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EFFECT OF SHEAR FORCES ON MONOPANEL BEAM SPECIMENS

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ABSTRACT:

A monopanel system is a new building material system of ferrocement that consists of two thin ferrocement block-like faces and a thick layer of low strength, density and cost polystyrene foam insulation between them as a core.

The simple structural idealization of a monopanel system is that the core provides shear transfer between the faces that provide flexural and compression resistance. Transverse trusses made of steel bars having a diameter of 3.2 mm, which serve as tie reinforcement to prevent the thin ferrocement skins from local buckling, have been used in the present work. These transfer system consist of two longitudinal bars connected by inclined steel bar forming trusses shape making an angle equals to 60^{o} with the longitudinal bars.

The main object of this research is to present an experimental investigation on the behavior and load carrying capacity of monopanel beams. The experimental work includes testing nine monopanel beams, and has been investigated the effect of a different depths of monopanel beams on the behavior and the ultimate load capacity. Also comparison of these results with the ACI code formulations have been made.

الخلاصة:

نظام المونوبنل هو نوع من البناء الجديد الذي يتكون من طبقتين رقيقتين من الفيروسمنت تتخللهما طبقة سميكة من مواد عازلة ذات مقاومة وكثافة قليلتين. في هذا البحث ربطت هاتين الطبقتين مع بعضهما بواسطة عوارض مشبكه جملونيا مصنوعة من قضبان فولاذية بقطر ٣.٢ ملم على هيئة قضبان طولية عدد ٢ تربطهما أخرى تميل بزاوية مقدارها ٦٠ درجة مع القضبان الطولية ، هذه القضبان المائلة تعمل كروابط بين قشرتي الفيروسمنت الرقيقة وتمنعهما من الانبعاج الموضعي وتقوم بمقاومة قوى القص المسلط عليها.

لقد تناول هذا البحث دراسة سلوك و سعة التحمل للأعتاب المصنعة في المختبر بموجب نظام المونوبنل. ومن خلال التجارب العملية لتسعة نماذج من أعتاب المونوبنل تمت دراسة تأثر أحمال الفشل باختلاف عمق الأعتاب حيث تمت دراسة هذه المتغيرات على السلوك والحمل الأقصى للنماذج كذلك تم مقارنة النتائج مع نتائج علاقات مدونة ال **ACI** لقوى القص.

INTRODUCTION

Construction materials have a huge regarding of the engineering within the end of the 19^{th} century and were developed quickly within the passed years. This development considers the cost, construction time and safety to product the ideal construction materials; the monopanel system is one of solutions.

A monopanel system is a new building type having a lightweight and a low cost with respect to alternative systems. This system has an isolation core made of polystyrene foam and contains trusses shape, called lacing made of steel bars having diameter of 3.2 mm making an angle equals to 60^o with the longitudinal skeletal bars, which is usually made of the same material. This lacing system resists the shear effects.

The core material can be made of aerated concrete, expanded polystyrene concrete, polyurethane foam, no fines concrete, polystyrene foam, etc. The density of polystyrene foam is very low equals 16 kg /m^3 . This low density and porous structure give the core excellent thermal and sound insulation properties. Also the monopanel system can be made in site or precast to very accurate and controlled dimensions (1).

EXPERIMENTAL WORK

Materials:

1-Cement:

Ordinary Portland cement produced at Al_ kufa cement factory was used throughout this research . It was kept in airtight plastic containers to avoid humidity effect .The chemical properties of the cement are presented in Table (1). The result conforms with the Iraqi standard no. 5/1984 .

Table (1) Chemical composition of cement

No.	Chemical composition	Tested cement %	Iraqi Standard No. 5/1984 Limits %
1	SiO_2	20.1	----
2	CaO	61.09	---
3	MgO	2.01	≤ 5
4	Fe_2O_3	3.44	---
5	Al_2O_3	5.75	---
6	SO_3	2.61	≤ 2.8
7	Loss on ignition	2.21	≤ 4
8	Insoluble residue	1.47	≤ 1.5
9	Lime saturated factor	0.92	0.66- 1.02
10	C_3A	9.73	≥ 5

2-Sand:

The fine aggregate used in this research was brought from Al-Najaf valleys region. Table (2) presents the sand properties .The properties was conformed with the Iraqi specification No.45/1984 .Since the sand passing through the 2.36 mm (B.S. sieve No.7) was used.

Table (2) Grading and physical composition of sand.

