Analysis of Structure Having Different Stiffness under Blast Loads

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Abstract— International economic pressures and unbalance of power caused by globalization leads to increased number of terrorist activities, which primarily targets civil infrastructure such as strategically important buildings and bridges similarly, gas stations located close to residential buildings sometimes may explode due to lack of control and ignorance. The main objective of this paper is to study is to see the variation of storey displacement and storey drift when the redundancy (stiffness) of the structure is change.

Keywords: Structure Redundancy, Blast Yield, Storey Displacement, Storey Drift

I. Introduction

Buildings can collapse partially or totally as a result of blast loading as one or multiple columns fail. The beam-column joints no longer being supported by columns not only increase their span length to almost double the original span length, but also the tension reinforcement location at the joints being top of the beam would cause a great weakness for bending of the unsupported large span. Including the dynamic effect of immediate removal of a column, it is easy to expect that the supported columns, beams, and slabs above the collapsed column will fail by its own weight. This study gradually enhanced the understanding of the role that structural details play in affecting the behavior. The strategy for dealing with the blast-induced threats against a structure requires attention from planning and design stages, as introducing or altering various blast response mitigation strategies becomes either difficult or impossible later on. Blast response mitigation strategies can be incorporated in the structural design at concept stage, leading to a well-designed and constructed structure that can exhibit improved blast resistance and at the same time maintain its architecturally appealing appearance.

A. Type of Case Analyzed

1) Case 1: Without infill structure with 3 bays of 4m each in both directions.
2) Case 2: Without infill structure with 4 bays of 3m each in both directions.
3) Case 3: Without infill structure with 6 bays of 2m each in both directions.

In above all three cases blast load is applied of 300kg TNT at 30m standoff distance

II. Structural modeling

A G+3 storey symmetrical models have been made in Etabs 2015. Model is 12m x 12m in plan and height of building is 14m. Height of each storey is 3.5m and height of plinth is 1.5m.Beam having size of 300x400mm and column having size of 450x450 mm have been provided. Slab of 200mm thickness have been provided. Grade of steel and concrete are fe500 and M30 respectively.

1) Case 1: Without infill structure with 3 bays of 4m each in both directions.

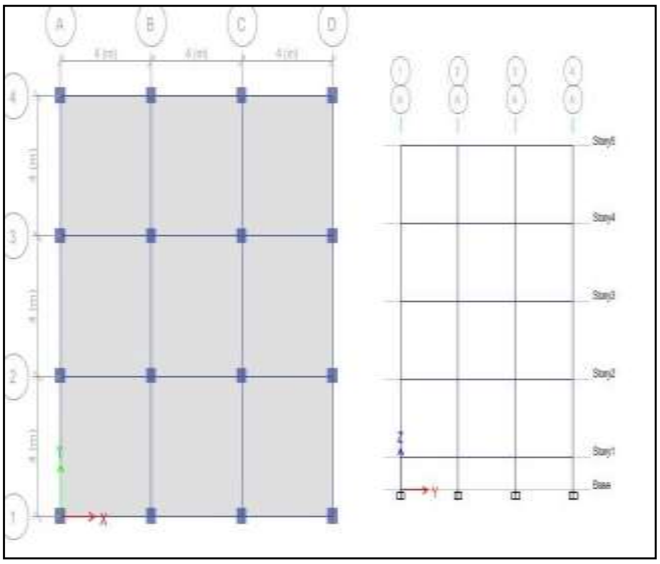


Fig. 1: Plan and elevation of model

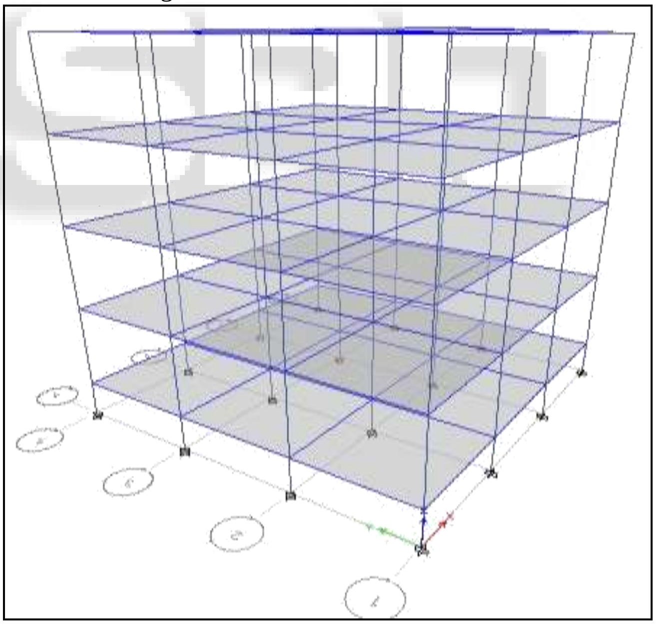


Fig. 2: 3D view of model

2) Case 2: Without infill structure with 4 bays of 3m each in both directions.

