

# Static and Dynamic Analysis of Multistory Building

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**Abstract**—Analysis of buildings for static forces is a routine affair these days because of availability of specialized programs which can be used for the analysis. On the other hand, dynamic analysis is a time consuming process and requires additional input related to mass of the structure, and an understanding of structural dynamics for interpretation of analytical results. Reinforced concrete (RC) frame buildings are most common type of constructions in urban India, which are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads, wind and dynamic forces due to the wind and earthquake.

This paper is on G+7 storied regular building. The static and dynamic analysis has with the help of STAAD - Pro software using the parameters for the design as per the IS-1893- 2002-Part-1 for the Zone V and the post processing result obtained has summarized.

**Keywords** -RCC Building, Static Analysis, Response Spectrum Analysis, Displacement

## I. INTRODUCTION

At present people are facing problems of land scarcity, cost of land. The population explosion and advent of industrial revolution led to the exodus of people from villages to urban areas i.e. construction of multi-storied buildings has become inevitable both for residential and as well as office purposes. The high raised structures are not properly analyzed for the resistance of lateral forces. It may cause to the complete failure of the structures.

The earthquake resistance structures are designed based on some factors. The factors are natural frequency of the structure, damping factor, type of foundation, importance of the building and ductility of the structure. The structures designed for ductility need to be designed for less lateral loads as it has better moment distribution qualities.

Structural analysis is mostly concerned with finding out the manner of a structure when exposed to some action. This action can be in the form of load due to the mass of things such as people, furniture, wind, snow, etc. or some other kind of excitation such as an earthquake, shaking of the ground due to a blast nearby, etc. In spirit all these loads are dynamic with the self-weight of the structure because at some point in time these loads were not there. The difference is made between the dynamic and the static analysis on the basis of whether the applied action has enough acceleration in contrast to the structure's natural frequency. If a load is applied adequately slowly, the inertia forces can be ignored and the analysis can be simplified as static analysis. Structural dynamics, therefore, is a type of structural analysis which covers the behavior of structures subjected to dynamic loading. Dynamic loads include people, wind, waves, traffic, earthquakes, and blasts. Any structure can be exposed to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis. In the present study, Response Spectrum Analysis is performed to compare the results with Static Analysis.

So, the models are evaluated by different elements and methods, such as construction stage analysis, to study the impact these have on the results. In order to perform the seismic analysis and design of a structure to be built at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further, the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as the response of the structure depend upon the frequency content of ground motion and its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is the most popular tool in the seismic analysis of structures

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following buildings:

- a) Regular buildings - Those greater than 40 m in height in Zones IV and V and those greater than 90 m in height in Zones II and III.
- b) Irregular buildings - All framed buildings higher than 12m in Zones IV and V and those greater than 40m in height in Zones II and III.

This paper deals with Static and Dynamic analysis its application to various types of the structures.

## II. LITERATURE REVIEW

**BahadorBagheri, [1]**, in this paper a Multi-storey irregular buildings of 20 stories had been analyzed. This paper also deals with the effect of the variation of the building height on the structural response of the shear wall building. The first floor is of 3m and the rest are of 3.2 m. Static and dynamic analysis is carried out with help of equivalent static, response spectrum & time history method and results are compared with each other. Equivalent analysis is carried out for low to medium rise buildings. Time history and response spectrum method is used for buildings with height 90 m for zone i and zone ii and 40 m for zone V. The results obtained by using these methods for zone v, the equivalent static analysis gives maximum displacement and maximum displacement of center of mass in X & Y direction as compared to response spectrum and time history analysis.

**Mohit Sharma, [2]**, in this paper problem taken is on a G+30 storied regular building. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 114 m. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS-1893 – 2002 – Part-1 for the zones- 2 and 3 and the post processing result obtained has summarized. RCC frame structure is analyzed both statically and dynamically and the results are compared for the following three categories namely Axial Forces, Torsion and Moment at different nodes and beams. As per the results there is not much difference in the values of Axial Forces as obtained by Static and Dynamic Analysis of the RCC Structure. The values for Torsion at different points in the beam are negative and for Dynamic Analysis the values for Torsion are positive. Values for Moment at different points in the beam are 10 to 15% higher for Dynamic Analysis than the values obtained for Static Analysis for the Moment at the same points. The values for displacement at different points in the beam are 17 to 28 % higher for Dynamic Analysis than the values obtained for Static Analysis for the displacement at the same points. The performance of RCC Framed Structure is analyzed for zone II and III both Static and Dynamic Analysis. It can be concluded that the results as obtained for the Dynamic Analysis are higher than the values as obtained by Static Analysis for the same points and conditions.

