ISSN: 2633-4828 Vol. 5 No.4, December, 2023

International Journal of Applied Engineering & Technology

SEISMIC PERFORMANCE OF HIGH RISE BUILDINGS WITH FLOATING COLUMNS AND SHEAR WALL

Mr. Bachal Kedar Dattatray[1] and Prof. Y. R. Suryavanshi[2]
[1]PG Student (M.E Structural Engineering), Department of Civil Engineering, Imperial College of Engineering and Research, Wagholi, Pune-412207
[2]Head of, Department of Civil Engineering, Imperial College of Engineering and Research, Wagholi, Pune-412207

ABSTRACT

This study investigates the structural behavior of buildings with and without floating columns, focusing on the impact of floating columns on the overall performance of the structure. The analysis includes the evaluation of story drift, displacement, axial forces in conventional columns, and the effectiveness of shear walls in enhancing the strength and stability of the structure. The study finds that structures with floating columns experience a reduction in dead load and an increase in displacement compared to those without floating columns. Additionally, the presence of shear walls significantly improves the strength and stability of the structure, with up to 70% increase in strength observed. However, it is noted that the installation of shear walls in structures with lesser height may not be economically viable. Overall, the findings provide valuable insights for structural engineers and designers in optimizing the design of buildings with floating columns.

Keyword: Floating column, Story drift, Displacement, Axial forces, Shear wall, Base shear

INTRODUCTION

Seismic Analysis of high rise building is required to carry out for the determination of seismic responses of building so as to understand the actual behavior of the structure so this can be done either by dynamic or simple equivalent static analysis this Linear static method can be used for regular structure with limited height, A Linear dynamic analysis can be executed by response spectrum method so nonlinear dynamic analysis i.e. time History analysis is the only method to label the real performance of a building during seismic excitation(Fajfar, 2018). Determination of earthquake demands on the structure is one of the challenging jobs in the field of structural engineering Lot of research is carried out in this area to propose simplified methods that will predict results with reasonable accuracy and it was found that except detailed nonlinear time history analysis, the available methods have limited areas of the application and cannot be used for all type of building(Fajfar, 2018). One of the most difficult duties in structural engineering is determining the seismic demands on the structure. There has been a lot of study done in this field in order to provide simpler techniques that can anticipate results with a fair degree of accuracy. The seismic analysis approaches that have been utilized to estimate the demand

