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Earthquake Vibration Control using Framed Shear Walls

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Abstract: The shear wall plays important role in the earthquake resistant buildings. This study deals with shear wall for earthquake resistant building. Most of the buildings were usually designed by static methods, ignoring the dynamic characteristics of the structure as well as characteristics of the ground motion. Therefore, it is important to carry out the detailed investigation of seismic behaviour of buildings in order to assess and evaluate the safety of existing buildings and improve the design guidelines for moderately high buildings to be constructed in the future. In earthquake regions major problem is rehabilitation of vulnerable buildings. Recently a number of techniques have been developed to strengthen the building in such regions. The present work attempts to study the technique of shear wall. This study deals with the method of analysis and design of a shear wall for G+5 buildings (residential) located in Zone-2. The scope behind this work is to learn necessity of a shear wall in these modern days by using software STAAD-PRO under the dead load, seismic load, live load (u.d.l) acting on the structure.
Keywords: Earthquakes, Shear Wall, Storey Displacement, Shear Force, Bending Moment, Response spectrum, Staad Pro v8i.

I. INTRODUCTION

Earthquakes are natural hazards which causes disasters are mainly caused by damage too or collapse of buildings and other manmade structures. Experience has shown that for new constructions, establishing seismic resistant controls and their implementation is the important safeguard against seismic induced damage. As considers real structures, it is necessary to calculate the strengthen based on evaluation criteria before an earthquake. Structure design must be such as to ensure that the structure has acceptable strength, high ductility, and will remain as one, even when applied to very large deformations sociologic factors are also crucial, such as density of population, time of day of the seismic occurrence and community preparedness for the possibility of such an event up to now we can do little to diminish direct seismic effects. Nonetheless we could do much to reduce risks and thereby reduce disasters provided we design and build or strengthen the buildings so as to minimize the losses based on the knowledge of the earthquake performance of different building types during an earthquake. Observation of structural performance of buildings during an earthquake can clearly identify the strong and weak aspects of the design, besides the desirable qualities of materials and techniques of construction and site selection. The research of damage therefore provides an important step in the evolution of strengthening measures for different types of buildings. The need for high rise buildings is increasing in the country. Land in the rapidly developing cities is becoming scarce and this is encouraging the commercial utilization and the construction of high rise buildings. In order to fulfil these needs an economical and efficient design of high-rise buildings has to be introduced. Socio-economic development and the high-rise building is a product of scientific and technological progress. With the development of places, shortage of land, land price hike, modern high-rise buildings, elevators invention of a more high-rise buildings are constructed so that higher. The magnificent high-rise building is a symbol of economic strength has an important propaganda effect, in an increasingly intense business competition, but also played an important role. The intention of this study is therefore, to investigate the effect of position of shear wall in earthquake performance while take regular and irregular structure by comparing it with shear wall at different position. This is going to be done in this study work, by carrying out a comprehensive literature survey and analysis of 5 storey buildings for zone-II earthquake zone.

A. Need for the Study

Reinforced concrete framed building are adequate for resisting both the vertical and the horizontal load acting on them. Shear wall systems are one of the most commonly used lateral-load resisting systems in high-rise buildings. Shear walls have very high in-plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. Hence, this study has been described to determine the most efficient shear wall based on the results. A RCC building (5 stories) has been considered to carry out this study. In this regard, Staad

Pro V8i software package have been considered as two tools to perform. Zone- II in India has been considered to find out the most efficient shear wall in the building.

B. Objective of The Study

The main objectives of this study are: -

1) To show how shear wall performance varies at different position in a building frame.
2) To investigate the most efficient shear wall placed at different positions to withstand different seismic force parameters.
3) To study the simulation results in term of Bending Moment, Shear Force and Storey Displacements for different types of shear walls placed in regular and irregular geometry.

II. LITERATURE REVIEW

Venkata Sai ram Kumar (2014) discussed about the application of cyclic load tests and the behaviour of different types of shear walls in cyclic application of loads. Researches studies various parameters like enhancement of stiffness, drift, development forces in the building and also to observe perfect location of shear wall. It was observed that buildings which are tall can be affected with lateral forces like earthquake and wind forces can be constructed with the help of shear wall. Internal shear walls are more efficient than external shear walls.

