Literature Survey on Stainless Steel Wire Mesh Reinforced Concrete Slab

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Abstract— In this paper, experimental and analytical study on the flexural behaviour of stainless steel wire mesh RC slabs were reported. Single point flexure test on four slabs is conducted and the wire mesh is impregnated in different layers with providing constant cover of about 20mm respectively. The dimensions of the slabs are 0.75 x 0.75 x 0.1m. These slabs are casted using self-compacting concrete. The experimental tests include the testing of panels under static loading. Load is applied using a 500kN hydraulic jack. Linear voltage displacement transducers with 50 mm gauge range are used to measure the transverse deflections. The test results includes the ultimate load-bearing capacity, load-deflection profiles, typical modes of failure and cracking patterns under constantly increasing the loads were discussed. The experimental and analytical results are compared and reported.

Keywords: Stainless Steel, Self-Compacting Concrete, Wire Mesh

I. Introduction

Concrete is a heterogeneous material which is widely used for construction purpose all over the world. Reinforced concrete is a composite material in which concrete as well as steel is used. As concrete is weak in tension the tensile stresses in flexural member is resisted by steel reinforcement. Being much stronger than concrete in compression as well, reinforcing steel can also supplement concrete in bearing compressive forces as in column.

The slab, or flexural member, is frequently encountered in structures and machines, and its elementary stress analysis constitutes one of the more interesting facets of mechanics of materials. A slab is a member subjected to loads applied transverse to the long dimension, causing the member to bend

Ferro-cement is truly the first invention of reinforced concrete with some differences. The main difference is in scale of the element. Ferro-cement uses small sized reinforcement, rather than large steel rods, such as wire meshes.

Ferro-cement was invented by a Frenchman, Joseph Louis Lambot, in 1848. The rapid development of reinforced concrete stifled the development of ferro-cement until the second half of the 20th century. However, today there is increased recognition of ferro-cement in applications where its properties, ease of construction and cost effectiveness provide a convincing extension to reinforced concrete technology

Though ferro-cement is a 160 years old technology, it is environmentally sound and has many advantageous improved properties such as strength, toughness, water-tightness, lightness, durability, fire resistance and environmental stability that cannot be matched by any other thin construction material.

The engineering properties of ferro-cement structure are equivalent to normal concrete, and in some applications it performs better. The tensile strength of ferro-cement is a result of the volume of reinforcement used in the structure. Apart from the volume of reinforcement, the direction of its use in line with the force direction and tensile stress direction is also important. The tensile performance of the ferro-cement concrete or structure can be grouped into three, namely, the pre cracking phase, post cracking phase, and finally the post yielding phase. A ferro-cement member subjected to upwards tensile stress behaves something like linear elastic material until the first crack appears. Beyond this, the member will enter the multiple cracking and eventually continuing to a point where the mesh starts to experience yielding. Once at this stage the number of cracks will continue to grow with the increase in the tensile force or stress. The specific surface area of ferro-cement member or element has been found to influence the first crack in tension, as well as the width of the cracks. The maximum stress at first crack for ferro-cement matrix increases in proportion to the specific area of the element. The behaviour of ferro-cement element under compression mainly depended on mix design.

The well distributed and aligned reinforcement has made the ferro-cement to behave like steel plates. Ferro-cement is also has other outstanding properties besides its engineering properties compared to normal concrete. Ferro-cement exhibits very easy mold-ability characteristics, that it can be used to produce any desired shape of structure. Besides that due to superior tensile behaviour and water tightness, the material is widely used for lightweight construction and water tight structure as well as for potable structure. Some of the successful application of ferro-cement includes boat, sampan, pipes, shell roofs, wind tunnels, modular housing, sandwich pools, permanent form of concrete structures etc.

