COMPARATIVE ANALYSIS OF RESPONSE OF BUILDINGS WITH SETBACKS TO SEISMIC LOADING

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

Assistant Prof Poonam Dhiman

By

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173 234

HIMACHAL PRADESH INDIA

June, 2016

CERTIFICATE

This is to certify that the work which is being presented in the project title **"COMPARATIVE ANALYSIS OF RESPONSE OF BUILDINGS WITH SETBACKS TO SEISMIC LOADING"** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Ajay Singh Gulshan(121695), Mudit Negi (121694), Vinay Thakur (121623)**during a period from August 2015 to May 2016 under the supervision of **Prof. Poonam Dhiman** Assistant Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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JUIT Waknaghat	JUIT Waknaghat	

TABLE OF CONTENTS

ACKNOWLEDGEMENT

Our project titled - **“Comparative analysis of response of buildings with setbacks to seismic loading”** is the part of final year B. tech project, **Department of Civil Engineering, JUIT, Waknaghat**. We take this opportunity to express our deep regards and profound gratitude to some faculty staff members who have helped us with their immense knowledge ,inspiration and support .We would like to express our indebtedness to our project guide **Assistant Prof: Poonam Dhiman**, **Department of Civil Engineering, JUIT** for her exemplary guidance ,supervision and encouragement throughout the entire period .The guidance ,inspiration and encouragement provided by her is going to carry us a long way in the journey of life which we are about to embark. Their timely help and advice has been of immense help to us. We can’t forget to express our token of thanks to the entire teaching and non-teaching faculty of Dept. of Civil Engineering of JUIT for their unflinching support and endless encouragement. Lastly, we thank all those who are directly or indirectly involved in our B. tech project.

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ABSTRACT

During earthquake, failure of the structure starts at the point of weakness. Weakness in any structure arises due to the discontinuity in mass, stiffness and geometry of structure. These type of structures are called irregular structures and can be seen in most of the urban infrastructure. One such type of irregularity is setbacks or vertical geometric irregularity. In the present work, six frames and structures with setbacks at different floors are compared with the regular frame and structure respectively, keeping the dimensions of 2-D and 3-D frames constant throughout the work. The comparison of analysis results of 2-D and 3-D frames was done by two different methods. Static analysis and Response Spectrum Analysis of all the frames was done and various seismic responses like bending moment, shear force and axial force for beams at setbacks were calculated. In Static Analysis it was found that for most of the cases the values of shear force and axial force in beams and columns at setbacks were coming more in irregular frame then in regular frames, whereas Response Spectrum Analysis suggests that the value of axial force in all beams and columns are increasing drastically as we move from regular to irregular structure where all the other forces i.e. shear force and bending moment decreasing as we move from regular to irregular structure. Comparison of both the methods was also done and it was found that the static analysis gave fluctuating results, whereas the response spectrum gave more reliable result. It was interesting to note that, however the mass of the building is reducing but the forces at setbacks increases to a great extent. The analysis suggest that the setbacks introduced in a building can be proven disastrous at the time of earthquake, hence it is not recommended to introduce setbacks in a building.

LIST OF FIGURES

CHAPTER 1

IRREGULARITIES IN BUILDINGS

1.1. INTRODUCTION

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example, structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated.

1.2. OBJECTIVE OF STUDY

- To study vertical geometric irregularities.
- To analyse structures with 6 type of setbacks.
- To compare the response of structures with setbacks with regular structures.

1.3. LITERATURE REVIEW

1.3.1. Ankesh Sharma & Biswobhanu Bhadra (2013) conclusion is as follows:

Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. All three kinds of irregular RC building frames had plan symmetry. Response spectrum analysis (RSA) was conducted for each type of irregularity and the storey shear forces obtained were compared with that of a regular structure. Three types of ground motion with varying frequency content, i.e., low, intermediate, high frequency were considered. Time history analysis (THA) was conducted for each type of irregularity corresponding to the above mentioned ground motions and nodal displacements were compared. Results are as follows-

- According to results of RSA, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases.
- According to results of RSA, it was found that mass irregular building frames experience larger base shear than similar regular building frames.
- According to results of RSM, the stiffness irregular building experienced lesser base shear and has larger inter storey drifts.
- The absolute displacements obtained from time history analysis of geometry irregular building at respective nodes were found to be greater than that in case of regular building for upper stories but gradually as we move to lower stories displacements in both structures tended to converge. This is because in a geometry irregular structure upper stories have lower stiffness (due to L-shape) than the lower stories. Lower stiffness results in higher displacements of upper stories.
- In case of a mass irregular structure, Time history analysis yielded slightly higher displacement for upper stories than that in regular building, whereas as we move down, lower stories showed higher displacements as compared to that in regular structures.
- When time history analysis was done for regular as well as stiffness irregular building (soft storey), it was found that displacements of upper stories did not vary much from each other but as we moved down to lower stories the absolute displacement in case of soft storey were higher compared to respective stories in regular building.
- Tall structures have low natural frequency hence their response was found to be maximum in a low frequency earthquake

1.3.2. Dileshwar Rana et al (2015) concluded:

The comparison of results has been done storey wise for each bay and then bay wise for same building height. It is concluded that as the amount of setback increases the shear force also increases. The fluctuation of critical shear force from regular to vertical geometric irregular is very high Based on the work presented in this thesis following point-wise conclusions can be drawn:

- It is concluded that as the amount of setback increases, the critical shear force also increases. The regular building frames possess very low shear force compared to setback irregular frames.
- The critical bending moment of irregular frames is more than the regular frame for all building heights. This is due to decrease in stiffness of building frames due to setbacks. Thus there is need for providing more reinforcement for irregular frames.
- It is seen that the critical seismic parameter of 4 bay building frames up to eight storey building height is less than corresponding 8 bay building frames. Therefore 4 bay building is appropriate for lower building heights.
- For higher storey building (twelve & sixteen storey) 8 bay configurations should be preferred because they have generally lesser values of critical seismic parameters than 4 *bay*. Thus this study demonstrated that with the increase in number of bays the seismic performance of both regular and setback building improves.
- The seismic performance of regular frame **R** is found to be better than corresponding irregular frames in nearly all the cases. Therefore, it should be constructed to minimize the seismic effects. Among setback frames, Type **V1** building configuration is found superior than others.

1.3.3 Poonam et al. (2012) concluded:

Results of the numerical analysis showed that any storey, especially the first storey, must not be softer/weaker than the storeys above or below. Irregularity in mass distribution also contributes to the increased response of the buildings. The irregularities, if required to be provided, need to be provided by appropriate and extensive analysis and design processes

1.4 TYPE OF IRREGULARITIES

Irregularities are of two type:

Plan irregularities and Vertical irregularities.

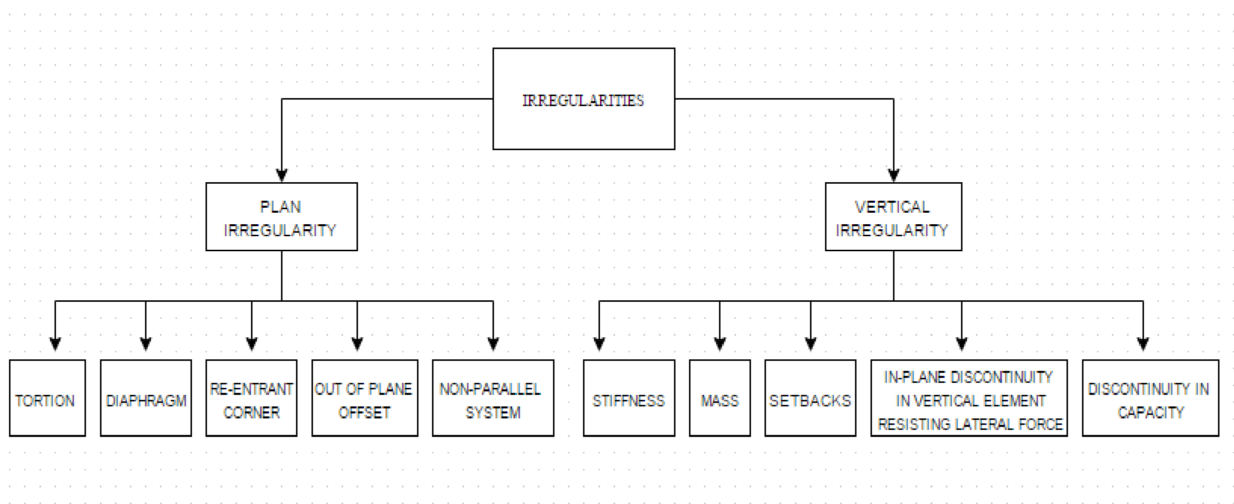


Fig.1.4 Types of Irregularities

1.4.1. PLAN IRREGULARITIES

Plan irregularities are of 5 types:

a) Torsion irregularity: To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Torsional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure.

b) Re-entrant Corners: Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond there-entrant corner are greater than 15 percent of its plan dimension in the given direction

c) Diaphragm Discontinuity: Diaphragms with abrupt discontinuities or variations in stiffness, including those having cut-out or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one storey to the next

d) Out-of-Plane Offsets: Discontinuities in a lateral force resistance path, such as out-of-plane offsets of vertical elements

e) Non-parallel Systems: The vertical elements resisting the lateral force are not parallel to or symmetric about the major orthogonal axes or the lateral force resisting elements

1.4.2.VERTICAL IRREGULARITIES

Vertical irregularities are of five types:

a.1) Stiffness Irregularity —Soft Storey
A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storeys above.

a.2) Stiffness Irregularity —Extreme Soft Storey
an extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storeys above. For example, buildings on STILTS will fall under this category.

b) Mass Irregularity*:* Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200percent of that of its adjacent storeys. The irregularity need not be considered in case of roofs.

c)Vertical Geometric Irregularity:
Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey.

d)In-Plane Discontinuity in Vertical Elements Resisting Lateral Force:
An in-plane offset of the lateral force resisting elements greater than the length of those elements.

e) Discontinuity in Capacity — Weak Storey
A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above, the storey lateral strength is the total strength of all seismic force resisting elements sharing the storey shear in the considered direction.

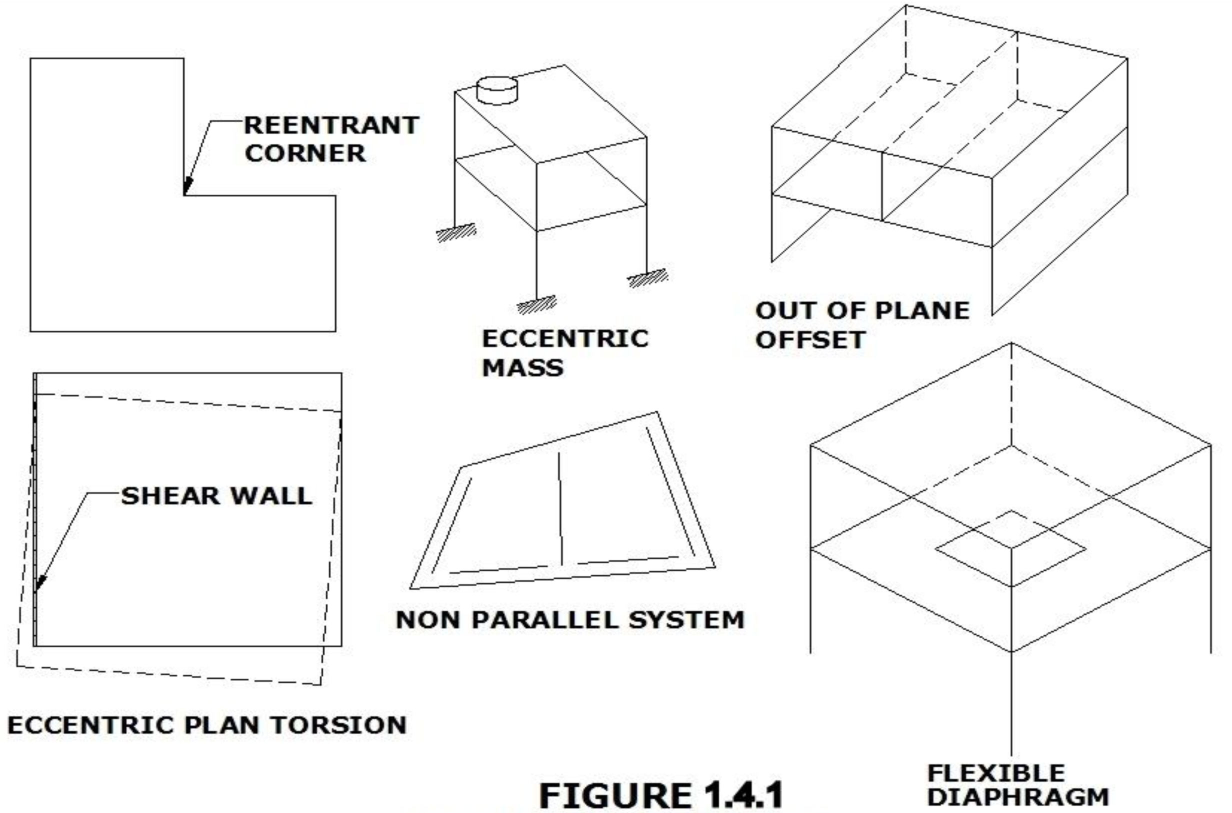


FIGURE 1.4.1
PLAN IRREGULARITY

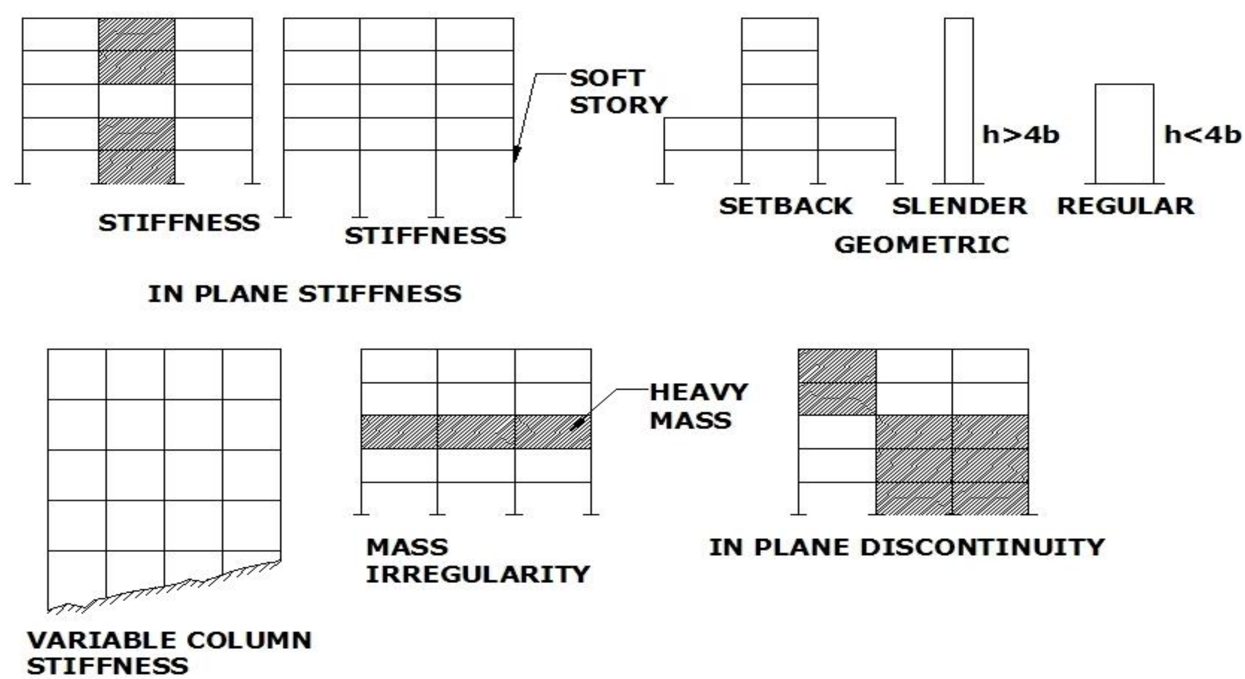


FIGURE 1.4.2
VERTICAL IRREGULARITY

1.5. EFFECTS OF IRREGULARITES ON BUILDINGS

- Vertical members placed uniformly in plan of building, more mass on one side causes the floors to twist.
- Twist in buildings, called torsion by engineers, makes different portions at the same floor level to move horizontally by different amounts. This induces more damage in the frames and walls on the side that moves more.
- For stiffness irregular ground storey the relative horizontal displacement in the ground storey is much larger than what each of the storeys above it does.
- The presence of much stiffer upper storeys than the ground storey makes the upper storeys move almost together as a single block, and most of the horizontal displacement of the building occurs in the soft ground storey itself. Thus, such buildings swing back-and-forth like inverted pendulums during earthquake shaking which may even lead to collapse of the building.
- In geometry irregular structure the stiffness in lower storeys is far more than that of regular structure. So the displacement in lower storeys of geometry irregular structure is very less as compared to regular structure.
- The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path. Buildings with vertical setbacks cause a sudden jump in earthquake forces at the level of discontinuity. Any deviation or discontinuity in the load transfer path results in poor performance of the building.

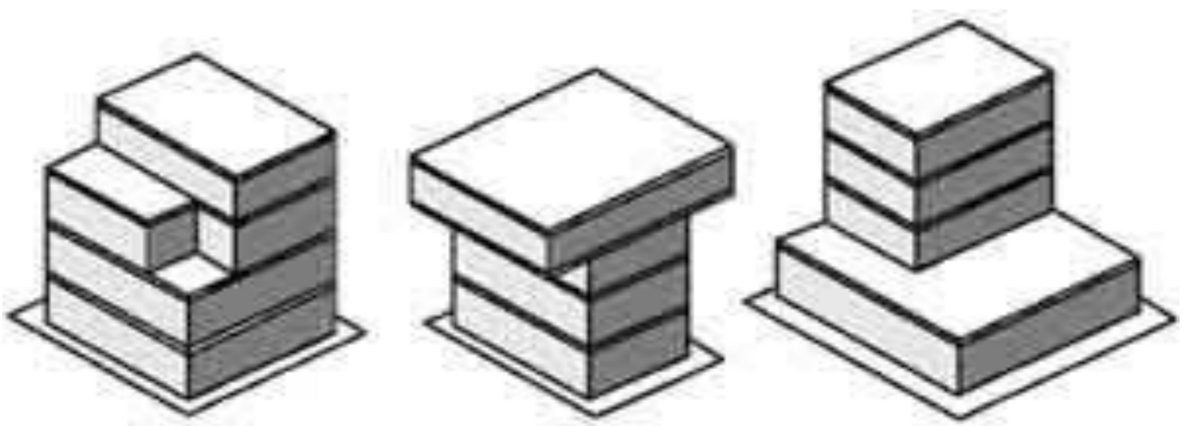
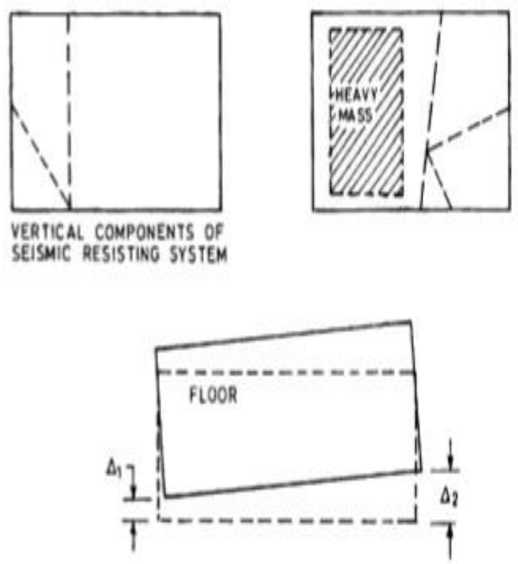


Fig 1.5.1: Geometry Irregular Structure

1.6. IS 1893 (PART 2): 2002 SPECIFICATIONS ARE:

1.6.1 PLAN IRREGULARITIES



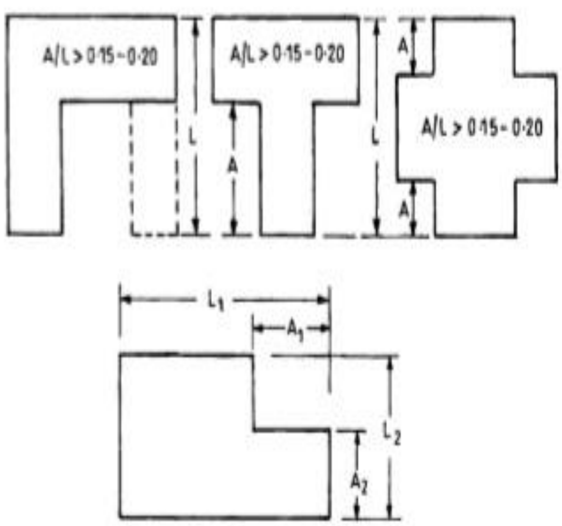
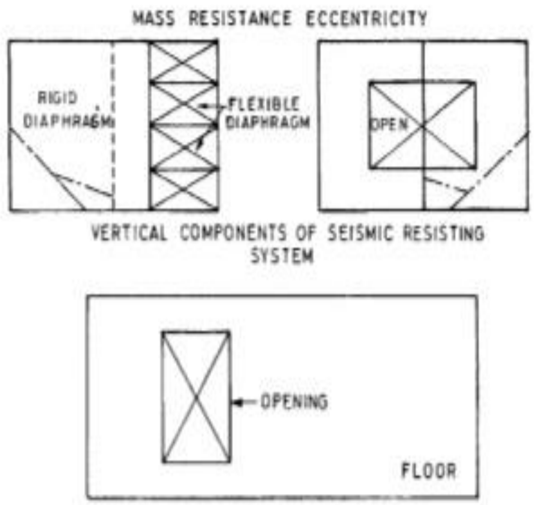


Fig.1.6.1.1 Torsion Irregularity **Fig.1.6.1.2 Re-entrant Corner**



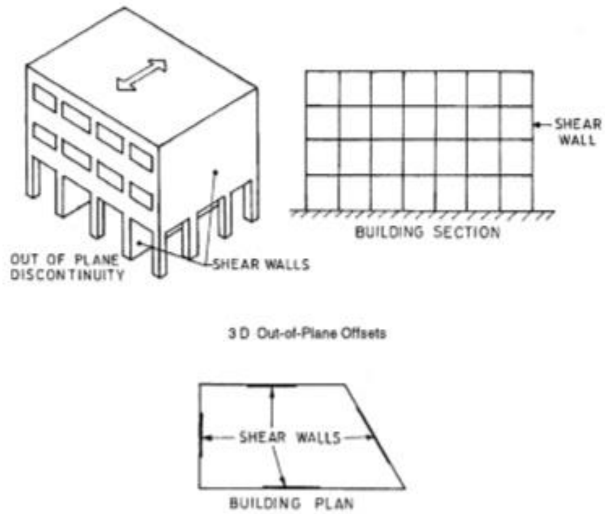
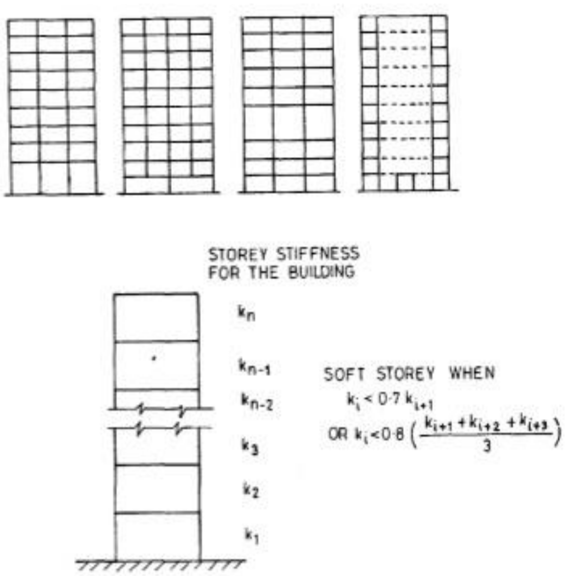


Fig.1.6.1.3 Diaphragm Discontinuity **Fig.1.6.1.4 Non-Parallel System**

1.6.2 VERTICAL IRREGULARITIES



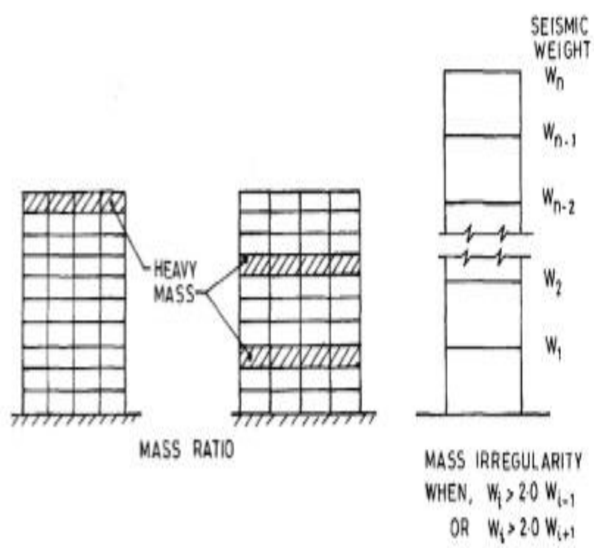


Fig.1.6.2.1 Diaphragm Discontinuity **Fig.1.6.2.1 Non-Parallel System**

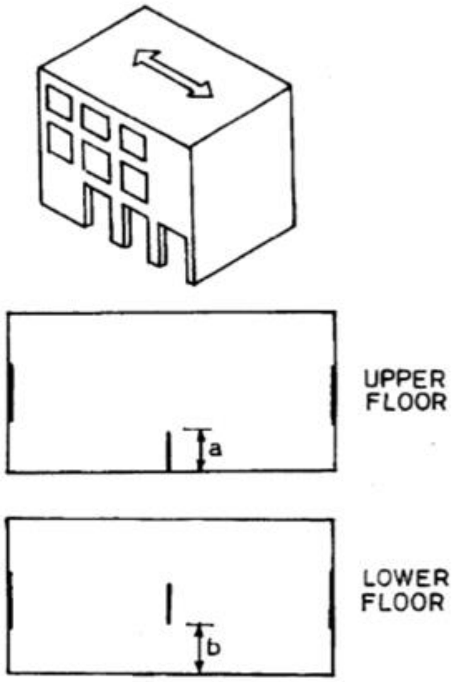


Fig.1.6.2.4 In-Plane Discontinuity in Vertical Elements Resisting Lateral Force when $b > a$

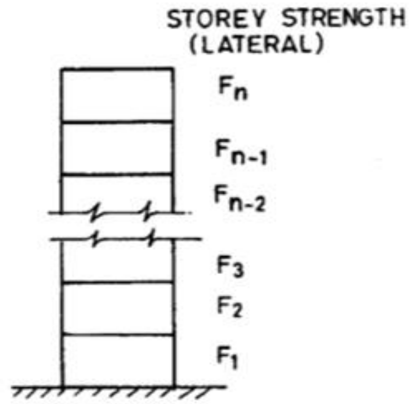


Fig.1.6.2.5 Weak Storey when $F_i < 0.8\ F_i + 1$

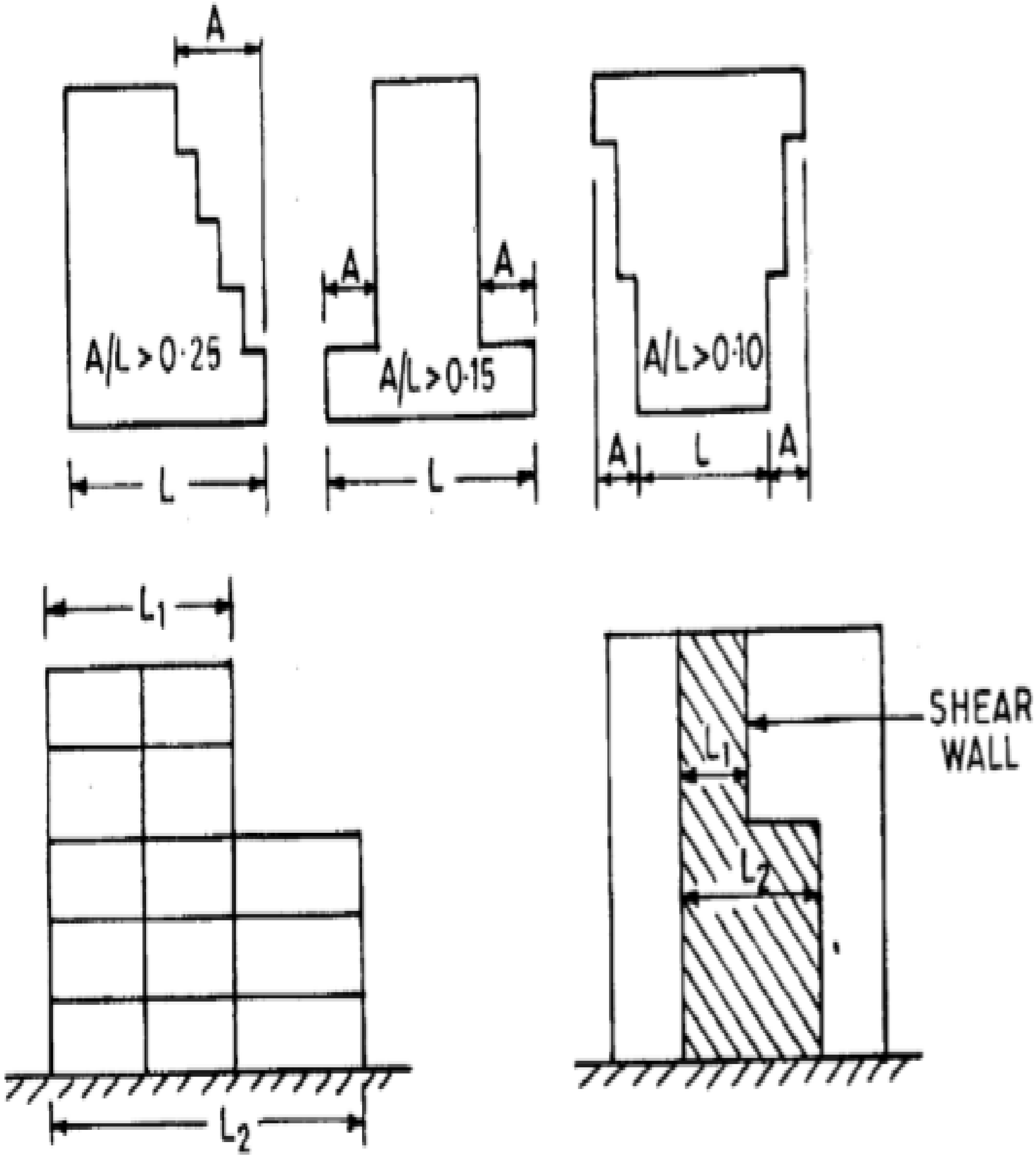


Fig.1.6.2.6 Vertical Geometric Irregularity when $L_2 > 1.5\ L_1$

CHAPTER 2

ANALYSIS OF BUILDING FRAME WITH IRREGULARITES

The analysis is done firstly for two dimensional frames and then for three dimensional structure. The method analysis used is linear static analysis and response spectrum analysis respectively. Both 2-D frames as well as 3-D structures have the same specification, the only difference is method of analysis. The types of frames (2-D) and type of structure (3-D) are shown as follows:

2.1 TYPES OF FRAMES

2.1.1 FRAME 1

Frame 1 consist of 8 storeys, each storey have height 3.2 m and width 5 m and is a regular structure. The height and width of the building frame is 25.6m and 20m respectively. Earthquake load along with dead load and live load are applied on the frame and the response of building frame is noted.

