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STATIC LINEAR AND NON-LINEAR PERFORMANCE ANALYSIS OF EXISTING G+3 RC FRAME STRUCTURE

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Abstract- The paper deals with the performance of the RC frame structure to calculate performance capacity of the RC frame. The existing octagonal shaped RC structural frame is modelled in STAAD Pro V8i software by considering dead load using IS 875 : 1964(Part-1), live load using IS 875:1964 (Part-2) and earthquake load using IS 1398:2002. The various combinations of loads were created using IS-456 and IS-1398. The frame performance is evaluated on the parameters like Bending moment, Shear force, axial force and storey drift for static elastic and inelastic conditions using Staad pro V8i and SAP 2000 respectively. The building is constructed in Bhopal city and hence as per the IS 1893:2002 seismic zone II and soft soil is considered for the performance analysis. The performance comparison of static elastic (Linear) and inelastic static performance (Non Linear) is made in this research paper.

1. INTRODUCTION

It has been discussed in the various research papers that the strength of the structural construction material is always under-utilized. Designers often consider the material strength up-to its elastic limit and as a result the exact performance is not evaluated by the designers. Once the structural model has been selected, it is possible to perform analysis to determine the seismically induced force in the structure. There are different methods of analysis which provide different degrees of accuracy. The analysis process can be categorized on the basis of 3 factors:-The type of the externally applied load, the behaviour of structure/ structural material, and the type of structural mode selected.

Based on the type of external action and behaviour of structure, the analysis can be further classified as: Linear static analysis, Linear dynamic analysis, Non-linear static analysis or non-linear dynamic analysis.

Linear static analysis or equivalent static analysis can only be used for regular structure with limited height. Linear dynamic analysis can be performed in two ways: Either by mode superposition method or response spectrum method and elastic time history method. This analysis will produce the effect of higher mode of vibration and the actual distribution of forces in the elastic range in a better way. They represent an improvement over linear static analysis. The significant difference between linear static and dynamic analysis is the level of force and their distribution along the height of the structure. Non-linear static analysis is an improvement over the linear static and dynamic analysis in the sense that it allows the inelastic behaviour of the structure. The method still assume a set of static incremental lateral load over the height of structure. The method is relatively simple to implement, and provides information on the strength, deformation and ductility of the structure and the distribution of demands. This permits to identify the critical members likely to reach limit state during the earthquake, for which attention should be given during the design and detailing process. But this method contains many limited assumptions, which neglect the variation of loading patterns, the influence of higher modes, and the effect of resonance.

Main feature of seismic method of analysis (Riddell and Llera, 1996) based on Indian standard 1893 (Part1):2002 are described as follows:-

1.1 Equivalent Lateral Force Method

Seismic analysis of most of the structures is still carried out on thebasis of lateral (horizontal) force assumed to be equivalent to the actual (dynamic) loading. The base shear which is the total horizontal force on the structure is calculated on the basis of structural mass and fundamental period of vibration and corresponding mode shear. The base shear is distributed along the height of the structure in terms of lateral forces according to code formula. This method is usually conservation for low to medium height buildings with a regular confirmation.

1.2 Pushover Analysis Method

The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earthquake-induced forces. A plot of total base shear versus top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. On a building frame, load/displacement is applied incrementally, the formation of plastic hinges, stiffness degradation, and plastic rotation is monitored, and lateral inelastic force versus displacement response for the complete structure is analytically completed. This type of analysis enables weakness in the structure to be identified. The decision to retrofit can be taken on the basis of such studies.

