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Effect of Number of Wire Mesh Layers and Depth Ratio on Ultimate Shear Force for Monopanel Beam Specimens

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Abstract:

A monopanel is the system building witch consists of two thin ferrocement block as a faces and between them a bushy layer of low strength, density and cost as a core made from lightweight material for example from polystyrene foam as using in this investigation or any material as an insulation .

The simple structural idealization of a monopanel system is that the core provides transverse trusses between the faces that prevent flexural ,shear force and compression. Transverse trusses made of steel bars having a diameter of 3.2 mm, which make available 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 six groups of monopanel beams, and has been investigated the effect of a different depths of monopanel beams and number of layer of wire mesh of skin faces (one or two layers) on the behavior and the ultimate load capacity. Also comparison of these results with the ACI code 318M-08 formulations have been made.

Keyword : Monopanel system, Lightweight material, Ferrocement, Wire mesh, Shear force and compression.

الخلاصة :

نظام المونوبنل هو نوع من البناء الجديد الذي يتكون من طبقتين رقيقتين من الفيروسمنت تتخللهما طبقة سميكة من مواد خفيفة الوزن ذات مقاومة وكثافة قليلتين على سبيل المثال رغوة البوليسترين والتي استخدمت في هذا البحث أو أي مادة عازلة أخرى .

في هذا البحث ربطت هاتين الطبقتين مع بعضهما بواسطة عوارض مشبكه جملونيا مصنوعة من قضبان فولاذية بقطر 3.2 ملم على هيئة قضبان طولية عدد 2 تربطهما أخرى تميل بزاوية مقدارها 60 درجة مع القضبان الطولية ، هذه القضبان المائلة تعمل كروابط بين قشرتي الفيروسمنت الرقيقة وتمنعهما من الانبعاج الموضعي وتقوم بمقاومة قوى الانثناء والقص و الانضغاط المسلط عليها.

لقد تناول هذا البحث دراسة سلوك و سعة التحمل للأعتاب المصنعة في المختبر بموجب نظام المونوبنل. ومن خلال التجارب العملية لستة مجاميع من نماذج أعتاب المونوبنل تمت دراسة تأثر أحمال الفشل باختلاف عمق الأعتاب و عدد طبقات المشبكان في فلاف النماذج (طبقة واحدة أو طبقتين) حيث تمت دراسة هذه المتغيرات على السلوك والحمل الأقصى للنماذج كذلك تم مقارنة النتائج العملية مع النتائج النظرية التي تم استحصالها باستخدام علاقات قوى القص لمدونة أل ACI 318M-08.

الكلمات المفتاحية : نظام مونوبانيل، مواد خفيفة الوزن، فيروسيمنت، شبكة سلكية، قوة القص والضغط.

Introduction

Construction materials have a vast concerning of the engineering within the end of the last 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.

The 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 Monopanel structural building system is reinforced concrete that consists of two thin ferrocement exterior skins ,that consists of a composite thin sheet of cement mortar, which reinforced with a cage made of wire mesh, and steel skeletal bars .The thickness of the composite thin sheet is about 15 mm for one layer of wire mesh and about 25 mm for two layer in each side.

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 (Al-talqany , 2007)

Experimental Work

Materials:

1- Cement:

Ordinary Portland cement produced at Al-Najaf 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 .

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 (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	2.2	≤ 5
4	Fe_2O_3	3.42	---
5	Al_2O_3	5.70	---
6	SO_3	2.61	≤ 2.8
7	Loss on ignition	2.23	≤ 4
8	Insoluble residue	1.46	≤ 1.5
9	Lime saturated factor	0.90	0.66- 1.02
10	C_3A	9.71	≥ 5

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 =2.62			

3 - Polystyrene Foam:

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

4 - Water:

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

5 - Reinforcement:

5.1 - 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.

5.2 - 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)
0.6	350	520	180000
3.2	400	650	200000

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

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	21.2	25. 8	2.23	2.62	22648

Experimental Results and Discussion:

Six groups of Monopanel beam specimens with different properties were cast. Table (5) shows the details of monopanel beam specimens. Figure (1) shows the geometry of Monopanel beam specimen.