Venkatesh, H. Sharada Bai (2014), conducted linear static analysis with considering internal and external shear wall performance on a 10 storey framed structure for investigation of maximum joint displacement, support reaction, column forces and beam forces and found that performance of square shear walls gave better results than rectangular column of different orientations under lateral loads. Thickness of shear forces does not have much effect on decreasing of shear stresses and performance of interior shear walls are good when compared to external shear walls. External shear walls are treated as alternative to internal shear walls in retrofitting techniques. Tarigan Department of Civil Engineering, (Universitas Sumatera utara) discussed that the utilization of shear wall can contribute in increasing stiffness of structure. It reduces the natural period of a structure, lateral displacement and story–drift significantly. Position of shear wall need to be considered carefully because it gives difference performance to resisting earthquake load. This review says that the optimum location for the structure is the shear wall at the core symmetrically.

Sonali Pandey (2017) discussed that providing shear walls at adequate locations substantially reduces the displacement due to the earthquake and shear wall along periphery is most efficient among shear walls considered. With constructing shear walls damages due to effect of lateral forces due to earthquake and high winds can be optimized. This review says that steel plate shear walls occupy less than R. C. C walls. Shear walls along periphery is most efficient among all the shear walls considered. Shear wall is effective in reducing soft story effect. Shear walls are more effective in high rise buildings than in low rise buildings.

Varsha R. Harneanalysed discussed that a six storey building subjected to earthquake loading in zone II using STAAD Pro and calculated earthquake load using seismic coefficient method (IS 1893 Part II). Four different cases were analysed comprising of a structure without shear wall, structure with L type shear wall, structure with shear wall along periphery, structure with cross type shear wall. The lateral deflection of column for building with shear wall along periphery is reduced as compared to other types of shear walls. It was found that shear wall along periphery is most efficient among all the shear walls considered.

Chandurkar present a paper in determining the shear wall location of four different types of models varying with earthquake load with zones II, III, IV, V as per IS: 1893: 2002 and calculated lateral displacement, story drift and total cost required for ground floor are calculated by replacing column with shear wall. It was found that shear wall in short span at corner in model 4 was economical and effective in high rise buildings. Shear wall with large dimensions are effective in high amounts of horizontal forces and providing shear wall at suitable location displacements can be reduced due to earthquake.

Arturo E. Schultz conducted experiments on precast shear walls, to develop a calibrated experiments and accurate behaviour of models and design rules of precast shear walls. Application of cyclic lateral load test was conducted of twelve 2/3 scale specimens. Vertical joint connection used are notched shear plate, slotted flexure plate, inclined flat bar, pinned tension strut, brass friction device, U-shaped flexure plate. Unlike the five connections U-shaped flexure plate performance, it was not possible to proportion the U-shaped plate to resist the shear forces. Panels made with notched shear plate and slotted flexure plate, assemblage acted as a monolithic unit and found with large initial elastic stiffness.

Shahabodin. Zaregairizi investigated on using shear wall and infill to improve seismic performance of existing buildings. On doing static analysis to compare effectiveness of both methods it was observed that concrete in-fills showed greater strength than brick one but brick in-fills accepted large displacement than concrete in-fills. So if they are used in combination their individual negative effects will be reduced.

III. PROBLEM FORMULATION AND METHODOLOGY

A. General

Thus the state of the art has progressively moved from elastic static analysis to dynamic Analysis. The literature survey in the performance and behaviour of shear wall when subjected to seismic loads suggests that the requirement of establishing a methodology for studying the response of shear wall to earthquake loads has become essential. This will move us toward implementing performance based analysis by using nonlinear static analysis. In the present scenario, because of the wide range of geometry possible, the accumulated understanding is still limited thus there is need of an attempt to investigate the behaviour of shear wall at different positions of the building frame which will be used as general guidelines for the performance study of shear wall subjected to seismic loading.

B. Problem Formulation

This study includes comparative behaviour of structures with 5 storey frames by changing the position of shear wall under earth quake forces. A comparison in analysis results are displacements, moments and axial forces has been carried out as a result.