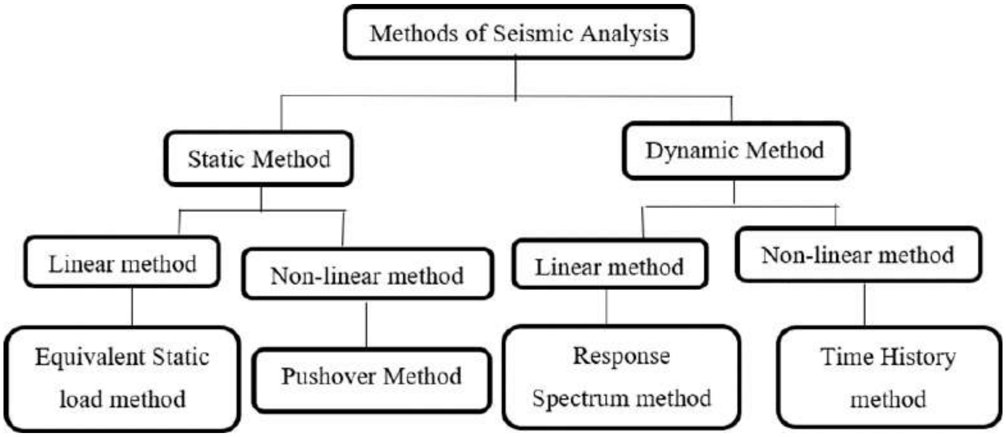

Figure 1 Methods of Seismic Analysis

LITERATURE REVIEW

Yan Shing Lina, Ricky W. K. Chana & Hiroshi Tagawab (2020), In this review a new seismic risk mitigation technique by connecting a base isolation system with the EEW is suggested. Proposes a smart system which changes the property of a base isolation system over EEW signal. When there is no risk of earthquake, the base isolation system is locked by shear keys. As the earthquake is signalled by the EEW system, mechanical system releases the base isolation system. Whenever the earthquake ceases, the system resets & base isolation is locked again. Vibration sensors are added to activate the system when EEW fails to detect incoming waves. In the results it maximizes the vibration isolation effectiveness. Described and demonstrated a conceptual framework of proposed system by laboratory scaled experiments. A 6-storey test frame is tested on a shake table subjected to historical earthquakes. Results shows that the proposed system is effective in reducing earthquake responses on the building.

Ehsan Kazeminezhada, Mohammad Taghi Kazemib & S. Mohammad Mirhosseinia (2020), As earthquakes are natural phenomena which damage structures and buildings. Preventing the transfer of earthquake vibrations to the buildings is important to reduce the damage & to protect the residents. One of the desirable methods to prevent the transfer of seismic vibrations to buildings is base isolation with lead rubber isolator. Iterative methods are required to design these isolators. In this review they described two procedures for isolator design, first one is usual design procedure based on AASHTO and ASCE7 codes & second one is, design based on the performance point which is completely presented in this paper. Carried out non-linear time history analysis for building analysis. Results shows that the performance point method (PPM) is more accurate than the previous usual method. Base shear force, relative displacement of a fixed base & the isolated buildings has been calculated and compared

Yutaka Nakamura & Keiichi Okada (2019), In their review seismic isolation & response control methods of buildings to make buildings resilient against earthquakes is shown, also three types of laminated rubber bearings and three kinds of damping devices is shown. Seismic isolation provides structural safety as well as safety and security for people with properties in the building. The paper describes three foremost response control dampers which are steel hysteretic damper, the viscoelastic damper & the viscous fluid damper. Effects of seismic isolation & response control methods were verified using shaking table tests, structural health monitoring and earthquake response analyses.

Donato Cancellara & Fabio De Angelis (2019), In this review analysis of the dynamic behavior of base isolated multistorey structures characterized by high irregularity in plan is completed. High Damping Rubber Bearings isolators were adopted & then placed in parallel with Friction Sliders isolators. Two different types of dynamic analysis are investigated which are dynamic analysis with response spectrum and nonlinear dynamic analysis. With regard to the recent Italian seismic code the comparative evaluation of the results are obtained. The results of the current study are illustrated within the terms of calculations of the deformations and the stresses of the base isolated structure. For the deformations interest is given to the inter storey drifts at the various levels of the multi storey structure. For the stresses associated to the seismic loadings the interest given on bending moment, axial force and shear within the columns & bending moment & shear within the beams.

M. Suneel Kumara, R. Senthilkumarb & L. Sourabhaa (2019), In their review seismic performance of regular 6, 9, 12 and 15 storey special concentric X-braced frames in which tension bracings are designed for the lateral loads of 100%, 70% & 60% of base shear is shown. DCR is varied in beam and columns in range of (0.4–0.7) and bracing in range of (0.6–0.9) under designed lateral loads. Pushover curves are designed to determine the strength & ductility of the frame for all the DCR values. If the terms of strength and ductility are considered then column DCR of 0.4 and 0.5 is proven to be more effective with bracing DCR of 0.8 and 0.9 also it shows that the displacement demand for the frames designed for 60% of the total base shear under maximum considered earthquake is within acceptable limit.

