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SEISMIC RESPONSE OF MULTI-STOREY STRUCTURES WITH FLOATING COLUMNS

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ABSTRACT:

The civil engineering structures with floating column are a regular element in the cutting edge multistory construction. Such elements are profoundly undesirable in building implicit seismically dynamic ranges. This study highlights the significance of expressly perceiving the vicinity of the structures with and without floating columns. Seismic analysis is carried out on G+7 story building with different alternative location for floating column considering the presence and absence of infill effect. Different structural configurations such as Floating column resting on beam which is supported on column, and Providing RCC wall between columns which is supported by frame having floating column are analysed using professional software Etabs-2013. The response of structure is studied in form of Base-Shear, Storey Shear and Storey Displacement, Member forces of Buildings with and without Floating Columns for seismic zone IV subjected to medium soil profile by seismic coefficient method and response spectrum method referring to IS 1893-2002.

KEYWORDS: Floating columns, Infill effect, Base-Shear, Storey Shear and Storey Displacement, Member forces, equivalent static load method, response spectrum method etc.

1.1 INTRODUCTION:

India is a developing country, where urbanisation is at the faster rate in the country including adopting the methods and type of constructing buildings which is under vast development in the past few decades. As a part of urbanisation multi-storey buildings with architectural complexities are constructed and have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey.

The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height and these forces are needed to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks cause a sudden jump in earthquake forces at the level of discontinuity. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path.

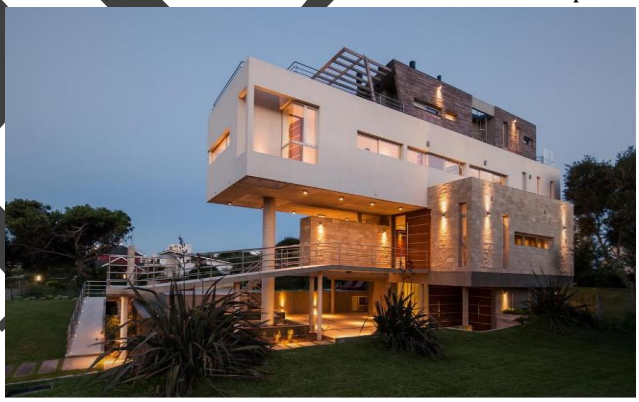
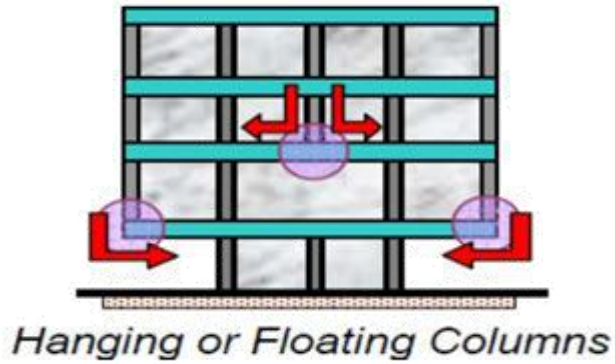


Fig 1.1: Hotel building having floating column

1.2 FLOATING COLUMN CONCEPT:

A column should be a vertical part beginning from establishment level and exchanging the heap to the ground level. The term gliding section is additionally a vertical component which (because of engineering outline/ site circumstance) at its lower level (end Level) lays on a shaft which is a flat part. The bars thus exchange the heap to different segments beneath it.



Floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

2.1 METHODOLOGY:

To study this structural behavior the software ETABS 2013 program has been to used. ETABS 2013 is an analyzing program that offers general purpose structural analysis and design along with the extensive model generation and post processing facilities. Dynamic analysis shall be performed to obtain design seismic force and its distribution to different levels along the height of the building and lateral loads are assumed to be concentrated at the floor levels for the buildings. The Static and dynamic analysis shall be done by using Static coefficient and response spectrum method resp. according to IS 1893:2002.

