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Parametric Study of a Multi-Storey Building's with Different Hollow Cross Section in Beam for Seismic Response Spectrum Analysis Using SAP 2000

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Abstract

Building design must be such as to ensure that the building has adequate strength, high ductility, and will remain as one unit, even while subjected to very large deformation. Earthquakes are natural hazards under which disasters are mainly caused by damage to or collapse of buildings and other man-made structures. Experience has shown that for new constructions, establishing earthquake resistant regulations and their implementation is the critical safe guard against earthquake-induced damage. With our development in modern society and continuous technological advancement, we have achieved sustained performance in structural infrastructure, from residential buildings to industrial buildings to thermal power stations, bridges and dams. Three Multi-storey building models are selected which contain different number of storey as each and every model contains 25 columns and 40 beams in each floor. Use M-30 concrete and Fe-250 grade steel. In proposed work different shapes of beam with equal perimeter. We use Csi software SAP2000. Five hollow cross-sections (Chamfer, Circular, Hexagonal, Rectangular and Square) beams are considered with constant span length and unchanged perimeter. The example of hollow beam is modeled and analyzed in SAP 2000 and the responses are found to be fairly matching. For the purpose of the parametric study, the five hollow cross-sections are modeled in SAP2000. The span length, cross-section and material propertyre main unchanged. The best cross section and find minimum deflection and bending moment we choose a 10, 15, and 20-storey buildings of 20-meter-wide and height of each column is 3m.

Keyword: Longitudinal Bending Stress; Shear Lag; Transverse Bending Stress; SAP 2000.

Introduction

Concrete is a good building material and has many advantages due to its variable compressive strength and shape. Concrete has the lowability to resist tension and very less ductility. With our development in modern society and the continuous improvement of technology, we have achieved the continuous performance of the structural infrastructure, from residential buildings to industrial buildings to thermal power plants, bridges and dams. For the better performance of the existing structure, we need for strengthening in the structure. With the development of modern analysis tools such as the finite element method and the finite band method, these discrete methods can now be used to analyze structures, and all structural effects can be found in these methods. The vertical and horizontal direction and the interaction between them can be considered together. In the present paper a detailed study of five cross-sections (Chamfer, Circular, Hexagonal, Rectangular and Square) has been carried out using finite element code SAP-2000.

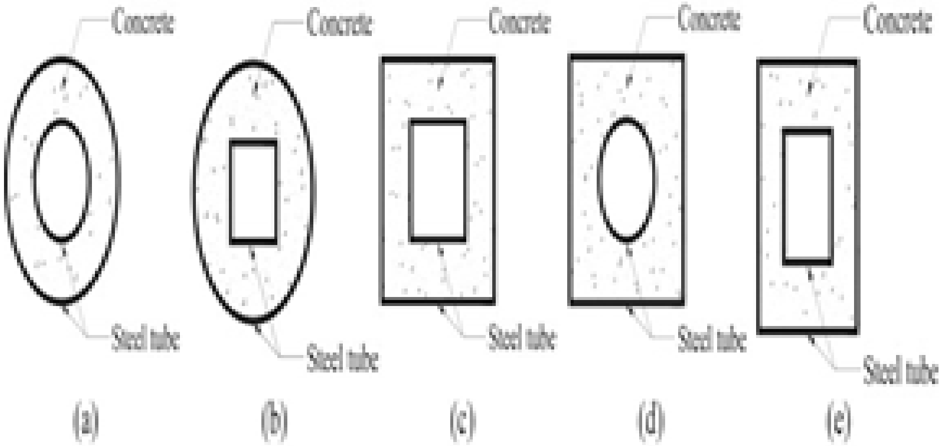

Fig. 1: Different Type of Hollow Sections

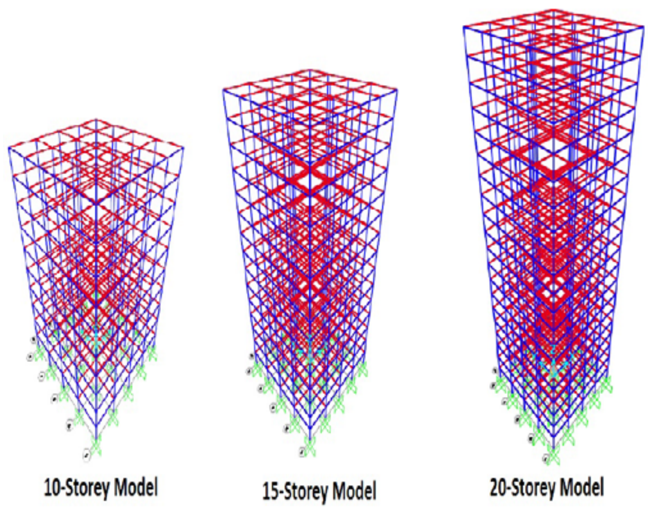

Fig. 2: Different Models

Design of Proposed Work

Five hollow cross-sections (Chamfer, Circular, Hexagonal, Rectangular and Square) beams are considered with constant span length and unchanged perimeter. The example of hollow beam is modeled and analyzed in SAP 2000 and the responses are found to be fairly matching. For the purpose of the parametric study, the five hollow cross-sections are modeled in SAP2000. The span length, cross-section and material propertyre main unchanged.

Calculation of Section Dimension with Constant Perimeter (P)

