Flexural and Shear Behavior of RC Concrete Beams Reinforced with Fiber Wire Mesh

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Abstract

This work aims to study the effect of using fiber wire mesh on the flexural and shear properties of RC concrete beams. Six reinforced concrete beams (120*180*1220mm) were tested under two load points. Fiber wire mesh was applied with two manners, first one is three layers as U shape around the section of the beam, the second one is four layers around overall section of beam. The test results indicated that using of fiber wire mesh as additional reinforcement can increase the ultimate load of about (1.85-3.58% in the case of flexural) and (17.7-23.7% in case of shear). Also, results showed that an increasing in first cracking load is obtained from (42.8-85.7% in case of flexural) and from (41.2-76.5% in case of shear). Also the shear behavior of beams becomes more ductile when the fiber wire mesh was used in beams. The cracks of shrinkage was disappeared when the fiber wire mesh surround the section of the beam.

Keywords: RC beams, Fiber wire mesh, Shear, Flexural, Experimental

الخلاصة

هذا البحثِ يهدف الى دراسة تأثير استخدام شبكة الاسلاك الليفية على خصائص الانحناء والقص للأعتاب الخرسانية المسلحة. ستة اعتاب خرسانية مسلحة (120*180*1220ملم) فحصتَ تحت عِدّة حالات تحميلِ. شبكة الاسلاك الليفية وضعت بطريقتين الاولى ثلاثة طبقات على شكل حرفU حول مقطع العتبة ، الثانية عبارة عن اربعة طبقات حول كل مقطع العتبة.نتائج الفحص بينت ان ملائمة استخدام شبكة الاسلاك الليفية كتسليح اضافي للأعتاب الخرسانية المسلحة ويمكن ان تعطي زيادة بالحمل الاقصى(1.85-3.58% في حالة الانحناء) و (17.7-23.7% في حالة القص) بينما يمكن ان تعطي زيادة بحمل التشقق الاولي (85.7- 42.8% في حالة الانحناء) و (41.2-76.5% في حالة القص) . كذلك سلوك القص اصبح اكثر مطيليه عندما تم استخدام شبكة الاسلاك الليفية في الاعتاب. تشققات الانكماش اختفت عندما تم استخدام شبكة الاسلاك الليفية حول كل مقطع العتبة.

الكلمات المفتاحية : الاعتاب الخرسانية المسلحة ، شبكة الاسلاك الليفية ، ألقص، الانحناء ، عملي .

1. Introduction

Nowadays, the enhancing properties of RC beams becomes necessary especially with the evaluation of construction materials. Almost of the approaches that used to improve properties of concrete beams required high cost. The previous researches deal with wire mesh as strengthening part after casting. (Xing *et.al.*, 2010) tested five simply supported (T) beams to study the effect of strengthening with steel wire mesh embedded in polymer mortar overlay. The experimental results showed that using steel wire mesh is an effective means of strengthening RC beams in flexure.

(Matori *et.al.*, 2012) discussed the flexural behavior of plain concrete beams bonded with wire mesh-epoxy composite. Four beams were tested. Three specimens were bonded with same amount of wire mesh-epoxy with varying width of wire-mesh application and one as a control. The large width application of wire-mesh indicated better behavior in energy absorption capability.

(Makki , 2014) studied the behavior of reinforced concrete beams retrofitted by ferrocement and steel wire mesh in both shear and flexure. Results showed that the rehabilitation technique can increase the ultimate load of about (69.8-175% in case of strengthening) and (50.94-125% in case of repairing) compared with the control samples.

As can be observed from the above discussion, the majority of earlier research efforts related to strengthening of RC beams under flexural and shear. In this project fiber wire mesh was used as layers applied in the wood mold before casting. This mesh is very easy to use and low cost. Presence this mesh at the faces of the beam will change the behavior of the beam especially that the bond between mesh and concrete is fully bonded.

