

## **COMPARATIVE STUDY OF STONE AND BRICK CHIPS CONCRETE WITH BAMBOO FIBRE**

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### **Abstract**

Communities around the world rely on concrete as a safe, strong and simple building material. It is used in all types of construction; from domestic work to multi-storey office buildings and shopping complexes. Despite the common usage of concrete, few people are aware of the considerations involved in designing strong, durable and high quality concrete. For this reason, it is important to know the properties of plain concrete. The study was undertaken to know the tensile strength of plain concrete and to investigate the effect of bamboo fibre reinforcement in the concrete. For this purpose, cement, sand, brick chips, stone chips and bamboo fibre were used with different proportions (1:2:4, 1:2.5:5 and 1:3:6) to cast concrete cylinder. The concrete cylinders were tested by the compression testing machine to observe their strength after required curing. Highest strength was obtained for stone chips rather than brick chips. Further cylinders were casted with bamboo fibre. It was found that the tensile strength began to climb up and it was maximum for stone chips containing 1% bamboo fiber. Beyond 1% bamboo fibre the tensile strength tends to decrease for both the aggregates. Among three mix proportions, 1:2:4 was more significant as it showed the highest strength in all cases.

**Keywords:** Concrete, brick chips, stone chips, bamboo fibre, tensile strength.

### **Introduction**

Concrete is prepared by mixing cement, sand, coarse aggregate and water with specific proportions (Wang and Salmon, 1998). Mineral admixtures may also be added to improve certain properties of concrete. Thus, the properties of concrete regarding its strength and deformations depend on the individual properties of cement, sand, coarse aggregate, water and admixtures (Hudson, 1999). Generally, brick chips and stone chips are used as a coarse aggregate. Naturally stone chips are not available in all over the world. But the brick chips are available and the price comparatively lower than other materials. The compressive and tensile strength of concrete may vary by making specimen with these coarse aggregate. So there is an ample scope of study to know the strength properties of these aggregates. Concrete is widely used in most of the countries as the construction material for the infrastructure because it is economical, readily available, excellent resistance to water, low maintenance and has suitable building properties such as its ability to support large compressive loads (Muxing Ding, 2015). After preparation and placement of concrete needs curing to attain strength. However, the use of concrete is limited as a tensile material as it is very good in compression but weak in tension.

To overcome the disadvantage of low tensile strength, a composite material called reinforced concrete (RC) was developed in 1849 by Joseph Monier, a Parisian garner. The reinforcements are usually used steel as reinforcing bars (rebar). But in recent years, the prices of steel have soared. For developing countries, steel is difficult to obtain because of expensive prices (Masakazu TERAJ and Koichi MINAMI, 2012). This high cost of bar as well as the increasing emphasis on sustainable construction materials has led researchers to investigate alternatives to steel reinforcement (Adom-Asamoah Mark and Afrifa Owusu Russell, 2011). In recent years, many investigations have been conducted to explore the use of low cost and readily available construction material. Among the many possibilities, bamboo can be considered for such substitutions which are one of the fastest growing plants and will have a tremendous economical advantage (Amada and Untao, 2001). Moreover, bamboo reaches its maximum mechanical resistance in just few years. Bamboo can be found mostly in tropical and subtropical areas with a few

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species reaching into temperate areas (Muxing Ding, 2015). Therefore, the production cost of bamboo is low compared with steel. So it is widely expected to use in those countries that have no advanced manufacturing technology and construction techniques.

Developing countries have the highest demand for steel-reinforced concrete, but often do not have the means to produce the steel to meet that demand. Rather than put themselves at the mercy of a global market dominated by developed countries. Abundant, sustainable, and extremely resilient bamboo has potential in the future to become an ideal replacement in places where steel cannot easily be produced. Therefore, this study was involved a set of experiments to address the following objectives.