Square Section: 500*500 mm

Rectangular Section: Length=600mm, Width=400mm

Circular Section: Perimeter (P) = 2000mm

$P = 2\pi r$

r=318.30mm

Chamfer Section: 4x+4y=2000mm

Let, x=300mm then y=200mm

Hexagonal Section:	4x+2y=2000mm
Let,	x=330mm then y=340mm
Column Size	=300*300mm

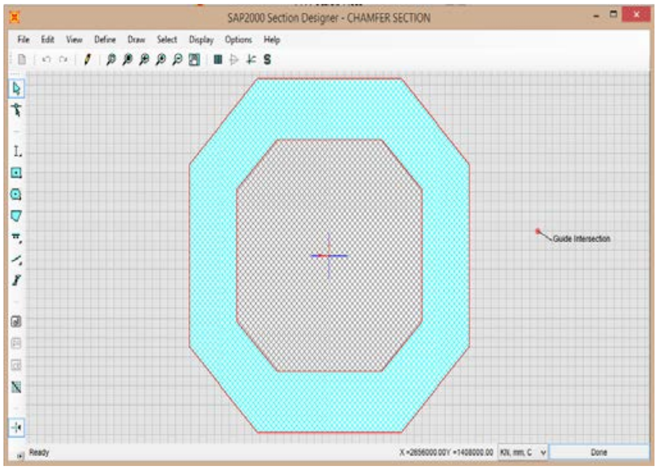

Fig. 3: Hollow Chamfer Section

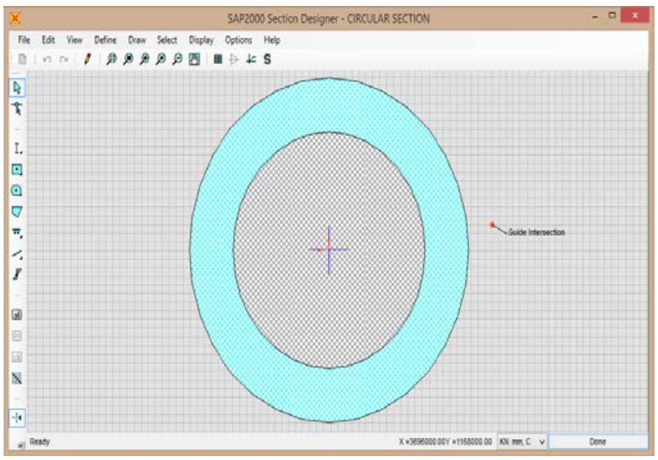

Fig. 4: Hollow Circular Section

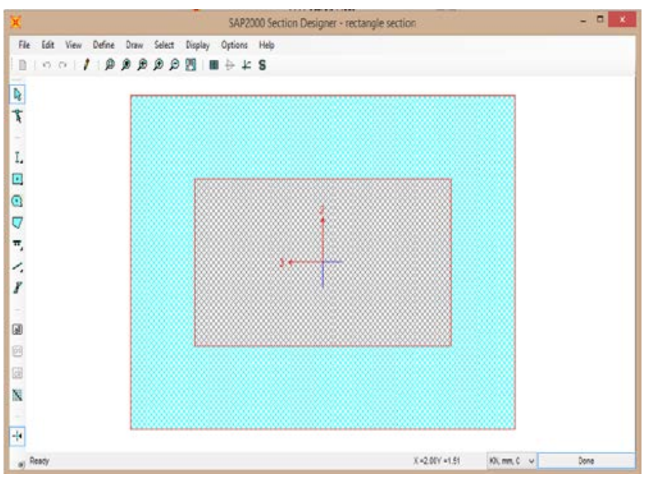

Fig. 5: Hollow Rectangular Section

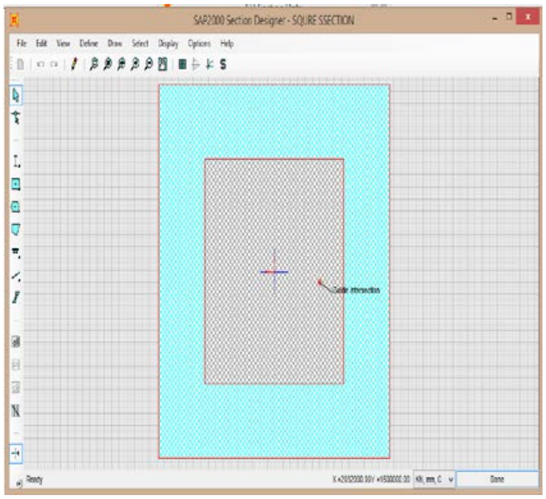

Fig. 6: Hollow Square Section

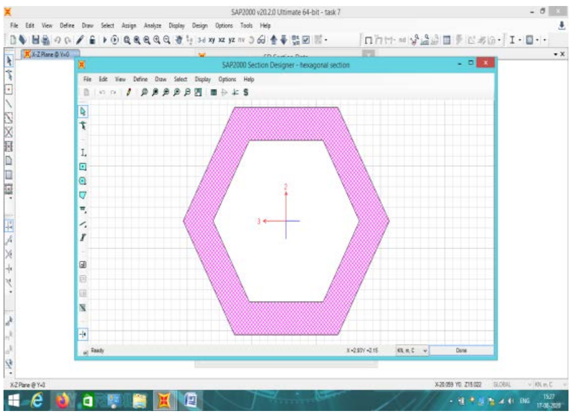

Fig.7: Hollow Hexagonal Section

Result and Discussion

In this study for taking the best cross section and find minimum bending moment we choose a 10, 15, and 20-storey buildings of 20-meter-wide and height of each column is 3m, for run and analysis of this structure we use CSI software SAP2000. This section provides structure results, including items such as structural periods and base reactions.

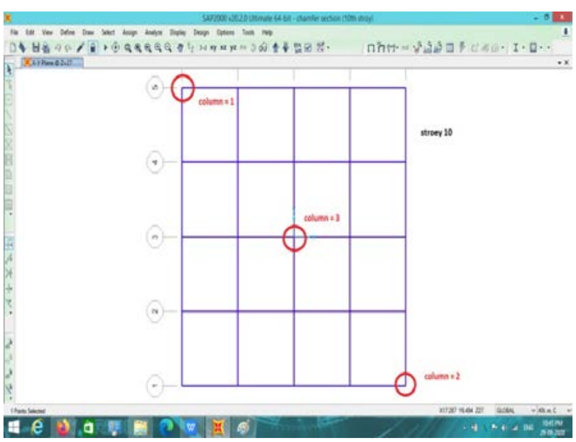

Fig. 8: Top View of 10-Storey Model

Graphical Representation of Bending Moment of 10 Storey Model

On X-axis plot storey height (m) and on Y-axis bending moment (KN-mm)