2. **Experimental Plan**

A simply supported RC beams were prepared and tested with two points load as shown in Fig(1). Three samples were tested for shear behavior and the others were tested for flexural behavior.

2-1 Tested Beams Details

All beams were 122 cm total length with (12x18cm) cross section as shown in Fig.(2). The flexural samples were reinforced with two Φ8mm top and bottom longitudinal reinforcement. The shear samples were reinforced with four Φ8mm bottom longitudinal reinforcement and two Φ8mm top longitudinal reinforcement. Deformed Φ5 mm diameter stirrups were located at spacing of 70 mm C/C for both flexural and shear behavior beams depending on ASTM C 702 as shown in Fig.(3). The test beams have been given expressive names as shown in Table (1). The fiber wire mesh placed as two layers on the side of mold and one layer at bottom of beam, while the forth layer "for beams with fiber wire mesh overall the section" was placed above the beam after casting fresh concrete as shown in Fig.(4). It can be noted that the cement mortar permeate the opening of fiber wire mesh as shown in Fig.(5). The design of beams was according to ACI code318M.

2-2 Properties of Materials

2-2-1Steel Reinforcement. The average yield stress of ϕ8 mm diameter steel bar used for longitudinal reinforcement was 456 MPa, determined from three specimens "according to ASTM A615 specification" and the 6 mm diameter steel bar average yield stress was 425 MPa used for stirrups.

2-2-2 Compressive Strength (f'_c)

A trial mix design was used to reach the planned compressive strength of 28MPa. Mixture details are given in Table (2) "according to ASTM C496". The compressive strength obtained by testing three standard cylinders (100mm x 200mm) at 28days age was 27.2MPa.

2-2-3Fiber Wire Mesh Properties

The properties of fiber wire mesh : dark gray color, small wire diameter of 0.15mm and the grid size of mesh was (2*2 mm) as shown in Fig(6). The tension tests were accomplished to estimate physical properties according to "ASTM D412" using the special testing machine as shown in Fig(7). The physical properties are listed in Table (3).

2-3Test Set-Up and Measurements

All beams were subjected to gradual loading up to failure using a hydraulic machine of 150 kN capacity "according to ASTM C192/C192M" The load was applied incrementally in 0.2 kN steps, as shown in Fig(8). Four elastomeric bearing pads were placed at the supports and points of load to prevent stress concentration at these points. Vertical displacements were measured near the supports and midspan using dial gauges so that the net displacement can be obtained by deducted midspan displacement from the average of displacements near supports.

3-Testing Reaults

As mention earlier, the test result will be discussed for the two cases of failure (shear and flexural). First crack load, ultimate load, ductility and Failure modes of all test specimens are listed in Table (4).

3-1 Beams with shear failure

Three beams were tested to study the effect of fiber wire mesh on shear failure see Table (1). The results of these tests are shown in Figs.(9,10,11 and12) referred to obviously change in the behavior of these beams (first crack load, ultimate load and ductility).

3-2 Beams with flexural failure

Three beams were tested to study the effect of fiber wire mesh on flexural failure F , FU and FA. The results of these tests are shown in Figs.(13,14,15 and16) referred to noticeably change in the behavior of these beams (first crack load and ductility) while the effect on ultimate load was slight.

Conclusions

One can notice the following conclusions from test results:

1. The fiber wire mesh reinforcement transforms the failure criteria of shear from sudden failure to ductile failure (increase ductility) as shown in Fig(17).
2. Using fiber wire mesh as U shape (FU and SU) increase first cracking load 42.8% and 41.2% for flexural and shear respectively.
3. The percent of increase in first cracking load of samples with fiber wire mesh around overall section (FA and SA) were 85.7% and 76.5% for flexural and shear respectively.
4. The effect fiber wire mesh on the ultimate load for flexural members was slightly 1.85% for U shape and 3.58% for fiber wire mesh around overall section, while of shear members was obviously 17.7% for U shape and 23.7% for fiber wire mesh around overall section.
5. The upper layer of fiber wire mesh prevents the cracks caused by shrinkage.
6. In spite of the low cost of fiber wire mesh, the results obtained from using it was very good, especially in the value of first cracking load and ductility.