Peyman Narjabadifam, Patrick L. Y. Tiong & Ramin Mousavi Alanjagh (2019), In this review effects of characteristics of both isolation system and superstructure on seismic performances of a seismically base isolated buildings subjected to near and far field ground motions through the extensive numerical analyses is investgated. Considered superstructures of 3, 7, and 11 story buildings with steel and reinforced concrete moment resisting and braced frames. By using the isolation systems seven isolation strategies are practically designed, using three target displacements and two coefficients of friction. Created 84 structural models. Carried out nonlinear time history analysis on the two dimensional model of the isolated buildings subjected to seven near field and seven far field ground motions. Studied base shears, story displacements, and story accelerations. Shown that the effectiveness of aseismic base isolation depends significantly on inherent mass, stiffness, and damping of the structure, also effect of isolation damping is more than mass and stiffness of the superstructure. The effectiveness of aseismic base isolation with the design strategies increases as there is increase in the inherent mass and stiffness of the superstructure. In this study, it is found that FPS performs better than HRB, specifically in near field excitations.

Kun Ye, Yan Xiao & Liang Hu (2019), In their review direct displacement based designprocedure in short is shown, to satisfy performance base-isolated building structure with lead-rubber bearing. DDBD for normal building with the two-degree-of-freedom modelled thoroughly for base-isolated building structures. applied modal & response qualitative analysis. they need given the displacement requirements, relationship facilitates & solution of the structural parameters for base-isolated building structure. Alternative direct-displacement based design procedure is then developed and detailed & verified by numerical examples, which is finished by the nonlinear time-history analysis. Compared design solutions of the proposed procedure with an existing one. Numerical results indicate direct-displacement based design procedure is reliable, straightforward & convenient for seismic design of base-isolated building structures using LRBs.

METHODOLOGY

Linear Static Method

This approach, often referred to as the Equivalent Static Method, is used to gauge demand for structures whose responses are mostly dominated by the first mode and predicted to exhibit elastic behaviour. In this procedure, the demands are estimated and the lateral loads are calculated based on the structural system's fundamental period and applied to the design centre of mass at each floor level. The size of these fictitious lateral loads has been chosen with the goal of producing the design displacement anticipated during the design earthquake when applied to the linearly elastic model of the building. The computed internal forces will be a decent approximation of those anticipated during the design earthquake if the building reacts elastically to the earthquake. This approach, often referred to as the Equivalent Static Method, is used to gauge demand for structures whose responses are mostly dominated by the first mode and predicted to exhibit elastic behaviour. In this procedure, the demands are estimated and the lateral loads are calculated based on the structural system's fundamental period and applied to the design centre of mass at each floor level. The size of these fictitious lateral loads has been chosen with the goal of producing the design displacement anticipated during the design earthquake when applied to the linearly elastic model of the building. The computed internal forces will be a decent approximation of those anticipated during the design earthquake if the building reacts elastically to the earthquake.

RESULT AND DISCUSSION

Analysis of 10 Storey RC Building

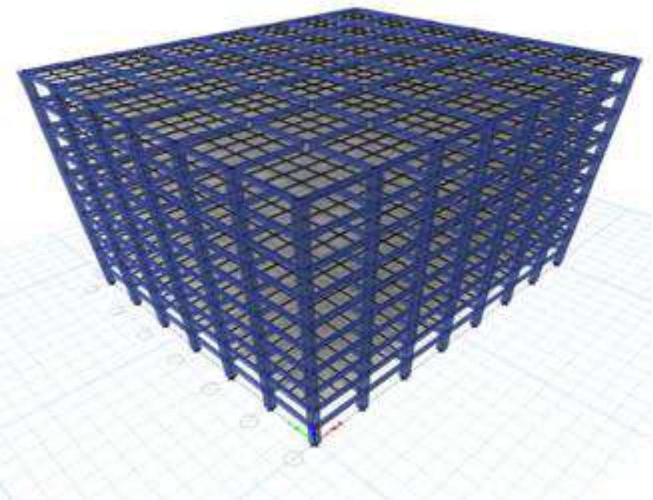

Figure 3 3D view (P2)

