RESEARCH ARTICLE OPEN ACCESS

Evaluation of Effect of Lateral Forces on Multi-Storeyed Rcc Frame by Considering Eccentricities of column loads.

Dr. S. S. Patil*, Yash S Sale**
*Professor (Head of Department of Civil Engineering, Walchand Institute of Technology, Solapur, Maharashtra, India)
**Post Graduate Student (Department of Civil Engineering, Walchand Institute of Technology, Solapur, Maharashtra, India)

ABSTRACT
Reinforced concrete column with varying cross-sectional dimensions are commonly used in many engineering structures since use of such elements in a structural system may reduce the weight of the system, since neither axial load nor stiffness is constant along the column height the stability analysis of a stepped column is usually more complicated than that of a uniform column. The lateral forces can produce critical stresses in the structure, induce undesirable vibrations or cause excessive lateral sway of the structure. The present study deals with the comparison of Concentric Non-Prismatic columns and Stepped columns under the effect of static, wind and dynamic loads with the help of ETABS Software.
Keywords – Non- Prismatic Columns, Stepped Columns, Displacement, Inter-Storey Drift, Base Shear.

I. INTRODUCTION

A Multi-Storeyed Building is a structure with multiple floors above ground. From a structural engineer's point of view a multi-storeyed building can be defined as one that, by virtue of its height, is affected by lateral forces due to wind or earthquake or both to an extent that they play an important role in the structural design

In contrast to the vertical load, the lateral load effects on buildings are quite variable and increases rapidly with increase in height. Most lateral loads are live loads whose main component is horizontal force acting on the structure. Typical lateral loads are wind load, earthquake load. Most lateral loads vary in intensity depending on the buildings, geographic location, structural material, height, shape and size.

A column forms a very important component of structure. Columns support beams which in turn support walls and slabs. It should be realized that the failure of a column results in the collapse of the structure. Reinforced concrete columns whether in building structures or civil works are subjected to combined axial loads and uniaxial or biaxial bending or both due to their position in the structure, their shape of the section or nature of the external actions. Moreover depending on the load distribution and the support condition at its ends, the eccentricities of axial load applied at the ends can be equal in direction, dimension and orientation, or unequal in direction, dimension and orientation.

The purpose of this work is to study the behaviour of the column under the effect of lateral forces in different cases such as concentric non-prismatic columns and stepped columns. The details of the structure are shown as below.

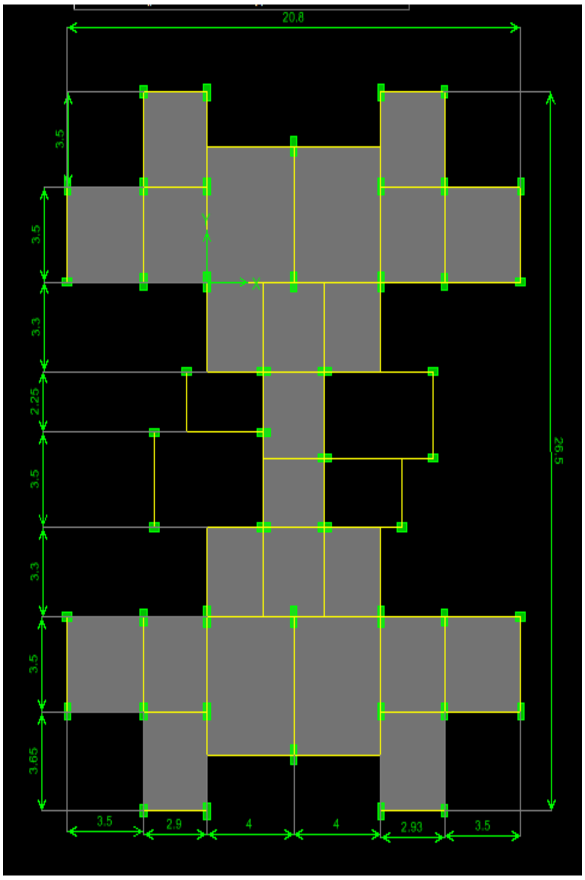


Fig. 1 Plan of the structure.

