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Analysis of Ultra High Performance Concrete Wall Panel with Opening in One and Two Way Action

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Abstract: ***Ultrahigh-performance concrete (UHPC) is a new class of concrete that has been developed in recent years which has a compressive strength more than 100 N /mm^2 .When compared with high performance concrete, UHPC tends to exhibit advanced mechanical and durability properties. In present study Finite Element Method (FEM) is used to investigate the structural behavior of vertically loaded Ultra High Performance reinforced concrete walls with openings. The variables are, one-way and two-way actions, and the slenderness ratio (wall height over thickness).Static and model analysis was carried out on wall panel. The result indicate that buckling load decreases with slenderness ratio and buckling load of two way action wall panel is greater than one way action wall panel.***

Keywords: Ultra High Performance Concrete, Wall panel, One-Way Action, Two-Way Action.

1. Introduction

Reinforced Concrete wall are often used on building industries due to their advantages like high strength, stiffness, easiness in construction, speed in construction and it require less space. Several investigations are also going on wall panels using new generation materials like high strength concrete, high performance concrete etc. Advances in the science of concrete materials have led to the development of a new class of cementations composites, namely ultra-high performance concrete. (UHPC)Ultra High Performance Concrete is a class of concrete defined by its exceptionally high strength and durability. It was developed in Europe in the 1980s for specialized applications that demand superior strength and corrosion resistance. In UHPC the homogeneity of concrete is improved by using sand, with particle size between 150 and 600 µm, as the only aggregate. The density is increased by using silica fume as partial cement replacement. Its great smoothness gives it a very good filling capacity and, combined with its amorphous structure. Its strong puzzolanicity increases the resistance of the concrete and improves its durability. In recent years RC wall construction has become increasingly popular all over the world. Many researchers have done theoretical and experimental investigation on ordinary strength reinforced concrete walls Studies were also conducted on thin RC walls with ribs recent advances in concrete technology like development of high strength concrete triggered corresponding research work in wall panels also.

2. Finite element modeling of wall panels

The selection of finite element model to simulate the response of a structure is very important task in any analysis. The Finite Elemental Method (FEM) discretizes the structure in to a discrete number of elements from which an approximate numerical solution is obtained. With the easy of simulating the mathematical model in FEM on personal computer, this approach provides an accurate solution for many structural analysis problems. The accuracy of result depends on the selection of suitable elements with the appropriate material characteristics modeling.

2.1 Geometric Model

ANSYS finite element software is used to model five reinforced concrete walls panel having openings of 300mmx300mm and variable thickness.Solid65 finite element is utilized. It is a dedicated three-dimensional eight noded isoparametric element with three degrees of freedom at each node, translations in the x, y and z directions. Several computer iterations were carried out to determine the proper load step and element size. The fine elements have been distributed in regions of disturbed stress flow such as openings

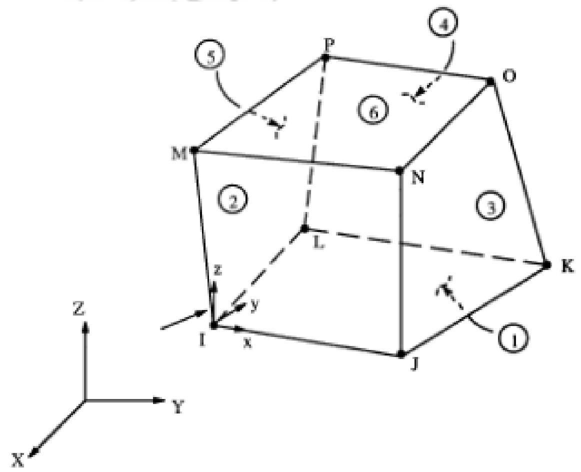

Figure1: Solid65 – 3-D reinforced concrete solid

The solid65 element models the nonlinear response of reinforced concrete. It is capable of plastic deformation; cracking in three orthogonal directions at each integration point. The cracking is modeled through an adjustment of the material properties that is carried out by changing the element stiffness matrices. If the concrete at an integration point fails in uniaxial, biaxial or triaxial compression, the concrete is assumed crushed at that point. Crushing is defined as the complete deterioration of the structural integrity of the concrete. ANSYS allows entering three reinforcement bar materials in the concrete, each material corresponding to the x, y and z directions of the smeared element