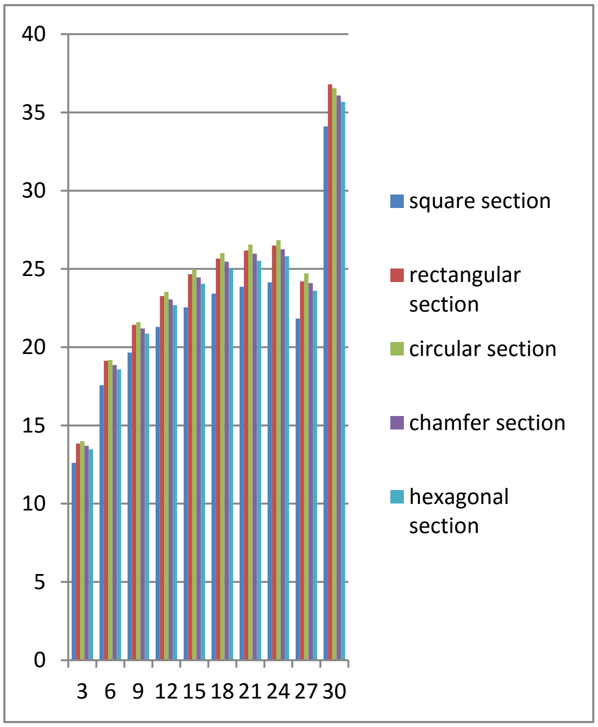

Fig. 9: Bending Moment (KN-mm) for Column No. 1

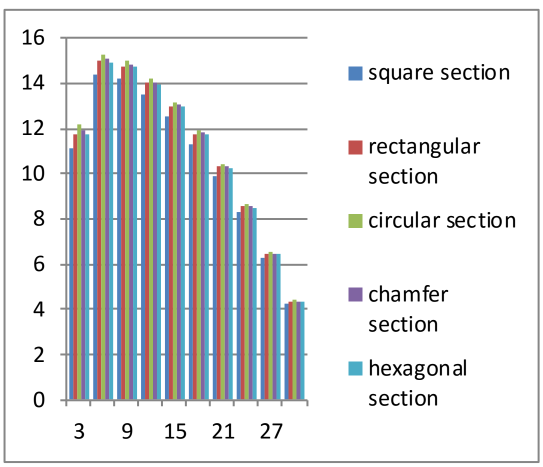

Fig. 10: Bending Moment (KN-mm) for Column No. 2

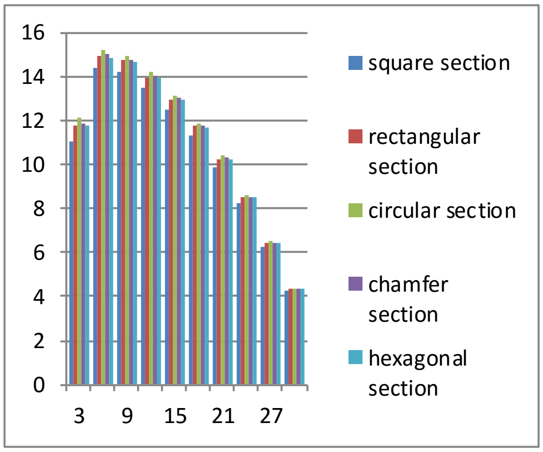

Fig.11: Bending Moment (KN-mm) for Column No. 3

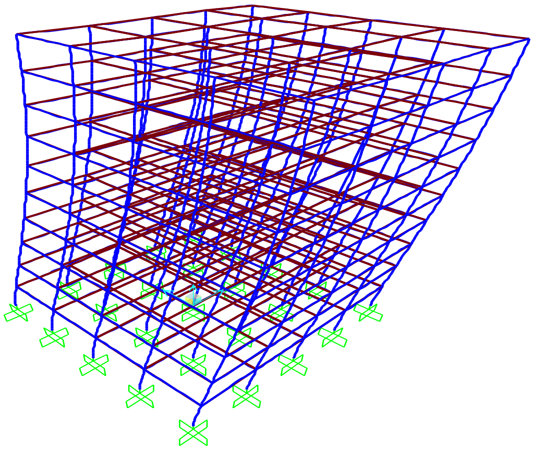

Fig.12: Deformed shape of 10-Storey Model

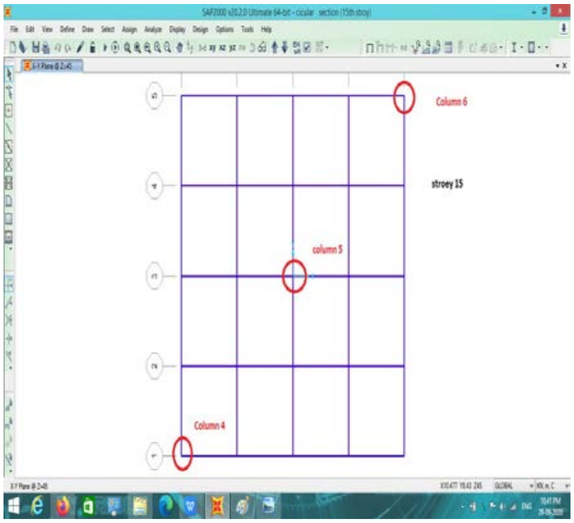

Fig. 13: Top View of 15-Storey Model

Graphical Representation of Bending Moment of 15-Storey Model

On X-axis plot storey height (m) and on Y-axis bending moment (KN-mm)