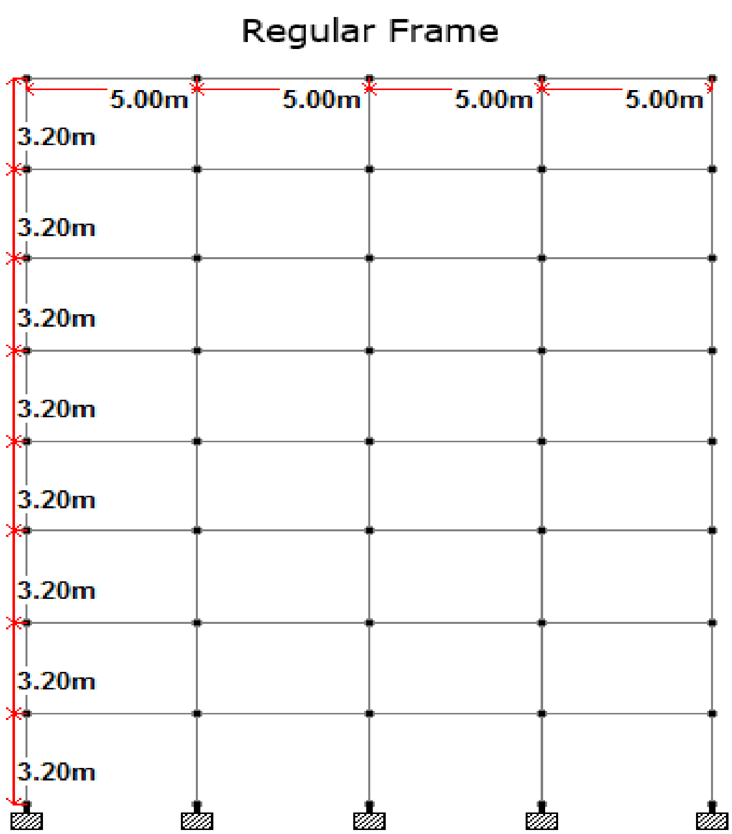


Fig.2.1.1 Frame 1

2.1.2 FRAME 2

Frame 2 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building frame is 25.6 m and 20m respectively. The structure is L shaped with setback at 6th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if L2>1.5 x L1, then structure is irregular, here L1=10m and L2=20m and 1.5 x L1is coming out to be 15, hence L2>1.5 x L1, therefore the given frame is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the frame and the response of building frame is noted.

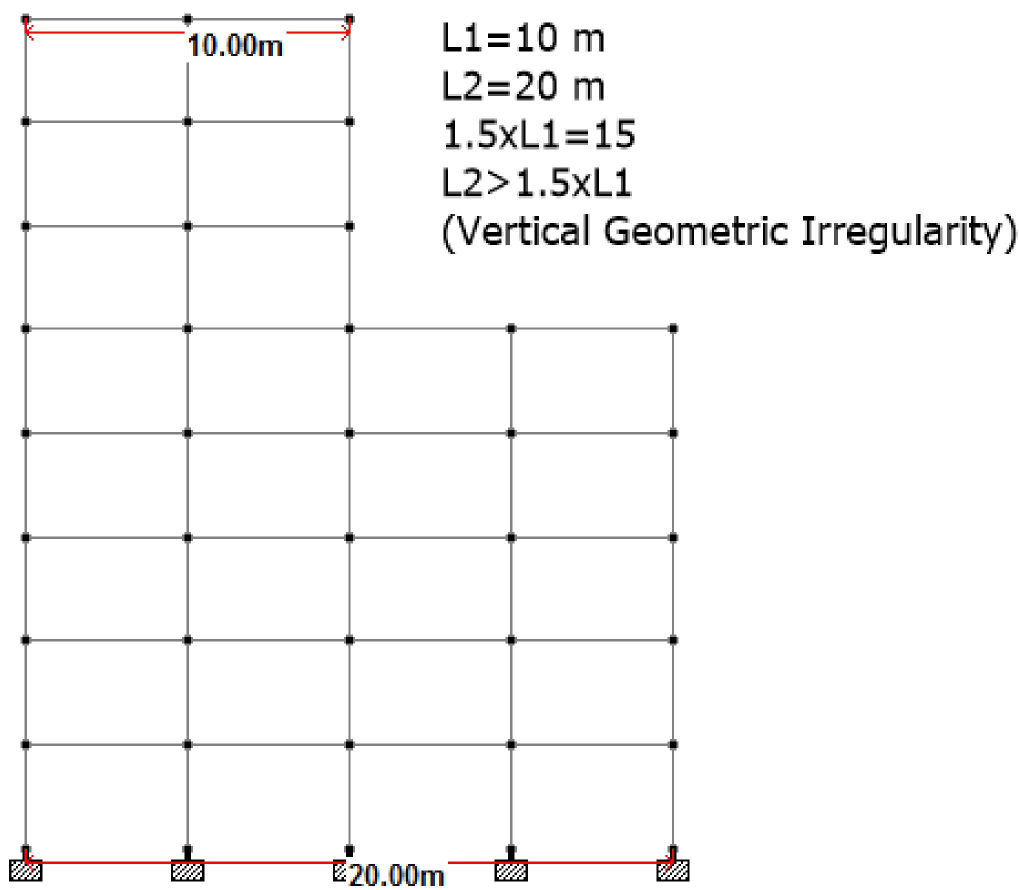


Fig.2.1.2 Frame 2

2.1.3 FRAME 3

Frame 3 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building frame is 25.6 m and 20m respectively. The structure is heaving setback at 5^{th} and 7^{th} storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.25 then structure is irregular, here the value of A/L is coming out to be 0.50 which is greater than 0.25, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the frame and the response of building frame is noted.

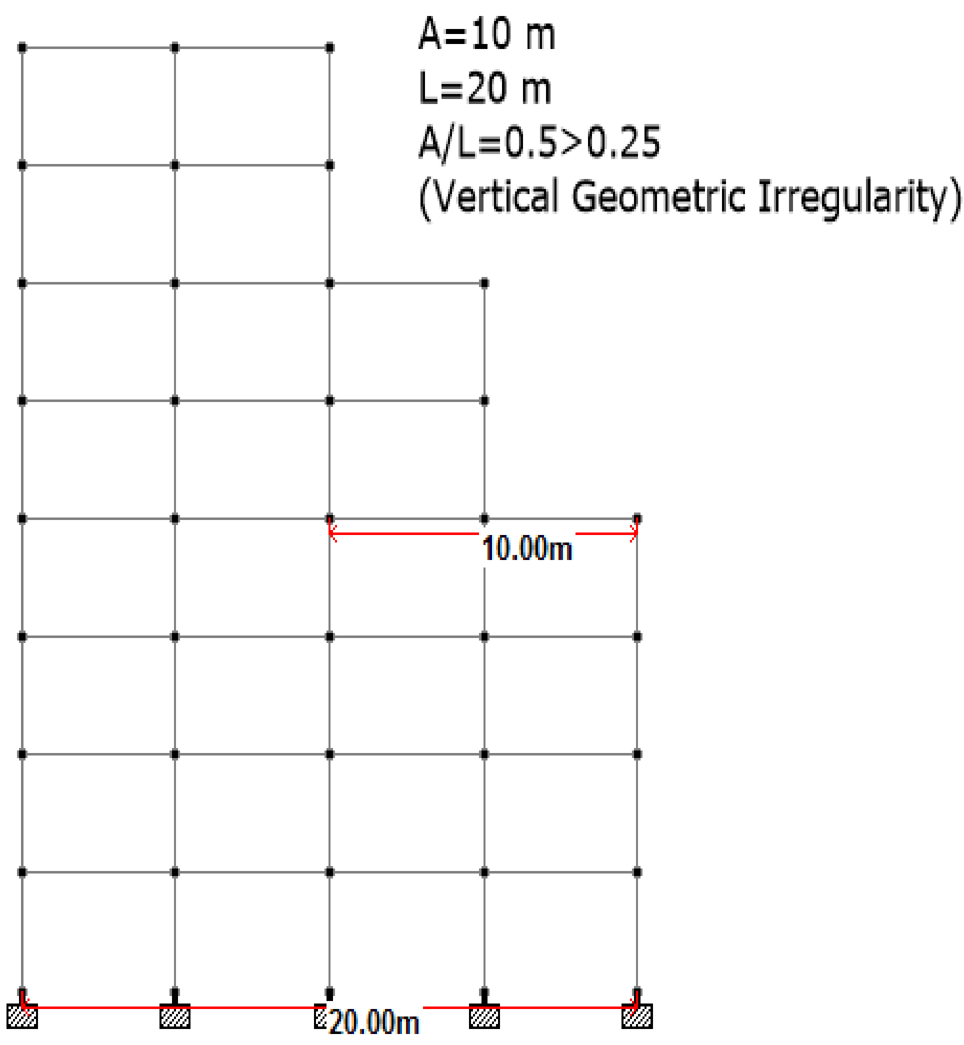


Fig.2.1.3 Frame 3

2.1.4 FRAME 4

Frame 4 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building frame is 25.6 m and 20m respectively. The structure is heaving setback at 3rd, 5th and 7th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.25 then structure is irregular, here the value of A/L is coming out to be 0.75 which is greater than 0.25, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the frame and the response of building frame is noted.

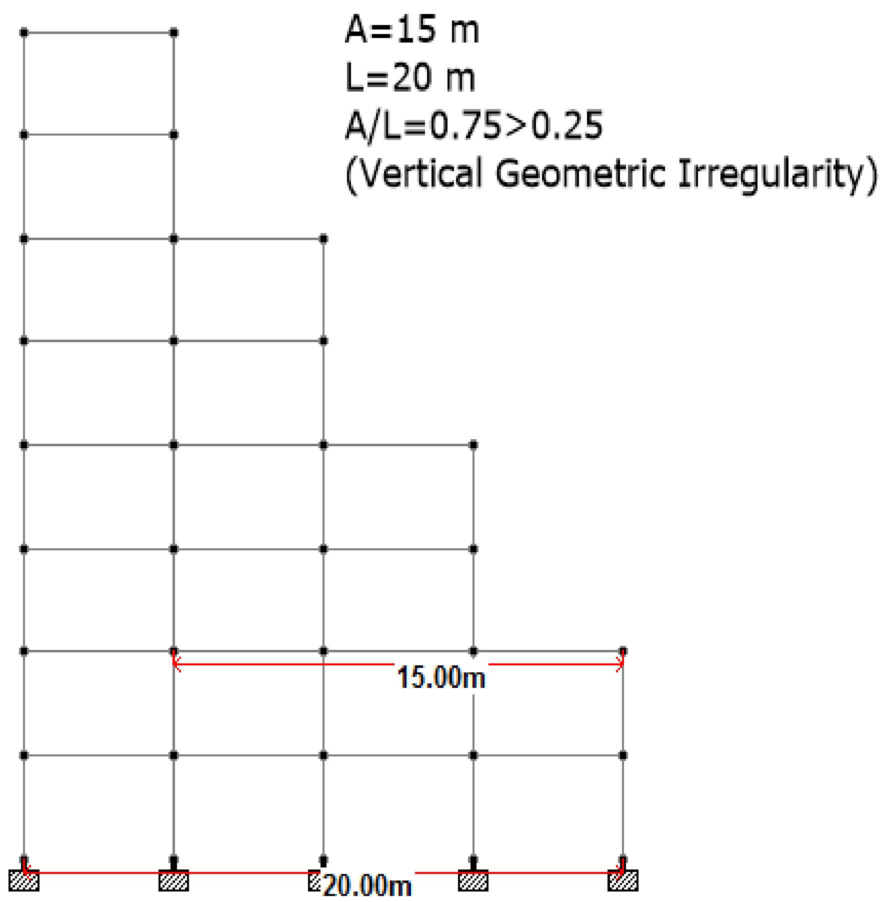


Fig.2.1.4 Frame 4

2.1.5 FRAME 5

Frame 5 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building frame is 25.6 m and 20m respectively. The structure is an inverted T shaped frame with setback at 6th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.15 then structure is irregular, here the value of A/L is coming out to be 0.25 which is greater then 0.15, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the frame and the response of building frame is noted.

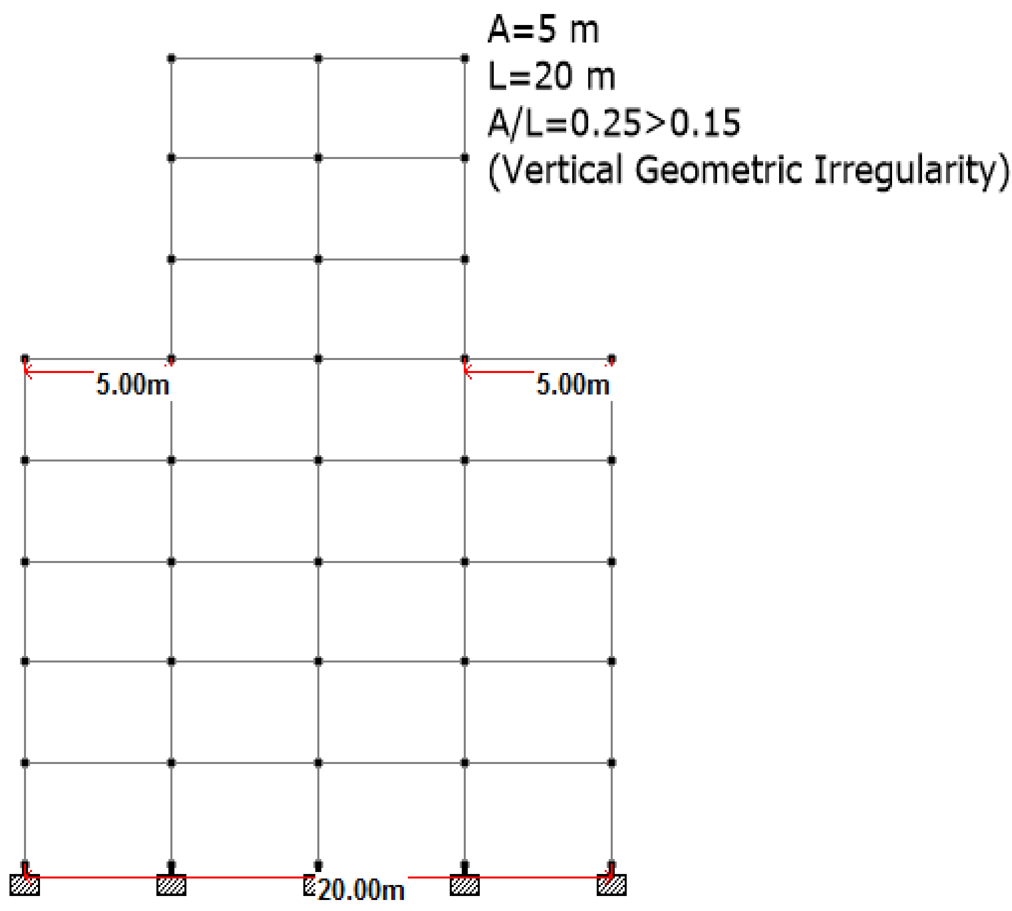


Fig.2.1.5 Frame 5

2.1.6 FRAME 6

Frame 6 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building frame is 25.6 m and 20m respectively. The structure is inverted T shaped frame with setback at 4th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.15 then structure is irregular, here the value of A/L is coming out to be 0.25 which is greater than 0.15, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the frame and the response of building frame is noted.

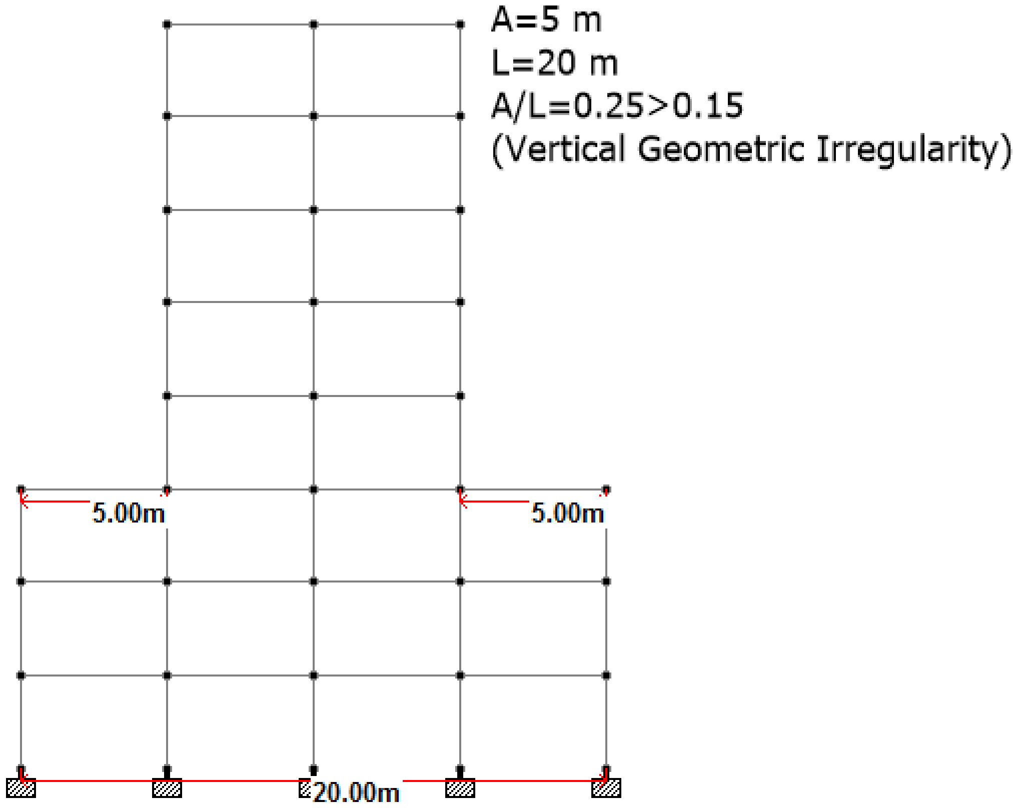


Fig.2.1.6 Frame 6

2.1.7 FRAME 7

Frame 7 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building frame is 25.6 m and 20m respectively. The structure is an inverted T shaped frame with setback at 6th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.15 then structure is irregular, here the value of A/L is coming out to be 0.25 which is greater than 0.15, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the frame and the response of building frame is noted.

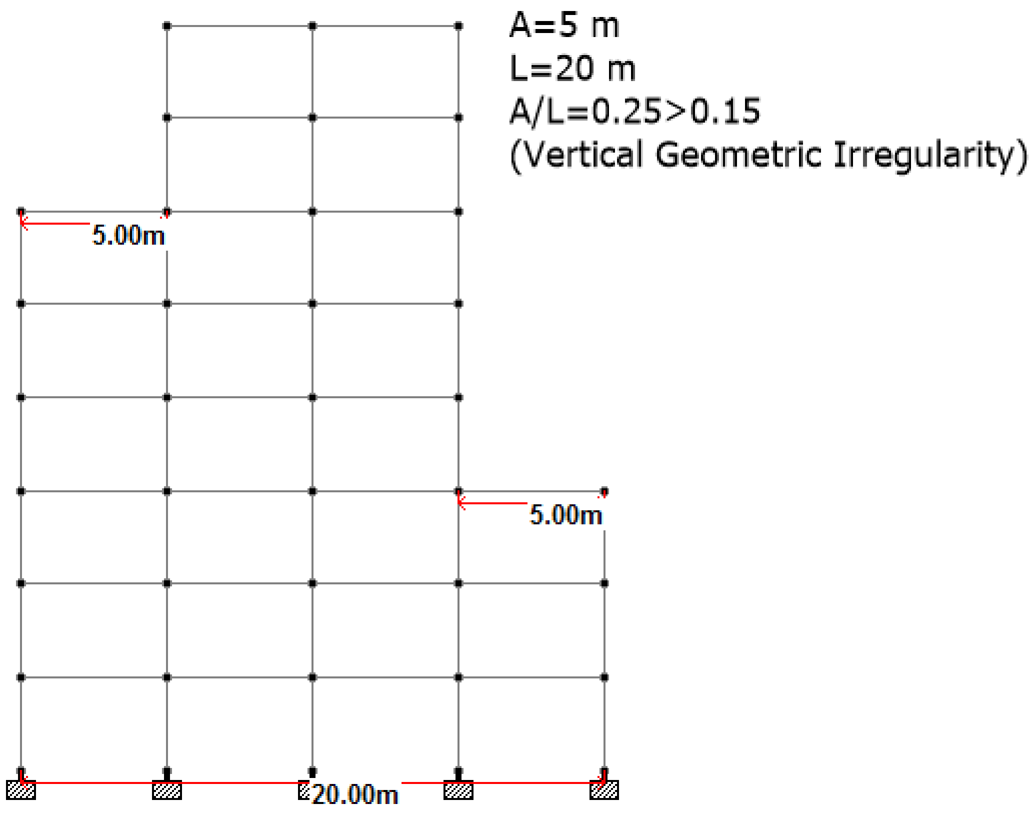


Fig.2.1.7 Frame 7

2.2 TYPE OF STRUCTURES

2.2.1 STRUCTURE 1

Structure 1 consist of 8 storeys, each storey have height 3.2 m and width 5 m and is a regular structure. The height and width of the Structure is 25.6m and 20m respectively. Earthquake load along with dead load and live load are applied on the structure and the response of building structure is noted.

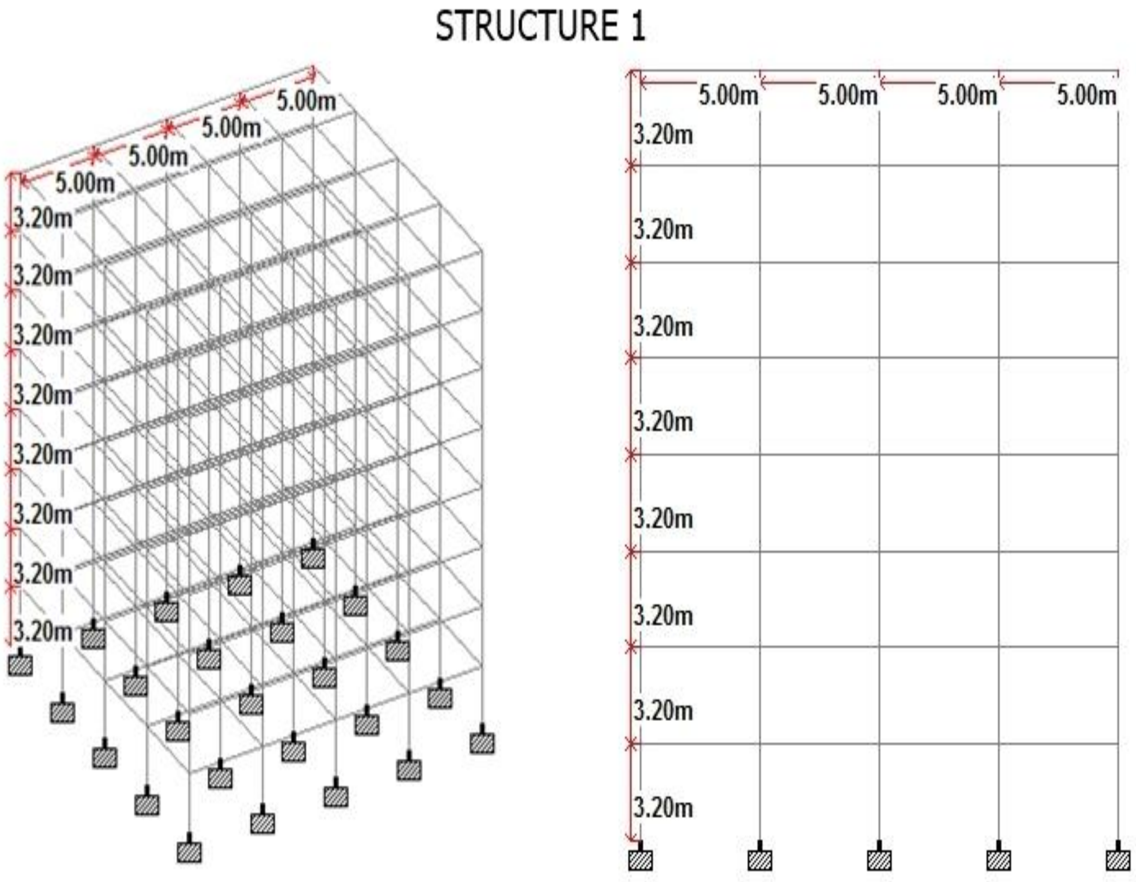


Fig.2.2.1 Structure 1

2.2.2 STRUCTURE 2

Structure 2 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the structure is 25.6 m and 20m respectively. The structure is L shaped with setback at 6th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if

L2>1.5 x L1, then structure is irregular, here L1=10m and L2=20m and 1.5 x L1is coming out to be 15, hence L2>1.5 x L1, therefore the given frame is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the structure and the response of building structure is noted.

