Analysis of Multistoried Building with Different Shear Wall Opening Condition using ETABS

Praveen K
PG Student
Department of Civil Engineering
AIT, Chikkamagaluru
Chikkamagaluru, India

Chethan V R
Assistant Professor
Department of Civil Engineering
AIT, Chikkamagaluru
Chikkamagaluru, India

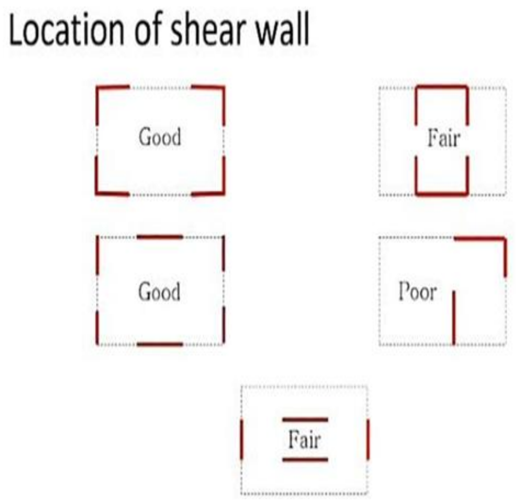
***Abstract*: In modern days construction of high rise building becomes more popular for aesthetic purpose and also scarcity of land, Impact of lateral forces on tall structure is more .i.e. wind load and seismic load, so shear wall is generally adapted to minimizing the cause of damage. Openings are provided in shear wall building for ventilation purpose doors and window. The size and location of opening may change based on requirement and architectural consideration. In most of the buildings size and location of openings in is provided without considering its effect on structural behavior of the building. In this study analysis is carried out on G+10 storied building by response spectrum method using ETABS 2016. Five different models are analyzed by changing the location of opening and changing the size opening and comparing the analysis results of all models and consider the best suitable position of opening. The structure is analyzed for seismic Zone V and type 2 soil conditions. Results compared are story drift, maximum displacement, story shear.**

Keywords—: Shear wall, openings, storey drift, storey displacement, ETABS

INTRODUCTION

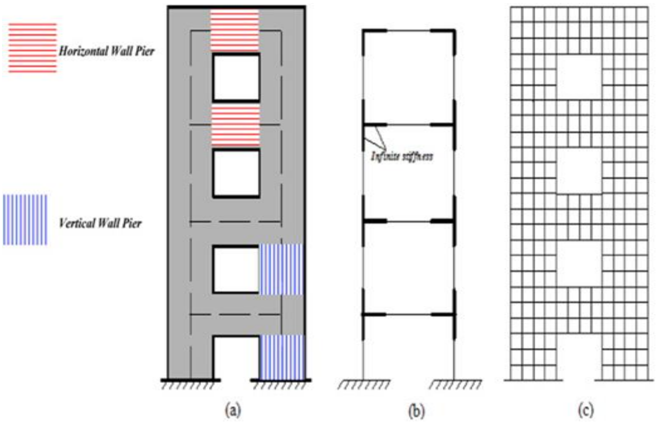
Earthquake is unpredictable it occur anywhere on the ground in this world and it is more dangerous for tall structure during massive earthquake, so special attention should be provided in its analysis and design, as tall building often has thousands of occupants. The structure should be designed to perform well during an earthquake and ensure that the building remains serviceable without causing major damage to the structure. Building need to be design to with stand lateral force this can be achieved by improve the stiffness of the building. Stiffness increased by adding shear wall. Framed building is less stiff compared to building with structure wall along with the frame and reduces the damage and excessive deformation to the structure. When reinforced concrete multi storied buildings are constructed with no shear wall, size of frames increases. From an economical and deflection control perspective, shear wall may become very essential. Shear force tends to tear the wall as if it attached with paper piece, and racking is the process of changing the shape of the frame from a rectangle to a parallelogram. Shear walls have a tendency to be pushed downward at the end and away from the force. Up until the point of overturning, this motion provides resistance.

SHEAR WALL: Shear wall is one of the suitable structure features to withstand lateral/horizontal stresses applied by wind and earthquake in high-rise or tall structure. In building construction, the shear wall is rigid vertical diaphragms capacity to transferring horizontal loads from the outer walls, floors, and ceilings to the base level in the on their plane i.e. reinforced-concrete walls or trusses. The thickness, age, length of the wall and materials used for construction of walls will impact on performance of the wall in building. Typically, these walls run for the length and width, beginning at foundation level. In tall structures, shear walls are frequently used to prevent failure and increase the multi-story structures' reaction to lateral pressures.



