fiber is more suitable as construction material due to its high tensile capacity together with other properties including durability over other fibers [3]. There are many general advantages of coconut fibers, e.g. they are moth-proof, resistant to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, flame-retardant, unaffected by moisture and dampness, tough and durable, totally static free and easy to clean[4]. As per recent researches coir fiber is widely used as reinforcement in concrete to increase shear capacity of concrete elements [5]. Eventhough coir fiber is used in concrete; it is not used in cement block up to now. Therefore study on coir fiber application in hollow cement block is very important, especially in earthquake resistive wall design. The current practice of using steel in earthquake resistive wall design is not affordable by local middle class peoples. Therefore , Coir fiber reinforced hollow cement block can be one solution, which required suitable quantities of coir fibers in standard hollow cement block mixture. Coir fiber is available in Papua New

Figure 1: Seismic Designed Cement Hollow Block Wall

Figure 2: Coconut Fiber

Guinea and cost of production is very low, hence the additional cost of building is negligible.

The current urban buildings in Papua New Guinea are mostly 2 storied building and build with cement hollow block providing required reinforcement for earthquake load, e.g. Fig. 1. However, there are considerable failure cases in building due to frequent occurrence of moderate earthquake. Therefore, replacement of normal cement hollow block by coir reinforced cement hollow block may be a sustainable, economical and practical solution to improve earthquake resistivity of the building while reducing total steel requirement.

II. Experimental Procedure

Raw Materials: Ordinary Portland cement, locally available fine sand (d_{50} = 1.0mm), water and locally available brown coir fiber were used for making cement hollow blocks.

Preparation of Coir Fibers: Coir fibers were extracted from local brown coconut husks. Those fibers were immersed in water for the period of two weeks before final clearing. The cleaned fibers were combed before placing in an Owen for 1 day. During this processes 80% of moisture was removed; and then fibers were dried in the open air. After completing drying processes, fibers were again combed and cut into 5.0 cm length. The following Fig. 2 showed some extracted clean coir fiber.

Figure 3: Pan Type Mixture

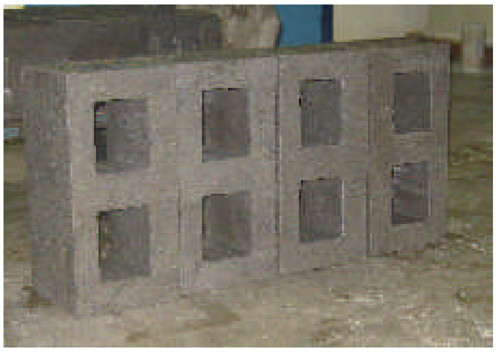

Figure 4: Finished bricks

Figure 5: Compressive Strength Test

Table 1: Compressive Strength Test Results

Sample No.	Coir content by cement weight (%)	Compressive strength (MPa)
1	0	13
2	0	12
3	0	13
4	0	12
5	1	13
6	1	13
7	1	12
8	1	12
9	2	12
10	2	11.8
11	2	11.8
12	2	11.6
13	3	11
14	3	11
15	3	11
16	3	11

Mix Design and Casting Procedure

For cement brick mixture, the mix design ratio for cement and sand was 1 and 4, respectively with water cement ratio of 0.40. The mix design for coir fiber reinforced brick mixtures were the same as above except that addition of coir fiber 1%, 2% and 3% by cement weight in each cases.

The pan type of concrete mixture, shown in above Fig. 3, was used in preparing brick mixture. For making bricks without coir fiber, first, sand and cement were put into the concrete mixture and allowed to mix it for three minutes and then water was added very slowly with a measuring container and mixed for three minutes to form brick mixture for casting bricks. For the coir fiber reinforced brick mixture, same process was followed with spreading coir fiber on sand and cements mixture after adding water and allowed to mix for three minutes. The prepared mixture was put into a brick mould and well compacted to form hollow cement blocks. The following Fig. 4 shows finished hollow brick samples. All the blocks were well cured for 28 days before testing.

Compressive Strength Test for Cement Hollow Blocks

After 28 days of curing, a total of 16 numbers of cement hollow blocks, 4 numbers from each 0%, 1%, 2% and 3% coir fiber mixed blocks were tested for compression. All compressive strength tests were carried out according to Papua New Guinea standard specifications. The testing is shown on Fig.5 and the results are shown on the Table 1.

Shear testing for Cement Hollow Blocks.

So far mechanical strength properties are representing the compressive strength bricks only. No much work on shear strength of brick was reported by researchers. But fiber reinforced concrete possesses improvement in shear. Bairagi N.K [6] proposed a method to determine the shear strength of fiber reinforced concrete, which was applied to measure the shear strength of hollow block mixtures in this study.

Based on literature, L-shaped shear test specimens were prepared from 150mm cubes by inserting a wooden block of 90mmx60mm in cross section and 150mm high into the cube moulds before casting of concrete. All test specimens were casted and cured for 28 days. The specimens were placed as shown in Fig. 6 on compression testing machine. A 150x85x10 mm size MS plate was placed on 90 mm face of left side portion. Mild steel bar of 12mm diameter was placed over the centre of the plate. Another 22mm diameter MS bar was placed at the edge of the plate. Over these bars, another MS plate of size 150x110x10mm was placed. Load was applied on the plate which forms shear plane below the centre of 22mm diameter bar. The loading was continues until the specimen failure. The shear strength was obtained using the following equation:

$$f_s = \frac{P}{A}$$

Where, f_s – shear strength, P – Applied compression load, A – Shearing area

Average shear strength for 12 tested samples according to percentages of coir content by cement weigh are shown on the following Table 2.

