Performance enhancement of damaged two way concrete slabs

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Abstract

This paper studying the flexural behavior of reinforced concrete with two-way slabs repairing by (CFRP). Normal concrete was used to cast the reinforced concrete two-way slabs. The experimental works includes testing four reinforced concrete with two-way slabs having dimensions (1050 mm x1050 mm x 60 mm) and with reinforcement (Ø8 @100 mm). All slabs had been subjected to concentrated load and tested as simply supported for all four sides of slabs. So this work including one slab which is not repairing as (control) and three slabs with repairing, the three slabs can be divided into two groups tested as different percentage (50 % and 75 %) of load, and as different configuring shapes of repairing (two shapes).

Keywords: CFRP , FRP, Repairing slab.

1.Introduction

During the lifetime of bridges, buildings, etc. Concrete structures, concrete members may be exposed to mechanical, environmental and excessive loading due to design changes and requirements Population density increase. This can lead to cracking and the loss of performance of these organs has been felt since then it is a fragile substance. To prevent this, strengthening or repair is required. There are various repair techniques such as FRPs, steel plates, expand the section, And ferrocement . in the 1980s, FRPs were first introduced. The only success the FRP industry has achieved is its use of repair and consolidation. Compared to traditional repair techniques, fiber-reinforced polymers were created as an effective method that applies to many types of concrete structures such as reinforcement, grating in concrete, and edges around columns and sidewalks are just a few examples of the wide applications of these compounds[1],because repair using FRP
materials has many advantages, such as wear resistance, lower maintenance cost, high energy-to-weight ratio, and quick and easy configuration Compound .fiber reinforcement materials have higher final strength and lower density than steel. The low weight makes handling and installation much easier than steel. Among these advantages of this technique are reducing the service load pressure in the rebar, the slit width decreases and means the slitting distance, and the corresponding resistance increases to the first longitudinal steel production [2]. Three types of fiber reinforced polymers are mainly used to repair existing structures (GFRP, CFRP, AFRP) in this paper (CFRP) is used for repair. Nearly 95% of all are made of carbon fiber to enhance civil engineering applications [3]. Carbon-fiber reinforced polymer (CFRP) has high strength for weight ratio and appropriate fatigue behavior and is excellent resist electrochemical corrosion to make it practical suitable for structural application [4]. Toong and Li [5] studied the effect of carbon use fiber reinforced polymer sheets strengthen the one-way span slab to increase bending ability with special focus on cracking behavior at work load. Enhance all CFRP samples showed a significant increase in pregnancy capacity ranges from 60% to 140%. The examination of Obaida and Marzouq (2004) [6] use FRP (carbon fiber reinforced) strips polymer (CFRP) and glass fiber reinforced polymer (GFRP) to reinforce two-way reinforced concrete (RC) panels. The samples were loaded initially to 50% of the maximum carrying capacity reference samples before stiffeners. Rate 40% increase in load capacity over that reference it was recorded when using CFRP tapes, and about 31% when using GFRP. Enhanced samples showed a 99% increase in stiffness for CFRP strips, 138% for GFRP chips, and reduced ductility due to the fragile nature FRP material. Haddad et al. (2011) [7] 16 tests for damaged temperature RC panels are fixed with CFRP and GFRP leaves under four loaded points. Test results showed increased overload for repaired samples 158% and 125%, with increased rigidity 319% and 197% compared to control samples, respectively. The results also showed a decrease with a deviation of 66.5% and 45.1% for CFRP and GFRP sheets, respectively. Epoxy is used for packing the plate only fails in the back of the bending members with much higher loads than required [8].

2. Experimental program
   - Test specimens

four two-way slabs were tested. All specimens belonging to one group had the same geometry and characteristics. with a length of 1050 mm and cross-section of 1050 mm 60 mm, width and depth. Were reinforced with diameter 8mm @100mm the steel was conforming to ASTM – A615 Specifications[9]. The concrete mix is designed by ACI code to resist compression (fc) (30 mpa).
-Material properties

The concrete mixture was prepared using ordinary Portland cement, coarse aggregate, fine aggregate and water. Standard tests are performed according to the American Society for Testing and Materials (ASTM) and Iraqi specifications to determine the properties of the material. A 0.48 water ratio was used in the cement mixed design. Several experimental mixtures were performed to obtain the best ratio depending on the characteristics of the materials used according to the ACI recommendations[10].