No.	Sieve Size (mm)	Tested Sand passing %	Iraqi Standard Limits %
1	4.75	100	90-100
2	2.36	96.2	85-100
3	1.18	91.2	75-100
4	0.600	76.3	60-79
5	0.300	25.5	12-40
6	0.150	2.3	0-10
Specific gravity =2.6			

3-Reinforcement:

3.1 Wire Mesh Reinforcement:

Locally available mild galvanized steel welded wire meshes of 12.7 mm square opening with a diameter 0.8 mm have been used throughout the experimental work.

3.2 Steel Bar Reinforcement:

Smooth mild steel with an average diameter of 3.2 mm was used for the lacing and skeletal reinforcement .

Table (3) shows the properties of reinforcement that tested in strength of material laboratory (Mechanics Engineering Department).

Table (3) Properties of reinforcement.

Measured diameter (mm)	f_y (MPa)	f_u (MPa)	Modulus of elasticity (MPa)
0.8	350	560	175000
3.2	400	680	200000

4-Polystyrene Foam:

A polystyrene foam with low density of (16 kg / m^3) was used as a core filling material.

5-Water:

Ordinary tap water was used throughout this investigation for mixing and curing test specimens.

Mix Design:

The mixing process of mortar was performed in a pan type mixer. The specified dry materials (cement and sand) were well mixed to attain uniform mixing. The required amount of tap water was then added and the whole mix ingredients were mixed for 3-minutes.

One type of mix proportion was considered throughout the research. The sand and cement were thoroughly mixed in a ratio of one part by weight of cement to two and half parts of sand (1: 2.5). The water cement ratio used to maintain a slump of (100±5 mm) was 0.5. To establish the mortar mechanical properties shown in Table (4), a number of control specimens were cast and tested, three cylinders of 100 x 200 mm, three cubes of 50 x 50 x 50 mm and three cylinders of 150 x 300 mm were used to estimate the compressive strength, the modulus of elasticity and the split tensile strength. Three prisms of 100 x 100 x 400 mm have been used to estimate the modulus of rapture. These tests were in accordance with the British standard BS.1881 and the American standards ASTM-C39, ASTM-C109, ASTM-C469 and ASTM-C78.

Table (4) Mechanical properties of mortar mix (average of three specimens)

Mix proportion (Cement-Sand)	Compressive strength (MPa)		Splitting strength (MPa)	Modulus of rupture (MPa)	Modulus of elasticity (MPa)
	f'_c	f_{cu}	f_{ct}	f_r	E_m
1:2.5	20.3	26.6	2.12	2.71	22646

Results of Monopanel Beams Tests:

The experimental work of the nine Monopanel beams was divided into three groups (A,B and C). Table (5) shows the beam specimen details of groups A,B and C. Figure (1) shows the geometry of groups A,B and C of Monopanel beam specimens.

Table (5) Details of groups A, B and C of Monopanel beam specimens

Group	Depth H (mm)	Width B (mm)	Length L (mm)	Face thickness t (mm)	Lacing spacing Ls (mm)	Core Depth (mm)
A	200	200	1200	25	85	180
B	300	200	1200	25	85	280
C	400	200	1200	25	85	380

