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Seismic Performance of High-Rise Building with Inclined Column Using ETABS

Anant Patel[1*], Arjun M. Butala[2]
[1]*Student, Department of Civil Engineering, U. V. Patel College of Engineering, Gujarat, India*
[2]*Assistant Professor, Department of Civil Engineering, U. V. Patel College of Engineering, Gujarat, India*

***Abstract*: Its new trend to Construction of Twisted, Tapered and Tilted Building for Architectural view. Column cannot be vertical so, its need to be inclined at some angle of its specified line. Before implementing this technique, it is important to investigate it in depth and determine the output of such a structure under seismic loading. This project is an attempt to study the performance of building having inclined columns of different angles and to compare a result with Conventional building by response spectrum analysis using ETABS software.**

***Keywords*: Inclined column, seismic load, angle of inclination, response spectrum analysis, ETABS**

1. Introduction

Columns are frequently used to support beams or arches on which the upper parts of walls or ceilings rest. In architecture, "column" refers to such a structural element that also has certain proportional and decorative features. Nowadays, it is a new trend of architecture and structural engineering that many tall buildings on all over the world have a complex shape such as twisted, tapered and tilted. Those buildings are regarded as landmarks of a nation and symbols of technological achievement. The complex-shaped tall building disassembles the orthogonality between beams and columns. Especially, such type of structural system can be found frequently in buildings having inclined columns. The inclined columns can transmit the gravity and lateral load simultaneously, and are necessary to display the architectural complexity. This study focuses on the seismic performance of the building with inclined column of different angles at different height and to know how much variations are there in different parameters like storey displacement, Story drift and storey stiffness.

2. Objective

- To Study a result of Building with different angle of inclination of inclined column.
- To compare a result of Circular inclined column with square inclined column.
- Compare a result of inclined column at different storey level using ETABS Software.

3. Scope

- To optimize angle and shape of inclined column.
- Provide review for analyzing a High rise building with inclined column.

4. Methodology

The methodology of this study to comparison of RCC building with inclined column and conventional RCC building under seismic load is observed. Here Multi storey building is taken and a different 3, 5˚,8˚,10˚,12˚ angle of inclination of inclined column used in buildings and compare a result like Story Displacement, Story Drift and Story Stiffness with conventional RCC building. The framed buildings are subjected to vibrations because of earthquake. Seismic analysis is essential for these building frames. The fixed base system is analyzed for High rise building frames in seismic zone III by Response spectrum analysis using ETABS software.

1) *Building Configuration*

Below Table-1 shows that description of Building which created for analysis.

2) *Loading Consideration*

- Live load: 3kN/m²
- Floor finish: 1kN/m²
- Seismic loading (IS 1893:2016)
- Zone factor: 0.16 (zone III)
- Medium soil
- Response reduction factor: 3
- Importance factor: 1

3) *Model Created*

Below table-2 shows that Notation of all Models which are created.

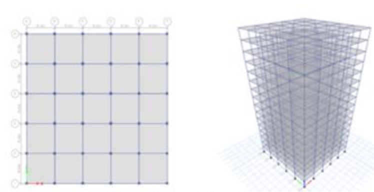

Fig. 1. Plan and Elevation of N

*Corresponding author: patelanant1997@gmail.com

Table 1
Building Description

Type of Frame	Ordinary Moment Resisting RC Frame (OMRF)
Seismic zones	III
Number of stories	G+15
Floor height	3.5m
Depth of slab	150mm
Size of beam	(450× 650) mm
Size of normal column (90 degree)	(450× 450) mm
Size of Inclined column	(450× 450) mm
Spacing between frames in X-direction	5m
Spacing between frames in Y-direction	5m
Materials	M30, Fe500
Dimension of building in X direction	25m
Dimension of building in Y direction	25m