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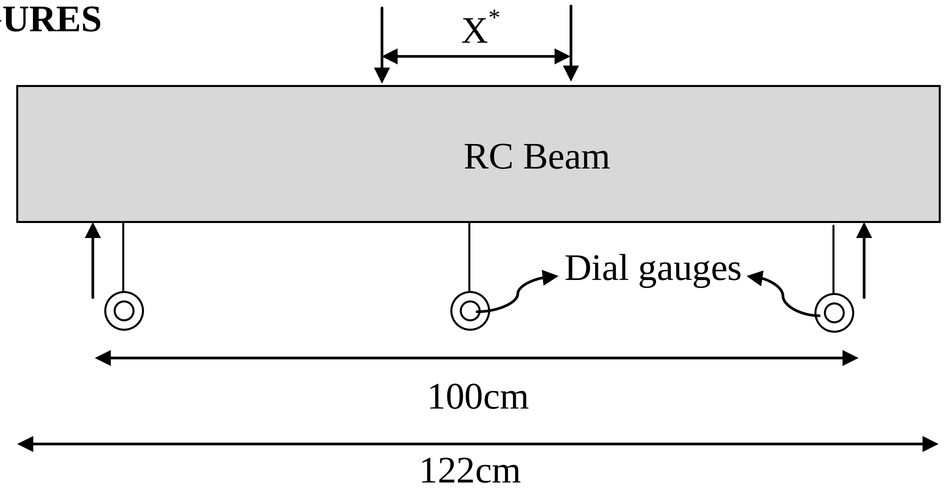
FIGURES



