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The Influence of Recycled Crushing Strength of RC Beams under Repeated Loading

Abstract- *This paper describes a study of the effect of crashed (recycle) concrete on reinforced concrete beams. Three-dimensionally nonlinear finite elements analysis has been used conducted the numerical investigations of the general study of recycling-beam. ANSYS.11.0 computer-program using in this paper. Solid65 using as element of concrete, link8 for steel. The compression strength of the concrete mix decrease due to the strength of crashing concert. It's weaker than gravel aggregate, that lower strength due to weak of old mortar cement around the aggregate and due to crashed process. The percentage of decrease of the compressive strength equal to (59.8) % and deflection of beam increase due to weak of concrete and the load of initial crack, it's lower than traditional concrete contains natural aggregate.*

Keywords- *crushing concrete, repeated load, finite elements.*

1. Introduction

The need to develop economic and efficient methods to repair and recycle of concrete by crashing concrete and study the effect of repeated load on behavior beams composed by crashing concrete, that All results compared with finite element (Ansys program) final the paper found good agreement between them, but the comparison strength for crashing concrete weaker than the normal concrete with normal gravel due to replace crashing concrete with normal gravel because the crashing concrete weaker than normal gravel that will decrease the comparison strength of concrete and increase the deflection of beam.

2. Materials

I. Cement

Table 1 and 2 shown chemical and Physical properties analysis of Ordinary Portland cement is used in this investigation and compared with Iraqi stander for Ordinary Portland cement type.

Table 1: Results of Chemical analysis components for O.P.C.*

Oxides composition	Component %	Iraqi Stander No5_1984
CeO	58.4	___
SiO2	20.1	___
Al2O3	4.9	___
Fe2O3	3.0	___
Mg.O	1.99	< 5.00
SO3	1.6	< 2.80
Limit of Iraqi stander	2.6	< 4.00
Residue of insoluble	0.51	< 1.50
Factor of Lime Saturation	0.84	0.66 - 1.02
The main compounds		
C3S	39.99	___
C2S	31.02	
C3A	8.78	> 5.00
C4AF	8.51	___

* Tests are conducted by the General Company for Geological Surveying and Mining

Table 2: Physical properties of cement*.

Physical Properties	Test results	Limits of Iraqi specification No.5/1984
Specific surface area (Blaine method), m^2/kg	483	$\geq$ 230
Setting time (Vicat apparatus), The initial setting, hr: min The final setting, hr: min	2:45 4:45	$\geq$ 00:45 $\leq$ 10:00
Compressive strength, MPaThree days Seven days	31.30 41.00	$\geq$ 15.00 $\geq$ 23.00
Soundness (Autoclave method), %	0.35	$\leq$ 0.8

* Tests are conducted by the General Company for Geological Surveying and Mining.

II. Sand

Fine natural sand from Al-Ekhaider was used; its grading is shown in Table 3, and Figure 1.

Table 4 shows the specific gravity and sulfate content of fine sand, the latter being within the requirements of the Iraqi specification No. 45/1984. The sand was tested in the General Company for Geological Surveying and Mining.

Table 3: Sand Grading according to British stander

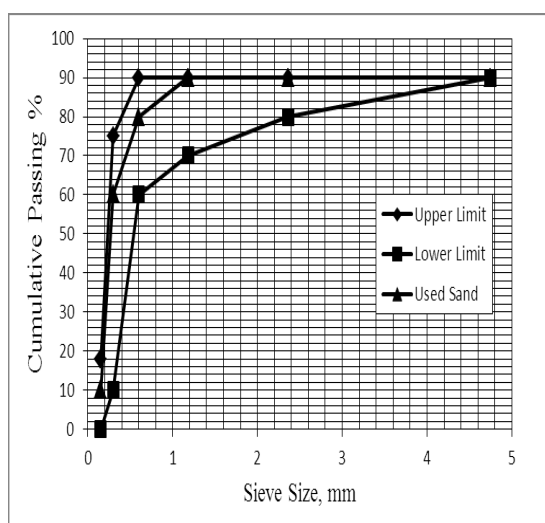| size (mm)	passing %	% limits of B.S. of sand grading
5.00	100	100
2.36	100	80-100
1.18	100	70-100
0.60	93.3	55-100
0.30	42	5-70
0.15	0	0-15

Figure 1: Sieve analysis results of fine sand based on B.S. 882:199.