- i. To compare the tensile strength of brick chips and stone chips concrete without bamboo fibre.
- ii. To identify the effect of bamboo fibre for improving the tensile strength of concrete.
- iii. To compare the construction cost of concrete.

## Materials and Methods

The study was undertaken in January 2016 at the department of Agricultural Construction and Environmental engineering, Sylhet Agricultural University, Sylhet. The materials which were used in this study are shown in Fig. 1.



**Fig. 1. Materials for casting the concrete cylinder**

### Cement

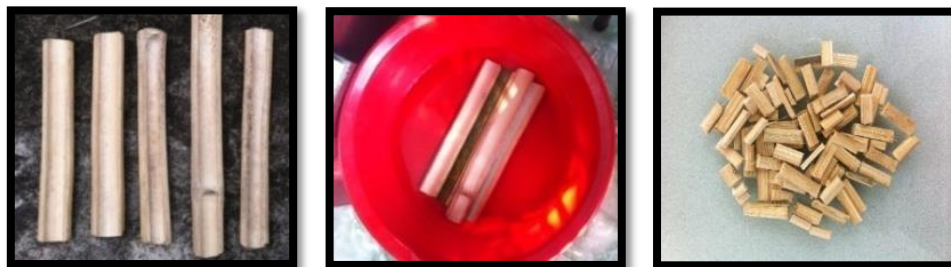
The cement used for this study was ordinary Portland cement (Type-1). The property of cement is given in Table 1.

### Aggregates

The sand was used as fine aggregate and it was collected from nearby river bed. The brick chips and stone chips were used as coarse aggregate. The sand has been sieved in 4.75 mm sieve. The average size of stone chips and brick chips, bulk density and specific gravity are given in Table 1.

### Bamboo fibre

For making bamboo fibre, the bamboos were splitted along the horizontal axis. Then the bamboo specimens were soaked in water for seven days. After that it was dried in sun for 7 days to improve the strength and durability of specimen. The different percentage of bamboo fibre such as 0.5%, 1%, 1.5% and 2% were used in this experiment. The following figures (Fig. 2) were shown the treated bamboo fibre.



Mix proportion for

**Fig. 2. Bamboo fibres after treatment bamboo**

concrete

The concrete mix (cement, sand and khoa or stone) of proportions 1:2:4, 1:2.5:5 and 1:3:6 were selected for bamboo reinforced concrete. The water cement ratio of supplied cement was 0.48.

**Table 1. Specification of the materials**

<b>Cement</b>		
1	Normal consistency	35%
2	Initial setting time	45 minutes
3	Compressive (after 7 days)	32.50 N/mm <sup>2</sup>
4	Tensile strength (after 7 days)	2.55 N/mm <sup>2</sup>
<b>Coarse aggregate</b>		
1	Average size of stone and brick chips	25mm
2	Bulk density	1525 kg/m <sup>3</sup>
3	Specific gravity	2.68
<b>Sand</b>		
1	Fineness modulus	3.0
<b>Bamboo fibre</b>		
1	Density	1483.33 kg/m <sup>3</sup>
<b>Mix Design</b>		
1	Grade of concrete	M20
2	Mix design ratio	1:2:4, 1:2.5:5, 1:3:6
3	Water cement ratio	0.48

### Experimental Procedures

In this study two sets of experiment were carried out to cast the concrete cylinder one is plain concrete and other one is bamboo fibre concrete.

