Global Journal of Engineering Science and Research Management

INCREASING ULTIMATE STRENGTH OF REINFORCED CONCRETE SLAB BY USING GEOGRID

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DOI: 10.5281/zenodo.1441060

KEYWORDS: slab, geogrid, concrete, deflection, flat plate slab, two-way slab.

ABSTRACT

The main purpose behind the search is to study the punching shear behavior of nine specimens of two way flat plate slabs with geogrid mesh, all slabs are dimensioned in (400*400*60) mm and F'c is (30)MPa and all slabs contain a (6 mm) diameter of steel reinforcement and all slabs contain geogrid pieces of different shapes and dimensions except the reference slab (R000), geogrid is used as strips with a dimensioned (10*38)cm in slabs (NGI0, NGI-, NGX0) in deferent shapes (I, +, X) respectively, It was used in squares with different dimensions (15,20,25)cm in slabs (NGS15, NGS20, NGS25) respectively, and it was used as a complete piece with dimensions (38*38)cm with steel reinforcement in slab (NGST) and without steel reinforcement in slab (NG00). Laboratory tests show that the first crack of the slab (NGST) more than the reference slab (R000) by (100) % and ultimate load more than the reference slab (R000) by (132.43) % as the deflection is reduced in this model where it was (5.44) mm, the reason is that the geogrid worked with steel reinforcement as a single piece, which increased the resistance of the model and at the same time worked to reduce the deflection. either in the slab (NG00) It was the F.C.L less than the reference slab (R000) by (38.46) % as well U.L less by (16.67) % and the deflection it was more than a reference slabby (66.5) % The reason is that the slab contains a whole piece of geogrid without steel reinforcement. the other slabs showed an increase in bearing and a decrease in deflection.

INTRODUCTION

A flat.plate is a slab resting directly on columns. The slab is reinforced in such a manner to be capable of transmitting the loads directly and safely to the supporting columns without the need of using column capitals or drop panels. A flat plate construction does not necessarily mean complete beamless construction since such beams often used at some location such as around staircases and around large openings in the slab. Each structural member has different levels of load sensitivity. Concrete slabs are the most sensitive structural elements during construction phases and are the reason for their dependence on shear.

Of the most failure type of failure occurring in the slabs is the punch shear. This type of failure occurs around the columns as a result of a concentrated load and the type of failure is dangerous where a sudden occurrence occurs without warning and the failure is a conical type and starts from the upper edge of the slab.
The geosynthetic material, the geogrid is made of polymer material and formed by means intersecting networks (grid). Polymers materials such as polyester, high-density polyethylene and polypropylene are major geogrid compounds. These grids are formed by material ribs that are intersected by their manufacture in two directions: the first in the machine direction (MD), which is conducted in the direction of the manufacturing process. The second direction is vertical on the ribs of the direction of the machine, which are called the cross-machine direction (CMD). There are three most commonly used methods for geogrid: By Extruding, By Knitting or Weaving, By Welding and Extrusion.

Analyzed the punching shear behavior of slab-to-column connection. The conclusion reached was that the value of punching force depends on the ratio of shear forces and bending moments acting within the critical section; the more is the ratio, the greater punch resistance may be achieved. [1]. studied the punching shear tests on column footing. Find out that the columns footing are supplied with shear reinforcement have a higher percentage of columns not fitted with shear reinforcement the ratio was about 35-55 % [2]. Behavior and strength of reinforced concrete slabs were investigated under the effect of punching shear force. This research aims to evaluate experimentally the punching shear behavior of reinforced concrete slabs strengthened by using geogrid mesh with different percentage of steel reinforcement ratio (ρ), where the main parameters which adopted in the experimental program were the presence of geogrid mesh, steel reinforcement ratio (0.01, 0.0052, 0.0026 and 0.0013) and concrete compressive strength. Three type of concrete were utilized as normal strength concrete (NSC), high strength concrete (HSC) and reactive powder concrete (RPC). Fifteen slabs were made five for each type of concrete, in the same group one of the slabs was without geogrid mesh, and four were strengthened with geogrid, the other four are different in steel reinforcement ratio (ρ). The dimensions of slabs in present work were (850x450x70) mm for length, width and thickness, all slabs were simply supported along the four edges and loaded concentrically by a square column of dimensions (40x40) mm. corner uplifts were prevented, Practical results showed that with plastic grids there is an increase in the maximum load value [3]. Other researcher studied the shear strength of slabs loaded by concentrated loads near the supports. From these tests, he suggested that shear capacity decreases as the loads are moved away from the supports, and shear strength increases with the increase in concrete strength, but it was found that the increase is not proportional to the increase in compressive strength [4]. The researcher studied of slabs loaded by Loaded with concentrated loads near the stents, it was suggested through tests shear capacity was reduced when the loads were moved away from the stents The shear strength increases with increased concrete strength, but the increase does not correspond to an increase in compressive strength [5]. Another researcher studied the effect concrete strength on the punch shear strength where 18 square slab with a thickness of 125 mm were made and with different concrete strength ranging from 32 to 120 MPa, the tiles were reinforced evenly in the perpendicular directions and without the use of shear reinforcement, the punching load was carried through a column in the center of the bottom of the slab showing the examination results that the punch shear resistance increase with the increase in concrete comprises strength [6].

