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An Investigation on the Behavior of One-layer and Two-layer 3D Panels in Shear and Flexural Test

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Abstract
The 3D panels are a new system of construction. This system is used as wall and ceiling in buildings. The structural behavior of 3D panels is dependent on the strength and rigidity of connector elements. In this article flexural and shear tests have been conducted on six 3D panels. The results have been compared with results of finite element software, ANSYS. The details and results of the test program are described, and the observed behaviour patterns are discussed.

Keywords
3D panel, Shear test, Flexural test

1. Introduction

Precast concrete sandwich panels (PCSP) have two concrete faces and one polystyrene layer between concrete faces. The concrete faces are connected to each other with shear connectors. The arrangment and spacing of shear connectors in PCSP vary depending on several factors, such as desired composite action, applied load, span of the panel and type of shear connectors used. There aro no specific rules for arranging the connectors. The complex behaviour of PCSP due to its material nonlinearity, the uncertain role of the shear connectors and the interaction between various components has led researchers to rely on experimental investigations backed by simple analytical studies. The lack of information on the behaviour of this important type of concstruction is due to the high cost of full scale testing and the extreme difficulty of fabrication of small-scale models.

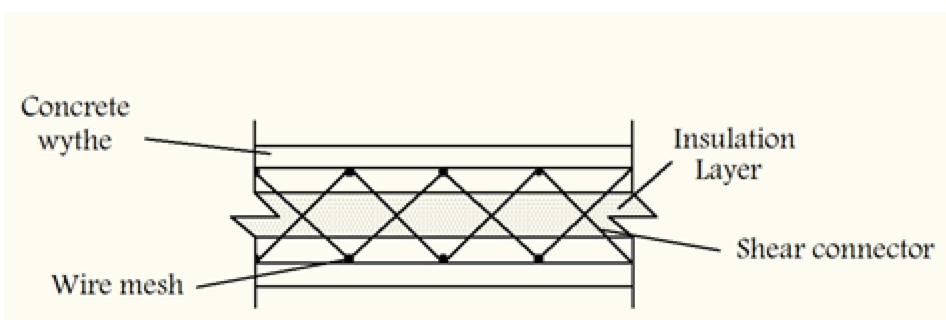

Figure 1: 3D Panel

2. Experimental Studies

2.1 Characteristics of Panels

The dimension of all panels is 3×1×0.15 m. The diameter of longitudinal bars and shear connectors is 3 mm. The thickness of concrete wythe in two-layer panels is 5 cm. In One-layer panels the middle wythe is concrete instead of foam. The distance between longitudinal bars is 10 cm. The dimensions are shown at figure 2. Characteristics of panels are as Table 1.

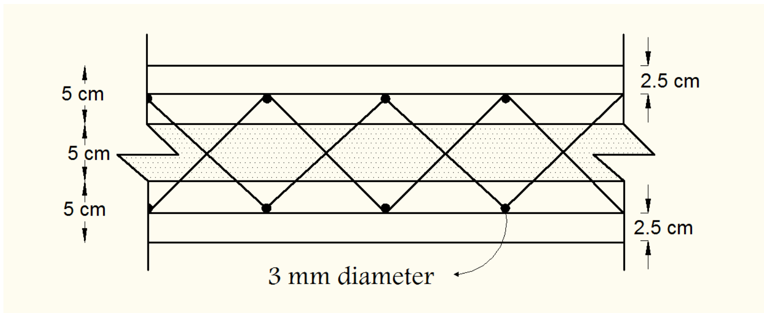

Figure 2: 3D Panel

Table 1: Characteristics of Panels

No.	Dimension (m)	Compressive strength 10×10×10 (kg/cm^2)		f_c'	
1	0.15×1×3	284	Top.	227.2	Top.
		305	Bot.	244	Bot.
2	0.15×1×3	318	Top.	254.4	Top.
		298	Bot.	238.4	Bot.
3	0.15×1×3	315		252	
4	0.15×1×3	303		242.4	
5	0.15×1×3	313	Top.	250.4	Top.
		300	Bot.	240	Bot.
6	0.15×1×3	315		244.8	

2.2 Flexural Test

The panels were tested using four-point test according to ASTM D3043 and data were transferred to computer. Etch test was continued until the complete failure of the panel. Cracking pattern was similar in all panels at this stage. The test set up for flexural test is shown at Figure 3.