Table 2
Notation of model

Notation	Description
NB	G+15 Story building with Normal column (Square)
3MH	G+15 Story building with 3˚ Column up to Mid-height
5MH	G+15 Story building with 5˚ Column up to Mid-height
8MH	G+15 Story building with 8˚ Column up to Mid-height
10MH	G+15 Story building with 10˚ Column up to Mid-height
12MH	G+15 Story building with 12˚ Column up to Mid-height
3TH	G+15 Story building with 3˚ Column up to Top-height
5TH	G+15 Story building with 5˚ Column up to Top-height
8TH	G+15 Story building with 8˚ Column up to Top-height
10TH	G+15 Story building with 10˚ Column up to Top-height
12TH	G+15 Story building with 12˚ Column up to Top-height
NBC	G+15 Story building with Normal column (Circular)
3MHC	G+15 Story building with 3˚Circular Column up to Mid height
5MHC	G+15 Story building with 5˚Circular Column up to Mid-height
8MHC	G+15 Story building with 8˚Circular Column up to Mid-height
10MHC	G+15 Story building with 10˚Circular Column up to Mid-height
12MHC	G+15 Story building with 12˚Circular Column up to Mid-height
3THC	G+15 Story building with 3˚Circular Column up to Top-height
5THC	G+15 Story building with 5˚Circular Column up to Top-height
8THC	G+15 Story building with 8˚Circular Column up to Top-height
10THC	G+15 Story building with 10˚Circular Column up to Top-height
12THC	G+15 Story building with 12˚Circular Column up to Top-height

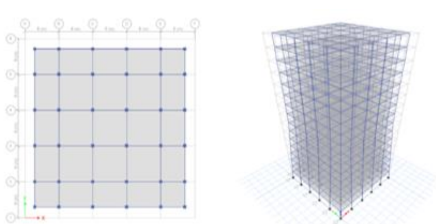

Fig. 2. Plan and Elevation of 3MH

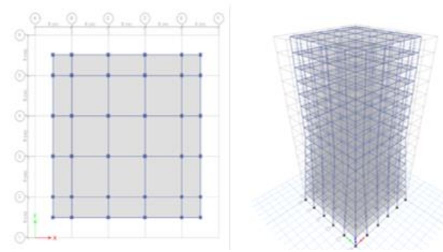

Fig. 3. Plan and Elevation of 5MH

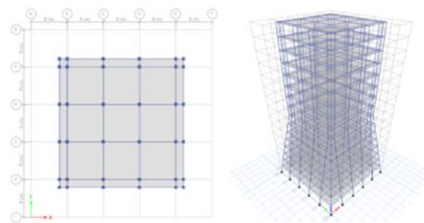

Fig. 4. Plan and Elevation of 8MH

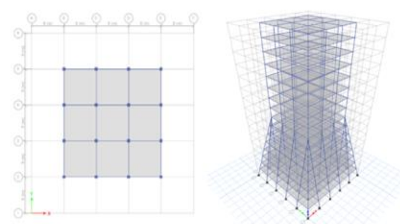

Fig. 5. Plan and Elevation of 10MH

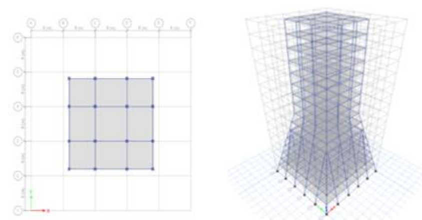

Fig. 6. Plan and Elevation of 12MH

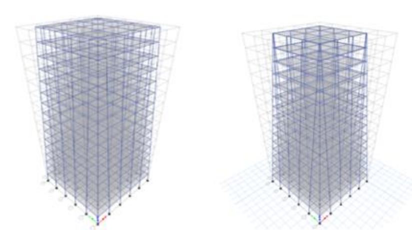

Fig. 7. Elevation of 3TH & 5TH

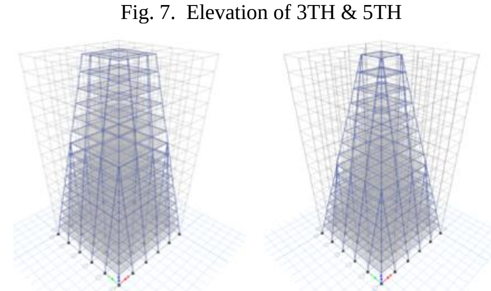

Fig. 8. Elevation of 8TH & 10TH

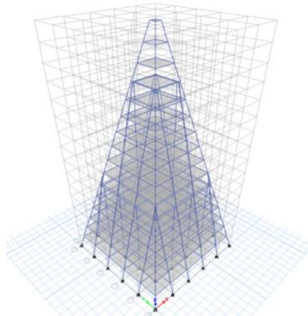

Fig. 9. Elevation of 12TH

5. Result and Discussion

1) Story Displacement

Below Table-3 shows that Max. Story Displacement for various models.