TABLE I
Parameters Selected For Analysis

S.NO	DESCRIPTION	PARAMETERS
1.	Shear Wall Thickness	800mm
2.	Depth of Foundation	3.0m
3.	Floor to Floor Height	3.0m
4.	Column Size	0.23mX0.30m
5.	Beam Size	0.23mx0.23m
6.	Unit Weight of Masonary Wall	22KN/m^3
7.	Slab Thickness	130mm
8.	Zone	II
9.	Floor Load	3.25KN /m^2

C. Loading Conditions

1) Following loadings are adopted for analysis
a) Self-weight. of slab considering 130mm thickness = 0.13 x 25 = 3.25+ 1= 4.25 kN/m^2
b) Brick load (u.d.l) on beams = 22x1x0.23x3 = 15KN/m
c. Unit weight of R.C.C = 25KN/m^3
2) Live Loads:
a) Live Load on floors = 3.25 KN/m^2
3) *Earthquake Loads:* Building frames are analysed for seismic zone II

The earth quake loads are derived for following seismic parameters as per IS: 1893(2002)
a) Earth Quake Zone-II
b) Response Reduction Factor: 5
c) Importance Factor: 1
d) Damping Ratio: 0.5%
e) Soil Type: Medium Soil
f) Zone Value: 0.1

4)Compressive strength of the building(Fc): 25000KN/m^3
5)Yield strength of the building (Fy): 415000KN/m^3

D. Methodology

In order to achieve the objectives of the study the following methodology is proposed: STAAD Pro V8i software package is used as a tool for analysing the problem.

1) *Step-1* Modelling of Building Frames In this regards 5 storey with different member properties are modelled. In this study to ensure same cost, the length and the thickness of shear walls have been kept same in all models

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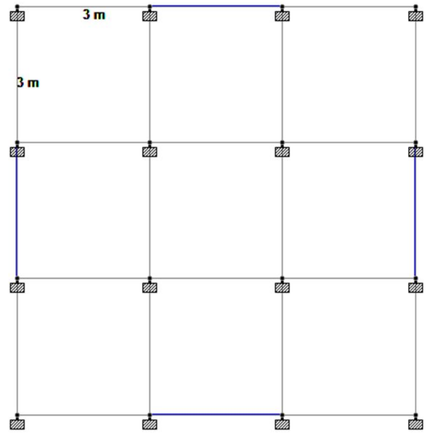

Fig.1 Plan of G+5 storey building frame

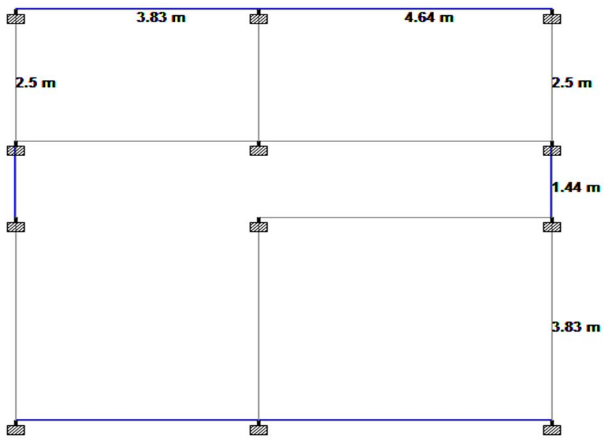

Fig.2 Plan of G+5 storey building frame

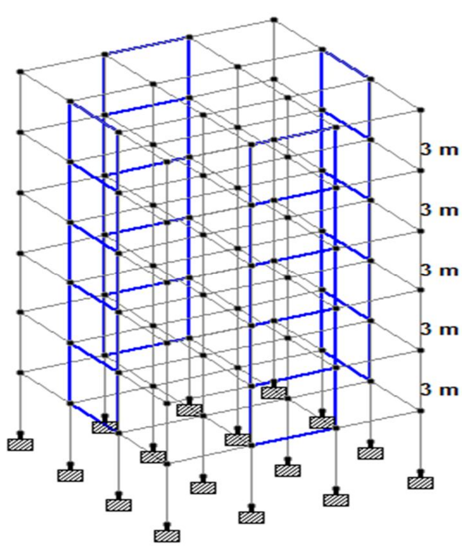

Fig.3 Dimensional view of G+5storey building frame

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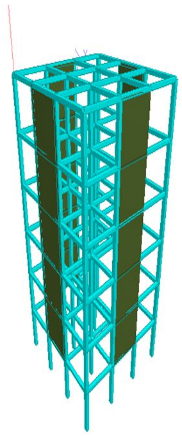