2. METHODOLOGY

2.1Problem Statement

The octagonal shaped building is modelled on STAAD Pro. The geometrical specifications of the building are as follows:

Table-2.1 The Geometrical Specifications of the Building

S. No.	Description		Values
1.	No. of storey	3	
2.	Storey height	3.65 m	
3.	Thickness of brick wall	200mm	
4.	Height of building	14.6 m	
5.	Beams Property	B_1	300x600 mm
		B_2	400X600 mm
		B_3	200x650 mm
		B_4	200x600 mm
		B_5	200x400 mm
		B_6	200x650 mm
		B_7	200x500 mm
		B_8	200x130 mm
6.	Thickness of slabs	S_1	130 mm
		S_2	150 mm
7.	Columns	C_1	400x600 mm
		C_2	400x500 mm
		C_3	300x600 mm
		C_4	300x500 mm
		C_5	400φ mm

Table-2.2 Material Properties

S. No.	Material property	Values
1.	Grade of concrete	M-20
2.	Young's modulus of concrete, E_c	2.17x104 N/mm^2
3.	Poisson's ratio	0.17
4.	Grade of steel	Fe-415

2.2 Steps Followed

- First of all the whole building is modeled in STAAD-Pro i.e. the various properties along with dimensions and materials of all the beams, columns and slabs is created and assigned respectively.
- The dead load as well as live load (as per IS: 875 (part-2) 1987 is applied on the whole structure.
- Analysis is done for the applied loads and results generated accordingly.
- Seismic loads as per IS: 1893(part-1)-2002 are calculated and applied respectively.
- Analysis is done for the applied seismic loads and results generated accordingly.
- The various parameters like shear force, bending moment, axial forces obtained in step 3 and 5 are compared through graphs in MS Excel.
- The whole structure is imported in SAP 2000, pushover analysis is done and graphs generated accordingly.