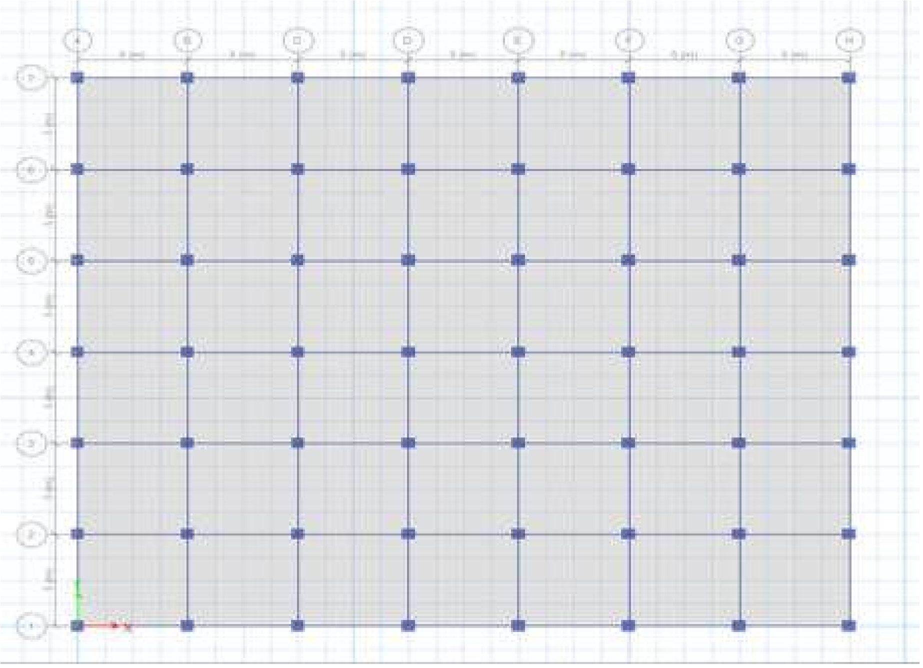

Figure 4 Plan view (P3)

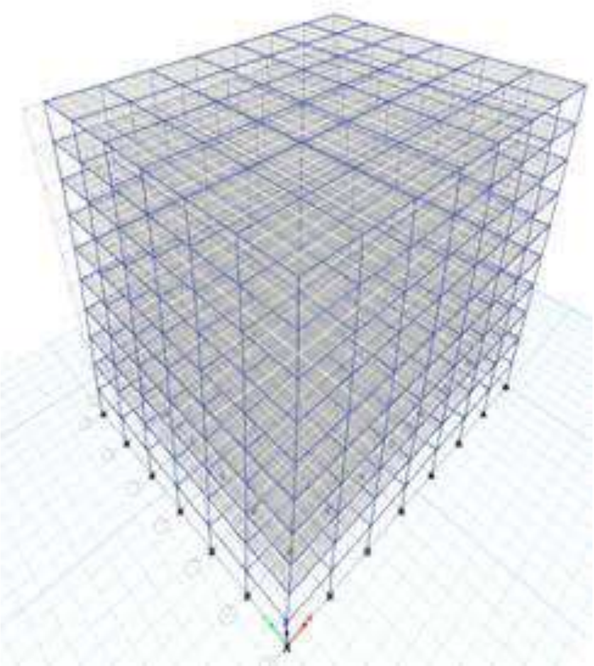

Figure 5 Deformed Shape mode1 (P2)

