COMPARATIVE STUDY OF STATIC AND DYNAMIC SEISMIC ANALYSIS OF MUILT-STORIED RCC BUILDING BY USING STAAD PRO

Kandhira Sujith[1], G.V.Ramanjaneyulu[2]

[1]M.Tech scholar, Department of Civil Engineering, ST. Mary's Group of Institutions Guntur, Andhra Pradesh, India
[2]Assistant Professor, Department of Civil Engineering, ST. Mary's Group of Institutions Guntur, Andhra Pradesh, India

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ABSTRACT: Structural analysis is mainly concerned with finding out the behaviour of a structure when subjected to some action. This action can be in the form of load due to weight of things such as people, furniture, snow etc. or some other kind of excitation such as earthquake, shaking of the ground due to a blast nearby etc. In essence all these loads are dynamic including the self-weight of the structure because at some point in time these loads were not there. The distinction is made between the dynamic and static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. If a load is applied sufficiently slowly, the inertia forces (Newton's second law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics, therefore, is a type of structural analysis which covers the behaviour of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquake and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis. Reinforced concrete multi-storied buildings in India were for the first time subjected to a strong ground motion shaking in Bhuj earthquake. It has been concluded that the principal reasons of failure may be attributed to soft stories, floating columns, mass irregularities, poor quality of construction materials and faulty construction practices, inconsistent earthquake response, soil and foundation, effect of pounding of adjacent structures. All over world, there is high demand for construction of tall buildings due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damages to tall structures. Since earthquake forces are random in nature and unpredictable, the engineering tools need to be sharpened for analysing structures under the action of these forces. So in the thesis an attempt was made to analysis the structure with static and dynamic seismic analysis and results are compared with each other. The present study a multi-storied framed structure of (G+10) pattern is selected. Linear seismic analysis is done for the building by static method (Seismic Coefficient Method) and dynamic method (Response Spectrum Method) using STAAD-Pro.

Keywords: Equivalent Coefficient Method, Response Spectrum Method.

1. INTRODUCTION

Earthquake is a spasm of a ground shaking caused by a sudden release of energy in the earth's lithosphere (i.e. the crust plus a part of the upper mantle).This energy arises mainly form stresses built up during the tectonic processes, which consist of interaction between the crust and the interior of the earth. In some parts of the world earthquakes are associated with volcanic activities.

1.1 Terminology:

Earthquake is essentially a sudden and transient motion and series of motions of the earth's surface originating in a limited underground region due to disturbance of the elastic equilibrium of the rock mass and spreading from there in all directions.

The source of the elastic energy i.e. the focal region is generally an extended volume of rock mass of irregular shapes. The centroid of this volume is the 'focuses. The centre of vertical projection of this volume of rock mass on the earth's surface is called the 'epicentre, of the earthquake and the distance from the epicentre to any point of interest is called the 'epicentre distance' as show in the figure below. A number of small size earthquakes take place before and after a big earthquake (i.e. the main shock). Those occurring before the big one is called fore shocks and the ones after are called aftershocks.

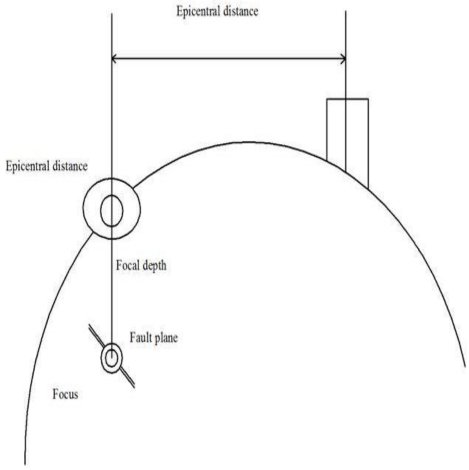


Figure1: Graphical representation of occurrence of earthquake

Table1: Global occurrence of earthquake:

Type	Depth
Deep focus earthquakes	Exceeding 300 km
Intermediate focus earthquakes	Between 55-300 km
Shallow focus earthquakes	Less than 55 km

1.2 SEISMIC BEHAVIOUR AND DESIGN OF MULTISTORIED BUILDINGS

Structurally a multi-storey building may consist of a frame with rigid connections, a frame with braces, parallel sets of shear wall, box units or a combination of these sets of elements. Design of multi-storey buildings for earthquake motions requires the consideration of several factors such as probable intensity of earthquake, stiffness of the structure and its ductility and without impairing its functional utility. "The response of any structure during an earthquake is a dynamic phenomenon and the principles of dynamics must be used to explain the behaviour of the buildings during ground motions. Two broad approaches of earthquakes analysis of multi-storeyed structure in present day are:

I. Equivalent static approach

II. Dynamic method of analysis.

Equivalent static approach:

This method is adopted in most of the building codes for moderately high buildings. The static horizontal forces are applied based on the values seismic coefficients to simulate the effect of earthquake. The distribution of shears along the height is adopted to be similar to that obtained by analysis.