Table 4 Physical properties of sand*

Physical properties	Test results	Limits of Iraqi specification No.45/1984
Specific gravity	2.7	-
Sulfate content %	0.21	$\leq$0.5

* Conducted by the General Company for Geological Surveying and Mining.

3. Crashed (recycle) concrete

The crushed recycled concrete of maximum size 19mm was used in this investigation. The grading of crushed recycle concrete compared with Iraqi and ASTM C33 2002 stander, Table 5 shown that.

Table 5: Grading of crushed recycle concrete

Sieve Size mm	% Passing	Limit of Iraqi specification I.O.S. 45/1984	ASTM Standard C33-2002 Limitations
19	100	100	100
14	96	100	100
10	88	85-100	90-100
5	17	0-25	20-55
2.36	1.2	0-5	0-10

4. Compressive Strength

To select the mix proportion for the concrete used in preparing the reinforced concrete beams, three trial mixes were carried out to obtain cylinder strength of 30 MPa at 28 days by using the method of the design proposed by Nevile 2000. The final mix used was 1:1.42:2.41 by weight. The water-cement ratio was equal to 0.455 and cement content was 450 kg/m3, Table 6 shown that.

5. Specimens Description

Nine reinforced reactive powder concrete beams with rectangular cross-sectional dimensions of 150 mm width by 250 mm height and 2000 mm length were cast. The flexural reinforcement of the beams consisted of 2Φ12 mm tension bottom bars at the tension face and 2Φ12 mm top bars at the compression face. To avoid shear failure, the beams were over reinforced for shear with Φ10 mm closed stirrups spaced at 100 mm on center. Figure 2 shows specimen dimensions, reinforcement details, support locations, and location of loading points [4-5].

Table 6: Properties of mixing with crashed (recycle) concrete

Specimens Designation	crashed (recycle) concrete percentage of Gravel	Compressive Strength f'c' (MPa)
M-0-1.0	0.0	36.89
M0.2-0.8	0.2	32.88
M0.4-0.6	0.4	31.06
M0.6-0.4	0.6	29.97
M0.8-0.2	0.8	26.07
M1.0-0	1.0	22.07
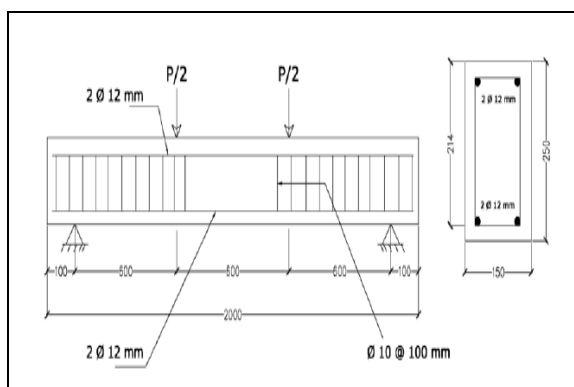
Figure 2: Geometry and reinforcement of laboratory specimens [4-5].

I. Steel Reinforcement

For all beams, two sizes of steel reinforcing deformed bars are used. Bar size Φ12 mm used as longitudinal reinforcement, and bars of size Φ10 mm were used as transverse reinforcement (closed stirrups). Table 7 shows the properties of steel reinforcement bars.

6. Finite Analysis

The finite element method is a numerical procedure, which can be applied to solve numerous engineering problems, that has become a powerful and versatile tool for structural analysis in both linear and nonlinear formulations

of reinforced concrete structures. In the study, the finite element software ANSYS-Ver. 11 is used in the analysis. Some features of this program are discussed below [7].

