Journal of Engineering and Applied Sciences 14 (Special Issue 2): 5413-5417, 2019
ISSN: 1816-949X

Reduce Structural Cracks in the Reinforced Concrete Beams using Steel Mesh

Zaid Ali Kadhim, Salam Al-Obaidi and Alaa Jaleel Naji
Department of Roads and Transportations Engineering, University of Al-Qadisiyah,
Al Diwaniyah, Iraq
Tel. 00964789720719, email: salammaitham@yahoo.com

Abstract: In this study, the effect of addition of layers of steel mesh with the dimensions 3×3 and 6×6 cm to a section of concrete reinforced beam on both of the maximum load and the amount of deflection as well as the width of the shear crack and flexure crack of the section has been studied. The six samples were examined; The two of which as reference beams. The two beams were added a layer of steel mesh with the dimensions (3×3 cm) to the sides and down, respectively as well as two samples have been added layer of steel mesh with the dimensions (6×6 cm). Deflection and width of cracks as well as the maximum load were measured, the failure pattern for each samples were also observed. Depending on the results it was concluded that adding steel mesh increases maximum crackload by 25% for dimensions (3×3 cm), on the other hand, the dimensions (6×6 cm), the increase was 7% when used at the bottom while up to 25% when used from the sides.

Key words: BRC, crack, deflection, pattern of failure, shear failure, dimensions

INTRODUCTION

There are many different types of concrete cracks and are due to different factors such as heat shrinkage cracks and plastic shrinkage cracks and structural cracks (ACI Committee 318, 2005) in this project we will study structural cracks. Structural cracks: reinforced concrete is subjected to tensile stresses when loading the structure, therefore, cracks occur in the beams in the side exposed to the tensile under the influence of bending moment. If the steel reinforcement used is properly distributed and the concrete was of good quality then these cracks are sufficiently accurate to avoid steel corrosion, generally, these cracks are acceptable, if they are thick (0.2 mm), experiments have shown that corrosion and rust increase rapidly when the thickness of the crack >(0.4 mm) (Diab, 2008; Al-Nasra and Asha, 2013; Tejaswini and Raju, 2015).

Some cracks may appear as a result of shear stresses and be slanted cracks at a 45° angle and it is caused by defects in the bonding of large-diameter steel reinforcement with concrete, especially, if the cover of the steel thickness is low. However, in some cases the cracks appear to be dangerous like: bending moment and shear cracks that are continuously enlarged in a continuous form, cracks occur in concrete parts subjected to compression indicating that unusual behavior occurs in the structure. Crushing of concrete in compression areas and this situation is the most dangerous to the structure.

When such types of cracks occur, it is necessary to strengthen the structure and remove loads immediately and then examine the basis and source of the defect in this structure and it begins to solve the problem of strengthening the structure and how to repair the cracks. As a geometric work, it is necessary to take the necessary precautions to prevent the occurrence of such cracks in the concrete beams.

The occurrence of cracks in the concrete beams in the future lead to serious complications and sometimes lead to the collapse of structure because the cracks allow the entrance of the moisture and air into the concrete, resulting in corrosion of the steel and thus, a failure in the tensile areas in the concrete (Elbasha, 2012).

Most studies focus on how to repair cracks and reduce the resulting effects in a variety of ways and sometimes economically expensive or there may not be a radical repairing to reduce the risk of cracks (Al-Nasra and Asha, 2013; Tejaswini and Raju, 2015; Elbasha, 2012; Chan and Anson, 1995).

With the development of experience and the development of knowledge and after most equations (ACI) (ACI Committee 318, 2005) depends on the occurrence of failure or not and therefore, the design depends upon the occurrence of a crack or not.

Equations have been developed based on the ratio of steel reinforcement, subjected loads and influencing moments and how to calculate them to reduce the occurrence of cracks in the concrete beams and this caused a breakthrough in the process of reducing cracks and calculate the quantity of steel accurately, so that, there is no failure of tension or compression in the future.

Corresponding Author: Zaid Ali Kadhim, Department of Roads and Transportations Engineering, University of Al-Qadisiyah, Al Diwaniyah, Iraq

MATERIALS AND METHODS

Experimental work: In this study, we will discuss the primary materials used in the study as well as their properties and quantities and their conformity with the Iraqi and international standard specifications where construction materials were examined raw (cement, gravel, sand, steel reinforcement) as well as the wood briquettes used in this study and the equipment.