2.2 FORMULATION:

In the present study, the multistoried RC moment resisting space framed buildings having Floating Column with and without infill as well as when provided with and without Stay are modeled and analyzed using professional software ETABS 2013 in compliance with the codes IS 456:2000 and IS 1893(Part 1): 2002. Parametric investigation is carried out mainly to study the behavior of Floating Column in presence and absence of infill effect and to check the best possible accommodation of Floating Column with minimum deformations. Parameters such as Base-Shear, Storey Shear, Storey Displacement and Member forces of Buildings when Stay is provided below the floating column is studied and results are obtained so that failures of Floating Column will be avoided and the risk in designer's mind will vanish. Various cases that are taken for study are given in tabular form representing the investigation work.

2.3 DESCRIPTION OF MODELS WITH DIFFERENT STRUCTURAL SYSTEMS:

Case No	Name of Structural System
I	Floating column resting on beam which is supported on column.
II	Providing RCC wall between columns which is supported by frame having floating column.

2.4 BUILDING DESCRIPTION:

Sr. No	Structural Element	Dimension
1	Material Used	Concrete M-30 Reinforcement Fe-500
2	Number of Storey	7
3	Plan Dimensions	16 X 16 m
4	Type of Structure	RCC
5	Typical Storey Height	3.2 m
6	Beam	0.300 X 0.450 m
7	Column	0.300 X 0.300 m
8	Thickness of Slab	0.200 m
9	Thickness of Masonry Wall	0.150 m
10	Method of Analysis	Seismic Coefficient Method Response Spectrum Method

2.5 MODELLING USING ETABS:

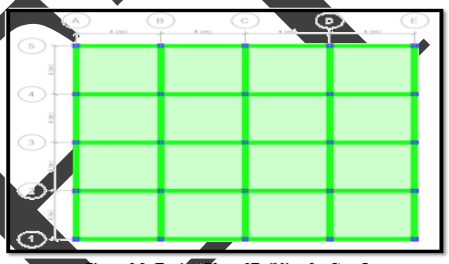


Figure 2.1: Typical Plan of Building for Case I

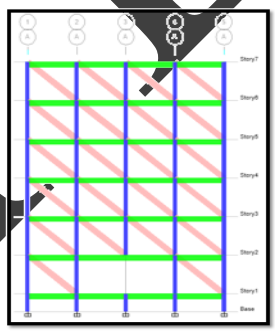


Figure 2.2: Elevation of Building for Case I

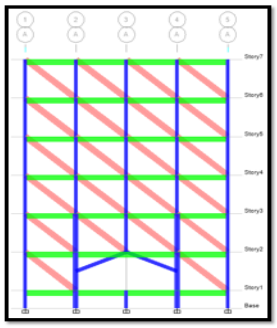


Figure 2.3: Elevation of Building for Case I

CASE I

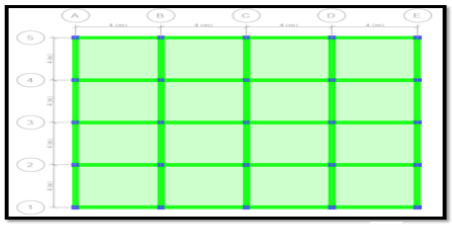


Figure 2.4: Typical Plan of Building for Case II

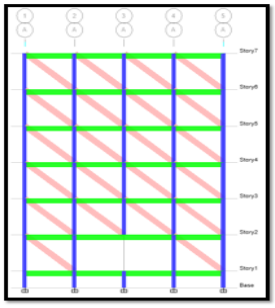


Figure 2.5: Elevation of Building for Case II

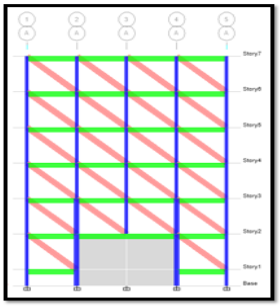


Figure 2.6: Elevation of Building for Case II

CASE II

2.6 OBJECTIVE AND SCOPE:

The objective of the present work is to study the Seismic Response of Multi-Storey Structures with Floating Columns. This study is important as Floating Column is unavoidable feature and if not properly analysed or designed will lead to massive failure of structure. Thus G+7 Storey building are studied when Floating Column is provided and when Floating Column is not provided. From this study, we can clearly get an idea of best suitable position for Floating Column. Linear Seismic Analysis is carried out to study the behavior and effect of Floating Column.

