Experimental study has been carried for different configurations, such as different core and skin thickness as shown in figure 2. The core thicknesses of 40 mm, 60 mm, 80 mm, 100 mm, 120 mm and 150 mm have been used to find the optimal core thickness of the panel. Similarly, the skin thicknesses of 0.05 mm, 0.15 mm, 0.30 mm, 0.45 mm, 0.60 mm, 0.75 mm, 0.90 mm, 1.05 mm, 1.20 mm, 1.35 mm, and 1.5 mm have been used to find the optimal skin thickness of the panel. The frames comprising different core and skin thicknesses were subjected to in plane loading and the optimal core and skin thickness were identified. Numerical analysis has been carried out using FEA (ABAQUS) software.

Figure 2. RC frame infilled with PU Sandwich wall panel test setup

3. Result and Discussions

3.1. Bare Frame Analysis

The FEA (ABAQUS) software was used to conduct an analytical investigation of a masonry and PU sandwich panel infilled RC frame, as depicted in Figure 7. Material properties for concrete with a grade of M25 and steel with a grade of Fe415 were inputted into the model. The Quad 3D element type was utilized to model the linear shape of the column and beam with rectangular meshes selected accordingly. In the finite element model, the embedded connection technique was used to connect the concrete and reinforcement, while tie connections were utilized to connect the concrete to the mesh.

To ensure accurate analysis, a Mesh Convergence Study was carried out with mesh sizes ranging from 20 to 140 mm^2 at an incremental rate of 20 mm^2. The displacement values with respect to mesh size are shown in Figure 3, and it was observed that beyond 50 mm^2, there is minimal deviation in displacement. Therefore, an average mesh size of 70 mm^2 was selected for further analysis.

For the analysis, a uniformly distributed load 1 kN was applied with fixed support conditions at the bottom of the frame. Material properties were determined through experimental investigations, wherein the Young's modulus and Poisson ratio of the cylinder were derived from the compressometer test as 25 N/mm^2 and 0.2, respectively.

Computational analysis has been carried out using ABAQUS and the computed stiffness and displacement were found to be 7.35 kN/mm and 41.97 mm respectively. Figure 4 shows the developed numerical model of the bare frame for the plane loading.

3.2. Analysis of Single Frame with Infilled Masonry

Numerical model has been developed for the laboratory model constructed by (Umar et.al, 2021). Based on the experimental investigation, they have calculated the stiffness of masonry infilled RC frame as 26.89 kN/mm. The displacement of masonry infilled RC frame was calculated as 40.05 mm. Whereas the stiffness and displacement from numerical analysis were computed as 27.76 kN/mm and 40mm respectively. Figure 5 shows the developed numerical model of the masonry infilled RC frame for the in-plane loading.