Dynamic method analysis:

A multi-storey rigid frame is a typical examples of multiple degree of freedom system in which masses are concentrated at the floor levels and restoring force is mainly provided by columns during vibrations. The equation of motion for a system subjected to ground motion is well known.

[M]{Z}+[C]{Z}{R}Z}=[M]{Y}

In which {Z} is a vector of relative displacements ,R[Z] is the restoring force depending on [Z], which for linear analysis in equal to {K}[Z];[M],[C] and{K} are mass damping and stiffness matrices, any 'Y' is ground acceleration where the superscript dot depots differentiation with to time. Depending on the intensity of earthquake a structure may remain elastic and may show inelastic behaviour for severe earthquake. Consequently the methods of dynamic analysis may be classified as

- Elastic dynamic analysis
- Inelastic dynamic analysis

1.3 INDIAN STANDARD CRITERIA FOR EARTH QUAKE RESISTANCE DESIGN OF STRUCTURE

The response of the structure to the ground vibrations is a function of the nature of the foundation soil; materials, size and mode of construction for the structure, and the duration and intensity of ground motion. This standard design seismic coefficient for structures standing on soils or rocks, which will not settle or slide due to loss of strength during vibrations

The seismic coefficients recommended in this standard are based on practice conventionally followed and performance of structures in past earthquakes. It is well known that earthquakes would be large than specified in this standard as basic seismic coefficients. In order to take care of this gap, for special cases important factor and performance factor (where necessary) are specified in this standard elsewhere

In case of structures designed for horizontal seismic force only, it shall be considered to act in any one direction at a time where both horizontal and vertical forces are taken into account simultaneously. The vertical seismic coefficient shall be considered in the case of structures in which stability is a criterion of design or for overall stability analysis of structures except as otherwise stated in the relevant clauses.

Equipment and systems supported at various levels of structures will be subjected to motions corresponding to vibrations at their support points. In important cases, it may be necessary to obtain response spectra for design.

2. LETERATURE

Balaji U & Selvarasan M. E.2012 studied a residential building G+13 storied. The building was analyzed for earthquake loads using ETABS. Assuming that the material properties were linear, static and dynamic analysis was performed. These non-linear analyses were carried out by considering severe seismic zones and the behaviour was assessed by taking types II soil condition. Different response like displacement & base shear were calculated and it was observed that displacement increased with the building height.

Anirudh Gottala, shaik Yajdhani et al.2007 studied static and dynamic analysis of G+9 multi-storeyed building. Linear seismic analysis was done by static method (Seismic Coefficient Method) and dynamic method (Response Spectrum Method) using STAAD-Pro as per the IS-1893-2002-Part-1. Parameters such as Bending moment, Axial force, Torsion, Displacement, Nodal displacement, beam and column end forces etc. were calculated. The authors concluded that,

- The values for Moments are 35 to 45 % higher for Dynamic analysis than the values obtained for Static analysis.
- The values of Torsion of columns are negative for Static analysis and for Dynamic analysis the values of torsion are positive.
- The values of Nodal Displacements are 50% higher for Dynamic analysis than the values obtained for Static analysis.
- Nodal Displacements and Bending moments in beams and columns due to seismic excitation showed much larger values compared to that due to static loads.

Mahesh N. Patil, Yogesh N. Sonawane in 1998 studied seismic analysis of 8 storey building. A 22.5m x 22.5 m, 8 storey multi storey regular structure was considered for the study. Storey height was 3m. Modeling and analysis of the structure was done on ETABS software. Analysis of the structure was done and then the results generated by the software were compared with manual analysis of the structure using IS 1893:2002.

Mohit Sharma, Savita Maru et al 2001 studied static and dynamic analysis with the help of STAAD-Pro software using the parameters for design as per the IS 1893-2002-part-1for the zones-2 and 3. G+30 storied regular building was analyzed. These buildings had the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation was 2.4 m and total height of chosen building including depth of foundation was 114 m.

