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A Comparative Study of Stress Parameters Obtained by STAAD-Pro and ETAB

Ms. Monal P Tayade.[1], M. R. Vyawhare[2]
[1]PG Student Structural Engineering, B.N. College of Engineering, Pusad, Yavatmal (445215) Amravati university , Maharashtra, India
[2]Associate Professor, Department of Civil Engineering, B.N. College of Engineering, Pusad, Yavatmal (445215) Amravati University, Maharashtra, India

Abstract:-Staad-PRO and ETAB are the most popular software's for analysis of multistoried buildings. It has been observed that results obtained by both the software's are not same in most of the cases. This study is an attempt to investigate and compare the results for building with different stories. A regular plan building with G+5, G+10 and G+15 stories have been considered in this study. It has been observed that buildings with less no of stories when analyzed by STAAD-PRO give conservative results and buildings with high number of stories when analyzed by ETAB produced conservative results.
keywords :-staad-pro, etab, Response spectrum analysis, multistoried building

I. INTRODUCTION

Seismic Analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent.

The action applied to a structure by an earthquake is a ground movement with horizontal and vertical components. The horizontal movement is the most specific feature of earthquake action because of its strength and because structures are generally better designed to resist gravity than horizontal forces. The vertical component of the earthquake is usually about 50% of the horizontal component, except in the vicinity of the epicenter where it can be of the same order.

Steel structures are good at resisting earthquakes because of the property of ductility. Experience shows that steel structures subjected to earthquakes behave well. Global failures and huge numbers of casualties are mostly associated with structures made from other materials. This may be explained by some of the specific features of steel structures. There are two means by which the earthquake may be resisted

Option 1 structures made of sufficiently large sections that they are subject to only elastic stresses

Option 2 structures made of smaller sections, designed to form numerous plastic zones

Our project involves comparative analysis and of multi-storied using a very popular designing software STAAD Pro and E-TAB.

STAAD-Pro features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD-Pro is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

STAAD-Pro consists of the following

The STAAD-Pro Graphical User Interface: It is used to generate the model, which can then be analyzed using the STAAD engine. After analysis and design is completed, the GUI can also be used to view the results graphically. he STAAD analysis and design engine: It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete, Timber and Aluminum design..

E-TAB consists of the following

ETABS is the solution, whether you are designing a simple 2D frame or performing a dynamic analysis of a complex high-rise that utilizes non-linear dampers for inter-story drift control.

II. LITERATURE REVIEW

Abu Lego (2010)Site Response Spectra was used to study the response of buildings due to earthquake loading. . According to the

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Indian standard for Earthquake resistant design (IS: 1893), the seismic force or base shear depends on the zone factor (Z) and the average response acceleration coefficient (Sa/g) of the soil types at thirty meter depth with suitable modification depending upon the depth of foundation. In the present study an attempt has been made to generate response spectra using site specific soil parameters for some sites in Arunachal Pradesh and Meghalay in seismic zone V and the generated response spectra is used to analyze some structures using the design software STAAD Pro. [2]

Saptadip Sarkar (2010) by using STAAD Pro he studied the design of earthquake resistant RC buildings on sloping ground by changing the number of bays and floor heights. From the analysis results various graphs were drawn between the maximum axial force, maximum shear force, maximum bending moment, maximum tensile force and maximum compressive stress being developed for the frames on plane ground and sloping ground. From the studies the "Short column effects" were carefully studied. It was concluded that the software STAAD is a good tool in studying static linear behavior of the buildings.

Durgesh C. Rai (2005) He has developed guidelines for seismic evaluation and strengthening of buildings. The document was developed as part of project "Review of Building Codes and Preparation of Commentary and Handbooks" awarded to Indian Institute of Technology Kanpur by the Gujarat State Disaster Management Authority (GSDMA), Gandhinagar through World Bank finances. This document is particularly concerned with the seismic evaluation and strengthening of existing buildings and it is intended to be used as a guide.

SiamakSattar and Abbie B. Lielquantified the effect of the presence and configuration of masonry infill walls on seismic collapse risk. Infill panels are modeled by two nonlinear strut elements, which have compressive strength only. Nonlinear models of the frame-wall system were subjected to incremental dynamic analysis in order to assess seismic performance. There was an increase observed in initial strength, stiffness, and energy dissipation of the infilled frame, when compared to the bare frame, even after the wall's brittle failure modes. Dynamic analysis results indicated that fully-infilled frame had the lowest collapse risk and the bare frames were found to be the most vulnerable to earthquake-induced collapse.