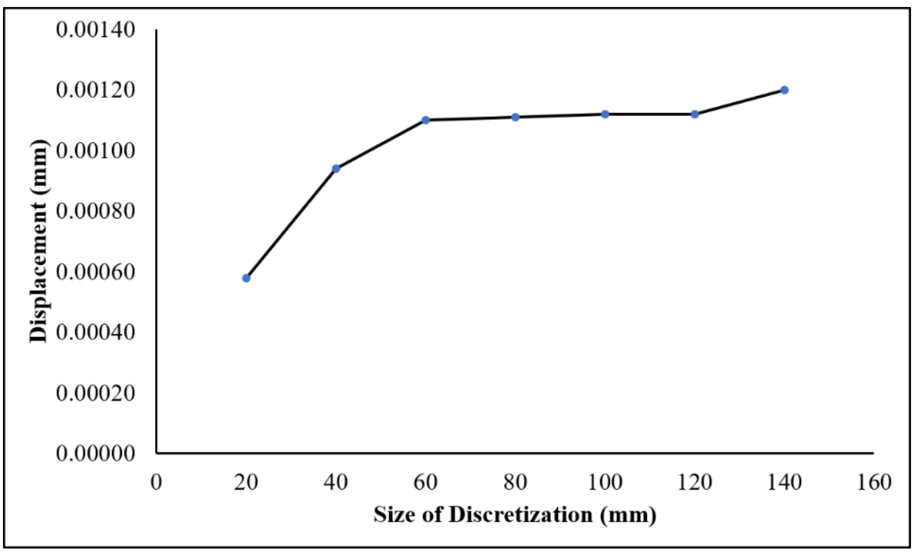

Figure 3. Displacement values for different size of meshes

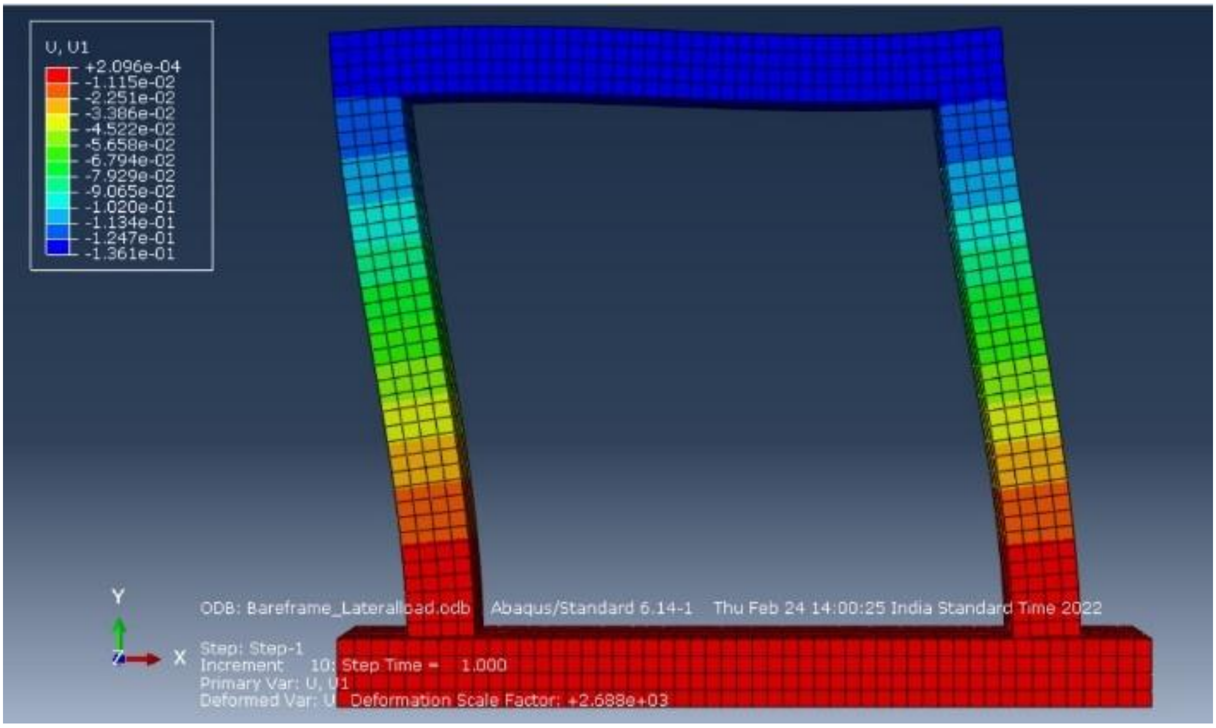

Figure 4. Numerical model of bare frame under laeral loading

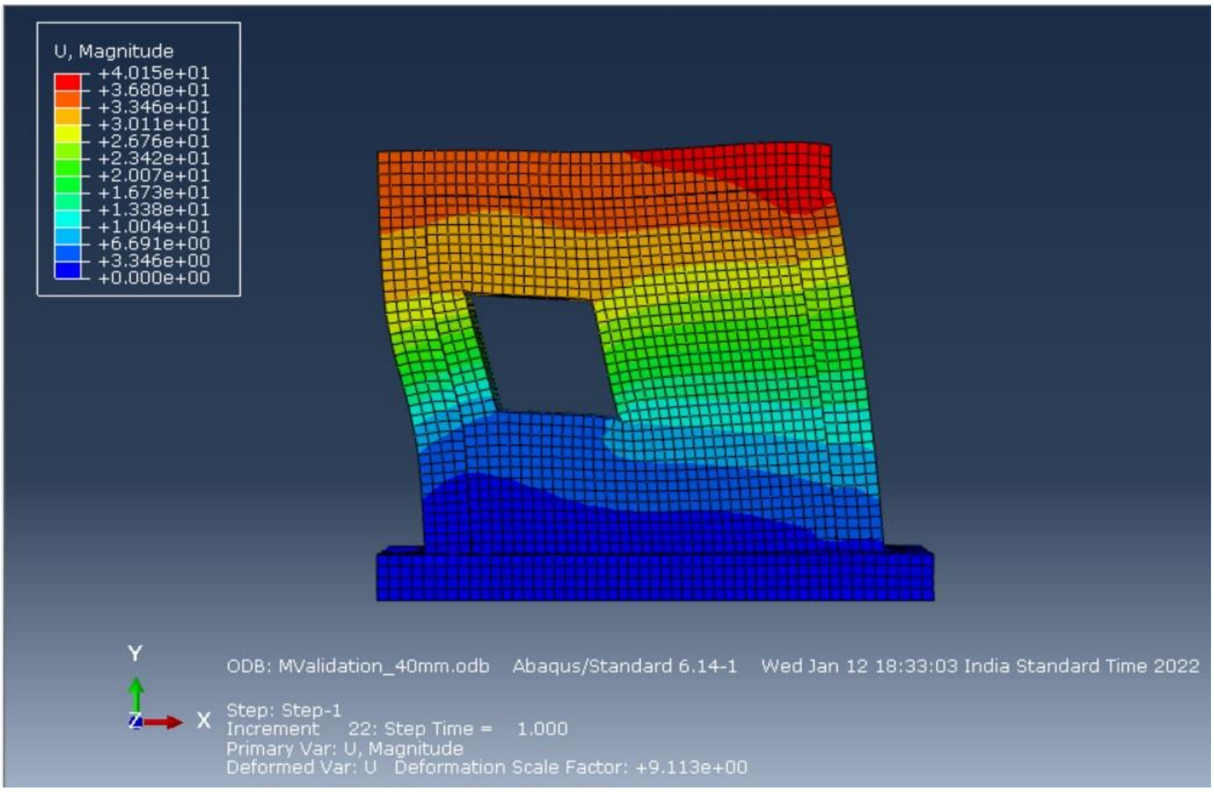

Figure 5. Numerical model of the masonry infilled RC frame for the plane loading

Comparison of experimental and computational analysis results clearly indicated that the computed values are in close proximity with the experimental values. Figure 6 shows the load Vs deflection graph obtained from numerical analysis.

3.3. Analysis of Single Sandwich Panel (Honey Comb Core)

3.3.1. Thickness Optimization of Skin of Sandwich Panel

In order to optimize the core and skin thickness, sandwich panel is considered for analysis. Several core and skin thickness were taken in to account for scrutiny. Table. 