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Seismic Analysis of a Residential Building Considering Different Types of Opening Arrangement in the Infill Wall

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***Abstract:** Infill walls are inevitable components of any structure to create dispassion between interior space and external condition. In general, there are some prevalent openings inside the infill walls because of practical needs, architectural observations or aesthetic inspections. In current design practice, strength and inflexibility contribution of infill walls aren't thought of. However, the presence of infill walls may impact the seismic reaction of structures exposed to earthquake loads and cause a conduct which is not the same as that estimated for a bare frame. Additionally, partial openings inside infill walls are significant parameter prompting the seismic behaviour of infilled frames in this manner retreating lateral stiffness and strength. In this study is proposed to compare various models of buildings considering the openings (10% of surface area) at different locations in the infill walls for the seismic behaviour. A G+13 residential building is considered in Zone III with soil type II and analysis is carried out by Response Spectrum Method. Various parameters are considered such as Natural Time period, Base shear, Storey displacement, Storey drift and Storey stiffness were studied. The comparative study could simplify designers and code developers in selecting and recommending appropriate analytical models for estimating strength, stiffness, failure modes and other properties of infill frames with openings.*

***Keywords:** Residential Building, Openings Infill Wall, ETAB Software, Natural Time Period, Base Shear, Storey Shear, Storey Displacement, Storey Drift, Storey Stiffness.*

I. INTRODUCTION

In many countries, construction of RC framed buildings with masonry infill is a common practice. It is the one of the oldest construction material still in use because of its functionality and availability .RC framed buildings are generally designed without considering the structural behavior of masonry infill walls .These walls are widely used as partitions and considered as non-structural elements. But they affect both the structural and non-structural performance of the RC buildings under lateral loads. Their impact is perceived in the worldwide behavior of reinforced concrete frames exposed to seismic earthquake loadings. In the course of the most recent years, numerous authors have considered the impacts of the infill panels on the reaction of reinforced concrete structures and the need of consideration of these non-structural components on the basic seismic evaluation and design process is perceive. Openings in the walls are accommodated for different purposes, for example for arrangement of doors, windows, ventilations ac ducts etc. Due to openings the stiffness of the structure reduces depending upon the size of the opening. When the size of the opening is small then only strut action is possible. If the opening size increases the stiffness of the structure decreases.

II. OBJECTIVE OF STUDIES

To study the behavior of RC multi-storey residential building under gravity and earthquake loads.

1) To study the function of residential building considering with and without openings in the infill wall, at different location during seismic disturbances.
2) To study the different factors such as natural time period, storey displacement, storey stiffness, base shear and storey drift of the models, (models are considering without opening, with shear wall & opening on the left, center and right of building).
3) To find optimized model under given loads.

III. METHOD OF ANALYSIS

A. *Response Spectrum Method*

Response spectrum method is a method in which there is a plot of curves shown between the maximum responses of seismic or earthquake ground motion and with its time period .Response spectrum method is also explained that, it is the locus of maximum response of a Single Degree of Freedom system for the given damping ratio. This method is also determining the maximum structural responses which is under the linear range, this linear range helps for evaluating the horizontal forces which shown in the structure due to seismic or earthquake thus providing in the earthquake-resistant design of structures.

For each and every mode, there is a response which is clear from the design spectrum, which is totally depend on the frequency of modal and for the mass of modal, and then it is shared to give an estimate of the total response of the structure.

Earthquake or seismic analysis is a part of structural analysis which contains in the estimation of the response of a structural system which is subjected to earthquake. There are many seismic data's which are necessary for taken out in the seismic analysis of the structures. The seismic analysis for the response of the structures is regulated under earthquake and calculated using response spectrum analysis method. The analysis for the response is considered for model as the single degree of freedom system and discrete Multi degree of freedom system.

1) *Natural Period:* Natural Period 'Tn' of a building is the time taken by it to undergo one complete cycle of oscillation. It is an essential property of a building controlled by its mass 'm' and stiffness 'k'. These three quantities are related by:

$$\mathbf{T_n = 2\Pi\sqrt{(m/k)}}$$

Its units is seconds (s).