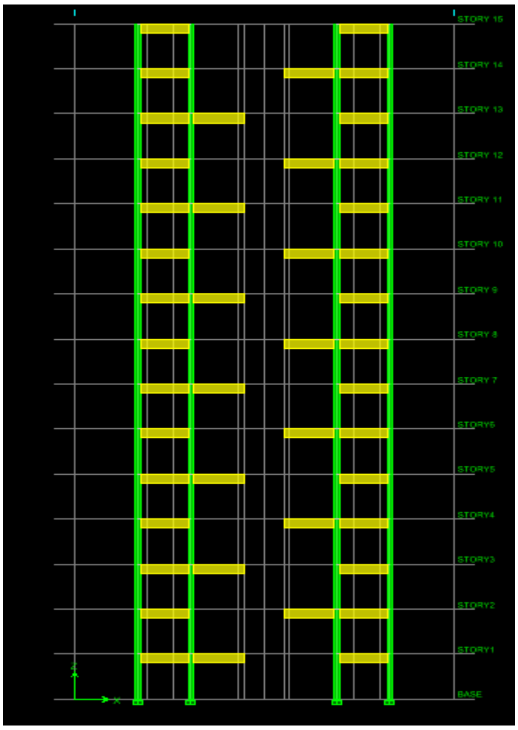


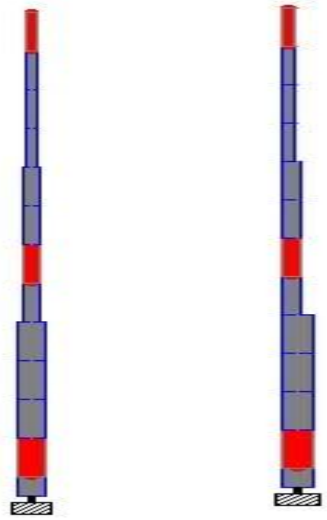
Fig. 2 Elevation of the structure.

II. MATHEMATICAL FORMULATION

A (G+14) RCC structure has been considered for Analysis.

Table 1 Data for Analysis

Plan dimension	20m x 26m
Height of each Storey	3m
Slab thickness	150 mm
Wall Thickness	230 mm
Live Load	3 kN/m^2
Grade of Conc.	30 N/mm^2
Grade of Steel	500 N/mm^2
Location	Solapur city
Seismic Zone	III
Importance Factor	1
Type of Soil	Rock or Hard Soil
Damping Ratio	5 %
Earthquake load	As per IS-1893 (Part 1) - 2002
Basic Wind Speed	39 m/s
Terrain Category	3
Structure Class	B
Wind load	As per IS-875 (Part 3) - 1987



Case A Case B

Fig.3 Case A) Concentric Non- Prismatic Columns
Case B) Stepped Columns

The following results were obtained for the Multi-storeyed RCC structure under the effect of Earthquake Forces (EQ) and Wind Load (WL).

Table 2 Variation of Displacement (EQ)

DISPLACEMENT (mm)		
STOREY NO.	CASE A: Concentric Non-Prismatic Columns	CASE B: Stepped Columns
15	15.58	15.75
14	15.08	15.26
13	14.33	14.53
12	13.36	13.57
11	12.34	12.57
10	11.19	11.45
9	9.94	10.20
8	8.71	8.961
7	7.44	7.69
6	6.14	6.36
5	4.90	5.08
4	3.67	3.83
3	2.48	2.58
2	1.40	1.43
1	0.48	0.49

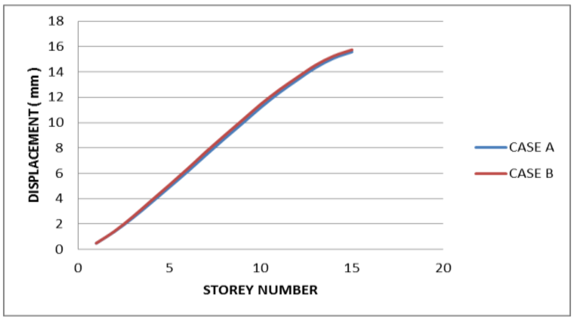


Fig. 4 Graph for Displacement v/s Storey Number (EQ)

Table 3 Variation of Drift (EQ)

DRIFT (mm)		
STOREY NO.	CASE A: Concentric Non-Prismatic Columns	CASE B: Stepped Columns
15	0.49	0.49
14	0.75	0.73
13	0.97	0.96
12	1.02	1
11	1.15	1.12
10	1.25	1.25
9	1.23	1.23
8	1.27	1.27
7	1.3	1.33
6	1.24	1.27
5	1.23	1.255
4	1.19	1.25
3	1.08	1.15
2	0.92	0.94
1	0.48	0.49

