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ANALYSIS OF REGULAR AND IRREGULAR CONFIGURATION OF MULTISTOREY BUILDING USING EQUIVALENT STATIC AND RESPONSE SPECTRUM METHODS

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ABSTRACT :
These days, analysis and design of buildings for static forces has become a common practice because of availability of affordable computers and specialized programs which are used for the analysis. Reinforced concrete (RC) frame buildings are most usual type of constructions in urban areas of India, which are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to the wind and earthquake loads. Reinforced concrete multi storey buildings are susceptible to most wild earthquakes. It has been studied that main reason for failure of RC building is irregularity in its plan dimension and its lateral force resisting system. In this paper an analytical study is made to establish response of a regular and an irregular structure located in zone IV. Analysis has been made by taking 10 storey building by static and dynamic methods using ETABS 2016 and IS code 1893-2002 (part1). Dynamic Analysis can be carried out by dynamic Time History Analysis or a linear Response Spectrum Analysis. Behaviour of structures will be found by comparing responses in the form of storey displacement for regular and irregular structures. Different type of analysis methods such as equivalent static method and response spectrum method are adopted in order to study the storey displacement. In this present work two types of structures considered are reinforced concrete regular 10 storey building and irregular 8 storey building and are analysed by static and dynamic methods. Presently there are two models. One is of regular structure and the other is an irregular H-shaped structural models. This paper exhibits that behaviour of irregular structures as compared to regular structure.

Key Words: RC building, regular, irregular, equivalent static, response spectrum, ETABS 2016, IS 1893-2002

1. INTRODUCTION

Earthquakes are most uncertain and damaging among all typical disasters. Earthquakes have the potential for causing the greatest damages with massive loss of life and property. Since earthquake forces are accidental in nature and unpredictable, they not only cause great destruction to human but also have a huge economic impact on the areas which are influenced by earthquake. When a construction is resting on motion of ground by earthquake load it counters to shaking movements. Those ground motions cause the building to vibrate in all the three directions; the principal vibrating direction is horizontal at the time of an earthquake. The destruction is initiated at the structurally weak portion present in the building frame. High rise structures are more often occupied by many people. Thus their loss and destruction adversely affects the economy of that area. Each high rise structure represents a large investment and thus high rise structures are analysed by more sophisticated methods. Thus, it is very essential for the structural engineers and researchers to understand the modern techniques for the seismic analysis of high rise buildings.
In this modern era, most of the structures are outlined by irregular in both plan and vertical configuration. For the analysis and design of such irregular structures more effort is needed. There will be more damage and loss in the irregular structures compared with the regular one. Thus, careful structural analysis of the irregular structures is to be done for the subsidence of the acceptable behaviour throughout a disastrous earthquake. In many cases the shape of the plot may not be a regular one to construct a structure. Thus, the shape of the building can be influenced by the shape of the plot. Moreover, it will be interesting for the study of the building with different shape and their behaviour

against seismic and other forces. Hundred percent earthquake proof structures cannot be designed by any structural engineer, but its seismic resistance can be increased. Proper design and maintenance is given according to the Zone, where the structure is located. From the stage of planning to the completion of the structure, it is needed to check for avoiding the failure of structure and to overcome loss of property.
Structural analysis is mostly concerned to find out the behaviour of a structure when influenced by any action. That action may be in the form of load like weight of things such as people, furniture, wind etc. Or any other type of excitation like earthquake, vibration of the ground due a blast nearby etc. All the loads are dynamic because at some point with the passage of time these loads will not be there. The classification of static and dynamic analysis is done based on whether the applied load has high acceleration in comparison to the natural frequency of the structure. If the load is applied sufficiently slowly, the inertia forces can be ignored and the analysis is termed as static analysis. The type of structural analysis which covers the behaviour of the structures subjected to dynamic loadings is called as dynamic analysis. Any building can be subjected to dynamic loading such as weight of people, wind load, traffic, earthquake, blasts etc. By dynamic analysis, we can found dynamic displacement, time history and modal analysis. In the present study, static analysis and response spectrum analysis in both irregular and regular structures are performed and the results are compared.

1.1 : Behaviour of Reinforced Concrete Buildings:
In India, in these days, reinforced concrete building has become very usual, especially in urban regions. Reinforced concrete consists of two principal materials, like concrete with reinforcing steel bars. Concrete is made of sand, aggregates and cement, all mixed with pre-determined amount of water. Concrete can be moulded into any desired shape, and steel bars can be bent into many shapes. Thus, structures of complex shapes are possible with reinforced concrete. A typical RC building is made of horizontal members i:e; beams and slabs and vertical members i:e; columns and walls and supported by foundations that rest on ground. RC frame is defined as the system that comprises of RC columns and connecting beams. The RC frame resists the earthquake forces. Inertia forces in the building, which are proportional to the building mass are generated by earthquake shaking. Earthquake-caused inertia forces firstly develop at the floor levels because most of the building mass is present at floor levels. These forces travel downwards - through slab and beams to columns and walls, and then to the foundations from where they are dispersed to the ground.

1.2 : Importance of Seismic Design Codes
Ground vibrations during earthquakes give rise to forces and deformations in structures. Structures need to be designed to resist such forces and deformations. Seismic codes assist to improve the behaviour of structures so that they may resist the earthquake effects without significant loss of life and property. Countries around the world have procedures formed in seismic codes to advise design engineers in the planning, designing, detailing and constructing of structures. An earthquake-resistant building has four moralities in it, namely:
(a) Good Structural Configuration:
The size, shape and structural system carrying loads of the structure should be in such a manner that they make sure a smooth flow of inertia forces to the ground.
(b) Lateral Strength:
The maximum lateral i.e. horizontal force that the building can withstand should be such that the damage produced in it does not result in collapse.
(c) Adequate Stiffness:
The lateral load resisting system of the structure should be such that under low-to-moderate shaking the deformations caused by the earthquake do not damage it.
(d) Superior Ductility:

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In spite of yielding of the structure under acute earthquake shaking the ability to withstand large deformations, should be upgraded by beneficial design and detailing strategies. Seismic codes cover all the above discussed aspects.

1.3 : Seismic effects on structures:

- Inertia Forces in Structures:

Shaking of the ground caused by earthquake will lead to impose motion over the building base. With reference to Newton's First Law of Motion, the roof of a building will intend to stay at its original position even though the base of the building moves with respect to ground
and they drag the roof along with the walls as the columns relate to it.