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 (5) Details of Monopanel beam specimens

Group	Depth H (mm)	Depth ratio H/B (mm)	Length L (mm)	Number of wire mesh layers	Face thickness t (mm)	Number of lacing
A_1	200	1	1200	1	15	3
B_1	300	1.5	1200	1	15	3
C_1	400	2	1200	1	15	3
A_2	200	1	1200	2	25	3
B_2	300	1.5	1200	2	25	3
C_2	400	2	1200	2	25	3

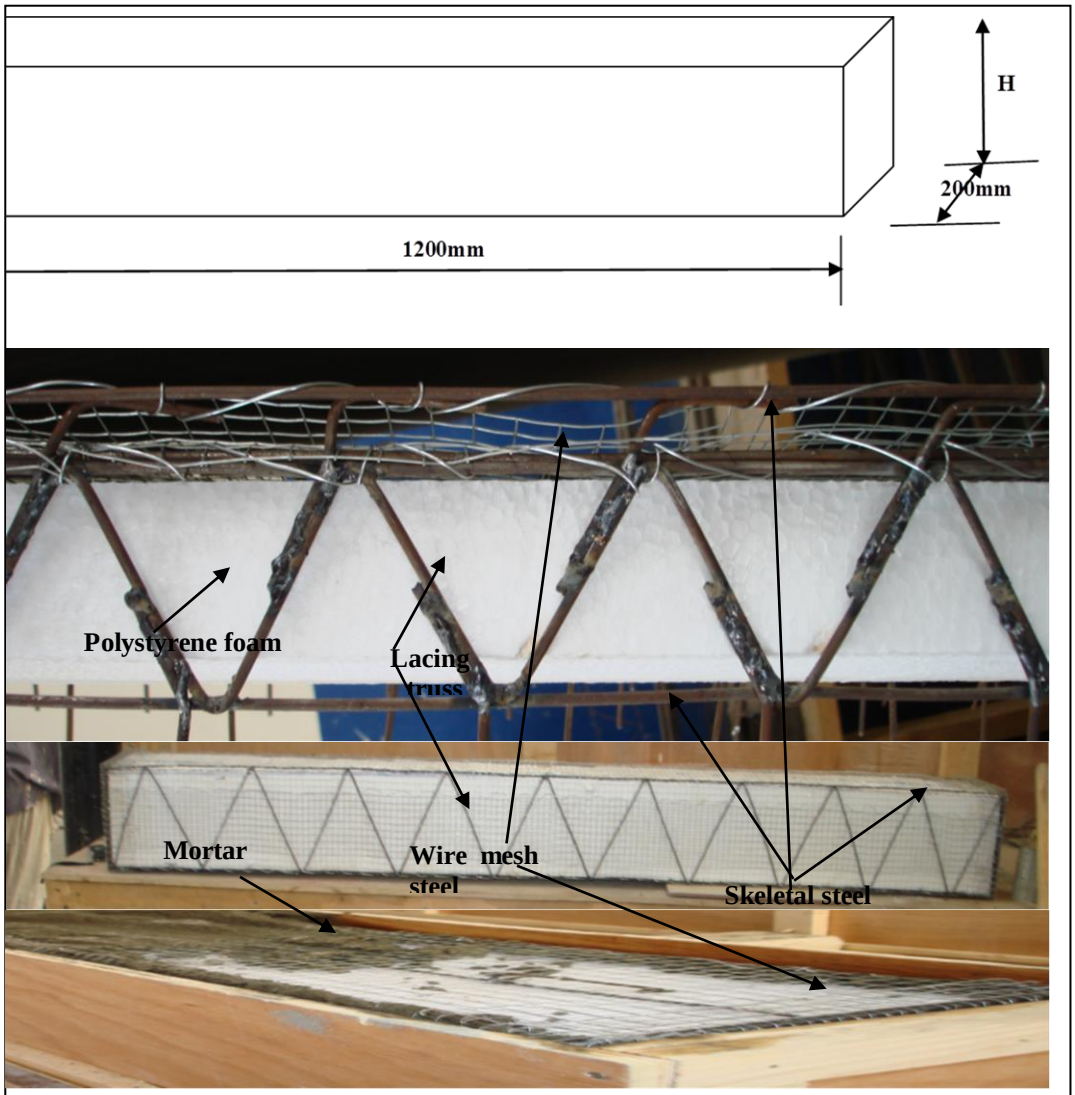

Fig. (1) Geometry and reinforcement details of Monopanel beam specimens

Group	Depth ratio H/B (mm)	Exp. Ultimate load (kN)	Theory Ultimate load according to ACI - Code 318 M-08 (kN)	$\frac{P_{ACI}}{P_{Exp.}}$
A_1	1	**15**	**14.301**	**0.9534**
B_1	1.5	**20.5**	**18.315**	**0.8934**
C_1	2	**25**	**22.351**	**0.8940**
A_2	1	**26.5**	**24.829**	**0.9369**
B_2	1.5	**34**	**32.316**	**0.9505**
C_2	2	**43**	**39.802**	**0.9256**

According to the experimental results, when using depth ratio of monopanel beam specimens equals 1, the ultimate shear force increases by 76.66 percent and the mid span deflection at ultimate stage decreases by 22.79 percent if the number of wire mesh layers increases from one to two. In addition, if the number of reinforcement wire mesh layers of each side for monopanel beam specimens increases from one to

two, the ultimate shear force increases by 65.85 percent and the mid span deflection at ultimate stage decreases by 42.85 percent when using depth ratio of monopanel beam specimens equals 1.5. While, when the depth ratio of monopanel beam specimens equals 2, the ultimate shear force increases by 72.0 percent and the mid span deflection at ultimate stage decreases by 38.88 percent if the number of wire mesh layers increases from one to two.

Beside that, when using one layer of reinforcement wire mesh of each side for monopanel beam specimens. When the depth ratio increases from 1 to 1.5, the ultimate shear force increases by 36.66 percent and the mid span deflection at ultimate stage decreases by 37.24 percent. Also when the depth ratio of specimen increases from 1 to 2, the ultimate shear force increases by 66.66 percent and the mid span deflection at ultimate stage decreases by 45.05 percent. While, when the depth ratio of specimen increases from 1.5 to 2, the ultimate shear force increases by 21.95 percent and the mid span deflection at ultimate stage decreases by 17.25 percent.

Moreover, when using two layer of reinforcement wire mesh of each side for monopanel beam specimens. When the depth ratio increases from 1 to 1.5, the ultimate shear force increases by 28.30 percent and the mid span deflection at ultimate stage decreases by 29.12 percent. Also when the depth ratio of specimen increases from 1 to 2, the ultimate shear force increases by 62.26 percent and the mid span deflection at ultimate stage decreases by 38.88 percent. While, when the depth ratio of specimen increases from 1.5 to 2, the ultimate shear force increases by 26.47 percent and the mid span deflection at ultimate stage decreases by 12.77 percent.