MATERIALS AND METHODS

All the samples were designed according to (ACI-318-14) [7]. as shown below and in figure (1):

$\rho=AS/(b\times d)$

Use Ø6 mm

$ASb= (6^2\times \pi)/4$

$ASb=28.27$

Use 5 bars $d=60-10-6.5$, $d=43.5$ mm

$AST= 5\times 28.27$

$AST= 141.35$ mm2

$\rho=141.35/(400\times 43.5)$

$\rho=0.008123$

$\rho_{min}=0.00018$

$\beta=0.85-0.05/7(30-28)$

$\beta=0.836$

$\rho max=0.85\times 0.836\times 30/420\times 0.003/(0.003+0.004)$

$\rho max=0.0217$

$\rho max>0.008123>\rho min\ldots\ldots\ldots ok$

$S=ASb/AST\times B$

$S=28.27/141.35\times 400$

S=80 mm ………… use Ø6 at 75 mm

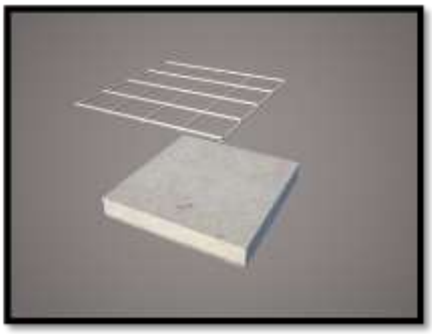


Figure. 1 show all models and geogrid shapes

eight structural specimens (reduced-scale) slab are prepared for the experimental work purposes. all models with dimensions (400*400*60) mm, all models have a geogrid theme in different ways except the reference model as shown in fig.1, Normal strength concrete mix. Consisting of cement, fine sand and Crushed. aggregate. Used to cast the (NSC) slabs and the control specimens (cubes, prisms, and cylinders). Table (1) gives mix proportions of (NSC) used in this research.

Table 1. Normal Concrete Proportion Mixture

Cement Kg/m^3	Sand Kg/m^3	Gravel Kg/m^3	Water/Cement %
400	600	1200	0.45

The mold used in casting the samples of research made of ply-wood lubricated with special oil to resist moisture. Figure (2):

Figure. 2 show the molds

After the casting process and curing the models put them in water for 28 days as shown in the figure below.

Figure. 3 Explain the process of casting and curing.

Before the testing day, the slabs were taken out from the container of curing and dried for one day in fresh air. During the drying time, the slab specimens were cleaned and painted with white paint on both surfaces, to achieve clear visibility of cracks during testing. Before testing the specimens, positions of supports, centrally applied load, and dial gauge were marked. The central deflection of the slab specimen was measured at the center of the slab by using a dial gauge of 0.01mm (ELE type) and (30mm) sensitivity. The load is applied at an increment of 10 kN. This amount of increased loading allowed sufficient loads and corresponding reflections to be taken during the test, which gave a good picture of the structural behavior of the slab. The load was observed at the first crack in addition to the ultimate load with the corresponding deflection at the center of the slab. A special supporting frame was manufactured and used inside the testing machine with a clear distance of supporting of (400x400) mm, to provide the required space for the board. This supporting frame is manufactured using four welded steel beams to form a square shape. These four steel beams contain a 25 mm welded steel tape on the upper face to provide simple support for the edge of the board Solid square steel cube of dimensions (40X40) mm placed over the center of the slab to provide a concentrated load as shown in figure (4) shows the details of slab testing.