I. **OPENINGS IN SHEAR WALL:** In modern tall building providing shear wall as vertical component becomes common for resisting the horizontal forces that may create from seismic and wind load. Shear walls are generally located at outside face of building and at core part of the building for lift and staircase purpose. Openings are very much required in all the buildings, in masonry buildings are provided with openings which does not act as a lateral load resisting structural component Openings for doors, windows, and other purposes are given in the shear wall due to functional requirements. The size and positions of openings in shear wall varies based on requirement.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 11, November-2022



1. LITERATURE REVIEW:

Ruchi Sharma.et.al.,(2016): In this study the structure analyzed for 30 storied building. The aim is to investigate and critically asses' different size of shear wall openings and the response and behavior of multistoried. The structure analyzed for Response Spectrum and Time History Method. Analysis concludes that stiffness of shear wall will decrease by increasing the size of openings and displacement and drift of the building will affected by change in shape of the openings. The horizontal displacement of the structure increased to 20.955 and storey drift increased to 23.63%.

Swetha K S.et.al., (2017): In this study 10 story building is analyzed with different shear wall opening patterns .i.e horizontally, vertically and in staggered condition (zig-zag) and analyze the structure using ETABS software for time history analysis. By this analysis they try to find out the best suitable position of shear wall opening and also to find the maximum allowable percentage of opening that can be provided. To check the impact of providing openings on structural behavior. Comparing the analyzed results like base shear, displacement, story drift says that staggered opening pattern performs well in seismic prone areas.

Naresh Kumar Varma.et.al., (2020): This paper studies about the performance of multistoried building with shear wall position and openings in two orthogonal directions when it is subjected to seismic load. The structure is analyzed using ETABS software and seismic forces are applied based on IS 1893-2016 code book and structure analyzed for seismic zone IV and type II soil condition (medium soil). This study helps in finding out the suitable opening position in shear wall in both the direction. After analysis the results show that increasing in shear wall opening leads to decreasing in stiffness of the structure and increasing the displacement of the structure and also width of opening plays a major role providing shear wall at corner of the building has greater stiffness compared to shear wall at center of bay.

OBJECTIVE OF THE STUDY

1. Analysis of G+10 storied framed structure using ETABS software.
2. To study the response of building with openings arranged in different patterns and varying the size of opening for seismic zone V.
3. Comparing the analysis results like story drift, displacement and base shear results of all models and check the best method of opening.

Methods of analysis

Equivalent static analysis: The equivalent static approach is a quick way to apply a static force laterally to a structure in place of the dynamic loading of a predicted earthquake. Parallel to main axis of the building total loads are applied in two horizontal directions. It expects that the structure will react in its default lateral mode. To prevent torsional movement beneath, the structure must not be high rise and sufficiently symmetric in order for this to be true. The structure must be capable of withstanding seismic effects that come from either direction, but not from both side simultaneously.

Response spectrum method:

This is a linear dynamic analysis Plotting maximum response versus the natural frequency of a SDOF is known as the "response spectrum approach" (SDOF). This method is linear dynamic method. This method of analysis is generally adopted to check the peak response of the building. This method is adopted when analysis is carried out for tall buildings and irregular buildings.

SHEAR WALL OPENING DETAILS

Below table shows the openings of different sizes and patterns considered for the analysis.

Table 1: Details of wind load

OPENING PATTERNS	
MODEL 1	Without opening
MODEL 2	Opening in all panels
MODEL 3	Horizontal opening
MODEL 4	Vertical opening
MODEL 5	Zig-zag opening

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 11, November-2022

2 STRUCTURAL DETAILS

Table 2: Structural Consideration

General structural consideration	
Type of structural element	RCC framed structure
Nature of building	Residential building
Building dimension	30m*30m
Total area	8606.72 Sq.ft (Each floor)
Number of stories	11 (G+10)
Total height	33 meters
Height of each floor	3 meters
Material properties	
Grade of concrete	M30
Grade of steel	Fe 500
Sectional properties	
Size of column	300*600mm
Size of beam	230*450mm
Thickness of slab	150mm
Thickness of shear wall	230mm
Loads applied	
Imposed load on slab	2 kN/m^2
Floor finish on slab	0.5 kN/m^2
Unit weight of concrete	30 kN/m^3
Unit weight of steel	500 kN/m^3

PLAN OF THE BUILDING

In this study structure is analyzed for below plan. The plan is 30 meter on both orthogonal direction, columns are placed at 5 m interval on both direction, total floor area of the building 8606.72 m^2. The height of each floor is 3mt.