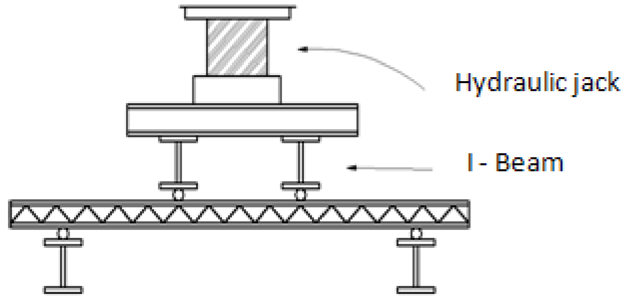

Figure 3: Flexural Test Set up

Figure 4: Cracking Pattern in one Layer Panel

Figure 5: Cracking Pattern in two Layer Panel

2.3 Shear Test

The shear test set up is shown at Figure 6. The load is near to one of the supports in order to simulate pure shear conditions.

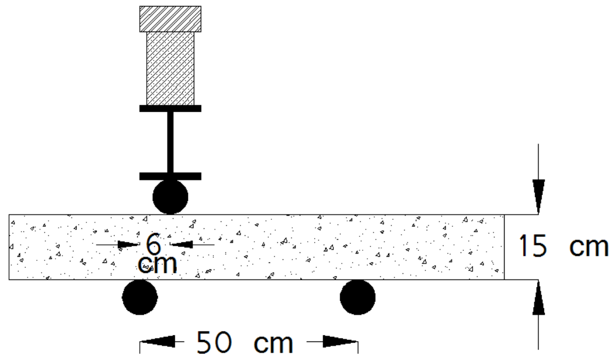

Figure 6: Shear Test Set up

Cracking pattern for two-layer and one-layer panels is shown at Figure 7 and 8 .

Figure 7: Cracking Pattern for Two-layer Panel in Shear Test

Figure 8: Cracking Pattern for One-layer Panel in Shear Test

3. Results and discussions

3.1 Flexural Test Results

Flexural test results are shown in Figure 9. The load bearing capacity of one-layer panel is more than two-layer panel but the ductility of two-layer panel is more.

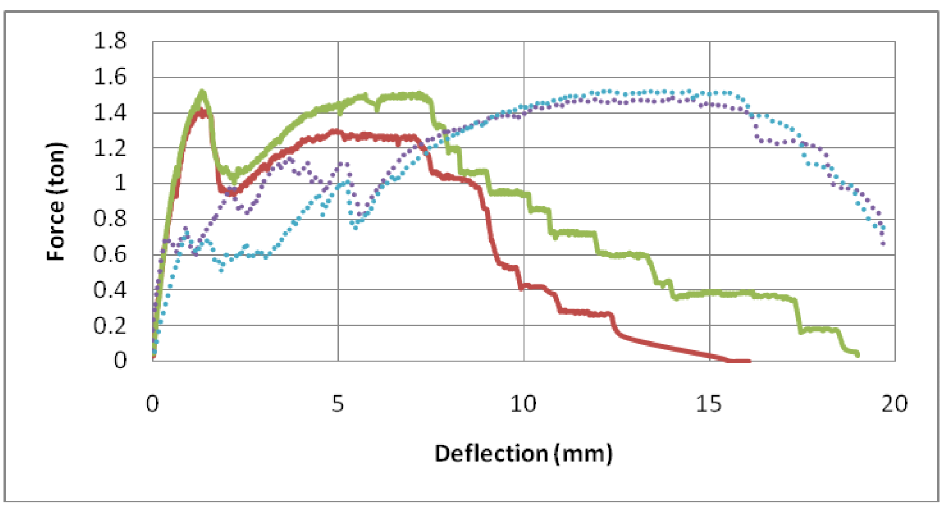

Figure 9: Load-deflection Curve for Panels at Flexure

3.2. Shear Test Results

In shear test, one-layer 3D panels fail at 14 ton and have brittle behavior but two-layer panels have a ductile behavior although their load bearing capacity is about 5 ton. Figure 10 shows the behavior of one-layer and two-layer 3D panels in shear test.

