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Flexural characteristics of lightweight ferrocement beams with various types of core materials and mesh reinforcement

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HIGHLIGHTS

- The main objective is to studying the flexural behaviour of ferrocement beams with lightweight cores and types of mesh reinforcement.
- Cores were made of autoclaved aerated lightweight brick, extruded foam, and lightweight concrete cores; and are reinforced with expanded metal mesh, welded wire mesh and fibre glass mesh.
- Flexural behaviour including first crack loads and deflections, ultimate loads and deflections, ductility index, strain characteristics, crack pattern and failure mode were investigated.
- Effect of different types of core materials and mesh reinforcement on the flexural behaviour of studied beams was investigated.
- Ferrocement beams of light weight cores may be promising as an alternative to conventional beams especially for low cost residential buildings.

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ABSTRACT

Sixteen reinforced concrete beams having the cross-sectional dimensions of 100 × 200 × 2000 mm and clear span of 1800 mm were cast and tested until failure under a single mid-span concentrated load. Ferrocement beams in this research contained either an Autoclaved Aerated lightweight brick Core (AAC), Extruded Foam Core (EFC), or a Lightweight Concrete Core (LWC); and were reinforced with either Expanded Metal Mesh (EMM), Welded Wire Mesh (WWM) or Fibre Glass Mesh (FGM). Structural behaviour of studied beams, including first crack, ultimate load, deflection, ductility index, strain characteristics, crack pattern and failure mode were investigated. Experimental work results showed that ferrocement beams exhibited higher ductility indices than those of the control normal and lightweight test beams to different degrees. Ferrocement beams made of EFC core generally gave the lowest ductility index while the highest ductility index was found for beams made of AAC and LWC cores. Ferrocement beams demonstrated better crack control and did not undergo spalling as opposed to the conventional beams. Specimens reinforced by EMM showed better ductility than those reinforced by WWM and even after increasing the reinforcement ratio of WWM, the situation did not change. Specimens reinforced by FGM had the lowest ductility compared to specimens reinforced by steel mesh. Cracks were found to develop more rapidly in beams reinforced by EMM, while beams reinforced by FGM exhibited the least amount of cracks. The results of this research showed that ferrocement beams of light weight cores may be promising as an alternative to conventional beams and may be viable alternatives especially for low cost residential buildings.

1. Introduction

Cementitious composites including ferrocement are considered as construction materials with the potential of meeting the increasing demand for high performing, economical, sustainable and complex structures. The production and application of

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cement-based composites is environment friendly as it consumes less embodied energy, making these materials one of the preferred sustainable construction alternatives. Various investigations into the physical and mechanical properties of ferrocement shows that it has excellent strength properties, crack control, impact resistance and toughness which gives it an advantage over other thin construction materials [1–8]. This was attributed to the close spacing and uniform distribution of reinforcement within the material. The short steel fibres added to ferrocement improve its cracking and stress-strain behaviour thereby making ferrocement a superior construction material [9]. Ferrocement affords the opportunity of producing relatively light prefabricated structural elements which can be made into interesting architectural forms for low cost housing. Ferrocement as a construction material has been used in silos, roofs, tanks and also in the construction and repair of reinforced concrete structures [10–12]. As an alternative to the conventional steel and wooden formwork, ferrocement laminates have also been utilized as permanent forms which eventually remain as part of structural elements such as beams and slabs as it is more cost-effective [13–16]. Ferrocement permanent formwork was found to offer great potential for speedy construction and material maximization at minimal cost, especially in curved structures. It also gives an advantage of reducing the required tensile reinforcement in beams and slabs as it incorporates steel meshes which contributes to the tensile capacity of the structural elements [17–19]. The effect of steel mesh type and the number of steel mesh layers on the performance of the beams of U-shaped ferrocement formwork was investigated [19]. Results showed that these beams gave better performance in terms of high ultimate and serviceability loads, enhanced crack control, high ductility and improved energy absorption. Similar results were reported by Shaheen and Eltehawy [8] who investigated the effectiveness of U-shaped ferrocement forms reinforced with different types of reinforcement for the construction of reinforced concrete slabs.