III. LOADS CONSIDERED

A. Dead loads

B. Imposed load

C. Seismic load

D. Design lateral force

The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels. The overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action.

Design Seismic Base Shear

The total design lateral force or design seismic base shear (Vb) along any principal direction shall be determined by the following expression:

Vb = Ah W Where,

Ah = horizontal acceleration spectrum

W = seismic weight of all the floors

1) *Fundamental Natural Period:* The approximate fundamental natural period of vibration (T,), in seconds, of a moment-resisting frame building without brick in the panels may be estimated by the empirical expression:

$Ta=0.075\ h^{0.75}$ for RC frame building

$Ta=0.085\ h^{0.75}$ for steel frame building

Where,

h = Height of building, in m.

The approximate fundamental natural period of vibration (T,), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:

$T=.09H/\sqrt{D}$

Where,

h= Height of building

d= Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

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2) *Distribution of Design Force:* Vertical Distribution of Base Shear to Different Floor Level

The design base shear (V) shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

Where,

Qi=Design lateral force at floor

Wi=Seismic weight of floor

hi=Height of floor measured from base, and

n=Number of storeys in the building is the number of levels at which the masses are located.

3) *Load combination:* IN designing for seismic forces the following two combinations can be considerd

1. 0.9DL+1.5EQ1
2. 0.9DL+1.5EQ2

Where, EQ1 is X Direction in Staad-pro and Etab

EQ2 is Z Direction in Staad-pro and Y Direction in Etab

IV. SEISMIC ANALYSIS

A. Seismic analysis

Seismic analysisis a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design.

Analysis methods are

Equivalent static analysis

Response spectrum analysis

Linear dynamic analysis

Nonlinear static analysis

Nonlinear dynamic analysis

B. Response spectrum analysis

This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except for very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building.. Combination methods include the following

Absolute - peak values re added together.

Square root of the sum of the squares (SRSS)

Complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes.

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum.

In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis.

C. Objective and Scope

The present project deals with comparative study of seismic analysis of RC building by Response spectrum method using Structural

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Analysis (STAAD Pro.) and E-TAB software and considering Indian Standard code IS1893(2002).

D. Methodology

Design horizontal seismic coefficient (Ah) for a structure shall be determined by the following expression:

$$Ah = \frac{z}{2} x \frac{I}{R} x \frac{Sa}{g}$$

Where,

Z=Zone factor=0.16(for 3rd zone)

I=Importance factor=1.5(for important building)

R=Response reduction factor=5

Sa/g=Average response acceleration coefficient

V. MODELING

A. Introduction

The present project deals with comparative study of seismic analysis of RC building by Response spectrum method using Structural Analysis and Design (STAAD Pro.) and E-TAB software and considering Indian Standard code 1893(2002).

Physical parameters of buildings

Particulars	Model-01	Model-02	Model-03
Plan Dimension	25mx20m	25mx20m	25mx20m
No Of Story	5	10	15
Height Of Each Story	3	3	3
Total Height	17	32	47
Depth Of Footing	2m	2m	2m
Size Of Beam	230mmx600mm	230mmx600mm	230mmx600mm
Size Of Column	300mmx600mm	300mmx600mm	300mmx600mm
Slab Thickness	150	150	150
Dead Load	1kn/M2	1kn/M2	1kn/M2
Live Load	2kn/M2	2kn/M2	2kn/M2
Seismic Zone	Iii	Iii	Iii
Soil Condition	Medium	Medium	Medium
Response Reduction Factor	5	5	5
Importance Factor	1	1	1
Zone Factor	0.16	0.16	0.16
Grade Of Concrete	M30	M30	M30
Grade Of Reinforcing Steel	Fe500	Fe500	Fe500
Density Of Concrete	25 Kn/M3	25 Kn/M3	25 Kn/M3
Density Of Brick Masonry	20 Kn/M3	20 Kn/M3	20 Kn/M3
Damping Ratio	5%	5%	5%

B. Working With Staad-Pro

1) Steps of analysis of rc building using staad. Pro

Step - 1 : Creation of nodal points.

Based on the column positioning of plan we entered the node points into the STAAD file

Step - 2 : Representation of beams and columns.

By using add beam command we had drawn the beams and columns between the corresponding node points.

