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The combined effect of conventional reinforced concrete beams that are encased with a thin layer of ferrocement on the impact resistance concrete

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Abstract

The present research deals with the effect for each number of layers to net the steel beams on the ferrocement layer considering the thickness of layer , strength of mix and distributed of steel. It found the strength of impact for combined beams greats than the base beams and number of layers effect clearly on the strength of impact, also the increase in thickness can increase resistance and there is an optimum of wire mish layer for ferrocement to increase the impact resistance.

التأثير المشترك للأعضاء الخرسانية مع طبقة من الفيروسمنت على مقاومة الخرسانة

نزار حسن محمد

الخلاصة

يتناول البحث التأثير المشترك لكل من عدد الطبقات لشبكة الأسلاك الحديدية على طبقة حديد – سمنت مع الأخذ بالنظر الاعتبار سمك الطبقة ومقاومة الخلطة وتوزيع الحديد وقد وجد ان مقاومة الصدم للأعضاء المتراكبة اكبر من الأعضاء الأصلية وكذلك عدد طبقات الأسلاك يؤثر نوعيا وبشكل واضح على مقاومة الصدمة وكذلك وجد أن زيادة سمك الطبقة يؤدي إلى زيادة مقاومة الصدمة ،وان شبكة الأسلاك الحديدية عندما يتم اختيارها بشكل أفضل تؤدي إلى زيادة المقاومة وبشكل مميز وواضح .

1-INTRODUCTION

1.1 Introduction

Structure integrity is the important factor in design of multistory building , this is due to the initiation of progressive collapse cause by some abnormal loading eventually results in the collapse of a whole building ,such abnormal loading is caused by gas or bomb explosive, vehicular and aircraft collision with the building and errors in design and construction.

the advantages of which method are that the shrinkage of the Ferro cement is neutralized by the wire mesh ,and that the wire mesh acts as reinforcement without connecting it to reinforced concrete beam (3).

1.2 ferrocement

Ferro cement is a type of thin reinforced concrete ,whole cement – sand mortar is reinforced with closely spaced small diameter wire mesh with or without steel bars of small diameters called skeletal steel bars . Ferro cement has a very high tensile strength to weight ratio and superior cracking behavior in comparison with reinforced concrete(5).

1.3 Impact Load

The impact load applied to a structure depends on the impactor velocity,the masses of structure and impactor ,the resulting deformations and material properties of both bodies. The effective resistance of any structure to impact is mainly dependant upon its ability to absorb energy and the more ductile target has a higher ability to absorb energy (7).

1.4 Impact Resistance of Ferro cement

(2) Ali investigated the adequacy of a wall consisting of a steel skeleton gladded with ferro cement plates of dimension (100 X 800 X 50mm) on its exterior and interior sides and a sand filled cavity in between against the fragmentation of a (250 kg G.P) bomb exploding at (7.5m) from the wall.

(8) Shah and Key presented the impact test specimens of dimension (22 x 225 x 12.5mm) each specimens was reinforced with sex layers of galvanized wire meshes of woven or welded type.

Two ballistic pendulums of (11.2kg) were used . The maximum possible height of drop was (2.4m).

The critical case the impact resistance of critical case was the amount of water flow through the damaged plates during a specified time . It was concluded that the impact resistance increased as the ductility tensile strength and specific areas of the meshes increased (1) .

(9) Rao carried out tests on simply supported Ferro cement panels of dimensions (300 x 300x25mm). The Ferrocement panels were subjected to cumulative central impact by using a (1kg) projectile .the specimens were reinforced with different types of meshes (hexagonal woven and welded) .

The effect percentage of the reinforcing meshes and the type of the projectile head were also studied . The impact force and transient deflection – time histories were recorded.

1.5 Object and scope

There has been little research on the combined effect of conventional reinforced concrete beams that are encased with a thin layer of ferrocement on the impact resistance concrete .The ability of thin layer ferrocement in this work which encased rectangular reinforced concrete beams was subjected to the impact load to enhance.

The experimental program covers the effect of variable the effect the application of ferrocement .Hence the present investigation is concreted with

1. Effect of the number of layer of wire mesh.
2. Effect of thickness of ferrocement .
3. Effect of mortar strength .
4. Effect of skeletal steel and its distribution .

2-EXPERMINTAL WORK

2.1 Introduction

This work is to show the effect of combination of conventional reinforced concrete beam encasement with a thin layer of ferrocement to improve its resistance to impact load.

2.2 materials

the constituent materials of concrete mortar ,steel bar and hexagonal wire mesh used throughout this investigation are given below. The same source of materials was used throughout the work .

2.2.1 Cement

The cement used was ordinary Portland cement from Kubasia . It confirms to Iraqi standard No.5.

2.2.2 Fine Aggregate

Al- Akhaider natural sands was used .

2.2.3 Coarse Aggregate

Natural aggregate with (4.75-19) normal size was used .

2.3 Mix Design

For reinforced concrete beams two different concrete mixes were used to give high and normal strength of concrete the first was(1:1.2:2.6 with w/c 0.4) and the second was (0.6 w/c 1:1.5:3 with slump of (80 mm) for the first mix and collapse for the second . For ferrocement three different mortar mixes were used to give different strength of mortar (0.6 w/c 1:2, 0.6 w/c 1:3 and 0.6 w/c 1:5).

2.3 Mixing procedure

The mixing of concrete and mortar was carried out in a rotary pan type mixer of (0.2 m^3) capacity. in all concrete mixes, the aggregates and cement were first mixed dry for about (60)second and after the additional of water for further 120 second .

