The Effect Of Steel Fiber On The Deflection Of Self Compacted Reinforced Concrete One Way Slab With And Without Repairing

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Abstract:

The effect of steel fiber on the deflection of self- compacted slab with and with out repairing was investigated experimentally in this study. Three specimens were used in this study and six tests were taken. All specimens were tested under two point loads to found the deflection of the slabs with and without repairing.

The results showed that, when used (0.2-0.5%Vf) steel fiber added to concrete the deflection of the slabs decreases from (46% t0 43%) than slabs without fiber under the same loads, since the steel fiber increased the tensile capacity for concrete. The results also showed that the load capacity can be increased after repairing as compared with before repairing to (5.3%, 9.6% and 17.6%)for slabs with (0,0.2 and 0.5% Vf)steel fiber respectively. On the other hand the results was checked with finite elements method by using sophisticated finite element programme (ANSYS) and it found that the result was acceptable the difference was not more than 9%.

الخلاصــــــــة:

يدرس عمليا" تأثير الفيبر المصنوع من الحديد على فشل البلاطات الكونكريتية المسلحة قبل و بعد تقويتها بواسطة قطعة مستطيلة من الحديد تثبت على سطح البلاطة بواسطة الايبوكسي. تؤخذ ثلاثة نماذج من البلاطات لكل نموذج هناك فحصين الأول قبل التقوية والثاني بعد التقوية فتصبح عدد الفحوصات ستة فحوصات. جميع هذه النماذج تختبر عمليا" بتسليط حملين متساويين على البلاطات لإيجاد نسبة الفشل بوجود و عدم وجود التقوية . أظهرت النتائج انه بإضافة نسبة حجميه من الفيبر (0.2-0.5 %) إلى الكونكريت المرصوص فأن الفشل في البلاطات يقل من (46%-43 %) مقارنة بالبلاطة بدون فيبر تحت تأثير نفس الأحمال المسلطة, ذلك لان الفيبر يزيد من مقاومة الشد الكونكريت . و تحميل الطاقة الاستيعابية للإصلاح التصدع العميق الحزم من قبل شرائح KFRC كما تم التحقيق فيها ومناقشتها. تظهر النتائج أيضا انه مقاومة البلاطات للأحمال يزداد بعد تقويتها تزداد بنسبة (5.3 ، 9.6، 17.6%) لنسب الفيبر المضاف (0، 0.2، 0.5%) على التوالي و من جهة أخرى تم تدقيق النتائج مع طريقة العناصر المحددة باستعمال برنامج خاص (ANSYS7.0) و قد وجد أن النتائج مقبولة و نسبة الاختلاف لا تتجاوز 9% و هي نسبة مقبولة للأغراض العملية مع مراعاة ظروف التجارب.

1-Introduction:

Steel fibers are used instead of ordinary steel reinforcement or in addition to reinforcing bars. Both under service and ultimate loading conditions, the fiber reinforcement is subjected to resist tensile forces [(1)].

Steel fiber reinforced concrete is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. The addition of steel fibers to concrete changes its mechanical properties. Depending on the type and amount of fibers an increase in ductility and better cracking behavior can be achieved [(2)]. Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce bleeding of water. The amount of fibers added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibers) termed volume fraction (Vf). Vf typically ranges from (0.1-3%). Aspect ratio (L/d) is calculated by dividing fiber length (L) by its diameter (d). Increase in the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. However, fibers which are too long tend to ball in the mix and create workability problems.

Steel fibers are manufactured in different types: hooked, undulated or flat, according to the construction project [(3)]

2- Self-compacted concrete:

Self- compacted concrete was developed around 1988 in Japan, to improve the durability of concrete structures. The early stage deteriorations of concrete structures are results of the manual placing and the inadequate consolidation. Therefore, the need for development of concrete with high fluidity and no segregation was felt. For several years, the problem of the durability of concrete structures has been a major problem posed to engineers. To make durable concrete structures, sufficient compaction is required. Compaction for conventional concrete is done by vibrating. Over vibration can easily cause segregation. If steel is not properly surrounded by concrete it leads to durability problems. The answer to the problem may be a type of concrete which can get compacted in to every corner of formwork and gap between steel, purely by means of its own weight and without the need for compaction. The SSC concept can be stated as the concrete that meets special performance and uniformity requirements that cannot always be obtained by using conventional ingredients, normal mixing procedure and curing practices[(4)].