Step - 3: 3D view of structure.

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Here we have used the Transitional repeat command in Y direction to get the 3D view of structure.

Step - 4: Supports and property assigning.

After the creation of structure the supports at the base of structure are specified as fixed. Also the materials were specified and cross section of beams and columns members was assigned.

Step - 5: 3D rendering view.

After assigning the property the 3d rendering view of the structure can be shown

Step - 6: Assigning seismic loads.

In order to assign Seismic loads firstly we have defined the seismic loads according to the code IS 1893:2002 with proper floor weights. Loads are added in load case details in +X,-X, +Z,-Z directions with specified seismic factor.

Step - 8: Assigning dead loads.

Dead loads are calculated as per IS 875 PART 1 for external walls, internal walls, parapet wall
Including self-weight of structure.

Step - 10: Assigning live loads.

Live loads are assigned for every floor as 2 kN/m2 based on IS 875 PART 2.

Step - 11: Adding of load combinations.

After assigning all the loads, the load combinations are given with suitable factor of safety as per **IS 875**

Step - 11: Analysis.

After the completion of all the above steps we have performed the analysis and checked for errors.

2) Analysis Of Rc Framed Building Using Staad.Pro

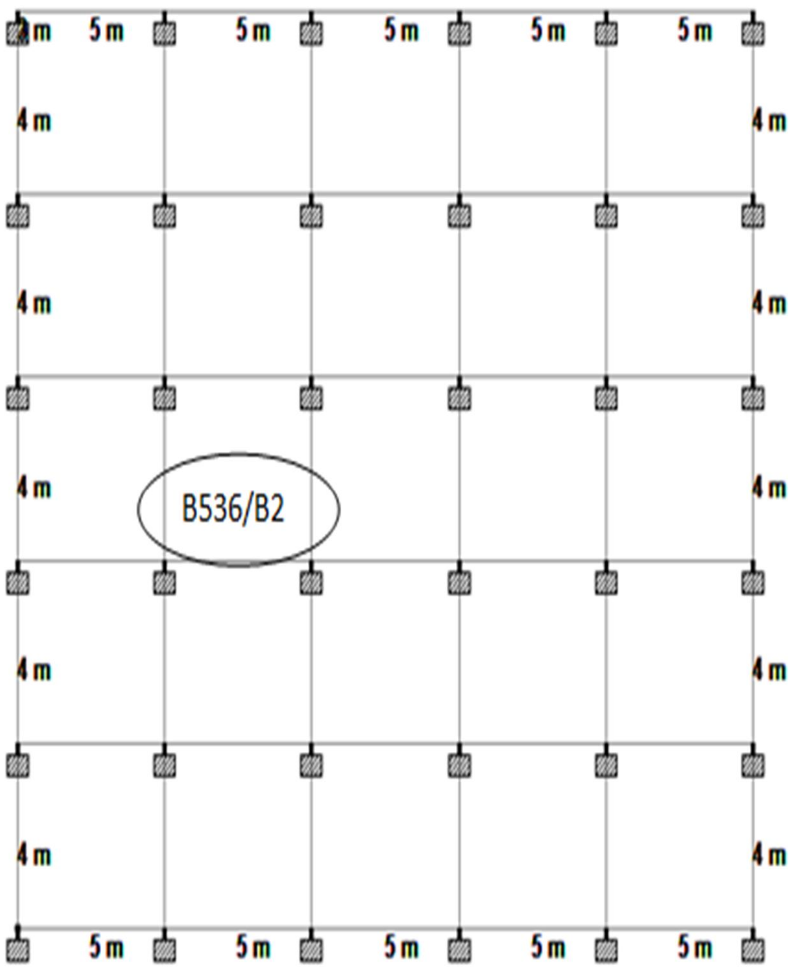

Fig. 5.1 : Plan for Model-01, 02 and 03

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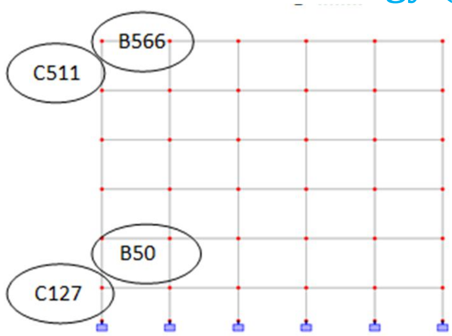