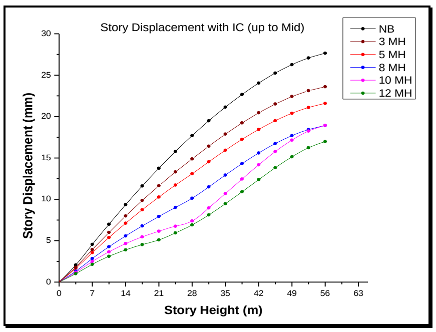

Fig. 10. Story Displacement of Buildings with IC (up to Mid-height)

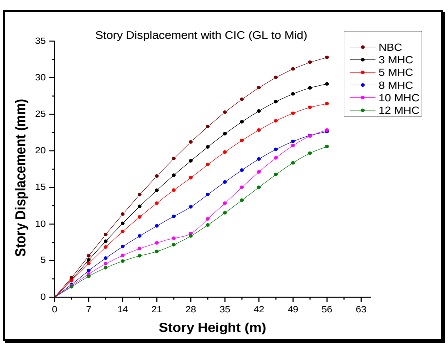

Fig. 11. Story Displacement of Buildings with CIC (up to Mid-height)

Below Fig-10 and Fig-11 Shows that Result of Story Displacement vs Story height of Buildings with different angles of IC and CIC up to Mid-height.

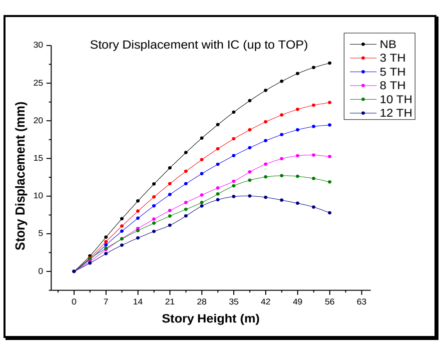

Fig. 12. Story Displacement of Buildings with IC (up to Top-height)

Table 3

Max. Story Displacement of various model

Model	Max. Story Displacement (mm)	Model	Max. Story Displacement (mm)
NB	27.649	NBC	32.762
3MH	23.602	3MHC	29.146
5MH	21.575	5MHC	26.453
8MH	18.917	8MHC	22.627
10MH	18.933	10MHC	22.841
12MH	16.983	12MHC	20.58
3TH	22.427	3THC	27.716
5TH	19.433	5THC	23.449
8TH	15.448	8THC	18.535
10TH	12.707	10THC	15.268
12TH	10.015	12THC	11.721

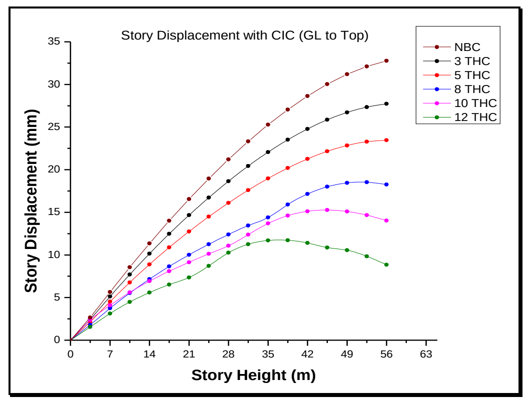

Fig. 13. Story Displacement of Building with CIC (up to Top-height)

Below Fig-12 and Fig-13 Shows that Result of Story Displacement vs Story height of Buildings with different angles of IC and CIC up to Top-height.

2) Story Drift

Below Table-4 shows that Max. Story Drift for various models.

Table 4

Max. Story Stiffness of various model

Model	Max. Story Stiffness (kN/m)	Model	Max. Story Stiffness (kN/m)
NB	702648.1	NBC	456726.1
3MH	805508.9	3MHC	481981.8
5MH	870507.3	5MHC	521281.8
8MH	1079585	8MHC	650627.4
10MH	1129260	10MHC	678071.3
12MH	1264295	12MHC	767493.9
3TH	804665.7	3THC	481757.2
5TH	900039	5THC	539766.5
8TH	1077328	8THC	645852.2
10TH	1035982	10THC	678805.9
12TH	1366991	12THC	802389.5