Its important to test whether the concrete is self-compactable or not and also to evaluate deformability or viscosity for estimating proper mix proportioning if the concrete dose not have sufficient self- compact actability.

The existing procedures for self- compacting characteristics are those, which measure height different points under free flow and also resistance against blocking. There is some test to show whether the concrete is self- compacted or not these test are [5]:

1- Slump flow Test for measuring flow ability.

2- V- Fannel Test.

3- U-Type Test.

4- L- Box Test.

5- Fill Box Test.

6- Ring Combination Test.

7- GTM segregation test.

8- Orimet\J-ring combination Test.

In our study,the V-Fannel, U-Type and L-box tests were used to found the content of our mixtures.

2-1 Mix design:

Self- compatibility can be largely effected by the characteristics of materials and the mix proportion. A rational mix design method for SCC using a variety of materials is necessary. The mixed design as proposed is [6]:

A- Coarse aggregate content is fixed at 50% of the solid volume,

B- Fine aggregate content is fixed at 40% of the mortar volume,

C- Water powder ratio in volume is assumed as 0.9 to 1.0 depending on

the properties of the powder,

D- Super plasticizer dosage and the final water- powder ratio are determined so as to ensure compatibility.

The mix design is shown in Table (1).

3- Experimental work:

In this study, the effect of steel fiber on the deflection of self- compacted concrete slab was studied using slab specimens with dimensions of (600x250 mm) with thickness of 70mm. The slabs were reinforced with steel bars in two directions (in short direction ø4@145mmc/c) and (in long direction ø4@115mmc/c)as shown in Figure (1).

Three slabs were tested:

1/ Self- compacted concrete slab without steel fiber (SL1).

2/ Self- compacted concrete slab with {0.2% Vf} steel fiber added to concrete mix (SL2).

3/ Self- compacted concrete slab with {0.5%Vf} steel fiber added to concrete mix (SL3).

The slabs were repaired with a plate of dimensions (250*250) with 0.5mm thickness, when the cracks were appeared on the surface of the slabs. The repairing plate was fixed on the surface of the slab by epoxy as shown in Figure (2).

Table (1) Mix design used for self- compacted fiber reinforced concrete slab

Used materials	Amount content
cement	550 Kg/m^3
Coarse aggregate	832 Kg/m^3
Fine aggregate	825 Kg/m^3
Water/ cement ratio	0.21
Super plasticizer %from weight of cement content	9.5%

Nine concrete cubes were tested to found the compressive strength for three slabs and the average values for these cubes for slabs (SL1 to SL3) are shown in table (2) for twenty eight days curing.

In all mixes, the cement was Ordinary Portland cement, Type I, which was manufactured by United Company Cement factory/Iraq. Al-Ekhaider natural sand of (4.75mm) maximum size was used as fine aggregate. while the coarse aggregate was crushed gravel with max size of (19mm). The properties of the steel fibers added to concrete are listed in table (3) while the properties of steel reinforcement and steel plate are listed in table (4) . Twenty four hours after pouring, the slabs were stripped out from moulds and cured in water containers for twenty eight days. Then the slabs were removed from the water containers and then tested in a compression machine under two point loads as shown in Figure (3).

The two point loads were applied gradually until the cracks were appeared. The slabs (i.e. SL1 to SL3) were repaired with a repairing plate after the cracks were appeared on the surface of the slabs and then the slabs were retained back to the compression machine and the loads applied gradually until the slabs was failure. The gage of the machine was read the deflection of the slab with every applied load.