**E. Pavan Kumar, [3]** in this paper the earthquake occurred in multistoried building shows that if the structures are not well designed and constructed with and adequate strength it leads to the complete collapse of the structures. To ensure safety against seismic forces of multi-storied building hence, there is need to study of seismic analysis to design earthquake resistance structures. In seismic analysis the response reduction was considered for two cases both Ordinary moment resisting frame and Special moment resisting frame. The main objective this paper is to study the seismic analysis of structure for static and dynamic analysis in ordinary moment resisting frame and special moment resisting frame. Equivalent static analysis and response spectrum analysis are the methods used in structural seismic analysis. We considered the residential building of G+ 15 storied structure for the seismic analysis and it is located in zone II. The total structure was analyzed by computer with using STAAD PRO software. We observed the response reduction of cases ordinary moment resisting frame and special moment resisting frame values with deflection diagrams in static and dynamic analysis. The special moment of resisting frame structured is good in resisting the seismic loads.

**A.M. Mwafy, [4]** in this paper, twelve RC buildings are considered, split into three groups: sets of four 8-storey irregular frame, four 12- storey regular frame and four 8-storey dual frame-wall structures. Within each group, combination of two design ground accelerations (0.15 and 0.30 g) and three design ductility classes (High, Medium and Low) lead to the four cases. Each building has been designed and detailed in accordance with Euro code 8, parts 1-1 to 1-3. The overall plan dimension considered are 15 m x 20 m. The total heights are 25.5, 36 and 24 m for groups 1, 2 and 3, respectively, with equal storey heights of 3 m except the first storey of group 1, which is 4.5 m high. Live loads and loading from floor finishes and partitions are both assumed to be 2.0 KN/m<sup>2</sup>. All buildings are assumed to be founded on medium soil type 'B' of EC8. Results suggest that, pushover analysis can provide insight into the elastic as well as the inelastic response of buildings when subjected to earthquake ground motions. Static pushover analysis is more appropriate for low rise and short period frame structures. The investigation carried out on two sets of four 12-storey frame buildings and four 8-storey frame-wall structures that a conservative prediction of capacity and a reasonable estimation of deformation is obtained using the simple triangular or the multimodal load distribution. The results of the dynamic collapse analysis show clearly that each earthquake record exhibits its own peculiarities, dictated by frequency content, duration, sequence of peaks and their amplitude.

**Li Qiusheng, [5]**, in this paper the equations of static equilibrium, the governing differential equation of shear and flexural vibrations of straight bars with variable cross-section are written in the form of unified self-conjugate differential equations of the second-order. These can be reduced to Bessel's equations. Based on an experimental study, the Guangzhou Hotel Building is treated as a cantilever beam of non-uniform section in free vibration analysis. The computed value of the natural frequency obtained by use of the proposed method of this paper approaches the measured value. The governing equations for stability analysis of a variable cross-section bar subjected to variably distributed axial loads and for dynamic analysis of multi-storey buildings and tall buildings and other systems are written in the form of a unified self-conjugate differential equation of the second order. The numerical example shows that the calculated results are close to the measured data, which illustrates that the calculation methods proposed herein are applicable to engineering application and practice.

**Romy Mohan, [6]**, in this paper, two multi storey buildings, one of six and other of eleven storey have been modelled using software package SAP 2000 12 for earthquake zone V in India. Six different types of shear walls with its variation in shape are considered for studying their effectiveness in resisting lateral forces. The paper also deals with the effect of the variation of the building height on the structural response of the shear wall. Dynamic responses under prominent earthquake, El-Centro have been investigated. This paper highlights the accuracy and exactness of Time History analysis in comparison with the most commonly

adopted Response Spectrum Analysis and Equivalent Static Analysis. The result found out Equivalent Static Method can be used effectively for symmetric buildings up to 25 m height. For higher and unsymmetrical buildings Response Spectrum Method should be used. For important structures Time History Analysis should be performed as it predicts the structural response more accurately in comparison with other two methods.