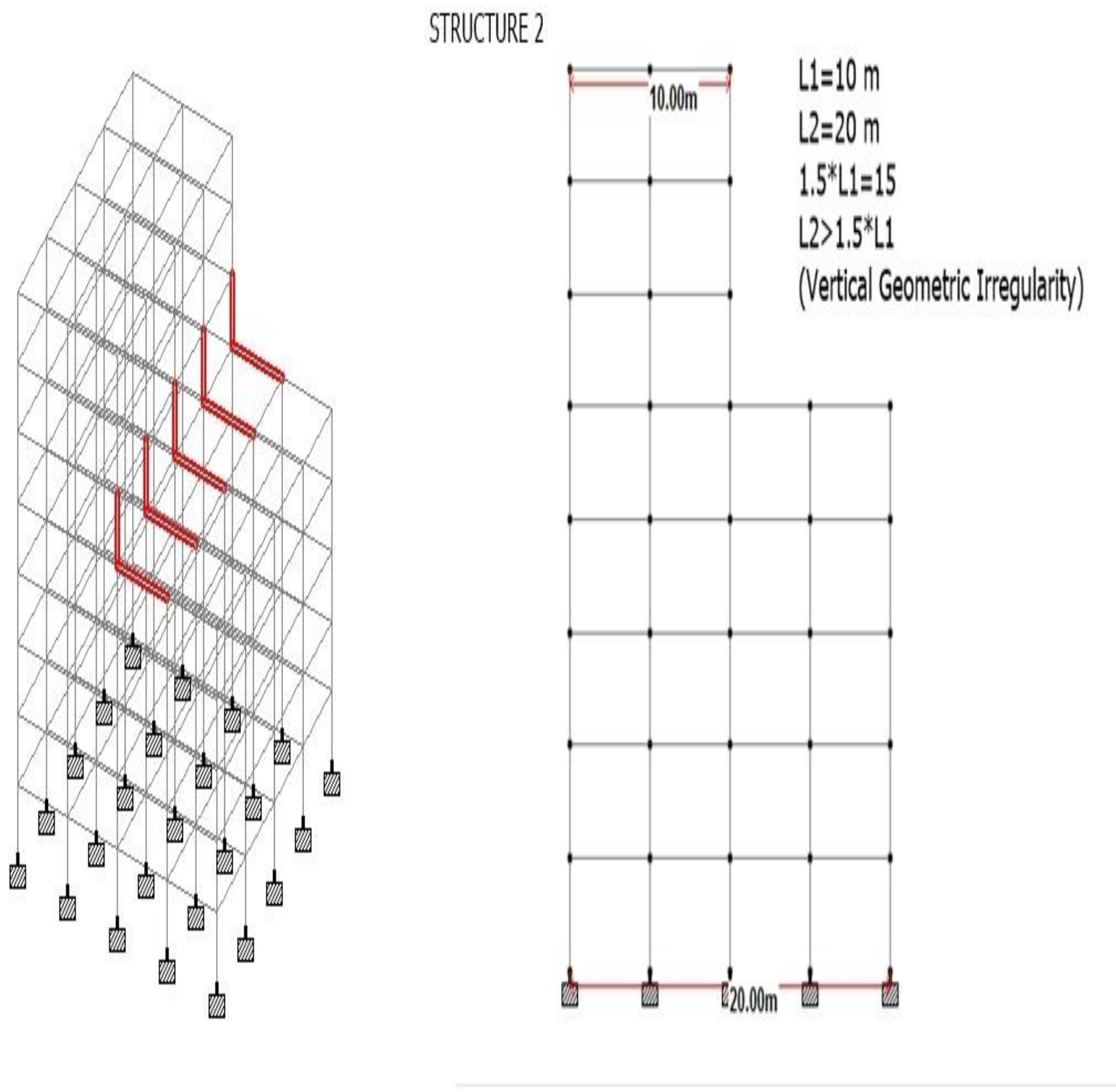


Fig.2.2.2 Structure 2

<u>2.2.3 STRUCTURE 3</u>

Structure 3 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building structure is 25.6 m and 20m respectively. The structure is heaving setback at 5^{th} and 7^{th} storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) –

2000, if A/L ratio exceed 0.25 then structure is irregular, here the value of A/L is coming out to be 0.50 which is greater than 0.25, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the structure and the response of building structure is noted.

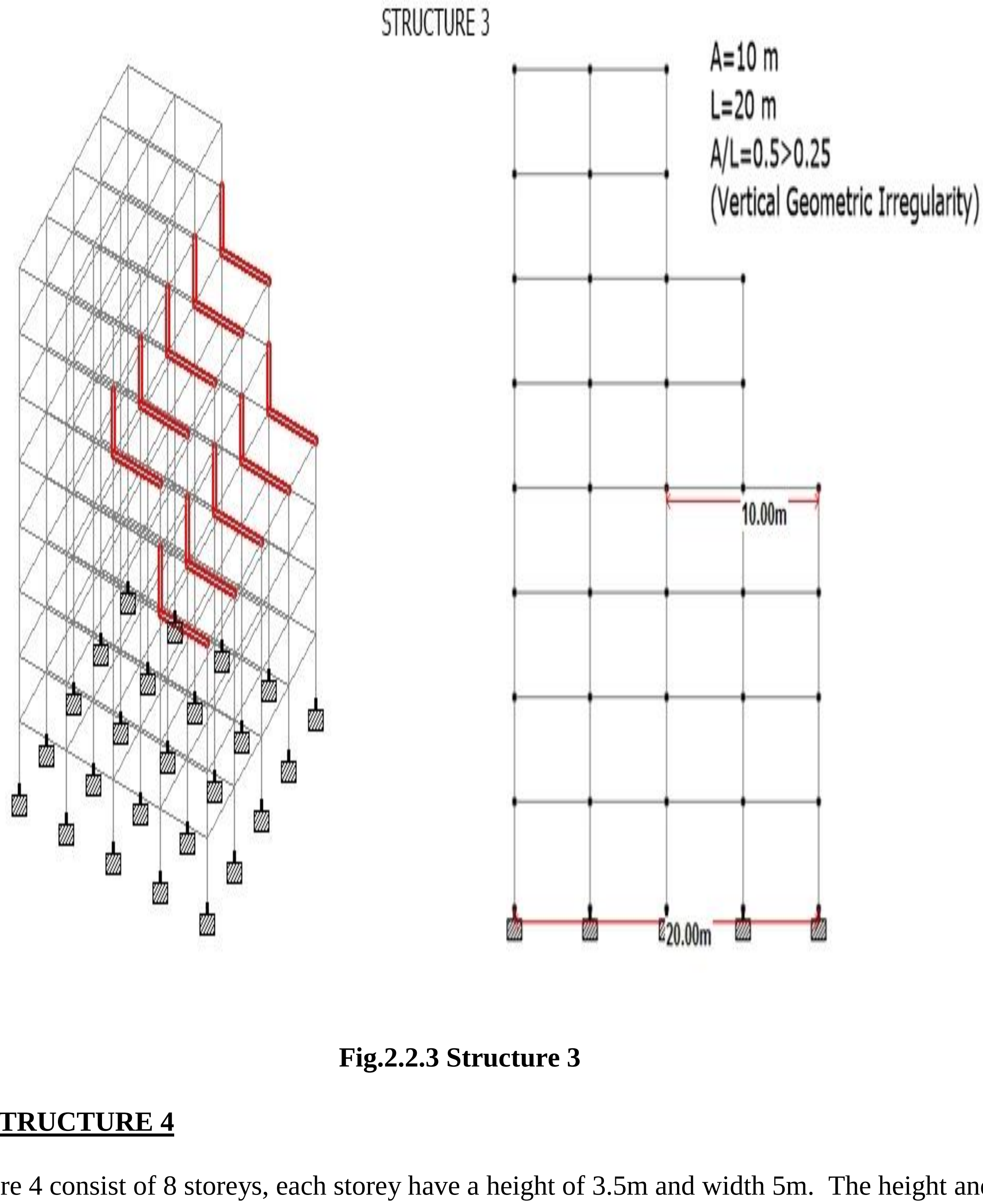


Fig.2.2.3 Structure 3

2.2.4 STRUCTURE 4

Structure 4 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building structure is 25.6 m and 20m respectively. The structure is having setback at

3rd, 5th and 7th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.25 then structure is irregular, here the value of A/L is coming out to be 0.75 which is greater than 0.25, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the structure and the response of structure is noted.

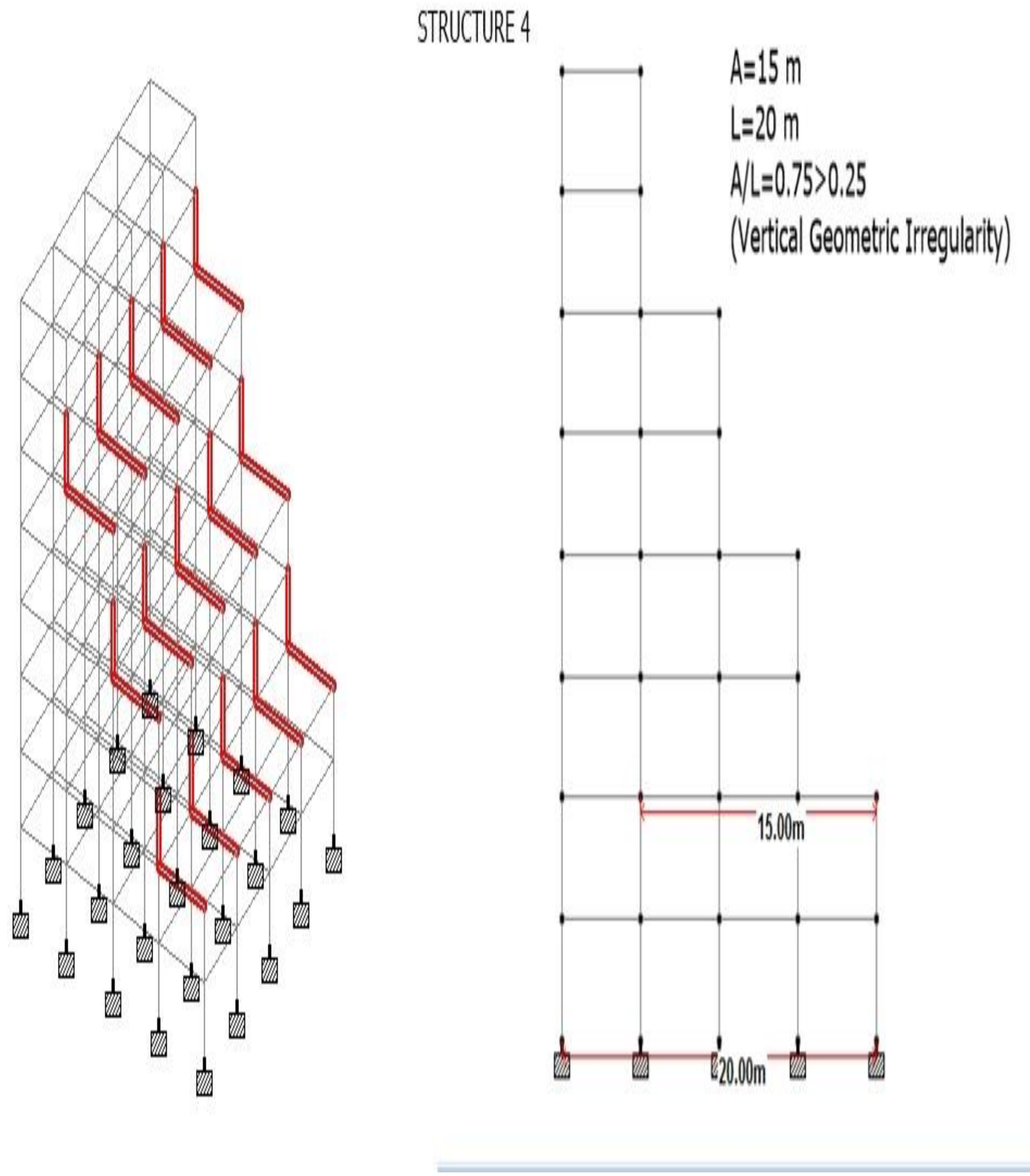


Fig.2.2.4 Structure 4

2.2.5 STRUCTURE 5

Structure 5 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building structure is 25.6 m and 20m respectively. The structure is an inverted T shaped frame with setback at 6th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.15 then structure is irregular, here the value of A/L is coming out to be 0.25 which is greater than 0.15, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the structure and the response of structure is noted.

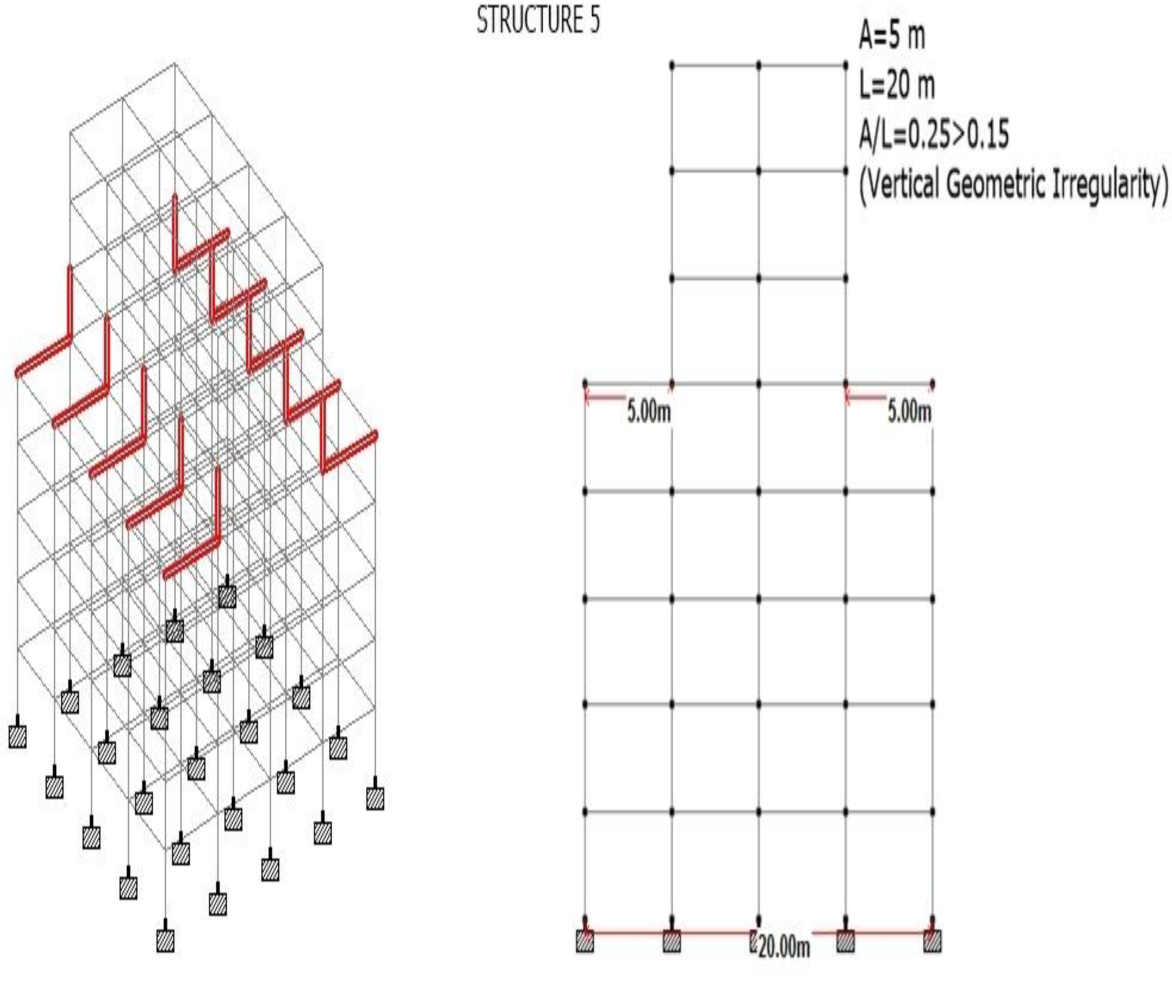


Fig.2.2.5 Structure 5

2.2.6 STRUCTURE 6

Structure 6 consist of 8 storeys, each storey have a height of 3.5m and width 5m. The height and width of the building structure is 25.6 m and 20m respectively. The structure is inverted T shaped frame with setback at 4th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.15 then structure is irregular, here the value of A/L is coming out to be 0.25 which is greater than 0.15, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the structure and the response of building structure is noted.

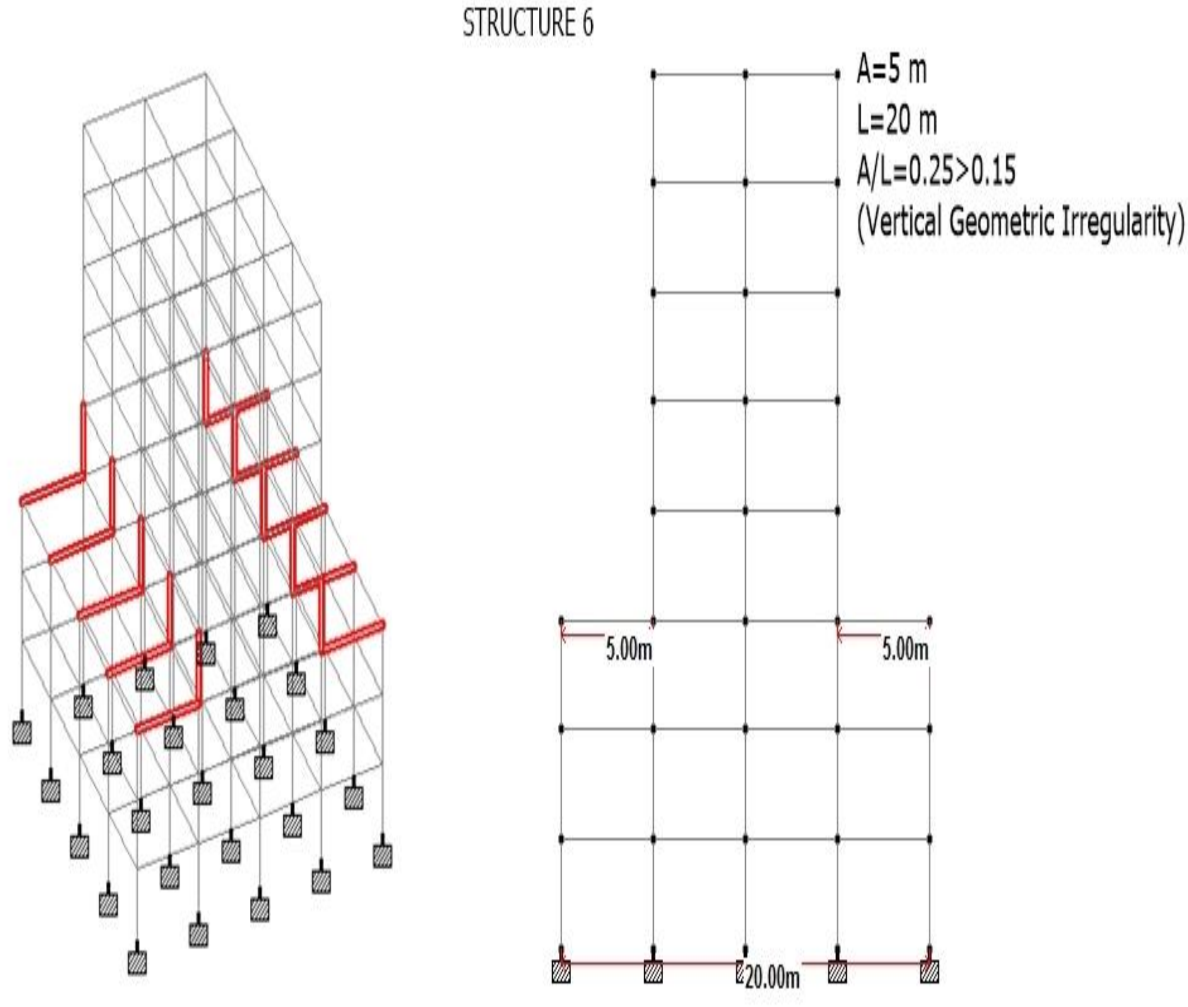


Fig.2.2.6 Structure 6

2.2.7 STRUCTURE 7

Structure 7 consist of 8 storeys, each storey has a height of 3.5m and width 5m. The height and width of the building structure is 25.6 m and 20m respectively. The structure is an inverted T shaped frame with setback at 6th storey and is a vertical geometric irregular structure. According to IS 1893 (part 1) – 2000, if A/L ratio exceed 0.15 then structure is irregular, here the value of A/L is coming out to be 0.25 which is greater than 0.15, hence it is a vertical geometric irregular structure. Earthquake load along with dead load and live load are applied on the structure and the response of structure is noted.

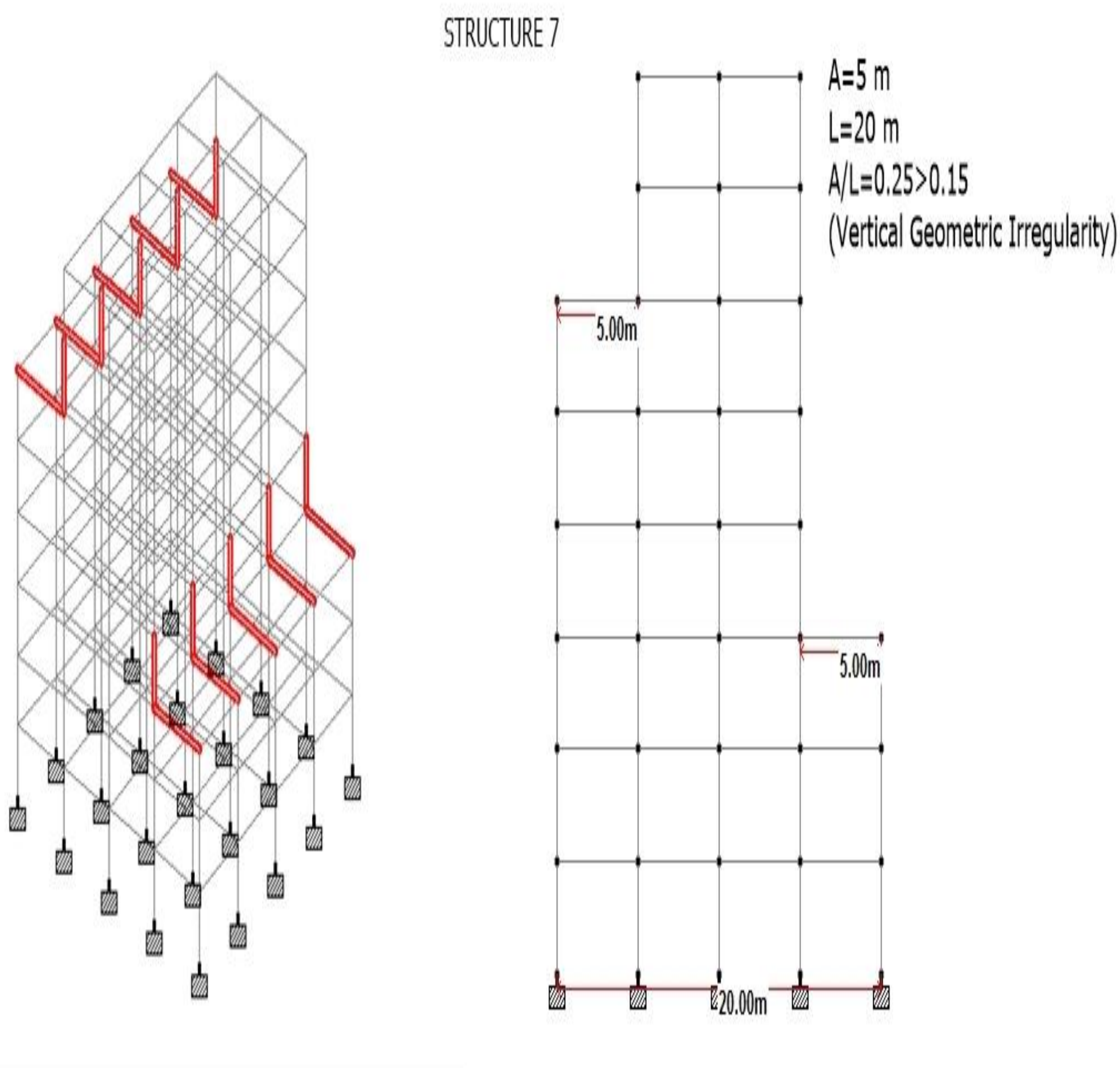


Fig.2.1.7 Structure 7

2.3 SPECIFICATIONS:

Live Load	15kN/m^2
Dead Load	20kN/m^2
Density of RCC considered:	25kN/m^3
Depth of beam	400mm
Width of beam	300mm
Dimension of column	400x400mm
Height of each floor	3.2m
City	Shimla
Earthquake Zone	IV
Damping Ratio	5%
Type of building	Important
Importance factor	1 .5
Type of Soil	Hard
Type of structure	Special Moment Resisting Frame

2.3. METHODOLOGY

Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. In the past the buildings were designed just for gravity loads and seismic analysis is a recent development. It is a part of structural analysis and a part of structural design where earthquake is prevalent.

There are different types of earthquake analysis methods. We are using the following methods in our project.

2.3.1 LINEAR STATIC ANALYSIS

When loads are applied to a body, the body deforms and the effect of loads is transmitted throughout the body. The external loads induce internal forces and reactions to render the body into a state of equilibrium.

Linear Static analysis calculates displacements, strains, stresses, and reaction forces under the effect of applied loads.

Linear static analysis makes the following assumptions:

Static Assumption. All loads are applied slowly and gradually until they reach their full magnitudes. After reaching their full magnitudes, loads remain constant (time-invariant). This assumption allows us to neglect inertial and damping forces due to negligibly small accelerations and velocities. Time-variant loads that induce considerable inertial and/or damping forces may warrant dynamic analysis. Dynamic loads change with time and in many cases induces considerable inertial and damping forces that cannot be neglected.

Linearity Assumption: The relationship between loads and induced responses is linear. For example, if you double the loads, the response of the model (displacements, strains, and stresses), will also double. You can make the linearity assumption if:

- All materials in the model comply with Hooke's law, that is stress is directly proportional to strain.
- The induced displacements are small enough to ignore the change in stiffness caused by loading.
- Boundary conditions do not vary during the application of loads. Loads must be constant in magnitude, direction, and distribution. They should not change while the model is deforming.