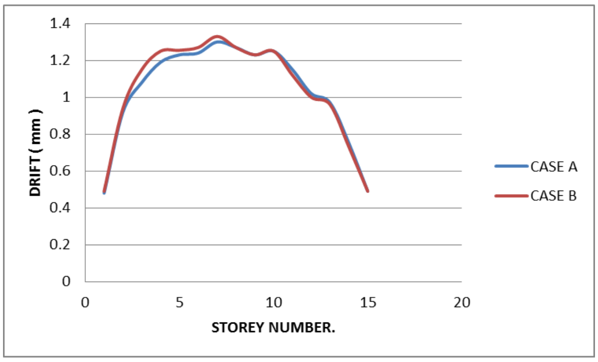


Fig. 5 Graph for Drift v/s Storey Number (EQ)

Table 4 Variation of Column Axial Force (EQ)

AXIAL FORCE (KN)		
Column	CASE A: Concentric Non-Prismatic Columns	CASE B: Stepped Columns
Corner column	2931.25	2927.23
Side column	4485	4484.71
Inner column	6499.48	6497.7

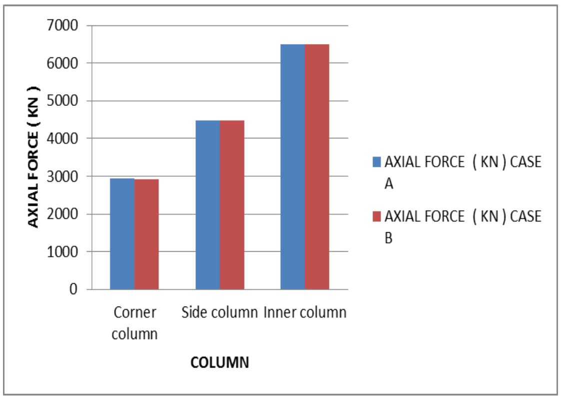


Fig. 6 Graph for Column Axial Load (EQ)

Table 5 Variation of Column Moments (EQ)

COLUMN MOMENTS (KN-m)		
Column	CASE A: Concentric Non-Prismatic Columns	CASE B: Stepped Columns
Corner column	65.4	90.1
Inner column	42.4	61.02
Side column	25.58	39.93

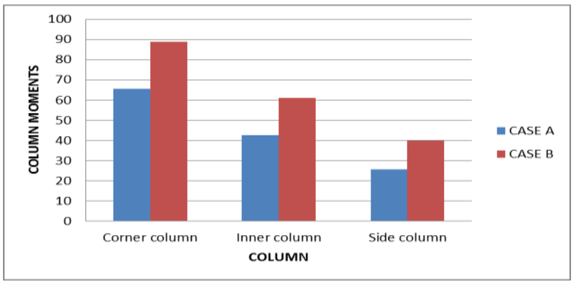


Fig. 7 Graph for Column Moments (EQ)

Table 6 Variation of Base Shear (EQ)

BASE SHEAR (KN)	
CASE A: Concentric Non-Prismatic Columns	CASE B: Stepped Columns
892.31	892.62

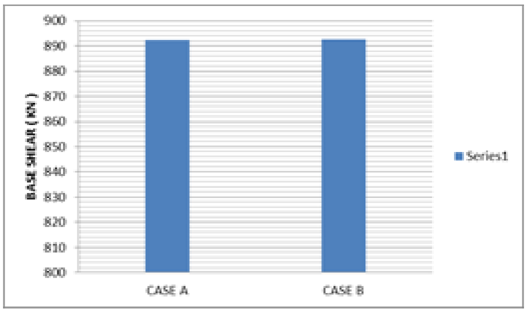


Fig. 8 Graph for Base Shear (EQ)

Table 7 Variation of Displacement (WL)

DISPLACEMENT (mm)		
STOREY NO.	CASE A Concentric Non - Prismatic Column	CASE B Stepped Column
15	18.8678	19.08
14	18.4486	18.67
13	17.8106	18.0464
12	16.9444	17.1841
11	15.9745	16.2217
10	14.8319	15.0998
9	13.5183	13.7796
8	12.1541	12.4028
7	10.6639	10.9215
6	9.0529	9.2806
5	7.4261	7.6127
4	5.7246	5.8926
3	3.9778	4.081
2	2.3221	2.3484
1	0.8288	0.832