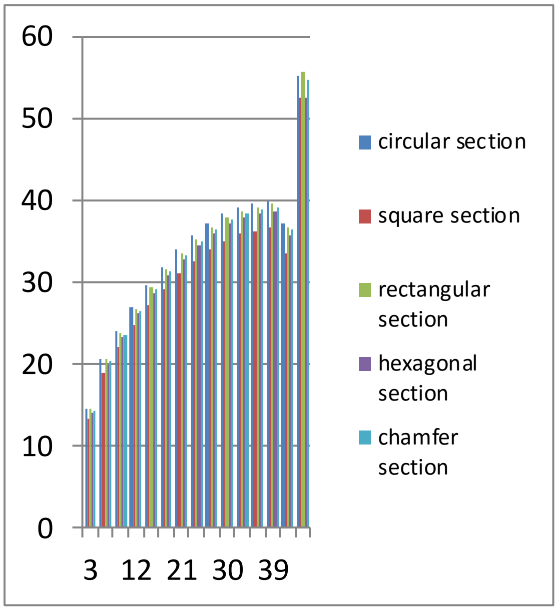

Fig. 14: Bending Moment (KN-mm) for Column No. 4

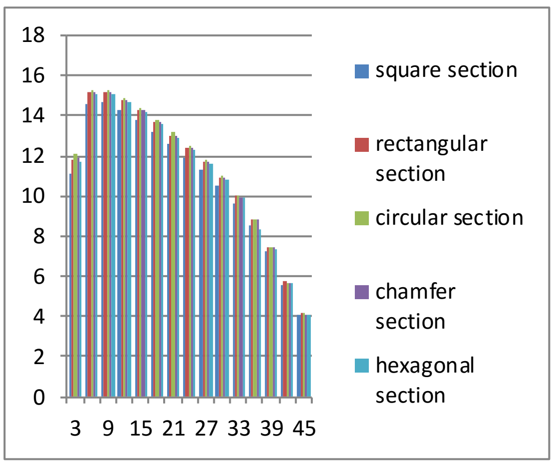

Fig.15: Bending Moment (KN-mm) for Column No. 5

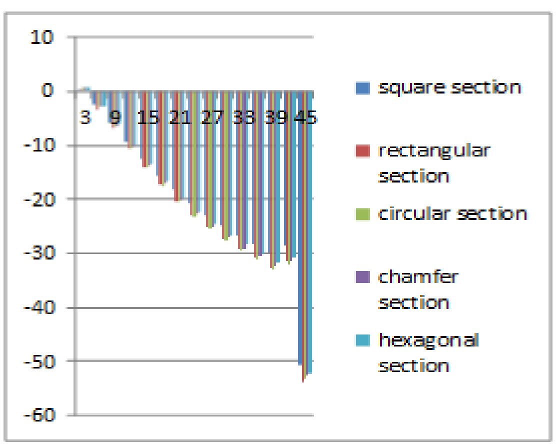

Fig.16: Bending Moment (KN-mm) for Column No. 6

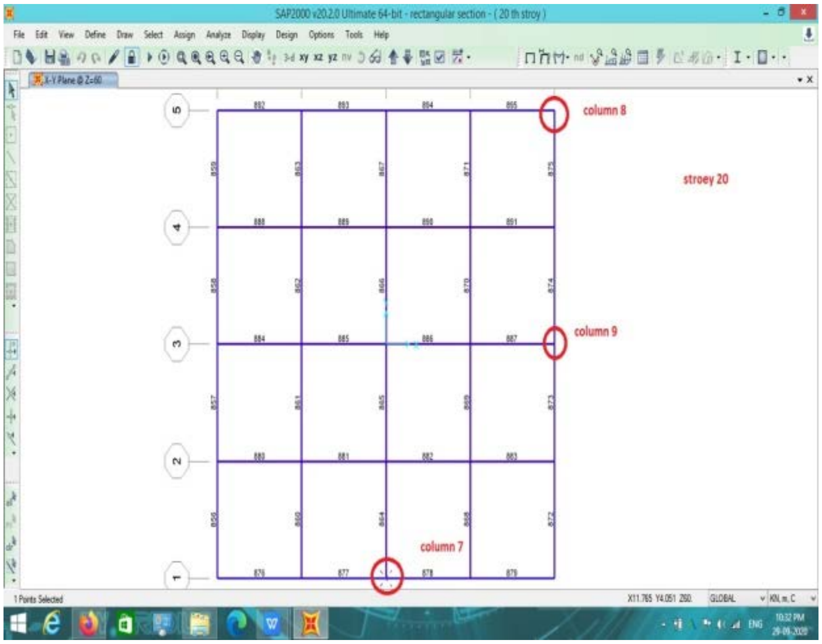

Fig. 17: Top View of 20-Storey Model

Graphical Representation of Bending Moment of 20-Storey Model

On X-axis plot storey height (m) and on Y-axis bending moment (KN-mm)

