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"P-DELTA ANALYSIS AND COMPARISON OF STEEL STRUCTURE FOR DIFFERENT BRACING SYSTEM"

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ABSTRACT: During analysis of a building structure, normally after complete modelling full loads are applied on entire building frame and linear static analysis is done. But in actual practice the dead load due to each structural element is applied in various construction stages of each story of the building structure due to the material non-linearity behaviour. The loads considered in linear static analysis change in transitory situation and hence the outcomes will not be suitable and satisfactory.

Therefore the building structure should be analysed at every stage of construction taking into account the load variations. A tall building is defined as one in which the structural system is adopted such that to make it sufficiently economical and also to resist lateral forces due to wind or earthquakes within the prescribed criteria for strength, drift and comfort of the occupants. ***Keywords-*** *Steel structure, Design, Modelling, Review, P-delta*

I. INTRODUCTION

High rise design comes into play when a structure's slender nature makes it sensitive to lateral loads. In the design of multi-storey structures, allowance should be made for "p-delta" effects. The p-delta effects are dependent on the applied load and material characteristics, in addition to parameters such as height and stiffness of a building. The degree of its asymmetry may also be of importance. P-delta effects become more significant when the columns are slender.

As per the code India is divided into several seismic zones, i.e. Zone II, III, IV & V as shown in fig.1.1 Magnitude and seismic zone factor of each zone are given in table 1.1 and 1.2. The effect of earthquake on building as depicted in fig 1.2.

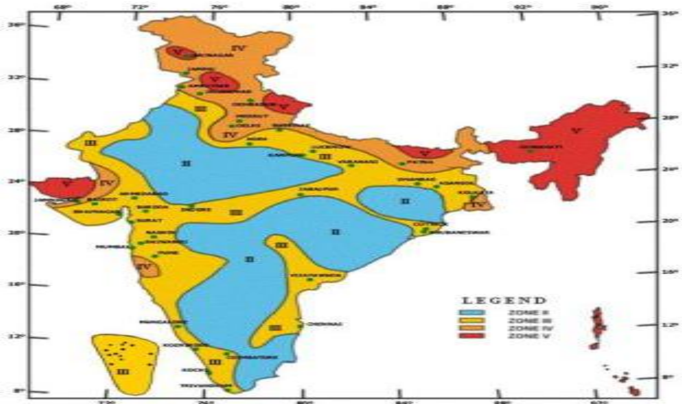

Fig.1.1 Eq zones of India

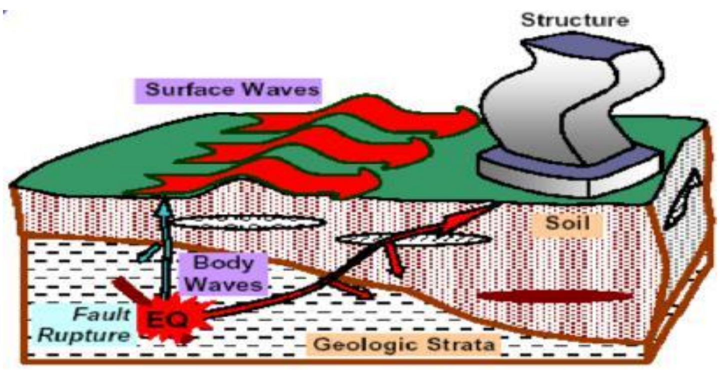

fig.1.2 Eq effect on building

1.1 OBJECTIVES

- P-delta effect is one of the important and most commonly used analyses in tall buildings (high rise structures).
- To study the response of tall structure under P-Delta analysis.
- To reduce the P-Delta effect by increasing the lateral stiffness of the structure.

II. METHODOLOGY

2.1 RESPONSE SPECTRUM METHOD

In this method, vibration modes are obtained in shape and the usual way gives the period and the magnitude is determined in corresponding to each mode with reference to response spectrum. The main two disadvantages of response spectrum method are:

- Computation of large amount of output information is tedious.
- Method is repeated for several significant mode of earthquake.