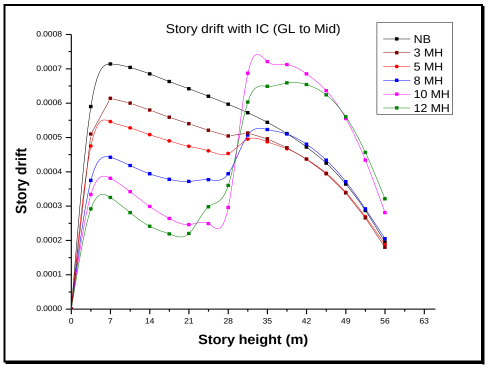

Fig. 14. Story Drift of Buildings with IC (up to Mid-height)

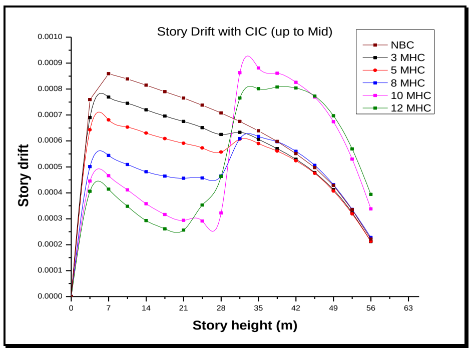

Fig. 15. Story Drift of Buildings with CIC (up to Mid-height)

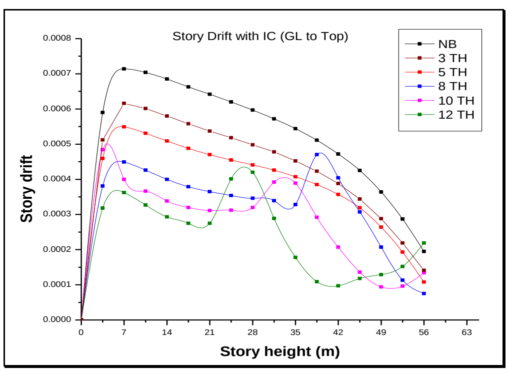

Fig. 16. Story Drift of Buildings with IC (up to Top-height)

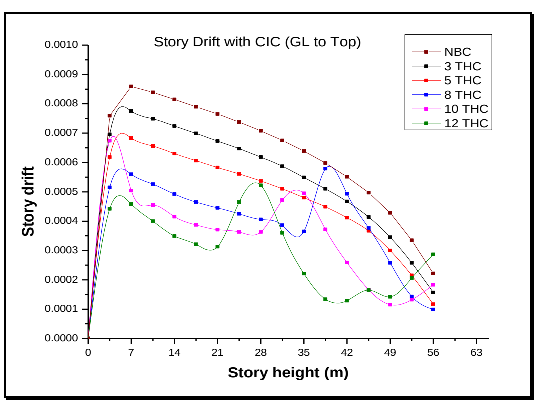

Fig. 17. Story Drift of Buildings with CIC (up to Top-height)

Below Fig-16 and Fig-17 Shows that Result of Story Drift vs Story height of Buildings with different angles of IC and CIC up to Top-height.

3) *Story Stiffness*

Below Table-5 shows that Max. Story stiffness for various models.

Table 5
Max. Story Stiffness of various model

Model	Max. Story Stiffness (kN/m)	Model	Max. Story Stiffness (kN/m)
NB	702648.1	NBC	456726.1
3MH	805508.9	3MHC	481981.8
5MH	870507.3	5MHC	521281.8
8MH	1079585	8MHC	650627.4
10MH	1129260	10MHC	678071.3
12MH	1264295	12MHC	767493.9
3TH	804665.7	3THC	481757.2
5TH	900039	5THC	539766.5
8TH	1077328	8THC	645852.2
10TH	1035982	10THC	678805.9
12TH	1366991	12THC	802389.5

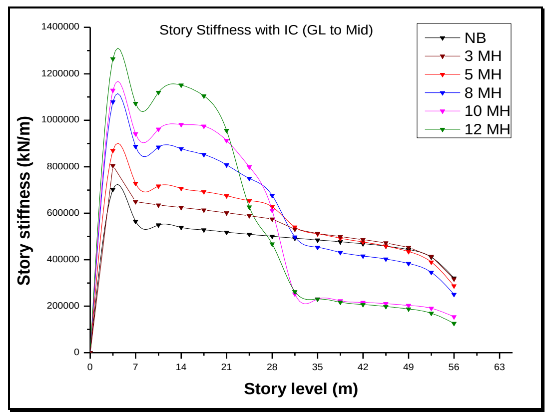

Fig. 18. Story Stiffness of Buildings with IC (up to Mid-height)