Structural materials: Laboratory tests for construction materials were carried out in the engineering laboratories and were in accordance with the specifications according to Iraqi standard specifications. The five wood moldings were made with the appropriate hand dimensions of (120 cm) length (20 cm) width and (30 cm) high. The wood reinforced was used for its high resistance to water and it also had the strength to withstand and contain the concrete as shown in Fig. 1.

Mixture: After the preparation of the primary materials conforming to the standard specifications and the completion of the preparation of the molds began to work on the concrete mix where a mixing ratio (1:1.5:3) was chosen and the ratio of the water content to the weight of cement (0.5%). The quantities of structural materials required for the research of the concrete mix were also, calculated to produce the five samples of the concrete beams with the dimensions mentioned above. The total size of the concrete required for casting the beams samples with the concrete of the cubes with a damage factor of 10% is 0.4005 m^3 and according to this volume was calculated as shown in Table 1. Concrete slump testhas been conducted to ensure that the workability is suitable and according to the Iraqi standard specifications.

Fig. 1: Molding of wood

Compressive strength: The compressive strength of the concrete was tested in two stages; the first stage was performed before the process of casting the concrete beams to obtain appropriate resistance to design a primary design. The second with the process of casting the concrete beams to confirm the validity of the resistance may not have occurred correctly in the first, instance with the adoption a mixing ratio (1:1.5:3) and the water cement ratio was (0, 5) from cement content with a percentage of the damage factor of 10%. A total of 12 concrete cubes were casted after calculating the required quantities of materials. The dimensions of the cubes used were (15*15*15 cm), (6) at 28 days, the remaining (6) precaution and the results of the examination as shown in the Table 1 (Fig. 2).

Table 1: Cube test results for concrete mix

Force (kN) at 28 days	f_{cu} (28 days) (MPa)
567.36	25.2
573.32	25.5
695.81	30.9
660.76	29.4
613.80	27.3
638.70	28.4

(a) (b) (c)

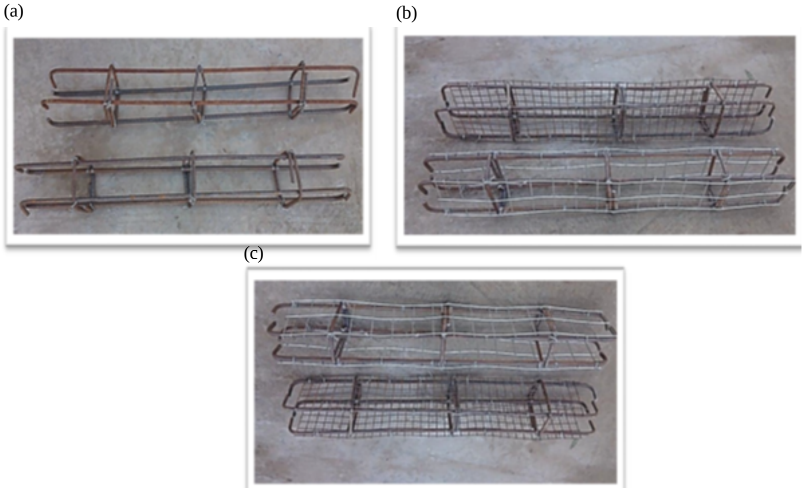

Fig. 2: a-c) Reinforcing the reference beam

Fig. 3: Main test device

Fig. 4: Crack meter

Casting the specimens: The five samples of reinforced concrete beams of the aforementioned dimensions were casted and divided in to three groups, the first group: standard sample and unused of steel mesh. The second group using steel mesh with deferent dimensions 3×3 and 6×6 cm in the sides of steel reinforcement. The third group; using steel mesh with deferent dimensions (3×3) and (6×6 cm) at the bottom of the reinforced section as shown in Fig. 2.

The samples were cast in the laboratories using the appropriate equipment and tool such as (pan mixer) with 0.2 m^3 capacity, vibrators and some tools necessary for work. The materials were mixed using a pan mixer to cast six samples. The materials were mixed with a blower to cast six samples which were mixed well to homogenize the initial materials with each other and then the process of casting the samples was carried out. The process of curing was carried out using shale and sprayed with water during the period of cure as shown in Fig. 3.