Response spectrum based on various ground motion records represents the upper bound. Thus, design spectrum given in IS: 1893-2002 is used.

Response spectrum analysis method is as follows:

- Design spectrum from the code is selected.
- Mode shape is determined and period of analysis is included.
- Now the level of response from the spectrum for each period of modes is read.
- Now each mode of participation corresponding to single degree of freedom is calculated.
- Maximum response is got by adding the effect of modes.
- This maximum response is converted into shear and moment for design of the structure.
- Then structure is analysed for resulting moment and shear.

2.2 MODELLING

The basic method of modelling is grid lines are set, material and structural properties are defined, these defined structural objects are placed relatively to the points on the grid line, various loads are defined and assigned to the relative structural objects.

In case of dynamic analysis, structural properties such as mass source, total number of mode shapes and its directions are defined. Further, analysis of structure is carried out and the results obtained are tabulated for use in other programs.

Table 2.1 Modelling data

Structure	Steel structure
Number of storeys	G+19
Floor to Floor height	3.6m
No. of bays	6,5 (X,Z axes) of 5m each
Lateral force	Applied in ratios

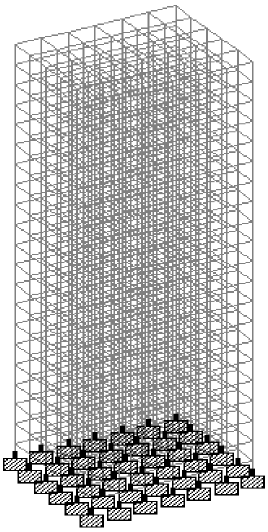

Fig 2.1 Unbraced structure

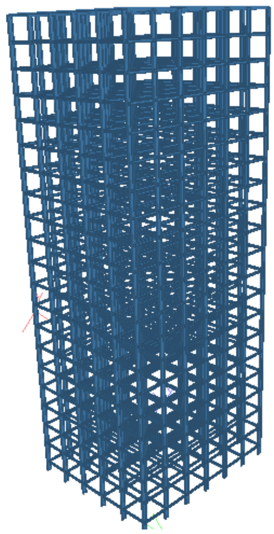

Fig 2.2 Rendered Unbraced structure

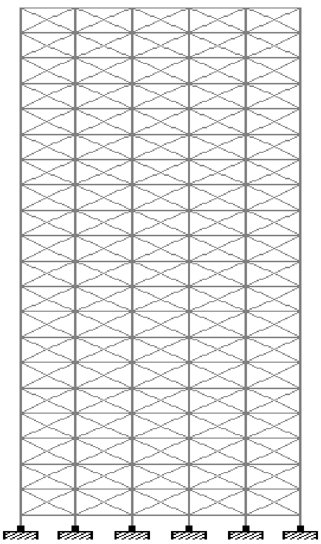

Fig 2.3 X Bracing

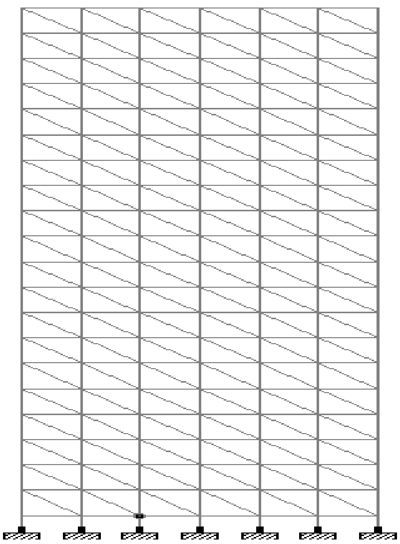

Fig 2.4 Diagonal Bracing

III. ANALYSIS

In the present study, an exertion is made to know the reasons for distinctive propping framework and its course of action in the structure furthermore the expense of bracings regarding least removal, between storey float and interior strengths of the basic individuals.