Fig. 5.2 : Elevation for Model-01 Along Z-Direction

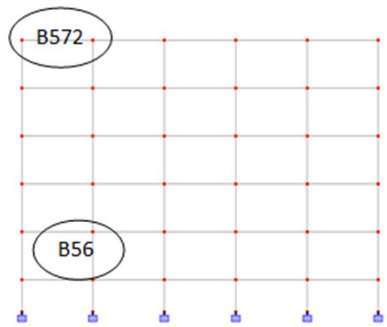

Fig. 5.3 : Elevation for Model-01 Along X-Direction

C. Working with etab

1) Steps Of Analysis Using Etab

Step - 1 : Step by Step procedure for ETABS Analysis

The procedure carried out for Modelling and analyzing the structure involves the following flow chart.

Step - 2 : Creation of Grid points & Generation of structure

After getting opened with ETABS we select a new model and a window appears where we had entered the grid dimensions and story dimensions of our building. Here itself we had generated our 3D structure by specifying the building details in the following window.

Step - 3: Defining property

Here we had first defined the material property by selecting define menu □□material properties. We add new material for our structural components (beams, columns, slabs) by giving the specified details in defining. After that we define section size by selecting frame sections as shown below & added the required section for beams, columns etc.

Step - 4: Assigning Property

After defining the property we draw the structural components using command menu □Draw line for beam and create columns in region for columns by which property assigning is completed for beams and columns.

Step - 5: Assigning of Supports

By keeping the selection at the base of the structure and selecting the nodes at the bottom of columns we assigned supports by going to assign menu □□joint\frame □□Restraints (supports) □fixed.

Step - 6: Defining of loads

In STAAD program we define only seismic and wind loads where as in ETABS all the load considerations are first defined and then assigned. The loads in ETABS are defined as using static loadcases command

Step - 7: Assigning of Dead loads

After defining all the loads dead loads are assigned for external walls, internal walls.

Step - 8: Assigning of Live loads. Live loads are assigned for the entire structure including floor finishing.

Step - 9: Assigning of Seismic loads

Seismic loads are defined and assigned as per IS 1893: 2002 by giving zone, soil type, and response reduction factor in X and Y directions

Step - 10: Assigning of load combinations

Load combinations are given as mentioned in STAAD. Pro based on IS 875 1987 PART 5 using load combinations command in define menu

Step - 11: Analysis

After the completion of all the above steps we have performed the analysis and checked for errors.

2) Analysis of RCC Framed Building Using E-TAB

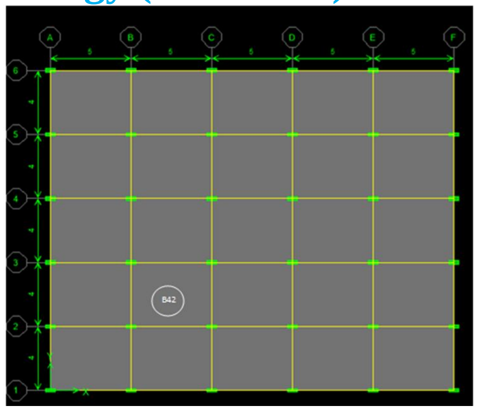

Fig 5.4: Plan for Model-01, 02 and 03.

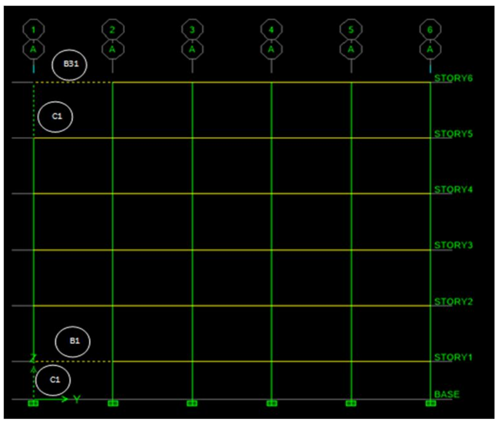

Fig. 5.5 : Elevation Along Y for Model-01

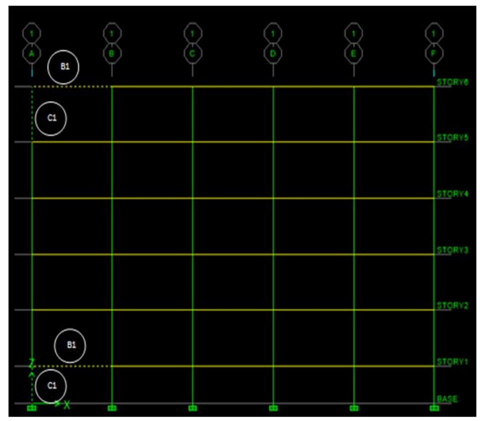

Fig. 5.6 : Elevation Along X for Model-01

VI. RESULTS AND DISCUSSIONS

Some of the sample analysis results have been shown below for different models like model-01, model-02 and model-03.