3. RESULTS AND DISCUSSIONS:

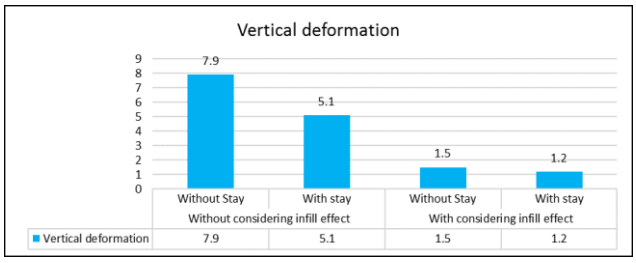
Linear analysis has been carried out by Seismic Coefficient Method (SCM) and Response Spectrum Method (RSM). After carrying out various investigations on structural configuration like types of building frame i.e. studying floating column behavior firstly when floating column is resting on beam supported on column, secondly by providing shear-wall below Floating Column. Also, complete investigation of frames is carried out by providing Stay and without Stay in presence and absence of infill effect on Floating Column. The results of seismic parameters such as Base-Shear, Storey Shear and Storey Displacement, Member forces of Buildings with and without Floating Columns. For seismic zone IV subjected to medium soil profile. Results are presented in the form of Tables and Graph respectively.

STATIC COEFFICIENT METHOD:

CASE -I

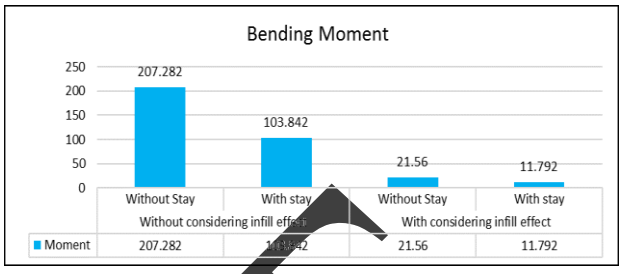
Table No. 3.1: Comparison of Vertical Deformation, Bending Moment, Shear Force, Base-Shear.

Type		Without considering infill effect		With considering infill effect	
		Without Stay	With stay	Without Stay	With stay
Beam Below the Floating Column	Vertical deformation	7.9	5.1	1.5	1.2
	Bending Moment	207.28	103.84	21.56	11.79
	Shear force	148.56	95.427	21.84	17.15
	Base Shear	660.05	763.71	1695.14	1688.07



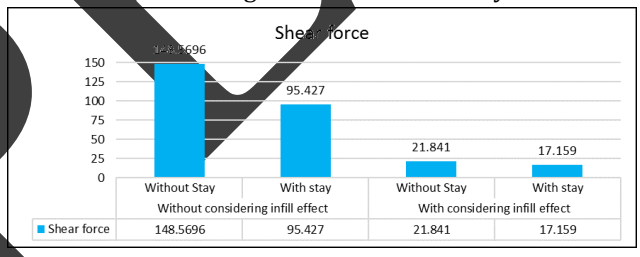
Graph No 1: Comparison of Vertical Displacement.

1. There is sudden drop is observed in vertical deformation by providing the stay below the floating column.
2. The vertical deformation is reducing by 36% and 20% in case of with and without infill effects.



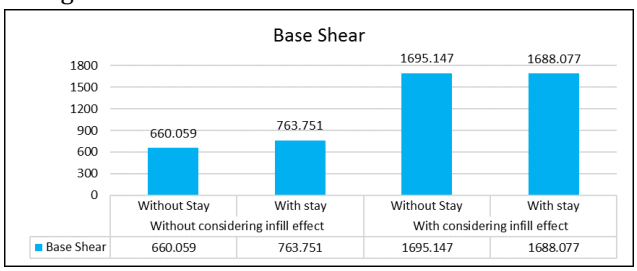
Graph No 2: Comparison of Bending Moments when Floating Column is resting on Beam which is Supported by Column.

1. Fall of 50% in value of bending moment is observed after comparing frame with and without stay in case of frame without infill effect.
2. Similarly, after comparing frame with and without infill effect for with and without stay case drop of approximately 88% in value of bending moment is commonly observed.



