Design and Development of Abaca Fiber Sand Cement Frogged Brick Composites

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An attempt is made to fabricate at room condition short abaca fiber sand cement composite material using the conventional mixing method. Frogged bricks have been designed and developed as a novel material built upon the foundation of concurrent engineering practice. Through this process, the brick molder and the fabricating rig are conceived. Abaca fibers are natural fibers which are classified as leaf fibers among the plant fibers. These fibers are impregnated with a mixture of sand and cement water ratio which cures at room temperature by hydration process. The fabrication, constituent proportion, and compressive strength of fabricated frogged brick composites are described. The fabricating facility is designed to accommodate fabrication of four bricks in one setting. Accordingly, for a given fiber length, the compressive strength increases as the volume fraction increases to a limiting value of 10% fiber volume fraction. The product lends its application in the building industry.

Keywords: Abaca Fibers, frogged bricks, sand cement water ratio, fabricating rig, composite material

INTRODUCTION

Brick is an artificial stone made by forming clay into rectangular blocks, which are hardened either by burning in a kiln or by sun-drying. Bricks may be made from clay, shale, soft slate, calcium silicate, concrete, or shaped from quarried stone. Modern clay bricks have been developed in one of three processes - soft mud, dry press, or wire cut. Bricks are used for building and pavement. The brick in this study is made of sand in a water cement matrix with unprocessed abaca fibers. The consolidation of constituent anticipates in enhancing the mechanical properties of frogged bricks (Tobias, 1990). The addition of abaca fibers in the composite material renders less cement proportion which could make the product affordable for the construction industry. A proper ratio formulation is the key to the success in developing a quality frogged brick.

BACKGROUND

In most cases wherein concrete is subjected to heat, it degrades some of its important properties. Concrete will have a decrease in its toughness and strength when subjected with extreme conditions thus becoming brittle in the process (Boyd, 2002). Commonly used also for walls and partitions in construction is the hollow blocks technology. For this reason, concrete and other related products must have the strength and toughness to withstand load bearing conditions. Frogged bricks, in essence, are to be characterized in terms of their mechanical properties, specifically, toughness and compressive strength.

CONSTITUENTS

The constituent proper proportions of abaca fiber, sand, and water-cement ratio need to be optimized. Abaca fiber is one of the strongest of the hard fibers, commercially known as Manila hemp. It is obtained from the leafstalks of a member of the banana family, Musa textilis (Abaca, n.d.). Sand is a substance that consists of fine loose grains of rock or minerals, found on beaches, in the desert, and in soil. Portland cement is a common type of cement generally used as a basic ingredient of concrete and mortar. Moreover, the water cement ratio influences the constituents to be molded into sound frogged bricks product.

Cement

This material consists of a mixture of oxides of calcium, silicon and aluminum. Portland cement and similar materials are made by heating limestone (as source of calcium) with clay or sand (as source of silicon) and grinding the product (clinker), with a source of sulfate (most commonly gypsum). The resulting powder, when mixed with water, will become a hydrated solid over time. The cement was first manufactured in Britain in the early part of the 19th century, and its name is derived from its similarity to Portland Stone, a type of building stone that was quarried on the Isle of Portland in Dorset, England. The patent for Portland cement was issued to Joseph Aspdin, a British bricklayer, in 1824 (Portland Cement, n.d.).

Sand

Sand is often a principal component of the aggregate used in the preparation of concrete. Sand manufactured at rock crusher plants for use as an aggregate is called man sand. Graded sand is used as an abrasive in sandblasting and is also used in media filters for filtering water (Matthews, 2006).

Abaca fiber

The plant resembles the fruiting banana, but is a bit shorter in stature, bears small inedible fruits, and has leaves that stand more erect than those of the banana, and that are slightly narrower, more pointed, and 5–7 ft (1.5–2 m) long. The plant was domesticated long ago in the southern Philippines. Abaca prefers a warm climate with year-round rainfall, high humidity, and absence of strong winds. Soils must always be moist, but the plant does not tolerate water logging. Abaca grows best on alluvial soils in the southern Philippines and northern Borneo below 1500 ft (450 m) elevation. The plant is best propagated by rootstalk suckers. There are about 75 varieties grown in the Philippines, grouped into seven categories, each of which varies slightly in height, length, quality, and yield of fiber. The fiber ranges 6–14 ft (1.8–4.2 m) in strand length, is lustrous, and varies from white to dull yellow. As one of the longest and strongest plant fibers, resistant to fresh and salt water, abaca is favored for marine hawsers and other high-strength ropes. Abaca is also used in sackings, matting, strong papers, and handicraft art goods (Fibers of Abaca, n.d.).

THEORETICAL FRAMEWORK

Rule of mixture is primarily the design of composites materials which emphasizes volume fractions of the constituents (Tobias, 1990). Mixing proportions considered in this study were 9:1 ratio (90% sand and 10%

abaca fiber), 8:2 ratio (80% sand and 20% abaca fiber), and 7:3 ratio (70% sand and 30% abaca fiber) with constant water-cement ratio. Frogged brick composites stipulate a major constituent of a particulate type. In this case, micro-mechanics analysis was used to stipulate the theoretical aspect of the development of the material. In retrospect, the sand-cement composite falls under concrete technology in particular mortar/grout mixture. In such case, only consolidation of the mixture becomes a paramount consideration for practical consideration.

