International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 5 Issue 1, January - 2021, Pages: 78-87

Shear Failure Behavior of Monopanel Slabs Structural

Faris Jassim Jaber[1] and Samir Thamer Saeed [2]

[1]Professor of Civil Engineering, Faculty of Engineering, University of Kufa
Al-Najaf, Iraq
faris.altalqany@uokufa.edu.iq
[2]M.Sc. Candidate of Civil Engineering, Faculty of Engineering, University of Kufa
Al-Najaf, Iraq
Eng.samirthamer@gmail.com

Abstract— *Monopanel is a new building system consisting of two thin layers of ferrocement, interspersed with a thick layer of low-density material, and the two layers of ferrocement are connected together by means of reinforcement lacing with a diameter of (4 and 5) mm containing longitudinal bars and inclined bars at an angle of 45 degrees. The longitudinal bars works to resist bending and the inclined members resists shear stresses as this system works as a one slab where the loads are distributed between them. In this research, continuous Monopanel slabs with two spans were used to study its structural behavior. Twelve samples were constructed where it designed for shear failure, where the force was applied near the middle support of each span. In this research the parameters were adopted, number of lacing and number of layers of wire mesh. The focus in this research was on the load of first crack, ultimate load, service deflection, maximum deflection and the width cracks.*

Keywords— Monopanel, slab, lacing, wire mesh and shear failure.

1. Introduction

Structural buildings developed and became more complex, so the search for materials that reduce costs, weights and ease of work began. In this research, the Monopanel system, which appeared recently, and which is characterized by several characteristics was studied that makes it a good choice for many simple and medium buildings (such as homes, schools, service buildings, etc.).

The Monopanel system is characterized by its light weight compared to normal concrete, reaching 50% of the density of normal concrete. In addition to being easy to work and the availability of its materials in the local market. It consists of two layers of ferrocement, which is consisted core with low-density foam material (12 kg / m3) and contains a lacing reinforcement with a diameter of 4 mm for the longitudinal bar and 5 mm for the inclined bar at an angle of 45 degrees. This reinforcement is covered with wire mesh, which is in the form of layers wrapping around lacing to be poured cement mortar with a thickness of (25-45) mm, to be the required structural slab.

2. EXPERIMENTAL WORK

2.1 Material

2.1.1 Cement

Ordinary Portland cement - obtained from Al Kara Factory in Najaf city- was used in the present investigation. Bags of (50 kg) were used. Physical and chemical tests have been done for this type of cement according to (The Iraqi Specification 5/2016),Table1.

2.1.2 Sand

Natural silica sand obtained from (Bahr Al Najaf) area was used as fine aggregate in mortar mix. Maximum aggregate size was (4.75 mm). Sand used in this study was tested and the results matching the (Iraqi Specification 45/2016) (zone 2) as shown in Table 2.

Table 1. Chemical properties of cement

Components		Results	Specification (5/2016)
Silicon Dioxide	SiO_2	20.88 %	-----
Aluminum Trioxide	Al_2O_3	2.24 %	-----
Ferric Oxide	Fe_2O_3	4.68 %	-----
Calcium Oxide	CaO	59.77 %	-----
Lime Saturation Factor	L.S.F	0.89 %	(0.66-1.02) %
Magnesium oxide	MgO	3.06 %	< 5 %
Tricalcium Silicate	C_3A	0.21 %	< 3.5 %
SO_3 when C_3A < 5 %		1.81 %	< 2.5 %
SO_3 when C_3A > 5 %		-----	< 2.8 %

Loss on Ignition	L.O.I	3.09 %	< 4 %
Insolvent Materials	Ins. Res	0.82 %	< 1.5 %

Table 2. Sieve analysis of sand

Sieve Size (mm)	Passing %	Iraqi Specification (45/2016), Zone 2
10	100	100
4.75	95.6	90-100
2.36	86.8	75-100
1.18	74.3	55-90
0.6	44.0	35-59
0.3	18.8	8-30
0.15	2.6	0-10
75 microns	3.8 %	< 5 %
Sulfate Content	0.37 %	< 0.75 % (other)

2.1.3 STEEL REINFORCEMENT

2.1.3.1. Steel bars

In Skeletal lacing used two diameters of deformed steel bars:

- 5 mm for the longitudinal bars of lacing.
- 4 mm for the zigzag members of lacing.

