Supporting of Concrete bridge Damage by using Composite Materials

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Abstract:

Reinforced concrete is one of the most widely used modern building materials. The objective of this research is to study , experimentally behaviors and load carrying capacity of reinforced concrete bridge externally strengthened and repaired with Kevlar Fiber Reinforced concrete (KFRC) in compression test. The main aims of this research work are as follows: Experimentally investigate the comparison behavior of reinforced concrete deep beams strengthened with KFRC strips., Comparison between the behaviors of strengthened and repaired column .six sample are used for this project, three of this are made of concrete , three with knock and three with reinforced by Kevlar mat , for testing concrete deep beams. the load carrying capacity of repaired cracked deep beams by KFRC strips have also been investigated.

Keywords : *compression test , notch , Kevlar reinforced concrete.*

الخلاصـــــــة:

ان الخرسانة المسلحة هي واحدة من مواد البناء الحديثة الأكثر استخداما. والهدف من هذا البحث هو دراسة تجريبيا السلوكيات وتحميل الطاقة الاستيعابية للعمود من الاسمنت المسلح من الخارج وتعزيز وتدعيم بالخرسانة المقواة بالمواد المركبة (الياف الكيفلر) (KFRC) في اختبار الضغط. الأهداف الرئيسية لهذا البحث هي كما يلي : دراسة عملية في سلوك تجريبية للخرسانة المسلحة العميقة المعززة مع حصائر الكفلر (KFRC). ، و مقارنة بين سلوك الاسمنت والاسمنت المدعم بالمواد المركبة وإصلاح العمود. تم استخدام ستة نماذج لهذا المشروع , ثلاثة من هذه النماذج مصنوعة من الخرسانة المسلحة ، وثلاثة نماذج مصنوعة من الخرسانة المسلحة وعمل بها شق وثلاثة نماذج مصنوعة من الخرسانة المدعمة بحصيرة الكيفلر ، وعرضت لاختبار الضغط.

و تحميل الطاقة الاستيعابية للإصلاح التصدع العميق الحزم من قبل شرائح KFRC كما تم التحقيق فيها ومناقشتها.

1. Introduction :

The term ultra high strength concrete (UHSC). Is generally used for concrete having a 28 days cube . the use of ultra high strength concrete in construction industry has steadily increased over the past years ,since it reduces the dead weight of structural element. This in turn leads to the smaller sections , allowing longer span and more usable area of buildings [1]. The use of concrete having strengths higher than the normal is economically attractive in some applications . for instance ,doubling the strength of concrete from (35-70 N⁄mm^2), leads only to marginal increase in material cost and may lead to a decrease in structural cost , however , the applications of ultra-high strength concrete are hindered by it is relative brittleness or lack of ductility . it is generally agreed that the higher the strength of concrete ,the lower it is ductility so that the observed inverse relationship between strength and ductility is considered in some structural applications. However , such a drawback can be overcome by the addition of strong discontinuous fiber .the concept of using fibers to improve the characteristics of construction material is very old. the addition of fiber to concrete makes it more homogeneous and isotropic and transform it from a brittle to a more ductile material [2],[3].

The reinforced concrete beams are commonly classified as deep and shallow beams according to their shear span-to-depth ratio or clear span to over all depth. Deep beams behave differently from shallow beams. They are identified as discontinuity regions where the strain distribution is significantly nonlinear and specific strut-and-tie models need to be developed, whereas shallow beams are characterized by linear strain distribution and most of the applied load is transferred through a fairly uniform diagonal compression field. Based on many experimental and analytical studies, the mechanisms of shear transfer in a cracked concrete shallow beam include the shear in the un cracked concrete compression zone, aggregate interlock along diagonal crack planes, dowel action of longitudinal reinforcement and truss action of vertical web reinforcement. On the other hand, deep beams, having a nonlinear strain distribution over the cross sectional depth due to a smaller shear span-to-overall depth ratio and extraordinarily high concentric load, carry a significant amount of the applied load by strut-and-tie action. Owing to shear deformation and redistribution of stresses in cracked concrete struts, the conventional beam theory or shear hypotheses developed for slender beams would not be applicable to deep beams [4]. In[5] , tested thirty-eight reinforced concrete beams of 1800 mm length strengthened in shear with externally bonded carbon fiber reinforced plastic plates. The relative performance of a group of sixteen beams with the same steel reinforcement but with different amounts of shear strengthening is discussed. All the beams were designed to fail in shear using a spreadsheet program.