2) *Base Shear:* The design base shear of a structure shall be designed by:

$$\mathbf{V_b = A_h \times W}$$

$$\mathbf{A_h} = \frac{\left(\frac{Z}{2}\right)\left(\frac{Sa}{g}\right)}{\left(\frac{R}{I}\right)}$$

Where,

A_h = Design horizontal acceleration spectrum

W= Seismic weight of the building

Factors and Coefficients

Seismic Zone Factor, Z [IS 1893-2016 Table 2]

Response Reduction Factor, R [IS 1893-2016Table 7]

Importance Factor, I [IS 1893-2016 Table 6]

Soil Type [IS 1893-2016 Table 1]

3) *Storey Shear:* The allocations of base shear at each storey of building is called storey shear, storey shear increases as the number of storey are increases.
4) *Storey Displacement:* The storey displacement can be considered as the displacement of any storey of building with regarding to ground level due to lateral loads is referred as storey displacement. According to EURO CODE 2004, permissible displacement is considered as H/250, Where H is total height of building above the ground level in millimeters (mm).
5) *Storey Drift:* Story drift can be defined as the displacement of one floor level relative to the other level above or below. As per IS 1893:2016, the storey drift shall not exceed 0.004 times the storey height.
6) *Storey Stiffness:* According to IS 1893-2016, soft story is define as story whose lateral stiffness value is less than that of story above.

IV. STRUCTURAL BUILDING DETAIL

The length and width of the building are 20m and 16m. The height of base floor is 3.2m and floor to floor height is 3m. The columns are assumed to be fixed at ground level. In this study, A G+13 storey RC building considering with and without openings in the infill walls. In this study, assume opening 10% of surface area. Below table shows details of the building that is used for the analysis of the building. The building has been analyzed using commercially available ETAB software.

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Table 1: Description of the Building

S.No.	Structural component	Dimensions
1	Building Height	(G+13)
3	Beam Size	300mm X 300mm
4	Slab Thickness	125 mm
5	Wall Thickness	230mm
6	Shear Wall Thickness	300mm
6	Plan Dimensions	20m x 16m (320 sq.m)
7	Length in X-direction	4m
8	Length in Y-direction	4m
9	Floor to Floor Height	3m
10	Base Floor Height	3.2m
11	Location	Lucknow (UP)
• Opening Size = 1.2 sq.m (10% of 4x3 sq.m)		

Table 2: Material Properties

S.No	Material	Grade
1	Reinforcement	HYSD FE500/Mild Steel Fe250
2	Concrete	M35
3	Young's modulus 'E'	$2.1x10^5 N/mm^2$
4	Shear modulus	$80000 N/mm^2$
5	Poisson's ratio	0.3

Table 3: SEISMIC DATA As per 1893:2016

1	Earthquake Zone	III
2	Zone Factor	Z = 0.16 (clause 6.4.2)
3	Damping Ratio	0.5
4	Importance Factor (I)	1.2 (clause 7.2.3)
5	Type of soil (Sa/g)	Medium soil(clause 6.4.2.1)
6	Response Reduction Factor (R)	3 (OMRF) (clause 7.2.6)

A. Loadings

1) Imposed load 2 KN/m2 as per code IS 875 Part II
2) Dead Load of Building as per code IS: 875- Part (I)
3) Earthquake/Lateral load as per code IS 1893:2016 Part (I)

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V. PROBLEM FORMULATION

A residential reinforcement concrete building with and without opening in the infill walls at different location subjected to under earthquake loading as per IS code 1893:2016. Seismic analysis of RC building with and without opening (10% of surface area) at different location in the infill walls model is carry out Response Spectrum method by using ETAB software.

1) *Model 1* -RC Building (G+13) without Opening.
2) *Model 2* -RC Building (G+13) with Opening at Center.
3) *Model 3* - RC Building (G+13) with Opening at Right.
4) *Model 4* - RC Building (G+13) with Opening at Left.
5) *Model 5* - RC Building (G+13) with Shear Wall.