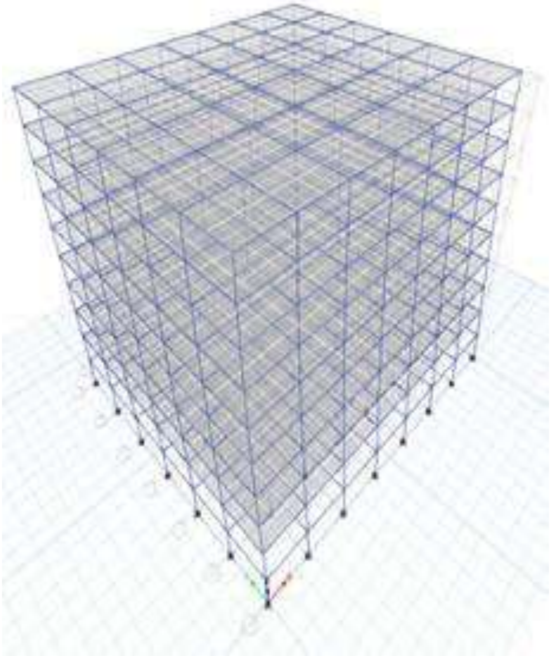

Figure 6 Deformed Shape mode2 (P2)

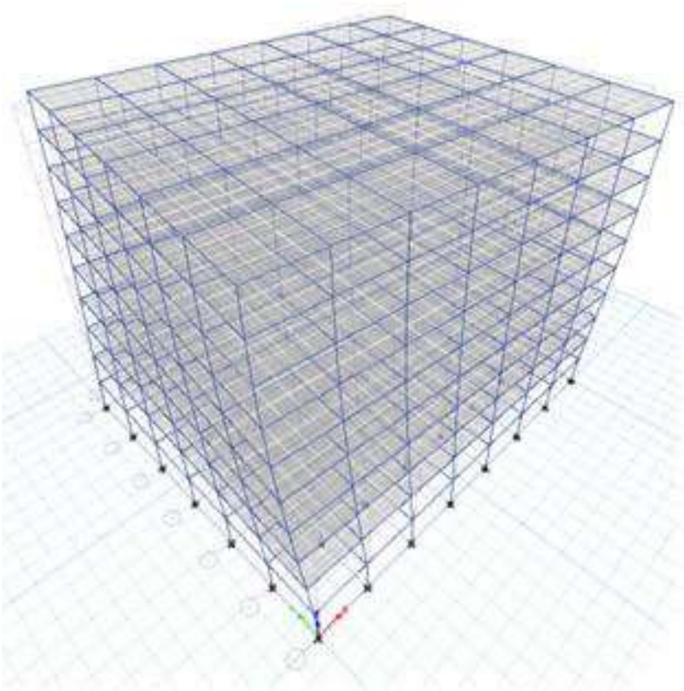

Figure 7 Deformed Shape mode3 (P2)

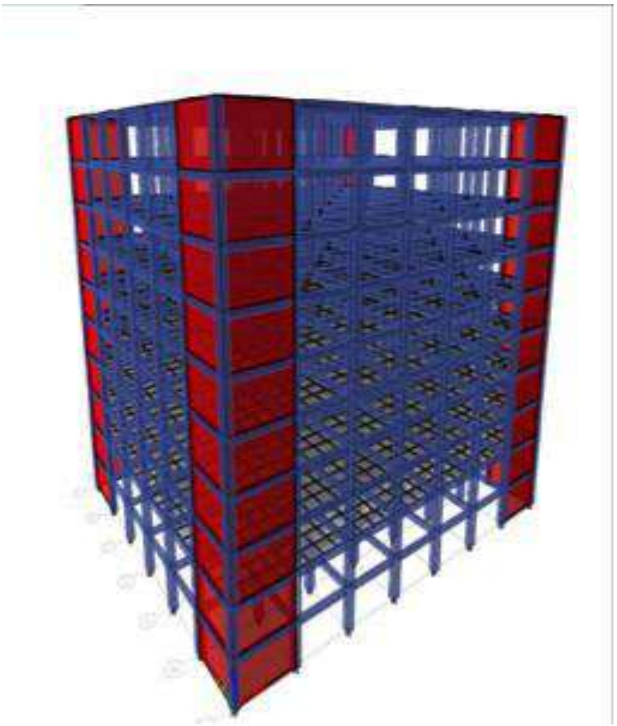

Figure 8 3D view (P3)