The spreadsheets were designed to ensure that the beams' flexural capacity exceeded the shear capacity after strengthening. The variables considered were main reinforcement ratio, spacing between links in the shear span and different configurations of KFRC on shear spans.

The majority of the beams tested showed a significant improvement in shear strength by the addition of CFRC, with increase ranging between 19-122% over the control beams. [6] tested five concrete columns strengthened with CFRC in order to investigate the mechanism of their shear behavior. The shear transfer mechanism of the specimens reinforced with CFRC was studied. The factors affecting the shear capacity of reinforced concrete columns strengthened with CFRC were analyzed. Several suggestions were concerning with the number of layers, width and tensile strength of the KFRC are proposed for this new strengthening technique. Also, simple and practical design method is presented. The calculated results of the suggested method are shown to be in good agreement with the test results [7].

2. Failure Criteria for Concrete

The concrete material model predicts the mode failure of brittle materials such as concrete. Both cracking and crushing failure modes are accounted for. The two input strength parameters ultimate uniaxial tensile and compressive strengths are needed to define a failure surface for concrete. Failure of concrete due to a multiaxial stress state can be calculated using William and Warnke [8] criterion

in 1975;

$$\frac{F}{f_c} - S \geq 0$$

where:

F = a function of the principal stress state (σxp, σyp, σzp)

S = failure surface expressed in terms of principal stresses and five input

parameters ft, fc, fcb, f1 and f2.

ft = ultimate uniaxial tensile strength

fc= ultimate uniaxial compressive strength

fcb= ultimate biaxial compressive strength.

f1=ultimate compressive strength for a state of biaxial compression

superimposed on hydrostatic stress state.

f2 =ultimate compressive strength for a state of uniaxial compression

superimposed on hydrostatic stress state.

σxp, σyp, σzp = principal stresses in principal directions.

However, the failure surface can be specified with a minimum of two constants,

ft and fc.

3.Experimental Work :

During its concrete reinforced that have different behavior under load with different material used for reinforced so in this study focus in using Kevlar for repair column of concrete and testing it under compression test below are the main steps for making the sample of test:

1- Mixing sand, cement, &gravel with water according to American ratio of mix.

Where ratio mix is;

a-cement 400g⁄cm^3

b-sand 750g⁄cm^3

c-gravel 1500g⁄cm^3.

d-water rang (0.4-0.5) cm^3.

Where that equal 1:1.2:2.8 cement sand gravel respectively .

2- Preparing the mold by cleaning and lubricated with oil.

3-Iron mold have volume of (10*10*10) cm^3 .

4-First preparing six sample solid with cubic shape see Fig.(1)

Fig.(1) the samples

5- After 24h opened the mold and put the sample in water for 28 days.

6- Make another six sample three with notch (with dimension 30mm*100 mm at V figures) and the other without. See Fig.(2)

Fig.(2)notch sample

7- After that make joining with Kevlar by using adhesive material .see Fig. (3)

Fig. (3) the sample with Kevlar

The material used to bonding between Kevlar and concrete is (p.v.c) it contain [methyl ethyl ketone ,tetra hydro furan ,& cyclo hexanon]

8- Allow it sufficient time to make good bonding

9- By making good surface roughness of concrete to make good bonding.

10- The compression test consist of three group;

A- group one sample without notch.
B- group two sample with notch.
C- group three sample repair notch with Kevlar , see Fig.(4) A,B ,C

Fig.(4) A. solid sample B. sample have notch C. repair sample with Kevlar .

