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Experimental investigation of ultimate capacity of wired mesh-reinforced cementitious slabs

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ABSTRACT

Experimental tests conducted on 27 square cementitious slabs of 490 × 490 mm simply supported on four edges and subjected to patch load are presented. The slabs had a clear span of 400 × 400 mm and provided with a 445 × 445 mm closed frame of 8 mm diameter steel bar to hold the reinforcement in place and to act as a line support. The test variables were the wire mesh volume fraction: four expanded and two square types; slab thickness: 40, 45, 50 and 60 mm; and the patch load pattern: square and rectangular. The test results showed that as the volume fraction increased the punching strength of the slabs was also increased. Adding a wire mesh to ordinary reinforcement increases significantly the punching resistance at column stub. Moreover, as the loaded area size increases both ductility and stiffness increases and the bridging effect due to the difference in the reinforcement ratio in orthogonal directions was clearly noticed. More research was needed to identify the volume fraction ratio at which the mode of failure alter from flexure to punching.

1. Introduction

Ferrocement is suitable for low-cost roofing, pre-cast units, man-hole covers, etc. It can be used for the construction of domes, vaults, shells, grid surfaces and folded plates. It is a good substitute for timber. It can be used for making furniture, doors and window frames, shutters and partitions. It can also be used for making water tanks, boats and silos. Ferrocement is the best alternative to concrete and steel. The most significant contribution of ferrocement is that most of the structures made of traditional materials can also be constructed in ferrocement [1,2].

Ferrocement has been used effectively for affordable roofing applications around the world hence at first glance it seems a viable solution for rural areas in Egypt. However, it is still not replacing steel and concrete to a large extent in spite of its major advantage over reinforced concrete because many engineers are not convinced about this material yet. Moreover, there are also some professionals who, without a proper study, have said that ferrocement is not a good material. The main reason is that they compare ferrocement to reinforced concrete. To adopt this material in actual Egyptian practice and to enrichment the information and understanding of its behavior, an experimental investigation was performed on cementitious slabs of thickness greater than the common thickness of ferrocement (range 10–25 mm) and reinforced with low cost local steel wire mesh to cover some of its behavioral aspects under patch loading. Since punching shear failure in reinforced concrete slabs subjected to concentrated load is brittle, evaluation of punching shear resistance of cementitious slabs reinforced with wire mesh should also be highlighted. Punching shear has been the object of an intense experimental effort since the 1950s. Punching failure of slabs based on experimental results was addressed by various authors, among others: Menetrey [3], Mansur et al. [4], Naaman et al. [5], and Aurelio Muttoni [6] whereas experimental study of flexural behavior of ferrocement and cementitious composite two way slabs were reported by many investigator among them: El Debs and Naaman [7] and Shannag et al. [8].

Since the punching capacity of cementitious slabs reinforced with wire mesh is the main objective of this study, an experimental investigation on 27 simply supported slabs is reported too. The slabs were tested to failure to investigate the deformation and strength characteristics under patch loading. The slab reinforcement is either expanded steel mesh or a square mesh. Four types of expanded steel mesh (diamond) and two types of square mesh were used. The slabs were square of side length of 490 mm and clear span of 400 mm. The specimens were provided with 8 mm diameter skeletal steel bar as a square closed frame with inner side dimension of 445 mm that should provide line support. Primary variables investigated include also the volume fraction of reinforcement, the slab thickness: 40, 45, 50 and 60 mm; and the centric load pattern: square area of 80 × 80 mm or rectangular area of 55 × 360 mm.

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Table 1
Sieve analysis results for the sand.

Sieve size (mm)	2.36	1.18	0.600	0.300	0.150	0.075
% Passing by weight	100	86.54	61.63	24.77	3.69	0.88
Sand grading [2]	800–100	50–85	25–60	10–30	2–10	N/A

Table 2
Types of mesh reinforcement.