Figure 9 Elevation (P3)

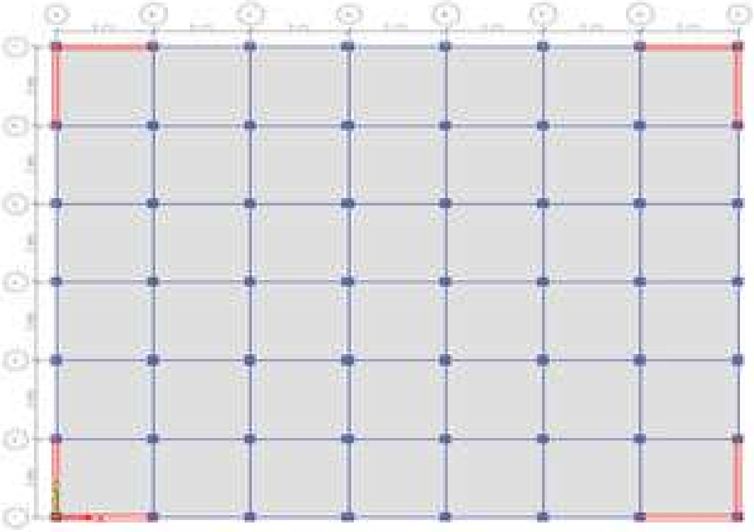

Figure 10 Plan view (P3)

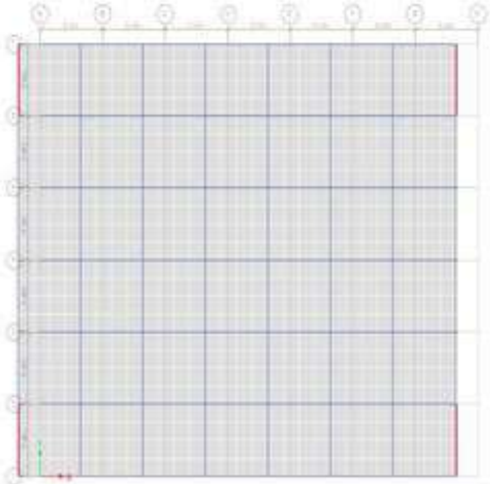

Figure 11 Deformed Shape mode1 (P3)

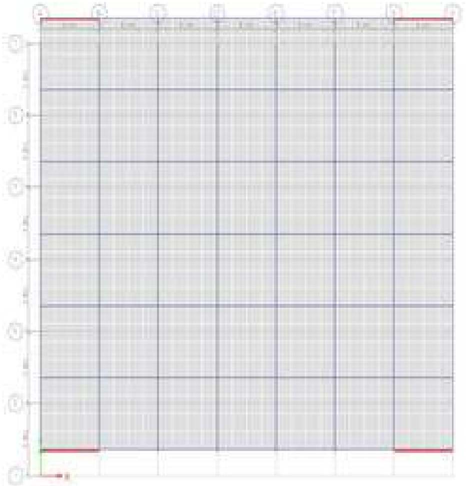

Figure 12 Deformed Shape mode2 (P3)

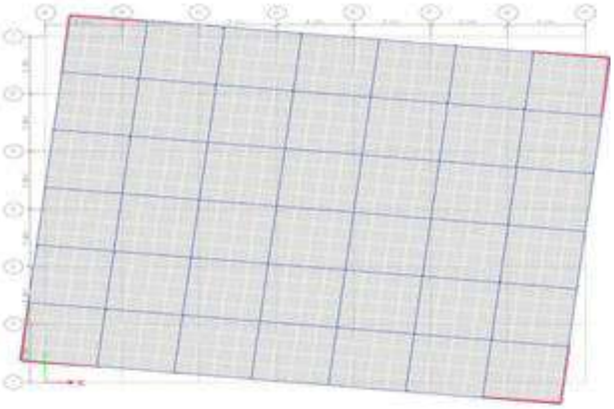

Figure 13 Deformed Shape mode3 (P3)