After mixing the concrete was poured into lightly oiled steel mould in three layers and well compacted by table vibrator for about 20 second for each layer to give adequate compaction. the specimens were then covered with polythene sheet supported on trestles and lifted undistributed until the moulds were stripped after (24 hours).

With each beam the following specimens were cast to determine the properties for the hardened concrete.

1-three (152 x 152 x152mm) cubes for compressive strength(f_{cu}).
2- three (152 x 305mm) cylinder for compressive strength(f_c').
3- three (100 x 100x500mm) prisms for modules of rupture (f_r').

the same procedure was used for mixing the mortar .each beam encasement included the following specimens of hardened mortar .

1. three (75x150mm cylinder compressive strength(f_{cf}).
2. three (50x150x50mm) cube for compressive strength(f_{cf}).
3. three (40x40x160mm) prisms for modules of rupture (f_{rf}).
4. three 8 shape specimens for direct tension (f_{rt}).

2.3.2 Properties of Fresh concrete

The standard slump test was carried out according to ASTM C143-78 .80 mm slump were approximately used.

2.4 Properties of steel

The stress- strain curves of steel bars and wire mesh reinforcement were investigated prior to manufacturing the structural members.

2.4.1 Steel Bars

Deformed steel bars with diameters of 9.9mm as well as plain steel bars with diameter of 5 mm were used in the present work . the material properties are given in table (2-1).

2.4.2 Wire Mesh

Woven hexagonal wire mesh was used the average diameter was (0.7mm) . Fig. (2-2) show the geometry dimension and stress –strain curve of the wire mesh used.

2.5 Casting and Curving of the Beams.

Steel mould with inner dimensions (150mm width 200mm height and 3000mm length) was prepared for casting all the 20 beams.

3-TEST RESULTS AND DISCUSSION

3.1 Introduction

Sudden failure of reinforced concrete beams due to impact load has a great importance.A progressive collapse may occur by some abnormal loading which causes local failure . This problem was investigated extensively by more than one different research with different beams against Impact load.

3.2.1 Effect of Number of Wire Mesh Layers

the effect of number of layers on impact resistance and deflection is show in figures . (3.1) to (3.4) .It may be observed that number of wire mesh layers has a significant effect on the impact resistance of reinforced concrete beams.

3.2.2 Effect of Ferrocement Element Thickness

the effect of ferrocement element thickness on the impact resistance and deflection is observed as show in figure (3.7 to 3.10) . The thickness of ferrocement has signification effect on the strength of impact load . For 2 layers the increase change from(178% to 306 % for 20 and 30 mm). Ferrocement thickness respect to reference beam so (367 to 420 %), the increasing of (4) layers to same varying of thickness (6) layers has similar increase from (267 to 367%) . A shape has increment of (711 to 778 %) .

3.2.3 Effect of Skeletal Steel and its Distribution

Figure (3.17 and 3.18) show the effect of skeletal steel to improve the impact strength and deflection . Use of the skeletal reinforcement with beam (5)increases the impact strength and comparison with (200 %) for the beam(3) with no skeletal reinforcement . Figure (3.19 and 3.20) show the effect of skeletal steel distribution. Using an extra amount of skeletal steel at bottom will enhance the impact strength and ductility more than the other face.

3.2.4 Mortar Compressive Strength

There is an optimum compressive strength for the ferrocement mortar to increase the impact resistance and ductility of the encased rectangular reinforced beams .Using very high or very low compressive strength of ferrocemcent mortar will yield lower impact resistance and ductility as shown in the figures (3.25 and 3.26) .

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Conclusions

The reinforced concrete beams encased by a ferrocement skin have shown a superior performance in resisting impact load as compared with ordinary reinforced concrete beams in the following respect.

1.Impact strength of the composite beams were up to 778 % higher than those of the reference beams due to the additional strength contributed by the skin elements .

2. composite action between the skin and core components was fully obtained until loss of the bearing capacity .In this stage and up to the failure a partial separation occurred therefore if mechanical bond projected on the contact surface were used or at last if clearly roughness was provided to the contact surface of the forms full composite action up to failure be obtained . Because of the large contact surface between the precast and in –situ components no special surface treatment is generally required

3. The number of layers of wire mesh has a significant effect on the strength of impact load . The magnitude of impact blows increases or is reduced clearly according to the increase in the number of wire mesh layers . There is an optimum number of wire mesh layers for the ferrocement to increase the impact resistance and ductility of the encased rectangular reinforced beams.

4. The thickness of the skin has significant effect on the strength of impact load . The increase in thickness can increase resistance especially at the beginning of failure ,for 2 layers (178 to 360 for 20 to 30 mm).

5. ferrocement has great influence on strengthening reinforced concrete with wide range of ultimate concrete strength .