I. Finite Element Idealization and Material Properties Concrete idealization

Three-dimensional brick element (Solid 65) is used to model the concrete with or without reinforcing bars (rebar). The element is capable of cracking in tension and crushing in compression.

II. Steel idealization

The steel reinforcing bars (tensile, compressive, and stirrups) are represented by using 2-node discrete representation (Link8 in ANSYS) and included within the properties of 8-node brick elements. Modeling of Reinforced Concrete Beam (Control Beam.

The major factor in convergence study is the increase in mesh in x-direction. As a result, and to save time and efforts, it is thought that the number of elements, which is equal to 3, 4 and 40 elements in z, y and x-direction is sufficient to give good results. By taking advantage of symmetry for both geometry and loadings of beams, a half of the entire model beam was used for finite element analysis (i.e. the total number of elements for half of beam BNo.1 would be equal to 240 elements). Discrete representation was used to model all internal reinforcement. Figure 3 shows the picture of a meshed beam BNo.1 it was adopted for this study. The mesh shown in Figure 3 for beam BNo.1 is used for all tested beams (BNo.1 to BNo.9). While the representation of internal steel reinforcement for all tested beams (BNo.1 to BNo.9) are shown in Figure 4.

Table 7: Properties steel reinforcement

Bar Size	Yield Stress (MPa)	Yield Strain	Ultimate Strength (MPa)	Ultimate Strain	Modulus of Elasticity* (MPa)
Φ12 mm	493	0.0025	620	0.0304	200000
Φ10 mm	461	0.0029	590	0.0326	200000

* ACI 318M-05 [6]
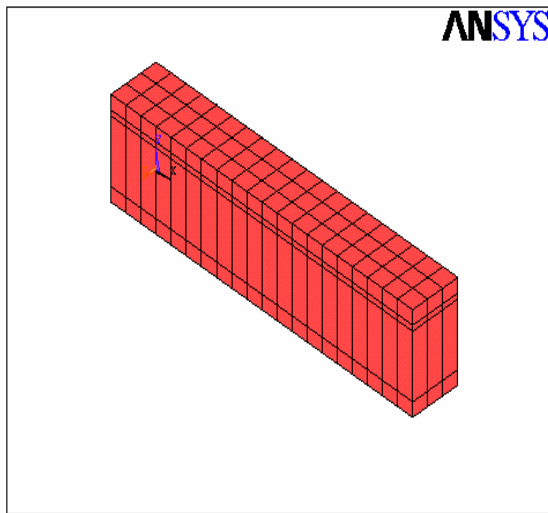
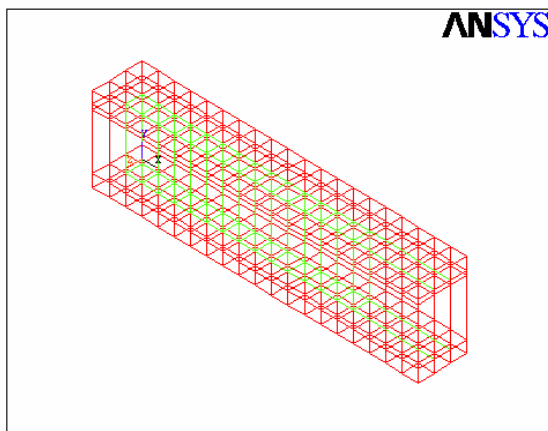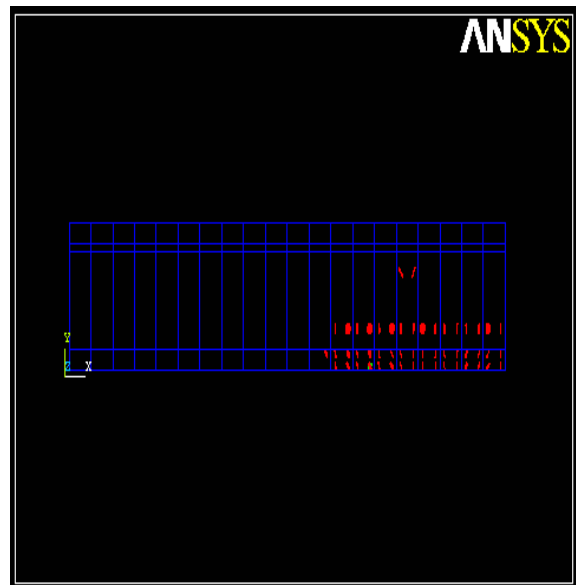**Figure 3: Mesh of concrete beam**

