“STUDY OF STRUCTURALLY IRREGULAR BUILDING FRAMES SUBJECTED TO SEISMIC EXCITATIONS”

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

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Under the supervision of

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CERTIFICATE

This is to certify that the work which is being presented in the thesis titled **"STUDY OF STRUCTURALLY IRREGULAR BUILDING FRAMES SUBJECTED TO SEISMIC EXCITATIONS"** in partial fulfilment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in "**Structural Engineering**" and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by ANSHUL SHARMA (Enrolment No. 142651) during the period from July 2015 to June 2016 under the supervision of Mrs. Poonam Dhiman, Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

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ABSTRACT

Past earthquakes in India have revealed that majority of the buildings are not designed to be earthquake resistant. Generally, buildings are designed taking into account only the gravity loads. Also, the current design seismic codes are not fully practiced while designing a building. Hence, a higher degree of damage may be expected during an earthquake if the seismic resistance of the building is inadequate. The present work describes the various reinforced concrete (RC) frames having different irregularities but with same dimensions which have been analysed to study their behaviour when subjected to seismic lateral loads. All the frames were analysed with the same method as stated in IS 1893-Part-1:2002. From the results, it has been interpreted that the base frame (regular) develops least story drifts while the building with floating columns shows maximum storey drifts on the soft story levels. Hence, this is most vulnerable to damages under this kind of loading. The other buildings with irregularities also showed unsatisfactory results to some extent. The frame with heavy loads develops maximum storey shears, which should be accounted for in design of columns suitably. The analysis proves that irregularities are harmful for the structures and it is important to have simpler and regular shapes of frames as well as uniform load distribution around the building. Therefore, as far as possible irregularities in a building must be avoided. But, if irregularities have to be introduced for any reason, they must be designed properly following the conditions of IS 13920:1993. The complex shaped buildings are now days getting popular, but they carry a risk of sustaining damages during earthquakes. Therefore, such buildings should be designed properly taking care of their dynamic behaviour.

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CHAPTER-1

INTRODUCTION

1.1 GENERAL

In India, about 50-60% of the total area is vulnerable to the seismic activity. Thus, the knowledge of earthquake resistant building. Past earthquakes occurrences demonstrate that, buildings with irregularity is prone to earthquake damages. In order it is essential to identify the seismic response of the structure even in low seismic zones to reduce the seismic damages in buildings. Irregularities in plan and lack of symmetry may imply significant eccentricity between the building mass and stiffness centers, giving rise to damaging coupled lateral/torsional response . Irregular structures need a more careful structural analysis to reach a suitable behaviour during a devastating earthquake.

The irregularity of the structure may can classify in two types i.e. plan and vertical, these can be characterized to five different types such as torsional , re-entrant corners, diaphragms discontinuity, out of plane offset and non parallel system for plan irregularity as well as vertical irregularity such as stiffness (soft storey), mass, vertical geometric, in plane discontinuity in vertical elements resisting lateral force and discontinuity in capacity (weak storey) (IS 1893(Part I): 2002).

The probable reasons for the need of proper analysis of a building may be as follows:

1. Buildings have not been designed and detailed to resist seismic forces.
2. Buildings may have designed for seismic forces, before the publication of current design seismic codes.
3. The lateral strength of the building does not satisfy the seismic forces as per the revised seismic zones or designed base shear.
4. Construction is apparently of poor quality.
5. There have been additions of change of use of building with increased vulnerability

Vertical Irregularity: Vertical irregularity results from the uneven distribution of mass, strength or stiffness along the elevation of a building structure. Mass irregularity results from a sudden change in mass between adjacent floors, such as mechanical plant on the roof of a structure. Stiffness irregularity results from a sudden change in stiffness between adjacent floors, such as setbacks in the elevation of a building.

Plan Irregularity: Plan irregular structures are those in which seismic response is not only translational but also torsional, and is a result of stiffness and/or mass eccentricity in the structure. A regular structure may actually be asymmetric if the structure has masonry infill walls or stiffer lateral resisting systems on one side of the structure that has not been taken into consideration in the analysis. Asymmetry may in fact exist in a nominally symmetric structure because of uncertainty in the evaluation of centre of mass and stiffness, inaccuracy in the measurement of the dimensions of structural elements.

1.2 OBJECTIVES OF THE THESIS

Most of the residential buildings have been designed only for dead and live loads. People are not aware of the seismic design of buildings. But for the various buildings which are located in the zone IV or V needs to be seismic resistant.

In this thesis, an existing building has been undertaken for retrofitting. Consider a G+ 9 storeyed residential existing building. It is a framed structure with total eight stories above ground level. The ground level is an open storey being utilized as parking. It thus makes up a soft storey. On the roof, there is a water tank too. This building has already been designed for the dead and the live loads only. Thus, two main problems are identified in this building with respect to the seismicity of the building. Firstly, the building has not incorporated in it the Earthquake loads. Secondly, no provisions have been made up for the existing soft storey. So, ground storey needs to be given special attention.

The main objective of this study is to understand the behavior of the structure in high seismic zone. In this purpose a ten storey-high building on eight different configurations having re-entrant corners with a regular configuration which served as a comparison, initially were investigated. These irregularities are taken as per clause 7.1 of the Indian standard code, IS 1893 (Part I): 2002. The whole models were analysed with the help of STAADPro. The current study also considered the accidental torsion in both negative and positive of both X and Y directions

CHAPTER-2

LITERATURE REVIEW

Analysis specifically aims to enhance the structural capacities (strength, stiffness, ductility, stability and integrity) of a building that is found to be deficient or vulnerable. Till now an extensive research in this field has been conducted. Some of the previous work done in the study of retrofit of existing structures has been concluded below.

The paper titled, "Effect Of Plan Irregular RC Buildings In High Seismic Zone" authored by Amin Alavi and Srinivasa Rao [1] and is published in Australian Journal of Basic and Applied Sciences in November 2013. In this work, the re-entrant corner irregularity of plan asymmetric RC building structures about the Y direction of IS 1893 code was considered to obtain the behaviour or the seismic response of RC buildings during a strong ground motion.

- The results have been proved that, the code, IS 1893 doesn't consider the irregularity of buildings on both the fundamental natural periods and the linear static analysis method which indicates that the IS 1893 code should seriously consider the upgrading of these specified to at least current operational code.
- The eccentricity between the center of mass and the center of resistance has a significant impact on the seismic response of structures even though, in the absence of the dual system.
- The maximum lateral top displacement and also the storey drift occurred in the Irr 8 which is more irregular than others and the least observed in the regular one.
- The results also have been proved that, building with severe irregularity are more vulnerable especially in high seismic zones.
- The elastic analysis underestimates the storey drift especially when the building enters to the nonlinear level.

The results showed that the displacements in X - direction is much more than Y - direction from Irr5 to Irr8 which means when the building is asymmetric about one direction it produces more displacement about its direction. It can be seen that the Irr1 and Irr2 have the similar displacement in both projections, which the structure beyond are less than 15% of its dimensions of the building, which may result in twisting of buildings.

The displacements in Z - direction don't depend on irregularity, in other words, the plan irregularity has no effects on the Z - direction. As the 0 implies the Z - displacements have just slightly different from each other.

The work on "Seismic Analysis of Structures With Irregularities" authored by Neha P. Modakwar, Sangita S. Meshram and Dinesh W. Gawatre [2] published in IOSR Journal of Mechanical and Civil Engineering in June 2014. The main objective of this study is to understand different irregularity and torsional response due to plan and vertical irregularity and to analyze cross shape and L shape building while earthquake forces acts and to calculate additional shear due to torsion in the columns.

The Re-entrant corner columns are needed to be stiffened for shear force in the horizontal direction perpendicular to it as significant variation is seen in these forces. From the torsion point of view the re-entrant corner columns must be strengthen at lower floor levels and top two floor levels and from the analysis it is observed that behavior of torsion is same for all zones. Effect of torsion is much more when diaphragms at some level are removed, so in re-entrant corner building it is better to avoid irregularity in diaphragm.

The paper titled "Influence of Plan Irregularity of Buildings" authored by Raúl González Herrera1 and Consuelo Gómez Soberón [3] is published in The 14th World Conference on Earthquake Engineering on October 12-17, 2008, Beijing, China . A parametric studied of the influence of different plan irregular systems in the elastic displacements responses are presented in this paper. To do that elastic models or regular systems (square plant) and irregular models of rectangular, T L and U plants were subjected a ten characteristics accelerograms. The realized parametric studies allow us to identify the most important conditions of vulnerability in a qualitative and quantitative way. Within the most important results to date we can indicate the following:

• A summary of important seismic events from 1980 to 2008, where it is observed building damaged due to different irregularities causes. We conclude that constructions are more vulnerable when more irregular are.

• The demands distribution of acceleration in constructions with plan or/and elevation irregularity problems in many occasions surpasses to the lineaments established in the Federal District Codes. This reflection forces us to continue investigating in the matter to place more restrictive limits or to solicit for stricter analyses.

• The linear analyses provide important information for torsion behavior of weak structures like the studied. Despite we understand that elastic analysis underestimates the interstory drifts when the superstructure enters in nonlinear performance, and the behavior is adopted torsion mode.

The work on “Seismic behaviour of asymmetric RCC building” authored by Dr. S.K. Dubey and P.D. Sangamnerkar [4] is published in International Journal of Advanced Engineering Technology. The main objective of this study is to understand different irregularity and torsional response due to plan and vertical irregularity, and to analyze “T”-shaped building while earthquake forces acts and to calculate additional shear due to torsion in the columns. Additional shear due to torsional moments needs to be considered because; this increase in shear forces causes columns to collapse. So in design procedures this additional shear must be taken into account.

Soft storey-For all new RC frame buildings, the best option is to avoid such sudden and large decrease in stiffness and/or strength in any storey; it would be ideal to build walls (either masonry or RC walls) in the ground storey also. Designers can avoid dangerous effects of flexible and weak ground storeys by ensuring that too many walls are not discontinued in the ground storey, i.e., the drop in stiffness and strength in the ground storey level is not abrupt due to the absence of infill walls.

The paper titled “Seismic response of vertically irregular RC frame with stiffness irregularity at fourth floor” authored by Shaikh Abdul Aijaj Abdul Rahman and Girish Deshmukh [5] is published in International Journal of Emerging Technology and Advanced Engineering on August 2013. The present paper attempts to investigate the proportional distribution of lateral forces evolved through seismic action in each storey level due to changes in stiffness of frame on vertically irregular frame. As per the Bureau of

Indian Standard (BIS) 1893:2002(part1) provisions, a G+10 vertically irregular building is modeled as an simplified lump mass model for the analysis with stiffness irregularityat fourth floor. To response parameters like story drift, story deflection and story shear of structure under seismic force under the linear static & dynamic analysis is studied. This analysis shows focuses on the base shear carrying capacity of a structure and performance level of structure under severer zone of India.

The result remarks the conclusion that, a building structure with stiffness irregularity provides instability and attracts huge storey shear. A proportionate amount of stiffness is advantageous to control over the storey and base shear. The analysis proves that vertically irregular structures are harmful and the effect of stiffness irregularity on the vertically irregular structure is also dangerous in seismic zone.

The paper titled "Qualitative review of seismic response of vertically irregular building frames" authored by Devesh P. Soni and Bharat B. Mistry [6] is published in ISET Journal of Earthquake Technology on December 2006. Criteria defining vertical irregularity as per the current building codes have been discussed. A review of studies on the seismic behavior of vertically irregular structures along with their findings has been presented. It is observed that building codes provide criteria to classify the vertically irregular structures and suggest dynamic analysis to arrive at design lateral forces. Most of the studies agree on the increase in drift demand in the tower portion of set-back structures and on the increase in seismic demand for buildings with discontinuous distributions in mass, stiffness, and strength. The largest seismic demand is found for the combined-stiffness-and-strength irregularity.

For the soft and weak first story structures, increase in seismic demand has been observed as compared to the regular structures. For buildings with discontinuous distributions in mass, stiffness, and strength (independently or in combination), the effect of strength irregularity has been found to be larger than the effect of stiffness irregularity, and the effect of combined-stiffness-andstrength irregularity has been found to be the largest.

The work on "Seismic behavior of buildings having horizontal irregularities" authored by Rakesh Sakale , R K Arora and Jitendra Chauhan [7] is published in International Journal of structural and civil engineering on Feb 2014. The study examines the seismic performance of multi-storey buildings having horizontal irregularities with different plan shapes. Four buildings are analyzed for zone II, zone III, zone IV and zone V. To study the effectiveness of all these buildings, the storey drift and lateral displacement are worked out.For all the frames considered, drift values follow a similar path along storey height with maximum value lying somewhere near the second to tenth storey. From drift point of view, in zone II, zone III and zone IV all the frames are within permissible limit, hence there is no requirement of shear wall in these zones. In zone V only building 4, i.e., C shape building exceeds permissible limits and requires shear wall throughout the height.

The paper titled “Effect of irregular configurations on seismic vulnerability of RC buildings” authored by Ravikumar C M , Babu Narayan K S , Sujith B V , Venkat Reddy [7] is published in Architecture Research 2012 . The present paper made an attempt to study two kinds of irregularities in the building models namely plan irregularity with geometric and diaphragm discontinuity and vertical irregularity with setback and sloping ground. These irregularities are created as per clause 7.1 of IS 1893 (part1)2002 code.

In conclusion it is proved that the eccentricity between centre of mass and centre of rigidity varies even though in the absence of dual systems i.e. shear walls. The buildings resting on sloping ground are more vulnerable to earthquake than rest of the models

CHAPTER-3

VERTICAL IRREGULARITIES IN BUILDING

3.1 INTRODUCTION

In the past several major earthquakes have expose the shortcomings in buildings which had caused them to damage or collapse. It has been found that regular shape buildings perform better during earthquakes. The structural irregularities cause non- uniform load distribution in various members of a building. There must a continuous path for these inertial forces to be carried from ground to the building. A gap in this transmission path results in failure of the structure at that location . There have been several studies on the irregularities like evaluation of torsional response multistory building using equivalent static eccentricity (Tabatabaci and Safari, 2011), three dimensional damage index for RC building with planner irregularities (Jeong and Elnashai, 2006), and evaluation of mass, strength, and stiffness limits for regular buildings specified by UBC (Valmundsson and Nau, 1997), etc. In the present chapter, response of 10 storeyed plane frame to lateral loads is studied for mass and stiffness irregularities in the elevation. These irregularities are introduced by changing the properties of members of the storey under consideration .

Various irregularities include story drift , heavy loads on the top floor, floating columns as well as unusually tall first storey. Effects on story-shear forces, storey drifts and deflection of beams is studied.

3.2 STRUCTURAL IRREGULARITIES

These are various types of irregularities in the buildings depending upon their location and scope, but mainly , they are divided into two groups – plan irregularities and vertical irregularities. In the present chapter the vertical irregularities are considered and described as follows.

3.2.1 STIFFNESS IRREGULARITY

3.2.2 SOFT STOREY; A soft story is one in which the lateral stiffness is less than 70 % of that in the storey above or less than 80% of the average lateral stiffness of three storeys above.

3.2.3 EXTREME SOFT STORY: An extreme soft storey is one in which the lateral stiffness is less than 60% of that in the storey above or less than 70% of the average stiffness of the thee storeys above. For example, buildings on stills that fall under this category.

3.3 MASS IRREGULARITY

Mass irregularity are considered to exist where the effective mass of any storey is more than 150% of the effective mass of an adjacent storey. The effective mass is the real mass consisting of the dead weight of the floor plus the actual weight of partition and equipment . Excess mass can lead to increase in lateral inertial forces , reduced ductility of vertical load resisting elements, and increased tendency towards collapse. Irregularities of mass distribution in vertical and horizontal planes can result in irregular response and complex dynamics. The central force of gravity is shifted above the basic in the case of heavy masses in upper floors resulting in the large bending moments.

3.4 VERTICAL GEOMETRIC IRREGULARITY

Geometric irregularity exists when thehorizontal dimension of the lateral force existing system in any storey is more than 150% of that in an adjacent storey. The setback can also be visualized as a vertical re-entrant corner. The general solution of a setback problem is the total seismic separation in plan through separation section , so that the portion of building is free to vibrate independently.

3.4.1 DISCONTINUITY IN CAPACITY- WEAK STOREY

A weak storey is one in which the storey lateral strength is less than 80% 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.

3.5 PROBLEM FORMULATION

Problem considered for the current study is taken from IS 1893- part 1 :2002 and also have been used by Valmundsson and Nau, 1997 . This 10 story building frame is considered with nine different irregularities as taken from IS 1893- part 1:2002. Thus we have ten frames including the base frame . These ten frames have been analysed using equivalent dynamic method of IS 1893- part 1:2002 while assuming seismic zone V ,and importance factor 1 . Analysis has been carried out using STAAD Pro program. Configuration of frames is given as below and shown in fig.

FRAME-1 : This is the basic and ten storey height of 3.5m and the bay width of 5m. The basic specifications of the building are : Dimensions of the beam = 0.450×0.25 m ; Column size = 0.30×0.30 ; Beam Length = 5 m ; Column Length = 3.5 m ; Dead load = 12 KN/m2 ; Live Load = 10KN/ m2

FRAME-2 : Frame having 1st and 2nd storeys soft. No floor slab has been provided which makes these two storeys less stiff, i.e , softer .

FRAME-3 : This frame has 4th and 5th storeys soft. No floor beams (Vertical) have been provided which makes these two storeys soft .

FRAME-4 : Frame with heavy loading on 3rd and 6th storeys. Two storeys of the building , i.e , 3rd and 6th storeys carry heavier loads, hence making the building irregular.

FRAME-5 : The frame carries heavier loading on the Top story, e.g, in the top story swimming pool has been introduced hence making the top storey heavy, and the building becomes irregular.

FRAME-6 : In this frame the intermediate columns are removed making the ground story soft and thus an irregularity is introduced in the building.

FRAME-7 : The frame is made irregular by removing the end columns and placing the intermediate columns in it.

FRAME-8 : This frame has 4th and 5th storeys soft. No floor beams (horizontal) have been provided which makes these two storeys soft .

FRAME-9 : In this frame the geometry of building is changed by changing the height of building in three bays and hence introducing the irregularity in the building.

FRAME-10 : In this frame along with geometric irregularity the intermediate columns are removed ,irregularity is introduced by doing so.

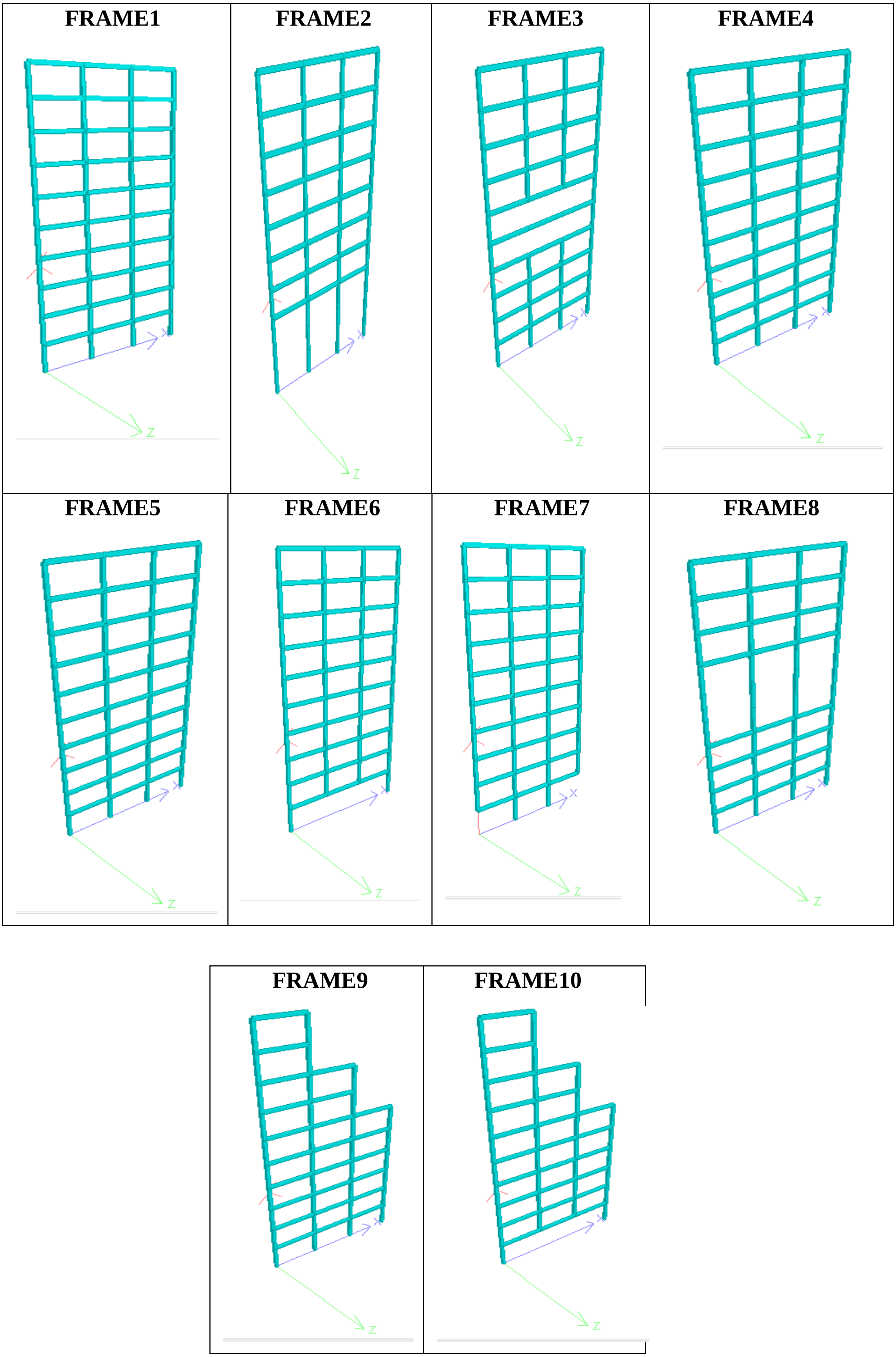


Fig. 3.1 2D Frames

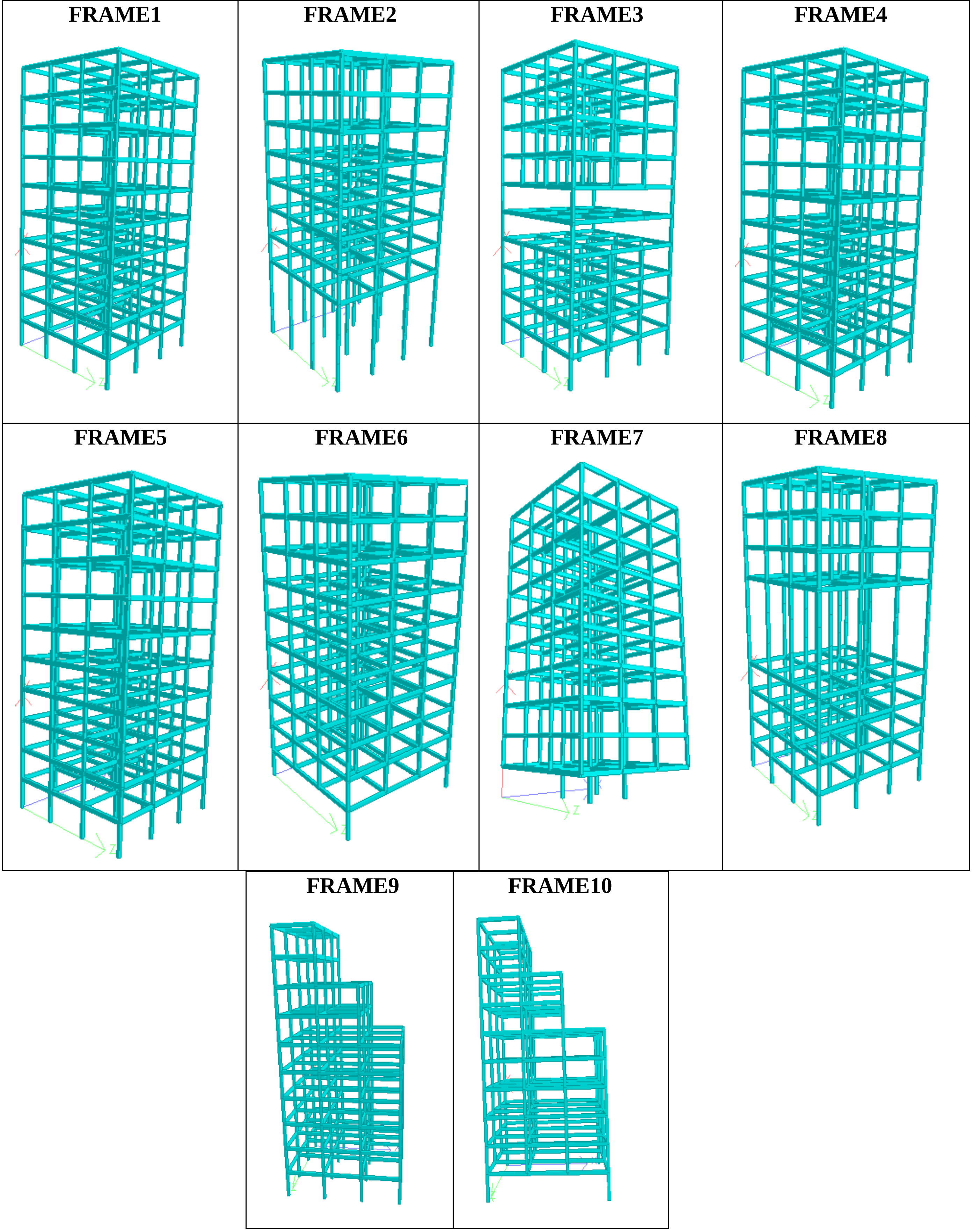


Fig. 3.2 3D Frames

3.5.1 BUILDING DATA

The following is the data of the ideal frame which is used for the comparison b/w the regular and the irregular frames.

