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Study on the effects of geometric non-linear behavior of RC framed structures

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Abstract - *Geometric non-linear effect is also called as p-delta effect. It is one of the major second order effects. The p-delta effects will be more pronounced in high rise structures. In the present paper, an attempt is made to study p-delta analysis on multistory RC framed structures. Also to quantify the influence of slenderness ratio of members and structures, and the influence of consideration of stiffness diaphragm on the magnification of internal forces due to geometric non-linearity. From this study it is found that the effect of p-delta decrease with decrease in slenderness ratio and the amount of p-delta will decrease when the stiffness diaphragm is considered.*

***Key Words*: Geometric non-linearity, P-delta effects, Moment Magnification, Stiffness Diaphragm.**

1. INTRODUCTION

Engineers today typically use linear static analysis to determine the design forces and moments resulting from loads acting on a structure. First order analysis assumes small deflection behavior the resulting forces and moments take no account of the additional effect due to the deformation of the structure under load.

As the structure becomes more slender and less resistant to deformation, it is necessary to consider 2nd order and to be more specific, P-delta effects arises. As a result, Codes of practice are referring engineers more and more to use of 2nd order analysis in order that P-delta and stress stiffening effects are accounted for when appropriate in design.
The magnitude of P-delta effects is related to the

1. Stiffness (or) slenderness ratio as a whole.
2. Slenderness ratio of individual element

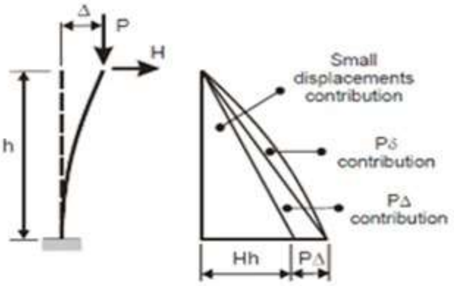


Fig -1: Representation of effects of P-Delta

2. PRESENT STUDY

To perform 1st order analysis and 2nd order Analysis of 15 story and 20 story on RC framed structure. To study on the effects of p-delta on the influence of slenderness ratio of members and structures and also to study the influence of consideration of stiffness of diaphragm on the moments and drift magnification from P-delta analysis.

3. METHODOLOGY OF PRESENT STUDY

In this present study the linear static analysis is carried out on 3D RC framed structures using ETABS, and the geometric non-linear analysis (P-delta analysis) on 3D RC framed structures using ETABS.

3D framed structures of 15storey and 20storey shall be considered. The columns and beam sections considered will be designed for gravity and lateral loads as per relevant Indian codes (IS456:2007, IS875:2000 and IS 1893:2016).

The slab element used as shell type i.e. stiffness diaphragm and results are obtained for moments and drift and compared with the membrane type of slab element.

4. MODELING AND ANALYSIS

In the present study, 15 story and 20 story are considered.