### III. METHODOLOGY

The building considered in the present study is G+7 storied R.C framed building of symmetrical rectangular plan with configuration of buildings having a plan area of 48m x 24m with a storey height 4.5 m each and total height of chosen building including depth of foundation is 40.5 m. Complete analysis is carried out for dead load, live load, wind and seismic load using STAAD PRO. Response spectra method for dynamic analysis is used. Loading combinations are considered as per IS 1893:2002.

The static and dynamic analysis has done on computer with the help of STAADPro software using the parameters as per the IS – 1893 – 2002 – Part-1 for the zone 5 and the post processing result obtained has summarized.

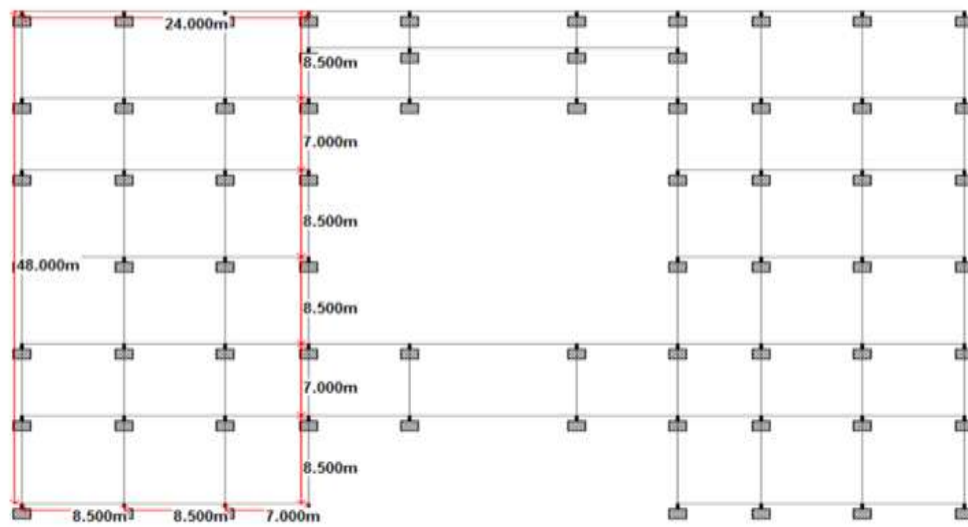


Figure 1: Plan of G+7 Building

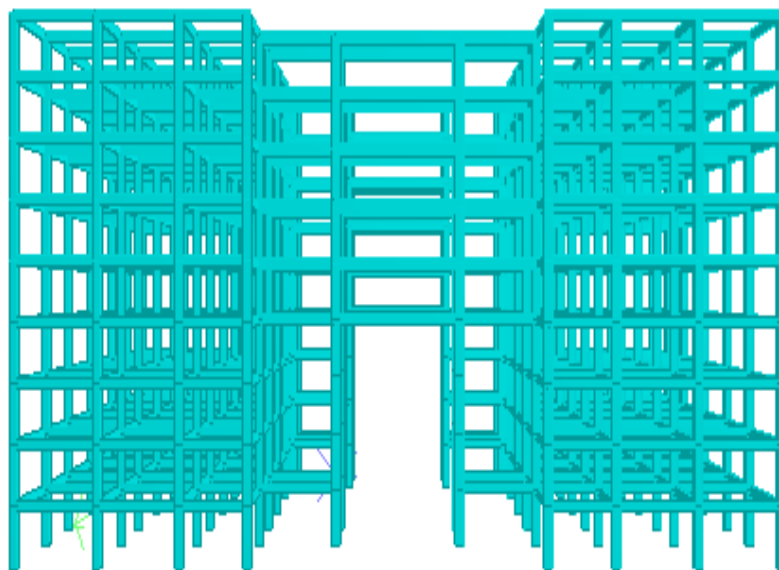


Figure 2: 3D Rendered view

**1) Building properties**

- **Site Properties:**
- Details of building: G+7 RC structure
- Outer and inner wall thickness: 200 mm
- Floor height: 4.5 m
- Height of the building: 40.5 m