Test setup: After the completion of the casting process and the cure of the samples were prepared for testing as explained in Fig. 3. The equipment of the laboratories of the Faculty of Engineering at the University of Al-Qadisiyah has been used to provide a gradual load that enables us to monitor the occurrence of cracks in the beams and measurement the cracks at each load. The width of the cracks was measured by using the crack meter which is consisting of a magnifying glass with axes in the form of letter (T), the testers rotate the axes perpendicular to crack and read the cracking width where the instrument measures (0.05 mm) as shown in Fig. 4.

RESULTS AND DISCUSSION

After conducting examination, we will review and discuss the results we have obtained.

Results of samples tests for crack width: After testing for all samples, the crack width values were recorded as shown in Table 2.

Table 2: Crack width values for the samples and maximum load

	Flexure crack		Shear crack		
Samples/Cracks	Load	Crack width (mm×10^{-3})	Load	Crack width (mm×10^{-3})	Maximum load (kN)
Ref					
1st crack	20	25	40	25	114
Final crack	80	213	80	80	
Steel mesh (3×3 cm) bottom					
1st crack	30	15	35	35	138
Final crack	80	60	80	90	
Side					
1st crack	30	20	35	10	143
Final crack	80	60	80	90	
Steel mesh (6×6 cm) bottom					
1st crack	30	20	40	15	122
Final crack	80	125	80	285	
Side					
1st crack	35	35	55	40	143
Final crack	80	128	80	135	

Table 3: Deflection values for the samples

		Steel mesh (3×3)		Steel mesh (6×6)	
Load (kN)	Reference	Side	Bottom	Side	Bottom
5	0.45	0.55	0.50	0.40	0.42
10	0.55	0.70	0.60	0.49	0.50
15	0.65	0.85	0.70	0.58	0.58
20	0.78 1st crack	1.09	0.80	0.68	0.69
25	1.01	1.38	0.97	0.78	0.78
30	1.16	1.67 1st crack	1.42 1st crack	0.87	1.22 1st crack
35	1.44	1.96	1.76	1.37 1st crack	1.45
40	2.09	2.36	2.09	1.53	2.00
45	2.30	2.59	2.28	1.74	2.30
50	2.45	2.87	2.54	2.46	2.74
55	2.92	3.15	2.78	2.69	2.85
60	3.05	3.41	3.01	3.27	2.90
65	3.38	3.68	3.22	3.55	3.05
70	3.47	3.76	3.70	3.70	3.22
75	3.56	3.91	3.74	3.96	3.48
80	3.83	4.13	3.92	4.20	3.63
85	4.05	4.31	4.20	4.36	4.07
90	4.31	4.68	4.50	4.55	4.68
95	4.68	4.92	4.71	4.76	4.92
100	4.95	5.05	4.92	4.89	5.15

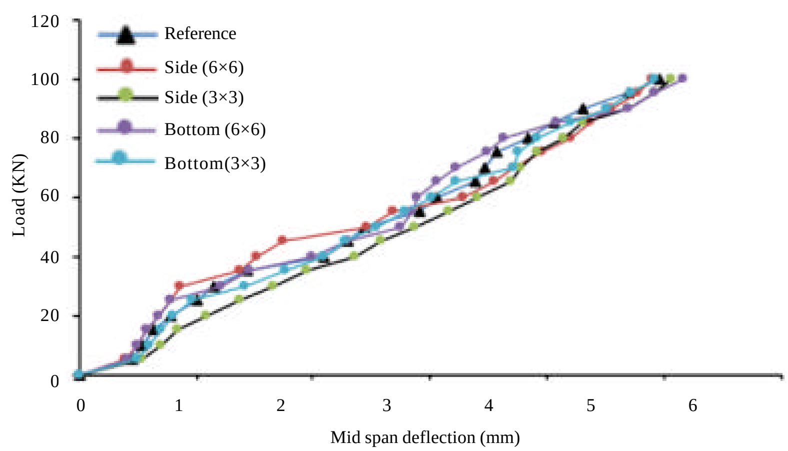

Fig. 5: Load-deflectioncurves for testing beams

Results of samples tests for the deflection: After testing for all samples, the values of the deflection were recorded at the middle of the length of beam as shown in Table 3.

Load-defle ctioncurves for samples: Figure 5 shows the load deflections curves for the tested specimens.