II. Literatures

Paramasivam.P., Lim.C.T.E. & Ong. K.C.G [1991] investigated "methods of repair and strengthening of reinforced concrete beams using ferrocement laminates attached onto the surface of the beams". The effects of the level of damage sustained by the original beams prior to repair; and the results of repeated loading on the performance of the strengthened beams were studied. The addition of ferrocement laminates to the soffit of the beams tested delayed the first crack load, restrained cracks from further widening, and increased the flexural stiffness and load capacities of the strengthened beams. The improvements in mid-span deflections and load capacities were lower in beams where composite action between the original beam and the strengthening ferrocement laminates was lost. Ferrocement is a viable alternative strengthening component for the rehabilitation of reinforced concrete structures.

Taha A, EI-Sayed, Abeer M, Erfan [1991] investigated "Improving shear strength of beams using ferrocement composite" The paper opens up a new issue of shear behaviour of beams reinforced by ferrocement. The experimental program includes seven beams were tested using two point loading. Beams with welded wire mesh exhibited some amount of increase in respect of beams with reference& expanded wire mesh. The nonlinear finite element analysis was performed using ANSYS. The analytical results demonstrated good consistent with the experimental results. The experimental program consists of seven reinforced concrete ferrocement beams of 150mm width 150mm depth and effective length of 1600mm with 650mm shear span and 300mm load distance is subjected to two point loading respectively. Expanded wire mesh & welded wire mesh RC beams exhibits higher load carrying capacity than controlled RC beams, but welded wire mesh superior than expanded wire mesh RC beams. Increasing the number of layers of wire mesh leads to improve the parameter such as stiffness, load deflection etc..,

Sulaimani.G.J., Basunbul.I.A. and Mousselhy. E. A [1991] studied "The shear behavior of ferrocement box beams" by conducting flexural tests on 15 beam specimens. The shear behavior is studied in relation to the total volume fraction of wire mesh reinforcement Vf, which includes mesh reinforcement in both webs and flanges. The major parameters used in the study were amounts of wire mesh reinforcement in webs and flanges, and shear span to depth ratio a/h. Beams had two different spans: 750mm to obtain a/h ratios of 1.2 and 1'5; and 1500 mm to obtain an a/h ratio of 3.0.Test results indicate that cracking and ultimate shear forces increase as wire mesh in webs is increased; placing wire mesh in flanges also increases shear resistance through arresting the tension cracks and causing them to be finer. The ACI equation for shear strength of conventional reinforced concrete beams without web reinforcement underestimates the cracking shear strength of ferrocement box beams. An increase in the amount of wire mesh reinforcement for a given a/h ratio causes cracks to be higher in number and finer in size, which leads to a larger ductility. The cracking and ultimate shear strengths of FC box beams increase as the a/h ratio is decreased.

Mohammed Arif, Pankaj, Surendra K. Kaushik [1991] estimated "The mechanical behaviour of ferrocement composites". In-plane tension, compression and bending tests were conducted on plain mortar and ferrocement specimens with woven and welded meshes. Tension tests were also carried out on meshes. Bending tests were conducted using specimens with centre point loading. The objective of the study was to investigate the behaviour of material reinforced with varying number of mesh layers and orientations and to evolve a set of elastic and inelastic material properties. It is observed that the conventional empirical relations based on mortar crushing strength overestimate the mortar modulus. The elastic moduli obtained using the rule of mixtures compares well with the values evaluated from the tests on ferrocement specimens. The 45° orientation emerges as the weakest configuration both in terms of the Young's modulus and ultimate stress because of the lowest volume fraction of wire mesh in the direction of loading at this orientation.

A.W. Hago, , K.S. Al-Jabri , A.S. Alnuaimi , H. Al-Moqbali , M.A. Al-Kubaisy [1995] investigated "The study ultimate and service behavior of ferrocement roof slab panels", by using monolithic shallow edge ferrocement beam considerably increase the service and ultimate of the panels. The slabs were designed as rectangular with 470mm width and 20mm depth of total length 2100mm, where channel section slabs were also designed by providing two integral beam of 50mm deep with 20mm thickness on the long sides of the panels. The slab panels were tested as simply supported slabs. The loads were applied as a two symmetrically arranged concentrated loads by using spreader steel beams and 5 tonnes hydraulic jack. The wire meshes are integrated in the different number of layers in each specimen respectively. The author concluded that by providing more layers of wire mesh leads to higher load carrying capacity and it also show higher ductility when compared to controlled specimens and the channel wire mesh section shows higher load carrying capacity than flat wire mesh section respectively.