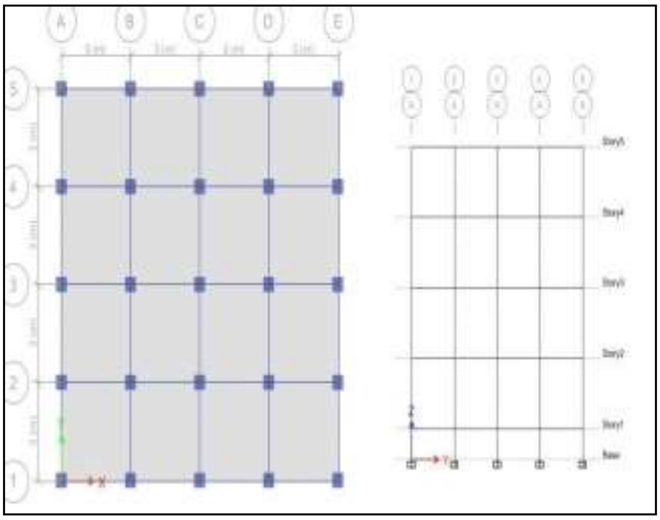


Fig. 3: Plan and elevation of model

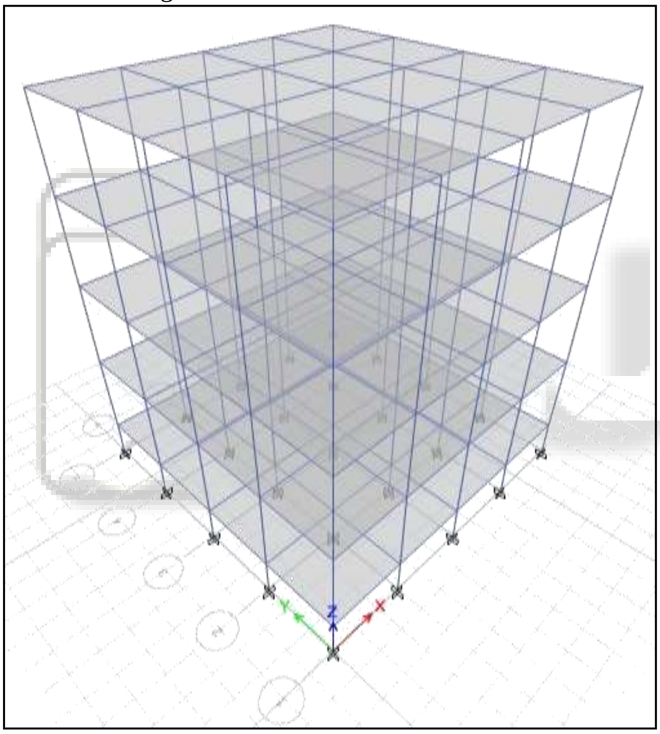


Fig. 4: 3D view of model

3) Case 3: Without infill structure with 6 bays of 2m each in both directions.