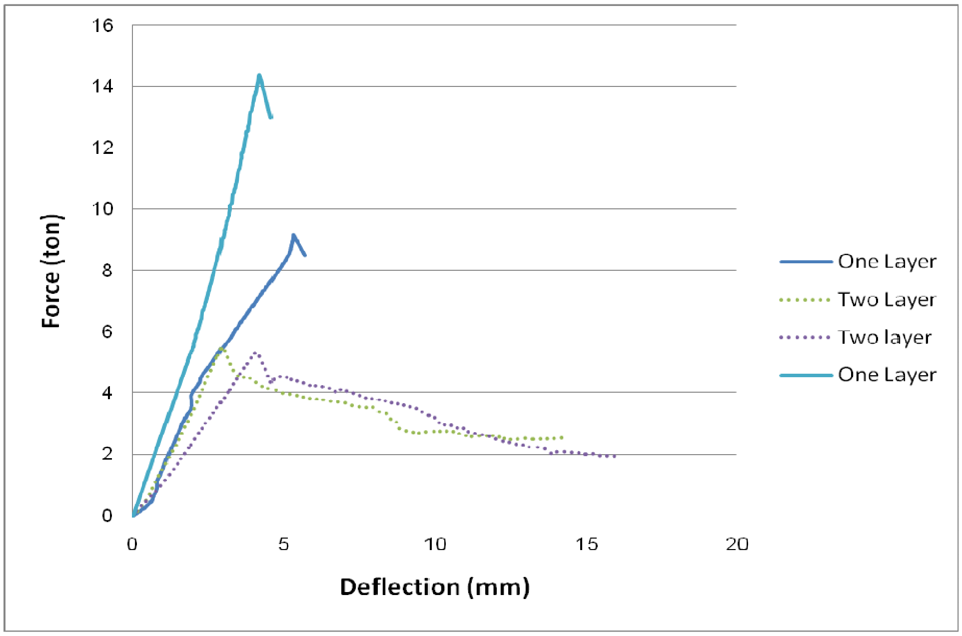

Figure 10: Load-deflection Curve for Panels in Shear

4. Theoretical Studies

4.1. Finite Element Modeling

Solid 65 and link8 elements are used to model concrete and bars in Ansys respectively. Translations at Z direction are restrained at both supports but at X direction only one support is restrained. The following figures (Figures 10-13) show the finite element models in flexure and shear.