According to 1893 (part 1) -2000, In limit state design of reinforced and per stressed concrete structures, the following load combination should be accounted for and we also considered all the load combination:

1) EL X+VE
2) EL X-VE
3) DL
4) LL
5) 1.5(DL+LL)
6) 1.2(DL+LL+EL X+VE)
7) 1.2(DL+LL - EL X-VE)
8) 1.5(DL+EL X+VE)
9) 1.5(DL-EL X-VE)
10) 0.9DL+1.5EL X+VE
11)0.9DL - 1.5EL X-VE

EL=EARTHQUAKE LOAD
DL=DEAD LOAD
LL= LIVE LOAD

2.3.2 RESPONSE SPECTRUM ANALYSIS

Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. In the past the buildings were designed just for gravity loads and seismic analysis is a recent development. It is a part of structural analysis and a part of structural design where earthquake is prevalent.

In order to perform the seismic analysis and design of a structure to be built at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further, the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as the response of the structure depend upon the frequency content of ground motion and its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is the most popular tool in the seismic analysis of structures. There are computational advantages in using the response spectrum method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode of vibration using smooth design spectra that are the average of several earthquake motions.

CHAPTER 3

RESULTS AND DISCUSSION

3.1. COMPARISON OF FRAMES: STATIC ANALYSIS

Static Analysis for seven types of building frames was done on regular and irregular frames using Staad.Pro.V8i. The axial force and maximum bending moment for columns, shear force and maximum bending moment for beam were calculated at the setbacks and each irregular frame is compared with the same members in regular frame.

Every irregular frame is compared with the regular frame and following variation are seen from load combination: 1.5(DL+ EL X +VE)

3.1. 1. FRAME 1 AND FRAME 2

In this section the comparison of frame 1 and frame 2 is done. The beams at the setback i.e. Column-50 and Beam-42 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

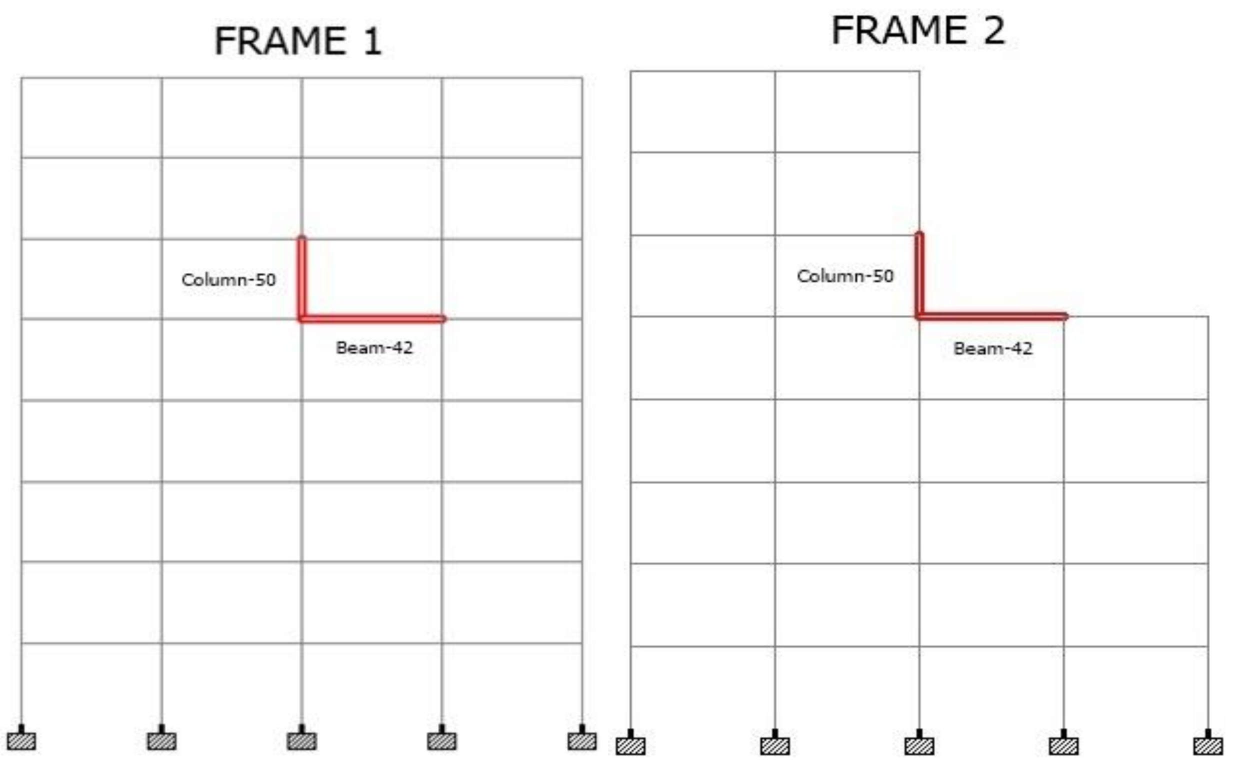


Fig.3.1.1.1 Frame 1 and Frame 2

COLUMN 50

When the forces of Column-50 of both the frames i.e frame 1 and frame 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 121 kN to 131 kN and rest of the forces i.e maximum axial force(Fx) and maximum bending moment(Mz) decreases from 592 kN to 509 kN and 211 kNm to 191 kNm respectively. It is noted that the maximum shear force(Fy) in Column -50 in irreguar frame comming out to be more then the same Column in regular structure.

BEAM 42

When the forces of Beam-42 of both the frames i.e frame 1 and frame 2 is compared, it is noted that the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.69 kN to 205 kN and 3.5 kN to 21.3 kN respectively but the value of maximum bending moment(Mz) decreases from 281 kNm to 221 kNm from regular to irregular frame. It is noted that the maximum axial force(Fx) and the maximum shear force(Fy) and in Beam-42 in irreguar frame comming out to be more then the same beam in regular structure.

3.1. 2.FRAME 1 AND FRAME 3

In this section the comparison of frame 1 and frame 3 is done. The beams at the setback i.e. Column-59, Beam-51, Column-43 and Beam-35 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

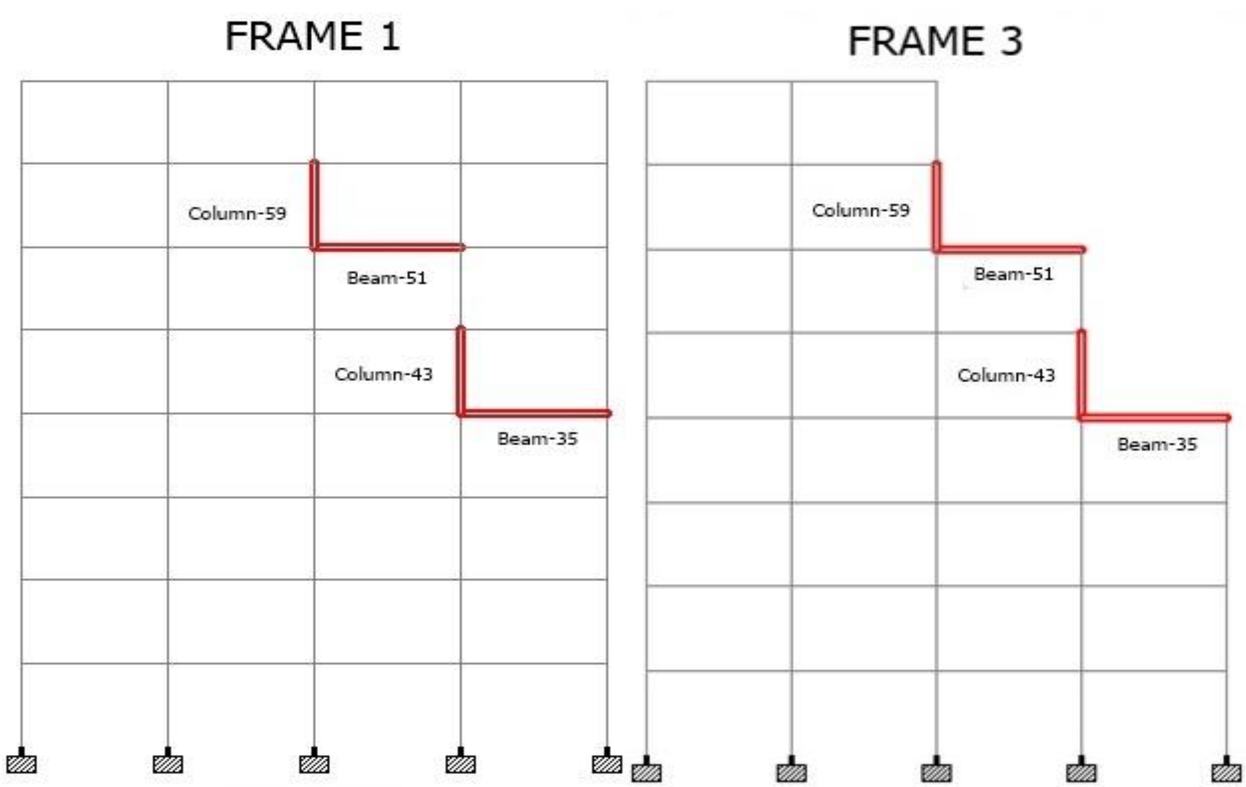


Fig.3.1.2.1 Frame 1 and Frame 3

COLUMN 59

When the forces of Column -59 of both the frames i.e frame 1 and frame 3 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 89 kN to 98.9 kN and rest of the forces i.e maximum axial force(Fx) and maximum bending moment(Mz) decreases from 395 kN to 307 kN and 165 kNm to 164 kNm respectively. It is noted that the maximum shear force(Fy) in Column -59 in irreguar frame comming out to be more then the same Column in regular structure.

BEAM 51

When the forces of Beam-51 of both the frames i.e frame 1 and frame 3 is compared, it is noted that the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.69 kN to 91.7 kN and 20.7 kN to 23.5 kN respectively but the value of maximum bending moment(Mz) decreases from 238 kNm to 223 kNm from regular to irregular frame . It is noted that the maximum axial force(Fx) and the maximum shear force(Fy) and in Beam-51 in irreguar frame comming out to be more then the same beam in regular structure.

COLUMN 43

When the forces of Column-43 of both the frames i.e frame 1 and frame 3 is compared, it is noted that the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 776 kN to 375 kN , 146 kN to 119 kN and 245 kNm to 174 kNm respectively. It is noted that the values of the forces maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) in Column-43 are more in regular frame.

BEAM 35

When the forces of Beam-35 of both the frames i.e frame 1 and frame 3 is compared, it is noted that the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -2.44 kN to 116 kN and -14.6 kN to 15.6 kN respectively but the value of maximum bending moment(Mz) decreases from 332 kNm to 241 kNm from regular to irregular frame . It is noted that the maximum axial force(Fx) and the maximum shear force(Fy) and in Beam-35 in irreguar frame comming out to be more then the same beam in regular structure.

3.1.3. FRAME 1 AND FRAME 4

In this section the comparison of frame 1 and frame 4 is done. The beams at the setback i.e. Column -57, Beam-49, Column -41, Beam-33, Column -25 and Beam-17 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

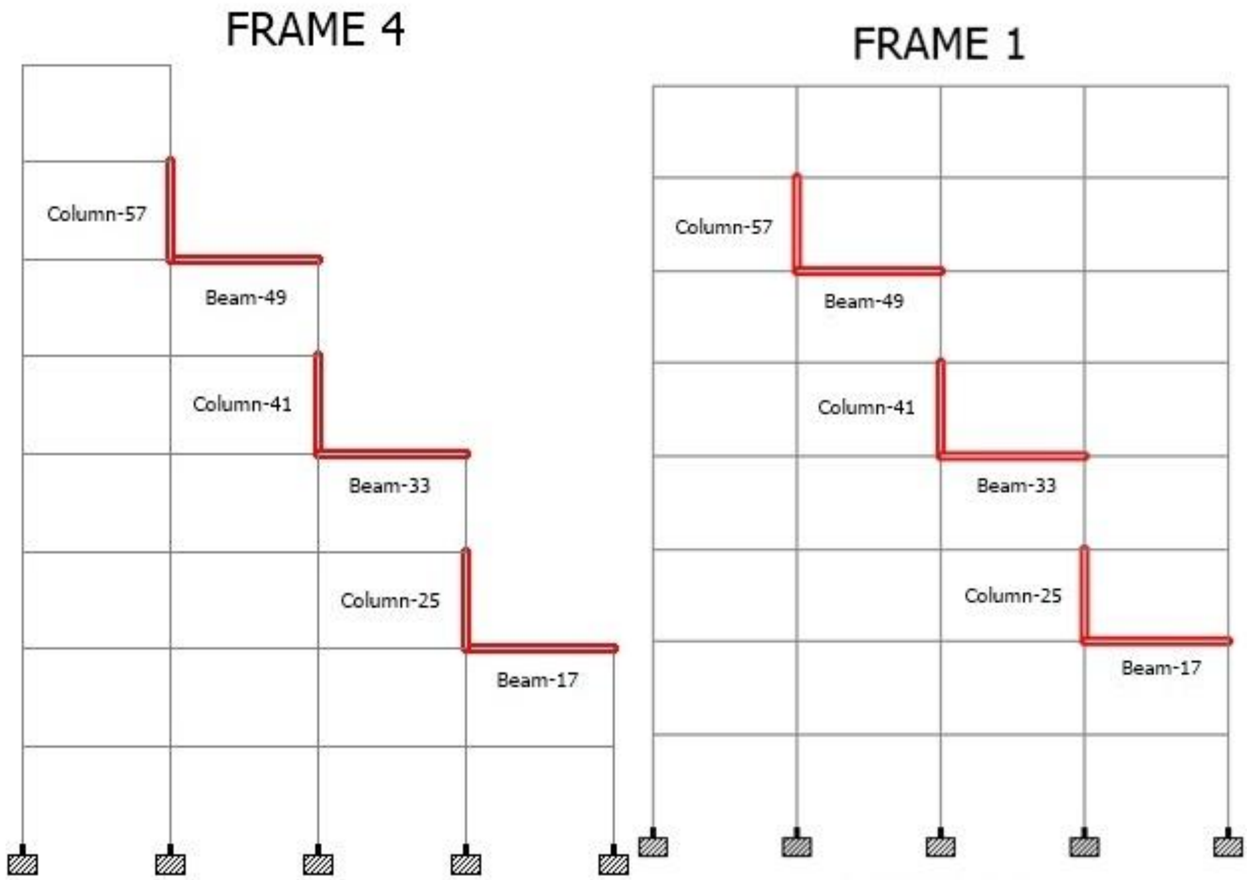


Fig.3.1.3.1 Frame 1 and Frame 4

COLUMN 57

When the forces of Column-57 of both the frames i.e frame 1 and frame 4 is compared, it is noted that the value of maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame increases from 81.4 kN to 110 kN and 152 kNm to 172 kNm respectively but the value of maximum axial force(Fx) decreases from 380 kN to 324 kN from regular to irregular frame . It is noted that maximum shear force (Fy) and maximum bending moment(Mz) and in Column-57 in irreguar frame comming out to be more then the same Column in regular structure.

BEAM 49

When the forces of Beam-49 of both the frames i.e frame 1 and frame 4 is compared, it is noted that the value of maximum axial force(Fx) and maximum bending moment(Mz) from regular frame to irregular frame increases from 0.672 kN to 97.7 kN and 238 kNm to 240 kNm respectively but the value of maximum shear force (Fy) decreases from 20.4 kN to 15.5 kN from regular to irregular frame . It is noted that maximum axial force(Fx) and maximum bending moment(Mz) and in Beam-49 in irreguar frame comming out to be more then the same beam in regular structure.

COLUMN 41

When the forces of Column -41 of both the frames i.e frame 1 and frame 4 is compared, it is noted that the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 789 kN to 388 kN , 143 kN to 126 kN and 241 kNm to 181 kNm respectively. It is noted that the values of the forces maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) in Column-41 are more in regular frame

BEAM 33

When the forces of Beam-33 of both the frames i.e frame 1 and frame 4 is compared, it is noted that the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.77 kN to 116 kN and -8.01 kN to 13.6 kN respectively but the value of maximum bending moment(Mz) decreases from 309 kNm to 244 kNm from regular to irregular frame . It is noted that the maximum axial force(Fx) and the maximum shear force(Fy) and in Beam-33 in irreguar frame comming out to be more then the same beam in regular structure.

COLUMN 25

When the forces of Column -25 of both the frames i.e frame 1 and frame 4 is compared, it is noted that the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 1155 kN to 384 kN , 167 kN to 111 kN and 269 kNm to 152 kNm respectively. It is noted that the values of the forces maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) in Column-25 are more in regular frame.

BEAM 17

When the forces of Beam-17 of both the frames i.e frame 1 and frame 4 is compared, it is noted that the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from 1.4 kN to 116 kN and -22.4 kN to 26.1 kN respectively but the value of maximum bending moment(Mz) decreases from 352 kNm to 213 kNm from regular to irregular frame . It is noted that the maximum axial force(Fx) and the maximum shear force(Fy) and in Beam-17 in irreguar frame comming out to be more then the same beam in regular structure.

3.1.4. FRAME 1 AND FRAME 5

In this section the comparison of frame 1 and frame 5 is done. The beams at the setback i.e. Beam-38, Beam-48, Beam-52 and Beam-44 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

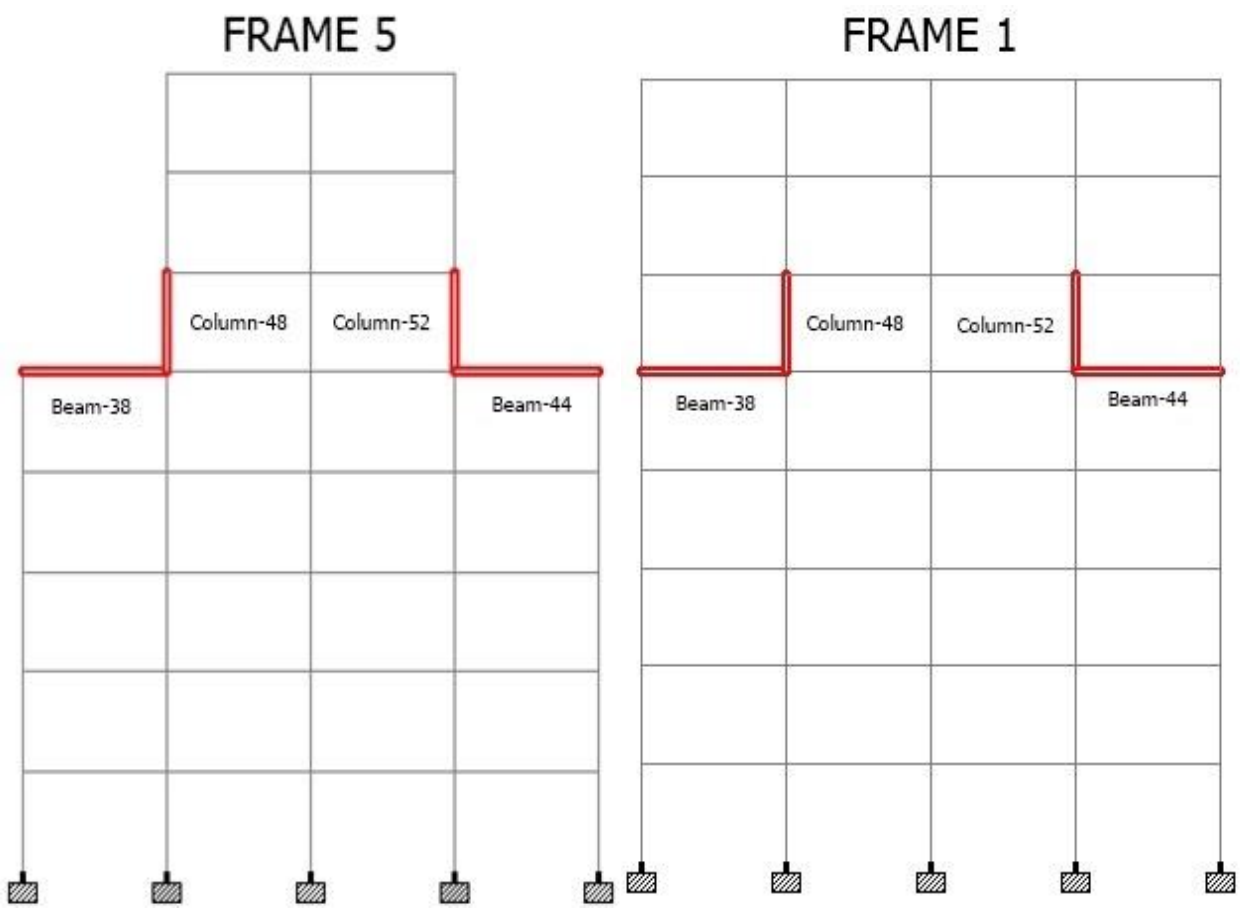


Fig.3.1.4.1 Frame 1 and Frame 5

BEAM 44

When the forces of Beam-44 of both the frames i.e frame 1 and frame 5 is compared, it is noted that the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -3.46 kN to 101 kN and -2.29 kN to 21.2 kN respectively but the value of maximum bending moment(Mz) decreases from 300 kNm to 225 kNm from regular to irregular frame . It is noted that the maximum axial force(Fx) and the maximum shear force(Fy) and in Beam-44 in irreguar frame comming out to be more then the same beam in regular structure.

COLUMN 52

When the forces of Column-52 of both the frames i.e frame 1 and frame 5 is compared, it is noted that the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 585 kN to 496 kN , 124 kN to 117 kN and 215 kNm to 172 kNm respectively. It is noted that the values of the forces maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) in Column-52 are more in regular frame.

COLUMN 48

When the forces of Column-48 of both the frames i.e frame 1 and frame 5 is compared, it is noted that the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 572 kN to 168 kN , 116 kN to 85.9 kN and 203 kNm to 107 kNm respectively. It is noted that the values of the forces maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) in Column-48 are more in regular frame.

BEAM 38

When the forces of Beam-38 of both the frames i.e frame 1 and frame 5 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 5.88 kN to 24 kN and rest of the forces i.e maximum axial force(Fx) and maximum bending moment(Mz) decreases from 1.98 kN to -29.2 kN and 265 kNm to 228 kNm respectively. It is noted that the maximum shear force(Fy) in Beam-38 in irreguar frame comming out to be more then the same beam in regular structure.

3.1.5. FRAME 1 AND FRAME 6

In this section the comparison of frame 1 and frame 6 is done. The beams at the setback i.e. Beam-20, Column-30, Column-34 and Beam-26 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

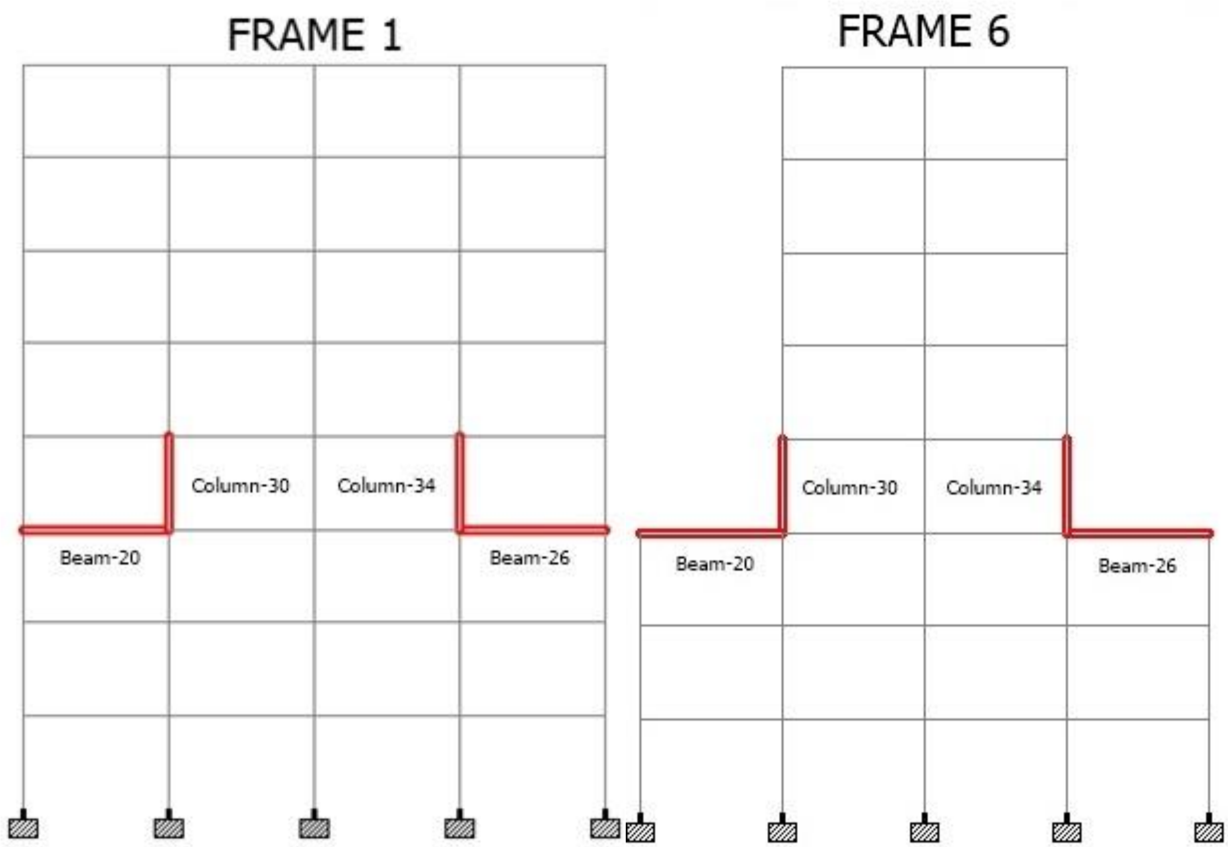


Fig.3.1.5.1 Frame 1 and Frame 6

BEAM 20

When the forces of Beam-20 of both the frames i.e frame 1 and frame 6 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from -17.4 kN to 9.98 kN and rest of the forces i.e maximum axial force(Fx) and maximum bending moment(Mz) decreases from -0.83 kN to -57.6 kN and 332 kNm to 268 kNm respectively. It is noted that the maximum shear force(Fy) in Beam-20 in irreguar frame comming out to be more then the same beam in regular structure.

COLUMN 30

When the forces of Column-30 of both the frames i.e frame 1 and frame 6 is compared, it is noted that the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 963 kN to 154 kN , 155 kN to 118 kN and 254 kNm to 126 kNm respectively. It is noted that the values of the forces maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) in Column-30 are more in regular frame.

COLUMN 34

When the forces of Column-34 of both the frames i.e frame 1 and frame 6 is compared, it is noted that the value of maximum axial force(Fx) from regular to irregular frame increases from 966 kN to 970 kN and rest of the forces i.e maximum shear force (Fy) and maximum bending moment(Mz) decreases from 160 kN to 147 kN and 263 kNm to 189 kNm respectively. It is noted that the maximum axial force(Fx) in Column -34 in irreguar frame comming out to be more then the same Column in regular structure

BEAM 26

When the forces of Beam-26 of both the frames i.e frame 1 and frame 6 is compared, it is noted that the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.32 kN to 125 kN and -21.6 kN to 10.7 kN respectively but the value of maximum bending moment(Mz) decreases from 350 kNm to 247 kNm from regular to irregular frame . It is noted that the maximum axial force(Fx) and the maximum shear force(Fy) and in beam-26 in irreguar frame comming out to be more then the same beam in regular structure.