2 shows the displacement and stiffness values of sandwich panel for different core and skin thickness obtained from the numerical analysis. Computational results indicated that the increase in thickness of the skin tends to increase the stiffness of the frame. Hence the minimal core thickness of 60 mm was considered as the optimal core thickness for the experimental investigation. Figure 7 shows the developed numerical model of the sandwich panel for the plane loading and figure 8 shows the comparative analysis of thickness optimization.

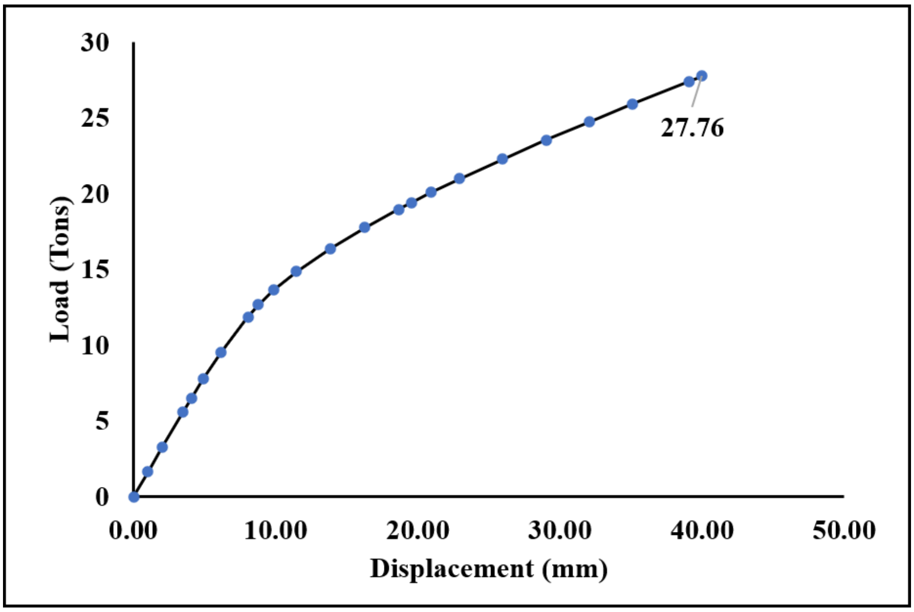

Figure 6. Load vs Displacement

Table 2. Thickness Optimization for Skin for various core thickness

Skin Thickness (mm)	Core Thick (mm)	Analytical Stiffness (kN/mm)	Experimental Stiffness (kN/mm)
0.05	60	16.05	18.33
0.05	80	20.86	23.83
0.05	100	26.09	29.80
0.05	120	29.36	33.54
0.05	150	33.56	38.34
0.15	60	48.05	54.89
0.15	80	62.38	71.26
0.15	100	78.00	89.10
0.15	120	88.03	100.56
0.15	150	100.59	114.90
0.3	60	96.06	109.73
0.3	80	124.72	142.47
0.3	100	155.91	178.10
0.3	120	175.99	201.03
0.3	150	201.17	229.80