The authors concluded that,

- For zone 2 and zone 3, the values of torsion at different points in the beam are negative and for Dynamic Analysis the values for Torsion are positive.
- Moments and Displacement at different points in the beam was 10 to 15% and 17 to 28 % higher for Dynamic Analysis than the values obtained for Static Analysis for moment and displacement at same point.

S. Mahesh, B. Panduranga Rao et al 2008 studied residential building of (G+11) regular and irregular configuration for earthquake and wind load using ETABS and STAAD PRO V8i. Assuming the material property to be linear, static and dynamic analysis was performed. This analysis was carried out by considering different seismic zones and for each zone; the behaviour was assessed by taking three different types of soils namely Hard, Medium and Soft. Authors compared both the regular and irregular configurations. Following conclusions were drawn,

- The base shear values and story drift values were more in regular configuration than irregular configuration.
- Base shear value was more in the zone 5 and that in the soft soil in regular configuration.
- Story drift value was more in the story 13 in the regular configuration.

3. STRUCTURAL MODELLING

Live Load	2 kN/m2
Dead load	3 KN/m2
Floor finish	1 KN/m2
Density of RCC considered:	25kN/m3
Thickness of slab	125mm
Depth of beam	400mm
Width of beam	350mm
Dimension of column	460x460mm
Zone	V
Thickness of outside wall	20mm
Thickness of inner partition wall	15mm
Height of each floor	3.0 m
Damping Ratio	5%
Importance factor	1
Type of Soil	Gravel
Type of structure	Special Moment Resisting Frame
Response reduction Factor	5

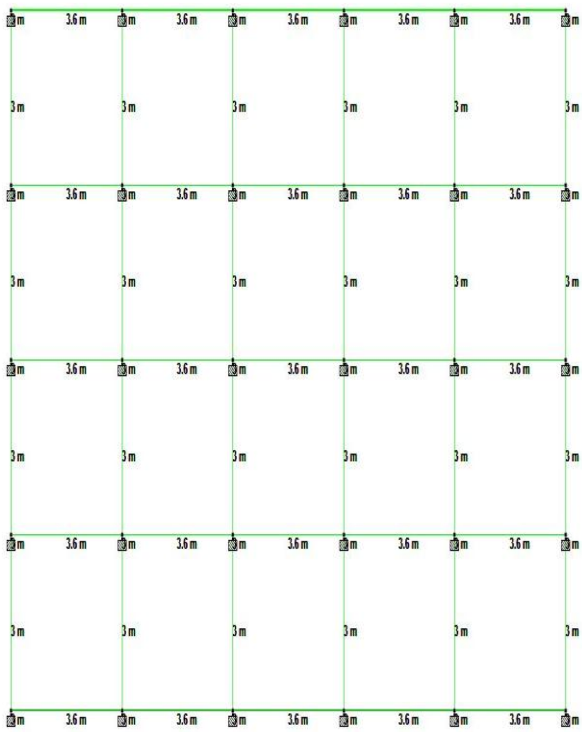


Figure 1. Plan of the structure 12x18m

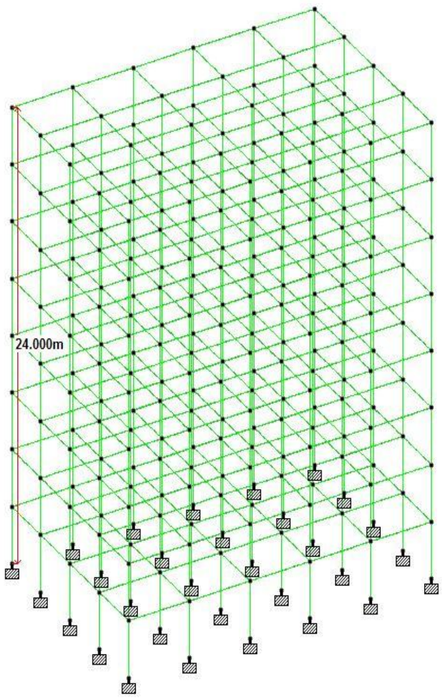


Figure 2. Height of the structure 24m

4. RESULTS & DISCUSSIONS

The RCC frame structure is analyzed both statically and dynamically and the results are compared for the following categories namely Beam Stresses, Axial Forces, Torsion, Displacements and Moment at different nodes and beams and the results are tabulated.