Model 1 -RC Building (G+13) without Opening

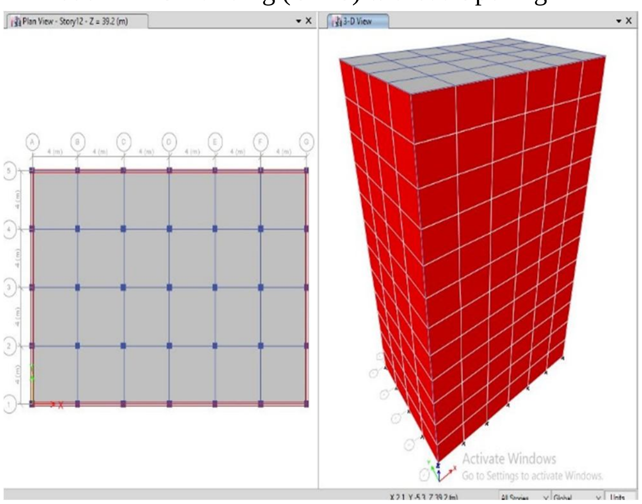


Figure: 1 Plan & 3-D View

Model 3 - RC Building (G+13) with Opening at Right

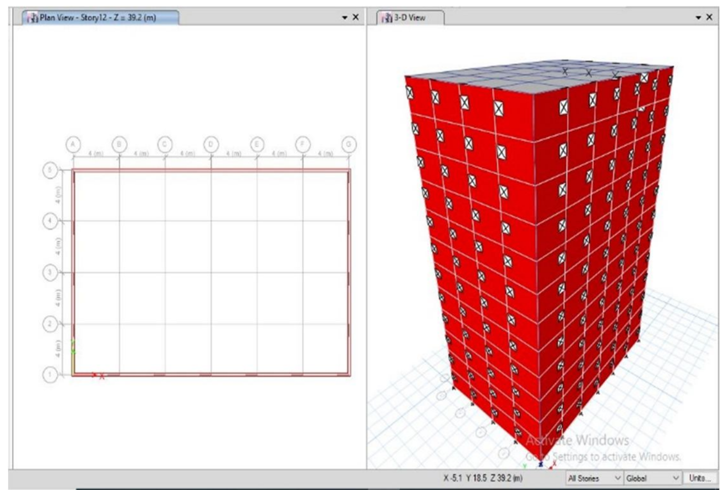


Figure: 3 Plan & 3-D View

Model 2 -. RC Building (G+13) with Opening at Center

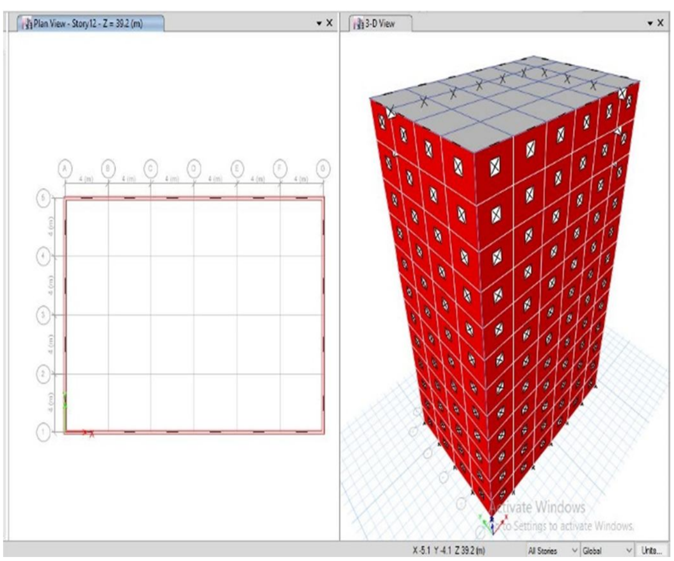


Figure:2 Plan & 3-D View

Model 4 - RC Building (G+13) with Opening at Left

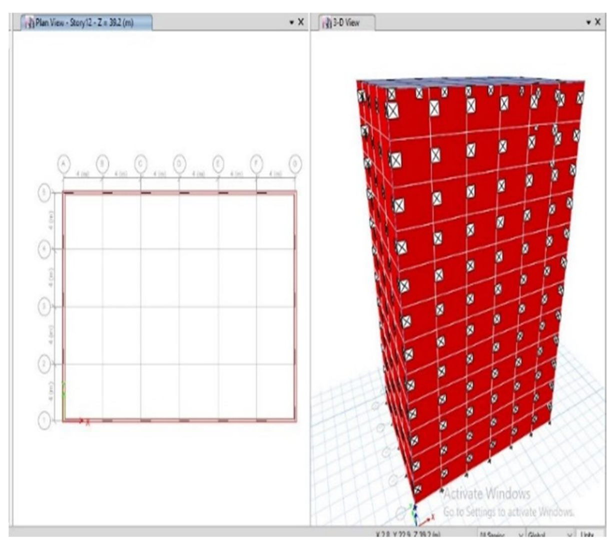
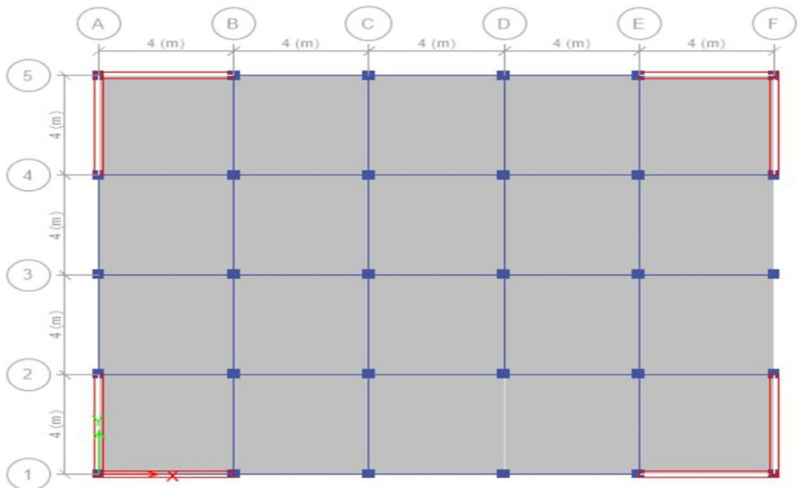


