PROPERTIES OF CEMENT BLOCKS CONTAINING HIGH CONTENT OF OIL PALM EMPTY FRUIT BUNCHES (EFB) FIBRES

Roslan Kolop, Haziman W. I.M, J. W. Eng
Faculty of Civil & Environmental Engineering, Universiti Tun Hussein Onn Malaysia

ABSTRACT: Natural fibres reinforced cement-based materials have gain increasing application in residential housing components. One of the natural fibres considered is oil palm empty fruit bunches (EFB) fibres which offer advantages such as availability, renewability, low cost and the established technology to extract the fibres. This study investigates the properties of cement block incorporated with large amount of oil palm EFB fibres. The blocks were mixed with 10 to 30% oil palm EFB fibres based on cement weight into the block. A total of 60 block samples of dimensions 100mm x 200mm x 400 mm were manufactured in this study using a high density operated block making machine with a cement-sand ratio of 1:6. Among the tests conducted was compressive strength, density, water absorption, drying shrinkage and prism tests. It was found that high EFB fibres content lead to lower strength, higher absorption and drying shrinkage. The results also indicate that high EFB fibres contents reduced the self-weight of the blocks and the resulting blocks can be classified as lightweight cement blocks suitable to be used as lightweight walling materials.

KEYWORDS: Cement blocks, compressive strength, lightweight blocks, oil palm empty fruit bunches fibres(EFB).

1. INTRODUCTION

The use of natural fibres to reinforce brittle building material can be traced back to Egyptian times when straws or horsehair were added to mud bricks. Aziz et. al (1984) reported that coconut coir, sisal, sugarcane bagasse, bamboo, jute and wood cement composites had already been investigated in more than 40 countries world-wide. In Malaysia, where oil palm cultivation has reached a staggering 3 million hectares and producing over 8 million tones of oil annually, oil palm industries has left a huge amount of lignocellulosic materials residues mainly in the form of fibres that can be readily turned into useful value added products. Oil palm fibre whether from trunk or empty fruit bunch (EFB) is a unique reinforcing material as it is non-hazardous, renewable, and readily available at relatively low cost due to established technology to extract the fibres compared to other commercially available fibres. To date only a small percentage of these residues are turned into useful products and the rest is either left to rot or worst, burnt and polluting the environment.

A research programme was therefore initiated to investigate some possible uses of oil palm EFB fibre cement composite for housing application. According to ACI 544.1R-82 fibre reinforced concrete is defined as a concrete made of hydraulic cements containing fine or fine or fine and coarse aggregate and discontinuous discrete fibres. The fibres can be made from natural material or manufactured product such as glass, steel, carbon and polymer. The major reason to incorporate fibres into the cement matrix is to provide some reinforcement for the concrete products and increase the tensile strength by delaying the growth of cracks, and to increase the toughness by transmitting stress across a cracked section so that much larger deformation is possible beyond the peak stress than without fibre reinforcement. Addition of fibre in concrete has also other advantages such increased fracture toughness, modify properties of elastic modulus and reducing density. Research has shown that the beneficial effect of fibres in concrete is at low fibre content of 1% to 3%. Higher fibre content use in concete is not plausible since it will cause ‘balling’ during mixing and hence will adversely affect the properties of concrete products.

One of the possible housing applications for oil palm EFB fibre is in cement masonry blocks. Chai(1986) has noted that among the various walling materials including reinforced concrete, clay bricks and treated timber, concrete hollow blocks appear to have the lowest cost yet still attains accepted quality for low cost housing. Cement block masonry may be reasonably strong in compression but relatively weak in tension. Improper handling of cement block masonry during transportation or slight movement of a cement block masonry building due to various reasons can easily crack this brittle material. Earlier research by Stephens(1994) on natural fibre reinforced concrete blocks as shown that addition of sugarcane bagasse fibre around 1% fibre volume can increase the compression and tensile strength of the concrete block slightly. Using 3% fibre volume will enhanced the impact resistance of the concrete block.

Thus, the aim of this study was to investigate whether the inclusion of high content of oil palm EFB fibre could enhanced the properties of cement block.

EXPERIMENTAL PROGRAMME

2.1 Materials

The oil palm empty fruit bunch (EFB) fiber strands was supply by Sabutek Sdn. Bhd., Teluk Intan, Perak, Malaysia. The fibres were copped to an approximate length of 10 -15 mm to minimize entanglement during mixing. Portland cement manufactured and conformed to MS 522: Part 1: 1989 with specific gravity of 3.15 was used as binder. The fine aggregate (sand) consists of clean river sand with fineness modulus of between 2.0 to 3.5 and the maximum size particle was 4.25 mm.