**2) Seismic Properties :**

- Seismic zone: V
- Zone factor: 0.36
- Importance factor: 1
- Response Reduction factor R: 5
- Soil Type: Hard soil

**3) Material Properties**

- Material grade of M25 used for the analysis.
- Loading on structure
- Dead load: self-weight of structure including infill.
- Live load: 4 KN/m<sup>2</sup>
- Wind load: As per IS 875(Part 3) 1987
- Seismic load: Seismic Zone -V

**4) Preliminary Sizes of members:**

- Column sizes: 750mm x 750mm
- Number of columns: 64 nos. at each floor
- Column sizes: 1000mm x 1200mm
- Number of columns: 4 nos. at each floor
- Beam sizes: 750mm x 350mm
- Beam sizes: 1000mm x 500mm
- Slab thickness: 250mm

**IV. RESULTS AND ANALYSIS**

Length of building is 48 m, width of building is 24 m, and height of building is 40.5 m. The base supports of the structure were assigned as fixed. The supports were generated using STAAD.pro support generator.

**SPECIFICATION FOR ANALYSIS OF BUILDING: - ZONE V**

- Columns = 0.75 x 0.75m & 1 x 1.2 m
- Beams = 0.75 x 0.35 m & 1 x 0.5 m
- Live load on the floors is 4 KN/m<sup>2</sup>
- Grade of concrete: Used M25 concrete

**MATERIALS FOR THE STRUCTURE:**

The materials for the structure were specified as concrete with their various constants as per standard Zone factor,

- Z (For zone V) = 0.36 Importance factor,
- I = 1 Response reduction factor,
- R = 5
- Type of soil = Hard

**CALCULATION OF WIND LOADS: -Wind loads are calculated as per IS 875 Part 3 (1987)**

For the Present work, the basic wind speed (V<sub>b</sub>) is assumed as 50m/s (As per IS 875- Appendix-A) and the building is considered to be open terrain with well scattered obstructions having height less than 10m with maximum dimension more than 50m and accordingly factors K<sub>1</sub>, K<sub>2</sub>, K<sub>3</sub> have been calculated as per IS 875 Part 3 (1987).

Terrain Category- 1(As per Clause 5.3.2.1)

Class of Structure- B (As per Clause 5.3.2.2, as all dimensions are bet 20m to 50m)

K<sub>1</sub>- Probability factor- 1 (Clause 5.3.1 & Table-1)

K<sub>2</sub>- Terrain, height and size factor- 1.15(Claude 5.3.2 & Table -2 for height bet 30 to 50m)

K<sub>3</sub>- Topography factor- 1(Claude 5.3.3 & Appendix- C, less than 3degree slope)



Design wind speed,  $V_z = V_b (K_1 \times K_2 \times K_3)$  (3)

$V_z = 57.5 \text{ m/s}$

Design pressure,  $P = 0.6 V_z^2$  (4) =  $1983.75 = 1.9 \text{ KN/m}^2$

Table 1: Result comparison of static and dynamic results

<i>Particulars</i>	<i>Static Analysis</i>	<i>Dynamic Analysis</i>
<b>Max Moments</b>		
MxKNm	38.635	92.934
MyKNm	1029.329	640.199
MzKNm	2169.87	3213.101
<b>Max Forces</b>		
FyKN	877.562	538.36
FzKN	368.041	99.638
<b>Axial Forces</b>		
FxKN	21311.26	1570.604
Deflection mm	22.343	0.91

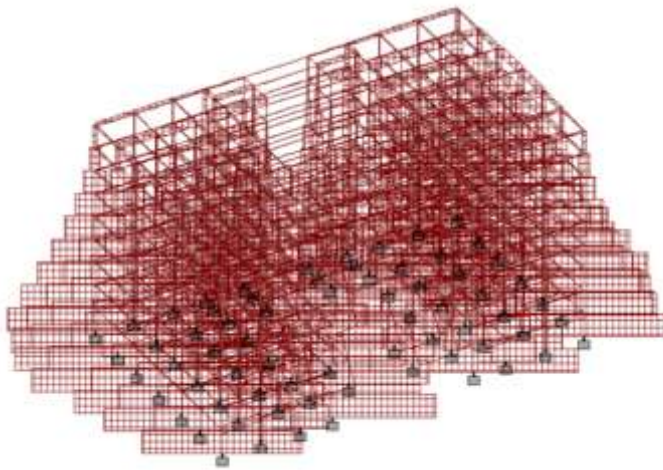


Figure 3: Axial Force Diagram (Static)