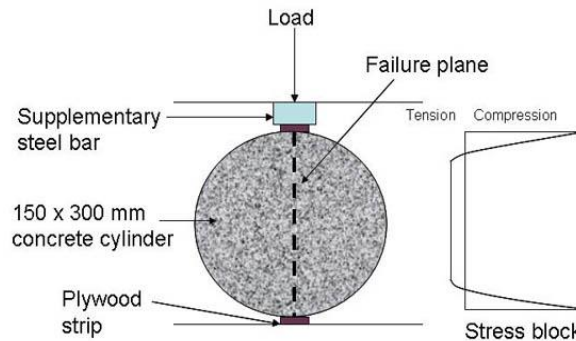
- i. Plain concrete cylinders (102mmx203mm) for brick chips and stone chips were casted with three mix proportions of cement, sand and khoa which were 1:2:4, 1:2.5:5 and 1:3:6, respectively. After 24 hours of casting the cylinders were impounded in water for 7 days to gain initial strength and 28 days of sun drying which were tested in compression testing machine to get tensile strength by indirect method (split tensile test). Tensile strength versus mix proportions were placed in a bar graph for brick and stone chips. The results obtain from the test was compared for the highest tensile strength.
- ii. Bamboo fibre concrete cylinders were casted for similar proportions with different percentage (0.5%, 1.0%, 1.5% and 2.0%) of bamboo fibre by weight basis and curing were accomplished in above same procedure. The cylinders were tested in compression testing machine for tensile strength by indirect test of concrete. Tensile strength versus percentage of bamboo fibre was placed in a bar graph for brick and stone chips. The results obtain from the test was compared for the highest tensile strength.



**Fig. 3. Curing and drying of concrete cylinder**

### Specimen setup and load calculation

The test was carried out in a compression testing machine. The machine was set for the required range. The dial gauge was set up at zero position. The plywood strip was kept on the lower plate and the specimen was placed. The specimen was aligned so that the lines marked on the ends were vertical and centered over the bottom plate. The other plywood strip was placed above the specimen. The upper plate was brought down to touch the plywood strip. The experimental set up is shown in Fig. 4.



**Fig. 4. Test setup for split tension test**

All the cylinders were tested for tensile strength in compression testing machine by split tension test after 28 days of curing. At first, load was applied gradually in the steps of 5kN and longitudinal deflections have been recorded. After that the load was applied continuously without shock at a rate of approximately 14-21 kg cm<sup>-2</sup> min<sup>-1</sup> (which corresponds to a total load of 9900kg min<sup>-1</sup> to 14850 kg min<sup>-1</sup>). The gauge reading was observed during loading. When force became sufficiently large, the sample ruptured along a vertical plane passing through the axis of specimen. Finally, the crushing load (P) was noted down for each cylinder. The formula which was used to calculate the tensile strength is –

$$T = \frac{2P}{\pi LD}$$

Where,

T = Tensile strength

P = Compressive load at failure

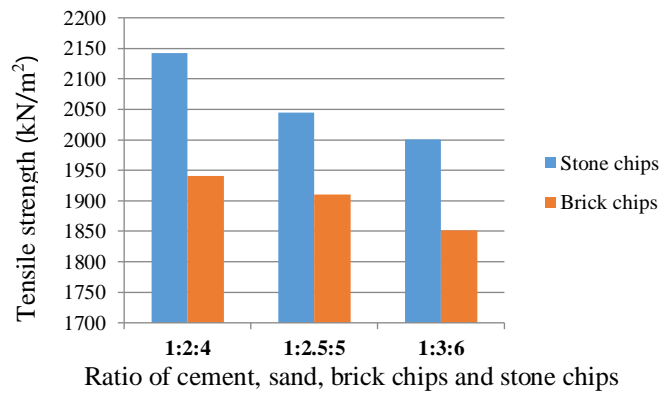
L = Length of the cylinder

D = Diameter of the cylinder

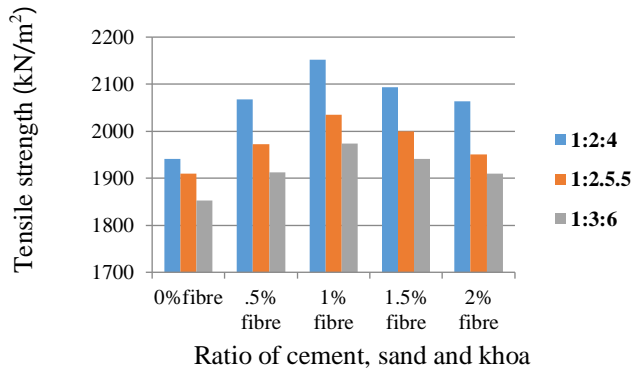
### Results and Discussion

The study was undertaken to compare the tensile strength of brick chips and stone chips concrete with bamboo fibre. To observe the effect of tensile strength, concrete cylinders were casted by using brick chips, stone chips and bamboo fibre.