ISSN 2349-4506
Impact Factor: 3.799
Global Journal of Engineering Science and Research Management

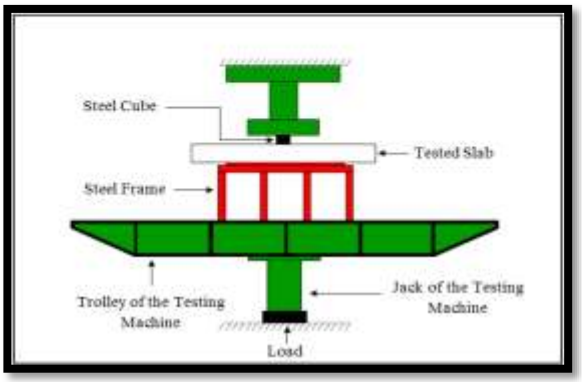
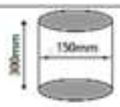
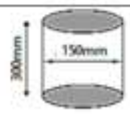
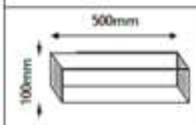


Figure. 4 The hydraulic Universal testing machine

The Table (2) below shows the standard of the material properties has been used.

Table 2. Stander Used in Test

Specimen	Number of specimens	Test
	3	Cube Compression Strength
	3	Cylindrical Compression Strength
	3	Splitting Tensile Strength
	3	Modulus of Rupture

This table 3 shows the results of the properties of the materials used at the age of 28 days. All results obtained are the average of three models:

Table 3. Material Test Result

Cylinders Compressive Strength f'_c (MPa)	Cubes Compressive Strength f_{cu} (MPa)	Modulus of Elasticity E_C (GPa)	Splitting Tensile Strength f_{sp}	Modulus of Rupture f_r (MPa)
31.3	35	27.3	3.96	4.6

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[Hussain* 5(9): September, 2018] ISSN 2349-4506
Impact Factor: 3.799

Global Journal of Engineering Science and Research Management

This table (4) shows the values of first crack and ultimate load for all models

Table 4. The Result of One-Point Load Teat

Group name	Specimens	First Crack load (F.C.L) (kN)	Ultimate load (U.L) (kN)	F.C.L/ F.C.L. R %	U.L/ U.L R %
geogrid	R000	6.5	30	-	-
	NG00	4	25	61.54	83.33
	NGI0	10	48	153.8	160
	NGI-	12.5	66	192.3	220
	NGX0	12	62.5	184.6	208.33
	NGST	17.5	72	269.2	240
	NGS15	10	40	153.8	133.33
	NGS20	11.5	45	177	150
	NGS25	12.5	50	192.3	166.67

The results obtained show a decrease in the values of the (F.C.L and U.L)in model (NG00) for the reference model (R000) by (38.46 and 16.67)% respectively this is due to the fact that the model contains a complete piece of geogrid without steel reinforcement, resulting in a weakening of the model. In the model (NGST) there was a marked increase in the value of (F.C.L and U.L) by (169.2 and 140) % respectively for reference model (R000), that because the model contains a complete piece of the geogrid with steel reinforcement, which increased the resistance of the model to the load on it.in models (NGI0, NGI- NGX0, NGS15, NGS20, and NGS25) These models showed an increase in the values of the (F.C.L and U.L) by (53,8, 92.3, 84.6, 53.8, 77 and 92.3) % respectively and by (60, 120, 108.33, 33.33, 50 and 66.67) % respectively for the reference model (R000), Because of the presence of geogrid in different forms with steel reinforcement.

The following figures shows (load- Deflection) for all samples:

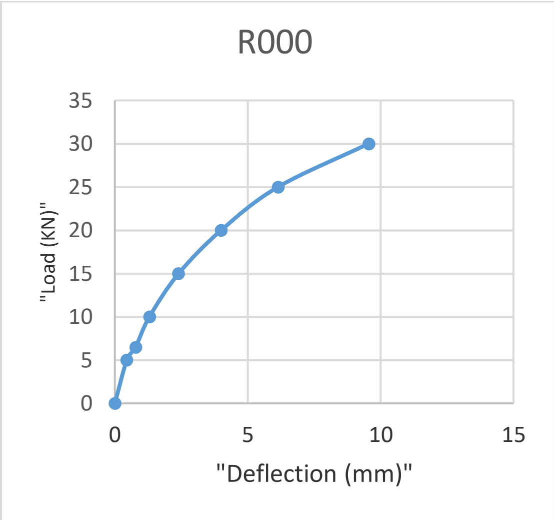

Figure. 5 Load – Deflection Curve of Specimen (R000)