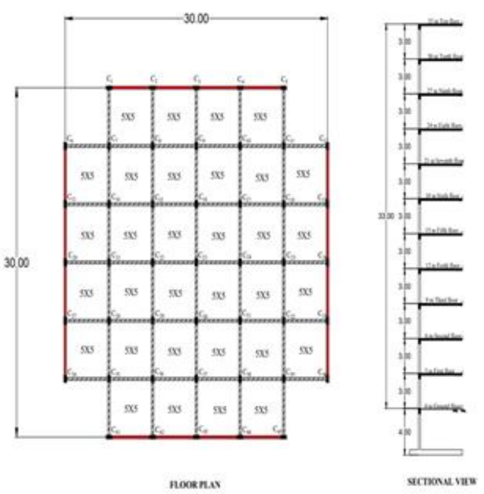
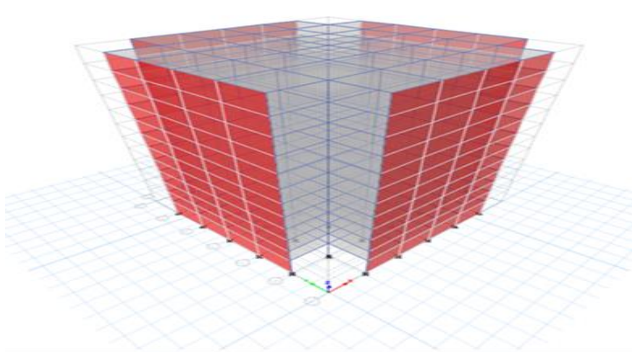


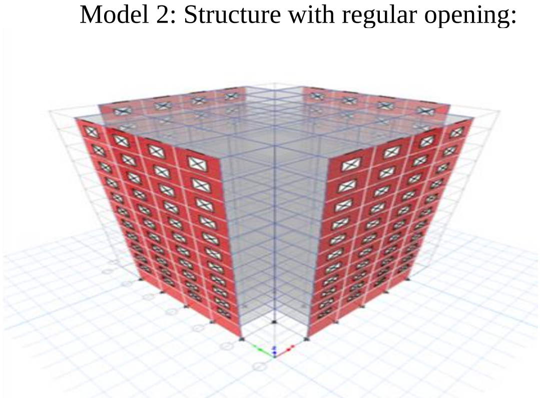
Fig 3.9: Plan and sectional view of building.

ETABS MODELS OF BUILDING

Model 1: Structure without opening:

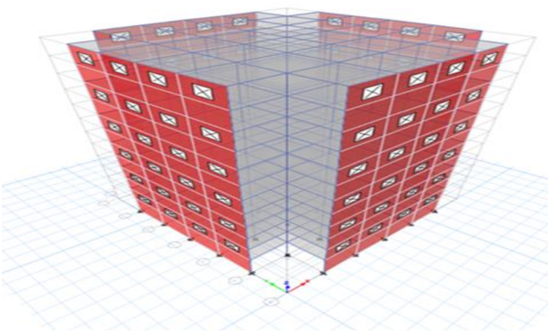


Model 2: Structure with regular opening:

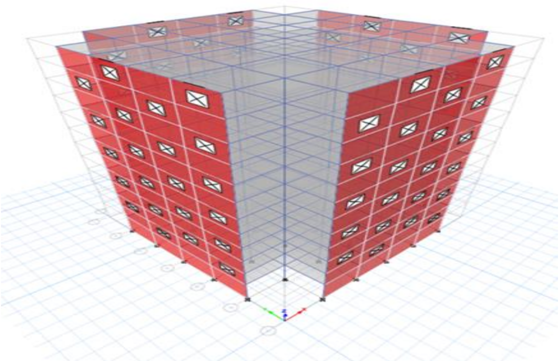


International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 11, November-2022

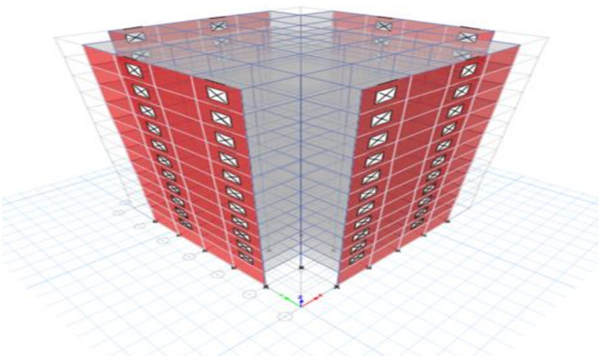
Model 3: Structure with horizontal opening:



Model 5: Structure with Zig-zag opening:



MODEL 4: STRUCTURE WITH VERTICAL OPENING:



RESULTS

STOREY DRIFT WITH DIFFERENT OPENING PATTERNS

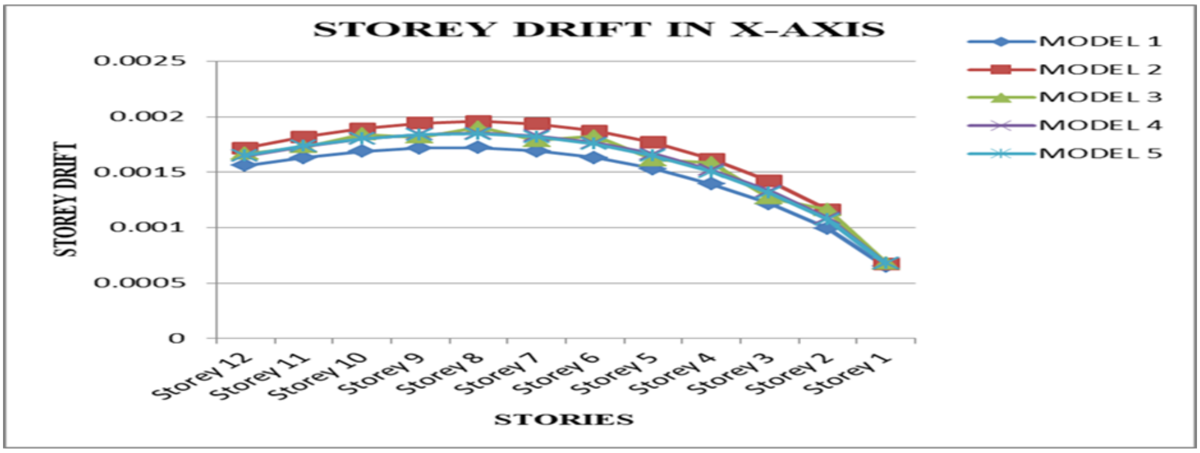
The results of storey drift obtained from software analysis of **response spectrum method** for G+ 10 storied framed structures with shear wall openings for seismic zone V are tabulated below.

Table 3: Storey drifts results for zone V in X-direction

Storey	Direction	Model 1	Model 2	Model 3	Model 4	Model 5
Top story	X	0.001559	0.001718	0.001669	0.001648	0.001652
Storey 11	X	0.001631	0.001817	0.001729	0.001734	0.001737
Storey 10	X	0.001686	0.001893	0.001841	0.001801	0.0018
Storey 9	X	0.001718	0.001942	0.001816	0.001842	0.001839
Storey 8	**X**	**0.001721**	**0.001958**	**0.001905**	**0.001852**	**0.001846**
Storey 7	X	0.001692	0.001935	0.001785	0.001828	0.001819
Storey 6	X	0.001629	0.001873	0.001826	0.001766	0.001754
Storey 5	X	0.00153	0.001767	0.001609	0.001663	0.001649
Storey 4	X	0.001393	0.001617	0.001584	0.001519	0.001503
Storey 3	X	0.001215	0.001419	0.001267	0.001329	0.001311
Storey 2	X	0.000993	0.001162	0.001162	0.001087	0.001076
Storey 1	X	0.000649	0.00067	0.000679	0.000677	0.000676

The above table shows that the storey drift is minimum at storey 1 then it increased till storey 8 (maximum) then it again decreased to top storey. The maximum allowable drift is 0.004H= 0.004(3) =0.012. So maximum storey drift is 0.001958 and it is within the limit.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 11, November-2022



By comparing the results Models 2, 3, 4, 5, is reduced by 13.77%, 10%, 7.61%, and 7.5% respectively compared to Model 1. So model 4 and 5 gives better results compared to other models with opening.

Table 4: Storey drifts results for zone V in Y-direction

Storey	Direction	Model 1	Model 2	Model 3	Model 4	Model 5
Top story	Y	0.001521	0.001771	0.001622	0.001603	0.001607
Storey 11	Y	0.001597	0.0019	0.00169	0.001694	0.001697
Storey 10	Y	0.001652	0.002	0.001798	0.001761	0.00176
Storey 9	Y	0.001685	0.002072	0.001779	0.001803	0.0018
Storey 8	**Y**	**0.00169**	**0.002106**	**0.001865**	**0.001816**	**0.001809**
Storey 7	Y	0.001663	0.002098	0.001753	0.001794	0.001785
Storey 6	Y	0.001603	0.002047	0.001791	0.001734	0.001723
Storey 5	Y	0.001507	0.001949	0.001583	0.001636	0.001622
Storey 4	Y	0.001373	0.001801	0.001558	0.001496	0.00148
Storey 3	Y	0.001199	0.001597	0.00125	0.00131	0.001293
Storey 2	Y	0.000982	0.001301	0.001147	0.001074	0.001064
Storey 1	Y	0.000642	0.000666	0.000672	0.00067	0.000669

The above table shows that the storey drift is minimum at storey 1. The storey drift in maximum in more in 8^{TH} storey in all the models and decreased in model 2 by 25.64%, maximum allowable drift is 0.012 so it is within the limit