*X=10 cm for flexural samples
X=25 cm for shear samples

Fig.(1). Test specimen

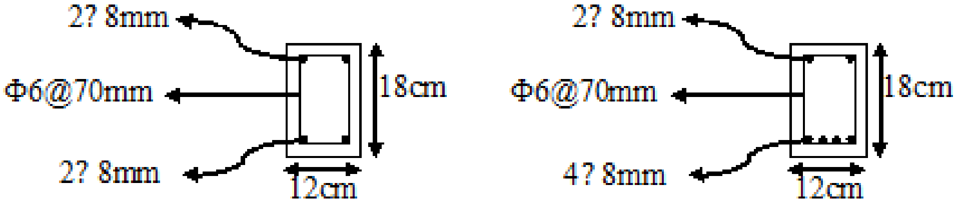


Fig.(2). Cross-section of test specimen

Fig.(3). Steel reinforcement

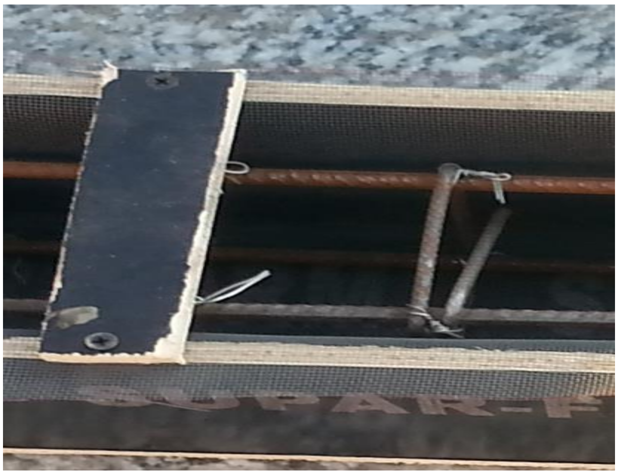


Fig.(4). Fiber wire mesh inside wood mold

Fig.(5). Fresh concrete permeated fiber wire mesh

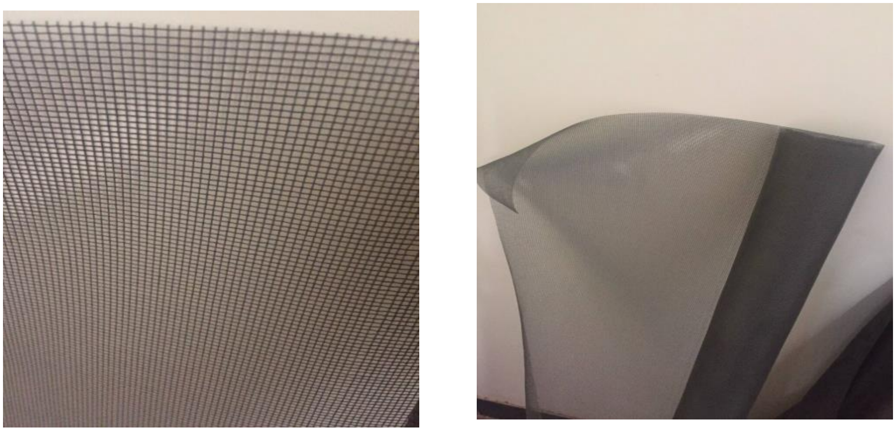


Fig.(6). Fiber wire mesh

Fig.(7). Testing machine of fiber wire mesh

Fig.(8). Testing machine of RC beams

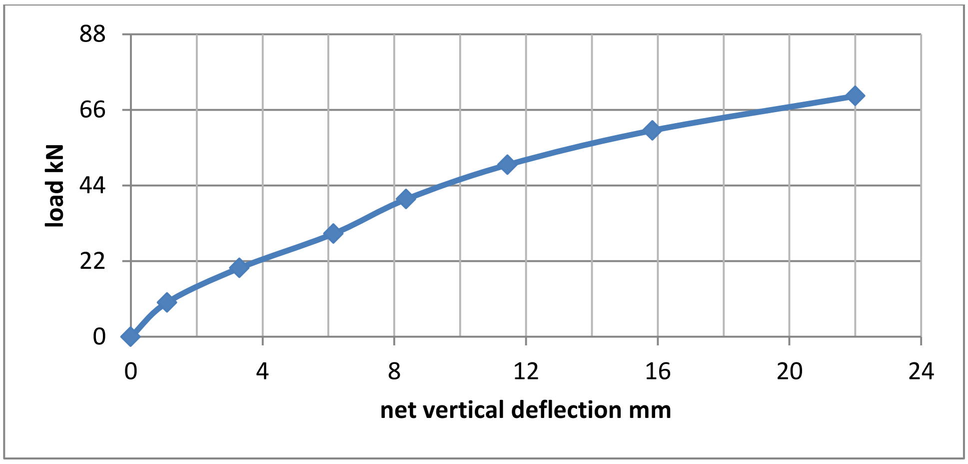


Fig.(9). Load vs net vertical deflection of RC beam S