Figure 4: Representation of internal reinforcements for a concrete beam

III. Loads and Boundary Conditions

To get a unique solution, the model should be constrained by using displacement boundary conditions. The displacement in Dx =0 (that 90^0 with the plane), but in the direction of load the displacement Dy≠0, the aim that, to the simulation of experimental conditions. The loading applied is repeated loa; Figure 5 shown the details of experimental conditions.
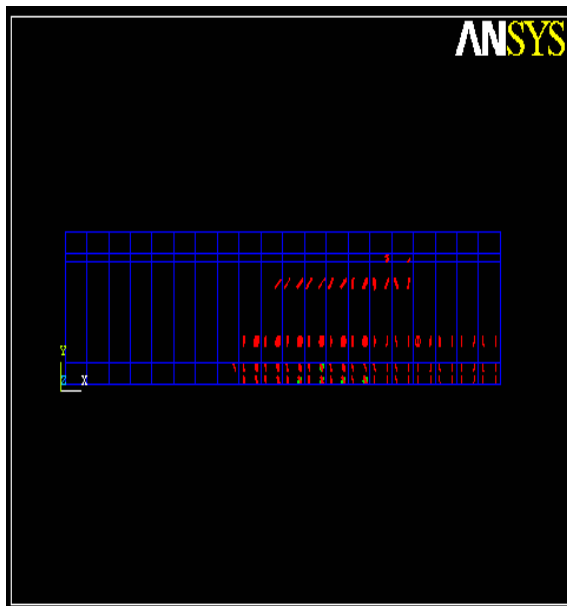

Figure 5: Details of boundary conditions and applied loads

The finite element model accurately predicts the failure load, cracks, moment and shear of the beam. The ANSYS program records the crack pattern at each applied repeated load step. Figure 6 shown the cracking load.

Figure 7: Variations in stress in X-direction for control beam

Figure 8: Variations in strain in X-direction for control beam

Figure 6: The Crack of BNo.1 (at load = 0.40 Pu At load = 0.60 Pu c) (at load = 0.80 Pu At load = 0.93 Pu d)

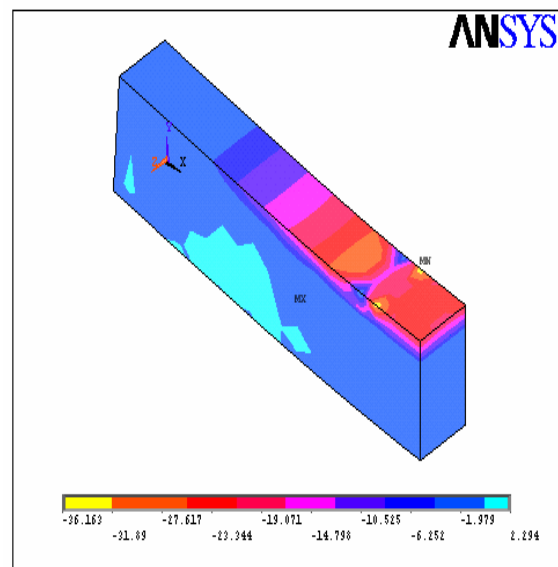On the other hand, the variations in stress and strain X-axis for beam are shown in Figure 6 and 7.