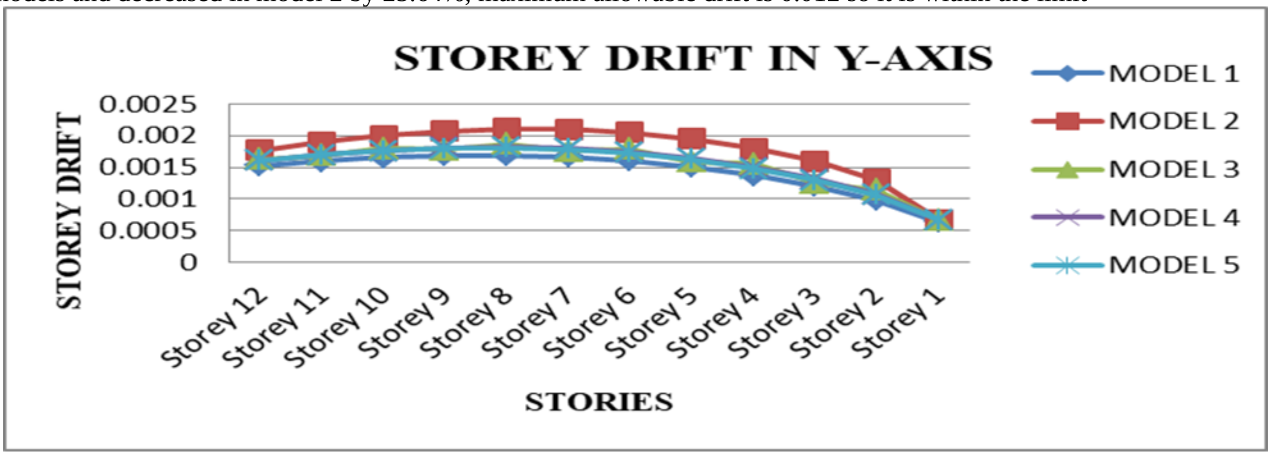


FIG 4.4.(B: GRAPHICAL REPRESENTATION OF STOREY DRIFT

By comparing the results Models 2, 3, 4, 5, is decreased by 24.64%, 9.38%, 7.45%, 7.43% respectively compared to Model 1. So model 4 and 5 gives better results compared to other models with openings.

STOREY DISPLACEMENT: The results of storey displacement obtained from software analysis of response spectrum method for G+10 storied residential building under seismic zone V are tabulated below.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 11, November-2022

Table 5: Storey displacement results for zone V in X-axis(mm)

Storey	Direction	Model 1	Model 2	Model 3	Model 4	Model 5
Top story	**X**	**52.669**	**59.711**	**57.039**	**56.656**	**56.41**
Storey 11	X	48.007	54.574	52.049	51.729	51.47
Storey 10	X	43.136	49.153	46.885	46.553	46.286
Storey 9	X	38.106	43.51	41.399	41.185	40.918
Storey 8	X	32.986	37.724	35.986	35.696	35.439
Storey 7	X	27.856	31.892	30.31	30.175	29.937
Storey 6	X	22.808	26.122	24.986	24.725	24.513
Storey 5	X	17.944	20.533	19.536	19.455	19.278
Storey 4	X	13.372	15.252	14.731	14.484	14.351
Storey 3	X	9.206	10.414	9.991	9.942	9.856
Storey 2	X	5.57	6.165	6.201	5.964	5.93
Storey 1	X	2.594	2.68	2.718	2.707	2.704

The above table shows that the storey displacement in X-axis of all stories of different models. Maximum displacement is at top storey in model 2 by increasing by 13.37%. The maximum allowable displacement is H/500= 33000/500=66mm so displacement is within the limit.