4.1 Comparison of Displacements for Vertical Members

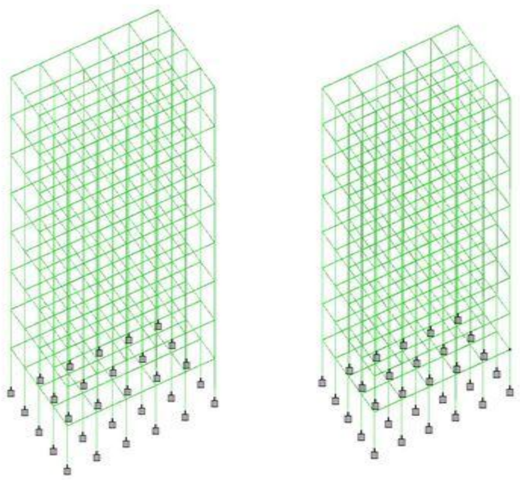
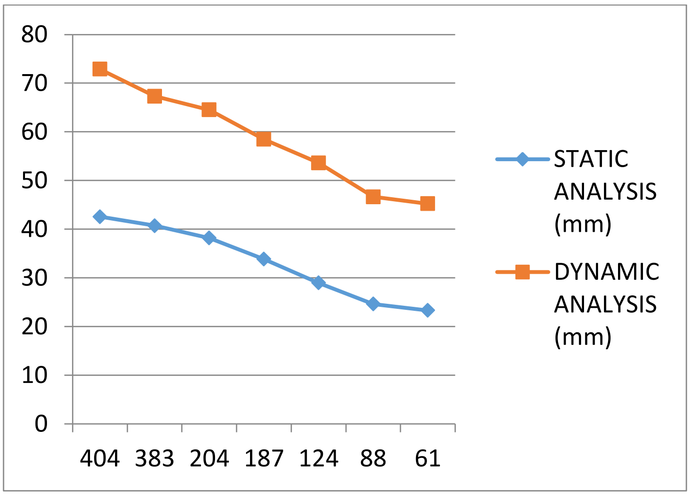


Figure 3. Displacement of static and dynamic models

Table 1. Comparison of Displacements

COLUMN NUMBER	STATIC ANALYSIS (mm)	DYNAMIC ANALYSIS (mm)
404	42.56	72.89
383	40.73	67.33
204	38.18	64.52
187	33.85	58.46
124	28.96	53.61
88	24.617	46.64
61	23.31	45.23



Graph 1.Comparison of Displacements of Static and Dynamic Analysis model.

4.2 Comparison of Beam Stresses in Static Analysis

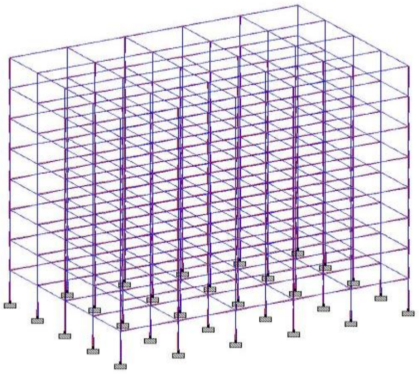
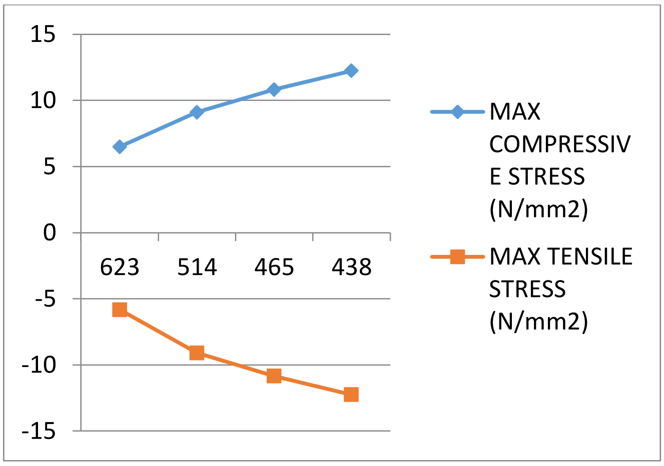


Figure 4. Static analysis model beam stresses

Table 2. Comparison of Beam Stresses in Static Analysis

BEAM	STATIC ANALYSIS	
	MAX COMPRESSIVE STRESS (N/mm²)	MAX TENSILE STRESS (N/mm²)
623	6.49	-5.82
514	9.1	-9.09
465	10.82	-10.84
438	12.24	-12.25
392	13.27	-13.29
349	13.93	-13.95
316	14.24	-14.29



Graph 2.Comparison of Beam stresses of Static Analysis model.