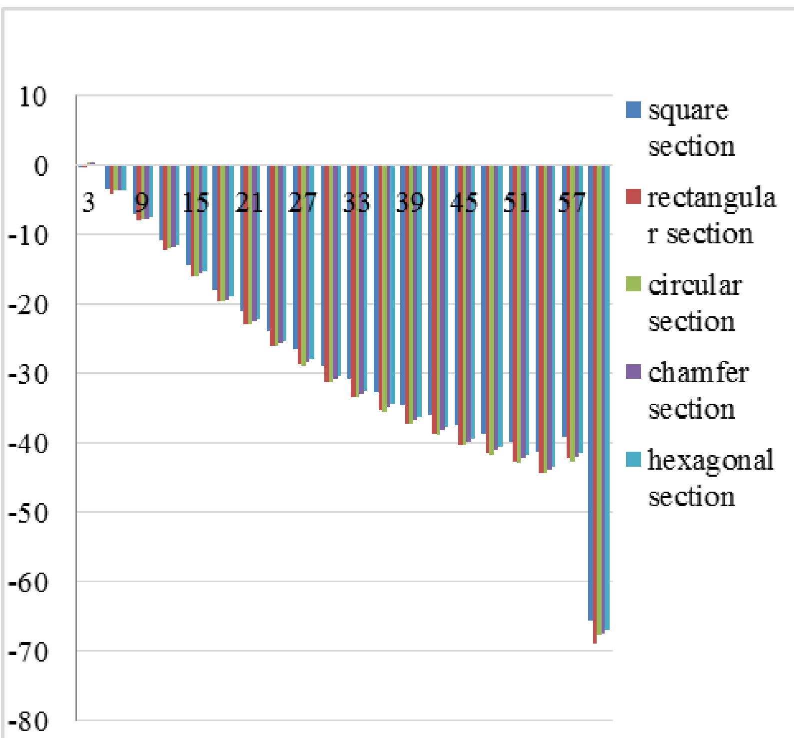

Fig.18: Bending Moment (KN-mm) for Column No. 8

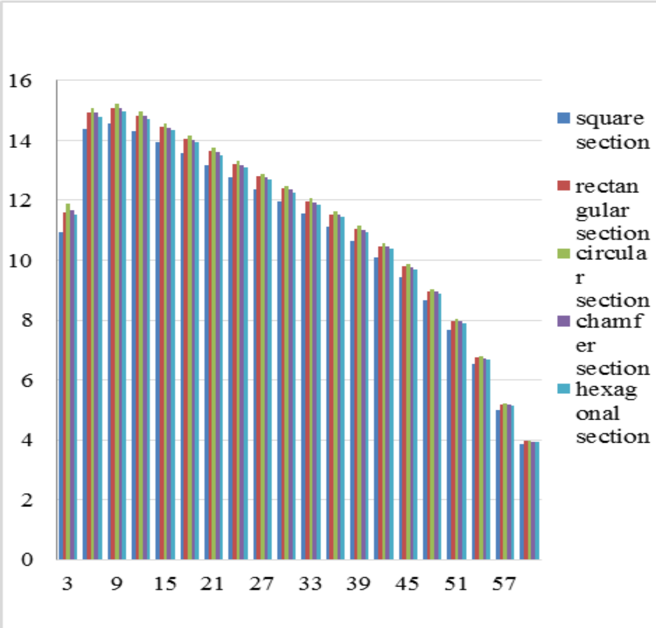

Fig. 19: Bending Moment (KN-mm) for Column No. 7

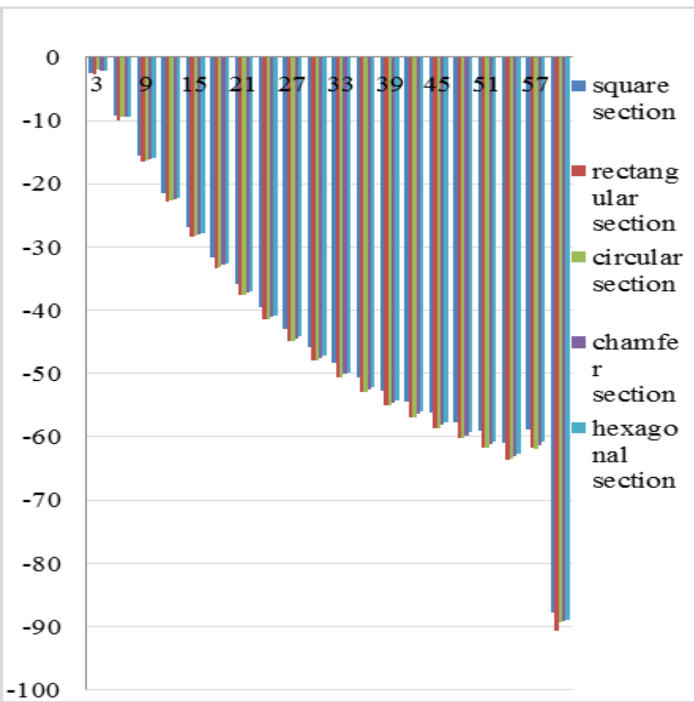

Fig. 20: Bending Moment (KN-mm) for Column No. 9

Graphical Representation of 10th Storeys Model- Storey Displacement

On X-axis plot storey height (m) and on Y-axis storey displacement (mm)

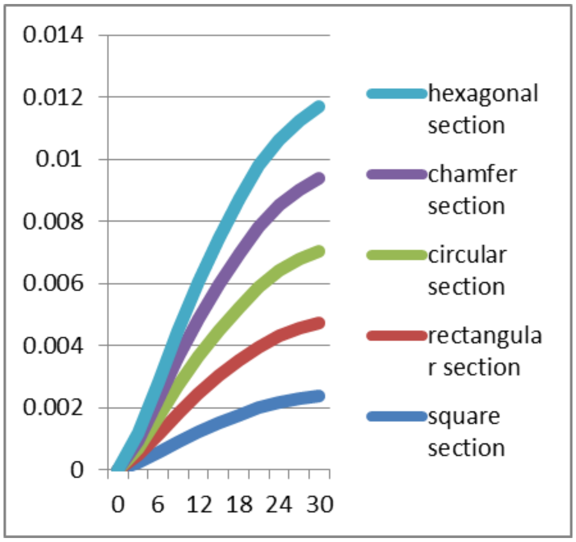

Fig. 21: 10th Storeys Model- Storey Displacement (mm) for Different Sections

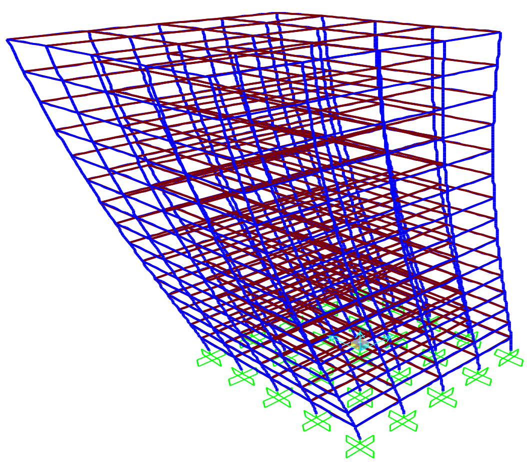

Fig. 22: Deformed shape of 15-Storey Model

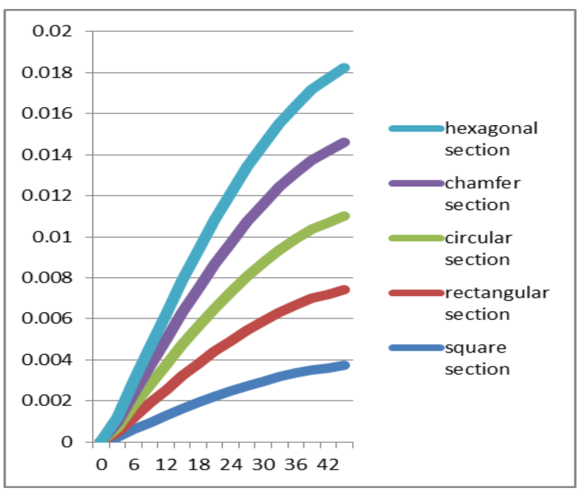

Fig. 23: 15th Storeys Model- Storey Displacement (mm) for Different Sections

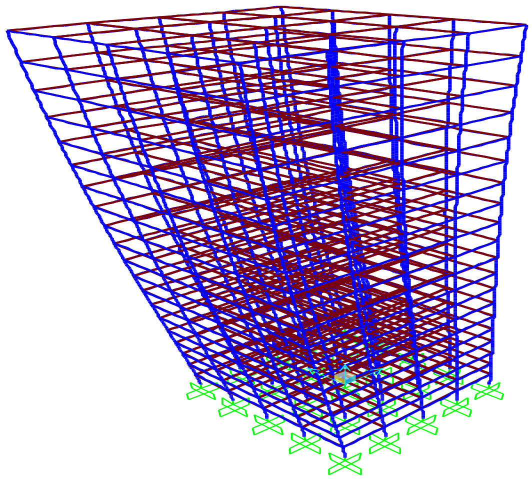

Fig. 24: Deformed shape of 20-Storey Model

Graphical Representation of 20th Storeys Model- Storey Displacement

On X-axis plot storey height (m) and on Y-axis storey displacement (mm)

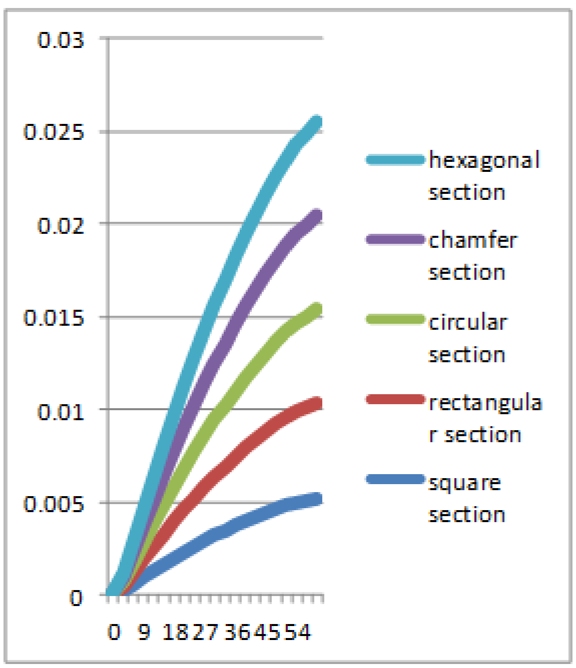

Fig. 25: 20th Storeys Model- Storey Displacement (mm) for Different Sections

Graphical Representation of Storey Drift (mm) for 10th Storey Model

On X-axis plot storey height (m) and on Y-axis storey drift (mm)