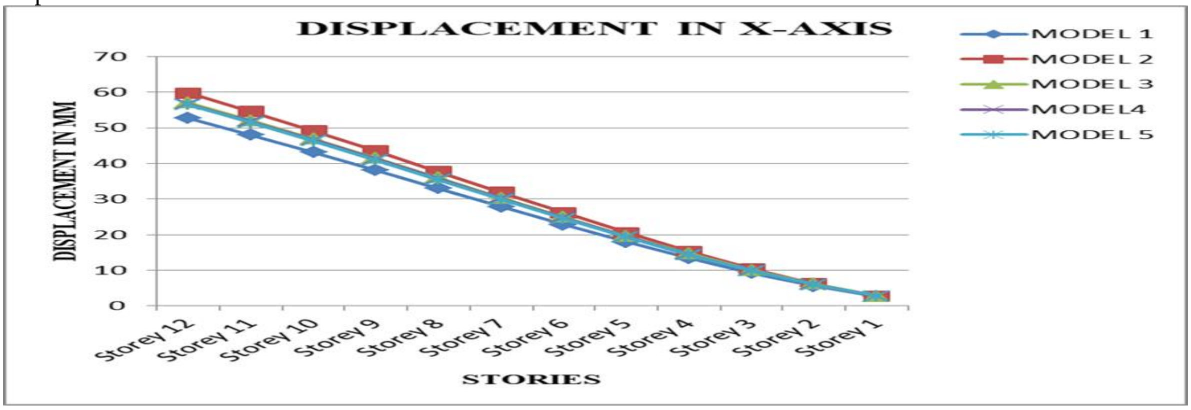


Fig 4.5.(a): Graphical representation Storey displacement in X-direction

By comparing the results Models 2, 3, 4, 5, is increased by 13.37%, 8.29%, 7.56%, and 7.55% respectively compared to Model 1. So model 4 and 5 gives better results compared to other models.

STOREY DISPLACEMENT ALONG Y-AXIS

Table 6: Storey displacement results for zone V in Y-axis (mm)

Storey	Direction	Model 1	Model 2	Model 3	Model 4	Model 5
Top story	**Y**	**51.761**	**64.274**	**55.941**	**55.587**	**55.343**
Storey 11	Y	47.213	58.981	51.092	50.793	50.537
Storey 10	Y	42.443	53.315	46.047	45.737	45.473
Storey 9	Y	37.516	47.358	40.689	40.489	40.226
Storey 8	Y	32.494	41.192	35.388	35.116	34.862
Storey 7	Y	27.457	34.923	29.832	29.706	29.47
Storey 6	Y	22.497	28.669	24.605	24.358	24.149
Storey 5	Y	17.712	22.561	19.259	19.182	19.008
Storey 4	Y	13.209	16.737	14.53	14.294	14.162
Storey 3	Y	9.102	11.348	9.869	9.82	9.736
Storey 2	Y	5.511	6.564	6.127	5.897	5.863
Storey 1	Y	2.567	2.664	2.69	2.678	2.675

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 11, November-2022

The above table shows that the storey displacement in Y-axis of all stories of different models. Maximum displacement is at top storey in model 2 by increasing by 24.17%. The maximum allowable displacement is H/500= 33000/500=66mm so displacement is within the limit.

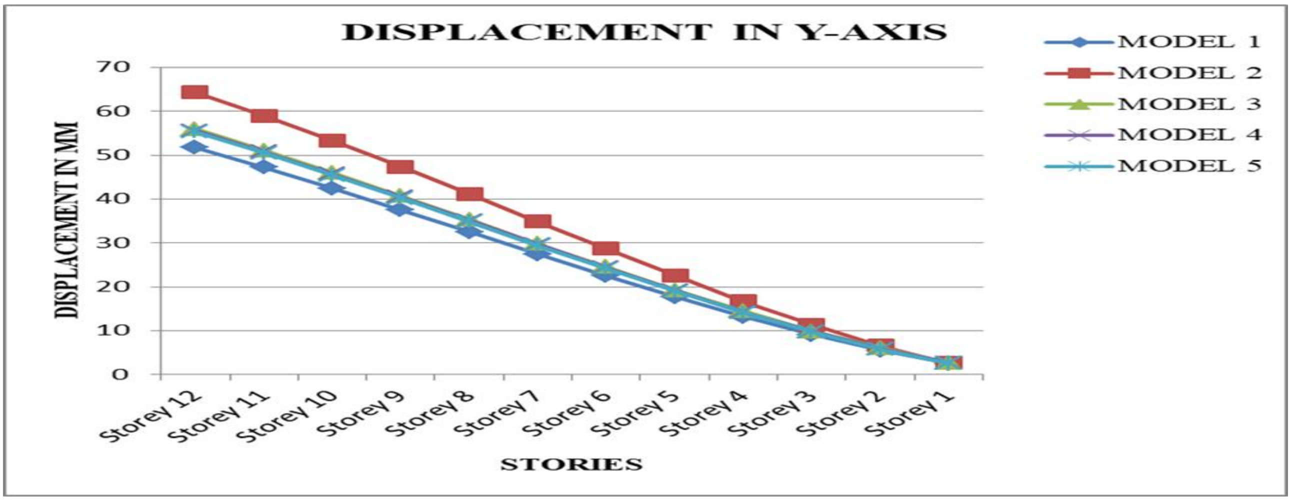


Fig 4.5.(b): Graphical representation Storey displacement in Y-direction

By comparing the results Models 2, 3, 4, 5, is increased by 24.174%, 8.29%, 7.39%, and 6.92% respectively compared to Model 1. So model 5 gives better results compared to other models with openings.

BASE REACTION

Below table shows the base shear results of all models with different opening patterns along X-axis.