A. Deflected Shape of Structure

Deflected shape for model-01 as show below

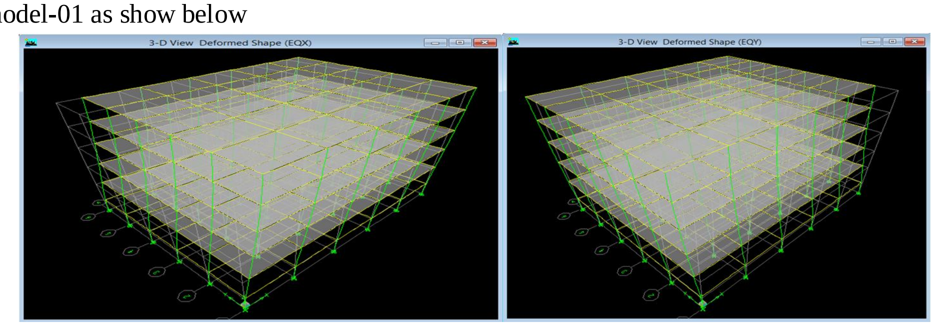

Fig. 6.1 : Deflected Shape Along x and y Direction for Model-01

B. Bending Moments and Shear Force for Sample Beam and Columns

Table 6.1 : Bending Moments and Shear Force for Sample Beam and Columns For Combination 1 (0.9DL+1.5EQ1) Model 1

Storey	Combination	Sample Beam and Column	B.M.(kN-M)		S.F.(kN)	
			STAAD	ETAB	STAAD	ETAB
Top Storey	Combination1 (0.9DL+1.5EQ1)	B566/B1	21.7	21.21	36	36.74
		B 572/B31	47.00	43.45	49.7	48.15
		B536/B42	25.2	23.112	40.3	48.55
		C511/C1	23.7	22.18	14.6	15.64

	Combination2 (0.9DL+1.5EQ2)	B566/B1	24.8	26.39	36.7	40.82
		B 572/B31	37.4	35.31	45.5	44.51
		B536/B42	35.5	33.82	42.6	44.38
		C511/C1	34.9	25.97	19.3	20.44
Bottom Storey	Combination1 (0.9DL+1.5EQ1)	B50/B1	17.3	18.22	26.9	28.06
		B 56/B31	52.8	54.03	43.3	44.05
		B20/B42	42.8	43.19	31.7	30.43
		C127/C1	14.7	14.30	5.2	5.83
	Combination2 (0.9DL+1.5EQ2)	B50/B1	51.4	51.25	42.1	47.59
		B 56/B31	25.9	26.9	32.2	32.36
		B20/B42	42.8	45.41	31.7	29.74
		C127/C1	18.3	13.63	10.9	10.27

As shown in above table it has been observed that the results of bending moment are conservative in STAAD-pro analysis and the percentage increase range is 2.25% to 0.29%

While the results of shear force are conservative in ETAB analysis and the percentage increase range is 2.01% to 11.53%.

Table 6.2 : Bending Moments and Shear Force for Sample Beam and Columns For Model 2

Storey	Combination	Sample Beam and Column	B.M.(kN-M)		S.F.(kN)	
			STAAD	ETAB	STAAD	ETAB
Top Storey	Combination1 (0.9DL+1.5EQ1)	B1046/B1	22.7	21.23	34.15	36
		B 1052/B31	23.04	22.9	25.34	34.6
		B1031/B42	48.27	40.5	33.7	36.9
		C991/C1	35.44	39.2	26.13	23.1
	Combination2 (0.9DL+1.5EQ2)	B1046/B1	26.6	25.7	34.09	37.1
		B 1052/B31	30	32.3	40.22	38.4
		B1031/B42	40.77	31.9	44.49	35.7
		C991/C1	35.63	44.6	27.85	24.9
Bottom Storey	Combination1 (0.9DL+1.5EQ1)	B50/B1	17.43	17	27.67	26.7
		B 56/B31	17.67	17.5	25.95	25.9
		B20/B42	48.69	49.3	32.65	32.9
		C127/C1	33.3	37	12.10	12.2
	Combination2 (0.9DL+1.5EQ2)	B50/B1	57.79	61	51.05	46.4
		B 56/B31	51.66	51.7	42.27	43.2
		B20/B42	16.6	16.5	19.86	19.7
		C127/C1	8.41	11.8	8.61	8.73