Table 2 continued

0.45	60	144.07	164.57
0.45	80	187.02	213.63
0.45	100	233.81	267.08
0.45	120	263.99	301.56
0.6	60	192.09	219.42
0.6	80	249.38	284.87
0.6	100	311.72	356.08
0.6	120	351.99	402.08
0.6	150	402.25	459.49
0.75	60	240.10	274.27
0.75	80	311.72	356.08
0.75	100	389.56	444.99
0.75	120	439.95	502.55
0.75	150	502.77	574.31
0.9	60	288.10	329.10
0.9	80	373.97	427.19
0.9	100	467.51	534.04
0.9	120	527.98	603.11
0.9	150	603.50	689.38
1.05	60	336.13	383.96
1.05	80	436.30	498.39
1.05	100	545.55	623.18
1.05	120	616.14	703.82
1.05	150	704.23	804.44
1.2	60	384.17	438.84
1.2	80	498.75	569.72
1.2	100	526.32	601.22
1.2	120	546.45	624.21
1.2	150	568.18	649.03
1.35	60	432.34	493.86
1.35	80	548.55	626.61
1.35	100	619.96	708.18
1.35	120	675.68	771.83
1.35	150	719.42	821.79
1.5	60	480.31	548.66
1.5	80	558.66	638.16
1.5	100	621.12	709.51
1.5	120	735.29	839.92
1.5	150	819.67	936.31