The quantities of cement, water, coarse aggregate and fine aggregate were 370, 185, 1373, and 440 kg/m³, respectively.

-Repair process

The four concrete slabs are divided into three groups. The first group contains one concrete slab loaded for failure (control slab). The second group contains two tiles loaded to 50% of the total load taken from the first slab (control slab). One of the tiles is repaired in shape (1) of the repair and the other tiles in shape (2) and then loaded to failure. The concrete slab of the third group is loaded to 75% of the total load of the first tile (control slab) and repair by the best repaired of the second group.

Procedure for identifying two-directional RC plate samples using CFRP sheet. The repair panels are preloaded with 50% and 75% off the ultimate load of the control panels. Load and the capacity of the repaired panels has been considered to find the most configuration repair the pre-loaded crack boards accordingly. Table (1) shown the properties of slabs

It was found that the high ultimate load and capacity of the two-directional plates repaired with shape (1) was better than the shape (2) for repair shown in figure (1).

Install CFRP strips on the slab the surface is polished and the surface is cleaned to remove dust. This process is necessary for the CFRP strips to adhere firmly to the slab by epoxy.
The test was carried out with a specially made steel frame to support the dimensions of the slab for this research. The panels were tested under the bend using a hydraulic test machine. LVDT was a linear variable differential placed in the middle of a period under slab samples to obtain deformation readings.

3. Results and discussion
-Cracking and Ultimate loads

The ultimate load capacity for all the specimen are showing figures (2, and 3) were ranging between (60.03 and 76.15) kN. The minimum value was for the slab S3 F1-2 while the greatest one had been gained by S2 F11 Compared with the control slab S1. In general the shape (2) of repairing is lower load capacity than shape (1) of repairing which was (71) kN for (50% ratio of load). While shape (1) of repairing had (76, 72) kN for the ratio of load (50% and 75%) respectively. The use of CFRP sheets to repair damaged panels had a significant impact on crack pattern by delaying crack appearance, and an increase in cracking loads to (26.7, 14.33, 20%) for concrete of normal strength (S 2F1-1, S3F1-2, S4F2-1) Respectively compared to the control panel (S1). Use two forms of repair by (CFRP) (Figure 1, Figure 2). Experimental test results showed that a better fix can be obtained when using shape 1. Both crack and final loads indicate all boards as well that the repaired structures have a high degree of integrity. The main concern that engineers usually have linked to the ability of repair materials to merging and behaving in a complex way with the parent materials there doesn't seem to be a problem with any repair the techniques that are investigated in this study.

![Figure (2) ultimate load of slab](image-url)
Figure (3) Load - Deflection Curve for two way concrete slab

-Ductility and toughness

All tested panels have a high ductility index of the reference plate with a range (2.84 to 5.29). Moreover, 75% of the load for shape (1) has the highest D.I (5.29), shown in figure (4).

Figure (4) Ductility index for two way concrete slab
The hardness showed that the control panel (S1) has higher hardness (1660.1 KN.mm) while lower (S2 F1-1) hardness (450.67). shown in figure(5)

![Toughness (KN.mm)](image)

**Figure(5) toughness for two way concrete slab**

Increasing the hardness of any slab when using (CFRP), especially when using CFRP sheets by (shape 1) reduces ultimate deflection and increases final load. Using CFRP sheet for repair, reduce crack width and reduce crack number, this is one of many advantages of using CFRP sheet.

4. Conclusion

Based on this study, the following conclusions could be drawn:

1- The repaired structures had higher ultimate loads and the capacity of the slabs compared to the control slab.
2- The use of CFRP sheets as an external fix has a significant impact on the cracking pattern of two-way reinforced concrete slabs by delaying the appearance of crack.
3- Improvements are greatly affected by the location, quantity, shape and dimensions of the CFRP strips available for these panels.
4- External CFRP sheets attached to the tensile faces of reinforced concrete panels increase the rigidity of the panels at all stages of loading, thus reducing deflection at the corresponding loads.
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