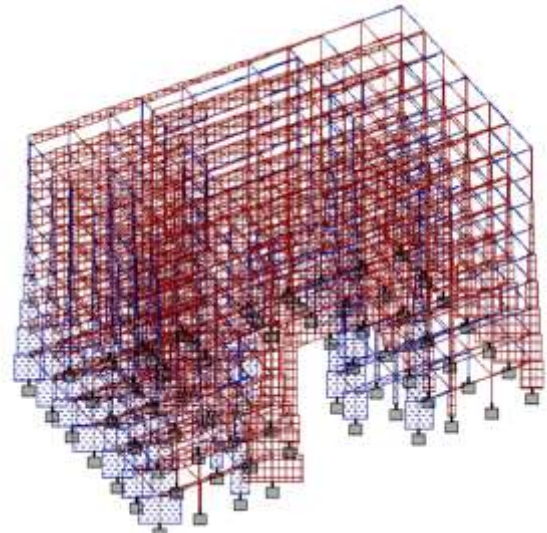


Figure 4: Axial Force Diagram (Dynamic)

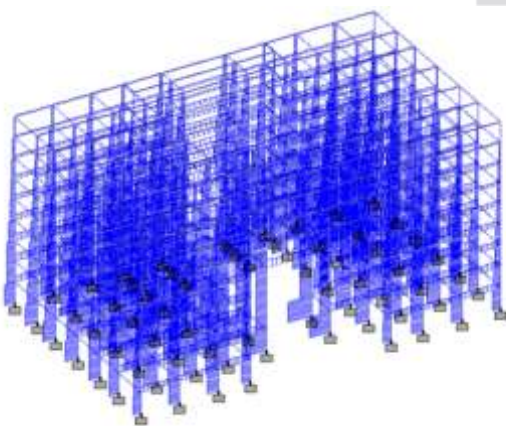


Figure 5: Shear Force Diagram (Static)

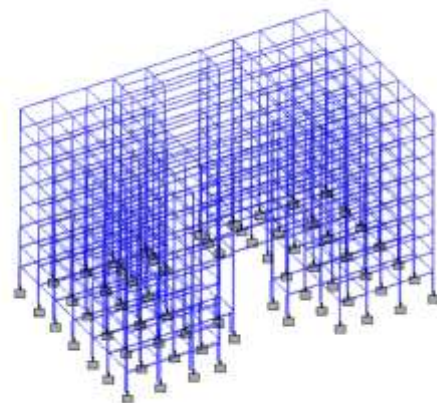


Figure 6: Shear Force Diagram (Dynamic)

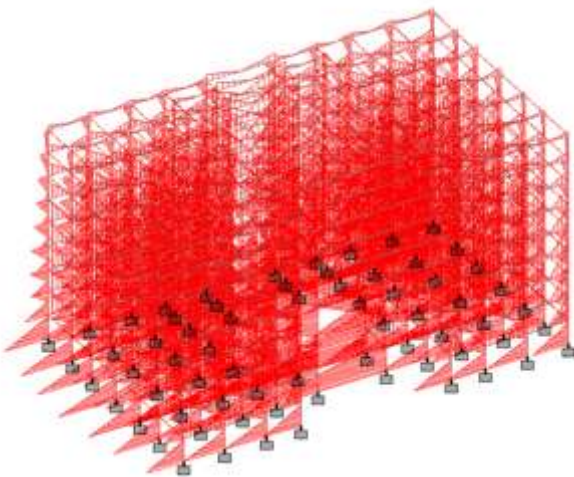


Figure 7: Bending moment (Static)