The above scenario can easily be illustrated with an example which most of us faced like we are standing in a standstill bus and the bus suddenly starts, at this situation as our feet is in direct contact with the bus will move but as our feet relates to our body it will tend to move which will lead to make our body to move in backword motion. This tendency of body to remain in the original condition is called as inertia. So, for the case of building as the flexible part is columns or walls so the motion of ground will be different with roof motion.

If we are considering a building whose roof is in rest over column. Now coming back to the bus-human analogy. We usually experience backward drift if our upper part of body experience opposite motion w.r.t lowers. Similarly, building will experience a backward drift
as and when the ground of the building moves by an external force which is termed as inertia. As per Newton's second law of motion if the roof has a mass "M" and it experiences a drift of acceleration "A" then the inertial force F=M*A will intend to an opposite direction of motion which will be mass times acceleration, which clearly states that we will experience more inertial force if the we have more mass which concludes lighter weighted building can bear earthquake effectively.

- Deformations Effect in Structures:

When the inertial forces of roof transferred to the lower part of the building this will lead to impose force in the building column. The above statement can be illustrated as, during an earthquake building columns experiences relative displacement between their ends, this movement between roof and the ground can be taken as "U". In a genuine situation column resist deformation when column come back to straight vertical position as with the straight vertical position columns no horizontal forces of earthquake with them, but they used to develop internal forces when it was forces to bend by external forces. Larger is the internal forces within the column the larger will be relative horizontal displacement "U" between bottom and top of the column, also force will be larger if columns are stiffer and bigger in size. Stiffness forces are those internal forces which generates within the column. In fact, we can say stiffness force in that column is relative displacement between its column ends of a building times the column stiffness.

- Horizontal and Vertical Shaking:

Earthquake causes shaking of the ground in all three directions – along the two horizontal directions (X and Y, say), and the vertical direction (Z, say). Also, during the earthquake, the ground shakes randomly back and forth (- and +) along each of these X, Y and Z directions. All structures are primarily designed to carry the gravity loads, i.e., they are designed for a force equal to the mass M (this includes mass due to own weight and imposed loads) times the acceleration due to gravity g acting in the vertical downward direction (-Z). The downward force Mg is called the gravity load. The vertical acceleration during ground shaking either adds to or subtracts from the acceleration due to gravity. Since factors of safety are used in the design of structures to resist the gravity loads, usually most structures tend to be adequate against vertical shaking. However, horizontal shaking along X and Y directions (both + and – directions of each) remains a concern. Structures designed for gravity loads, in general, may not be able to safely sustain the effects of horizontal earthquake shaking. Hence, it is necessary to ensure adequacy of the structures against horizontal earthquake effects.

 Flow of Inertia Forces to Foundations:

Under horizontal shaking of the ground, horizontal inertia forces are generated at level of the mass of the structure i.e. commonly situated at the floor levels. These lateral inertia forces are transferred by the floor slab to the walls or columns, to the foundations, and finally to the soil system underneath. So, each of these structural elements (floor slabs, walls, columns, and foundations) and the connections between them must be designed to safely transfer these inertia forces through them. Walls or columns are the most critical elements in transferring the inertia forces. But, in traditional construction, floor slabs and beams receive more care and attention during design and construction, than walls and columns. Walls are relatively thin and often made of brittle material like masonry. They are poor in carrying horizontal earthquake inertia forces along the direction of their thickness. Failures of masonry walls have been observed in many earthquakes in the past. Similarly, poorly designed and constructed reinforced concrete columns can be disastrous.

1.4 : Introduction to ETABS:

(E-TABS – EXTENDED 3D ANALYSIS OF BUILDING SYSTEMS)

ETABS is a enlightened, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS 2016 features an instinctive and strong graphical interface coupled with unmatched modelling, analytical, design, and detailing procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also manoeuvre the largest and most complex building models, including a wide range of nonlinear behaviours necessary for performance based design, making it the appliance of choice to the structural engineers in the field of designing structures.

• Basic Concepts of ETABS:

ETABS is a powerful program that can greatly intensify an engineer's analysis and design potentialities for structures. Part of that depends on an assemblage of options and features. The other part lies in how simple it is to use. The basic approach for using the program is very effortless. We have to establish grid lines and relative to the grid lines we have to place structural objects using joints, frames, links, tendons, and shells. And then we have to assign loads and structural properties to those structural objects (for example, a frame object can be assigned section properties; a joint object can be assigned spring properties; a shell object can be assigned slab or deck properties). Then based on the structural objects and their assignments we have to perform analysis, design, and detailing. Results are generated in a tabular form or in a graphical form which we can print or we can save the file for further use in other programs.

While using this ETABS program, we can manage the File, Edit the model, change the View, define the properties or load patterns and cases, draw something new in the model, Select that something, assign properties or loads, analyse the model, display analysis results for checking, design the structure, generate detailing construction documents, apply various options to achieve the desired outcome with optimum effort, utilize plugin tools to customize the program, and seek help when we need it. Those actions are the basis for the program menu structure. Thus, for expanding our ability to use ETABS we have to be familiar with the menu commands and their function.

2. OBJECTIVE:

This thesis inscribes the major objectives of the research work are as follows:

1. This paper deals with the comparison between equivalent static technique &response spectrum technique.

2. To know the structural performance under seismic load before construction because the earthquake effect leads to the damage of the property and loss of life.
3. To study the effect of geometric irregularity and performance level of the structure.
4. Comparison between regular and irregular frame on the basis of shear force, storey drift & storey displacement, storey stiffness and base reactions.
5. A comparative study was performed on 3-D analysis model created in ETABS, a commercial computer program for the analysis of structures.

- Objective of this analytical work:

The specific objectives of the present study are stated as under.

1. To convey a review of the literature for a detailed analysis.
2. To study the process of modelling and analysing.
3. To select the type of structure for the analysis.
4. To investigate the static loading effect and dynamic loading effect on the structure.
5. To overview the deformations of a regular building and an irregular building.
6. To analyse the various parameters and state its feasibility in the future.
7. To find out its suitable applications that can be used in the construction sector.

3. METHODOLOGY

Buildings that lack the ability to withstand seismic forces must undergo a seismic study. Since seismic analysis takes dynamic influences into account, the precise analysis can occasionally become difficult. For basic regular structures, equivalent linear static analysis suffices. When used for the examination of conventional and low-rise structures, this approach produces satisfactory results. The building is subjected to a dynamic analysis in accordance with the requirements of the code IS 1893-2002 (part1). For dynamic analysis, either the response spectrum approach or the site-specific time history method is used. The approaches that are presumptively used to communicate the analytical process are listed below.