Fig.4 CASE1: Storey regular geometry with external shear wall

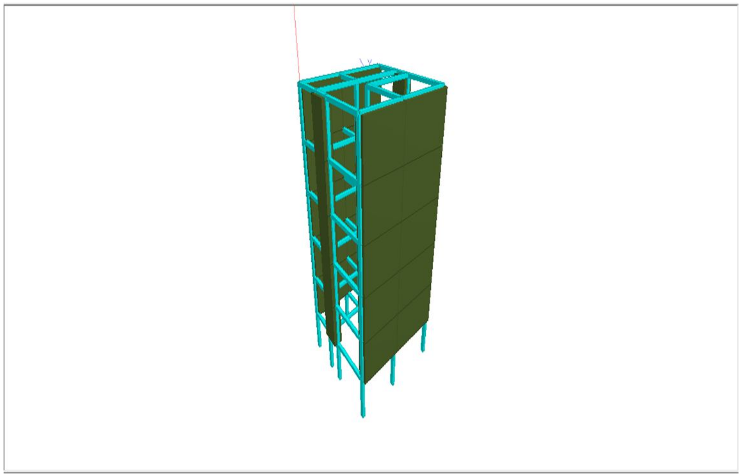

Fig.5 CASE1: Storey irregular geometry with external shear wall

2) Step-2 Generation of shear wall

Generate regular geometry shear wall and irregular geometry shear wall at different position for 5 storey building frames.

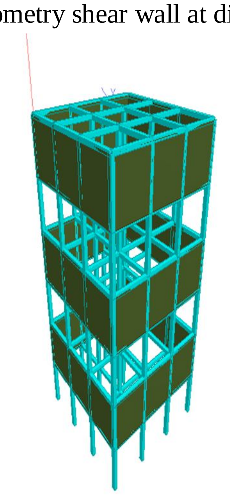

Fig.6 CASE2: Storey regular geometry with external alternate shear wall

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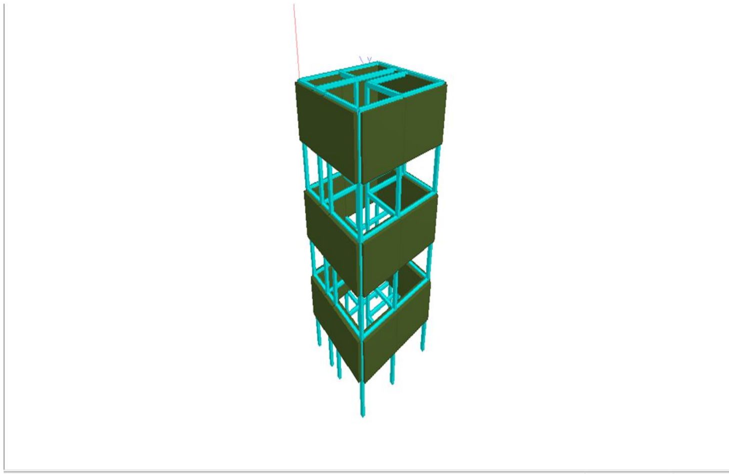