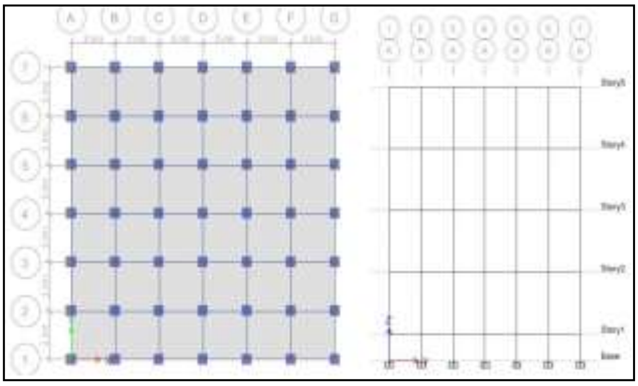


Fig. 5: Plan and elevation of model

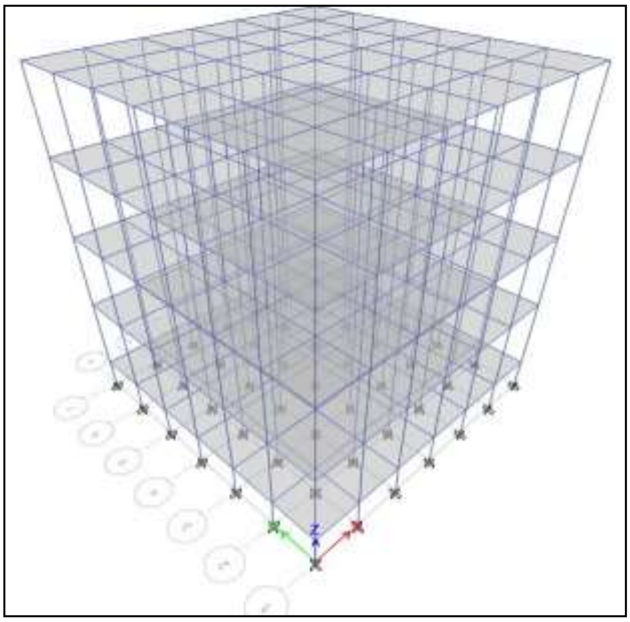


Fig. 6: 3D view of model

III. TYPE OF LOADS APPLIED ON STRUCTURE

- Dead load (self-weight)
- Live load (3KN)
- Super imposed load (floor loads) (1KN)
- Blast loads (according to IS 4991-1968 code) (300 kg TNT at 30 m standoff distance)

1) Case 1: 300 kg TNT at 30 m standoff distance for structure with 3 bays of 4m each in both directions.

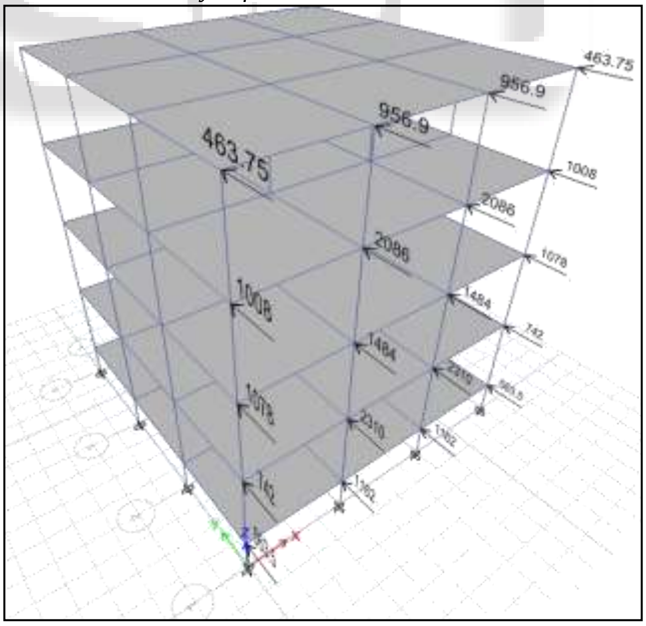


Fig. 7: Blast load applied over the structure

2) Case 2: 300 kg TNT at 30 m standoff distance for structure with 4 bays of 3m each in both directions.

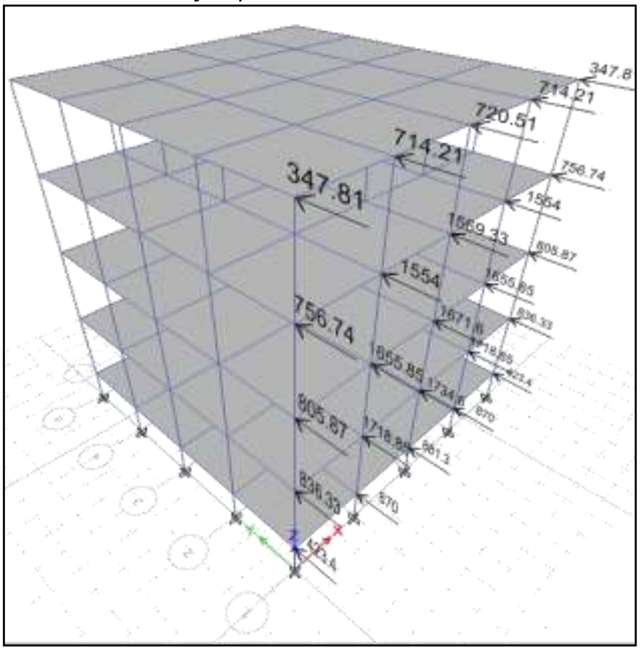


Fig. 8: Blast load applied over the structure

3) Case 3: 300 kg TNT at 30 m standoff distance for structure with 6 bays of 2m each in both directions.