- Equivalent static analysis:

The seismic design of buildings follows the dynamic nature of the load. But equivalent static analysis is sufficient for simpler, regular in plan configuration and it gives more systematic results. This analysis flows in a manner with the calculation of design base shear and its distribution to all storeys by using the specified formula as given in code. Therefore, this method can work well for low to medium-rise buildings without significant coupled lateral–torsional modes, in which only the first mode in each direction is of significance. Tall buildings (over, say, 75 m), where second and higher modes can be important, or buildings with torsional effects, are much less suitable for the method, and require more complex methods to be used in these circumstances.

- Response spectrum method:

The word spectrum in seismic engineering brings the idea that the response of buildings having a large range of periods is outlined in a single graph. For a given earthquake motion and a percentage of critical damping, a typical response spectrum will give a plot of earthquake- related responses such as acceleration, velocity, and deflection for a complete range, or spectrum of building periods. Thus, a response spectrum may be studied as a graphical representation of the dynamic response of a series of progressively longer cantilever pendulums with increasing natural periods subjected to a common lateral seismic motion of the base.

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis will be carried out according to the code IS 1893-2002 (part1). In this method the type of soil, seismic zone factor should be entered from IS 1893-2002(part1). The standard response spectra for type of soil considered is applied to

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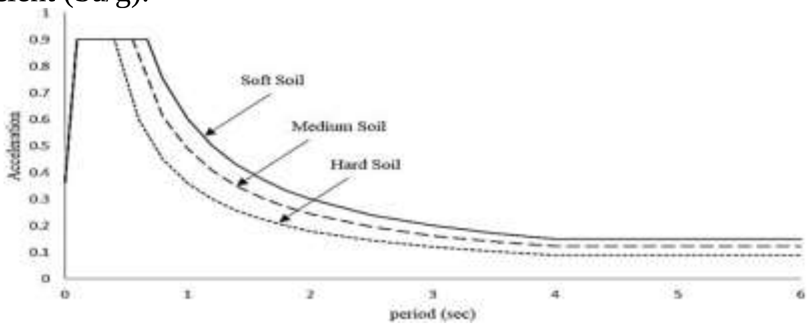
building for the analysis in ETABS 2016 software. Following diagram shows the standard response spectrum for the different types of soils and that is showed in the format of time period versus spectral acceleration coefficient (Sa/g).



Dynamic analysis of the building models is performed on ETABS (extended three- Dimensional analysis of building system). The lateral loads generated by ETABS correspond to the seismic zone IV and the 5% damped response spectrum given in IS: 1893. The natural period values are estimated by ETABS, by solving the Eigen value problem of the model. Thus, the total earthquake load generated and its distribution along the height corresponds to the mass and stiffness distribution as modelled by ETABS. Here, as in the equivalent static analysis, the seismic mass is calculated using full dead load plus 50% of live load.

3.1 MODELLING:

Basic Process of modelling:

The following comes up with the broad outline of the basic processes of modelling, analysis, design, and detailing:

1. Selection of the Base Units and Design Codes
2. Set up of the Grid Lines
3. Defining the Storey Levels
4. Defining the Material Properties
5. Defining Section Properties
6. Drawing Structural Objects
7. Selection of Objects
8. Assignment of Properties
9. Defining Load Patterns
10. Assignment of Loads
11. Defining Load Cases
12. Defining mass source
13. Edition of the Model Geometry
14. View of the Model
15. Analysis of the Model
16. Display the Results for Checking
17. Designing the Model
18. Generating the Detail Documents
19. Output the Results and Reports
20. Save the Model

3.2 MODELLING DATA OF THE FRAMES TAKEN: Detail of buildings considered in this work is as follows: Rectangular shaped Frame:

Type of structure: Multi-storeyed rigid jointed frame Layout: Rectangular

No. of stories: G+9

Ground floor storey height: 4m Floor to floor height: 3.35m

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External wall: 250mm thick including plaster Internal wall: 150mm thick including plaster Live load: 3.5KN/m2
Material: M20 and Fe415
Seismic Analysis: Equivalent Static Method and Response Spectrum Method (IS 1893 part 1:2002)
Design philosophy: LSM, IS: 456:2000
Exterior column size: 300mm*500mm Interior column size: 300mm*300mm Size of beams: 300mm*450mm
Total depth of slab: 120mm Plinth Beam: 250mm*400mm
H-shaped Frame:
Type of structure: Multi-storeyed rigid jointed frame Layout: H-shape
No. of stories: G+7
Ground floor storey height: 4m Floor to floor height: 3.35m Live load: 3KN/m2
Material: M25 and Fe415
Seismic Analysis: Equivalent Static Method and Response Spectrum Method (IS 1893 part 1:2002)
Design philosophy: LSM, IS: 456:2000 Size of column: 500mm*500mm
Size of beams in longitudinal and transverse direction: 300mm*600mm Total depth of slab: 150mm
Plinth Beam: 300mm*450mm