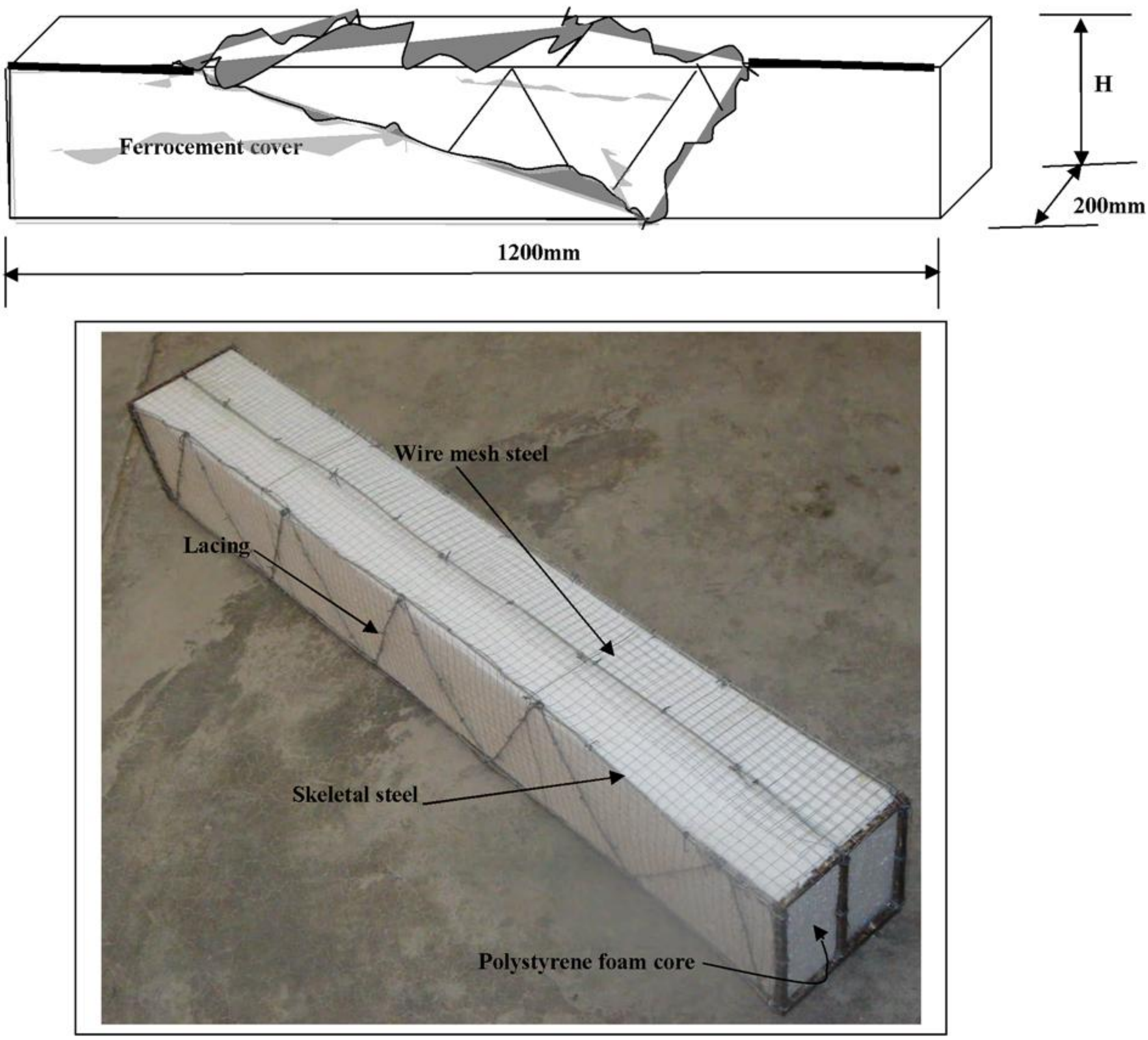

Fig. (1) Geometry and reinforcement details of Monopanel beam specimens used for groups A,B and C

The experimental results included the measured failure loads, mid span deflection and failure modes.

All Monopanel beams were tested under a transverse force applied at a distance **H** from each end supports of a simple beam up to failure. Table (6) gives the details of the ultimate loads of each Monopanel beam groups. The ratios of ACI-Code 318 M-08 ultimate load to the value of experimental ultimate loads are listed in Table (6) too.

Table (6) Ultimate loads for Monopanel beam specimens

Group	H (mm)	Experemental Ultimate load (kN)	Ultimate load (kN) according to ACI-Code 318 M-08*	$\frac{P_{ACI}}{P_{Exp.}}$
A	**200**	**19**	**17.794**	**0.936**
B	**300**	**28.5**	**27.680**	**0.971**
C	**400**	**38**	**37.325**	**0.982**

* Theory value was obtained according ACI-Code 318 M-08 (11.4 provisions)

According to the experimental results, when the depth of the specimen increases in a ratio from 1 to 1.5, the ultimate shear force increases by 42.5 percent and the mid span deflection at ultimate stage decreases by 24.82 percent. Also when the depth of specimen increases in a ratio from 1 to 2, the ultimate shear force increases by 85 percent and the mid span deflection at ultimate load decreases by 29.04 percent. While, when the depth of specimen increases in a ratio from 1.5 to 2, the ultimate shear force increases by 33.33 percent and the mid span deflection at ultimate stage decreases by 5.62 percent.

Figures (2) to (4) exhibits the load –central deflection behavior obtained at different loading stages for Monopanel beam specimens. Figure (5) shows the relationship between the ultimate experimental shear force and the ratio of the depth for monopanel beam specimens. While, figure (6) presents the crack pattern for Monopanel beam specimens.