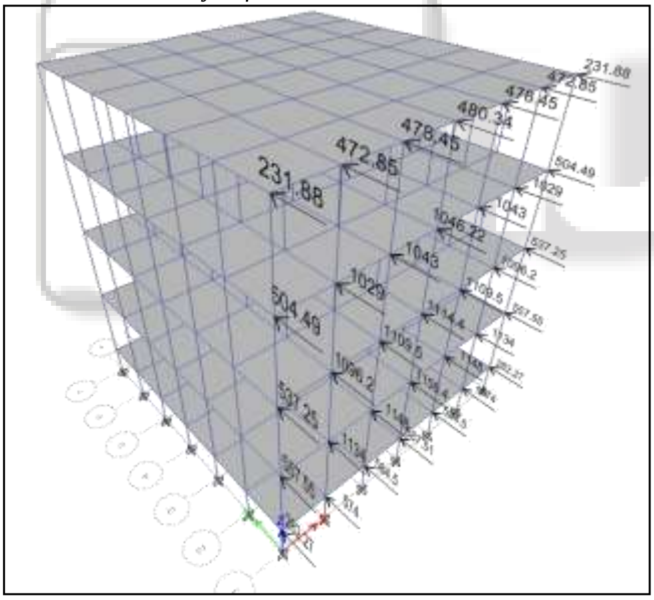
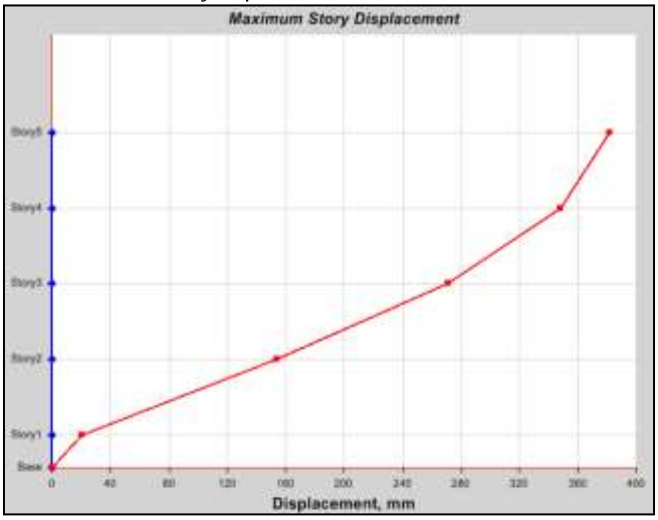


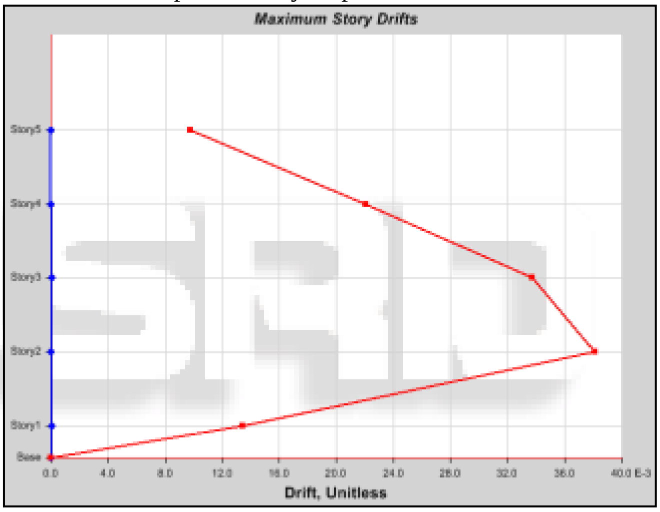
Fig. 9: Blast load applied over the structure

IV. ANALYSIS RESULTS

1) Case 1: 300 kg TNT at 30 m standoff distance for structure with 3 bays of 4m each in both directions.