5.3 Comparison of Beam Stresses in Dynamic Analysis

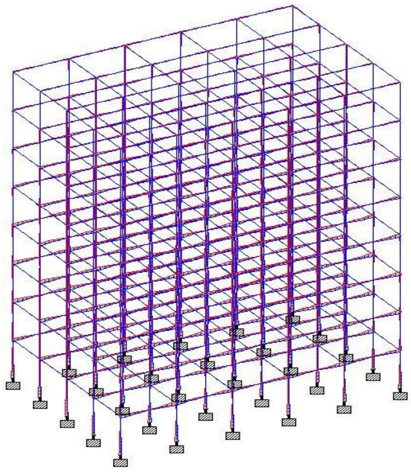
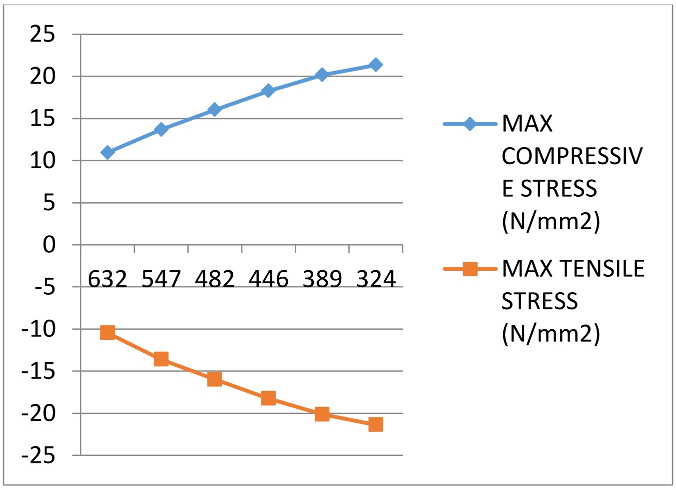


Figure 5. Dynamic analysis model beam stresses

Table 3. Comparison of Beam Stresses in Dynamic Analysis

	DYNAMIC ANALYSIS	
BEAM	**MAX COMPRESSIVE STRESS (N/mm2)**	**MAX TENSILE STRESS (N/mm2)**
632	10.94	-10.45
547	13.67	-13.6
482	16.01	-15.98
446	18.27	-18.24
389	20.16	-20.13
324	21.34	-21.36



Graph 3.Comparison of Beam stresses of Dynamic Analysis model.

4.4 Comparison of Moment for Vertical Members

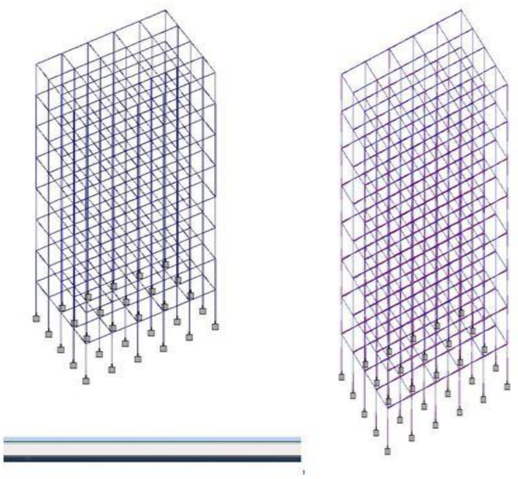
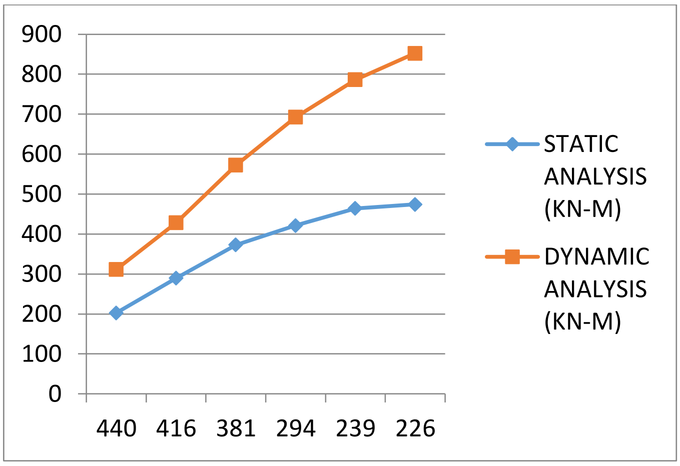


