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INFLUENCE OF OPENINGS IN RC SHEAR WALL STRUCTURE SUBJECTED TO DYNAMIC LOADING

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ABSTRACT

In high rise buildings, shear walls are generally used as a vertical structural element for resisting the lateral loads that are induced by the effect of wind and earthquake. A shear wall may contain many openings due to the functional requirements such as doors and windows, which may largely affect the overall dynamic response of the structure. This study is carried out on a typical G+9 storey RC framed building with different positions of shear wall along with varying the percentage of openings from 0% to 100% of shear wall. Modal Analysis is performed to obtain Natural frequency of all the models.

Keywords: *Central Core, IS Code, Modal Analysis, Natural frequency, Stiffness*

1. INTRODUCTION

Shear wall is vertical structure member which can resist moment, shear and axial load arising due to gravity and lateral loads. It offers adequate rigidity for lateral load and provides sufficient stiffness to whole structure. To serve for architectural and functional purposes openings are provided in shear wall with varying sizes and at different locations. The openings in shear wall influences its behavior, such as changing its force transfer mechanism, deducting its strength and stiffness and decreasing its ductility level.

2. BACKGROUND

Numerous studies have made on the dynamic analysis of RC Shear wall structure with and without openings, as well as frame with varying percentage of openings in Shear wall. A brief review of the available information studies are presented below.

Shahzad Jamil Sardar, Umesh. N. Karadi (2013) [1],Varsha R. Harne (2014) [2],S. M. Yarnal, S.et al. (2015) [3], P. S. Kumbhare, A. C. Saoji (2016) [4], A. B. Karnale and Dr. D. N. Shinde (2016) [5],Fazal U Rahman Mehrabi., (2017) [6] and many more have carried out studies on RC Shear wall frames with and without openings. In continuation, this study is carried out on a typical RC structure varying the position of shear wall along with percentage of openings.

3. OBJECTIVES AND METHODOLOGY

The Objectives of the study are:

- To study the dynamic behavior of Shear walls with and without openings.
- To carry Modal Analysis on RC Shear wall structure varying its positions and percentage of openings
- Comparing the results of natural frequencies with that of the IS codal formulation

The Methodology to achieve the objectives are:

- The modal analysis is carried out on a typical G+9 storey RC framed structure with six different configurations of shear wall positions along with 0% to 100% opening in shear wall to obtain the natural frequencies using ETABS software.
- Comparison of the results obtained from the modal analysis for all the configurations of RC shear wall structure with the codal formulation as per IS 1893 (part-1):2016.

4. MODELING AND ANALYSIS

The response of structure under dynamic loading depends on characteristics of the structure such as Natural Frequency. The RC shear walls are designed Indian standard codes, IS 456-2000, “plain and reinforced concrete code of practice”, IS 1893-(part-1):2016, “Criteria for earthquake resistant design of structure” and detailed as per IS 13920-2016, “Ductile design and detailing of reinforced concrete structures subjected to seismic forces". FE Analysis involving modal analysis is performed using ETABS software and the natural frequencies are tabulated and compared.

4.1 Details for modeling

Model Properties

- Number of storey: G + 9
- Floor plan dimension: 30m x 30m
- Bay width: 6m x 6m
- Floor height: 3.0 m
- Size of beam: 300 mm x 450 mm
- Size of column: 600 mm x 600 mm
- Depth of Slab: 150 mm
- Thickness of shear wall: 300mm
- Materials: M 40 concrete, Fe 500 steel

Preliminary load considerations

- Live load: 3 kN/m²
- Floor finish: 1.0 kN/m²
- Wall load (periphery): 13 kN/m

Table1: Notations of the models used for the analysis

Nomenclature	Models
Bare Frame	BF
Central Core Shear wall	Core
Edge Shear wall	ESW
Edge Shear wall + Core	ESWC
Corner Shear wall	CSW
Corner shear wall + Core	CSWC

