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Study on Performance of Prefabricated Ferrocement Slabs

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Abstract:- Prefabrication has been found to be an optimum solution for speedy construction over the years and. Ferrocement is found to be an ideal alternative for RCC considering the cost of construction. Prefabricated Ferrocement elements can be a better solution for low cost housing with speedy construction. This paper studies the performance of prefabricated ferrocement slabs. Ferrocement slabs of size 1m x 1m with 5cm thickness were casted and tested in laboratory and their breaking load capacity was studied. The number of layers of wire mesh was varied in order to compare the test results. The slab with two layer of wire mesh was found to be better compared to slab with one layer of wire mesh.

Keywords:- Ferrocement, Prefabrication, Slabs, Wire-Mesh, Breaking Load Capacity

I. INTRODUCTION

Shelter is one of the basic needs of human being. But most of the population in the world suffer from housing shortages resulting from population growth, internal migration, war, natural disaster, to mention a few. There is an urgent need to explore a building material that is structurally efficient but at the same time, should be lightweight, eco-friendly, cost effective and especially the ones that can perform the desired functions.

Ferrocement is such a material that is slim and slender but at the same time strong and elegant which provides a potential solution to roofing problems. In countries in continuous growth and low resources economic, where the demand of house of low cost is very high, the ferrocement has been used like an effective alternative that, on the one hand, offers durable houses and of good quality, and, on the other hand, it offers a constructive system with base in not described intensive manpower. Prefabrication saves engineering time on the construction site in civil engineering projects. Prefabricated elements and systems offer bridge designers and contractors significant advantages in terms of construction time, safety, environmental impact, constructability, and cost. The use of prefabricated ferrocement components for construction could possibly reduce the cost of construction and time for completion.

A. Ferrocement

In the early 1940s, Pier Luigi Nervi resurrected the original ferrocement concept when he observed that reinforcing concrete with layers of wire mesh produced a material possessing the mechanical characteristics of an approximately homogeneous material and capable of resisting impact [1].

Ferrocement is a building material composed of a relatively thin layer of concrete covering a steel reinforcing material such as wire mesh. Since these materials are widely available and are relatively low in cost, and since the building techniques are simple enough to be done by unskilled labour, ferrocement is as attractive type of construction for many developing countries [3].

B. Prefabrication

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located [2]. Prefabrication techniques are used in the construction of apartment blocks, and housing developments with repeated housing units. The quality of prefabricated housing units had increased to the point that they may not be distinguishable from traditionally built units to those that live in them. Prefabrication saves engineering time on the construction site in civil engineering projects. This can be vital to the success of projects such as bridges and avalanche galleries, where weather conditions may only allow brief periods of construction [4].

II. LITERATURE SURVEY

Studies have shown that ferrocement provides as an ideal alternative towards low cost construction while meeting the desired characteristics and the use of prefabrication reduces the construction time. Hence prefabricated ferrocement is an optimum solution towards the problem of low cost housing with speedy construction.

Kantharaju, K.Vasudev et al. [5] have concluded based on their studies that, Ferrocement products are an ideal substitute for wood and they can be extensively used in various components of a housing like door, Roofing etc., Indian Experiences have shown that construction cost could be reduced by about 20 to 40% if ferrocement products are used in place of conventional wood or R.C.C. Components. Developing countries where mass social housing projects are being taken up the use of ferrocement components would go a long way in helping them to build houses at economical cost and also at a faster rate.

A.W. Hago et al. [6] studied the ultimate and service behaviour of ferrocement roof slab panels. The parameters of their study included: the effect of the percentage of wire mesh reinforcement by volume and the structural shape of the panels on the ultimate flexural strength, first crack load, crack spacing and load-deformation behaviour. Based on their studies they found that, slabs showed good ductility represented by large deflections giving a horizontal plateau in the load-deflection plot ample warning was given prior to failure. Also, Slabs with channel sections supported larger ultimate loads and behaved better under service loads than their flat slabs counterparts.