Figure 6.Comparison of moments of static & Dynamic models

Table 4. Comparison of Moment

COLUMN NUMBER	STATIC ANALYSIS (KN-M)	DYNAMIC ANALYSIS (KN-M)
440	202.49	311.6
416	289.37	428.17
381	372.72	572.18
294	421.2	692.36
239	464.21	786.2
226	474.15	852.07



Graph 4.Comparison of Beam stresses of Dynamic Analysis model.

4.5 Comparison of Axial Forces for Vertical Members

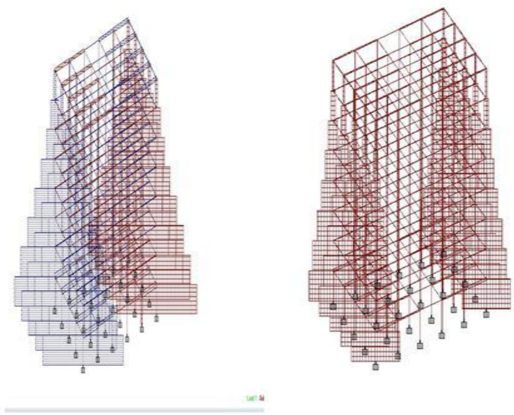
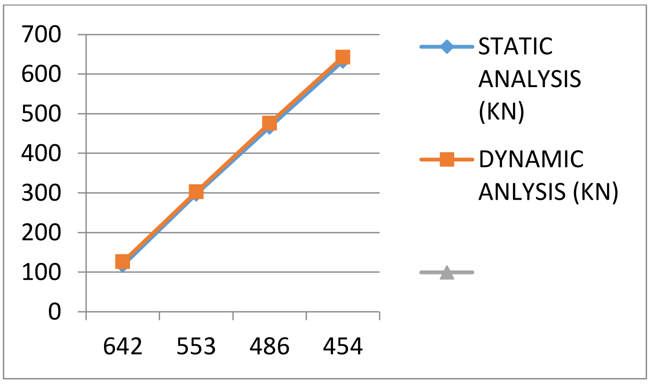


Figure 7. Axial forces of models

Table 5. Comparison of Axial Forces

COLUMN NUMBER	STATIC ANALYSIS (KN)	DYNAMIC ANLYSIS (KN)
642	116.9	126.3
553	296.5	302.5
486	465.8	475.7
454	632.1	642.6
347	804.7	813.03
322	970.647	975.007



Graph 5.Comparison of axial forces of Dynamic Analysis model.

4.6 Comparison of Torsion for Vertical Members (EQ+x)

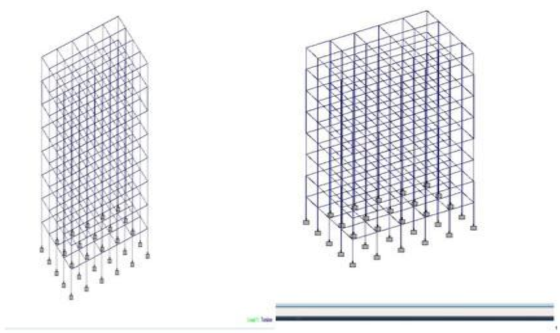
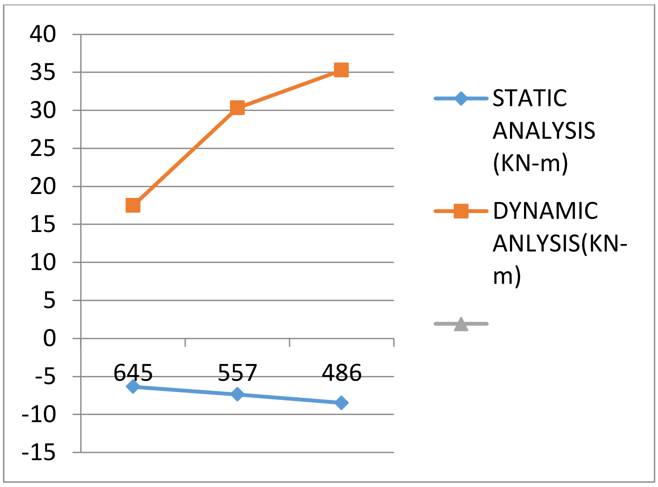