4.2 Models used for analysis

All the models used for analysis are shown from Fig.1 to Fig.6

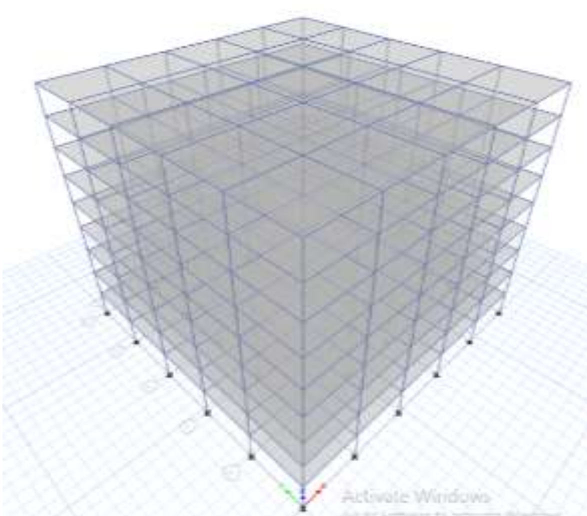

Fig1: Bare frame model

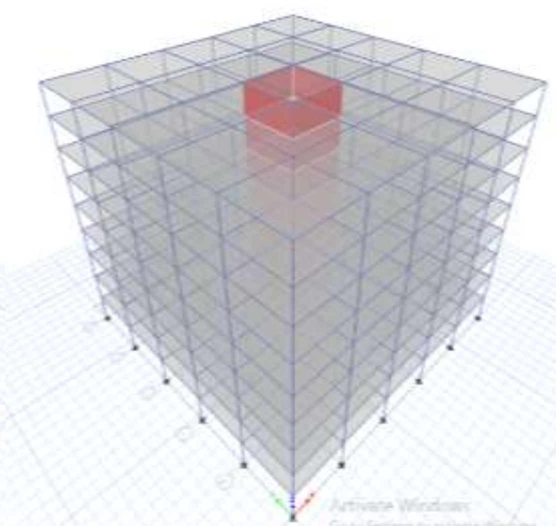

Fig2:Central Core Shear wall model

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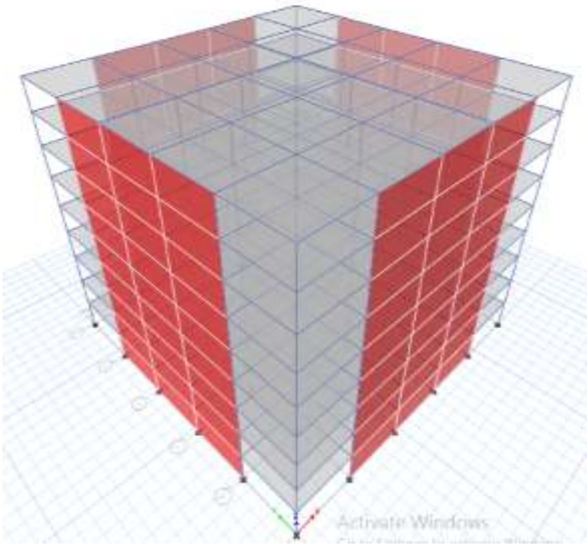