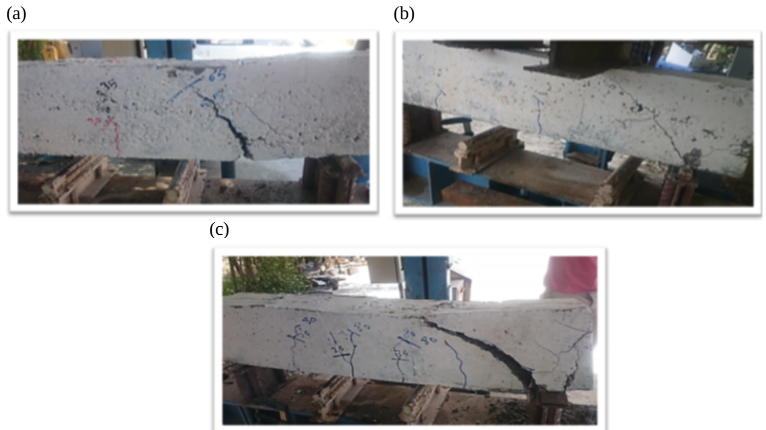

Fig. 6: a-c) Flexural failure for standard (reference) beam

Table 4: The failure patterns for testing samples at the maximum load

Name of simple	Types of failure
Ref	Shear
BRC 3*3	
Bottom	Shear
Side	Shear
BRC 6*6	
Bottom	Shear
Side	Shear

Patterns of failure: After completion of the examination, the failure patterns at the maximum load as indicated in Table 4 and shown in Fig. 6.

CONCLUSION

Depending on the results of the practical study conducted it is possible to conclude the following; adding steel mesh to the sample as an additional reinforcement to the main reinforcement to the types of the section (3×3) (6×6 cm) in the bottom and side of the sample has a clear effect on first crack load where there has been an increase in bearing the beam (3×3 cm) Reinforced (BRC) in the bottom and side by 25% while the beam 6*6 cm reinforced in the bottom the increase wasnly 7% while the increase when used from the sides is 25%. Al-Obaidi *et al*. (2018). There is no obvious effect of steel mesh when used on the deflection values (Abid and Al-Lami, 2018). Using steel mesh reduces the width of the crack (Al-lami, 2015) by flexing by 72% for dimensions 3*3 cm and 40% when the dimensions (6*6 cm). The sample with dimensional (3×3 cm) steel mesh from the side is the best in terms of loading, slumped and crack width.

ACKNOWLEDGEMENT

Researchers would thank their collegues for their guidance and advice on this project. Researchers also would thank their students for their support and help on experimental work of this project: researchers extend their sincer appreciation to Mr. Qanim for his help in setting up the data acquisition system and facilitating the experimental works.

REFERENCES

ACI Committee 318, 2005. Building Code Requirements Concrete (ACI 318-05 and Commentary (ACI 318R-05). American Concrete Institute, Farmington Hills, Michigan, Pages: 430.

Abid, S.R. and K. Al-Lami, 2018. Critical review of strength and durability of concrete beams externally bonded with FRP. Cogent Eng., 5: 1-27.

Al-Nasra, M.M. and N.M. Asha, 2013. Shear reinforcements in the reinforced concrete beams. Am. J. Eng. Res., 2: 191-199.

Al-Obaidi, S., T. Salim and S.A. Hemzah, 2018. Flexural behavior of concrete filled steel tube composite with different concrete compressive strength. Intl. J. Civil Eng. Technol., 9: 824-832.

Al-lami, K.A., 2015. Experimental investigation of fiber reinforced concrete beams. MSc Thesis, Department Civil and Environmental Engineering, Portland State University, Portland, Oregon, USA.

Chan, S.Y. and M. Anson, 1995. High-strength concrete: The Hong Kong experience. Mag. Concr. Res., 7: 121-132.

Diab, A.M., 2008. Lap splices in reinforced concrete beams subjected to bending. Master Thesis, University of Alexandria, ?Alexandria, Egypt.

Elbasha, N.M., 2012. A New Reinforced Concrete Beam. In: High Performance Structures and Materials VI, Wilde, W.P., C.A. Brebbia and S. Hernandez (Eds.). WIT Press, London, UK., ISBN:9781845645960, pp: 53-62.

Tejaswini, T. and M.V.R. Raju, 2015. Analysis of RCC beams using ABAQUS. Intl. J. Innovations Eng. Technol., 5: 248-255.