Table (2-1)Properties of wire mesh and steel bar reinforcement

Type of Reinforcement	***Diameter (mm)***	***Yield Stress (f_y) N/mm^2***	***Ultimate Strength (f_u) N/mm^2***	***Modules of Elastic (E_s) N/mm^2***
Wire mesh	0.7	310	520	67000
Skeletal	5	490	582	199810
Longitudinal	9.9	370	560	194700

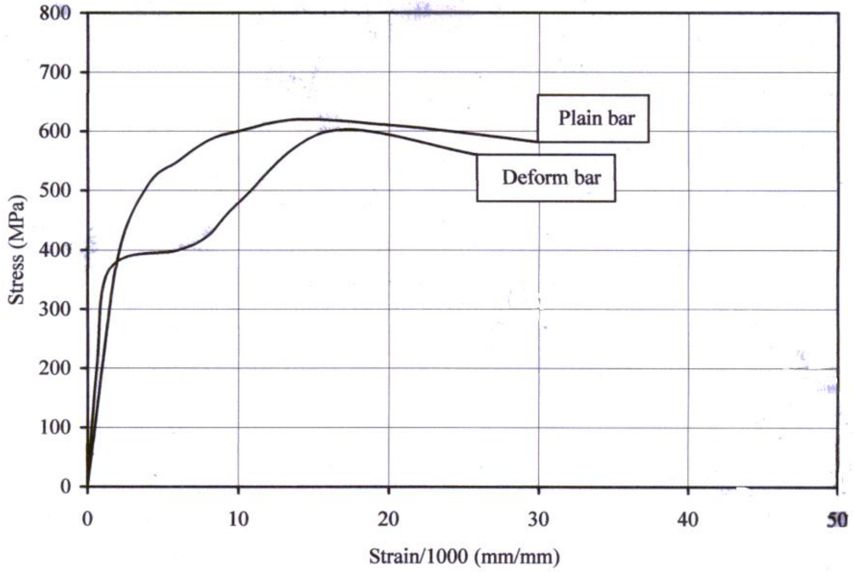


Fig. (2.1) Stress-strain curves for steel bars.

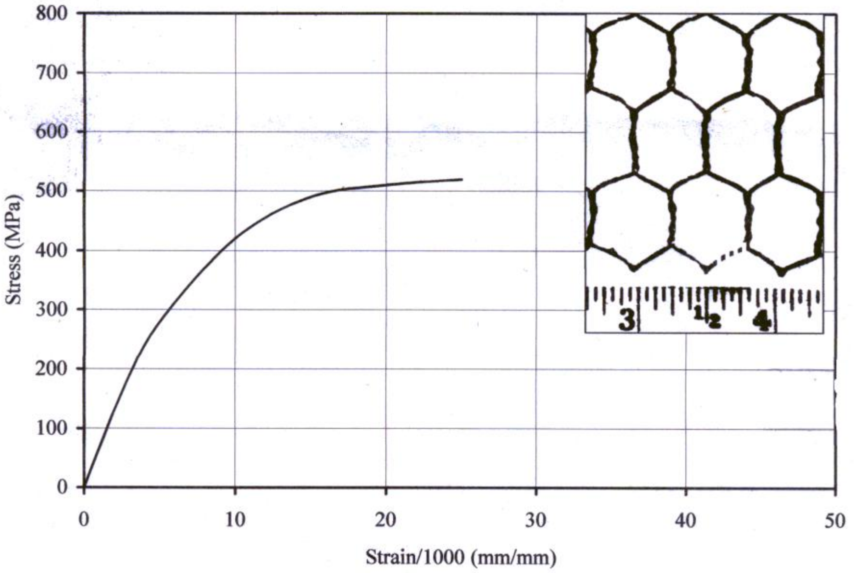
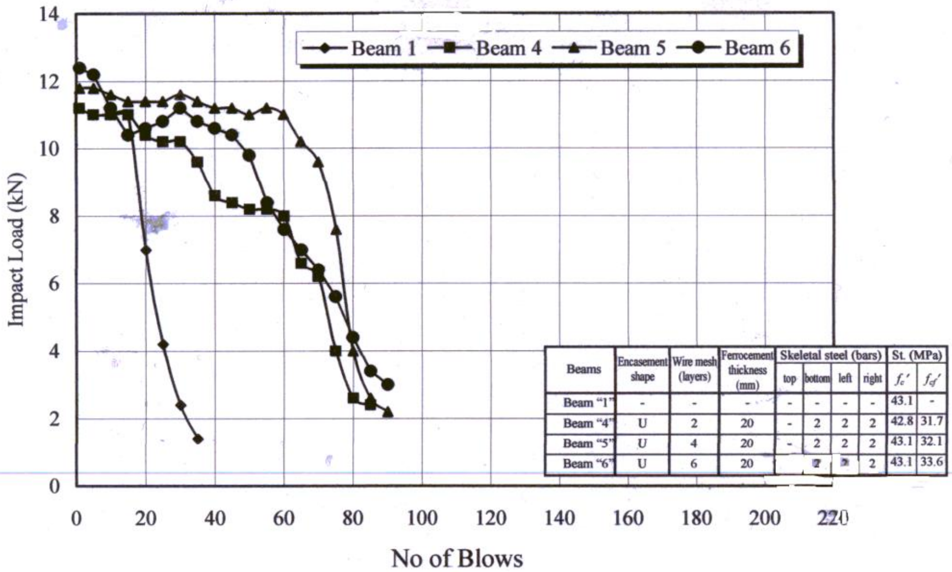


Fig. (2.2) Geometry dimension and stress-strain curve for wire mesh.



Beams	Encasement shape	Wire mesh (layers)	Ferrocement thickness (mm)	Skeletal steel (bars)				St. (MPa)	
				top	bottom	left	right	f_c'	f_{cf}'
Beam "1"	-	-	-	-	-	-	-	43.1	-
Beam "4"	U	2	20	-	2	2	2	42.8	31.7
Beam "5"	U	4	20	-	2	2	2	43.1	32.1
Beam "6"	U	6	20		2	2	2	43.1	33.6

Fig (3.1) Effect of number of wire mesh layers on the impact resistance for 20 mm thickness of ferrocement.