Figure 8.Torsion for vertical moments of models

Table 6. Comparison of Torsion moments

COLUMN NUMBER	STATIC ANALYSIS (KN-m)	DYNAMIC ANLYSIS (KN-m)
645	-6.36	17.47
557	-7.36	30.3
486	-8.47	35.27
458	-8.62	54.86
349	-8.65	65.58
323	-8.42	74.71



Graph 6.Comparison of axial forces of Dynamic Analysis model.

4.7 Comparison of Nodal-Displacements in Z-Direction

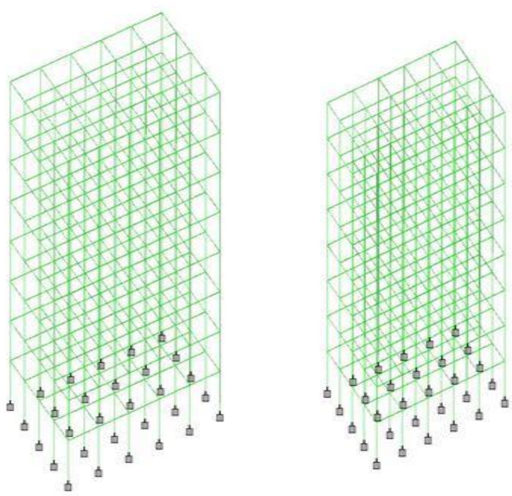
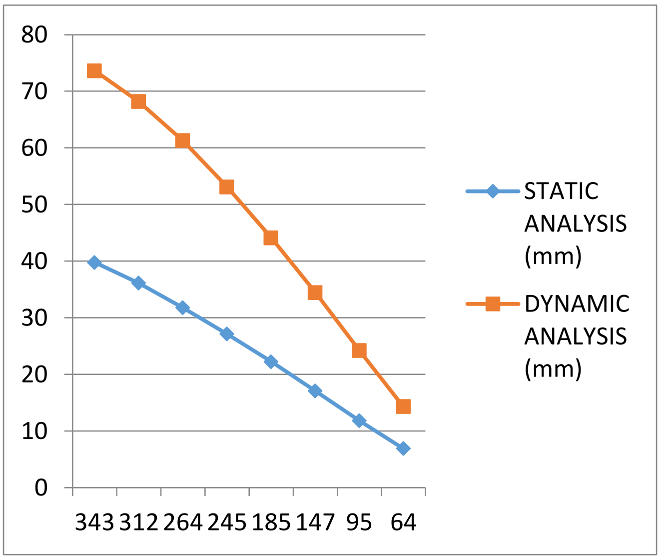


Figure 9. Nodal-displacement of models

Table 7. Comparison of Nodal-Displacement of members

NODE NUMBER	STATIC ANALYSIS (mm)	DYNAMIC ANALYSIS (mm)
343	39.78	73.64
312	36.12	68.17
264	31.78	61.27
245	27.14	53.12
185	22.25	44.11
147	17.09	34.45
95	11.82	24.21
64	6.91	14.3



Graph 7.Comparison of Nodal-Displacement of members.

5. CONCLUSION

The results as obtained using STAAD PRO series 5 software and the Static and Dynamic Analysis are compared for different categories

- From the test results we can see that the values for Moments are 35 to 45% higher for Dynamic analysis than the values obtained for Static analysis from table 3.
- From the test results we can see that there is not much difference in the values of Axial Forces as obtained by Static and Dynamic Analysis of the RCC Structure from table 5.
- From the test results we can see that the values of Torsion of columns are negative for Static analysis and for Dynamic analysis the values of torsion are positive from table 6.
- From the test results we can see that the values for Displacements of columns are 40 to 45% higher for Dynamic analysis than the values obtained for Static analysis from table 1.
- From the test results we can see that the values of Nodal Displacements in Z direction are 50% higher for Dynamic analysis than the values obtained for Static analysis table 7.
- From the test results Compressive and tensile stresses in the studied beams were approximately equal.
- Nodal Displacements and Bending moments in beams and columns due to seismic excitation showed much larger values compared to that due to static loads.

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