Table 7: Base shear results for zone V in X-direction (kN)

MODEL	DIRECTION	REACTION
Model 1	**X**	**49920.15**
Model 2	**X**	48550.89
Model 3	**X**	49331.09
Model 4	**X**	49289.21
Model 5	**X**	49274.18

The above table shows the maximum base shear in model 1 and least in model 2 by decreasing 2.75%. Increasing % of opening will decrease the base shear.

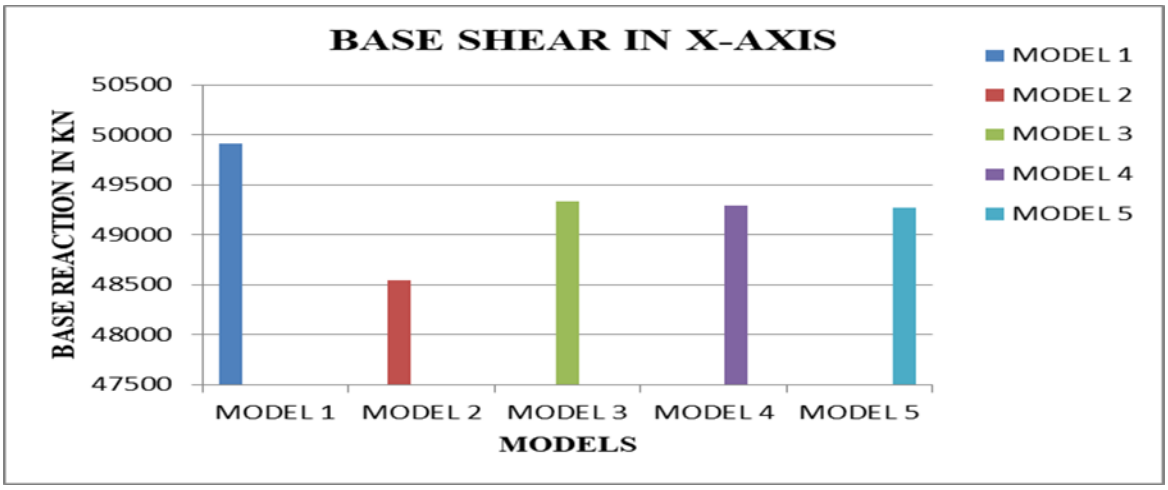


Fig 4.7.(a): Graphical representation base shear in X-direction

By comparing the results base reaction in Models 2, 3, 4, 5, is decreased by 2.75%, 1.18%, 1.26%, and 1.29% respectively compared to Model 1. So model 5 gives better results compared to other models with openings.

BASE REACTION ALONG Y-AXIS

Below table shows the base shear results of all models with different opening patterns along Y-axis.

Table 8: Base reaction results for zone V in Y-direction (kN)

MODEL	DIRECTION	REACTION
Model 1	**Y**	**49959.74**
Model 2	Y	48489.01
Model 3	Y	49378.01
Model 4	Y	49335.1
Model 5	Y	49319.67

The above table shows the maximum base shear in model 1 and least in model 2 by decreasing 2.94%. Increasing % of opening will decrease the base shear.

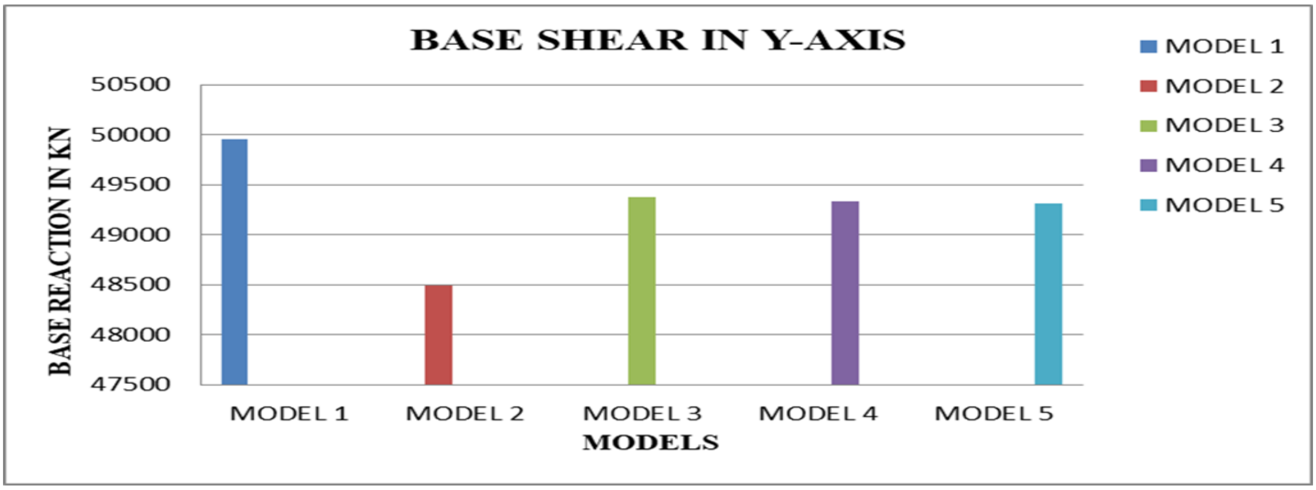


Fig 4.7.(b): Graphical representation Base reaction in Y-direction

: By comparing the results base reaction in Models 2, 3, 4, 5, is decreased by 2.94%, 1.16%, 1.25%, and 1.28% respectively compared to Model 1. So model 5 gives better results.