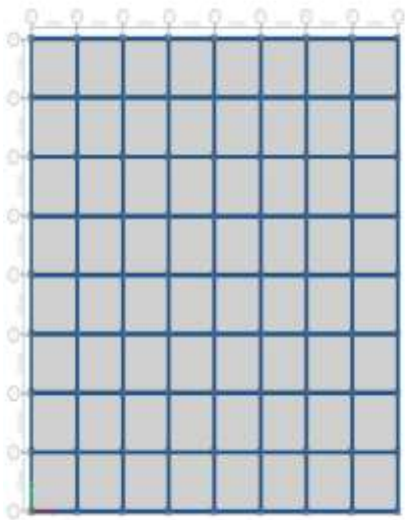


Fig -2: Typical plan for the structures considered

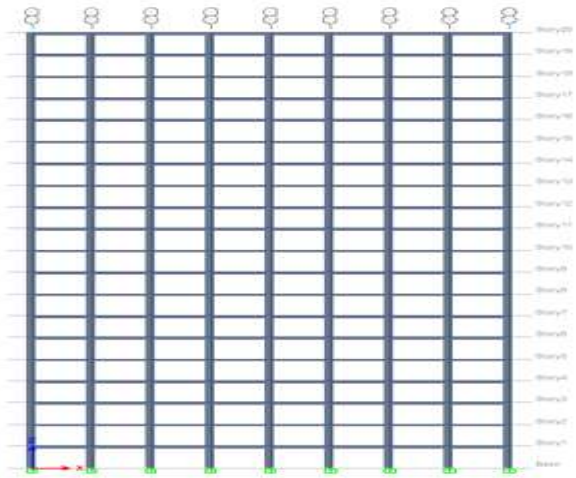


Fig -3: Elevation for the structures considered

Table -1: Detailed structural parameters considered

Material and Geometry Data		Loading data	
Span of slab	5.5m X 5.5m	Live Load	3kN/sq.m
Typical height story	3.5m	Finishing Load	1.5kN/sq.m
No of storeys	15,20	Loads due to wall	14kN/m
Grade of concrete	M25	Seismic Zone	Zone 2
Grade of steel	Fe500	Soil type	Type 2 (Medium soil)
Beam size	300 X 450mm	Importance Factor	1.2
Column size	Varies	Response reduction Factor	3 (OMRF)
Slab thickness	160mm	Time period	Varies