<u>3.1.6. FRAME 1 AND FRAME 7</u>

In this section the comparison of frame 1 and frame 3 is done. The beams at the setback i.e. Beam-47, Column-57, Column-34 and Beam-26 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

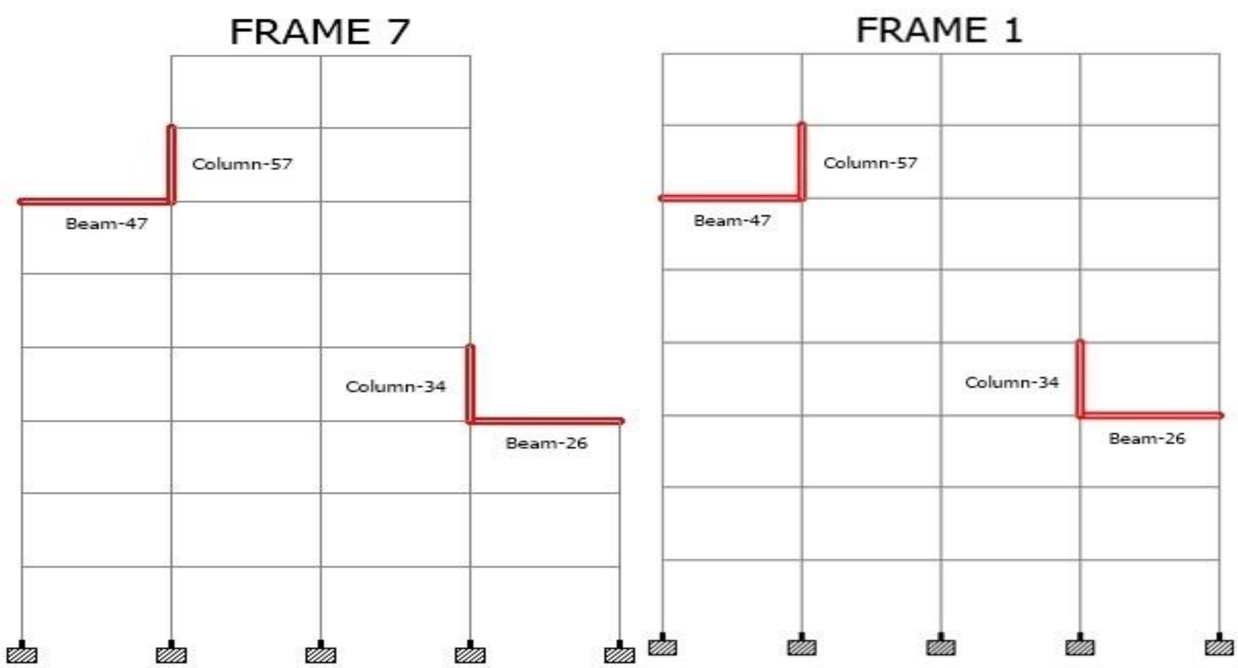


Fig.3.1.6.1 Frame 1 and Frame 7

BEAM 47

When the forces of Beam-47 of both the frames i.e frame 1 and frame 7 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 25.6 kN to 26.4 kN and rest of the forces i.e maximum axial force(Fx) and maximum bending moment(Mz) decreases from 5.45 kN to -21.6 kN and 217 kNm to 216 kNm respectively. It is noted that the maximum shear force(Fy) in Beam-47 in irreguar frame comming out to be more then the same beam in regular structure.

COLUMN 57

When the forces of Column-57 of both the frames i.e frame 1 and frame 7 is compared, it is noted that the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 380 kN to 139 kN , 81.4 kN to 63.5 kN and 152 kNm to 101 kNm respectively. It is noted that the values of the forces maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) in Column-57 are more in regular frame.

COLUMN 34

When the forces of Column-34 of both the frames i.e frame 1 and frame 7 is compared, it is noted that the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 966 kN to 887 kN , 160 kN to 133 kN and 263 kNm to 189 kNm respectively. It is noted that the values of the forces maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) in Column-34 are more in regular frame

BEAM 26

When the forces of Beam-26 of both the frames i.e frame 1 and frame 7 is compared, it is noted that the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.32 kN to 131 kN and -21.6 kN to 8.04 kN respectively but the value of maximum bending moment(Mz) decreases from 350 kNm to 257 kNm from regular to irregular frame. It is noted that the maximum axial force(Fx) and the maximum shear force(Fy) and in Beam-26 in irreguar frame comming out to be more then the same beam in regular structure.

3.2. COMPARISON OF STRUCTURES: RESPONSE SPECTRUM ANALYSIS

Response spectrum analysis for seven types of structure was done on regular and irregular structures using Staad.Pro.V8i. The axial force and maximum bending moment for columns, shear force and maximum bending moment for beam were calculated at the setbacks and each irregular structure is compared with the same members in regular structure.

3.2.1 STRUCTURES 1 AND STRUCTURES 2

In this section the comparison of structure 1 and structure 2 is done. The beams and column at the setback i.e. column-350 and Beam-281 are compared with the regular structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

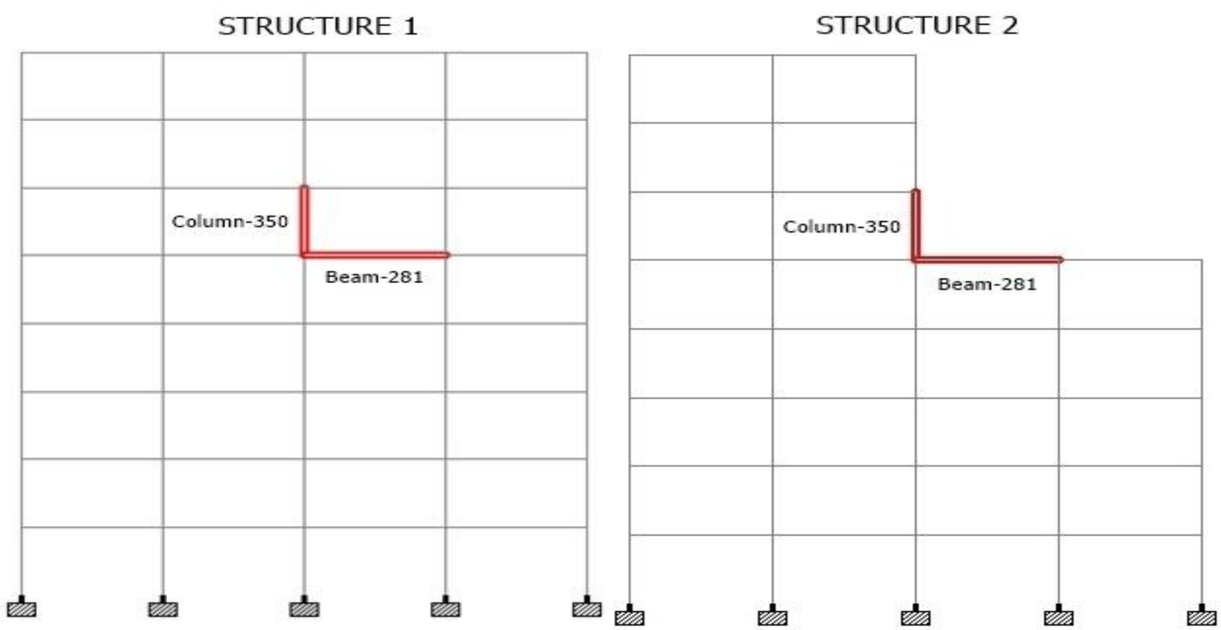


Fig.3.2.1.1 Structure 1 and Structure 2

COLUMN 350

When the forces of column-350 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 977 kN to 98 kN, maximum axial force(Fx) increases from 4.7 kN to 165 kN and maximum bending moment(Mz) decreases from 1642 kNm to 182 kNm. It is noted that the maximum axial force(Fx) in column-350 in irreguar frame coming out to be more than the same column in regular structure.

BEAM 281

When the forces of Beam-281 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 638 kN to 51 kN and 1594 kNm to 140 kNm respectively but the value of maximum axial force(Fx) increases from 7.7 kN to 152 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-281 in irreguar structure coming out to be more than the same beam in regular structure.

3.2.2. STRUCTURES 1 AND STRUCTURES 3

In this section the comparison of structure 1 and structure 3 is done. The beams and columns at the setback i.e. column-415, column-286, Beam-346 and Beam-217 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

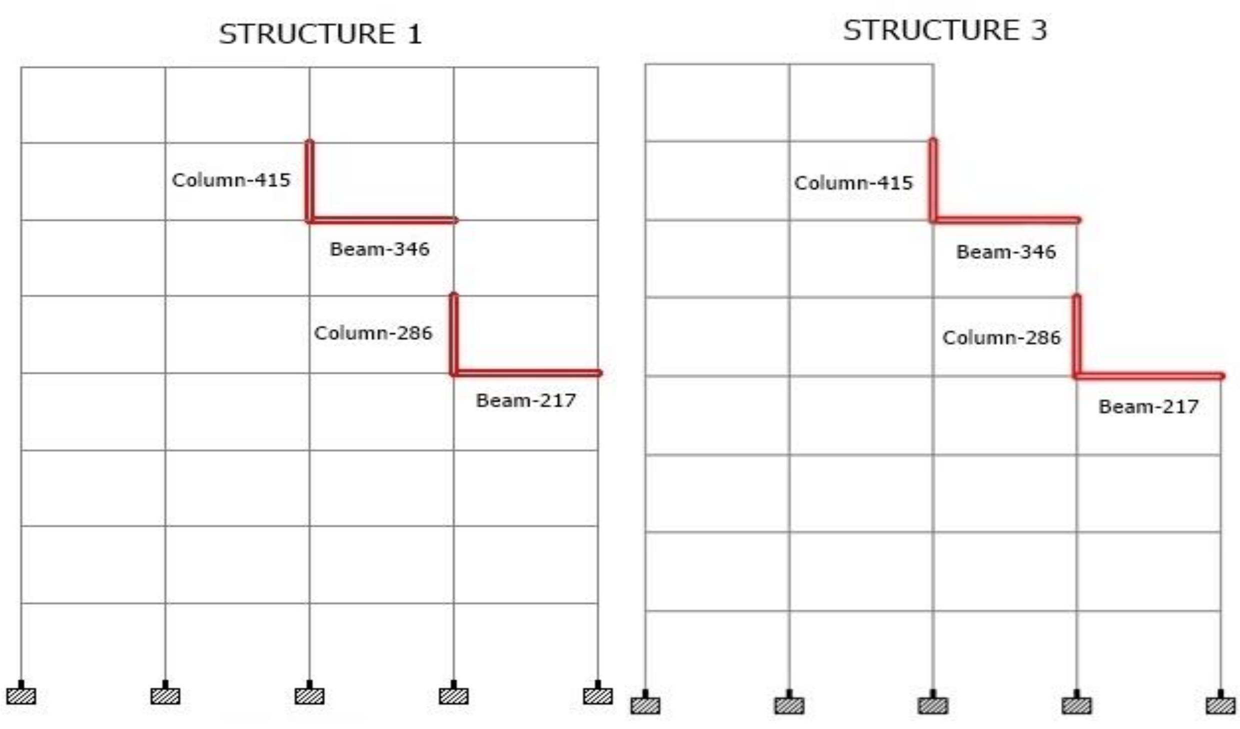


Fig.3.2.2.1 Structure 1 and Structure 3

COLUMN 415

When the forces of column-415 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 782 kN to 80 kN, maximum axial force(Fx) increases from 3.2 kN to 86 kN and maximum bending moment(Mz) decreases from 1389 kNm to 131 kNm. It is noted that the maximum axial force(Fx) in column-415 in irreguar frame coming out to be more than the same column in regular structure.

COLUMN 286

When the forces of column-286 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 1070 kN to 88 kN, maximum axial force(Fx) increases from 58 kN to 133 kN and maximum bending moment(Mz) decreases from 1765 kNm to 162 kNm. It is noted that the maximum axial force(Fx) in column-286 in irreguar frame coming out to be more than the same column in regular structure.

BEAM 346

When the forces of Beam-346 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 546 kN to 52 kN and 1765 kNm to 146 kNm respectively but the value of maximum axial force(Fx) increases from 5.4 kN to 59 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-346 in irreguar structure coming out to be more than the same beam in regular structure.

BEAM 217

When the forces of Beam-217 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 733 kN to 61 kN and 1901 kNm to 157 kNm respectively but the value of maximum axial force(Fx) increases from 27 kN to 75 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-217 in irreguar structure coming out to be more than the same beam in regular structure.

3.2.3. STRUCTURES 1 AND STRUCTURES 4

In this section the comparison of structure 1 and structure 4 is done. The beams and columns at the setback i.e. column-414,285,156, Beam-345, 216, 87 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

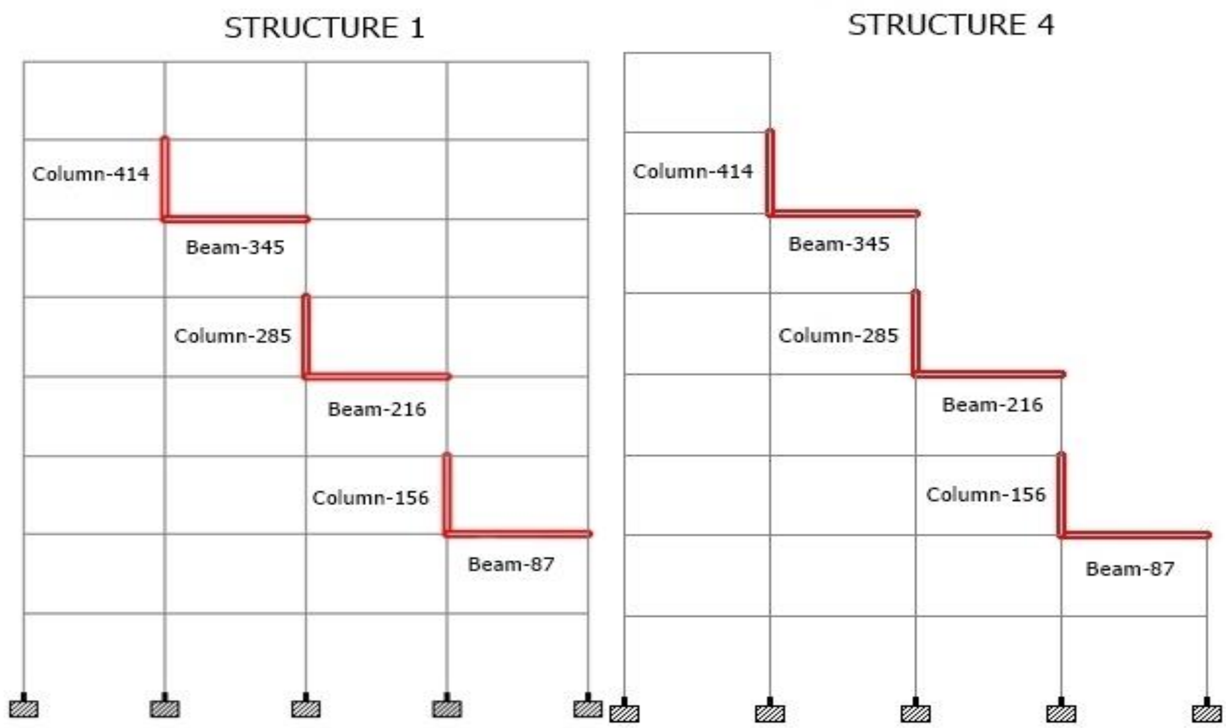


Fig.3.2.3.1 Structure 1 and Structure 4

COLUMN 414

When the forces of column-414 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 773 kN to 94 kN, maximum axial force(Fx) increases from 3 kN to 112 kN and maximum bending moment(Mz) decreases from 1371 kNm to 162 kNm. It is noted that the maximum axial force(Fx) in column-414 in irreguar frame coming out to be more than the same column in regular structure.

COLUMN 285

When the forces of column-285 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 1067 kN to 94 kN, maximum axial force(Fx) increases from 6 kN to 147 kN and maximum bending moment(Mz) decreases from 537 kNm to 176 kNm. It is noted that the maximum axial force(Fx) in column-285 in irreguar frame coming out to be more than the same column in regular structure.

COLUMN 156

When the forces of column-156 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 1315 kN to 94 kN, maximum axial force(Fx) increases from 24 kN to 143 kN and maximum bending moment(Mz) decreases from 2169 kNm to 170 kNm. It is noted that the maximum axial force(Fx) in column-156 in irreguar frame coming out to be more than the same column in regular structure.

BEAM 345

When the forces of Beam-345 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 544 kN to 65 kN and 1359 kNm to 165 kNm respectively but the value of maximum axial force(Fx) increases from 5.2 kN to 64 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-345 in irreguar structure coming out to be more than the same beam in regular structure.

BEAM 216

When the forces of Beam-216 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 700 kN to 63 kN and 1751 kNm to 161 kNm respectively but the value of maximum axial force(Fx) increases from 13 kN to 75 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-216 in irreguar structure coming out to be more than the same beam in regular structure.

BEAM 87

When the forces of Beam-87 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 901 kN to 66 kN and 2335 kNm to 168 kNm respectively but the value of maximum axial force(Fx) increases from 24 kN to 80 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-87 in irreguar structure coming out to be more than the same beam in regular structure.

3.2.4. STRUCTURES 1 AND STRUCTURES 5

In this section the comparison of structure 1 and structure 5 is done. The beams and columns at the setback i.e. column-349, 351, Beam-279, 282 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

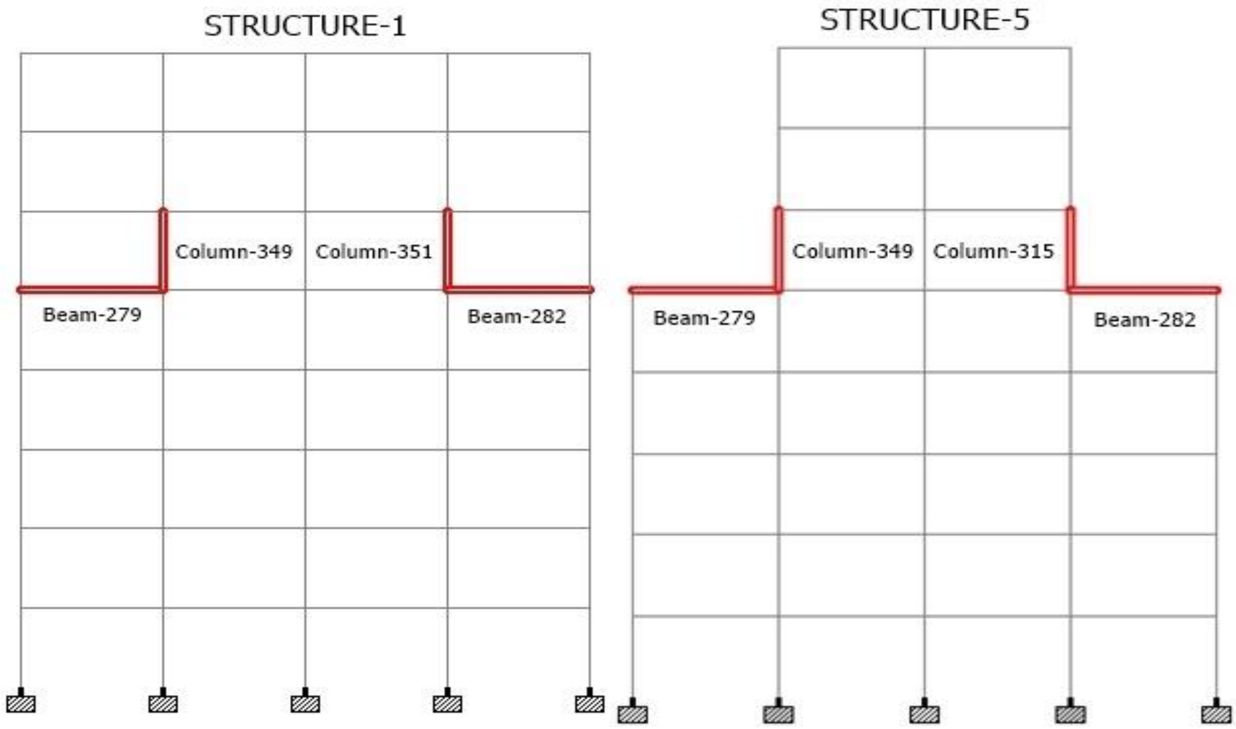


Fig.3.2.4.1 Structure 1 and Structure 5

COLUMN 349

When the forces of column-349 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 974 kN to 90 kN, maximum axial force(Fx) increases from 98 kN to 159 kN and maximum bending moment(Mz) decreases from 1636 kNm to 169 kNm. It is noted that the maximum axial force(Fx) in column-349 in irreguar frame coming out to be more than the same column in regular structure.

COLUMN 351

When the forces of column-351 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 974 kN to 90 kN, maximum axial force(Fx) increases from 33 kN to 159 kN and maximum bending moment(Mz) decreases from 1636 kNm to 169 kNm. It is noted that the maximum axial force(Fx) in column-351 in irreguar frame coming out to be more than the same column in regular structure.

BEAM 279

When the forces of Beam-279 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 662 kN to 54 kN and 1716 kNm to 140 kNm respectively but the value of maximum axial force(Fx) increases from 13 kN to 61 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-279 in irreguar structure coming out to be more than the same beam in regular structure.

BEAM 282

When the forces of Beam-282 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 659 kN to 54 kN and 1711 kNm to 139 kNm respectively but the value of maximum axial force(Fx) increases from 14 kN to 61 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-282 in irreguar structure coming out to be more than the same beam in regular structure.

3.2.5. STRUCTURES 1 AND STRUCTURES 6

In this section the comparison of structure 1 and structure 6 is done. The beams and columns at the setback i.e. column-219, 221, Beam-149, 152 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

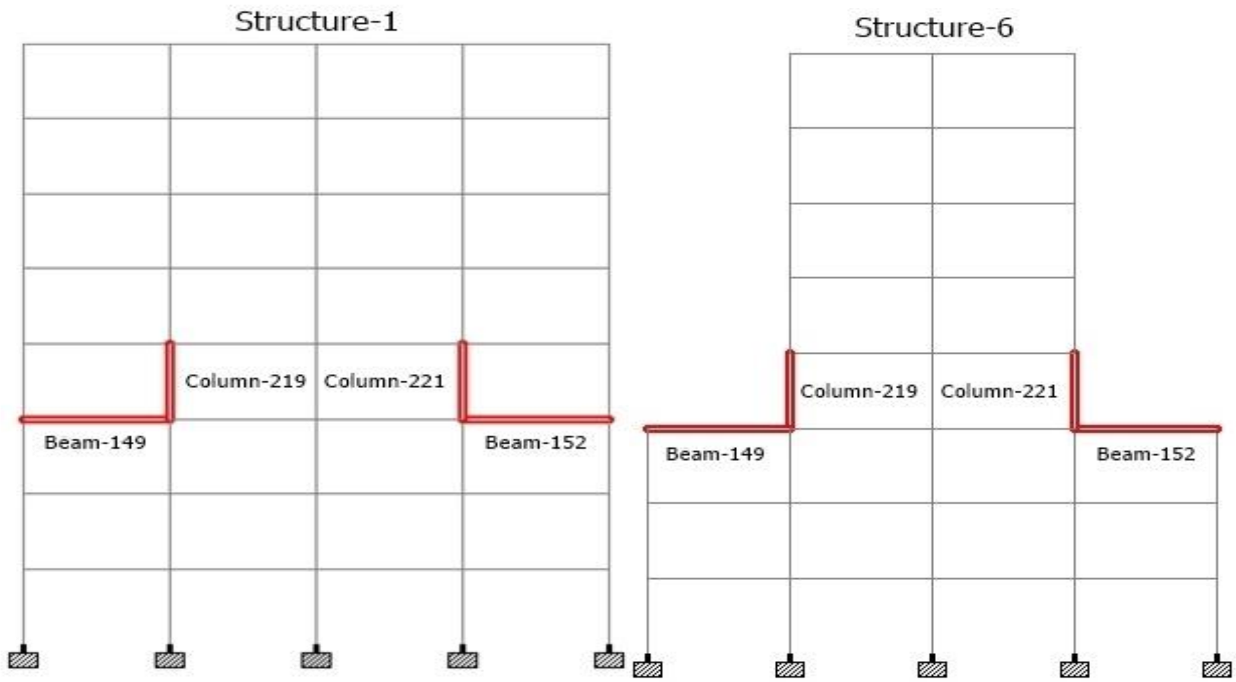


Fig.3.2.5.1 Frame 1 and Frame 6

COLUMN 219

When the forces of column-219 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 1180 kN to 100 kN, maximum axial force(Fx) increases from 93 kN to 348 kN and maximum bending moment(Mz) decreases from 1957 kNm to 200 kNm. It is noted that the maximum axial force(Fx) in column-219 in irreguar frame coming out to be more than the same column in regular structure.

COLUMN 221

When the forces of column-221 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 1180 kN to 100 kN, maximum axial force(Fx) increases from 91 kN to 347 kN and maximum bending moment(Mz) decreases from 1957 kNm to 200 kNm. It is noted that the maximum axial force(Fx) in column-221 in irreguar frame coming out to be more than the same column in regular structure.

BEAM 149

When the forces of Beam-149 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 822 kN to 59 kN and 2130 kNm to 154 kNm respectively but the value of maximum axial force(Fx) increases from 28 kN to 69 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-149 in irreguar structure coming out to be more than the same beam in regular structure.

BEAM 152

When the forces of Beam-152 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 820 kN to 59 kN and 2126 kNm to 154 kNm respectively but the value of maximum axial force(Fx) increases from 28 kN to 69 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-152 in irreguar structure coming out to be more than the same beam in regular structure.

3.2.6. STRUCTURES 1 AND STRUCTURES 7

In this section the comparison of structure 1 and structure 6 is done. The beams and columns at the setback i.e. column-414, 221, Beam-344, 152 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

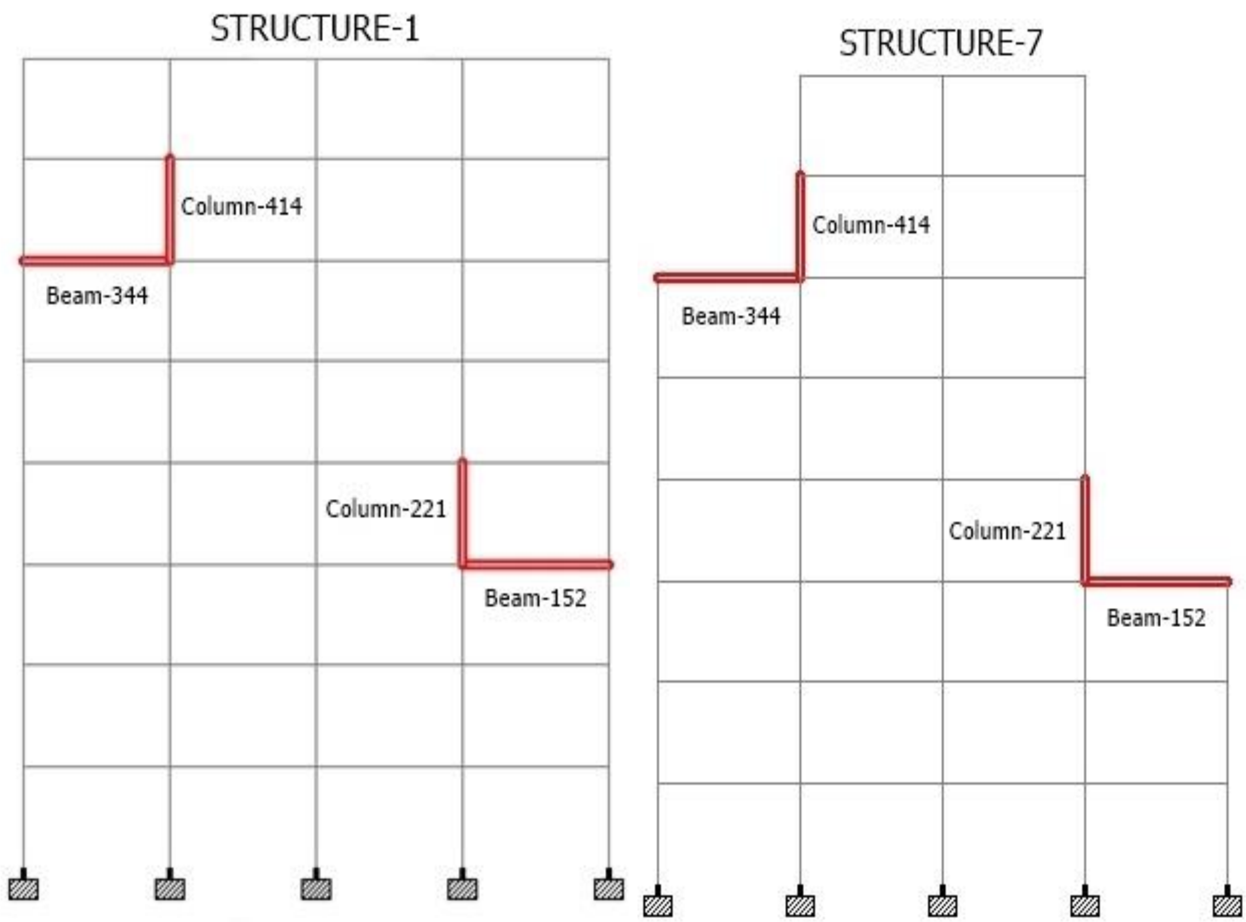


Fig.3.2.6.1 Frame 1 and Frame 1

COLUMN 414

When the forces of column-414 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 773 kN to 79 kN, maximum axial force(Fx) increases from 76 kN to 87 kN and maximum bending moment(Mz) decreases from 1371 kNm to 131 kNm. It is noted that the maximum axial force(Fx) in column-414 in irreguar frame coming out to be more than the same column in regular structure.