Table (2) Compression strength of SCC tested slabs

No. of slab	**%Vf steel fiber content**	**Compression Strength Mpa**
SL1	0%	34.85
SL2	0.2%	35.1
SL3	0.5%	37.7

Table (3) Properties of Steel Fiber

Property	Specifications
Density	7860kg/m^3
Ultimate strength	1130Mpa
Modulus of elasticity	200x10^{3}Mpa
Strain at proportion limit	5650x10^{-6}
Average length	250mm
Normal diameter	0.4mm
Aspect ratio(L\d)	625

Table (4) Properties of Steel Reinforcement and Steel plate used for repairing

Name of Steel Part	Dimensions (mm)	Yield strength (Mpa)	Modulus of elasticity Mpa	Poisson's ratio
Steel Bar Reinforcement	Diam ø4	420	200x10^3	0.3
Repairing Plate	250x250x0.5	250	200x10^3	0.3

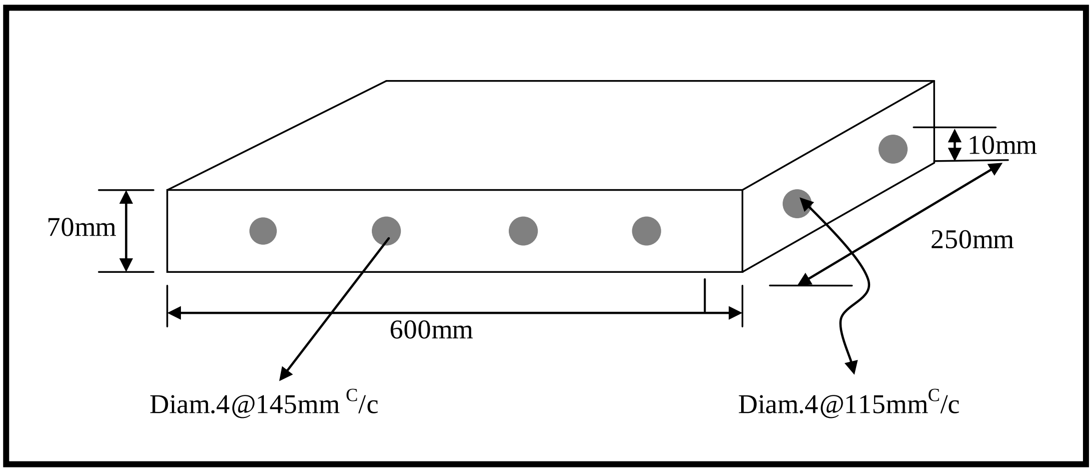


Fig. (1) Tested slab's dimensions and reinforcement.