8. Results of Analysis Beams

On a show that legitimacy of the suggested numerical system for the dissection from claiming strengthened solid beams, the sum tried beams (BNo. 1 with BNo. 6) will be analyses by utilizing ANSYS workstation program, as specified formerly. The examination takes after the same system Likewise that provided for clinched alongside parts five What's more six taking under record the variety done material properties, measurements and other determinations depicted formerly paper. With incorporate the impact of strain solidifying to steel reinforcement, the stress-strain curve, following yielding for steel reinforcement, will bring incline equivalent to 2% from claiming that in front of yielding.

1. Load-deflection (under repeated load) Curves:

The deflection was measured in the medal of the beam. Figure 9-17 show the deflection load curves ware plotted by finite elements compared with experimentally beam.
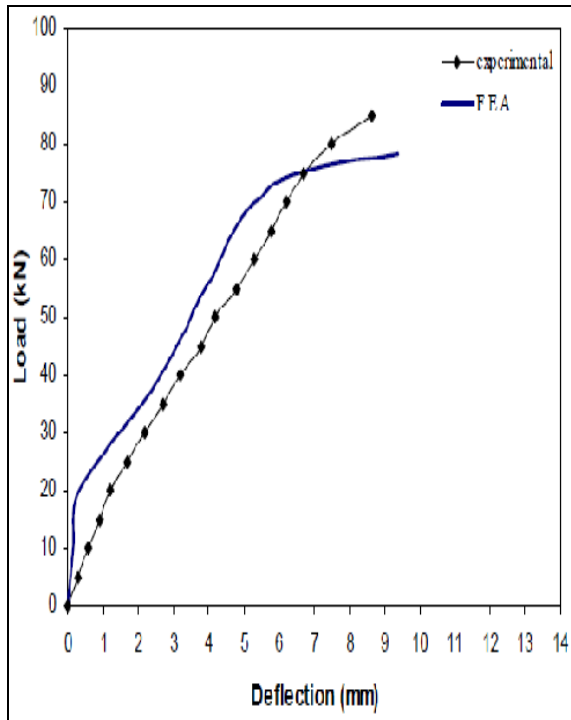

Figure 9: The Load-deflection by repeated load curve for beam BNo1
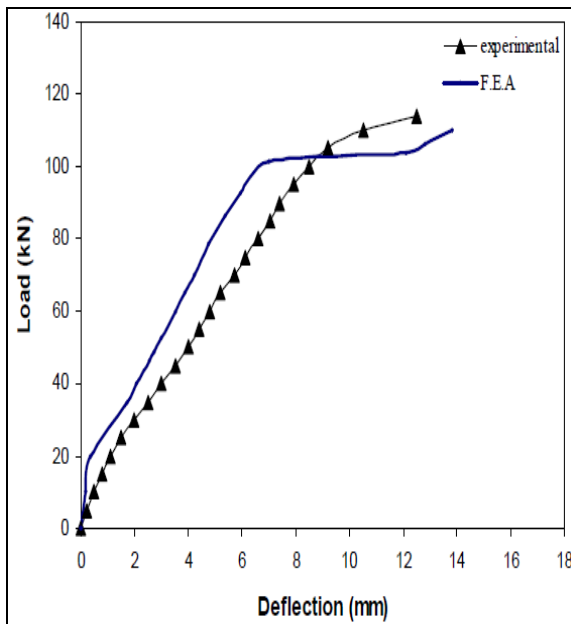