COLUMN 221

When the forces of column-221 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular structure decreases from 1180 kN to 96 kN, maximum axial force(Fx) increases from 90 kN to 292 kN and maximum bending moment(Mz) decreases from 1957 kNm to 177 kNm. It is noted that the maximum axial force(Fx) in column-221 in irreguar frame coming out to be more than the same column in regular structure.

BEAM 344

When the forces of Beam-344 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 560 kN to 57 kN and 1453 kNm to 144 kNm respectively but the value of maximum axial force(Fx) increases from 5 kN to 61 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-344 in irreguar structure coming out to be more than the same beam in regular structure.

BEAM 152

When the forces of Beam-152 of both the structures i.e structure 1 and structure 2 is compared, it is noted that the value of maximum shear force(Fy) and maximum bending moment(Mz) from regular structure to irregular structure decreases from 820 kN to 68 kN and 2126 kNm to 174 kNm respectively but the value of maximum axial force(Fx) increases from 28 kN to 82 kN from regular to irregular frame. It is noted that the maximum axial force(Fx) in Beam-152 in irreguar structure coming out to be more than the same beam in regular structure.

3.3 FRAMES AND STRUCTURE UNDER LOAD

3.3.1 FRAMES UNDER STATIC LOAD

3.3.1.1 REGULAR FRAME

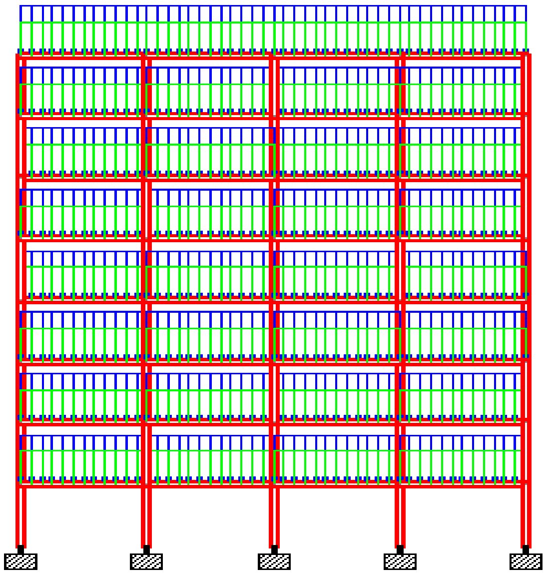


Fig.3.3.1.1.1 Frame under Dead and Live load

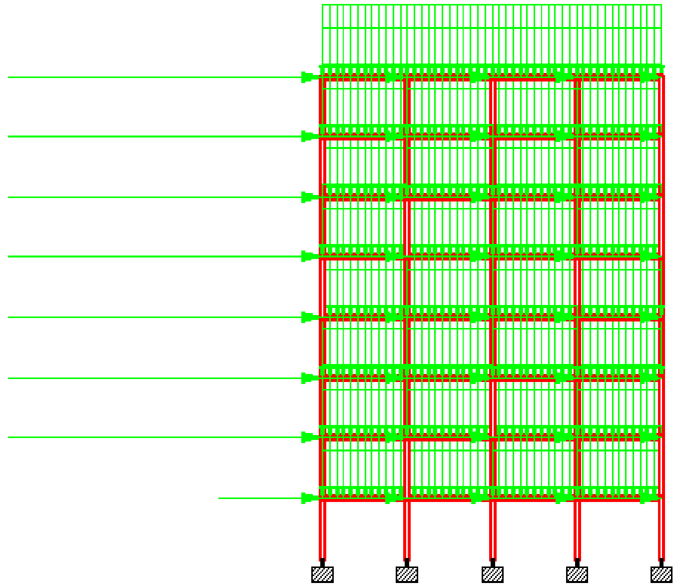


Fig.3.3.1.1.2 Frame under Earthquake Load

3.3.1.2 IRREGULAR FRAME

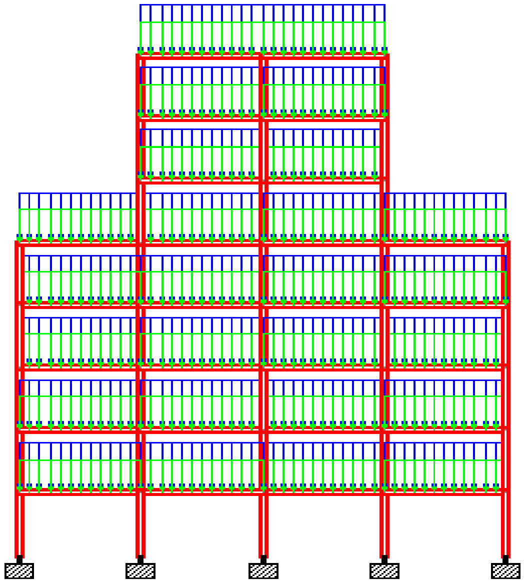


Fig.3.3.1.2.1 Frame under Dead and Live load

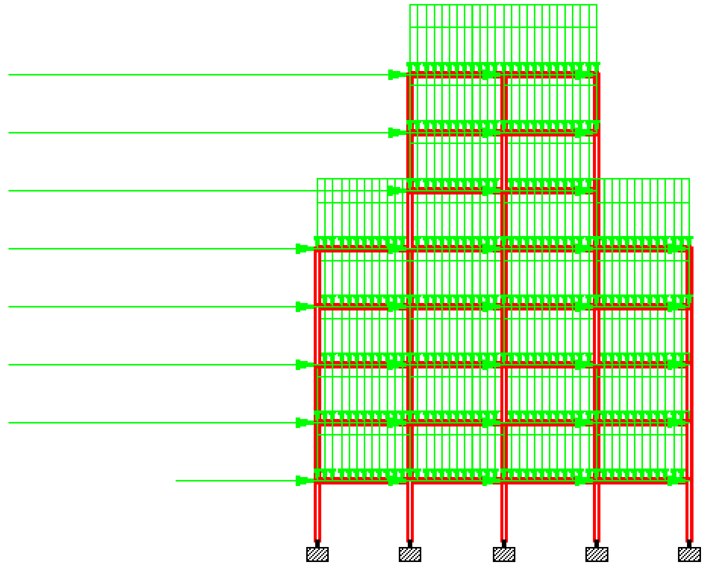


Fig.3.3.1.2.2 Frame under Earthquake Load

3.3.2 FRAMES UNDER DYNAMIC LOAD

3.3.2.1 REGULAR FRAME

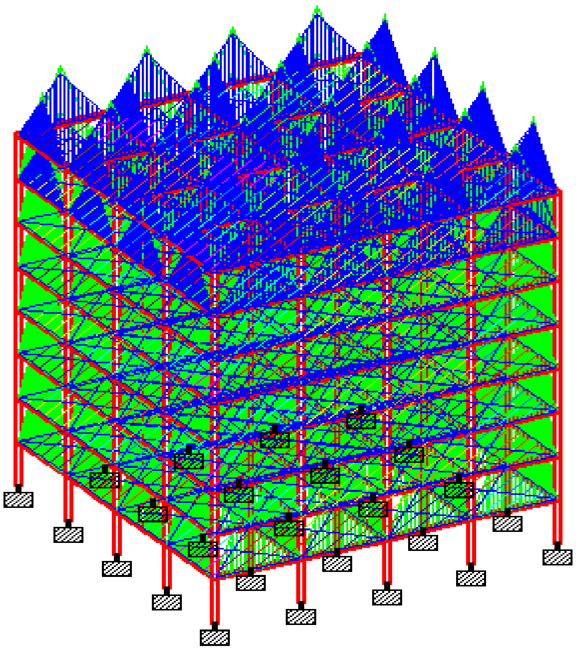


Fig.3.3.2.1.1 Structure under Dead and Live load

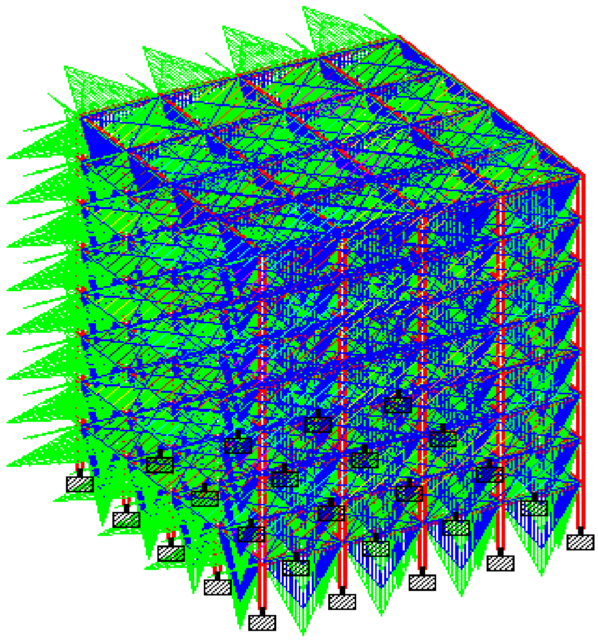


Fig.3.3.2.1.2 Structure under Earthquake Load

3.3.2.2 IRREGULAR FRAME

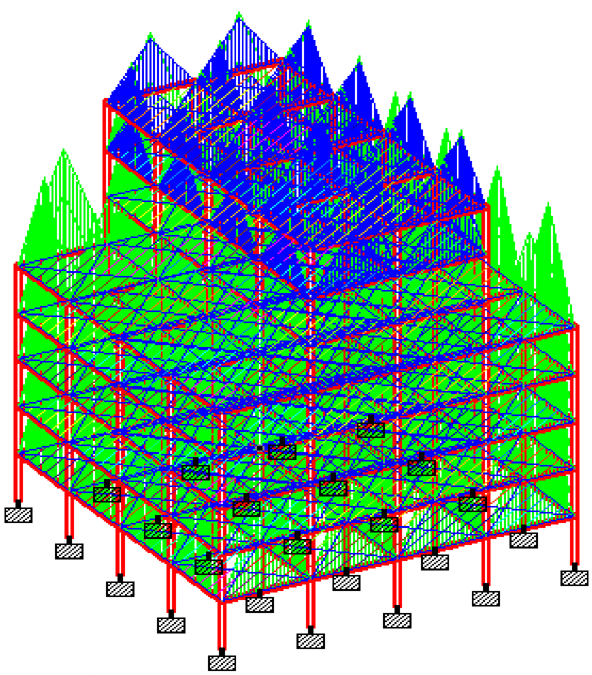


Fig.3.3.2.2.1 Structure under Dead and Live load

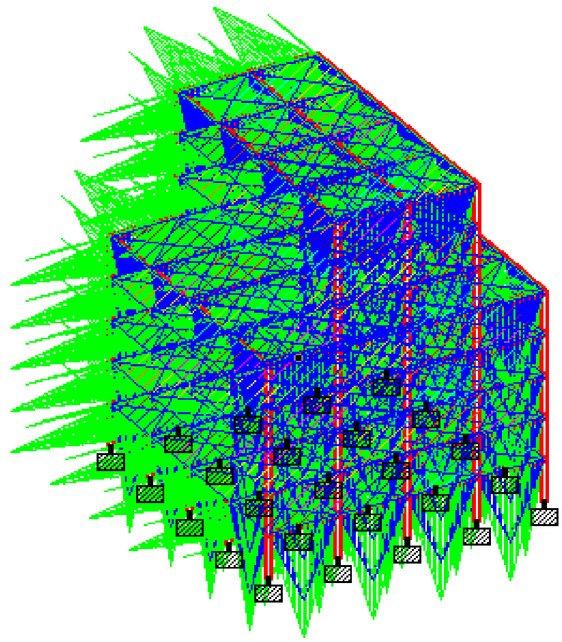


Fig.3.3.2.2.2 Structure under Earthquake Load

3.4 NODEL DISPLACEMENT

Following are the figures shows the nodel displacement after doing static analysis of all the seven frames:

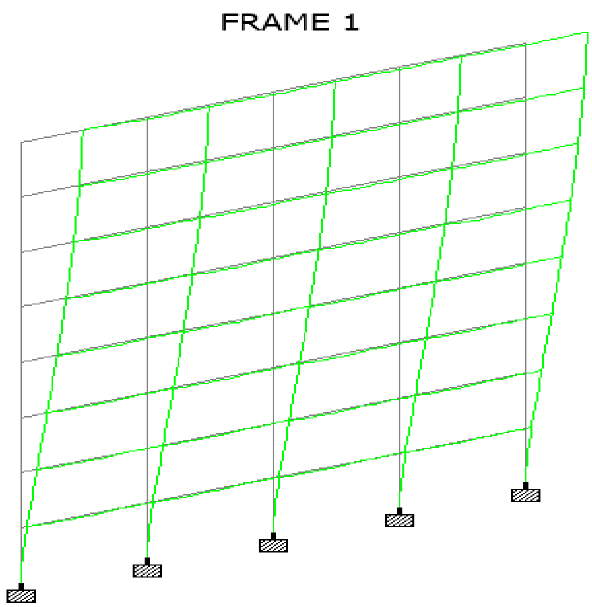


Fig.3.4.1 Frame 1

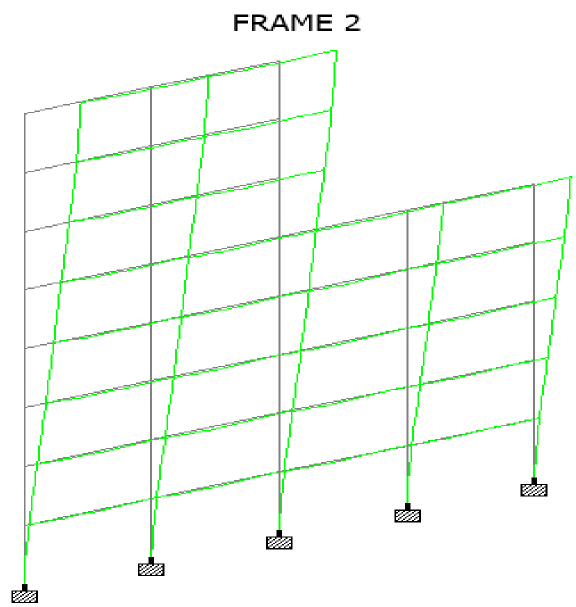


Fig.3.4.2 Frame 2

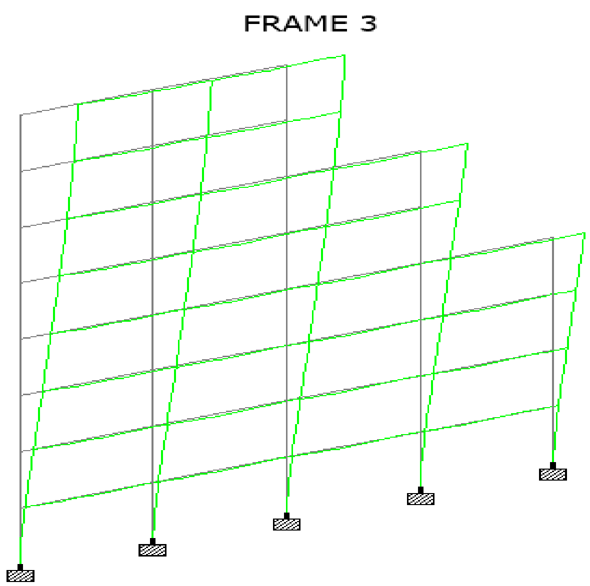


Fig.3.4.3 Frame 3

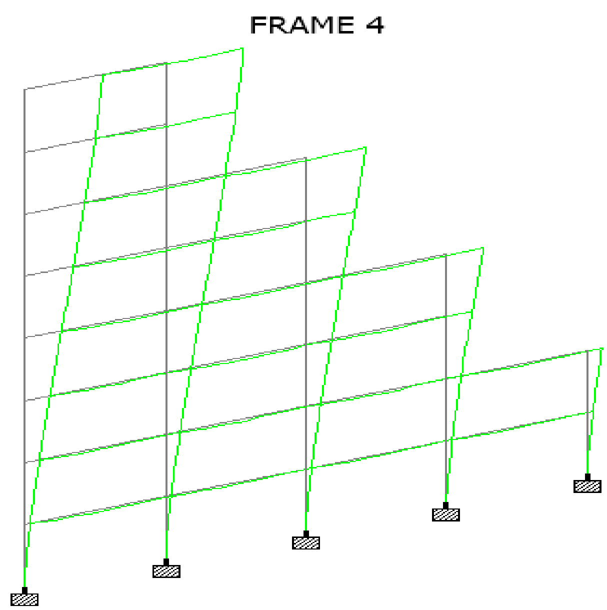


Fig.3.4.4 Frame 4

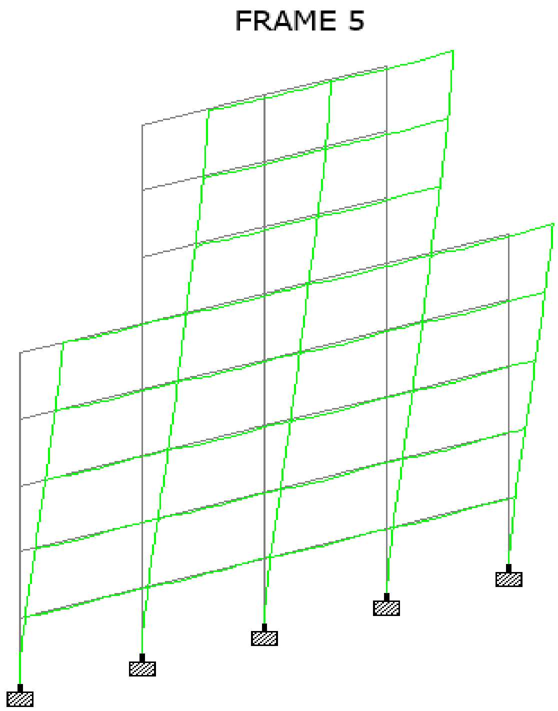


Fig.3.4.5 Frame 5

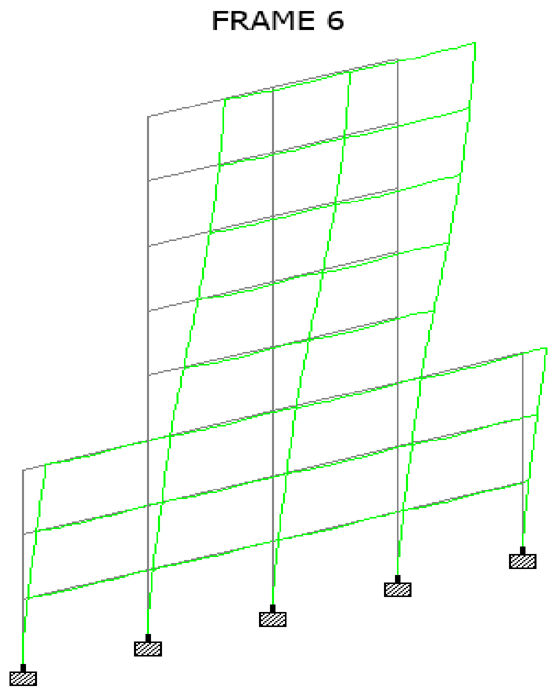


Fig.3.4.6 Frame 6

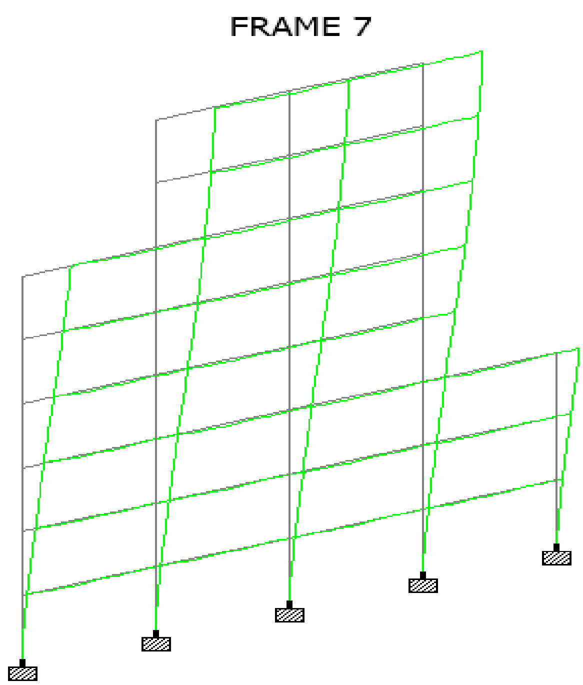


Fig.3.4.7 Frame 7

3.5 MODE SHAPES

Following are the mode shapes that is obtained after doing the response spectrum analysis of all the seven structures:

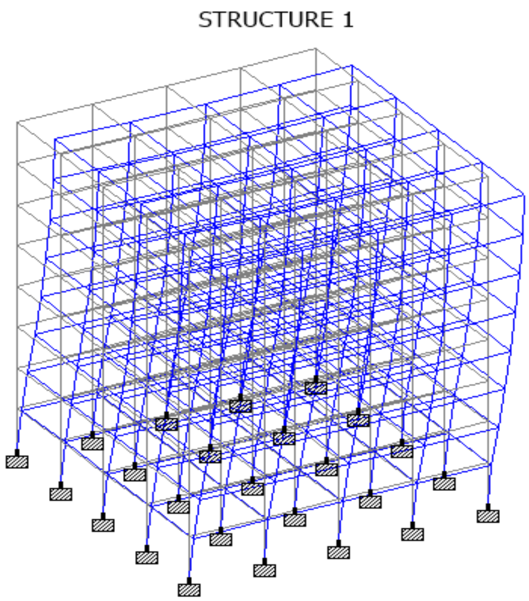


Fig.3.4.1 Structure 1

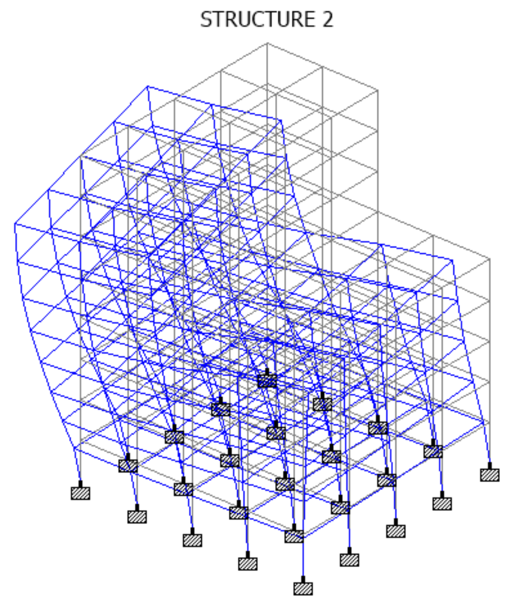


Fig.3.4.2 Structure 2

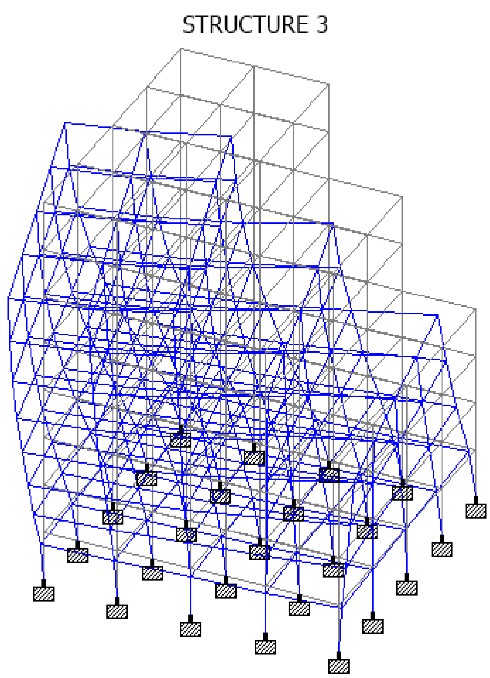


Fig.3.4.3 Structure 3

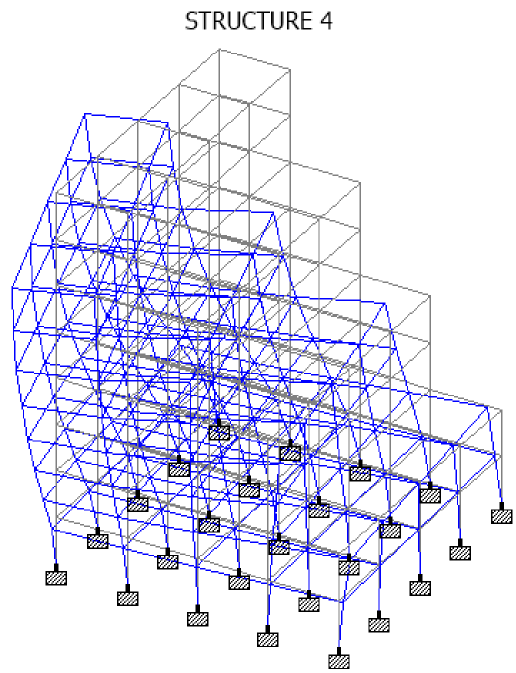


Fig.3.4.4 Structure 4

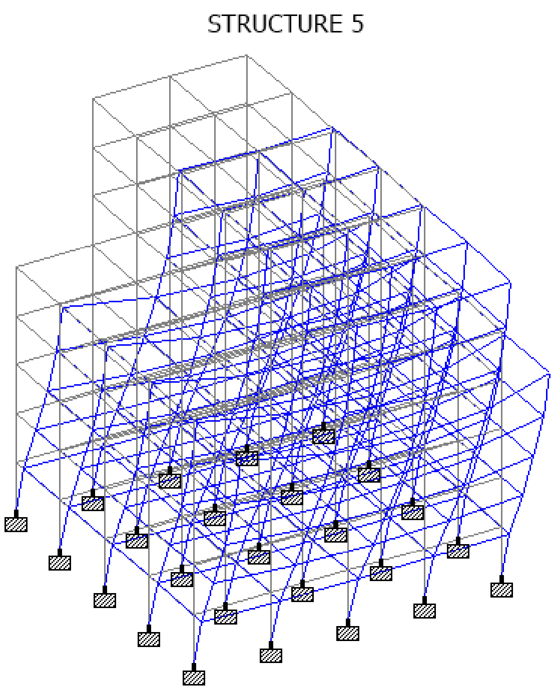


Fig.3.4.5 Structure 5

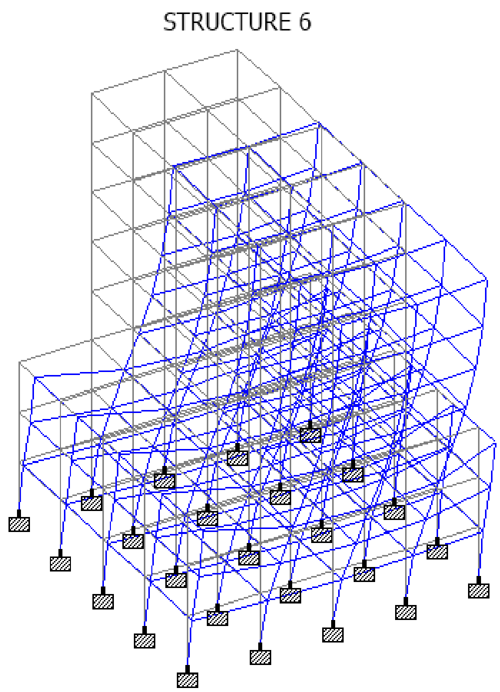


Fig.3.4.6 Structure 6

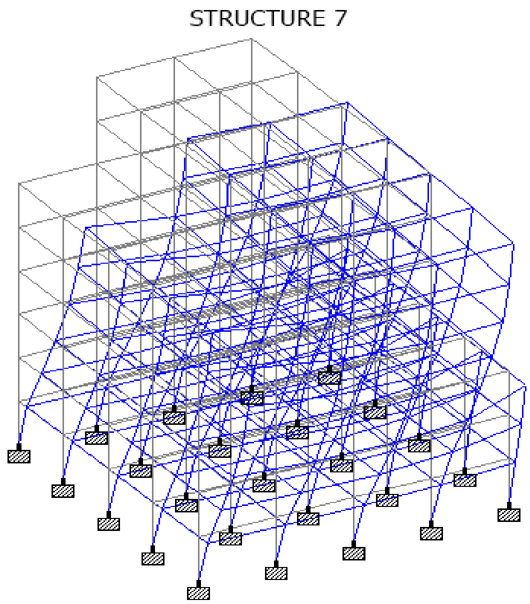


Fig.3.4.7 Structure 7

3.2. DISCUSSION

3.2.1 LINEAR STATIC ANALYSIS

3.2.1.1 FRAME 1 AND FRAME 2

- It is noted that in Column-50 the value of maximum shear force (Fy) from regular to irregular frame increases from 121kN to 131kN.
- It is noted that in Beam-42 the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.69 kN to 205 kN and 3.5 kN to 21.3 kN respectively.