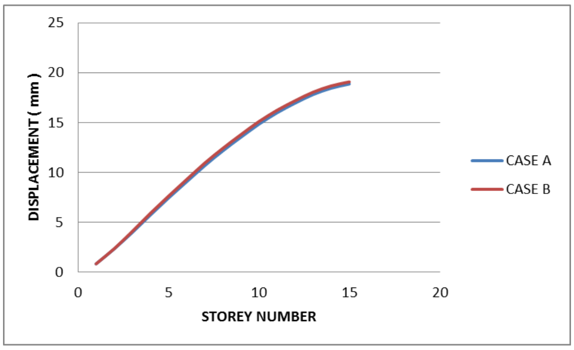


Fig. 9 Graph for Displacement (WL)

Table 8 Variation of Drift (WL)

DRIFT (mm)		
STOREY NO.	CASE A Concentric Non - Prismatic Column	CASE B Stepped Column
15	0.41	0.41
14	0.63	0.62
13	0.86	0.86
12	0.96	0.96
11	1.14	1.12
10	1.31	1.32
9	1.36	1.37
8	1.49	1.48
7	1.61	1.64
6	1.62	1.66
5	1.7	1.72
4	1.74	1.81
3	1.65	1.73
2	1.49	1.51
1	0.82	0.83

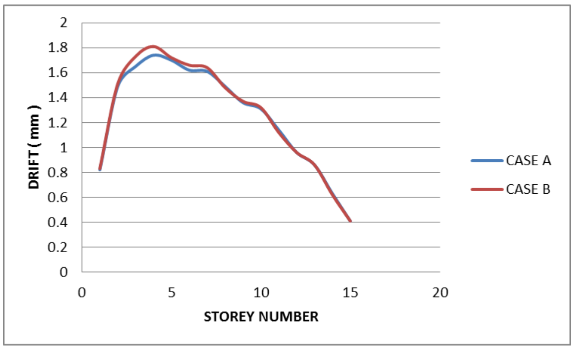


Fig. 10 Graph for Drift (WL)

Table 9 Variation of Axial Force (WL)

AXIAL FORCE (KN)		
COLUMN	CASE A CONCENTRIC NON - PRISMATIC COLUMN	CASE B STEPPED COLUMN
Corner Column	2953.57	2951.93
Side Column	4499.87	4498.85
Inner Column	6501.46	6500.75

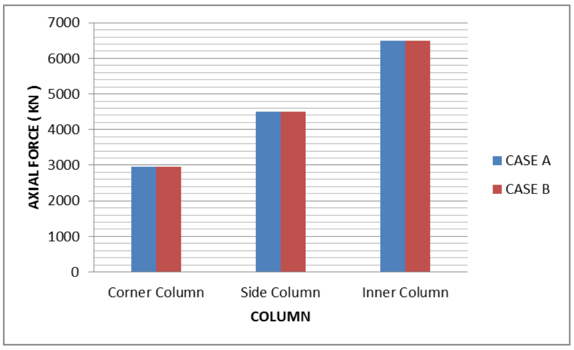


Fig.11 Graph for Axial Force (WL)

Table 10 Variation of Column Moments (WL)

COLUMN MOMENTS (KN-m)		
COLUMN	CASE A CONCENTRIC NON - PRISMATIC COLUMN	CASE B STEPPED COLUMN
Corner Column	64.05	92.13
Inner Column	63.55	89.21
Side Column	44.06	73.01

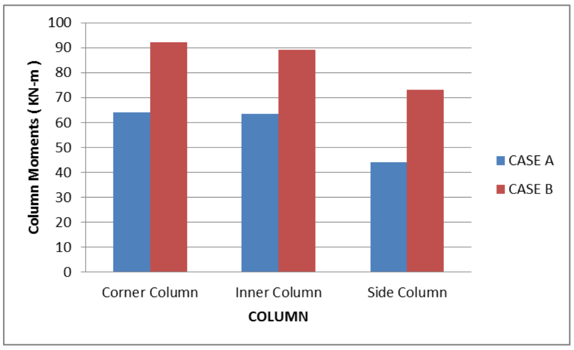


Fig. 12 Graph for Column Moments (WL)

Table 11 Variation of Base Shear (WL)

BASE SHEAR (KN)	
CASE A Concentric Non - Prismatic Column	CASE B STEPPED COLUMN
1586.58	1586.58

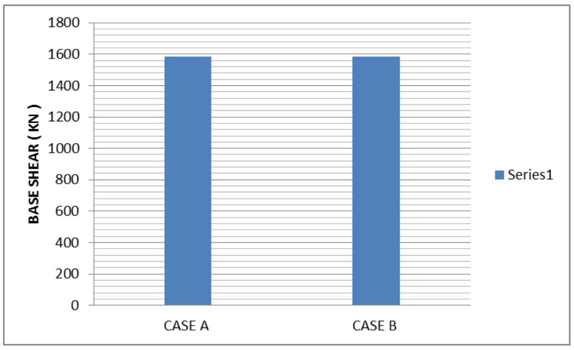


Fig. 13 Graph for Base Shear (WL)

III. CONCLUSION

[1] Displacement of Concentric Non- Prismatic Columns under the effect of Earthquake Forces is similar to that of Stepped Columns.