11- After 28days now the sample is ready to test. see Fig.(5)

Fig. (5) the samples after 28days in water

12-When the groups tested it is found that the load carry by it. After test the sample cracked see Fig.(6)

Fig.(6) the sample failure

The results obtained from the test are, in first stage preparing six samples of natural concrete and without k notch is to be tested and read the Force. The sample is tested and below is the load carry by it (after 28 days)and To determine the stress of these samples by the equation :

Stress(MPa)=F/A

F:Force (N)

A:Area ($mm^{2)}$

For:

1- A-Solid state

stress =F/A

F=157.25KN

A=10*10cm^2

stress=157.25*10^3(N)/10*10*10^2 mm^2

stress=15.725 MPa

2-sample have notch

stress =F/A

F=93.055KN

A=7*10cm^2

stress=93.055*10^3(N)/7*10*10^2 mm^2

stress=13.3115 MPa

3- C-sample have notch and repairs by Kevlar

stress =F/A

F=145.01KN

A=10*10cm^2

stress=145.01*10^3(N)/10*10*10^2 mm^2

stress=15.5 MPa

Table (1.1) : show in below the average results of examples for three statements.(after 28 days)

Specimens	Force (KN)	Stress (MPa)	Average stress (MPa)
A-Solid state	155.5	15.55	15.725
	159	15.9	
B-Sample have notch	87.31	12.473	13.3115
	98.8	14.15	
C-Sample have notch and repairs by Kevlar	146.51	14.651	14.51
	147.37	14. 37	

*And the curve below is show the relation between stress and strain for the samples of this table for statement A (solid state).

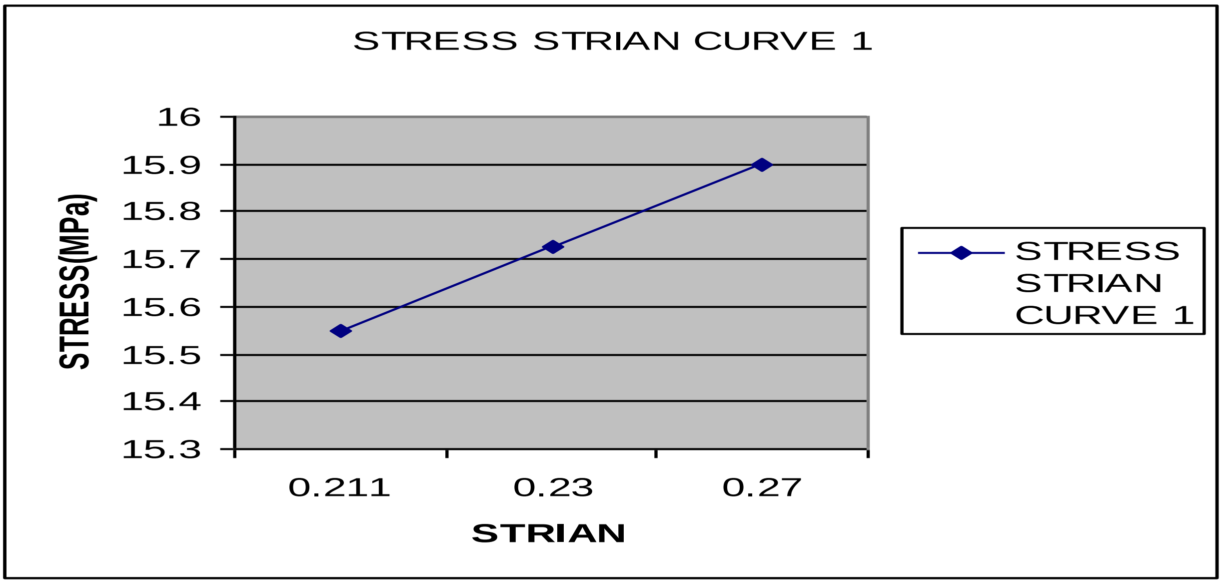

Fig.(7) the result of samples(A)

*And the curve below is show the relation between stress and strain for the samples of this table for statement B (Sample have notch).