Table 2: Shear Strength Test Results

Series No.	Coir content by cement weight (%)	Average shear strength (MPa)
1	0	2.9
2	1%	3.8
3	2%	4.0
4	3%	4.1

Figure 6: Shear testing

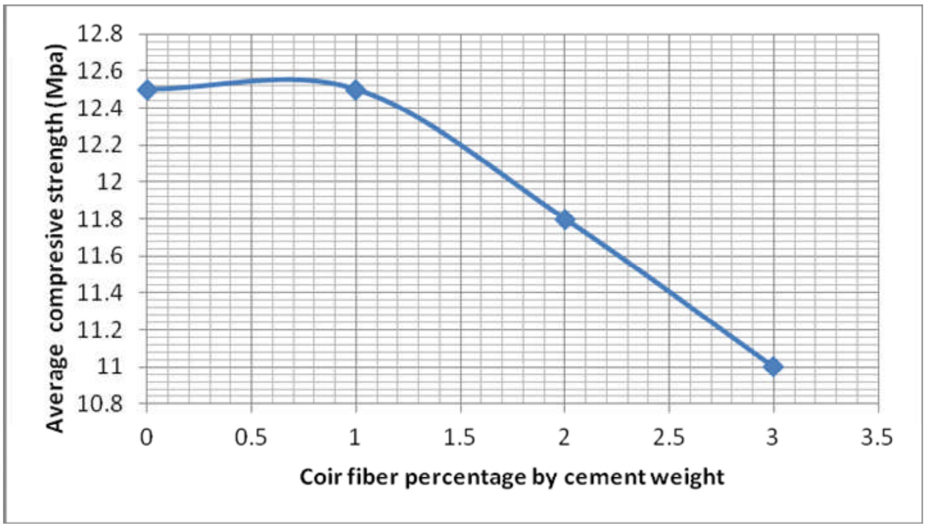

Figure 7: Average Compressive Strength Variation

Shear strength test results. Average shear strength variation for 12 tested samples are shown on the following Fig. 8. It can be seen from the graph that shear strength of cement hollow block mixture is increasing with the increases of coir fiber percentage.

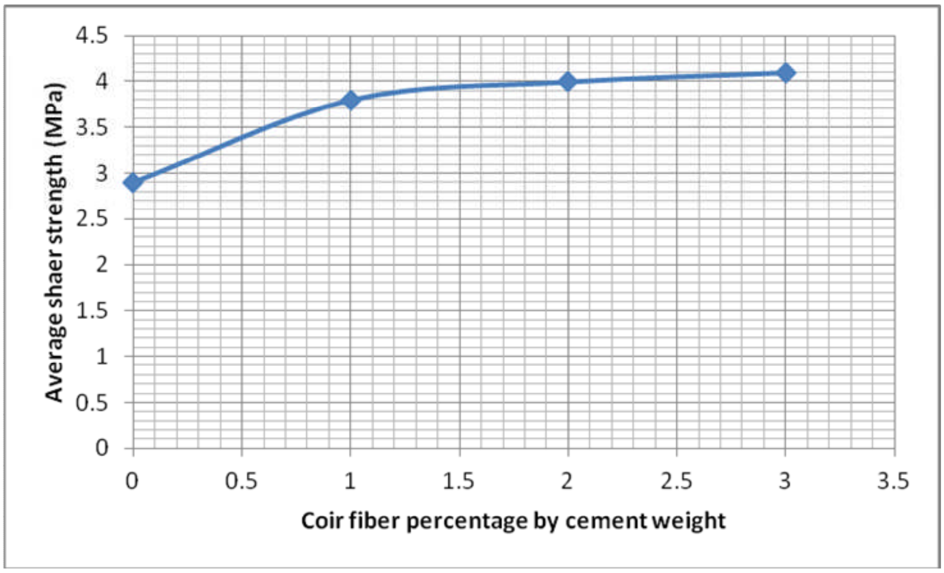

Figure 8: Average Shear Strength Variation

III. Test results and Analysis

Compressive strength test results. Average compressive strength of cement hollow block for each coir fiber percentages are shown in the following Fig. 7. It can be seen from the results that compressive strength of concrete is reducing with the increases of coir fiber percentage.

IV. Conclusion

This study was focused to increase shear strength of cement hollow blocks by coir fiber reinforcement without altering its compressive strength. The study was carried out by testing series of cement hollow blocks with and without coir fiber reinforcement. The workability of standard mixtures for cement hollow block have not carried out due to slump value is negligible with small water contents in the mixtures. Eventhough, wall shear testing is the most common practice to check the shear strength of bricks , in this study L shape block testing's were carried out to compare the enhancement of shear strength with coir fiber reinforcement. It can be seen from the results on Fig. 7 that compressive strength is slightly affected with increases of coir fiber content. The percentage reductions of Compressive strength are 0%, 5.6% and 12% for 1%, 2% and 3% of coir fiber percentages by cement weight respectively. It can also be seen from the shear strength variation on Fig. 8 that shear capacity of cement hollow block considerably increased with increases of coir fiber content. The percentage enhancements of shear strength are 31%, 38% and 41% for 1%, 2% and 3% of coir fiber percentages by cement weight respectively. With the above results, it can be concluded that 2% of coir fiber by cement weight is suitable to increase the shear strength of masonry cement hollow block shear wall. Therefore using coir fiber reinforced cement hollow block instead of normal cement hollow block for building earthquake resistive wall; required steel quantity to resist shear can be reduced. Hence overall construction cost of earthquake resistive walls can be reduced. However, further studies of masonry shear wall testing should be carried out for quantifications.

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