2.3 Flowchart

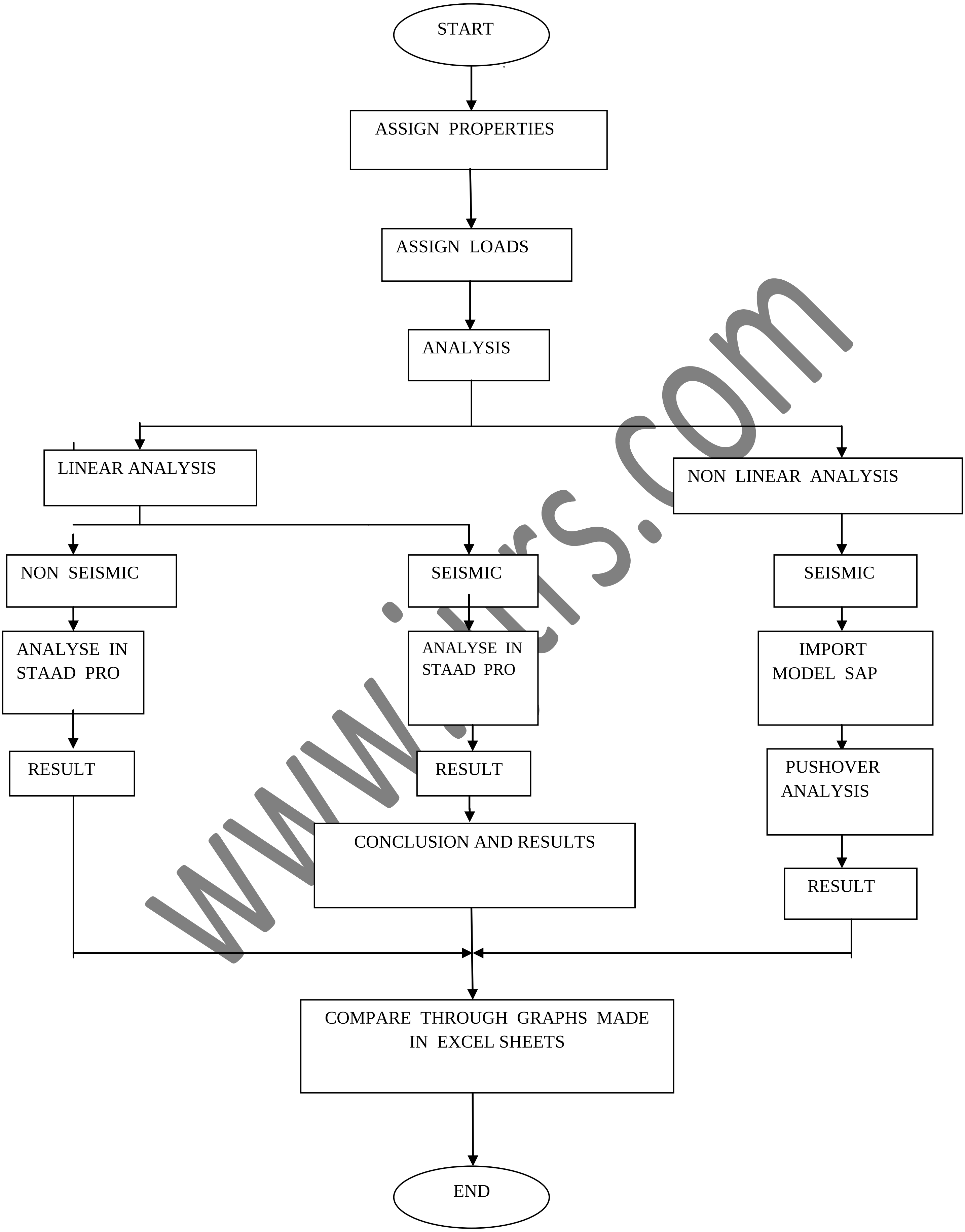

Fig. 2.1 Flowchart

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3. RESULTS

3.1 Graphs Comparing the Results of