Desayi and El-Kholy [20] studied the stress-strain characteristics of lightweight fibre reinforced ferrocement specimens in uniaxial tension. The study reported that due to fibre inclusion in the ferrocement specimens, failure was by a single major crack developed which indicates the fibre reinforced ferrocement tension members behave as if they are made of an 'homogenous' material as opposed to the behaviour of specimens made with ferrocement only. Studies conducted by El-Wafa and Fukuzawa [21], on the effect of wire mesh reinforcement on the tensile behaviour of ferrocement composite plates shows improvement in the service and ultimate tensile crack behaviour of the composite plates with failure occurring after sufficient warning. El-Wafa and Fukuzawa [22] investigated the characteristics of ferrocement thin composite elements with stainless steel and E-fiberglass meshes under flexure. Their variables were the effect of mesh type, number of mesh layers, mesh wires diameters with opening size and type of mortar material. They reported that stainless steel meshes resulted in improved bending behaviour as their crack pattern was in the form

Table 1
Details of specimens.

Group	Specimens Designation	Specimen's Core Configuration	Reinforcement details				
			Tension Steel bars	Compression Steel bars	Links	No. of Layers	Type of Mesh
A	A1	. . ..	2 φ 12	2 φ 10	φ 6 @ 150 mm		. . ..
	A2	. . ..	2 φ 12	2 φ 10	φ 6 @ 150 mm		. . ..
	B1	AAC	2 φ 12	2 φ 10	. . ..	1	Expanded Metal Mesh (EMM)
B	B2	AAC	2 φ 12	2 φ 10	. . ..	2	Expanded Metal Mesh (EMM)
	B3	AAC	2 φ 12	2 φ 10	. . ..	2	Welded Wire Mesh (WWM
	B4	AAC	2 φ 12	2 φ 10	. . ..	4	Welded Wire Mesh (WWM)
	G1	EFC	2 φ 12	2 φ 10	. . ..	1	Expanded Steel Mesh (EMM)
	G2	EFC	2 φ 12	2 φ 10	. . ..	2	Expanded Steel Mesh (EMM)
G	G3	EFC	2 φ 12	2 φ 10	. . ..	2	Welded Wire Mesh (WWM)
	G4	EFC	2 φ 12	2 φ 10	. . ..	4	Welded Wire Mesh (WWM)
	F1	LWC	2 φ 12	2 φ 10	. . ..	1	Expanded Steel Mesh (EMM)
	F2	LWC	2 φ 12	2 φ 10	. . ..	2	Expanded Steel Mesh (EMM)
F	F3	LWC	2 φ 12	2 φ 10	. . ..	2	Welded Wire Mesh (WWM)
	F4	LWC	2 φ 12	2 φ 10	. . ..	4	Welded Wire Mesh (WWM)
	F5	LWC	2 φ 12	2 φ 10	. . ..	3	Fibre Glass Mesh (FGM)
	F6	LWC	2 φ 12	2 φ 10	. . ..	6	Fibre Glass Mesh (FGM)

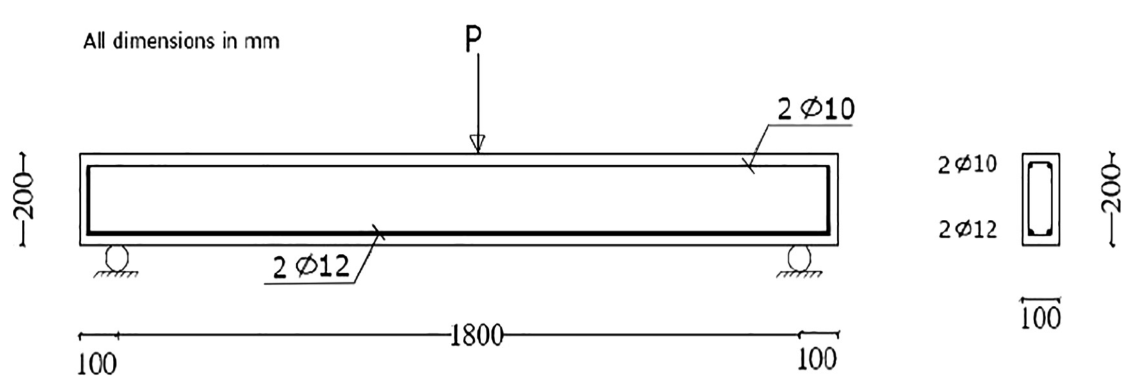

Fig. 1. Test specimens' dimensions.