[2] Inter-Storey Drift of Concentric Non-Prismatic Columns under the effect of Earthquake Forces is similar to that of Stepped Columns.

[3] Column Axial Force of Concentric Non-Prismatic Columns under the effect of Earthquake Forces is similar to that of Stepped Columns.

[4] Moments of corner column of Stepped Columns under the effect of Earthquake Forces increased by 38% as compared to Concentric Non – Prismatic Columns.

[5] Moments of inner column of Stepped Columns under the effect of Earthquake Forces increased by 44% as compared to Concentric Non – Prismatic Columns.

[6] Moments of side column of Stepped Columns under the effect of Earthquake Forces increased by 56% as compared to Concentric Non – Prismatic Columns.

[7] Base Shear for Concentric Non- Prismatic Columns under the effect of Earthquake Forces is similar to that of Stepped Columns.

[8] Displacement of Concentric Non- Prismatic Columns under the effect of Wind Load is similar to that of Stepped Columns.

[9] Inter-Storey Drift of Concentric Non-Prismatic Columns under the effect of Wind Load is similar to that of Stepped Columns.

[10] Column Axial Force of Concentric Non-Prismatic Columns under the effect of Wind Load is similar to that of Stepped Columns.

[11] Moments of corner column of Stepped Columns under the effect of Wind Load increased by 44% as compared to Concentric Non – Prismatic Columns.

[12] Moments of inner column of Stepped Columns under the effect of Wind Load increased by 40% as compared to Concentric Non – Prismatic Columns.

[13] Moments of side column of Stepped Columns under the effect of Wind Load increased by 66% as compared to Concentric Non – Prismatic Columns.

[14] Base Shear for Concentric Non- Prismatic Columns under the effect of Wind Load is similar to that of Stepped Columns.

[15] The values of Displacement, Drift, Column Moments and Base Shear under the effect of Wind Load increased as compared to the Earthquake Forces.

REFERENCES

Journal Papers:

[1] Anibal A. Manzelli, I. E. Harik, "Prismatic And Nonprismatic Slender Columns And Bridge Piers", *American Society of Civil Engineers, 09/23/14.*

[2] Nasreddin El-Mezaini, Can Balkaya, Ergin Citipitioglu, "Analysis Of Frames With Nonprismatic Members", *American Society of Civil Engineers, 09/23/14.*

[3] Sekhar Chandra Dutta, Prithwish Kumar Das, Rana Roy, "Seismic Behavior of Code-Designed Bidirectionally Eccentric Systems", *American Society of Civil Engineers, 10.1061/(ASCE)0733-9445(2005)131:10(1497)*

[4] Jaime De-la-Colina, Bernardino Benítez, and Sonia E. Ruiz, "Accidental Eccentricity of Story Shear for Low-Rise Office Buildings", *2011 American Society of Civil Engineers, 10.1061/(ASCE)ST.1943-541X.0000302.*

IS Codes:

[1] IS 456:2000, "Indian Standard code of practice for Plain and Reinforced concrete", *Bureau of Indian Standards, New Delhi, India.*

[2] SP 16, "DESIGN AIDS FOR REINFORCED CONCRETE TO IS: 456-l 978", *Bureau of Indian Standards, New Delhi, India.*

[3] IS 875(part1 to 5):1987, "Code of Practice for design loads for buildings and structures", *Bureau of Indian Standards, New Delhi, India.*

[4] IS 1893 (Part 1): 2002, "Criteria For Earthquake Resistant Design Of Structures", *Bureau of Indian Standards, New Delhi, India.*

Books:

[1] H. J. Shah, S. B. Junnarkar, *Strength of materials*

[2] Pankaj Agarwal, Manish Shrikhande, *Earthquake resistant design of structures.*

[3] S. Ramamrutham, *Design of reinforced concrete structures.*

Miscellaneous:

[1] Dr. H. J. Shah, Dr. Sudhir K Jain, "Design of Six-Storey Building".

[2] Carlo A. Castiglioni, "Stepped Columns: A Simplified Design Method"