Figure:4 Plan & 3-D View

Model 5 -RC Building (G+13) with Shear Wall



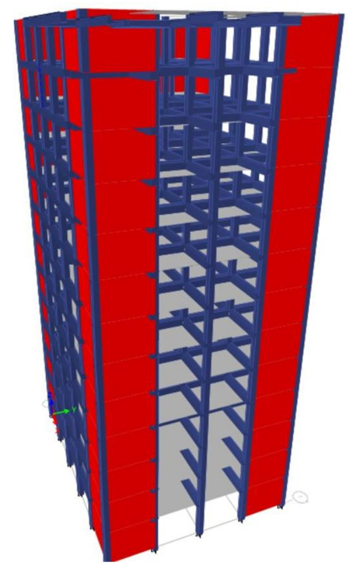


Figure:5 Plan & 3-D View

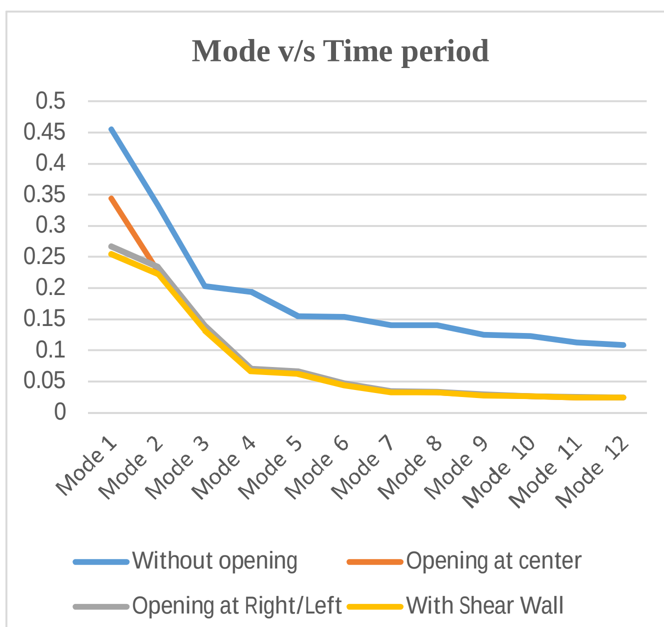
VI. RESULT AND DISCUSSION

The parametric study of Natural Time period, base shear, storey drift and storey stiffness of building in different stories by response spectrum analysis for (G+ 13) storeys is performed here. The results obtained from the analysis are compared by Graphical representation:

A. Natural Time Period

Table 4: Natural Time Period

MODE	Without opening sec.	Opening at center sec.	Opening at Right/Left sec.	With Shear Wall Sec.
Mode 1	0.455	0.344	0.267	0.255
Mode 2	0.333	0.227	0.234	0.223
Mode 3	0.203	0.136	0.140	0.132
Mode 4	0.194	0.068	0.071	0.066
Mode 5	0.155	0.063	0.066	0.062
Mode 6	0.154	0.046	0.047	0.044
Mode 7	0.14	0.034	0.035	0.033
Mode 8	0.14	0.032	0.034	0.032
Mode 9	0.125	0.028	0.029	0.027
Mode 10	0.123	0.026	0.026	0.026
Mode 11	0.113	0.024	0.025	0.024
Mode 12	0.109	0.024	0.024	0.024



period

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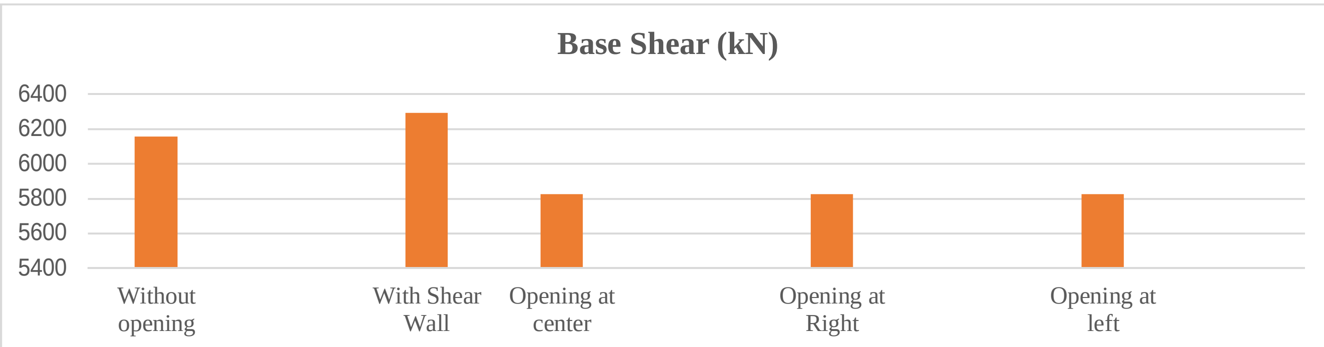
B. *Comparison Of Base Shear*

Table 5: Base Shear

Model	Base Shear (kN)
Without opening	6156.5458
With Shear Wall	6292.6461
Opening at center	5824.1989
Opening at Right	5824.1989
Opening at left	5824.1989