Different kind of propping framework and its course of action in the structure is demonstrated, investigated and contrasted with the unbraced model for concentrating on the accompanying parameters:

- DISPLACEMENT
- AXIAL FORCE
- STOREY DRIFT
- BENDING MOMENT
- SHEAR FORCE

3.1 DISPLACEMENT FOR DIFFERENT TYPES OF BRACING SYSTEMS

Table 3.1: Displacement for continuous type bracing Systems

Type of Bracing	Static analysis (mm)	P-delta analysis (mm)
Unbraced	412.496	637.974
X Bracing	268.668	446.278
V Bracing	357.518	478.097
Inverted V Bracing	328.937	514.475
Diagonal	364.386	521.248

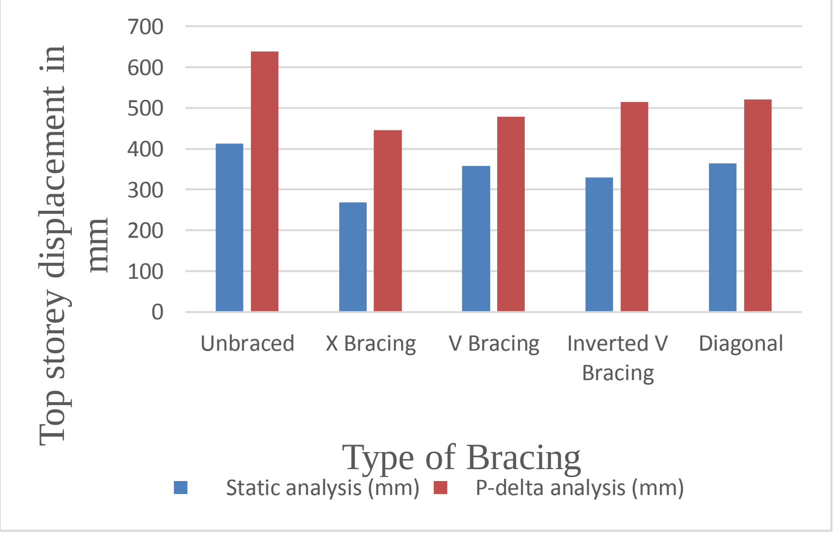

Fig3.1: Top Storey Displacement for Different types of Bracing Systems

- The above graph illustrates the variation of displacement of different types of bracing systems for static and P-Delta analysis.
- As seen in the graph, displacement for P-Delta analysis is more than static analysis.

3.2 AXIAL FORCE FOR DIFFERENT TYPES OF BRACING SYSTEMS

Table 3.2: Axial Force for **Different types of Bracing Systems**

Type of Bracing	Static Analysis (kn)	P-delta analysis (kn)
Unbraced	3380.15087	4065.4492
X Bracing	4871.5795	5870.8658
V Bracing	4652.7264	4982.5594
Inverted V Bracing	4524.6724	4789.2071
Diagonal	4365.2690	4754.0286