As shown in above table it has been observed that the results of bending moment are conservative in STAAD-Pro analysis and the percentage increase range is 6.60 % to 5.26%

While the results of shear force are conservative in ETAB analysis and the percentage increase range is 5.13% to 9.10%.

Table 6.3 : Bending Moments and Shear Force for Sample Beam and Columns For Model 3

Storey	Combination	Sample Beam and Column	B.M.(kN-M)		S.F.(kN)	
			STAAD	ETAB	STAAD	ETAB
Top Storey	Combination1 (0.9DL+1.5EQ1)	B1526/B1	25.4	26.84	38.3	38.68
		B 1532/B31	20.8	20.56	35	34.26
		B1511/B42	48	44.43	48.3	46.35
		C1471/C1	50.3	44.92	29	33.78
	Combination2 (0.9DL+1.5EQ2)	B1526/B1	26.7	25.58	37.8	39.41
		B 1532/B31	31.4	25.52	39	38.24
		B1511/B42	43	43.51	46	45.76
		C1471/C1	52.5	42.43	29	33.56
Bottom	Combination1	B50/B1	16.5	16.55	26.4	26.5

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Storey	(0.9DL+1.5EQ1)	B 56/B31	18.3	17.67	26.3	26.01
		B20/B42	48.1	52.38	20.1	30.09
		C127/C1	38.1	43.22	13	14.82
	Combination2 (0.9DL+1.5EQ2)	B50/B1	59.4	60.47	45.7	51.16
		B 56/B31	51.2	57.78	42.9	45.36
		B20/B42	15.22	16.97	13.38	19.95
		C127/C1	11.8	8.89	8.66	9.03

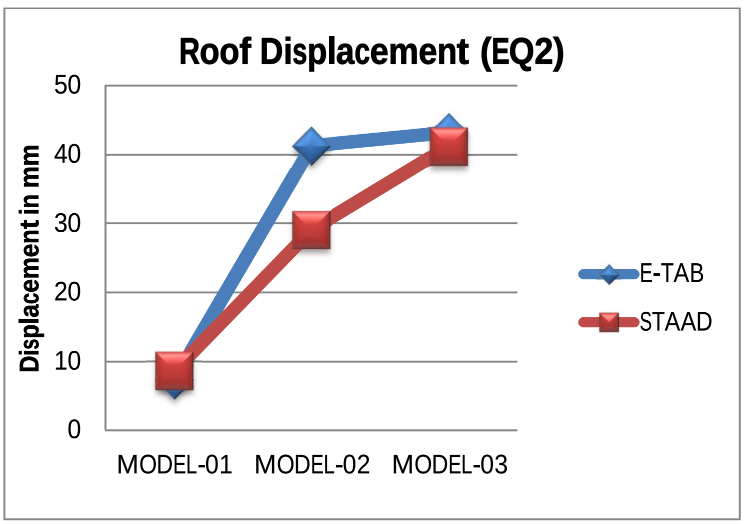
As shown in above table it has been observed that the results of bending moment are conservative in STAAD-Pro analysis and the percentage increase range is 5.36 % to 1.76%

While the results of shear force are conservative in ETAB analysis and the percentage increase range is 0.98% to 10.67%.

C. Roof Displacement Along EQ1 & EQ2 for Model 1, Model 02 and Model-03

Table 4.4 :Roof Displacement Along EQ1 & EQ2

Models	Displacement in mm			
	EQ1		EQ2	
	STAAD	ETAB	STAAD	ETAB
MODEL-01	4.355	3.9	7.477	11.1
MODEL-02	11.087	9.7	18.591	26.3
MODEL-03	16.547	15	28.943	32.9



Graph 4.1 :Roof Displacement Along EQ2

As shown in above table it has been observed that the results of roof displacement are conservative in STAAD-Pro analysis along EQ1 and along EQ2 the results are conservative in ETAB analysis.