Graph No 3: Comparison of Shear Force when Floating Column is resting on Beam which is Supported by Column.

1. Similar pattern of drop is observed in Shear force value of around 83% of frame with and without infill effect in case of with and without stay after observing drop pattern of Bending moment.

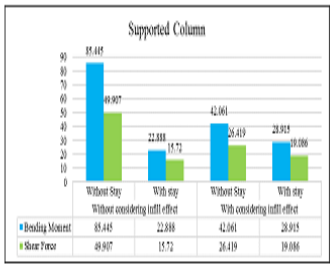


Graph No 4: Comparison of Base-Shear when Floating Column is resting on Beam which is Supported by Column.

1. There is increase in value of base shear after providing infill effect in the both with and without stay cases.
2. The base shear value is increased by 61% and 55% in case of without stay and with stay by considering infill effect.

Table No. 3.2: Results of Supported Column Which Supports Beam Having Floating Column.

Type		Without considering infill effect		With considering infill effect	
		Without Stay	With stay	Without Stay	With stay
Supported Column	Bending Moment	85.44	22.88	42.06	28.91
	Shear force	49.90	15.72	26.41	19.08
	Axial Force	1779.88	1802.06	1781.55	1430.25



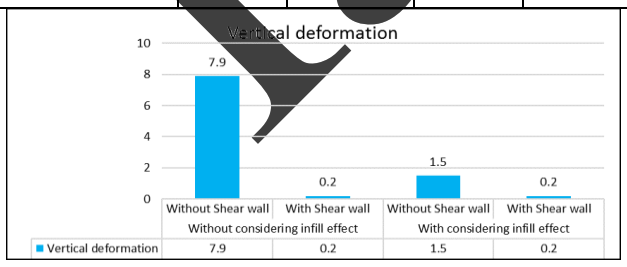
Graph No 5: Comparison of Bending Moment and Shear Force of Supported Column.

1. From above graph, it is observed that by providing stay there is decreasing value of shear force and bending moment in the support column.
2. In case of without infill effect shear force and bending moment, values are decreased by 68% and 73% respectively. Similarly, in case of infill effect they are decreased by 32% and 28% respectively.

CASE -II

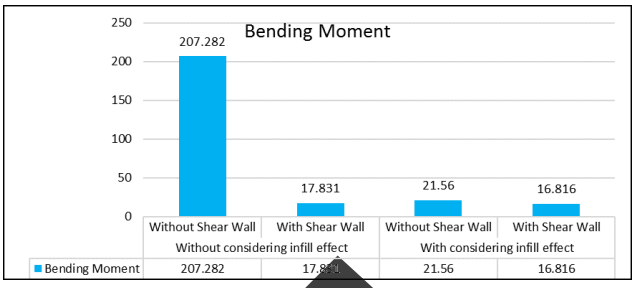
Table No. 3.3: Comparison of Vertical Deformation, Bending Moment, Shear Force, Base-Shear.

Type	Without considering infill effect		With considering infill effect	
	Without Shear Wall	With Shear Wall	Without Shear Wall	With Shear Wall
Vertical deformation	7.9	0.2	1.5	0.2
Bending Moment	207.28	17.83	21.56	16.81
Shear Force	148.56	19.21	21.84	18.56
Base Shear	660.05	835.78	1695.14	1687.51



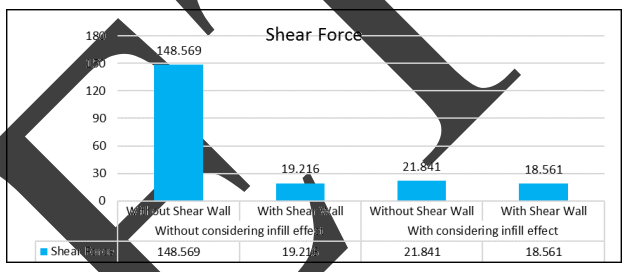
Graph No 6: Comparison of Vertical Displacement.