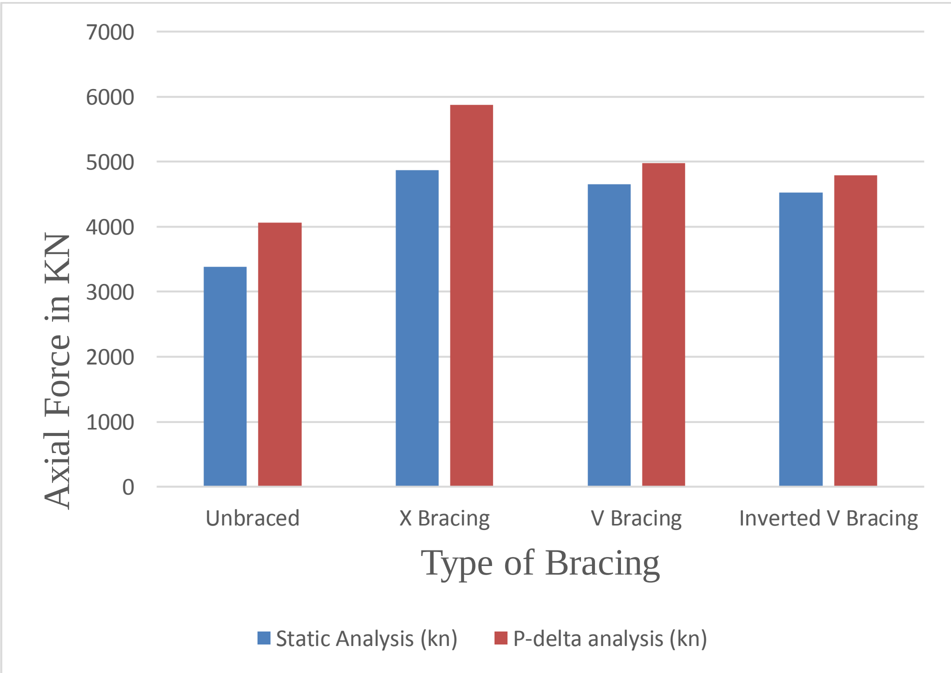

Fig3.2: Axial Force for Different types of Bracing Systems

- The above graph illustrates the variation of axial force of different types of bracing systems for static and P-Delta analysis.
- As seen in the graph, axial force for P-Delta analysis is more than static analysis.

3.3 STOREY DRIFT FOR DIFFERENT TYPES OF BRACING SYSTEMS

Table 3.3: Storey Drift for Different types of Bracing Systems

Type of Bracing	Top storey drift for Static Analysis	Top storey drift for P-delta analysis
Unbraced	0.0015	0.0033
X Bracing	0.0046	0.0073
V Bracing	0.0043	0.0073
Inverted V Bracing	0.0037	0.0064
Diagonal	0.0033	0.0059

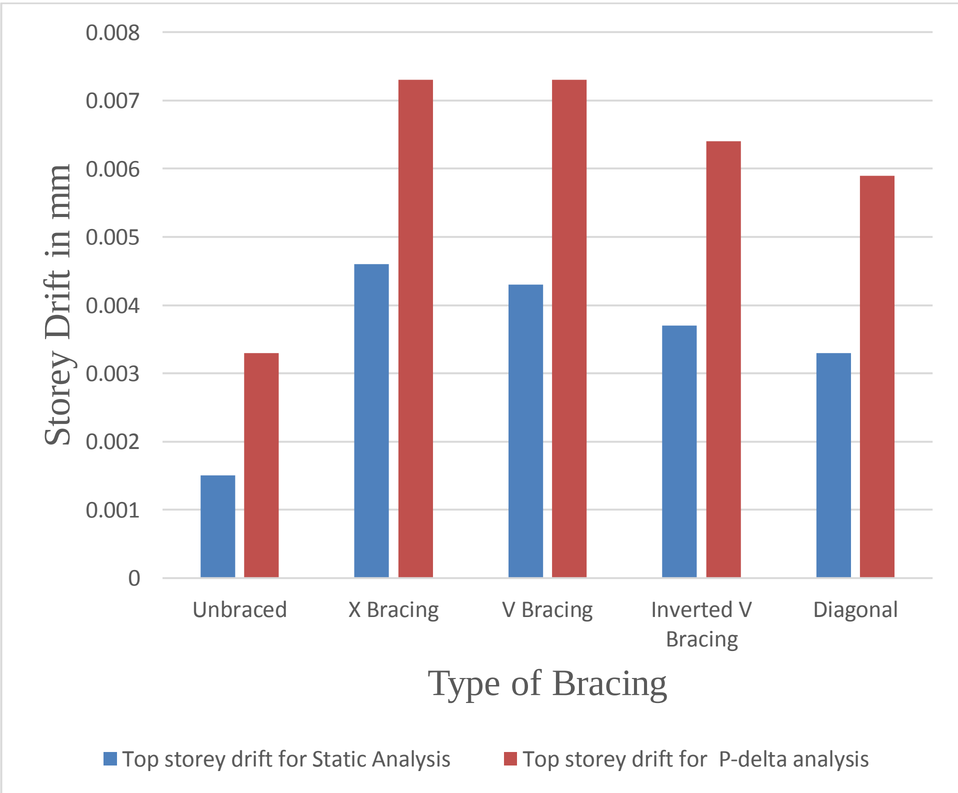

Fig 3.3: Storey Drift for Different types of Bracing Systems

- The above graph illustrates the variation of storey drift of different types of bracing systems for static and P-Delta analysis.
- As seen in the graph, storey drift for P-Delta analysis is more than static analysis.