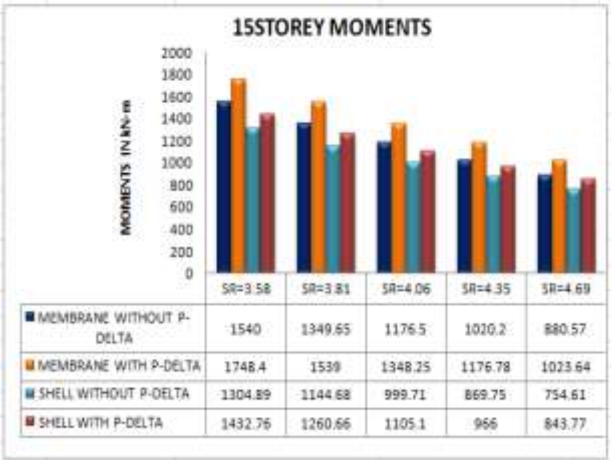


Chart -1: Comparison of moments for 15-storey structure

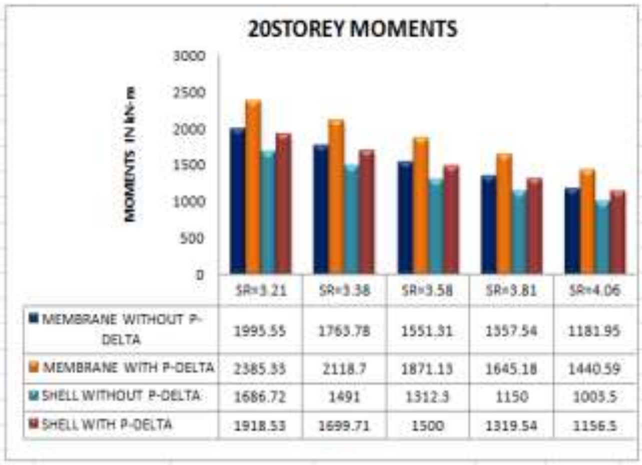


Chart -2: Plot of story moments for 40-storey structure with & without core wall

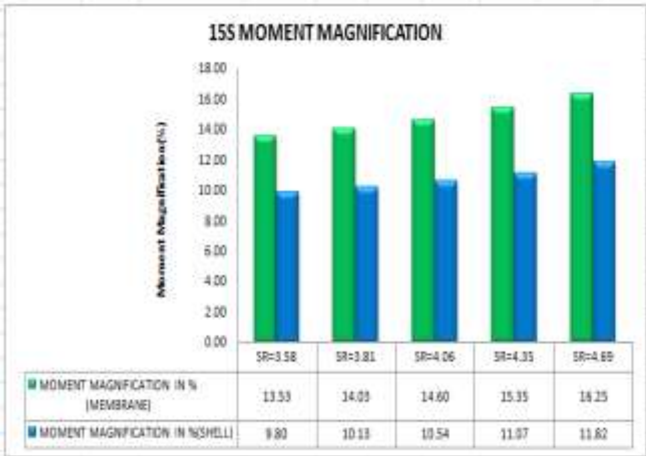


Chart -3: Comparison of moment magnification for 15-storey structure

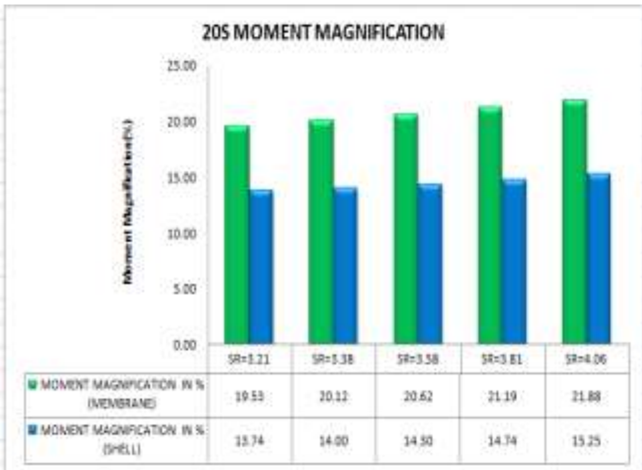


Chart -4: Comparison of moment magnification for 20-storey structure

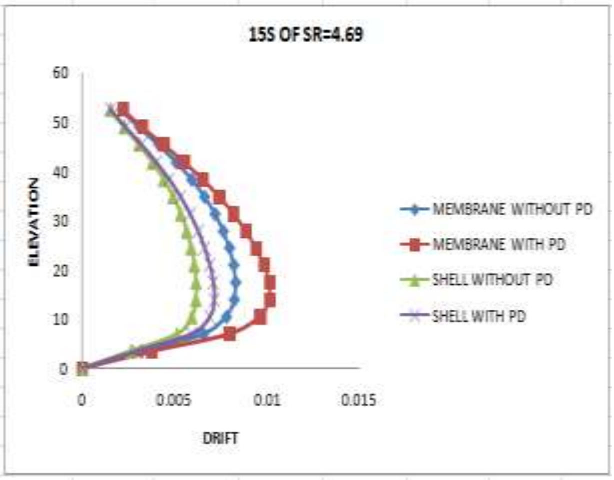