3.5.2 SPECIFICATIONS

Table-3.1: Specifications

Live Load	$10N/m^2$ (for all floors)
	5 kN/m^2(and the roof)
Dead Load	12 kN/m^2 + 8kN/m^2
Density of RCC considered:	25 kN/m^3
Depth of beam	450 mm
Width of beam	250 mm
Dimension of column	300 × 300mm
Height of each floor	5 m
City	Shimla
Earthquake Zone	V
Damping Ratio	5%
Type of building	Important
Importance factor	1
Type of Soil	Medium
Type of structure	Special Moment Resisting Frame

3.5.3 SEISMIC ANALYSIS OF FRAMES

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 static analysis and dynamic analysis in our project.
According to 1893 (part 1) -2000 the following load in limit state design of reinforced and perstressed concrete structures, following load combination should 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

3.6 METHODOLOGY

Analysis methods are widely characterized as linear and nonlinear static and dynamic. Among them the linear static and dynamic methods are suitable when the structural loads are small.

The main difference between the equivalent static procedure and dynamic analysis procedure lies in the magnitude and distribution of lateral forces over the height of the buildings. In the dynamic analysis procedure the lateral forces are based on properties of the natural vibration modes of the building, which are determined by the distribution of mass and stiffness over height. In the equivalent lateral force procedure the magnitude of forces is based on an estimation of the fundamental period and on the distribution of forces as given by a simple formula that is appropriate only for regular buildings.

3.6.1 EQUIVALENT LINEAR STATIC ANALYSIS METHOD

In the equivalent static analysis method, the response of the building is assumed as linear elastic manner. To calculate equivalent linear static the IS 1893 (Part I): 2002 has given a formula as below.

$V_B = A_H.W$

Where,

$A_H = ZIS_a/2Rg$

Where Z is the zone factor, I is the importance factor, R is the response reduction factor and Sa/g is the average response acceleration coefficient which depends on the nature of foundation soil (rock, medium or soil site), natural period and the damping ratio of the structure (IS 1893(Part I): 2002). Z is the zone factor, I is the importance factor, R is the response reduction factor and Sa/g is the average response acceleration coefficient which depends on the nature of foundation soil (rock, medium or soil site), natural period and the damping ratio of the structure (IS 1893(Part I): 2002).

3.6.2 LINEAR DYNAMIC ANALYSIS METHOD (RSM)

The response spectrum method (RSM) was introduced in 1932 in the doctoral dissertation of Maurice Anthony Biot at Coltech. It is an approach to be found earthquake response structures using waves or vibration mode shapes. The concept of the "Response Spectrum" was applied in design requirements in the mid 20th century.

It came into widespread use as the primary theoretical tool in earthquake engineering in the 1970s when strong-motion accelerograph data become widely available. The maximum response of the building is estimated directly from the elastic or inelastic design spectrum characterizing the design earthquake for the site and considering the performance criteria for the building. The response spectrum method plays an important role in practical analysis of multistory buildings for earthquake motions. It is also helpful to analyse the performance level of the structure.

CHAPTER-4

STRUCTURAL ANALYSIS OF 2D FRAMES

4.1 INTRODUCTION

In this chapter, a brief of the problems identified by observing the building plan are given. Also, the static and the dynamic analysis are done. After doing the analysis, the output file is considered for comparing the reinforcements of the structural members.

4.2 PROBLEMS IDENTIFIED BY OBSERVING THE FRAMES

4.2.1 SOFT STOREY

It 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. In my thesis project, the ground storey consists of columns and beams with no infill walls. It contains the parking area and is considered as a soft storey. There should be special provisions made for the soft storey as far as the seismic loads are concerned. As per [10] IS 1893:2002, Dynamic analysis of building is carried out including the strength and stiffness effects of infill and inelastic deformations in the members, particularly, those in the soft storey, and the members designed accordingly. Alternatively, the following design criteria are to be adopted after carrying out the earthquake analysis, neglecting the effect of infill walls in other storey.

a) The columns and beams of the soft storey are to be designed for 2.5 times the storey shears and moments calculated under seismic loads specified in the other relevant clauses.

b) Besides the columns designed and detailed for the calculated storey shears and moments ,shear walls placed symmetrically in both directions of the building as far away from the centre of the building as feasible; to be designed exclusively for 1.5 times the lateral storey shear force calculated as before

4.3 ANALYSIS OF EXISTING FRAME

The building is then analysed using staad pro v8i software (figure 2).both the static and the dynamic analysis have been done for this building. Firstly, dead and the live loads are found out separately. The unit weights of the material are taken from is 875: part 1. The live loads of residential building, accessible and inaccessible roof is taken from [11] is 875 part 2. The seismic loads are taken out taking the help from is 1893:2002. Analysis and the design of the concrete building are then carried out

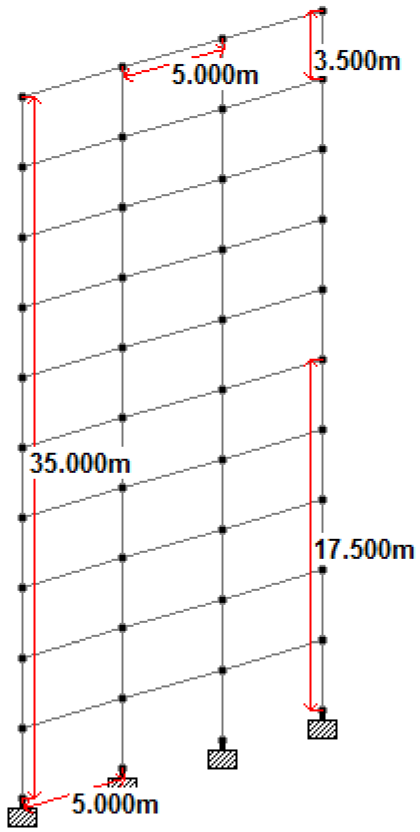


Fig.4.1 Ideal frame with Dimentions

4.4 COMPARISON OF FRAMES

Every irregular frame is compared with the regular frame and following variation are seen:

4.4.1 FRAME 1-2:-

In this section the comparison of frame 1 and frame 2 is done. The beams at the setback i.e. Beam-35, Beam-36, Beam-37, Beam-38, Beam-39 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

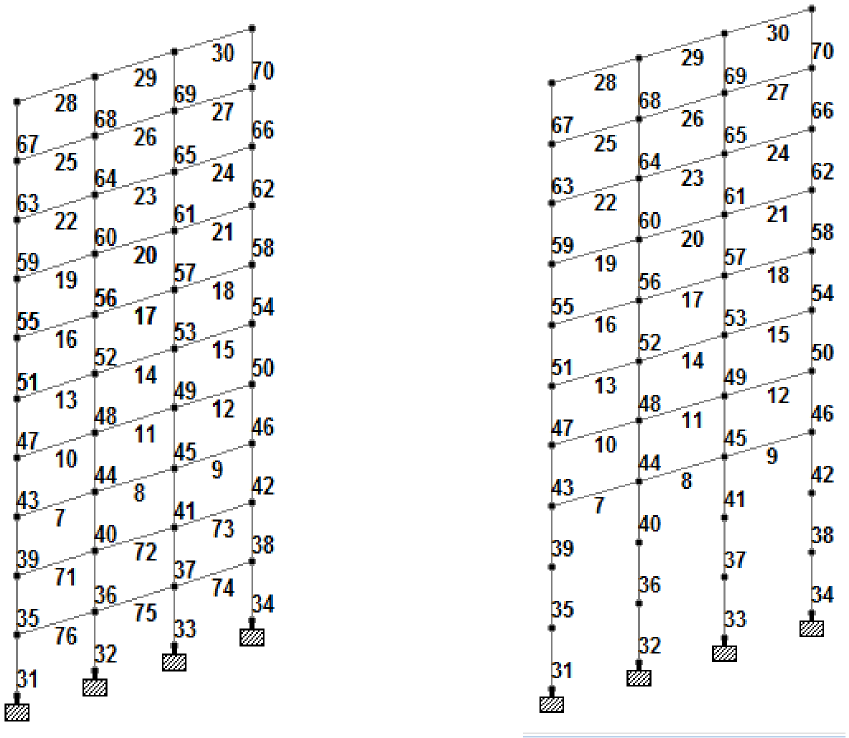
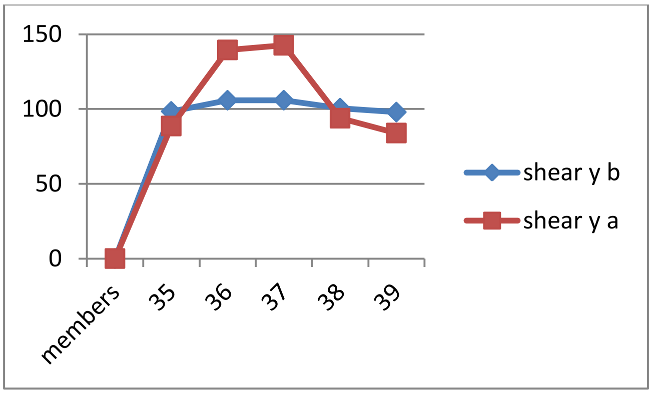


Fig.4.2 Frame 1 and Frame 2 with beam numbered

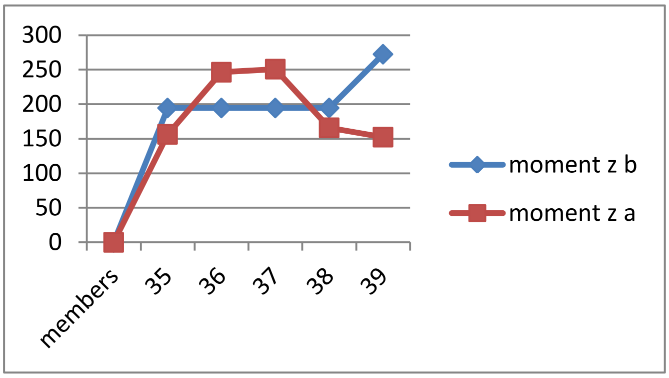
Table. 4.1 Shear stress in frame 1 & frame 2



	Frame 1	Frame 2
Member no	kN/m	kN/m
35	98.37	88.6
36	105.8	139.45
37	105.83	142.55
38	100.55	93.82
39	97.89	83.9

Fig.4.3 Graph of shear stress b/w frame 1 & frame 2

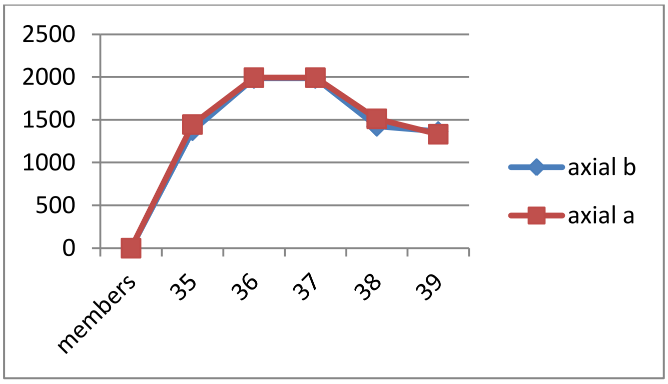
Table. 4.2 Bending moment in frame 1 & 2



	Frame 2	**Frame 1**
Member no	kNm	kNm
35	194.54	156.42
36	194.54	246.36
37	194.55	250.8
38	194.56	165.87
39	272.38	152.34

Fig.4.4 Graph of bending moment b/w frame 1 & frame 2

Table. 4.3 Axial force in frame 1 & frame 2



	Frame 2	**Frame 1**
Member no	kN	kN
35	1373.05	1445.84
36	1983.91	1993.72
37	1983.91	1993.72
38	1424.1	1512.11
39	1364.13	1332.23

Fig.4.5 Graph of Axial force b/w frame 1 & frame 2

When the forces of Beam-36, Beam- 37 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 105.83 kN/m to 142.55 kN/m and rest of the forces i.e maximum axial force(Fx) and maximum bending moment (Mz) decreases from 1993.72 kN to 1983.91 kN and 250.8 kNm to 194.56 KNm respectively. It is noted that the maximum shear force (Fy) in Beam-50 in irreguar frame comming out to be more then the same beam in regular structure.

4.4.2 FRAME 1-3:-

In this section the comparison of frame 1 and frame 3 is done. The beams at the setback i.e. Beam-51, Beam-13, Beam-14, Beam-15, Beam-54 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

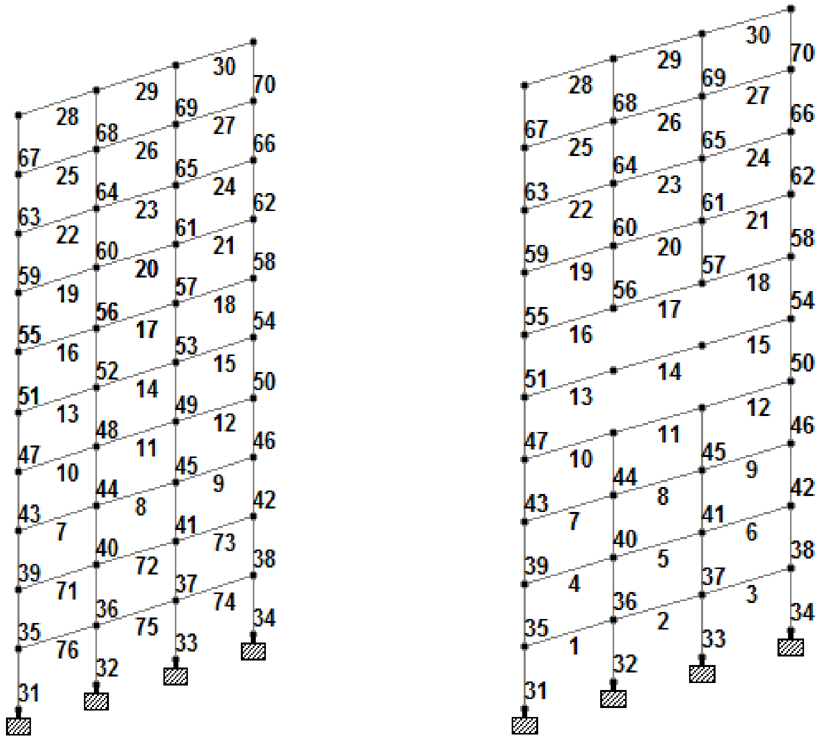
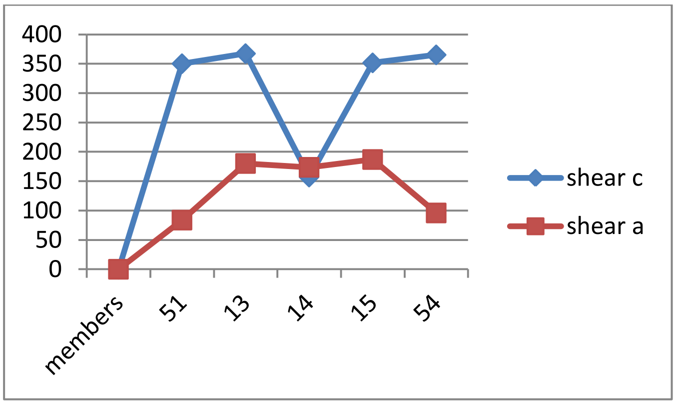


Fig.4.6 Frame 1 and Frame 3 with beam numbered

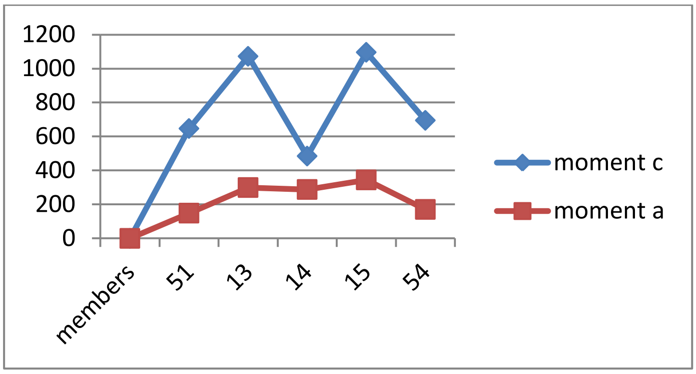
Table. 4.4 Shear stress in frame 1 & frame 3



	Frame 3	Frame 1
Member no	kN/m	kN/m
51	350.16	83.73
13	367.32	180.16
14	197.07	173.64
15	351.56	186.96
54	365.2	95.9

Fig.4.7 Graph of shear stress b/w frame 1 & frame 3

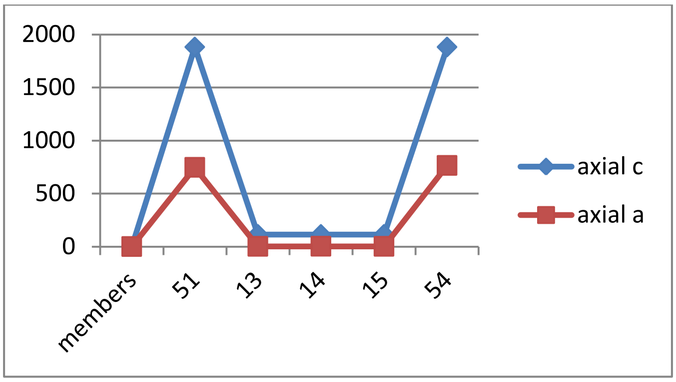
Table. 4.5 Bending moment in frame 1 & 3



	Frame 3	Frame 1
Member no	kNm	kNm
51	646.92	148.77
13	1071.94	299.36
14	484.65	288.02
15	1095.79	344.27
54	694.92	170.51

Fig.4.8 Graph of Bending moment b/w frame 1 & frame 3

Table. 4.6 Axial force in frame 1 & frame 3



	Frame 3	Frame 1
Member no	kN	kN
51	1880.55	746.36
13	114.35	15.65
14	114.35	20.75
15	114.35	18.65
54	1880.55	764.55

Fig.4.9 Graph of Axial force b/w frame 1 & frame 3

When the forces of Beam-13, Beam- 15 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 180.16 kN/m to 367.37 kN/m and rest of the forces i.e maximum axial force(Fx) and maximum bending moment(Mz) of Beam-51, Beam- 54 of both the frames increases from 764.36 kN to 1880.55kN and 170.51 kNm to 694.92 KNm respectively. It is noted that the maximum shear force(Fy) in Beam-54 in irreguar frame comming out to be more then the same beam in regular structure.

4.4.3 FRAME 1-4:-

In this section the comparison of frame 1 and frame 4 is done. The beams at the setback i.e. Beam-47, Beam-10, Beam-11, Beam-12, Beam-50 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn

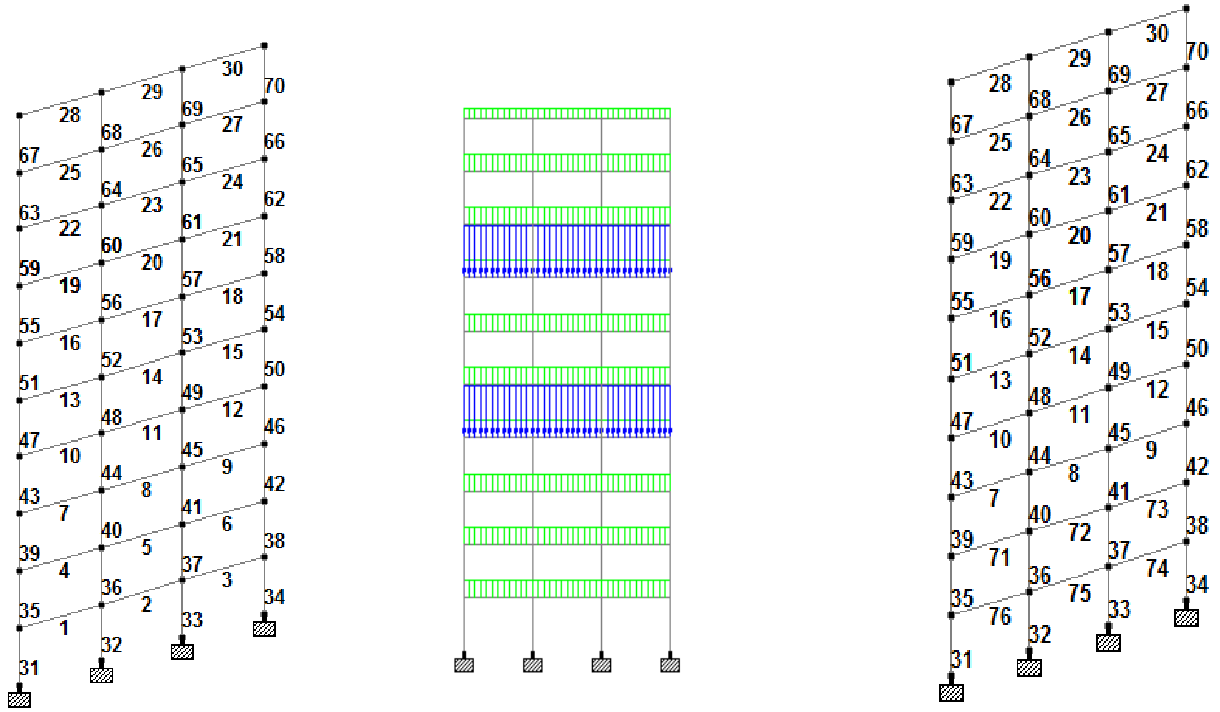
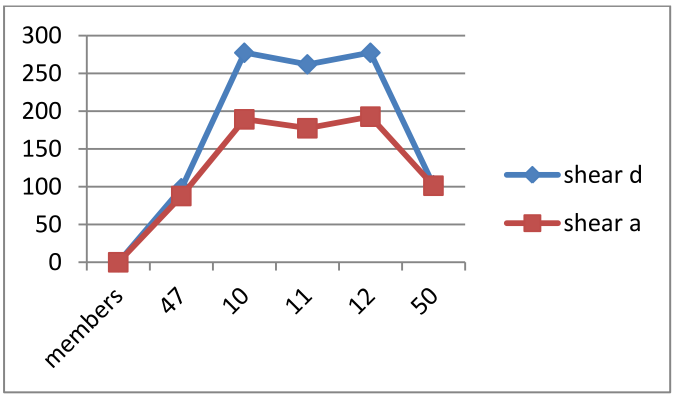


Fig.4.10 Frame 4 with beam numbered &Loading on Frame 1 and Frame 4 with beam numbered

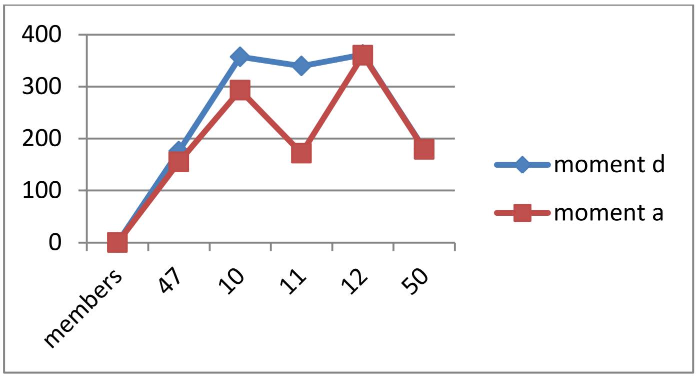
Table. 4.7 Shear stress in frame d & frame a



	Frame 4	Frame 1
Member no	kN/m	kN/m
47	97.93	87.71
10	277.26	189.12
11	261.87	177.34
12	277.26	192.71
50	101.97	101.34

Fig.4.11 Graph of shear stress b/w frame 1 &frame 4

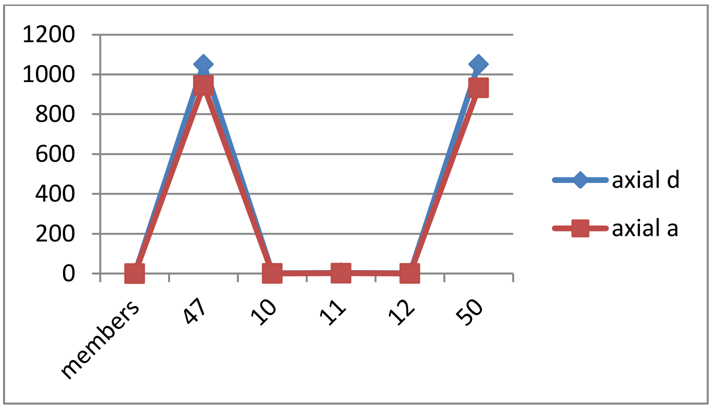
Table. 4.8 Bending moment in frame 1 & 4



	Frame 4	Frame 1
Member no	kNm	kNm
47	175.75	155.05
10	357.07	293.06
11	339.54	171.87
12	361.69	360.14
50	180.15	179.13

Fig.4.12 Graph of Bending moment b/w frame 1 & frame 4

Table. 4.9 Axial force in frame 1 &frame 4



	Frame 4	Frame 1
Member no	kN	kN
47	1050.79	944.65
10	2.3	0.79
11	3.92	1.99
12	2.3	0.72
50	1050.79	932.64

Fig.4.13 Graph of Axial force b/w frame 1 & frame 4 .

When the forces of Beam-10, Beam- 12 of both the frames i.e frame 1 and frame 4 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 192.71 kN/m to 277.26 kN/m and the force maximum bending moment (Mz)of Beam-10, Beam- 12 of both the frames when compared then it is noted that the value increases from 360.14 kNm to 361.69 kNm) and maximum axial force (Fx) of Beam-47, Beam- 50 of both the frames increases from 932.64 kN to 1050.79 kN respectively. It is noted that the maximum shear force(Fy) in Beam-12 in irreguar frame comming out to be more then the same beam in regular structure.