3.4 BENDING MOMENT OF CRITICAL COLUMN FOR DIFFERENT TYPES OF BRACING SYSTEMS

Table 3.4: Bending Moment of critical column for Different types of Bracing Systems

Type of Bracing	Bending Moment for Static Analysis	Bending Moment for P-delta analysis
Unbraced	668.988	704
X Bracing	370.495	395.26
V Bracing	384.264	397.44
Inverted V Bracing	388.621	403.51
Diagonal	557.480	582.19

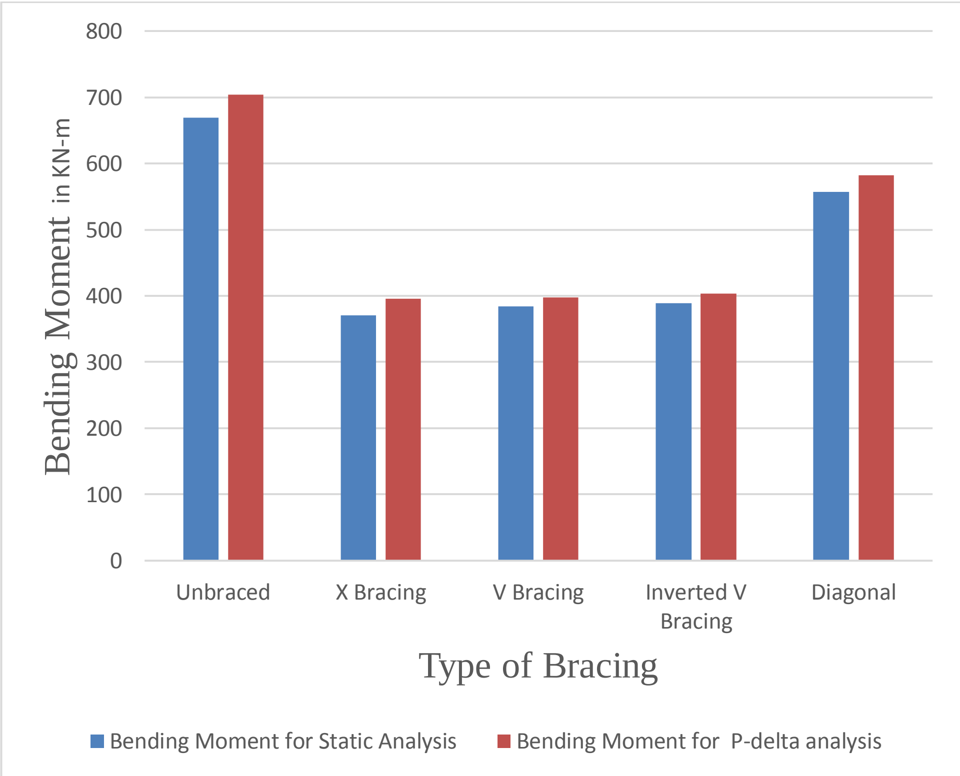

Fig 3.4: Bending Moment of critical column for Different types of Bracing Systems

- The above graph illustrates the variation of bending moment of different types of bracing systems for static and P-Delta analysis.

- As seen in the graph, bending moment for P-Delta analysis is more than static analysis.