2.1.3.2. Steel Wire mesh

Galvanized square chicken wire mesh smooth with 12 x12 mm opening and with an average wire diameter of 0.6 mm.

Table 3. Tensile strength test results of steel reinforcement

Diameter (mm)	Yielding Stress* fy (MPa)	Tensile Strength* fu (MPa)
5	573	730
4	558	659
0.6	329	437

*The result is average of six specimen.

2.1.4 POLYSTYRENE FOAM

A polystyrene foam with low density of (12 kg / m3) and low cost was use as a core filling material. The foam was cutting 10cm thick, where the width was different according properties of samples.

2.1.5 ADMIXTURE

The admixture used bonding agent type (Latex Modified Bonding Agent) produced by the company (PAC Technologies), and it complies with the standard (ASTM C1059 Type II), which is an aqueous emulsion specially formulated for use as a bonding agent and as an additive with cementitious mixes to improve the mix properties.

2.1.6 WATER

Pure water devoid from salt was use in mixing mortar of the samples.

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 5 Issue 1, January - 2021, Pages: 78-87

2.2 DETAILS OF SAMPLES

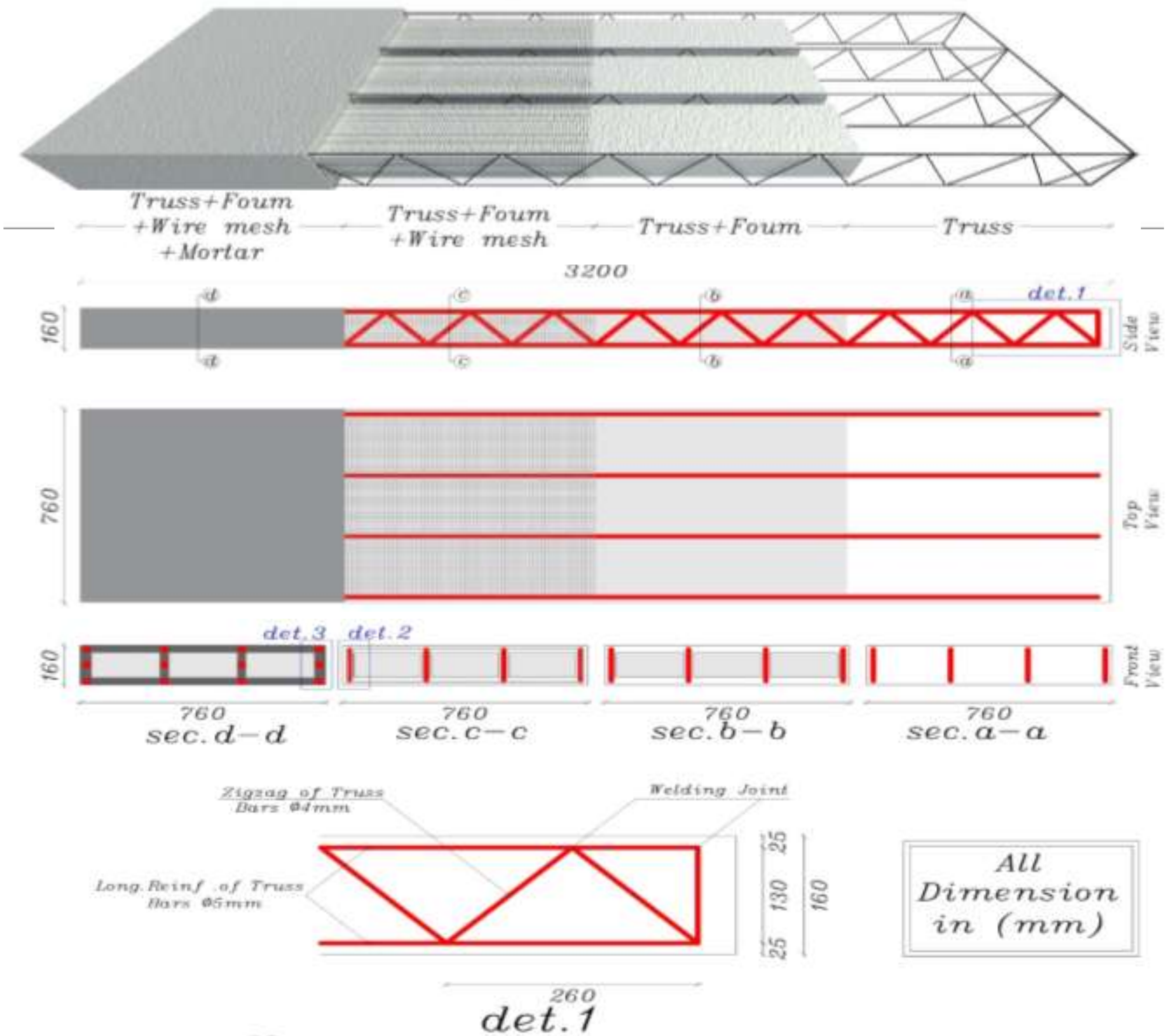

Fig. 1-a. Detail of test samples (4 lacing & one layer wire mesh).

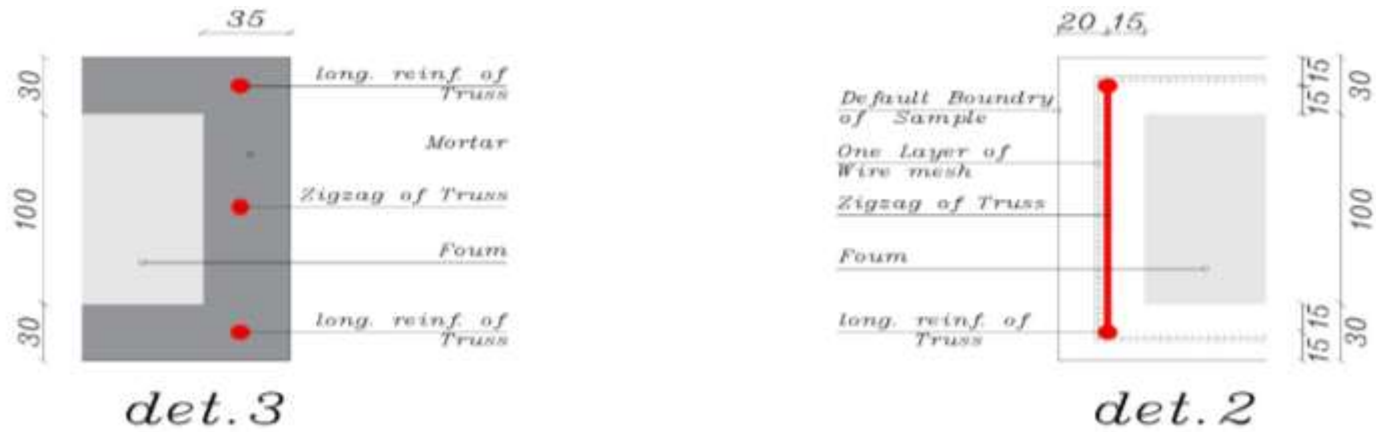

Fig. 1-b. Detail of test samples (4 lacing & one layer wire mesh).

Table 4. Details of samples.