Gul Ahmed Jokio, Fatehi Mansoor Saad, Yasmeen Gul, Syed Mohsin [2003] investigated "Uniaxial compression and tensile splitting tests on adobe with embedded steel wire reinforcement" Tests was carried out to investigate the effect of wire mesh reinforcement on the compressive strength and the tensile splitting strength of specimens. 30 cylinders of 150mm diameter and 300mm length were tested. The wire mesh is integrated in the single layer into the cylinder specimens. The steel wire mesh is integrated into the cylinder is the welded type of opening size 12.7mm*12.7mm with diameter of 1.042mm,where the steel wire mesh is welded type. The specimens were tested by using universal testing machine (UTM).The analytical and theoretical works is also carried to obtain the acceptable results by comparing with experimental values obtained. The author concluded that by using steel wire mesh we can obtain 3 times higher compressive strength comparing to specimen without reinforcing, but wire mesh does not increase the tensile strength, however it change the mode of failure from sudden brittle failure to more ductile one.

Soltani [1991] studied "The cracking response and local stress characteristics of RC membrane elements reinforced with welded wire mesh". The purpose of this study is to investigate the structural behavior and cracking response of RC membrane elements reinforced with welded wire mesh subjected to general in-plane stresses. The response of RC elements is computed based on micro mechanisms of stress transfer in RC domain involving interaction of concrete and reinforcing bars, anchorage effect of longitudinal and transverse wires and stress transfer across cracks due to aggregate interlock. New methodology has been developed and used for analysis of RC membrane elements reinforced with welded wire mesh based on the micro mechanism of stress transfer in cracked RC domain. In the described model, the response of element is computed based on the local stress–strain behavior of reinforcement and concrete. So, spatial average stress–strain relationship of concrete and reinforcement, and at the same time crack spacing, width and slip, can be computed through the proposed method. The structural response and the spatial average behavior of reinforcement and concrete in RC elements reinforced with welded wire mesh strictly depend on the wire spacing and type of reinforcements. For welded wire mesh with wire spacing less than 20 times of wire diameter, the crack spacing is independent on the type of reinforcements and bond performance, and for larger wire spacing, the bond stress controls the cracking behavior of the elements. Welded wire mesh, shows smaller crack spacing and crack width compared to conventional reinforcing bars, however it has smaller structure ductility one.

Kubaisy and Jumaat [2006] investigated on “Flexural behaviour of reinforced concrete slab with ferrocement tension zone cover”. This paper presents a study of the flexural behaviour of reinforced concrete slabs with ferrocement tension zone cover. The results of tests on 12 simply supported slabs are resented. All slabs were rectangular with 500 mm width, 75 - 85 mm total depth and a total length of 1500mm.The effect of the following parameters: percentage of wire mesh reinforcement in the ferrocement cover layer, thickness of the ferrocement layer and the type of connection between the ferrocement layer and the reinforced concrete slab on the ultimate flexural load, first crack load, crack width and spacing, and the load deflection relationship were examined. The results indicate that the use of ferrocement cover slightly increases the ultimate flexural load and increases in the first crack load. The first crack load increased with the increase in the percentage of mesh reinforcement and the ferrocement layer thickness. Considerable reduction in cracks width and spacing 64 - 84%. It was observed for specimens with ferrocement layer. The presence of a cold joint between the reinforced concrete slab and the ferrocement layer lowered the ultimate flexural load by 34%, however, cracks width and spacing were reduced. Specimens cast without structural connection, provided that concrete was cast within 1 - 1.5 h of casting the ferrocement cover, behaved in a very similar manner to those with structural connection. The deflections at service load and near ultimate load were smaller for specimens with ferrocement layer. The ferrocement layer thickness and the connection type influenced the reduction in deflection. Crack width of the tested reinforced concrete slabs was considerably narrowed by the use of ferrocement. Specimens with ferrocement cover showed higher stiffness and higher cracking moment than those with normal concrete cover. Deflection near service load was significantly reduced in the specimens with ferrocement cover. A slight improvement in the bending capacity of the specimens with ferrocement cover was observed.