Wail Nourildean Al-Rifaie et al. [7] have said based on his studies that the use of ferrocement in pre-fabricated buildings provides many advantages in terms of lightness of weight (since its thickness is usually between10 and 50mm), ease of handling, low labour cost in its production and a durable material requiring little maintenance. This would further lead to an "eco-friendly" low cost housing without any loss of structural integrity. Saving in cost is one of the several reasons for the popularity of ferrocement. It is recognized that the economics of ferrocement is dependent on several factors such as costs of raw materials and labour, and the relative cost of competitive materials. In this article a structural system for ferrocement building based on generic services facilities is introduced.

Xudong Zhao et al. [8] have said that, the key issue for promoting prefabrication is to seek for potential low cost techniques, including using sustainable/recycled materials, such as rammed earth, blast furnace slag, fly ash, or straw, increasing the size and reducing the number of the components used, use of modular design of house components, factory based mass production, advanced machinery technique, as well as intelligent computer aided design.

Vivian W.Y. Tama et al. [9] conducted a feasibility analysis in adopting prefabrication in construction activities. Advantages, hindrances and future development on prefabrication's applications were provided based on a questionnaire survey. The suitability in adopting prefabrication of various project types is also examined. Furthermore, a financial analysis is also investigated by a local case study. It found that wastage generation can reduce up to 100% after adopting prefabrication, in which up to 84.7% can be saved on wastage reduction. Based on their studies they concluded that, prefabrication can provide a better solution to the problems in huge waste generation on site activities, Adoption of prefabrication has potential in the construction industry though there are still many problems in the applications on prefabrication, Long-term construction costs can be reduced even if the initial construction cost is higher.

III. EXPERIMENTAL STUDY

A. Materials Used

Ferrocement consisted of cement mortar and wire mesh. The wire mesh acts as the layer of reinforcement in ferrocement. Welded steel wire mesh of aperture size 20mm and thickness 1mm was used for the specimen casting. The cement mortar imparts the compressive strength to the ferrocement structure. The ratio of cement to fine aggregate was 1:3 and the water/cement ratio was taken as 0.45

B. Details of Specimen

The size of the ferrocement slab is taken as 1m x 1m x 0.05m. Slabs with single layer of steel mesh and double layer of steel mesh were casted in order to compare the strength of slab with different layers of steel mesh. Two specimens of each were casted.

Mould for casting slabs was made out of timber. For casting slabs, the mould was placed on a flat surface and water was sprinkled on the base in order to reduce the water absorption. For casting of slabs with single layer of steel mesh, a first layer of mortar was placed up to half the thickness required. Then the steel mesh was placed over the first layer. The last layer of mortar was placed over the steel mesh, so that the mesh was sandwiched in between the mortar layers.

Fig.1: Casting of Slab

Fig.2: Finished slabs placed for curing

C. Testing of Specimen

The specimens casted were tested for their break load capacity using loading frame of capacity 100 tons after 28 days. For testing of slabs, hydraulic jack of 50T capacity was used. Load applied was measured using a dial gauge with 0.1T accuracy.

Fig.3: Slab placed on loading frame for testing

The slab specimens were of size 1000mm x 1000mm x 50mm with single layer and double layer of wire meshes. Two specimens of each were prepared and tested with simply supported condition. The specimens were tested after 28 days. The load carrying capacity of slab obtained after testing is as given in Table I.

Table I: Test results of slab

Designation	Type of Slab	Breaking Load		
		Tonnes	kN	Avg (kN)
NS1-SM	Slab with single layer of wire mesh	2.6	25.51	26.49
NS2-SM		2.8	27.47	
NS3-TM	Slab with double layer of wire mesh	4.0	39.24	39.73
NS4-TM		4.1	40.22	