VII. CONCLUSION

A. Bending Moment and Shear Force

The values of shear force and bending moment obtained by STAAD-Pro analysis are more as compare to ETAB analysis and difference is not so much.

As the storey level increases ETAB analysis gives conservative results.

B. Roof Displacement

The values of roof displacement are increases with increase in storey height. The values of roof displacement obtained by ETAB analysis are more compared to STAAD. Pro analysis but the difference is not so much.

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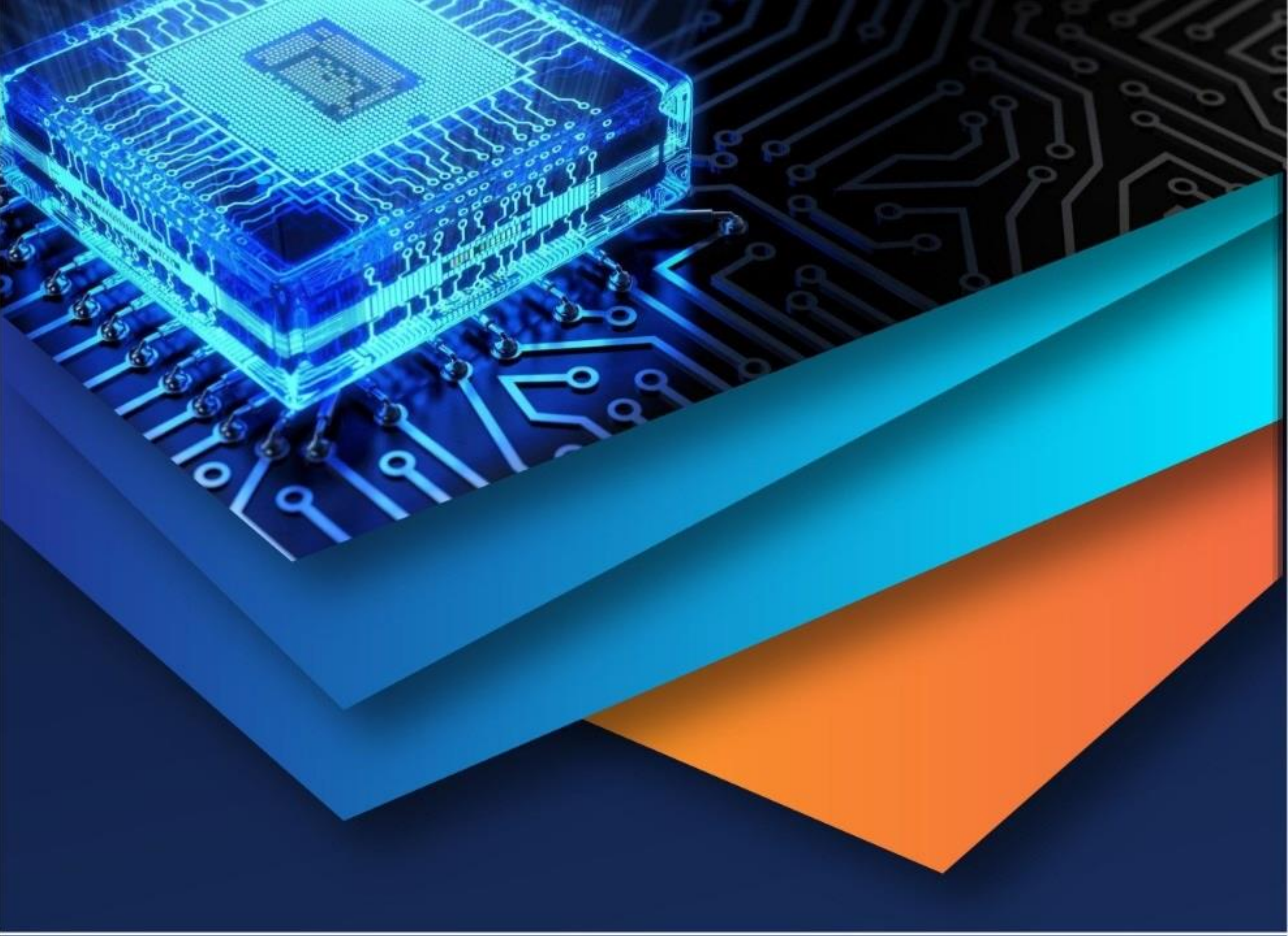

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