Noor Ahmed Memon, Salihuddin Radin Sumadi, Mahyuddin Ramli [2007] done “An experiment on ferrocement encased lightweight aerated concrete”. This paper presents the experimental study to investigate the applicability of a novel technique to produce lightweight sandwich composite elements. Sandwich composite is fabricated by encasing lightweight aerated concrete as core with high performance ferrocement box as skin layer. The performance of the sandwich elements is investigated in terms of ultimate compressive strength, flexural strength, water absorption, overall unit weight and the failure mode. The results are compared with control specimens made solely of the aerated concrete. The control and sandwich without wire mesh showed apparent first crack at about 90–96% of their failure load followed by their sudden and complete collapse at failure load. The behavior of the sandwich specimens with wire mesh was ductile and the first crack appeared at 60% to 80% of their failure load depending upon the type and wire mesh layers. Results showed the remarkable enhancement in the compressive strength and flexural strength while the water absorption is reduced to fractions as compared to that of the control specimens. Overall unit weight of the sandwich composite elements falls in the range of the lightweight structural elements. The failure mode of the sandwich elements reveals the ductile and composite behavior thus transforming a pure brittle material (aerated concrete) into ductile composite material because of the ferrocement encasement.

Hassan Mohamed Ibrahim [2011] investigated “Experimental Investigation Of Ultimate Capacity of Wired mesh-reinforced Cementitous Slabs”, the test conducted on 27 square Cementitous slabs of 490*490mm simply supported on four edges and subjected to patch load are presented. The slabs had a clear span of 400*400mm. Thickness of slabs are 40, 45, 50 and 60mm respectively. The author compared the test values of both diamond mesh and square mesh RC slab to find out the ultimate load carrying capacity and punching strength of RC slab. The results shows that volume fraction increased the punching strength of the slabs were also increased. Using single layer of diamond wire mesh of low volume fraction of 0.12% to numerous increase of plain slabs ductility by more than four times. Moreover, increasing the volume fraction of diamond mesh by 50% consequently increases the ultimate load and deflection by 50% and 84% respectively. Slab reinforced with square meshes exhibits a reduction in ultimate load and deflection than those of slabs reinforced with diamond mesh by 21% and 40% respectively. The ductile nature of diamond mesh over square mesh was obvious from these results.

Naveen and Suresh [2012]done “An experimental study on light weight ferrocement beam under monotonic and repeated flexural loading”. Light weight ferrocement is a composite material consisting of cement-sand mortar (matrix) along with light weight fine aggregate as a replacement of sand in some quantity reinforced with layers of small diameter wire meshes. Objectives is to study the effect of blast furnace slag on first crack and ultimate strength of the light weight ferrocement beams and also the behavior of light weight ferrocement beams under monotonic and repeated flexural loading. The study has been focused on the effect of blast furnace slag (BFS) on ultimate strength with replacement of slag by 0%, 10%, 20% and 30% and the behavior of Light weight ferrocement beam under monotonic load and repeated load with increased load. A total of 24 ferrocement specimens have been cast.It can be observed that, the first crack and ultimate strength increases up to 10% replacement of sand, and then decreases with the increased percentage of sand replacement. The light weight ferrocement specimens having increased wire mesh (Volume fraction) could sustain greater number of repetitions. Light weight ferrocement beams have good moment of resistant under both monotonic & repeated loading. The mesh wires are found to be more effective in increasing the margin between first crack and ultimate flexural strengths.