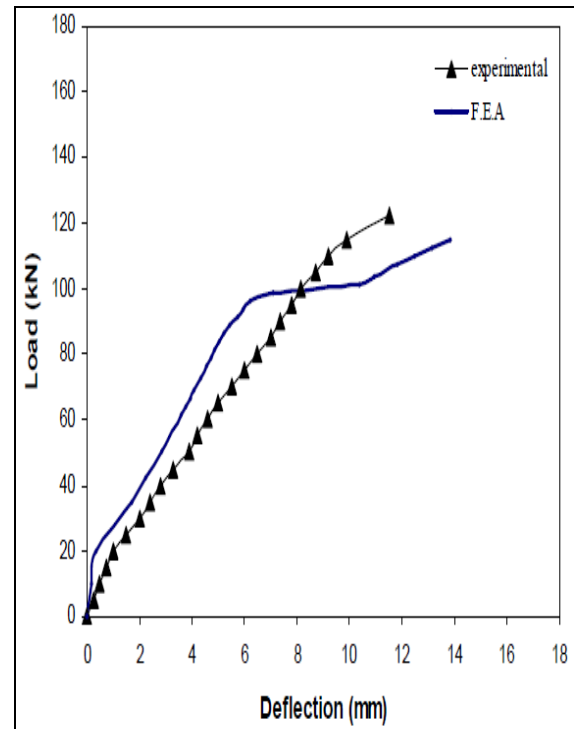**Figure 10: The Load-deflection by repeated load Curve for beam BNo2**

Figure 11: The Load-deflection by repeated load beam BNo3
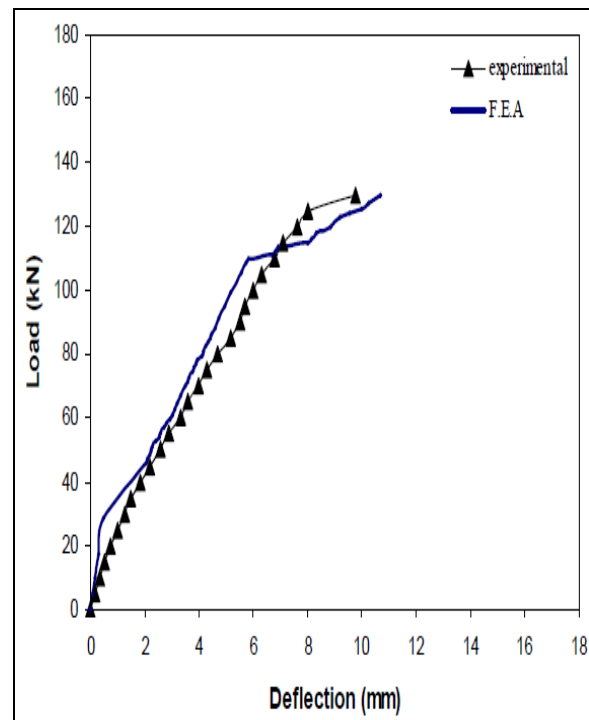

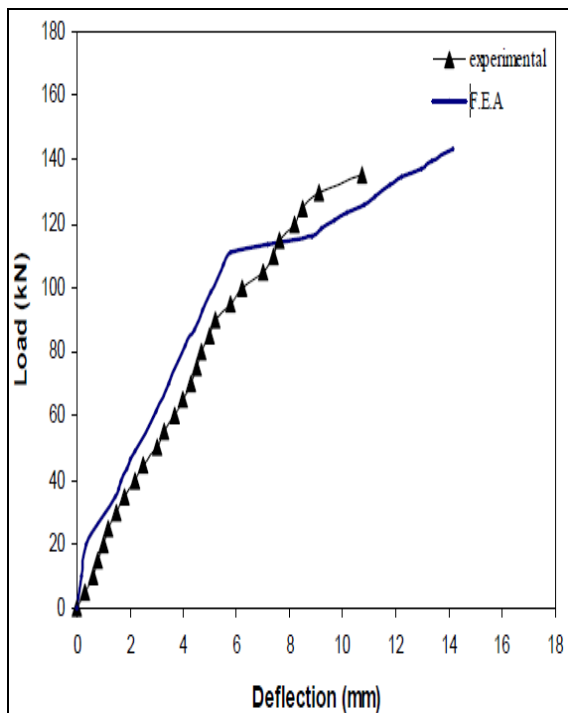**Figure 12: The Load-deflection by repeated load curve for beam BNo4**