Fig.7 CASE2: Storey irregular geometry with external alternate shear wall

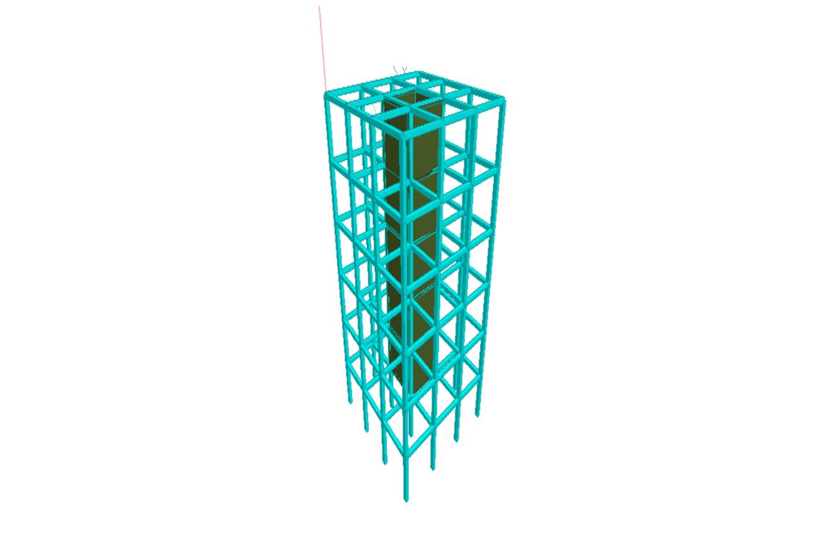

Fig.8 CASE3: Storey regular geometry with internal shear wall

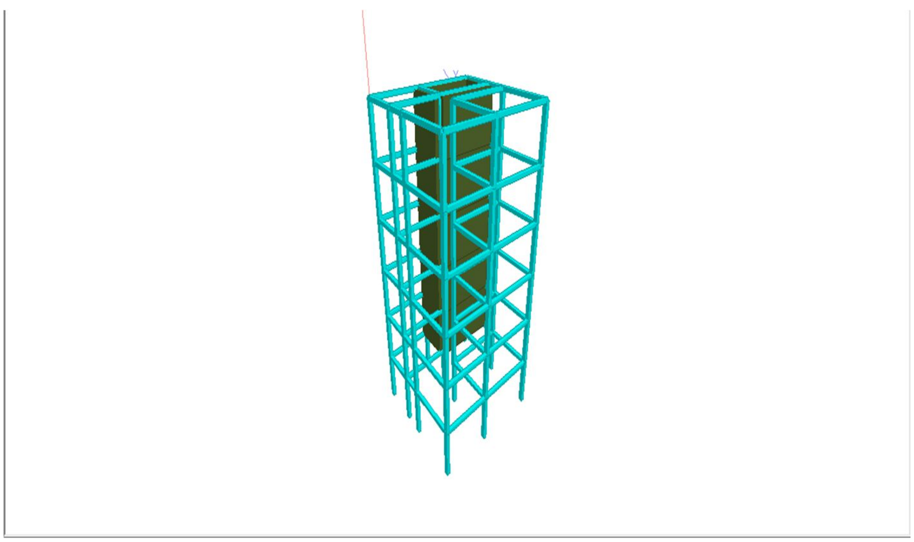

Fig.9 CASE3: Storey irregular geometry with internal shear wall at corner

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3) Step-3 Selection of seismic zone

TABLE II
Sesimic Zones For Different Cases And Models

TYPE	CASES	MODELS (5 STOREY)	SESMIC ZONES AS PER IS 1893 (PART-1):2002
TYPE-A(Regular Geometry)	CASE-1	External Shear Wall	II
	CASE-2	Alternate External Shear Wall	II
	CASE-3	Internal Shear Wall	II
TYPE-B(Irregular Geometry)	CASE-1	External Shear Wall	II
	CASE-2	Alternate External Shear Wall	II
	CASE-3	Internal Shear Wall	II

4) *Step-4* Formation of load combination
5) *Step-5* Analysis considering different geometry, seismic zone II and each load in X&Z Direction
6) *Step-6* Comparative study of results in terms of story displacement, moment and axial forces

IV. RESULTS AND DISCUSSIONS

Result of the analysis of all problems are discuss as follows

A. Maximum Bending Moment

Maximum Bending Moment X direction for all cases in seismic zone-II are shown in Table III and Fig. 10

TABLE III
Bending Moment (KNM) In Beam In X Direction

BENDING MOMENT IN BEAM X DIRECTION ZONE-II		
CASES	TYPE-A	TYPE-B
Case-1	2.06	4.18
Case-2	2.93	1.53
Case-3	0.41	0.37

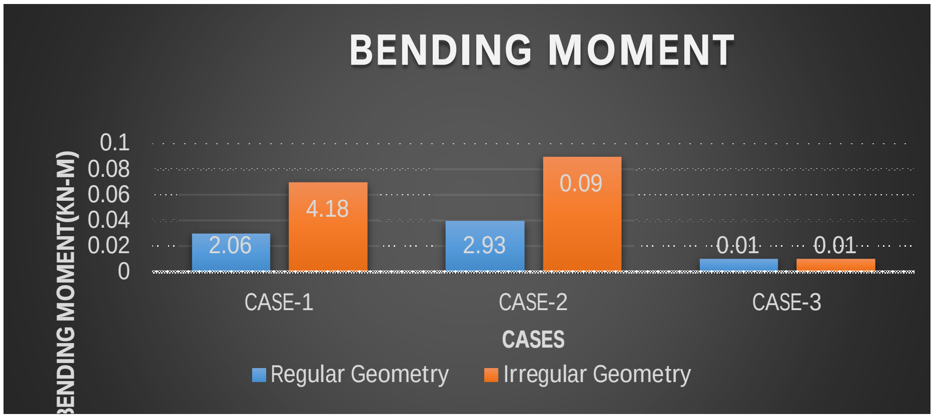

Fig.10 Bending moment in beam in X direction

Comparison of Bending moment of structure for 2 cases are shown in table III. From tableIII it is observed that, bending moment is higher for CASE-1 in X- direction which shows that bending moment is increase in case of external shear wall.
Comparison of Bending moment of structure for 2 cases are shown in table III. From table III, it is observed that, bending moment is lower for CASE-3 in X- direction which shows that bending moment is decrease in case of internal shear wall.