1. The vertical deformation is reducing by 97% and 87% in case of frame with and without infill effects.
2. Sudden drop of 81% in vertical deformation is observed from above graph after comparing space frame without infill effect and with infill effect in case of without shear wall.



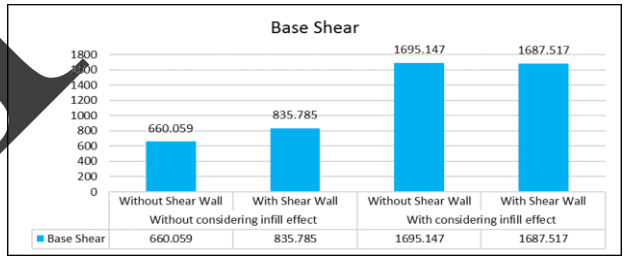
Graph No 7: Comparison of Bending Moments when Floating Column is resting on Shear wall.

1. From above graph, it is observed that shear wall frame with infill effect gives minimum Bending moment which can be best suitable.



Graph No 8: Comparison of Shear Force when Floating Column is resting on Shear wall.

1. Similar pattern of drop is observed in Shear force in the shear wall frame with infill effect gives minimum Shear force which can be best suitable.

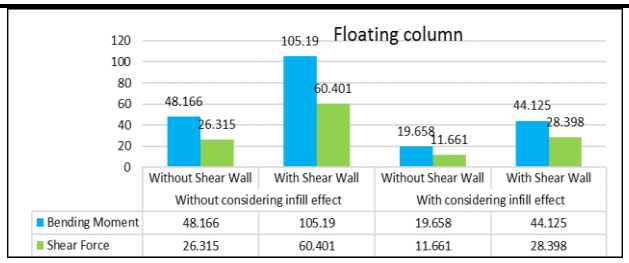


Graph No 9: Comparison of Base-Shear when Floating Column is resting on Shear wall.

1. There is increase in value of base shear after providing infill effect in the both frame with shear wall and without shear wall cases.
2. The base shear value is increased by 61% and 50% in case of frame without shear wall and with shear wall by considering infill effect.

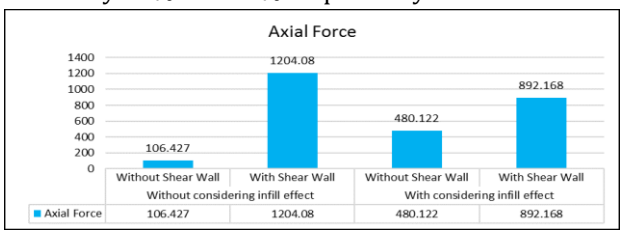
Table No. 3.4: Results of Floating Column

Type		Without considering infill effect		With considering infill effect	
		Without Stay	With stay	Without Stay	With stay
Floating Column	Bending Moment	48.166	105.19	19.658	44.125
	Shear force	26.315	60.401	11.661	28.398
	Axial Force	106.427	1204.08	480.122	892.168



Graph No 10: Comparison of Bending Moment and Shear Force on Floating Column.

1. There is increase in value of shear force and bending moment by providing shear wall below the floating column.
2. In case of without infill effect shear force and bending moment, values are increased by 56% and 54% respectively. Similarly, in case of infill effect they are increased by 60% and 58% respectively.



Graph No 11: Comparison of Axial force of Floating column.

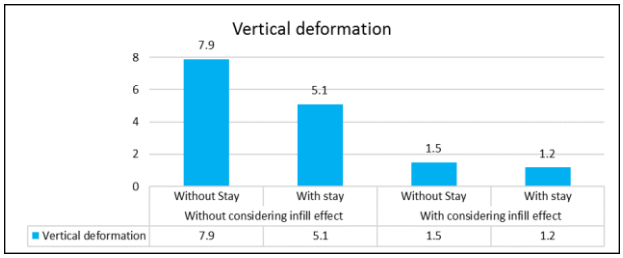
1. By providing shear wall there is drastically rise in value of axial forces in both infill effect and without infill effect frame.
2. Rise in value of 91% of axial forces is observed in case of without infill effect frame after providing shear wall.
3. Similarly, in case of frame with infill effect axial force value increased by 47%.