Names of sample	Length (mm)	Width (mm)	Height (mm)	Face thickness (mm)	No. of lacing	Lacing spacing (mm)	No. of wire mesh	Locate of load
MS-1	3200	760	160	30	3	360	1	
MS-2	3200	760	160	30	4	240	1	
MS-3	3200	760	160	30	6	145	1	
MS-4	3200	770	180	40	3	360	2	
MS-5	3200	770	180	40	4	240	2	Near mid. Suppor
MS-6	3200	770	180	40	6	145	2	
MS-7	3200	780	190	45	3	360	4	
MS-8	3200	780	190	45	4	240	4	
MS-9	3200	780	190	45	6	145	4	

2.3. MORTAR MIXING

Many cement mortar mixtures were made using materials with different weights (cement, sand, water and admixture) and the compressive strength was examined to obtain the best compressive strength with the best workability of the cement mortar, where the best compressive strength with good workability was obtained. Compressive strength test of cube specimen (50×50×50) mm has been carried out by using digital compressive machine according to (the British standard BS.1881 and the American standards ASTM-C39, ASTM-C109, ASTM-C469 and ASTM-C78.

Table 5. Property of mortar.

Cement : Sand	Water cement ratio w/c	Comp. strength f_{cu} 7 days (Mpa)	Comp. strength f_{cu} 28 days (Mpa)
1 : 1.5	0.45	22.11	29.72

2.4. SAMPLES PREPARATION

Plate 1. Samples preparation

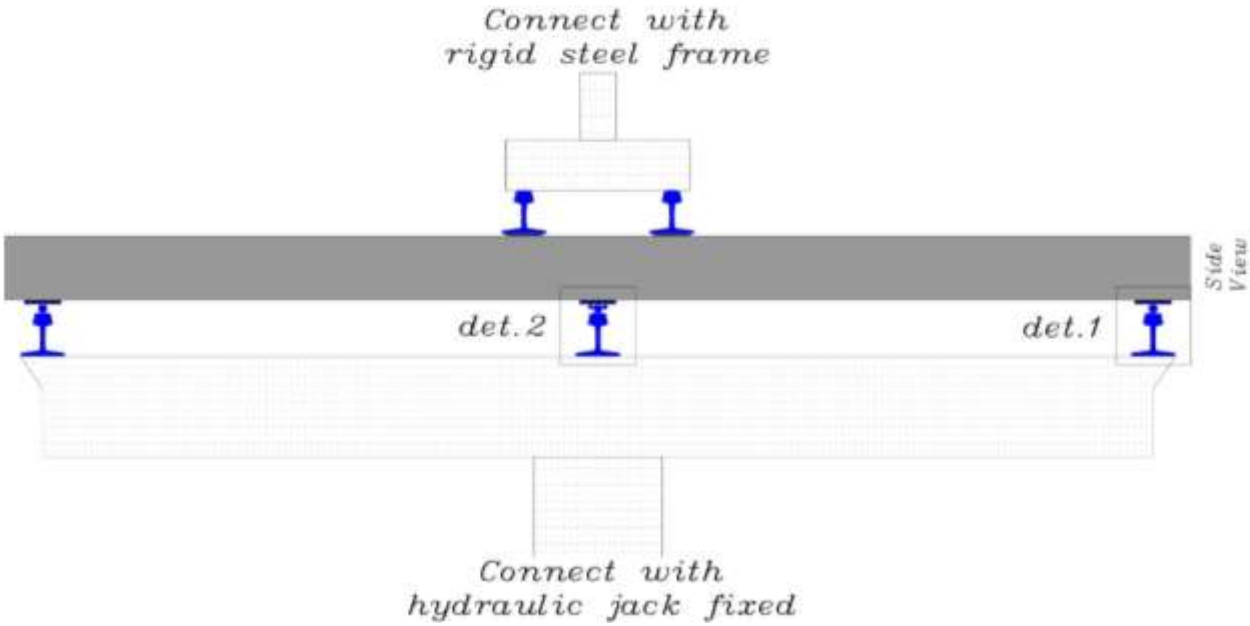

Fig.2. Sample during the test

3. EXPERIMENTAL RESULTS

Nine continues Monopanel slab were studied to test its structural behavior. The general behavior of the test of the slabs were showed as following below:

1. Most of the time, the first fissure appears in the shear zone stresses, where it begins to appear from the middle support to the applied load in the right or left span, where the crack begins to expand as the load increases.
2. Sometimes, the first crack appears in the tension zone at the top of the mid support, where it begins from the top and continues to expand and descend into the compression zone as the load increases.
3. All the cracks appeared only under the line load or above the mid support, or whatever in between. As for the rest of the span, it is free of any cracks.
4. The appearance of the first crack was in the late stages of loading, approximately after (81) % of the ultimate load (the percentage is an average of nine samples).

First crack load, ultimate load, maximum deflection and load-deflection curves are discussed in this chapter.

Table 6. Details of results for the test of samples.

Sample No.	MS-1’	MS-2’	MS-3’	MS-4’	MS-5	MS-6’	MS-7’	MS-8’	MS-9’
No. of wire mesh	4	4	4	2	2	2	1	1	1
No. of lacing	6	4	3	6	4	3	6	4	3
Pcr (KN)	60	75	120	60	70	80	60	70	85
Pu (KN)	74	101	138	70	79	94	80	91	110
Pcr / Pu %	81.08	74.25	86.95	85.71	88.60	85.10	75.00	76.92	77.27
Δs* (mm)	1.81	1.79	2.41	1.80	2.77	3.28	2.54	2.85	3.10
Δu (mm)	3.47	3.65	3.38	5.04	4.82	5.79	8.32	4.68	11.30

*Δs= service deflection (deflection at load of 70% of Pu)

Plate 2. Failure pattern of sample MS-2'.

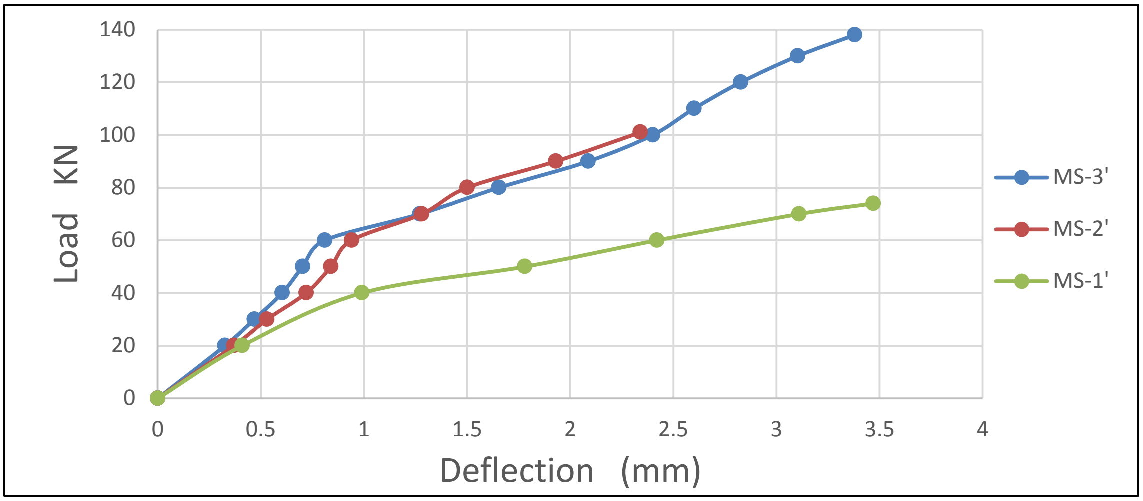

Fig.3. Load-Deflection Curves between MS-1', MS-2' and MS3'