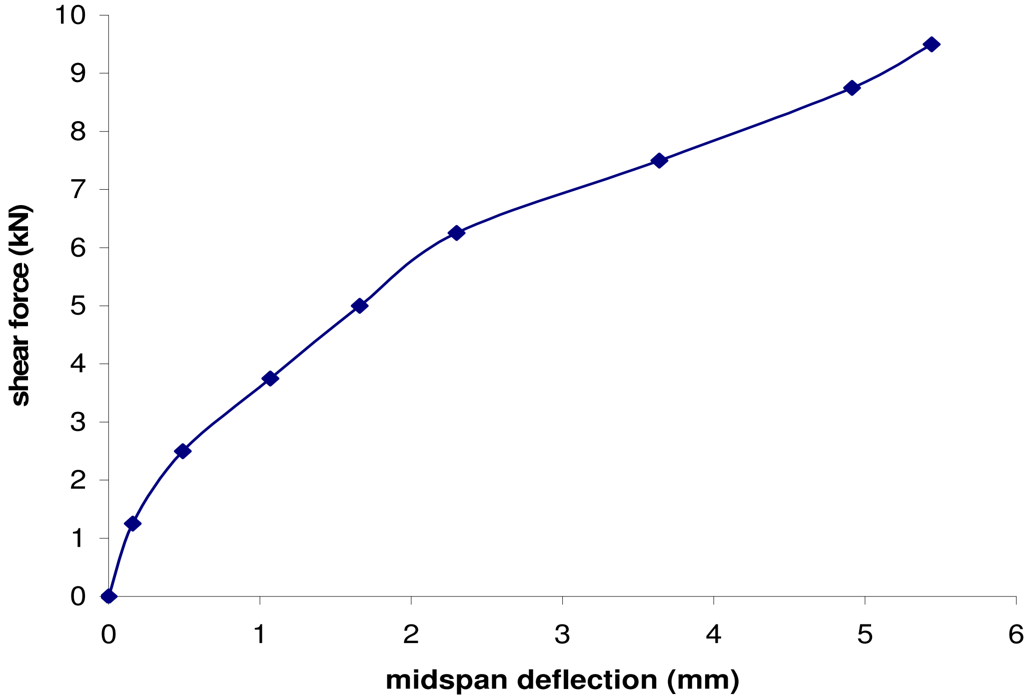

Fig.(2) Midspan diflection for Monopanel Specimen with H=200mm

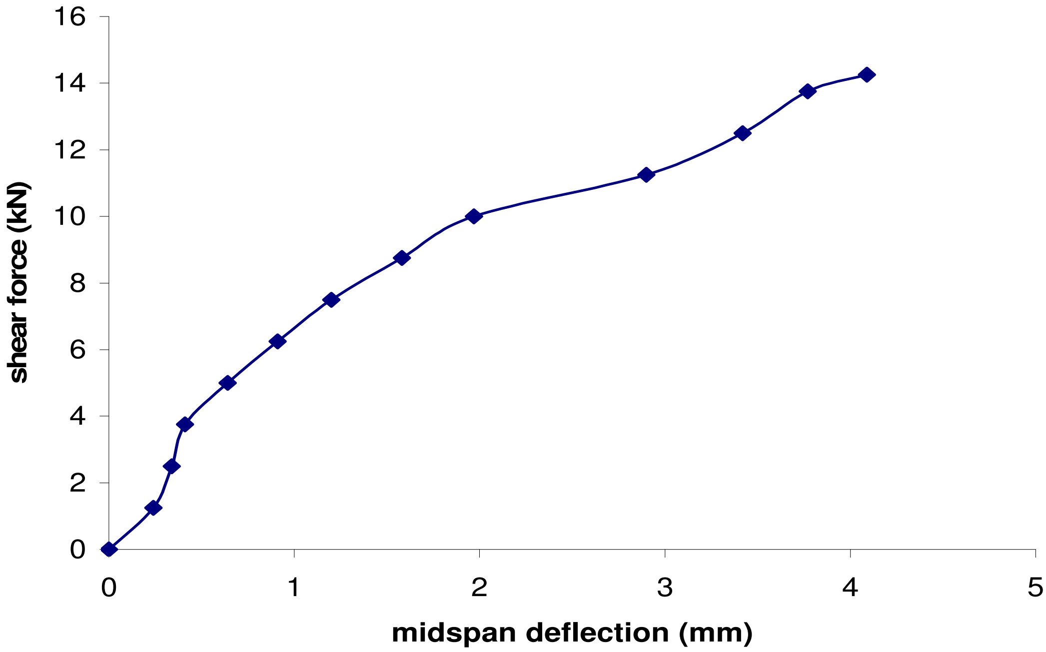

Fig.(3) Midspan diflection for Monopanel Specimen with H=300mm

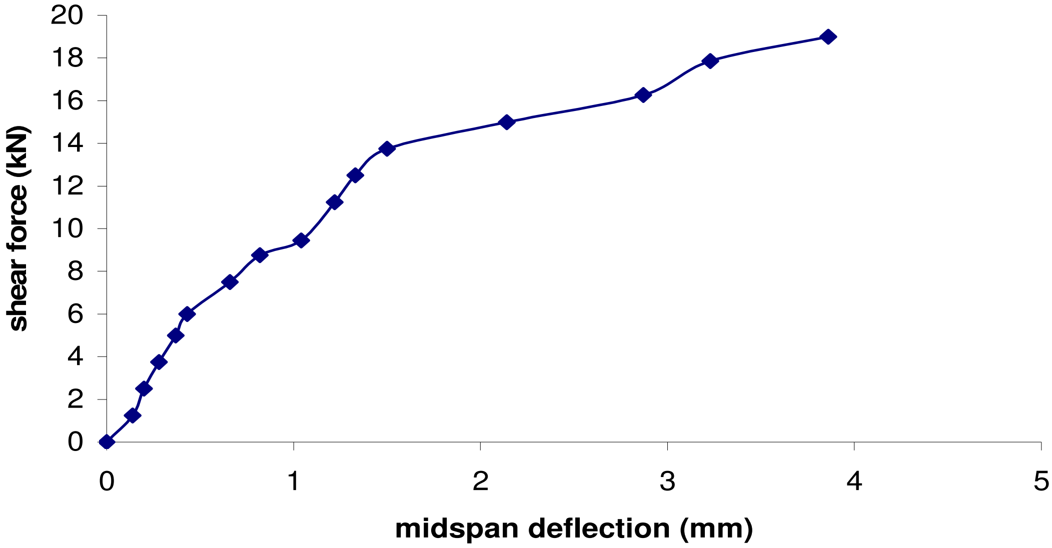

Fig.(4) Midspan diflection for Monopanel Specimen with H=400mm

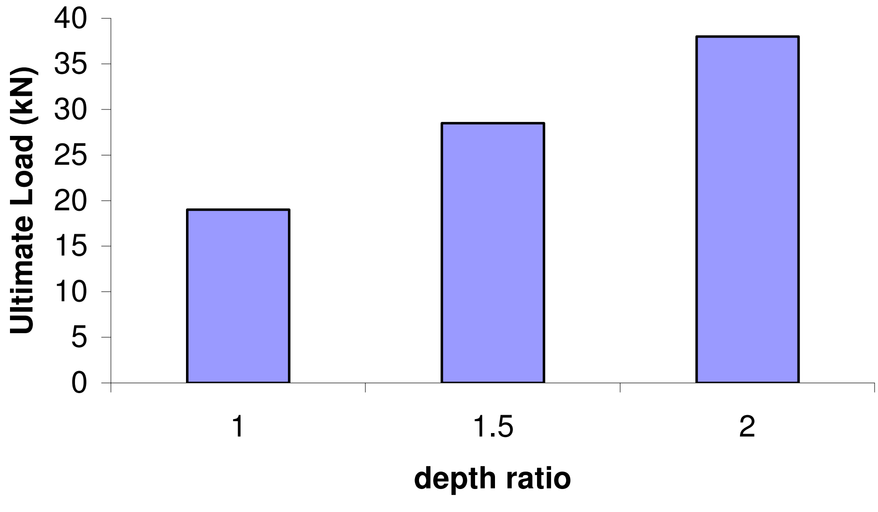

Fig.(5) Ultimate Load versus Depth Ratio of Monopanel Beam Specimens Relationshipe

Fig.(6)Shear crack pattern for Monopanel beam specimens

CONCLUSIONS

The conclusions emerged from the experimental work are summarized as following :-

1-Experimental results of testing Monopanel beam specimens reveal that they are acceptable structural elements for rushed construction processes, and they may safely be used to construct small housing units and small structures.

2- By increasing the depth of monopanel beam specimen, the mid span deflection is decreased. The experimental results show that when the depth of specimen increases in a ratio from 1 to 1.5, the mid span deflection at ultimate stage decreases by 24.82 percent. In addition, when the depth of specimen increases in a ratio from 1 to 2, the mid span deflection at ultimate stage decreases by

29.04 percent. While, when the depth of specimen increases in a ratio from 1.5 to 2, the mid span deflection at ultimate stage decreases by 5.62 percent.

3- It can be noted from the experimental results of Monopanel beams that the failure shear force increases when the depth is increased. It was found that when the depth of specimen increases in a ratio from 1 to 1.5, the ultimate shear force increases by 42.5 percent. Also when the depth of specimen increases in a ratio from 1 to 2, the ultimate shear force increases by 85 percent. While, when the depth of specimen increases in a ratio from 1.5 to 2, the ultimate shear force increases by 33.33 percent.

4- It can be noted that the failure shear force for Monopanel beam specimens are in good agreement with the ACI-Code 318 M-08 provisions.

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