4.4.4 FRAME 1-5:-

In this section the comparison of frame 1 and frame 5 is done. The beams at the setback i.e. Beam-28, Beam-29, Beam-30 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

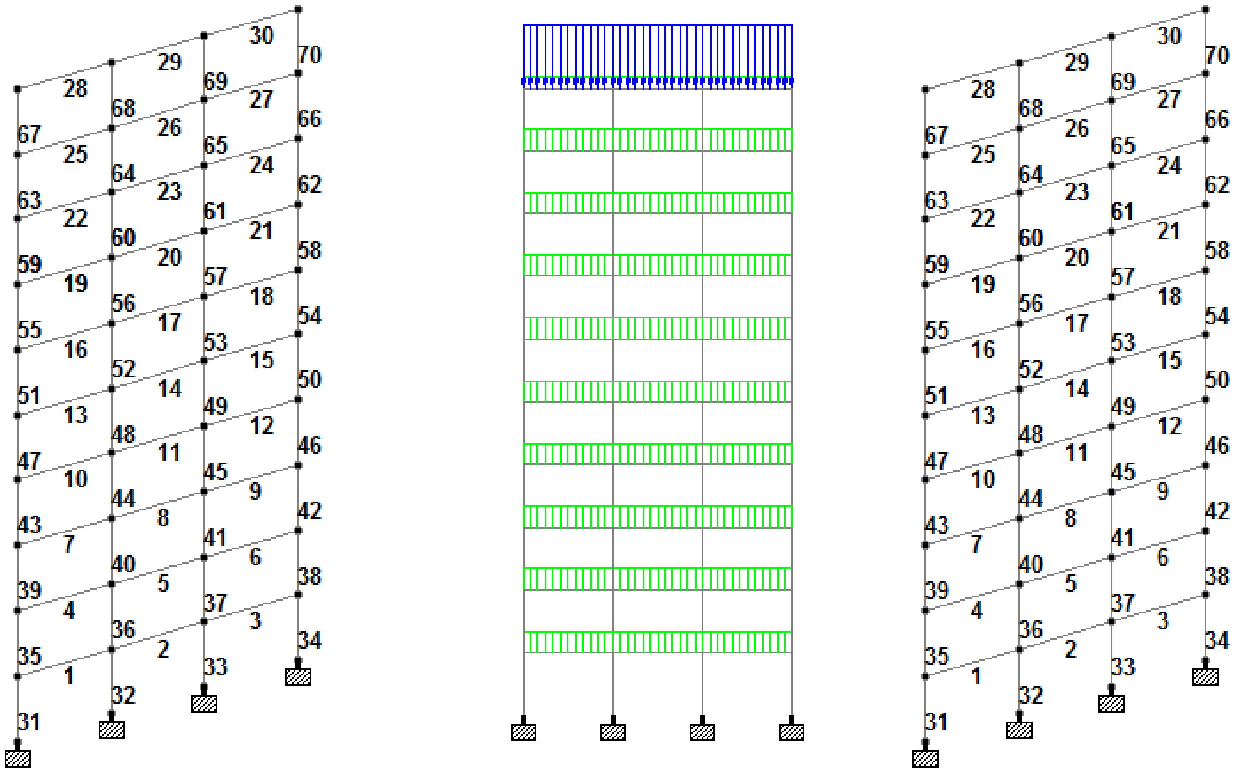
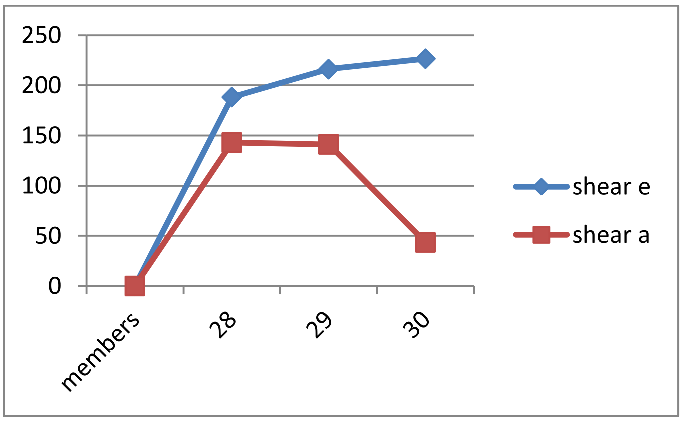


Fig.4.14 Frame 5 with beam numbered & Loading on Frame 5 and Frame 1 with beam numbered

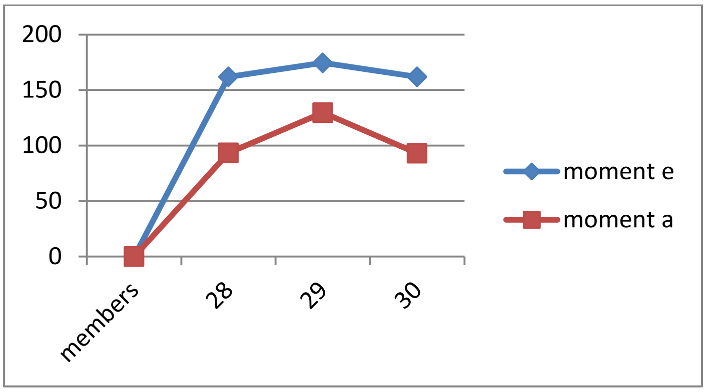
Table. 4.10 Shear stress in frame 1 & frame 5



	Frame 5	Frame1
Member no	kN/m	kN/m
28	188.34	143.07
29	216.19	141.19
30	226.59	43.48

Fig.4.15 Graph of shear stress b/w frame 1 & frame 5

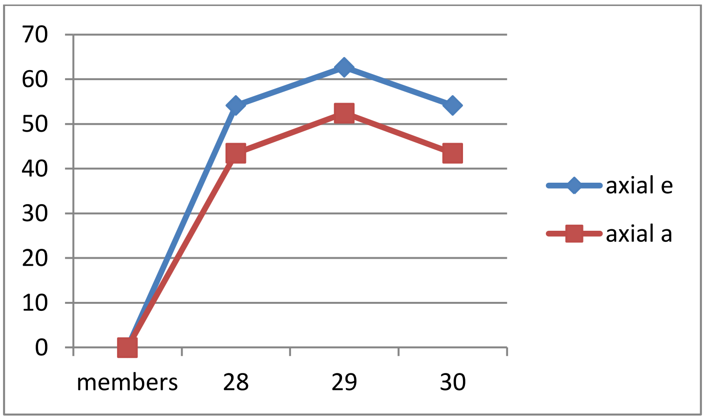
Table. 4.11 Bending moment in frame 1 & 5



	Frame 5	Frame 1
Member no	kNm	kNm
28	161.88	93.38
29	174.44	129.58
30	161.88	93.07

Fig.4.16 Graph of Bending moment b/w frame 1 & frame 5

Table. 4.12 Axial force in frame 1 & frame 5



	Frame5	Frame 1
Member no	kN	kN
28	54.16	43.48
29	62.69	52.43
30	54.16	43.48

Fig.4.17 Graph of Axial force b/w frame 1 & frame 5

When the forces of Beam-28, Beam- 29 , Beam-30 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 43.48 kN/m to 226.59 kN/m and rest of the forces i.e maximum axial force (Fx) and maximum bending moment (Mz) of Beam-28, Beam- 29 , Beam-30 of both the frames increases from 52.43 kN to 62.69 kN and 129.58 kNm to 174.44 KNm respectively. It is noted that the maximum shear force (Fy) in Beam-28 in irreguar frame comming out to be more then the same beam in regular structure

4.4.5 FRAME 1-6:-

In this section the comparison of frame 1 and frame 6 is done. The beams at the setback i.e. Beam-31, Beam-1, Beam-2, Beam-3, Beam-34 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

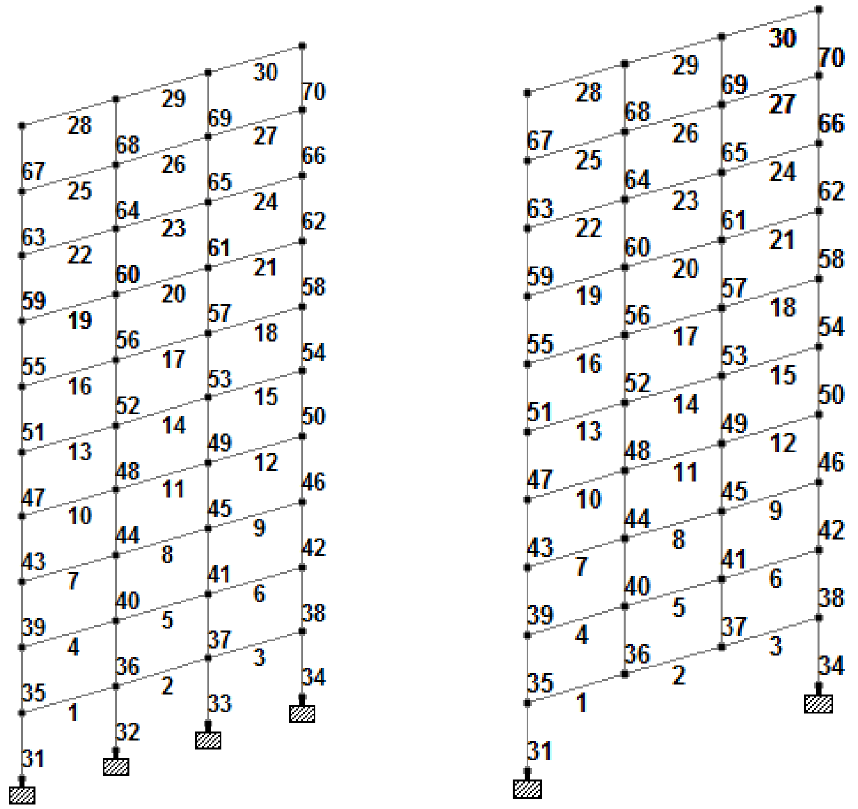
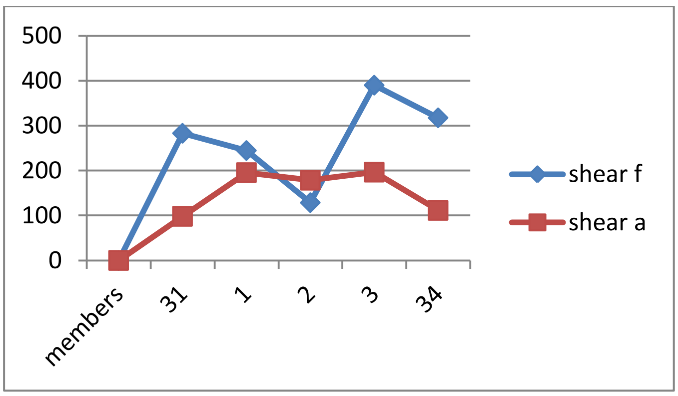


Fig.4.18 Frame 1 & Frame 6 with beam numbered

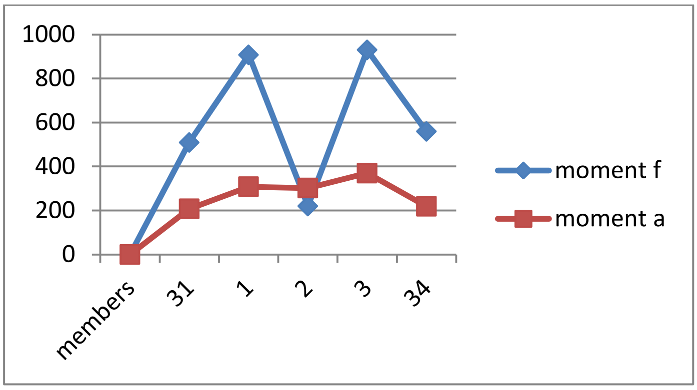
Table. 4.13 Shear stress in frame 1 & frame 6



	Frame 6	Frame 1
Member no	kN/m	kN/m
31	282.9	98.14
1	244.56	195.37
2	128.58	178.54
3	389.92	196.46
34	317.41	111.4

Fig.4.19 Graph of shear stress b/w frame 1 &frame 6

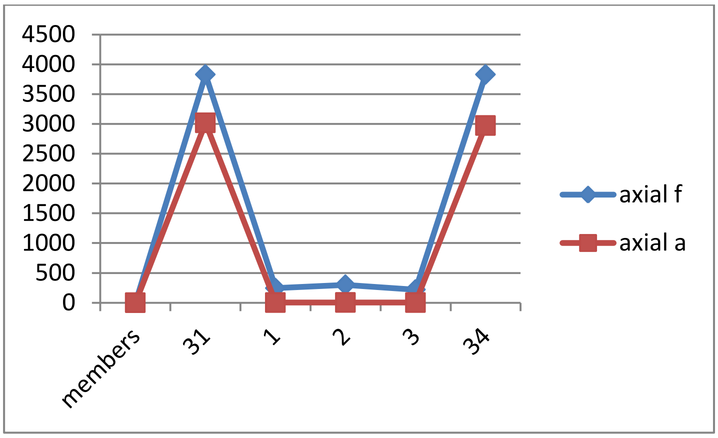
Table. 4.14 Bending moment in frame 1 & 6



	Frame 6	Frame1
Member no	kNm	kNm
31	508.93	207.59
1	907.37	308.15
2	219.91	302.11
3	930.06	369.8
34	559.33	219.15

Fig.4.20 Graph of Bending moment b/w frame 1 &frame 6

Table. 4.15 Axial force in frame 1 & frame 6



	Frame 6	Frame 1
Member no	kN	kN
31	3828.48	3017.62
1	244.56	2.29
2	301.27	3.93
3	220.39	2.29
34	3828.48	2972.47

Fig.4.21 Graph of Axial force b/w frame 1 & frame 6

When the forces of Beam-1, Beam- 3 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 196.46 kN/m to 389.92 kN/m and the force maximum bending moment (Mz) of Beam-1, Beam-3 of both the frames when compared then it is noted that the value increases from 369.8 kNm to 950.06 kNm and maximum axial force (Fx) of Beam-47, Beam- 50 of both the frames increases from 3017.62 kN to 3828.48 kN respectively. It is noted that the maximum shear force (Fy) in Beam-3 in irreguar frame comming out to be more then the same beam in regular structure.

4.4.6 FRAME 1-7:-

In this section the comparison of frame 1 and frame 7 is done. The beams at the setback i.e. Beam-35, Beam-1, Beam-2, Beam-3, Beam-38 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn**.**

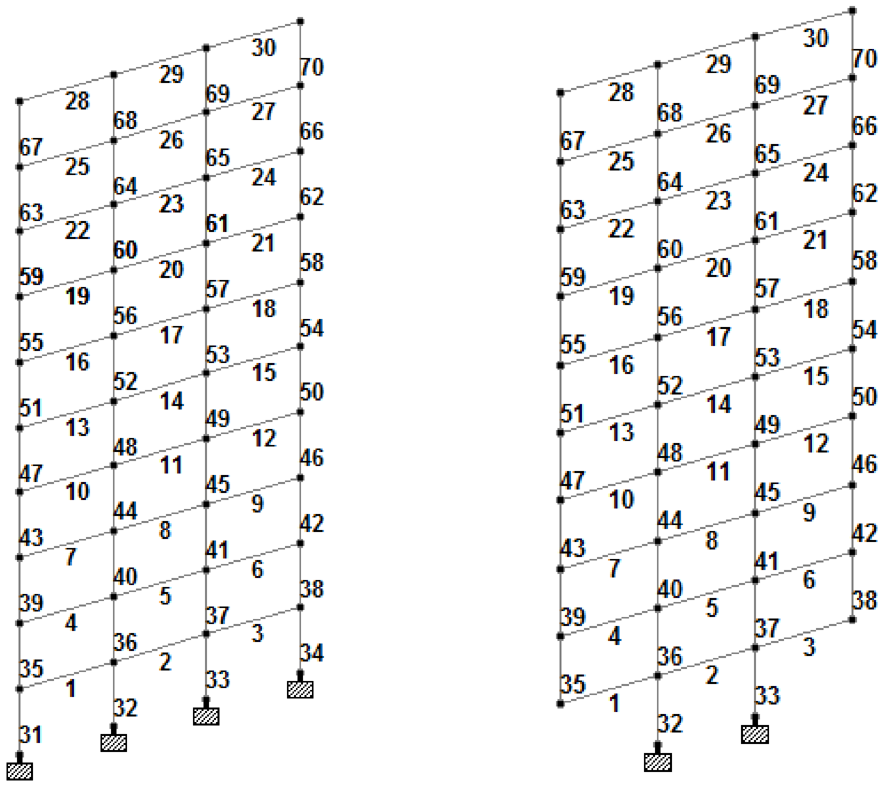


Fig.4.22 Frame 1 & Frame 7 with beam numbered

Table. 4.16 Shear stress in frame 1 & frame 7

	Frame 7	Frame 1
Member no	kN/m	kN/m
35	116.87	91.21
1	262.21	195.37
2	364.13	178.54
3	262.21	196.46
38	116.87	106.78

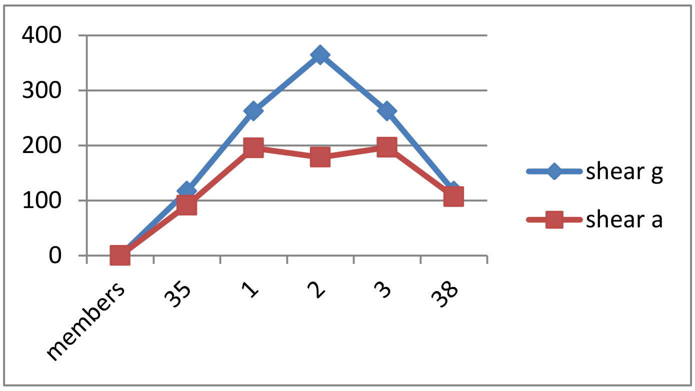
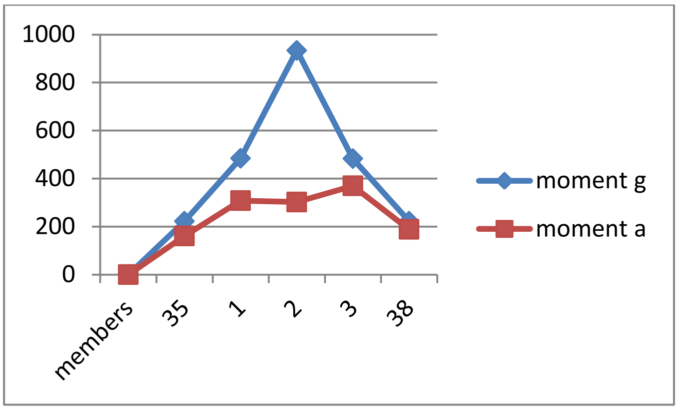


Fig.4.23 Graph of shear stress b/w frame 1 & frame 7

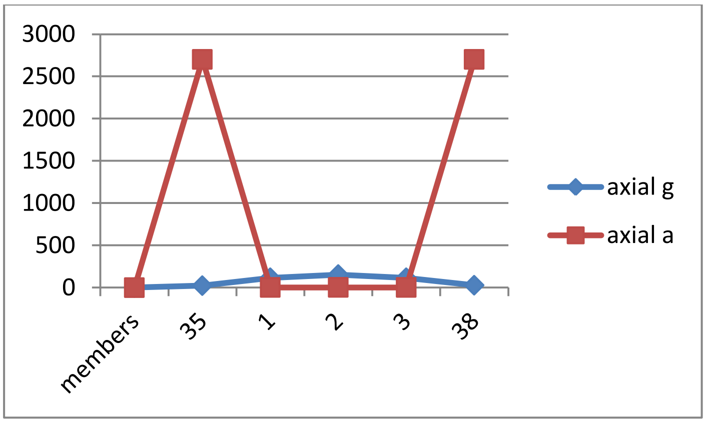
Table. 4.17 Bending moment in frame 1 & 7



	Frame 7	Frame 1
Member no	kNm	kNm
35	222.11	160.85
1	484.28	308.15
2	933.48	302.11
3	482.87	369.8
38	222.11	188.4

Fig.4.24 Graph of Bending moment b/w frame 1 & frame 7

Table. 4.18 Axial force in frame 1 & frame 7



	Frame 7	Frame 1
Member no	kN	kN
35	23.6	2701.78
1	117.02	20.31
2	154.79	31.14
3	117.02	20.31
38	28.37	2701.78

Fig.4.25 Graph of Axial force b/w frame 1 & frame 7

When the forces of Beam-2, Beam- 3 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 178.54 kN/m to 364.13 kN/m and the force maximum bending moment (Mz) of Beam-2, Beam-3 of both the frames when compared then it is noted that the value increases from 302.11 kNm to 933.48 kNm and maximum axial force (Fx) of Beam-2, Beam- 3 of both the frames increases from 31.14 kN to 154.79 kN respectively. It is noted that the maximum shear force (Fy) in Beam-2 in irreguar frame comming out to be more then the same beam in regular structure.

4.4.7 FRAME 1-8:-

In this section the comparison of frame 1 and frame 8 is done. The beams at the setback i.e. Beam-51, Beam-52, Beam-53, Beam-54 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

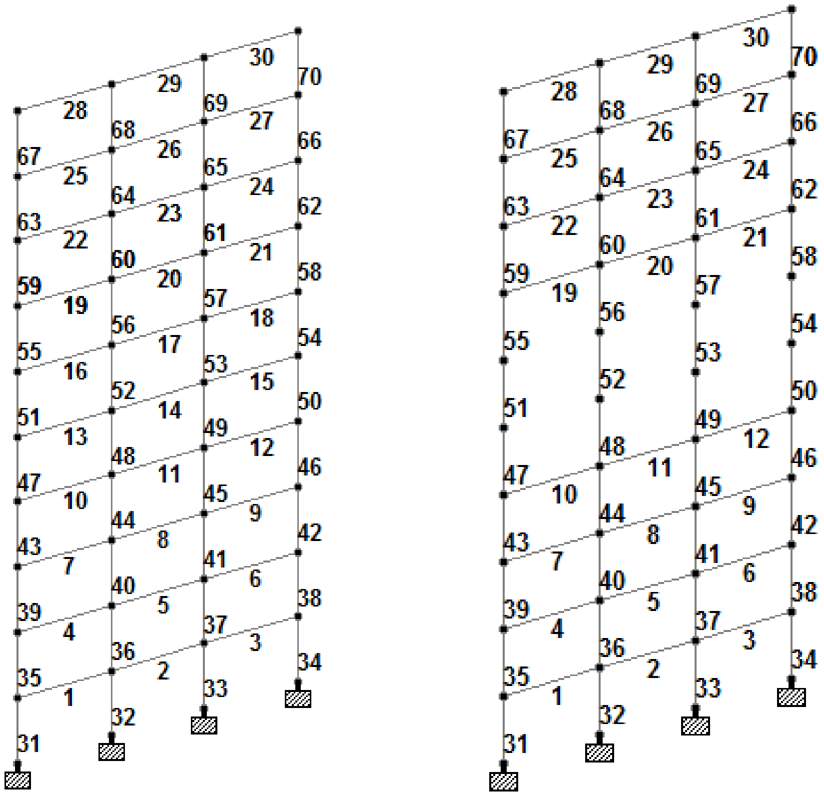
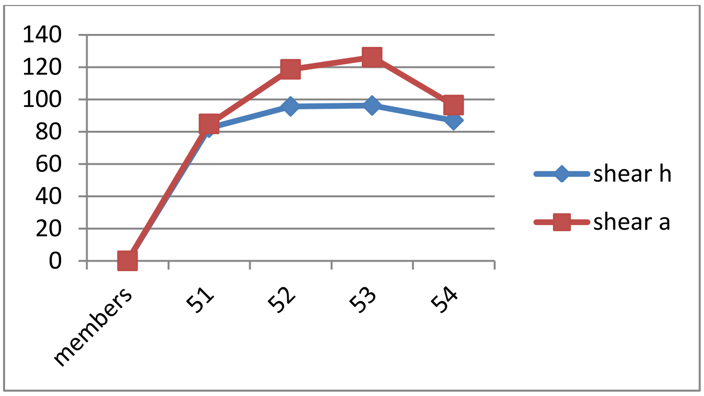


FIG 27. Frame 1 & Frame 8 with beam numbered

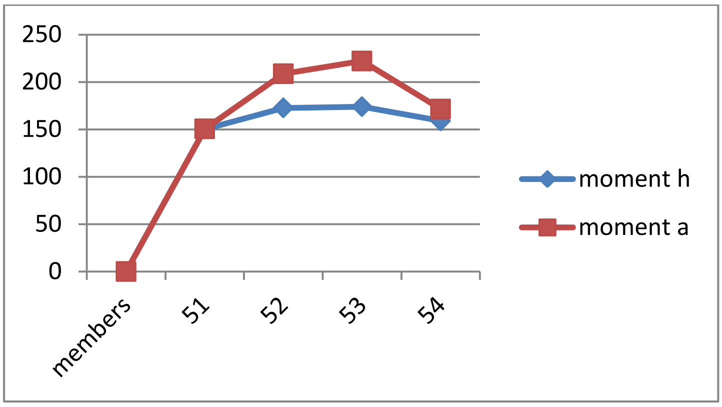
Table. 4.19 Shear stress in frame 1 & frame 8



	Frame 1	Frame 8
Member no	kN/m	kN/m
51	82.37	84.74
52	95.56	118.53
53	96.1	125.99
54	86.97	96.41

Fig.4.26 Graph of shear stress b/w frame 1 & frame 8

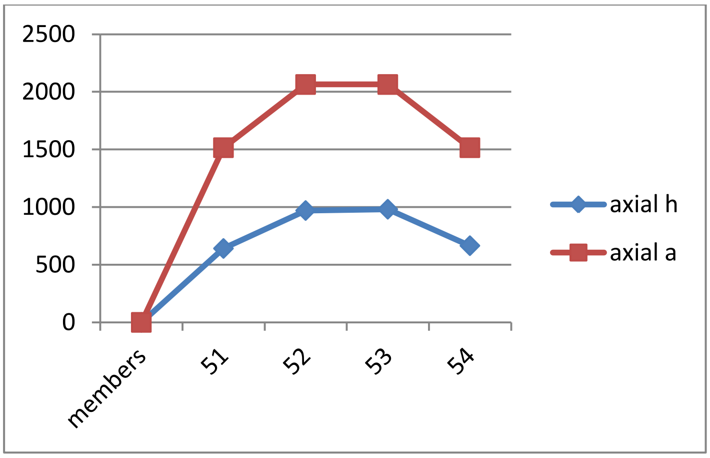
Table. 4.20 Bending moment in frame 1 and 8



	Frame 8	Frame 1
Member no	kNm	kNm
51	150.33	150.56
52	172.66	208.65
53	173.97	222.08
54	158.88	171.4

Fig.4.27 Graph of Bending moment b/w frame 1 & frame 8

Table. 4.21 Axial force in frame 1 & frame 8



	Frame 8	Frame 1
Member no	kN	kN
51	641.23	1515.49
52	970.37	2063.69
53	981.5	2063.69
54	665.18	1515.49

Fig.4.28 Graph of Axial force b/w frame 1 & frame 8

When the forces of Beam-52, Beam- 53 of both the frames i.e frame 1 and frame 8 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 96.1 kN/m to 125.99 kN/m and rest of the forces i.e maximum axial force(Fx) and maximum bending moment(Mz) of Beam-52, Beam- 53 of both the frames decreases from 2063.69 kN to 981.5 kN and 222.08 kNm to 173.97 kNm respectively. It is noted that the maximum shear force(Fy) in Beam-53 in irreguar frame comming out to be more then the same beam in regular structure.