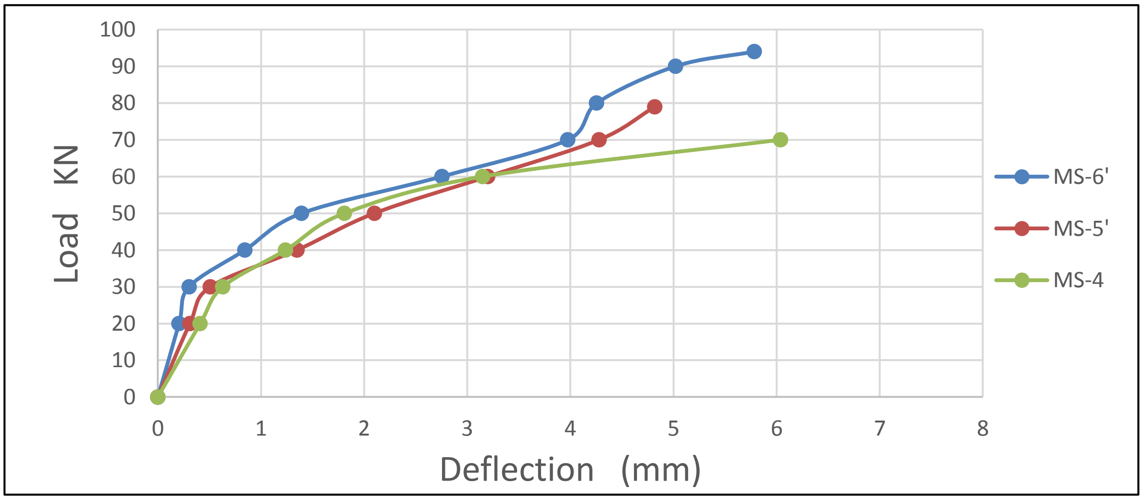

Fig.4. Load-Deflection Curves between MS-4', MS-5' and MS6'

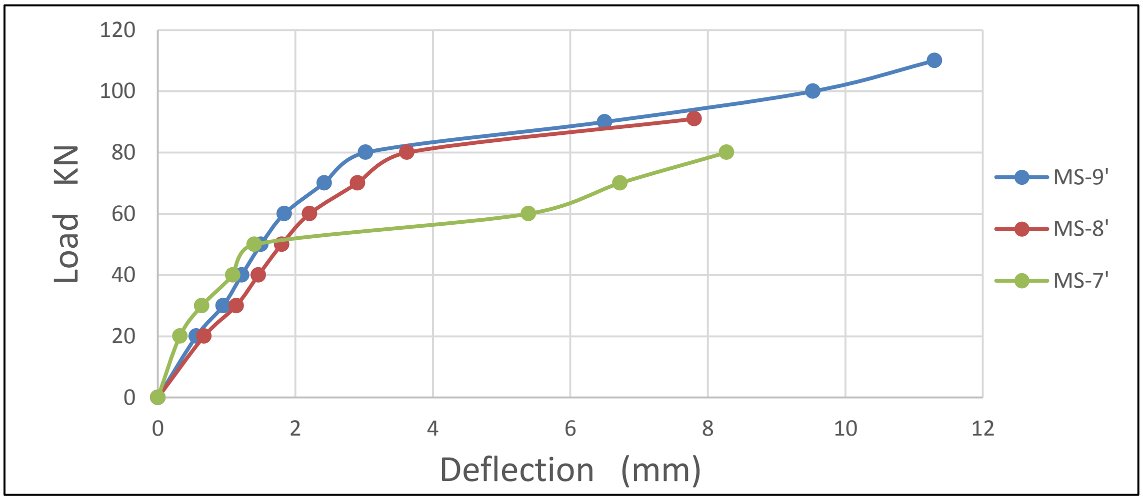

Fig.5. Load-Deflection Curves between MS-7', MS-8' and MS9'

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 5 Issue 1, January - 2021, Pages: 78-87