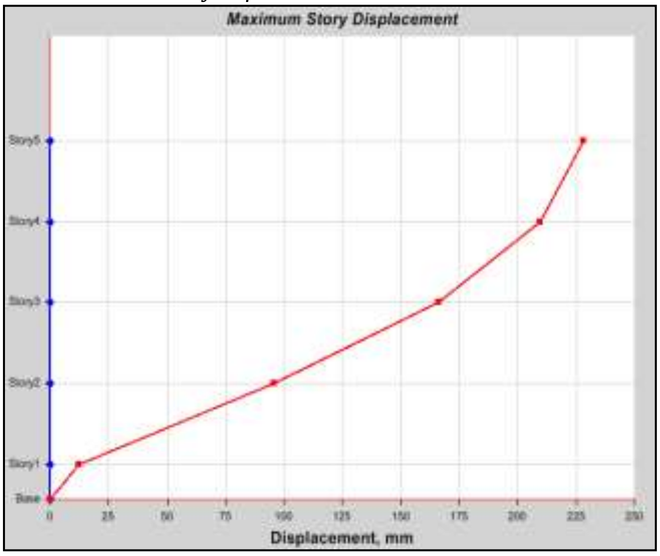


Graph 1: Storey displacement curve

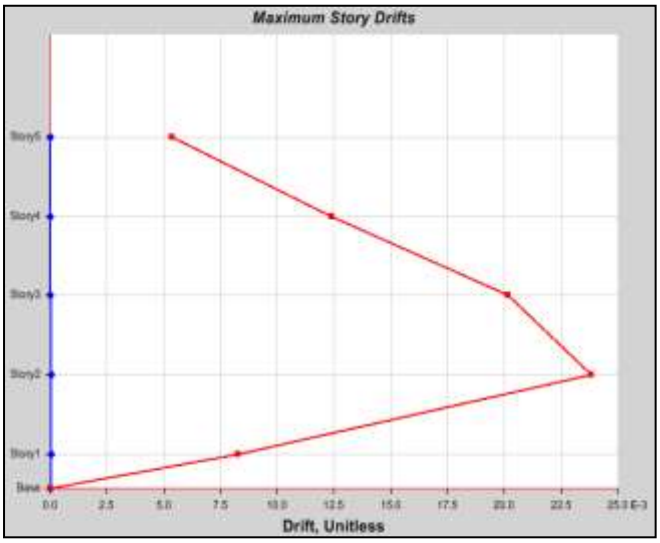


Graph 2: Storey drift curve

2) Case 2: 300 kg TNT at 30 m standoff distance for structure with 4 bays of 3m each in both directions.