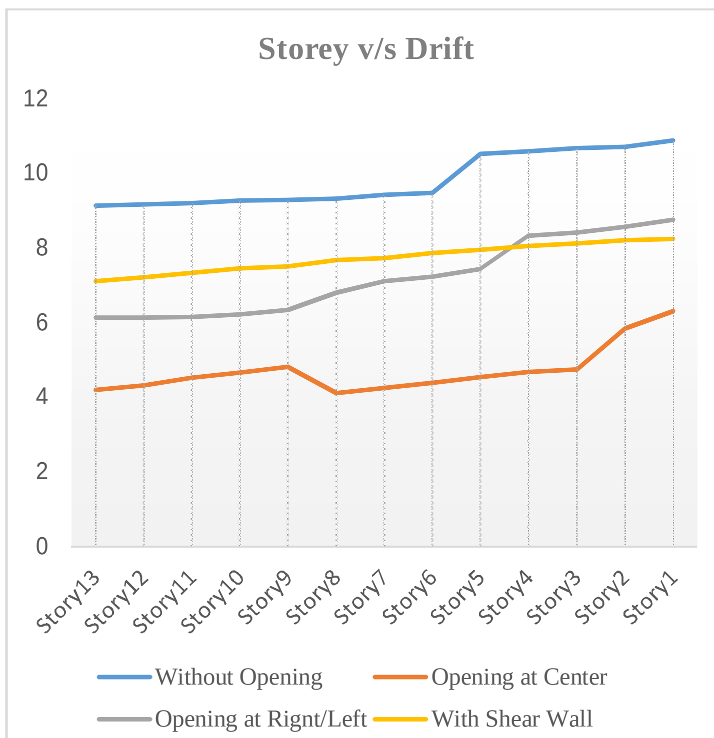


Graph 2: Comparison of Base Shear

C. *Storey Drift*

Table 6: Maximum Storey drift

Storey	Without Opening	Opening at Center	Opening at Rignt/Left	With Shear Wall	As per IS 1893 Code
	mm	mm	mm	mm	0.004xH (mm)
Story13	9.141	4.214	6.145	7.12	12
Story12	9.176	4.334	6.152	7.23	12
Story11	9.213	4.538	6.158	7.34	12
Story10	9.289	4.667	6.236	7.47	12
Story9	9.299	4.824	6.343	7.52	12
Story8	9.328	4.123	6.812	7.68	12
Story7	9.427	4.259	7.121	7.73	12
Story6	9.491	4.395	7.235	7.88	12
Story5	10.537	4.545	7.451	7.96	12
Story4	10.592	4.693	8.333	8.06	12
Story3	10.685	4.761	8.421	8.14	12
Story2	10.719	5.856	8.571	8.22	12
Story1	10.896	6.324	8.765	8.25	12



Graph 3: Comparison of Storey Drift

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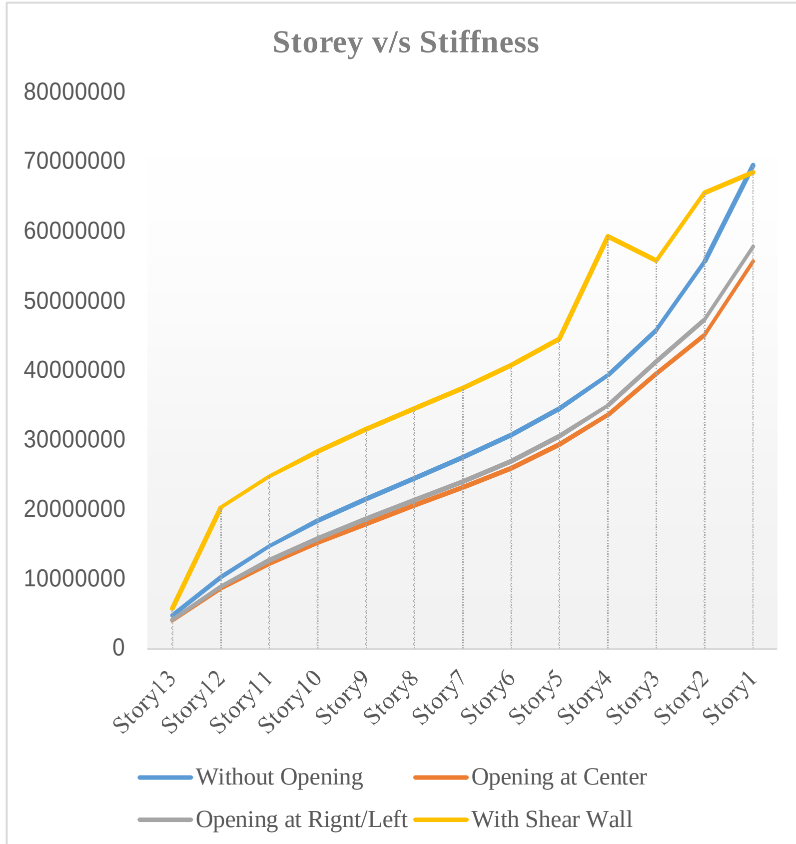
D. Storey Stiffness

Table 7: Maximum Storey Stiffness

Story	Without Opening	Opening at Center	Opening at Rignt/Left	With Shear Wall
	kN/m	kN/m	kN/m	kN/m
Story13	4752717.1	4030047.2	4146735.8	5754716.1
Story12	10325097	8591560.2	8884402.3	20327096
Story11	14747915	12255486	12692791	24749914
Story10	18383241	15290153	15850394	28385240
Story9	21549842	17962340	18649367	31548841
Story8	24514445	20568303	21334537	34516444
Story7	27505738	23148824	24030458	37504737
Story6	30758274	25985646	27000104	40756273
Story5	34562423	29334753	30523482	44563421
Story4	39346975	33617341	35027141	59345974
Story3	45831282	39631313	41378666	55830281
Story2	55612766	45072610	47296349	65612863
Story1	69539758	55689344	57822997	68530757