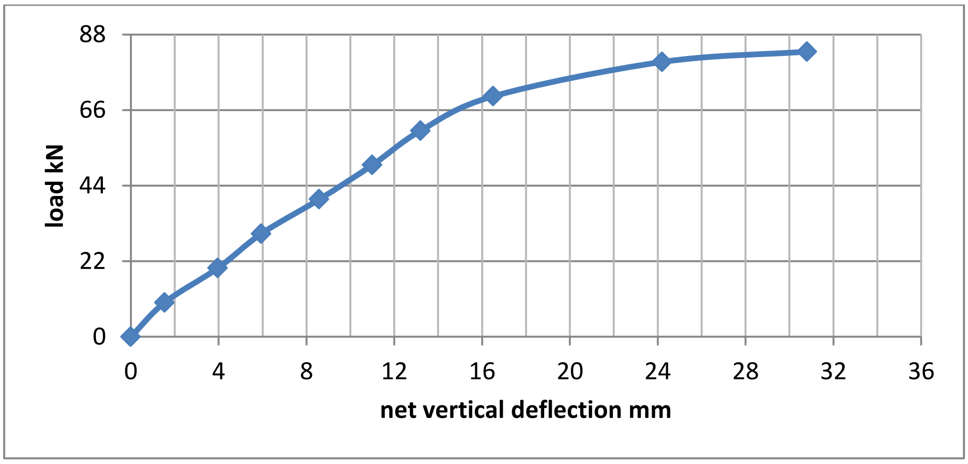


Fig.(10). Load vs net vertical deflection of RC beam SU

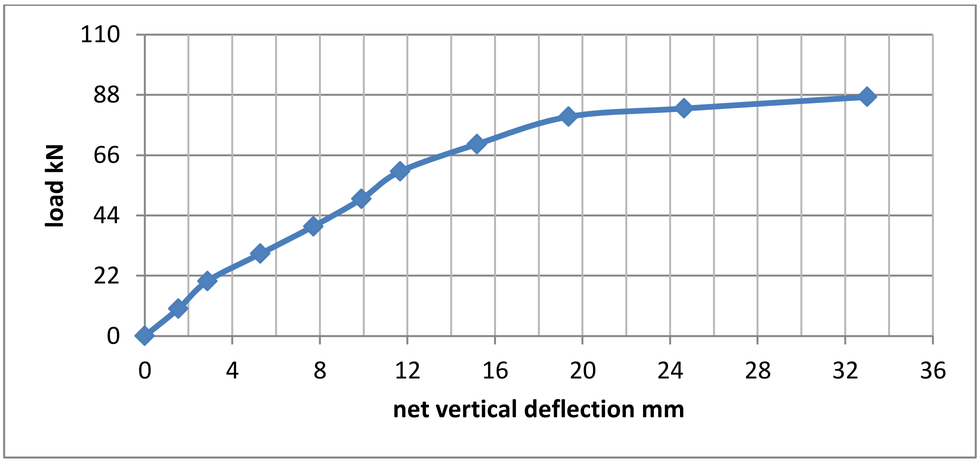


Fig.(11). Load vs net vertical deflection of RC beam SA

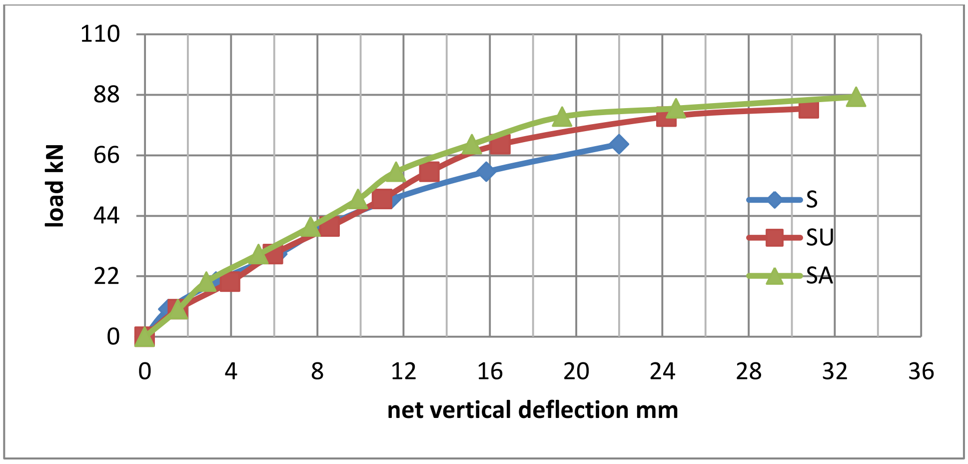


Fig.(12). Load vs net vertical deflection of RC beams S,SU and SA

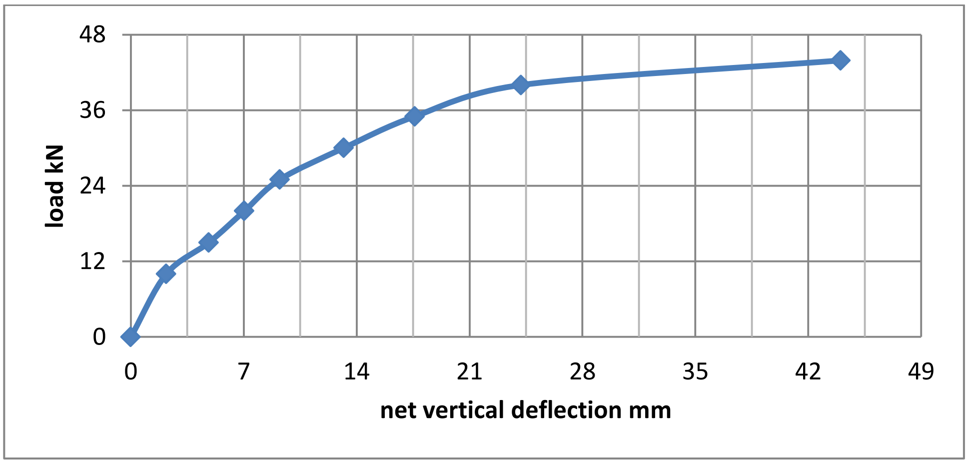


Fig.(13). Load vs net vertical deflection of RC beam F

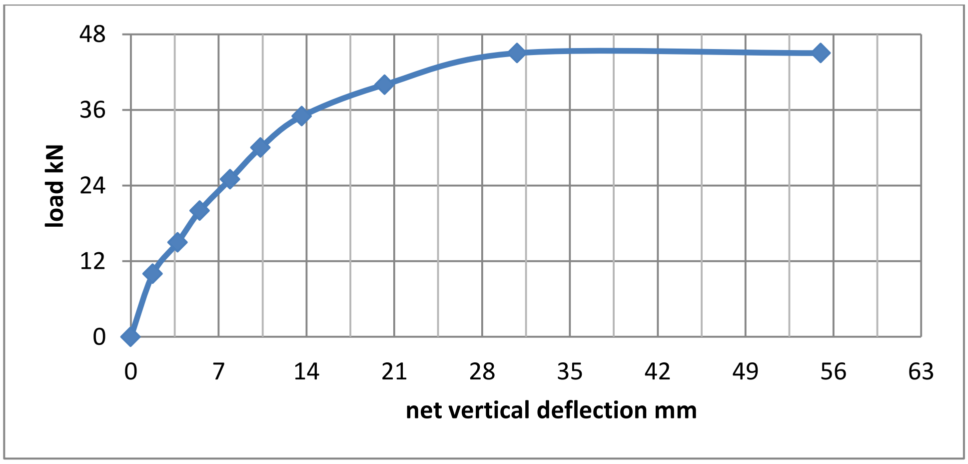


Fig.(14). Load vs net vertical deflection of RC beam FU

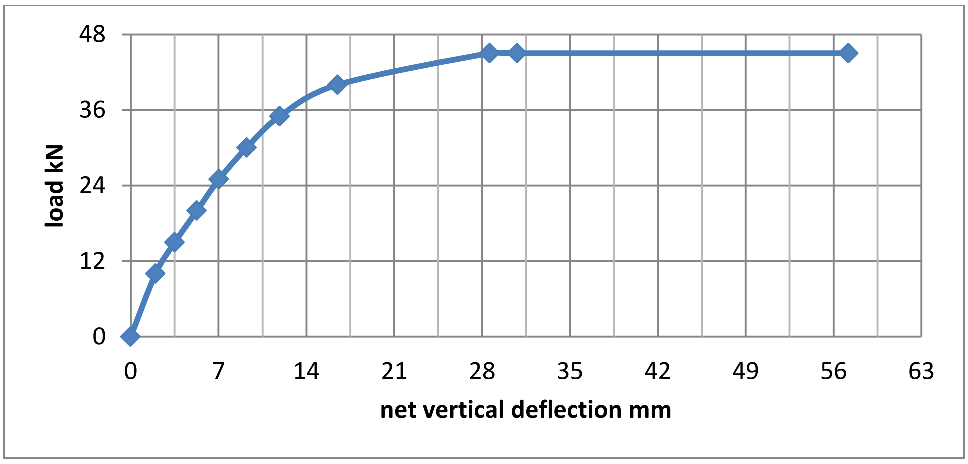


Fig.(15). Load vs net vertical deflection of RC beam FA