Non-Seismic and Seismic Analysis Done on STAAD Pro

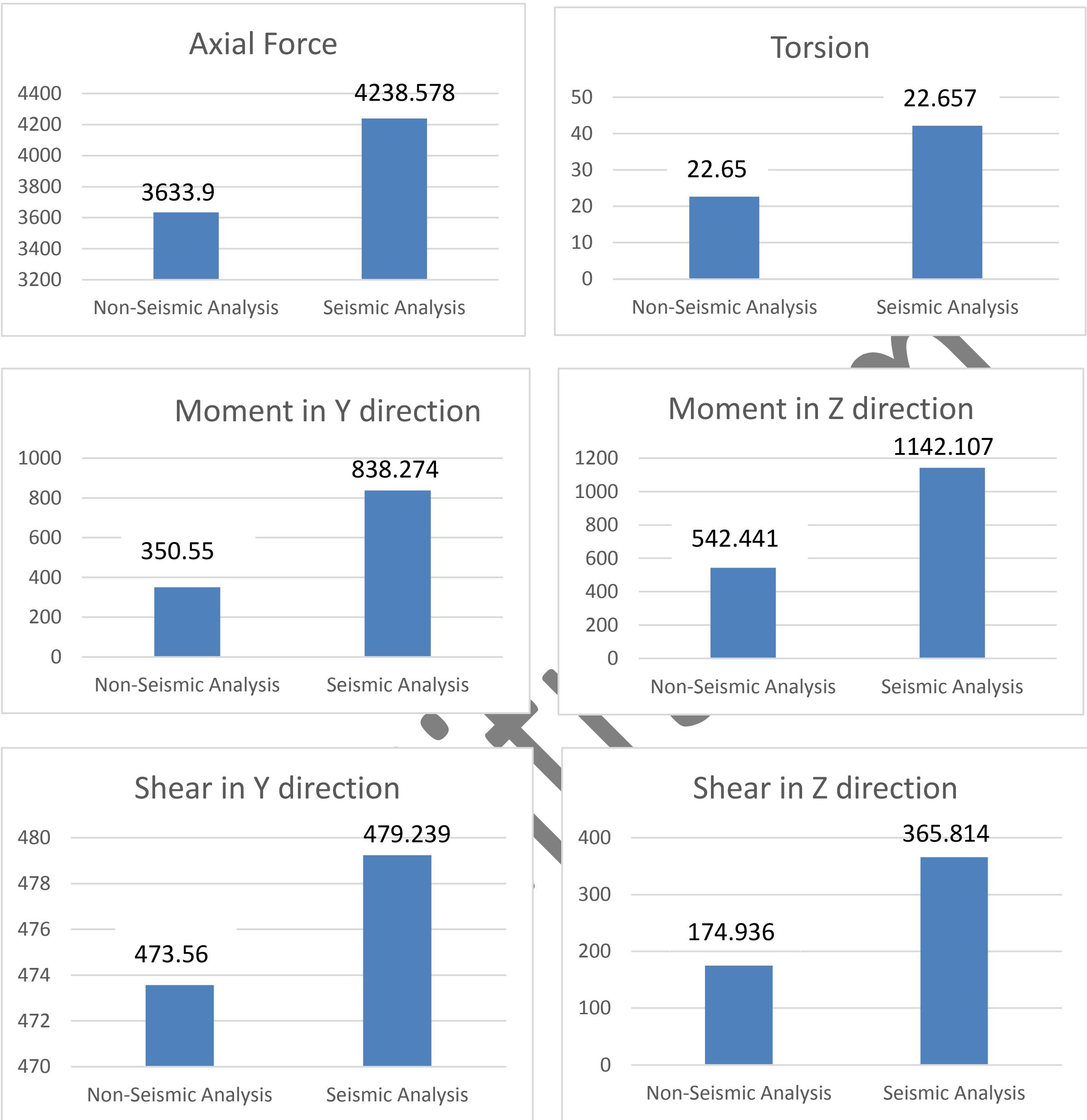
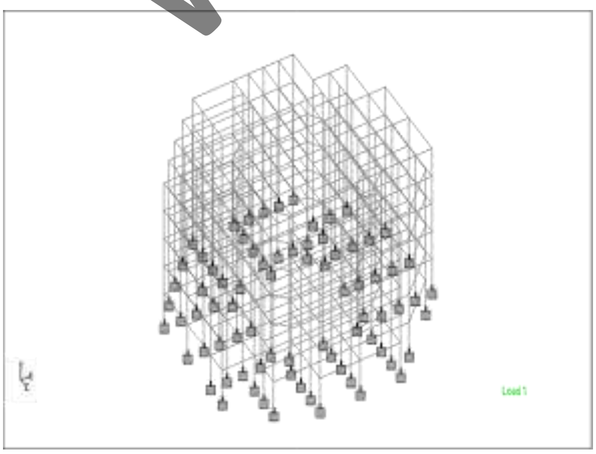
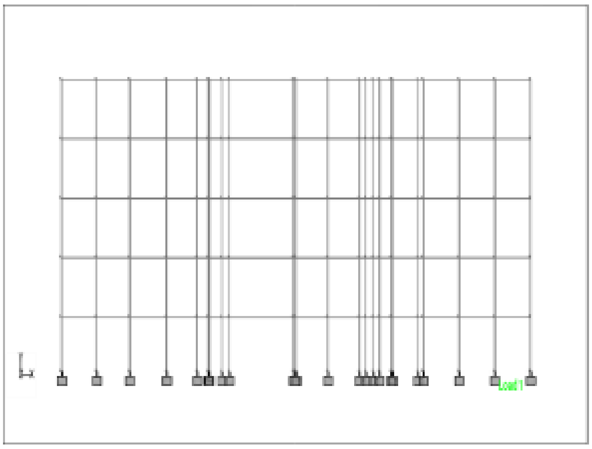