Graph 4:Comparison of Storey Stiffness



VII. CONCLUSIONS

From the above work the following conclusion are given below

A. Natural Time Period

From table 4 and Graph 1 of Natural Time period v/s Mode, the result is that With Shear Wall is taking least value of Natural Time period (sec) as related with Opening at Center and without Opening in the Infill Walls and it is evaluated that Opening at Right/Left is 72.41% efficient as compared to without Opening in the Infill Wall model.

Opening at Center is having less value of Natural Time Period (sec) as compared with model having Without Opening in the Infill Wall and it is evaluated 32.26 % efficient as compared model.

B. Base Shear

From table 5 of Base shear & graph 2 , the result is that With Shear Wall Opening model is taking more value of Base shear (kN) as related with different Openings models (Without/Center/Right/Left) and it is evaluated Without Opening model is 15.706 % efficient as compared to with Openings models.

C. Storey Drift

From table 6 and Graph 3 of Storey Drift v/s Storey , the result is that With Opening at center model is having least value of Storey Drift (mm) as related without Opening, With Shear Wall and Openings in Right/Left model in the Infill Walls and it is evaluated that Opening at Right/Left 24.31% efficient as compared to without Opening in the Infill Wall model.

Opening at Center is having Minimum value of Storey Drift (mm) as compared with model having Without Opening in the Infill Wall and it is evaluated 72.29 % efficient as compared model.

D. Storey Stiffness

From table 7 and Graph 4 of Stiffness v/s Storey , the analysis gives a result that With Shear Wall Opening model is taking more value of Stiffness (kN/m) as related with Opening at Center and Openings in Right/Left model in the Infill Walls and it is evaluated that 28.26 % efficient as compared to with Opening at Right/Left in the Infill Wall model.

Without Opening model is 24.87 % efficient as compared to Opening at Center in the Infill Wall model.

REFERENCES

[1] Nusfa Karuvattil, Priyanka Dilip, "Linear static analysis of masonry infilled soft storey RC buildings with and without opening for earthquake resistant design" International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Volume 2, Issue 5 (2016).

[2] Karam Singh Yadav, "Effect of openings in RC infilled frame structure under seismic loads", International Journal of Engineering Research & Technology (IJERT) Vol. 5 Issue 03, (2016).

[3] D.V. Mallick and R.P. Garg, "Effect of openings on the lateral stiffness of infilled frames", Volume 49 Issue 2, (1971), pp. 193-209.

[4] Asteris,P.G. "Lateral stiffness of brick masonry infilled plane frames" Journal of Structural Engineering, vol.8, (2003), pp 1071-1079.

[5] D.J. Kakaletsis, C.G. Karayannis, "Experimental investigation of infilled RC frames with eccentric openings" Structural Engineering and Mechanics, volume 26, (2007).

[6] Fatih Cetisli, "Effect of openings on infilled frame stiffness" Građevinar 8, (2015) , pp. 787-798.

[7] Nikhil Bandwal, Rahul Jichkar, Nitesh Thikare, "Influence of opening in the brick infilled wall on the stiffness of RCC frame" International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 11, (2015).

[8] Dev Raj Paudel , Santosh Kumar Adhikari" Effect of Masonry Infills on Seismic Performance of RC Frame Buildings:International Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 8, August 2015

[9] Chidananda HR Raghu K,G Narayana" Analysis of rc framed structures with central and partial openings in masonry infill wall using diagonal strut method"(2015), international journal of research in engineering and technology.