Chart -5: Plot of story drift for 15-storey structure with SR=4.69

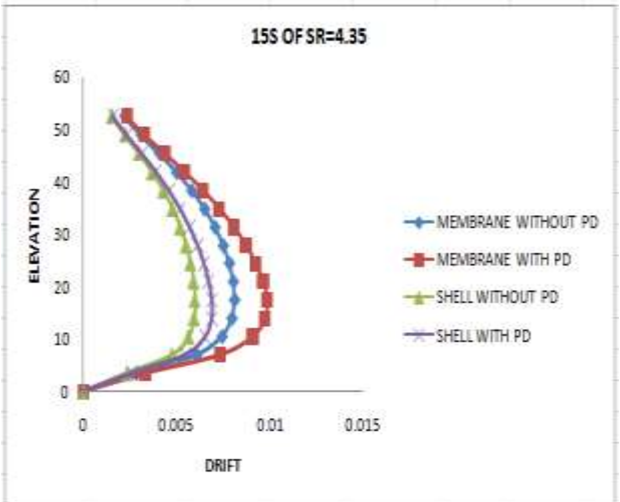


Chart -6: Plot of story drift for 15-storey structure with SR= 4.35

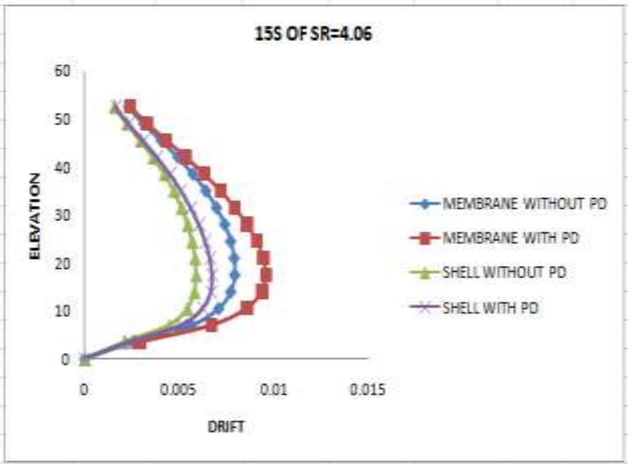


Chart -7: Plot of story drift for 15-storey structure with SR=4.06

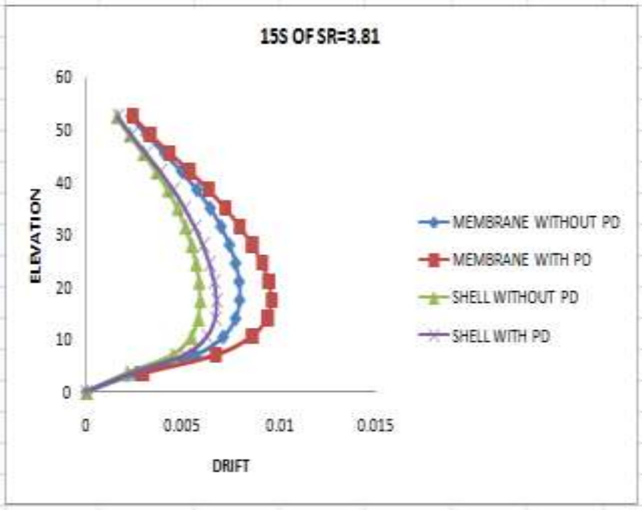


Chart -8: Plot of story drift for 15-storey structure with SR=3.81

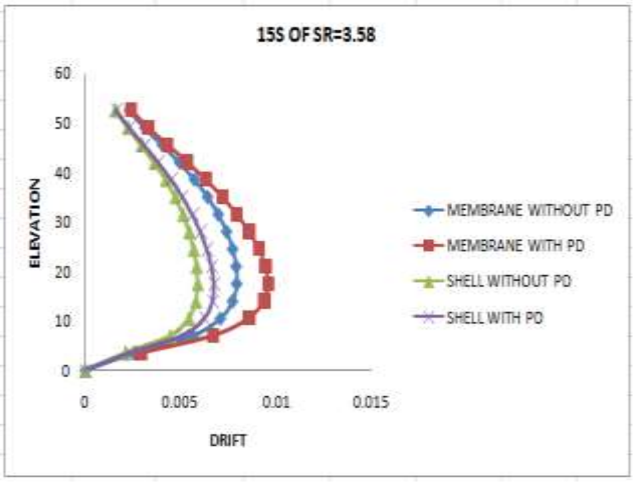
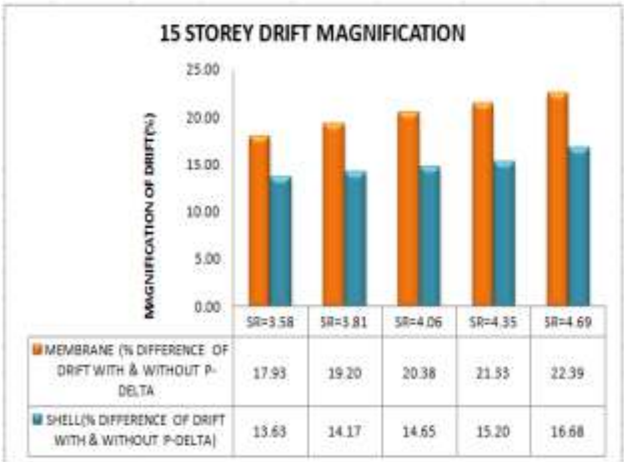