Mesh type	Long-way (mm)	Transverse (mm)	% Volume fraction (h = 40 mm)
Diamond 0.3 mm	17.5	7.5	0.12
Diamond 0.7 mm	22.5	12.5	0.18
Diamond 1.5 mm	37.5	17.5	0.60
Diamond 2.0 mm	22.5	57.5	0.60
Galvanized square 0.63 mm	10	10	0.18
Square 3.0 mm	50	50	0.70
Square 6.0 mm	100	100	1.41

2. Experimental program

The experimental program consists of 27 cementitious slabs. Two of these slabs were the control specimens and made of plain mortar. For the sake of comparison with traditional steel, two cementitious slab specimens reinforced with ∅6 mm steel bars arranged in two orthogonal directions and spaced 100 mm apart were cast. To evaluate the effect of combining traditional steel with wire mesh reinforcement on the punching shear capacity, a diamond wire mesh of diameter 1.5 mm was added to one of those slabs. All slab specimens were tested using a universal testing machine under monotonic loading up to failure. The slabs were square with a side length of 490 mm and thickness of 40–60 mm and were reinforced with a single layer of wire mesh placed at 10 mm from the tension side. They are identified using three abbreviated terms: the first term represents the wire mesh reinforcement type (D for diamond and S for square mesh); the second term represents the type of loading pattern (P for square patch loaded area of 80 × 80 mm with disk height of 20 mm and L for rectangular loaded area of 55 × 360 mm with maximum semi cylinder disk height of 70 mm at center area and, the last term represents the thickness of wire mesh (3.0, or 0.63 mm for square mesh, and 2.0, or 1.50, or 0.7, or 0.30 mm for diamond mesh).

2.1. Materials and mixing proportions

The mortar matrix consisted of ordinary Portland cement complying with ESS 373 [9] and ECCS 203 [10] and sand passing through a No. 7 sieve (2.36 mm), free from any deleterious substances. Grading of the sand was controlled in such a way

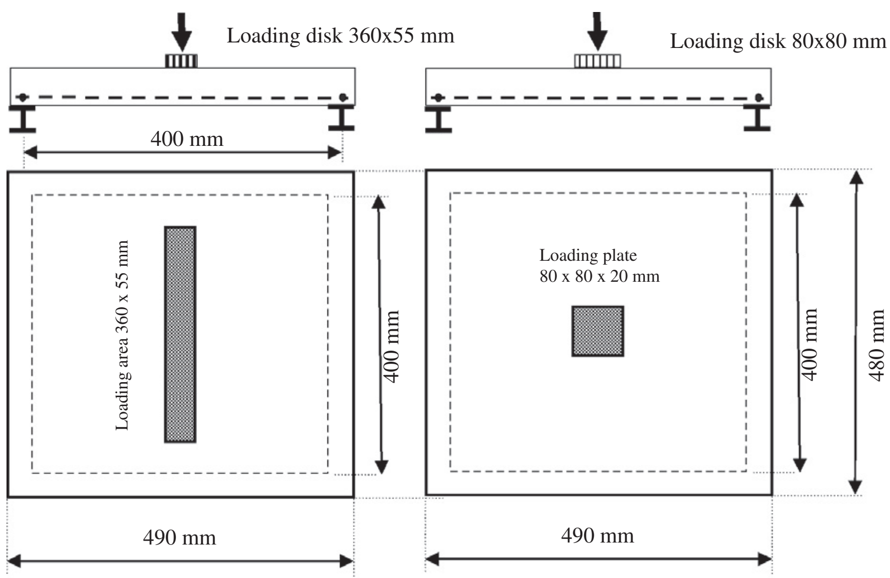

Fig. 1. Set-up for panel test under patch and line loads.

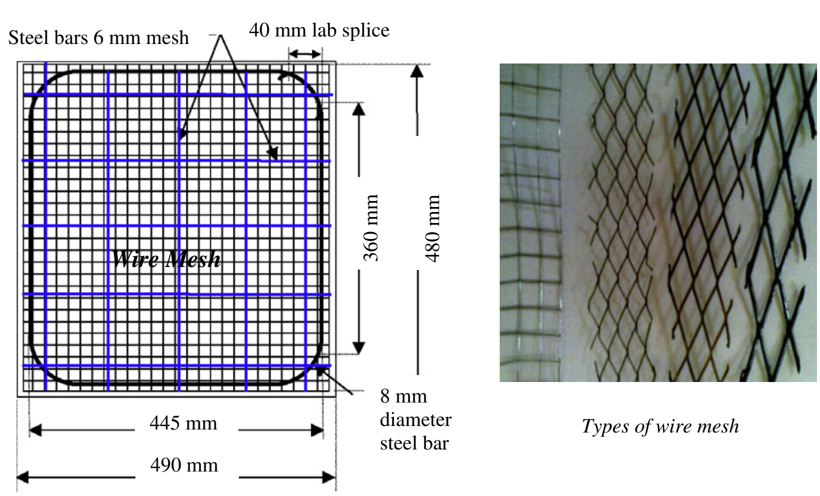

Fig. 2. Alternatives reinforcement details of the cementitious slabs.