METHODOLOGY

Both basic and applied types of research were undertaken in this study. The development of this type of bricks integrated the optimized proportions that have been achieved through experimental fabrication. It is based on the theoretical framework that uses the rule of mixture associated with fiber and matrix densities and their volume fractions (Tobias, Remoto, & Flores, 2010). Figure 1 represents the frogged brick specification, which dictates the type and size of the brick molder. This has gone to a process of concurrent engineering practice (Mott, 2004) undergoing conceptualization, technical interpretation, and fabrication (Figure 2).

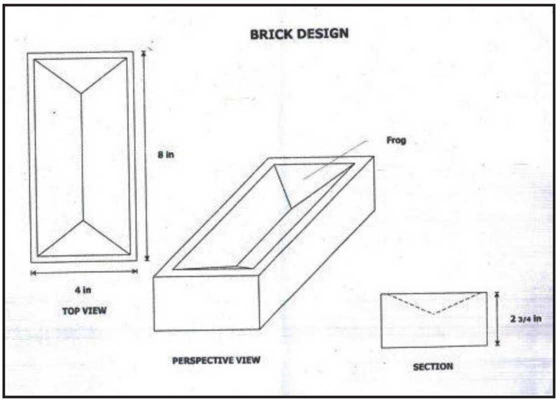

Figure 1. Frogged brick specification

Figure 2: Frogged

Figure 3. Frogged fabricating rig bricks with & without abaca fibers

Using the fabricating rig, frogged bricks (Figure 3) were produced as the desired outcome in this study, following the design and development of composite materials. Experimental analysis is paramount to the variation of the constituent proportion. Four bricks were produced using the brick molding machine shown in Figure 2.

In line with consistency of frogged brick fabrication, it is essential to follow its general procedure as follows: Sift the sand to separate the big particles from the small/fine ones. Cut the abaca fiber into small parts preferably 1 or 2 cm in length. Fill in the wooden box with the desired amount of sand. Also use the wooden box to fill the desired amount of cement. Mix the sand and cement properly by using a flat trowel or shovel. Sprinkle the desired amount of abaca fiber. Pour the desired amount of water. By using a shovel or flat trowel, mix the sand, cement, abaca fiber and water thoroughly. Place a small piece of plywood on the molder. The plywood will serve as a support for the brick. Pour the composite material to the molder. Turn on the machine. Press the Steel plates and lock the knot. Remove the bricks from the machine and let it dry for hours. After an hour or two, slowly remove the plywood from the base of the brick. Do a compression test after four days using a Universal Testing Machine (UTM).

RESULTS AND DISCUSSION

After four days, the 202mm x 100mm x 70mm brick samples have been developed under atmospheric condition. Table 1 shows experimental results under varying constituents proportions. In the first three samples, the water and cement content were the same; only the sand and abaca fiber were variable components. Meanwhile, the 4th and 5th samples vary with the first three experiments; instead of three cups of water, four cups were added. Also, the 5th sample has longer abaca fiber.

Table 1 Constituents proportions

Materials	No. 1	No. 2	No. 3	No. 4	No. 5*
Cement	1½	1½	1½	1½	1½
Sand	90%	80%	70%	90%	90%
Abaca Fiber	10% 3inch	20 % 3inch	30% 3inch	10% 4inch	10% 5inch
Water	3 cups	3 cups	3 cups	4 cups	4 cups

The fabricated bricks with length 202mm, width of 100mm, and thickness of 70mm were tested in compression using the UTM. Table 2 shows that among the three samples of the same cement and water composition this product had the highest strength with 3.61 MPa, followed by 1.72 MPa (3rd sample) with the ratio of 1½ cement, 90% sand, and 30% abaca fiber with three cups of water and the last is 1.65 (2nd sample) with ratio of 1½ cement, 90% sand, and 20% abaca fiber with three cups of water.

The second set of the experiment was with the ratio of 1½ cement, 90% sand, and 10% abaca fiber with four cups of water but with different abaca fiber length. The fourth sample is stronger than the fifth sample with the strength of 6.44MPa compared to the fifth sample with strength of 4.42MPa. Both experiment had the same ratio of cement, sand, and water except the length of abaca fiber. Experiment 5 had longer fiber but exhibited lower strength. Basing on the test results, the fourth sample exhibited better quality than the fifth sample. The fourth sample was more compact compared to the fifth. It has also been observed that the longer the fiber length, the more difficult it is to fabricate the material. Among the five experiments, sample 4 exhibits the highest strength while sustaining a maximum load of 129.988kN. Furthermore, the water-cement ratio made a difference in the quality.

Table 2 Compression test results

Sample No.	Maximum Load (kN)	Strength (MPa)
1	72.85	3.61
2	33.294	1.65
3	34.711	1.72
4	129.99	6.44
5	89.256	4.42

As observed, the fabrication of short abaca fiber consolidated frigged brick composites encountered some problem. It was a labor intensive exercise. Moreover, during the mixing process, balling of fibers was inevitable, when done at longer period.

However, frogged bricks have been successfully used as walls and partitions (Figure 4).

Figure 4. Frogged bricks showcased in building industry as external walls

CONCLUSIONS

Among the five samples of bricks that was fabricated, sample 4 possesses the best property among other experiments. The brick's formulated ratio was 1½ parts cement, 90% sand, 10% abaca fiber, and four cups of water. Based on compression test, the brick can sustain a maximum load of 129.998 kN and strength 6.435 MPa. Hence, the proportion identical to 90% sand, 10% abaca in appropriate water-cement ratio was found to be most reasonable for the frogged bricks. Problems in fiber preparation and mixing of constituent can be overcome at a given time.

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