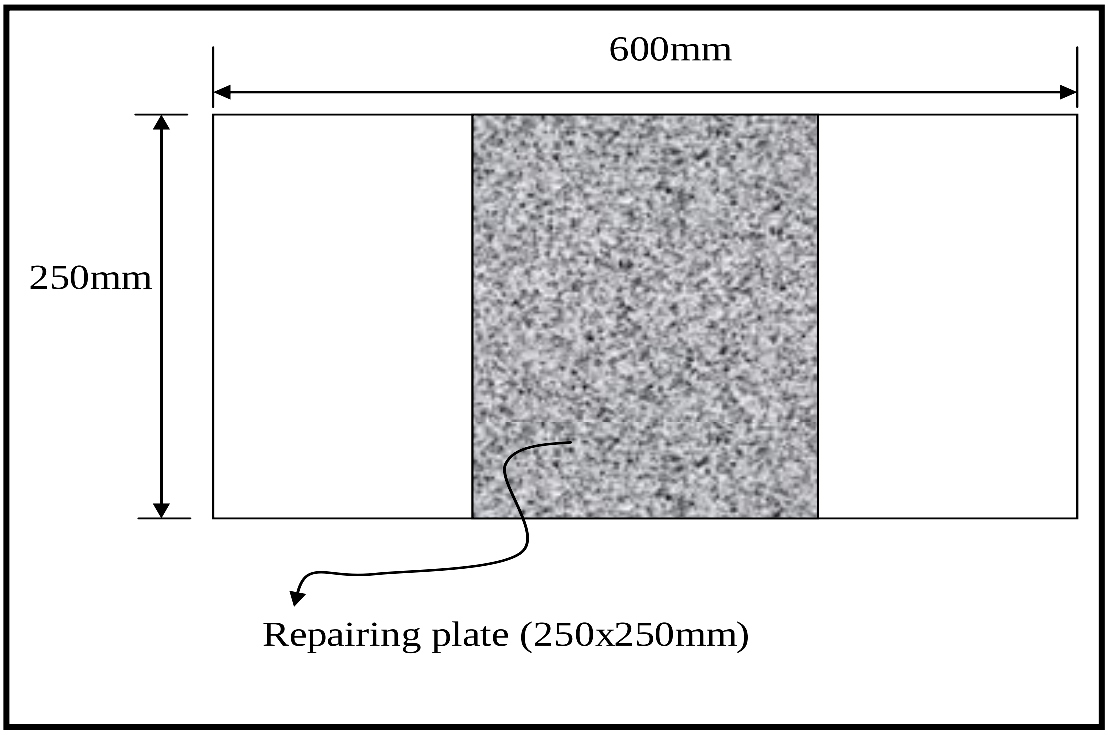


Fig.(2) Tested slab with repairing plate

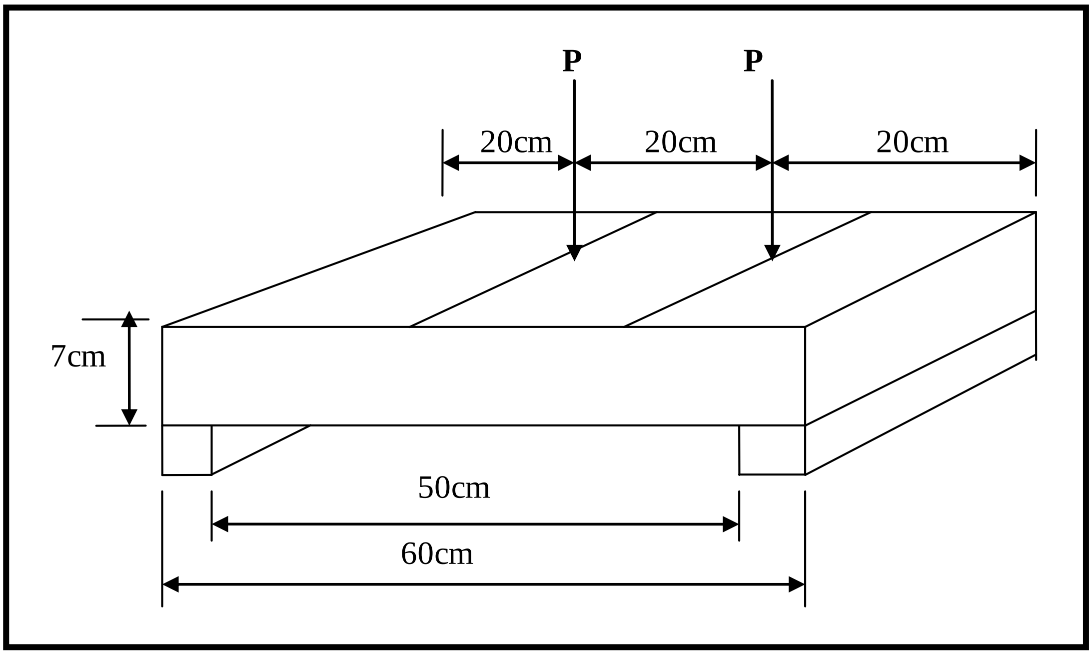


Fig.(3) Two point loads applied on the tested slabs with and without repairing plate

4-Theioritical Work:

4-1 Finite Element Software:

A successful analysis of an engineering problem needs the existence of an efficient code translation of the existing solution algorithm to be used by a digital computer. Finite element solutions are good examples of the fact due to the required target memories and tedious computations. For the present work purposes, it is sufficient to use a general pre-made programme, since neither special circumstances are met nor special aims are to be accomplished. On the other hand tables (5) represent the primary mesh for the case study in this paper.