A Link 8 element was used to model the steel reinforcement. Two nodes are required for this element. Each node has three degrees of freedom, – translations in the nodal x, y, and z directions. The element is also capable of plastic deformation. The geometry and node locations for this element type are shown in Figure

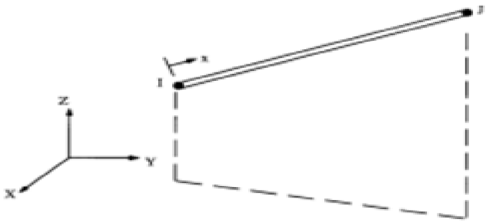

Figure 2 : Link8 – 3-D spar

The horizontal and vertical reinforcement provided were 0.25% and 0.15% of gross area of concrete respectively. Mild steel bars of 3 mm diameter were used as reinforcement. Minimum cover of 25 mm was provided on all faces of the wall panels.

2.2 Mesh Model

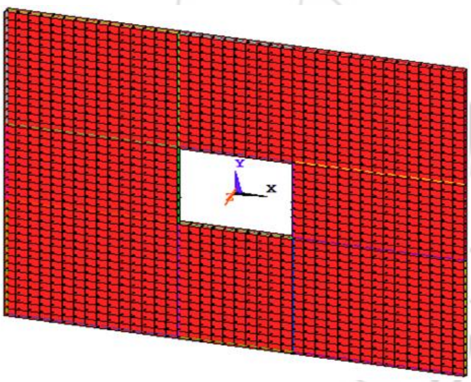

Figure 3: Meshed model

In meshing the geometric model is discretized in to small elements. The collection of these small elements is called a finite element model. Meshing the model is done after creating geometric model by assigning engineering data. Data's used for modeling are tabulated in table 1 and table 2.

2.3 Boundary condition

In one way action wall panel fixed support is provided at the top and bottom. In two way action wall panel fixed support is provided at the four side of wall panel.

Table 1: Properties of Concrete

Concrete	
Modulus of Elasticity E (N/mm2)	56120
Poisson ratio µ	0.2

Table 2: Properties of Steel

Steel	
Modulus of Elasticity E (N/mm2)	200000
Yield strength (N/mm2)	250
Poisson ratio µ	0.3

3. Modal and Static Analysis Using ANSYS

In structural engineering, modal analysis uses the overall mass and stiffness of a structure to find the various periods at which it will naturally resonate. These periods of vibration are very important in earthquake engineering. Building's natural frequency does not match the frequency of expected earthquakes in the region in which the building is to be constructed. If a structure's natural frequency matches an earthquake's frequency the structure may continue to resonate and it will experience structural damage. A dynamic analysis is performed for wall panel with self-weight only. Block Lanczos method was used for analysis. The frequency and mode shapes are read from the analysis. static analysis is done to obtain buckling load under different support conditions.

4. Results and Discussion

4.1 Natural Frequency

Table 3: Frequencies of One Way Action Wall Panels

Model Dimension(mm)	*F1 (Hz)*	*F2 (Hz)*	*F3 (Hz)*
1200×1200×25	2.87	3.37	5.69
1200×1200×30	5	4.2	6.81
1200×1200×40	5.3	9	11.72
1200×1200×50	5.7	6.7	14.29
1200×1200×55	6.25	7.30	15.89

Table3 shows the value obtained for frequency for one way action wall panel with opening. From the table it is clear that frequency decreases with slenderness ratio

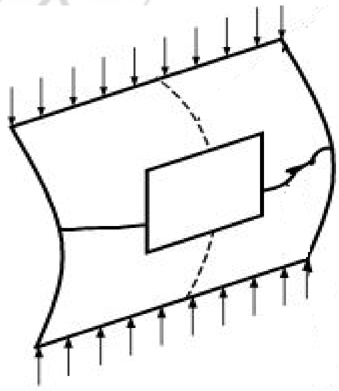

Figure 4: One way action wall panel with opening

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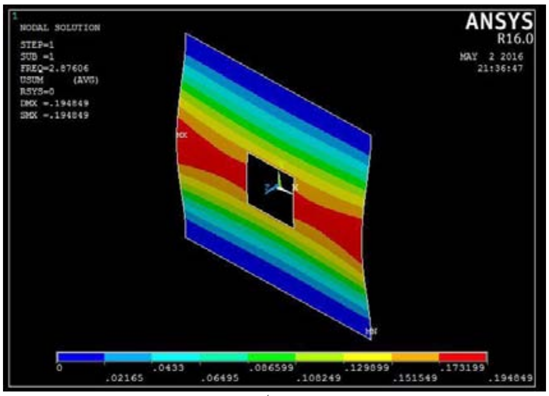