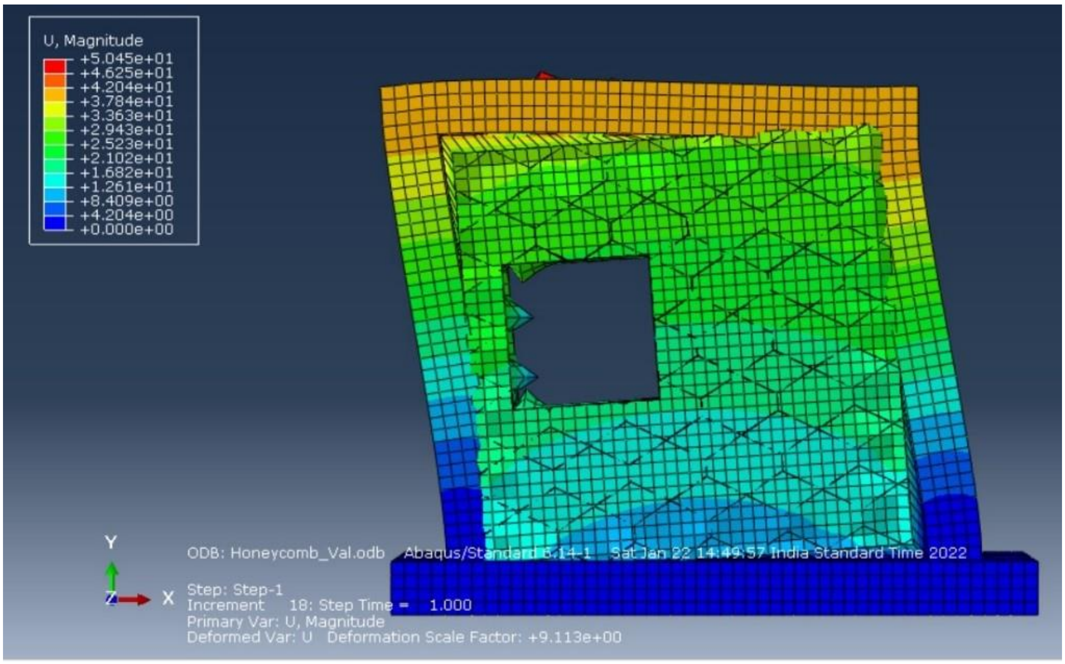

Figure 7. Numerical model of the single bay frame with sandwich panel

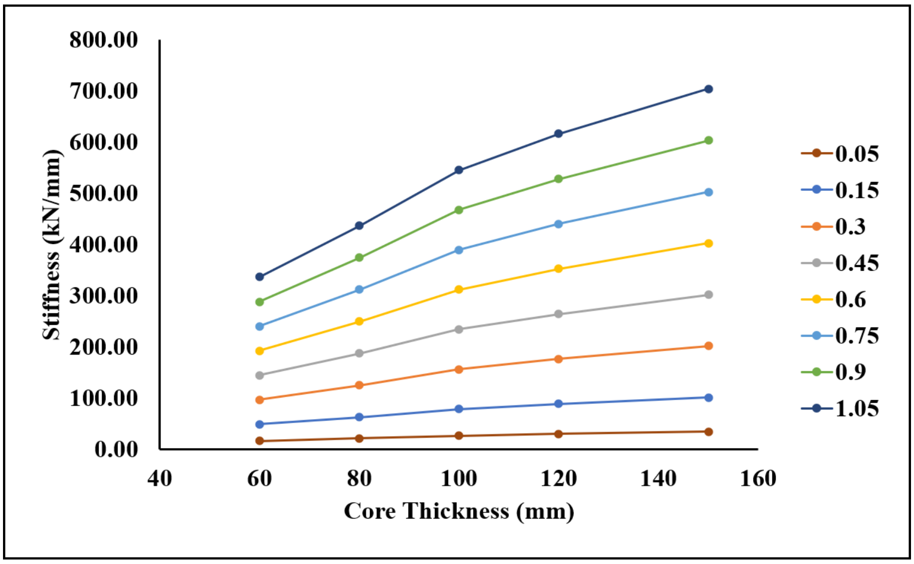

Figure 8. Analytical stiffness for various composite thickness

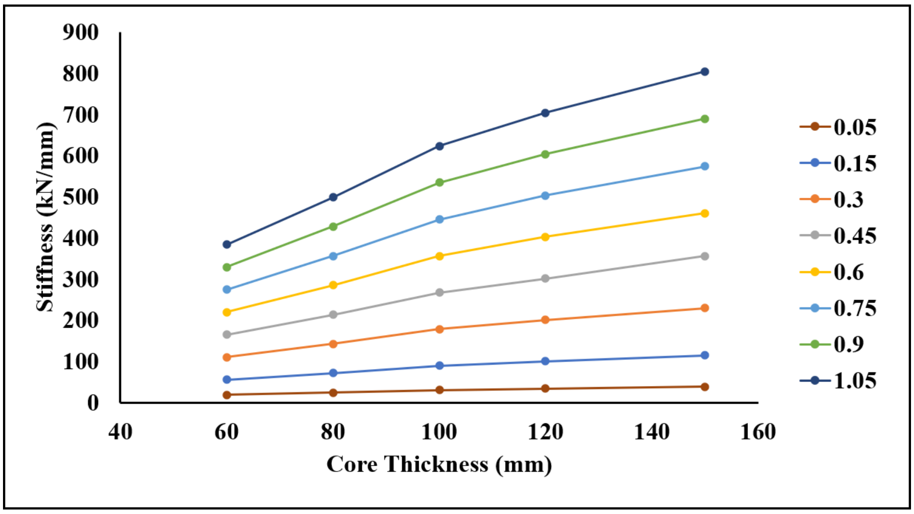

Figure 9. Experimental stiffness for various composite thickness

4. Conclusions

Under static loads, the influence of stiffness on RC frames filled with sandwich wall panels was investigated. The key conclusions are outlined below:

1. The experimental results clearly indicated that PU sandwich panel gained higher stiffness than the masonry infilled RC frames. PU sandwich panel with honeycomb structure gained stiffness of 38.94 kN/mm, whereas masonry infilled RC frame gained stiffness of 28.03 kN/mm based on the computational analysis.
2. The optimal skin and core thickness have been computed as 0.45mm and 60mm respectively for the design purpose. However, increase in thickness of the skin tends to increase the stiffness of the frame, in the economical point of view, 0.45mm thickness can be considered as skin thickness for better performance of the RC frame with sandwich panel.
3. On the whole, sandwich panel had resulted in an overall increase gain in the stiffness of 28.9% compared with the masonry infilled RC panel.
4. Masonry wall costs Rs. 1400 per square metre, whereas PU sandwich wall panel costs Rs. 900 per square metre, which is 35.71% cheaper than masonry wall panel.
5. The designers may assume when the sandwich panel is used as an infilling element for functional purpose, the entire system can be assumed to act as an infilled frame as in the case of masonry infills under in plane lateral loading.

Since there is no connection study for the RC frame and sandwich wall panel in this investigation, such a study may be conducted in the future.

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