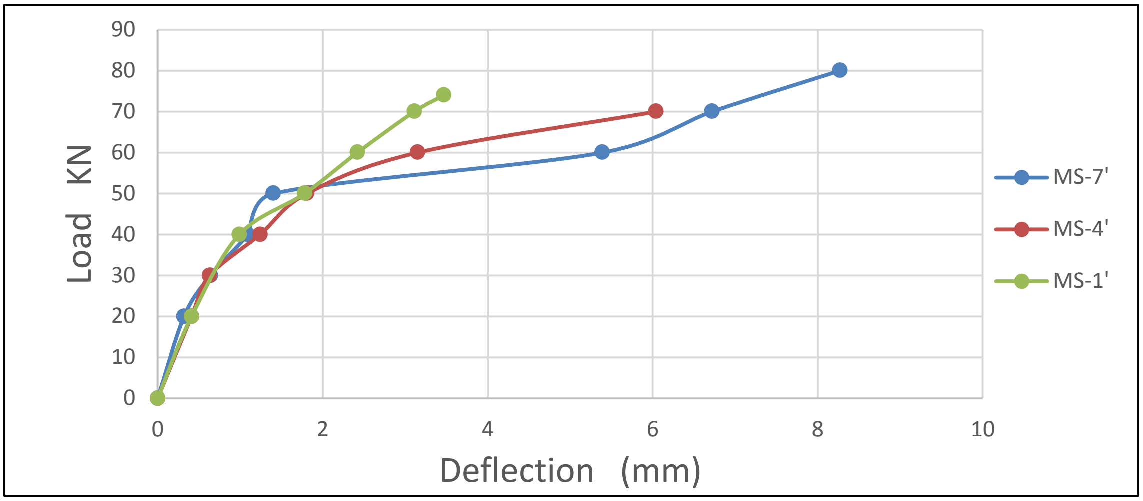

Fig.6. Load-Deflection Curves between MS-1', MS-4' and MS7'

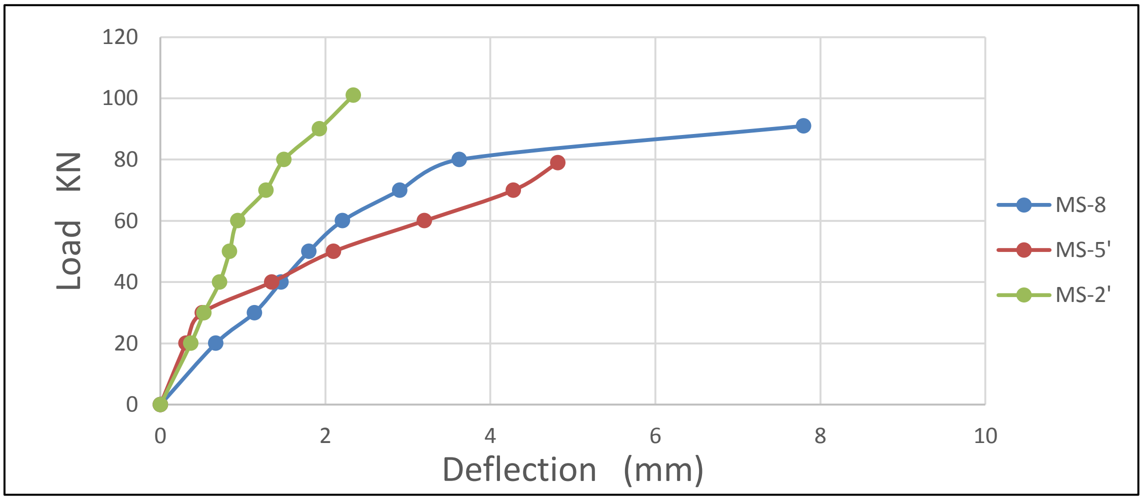

Fig.7. Load-Deflection Curves between MS-2', MS-5' and MS8'