4-2 ANSYS 7.0:

In this work, the commercial program ANSYS 7.0 [7] is used to accomplish the finite element solution. ANSYS 7.0 is an interactive finite element programme for the analysis of linear and nonlinear structural systems.

Static and dynamic analyses are achieved by a combination of one, two and three-dimensional elements. ANSYS 7.0 programme is capable of performing finite element analysis using about 100 elements.

4-3 Adopted Elements [7]:

The present study adopts several elements to simulate the reinforced slab and repaired slab as follows:

A- Solid 65 (Three- Dimensional Reinforced Concrete Element) :

This is used for the three- dimensional modeling of solids with or without reinforcing bars (rebar). The solid is capable of cracking in tension and crushing in compression in concrete applications, the solid capability of the element may be used to model the concrete while the rebar capability is available for modelling reinforcement behaviour as shown in Fig (4).(This element will be use for concrete and reinforced concrete parts).

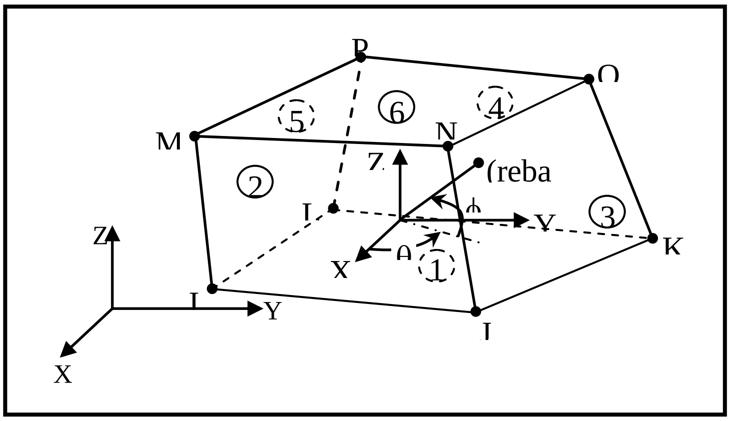


Fig.4 Solid65 three-dimensional reinforced concrete element

B- Shell 43:

This is well suited to model linear warped, moderately- thick shell structures. The element has six degrees of freedom at each node: translation in the nodal x, y, z directions and rotations about the nodal x, y, z axes as shown in Fig. (5). The deformation shapes are linear in both in-plan directions. This element will be use for steel plat using for repairing parts).

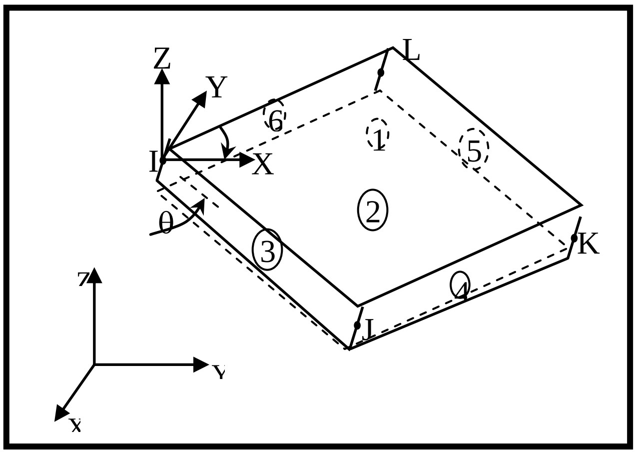


Fig.5 Shell 43 plastic large- strain element

C- Contact 52 (Point-to- Point Contact):

This represents two surfaces which may maintain or break physical contact and may slide relative to each other. The element is capable of supporting only compression in the direction normal to the surfaces ad shear (coulomb friction) in the tangential direction. The element has three degree of freedom at each node: translations in the node x, y, z directions as shown in Fig.(6). This element will be use representing the interface between concrete and reinforced concrete and the plate using in repairing parts (point to point contact element).