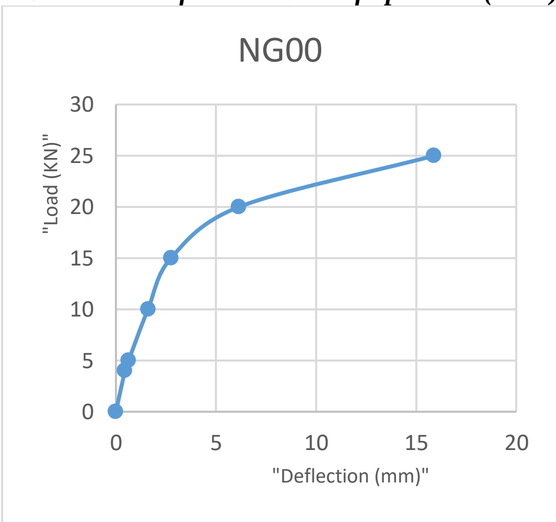

Figure. 6 Load – Deflection Curve of Specimen (NG00)

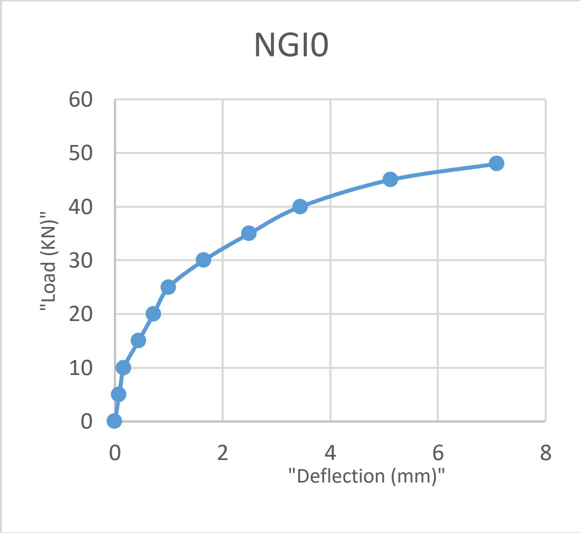

Figure. 7 Load – Deflection Curve of Specimen (NGI0)

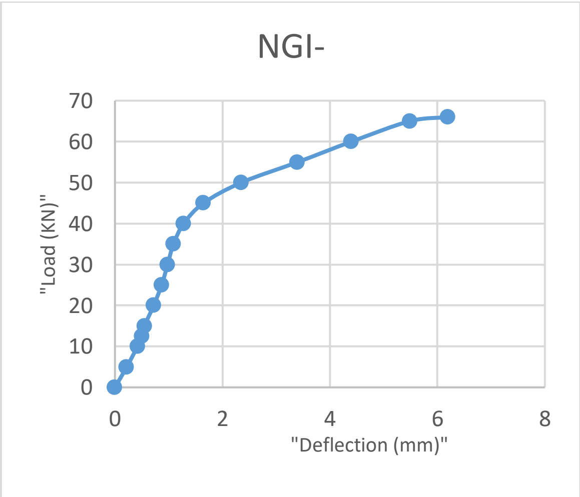

Figure. 8 Load – Deflection Curve of Specimen (NGI-)

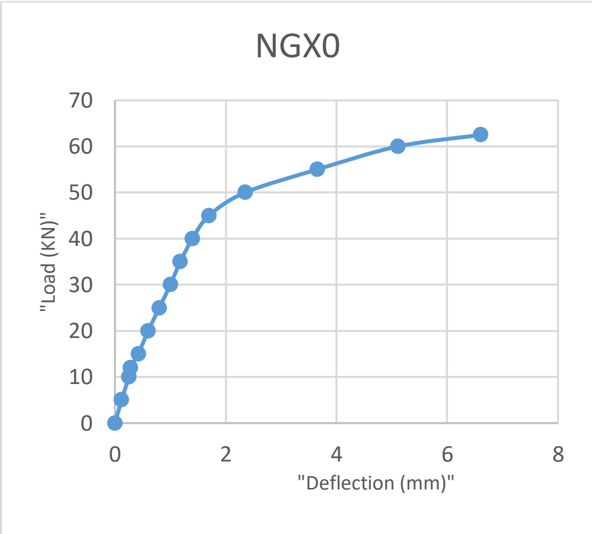

Figure. 9 Load – Deflection Curve of Specimen (NGX0)