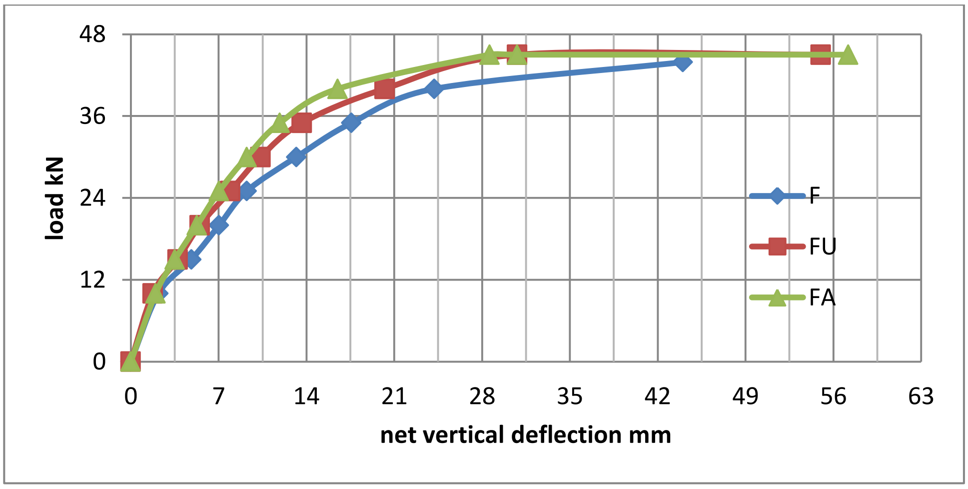


Fig.(16). Load vs net vertical deflection of RC beams F,FU and FA

Fig.(17). Tested RC beams

TABLES

Table (1) Beams Codes

Shear Behavior		Flexural Behavior	
Beams No.	Beams Name	Beams No.	Beams Name
Control beam	S	Control beam	F
Fiber wire mesh on three sides	SU	Fiber wire mesh on three sides	FU
Fiber wire mesh around over all section	SA	Fiber wire mesh around over all section	FA

Table(2) . Properties of Concrete Mix.

Parameter	Amount
Water/cement ratio	0.52
Water (kg/m^3)	234
Cement (kg/m^3)	450
Fine aggregate (kg/m^3)	670
Coarse aggregate (kg/m^3)	1040

Table (3). Specification and Test Results of Fiber Wire Mesh

Measured diameter (mm)	Ultimate strength (MPa)	Modulus of elasticity (GPa)
0.15	1120	185.3

Table (4). Results Obtained from The Test Specimens.

Sample code	First cracking load kN	Ultimate load kN	Failure Mode
F	7	43.92	Gradual flexural failure
FU	10	44.73	Gradual flexural failure
FA	13	45.49	Gradual(with slightly crushing at compression zone) flexural failure
S	17	70.7	Sudden shear failure
SU	24	83.19	Gradual(with slightly cracking at shear zone) shear failure
SA	30	87.45	Gradual(with slightly cracking at shear zone) shear failure