3.5 SHEAR FORCE OF CRITICAL COLUMN FOR DIFFERENT TYPES OF BRACING SYSTEMS

Table 3.5: Shear Force of critical column for Different types of Bracing Systems

Type of Bracing	Shear Force for Static Analysis	Shear Force for P-delta analysis
Unbraced	234.092	236.54
X Bracing	161.368	167.20
V Bracing	176.84	177.46
Inverted V Bracing	183	185.48
Diagonal	208	208.86

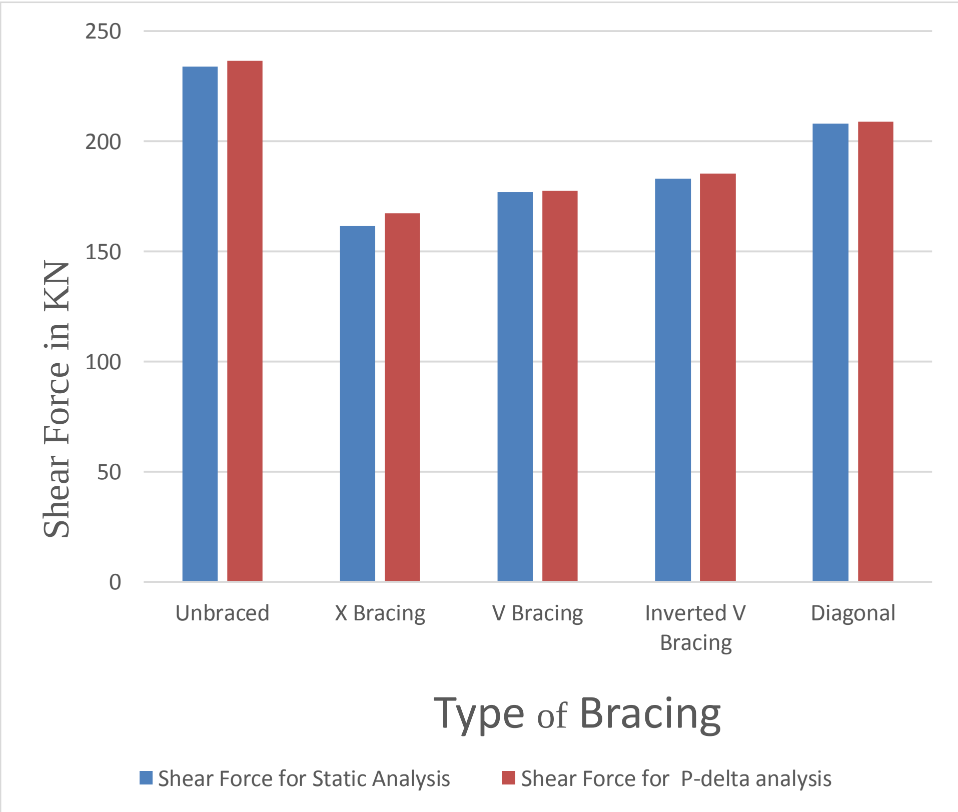

Fig 3.5: Shear Force of critical column for Different types of Bracing Systems

- The above graph illustrates the variation of shear force of different types of bracing systems for static and P-Delta analysis.
- As seen in the graph, shear force for P-Delta analysis is more than static analysis.

IV. CONCLUSION

- As number of storey increases P-delta effect becomes more important.
- The iterative method, in which the gravity load is transformed to an equivalent additional horizontal load, gives very accurate results for both shear and flexurally deforming structures.
- It could be summarized that analysing and designing STEEL high rise structure needs expert observation and understanding. Analysis found was versatile in characteristics but it could be said that displacement varies exponentially under P-Delta analysis with increase in height or increment in storey.
- The axial force, bending moment and shear force in columns and beams also increases under P-delta analysis.
- The results show that by providing different types of bracings, there is a decrease of about 18% to 30% in the displacement of top storey.
- By comparing different types of bracing systems, the percentage reduction of displacement in X Bracing is 30% which is better than the other bracing systems compared.
- X Bracing are more stiff and are effective in increasing the lateral stiffness of the structure.
- Second Order analysis must be done for tall structures, as it increases the Displacement, Bending Moment, Shear Force and Axial Force of tall structures. Hence, the Structural Engineer must consider the effect of P-Delta analysis.
- Linear Static and P-Delta both are necessary for steel structures and have to use after proper understanding to prevent any catastrophic. Hence we can say that, at least it is necessary to check the results of analysis with and without considering P-delta effect for the buildings.

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