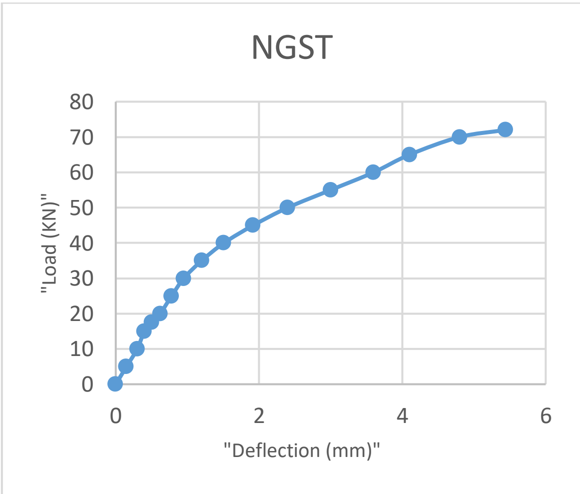

Figure. 10 Load – Deflection Curve of Specimen (NGST)

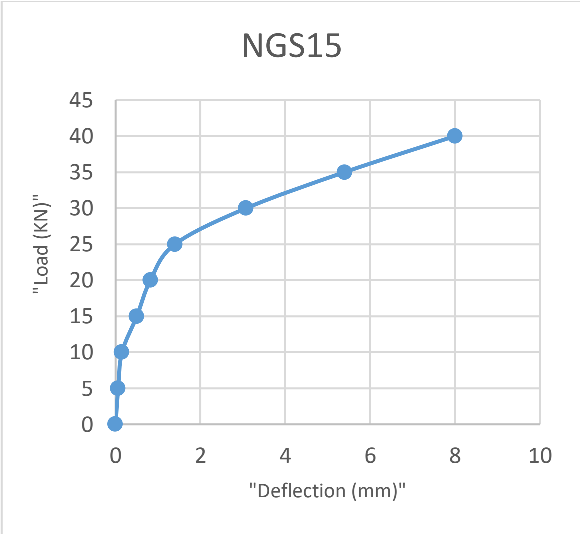

Figure. 11 Load – Deflection Curve of Specimen (NGS15)

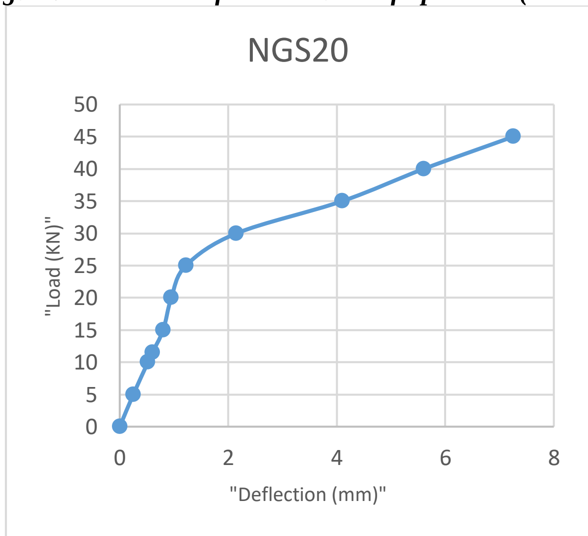

Figure. 12 Load – Deflection Curve of Specimen (NGS20)

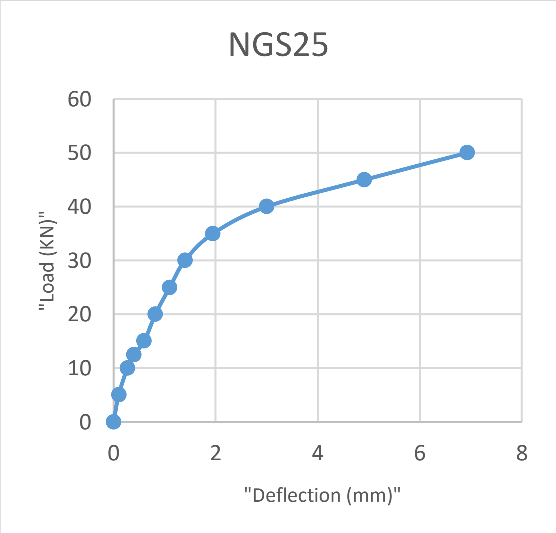

Figure. 13 Load – Deflection Curve of Specimen (NGS25)

