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Study of P-Delta Effect on Regular And Irregular RCC Buildings

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Abstract: *During earthquake, the building undergoes various random motions of the ground at its base, which induces inertia forces in the structure. Different types of irregularities are considered in the building viz. Mass irregularities and geometric irregularities in urban India, which are subjected to several types of forces. Earthquake load mainly induce lateral forces which causes lateral displacement of the structure. The effect of gravity load acting on the structures lateral displacement is called the P-delta effect. Due to P-delta effect, geometric nonlinearity induces in the building which creates additional moment and shear. It is generally observed that the regular buildings have a dominant fundamental results participation in their seismic responses and as the irregularity increases the contribution of it. Hence, In the present study, modelling and analysis of Regular and Irregular RCC building is carried out in SAP2000V16 considering P-delta effect using Time history analysis. Various parameters such as base shear, storey drift and overturning moment are obtained. It is found that p delta effect in building needs to be considered and controlled.*

Keywords: *P-delta effect, Regular buildings, Irregular buildings, Time history analysis, SAP.*

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I. Introduction

The engineers do not attempt to make earthquake proof buildings that will not get damaged even during the rare but strong earthquake; such buildings will be too robust and also too expensive. Instead, the engineering intention is to make buildings earthquake resistant; such buildings resist the effects of ground shaking, although they may get damaged severely but would not collapse during the strong earthquake. Thus, safety of people and contents is assured in earthquake-resistant buildings, and thereby a disaster is avoided. This is a major objective of seismic design codes throughout the world.

After minor shaking, the building will be fully operational within a short time and the repair costs will be small. And, after moderate shaking, the building will be operational once the repair and strengthening of the damaged main members is completed. But, after a strong earthquake, the building may become dysfunctional for further use, but will stand so that people can be evacuated and property recovered. The consequences of damage have to be kept in view in the design philosophy.

Time history analysis refers to dynamic response of the structure at each increment of time, when its base is subjected to a specific ground motion time history. Alternatively, recorded ground motions database from past natural events can be a reliable source for time histories but they are not recorded in any given site to include all seismological characteristics suitable for that site. Recorded ground motions are randomly selected from analogous magnitude; distance and soil condition category are the three main parameters in time history generation.

P-Delta effect, also known as geometric nonlinearity, involves the equilibrium and compatibility relationships of a structural system loaded about its deflected configuration of particular concern. It is the application of gravity load on laterally displaced multi-storey building structures. This condition magnifies story drift and certain mechanical behaviours while reducing deformation capacity. In structural engineering, the P-Delta effect refers to the abrupt changes in ground shear, overturning moment, and the axial forcedistribution at the base of a sufficiently tall structure or structural component when it is subjected to a critical lateral displacement.

Several researchers have presented their study in area of effect of p-delta analysis on various structures in several papers. Akshay Gupta and Helmut Krawinkler investigated the inelastic response of steel moment resisting frame. P-delta effect induces negative post yield storey stiffness as seen from pushover curve.The results lead on to the belief that P-delta problem is indeed a potential collapse hazards that needs to be considered in the present design process. EF Black introduced and evaluated two stability coefficients that can be used to quantify the P-delta effect during elastic and inelastic lateral displacement of regular steel SMRF. The study shows that the combined use of these two coefficients permit the accurate prediction of the load deformation curve of the SMRF affected by P-delta phenomena.H. Scholz studied a novel method to allow for the P-Delta effect of steel sway frames analyzed by elastic methods.A numerical example suggests that more

economical designs may be obtained, but a further comprehensive parametric study will be required to confirm this for the general case.

II. Frame Structure Details And Problem Statement

In the present study, effect of nonlinearity on the response of G+14 Regular RC building and G+14 Irregular Stepped RC building has been investigated. Nonlinearity is considered in terms of P-delta effect. In Regular building, the structure has 4 bays in both X and Y direction of 4m each with constant storey height of 3m. In Irregular building, the structure has 2 bays in X direction and 4 bays in Y direction in the 1st step, 3 bays in X direction and 4 bays in Y direction in the 2nd step and 4 bays in X direction and 4 bays in Y direction in the 3rd step from top to bottom. Width of bay is 4 m with constant storey height of 3.0m.