Fig. 3.1 Results of Non-Seismic and Seismic Analysis Done on STAAD Pro

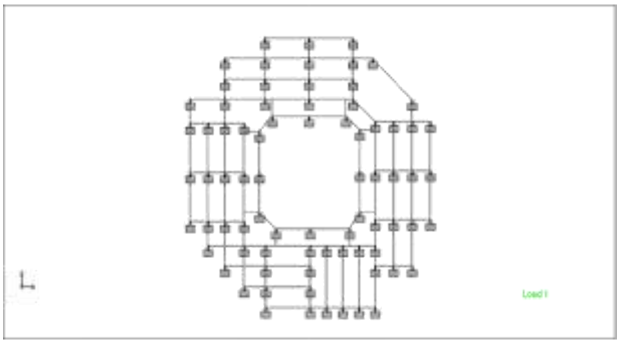
3.2 Report of Non-Seismic and Seismic Analysis Generated from STAAD-Pro



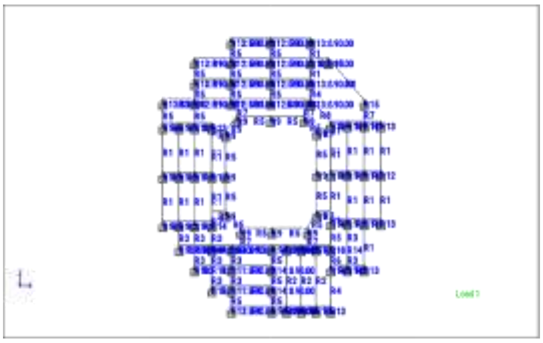
Isometric view

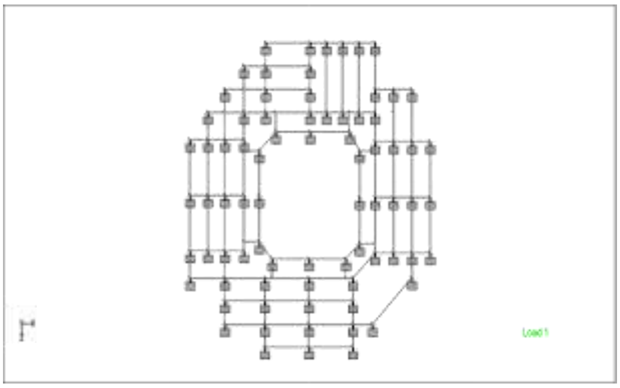


View from +Z axis

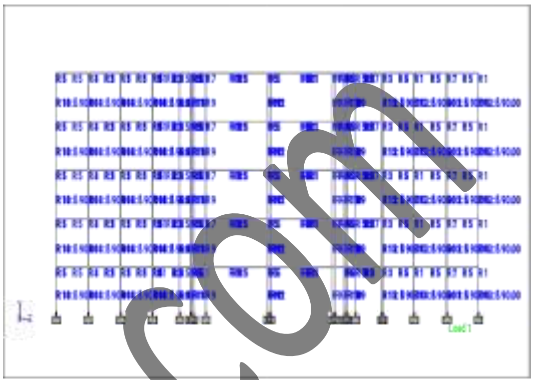


View from -Y axis





View from +Y axis



Properties assigned

Fig. 3.2 Results of Non-Seismic and Seismic Analysis Generated from STAAD-Pro

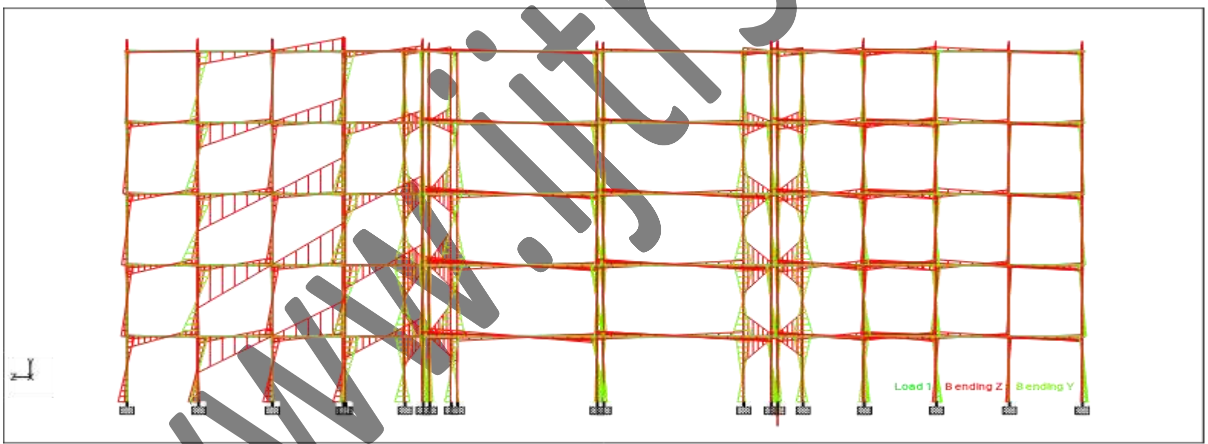