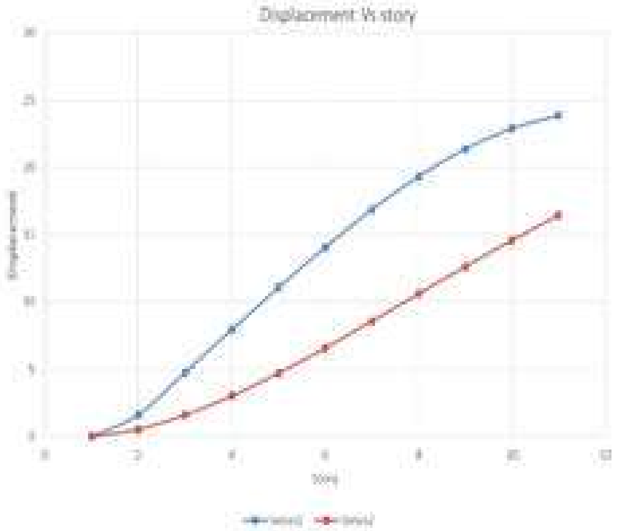

Figure 14 Displacement vs story

Table 1 Displacement vs story

Story	P2	P3
Base	0	0
Story1	1.601	0.529
Story2	4.757	1.587
Story3	7.92	3.001
Story4	11.056	4.692
Story5	14.064	6.573
Story6	16.852	8.565
Story7	19.321	10.601
Story8	21.365	12.621
Story9	22.886	14.584
Story10	23.857	16.437

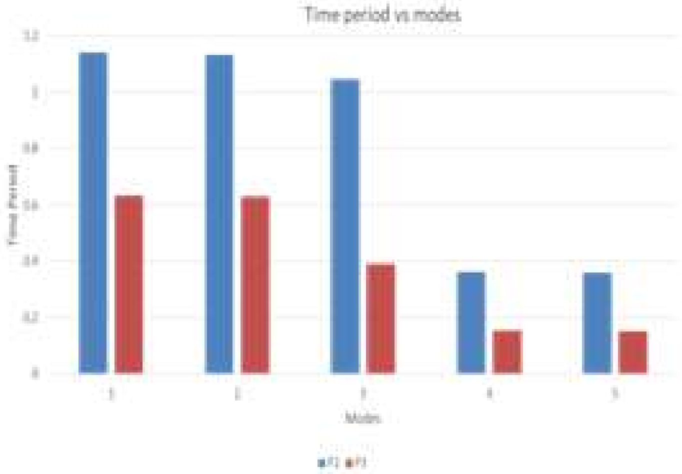

Figure 15 Time Period vs modes

Table 2: Mode vs Time Period

Mode	P2	P3
1	1.142	0.632
2	1.133	0.63
3	1.047	0.39
4	0.362	0.154
5	0.359	0.153
6	0.332	0.091
7	0.198	0.071
8	0.197	0.071
9	0.182	0.045
10	0.127	0.045
11	0.127	0.043
12	0.117	0.033