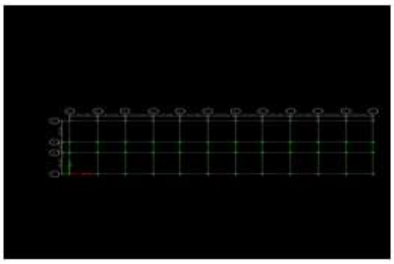

Fig 3.1: Plan of regular frame frame

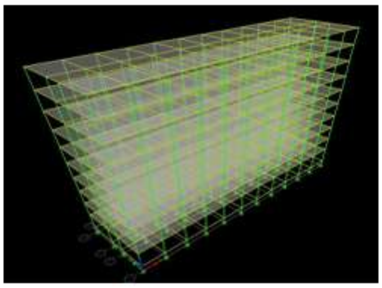

Fig 3.2: 3D view of regular

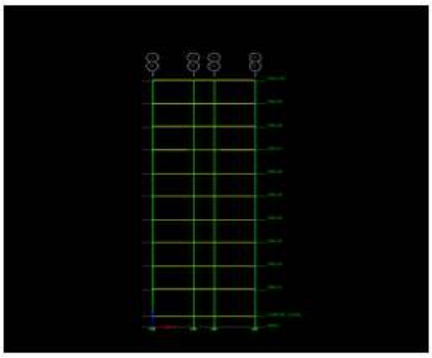

Fig 3.3: Elevation of regular frame

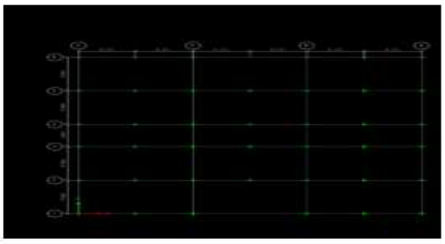

Fig 3.4: Plan of H-shaped frame

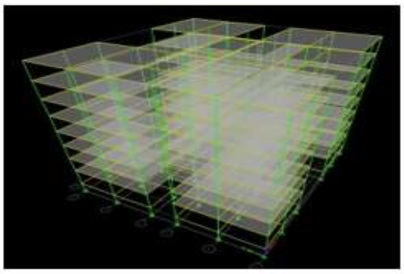

Fig 3.5: 3D view of H-shaped frame frame

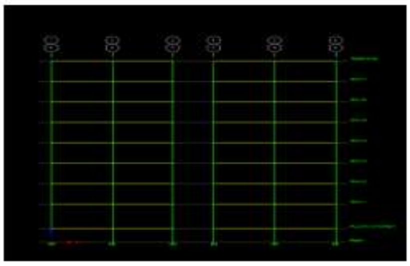

Fig 3.6: Elevation of H-shaped

3.3 MEMBER PROPERTY:
1) Material Property
2) Sectional Property
3) Support
4) Member loading
a. Dead Load
b. Live load
c. Seismic load
5) Load Combination

Lateral loads were acting at both X-direction and Y-direction.

Dead Load DL
Live Load LL
Earthquake Load in X direction EQ X
Earthquake Load in Y direction EQ Y

3.4 AUTO SEISMIC LOADING OF REGULAR FRAME:
IS1893 2002 Auto Seismic Load Calculation
This calculation presents the automatically generated lateral seismic loads for load pattern eqx according to IS1893 2002, as calculated by ETABS.
Direction and Eccentricity
Direction = X
Structural Period
Period Calculation Method = Program Calculated
Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2] Z = 0.24
Response Reduction Factor, R [IS Table 7] R = 5
Importance Factor, I [IS Table 6] I = 1
Site Type [IS Table 1] = II
Seismic Response
Spectral Acceleration Coefficient, Sa /g
[IS 6.4.5] Sa 1.36
=
g T Sa
= 0.628104
g
Equivalent Lateral Forces

Seismic Coefficient, Ah [IS 6.4.2] ZI Sa
g Ah = 2R

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	2.165	70925.3702	1069.164

Applied storey forces:

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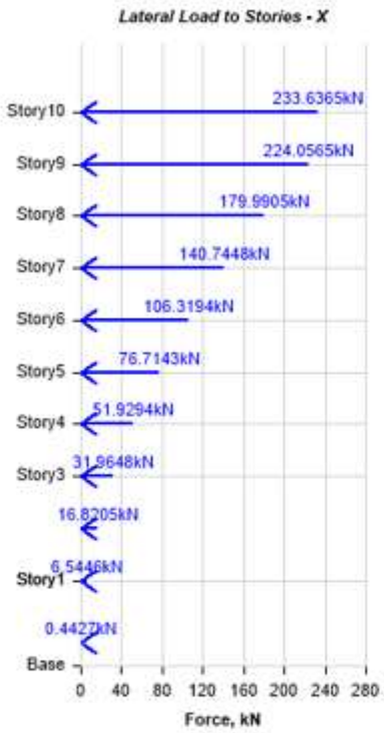

Story	Elevation	X-Dir	Y-Dir
	m	KN	KN
Story10	35.65	233.6365	0
Story9	32.3	224.0565	0
Story8	28.95	179.9905	0
Story7	25.6	140.7448	0
Story6	22.25	106.3194	0
Story5	18.9	76.7143	0
Story4	15.55	51.9294	0
Story3	12.2	31.9648	0
Story2	8.85	16.8205	0
Story1	5.5	6.5446	0
PLINTH LEVEL	1.5	0.4427	0
Base	0	0	0

IS1893 2002 Auto Seismic Load Calculation
This calculation presents the automatically generated lateral seismic loads for load pattern eqy according to IS1893 2002, as calculated by ETABS.
Direction and Eccentricity
Direction = Y
Structural Period
Period Calculation Method = Program Calculated
Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2] Z = 0.24
Response Reduction Factor, R [IS Table 7] R = 5
Importance Factor, I [IS Table 6] I = 1
Site Type [IS Table 1] = II

Seismic Response
Spectral Acceleration Coefficient, S_a /g [IS 6.4.5] $\frac{S_a}{g} = \frac{1.36}{T}$ $\frac{S_a}{g} = 0.468049$

Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (KN)	V_b (KN)
Y	2.906	70925.3702	796.717

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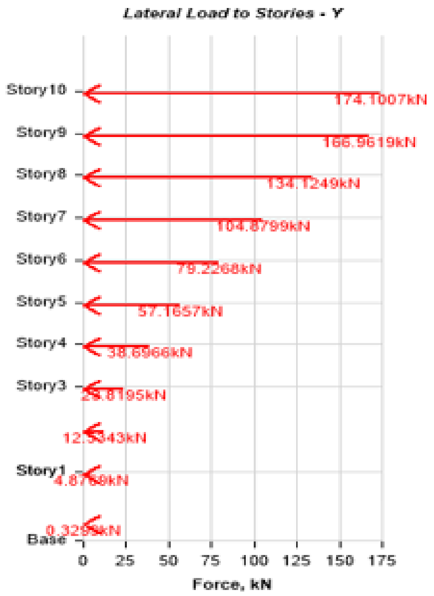
Applied storey forces:



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story10	35.65	0	174.1007
Story9	32.3	0	166.9619
Story8	28.95	0	134.1249
Story7	25.6	0	104.8799
Story6	22.25	0	79.2268
Story5	18.9	0	57.1657
Story4	15.55	0	38.6966
Story3	12.2	0	23.8195
Story2	8.85	0	12.5343
Story1	5.5	0	4.8769
PLINTH LEVEL	1.5	0	0.3299
Base	0	0	0

3.5 AUTO SEISMIC LOADING OF H-SHAPED FRAME:

IS1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern eqx according to IS1893 2002, as calculated by ETABS.