Fig. 3.3 Maximum Bending Moment Diagram

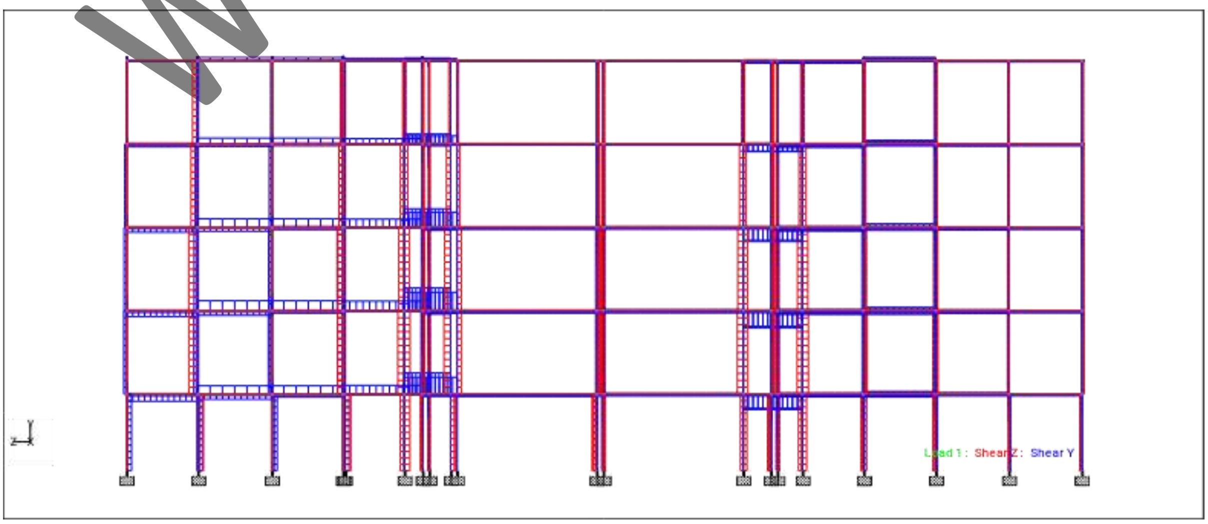


Fig. 3.4 Maximum Shear Force Diagram

3.3 Graphs of Pushover Analysis Generated from SAP 2000

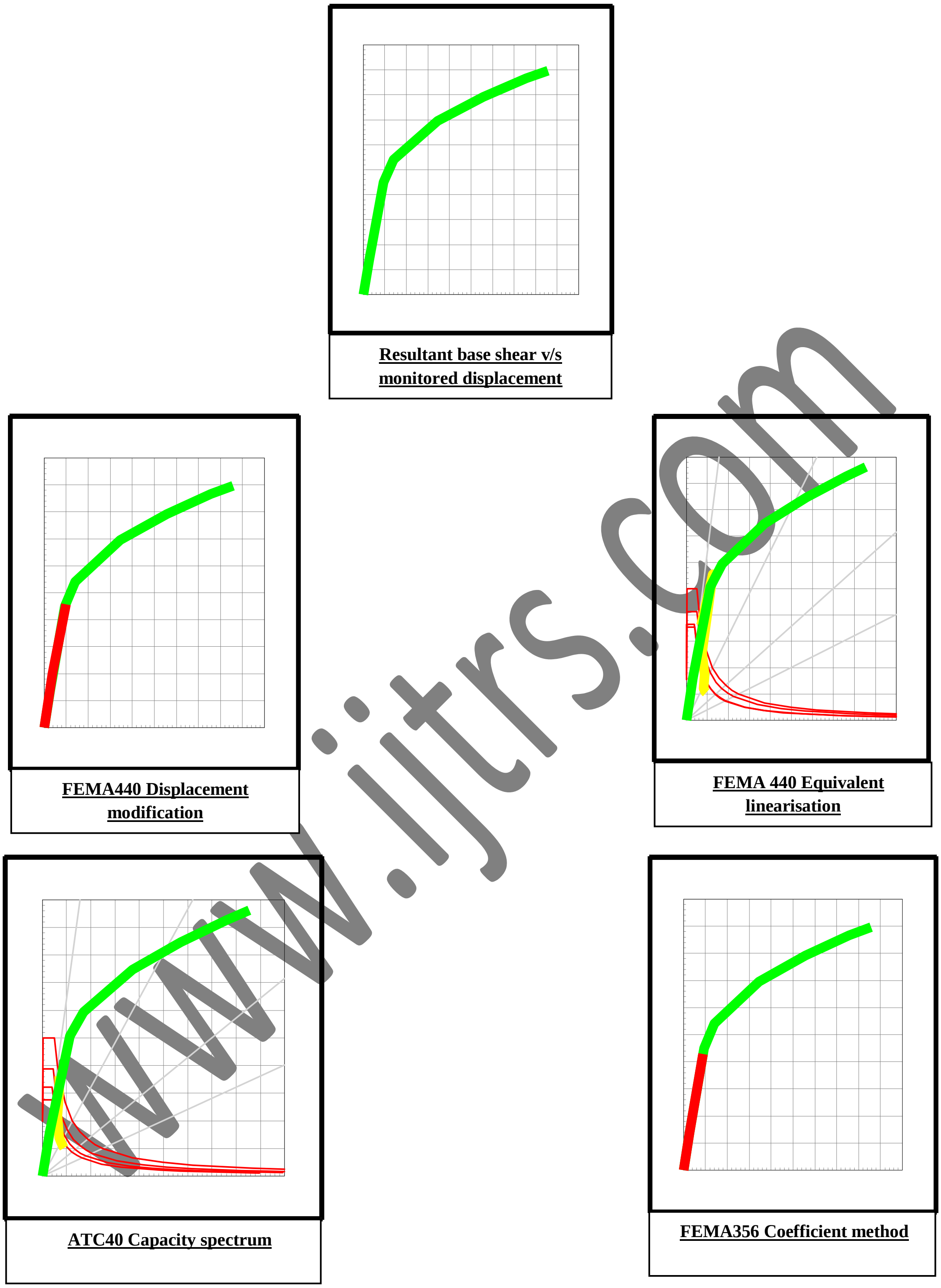


Fig. 3.5 Graphs of Pushover Analysis Generated from SAP 2000

CONCLUSION

- The percentage difference observed in axial force between non-seismic and seismic structure was 83.33%.
- The percentage difference observed in moment in y-direction between non-seismic and seismic structure was 83.33%.
- The percentage difference observed in moment in z-direction between non-seismic and seismic structure was 70.58%.

- The percentage difference observed in shear in y-direction between non-seismic and seismic structure was 77.5%.
- The percentage difference observed in shear in z-direction between non-seismic and seismic structure was 77.71%.
- The percentage difference observed in torsion between non-seismic and seismic structure was 61.53%.

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