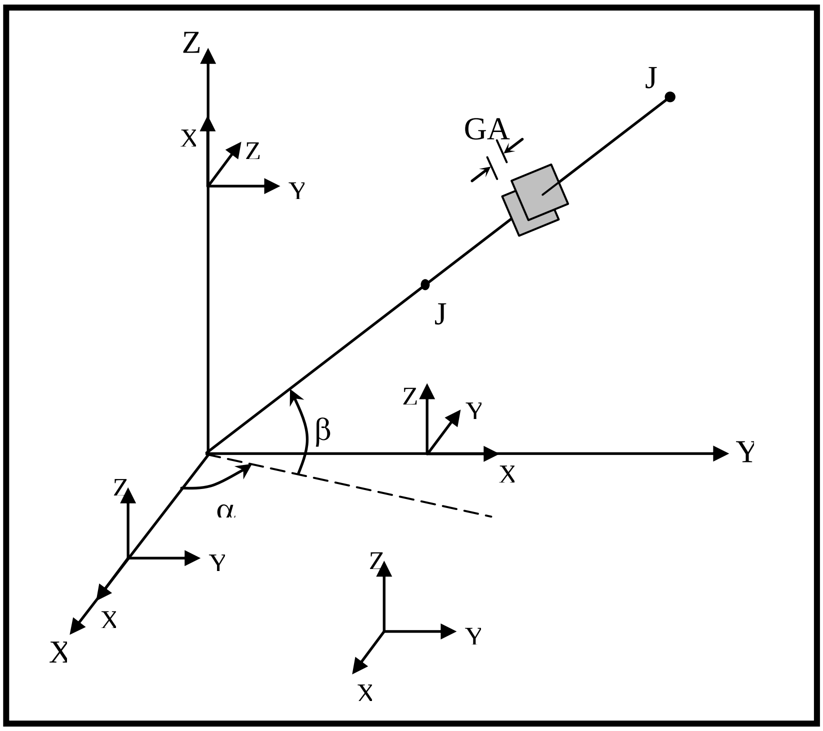


Fig. 6 Contact 52 (3D) point-to-point contact element.

Table (5) Numbers of elements at primary mesh (Per one layer)

Element type	Location of element	Numbers of elements per one layer
Solid 65	Concrete and reinforced concrete part	150000
Shell43	Steel plat using for repairing	62500
Contact52	Interface between concrete and plat (point to point)	63001

5- Discussion of the Results and Conclusions:

The ultimate strength in flexure could vary considerably depending up on the volume fraction of fiber, length and bond characteristics of the fiber and the ultimate strength of the fibers. Depending up on the contributions of these influencing factors, the ultimate strength of FRC could be either smaller or larger than its first cracking strength.