RESPONSE SPECTRUM METHOD:

CASE -I

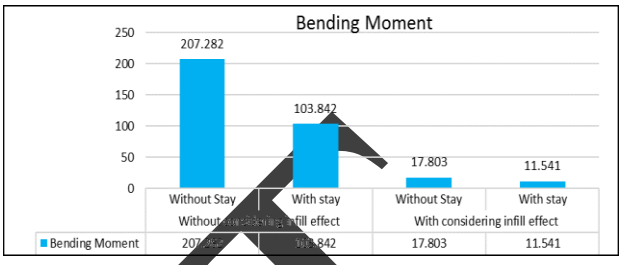
Table No. 3.5: Comparison of Vertical Deformation, Bending Moment, Shear Force, Base-Shear.

Type		Without considering infill effect		With considering infill effect	
		Without Stay	With stay	Without Stay	With stay
Beam Below the Floating Column	Vertical deformation	7.9	5.1	1.5	1.2
	Bending Moment	207.28	103.84	17.80	11.54
	Shear force	148.56	95.42	19.73	17.10
	Base Shear	553.54	606.87	1576.94	1562.60



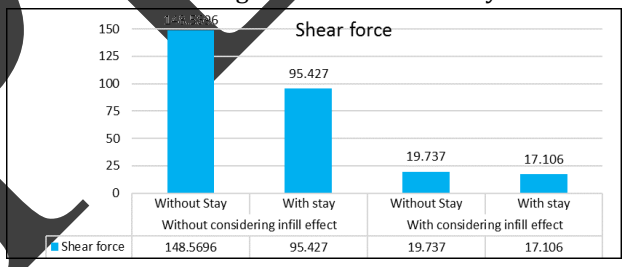
Graph No 12: Comparison of Vertical Displacement.

1. Sudden drop of 81% in vertical deformation is observed from above graph after comparing space frame without infill effect and with infill effect in case of without stay.
2. Similarly, in case of with stay drop of 76% in vertical deformation is observed from above graph after comparing space frame without infill effect and with infill effect.



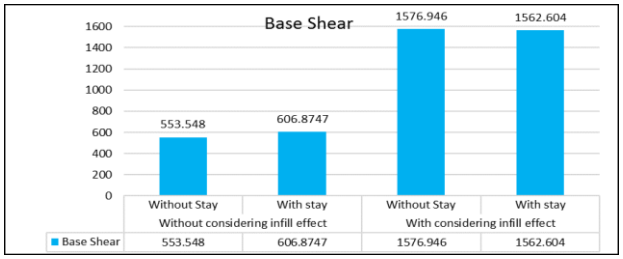
Graph No 13: Comparison of Bending Moments when Floating Column is resting on Beam which is Supported by Column.

1. Fall of 50% in value of bending moment is observed after comparing frame with and without stay in case of frame without infill effect.
2. Similarly, after comparing frame with and without infill effect for with and without stay case drop of approximately 90% in value of bending moment is commonly observed.



Graph No 14: Comparison of Shear Force when Floating Column is resting on Beam which is Supported by Column.

1. Similar pattern of drop is observed in Shear force value of around 85% of frame with and without infill effect in case of with and without stay after observing drop pattern of Bending moment.

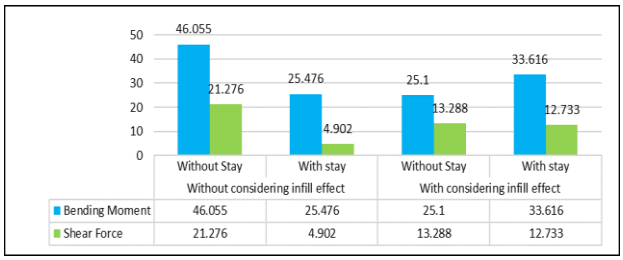


Graph No 15: Comparison of Base-Shear when Floating Column is resting on Beam which is Supported by Column.

1. There is increase in value of base shear after providing infill effect in the both with and without stay cases.
2. After comparing infill effect and without infill effect it is observed that base shear value is increased by 65% and 61% in case of with stay and without stay frame.