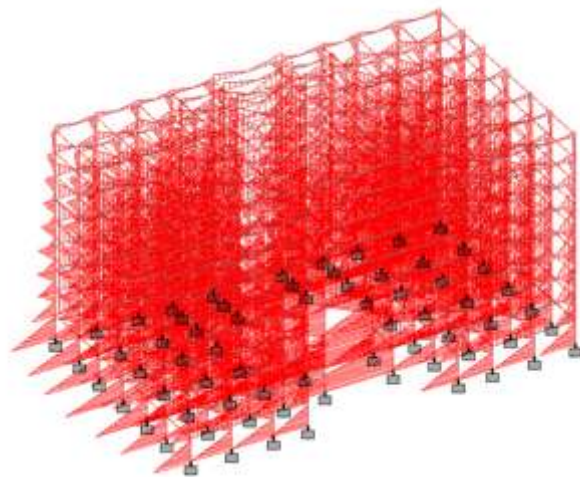


Figure 8: Bending moment (Dynamic)

The following were the graph obtained



Figure 9 &amp; 10: Maximum Moments

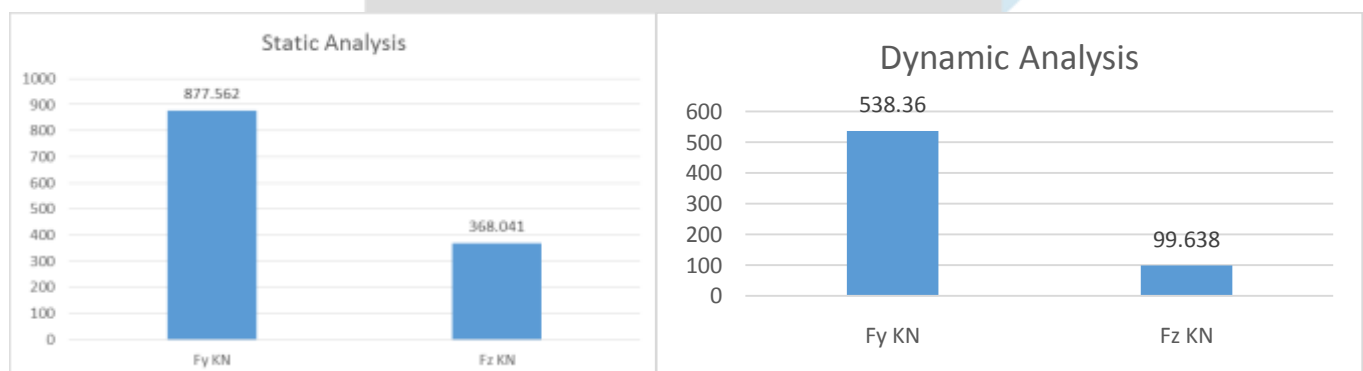


Figure 11 &amp; 12: Maximum Shear Force

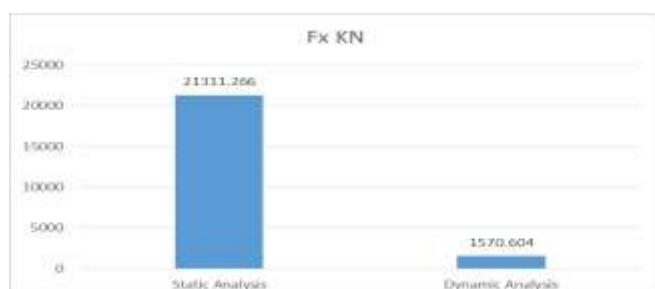


Figure 13: Maximum Axial Force

## V. CONCLUSION

In this dissertation work, the behavior of the buildings in Zone V are analyzed for Static and Dynamic condition. The parameters such as maximum deflection, maximum moments, maximum shear forces and axial forces are studied and comparison between these parameters are given between the Static and Dynamic state for Zone V.

1. There is remarkable increase in axial force for Static state as compared to Dynamic state.
2. There is remarkable increase in Shear force for Static state as compared to Dynamic state.
3. In beam the bending moments for Dynamic state is more as compared to Static state. As the floor height increases, the bending moment in beam decreases.
4. As a result the comparison between both the analysis it is observed that the deflection obtained by Static analysis is higher than Dynamic analysis.
5. As the effect of earthquake is more in bending moment in column, footing and beam displacement in column joint , if structure is designed for Static case it will not sustain earthquake load(Dynamic). So we have to consider the earthquake load for the analysis and design.
6. The bending moment due to earthquake load in column is highly increasing with the storey height. So if earthquake load is not considered for the analysis there will be possibilities for overturning.
7. The result of Static analysis are approximately uneconomical as the values of deflection are higher for Dynamic analysis.

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