4.4.8 FRAME 1-9:-

In this section the comparison of frame 1 and frame 9 is done. The beams at the setback i.e. Beam-64, Beam-23, Beam-61, Beam-57 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

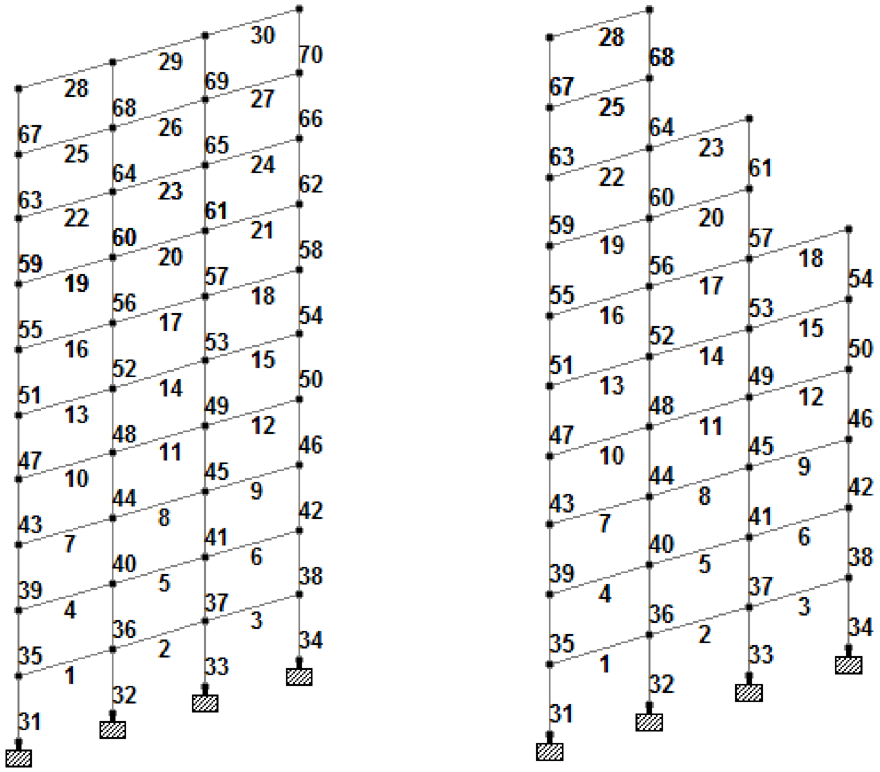
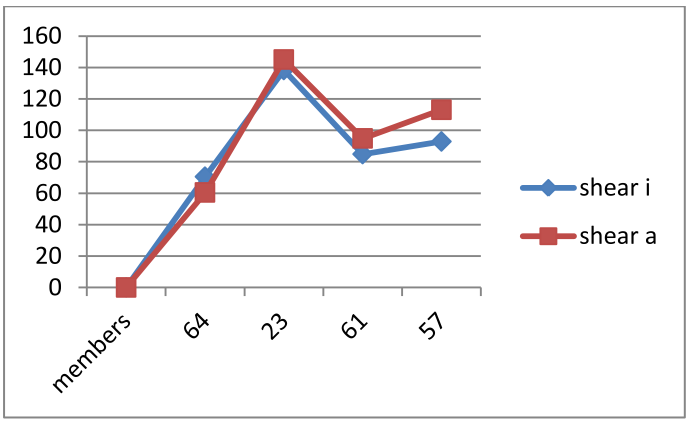


Fig.4.29 Frame 1 & Frame 9 with beam numbered

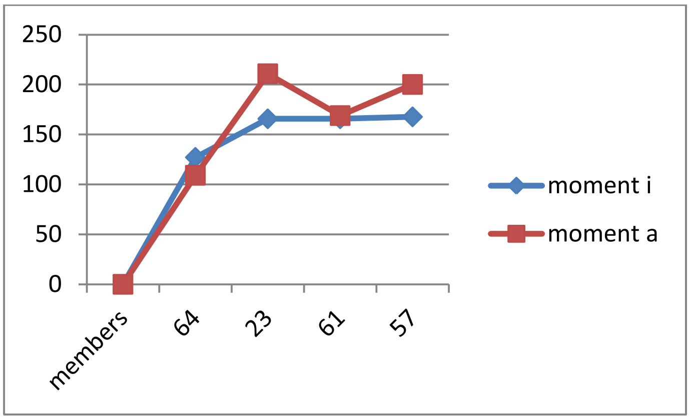
Table. 4.22 Shear stress in frame 1 & frame 9



	Frame 1	Frame 9
Member no	kN/m	kN/m
64	70.47	60.43
23	138.3	145.01
61	84.83	94.82
57	92.85	113.03

Fig.4.30 Graph of shear stress b/w frame 1 & frame 9

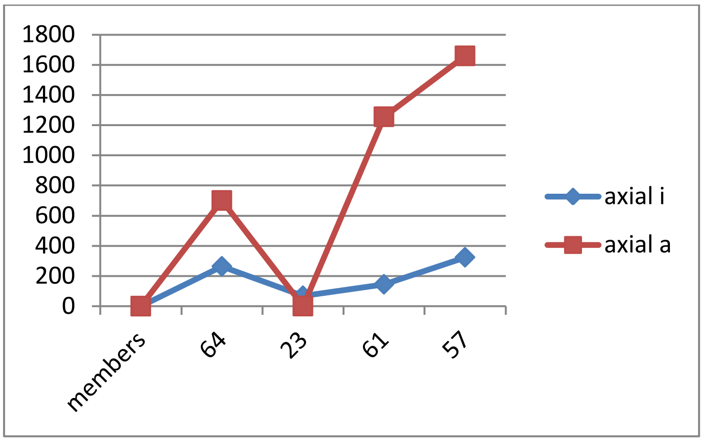
Table. 4.23 Bending moment in frame 1 & frame 9



	Frame 9	Frame 1
Member no	kNm	KNm
64	127.1	109.16
23	165.7	210.79
61	165.7	168.88
57	167.64	200.04

Fig.4.31 Graph of Bending moment b/w frame 1 & frame 9

Table. 4.24 Axial force in frame 1 & frame 9



	Frame 9	Frame 1
Member no	kN	kN
64	263.88	700.26
23	68.88	0.52
61	144.68	1255.1
57	323.77	1658.56

Fig.4.32 Graph of Axial force b/w frame 1 & frame 9

When the forces of Beam-23, Beam- 57 of both the frames i.e frame 1 and frame 9 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 138.3 kN/m to 145.01 kN/m and rest of the forces i.e maximum axial force(Fx) and maximum bending moment(Mz) of Beam-64, Beam- 57 of both the frames decreases from 1658.56 kN to 323.77kN and 200.04 kNm to 167.64 kNm respectively. It is noted that the maximum shear force(Fy) in Beam-23 in irreguar frame comming out to be more then the same beam in regular structure.

4.4.9 FRAME 1-10:-

In this section the comparison of frame 1 and frame 10 is done. The beams at the setback i.e. Beam-64, Beam-23, Beam-61, Beam-57 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

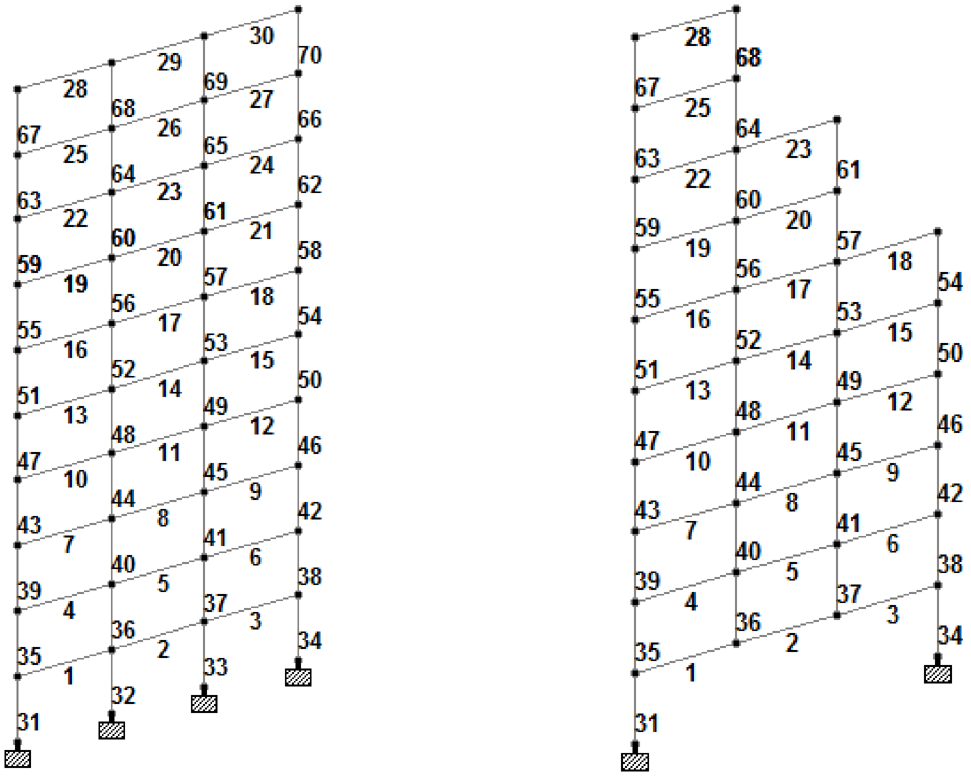
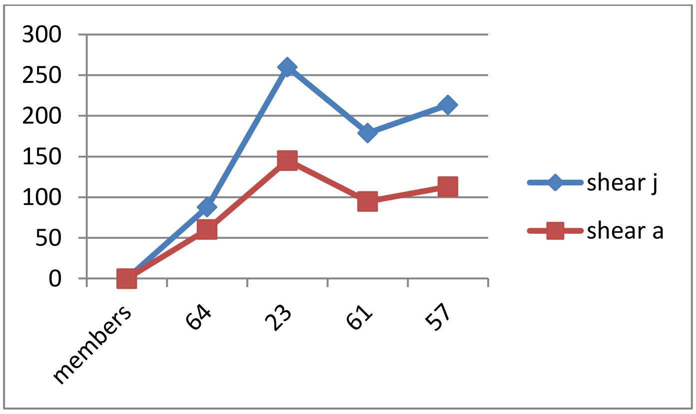


Fig.4.33 Frame 1 & Frame 10 with beam numbered

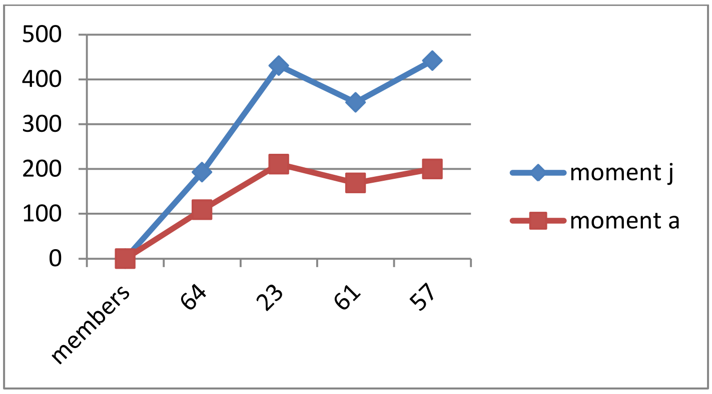
Table. 4.25 Shear stress in frame 1 & frame 10



	Frame 10	Frame 1
Member no	kN/m	kN/m
64	87.85	60.43
23	259.9	145.01
61	178.88	94.82
57	213.5	113.03

Fig.4.34 Graph of shear stress b/w frame 1 & frame 10

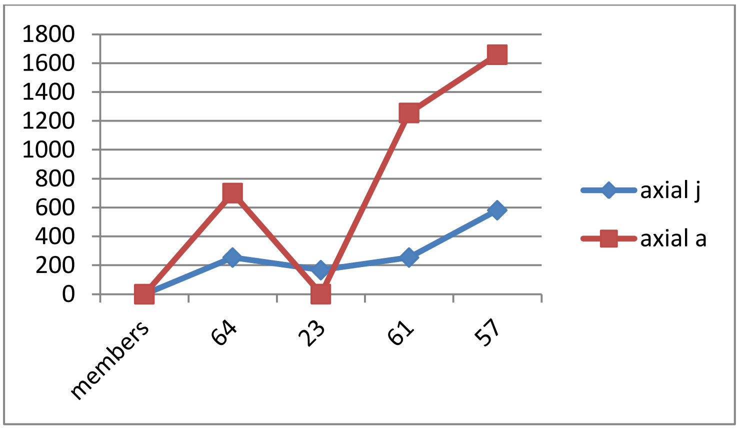
Table. 4.26 Bending moment in frame 1 & frame 10



	Frame 10	Frame 1
Member no	kNm	kNm
64	192.97	109.16
23	430.58	210.79
61	348.66	168.88
57	441.68	200.04

Fig.4.35 Graph of Bending momrnt b/w frame 1 & frame 10

Table. 4.27 Axial force in frame 1 & frame 10



	Frame 10	Frame 1
Member no	kN	kN
64	253.81	700.26
23	166.45	0.52
61	253.8	1255.1
57	581.38	1658.56

Fig.4.36 Graph of Axial force b/w frame 1 & frame 10

When the forces of Beam-23, Beam- 57 of both the frames i.e frame 1 and frame 10 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 145.01 kN/m to 259.9 kN/m and the force maximum axial force(Fx) increases from 200.04 kN to 441.68 kN and maximum bending moment(Mz) of Beam-64, Beam- 57 of both the frames decreases from 1658.56 kN to 581.38 kN and 200.04 kNm to 167.64 kNm respectively. It is noted that the maximum shear force (Fy) in Beam-23 in irreguar frame comming out to be more then the same beam in regular structure.

4.4.10 RESULTS OF STOREY DISPLACEMENT & DRIFT:-

Table. 4.28 Storey-Displacement (UX) in X-Direction (mm)

Column1	Frame 1	Frame 2	Frame 3	Frame 4	Frame 5	Frame 6	Frame 7	Frame 8	Frame 9	Frame 10
STOREY	UX	UX	UX	UX	UX	UX	UX	UX	UX	UX
10	39.88	97.39	57.43	48.99	54.79	43.44	97.1	95.57	55.1	33.64
9	38.46	96.12	56.33	39.88	54.69	42.11	89.87	94.18	49.8	31.68
8	35.96	93.89	53.54	35.96	50.18	39.66	81.67	91.7	44.6	28.77
7	32.58	90.87	50.19	32.58	44.37	36.35	72.58	87.54	42.5	25.95
6	28.54	87.26	45.78	28.53	38.15	32.39	62.8	68.84	22.37	25.95
5	24.01	83.21	32.52	24.01	31.68	27.95	52.51	37.28	19.16	22.05
4	19.16	78.84	18.79	19.16	25.06	23.19	41.84	17.89	15.46	18.48
3	14.12	73.38	13.53	14.12	18.37	18.24	30.92	12.55	11.48	14.64
2	9.01	52.15	8.63	9.01	11.68	13.23	19.84	7.983	7.36	10.65
1	3.94	17.94	3.77	3.95	5.11	8.039	8.745	3.915	3.23	6.492

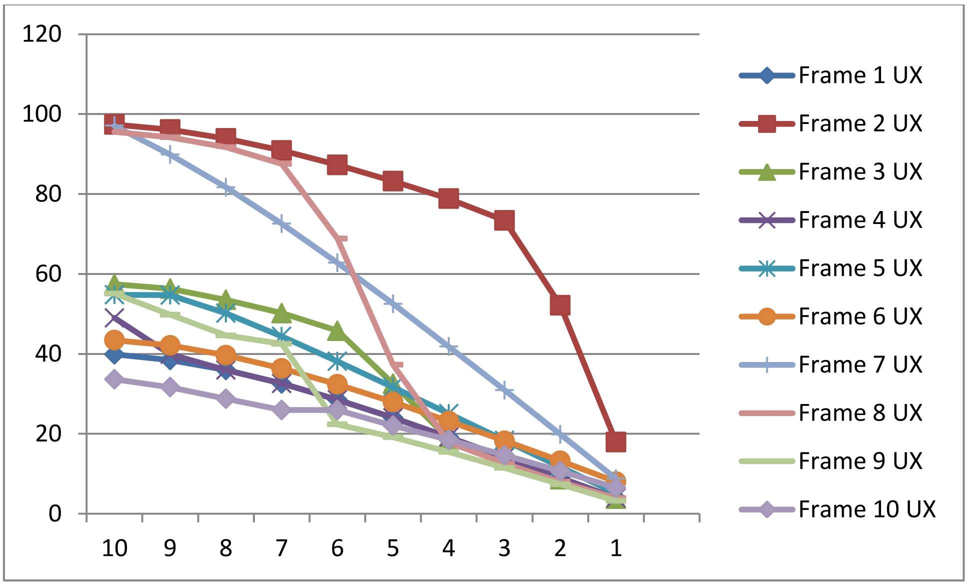


Fig.4.37 Graph of displacement of each frame w.r.t each storey

Table. 4.29 Storey-Drift (UX) in X-Direction (mm)

Column1	Frame 1	Frame 2	Frame 3	Frame 4	Frame 5	Frame 6	Frame 7	Frame 8	Frame 9	Frame 10
STOREY	UX	UX	UX	UX	UX	UX	UX	UX	UX	UX
10	1.4317	1.2798	1.4425	0.1057	1.1843	1.4042	7.2062	1.4028	1.9543	6.492
9	2.4958	2.2294	2.4917	4.5119	1.7664	2.4428	8.1993	2.4752	2.9188	6.8671
8	3.3771	3.0161	3.3514	5.8059	0.1089	3.3072	9.0894	4.1631	2.8612	5.258
7	4.0465	3.6137	4.389	6.2183	5.6019	3.9647	9.7786	18.5417	3.5209	5.2744
6	4.5289	4.0478	13.2986	6.4688	5.7598	4.4397	10.2964	31.959	3.2301	3.0515
5	4.8503	4.3717	13.7445	6.6209	0.0954	4.7577	10.6688	19.147	3.7033	3.5665
4	5.0374	5.46	5.2213	6.6908	7.2603	4.9475	10.9225	5.3336	3.9801	3.8445
3	5.1141	20.7465	4.898	6.6908	8.993	5.0144	11.0825	4.5693	4.1222	3.9841
2	5.0632	34.4464	4.8575	6.5657	8.9587	5.1934	11.0735	4.4911	4.1253	4.1762
1	3.9404	18.184	3.7745	5.1138	6.9974	8.033	8.7591	3.4912	3.2277	6.4771

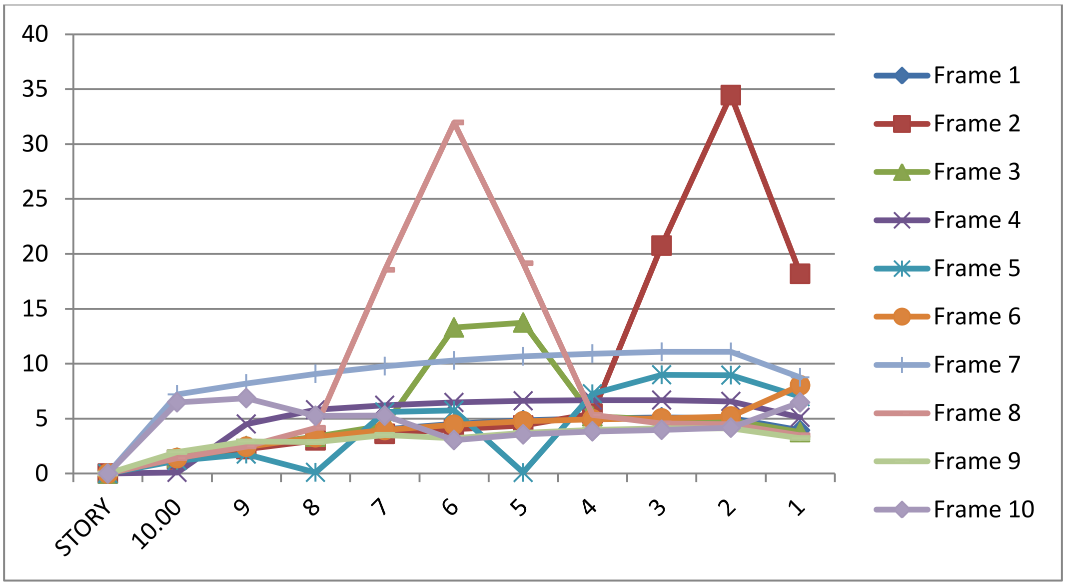


Fig.4.38 Graph of Storey-Drift (UX) in X-Direction (mm)