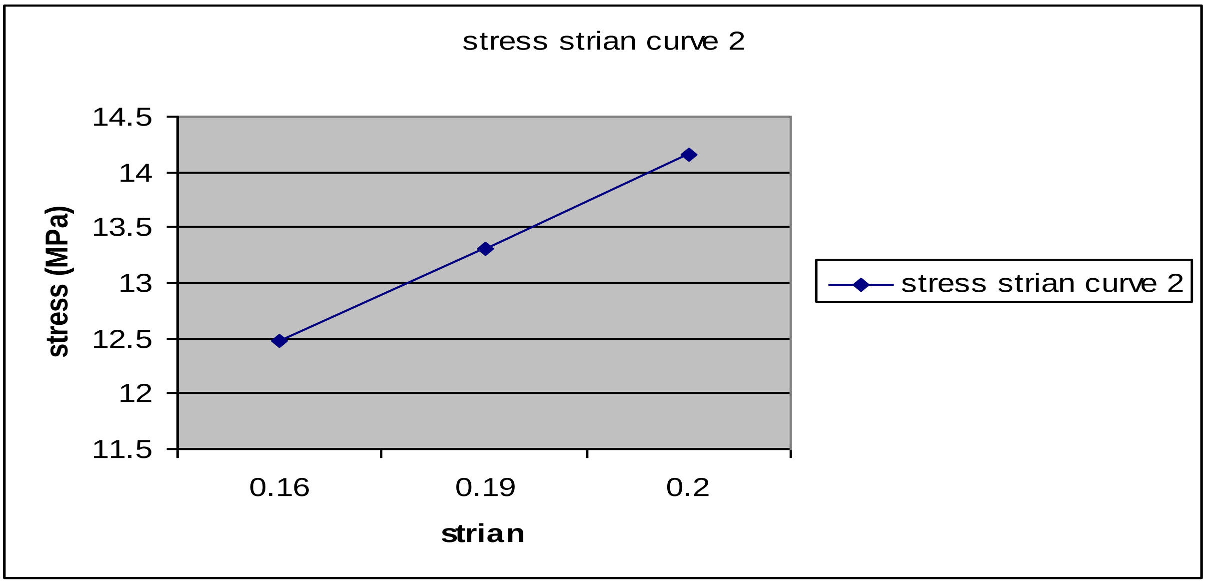

Fig.(8) the result of samples(B)

*And the curve below is show the relation between stress and strain for the samples of this table for statement C(Sample have notch repair by Kevlar).

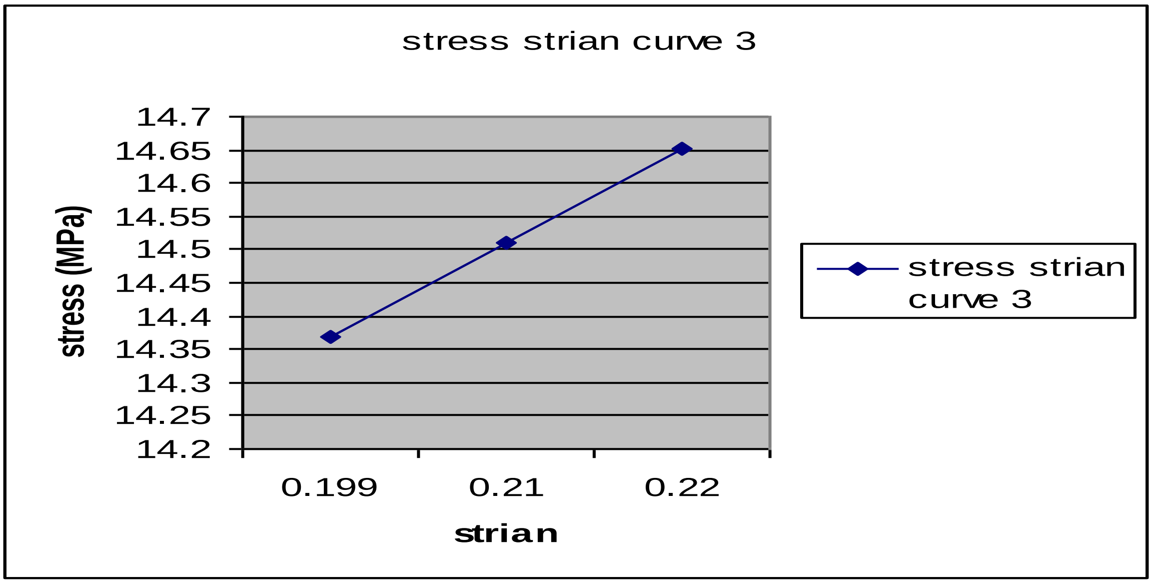

Fig.(9) the result of samples(C)

And Fig. (10)

