Toughness Characteristics of *Arenga pinnata* Fibre Concrete

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As a result, there exists today a wide range of fibre types available for use as fibres in concrete. These include steel, asbestos, glass, ceramic, polymer, and natural fibres such as hemp, sisal, cotton, coconut, and palm. Many research works have been carried out using steel, polymer and glass (Marikunte et al. 1997, Trottier and Banthia 1994, Zheng and Feldman 1993). However, investigations on the use of natural fibre are rather limited (Stephens 1994, Yao and Li 2003).

Principally, the sources of natural fibre are found in several plants, but not are all suitable for use as fibres in concrete. The advantage of using natural fibres is that it is readily available, environmental friendly, and cheap since there is no production cost incurred. The major problems associated with the use of natural fibres are due to poor durability, low modulus of elasticity, poor bonding, high water-absorption, and poor fire resistance. Natural fibres have been used in soil cement construction (Ghavami et al. 1999) but its application (Stephens 1994, Yao and Li, 2003) is mainly in non-structural components such as, roofing tiles, concrete masonry blocks, slab for roofing, and construction of water tanks.

The addition of fibres in concrete is also expected to improve its tensile strength, toughness and ductility. The fibres will also function as a bridge across cracks and help control its propagation (Banthia and Trottier 1995, Banthia and Yan 2000). This study is concerned with the toughness characteristics of concrete containing *Arenga pinnata* fibre as reinforcement. The basic difference between plain concrete and fibre reinforced concrete is in their toughness performance (Houssam and Gomez 1997). Toughness relates to the property of the concrete to sustain load after occurrence of the first-crack. A number of investigations on toughness characteristics of fibre reinforced concrete in the past (Ozyildirim et al. 1997, Gao et al. 1997, Trottier and Banthia 1994) were focused mainly on the fibre type, fibre volume, fibre length, fibre geometry, and matrix strength. Generally, the results show that the fibres provide the concrete with increased toughness.

The effect of fibres in concrete depends on two important parameters, namely fibre fraction volume and aspect ratio. Fibre fraction volume is the amount of fibres added to a concrete mix expressed as a percentage of the total volume of the composite. Aspect ratio is calculated by dividing the fibre length by its diameter. The performance of fibre concrete also depends on the matrix mix ingredients (Marikunte et al. 1997). The matrix strength has a significant influence on the toughness characteristics (Trottier and Banthia 1994). The matrix strength depends on the geometry, type, volume fraction of fibre, and bond strength of fibre in the matrix.

The addition of fibres to a concrete mix causes a reduction in the workability, normally indicated by low slump value. Fibres have relatively large surface area and as a result the water requirement for a given workability is much higher. This problem can be overcome by the use of water-reducing admixture or superplasticizer (Marikunte et al. 1997) in the concrete mix. The physical properties of the fibre which influence workability are the aspect ratio and the volume percent of fibre. In general, an aspect ratio of less than 100 and fibre content not higher from 2% is the maximum limit to obtain a mix with good workability (Berg 1993). Higher fibre content leads to reduce workability and longer mixing time. As the fibres are added to the fresh concrete mix manually in the mixer, the dispersion is not uniform and may result in ‘balling.’ Fibre dispersion in the wet mix is also an important factor to toughness of the concrete.

EXPERIMENTAL WORK

Material

Locally produced ordinary Portland cement (OPC) equivalent to ASTM Type 1 was used. The coarse aggregate was crushed granite ranging between 4.75 mm to 19 mm in size. The fine aggregate was siliceous sand and consists of the combination of particle size according to ASTM sieve sizes, namely coarse (8-16 mesh), medium (20-40 mesh), and fine (40-60 mesh). A sulphonated naphthalene formaldehyde based superplasticizer with 40% solids dosage was added to the mix to give the required workability at a constant water/cement ratio of 0.4. Mixing and curing water was taken directly from tap supply. The fibres used were obtained from the trunk of the *Arenga pinnata* or commonly known as the black sugar palm and illustrated in Figure 1. The physical andmechanical properties of the *Arenga pinnata* fibres are given in Table 1. A total of seven mixes which include the plain concrete mix which acts as the control and six fibre concrete mixes with fibre lengths of 15 mm, 25 mm and 35 mm in two volume fractions of 0.6% and 0.8% were produced. Table 2 presents the mix proportions used in the investigation.

Specimen Preparation

For each mix, twelve prisms measuring 100 _ 100 _ 500 mm^3 were cast for the toughness test. Mixing of the ingredients was carried out us-

FIGURE 1. Arenga pinnata tree

ing a pan mixer and the same mixing procedure was adopted for all the mixes. The sequence of mixing can be summarized as follows; aggregates and cement were mixed dry for approximately 1 1/2 minutes, then three quarters of the mixing water was added, followed by the superplasticizer and finally the remaining water. In the case of the fibre concrete, the fibres were added to the wet mix gradually in small amounts to avoid from clustering. The dosage of superplasticizer used varied between mixes so as to obtain a slump within 70 mm ± 10 mm. The slump test was performed immediately upon discharging. The fresh concrete was then filled into moulds in three layers and each layer was compacted using a vibrating table. The specimens were demoulded after 24 hours and subjected to full water curing in a tank until testing at the specified ages.

Test Procedure

The workability of fresh concrete was measured using the slump cone. The toughness of the concrete prisms was determined in accordance with ASTM C 1018-94b at 7, 28, 56, and 90 days. The toughness test was conducted using a Tritest Digital Machine with a 50 kN load cell attached. The prism specimen was subjected to third-point loading at a constant rate of travel of 0.05 mm/min to establish the first-crack load and post-cracking behaviour from the load-deflection plot during

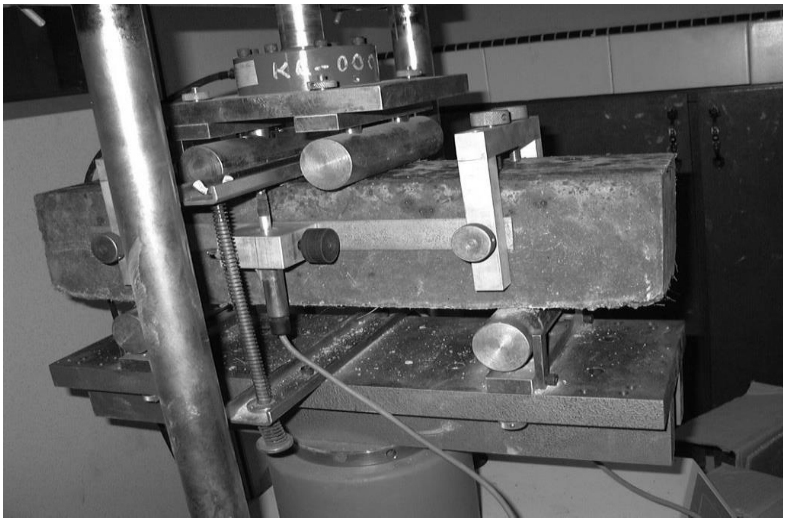

FIGURE 2. Flexural toughness test setup

the test. Two 5 mm displacement transducers were mounted at midspan on both sides of the prism by means of a rectangular jig to record the deflections, as shown in Figure 2. The mid-span deflections and loads were recorded using a portable PC-based data acquisition system which enabled a real time plot of the load and deflection values to be viewed and stored in the computer.

Full text availabe at :

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