TABLE IV
Bending Moment (KNM) In Beam In Z Direction

BENDING MOMENT IN BEAM Z DIRECTION ZONE-II		
CASES	**TYPE-A**	**TYPE-B**
Case-1	0.03	0.07
Case-2	0.04	0.09
Case-3	0.01	0.01

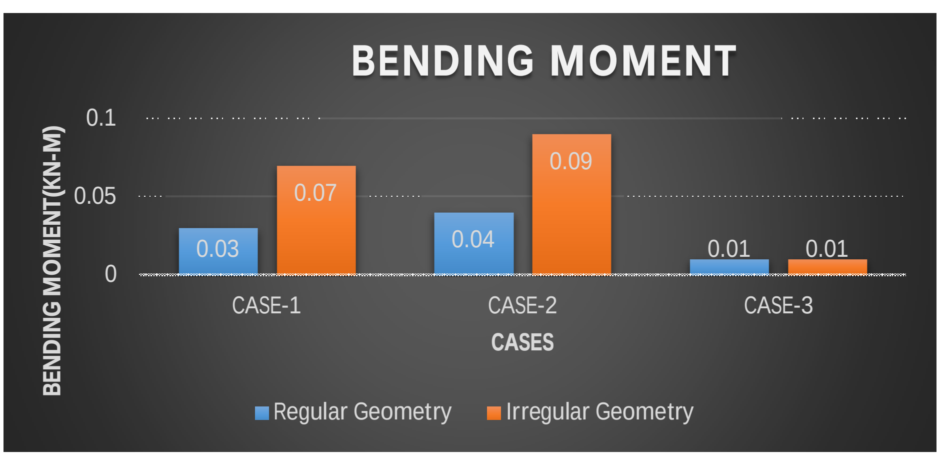

Fig.11 Bending moment in beam in Z direction

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Comparison of Bending moment of structure for 2 cases are shown in table IV. From table IV, it is observed that, bending moment is higher for CASE-2 in Z- direction which shows that bending moment is increase in case of alternate external shear wall.
Comparison of Bending moment of structure for 2 cases are shown in table IV. From table IV, it is observed that, bending moment is lower for CASE-3 in Z- direction which shows that bending moment is decrease in case of internal shear wall.

B. Storey Displacement

Maximum Displacement Storey in X direction for all cases in seismic zone-II are shown in Table V and Fig.12
Maximum Displacement Storey in X direction for all cases in seismic zone-II are shown in Table V and Fig.12

TABLE V
Storey Displacement (mm) IN Beam IN X Direction

DISPLACEMENT IN BEAM X DIRECTION ZONE-II		
CASES	**TYPE-A**	**TYPE-B**
Case-1	8.107	5.867
Case-2	10.290	10.390
Case-3	10.644	6.240