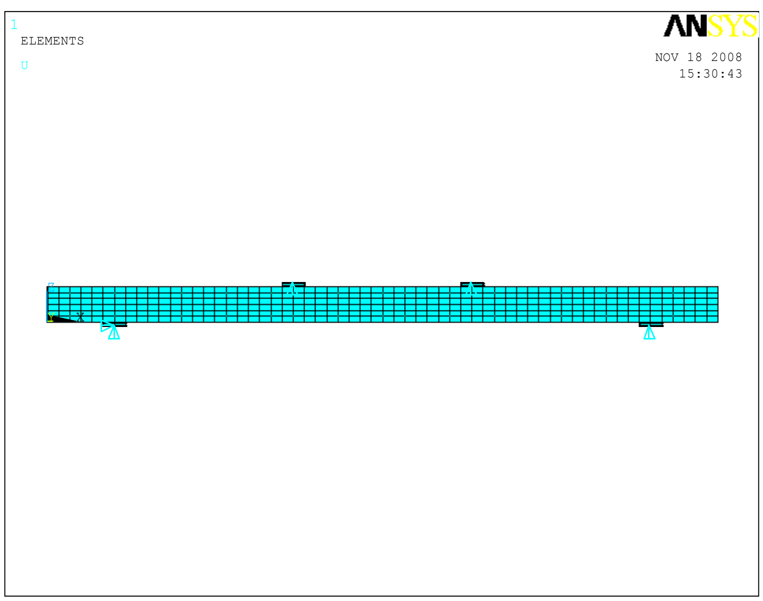

Figure 10: Model for One-layer Panel in Flexural Test

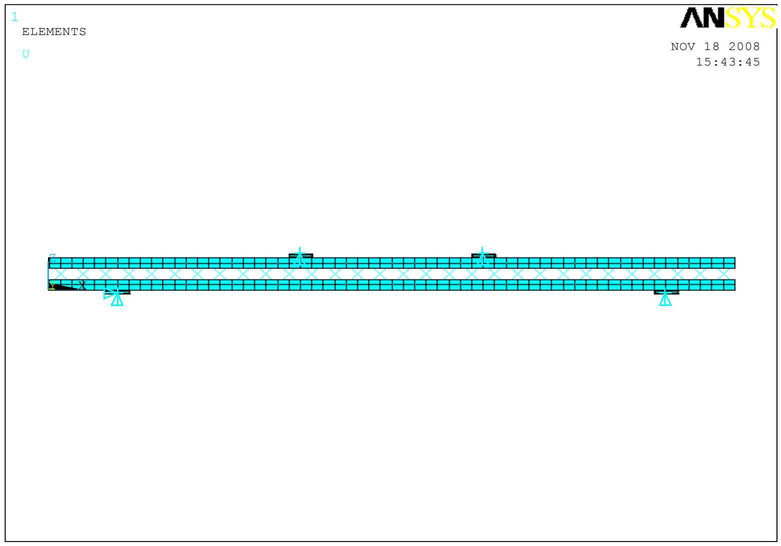

Figure 11: Model for Two-layer Panel in Flexural Test

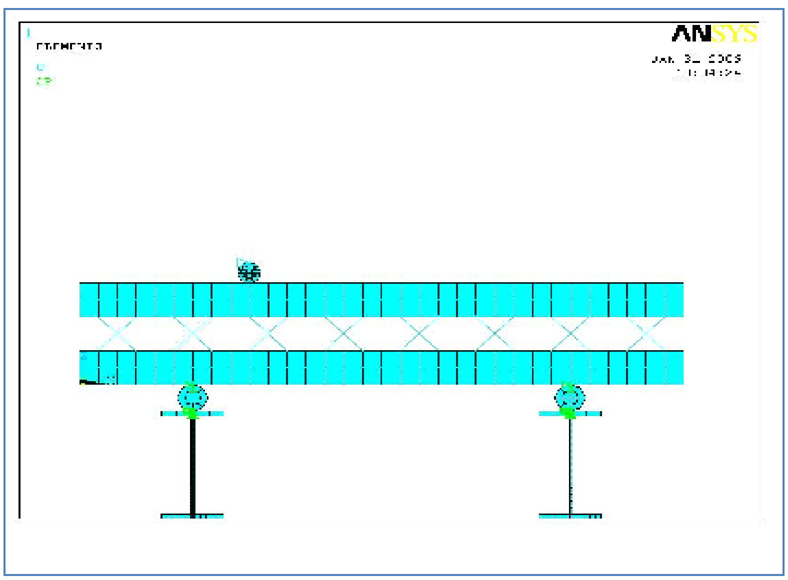

Figure 12: Model for Shear Test of Two-layer Panel

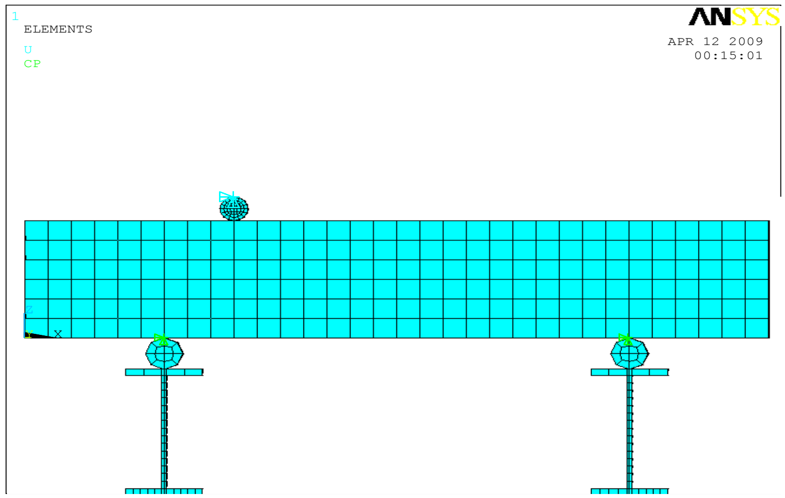

Figure 13: Model for Shear Test of One-layer Panel

4.2. Comparison of Theoretical and Experimental Studies

Experimental and theoretical results have been compared in Figures 14-17 for one-layer and two-layer panels.