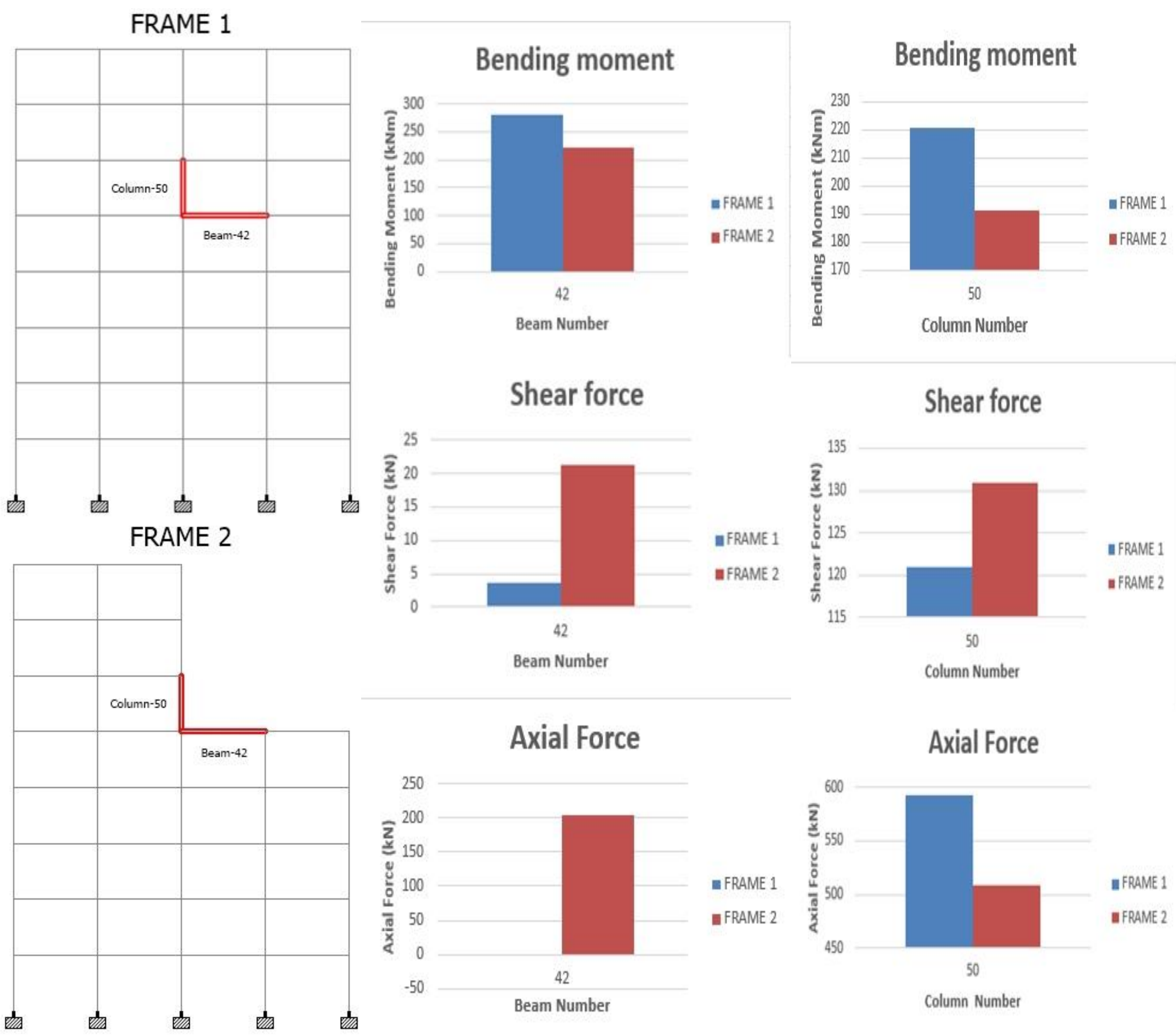


Fig.3.2.1.1 Forces in Frame 1 and Frame 2

3.2.1.2 FRAME 1 AND FRAME 3

- It is noted in that Column-59 the value of maximum shear force (Fy) from regular to irregular frame increases from 89kN to 98.9kN.
- It is noted that in Beam-51 the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.69 kN to 91.7 kN and 20.7 kN to 23.5 kN respectively.
- It is noted that in Column -43 the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 776kN to 375kN , 146kN to 119kN and 245kNm to 174kNm respectively.
- It is noted that in Bram- 35 the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -2.44 kN to 116 kN and -14.6 kN to 15.6 kN respectively.

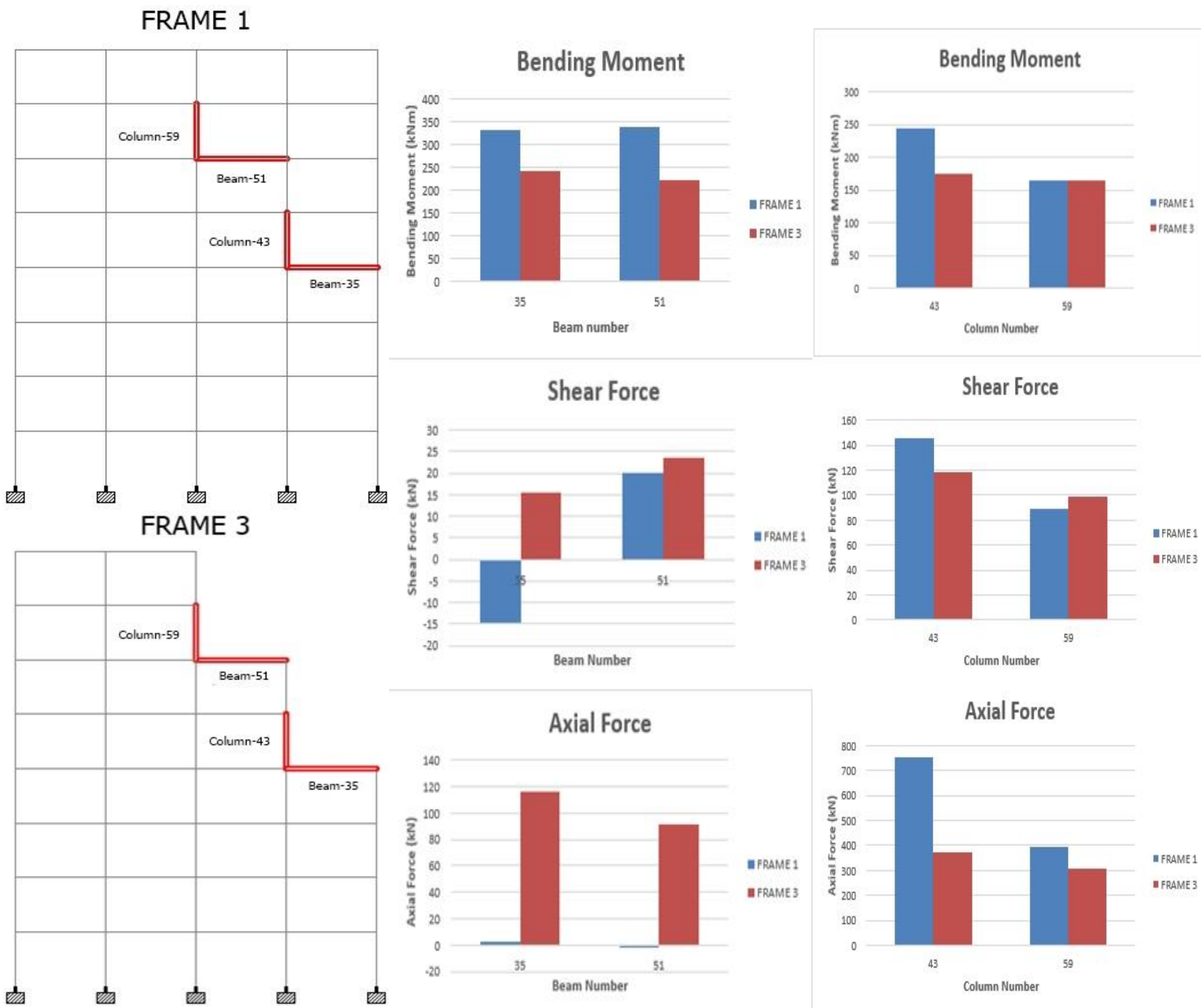


Fig.3.2.1.2 Forces in Frame 1 and Frame 3

3.2.1.3 FRAME 1 AND FRAME 4

- It is noted that in Column-57 the value of maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame increases from 81.4 kN to 110 kN and 152 kNm to 172 kNm respectively.
- It is noted that in Beam-49 the value of maximum axial force(Fx) and maximum bending moment(Mz) from regular frame to irregular frame increases from 0.672 kN to 97.7 kN and 238 kNm to 240 kNm respectively.
- It is noted that in Column-41 the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 789kN to 388kN , 143N to 126kN and 241kNm to 181kNm respectively.
- It is noted that in Beam-33 the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.77 kN to 116 kN and -8.01 kN to 13.6 kN respectively.
- It is noted that in Column-25 the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 1155 kN to 384 kN , 167 kN to 111 kN and 269 kNm to 152 kNm respectively.
- It is noted that in Beam-17 the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from 1.4kN to 116 kN and -22.4 kN to 26.1 kN respectively.

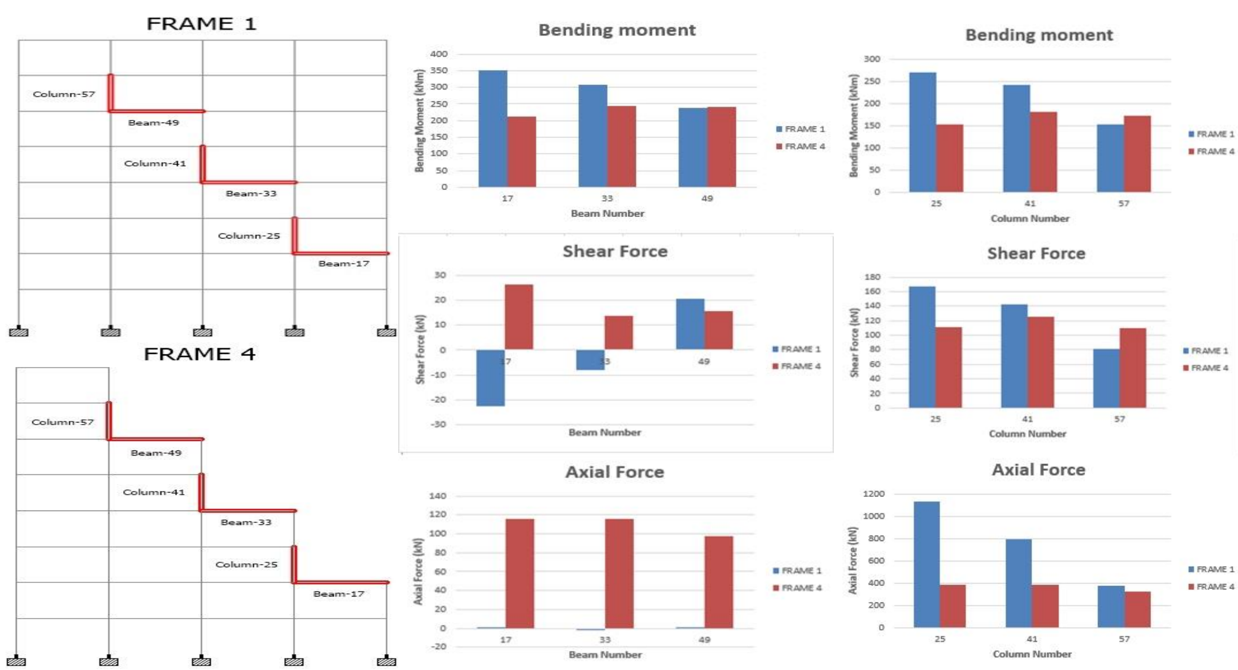


Fig.3.2.1.3 Forces in Frame 1 and Frame 4

3.2.1.4 FRAME 1 AND FRAME 5

- It is noted that in Beam-44 the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -3.46 kN to 101 kN and -2.29 kN to 21.2 kN respectively.
- It is noted that in Column-52 the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 585kN to 496 kN , 124 kN to 117 kN and 215 kNm to 172 kNm respectively.
- It is noted that in Column-48 the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 572kN to 168 kN , 116 kN to 85.9 kN and 203 kNm to 107 kNm respectively.
- It is noted that in Beam-38 the value of maximum shear force (Fy) from regular to irregular frame increases from 5.88 kN to 24 kN.

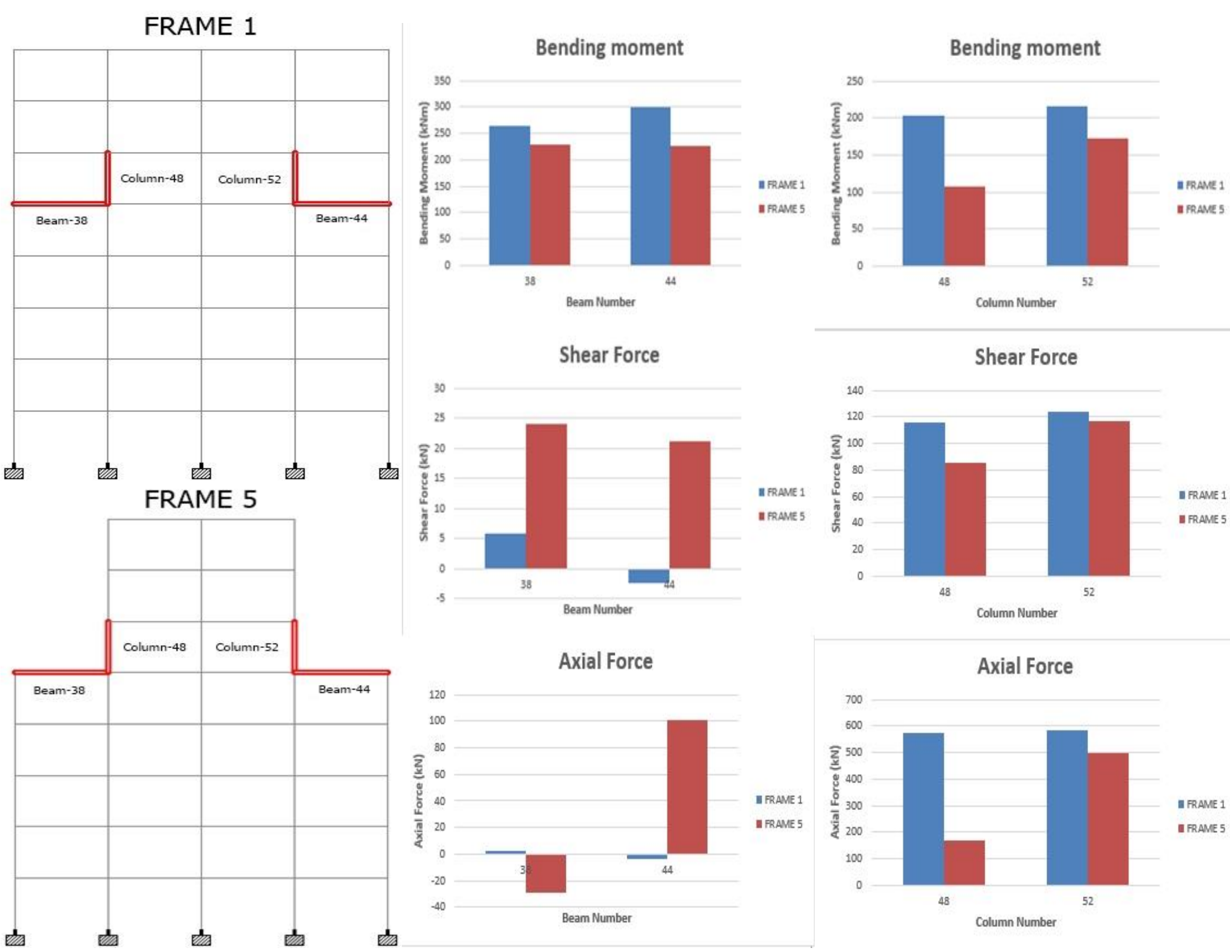


Fig. 3.2.1.4 Forces in Frame 1 and Frame 5

3.2.1.5 FRAME 1 AND FRAME 6

- It is noted that in Beam-20 the value of maximum shear force (Fy) from regular to irregular frame increases from -17.4 kN to 9.98 kN.
- It is noted that in Column-30 the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 963kN to 154 kN , 155 kN to 118 kN and 254 kNm to 126 kNm respectively.
- It is noted that in Column-34 the value of maximum axial force(Fx) from regular to irregular frame increases from 966 kN to 970 kN.
- It is noted that in Beam-26 the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.32 kN to 125 kN and -21.6 kN to 10.7 kN respectively.

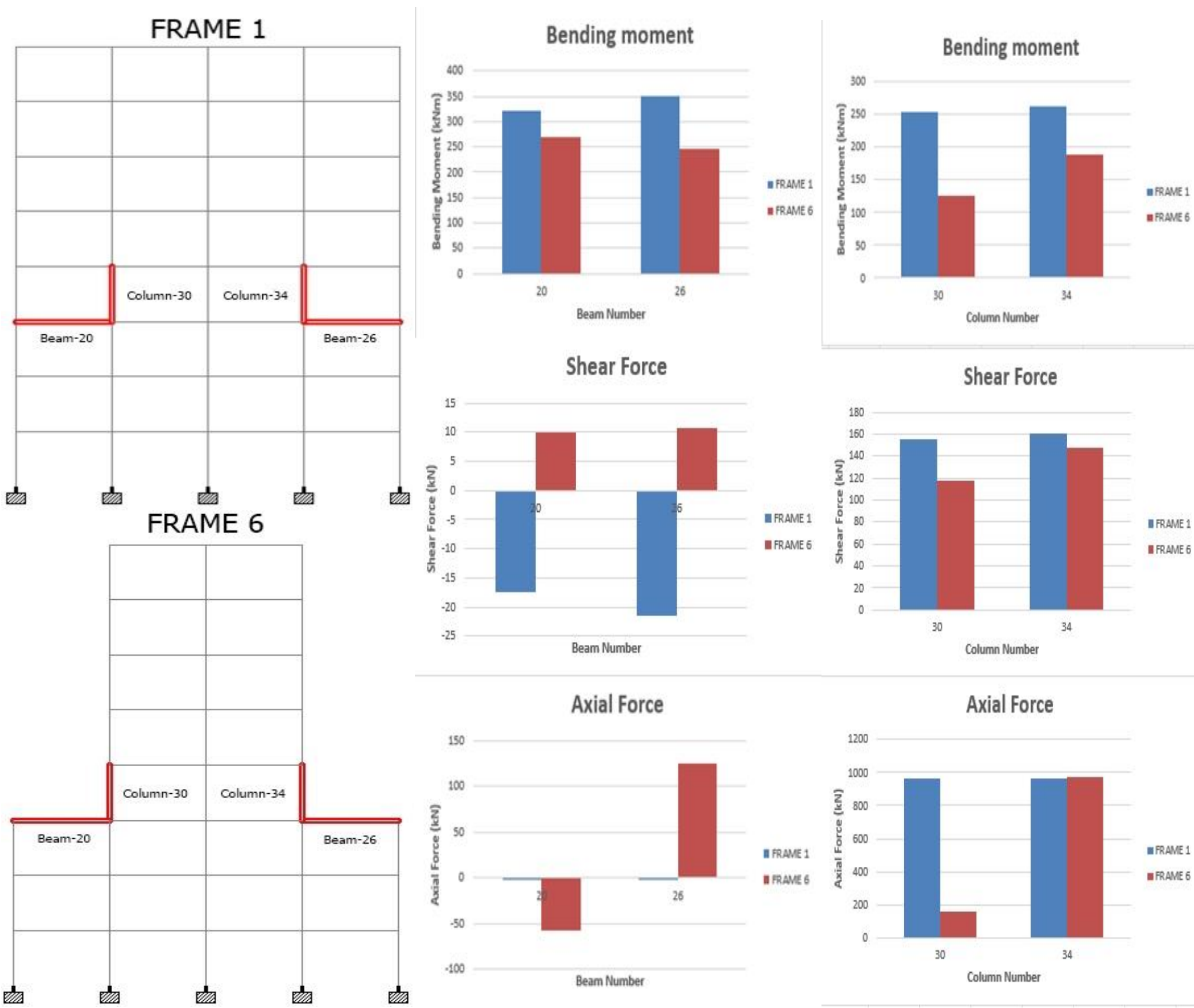


Fig. 3.2.1.5 Forces in Frame 1 and Frame 6

3.2.1.6 FRAME 1 AND FRAME 7

- It is noted that in Beam -47 the value of maximum shear force (Fy) from regular to irregular frame increases from 25.6 kN to 26.4 kN
- It is noted that in Column-57 the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 380 kN to 139 kN , 81.4 kN to 63.5 kN and 152 kNm to 101 kNm respectively.
- It is noted that in Column-34 the value of maximum axial force(Fx), maximum shear force (Fy) and maximum bending moment(Mz) from regular frame to irregular frame decreases from 966kN to 887 kN , 160 kN to 133 kN and 263 kNm to 189 kNm respectively.
- It is noted that in Beam-26 the value of maximum axial force(Fx) and maximum shear force (Fy) from regular frame to irregular frame increases from -1.32 kN to 131 kN and -21.6 kN to 8.04 kN respectively.