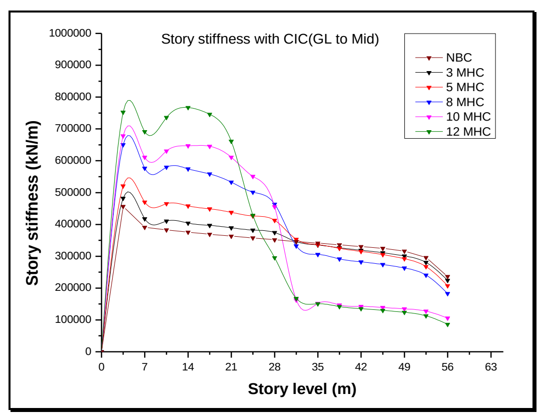

Fig. 19. Story Stiffness of Buildings with CIC (up to Mid-height)

Below Fig-20 and Fig-21 Shows that Result of Story Stiffness vs Story height of Buildings with different angles of IC and CIC up to Top-height.

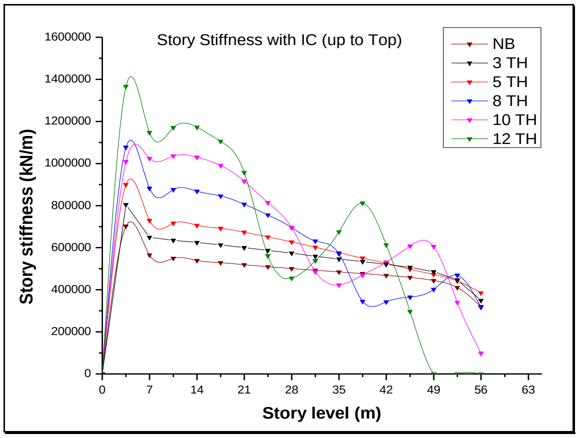

Fig. 20. Story Stiffness of Buildings with IC (up to Top-height)

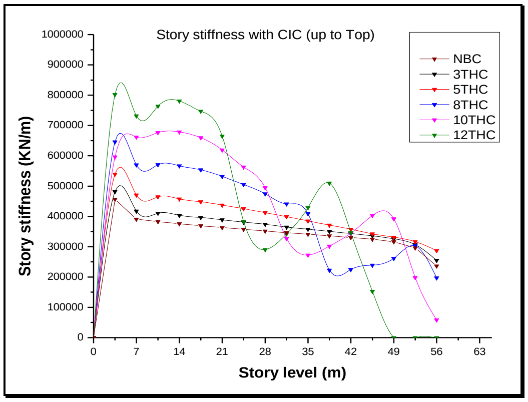

Fig. 21. Story Stiffness of Buildings with CIC (up to Top-height)

6. Conclusion

- Overall behavior of Building is studied. Inclined column is effective to controlling a Story drift and Story displacement of building under seismic Loading.
- Story displacement of model with inclined column 3˚,5˚,8˚,10˚ and 12˚ up to Mid-height decreased by 14%,21%,31%,31% and 38% Respectively than Normal column.
- Story displacement of model with inclined column 3˚,5˚ and 8˚provided from up to Top height decreased by 19%,29% and 42% Respectively than Normal column. And for Inclined column of 10˚ and 12˚ the value of Story displacement decreased by more than half of value of normal column.
- Max. Story Displacement in Structure Which Inclined column provide up to Mid-height is Higher than Inclined column provide up to Top-height.
- Max. Story drift decreased when increase in angle of inclined column.
- Model with 12˚ Inclined column up to Mid-height shows that 8% Reduction in Max. Story Drift. And 12˚ Up to Full height shows that 41% Reduction in Max. Story Drift.
- The story Stiffness Increased when angle of inclined column increased.
- Model with 12˚ Inclined column shows that 90% more Max. Story stiffness than normal structure.
- Overall result of Model which used Normal(rectangle) Inclined column is better than Circular Inclined column.
- Overall Result shows that inclined column up to Top height is better than inclined column up to Mid-height.

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