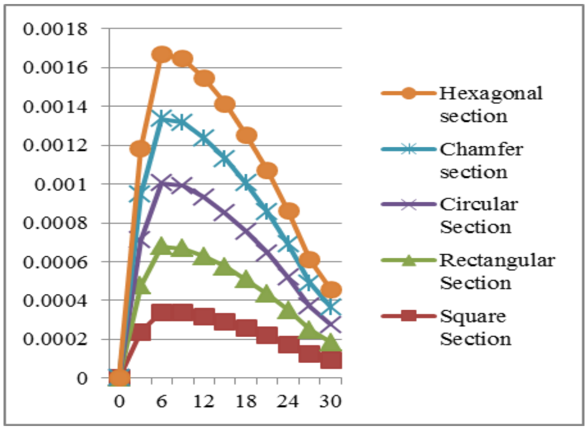

Fig. 26: 10th Storey Drift for Different Sections

Graphical Representation of Storey Drift (mm) for 15th Storey Model

On X-axis plot storey height (m) and on Y-axis storey drift (mm)

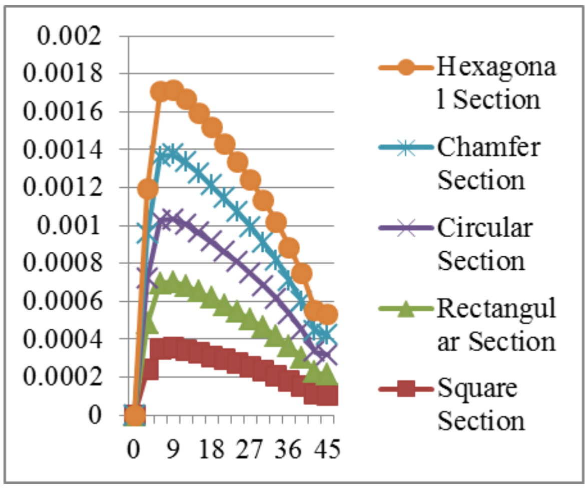

Fig. 27: 15th Storey Drift for Different Sections

Graphical Representation of Storey Drift (mm) for 20th Storey Model

On X-axis plot storey height (m) and on Y-axis storey drift (mm)

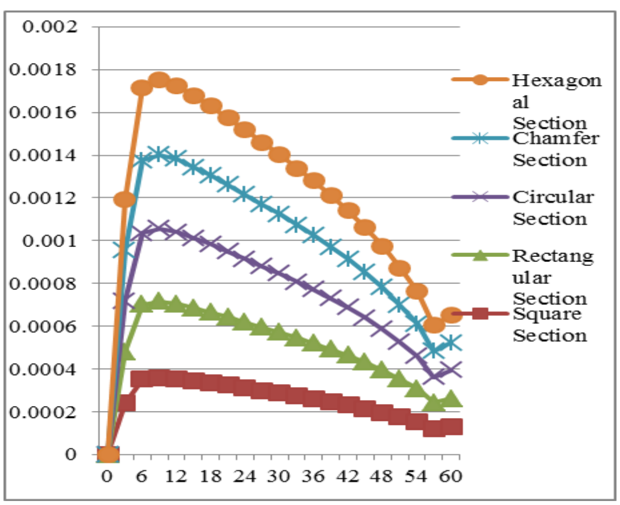

Fig.28: 20th Storey Drift for Different Sections

Comparative Analysis

On Y-axis storey drift (mm)

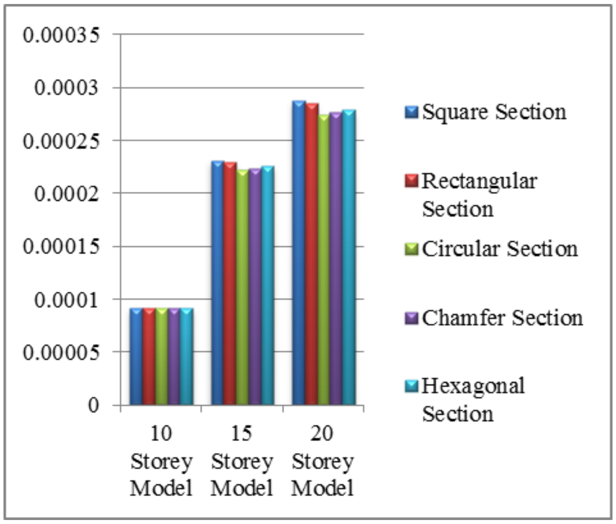

Fig. 29: Storey Drift (mm) at 10th Storey for 10, 15, and 20 Storey Models

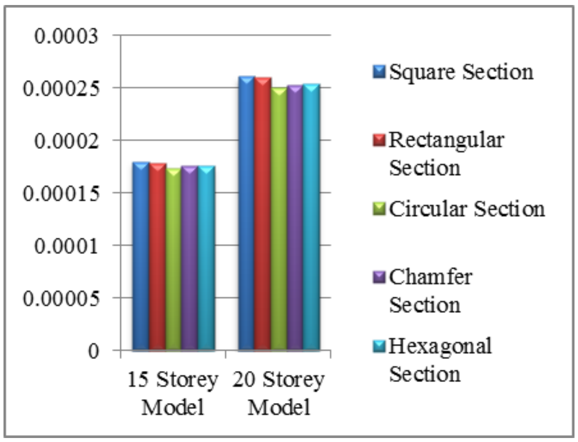

Fig.30: Storey Drift at 12th Storey for 15, and 20 Storey Models

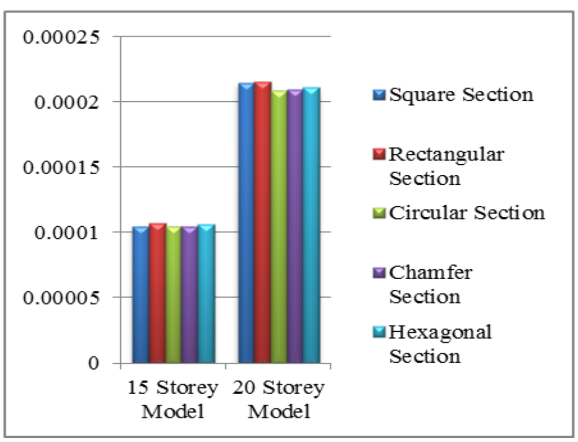

Fig. 31: Storey Drift at 15th Storey for 15, and 20 Storey Models

Graphical Representation of Base Shear for 10 Storey Model

On x-axis type of section and On Y-axis Base shear (KN)