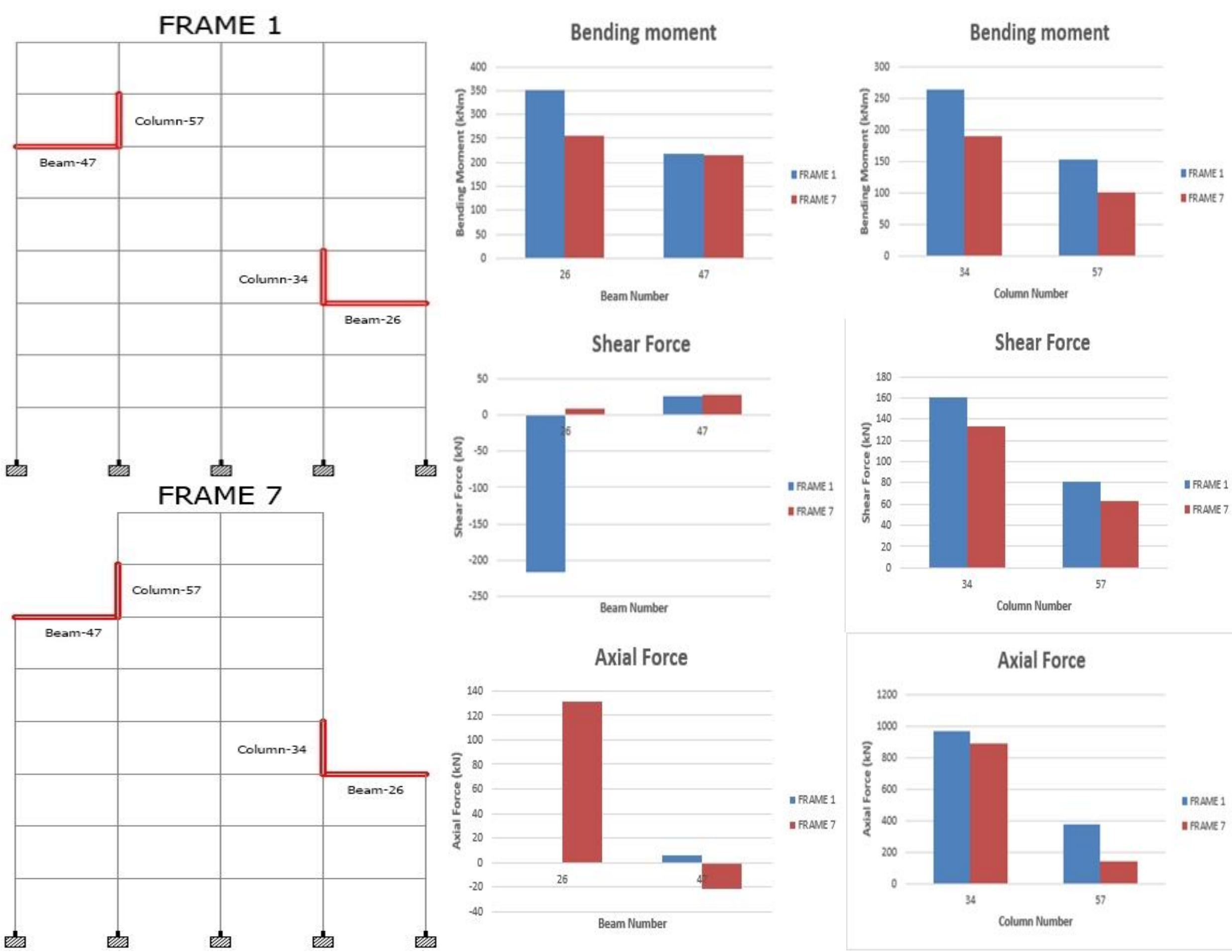


Fig.3.2.1.6 Forces in Frame 1 and Frame 7

3.2.2 RESPONSE SPECTRUM ANALYSIS

3.2.2.1 STRUCTURES 1 AND STRUCTURES 2

- It is noted that in Column-350 the value of maximum axial force(Fx) from regular to irregular frame increases from 4.7 kN to 165 kN
- It is noted that in Beam-281 the value of maximum axial force(Fx) from regular to irregular frame increases from 7.7 kN to 152 kN

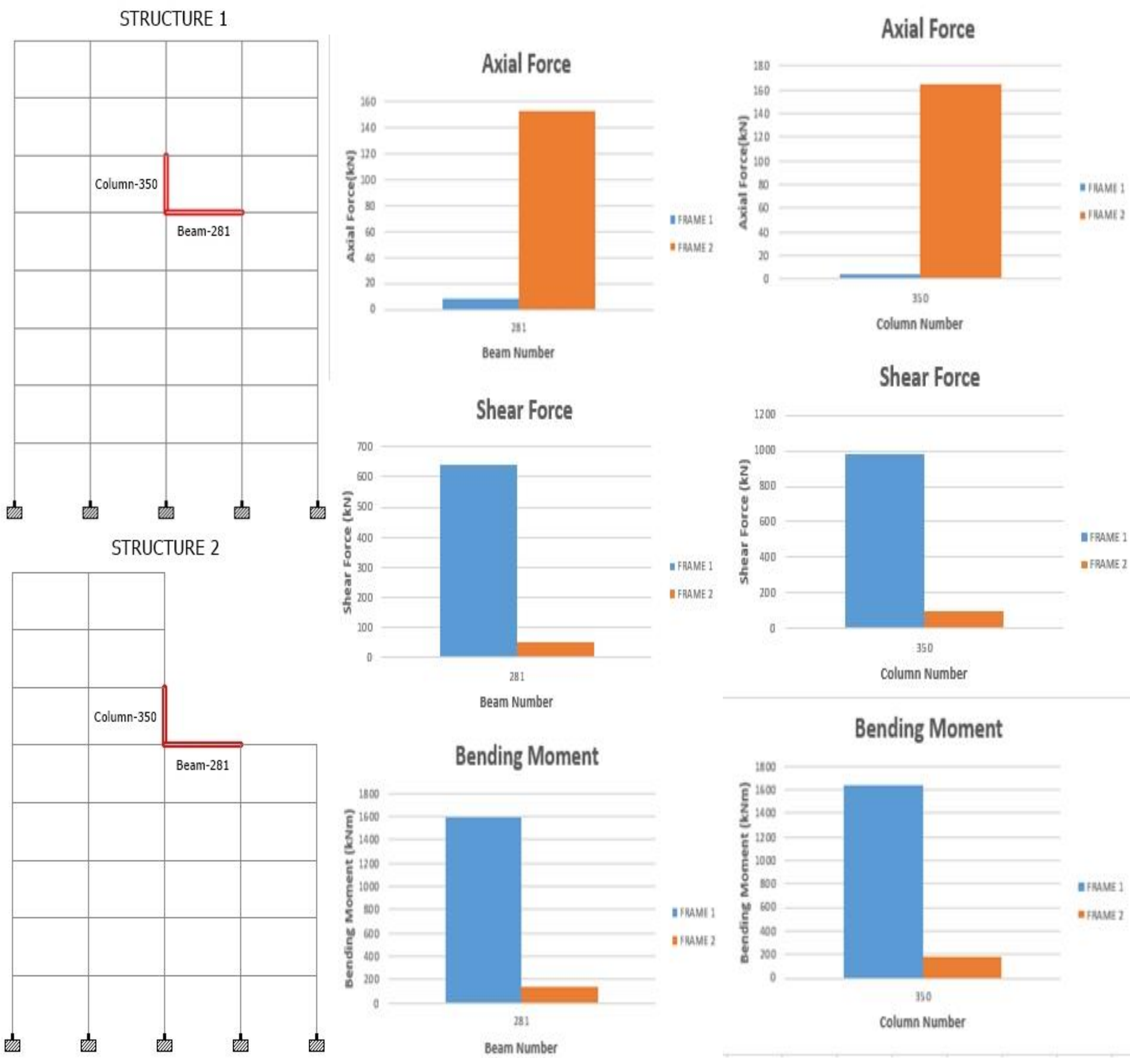


Fig.3.2.2.1 Forces in Structure 1 and Structure 2

3.2.2.2 STRUCTURES 1 AND STRUCTURES 3

- It is noted that in Column-415 the value of maximum axial force(Fx) from regular to irregular frame increases from 3.2 kN to 86 kN
- It is noted that in Beam-346 the value of maximum axial force(Fx) from regular to irregular frame increases from 5.4 kN to 59 kN
- It is noted that in Column-286 the value of maximum axial force(Fx) from regular to irregular frame increases from 58 kN to 133 kN
- It is noted that in Beam-217 the value of maximum axial force(Fx) from regular to irregular frame increases from 27 kN to 75 kN

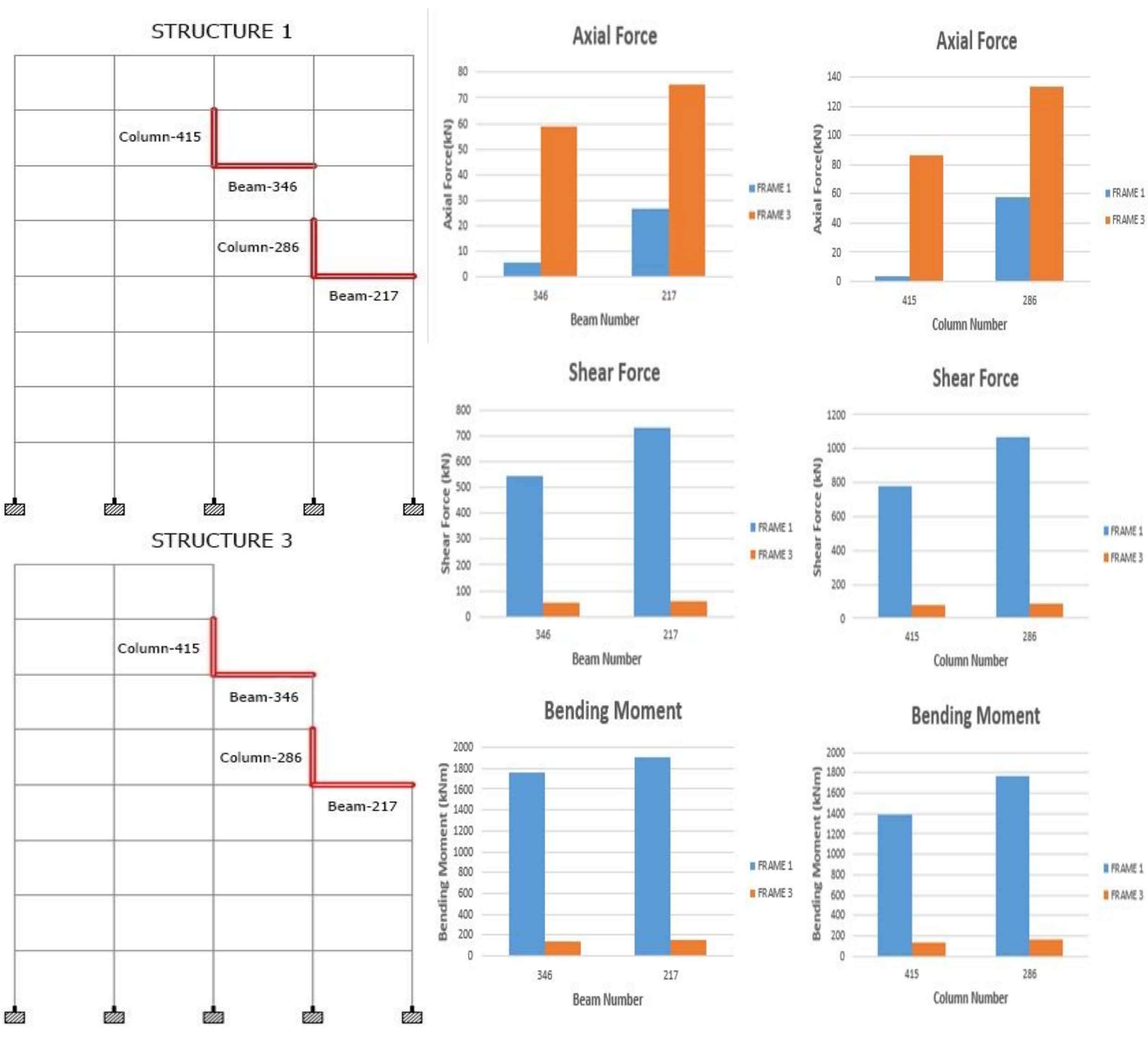


Fig.3.2.2.2 Forces in Structure 1 and Structure 3

3.2.2.3 STRUCTURES 1 AND STRUCTURES 4

- It is noted that in Column-414 the value of maximum axial force(Fx) from regular to irregular frame increases from 3 kN to 112 kN
- It is noted that in Column-285 the value of maximum axial force(Fx) from regular to irregular frame increases from from 6 kN to 147 kN.
- It is noted that in Column-156 the value of maximum axial force(Fx) from regular to irregular frame increases from 24 kN to 143 kN.
- It is noted that in Beam-345 the value of maximum axial force(Fx) from regular to irregular frame increases from 5.2 kN to 64 kN
- It is noted that in Beam-216 the value of maximum axial force(Fx) from regular to irregular frame increases from 13 kN to 75 kN
- It is noted that in Beam-87 the value of maximum axial force(Fx) from regular to irregular frame increases from 24 kN to 80 kN

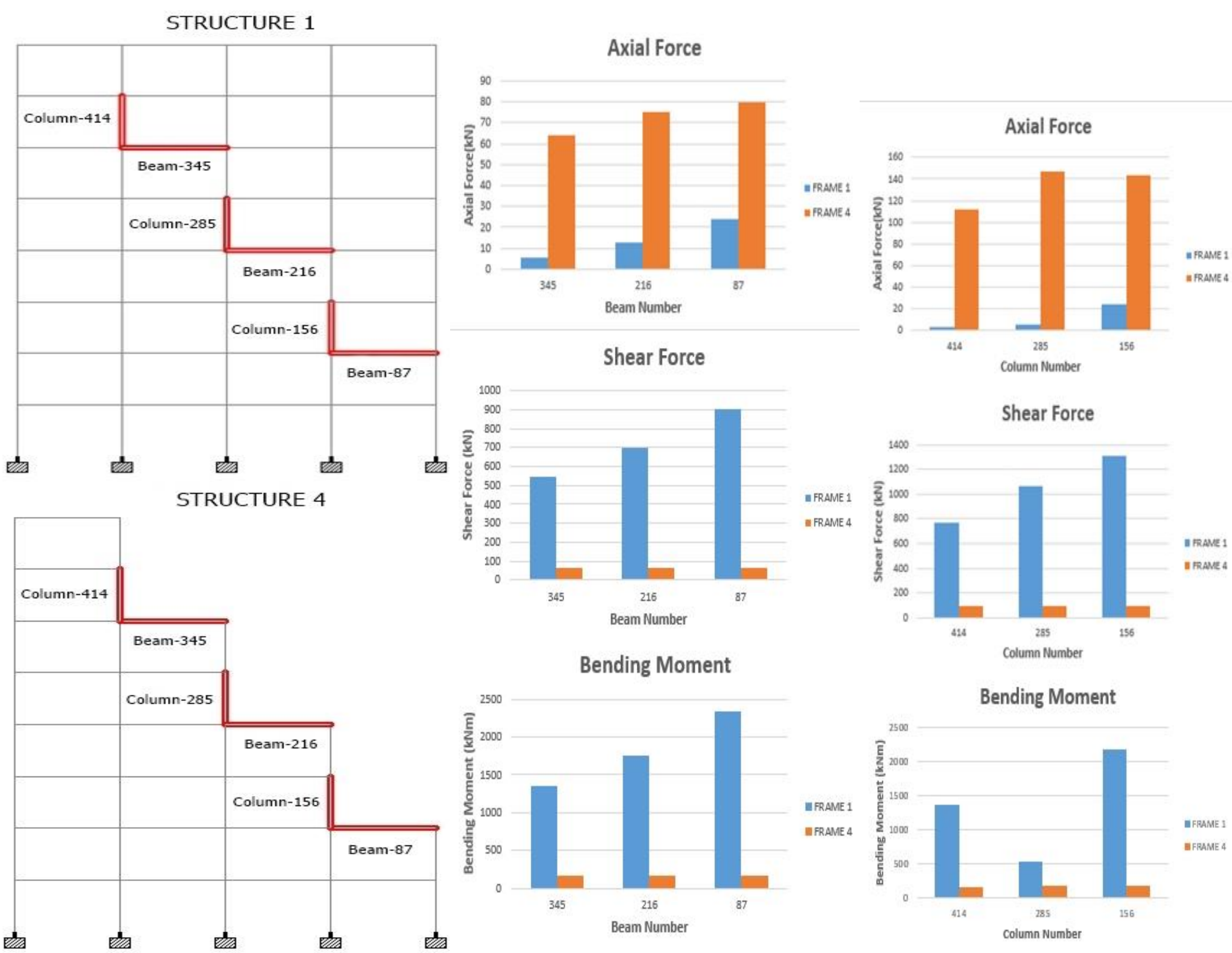


Fig.3.2.2.3 Forces in Frame 1 and Frame 4

3.2.2.4 FRAME 1 AND FRAME 5

- It is noted that in Column-349 the value of maximum axial force(Fx) from regular to irregular frame increases from 98 kN to 159 kN
- It is noted that in Column-351 the value of maximum axial force(Fx) from regular to irregular frame increases from 33 kN to 159 kN
- It is noted that in Beam-279 the value of maximum axial force(Fx) from regular to irregular frame increases from 13 kN to 61 kN
- It is noted that in Beam-282 the value of maximum axial force(Fx) from regular to irregular frame increases from 14 kN to 61 kN

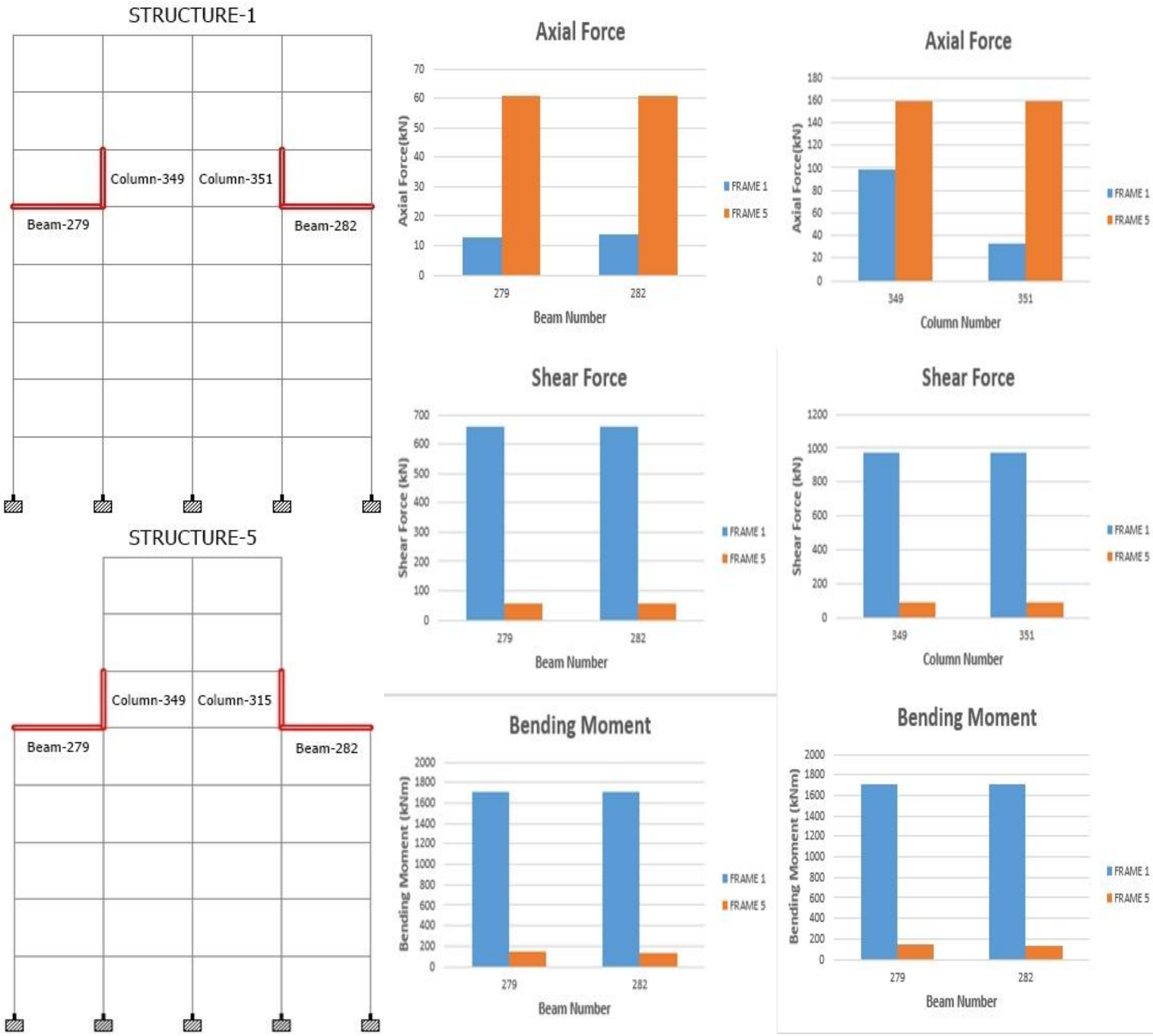


Fig.3.2.2.4 Forces in Frame 1 and Frame 5

3.2.2.5 STRUCTURES 1 AND STRUCTURES 6

- It is noted that in Column-219 the value of maximum axial force(Fx) from regular to irregular frame increases from 93 kN to 348 kN
- It is noted that in Column-221 the value of maximum axial force(Fx) from regular to irregular frame increases from 91 kN to 347 kN
- It is noted that in Beam-149 the value of maximum axial force(Fx) from regular to irregular frame increases from 28 kN to 69 kN
- It is noted that in Beam-152 the value of maximum axial force(Fx) from regular to irregular frame increases from 28 kN to 69 kN

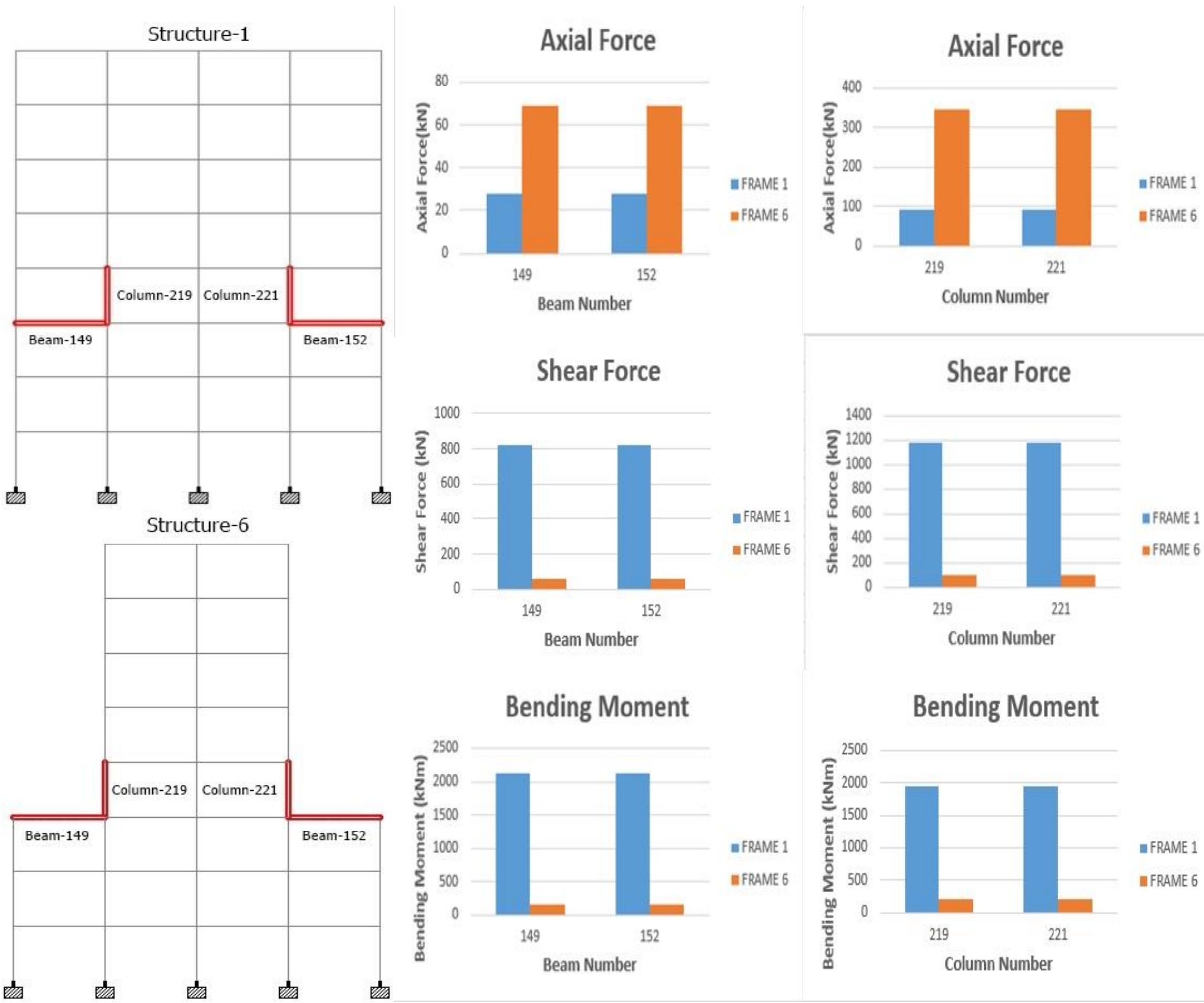


Fig.3.2.2.5 Forces in Frame 1 and Frame 6

3.2.2.6 STRUCTURES 1 AND STRUCTURES 7

- It is noted that in Column-414 the value of maximum axial force(Fx) from regular to irregular frame increases from 76 kN to 87 kN
- It is noted that in Column-221 the value of maximum axial force(Fx) from regular to irregular frame increases from 90 kN to 292 kN
- It is noted that in Beam-344 the value of maximum axial force(Fx) from regular to irregular frame increases from 5 kN to 61 kN
- It is noted that in Beam-152 the value of maximum axial force(Fx) from regular to irregular frame increases from 28 kN to 82 kN

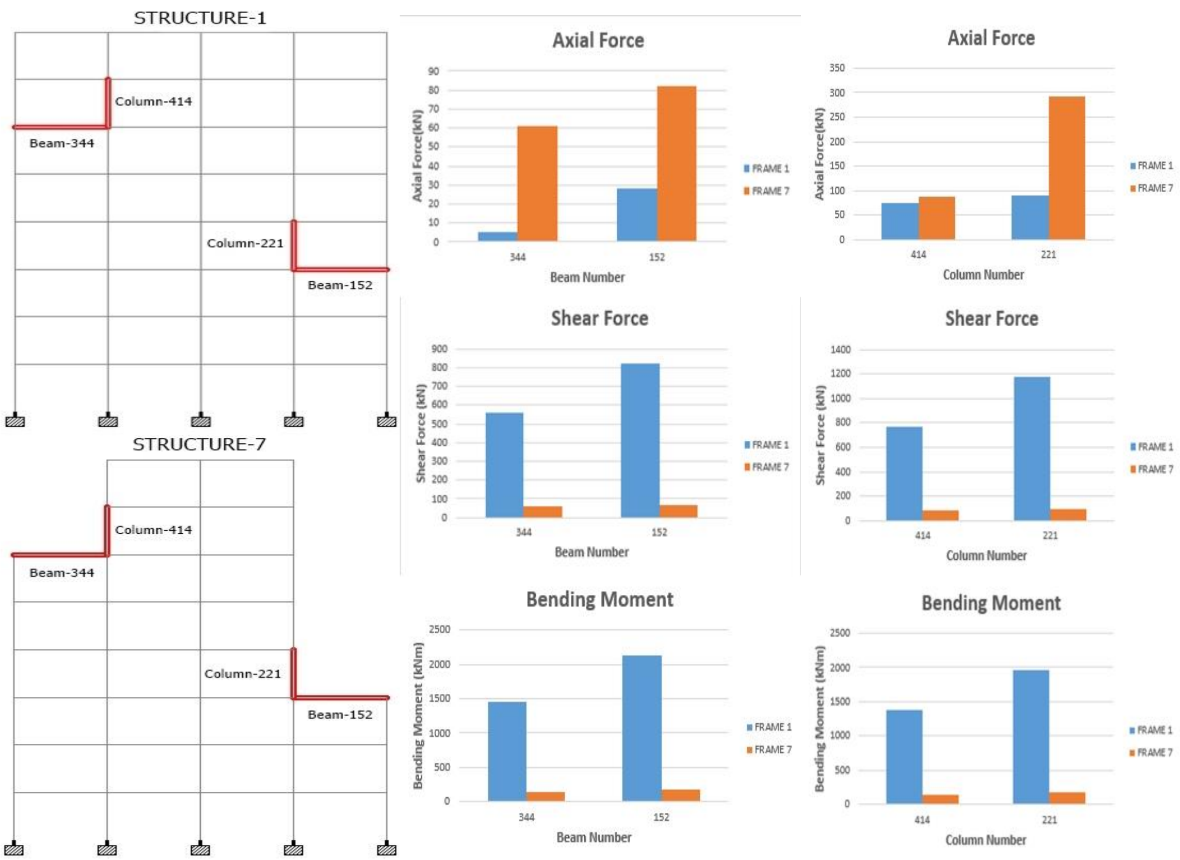


Fig.3.2.2.6 Forces in Frame 1 and Frame 7

CHAPTER-4

CONCLUSIONS

The comparison of response of all structures was done including the structures having setbacks on the basis of axial force, shear force and bending moment and the following observations were made for Static Analysis and Response Spectrum Analysis respectively:

4.1 STATIC ANALYSIS

- It was seen that at the location of setbacks, shear force and axial force is coming out to be high as compared to the same beams and columns in regular frame.
- Values of bending moment in most of the cases decreases from regular to irregular frames, but in some cases the value of bending moment increases from regular to irregular building.
- Except from Beams:
  Column-43 in Frame 1 and Frame3
  Column-41 in Frame 1 and Frame4
  Column-25 in Frame 1 and Frame4
  Column-52 in Frame 1 and Frame5
  Column-48 in Frame 1 and Frame5
  Column-30 in Frame 1 and Frame6
  Column-57 in Frame 1 and Frame7
  Column-34 in Frame 1 and Frame7

  In all beams and columns the one or two of the forces is coming more in irregular frames

4.2 RESPONSE SPECTRUM ANALYSIS:

- It was seen that the value of axial force is increasing by a very large amount as we move from regular to irregular structure.
- The value of shear force and bending moment however decreases from regular to irregular structure which is due to the reduction in mass of the structure.

Both the methods were compared with each other and it was seen that the static analysis gives fluctuating result and dynamic analysis i.e. response spectrum analysis gives more reliable result, from the above discussion it can be concluded that the building with setbacks results in poor performance and the chances of failure of beams and columns in these buildings become more due to increased stresses in columns as well as in beams at setbacks. That is why it is not recommended to introduce setbacks in the structure, if there is some constraint to introduce setbacks in a structure, they should be in permissible limits, otherwise it is not recommended to introduce irregularities in the structure

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e-ISSN : 2278-1684
p-ISSN : 2320-334X
IOSR-JMCE
IOSR Journal of Mechanical and Civil Engineering