Figure 5:1st Mode shape

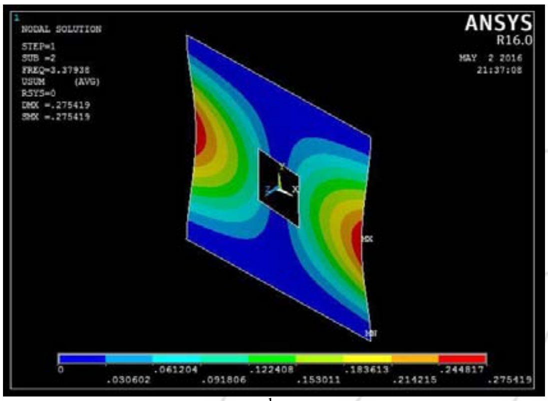

Figure 6:2nd Mode shape

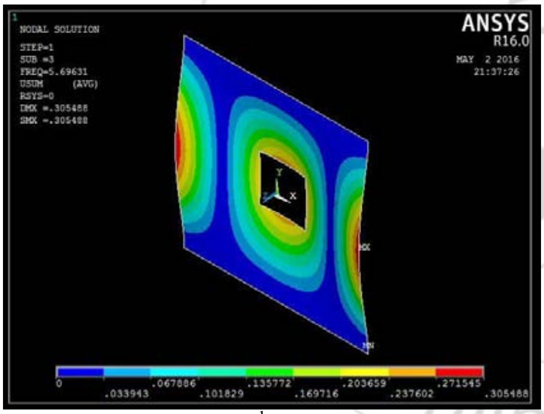

Figure 7:3rd Mode shape

Table 4: Frequencies of Two Way Action Wall Panels

Model Dimension(mm)	*F1 (Hz)*	*F2 (Hz)*	*F3 (Hz)*
1200×1200×25	5	8.58	12.8
1200×1200×30	6.11	10.5	15.32
1200×1200×40	7	13.5	20.19
1200×1200×50	9.6	16.6	24.88
1200×1200×55	10.6	18.1	27.15

Table4 shows the value obtained for frequency for two way action wall panel with opening. From the table it is clear that frequency decreases with slenderness ratio