Table 1: Specification of Models

Type of structure	G+14 storied (RC moment resisting frame)
Seismic zone	V, As per IS 1893 Part I, Z=0.36
Importance Factor	1
Damping Ratio	0.05
Imposed load for residential floor	2 KN/m2
Imposed load for commercial floor	3.5 KN/m2
Storey Height	3.0m
Specific Weight of RCC	25KN/m3
Specific Weight of Brick infill	20 KN/m3
Infill Wall	230mm
Column size	300X600
Beam size	230X600

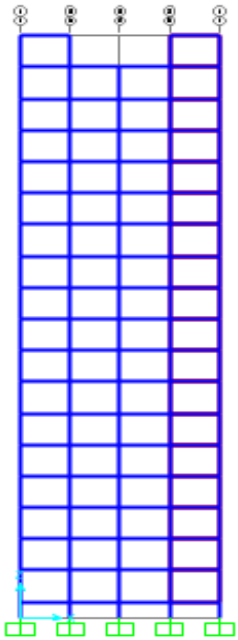

Fig. No.1: Front elevation of Regular building

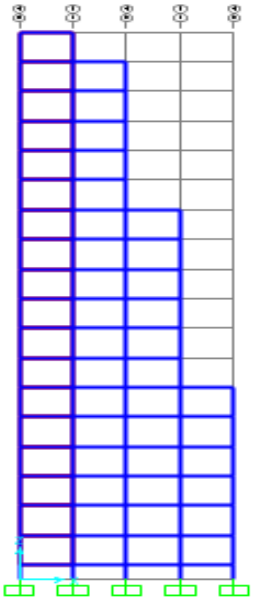

Fig. No.2: Front elevation of Irregular building

III. Methodology

In this paper, fourteen storied regular and irregular building frame is under the action of Imperial Valley (El-Centro) (1940) earthquake. Both RCC buildings are considered with the provision of lift and staircase for performing time history method of dynamic analysis. The building is analyzed for two combinations such as i) Without P-delta effect and ii) with P-delta effect modelled and designed in SAP2000 v16 using time history analysis and response quantities viz. displacement, base shear and overturning moment are obtained under considered earthquake.

IV. Results

The following table no.2 represents the value for Base shear, Displacement and overturning moment without P-delta effect for the two cases, i) Regular building ii) Irregular building

Table No 2: Represents without P-delta effect

Parameter	Regular Building	Irregular Building
Base Shear	143225.263	98378.236
Displacement	0.165124	0.58436
Overturning Moment	5432.56	6436.884

The following table no.3 represents the value for Base shear, Displacement and overturning moment with P-delta effect for the two cases, i) Regular building ii) Irregular building

Table No 3: Represents with P-delta effect

Parameter	Regular Building	Irregular Building
Base Shear (KN)	148954.771	103116.358
Displacement (mm)	0.2028	0.7112
Overturning Moment(KN.m)	6812.91	7762.86

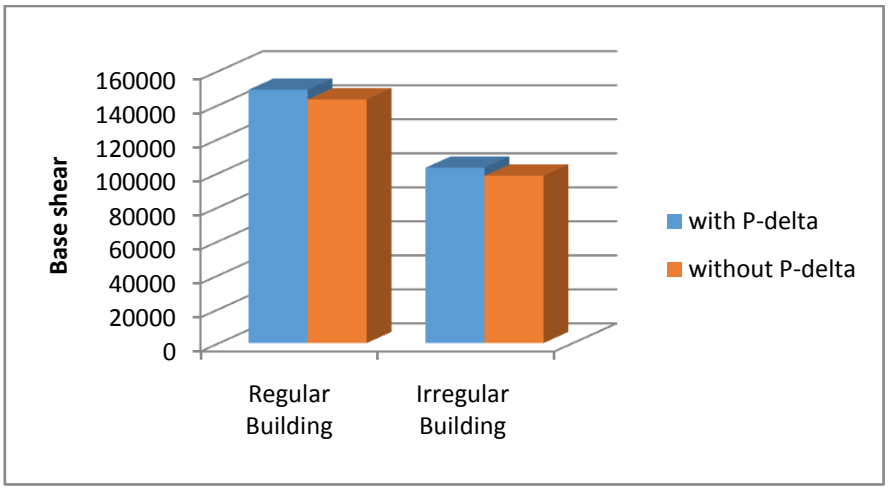

Fig. 3: Shows the difference between the Base Shear values for regular and irregular building for the two cases i) Without P-delta effect and ii) with P-delta effect