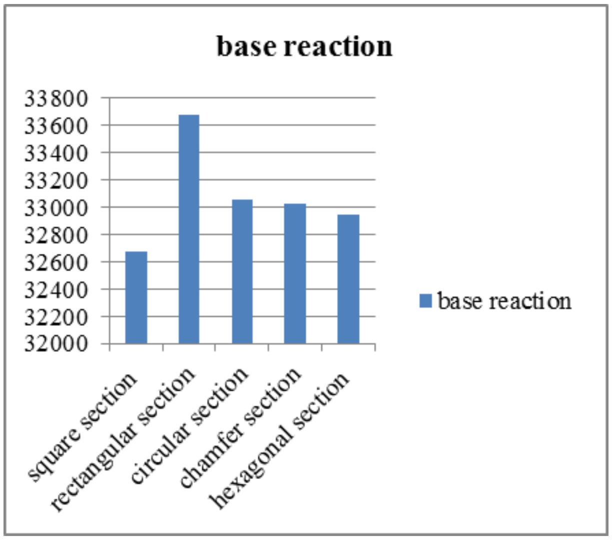

Fig. 32: Base Shear for 10-Storey Model in Z-Direction Due to Dead Load

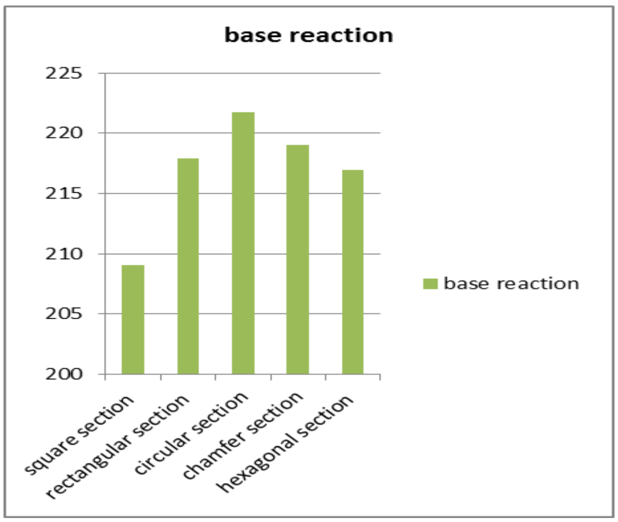

Fig. 33: Base Shear for 10-Storey Model in X-Direction Due to Load Combination

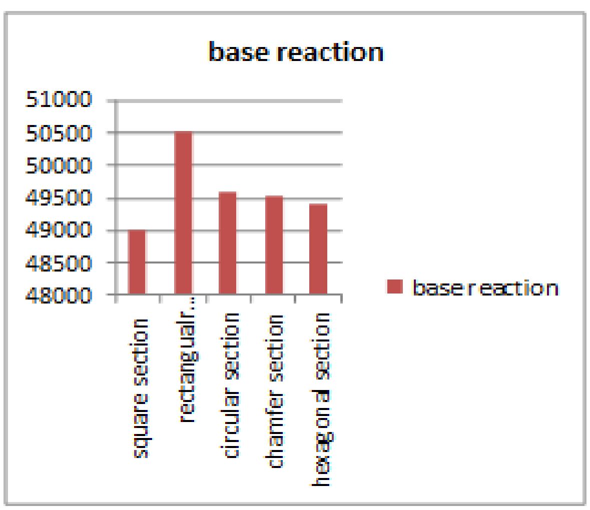

Fig.34: Base Shear for 10-Storey Model in Z-Direction Due to Load Combination

Graphical Representation of Base Shear for 15 Storey Model

On x-axis type of section and On Y-axis Base shear (KN)

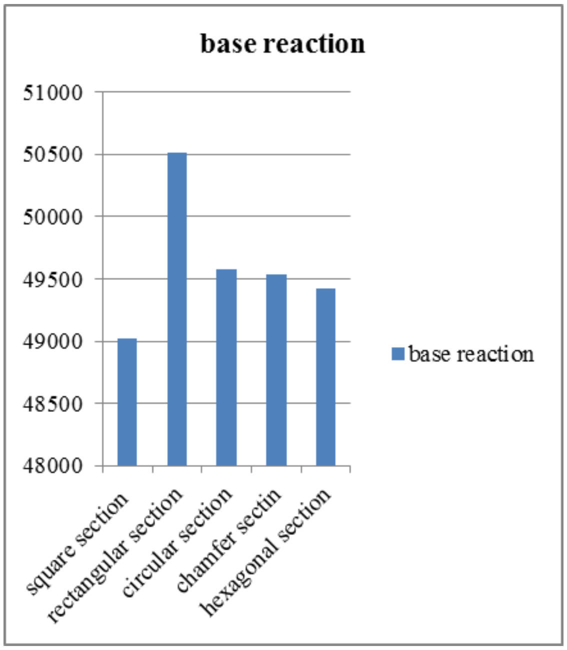

Fig. 35: Base Shear for 15-Storey Model in Z-Direction Due to Dead Load

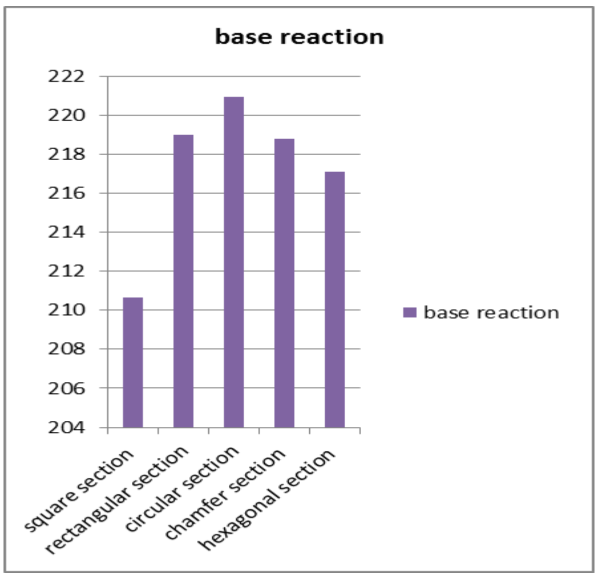

Fig. 36: Base Shear for 15-Storey Model in X-Direction Due to Load Combination

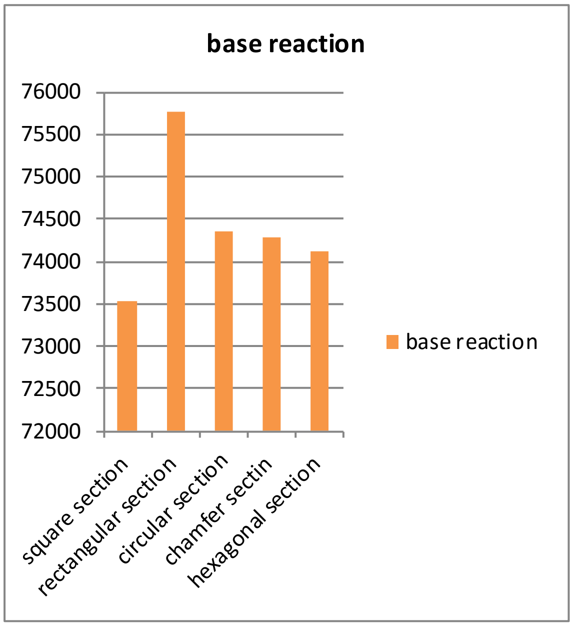

Fig. 37: Base Shear for 15-Storey Model in Z-Direction Due to Load Combination

Graphical Representation of Base Shear for 20 Storey Model

On x-axis type of section and On Y-axis Base shear (KN)