2.2 Block Specimen and Mix Proportion

The manufactured block size used in this investigation was 100 x 200 x 400 mm. The blocks were manufactured using High Density Hand Operated Block Making Machine with double vibrator systems powered by two 1.5 HP electrical motors producing a vibration of 6000Hz. A rotating mechanical mixer was used to mix the oil palm EFB fibres, sand, cement and water. Four different specimens of cement blocks were prepared. These specimens differ from one another by EFB fibres content in their mixes. The mixes was prepared by volume due to the fibres light weight and density. The control mix used was an economical proportion of 1:6:0 (cement:sand:fibres) which was capable of reaching a minimum load bearing strength using the machine.

Table 2.1 Mix proportion

Mix proportions/Ratios	Percentage of fibre by cement weight (%)
1:6:0	0
1:6:0.1	10
1:6:0.2	20
1:6:0.3	30

2.3 Method of Production

To manufacture the blocks, a very dry-zero slump mix was used so that the block didn't slump after demoulding. One of the advantage of using zero slump mix is that fibres can be added to whatever volume fraction percentage without causing 'balling' that usually plague normal concrete mixture.

Slump test was carried out to find the water/cement ratio that produces zero slump. This water/cement ratio would be used to produce the blocks during mass production. It was found that the suitable zero slump water/cement ratio range between 0.45 to 0.65. A ratio of water/cement ratio of 0.55 was used throughout the production. Sand, cement and fibres were mixed first so that the fibres were evenly distributed before water was added. Prior to mixing, the fibres were dipped in water for thirty minutes to saturate it and prevent the fibres from absorbing the water used in the mix. The fresh mix was manually poured inside the mould mounted on the vibrating table of the machine and vibrated for two minutes. After demoulding, the green block was transported to a curing area where it was air-cured for 28 days as shown in Figure1.

Figure 1: Air-cured EFB fibre cement block

2.4 Laboratory tests

The tests included in this investigation were water absorption, density, compression strength, shrinkage and prism tests. Test procedures for water absorption and compression strength were carried out in accordance with ASTM C140. Density classification was based on ASTM C90 and prism test procedure was based on ASTM E447.

3. RESULTS AND ANALYSIS

3.1 Absorption

Absorption measures the unit's total capacity to absorb moisture. Figure 2 shows the effect of percentage content of EFB fiber in blocks on water absorption after the blocks were immersed in the water for 24 hours. It can be seen that the block absorption of EFB fibres cement block increased as the fibre content were increased. This is because the present of dried fibres and voids inside the block has the tendency to absorb water during immersion of the block. Overall water absorption of the blocks was higher than specified by ASTMC90 for load bearing block.

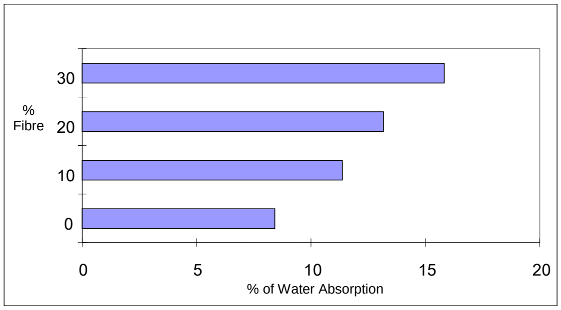

Figure 2: Relationship between the % EFB fibers and water absorption

3.2 Block Density

The density of concrete blocks is largely a function of the aggregate density, size and grading, degree of compaction and vibration rate, and also the density of EFB fiber. Generally, block with higher density gives better compressive strength. However, lower density block is easier to be transported and handled during construction. Figure 3 shows that the block density decreases as the content of fibres increases. All the blocks with fibre content of 10%, 20% and 30% were found to have a density below 1680 kg/m^3 which is categorized by ASTM C90 as lightweight concrete blocks.