C. Krishnaveni [2013] investigated the “Study of flexural behavior of hybrid ferrocement slabs” The paper investigate on flexural behavior of hybrid SCC ferrocement slab incorporating micro steel and polyester fibre, also to study the load carrying capacity & deformation ultimate load. 18 slabs were designed as 650mm length, 300mm width, 60mm thickness with integrating 0.75% and 0.25% of steel fibre and polyester fibre. The slabs panel were tested as simply supported slabs; the loads were applied as a two point loading by means of loading frame of 50 tonne and load cell of 250kn respectively. The author concluded that increasing the number of wire mesh layer increase the flexural strength of slabs, 3 layered wire mesh shows 117.85% greater strength when compared with one layered wire mesh slabs.

Tatsa .E.Z [2014] proposed a procedure for the design of components in bending similar to that of reinforced concrete elements. A technique for farthest point states configuration is displayed including outline for quality and serviceability considering split and diversion control. The proposed system is effectively programmable. Limit state of method was used in the method for the design and analysis of components made of ferrocement in bending has been presented. It is based on the approach that ferrocement may be considered as a form of reinforced concrete and therefore the limit states procedure is used in a manner similar to the design and analysis of reinforced concrete elements

Nassif and Najim [2015] done "an experimental and analytical investigation of ferrocement–concrete composite beams". Ferrocement laminates are introduced to enhance the overall performance of structures, such as composite bridge decks, beams, bearing walls, etc. Experimental and analytical study done on composite beams made of reinforced concrete overlaid on a thin section of ferrocement. In particular, the method of shear transfer between composite layers is examined. The beam specimens were cast in two groups. The dimensions were reduced geometrically from an actual bridge deck. Beams were cast in scaled dimensions of the actual bridge deck slabs between two adjacent girders. The first set of composite beams cast, were of dimensions 152 x 152 x 914 mm. The bottom 25.4 mm of these beams was a ferrocement laminate, with steel wire mesh as reinforcement. The top 127 mm of concrete with a No. 10 rebar was cast on top the ferrocement laminate. The rebar was located at 12.7 mm above the ferrocement laminates. A total of 24 simply supported composite beams specimens with hexagonal and square mesh are tested under a two-point loading system up to failure. Results from experimental data are compared to those from nonlinear analysis as well as a finite element study to model the overall non-linear behavior. Results show that the proposed composite beam has good ductility, cracking strength and ultimate capacity. The conclusion drawn from the paper are, full composite action between both layers cannot be attained based on rough surfaces without shear studs. It was observed that a minimum number of five studs is needed to provide full composite action between both layers. Beams having shear studs with hooks exhibited better pre-cracking stiffness as well as cracking strength than those with L-shaped studs. Beam specimens with square mesh exhibited better cracking capacity than the control beam as well as beams with hexagonal mesh.

Jun Li, hengquing Wu, Yu Su, Zhong-Xian Li [2017] investigated "A study of concrete slabs with steel wire mesh reinforcement under close in explosive loads" by conducting the field blast test results on reinforced concrete slabs under close in detonation are presented. Performance of slabs made of normal strength concrete slabs and steel fibre reinforced concrete, steel wired mesh fibre reinforced concrete slab are compared and discussed. Both field and laboratory tests are carried out. The author designed all the slabs for the blast test with same size 2000mm long, 800mm wide and 120mm thickness. The diameters of longitudinal rebar and stirrup rebar were 12mm and 10mm respectively. 8Kg TNT explosive and 12Kg TNT explosive were designed for the NSC, SFRC and SWM-SF reinforced slabs. The standoff distances in these cases were set as 1.5m. NSC slab experienced complete failure while SFRC slab showed plastics deformation with plastic hinge formed at mid span of slab. SFRC slab had small blast deflection and multiple cracks but SWM-SF slab responded elastic mode and showed no permanent deflection only hairline cracks are observed. So, Author concluded that steel wire mesh provided good blast resistance due to localised membrane effect and close spacing steel wire mesh.

III. CONCLUSIONS

– Stainless steel mesh will help in reduce the formation of corrosion.
– The amount of reinforcement bars will reduce due to usage of wire mesh.
– The self compacting concrete will reduce the labour work such as compacting etc..,
– The wire mesh RC slab will carry more loads when compared to conventional slab respectively.
– Self weight of slab will reduce due to small amount of reinforcement bars are provided.

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