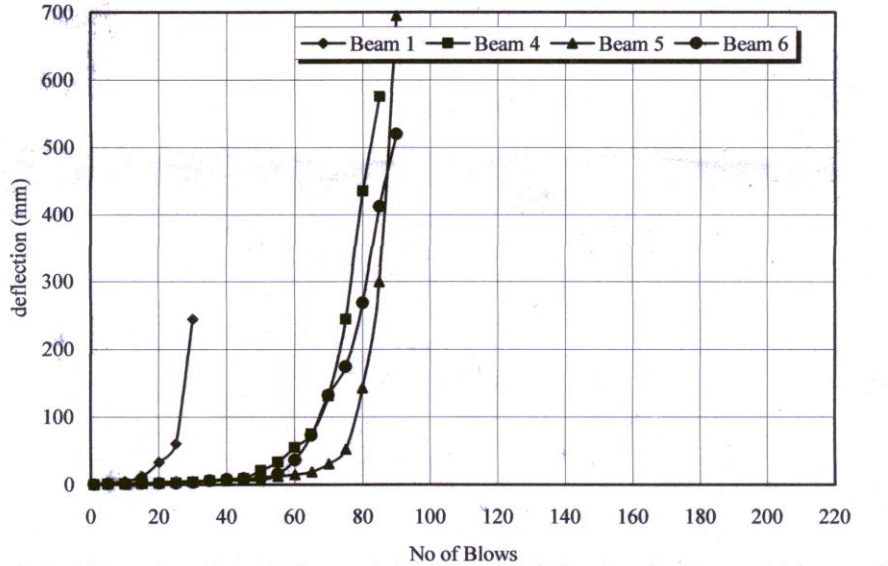
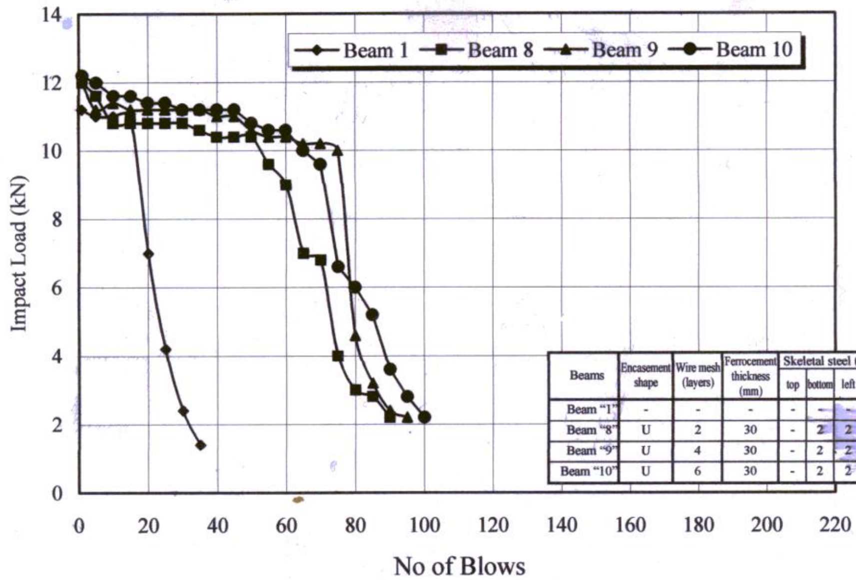


Fig (3.2) Effect of number of wire mesh layers on the deflection for 20 mm thickness of ferrocement.



Beams	Encasement shape	Wire mesh (layers)	Ferrocement thickness (mm)	Skeletal steel (bars)				St. (MPa)	
				top	bottom	left	right	f_c'	f_{cf}'
Beam "1"	-	-	-	-	-	-	-	43.1	-
Beam "8"	U	2	30	-	2	2	2	42.6	34.1
Beam "9"	U	4	30	-	2	2	2	43.3	33.5
Beam "10"	U	6	30	-	2	2	2	43.1	32.7

Fig (3.3) Effect of number of wire mesh layers on the impact resistance for 30 mm thickness of ferrocement.

