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Characterization of ferrocement slab panels containing lightweight expanded clay aggregate using digital image correlation technique

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HIGHLIGHTS

- DIC technique is used for the first time on leca-contained ferrocement slab panels.
- Effect of mesh volume fraction and leca on mechanical properties of ferrocement slab panels is investigated.
- DIC technique can monitor flexural capacity, energy absorption, ductility and crack width.
- Relation of superplasticizer and pore size of leca-contained mortar is evaluated.

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ABSTRACT

Ferrocement slab panels (FSPs) are thin-walled elements with appropriate strength, hardness, durability and lightness. The flexural behavior of FSPs has been investigated in this study. Specifically, 12 FSPs containing three expanded rib lath layers (i.e. one, two and three) and four volume contents of lightweight expanded clay aggregate (leca) (40, 20, 10 and 0 vol%) were constructed and exposed to three-point flexural test. Digital image correlation (DIC) technique as a full-field approach was used for measuring displacements and strains of the FSPs and the results were compared with those obtained from the displacement sensors. The cracking behavior of the FSPs was also evaluated using the DIC technique. The microstructure of the mortar of FSPs was finally investigated using scanning electron microscopy (SEM) imaging along with energy dispersive spectroscopy (EDS) analysis. The DIC results show that as the mesh volume fraction increases, the flexural capacity (about 14–70%), ductility index (about 9–24%), energy absorption (about 16–107%) and number of cracks increase but the length and width of cracks decrease. The DIC results also indicate that incorporating 10% leca leads to the highest increase of energy absorption (about 48%), ductility index (about 26%) and crack width (about 106%) of the FSPs. The results of microstructural analysis show that incorporating super-plasticizer admixture can decrease the total porosity of mixtures (by about 29–79%).

1. Introduction

Ferrocement slab panels (FSPs) are thin-walled elements constructed from cement, sand, water and various types of mesh [1–3]. Their appropriate strength, hardness, durability and lightness made them distinguished from other thin construction materials [3–6]. The effect of different parameters on the properties of FSPs has been studied different researchers. The results of Al-Kubaisy and Jumaat [7] who evaluated the crack behavior of FSPs indicate that using ferrocement can decrease the crack width in the reinforced concrete slabs. Thanoon et al. [8] analyzed the effect of different parameters on the crack pattern, load-deflection behavior and strain distribution on ferrocement-brick composite slabs. The results indicate the satisfactory response of the composite slab to the flexural loading. Furthermore, the study of Hago et al. [1] on the service behavior and ultimate load of FSPs indicates a satisfactory improvement in the corresponding results due to the increase in mesh volume fraction.

Researchers have also studied the utilization of different materials in the construction of FSPs in order to improve the desired characteristics [9–11]. Cheah and Ramli [12] examined the flexural behavior of ferrocement-composite slabs containing high calcium wood ash (HCWA). The results suggest that the use of HCWA leads to the improvement in cracking, serviceability moment and ultimate load capacity. They also studied the effect of HCWA on the

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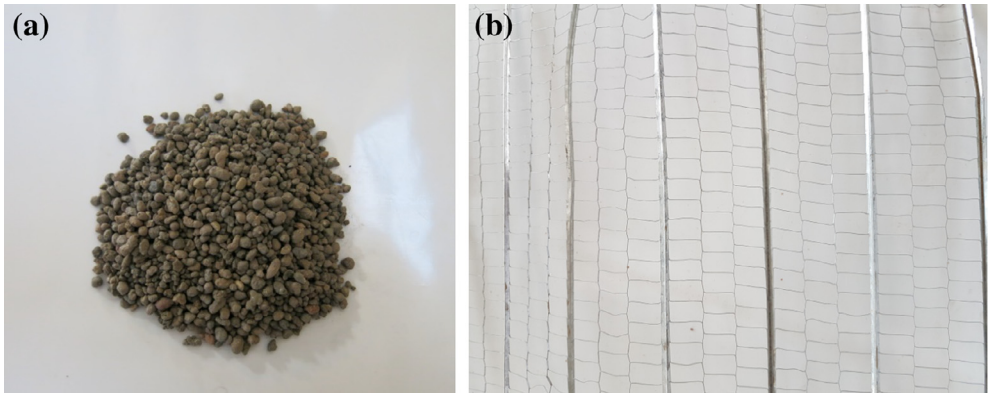

Fig. 1. The components used for producing the specimens: (a) Leca, and (b) Expanded rib lath.