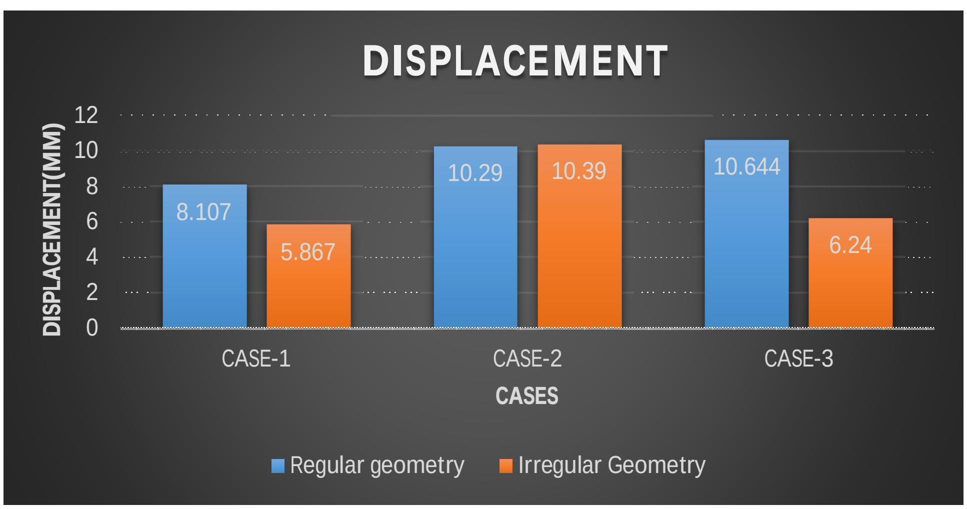

Fig.12 Storey Displacement in beam in X direction

Comparison of Storey Displacement of structure for 2 cases are shown in table V. From table V. it is observed that, storey displacement is higher for CASE-2 in X- direction which shows that bending moment is increase in case of Alternate external shear wall.
Comparison of Storey Displacement of structure for 2 cases are shown in table V. From table V., it is observed that, storey displacement is lower for CASE-3 in X- direction which shows that bending moment is decrease in case of internal shear wall

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TABLE VI
Storey Displacement (mm) IN Beam In Z Direction

SHEAR FORCE IN BEAM X DIRECTION ZONE-II		
CASES	TYPE-A	TYPE-B
Case1	-0.055	-0.028
Case-2	-0.005	-0.029
Case-3	-0.005	-0.026

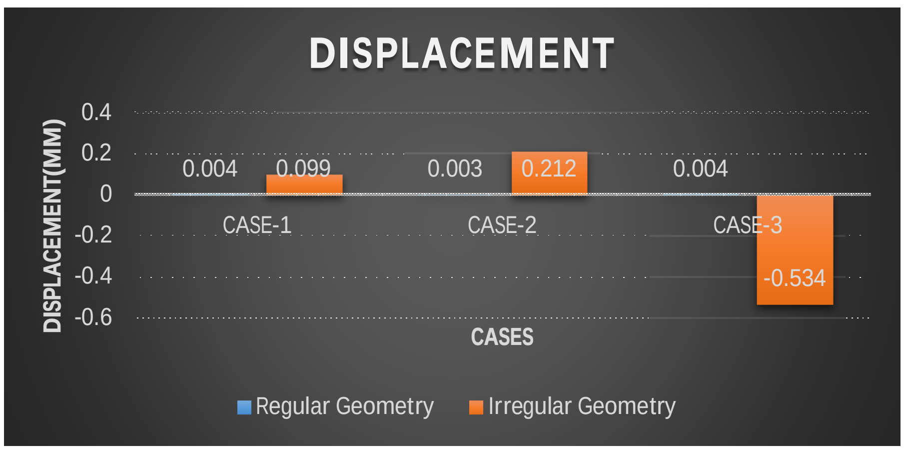

Fig.13 Storey Displacement in beam in Z direction

C. *Maximum Shear Force*

Maximum Shear Force(KN) in X direction for all cases in seismic zone-II are shown in Table VII and Fig. 14

TABLEVII
Shear Force (KN) IN Beam In X Direction

DISPLACEMENT IN BEAM Z DIRECTION ZONE-II		
CASES	TYPE-A	TYPE-B
Case-1	0.004	0.099
Case-2	0.003	0.212
Case-3	0.004	-0.534

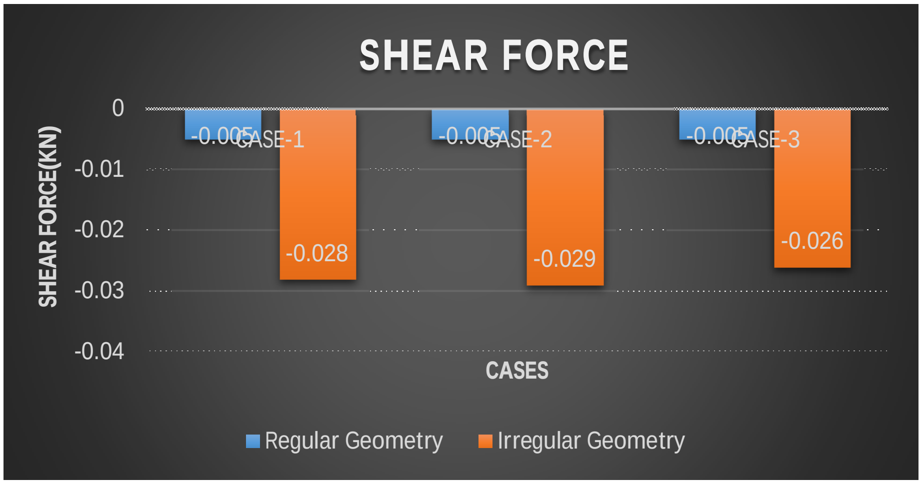

Fig.14 Shear Force in beam in X direction

Comparison of Shear force of structure for 2 cases are shown in table VII. From table VII, it is observed that, shear force is higher for CASE-2 in X- direction which shows that shear force is increase in case of Alternate external shear wall.