Direction and Eccentricity

Direction = X

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2] Z = 0.24

Response Reduction Factor, R [IS Table 7] R = 5

Importance Factor, I [IS Table 6] I = 1

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a/g [IS 6.4.5] $\frac{S_a}{g} = \frac{1.36}{T}$ $\frac{S_a}{g} = 0.889752$

Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	1.529	69934.0986	1493.3765

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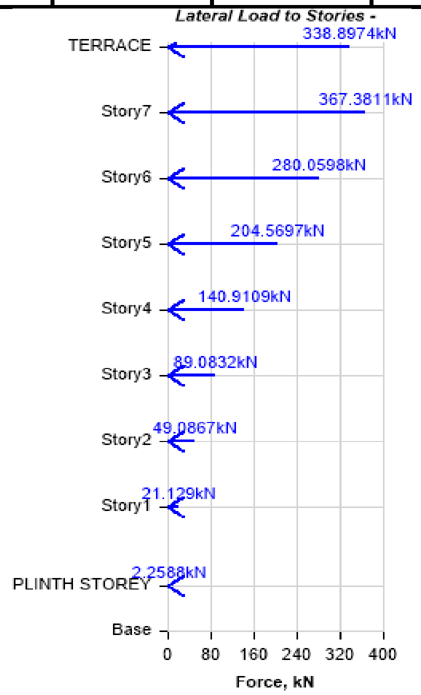
Applied storey forces:

Story	Elevation	X-Dir	Y-Dir
	M	kN	kN
TERRACE	29.75	338.8974	0
Story7	26.4	367.3811	0
Story6	23.05	280.0598	0
Story5	19.7	204.5697	0
Story4	16.35	140.9109	0
Story3	13	89.0832	0
Story2	9.65	49.0867	0
Story1	6.3	21.129	0
PLINTH STOREY	2.3	2.2588	0
Base	0	0	0



3.6 IS1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern eqy according to IS1893 2002, as calculated by ETABS.

Direction and Eccentricity

Direction = Y

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2] Z = 0.24

Response Reduction Factor, R [IS Table 7] R = 5

Importance Factor, I [IS Table 6] I = 1

Site Type [IS Table 1] = II

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Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS $\frac{S_a}{g} = \frac{1.36}{T}$ $\frac{S_a}{g} = 0.719758$

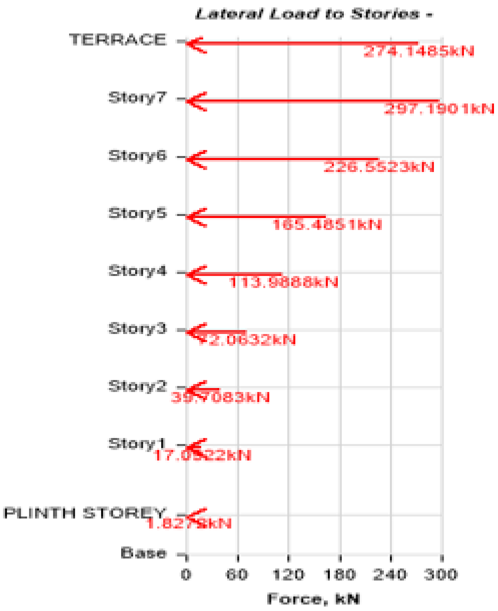
Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	1.89	69934.0986	1208.0556

Applied storey forces:



Story	Elevation	X-Dir	Y-Dir
	m	KN	KN
TERRACE	29.75	0	274.1485
Story7	26.4	0	297.1901
Story6	23.05	0	226.5523
Story5	19.7	0	165.4851
Story4	16.35	0	113.9888
Story3	13	0	72.0632
Story2	9.65	0	39.7083
Story1	6.3	0	17.0922
PLINTH STOREY	2.3	0	1.8272
Base	0	0	0

4. RESULTS AND DISCUSSIONS

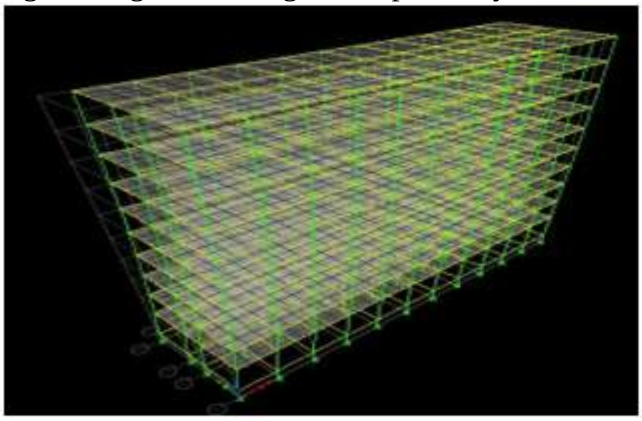
Different parameters that depict the seismic behaviour of the buildings are investigated here with respect to two different types of frames; regular frame and H shaped frame using the ETABS software. The various parameters considered here are:

1. Maximum storey displacements of the models
2. Storey drifts of the models
3. Base reactions of the models
4. Storey shear of the models
5. Storey stiffness of the models

Important Terminology :

- Maximum Storey shear:
- Maximum storey displacement:
- Storey stiffness:
- Storey drift:
- Base reactions:

The calculated values of the respective storey displacements for regular frame (static), regular frame(dynamic), H shaped frame(static) and H shaped frame(dynamic) are reflected in Figures 4.1, Fig 4.2, Fig 4.3 and Fig 4.4 respectively.



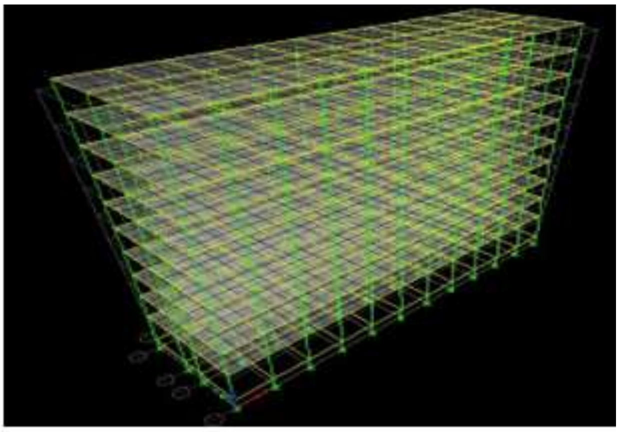
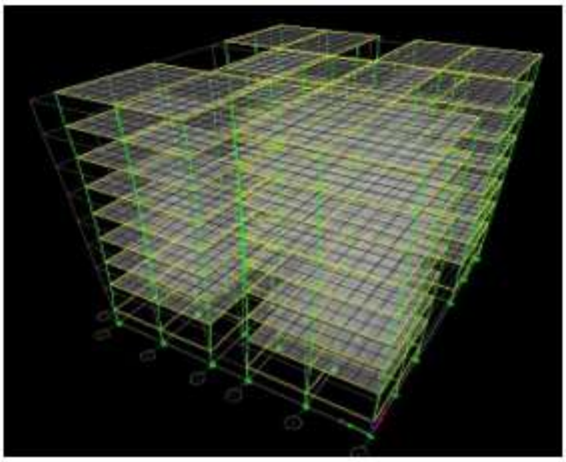