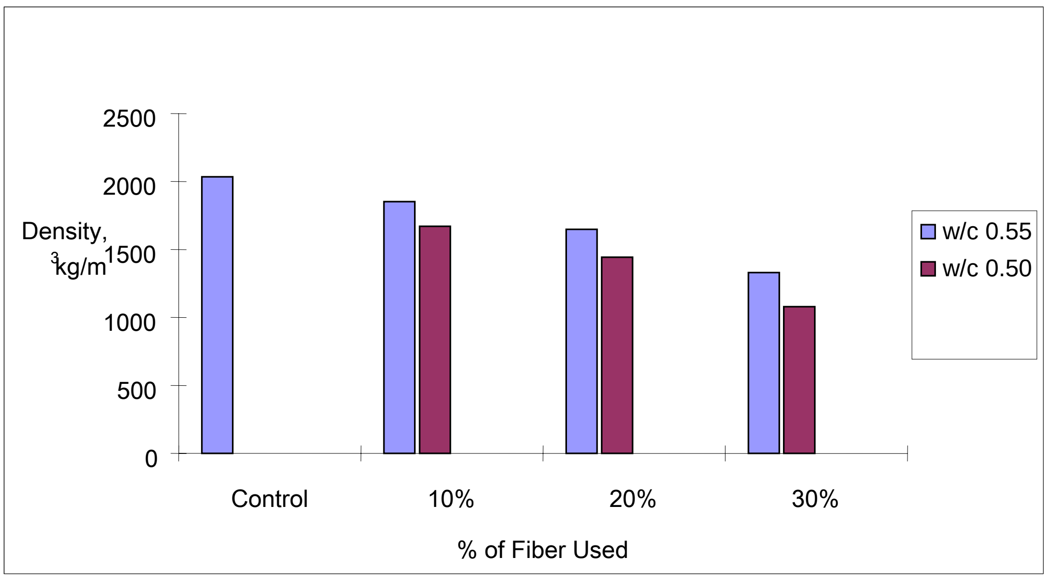

Figure 3: Relationship between the EFB fibre block and density

3.3 Dry Shrinkage

Similar to other cement products, concrete masonry units shrink with time. Control of shrinkage is important especially in long wall to prevent cracking. The most common shrinkage in green concrete masonry is termed as drying shrinkage. This shortening of unit is contributed by the hydration process of the cement paste which shrinks over time

Cement block walls are usually rendered and the major consequence of any shrinkage of the blocks is the possibility of cracks being induced in the rendering. However, a period of at least 28 days, but usually longer, elapses from the date of manufacture of the blocks to the time of rendering. It is therefore necessary to decide whether or not any significant shrinkage of cement blocks occurs after 28 days. Figure 4 shows the drying shrinkage of blocks which stabilized after 10 days of curing. Provided the blocks are used after 30 days of curing, no adverse effect form the unit's shrinkage is expected.

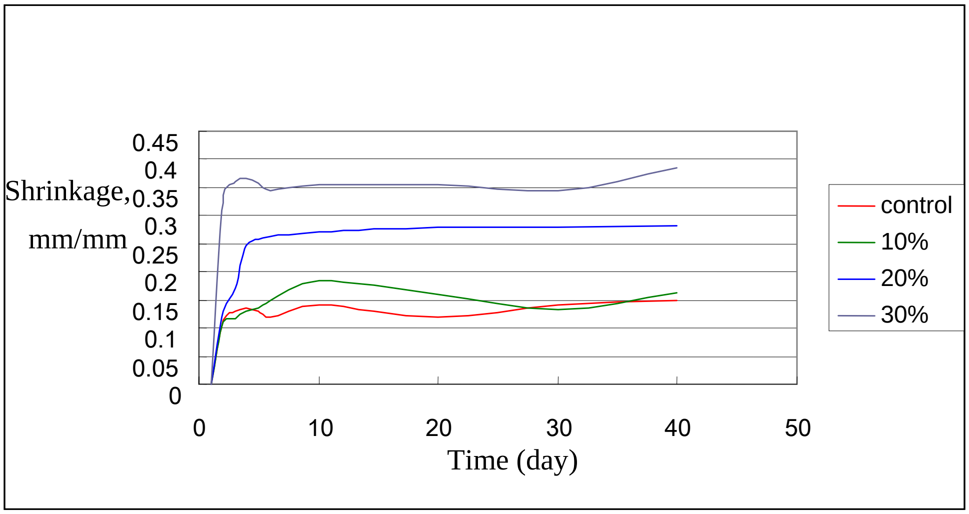

Figure 4: Shrinkage of EFB fibre blocks versus time

3.4 Compressive Strength

Table 2 shows the average strength of blocks at 28 days. It can be seen from the table that high fibre content in the block decrease the strength of the EFB fibre blocks to more than 50% compared to the control specimens. A similar finding from Augustine and Stephens (2005) has shown that higher sisal fibre volume reduces the compressive strength of concrete. The reduction is compressive strength is not surprising since the fibers themselves cannot resist axial compressive load and as such do not contribute to the compressive strength of blocks. Furthermore, it is difficult to compact higher EFB fibre content mix resulting in the increase of voids in the blocks.