Comparison of Shear force of structure for 2 cases are shown in table VII. From table VII, it is observed that, shear force is lower for CASE-3 in X- direction which shows that shear force is decrease in case of interior shear wall.

TABLEVIII
Shear Force (KN) IN Beam IN Z Direction

SHEAR FORCE IN BEAM Z DIRECTION ZONE-II		
CASES	TYPE-A	TYPE-B
Case1	0.000	0.029
Case-2	0.000	0.026
Case-3	0.001	0.000

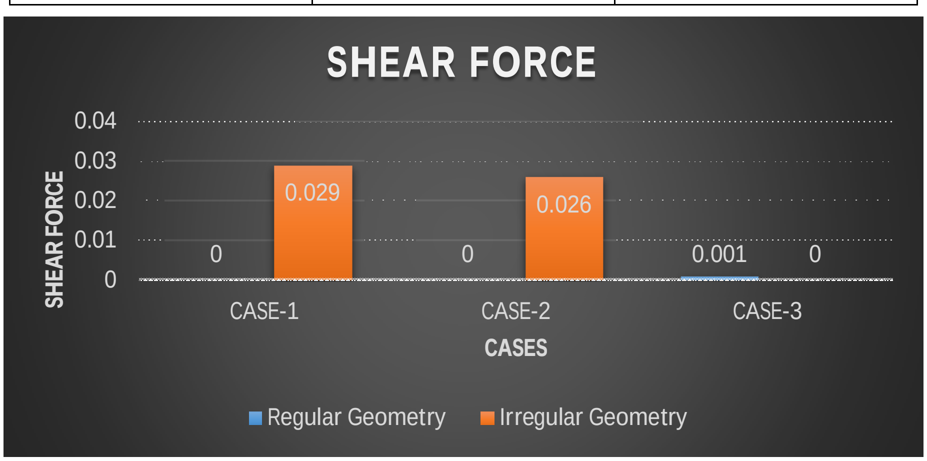

Fig.15 Shear Force in beam in Z direction

Comparison of Shear force of structure for 2 cases are shown in table VIII. From table VIII it is observed that, shear force is higher for CASE-1 in Z- direction which shows that shear force is increase in case of exterior shear wall.

Comparison of Shear force of structure for 2 cases are shown in table VIII. From table VIII it is observed that, shear force is lower for CASE-1 in Z- direction which shows that shear force is decrease in case of interior shear wall

V. CONCLUSIONS

A. Most of the buildings were usually designed by static methods, ignoring the dynamic characteristics of the structure as well as characteristics of the ground motion. Therefore, it is important to carry out the detailed investigation of seismic behaviour of buildings.

B. In order to assess and evaluate the safety of existing buildings and improve the design guidelines for moderately high buildings to be constructed in the future, it is necessary to consider the seismic behaviour of buildings

C. The results of analysis indicate that, due to the comparison of bending moment of structure for regular and irregular geometry, shows that the maximum bending moment is for external shear wall in X- direction of irregular geometry whereas in Z-direction the maximum bending moment is for alternate shear wall of irregular geometry

D. This results of analysis indicates that, due to the comparison of bending moment of structure for regular and irregular geometry, shows that the minimum bending moment is for internal shear wall in X and Z direction

E. Considering both the geometry, it is concluded that the maximum storey displacement in X and Z direction is for alternate exterior shear wall and minimum storey displacement in X and Z direction is for internal shear wall of irregular geometry

F. The axial force is less when compared with bending moment and storey displacement and results indicates that, the maximum shear force in X- direction is for alternate external shear wall whereas in Z-direction the maximum shear force is for external shear wall of irregular geometry.

G. The results also indicate that, the minimum shear force in X and Z directions is for internal shear wall of irregular geometry

H. Numerical results states that the most efficient shear walls to be used in the construction is the internal shear wall of irregular geometry.

I. Shear wall will be provided at different locations and best possible location should be analysed to reduce the lateral displacement and axial force in the column.

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