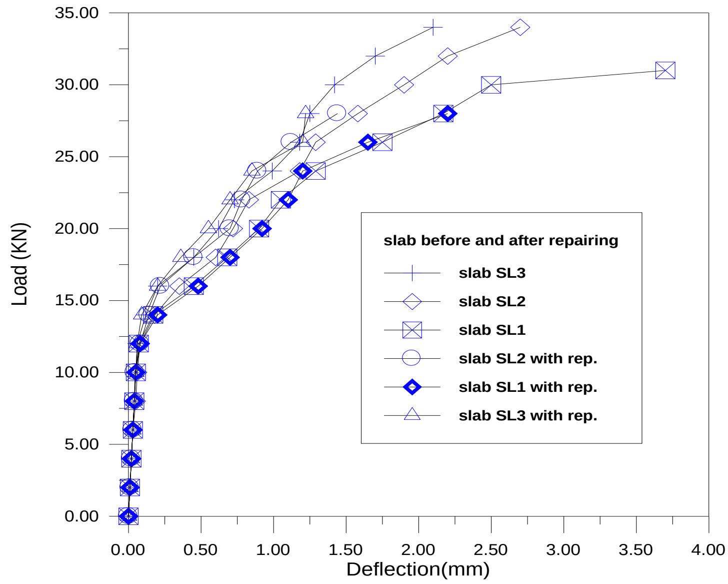
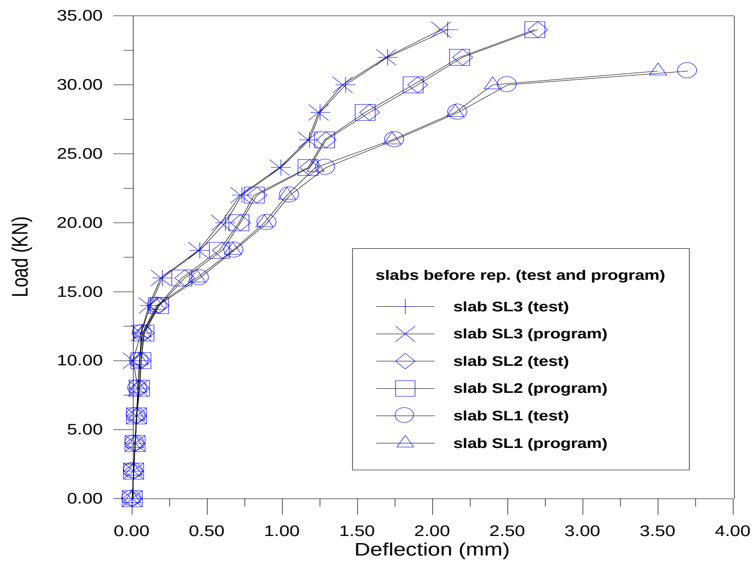
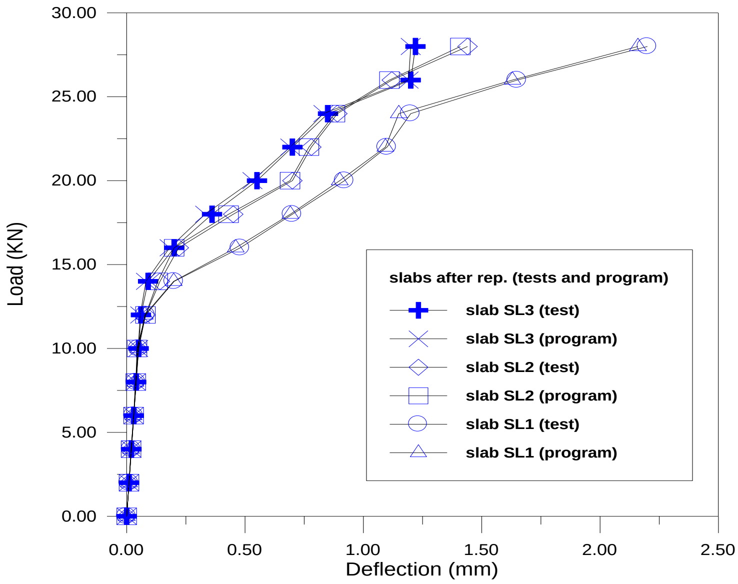


Fig. (7): Load-deflection curve before and after repairing.



Fig(8) Load- deflection curve for slabs before repairing (Test and Programs)



Fig(9) Load- deflection curve for slabs after repairing (Test and Programs)

The load deflection curves for slabs shown in Fig.(7) were nearly linear up to {11kN}. The strengthening mechanism in this portion of the behavior involves a transfer of stress from the matrix to the fibers by interfacial shear. The imposed stress is sheared between the matrix and the fibers until the matrix cracks at which was termed as "first cracking strength". After the first cracks stage the repairing plates were fixed on surface of the slabs as shown in Fig (2) , the slabs were retained back to the testing machine and the two point loads were applied on the surface of slabs gradually.

With increasing loads, the fibers tends to gradually pull out from the matrix leading to a nonlinear load- deflection response until the ultimate flexural load capacity for slabs(sl2, sl3) were reached. This point is termed as "peak strength". A post peak descending portion following the peak strength until complete failure of the composite. The load – deflection response in this portion of behavior and the degree at which loss in strength is encountered with increasing deformation is an important indication of the ability of the fiber composite to absorb large amount of energy before failure and is a characteristic that distinguishes fiber-reinforced concrete from plain concrete.

This characteristic is referred to as "toughness". From the load-deflection curve shown in Fig. (7), it is shown that:

1- when used 0.2% S.F. in slab (SL2), the load capacity in this slab increased by (8.8%) than (SL1), while deflection decreased to (46%). The deflection in slab (SL3) when 0.5% S.F. used, decreased to (43%) than slab(SL1) for the same load failure. .