Table 2: Compressive Strength of EFB Fibres Blocks

Weight of fibre content to cement (%)	Average compressive at 28 days (N/mm^2)
0	7.2
10	2.3
20	1.1
30	0.9

3.5 Prism Test

The objective of this test was to understand the stress-strain behaviour, cracking and failure modes of the EFB fibres block assembly. The mortar strength used was 6.62 N/mm^2. The deformation of the prisms was measured using a transducer which was connected to a data logger. Figure 5 shows the stress-strain relationships of the blocks. It can be seen that the control block prism has a well defined linear portion on the graph which did not exist in the EFB fibre block prism. The EFB fibre block prisms seem to exhibit elastoplastic behaviour. Abrupt failure can be seen on the control block prisms but in the case of EFB fibre prism it continued to deform plastically after yield.

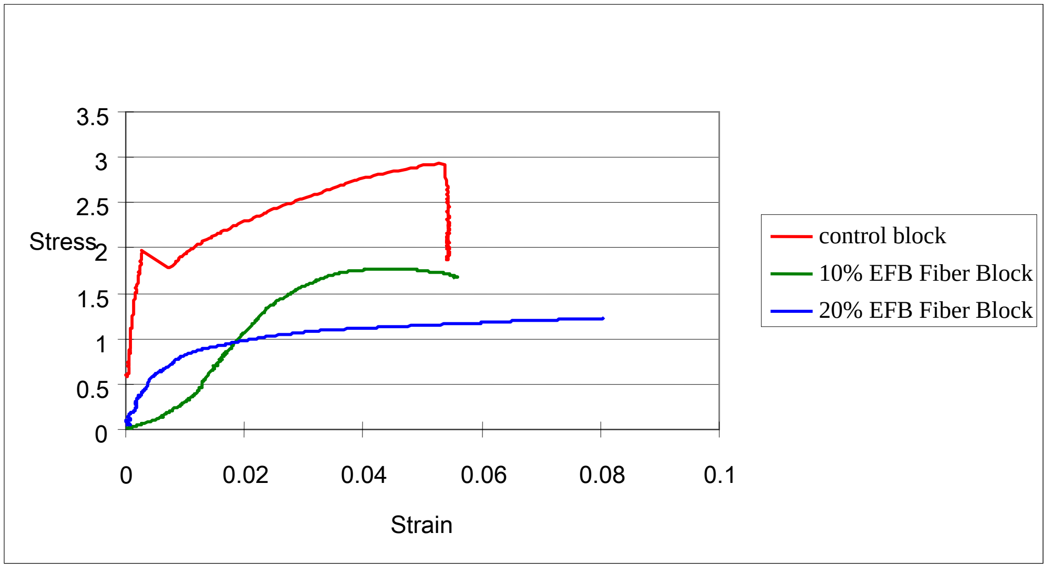

Figure 5: Stress-strain relationship of EFB fibres cement block prism

The difference in the stress-strain properties resulted in the difference mode of failure of the prisms. Figure 6 shows the failure characteristics of control block which failed by vertical crack typical to any concrete masonry prism. However, Figure 7 shows the typical failure of EFB fibre prisms which exhibit crushing failure shown by the bulging of the block without obvious cracking on the prism face.

Figure 6: Vertical splitting Failure Of Control Cement Block Prism

Figure 7: Bulging Failure of EFB fibre cement Block Prism.

4.0 Conclusion

The following conclusion can be made from the experimental investigation of cement block reinforced with oil palm EFB fibre that:

1. The incorporation of oil palm EFB fibre in cement block more than 10% of the cement weight using the mixture 1:6 (sand:cement) can produce block density less than 1680kg/m^3 which is considered as light weight blocks.

2. The increase in the use of EFB fibre in the block tend to increase water absorption of the block.
3. The EFB fibre block shrinkage stabilized after 10 days of curing. Usage of the block after 28 days will not cause shrinkage problem.
4. Incorporating high content of oil palm EFB fibre in cement blocks resulted in the reduction of more than 50% of the control block strength
5. Prism test of the EFB fibre reinforced block assembly shown an altered mode of failure. High content of fibre shown elastoplastic characteristics with very high ductility.

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