Fig3: Edge Shear wall model

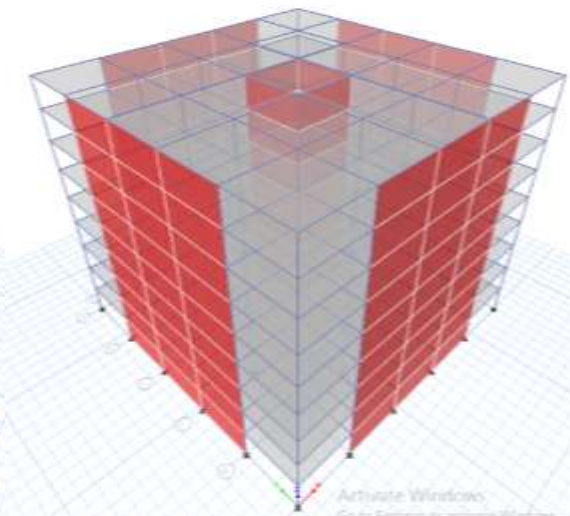

Fig 4: Edge shear wall + Core model

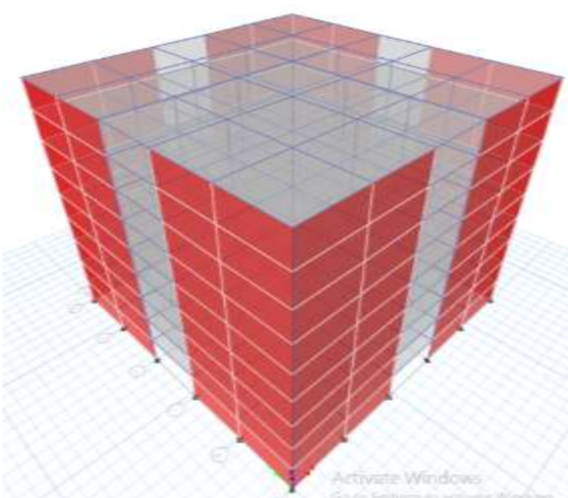

Fig 5: Corner Shear wall model

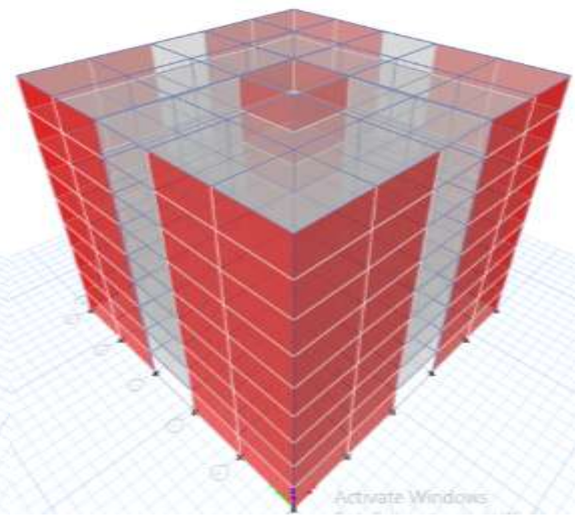

Fig 6: Corner Shear wall + Core model

5. RESULTS

5.1 Natural frequency

The modal analysis is carried out on a typical G+9 storey RC framed structure with six different configurations of shear wall positions along with 0% to 100% opening in shear wall. Natural Frequencies obtained from Modal analysis are tabulated in Table 2 in addition to the natural frequency obtained from formulation in IS 1893 (part-1):2016 code and graph is shown in Fig.7.

The fundamental natural period (T) for the buildings having shear walls as per IS 1893-2016 is

$$T_a = 0.09h/(\sqrt{d}) = 0.09 \times 30 / \sqrt{30} = 0.492 \text{ sec}$$

Natural Frequency $F = \frac{1}{T_1}$ = 2.028 Hz

Table 2: Natural frequency of shear wall without openings

Natural Frequency (Hz)	
As per IS code	2.028
BF	0.643
Core	2.078
ESW	4.422
ESWC	4.663
CSW	4.849
CSWC	5.036

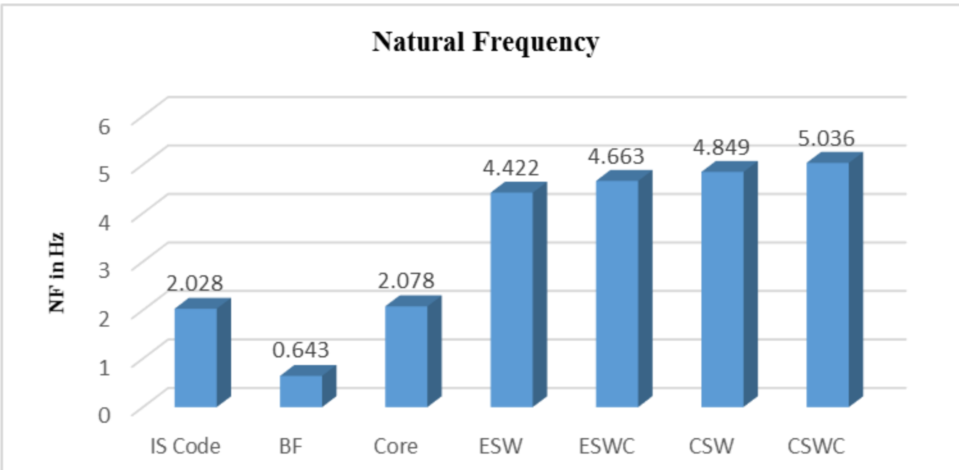

Fig 7: Comparison of Natural Frequencies (Hz) for RC Shear walls

Natural frequency of RC Shear wall located at different positions such as Core, ESW, ESWC, CSW and CSWC along with openings in Shear walls varying from 0% to 100% are tabulated in the Table 3and graphs are shown in Fig 8 to Fig 11.

Table 3: Natural frequency of shear wall with 0% to 100% openings

Natural Frequency (Hz)				
%Openings	**ESW**	**ESWC**	**CSW**	**CSWC**
0%	4.422	4.663	4.849	5.036
5%	4.245	4.512	4.644	4.868
10%	4.036	4.335	4.424	4.664
20%	3.639	4.013	3.958	4.267

30%	3.238	3.69	3.537	3.921
40%	2.855	3.402	3.121	3.595
50%	2.368	3.059	2.599	3.212
60%	1.953	2.787	2.158	2.912
70%	1.526	2.53	1.702	2.629
80%	1.246	2.38	1.406	2.466
90%	0.875	2.192	0.966	2.249
100% (BF)	0.643	0.643	0.643	0.643