Table 1
Details of mixture design for the FSPs.

Mixture design	Water/Cement	Water (kg)	Sand (kg)	Leca (kg)	Superplasticizer (kg)	Hardened density (kg/m^3)	Weight Reduction (%)
L1	0.5	168	963	278	6.6	1752	21.2
L2	0.5	224	1101	139	5.8	1918	13.7
L3	0.5	252	1238	69	4.4	2069	6.9
L4	0.5	280	1375	0	3.2	2223	–

Table 2
Details of the lightweight FSPs.

Designation	Slab panel thickness (mm)	No. of expanded rib lath layers	Mesh volume fraction	Leca (vol. %)
L1-1	40	1	0.0016	40
L1-2	40	2	0.0032	40
L1-3	40	3	0.0048	40
L2-1	40	1	0.0016	20
L2-2	40	2	0.0032	20
L2-3	40	3	0.0048	20
L3-1	40	1	0.0016	10
L3-2	40	2	0.0032	10
L3-3	40	3	0.0048	10
L4-1	40	1	0.0016	0
L4-2	40	2	0.0032	0
L4-3	40	3	0.0048	0

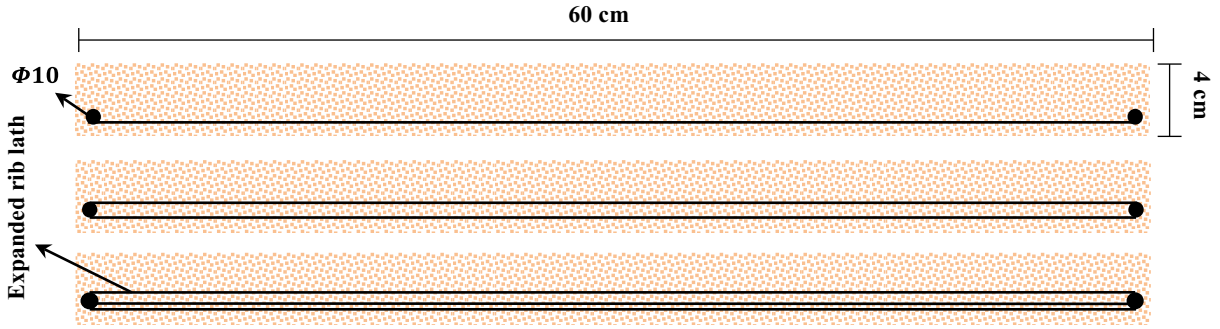

Fig. 2. Cross-sectional view of the FSPs with different number of expanded rib lath layers.

load carrying capacity and cracking behavior of thin FSPs exposed to flexural loading. The results show that the inclusion of HCWA in the mortar of FSPs improves the engineering performance of the slab panels, leading to the technological advancements in the field of sustainable construction materials [13]. Recently, the use of bamboo strips and chicken mesh as the reinforcement of FSPs was investigated by Chithambaram and Kumar [2]. The results of flexural tests illustrate the benefits of these applied materials in enhancing the ductility of such structural elements.

Considering the advantages of lightweight aggregates (LWAs) such as lightweight and thermal and sound insulation [14], the use of expanded perlite LWA in FSPs has been studied by Işıkdağ [15] who evaluated the ultimate capacity and cracking behavior of FSPs. The results indicate that an increase in expanded perlite