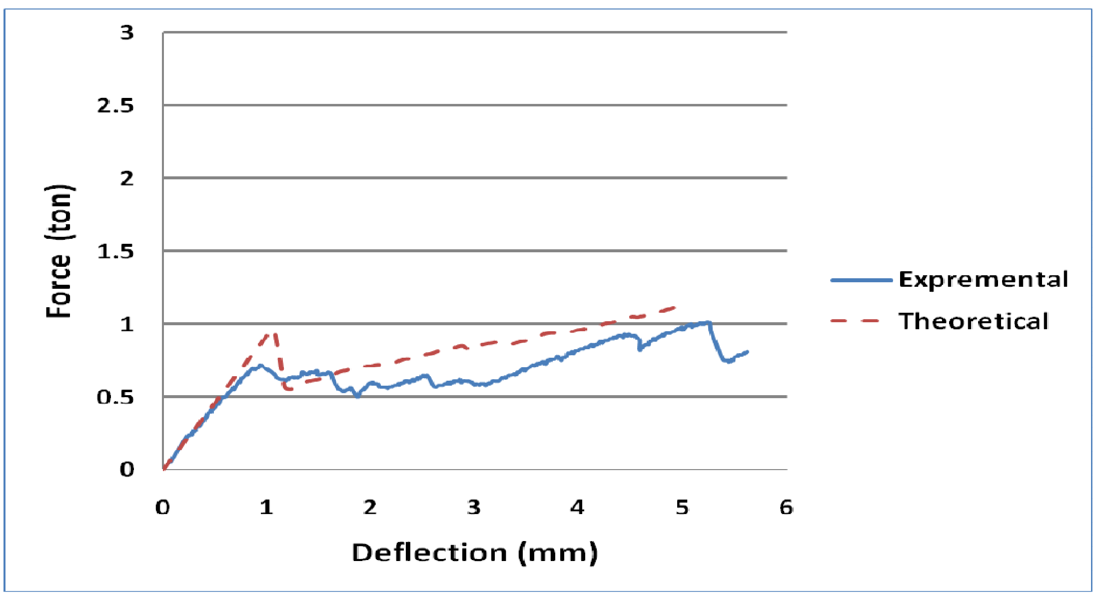

Figure 14: Comparison of Numerical and Experimental Results for Two-layer Panels in Shear

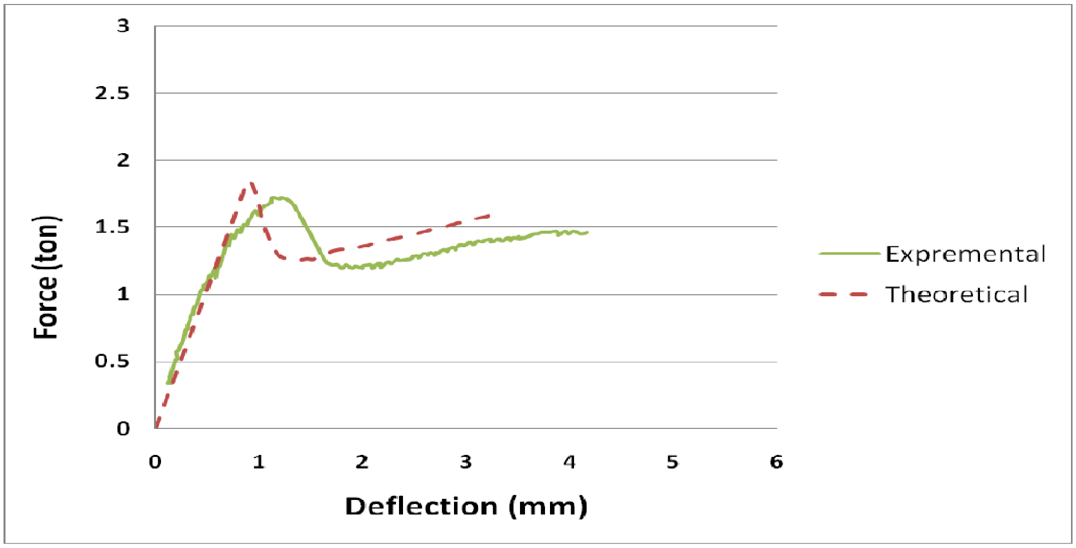

Figure 15: Comparison of Numerical and Experimental Results for One-layer Panels in Flexure