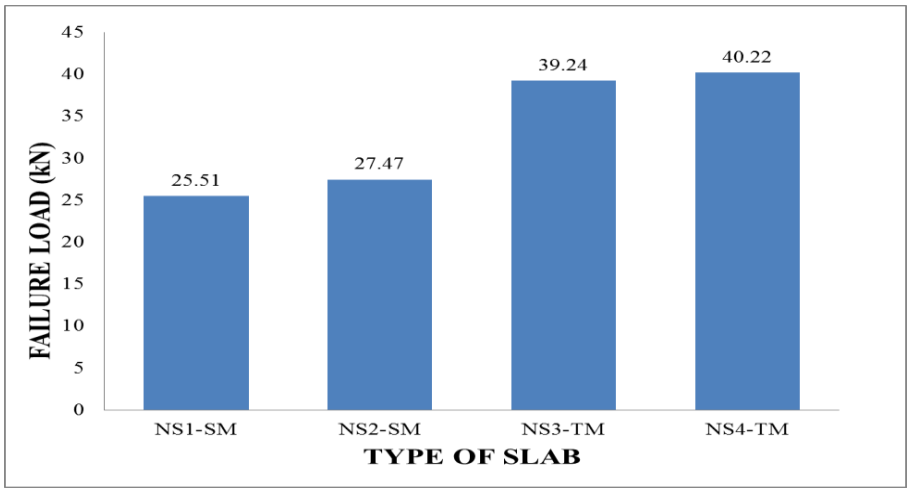

Fig.4: Graph showing failure load of slabs

Crack pattern after testing is as shown in Fig.5 & Fig.6 for slabs with single layer and double layer wire mesh respectively. It was noticed that cracks due to punching shear was developed in the slabs.

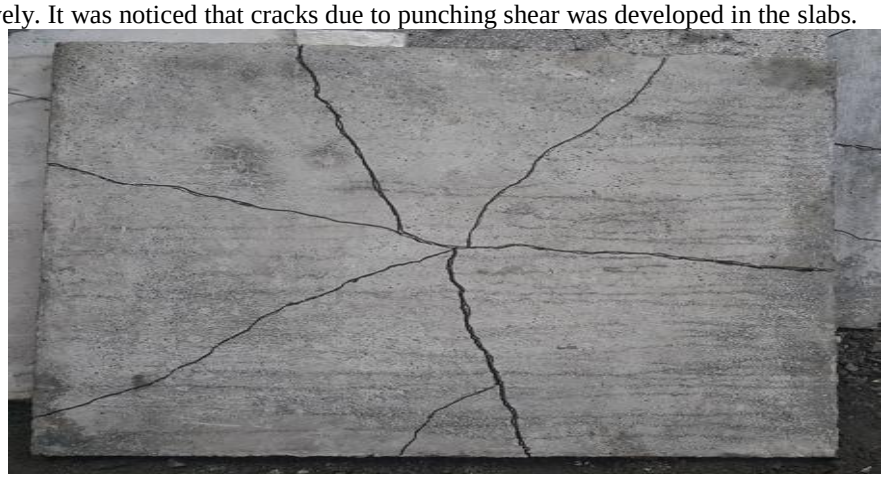

Fig.5: Crack pattern in slab with single layer of wire mesh

Fig.6: Crack pattern in slab with double layers of wire mesh

During testing it was observed that the slab did not break into pieces after failure, instead the cracks were found to widen. This is because the wire mesh holds together the cement mortar instead of breaking and falling off. By observing the cracks it was inferred that the slab with double layer of wire mesh has more crack pattern compared to slab with single layer of wire mesh. Also it was found out that the slab with double layer of wire mesh can take more loads compared to that of slab with single layer of wire mesh. Hence with increase in no. of layers of wire mesh we can increase the performance of ferrocement slabs.

IV. CONCLUSIONS

Shelter is a fundamental need which provides protection for human being from other elements such as weather. With increase in population around world, there has been increase in demand of shelters. Also several natural calamities and war out break at several countries has increased the demand of shelter at cheap price with speedy construction. Prefabricated ferrocement building can provide an ample solution to this problem.

For the study, model specimens were casted and tested in a loading frame UTM with a capacity of 100T. It was also observed that, the usage of wire mesh as reinforcement in ferrocement increases the crack pattern in the case of slabs. This helps in preventing the cement part of ferrocement from falling off even after the failure has occurred. Based on results obtained from the study, it can be concluded that the prefabricated ferrocement slab panels maybe used for the construction of low cost housing and it is also cheaper compared to RCC elements of similar size. With use of ferrocement elements the dead load can be reduced for a building.

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