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

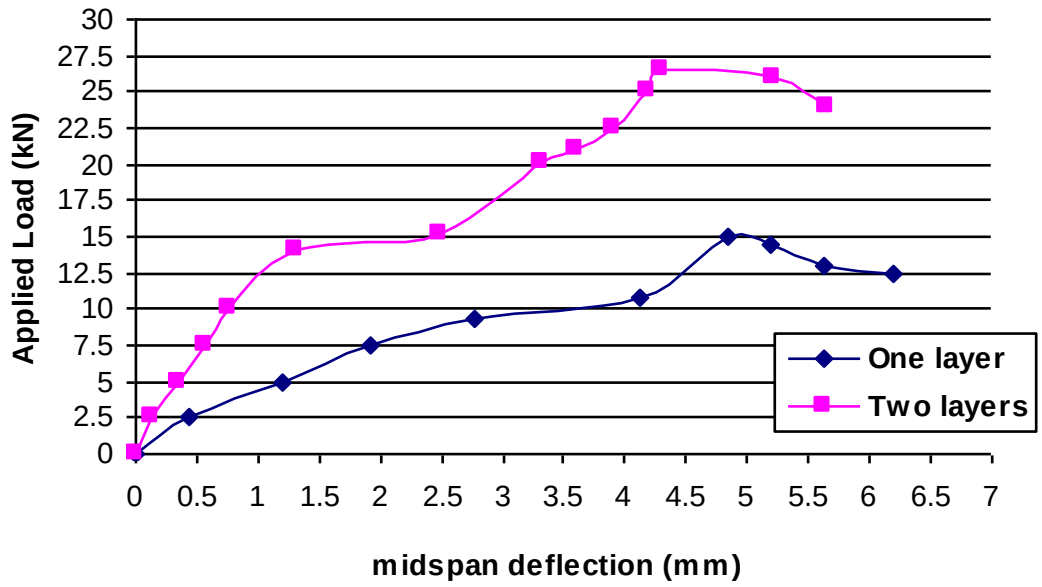

Fig.(2) Midspan Diflection for Monopanel beam Specimen with H/B =1

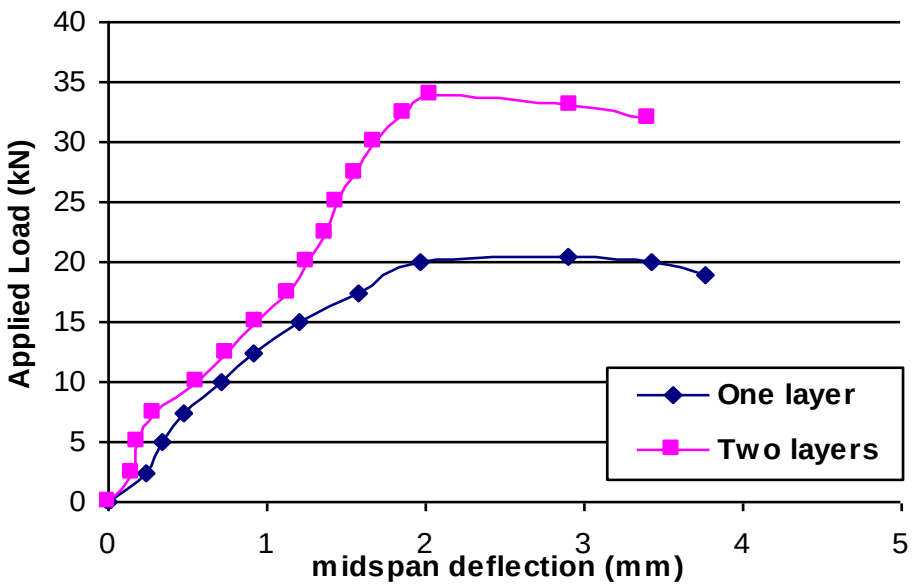

Fig.(3) Midspan Diflection for Monopanel beam Specimen with H/B =1.5

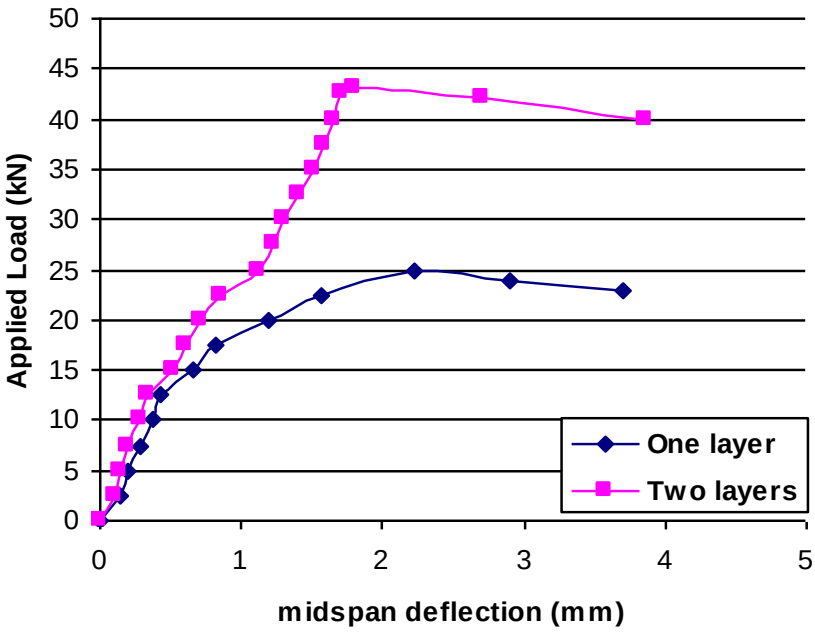

Fig.(4) Midspan Diflection for Monopanel beam Specimen with H/B =2

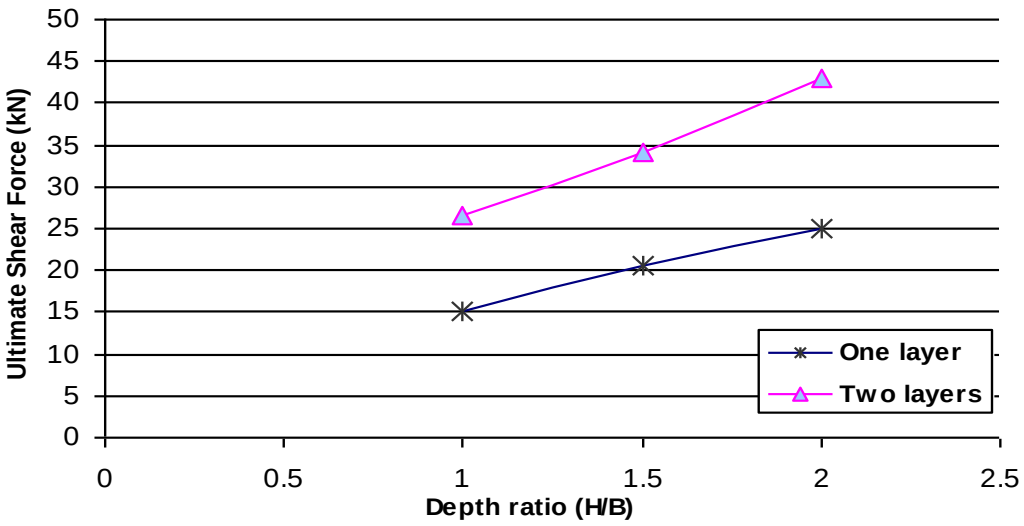

Fig.(5) Relationship between the depth ratio andUltimate Shear Force for Monopanel beam Specimen

Fig.(6)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-When using one layer of reinforcement wire mesh of each side for monopanel beam specimens. By increasing the depth ratio of monopanel beam specimen, the mid span deflection is decreased. The experimental results show that when the depth ratio of specimen increases from 1 to 1.5, the mid span deflection at ultimate stage decreases by 37.24 percent. In addition, when the depth ratio of specimen increases from 1 to 2, the mid span deflection at ultimate stage decreases by 45.05 percent. While, when the depth ratio of specimen increases from 1.5 to 2, the mid span deflection at ultimate stage decreases by 17.25 percent.

3- When using two layers of reinforcement wire mesh of each side for monopanel beam specimens. By increasing the depth ratio of monopanel beam specimen, the mid span deflection is decreased. The experimental results show that when the depth ratio of specimen increases from 1 to 1.5, the mid span deflection at ultimate stage decreases by 32.45 percent. In addition, when the depth ratio of specimen increases from 1 to 2, the mid span deflection at ultimate stage decreases by 38.88 percent. While, when the depth ratio of specimen increases from 1.5 to 2, the mid span deflection at ultimate stage decreases by 12.77 percent.

4- It can be noted from the experimental results when using one layer of reinforcement wire mesh of each side for monopanel beam specimens that the ultimate shear force increases when the depth ratio is increased. It was found that when the depth ratio of specimen increases from 1 to 1.5, the ultimate shear force increases by 36.66 percent. Also when the depth ratio of specimen increases from 1 to 2, the ultimate shear force increases by 66.66 percent. While, when the depth ratio of specimen increases from 1.5 to 2, the ultimate shear force increases by 21.95 percent.

5- It can be noted from the experimental results when using two layers of reinforcement wire mesh of each side for monopanel beam specimens that the ultimate shear force increases when the depth ratio is increased. It was found that when the depth ratio of specimen increases from 1 to 1.5, the ultimate shear force increases by 28.30 percent. Also when the depth ratio of specimen increases from 1 to 2, the ultimate shear force increases by 62.26 percent. While, when the depth ratio of specimen increases from 1.5 to 2, the ultimate shear force increases by 26.47 percent.

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

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