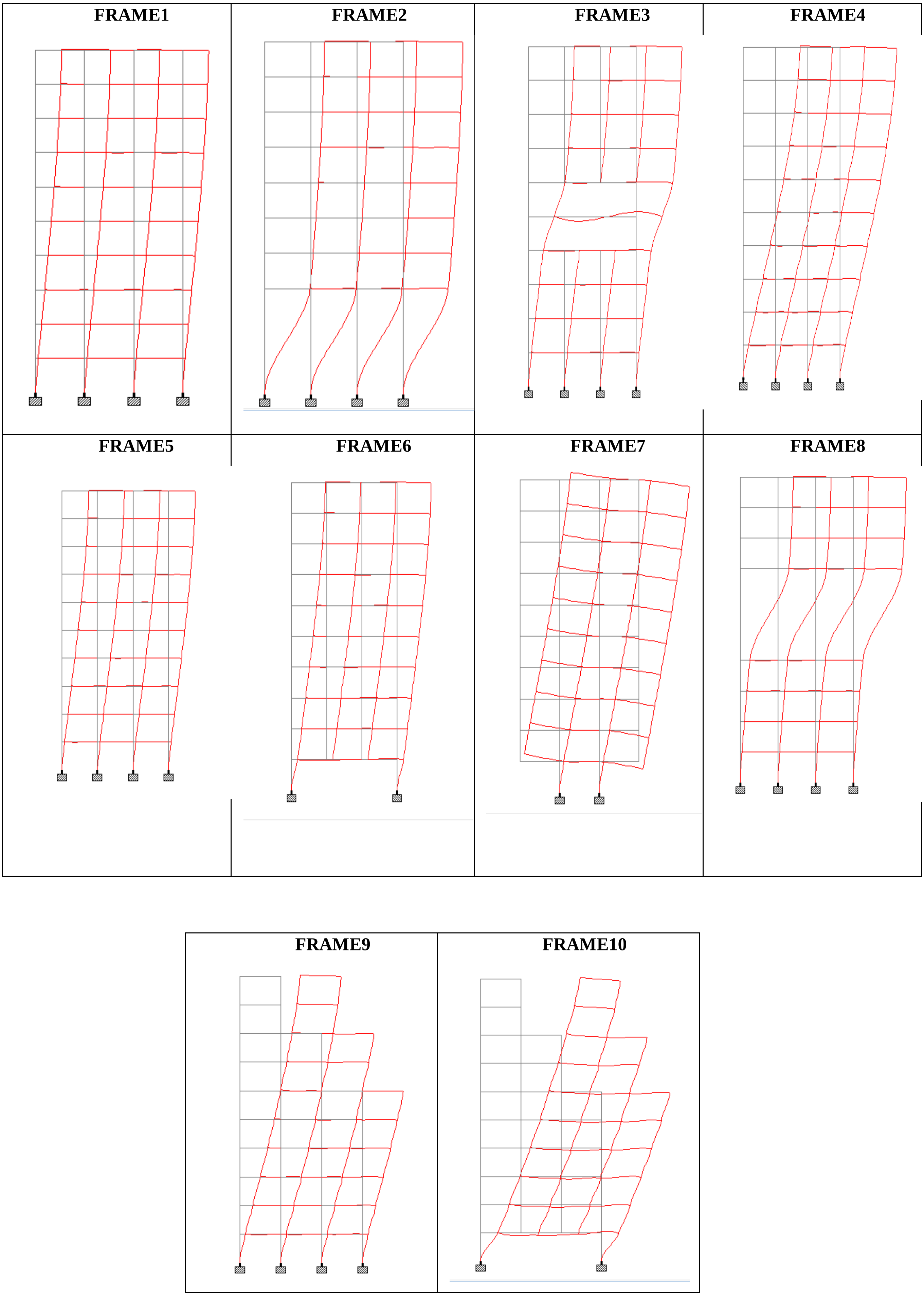


Fig.4.39 Displacement of Frames with Lateral Load

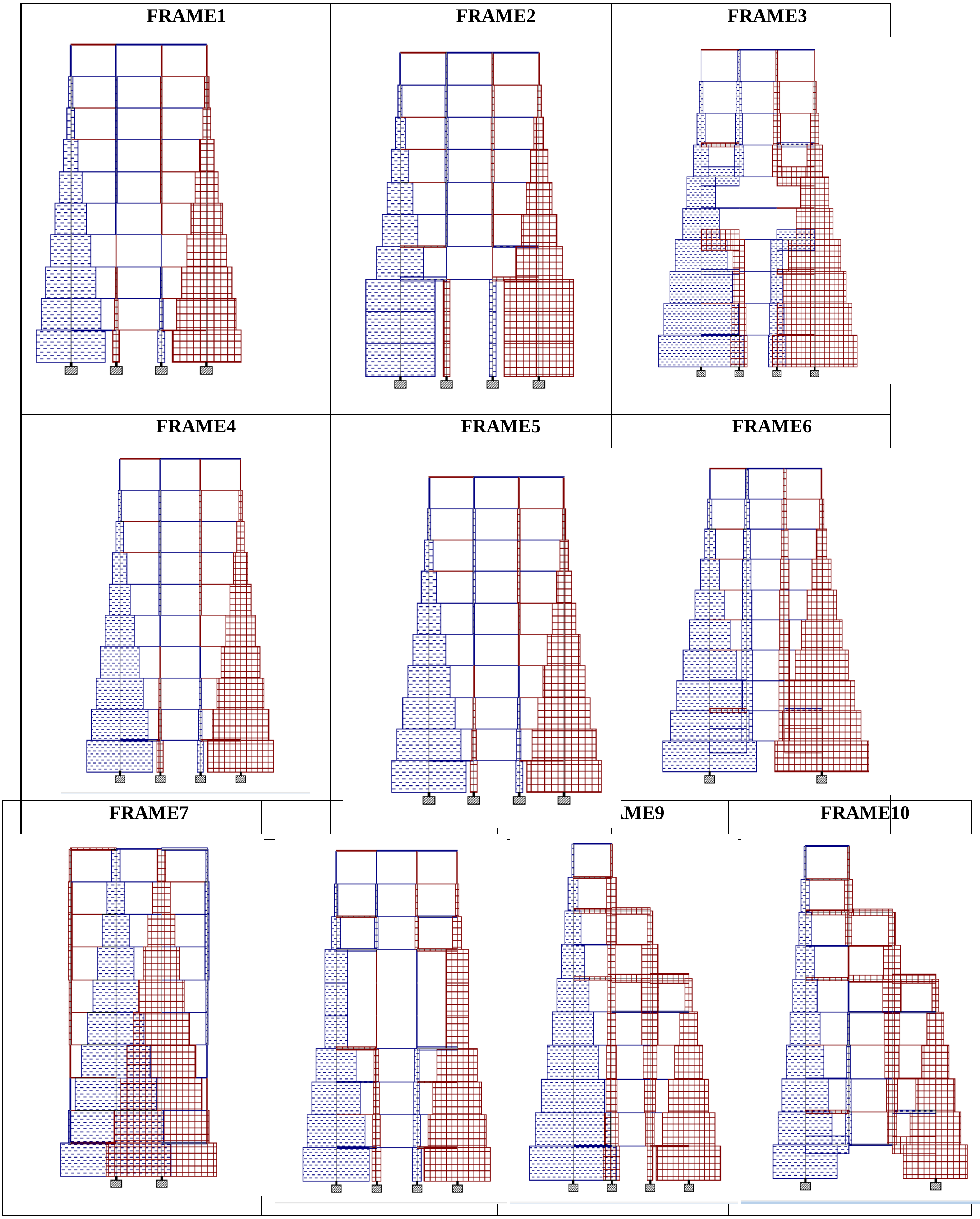


Fig.4.40 Axial Force Diagram of Frames

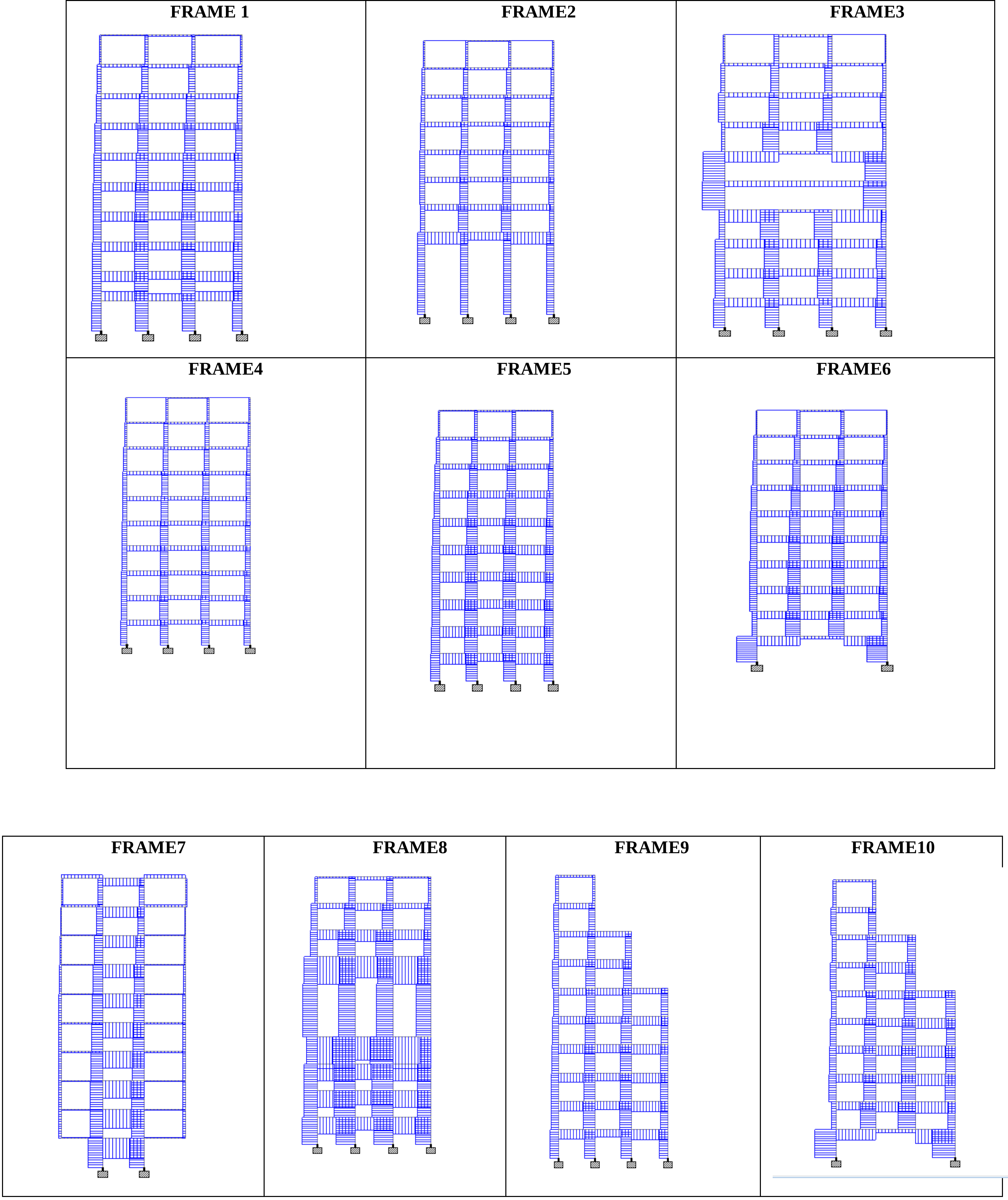


Fig.4.41 Shear Force Diagram of Frames

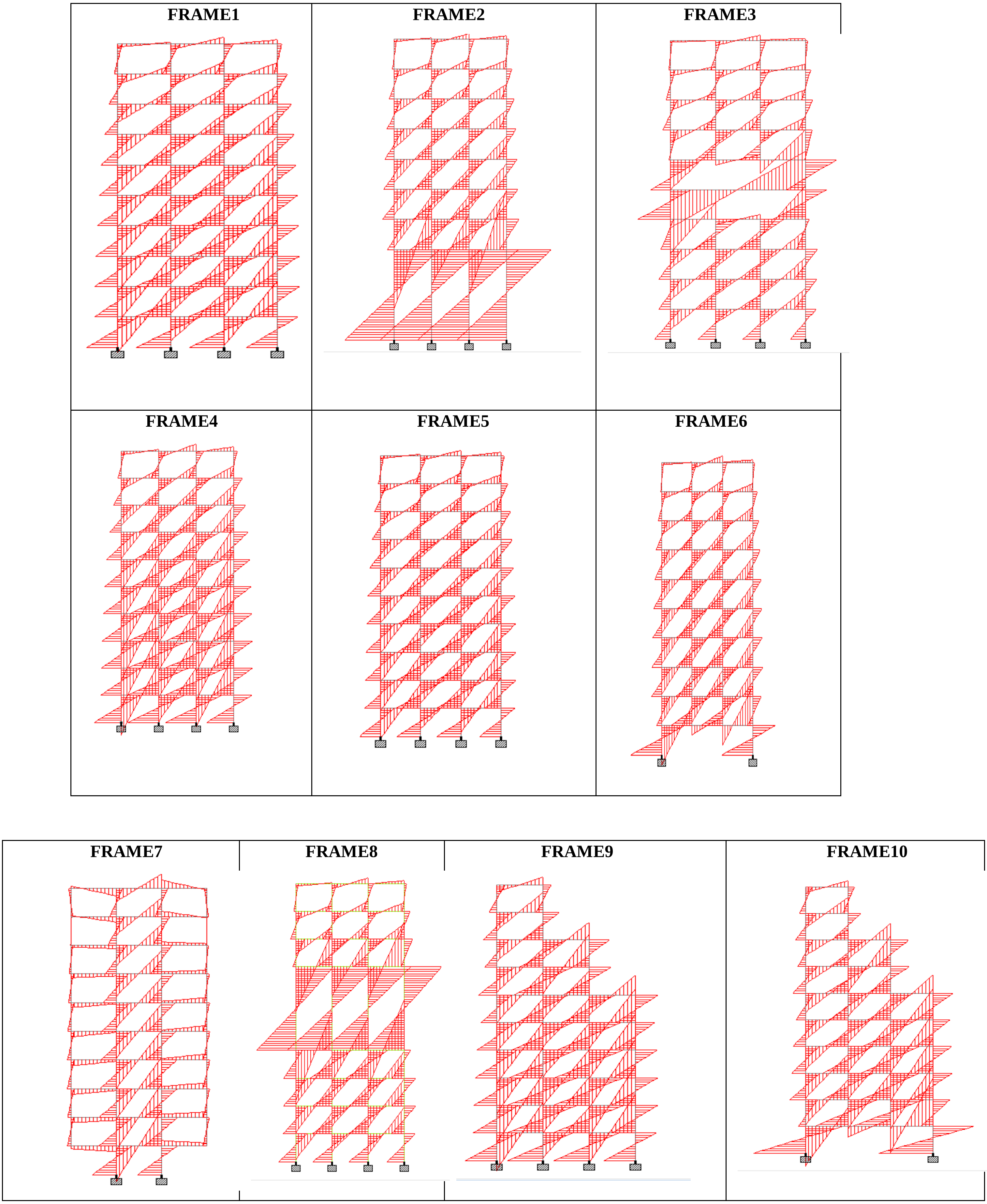
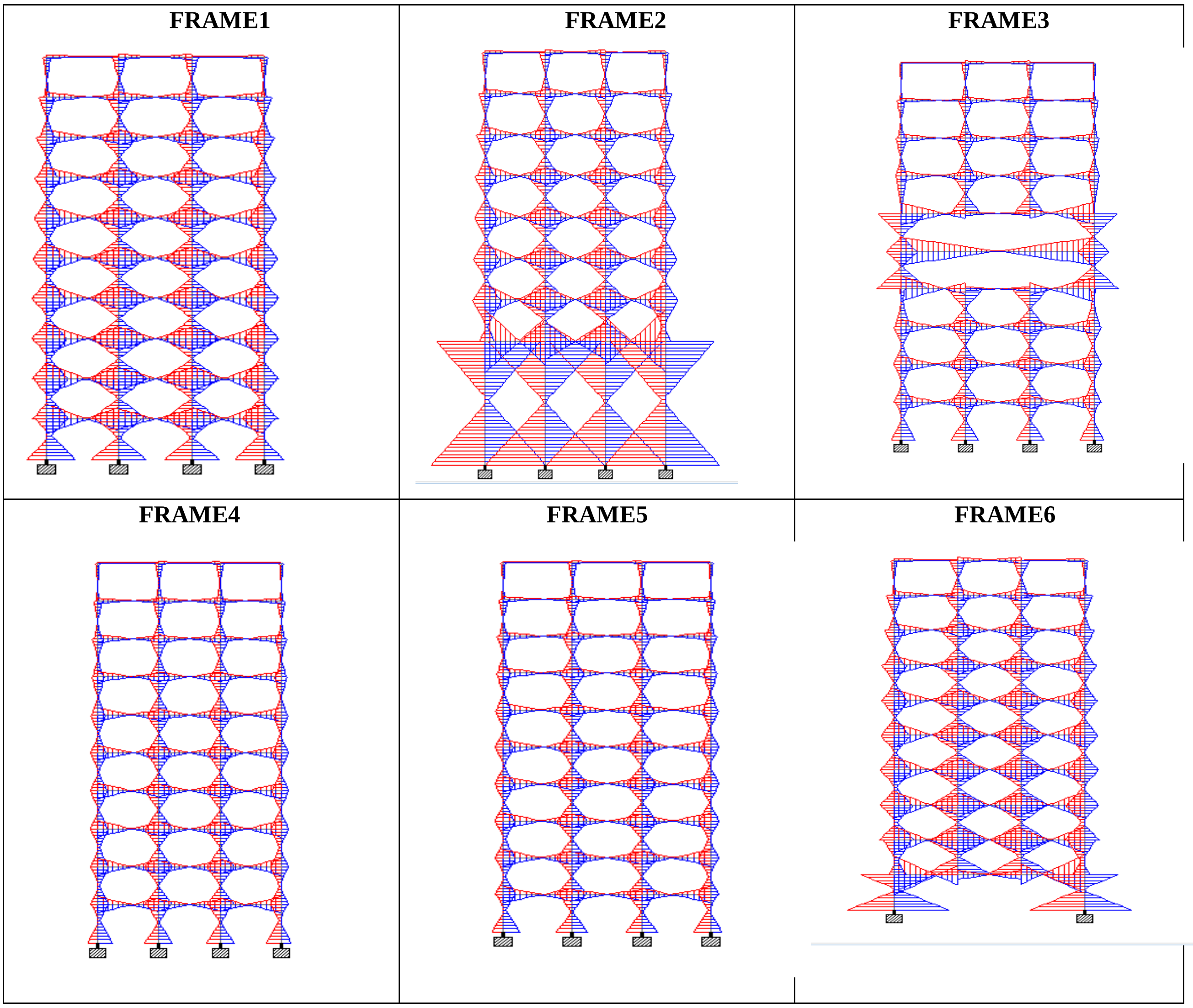


Fig.4.42 Bending Moment Diagram of Frames



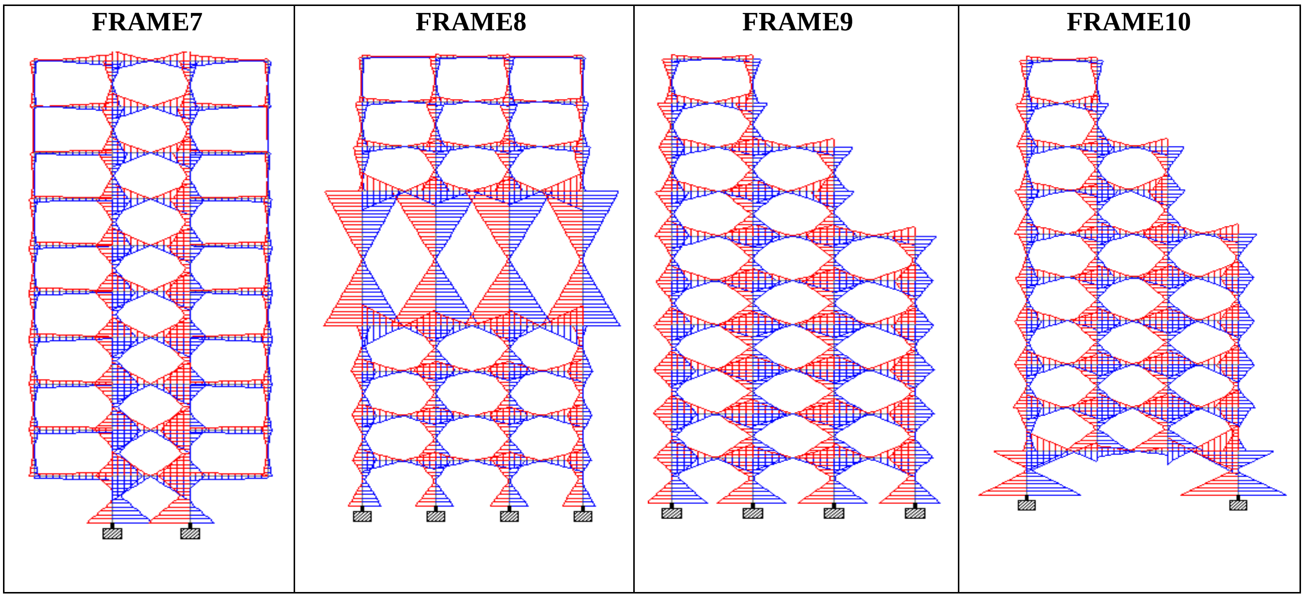


Fig.4.43 Beam stesses in Frames

4.5 DISCUSSION

4.5.1. FRAME 1 AND FRAME 2

- It is noted that in Beam 37 the value of maximum shear force (Fy) from regular to irregular frame increases from 105.83 kN/m to 142.55 kN/m.
- It is noted that in Beam 36 the value of maximum axial force(Fx) from regular frame to irregular frame decreases from 1993.72 kN to 1983.91 kN respectively.
- It is noted that in Beam 36 the value of maximum bending moment (Mz) from regular frame to irregular frame decreases from 246.36 kNm to 194.54 kNm respectively.

4.5.2. FRAME 1 AND FRAME 3

- It is noted in that Beam 13 the value of maximum shear force (Fy) from regular to irregular frame increases from 180.16 kN/m to 367.32 kN/m.
- It is noted that in Beam-15 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 344.27 kNm to 1095.79 kNm respectively.
- It is noted that in Beam-54 the value of maximum axial force (Fx) from regular frame to irregular frame increases from 764.55 kN to 1880.55 kN respectively

4.5.3. FRAME 1 AND FRAME 4

- It is noted that in Beam-10 the value of maximum shear force (Fy) from regular frame to irregular frame increases from 189.12 kN/m to 277.26 kN/m respectively.
- It is noted that in Beam-12 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 360.14 kNm to 361.69 kNm respectively.
- It is noted that in Beam 47 the value of maximum axial force (Fx) from regular frame to irregular frame increases from 944.65 kN to 1050.79 kN respectively.

4.5.4. FRAME 1 AND FRAME 5

- It is noted that in Beam-30 the value of maximum shear force (Fy) from regular frame to irregular frame increases from 43.48 kN/m to 226.59 kN/m respectively.
- It is noted that in Beam-29 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 129.58 kNm to 174.44 kNm respectively.
- It is noted that in Beam-29 the value of maximum axial force (Fx) from regular frame to irregular frame increases from 52.43 kN to 62.69 kN respectively.

4.5.5. FRAME 1 AND FRAME 6

- It is noted that in Beam-3 the value of maximum shear force (Fy) from regular to irregular frame increases from 196.46 kN/m to 389.92 kN/m.
- It is noted that in Beam-3 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 369.8 kNm to 930.06 kNm respectively.
- It is noted that in Beam-31 the value of maximum axial force (Fx) from regular to irregular frame increases from 3017.62 kN to 3828.48 kN.

4.5.6. FRAME 1 AND FRAME 7

- It is noted that in Beam-2 the value of maximum shear force (Fy) from regular to irregular frame increases from 178.54 kN/m to 364.13 kN/m.
- It is noted that in Beam-2 the value of maximum bending moment(Mz) from regular frame to irregular frame increases from 302.11 kNm to 933.48 kNm respectively.
- It is noted that in Beam-2 the value of maximum axial force(Fx) from regular to irregular frame increases from 3.14 kN to 154.79 kN.

4.5.7. FRAME 1 AND FRAME 8

- It is noted that in Beam-52 the value of maximum shear force (Fy) from regular to irregular frame decreases from 118.53 kN/m to 95.56 kN/m.
- It is noted that in Beam-53 the value of maximum bending moment (Mz) from regular frame to irregular frame decreases from 222.08 kNm to 173.79 kNm respectively.
- It is noted that in Beam-31 the value of maximum axial force (Fx) from regular to irregular frame decreases from 2063.69 kN to 970.37 kN.

4.5.8. FRAME 1 AND FRAME 9

- It is noted that in Beam-23 the value of maximum shear force (Fy) from regular to irregular frame increases from 138.3 kN/m to 145.01 kN/m.
- It is noted that in Beam-23 the value of maximum bending moment (Mz) from regular frame to irregular frame decreases from 210.79 kNm to 165.7 kNm respectively.
- It is noted that in Beam-57 the value of maximum axial force (Fx) from regular to irregular frame decreases from 1658.56 kN to 323.77 kN.

4.5.9. FRAME 1 AND FRAME 10

- It is noted that in Beam-57 the value of maximum shear force (Fy) from regular to irregular frame increases from 113.03 kN/m to 213.5 kN/m.
- It is noted that in Beam-57 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 200.04 kNm to 441.48 kNm respectively.
- It is noted that in Beam-57 the value of maximum axial force (Fx) from regular to irregular frame decreases from 1658.56 kN to 323.77 kN.

CHAPTER-5

STRUCTURAL ANALYSIS OF 3D STRUCTURES

5.1 INTRODUCTION

In this chapter, a brief of the problems identified by observing the building plan are given. Also, the static and the dynamic analysis are done. After doing the analysis, the output file is considered for comparing the reinforcements of the structural members.

5.2 PROBLEMS IDENTIFIED BY OBSERVING THE STRUCTURES

5.2.1 SOFT STOREY

It 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. In my thesis project, the ground storey consists of columns and beams with no infill walls. It contains the parking area and is considered as a soft storey. There should be special provisions made for the soft storey as far as the seismic loads are concerned. As per [10] IS 1893:2002, Dynamic analysis of building is carried out including the strength and stiffness effects of infill and inelastic deformations in the members, particularly, those in the soft storey, and the members designed accordingly. Alternatively, the following design criteria are to be adopted after carrying out the earthquake analysis, neglecting the effect of infill walls in other storey.

a) The columns and beams of the soft storey are to be designed for 2.5 times the storey shears and moments calculated under seismic loads specified in the other relevant clauses.

b) Besides the columns designed and detailed for the calculated storey shears and moments ,shear walls placed symmetrically in both directions of the building as far away from the centre of the building as feasible; to be designed exclusively for 1.5 times the lateral storey shear force calculated as before.