Figure 13: The Load-deflection curve by repeated load for beam BNo5

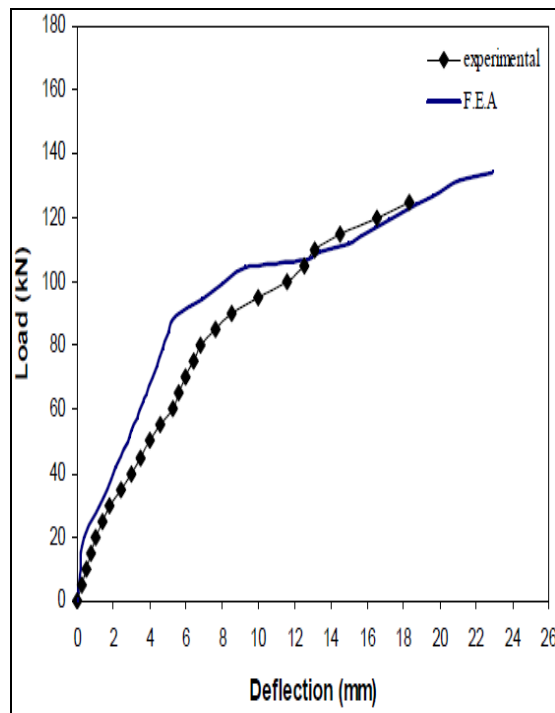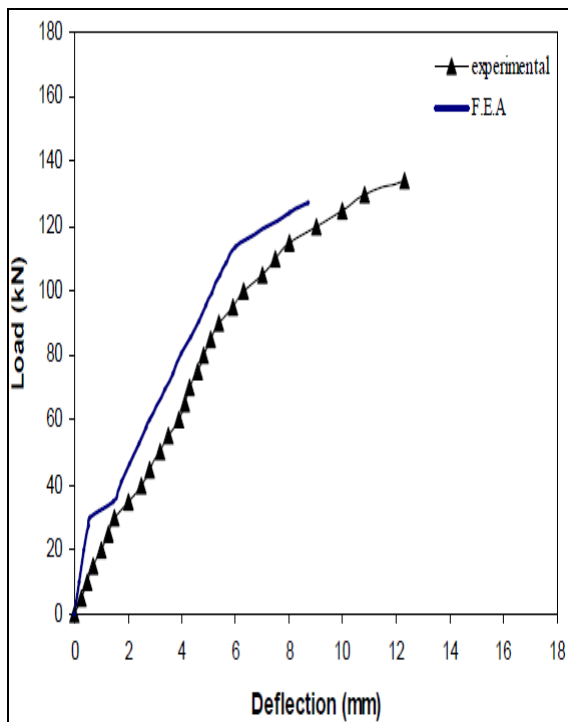**Figure 15: The Load-deflection curve by the repeated load for beam BNo7**

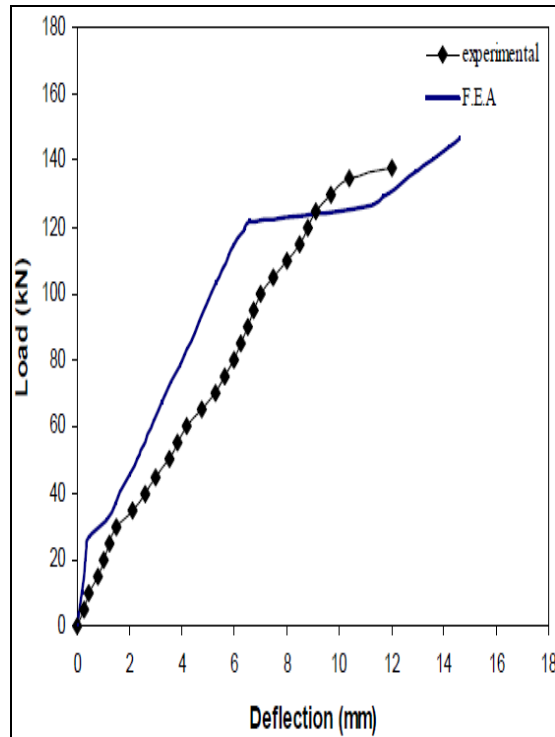**Figure 14: The Load-deflection curve by the repeated load for beam BNo6**