Fig 4.1: displacement of regular frame by static earthquake load Fig 4.2: displacement of regular frame by dynamic earthquake load



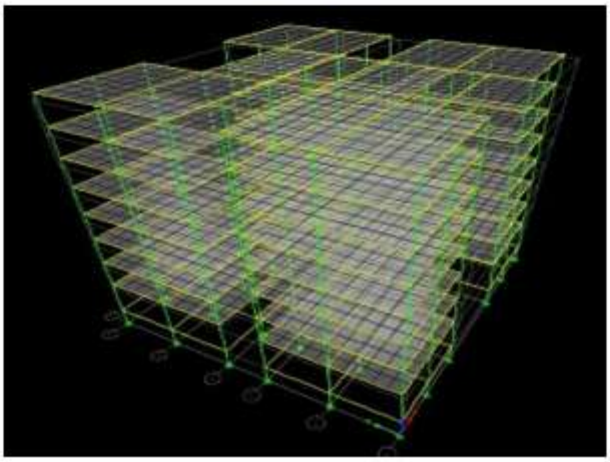


Fig 4.3: Displacement of H-shaped frame by static earthquake loading Fig 4.4: Displacement of H-shaped frame by dynamic earthquake loading

4.1 : RESULTS OF REGULAR FRAME:

The calculated values of the respective storey displacements for regular frame (static) and regular frame (dynamic) are presented in Table 4.1.

4.1.1 : Comparison of storey displacement:

Regular Frame Storey Displacement		
Displacement (MM)		
Storey	**Static**	**Dynamic**
Plinth level	4.48	4.81
storey 1	44.25	47.31
storey 2	71.83	77.29
storey 3	96.27	104.24
storey 4	118.12	128.63
storey 5	137.30	150.41
storey 6	153.73	169.76
storey 7	167.29	185.59
storey 8	177.85	198.47

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storey 9	185.28	207.68
storey 10	189.64	212.99

Table 1: Storey Displacement of regular frame

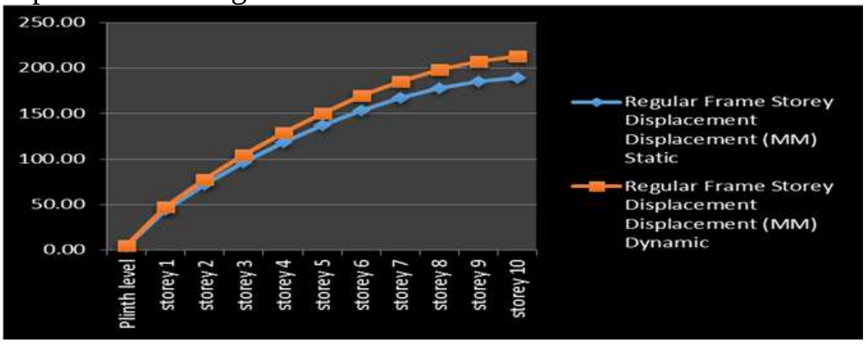

Fig 4.5: Comparison of storey displacement of regular frame

From the table of maximum storey displacement we can notice that the value increases with an increase in the number of storeys. It is studied from the graph that maximum displacement occurs in dynamic analysis as compared to the static analysis. At the plinth level the displacement remains almost same for both the static and dynamic method and then it differs gradually as the storey height increases.

a) Comparison of storey drift:

The calculated values of the respective storey drift for regular shaped frame (static) and regular frame (dynamic) are presented in Table 4.2.

Regular Frame Storey Drift		
	Storey Drift (MM)	
Storey	**Static**	**Dynamic**
Plinth level	4.48	4.81
Storey 1	39.78	42.52
Storey 2	27.58	30.13
Storey 3	24.44	27.49
Storey 4	21.85	25.51
Storey 5	19.19	23.53
Storey 6	16.43	21.41
Storey 7	13.56	18.94
Storey 8	10.56	15.86
Storey 9	7.44	11.83
Storey 10	4.35	6.92

Table 2: Storey Drift of regular frame

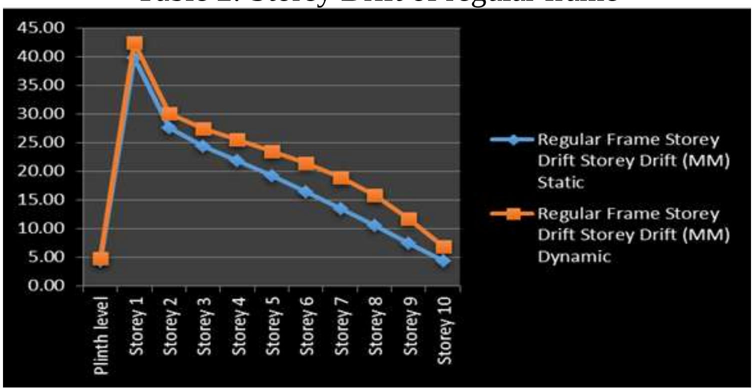

Fig 4.6: Comparison of storey drift of regular frame

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It studied from this result that the storey drift value is minimum at plinth level and suddenly increases in storey 1 and then gradually decreases with the increase in storey height. From this result it is found that there is an increase in maximum storey drift with increase in storey height from 6.9% to 37% in dynamic analysis as of static analysis.

b) Comparison of storey stiffness:

The calulated values of the respective storey stiffness of regular shaped frame (static) and regular shaped frame (dynamic) are presented in Table 4.3.