5.3 ANALYSIS OF EXISTING STRUCTURE

The building is then analysed using staad pro v8i software (figure 2).both the static and the dynamic analysis have been done for this building. Firstly, dead and the live loads are found out separately. The unit weights of the material are taken from is 875: part 1. The live loads of residential building, accessible and inaccessible roof is taken from [11] is 875 part 2. The seismic loads are taken out taking the help from is 1893:2002. Analysis and the design of the concrete building are then carried out

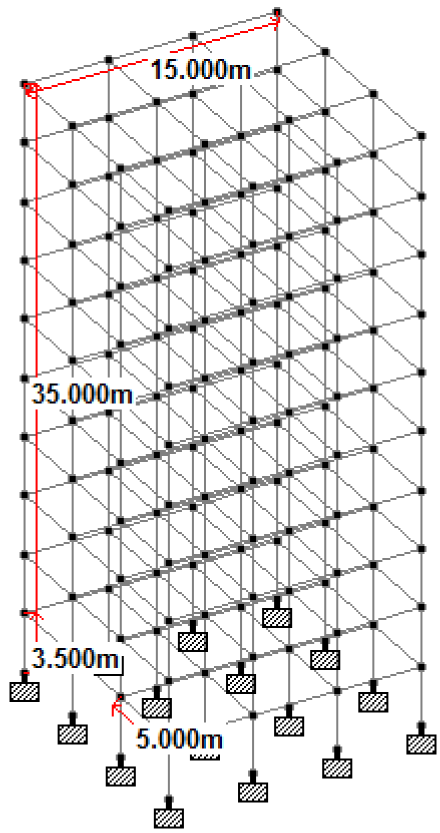


Fig.5.1 Ideal structure with Dimentions

5.4 COMPARISON OF STRUCTURE

Every irregular structure is compared with the regular structure and following variation are seen:

5.4.1 STRUCTURE 1-2:-

In this section the comparison of structure 1 and structure 2 is done. The beams at the setback i.e. Beam-31, Beam-35, Beam-39, Beam-43 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

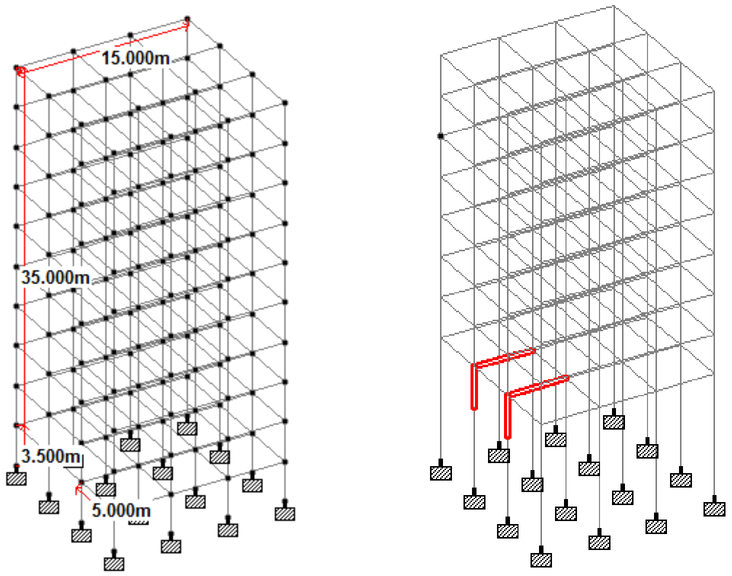
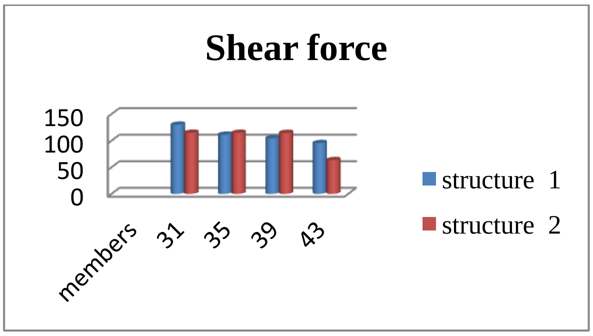


Fig.5.2 Structure 1 and Structure 2

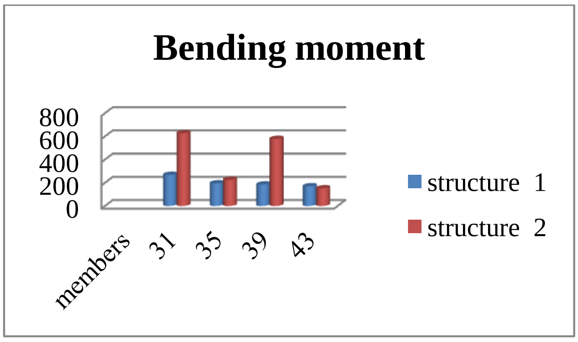
Table. 5.1 Shear stress in structure 1 & 2



	structure 1	structure 2
Member No.	kN/m	kN/m
31	130.07	114.9
35	111.36	114.82
39	104.56	114.57
43	95.55	63.44

Fig.5.3 Graph of shear stress b/w structure 1 & 2

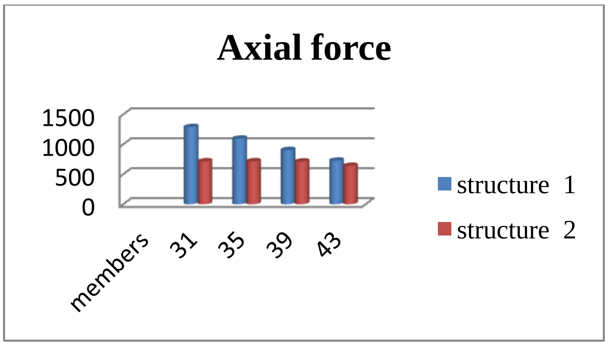
Table. 5.2 Bending moment in structure 1 & 2



	structure 1	structure 2
Member No.	kNm	kNm
31	268.19	626.9
35	194.88	224.73
39	184.84	578.12
43	169.67	151.85

Fig.5.4 Graph of bending moment b/w structure 1 & 2

Table. 5.3 Axial force in structure 1 & 2



	structure 1	structure 2
Member No.	kN	kN
31	1288.17	715.38
35	1094.63	715.38
39	904.29	712
43	726.59	641.38

Fig.5.5 Graph of Axial force b/w structure 1 & 2

When the forces of Beam-31 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 decreases from 130.07 kN/m to 114.9 kN/m and rest of the forces i.e maximum axial force (Fx) decreases from 1288.17 kN to 715.38 kN and maximum bending moment (Mz)incrases from 268.19 kNm to 626.9 kNm respectively. It is noted that the maximum shear force (Fy) in Beam-39 in irreguar frame comming out to be more then the same beam in regular structure

5.4.2 STRUCTURE 1-3:-

In this section the comparison of structure 1 and structure 3 is done. The beams at the setback i.e. Beam-51, Beam-307, Beam-271, Beam-387 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

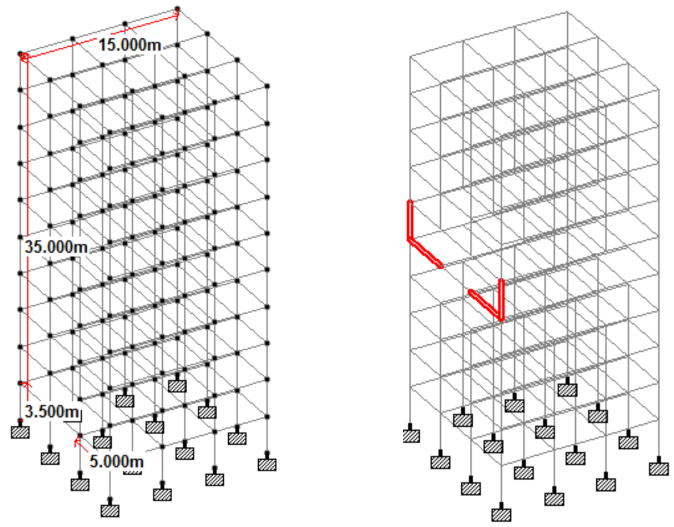
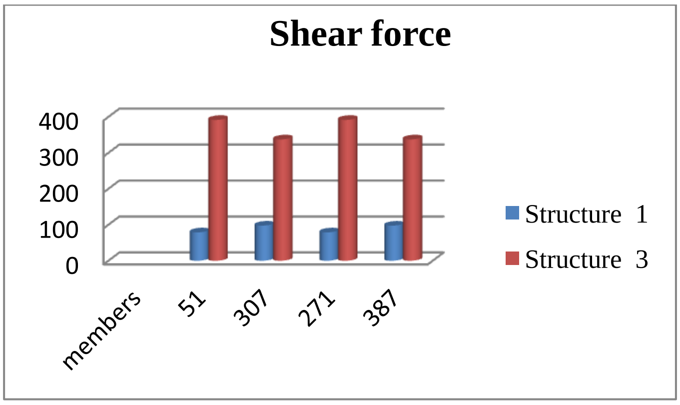


Fig.5.6 Structure 1 and Structure 3

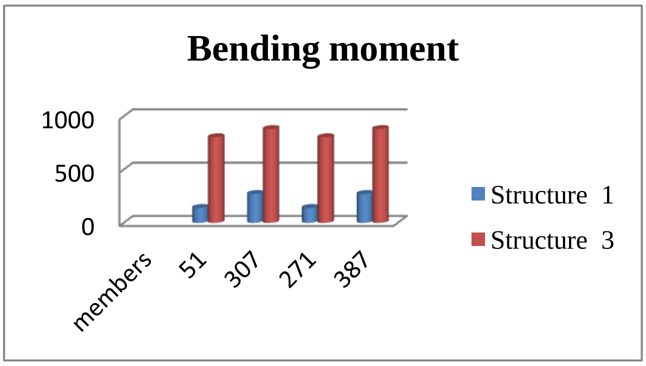
Table. 5.4 Shear stress in structure 1 & 3



	Structure 1	Structure 3
Member No.	kN/m	kN/m
51	78.8	391.66
307	97.61	337.42
271	78.75	391.66
387	97.52	337.42

Fig.5.7 Graph of shear stress b/w structure 1 & 3

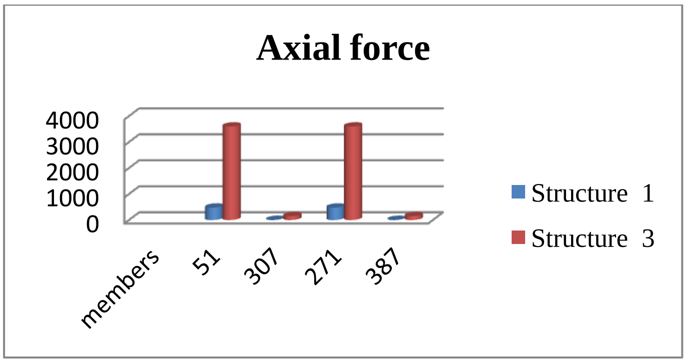
Table. 5.5 Bending moment in structure 1 & 3



	Structure 1	Structure 3
Member No.	kNm	kNm
51	140.42	804.3
307	271.59	881.02
271	140.42	804.3
387	271.38	881.02

Fig.5.8 Graph of Bending moment b/w structure 1 & 3

Table. 5.6 Axial force in structure 1 & 3



	Structure 1	Structure 3
Member No.	kN	kN
51	478.01	3599.9
307	4.8	149.47
271	478.01	3599.9
387	5.14	149.47

Fig.5.9 Graph of Axial force b/w structure 1 & 3

When the forces of Beam-51, Beam- 271 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 78.76 kN/m to 391.66 kN/m and rest of the forces i.e maximum axial force (Fx) and maximum bending moment (Mz) of Beam-51, Beam- 271 of both the frames increases from 478.01 kN to 3599.9 kN and 140.42 kNm to 804.3 kNm respectively. It is noted that the maximum shear force(Fy) in Beam-51,271 in irreguar frame comming out to be more then the same beam in regular structure.

5.4.3 STRUCTURE 1-4:-

In this section the comparison of structure 1 and structure 4 is done. The beams at the setback i.e. Beam-283, Beam-279, Beam-275, Beam-271 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn

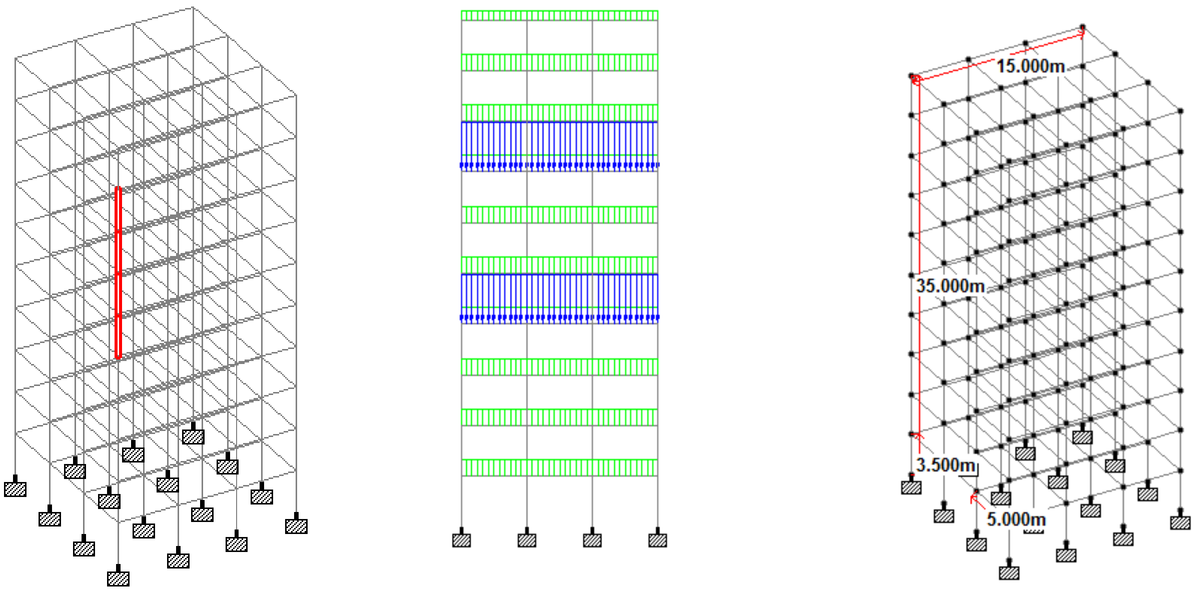
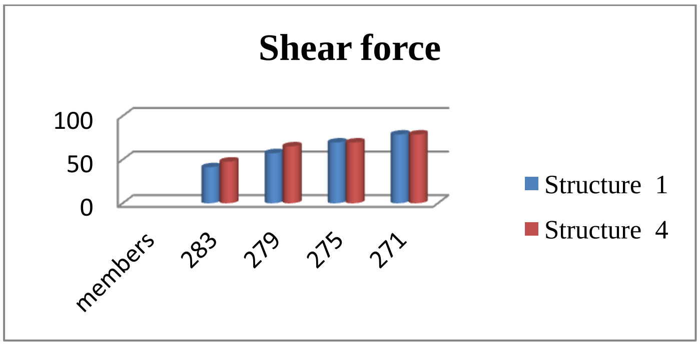


Fig.5.10 structure 4 with Loading and structure 1

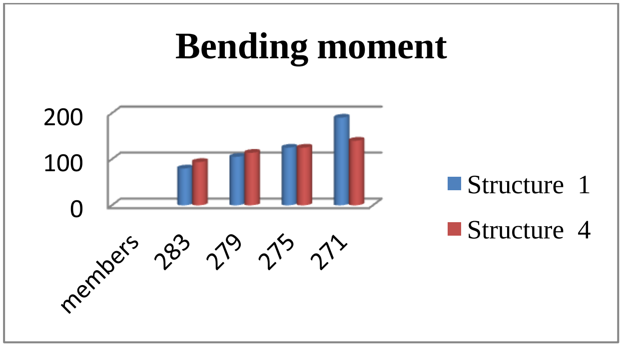
Table. 5.7 Shear stress in structure 1 & 4



	Structure 1	Structure 4
Member No.	kN/m	kN/m
283	41.26	47.69
279	57.36	65.15
275	69.62	69.62
271	78.75	78.75

Fig.5.11 Graph of shear stress b/w structure 1 & 4

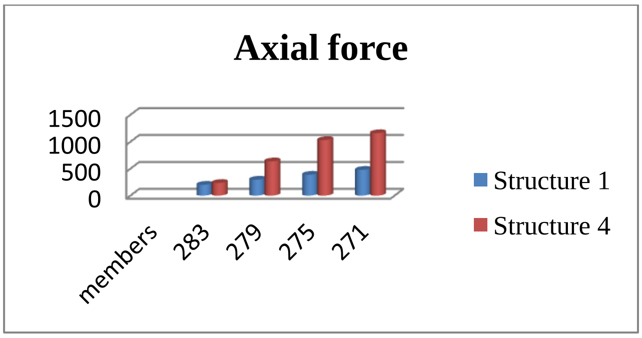
Table. 5.8 Bending moment in structure 1 & 4



	Structure 1	Structure 4
Member No.	kNm	kNm
283	80.1	94.14
279	105.3	114.13
275	125.29	125.29
271	190.42	140.42

Fig.5.12 Graph of Bending moment b/w structure 1 & 4

Table. 5.9 Axial force in frame structure 1 & 4



	Structure 1	Structure 4
Member No.	kN	kN
283	201.2	235.11
279	295.81	635.9
275	387.92	1032.67
271	478.01	1159.77

Fig.5.13 Graph of Axial force b/w structure 1 & 4

When the forces of Beam-275, Beam- 271 of both the frames i.e frame 1 and frame 4 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 78.75 kN/m to 78.8 kN/m and the force maximum bending moment (Mz)of Beam-271 of both the frames when compared then it is noted that the value decreases from 190.42 kNm to 140.42 kNm and maximum axial force (Fx) of Beam-275, Beam- 271 of both the frames increases from 387.92 kN to 1159.77 kN respectively. It is noted that the maximum shear force(Fy) in Beam-279 in irreguar frame comming out to be more then the same beam in regular structure

5.4.4 STRUCTURE 1-5:-

In this section the comparison of structure 1 and structure 5 is done. The beams at the setback i.e. Beam-28, Beam-73, Beam-74 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn**.**

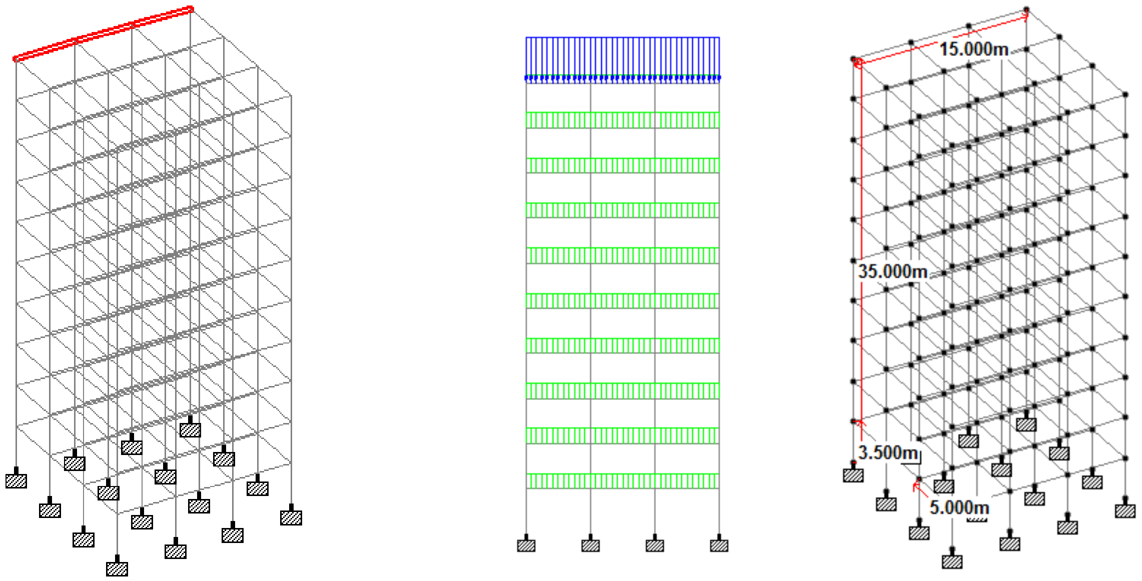
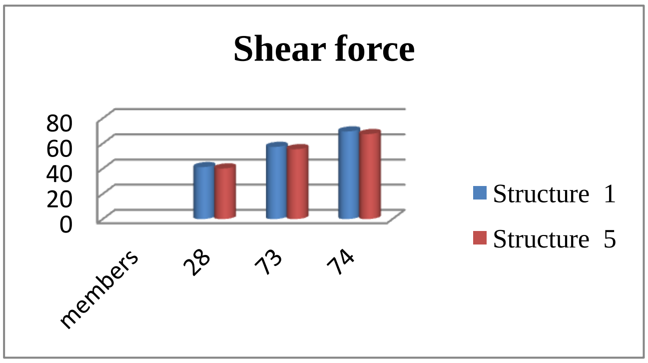


Fig.5.14 Structure 5 with Loading and structure 1

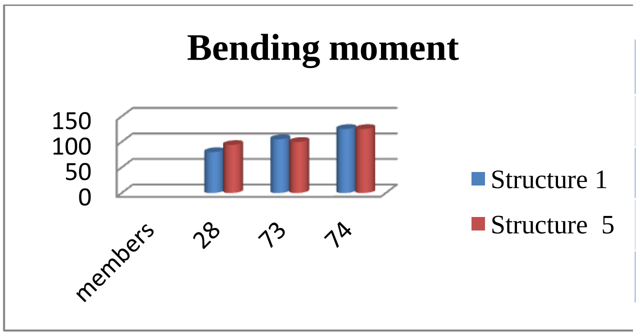
Table. 5.10 Shear stress in structure 1 & 5



	Structure 1	Structure 5
Member No.	kN/m	kN/m
28	41.26	40.2
73	57.36	55.5
74	69.62	67.5

Fig.5.15 Graph of shear stress b/w structure 1 & 5

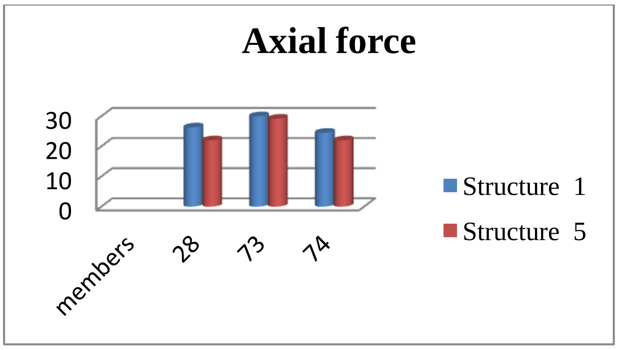
Table. 5.11 Bending moment in structure 1 & 5



	Structure 1	Structure 5
Member No.	kNm	kNm
28	80.1	94.14
73	105.32	100
74	125.29	125.29

Fig.5.16 Graph of Bending moment b/w structure 1 & 5

Table. 5.12 Axial force in structure 1 & 5



	Structure 1	Structure 5
Member No.	kN	kN
28	26.3	22.02
73	30	29.19
74	24.5	22.02

Fig.5.17 Graph of Axial force b/w structure 1 & 5

When the forces of Beam-28, Beam- 73 , Beam-74 of both the frames i.e frame 1 and frame 5 are compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 67.5 kN/m to 69.62 kN/m and rest of the forces i.e maximum axial force (Fx) and maximum bending moment (Mz) of Beam-28, Beam- 73 , Beam-74 of both the frames decreases from 26.3 kN to 22.02kN and 105.32 kNm to 100 kNm respectively. It is noted that the maximum bending moment (Mz) in Beam-28 in irreguar frame comming out to be more then the same beam in regular structure.

5.4.5 STRUCTURE 1-6:-

In this section the comparison of frame 1 and frame 4 is done. The beams at the setback i.e. Beam-278, Beam-274, Beam-275, Beam-271 are compared with the regular building frame and the bending moment diagram, shear force diagram and axial force diagram are drawn.

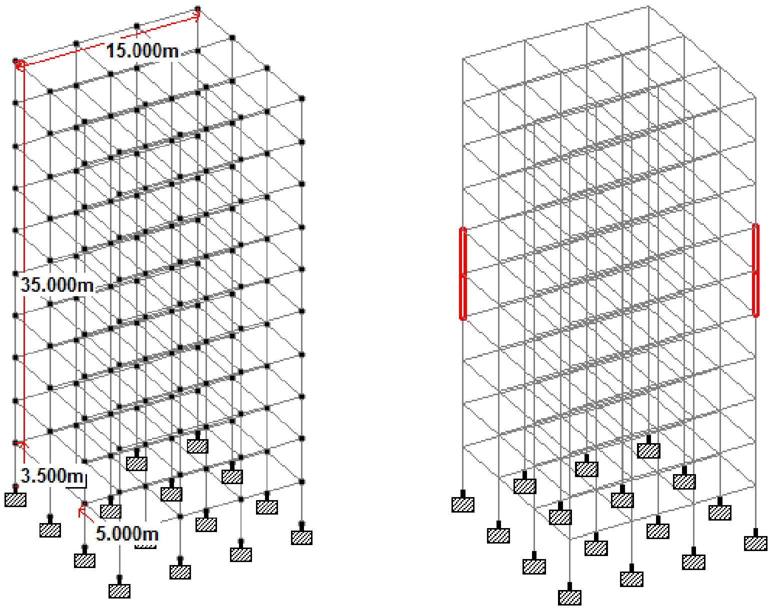


Fig.5.18 Structure 1 & Structure 6

Table. 5.13 Shear stress in structure 1 & 6

	Structure 1	Structure 6
Member No.	kN/m	kN/m
278	69.98	51.91
274	78.8	54.15
275	69.62	52.09
271	78.75	54.29

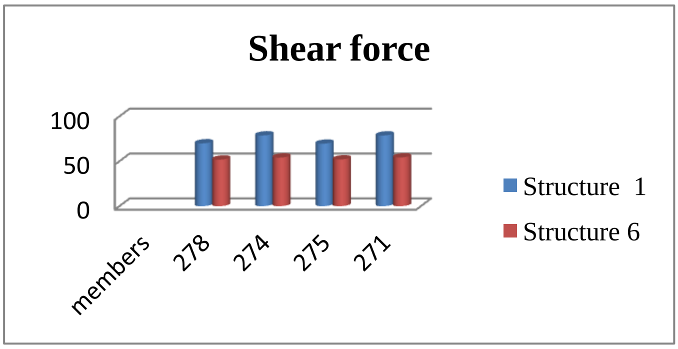
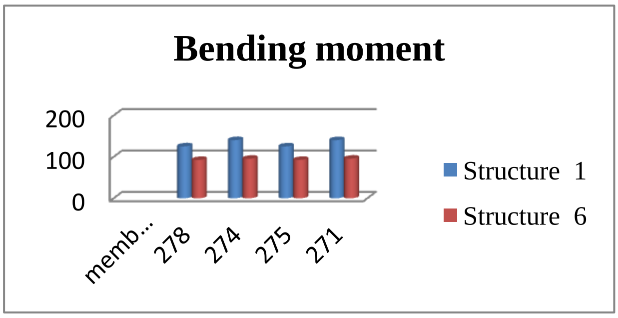


Fig.5.19 Graph of shear stress b/w structure 1 & 6

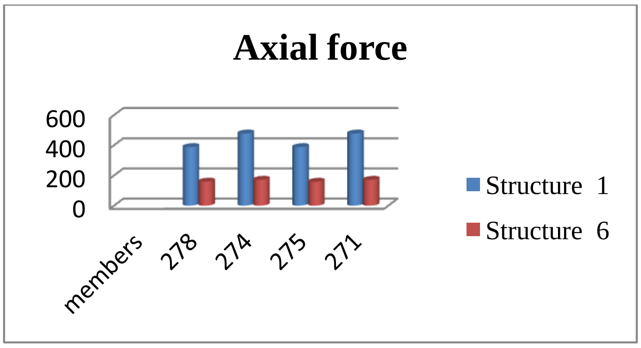
Table. 5.14 Bending moment in structure 1 & 6



	Structure 1	Structure 6
Member No.	kNm	kNm
278	125.39	92.5
274	140.52	95.48
275	125.29	92.72
271	140.42	95.73

Fig.5.20 Graph of Bending moment b/w structure 1 & 6

Table. 5.15 Axial force in structure 1 & 6



	Structure 1	Structure 6
Member No.	kN	kN
278	387.92	158.82
274	478.01	171.38
275	387.92	158.34
271	478.01	170.95

Fig.5.21 Graph of Axial force b/w structure 1 & 6

When the forces of Beam-271 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 decreases from 78.75 kN/m to 54.29 kN/m and the force maximum bending moment(Mz) of Beam-271, Beam- 274 of both the frames when compared then it is noted that the value increases from 95.73 kNm to 140.42 kNm and maximum axial force(Fx) of Beam-271, Beam- 274 of both the frames increases from 170.95 kN to 478.01 kN respectively

5.4.6 STRUCTURE 1-7:-

In this section the comparison of structure 1 and structure 7 is done. The beams at the setback i.e. Beam-51, Beam-47, Beam-278, Beam-274 are compared with the regular building Structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