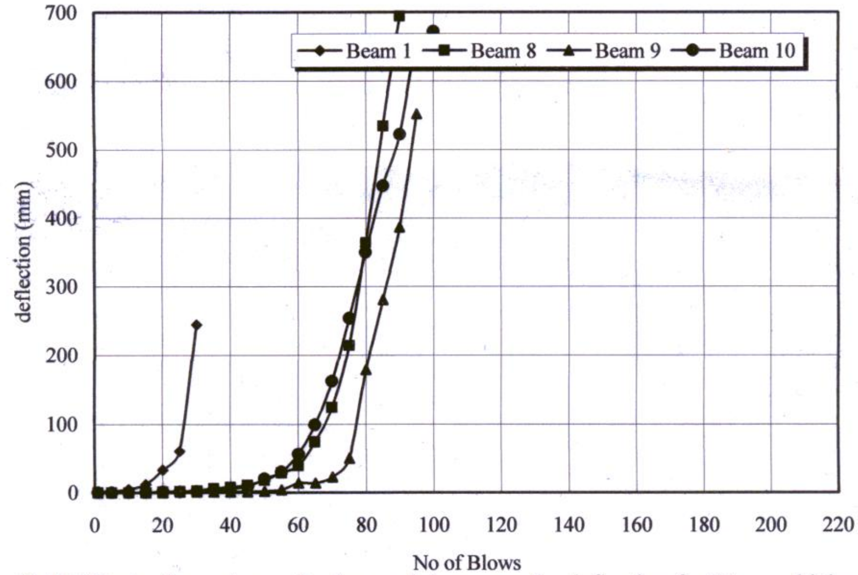
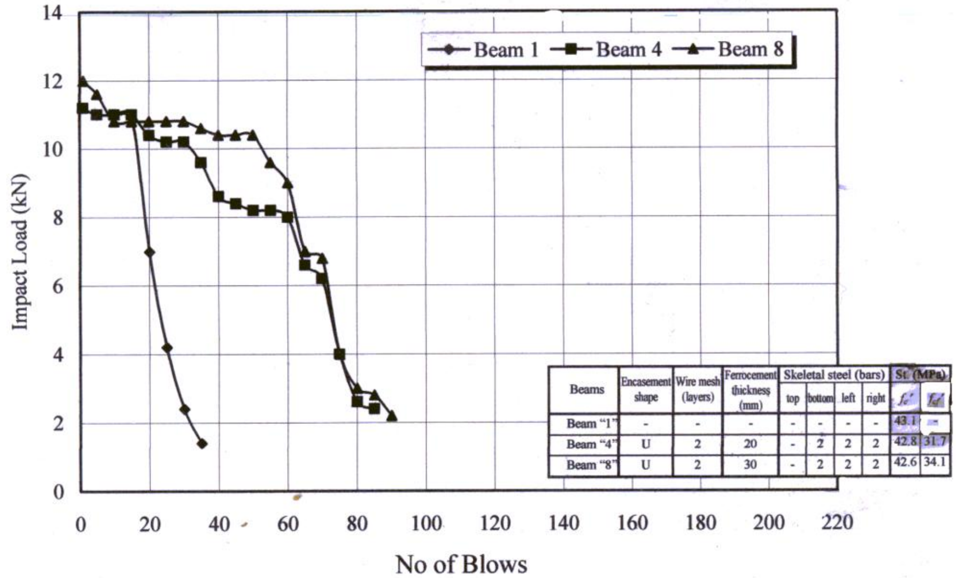


Fig (3.4) Effect of number of wire mesh layers on the deflection for 30 mm thickness of ferrocement.



Beams	Encasement shape	Wire mesh (layers)	Ferrocement thickness (mm)	Skeletal steel (bars)				St. (MPa)	
				top	bottom	left	right	f_c'	f_{cf}'
Beam "1"	-	-	-	-	-	-	-	43.1	-
Beam "4"	U	2	20	-	2	2	2	42.8	31.7
Beam "8"	U	2	30	-	2	2	2	42.6	34.1

Fig (3.5) Effect of ferrocement thickness with 2-layers of wire mesh on the impact resistance.

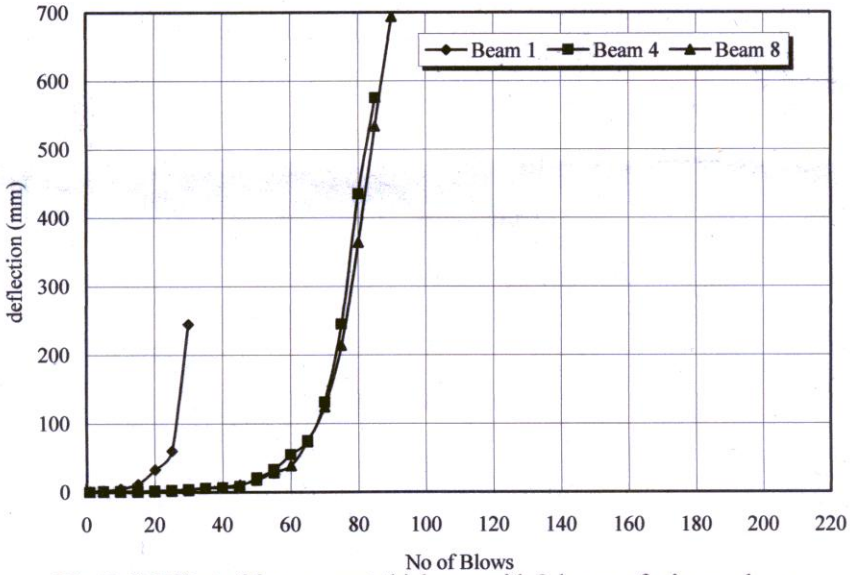
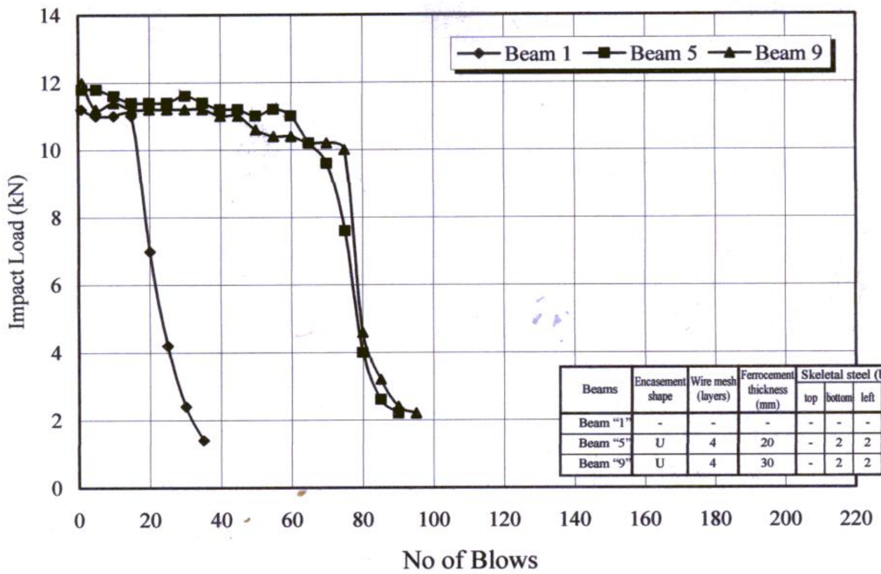


Fig (3.6) Effect of ferrocement thickness with 2-layers of wire mesh on the deflection.