Figure 16: The Load-deflection curve by the repeated load for beam BNo8
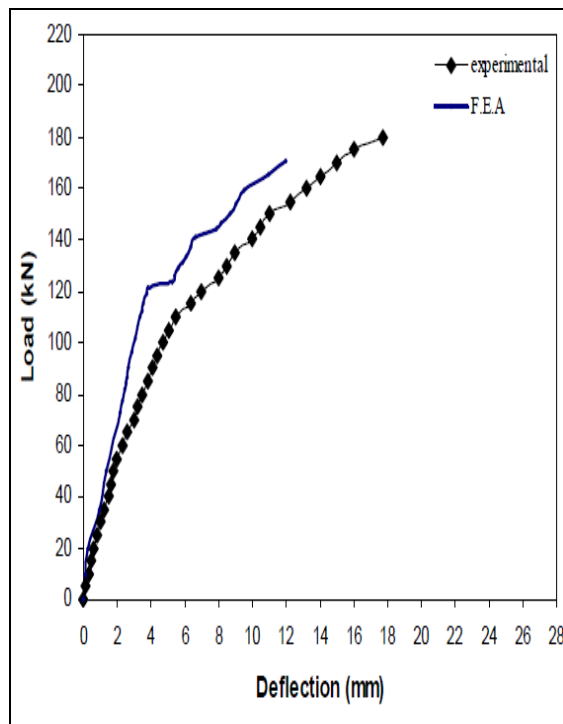
Figure 17: The Load-deflection curve by the repeated load for beam BNo9

9. The Crack & Ultimate Loads

The cracking and Ultimate loads for the experimental and finite element results shown in Tale 8 and 9.

Table 8: The crack load

Beam No.	loads of crack kn		Pcr) exp./ Pcr) theo.
	Pcr) exp.	Pcr) theo.	
BNo.1	30	25	0.833
BNo.2	32	28	0.875
BNo.3	32.5	29.5	0.907
BNo.4	35	31	0.885
BNo.5	39	33.5	0.858
BNo.6	37.5	32.5	0.866

Table 9: The ultimate load

Beam No.	ultimate loads kN		Pcr) exp. / Pcr) theo.
	Pcr) exp.	Pcr) theo.	
BNo.1	85	78.2	0.920
BNo.2	114	110	0.964
BNo.3	122	115	0.942
BNo.4	130	129.8	0.998
BNo.5	135.5	143.48	1.058
BNo.6	134	126.99	0.947

10. Conclusions

The Conclusions of this paper found the effect of add crashing concrete, found the compression strength of concrete mix decrease due to the strength of crashing concrete.It's weaker than gravel aggregate, that lower strength due to weak of old mortar cement around the aggregate and due to crashed process. The percentage of decrease of the compressive strength equal to (59.8) % and deflection of beam increase due to weak of concrete anda load of initial crack, it's lower than traditional concrete contains natural aggregate.

From compariso, finite element result found the increment (average) results about 18% for all result, that good aggregate.

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[6] ACI Committee 318M-05, "Building Code Requirements for Structural Concrete and Commentary (ACI 318M-05)," American Concrete Institute, Michigan, USA," 2005.

[7] ANSYS, "ANSYS Manual," Release 11.0, USA, Copyright 2007.