Chart -9: Plot of story drift for 15-storey structure with SR=3.58



	SR=3.58	SR=3.81	SR=4.06	SR=4.35	SR=4.69
MEMBRANE (% DIFFERENCE OF DRIFT WITH & WITHOUT P-DELTA)	17.93	19.20	20.38	21.33	22.39
SHELL(% DIFFERENCE OF DRIFT WITH & WITHOUT P-DELTA)	13.63	14.17	14.65	15.20	16.68

Chart -10: Plot of story drift magnification for 15-storey structure

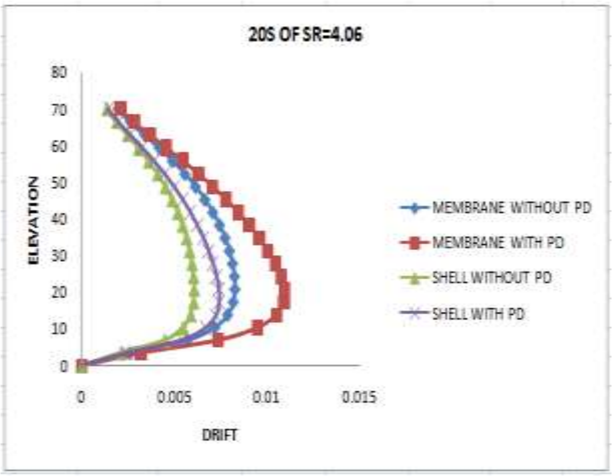


Chart -11: Plot of story drift for 20-storey structure with SR=4.06

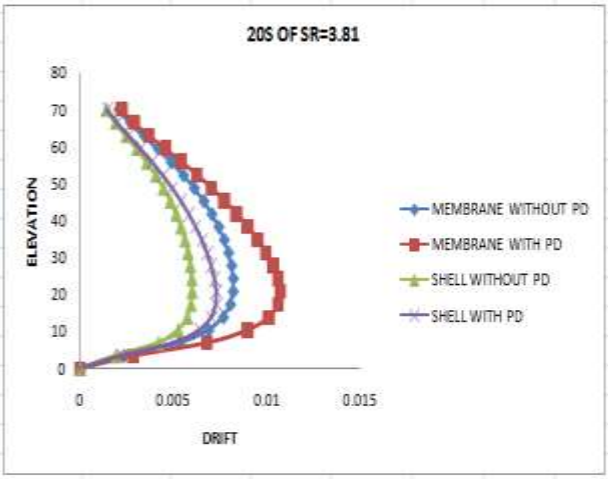


Chart -12: Plot of story drift for 20-storey structure with SR=3.81

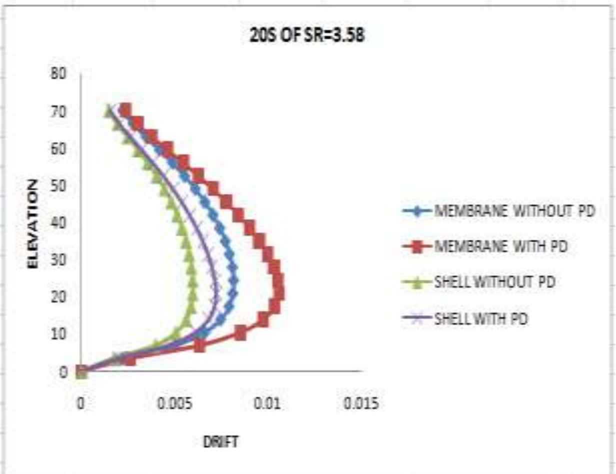


Chart -13: Plot of story drift for 20-storey structure with SR=3.58

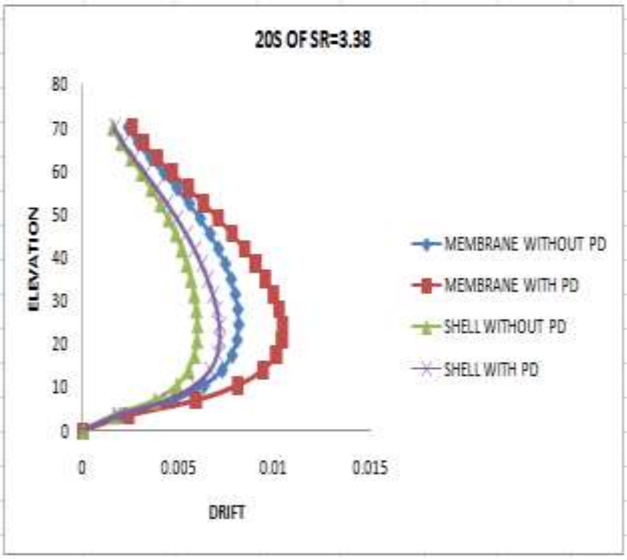


Chart -14: Plot of story drift for 20-storey structure with SR=3.38

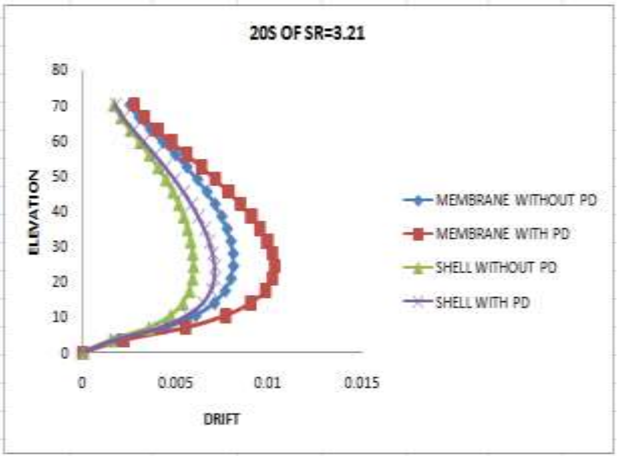


Chart -15: Plot of story drift for 20-storey structure with SR=3.21

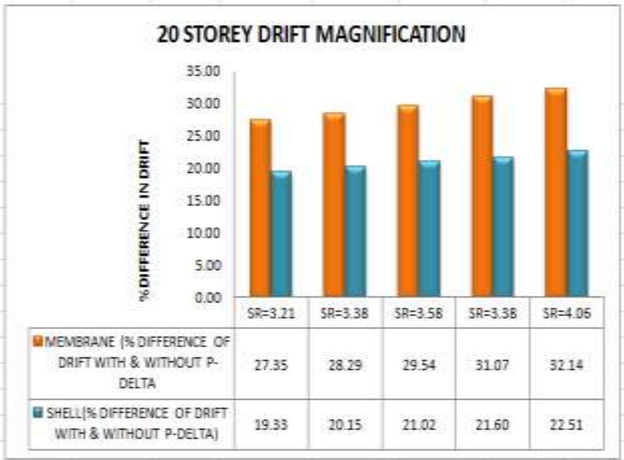


Chart -16: Plot of story drift magnification for 20-storey structure

5. CONCLUSIONS

Following inferences can be drawn from the comparison of moment magnifications and displacements for structure of different heights and different slenderness ratios, with and without the consideration of slab stiffness.

- The magnification of moments due to the effects of P-delta becomes extremely significant as the height of the structure increases and as the columns under consideration becomes slender.
- The influence of slab stiffness in the analysis significantly reduces the moment magnification due to p-delta effects.
- The difference in moment magnifications for the cases of with and without consideration of stiffness of diaphragm increases with increase in the height of the structure. It can be seen that the difference in the moment magnification is in the range of 4%-5% for 15 story structure and 6% - 7% for 20 story structure.
- The difference in drift magnifications for the cases of with and without consideration of stiffness of diaphragm increases with increase in the height of the structure. It can be seen that the difference in the displacement magnification is in the range of 4%-6% for 15 story structure and 8% - 10% for 20 story structure.

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