Beams	Encasement shape	Wire mesh (layers)	Ferrocement thickness (mm)	Skeletal steel (bars)				St. (MPa)	
				top	bottom	left	right	f_c'	f_{cf}'
Beam "1"	-	-	-	-	-	-	-	43.1	-
Beam "5"	U	4	20	-	2	2	2	43.1	32.1
Beam "9"	U	4	30	-	2	2	2	43.3	33.5

Fig (3.7) Effect of ferrocement thickness with 4-layers of wire mesh on the impact resistance.

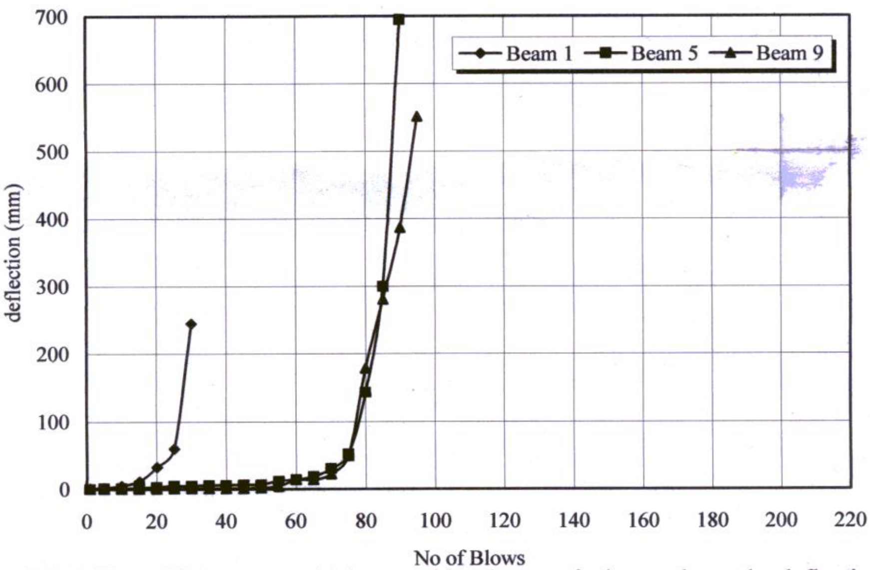
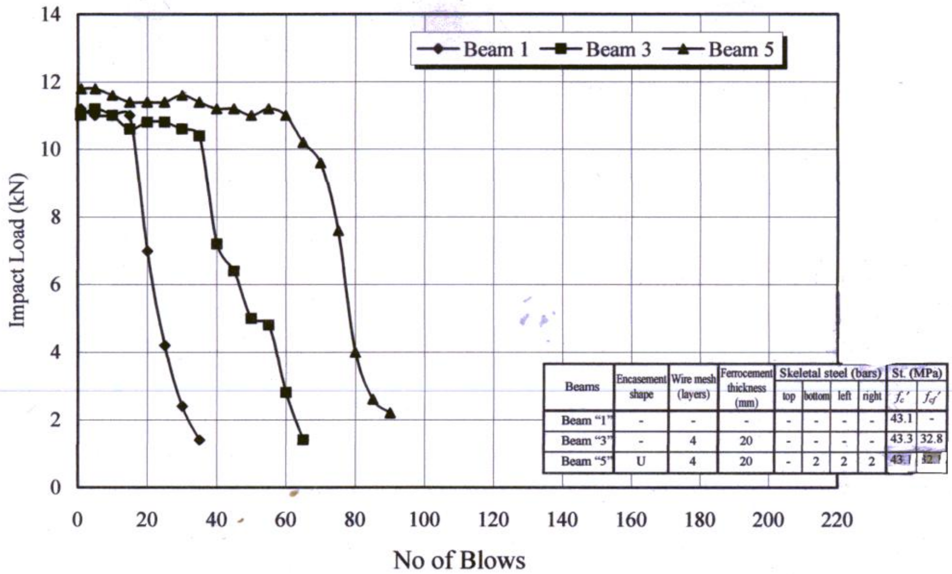


Fig (3.8) Effect of ferrocement thickness with 4-layers of wire mesh on the deflection.



Beams	Encasement shape	Wire mesh (layers)	Ferrocement thickness (mm)	Skeletal steel (bars)				St. (MPa)	
				top	bottom	left	right	f_c'	f_{cf}'
Beam "1"	-	-	-	-	-	-	-	43.1	-
Beam "3"	-	4	20	-	-	-	-	43.3	32.8
Beam "5"	U	4	20	-	2	2	2	43.1	[illegible]

Fig (3.17) Effect of skeletal steel on the impact resistance.