Table No. 3.6: Results of Supported Column Which Supports Beam Having Floating Column.

Type		Without considering infill effect		With considering infill effect	
		Without Stay	With stay	Without Stay	With stay
Supported Column	Bending Moment	46.05	25.47	25.1	33.61
	Shear force	21.27	4.90	13.28	12.73
	Axial Force	1366.81	1491.0	1057.98	1261.41



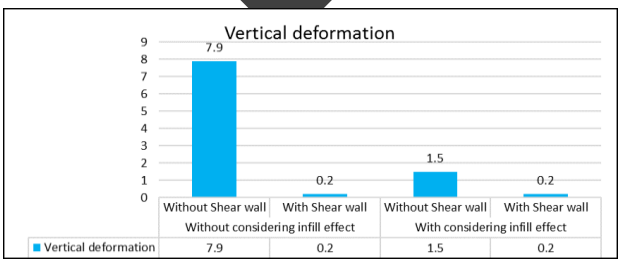
Graph No 16: Comparison of Bending Moment and Shear Force of Supported Column.

1. From above graph, it is observed that by providing stay there is decreasing value of shear force and bending moment in the support column in case of frame without infill effect.
2. In case of without infill effect shear force and bending moment, values are decreased by 77% and 45% respectively.

CASE -II

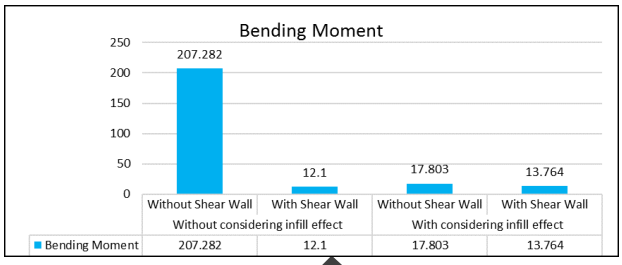
Table No. 3.7: Comparison of Vertical Deformation, Bending Moment, Shear Force, Base-Shear.

Type	Without considering infill effect		With considering infill effect	
	Without Shear Wall	With Shear Wall	Without Shear Wall	With Shear Wall
Vertical deformation	7.9	0.2	1.5	0.2
Bending Moment	207.28	12.1	17.80	13.76
Shear Force	148.56	18.61	19.73	17.19
Support Reaction	2157.00	1589.43	1853.15	2153.33
Base Shear	553.54	561.17	1576.94	1178.82



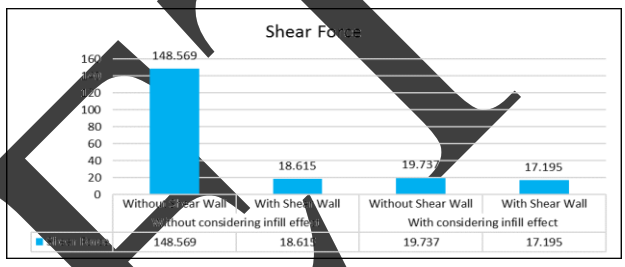
Graph No 17: Comparison of Vertical Displacement.

1. There is sudden drop is observed in vertical deformation by providing the shear wall below the floating column.
2. The vertical deformation is reducing by 97% and 87% in case of frame with and without infill effects.



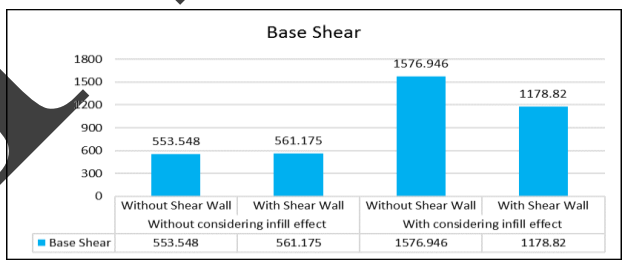
Graph No 18: Comparison of Bending Moments when Floating Column is resting on Shear wall.

1. From above graph, it is observed that shear wall frame with infill effect gives minimum Bending moment which can be best suitable.