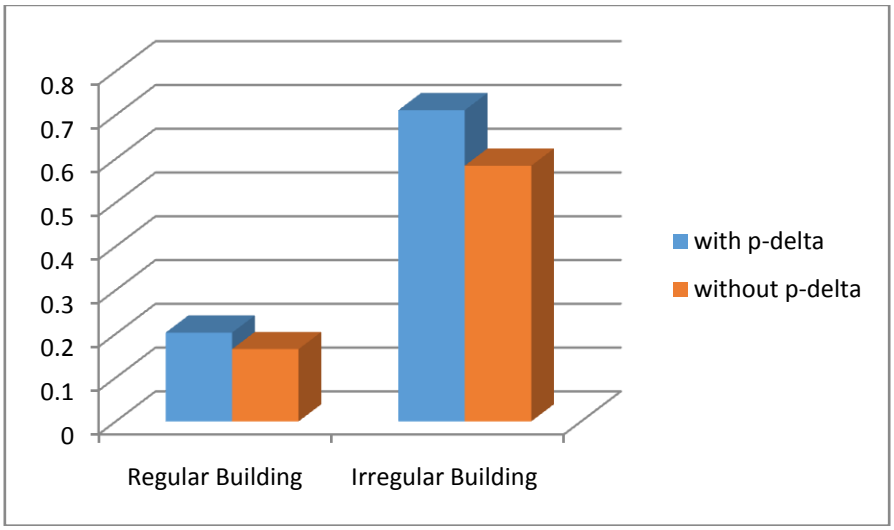

Fig. 4: Shows the difference between the Displacement values for regular and irregular building for two cases i) Without P-delta effect and ii) with P-delta effect

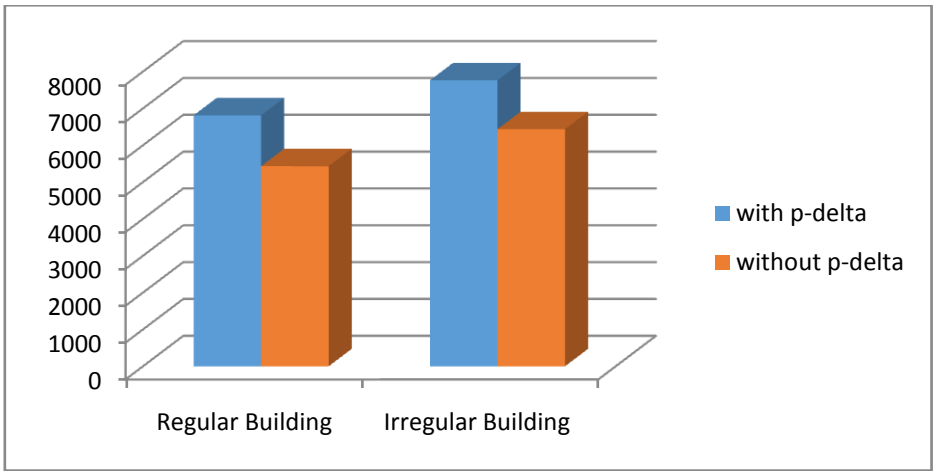

Fig. 5: Shows the difference between the Overturning moment values for regular and irregular building for two cases i) Without P-delta effect and ii) with P-delta effect

V. Conclusion

1) The Displacement values increases in case of irregular buildings along with p-delta effect.
2) Effect of non-linearity due to p-delta is predominant than that of the normal effect.
3) Base shear increases in case of p-delta consideration in both regular and irregular buildings.
4) It can be concluded that the performance of the building under P-delta effect should be considered and remedial measures should be taken.

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