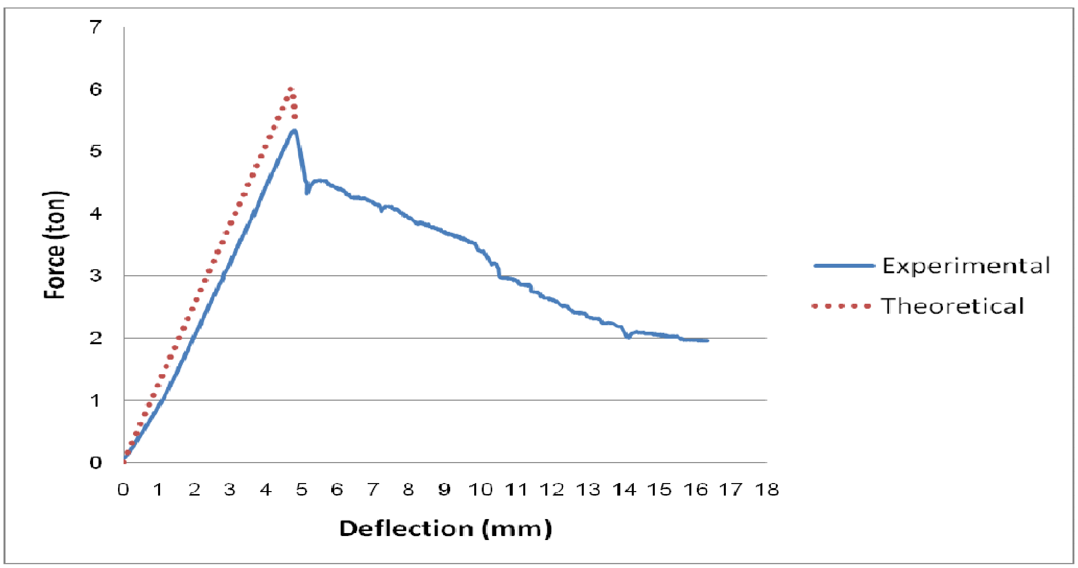

Figure 16: Comparison of Numerical and Experimental Results for Two-layer Panels in Shear

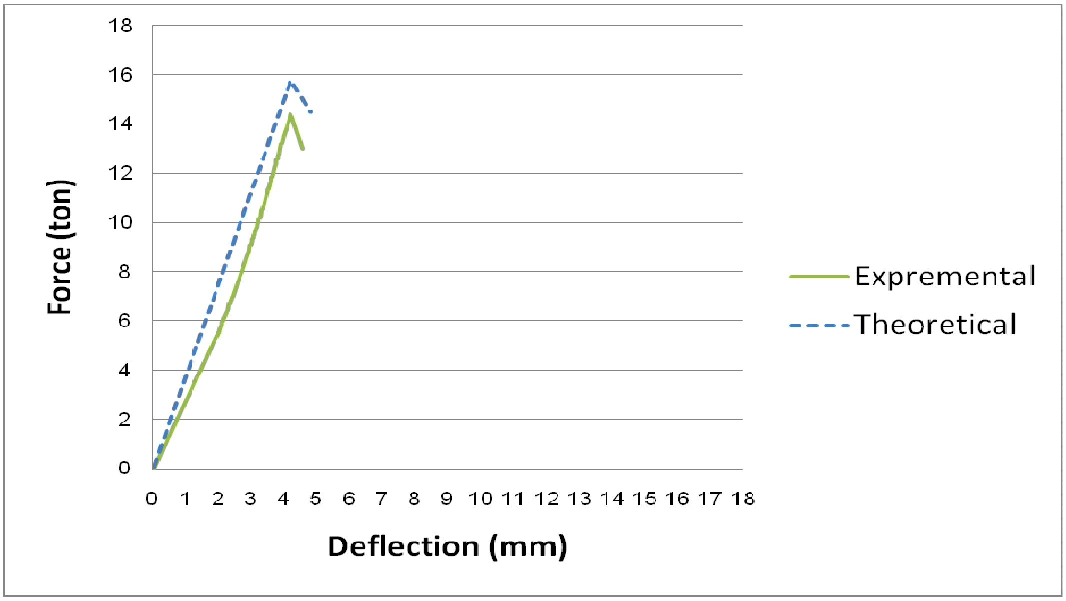

Figure 17: Comparison of Numerical and Experimental Results for Ono-layer Panels in Shear

5. Conclusions

a) The rigidity of one-layer panels is more than two-layer panels.

b) In flexure there is no difference in the load capacity of one-layer and two-layer panels although two-layer 3D panels have no concrete at the middle layer.

c) With eliminating concrete from middle layer and substituting it with bars the ductility of the panel increases.

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