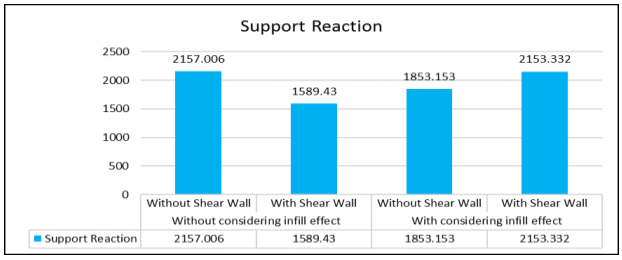
Graph No 19: Comparison of Shear Force when Floating Column is resting on Shear wall.

1. Similar pattern of drop is observed in Shear force in the shear wall frame with infill effect gives minimum Shear force which can be best suitable.



Graph No 20: Comparison of Base-Shear when Floating Column is resting on Shear wall.

1. Above graph shows there is small change in the value of base shear in case of frame without infill effect.
2. The base shear value is decreased by 25% case of frame with infill effect.

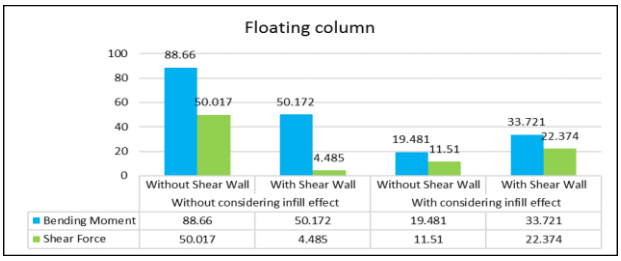


Graph No 21: Comparison of Support Reaction

1. From above graph, it is observed that there is decrease in value of support reaction by providing shear wall in case of without infill effect.
2. In case of infill effect frame the value of support reaction is increases.

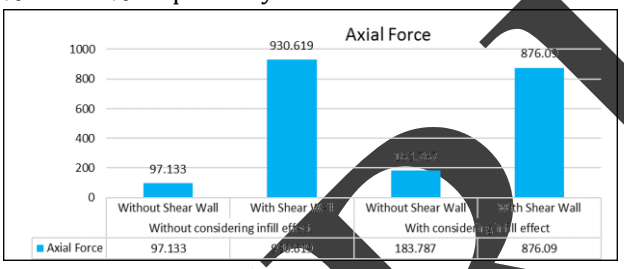
Table No. 3.8: Results of Floating Column

Type		Without considering infill effect		With considering infill effect	
		Without Stay	With stay	Without Stay	With stay
Floating Column	Bending Moment	88.66	50.17	19.48	33.72
	Shear force	50.01	4.48	11.51	22.37
	Axial Force	97.13	930.61	183.78	876.09



Graph No 22: Comparison of Bending Moment and Shear Force on Floating Column.

1. There is decrease in value of shear force and bending moment by providing shear wall below the floating column.
2. In case of without infill effect shear force and bending moment, values are decreased by 91% and 43% respectively, but in case of infill effect they are increased by 60% and 58% respectively.



Graph No 23: Comparison of Axial force of Floating column.

1. By providing shear wall there is drastically rise in value of axial forces in both infill effect and without infill effect frame.
2. Rise in value of 89% of axial forces is observed in case of without infill effect frame after providing shear wall.

4. CONCLUSIONS:

The Study presented in the paper compares the difference between building with and without floating column. The following conclusions were drawn based on the investigation.

1) From both analysis method, it is noticed that the floating column building without any structural configuration gives more displacements.
2) Dynamic analysis gives batter results as cross section sizes required are less as compared to static analysis.
3) Provision of floating columns into the structural system makes the system flexible there by reducing the base shear for seismic static and seismic dynamic loads.
4) With the provision of brick infills with floating column structures makes it less vulnerable to earthquake.
5) From above data, it can be concluded that by providing stay below floating column is the best structural configuration as Bending moment and Shear force values drastically reduces.
6) In case, when shear wall is provided below the floating column, axial forces in floating column tremendously increases for both static as well as dynamic analysis.

From the above analysis, it is concluded that increase in the sizes of beams and columns can affect the results of floating column. Change in structural configuration can gives better results for floating column.

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