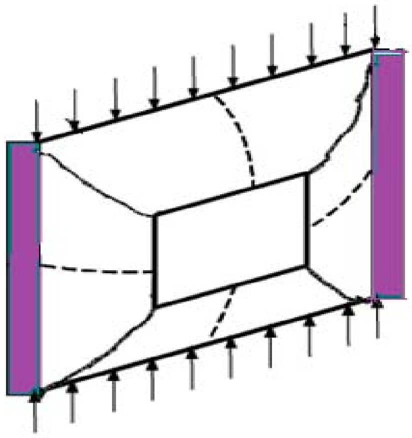

Figure 8: Two way action wall panel with opening

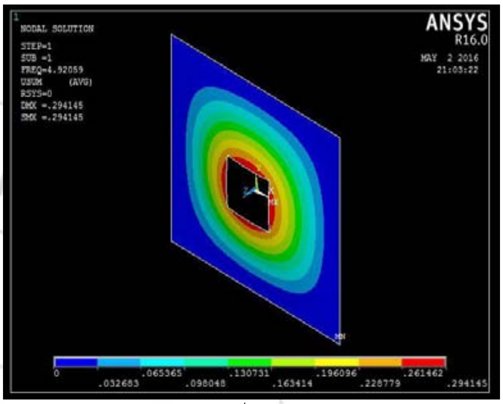

Figure 9:1st Mode shape

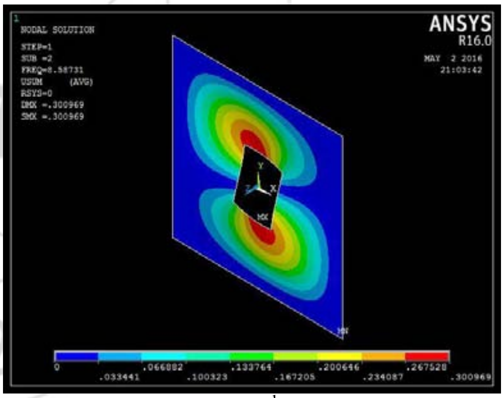

Figure 10:2nd Mode shape

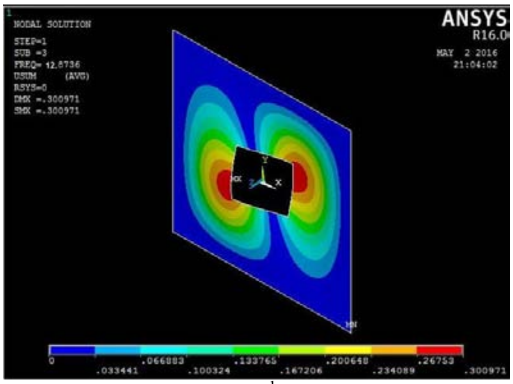

Figure 11:3rd Mode shape

Table3& Table4 shows the value obtained for frequency for one way action wall panel and two way action wall panel.

From the table it is clear that frequency decreases with slenderness ratio.

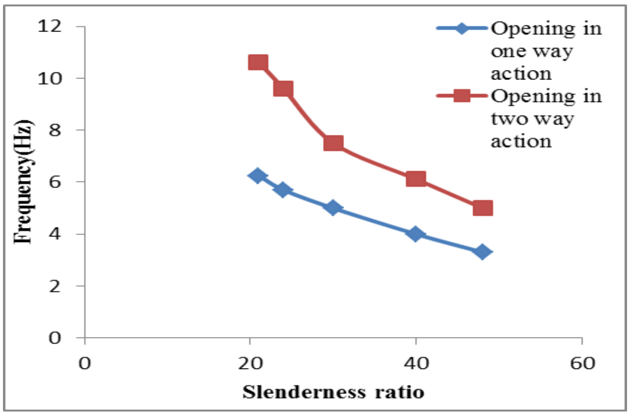

Figure 12: Slenderness Ratios – Frequency Curve

From the graph it is clear that frequency decreases with slenderness ratio and frequency of wall panel with opening in two way actions is greater than opening in one way action.

3.2. Buckling load

Table 5: Buckling Load for One Way and Two Way Action Wall Panels

Slenderness Ratio	*Buckling load (KN)*	
	One way action	*Two way action*
48	87.02	512.35
40	180.2	917.85
30	220.2	1273.5
24	520.2	3173.5
21	1202	6173.5

Buckling load obtained is shown in table5.It indicate that buckling load decreases with slenderness ratio and buckling load of two way action wall panel is greater than one way action wall panel.

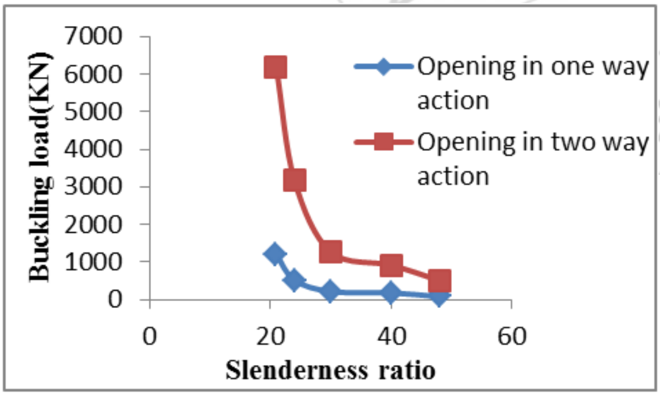

Figure 13: Slenderness Ratios – Buckling Load Curve

5. Conclusions and Future Scopes

5.1 Conclusions

From the analyses of UHPC wall panels, following conclusions are observed:

1) From the modal analysis of one way action wall panel the fundamental frequency increased to 117% as thickness increased from 25mm to 55mm and for two way action wall panel the fundamental frequency increased to 112% as thickness increased from 25mm to 55mm.
2) When opening in one way action, buckling load decreased to 93% and opening in two way action, buckling load decreased to 91% as slenderness ratio increased from 21 to 48.
3) The results indicate that the UHPC wall panels can be used as load bearing structures.

5.2 Future Scopes

Analysis can be performed on wall panel with varying opening size

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