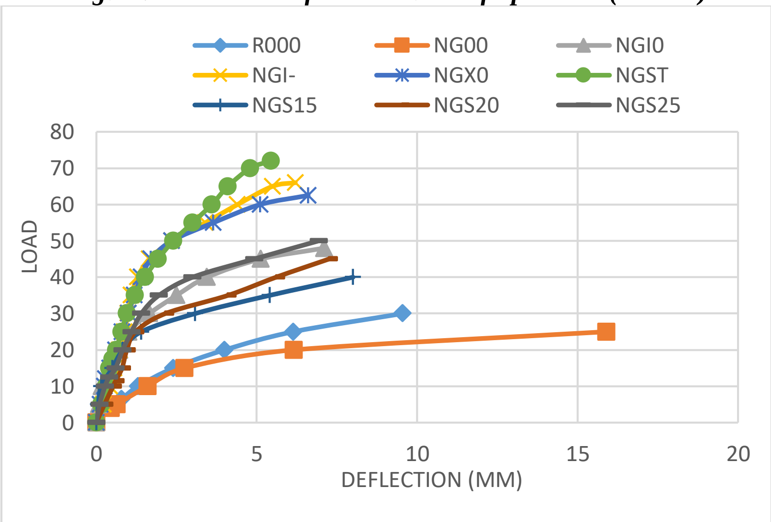

Figure. 14 Center Load-Deflection for all samples

Through the results obtained it has been shown that the model (NGST) has less deflection than the reference model (R000) by (43) % The reason is that the geogrid worked with the steel reinforcement as one piece, which increased the resistance of the model to tensile stresses exerted on it. The percentage of decrease in deflection in specimens (NGI0, NGI-, NGX0, NGS15, NGS20, NGS25) were (25.65, 35.1, 30.89, 16.23, 24,1, 27.43) % respectively from reference model, the reason is that the slabs contain geogrid with a steel reinforcement, which led to a decrease in deflections. The geogrid used in the slabs was different in shapes and dimensions. in the slab (NG00) has a higher deflection than the reference model by (66.5) %.

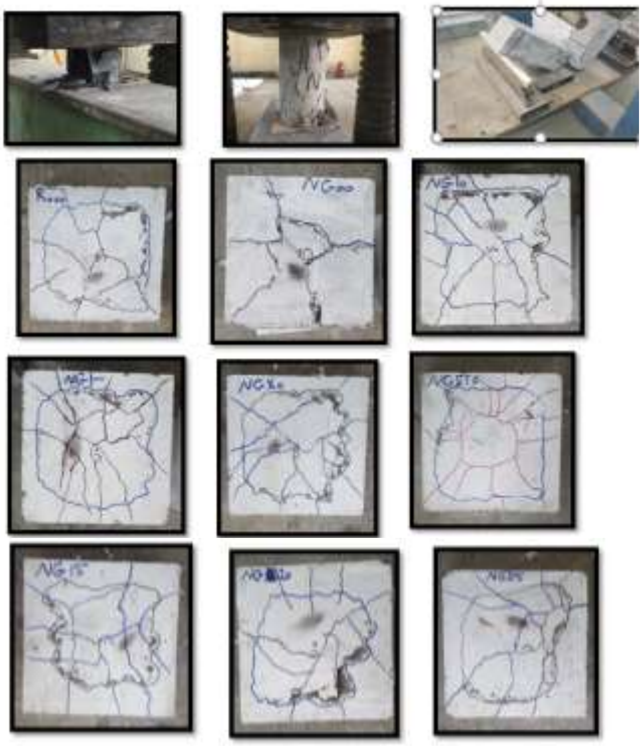

Figure. 15 The specimen after the test

CONCLUSION

It was concluded that the presence of the geogrid in the form of a complete piece with steel reinforcement gives very good results as it increases the bearing of the model for the mounted loads and also reduces the deflection. This section should be typed in character size 10pt Times New Roman, Justified

ACKNOWLEDGEMENTS

The authors wish to acknowledge the construction laboratory of Al-Mustansiriyah University College of Engineering and Building Research Directorate – Ministry of Construction and Housing Municipalities and Public Works for their facilitation to complete this research by introducing help to examine the materials and samples.

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ISSN 2349-4506
Impact Factor: 3.799

Global Journal of Engineering Science and Research Management

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