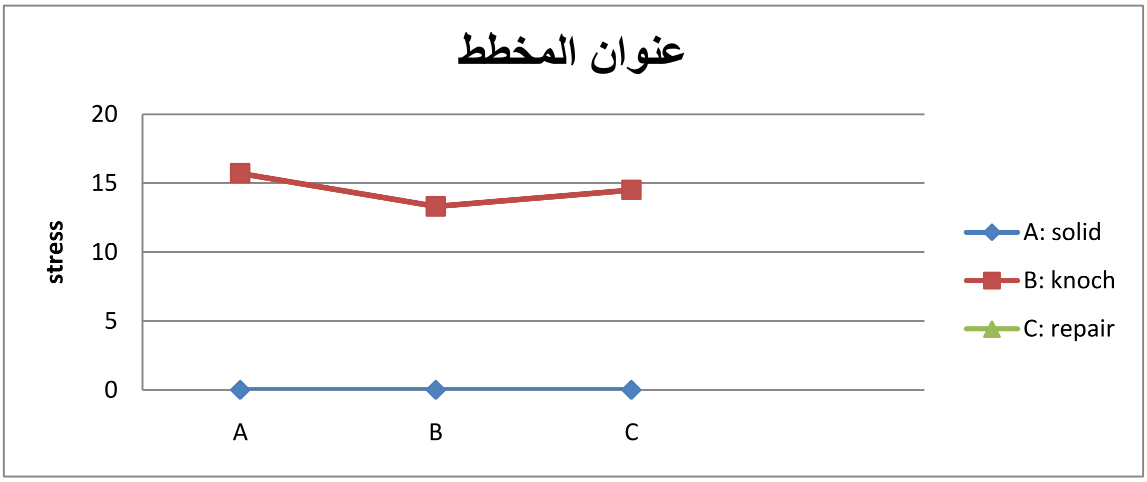

Fig.(10)the comparison between A,B,C specimen

In this Fig.(10) show the relation between statement (A,B,C) and the value of the yield stress

4. Discussion

Because of the damage and cracks in the concrete resorted to the need for quick fix and content of the towers, concrete structures and to obtain results close to the original state without damage from the forces of carrying qualities of resistance to the refuge need to research a process to address the damage using composite materials to repair the damage and get on the characteristics approach the situation Alasip.

Concerned The work contained in this research is primarily with studying the behavior and load carrying capacity of reinforced concrete deep beams strengthened or repaired by KFRC strips in compression test. The experimental work consisted of six cubic Columns divided into three groups. The cubic Columns dimensions were (10*10*10) cm3 in width, height and length respectively.

The experimental work indicated that the adopted strengthening significantly increases the compression capacity of the considered deep beams.

Ultimate loads were achieved for deep beams strengthened with KFRC strips as compared with unstrengthened control deep beam. It was found that for deep beams strengthened with KFRC strips in compression test., the ultimate load increased to ultimate load of control deep beam.

For deep beams repaired with KFRC strips in compression test., the ultimate load increased by (70% to 75%) with respect to ultimate load of control deep beam.

A decrease in the width of cracks due to presence of KFRC strips was occurred. The average decrease was about 73 % of the crack width of the control deep beams at ultimate load levels.

The percentage of increase in the load carrying capacity of the repaired deep beams is almost similar to that of the corresponding strengthened deep beams.

For reinforced concrete strengthened deep beams tested in this work, the concrete normal strain distribution was approximately linear in compressive zooms of beams cross section at low load levels, due to crack propagation.

In this study, the Notch block of concrete were repaired by composite materials type of FRC ranging , very fast curing. The detailed repair the following preliminary discussions are obtained:

While good interfacial bonding does not increase the overall compressive strength of the repaired samples to a noticeable degree, it does increase the stiffness significantly.

Reached in this research that address the fissures made in concrete by adding Kevlar return properties of the material in the concrete pressure test to the situation as transfer fault-tolerance in the amount of pressure.

5.Conculosion :

1- The composite materials can used to repair the concrete damage and this method is economy .

2- Can repair cracks in concrete happening without recourse to remove it, especially in the giant bridges and building structures.

3- Kevlar repair process by adding a light-weight composite materials and therefore do not affect the weight of concrete Rift.

4- As for the viability of composite materials high insulation so take advantage of this to improve the viability of testicular concrete segregation.

5- When adding an article Kevlar of the Rift is part of concrete to increase the power of endurance if the concrete does not by cracking (in the same strength and endurance).

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