CONCLUSIONS

i. Storey drift is more in model 2 and it is less in model 1 and it increased in model 3 by 10% and in model 4 by 7.61% and model 5 by 7.5%X- axis and Y-axis.
ii. Storey displacement is more in model 2 and less in model 1 and it increased in model 3 by 8.29%, model 4 and model 5 by 7.5% along X-axis and Y-axis
iii. Storey shear is more in model 1 and less in model 2 and it decreased in model 3 by 1.18%, model 4 and model 5 by 1.27% along X-axis and Y-axis
iv. Base shear is more in model 1 and less in model 2 and it decreased in model 3 by 1.18%, model 4 and model 5 by 1.27% along X-axis and Y-axis

By studying the results and comparing the results of models with different opening patterns we can say that providing openings will impact on the behavior of the shear wall component and results also shown that the importance of opening locations and size of opening. In this study we come to know that zig-zag pattern will be suitable choice for openings.

REFERENCES

[1] B.Vamsi Krishna , A.V.Prasanna Kumar, E. Rakesh Reddy"Shear Wall Analysis And Design Optimization In Case Of High Rise Buildings Using By Etabs" Solid State Technology Volume: 63 Issue: 2s Publication Year: 2020
[2] M. A. Amzar Kamarudin, S. W. Ahmad* , W. A. R. Wan Ariffin "The Behaviour of High-Rise Building with or without Shear Wall under Different Earthquakes" VOL. 1, ISSUE 2, 93 – 101 DOI: https://doi.org/10.15282/cons.v1i2.6957
[3] Structures Sharmin Reza Chowdhury M.A. Rahman, M.J.Islam A.K.Das "Effects of Openings in Shear Wall on Seismic Response of Structures" International Journal of Computer Applications (0975 – 8887) Volume 59– No.1, December 2012
[4] Ruchi Sharma a , Jignesh A. Amin "Effects of opening in shear walls of 30- storey building" e-ISSN: 2170-127X, © Mouloud Mammeri University of Tizi-Ouzou, Algeria
[5] Krishna G S Chaithra S "Nonlinear Analysis of Frame Shearwall Building with Different Opening Configurations" International Journal of Engineering Research & Technology (IJERT) Vol. 6 Issue 05, May – 2017
[6] Priya B. Kale Roshni John "THE EFFECT OF DIFFERENT OPENING CONFIGURATION IN MULTI-STORY RC BUILDING WITH SHEAR WALL" Vol. 4, Issue 5, ISSN No. 2455-2143, Pages 366-370
[7] Building Abhija Mohan P Arathi S **"**Comparison of RC Shear Wall with Openings in Regular and Irregular Building" International Journal of Engineering Research & Technology (IJERT Vol. 6 Issue 06, June – 2017
[8] H.-S. Kim, D.-G. Lee "Analysis of shear wall with openings using super elements" doi:10.1016/S0141-0296(03)00041-5
[9] Prafoolla Thakre , Sagar Jamle , Kundan Meshram "Opening Area Effect of Shear Wall in Multistorey Building under Seismic Loading" [Vol-7, Issue-2, Feb- 2020] https://dx.doi.org/10.22161/ijaers.72.17 ISSN: 2349-6495(P)
[10] M.Pavani, G.Nagesh Kumar, Dr. Sandeep Pingale Shear Wall Analysis and Design Optimization In Case of High Rise Buildings Using Etabs (software) International Journal of Scientific & Engineering Research, Volume 6, Issue 1, January-2015
[11] Reshma T V , Sankalpasri S S , Tanu H M , Nirmala M V "Multistorey Building Analysis and Its Behavior because of Shear Wall Location Underneath completely different Seismal Zones" doi:10.1088/1755-1315/822/1/012044
[12] Mir Rahman Naseri , Balwinder Singh "Seismic analysis of hybrid structures with and without shear walls" doi:10.1088/1755-1315/889/1/012045
[13] Le Yee Mon "Comparative Study on Dynamic Analysis of Irregular Building with Shear Walls" International Journal of Science and Engineering Applications Volume 3 Issue 2, 2014, ISSN-2319-7560