[10] Made Sukrawa "Earthquake response of RC infilled frame with wall openings in low-rise hotel buildings" The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5) :(2015)

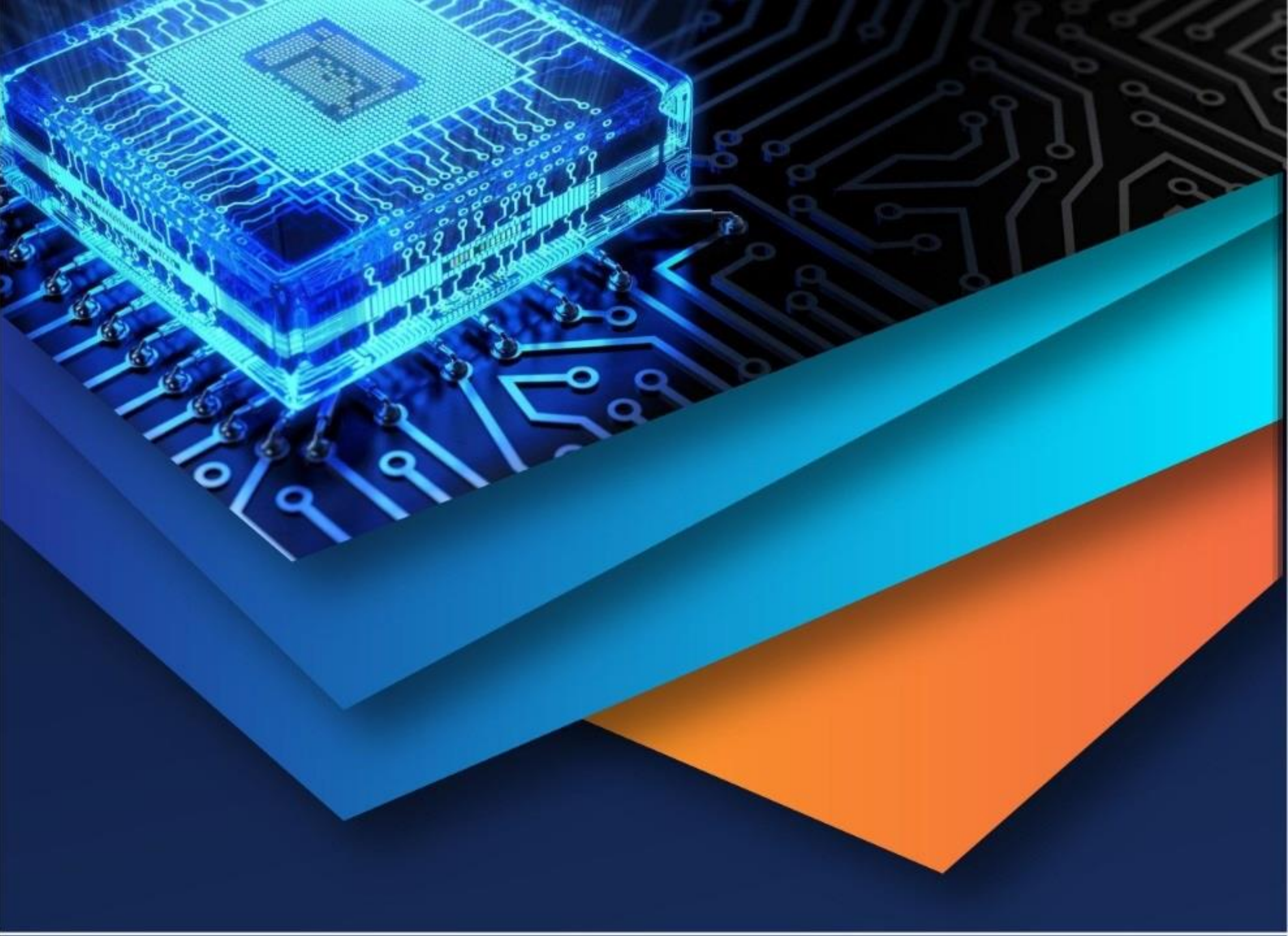
[11] Niruba S "Analysis of Masonry Infill in a Multi-Storied Building" Journal of Civil & Environmental Engineering, Niruba, J Civil Environ Eng 2014

[12] V. Sigmund & D. Penava "Experimental Study of Masonry Infilled R/C Frames with Opening "Josip Juraj Strossmayer University of Osijek, Faculty of Civil Engineering Osijek, Croatia ,15 WCEE (LISBOA 2012).

[13] IS: 1893(Part 1): 2016 "Criteria for Earthquake Resistant Design of Structures"

[14] IS: 875(Part 2)-1987 "Code of Practice for design loads for buildings and structures'"

[15] IS: 875(Part 1)-1987 "Code of Practice for design loads for buildings and structures".



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