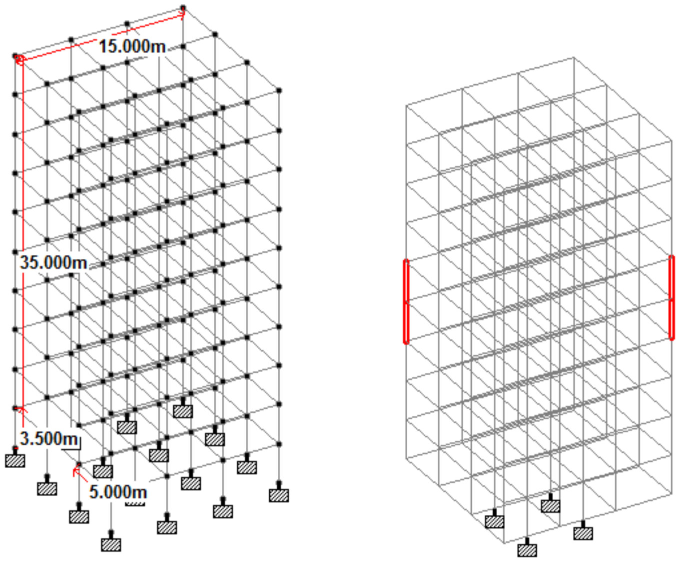


Fig.5.22 Structure 1 & Structure 7

Table. 5.16 Shear stress in structure 1 & 7

	Structure 7	Structure 1
Member No.	kN/m	kN/m
51	78.8	54.15
47	86.95	54.84
278	69.68	51.97
274	78.8	54.15

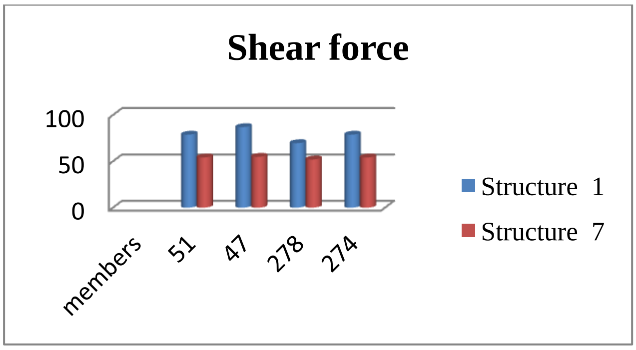
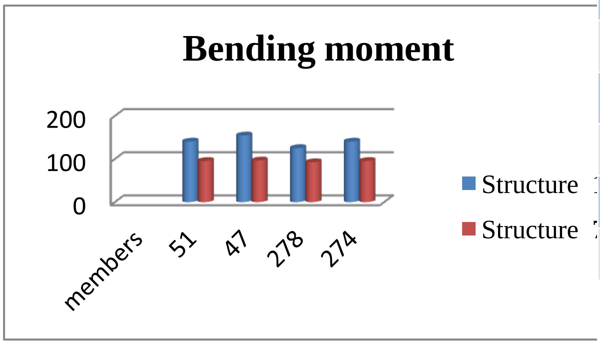


Fig.5.23 Graph of shear stress b/w structure 1 & 7

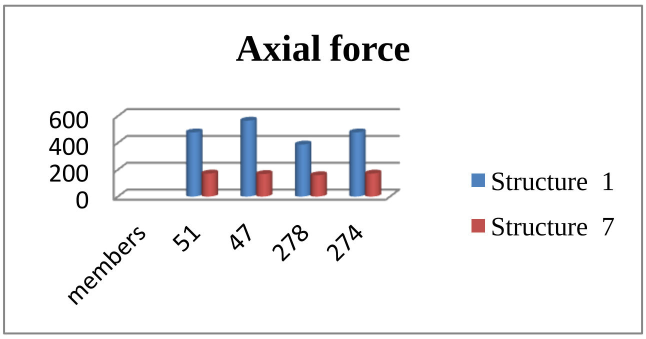
Table. 5.17 Bending moment in structure 1 & 7



	Structure 7	Structure 1
Member No.	kNm	kNm
51	140.52	95.48
47	154.59	96.63
278	125.39	92.5
274	140.52	95.48

Fig.5.24 Graph of Bending moment b/w structure 1 & 7

Table. 5.18 Axial force in structure 1 & 7



	Structure 7	Structure 1
Member No.	kN	kN
51	478.01	171.38
47	565.48	167.85
278	387.92	158.82
274	478.01	171.38

Fig.5.25 Graph of Axial force b/w structure 1 & 7

When the forces of Beam-51, Beam-278 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 to 54.5 kN/m to 78.8 kN/m and the force maximum bending momen t(Mz) of Beam-47, Beam-274 of both the frames when compared then it is noted that the value increases from 96.63 kNm to 154.59 kNm and maximum axial force (Fx) of Beam-51, Beam- 274 of both the frames increases from 171.38 kN to 478.01 kN respectively. It is noted that the maximum shear force(Fy) in Beam-51 in irreguar frame comming out to be more then the same beam in regular structure

5.4.7 STRUCTURE 1-8:-

In this section the comparison of structure 1 and structure 8 is done. The beams at the setback i.e. Beam-276, Beam-272, Beam-268 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

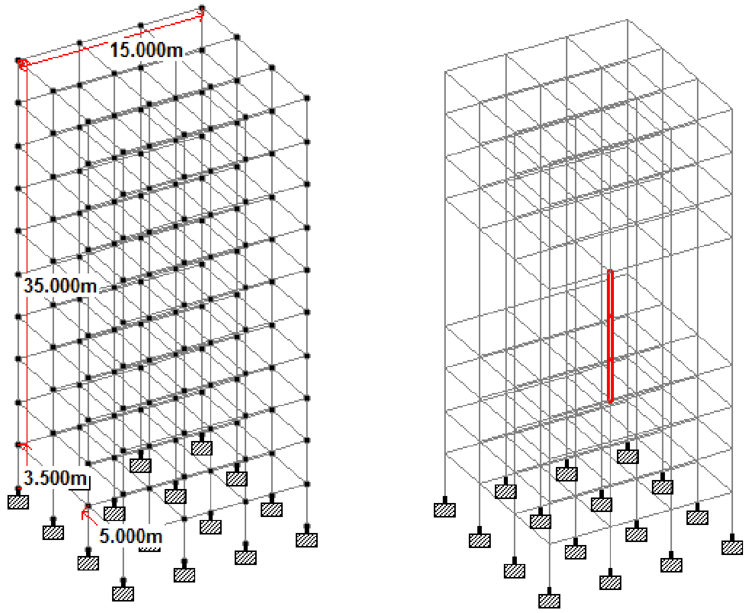


Fig.5.26 Structure 1 & Structure 8

Table. 5.19 Shear stress in structure 1 & 8

	Structure 1	Structure 8
Member No.	kN/m	kN/m
276	113.09	66.37
272	126.69	66.5
268	138.35	66.25

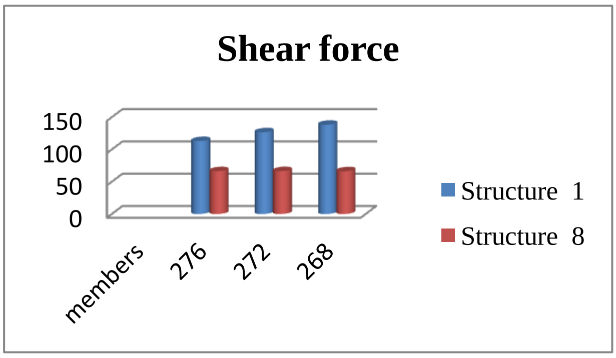
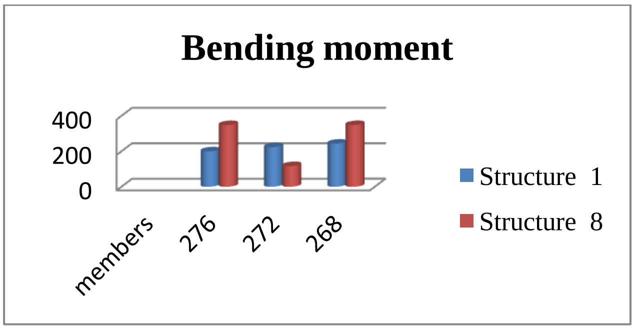


Fig.5.27 Graph of shear stress b/w structure 1 & 8

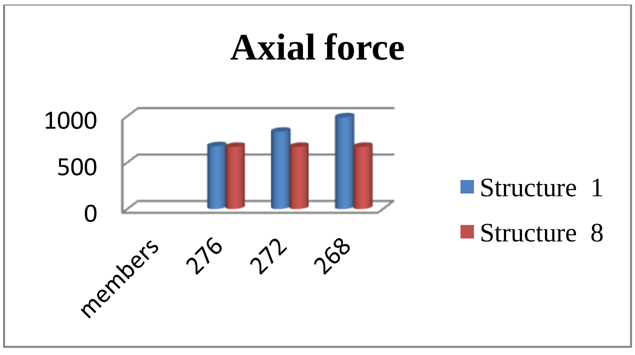
Table. 5.20 Bending moment in structure 1 & 8



	Structure 1	Structure 8
Member No.	kNm	kNm
276	199.88	348.34
272	223.13	116.74
268	243.46	348.54

Fig.5.28 Graph of Bending moment b/w structure 1 & 8

Table. 5.21 Axial force in structure 1 & 8



	Structure 1	Structure 8
Member No.	kN	kN
276	676.34	669.58
272	832.52	669.55
268	987.65	669.55

Fig.5.29 Graph of Axial force b/w structure 1 & 8

When the forces of Beam-272, Beam- 268 of both the frames i.e frame 1 and frame 8 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame decreases from 138.35 kN/m to 66.25 kN/m and rest of the forces i.e maximum axial force (Fx) of Beam-272, Beam- 276 of both the frames decreases from 832.52 kN to 669.55 kN and 987.65 kN to 669.55 KN) and maximum bending moment (Mz) of Beam-272, Beam- 276 of both the frames increases from 115.74 kNm to 223 kNm and 243.46 kNm to 348.54 kNm respectively. It is noted that the maximum shear force (Fy) in Beam-268 in irreguar frame comming out to be less then the same beam in regular structure

5.4.8 STRUCTURE 1-9:-

In this section the comparison of structure 1 and structure 9 is done. The beams at the setback i.e. Beam-211, Beam-243, Beam-281, Beam-168 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

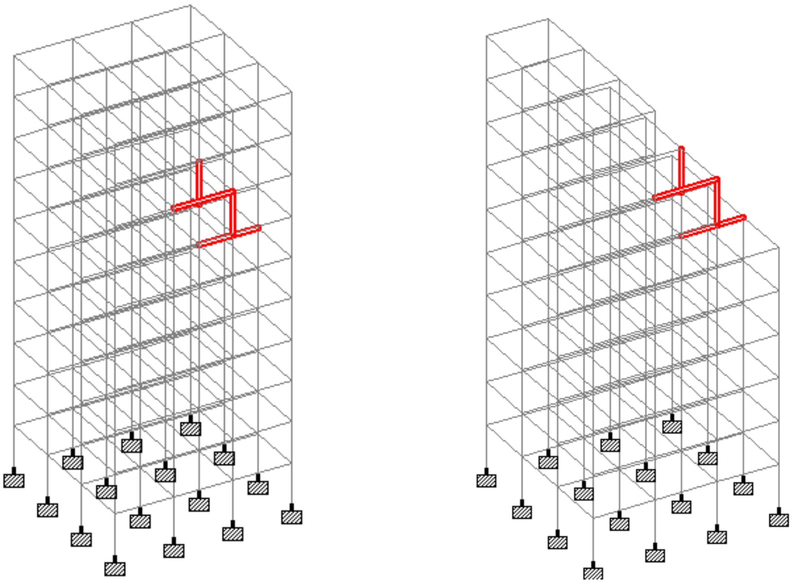


Fig.5.30 Structure 1 & Structure 9

Table. 5.22 Shear stress in structure 1 & 9

	Structure 1	Structure 9
Member No.	kN/m	kN/m
211	103.48	101.94
243	61.82	75.11
281	94.71	91.85
168	97.38	87.63

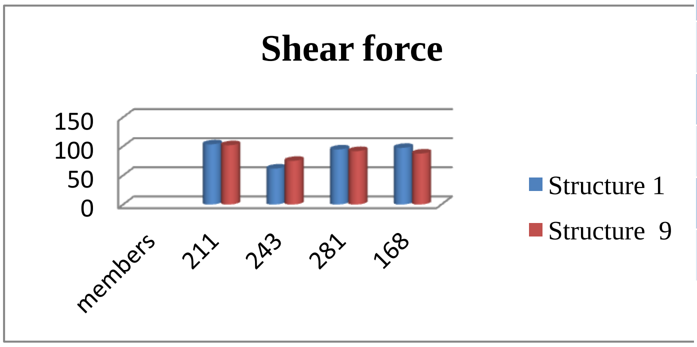
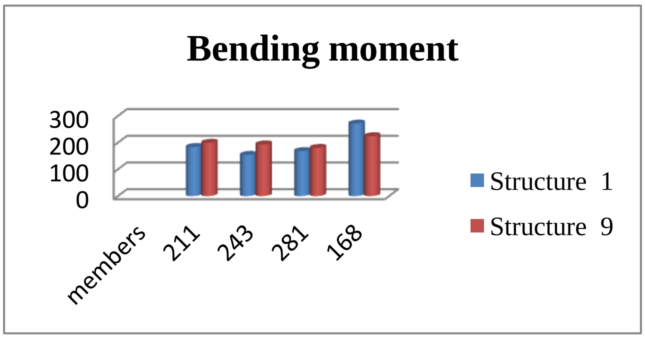


Fig.5.31 Graph of shear stress b/w structure 1 & 9

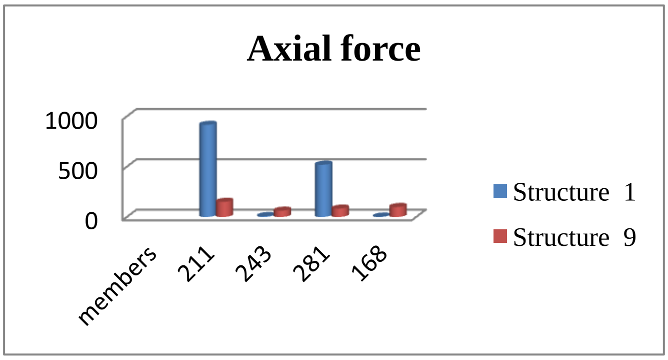
Table. 5.23 Bending moment in structure 1 & 9



	Structure 1	Structure 9
Member No.	kNm	kNm
211	183.94	199.83
243	154.57	193.84
281	168.83	180.69
168	271.68	224.55

Fig.5.32 Graph of Bending moment b/w structure 1 & 9

Table. 5.24 Axial force in structure 1 & 9



	Structure 1	Structure 9
Member No.	kN	kN
211	915.55	150.81
243	8.82	62.87
281	519.32	83.27
168	3.62	99.67

Fig.5.33 Graph of Axial force b/w structure 1 & 9

When the forces of Beam-211 of both the frames i.e frame 1 and frame 9 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 103.48 kN/m to 101.94 kN/m and rest of the forces i.e maximum axial force(Fx) of Beam-211, Beam-281 of both the frames decreases from 915.55 kN to 150.81 kN and 519.32 kN to 83.27 KN and maximum bending moment(Mz) increases from 183.94 kNm to 199.83 kNm and 168.83 kNm to 224.55 kNm respectively. It is noted that the maximum shear force(Fy) in Beam-23 in irreguar frame comming out to be more then the same beam in regular structure

5.4.9 STRUCTURE 1-10:-

In this section the comparison of structure 1 and structure 10 is done. The beams at the setback i.e. Beam-211, Beam-243, Beam-281, Beam-168 are compared with the regular building structure and the bending moment diagram, shear force diagram and axial force diagram are drawn.

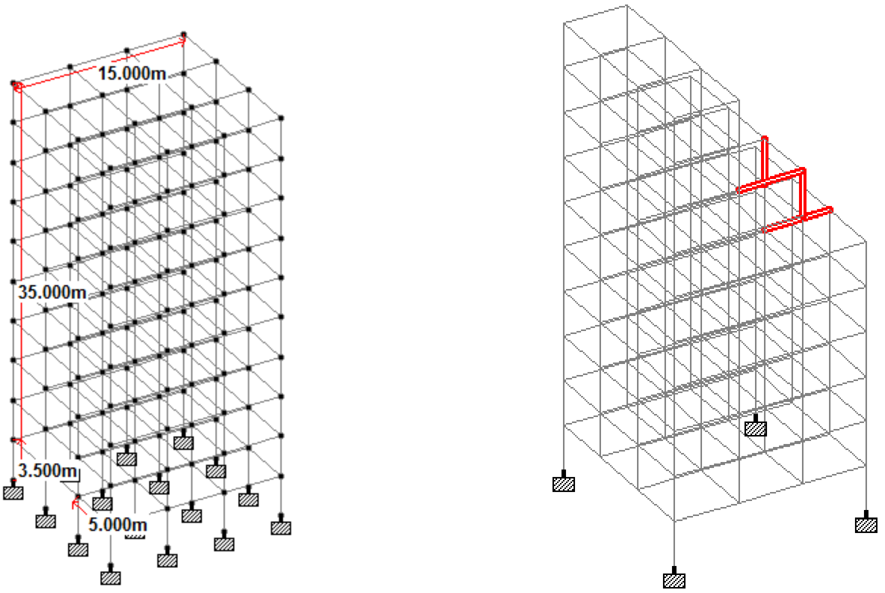


Fig.5.34 Structure 1 & Structure 10

Table. 5.25 Shear stress in structure 1 & 10

	Structure 1	Structure 10
Member No.	kN/m	kN/m
211	103.48	125.74
243	61.82	186.42
281	94.71	139.48
168	97.38	235.77

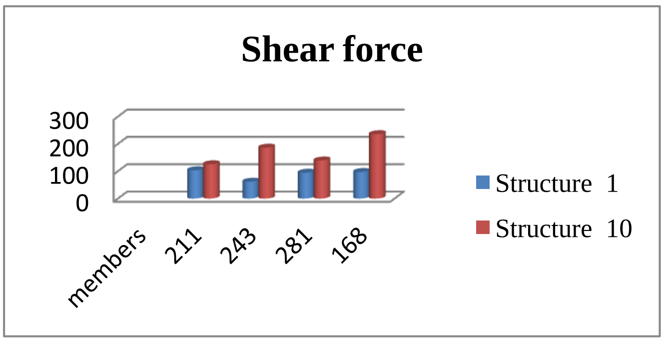
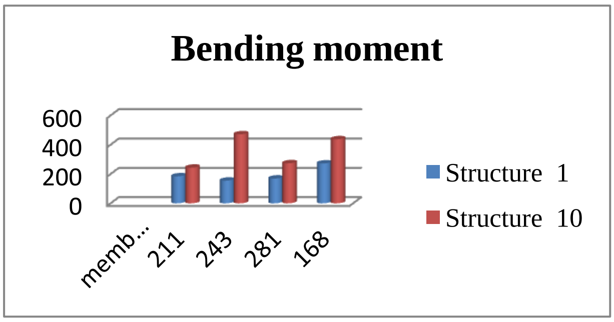


Fig.5.35Graph of shear stress b/w structure 1 & 10

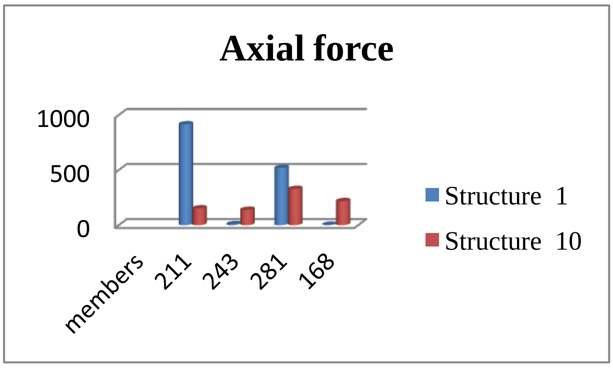
Table. 5.26 Bending moment in structure 1 & 10



	Structure 1	Structure 10
Member No.	kNm	kNm
211	183.94	243.25
243	154.57	470.98
281	168.83	273.16
168	271.68	437.05

Fig.5.36 Graph of Bending momrnt b/w structure 1 & 10

Table. 5.27 Axial force in structure 1 & 10



	Structure 1	Structure 10
Member No.	kN	kN
211	915.55	152.36
243	8.82	138.68
281	519.32	328.86
168	3.62	218.01

Fig.5.37 Graph of Axial force b/w structure 1 & 10

When the forces of Beam-243, Beam- 168 of both the frames i.e frame 1 and frame 10 is compared, it is noted that the value of maximum shear force (Fy) from regular to irregular frame increases from 97.38 kN/m to 235.77 kN/m and the force maximum axial force (Fx) decreases from 915.55kN to 152.36kN and maximum bending moment(Mz) of Beam-211, Beam- 168 of both the frames increases from 183.94 kNm to 243.25 kNm and 271.68 kNm to 437.05 kNm respectively. It is noted that the maximum shear force (Fy) in Beam-168 in irreguar frame comming out to be more then the same beam in regular structure

5.4.10 RESULTS OF STOREY DISPLACEMENT:-

Table. 5.28 Storey-Displacement (UX) in X-Direction (mm)

Column1	Frame 1	Frame 2	Frame 3	Frame 4	Frame 5	Frame 6	Frame 7	Frame 8	Frame 9	Frame 10
STOREY	UX	UX	UX	UX	UX	UX	UX	UX	UX	UX
10	40.88	97.39	57.43	48.99	54.79	42.44	98.1	95.57	55.13	33.64
9	36.46	96.12	56.33	39.88	54.59	49.11	89.87	94.18	49.89	35.68
8	32.96	93.89	53.54	35.96	50.28	39.66	81.67	91.79	44.68	25.77
7	36.58	90.87	50.19	32.58	44.47	36.35	72.58	87.54	42.58	26.95
6	22.54	87.26	45.78	28.53	39.25	32.39	62.8	68.84	22.37	24.95
5	34.01	88.21	31.52	24.01	32.68	27.95	52.51	37.28	19.16	26.15
4	19.16	77.84	18.79	19.16	25.06	23.19	41.84	17.89	15.46	18.98
3	11.12	73.38	14.53	14.12	18.37	18.24	30.92	12.55	11.48	24.64
2	9.51	52.15	8.63	9.01	11.68	13.23	19.84	7.983	7.36	20.65
1	4.94	16.45	3.77	3.95	5.11	8.039	8.645	3.915	4.23	7.492