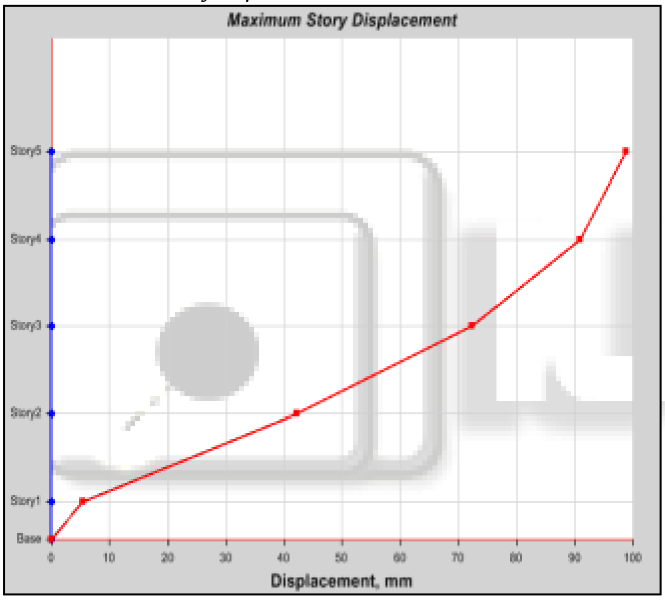


Graph 3: Storey displacement curve

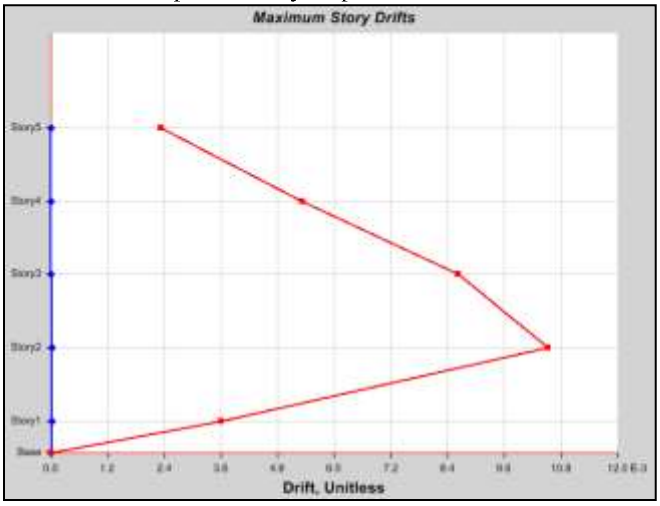


Graph 4: Storey drift curve

3) Case 3: 300 kg TNT at 30 m standoff distance for structure with 6 bays of 2m each in both directions.

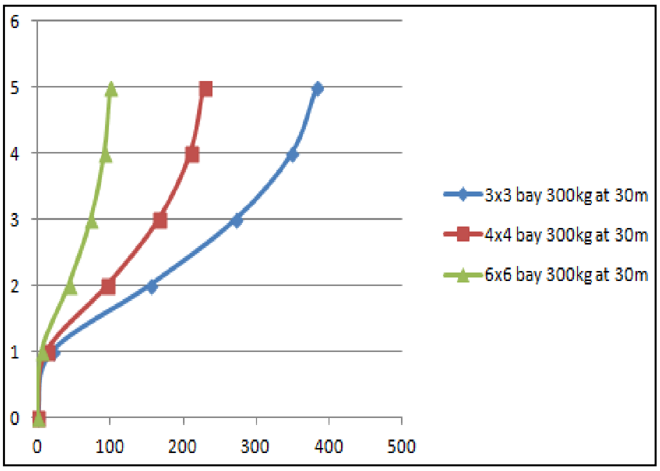


Graph 5: Storey displacement curve

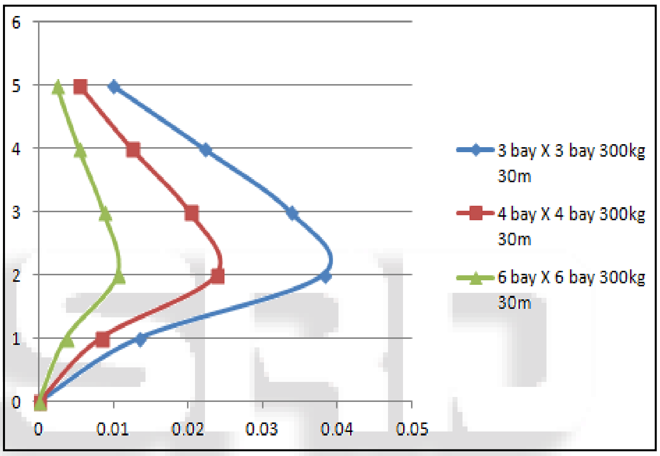


Graph 6: Storey drift curve

V. VARIATION IN STOREY DISPLACEMENT AND STOREY DRIFT WHEN STIFFNESS IS VARIED



Graph 7: Variation in storey displacement for case 1, 2 and 3



Graph 8: Variation in storey drift for case 1, 2 and 3

I. CONCLUSION

From a thorough analysis of reinforced concrete structure exposed to blast load, it can be drawn as a conclusion that structure designed for normal loads are not safe when it exposed to an explosion. For the safety of civilians and for the valuables, the important structures should be analyzed by blast criteria given by IS 4991-1968.

Following conclusions can be made from the analysis:-

1) In without infill structure we increase the number of columns and beams by increasing number of bays from 3 bays of 4 m to 4 bays of 3 m each in both X and Y direction without changing the size of column and beam. Yield of explosion and standoff distance is not changes then the maximum storey displacement are reduced by around 40 %., and maximum storey drift reduced by around 38%.
2) In without infill structure we increase the number of columns and beams by increasing number of bays from 3 bays of 4 m to 6 bays of 2 m each in both X and Y direction without changing the size of column and beam. Yield of explosion and standoff distance is not changes then the maximum storey displacement are reduced by around 74 %., and maximum storey drift reduced by around 72%.

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