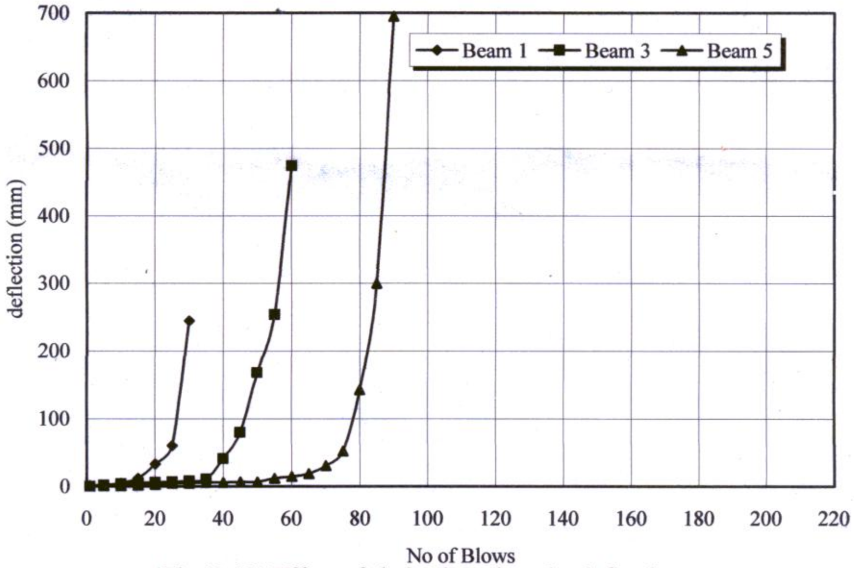
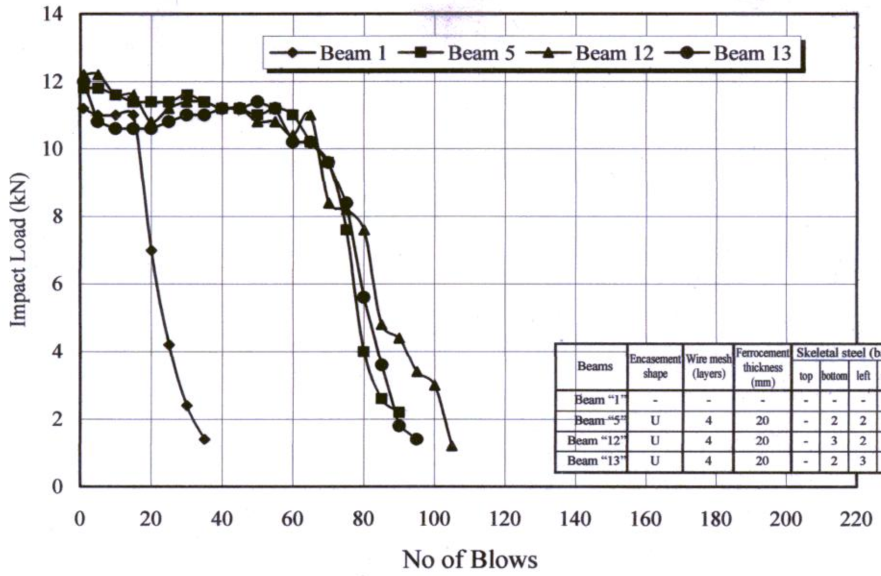


Fig (3.18) Effect of skeletal steel on the deflection.



Beams	Encasement shape	Wire mesh (layers)	Ferrocement thickness (mm)	Skeletal steel (bars)				St. (MPa)	
				top	bottom	left	right	f_{cu}^{*}	f_{cf}'
Beam "1"	-	-	-	-	-	-	-	43.1	
Beam "5"	U	4	20	-	2	2	2	43.1	32.1
Beam "12"	U	4	20	-	3	2	2	43.3	33.2
Beam "13"	U	4	20	-	2	3	3	43.4	32.7

Fig (3.19) Effect of skeletal steel distribution on the impact resistance.

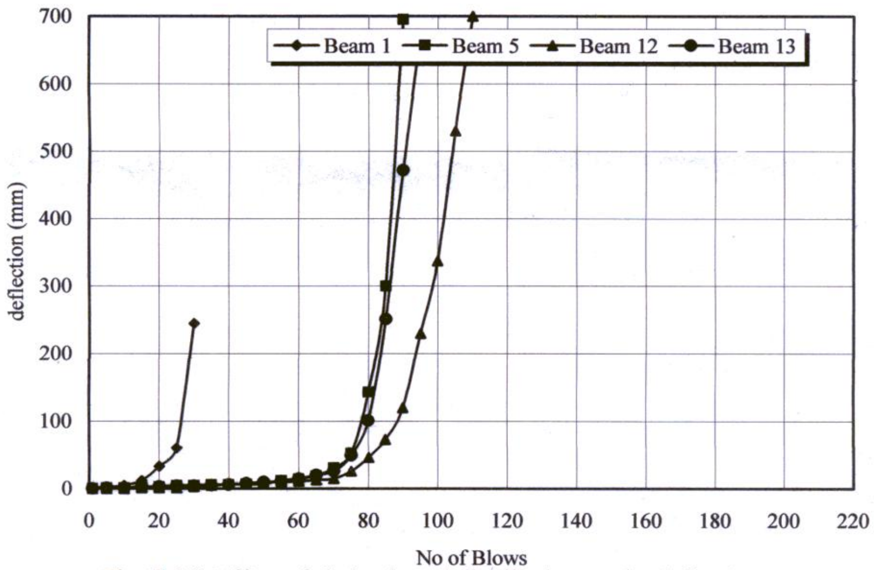
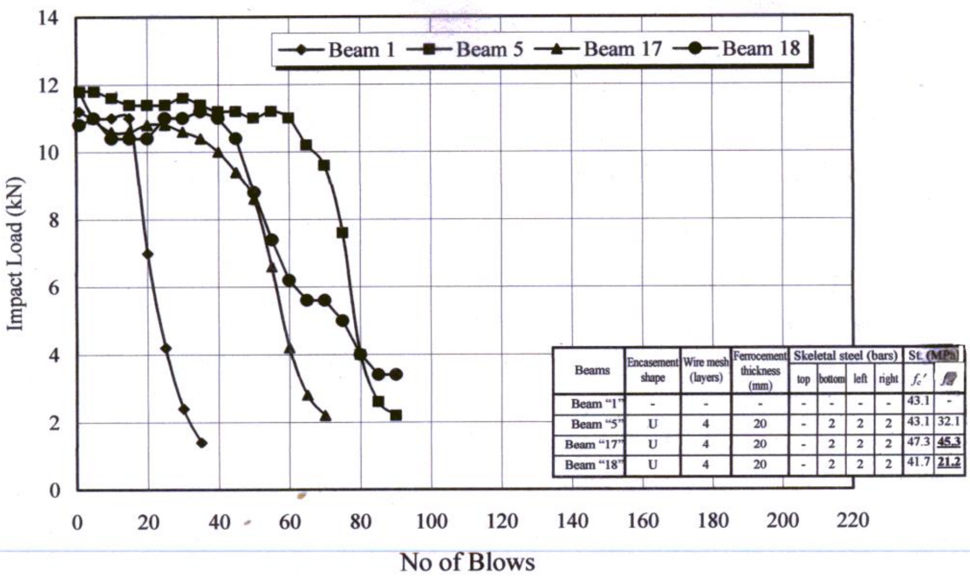