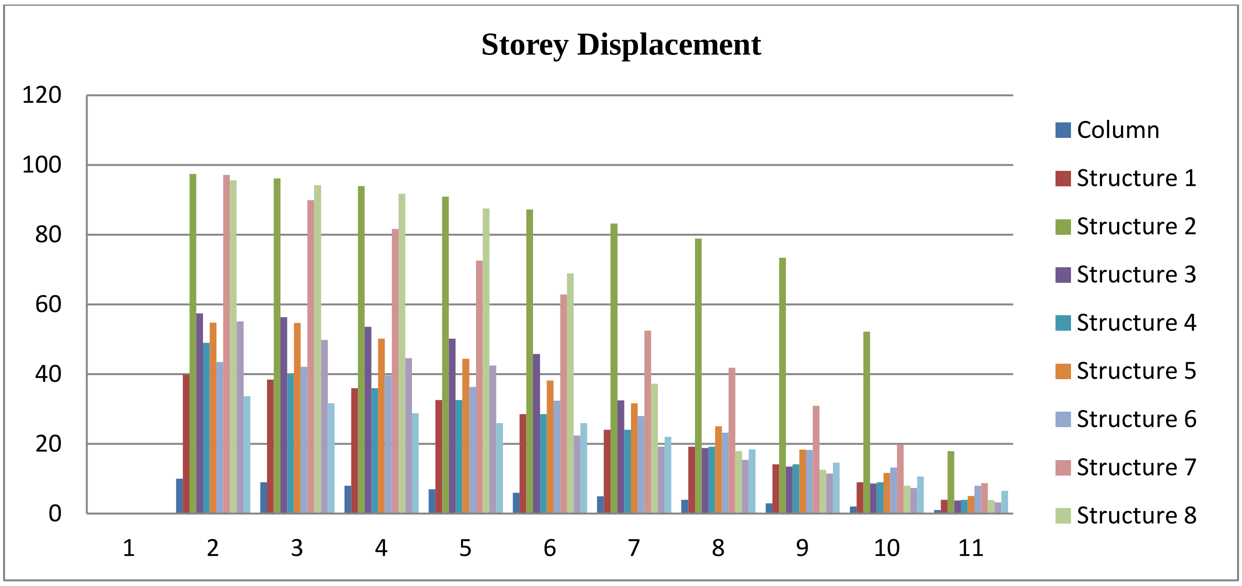


Fig.5.38 Graph of displacement of each structure w.r.t each storey

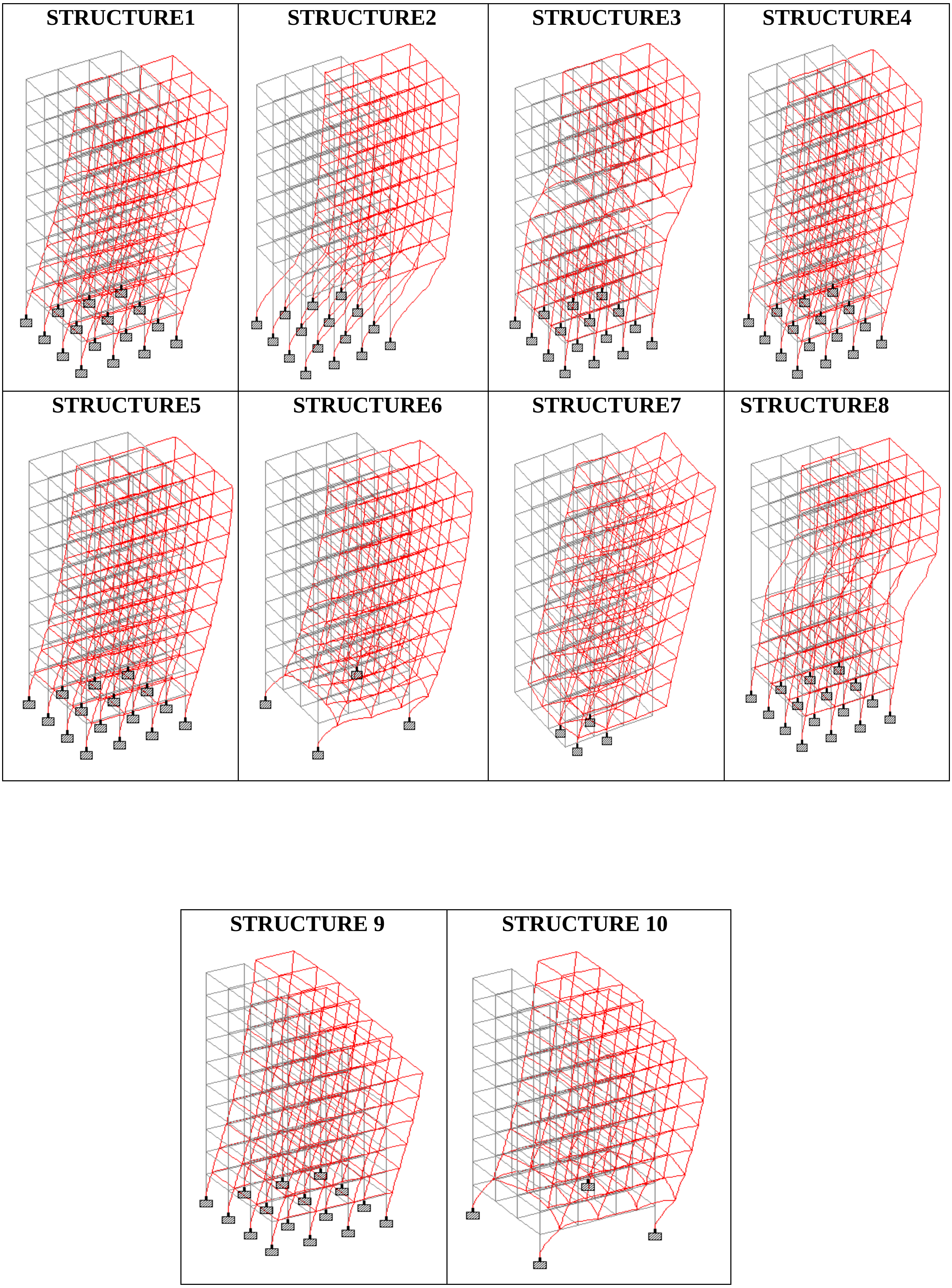


Fig.5.39 Displacement of Structures with Lateral Load

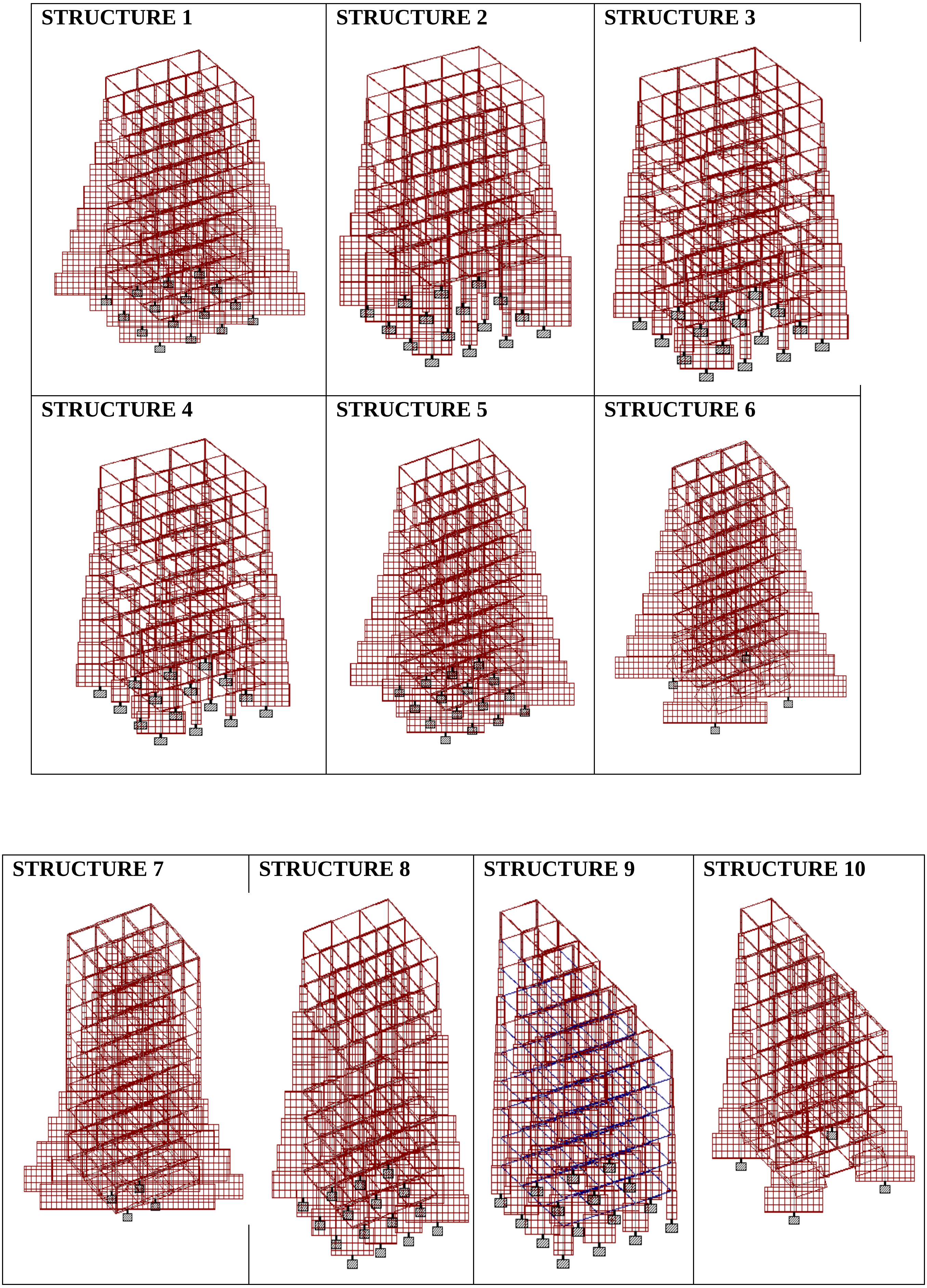


Fig.5.40 Axial Force Diagram of Structures

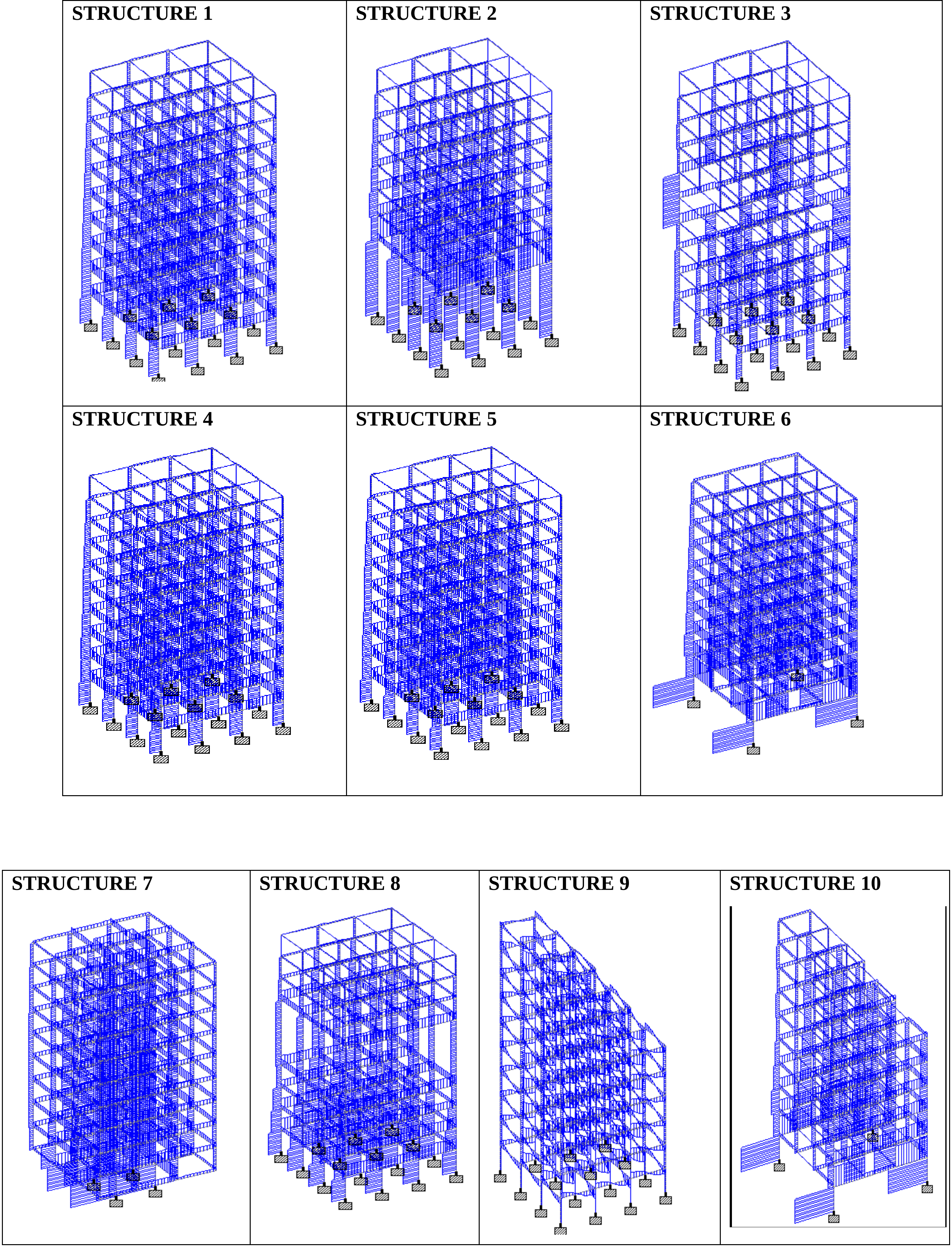
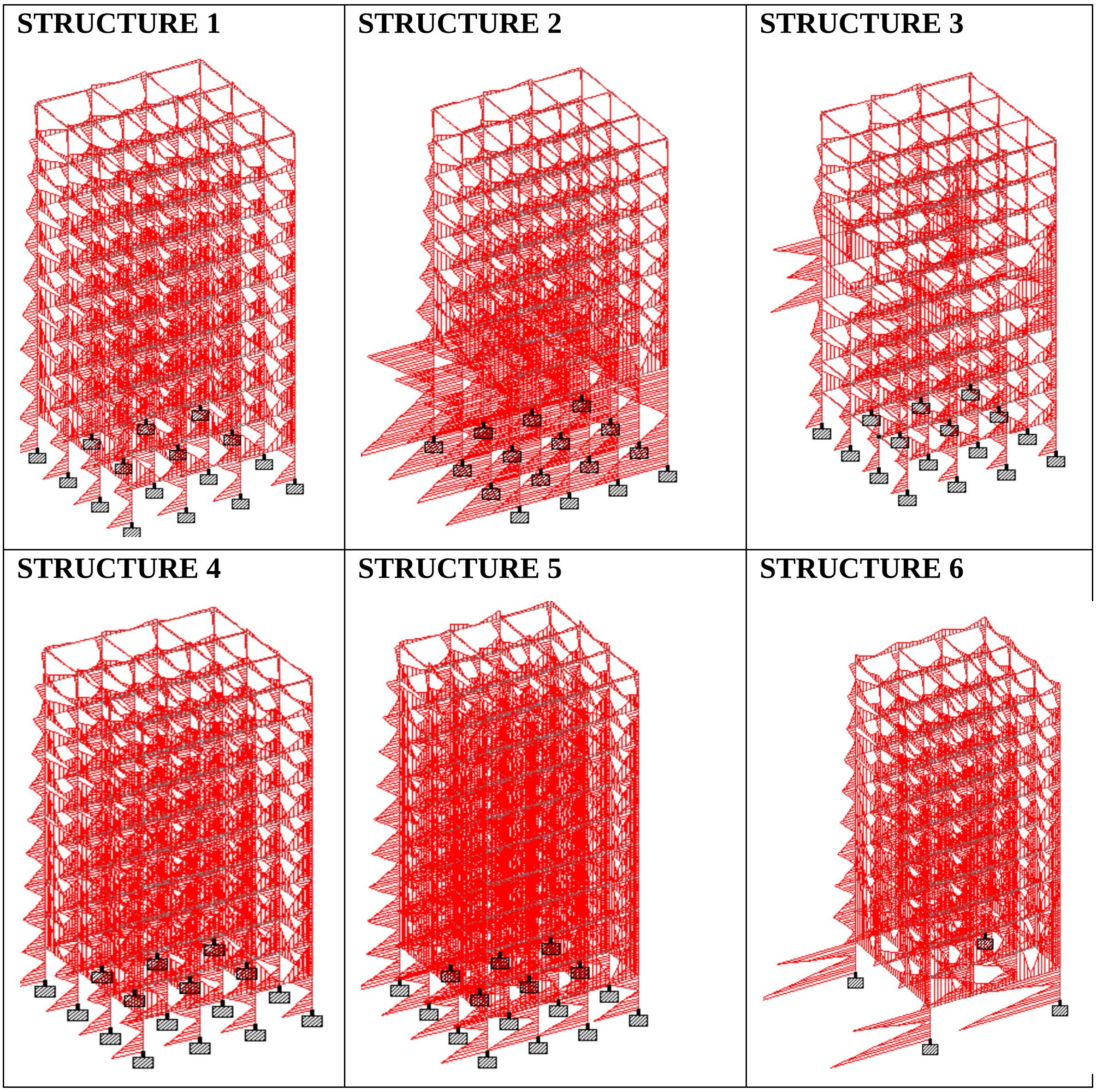


Fig.5.41 Shear Force Diagram of Structures



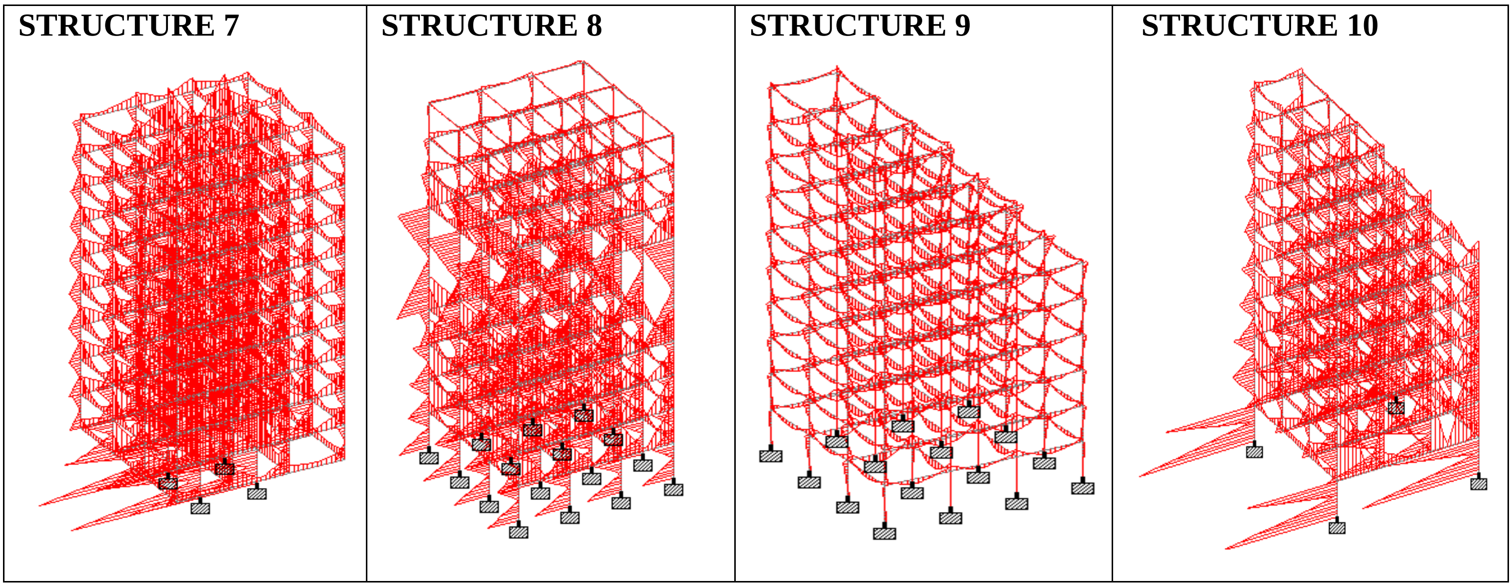


Fig.5.42 Bending Moment Diagram of Structure

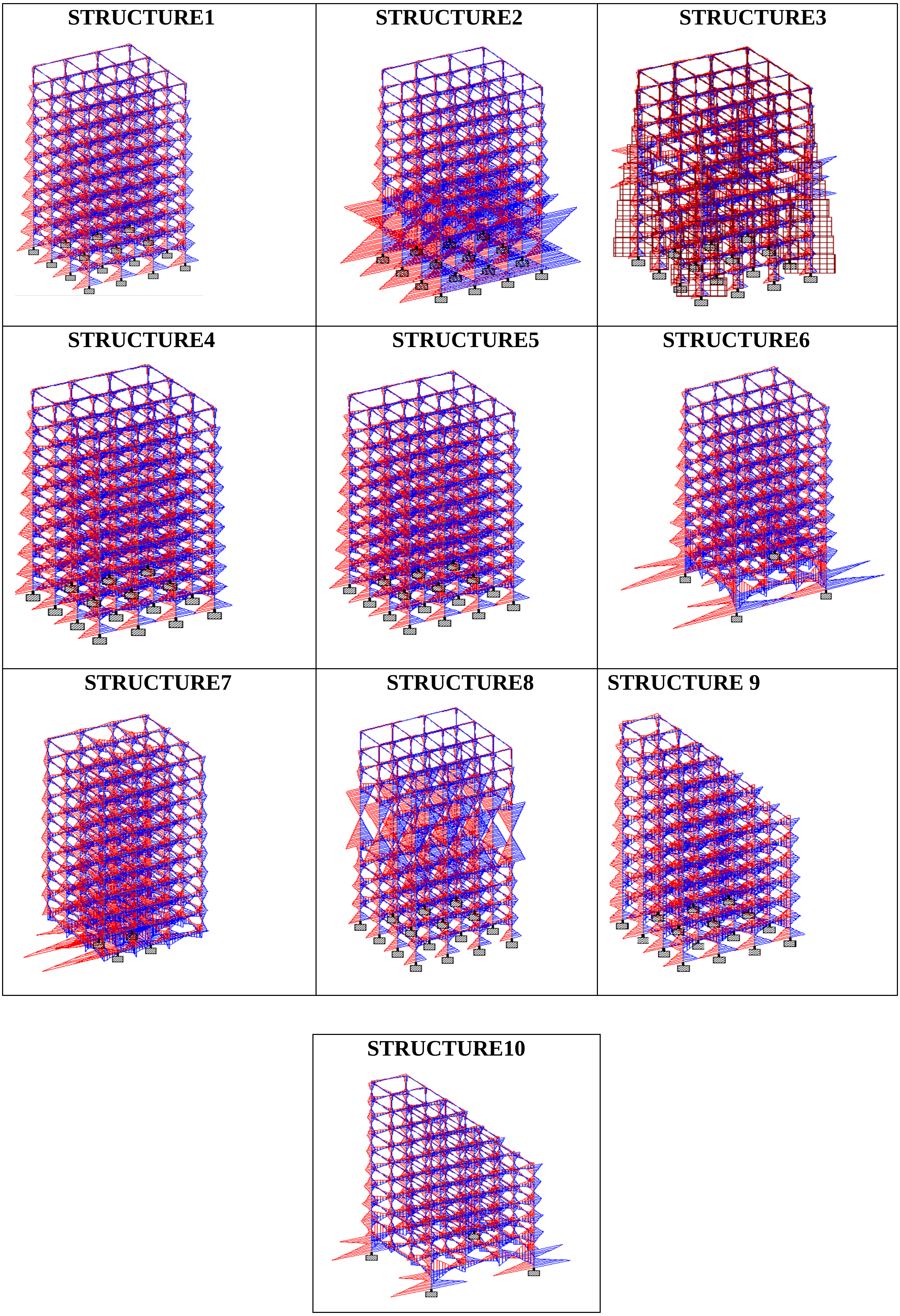


Fig.5.43 Beam stesses in Structures

5.5 DISCUSSION

5.5.1. STRUCTURE 1 AND STRUCTURE 2

- It is noted that in Beam 31 the value of maximum shear force (Fy) from regular to irregular frame decreases from 130.07 kN/m to 114.9 kN/m.
- It is noted that in Beam 36 the value of maximum axial force (Fx) from regular frame to irregular frame decreases from 1288.17 kN to 715.38 kN respectively.
- It is noted that in Beam 36 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 268.19 kNm to 626.90 kNm respectively.

5.5.2. STRUCTURE 1 AND STRUCTURE 3

- It is noted in that Beam 271 the value of maximum shear force (Fy) from regular to irregular frame increases from 78.75 kN/m to 391.66 kN/m.
- It is noted that in Beam-271 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 140 kNm to 804.3 kNm respectively.
- It is noted that in Beam-54 the value of maximum axial force (Fx) from regular frame to irregular frame increases from 478.01 kN to 3599.90 kN respectively

5.5.3. STRUCTURE 1 AND STRUCTURE 4

- It is noted that in Beam-271 the value of maximum shear force (Fy) from regular frame to irregular frame increases from 78.75 kN/m to 78.8 kN/m respectively.
- It is noted that in Beam-271 the value of maximum bending moment (Mz) from regular frame to irregular frame decreases from 190.42 kNm to 140.42 kNm respectively.
- It is noted that in Beam 47 the value of maximum axial force (Fx) from regular frame to irregular frame increases from 478.01 kN to 1159.77 kN respectively.

5.5.4. STRUCTURE 1 AND STRUCTURE 5

- It is noted that in Beam-74 the value of maximum shear force (Fy) from regular frame to irregular frame increases from 67.5 kN/m to 69.62 kN/m respectively.
- It is noted that in Beam-74 the value of maximum bending moment (Mz) from regular frame to irregular frame decreases from 105.32 kNm to 100 kNm respectively.
- It is noted that in Beam-74 the value of maximum axial force (Fx) from regular frame to irregular frame decreases from 26.3 kN to 22.02 kN respectively.

5.5.5. STRUCTURE 1 AND STRUCTURE 6

- It is noted that in Beam-271 the value of maximum shear force (Fy) from regular to irregular frame decreases from 78.75 kN/m to 54.29 kN/m.
- It is noted that in Beam-271 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 95.73 kNm to 140.42 kNm respectively.
- It is noted that in Beam-271 the value of maximum axial force (Fx) from regular to irregular frame increases from 170.95 kN to 478.01 kN.

5.5.6. STRUCTURE 1 AND STRUCTURE 7

- It is noted that in Beam-274 the value of maximum shear force (Fy) from regular to irregular frame decreases from 78.80 kN/m to 54.15 kN/m.
- It is noted that in Beam-51 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 96.63 kNm to 154.59 kNm respectively.
- It is noted that in Beam-274 the value of maximum axial force (Fx) from regular to irregular frame decreases from 478.01 kN to 171.38 kN.

5.5.7. STRUCTURE 1 AND STRUCTURE 8

- It is noted that in Beam-268 the value of maximum shear force (Fy) from regular to irregular frame decreases from 138.35 kN/m to 66.25 kN/m.
- It is noted that in Beam-268 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 243.46 kNm to 348.54 kNm respectively.
- It is noted that in Beam-268 the value of maximum axial force (Fx) from regular to irregular frame decreases from 987.65 kN to 669.55 kN.

5.5.8. STRUCTURE 1 AND STRUCTURE 9

- It is noted that in Beam-211 the value of maximum shear force (Fy) from regular to irregular frame decreases from 103.48 kN/m to 101.94 kN/m.
- It is noted that in Beam-211 the value of maximum bending moment (Mz) from regular frame to irregular frame increases from 183.94 kNm to 199.83 kNm respectively.
- It is noted that in Beam-211 the value of maximum axial force (Fx) from regular to irregular frame decreases from 915.55 kN to 150.81 kN.

5.5.9. STRUCTURE 1 AND STRUCTURE 10

- It is noted that in Beam-168 the value of maximum shear force (Fy) from regular to irregular frame increases from 97.38 kN/m to 235.77 kN/m.
- It is noted that in Beam-168 the value of maximum bending moment(Mz) from regular frame to irregular frame increases from 271.68 kNm to 437.05 kNm respectively.
- It is noted that in Beam-211 the value of maximum axial force(Fx) from regular to irregular frame decreases from 915.85 kN to 152.36 kN.

CHAPTER-6

CONCLUSIONS

Considering the storey displacement, the frame and structure with floating columns (frame 2) is the weakest since it suffers the maximum displacement while the base frame and structure exhibits the least displacement . As far as storey drift is concerned , frame 2 (with bottom two soft storeys) is the weakest since it has the maximum storey drift which changes abruptly. Frame 8 also shows similar pattern for bottom two storeys. Storey shear is however maximum in frame 4 and structure 4 (with 3^{rd} and 6^{th} storeys heavy). It can be inferred clearly that the frame and structure with floating columns represents the worse scenario since it faces the maximum displacement and is most prone to damages under this lateral loading . While, on the other hand it can be seen that the base frame ans structure has the least displacement and drift, hence least susceptible to the damage.

In this theisis various frames and structures having different irregularities but with the same dimension have been analysed to study their behaviour when subjected to lateral loads. All the frames and structures were analysed with the same method as stated in IS 1893- part 1 : 2002 . The base frame and structure (Ideal) develops least story drifts while the building with floating column shows maximum storey drifts on soft story levels. Hence this is the most vulnerable to damages under this kind of loading. The other buildings with irregularities also showed unsatisfactory results to some extent. The frame with heavy loads develops maximum storey shears which should be accounted for in design of columns suitably.The analysis shows that the dynamic approach gives us more rfined results as compared to static
analysis of the building.

The analysis also proves that irregularities are harmful for the structures and it is important to have simpler and regular shapes of frames as well as uniform load distribution around the building . Therefore, as far as possible irregularities in a building must be avoided. But if irregularities have to be introduced for any reason , the must be designed properly following the conditions of IS 13920: 1993 . Now a days, complex shaped buildings are getting popular but they carry a risk of sustaining damages during earthquakes. Therefore such buildings should be designed properly taking care their dynamic behaviour

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