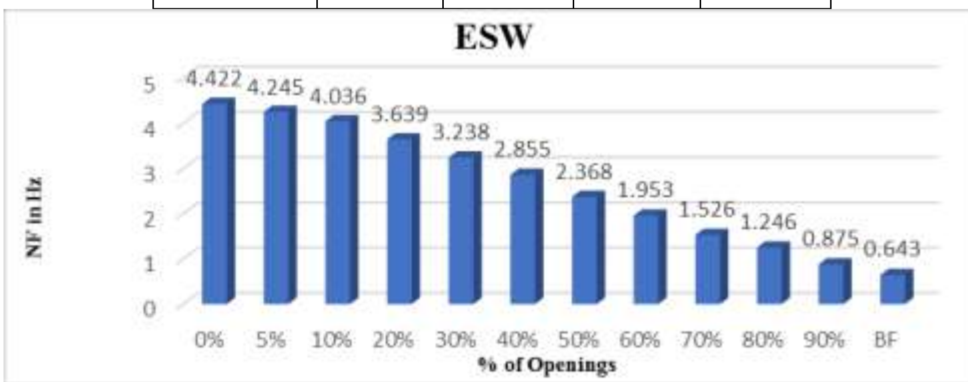

Fig 8: NF of ESW with 0%-100% openings

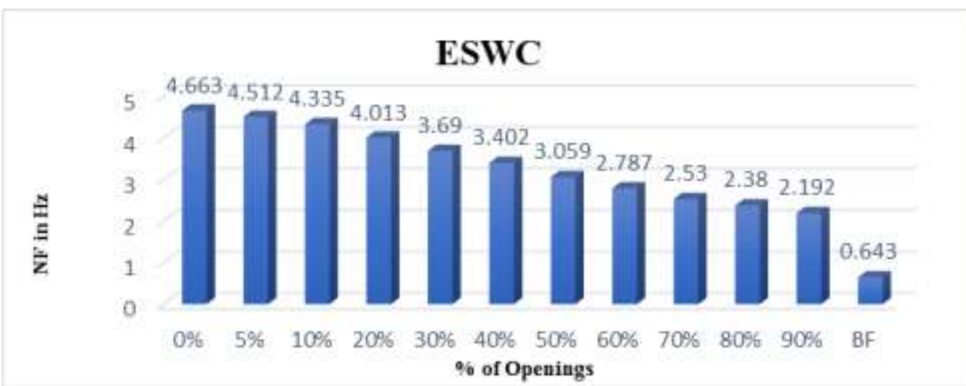

Fig 9: NF of ESWC with 0%-100% openings

Fig 10: NF of CSW with 0%-100% openings

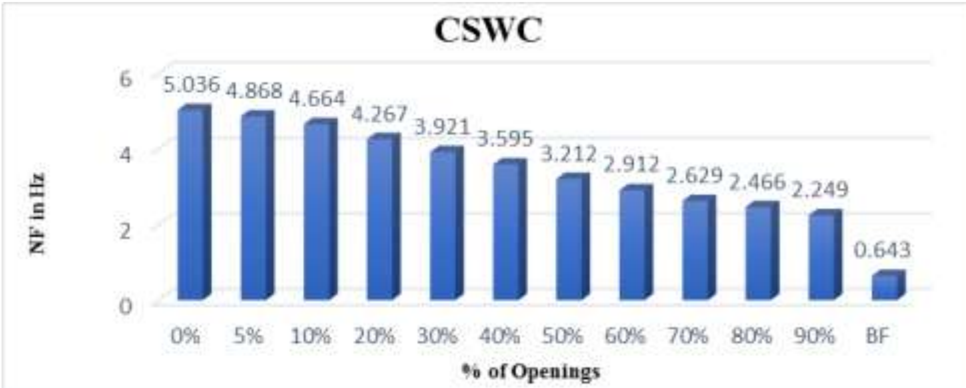

Fig 11: NF of CSWC with 0%-100% openings

6. CONCLUSIONS

Following are the conclusions drawn

- Natural Frequency obtained from IS 1893 (part-1):2016 closely matches only with the natural frequency of Central Core shear wall model (Core) emphasizing the shortfall of IS code.
- Natural Frequency of ESWC and CSWC is more compared to ESW and CSW models due to stiffness offered by the Central Core respectively.
- Natural Frequency of CSW is more compare to ESW highlighting the effectiveness of Shear wall in Corner compared to Edge.
- Natural Frequency of Central Core Shear wall (Core) is more than 3 times compared to bare frame (BF) underlining the influence of Central Core shear wall.
- As the percentage of opening increases the Natural frequency decreasesin all the models due to reduction in stiffness.
- Openings in ESW shows minimum frequency whereas CSWC is at maximum highlighting the influence of the central core.
- Natural frequency of ESWC and CSWC are decreases gradually as the percentage of opening increases due to presence of the central core.
- Finally it can be concluded that the Shear Wall at Central Core is more effective in controlling the natural frequency of the RC structure than shear wall at other locations.

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