Regular Frame Storey Stiffness		
	Storey Stiffness (KN/M)	
Storey	**Static**	**Dynamic**
plinth level	1913180.644	1958125.729
Storey 1	214771.782	214290.287
Storey 2	282141.962	283902.316
Storey 3	286721.045	288466.668
Storey 4	284823.191	286833.594
Storey 5	282391.486	285113.896
Storey 6	279492.169	283602.256
Storey 7	275741.752	282317.318
Storey 8	270073.825	280854.954
Storey 9	259452.174	277238.083
Storey 10	221779.212	247672.025

Table 3: Storey stiffness of regular frame

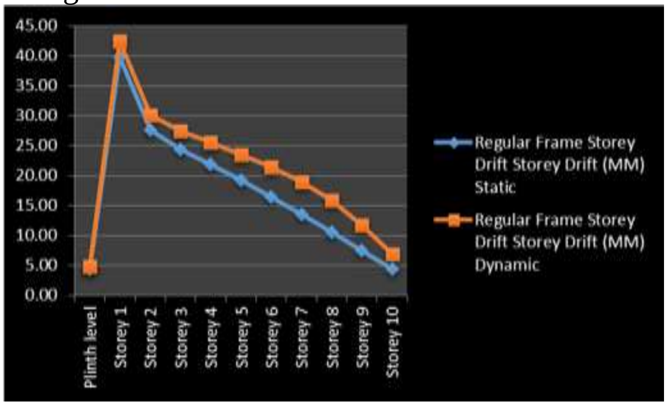

Fig 4.7: Comparison of storey stiffness of regular frame

From the result it is found that the stiffness is very high at the plinth level and it drops down in storey 1 and remains almost same in all stories and the top storey has very small stiffness.

c) Comparison of storey shear:

The calculated values of the respective storey shear for the regular frame (static) and regular frame(dynamic) are presented in Table 4.4.

Regular Frame Storey Shear		
	Storey Shear (KN)	
Storey	**Static**	**Dynamic**
plinth level	8560.897	9413.971
Storey 1	8542.4717	9112.3499
Storey2	7780.5246	8552.693

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Storey3	7008.2293	7929.8102
Storey4	6222.2705	7315.9484
Storey5	5418.2886	6708.1905
Storey6	4591.7007	6070.6487
Storey7	3737.8461	5346.7217
Storey8	2882.031	4453.0136
Storey9	1929.5454	3278.6142
Storey10	965.671	1714.6393

Table 4: Storey shear of regular frame

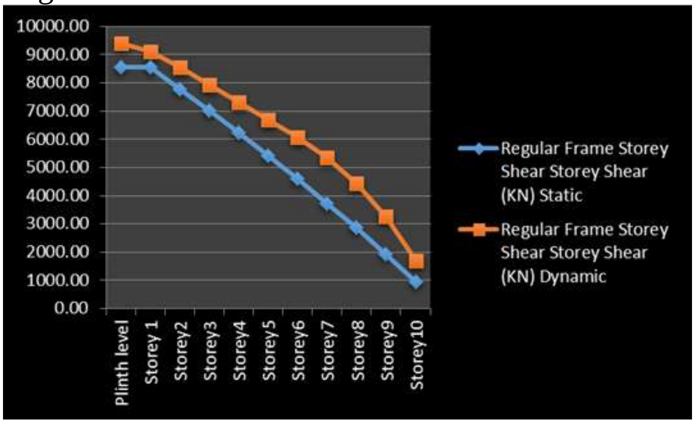

Fig 4.8: comparison of storey shear of regular frame

It is noticed from the graph that there is a difference of maximum storeyshear between stat and dynamicmethod goes on increasingaccording to storey height. Storey shearis highest at the base and lowest atthe top storey.

4.2 : RESULTS OF H-SHAPED FRAME:

a) 4..1: Comparison of storey displacement:

The calculated values of the respective storey displacements for H shaped frame (static) and H shaped frame(dynamic) are presented in Table 4.5.

H - Frame Storey Displacement		
	Storey Displacement (MM)	
Storey	**Static**	**Dynamic**
Storey 1	34.863	37.288
storey 2	51.356	55.17
Storey 3	65.41	70.616
Storey 4	77.497	84.441
Storey 5	87.552	95.357
Storey 6	95.446	104.293
Storey 7	101.038	110.554
Terrance	104.307	114.04

Table 5: storey displacement of H-shaped frame

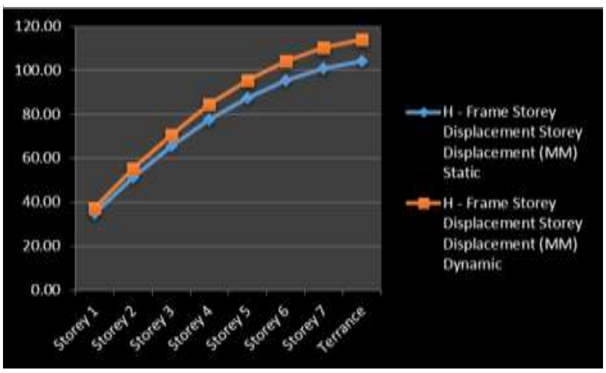

Fig 4.9: Comparison of storey displacement of H-shaped frame

It is studied from the graph that in H-shaped frame building the increase in maximum storey displacement in dynamic analysis is approximately 8.5% as compared to the static analysis.

b) 4.3.2: Comparison of storey drift:

The calculated values of the respective storey drifts for the H shaped frame (static) and the H shaped frame(dynamic) are presented in Table 4.6.

H - Frame Storey Drift		
	Storey Drift (MM)	
Storey	**Static**	**Dynamic**
plinth level	7.660	8.232
storey 1	27.249	29.128
storey 2	16.493	17.991
storey 3	14.055	15.825
storey 4	12.087	14.176
storey 5	10.055	12.377
storey 6	7.894	10.175
storey 7	5.592	7.378
Terrance	3.269	4.172

Table 6: Storey drift of H-shaped frame

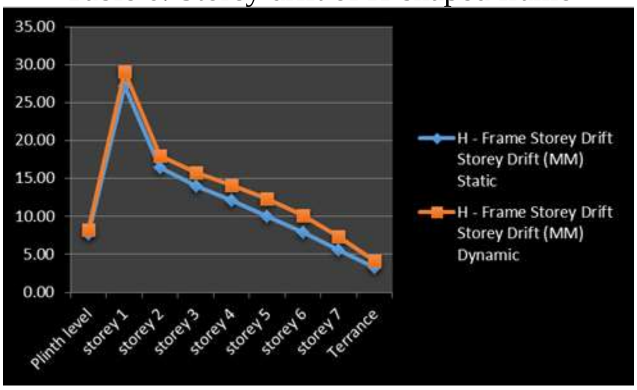

Fig 4.10: Comparison of storey drift of H-shaped frame

In the H-shaped frame building it is found that there is a relative increase in storey drift in dynamic analysis as compared to the static analysis.

c) Comparison of storey stiffness:

The calculated values of the respective storey stiffness for H shaped frame (static) and H shaped frame(dynamic) are presented in Table 4.7.