2- The patterns given the same behaviors after repairing, since the deflection decrease in slab (SL2) by (45.4%) than SL1 after repairing in both slabs, and load capacity in slab (SL3) increased to (12.5%) than (SL1) after repairing in both slabs, while the deflection decreased to (38.6%) for the same load.

3- The results are shown that the steel fiber increase the load capacity and decrease the deflection. Since, the steel fiber increased the tensile capacity for concrete.

4- The repairing for slabs (SL1 to SL3) shown the load capacity can be increased after repairing as compared with before repairing to (5.8%) in slab (SL1), (9.6%) in slab (SL2) and (17.6%) in slab (SL3).

5- The behaviors of all cases of slabs in the initial loads in load –deflection curves shown in Fig. (7) until (11 KN) , is same, after that each slab behavior depended on its properties from steel fiber ratio.

6- From Fig (8) and Fig (9) , the results of deflections of various slabs samples is checked with the results of finite elements with differences less than 9%. The difference in results is due to the differences in adopting of material properties and structural supports fixing at experimental and theoretical representations of samples.

Photos of The Experimental Work

Fig. (10) The Machine That To Be Used In The Work And The Tested Repairing Slab (Structural Libratory In College Of Engineering In Al- Mustansirya University)

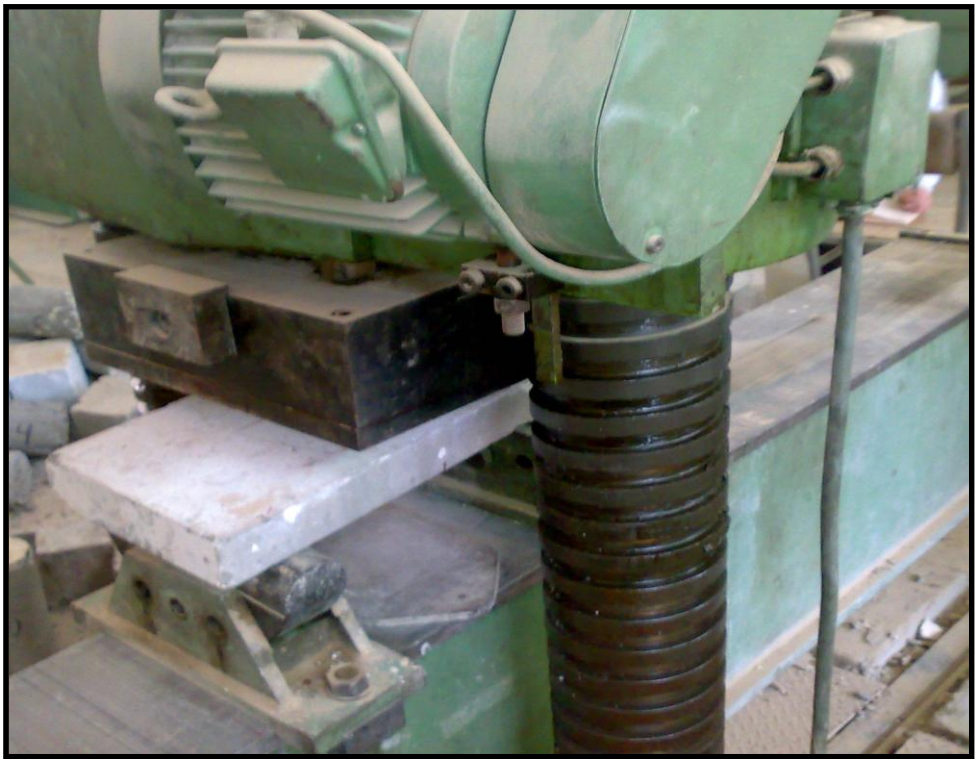


Fig (11) The Machine Applied Load On The Slab (Structural Libratory In College Of Engineering In Al- Mustansirya University)

Fig (12) Deflected Slab

Fig (13) Slab with Repairing Plat

5- References:

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