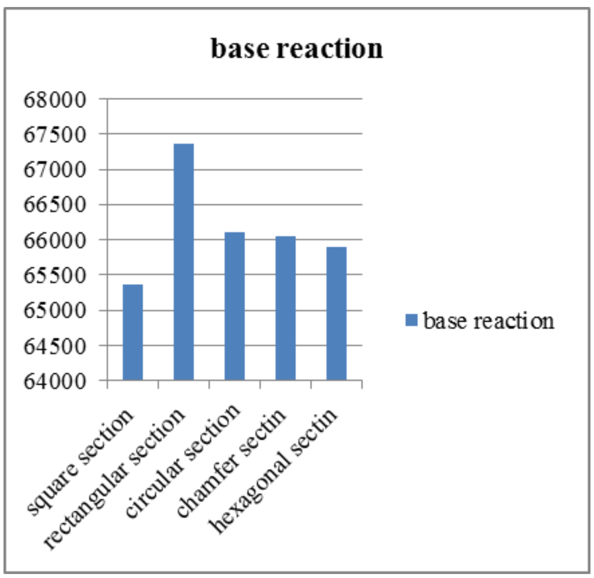

Fig. 38: Base Shear for 20-Storey Model in Z-Direction Due to Dead Load

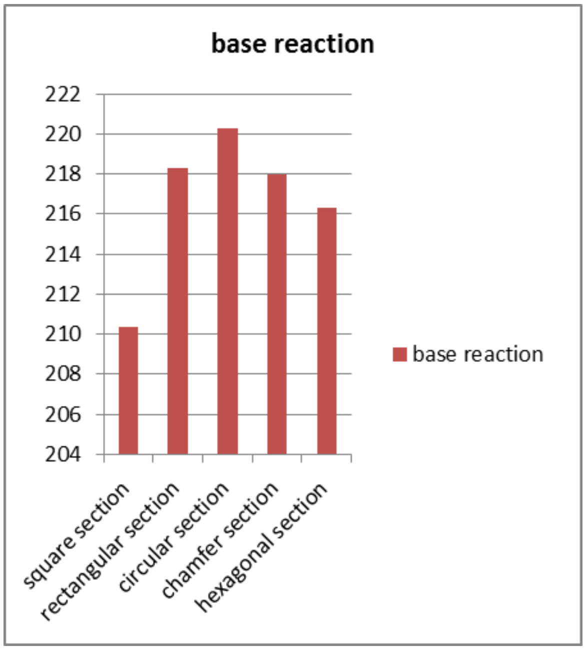

Fig. 39: Base Shear for 20-Storey Model in X-Direction Due to Load Combination

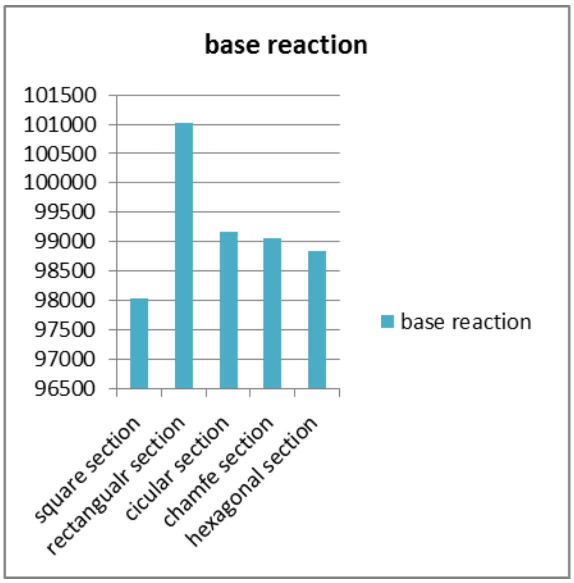

Fig. 40: Base Shear for 20-Storey Model in Z-Direction Due to Load Combination

Conclusion

- In this study bending moment, base shear, storey displacement, storey drift due to dead load and earthquake load is considered for each section.
- The comparison is made with all 5different type of cross-section condition of beam.

Bending Moment Results

- Bending Moment is Maximum for circular cross-section.
- Bending Moment is Minimum for square case and its value increases continuously for change in cross section property.

- Bending Moment for columns on outer boundary increases continuously with increase in height of model.
- Bending Moment for columns on center of model initially increase upto height 3m and after this decreases with increase in height of model.

Base Shear Results

10-Storey Model

- Base shear for 10-storey Model in z-direction due to dead load maximum in rectangular section.
- Base Shear for 10-Storey Model in X-Direction Due to Load Combination maximum in circular section.
- Base Shear for 10-Storey Model in Z-Direction Due to Load Combination maximum in rectangular section.

15-Storey Model

- Base shear for 15-storey model in z-direction due to dead load maximum in rectangular section.
- Base Shear for 15-Storey Model in X-Direction Due to Load Combination maximum in circular section.
- Base Shear for 15-Storey Model in Z-Direction Due to Load Combination maximum in rectangular section.

20-Storey Model

- Base shear for 20-storey model in z-direction due to dead load maximum in rectangular section.
- Base Shear for 20-Storey Model in X-Direction Due to Load Combination maximum in circular section.
- Base Shear for 20-Storey Model in Z-Direction Due to Load Combination maximum in rectangular section.

Storey Displacement

- Storey Displacement increase with storey height.
- Maximum storey displacement occurs in hexagonal and minimum in square section.

Stroey Drift

- Storey drift initially increase for some height and after that suddenly decrease with respect to height of storey.
- Maximum storey drift occur upto 6m height in hexagonal and minimum in square section.

Future Scope of the Work

- Model can be further examined for stresses by using finite element method.
- Geometry of section can be considered with different parameters like variation in thickness of top & bottom slabs, depth of section, and number of cells.
- Parametric study with different curvature can be done along with different cases considered in this study.

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