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H – Frame Storey Stiffness		
	Storey Stiffness (KN/M)	
Storey	**Static**	**Dynamic**
plinth level	1179700.648	1192905.738
Storey 1	330012.085	328616.399
Storey 2	486175.157	490048.029
Storey 3	499899.746	504312.211
Storey 4	496045.333	501994.039
Storey 5	488907.99	498442.313
Storey 6	478188.572	493772.985
Storey 7	457934.619	482095.774
Terrance	385901.011	406052.547

Table 7: storey stiffness of H-shaped frame

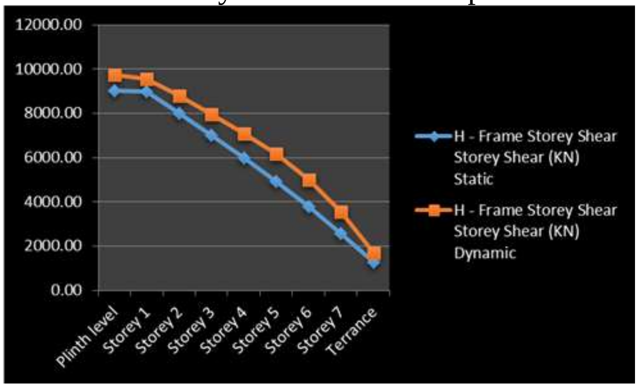

Fig 4.11: Comparison of storey stiffness of H-shaped frame

This graph shows higher stiffness in plinth level as compared to the higher storeys.

d) Comparison of storey shear:

The calculated values of the respective storey shear for H shaped frame (static) and H shaped frame(dynamic) are presented in Table 4.8.

H - Frame Storey Shear		
	Storey Shear (KN)	
Storey	**Static**	**Dynamic**
plinth level	9006.9221	9762.8445
Storey 1	8982.6654	9543.8445
Storey 2	8015.8175	8793.9903
Storey 3	7023.1957	7961.3394
Storey 4	5992.9529	7099.7922
Storey 5	4913.2691	6156.434
Storey 6	3772.3455	5016.1771
Storey 7	2558.4148	3554.7965
Terrance	1259.7291	1692.0105

Table 8: storey shear of H-shaped frame

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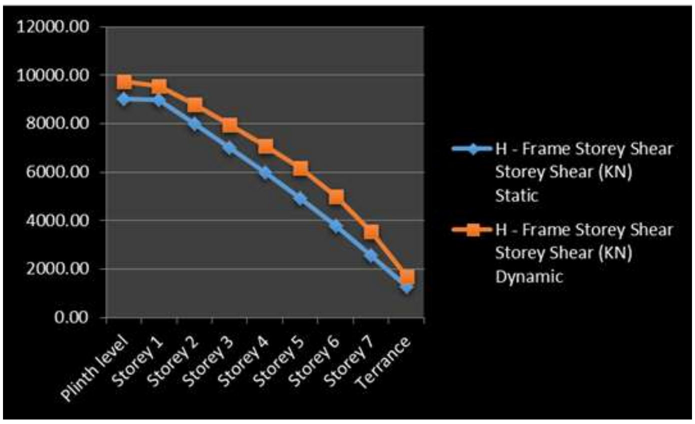

Fig 4.12: Comparison of storey shear of H-shaped frame

It is studied from the graph that the storey shear is maximum in H-shaped frame.

4.4: Comparison of base reactions:
The calculated values of the respective base reactions for the regular frame (static and dynamic) and H shaped frame (static and dynamic) are presented in Table 4.9.

	Base Reactions (KN)	
	Regular	Irregular
Static (X)	8089.914	8693.3765
Dynamic (X)	8930.207	9433.0214

Table 9: Base reactions of both frames

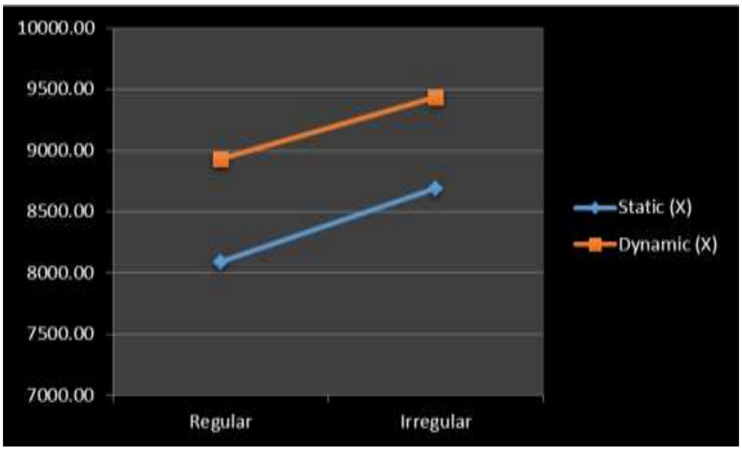

Fig 4.13: comparison of base reactions of both the frames

From this study of base reaction it is clear that base reaction is maximum in irregular frame (H- shaped frame) as of regular frame.

5. CONLUSION

In the above study, the different parameters like storey displacements, storey drifts, base reactions, storey shear and storey stiffness, that depict the seismic behaviour of the buildings are investigated for the two different types of frames; irregular frame and H shaped frame using the ETABS software. From the investigation, it is observed that, the dynamic analysis depicts values of higher magnitude

for almost all the cases compared to the static case. Also, the values in case of H-shaped frame reflects more values compared to the regular shaped model.
Following conclusions are put together from the above discussed study:
1. The analytical work justifies the behaviour of regular structures with irregular structures.
2. Storey drift, storey displacement, base shear are the important parameters for the analysis and to interpret the results.
3. Lower stories have insignificant displacement as compared to the higher stories that’s why dynamic analysis is required to be performed.
4. It is observed that upper stories have lower stiffness as compared to the lower stories. Lower stiffness results in higher displacement as of upper stories.
5. As the shape changes, displacement increases load carrying capacity also changes, so the shape of the building plays an important role in the design of the stable structure.
6. There is a percentage increase in storey drift w.r.t. storey height as compared to the static analysis. The value of the inter-storey drift becomes higher in dynamic analysis in comparison to the static analysis.
7. The values of storey drift are within the limit as specified by IS 1893-2002 (part 1).
8. The values of storey shear at the top storeys are significant it increases in lower storeys and reaches its peak in bottom storey. That’s why it is called as the base shear of the whole structure.
9. Shear force is maximum in H-shaped frame.
10. Regular shape buildings have to be given more preference than Irregular shape buildings as the irregular shape buildings induce larger deformation.
11. It is concluded from the above analysis that regular frame buildings perform well as of irregular frame building.
12. Both the above-mentioned shape of the buildings (rectangular and H-shaped) are secure in story drift as the estimated values are less than the permissible value.

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