Fig (3.20) Effect of skeletal steel distribution on the deflection



Beams	Encasement shape	Wire mesh (layers)	Ferrocement thickness (mm)	Skeletal steel (bars)				St. (MPa)	
				top	bottom	left	right	f_c'	[illegible]
Beam "1"	-	-	-	-	-	-	-	43.1	-
Beam "5"	U	4	20	-	2	2	2	43.1	32.1
Beam "17"	U	4	20	-	2	2	2	47.3	**45.3**
Beam "18"	U	4	20	-	2	2	2	41.7	**21.2**

Fig (3.25) Effect of mortar compressive strength on the impact resistance.

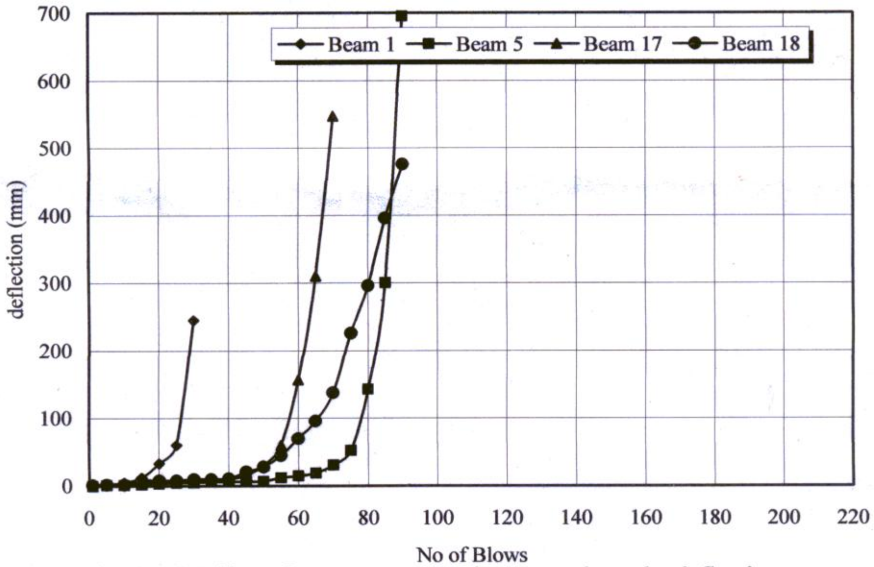


Fig (3.26) Effect of mortar compressive strength on the deflection.

FERANCES

1. Macleod, I.N. 1980 "***large panel structures*** " Handbook of concrete Engineering .pp433.
2. Ali, A.A, 1990 "***Impact resistance of ferrocement slabs"***,Msc .thesis president to the Department of Balding and Construction Engineering of the Universityof Baghdad ,pp 1-85.
3. Kar , A.K , 1979 " ***Impactive Effect of Tornado Missiles and Aircraft***" , Journal of structure division, ST ,Nov.
4. ACI ,publication SP. 61 ,1979 "***Ferrocement –Materials and Application"*** pp .1-195.
5. Subrahamanyam B.V. ,et .al 1979 "***Ferrocement Technology : a Critical Evolution , The International Jornal of Cement Composites*** " Volume 1, Number 3 October,pp 125-139.
6. Parmansivam , p., 1988 " ***Ferrocement Structural and Structure Element "*** , Elsevier Applied science ,London pp289-339.
7. ACI Committee 549 ,1988 " ***State –of –the -Art Report on Ferrocement"*** ACI Manual of Concrete practice ,part 5.
8. Shah .S.P,Key ,W.H ,1972 " ***Impact Resistance of Ferrocement*** " Journal of the Structure division proceedings of the American Society of Civil Engineering , Jan. pp111-123.
9. Rao P.S, 1981 " ***Impact Studies on Ferrocement Slabs*** " International Symp. On ferrocement ,Rilem.

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