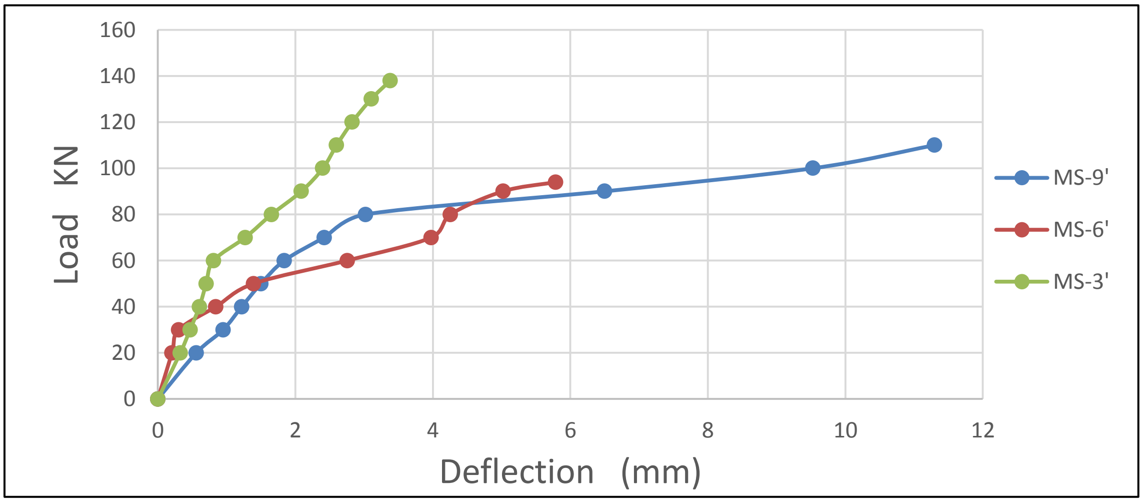

Fig.8. Load-Deflection Curves between MS-3', MS-6' and MS9'

4. CONCLUSIONS

From the research that were presented, which included nine samples for shear stresses failure test, the main conclusions can be summarized based on this study and the evaluation of the recorded data, the following conclusions are drawn:

- The increase in the reinforcement of the lacing reinforcement gave a very noticeable increase in terms of the ultimate load, as it gave an increase of (21.03)% when increasing of the lacing reinforcement from (3) to (4). In addition, the ultimate load increased by (52.75)% when increased the lacing from (3) to (6).
- The increased number of the wire mesh also gave a noticeable decrease in the ultimate load shear samples, where the ultimate load decreased by (19.69)% when the number of layers changed from (one layer) to (two layers). And the percentage decreased it reached more (7.36)% when the number of layers changed from (one layer) to (four layers).
- Deflection was really affected by the increase in the lacing reinforcement, as the ultimate deflection rate of samples decreased by (12.55)% when using (4) lacing instead of (3), and the rate of descent was further reduced to a percentage (26.55)% when using (6)lacing, but the deflection was increase when increasing the wire mesh.
- It was apparent that the crack appearing load and the width of the crack would be less with the increase in the number of lacing, while the variation between increase and decrease with the increase in the number of wire mesh layers.

5. REFERENCES

[1] Faris J. Al-Talqany., (2018), " Effect of Number of Wire Mesh Layers and Depth Ratio on Ultimate Shear Force for Monopanel Beam Specimens." Journal of University of Babylon, Engineering Sciences, Vol.(26), No.(1), pp. 407-413.
[2] Swamy R. N. and El-Ahboud M. I., 1988, “Application of Ferrocement Concept to Low Cost Lightweight Concrete Sandwich Panels”, Journal of Ferrocement, Vol.18, No.3, PP.285-292.
[3] Nanni A., and Chang W. F., 1986, “Ferrocement Sandwich Panels under Bending and Edge-Wise Compression”, Journal of Ferrocement, Vol.16, No.2, PP. 129-140.
[4] Faris J. Al-Talqany, December, 2007,”Structural Behavior of Monopanel Wall and Beam Elements” Ph.D. Thesis, Building and Construction Engineering Department, University of Technology.

Authors

Faris Jassim Jaber
Professor of Civil Engineering,
Faculty of Engineering, University of Kufa

Samir Thamer Saeed
M.Sc. Candidate of Civil Engineering,
Faculty of Engineering, University of Kufa