From test results, it was found that in all three proportion (1:2:4, 1:2.5:5 and 1:3:6) the stone chips showed the highest tensile strength. For both stone and brick chips the strengths were decreasing with increasing the proportions (Fig. 5).

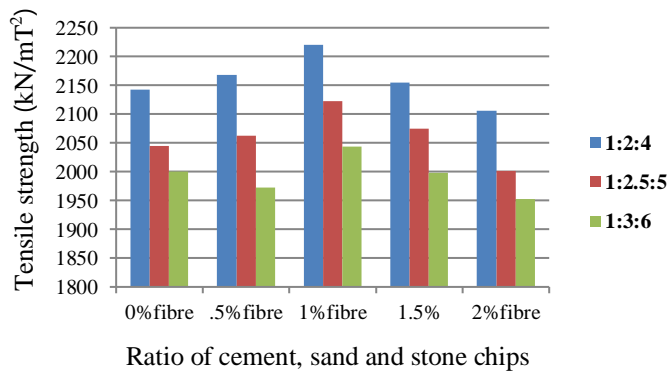


**Fig. 5. Tensile strength of concrete for brick chips and stone chips**



**Fig. 6. Tensile strength of concrete with bamboo fibres in various proportions for khoa**

In case of brick chips the relationship between tensile strength and proportions of concrete mix with different percent of bamboo fibre showed that (Fig. 6) for all proportions with all percentage of bamboo fibre the tensile strength was higher than that of plain concrete. After adding bamboo fibre the tensile strength was increased and reached at a peak value of 1% bamboo fibre and beyond this it was decreasing.



**Fig. 7. Tensile strength of concrete with bamboo fibres in various proportions for stone**

From figure 7 it was seen that tensile strength of concrete with bamboo fibres in various proportions for stone chips was higher than that of brick chips. For all percentage of bamboo fibre the tensile strength was highest at the

proportion of 1:2:4 and it was maximum for 1% bamboo fibre. Tensile strength of bamboo fibre concrete with stone chips similar trend was followed as that for brick chips.

### Cost Estimation

The costs of concrete cylinder with various proportions of aggregate and different percentage of bamboo fibre reinforcements were assessed on market price 2016. It was observed that with the addition of bamboo fibre the increase in cost of concrete cylinder is not significant enough.

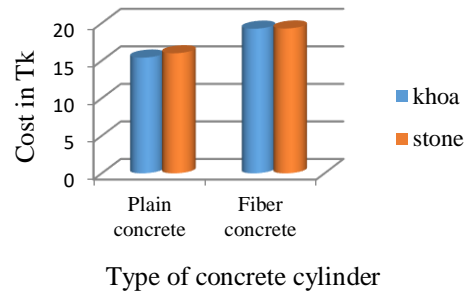


Fig. 8. Comparison of cost of cylinder with and without bamboo fibre

### Conclusion

An experimental study was carried out to compare the tensile strength of brick and stone chips concrete with bamboo fibre. Based upon the tests conducted, the following conclusions were drawn:

- i. The stone chips were shown highest tensile strength than brick chips concrete without bamboo fibre.
- ii. The tensile strength increased between 0.5 % to 1% fibre for both brick and stone chips concrete at mix proportion 1:2:4. Beyond it the tensile strength was decreased for all mix proportion.
- iii. Construction cost of fibre reinforcement concrete cylinder seems that it would be reasonable for the developing country like Bangladesh, Bhutan, Nepal and India.

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