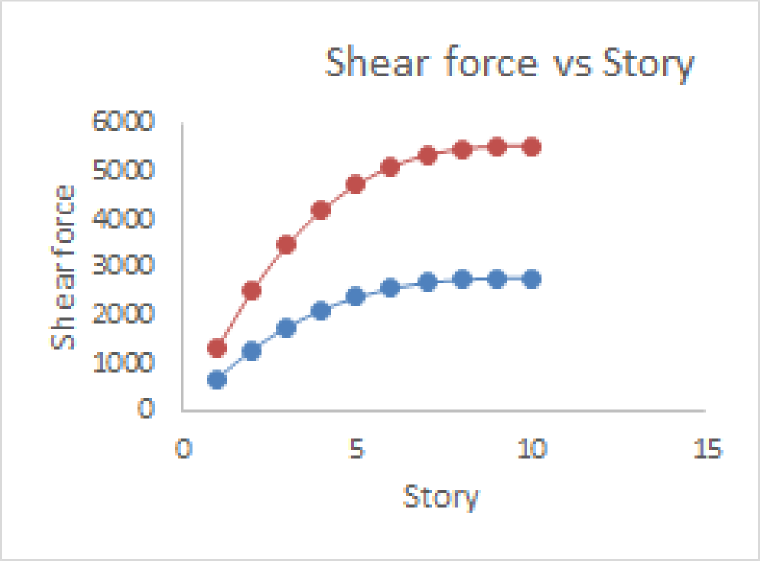

Figure 16 Shear force vs story

Table 3: Story vs Base Shear

Story	P2	P3
Story10	659.0916	1274.423
Story9	1258.754	2486.076
Story8	1732.561	3443.431
Story7	2095.319	4176.407
Story6	2361.836	4714.919
Story5	2546.917	5088.886
Story4	2665.368	5328.225
Story3	2731.998	5462.853
Story2	2761.245	5522.022
Story1	2764.287	5529.033
Base	0	0

Table 4 Frequecy

Mode	P2	P3
1	5.5031	1.583
2	5.5446	1.588
3	6.0033	2.566
4	17.3776	6.514
5	17.4958	6.522
6	18.934	10.937
7	31.7189	14.096
8	31.8823	14.105
9	34.4457	22.256
10	49.4021	22.266
11	49.6028	23.285
12	53.609	30.375

CONCLUSION

1. Structure which having floating column will reduce dead load of structure.
2. Story drift is decreasing with increasing height of structure in every model.
3. Maximum story drift and displacement values are increasing for floating column.
4. As the transfer of load of floating columns to conventional columns because of that axial forces are increasing in conventional columns.
5. In comparison to buildings without floating columns, it has been discovered that displacement is higher in buildings with floating columns.
6. Providing shear wall will give up to 70 % more strength and stability to the structure. Displacement in shear wall model will be lesser as compare to other structure.
7. Installation of shear wall in having lesser height won't be as of economic note.
8. Base shear is increased with increase in number of story and also in shear wall case.

REFERENCES

1. Abdolrahim Jalali and Peyman Narjabadifam "Optimum Modal Characteristics for Multi-Story Buildings Isolated With LRBS" 4th International Conference on Earthquake Engineering Taipei, Taiwan October 12-13, (2006)
2. Donato Cancellara, Fabio De Angelis "Dynamic assessment of base isolation systems for irregular in plan structures, Response spectrum analysis vs nonlinear analysis" @ Elsevier (2019).
3. Ehsan Kazeminezhada, Mohammad Taghi Kazemib, S. Mohammad Mirhosseinia "Modified procedure of lead rubber isolator design used in the reinforced concrete building" Institution of Structural Engineers @ Elsevier (2020).
4. Emrah Erduran, Nhan D. Dao and Keri L. Ryan "Comparative response assessment of minimally compliant low-rise conventional and base-isolated steel frames" John Wiley & Sons, Ltd. Earthquake Engineering Struct. Dynamics (2010)
5. Esra Mete Guneyisi & Ahmet Hilmi Deringol "Seismic response of friction damped and base-isolated frames considering serviceability limit state" Journal of Constructional Steel Structure @ Elsevier Jun (2018).

6. Esra Mete Guneyisi & Ahmet Hilmi Deringol "Seismic response of friction damped and base-isolated frames considering serviceability limit state" @ Elsevier (2018)
7. Peyman Narjabadifam, Patrick L. Y. Tiong, Ramin Mousavi Alanjagh "Effects of Inherent Structural Characteristics on Seismic Performances of Aseismically Base-Isolated Buildings" Iranian Journal of Science and Technology, Transactions of Civil Engineering @ Springer (2019).
8. Book of James M. Kelly "Earthquake Resistant Design with Rubber" @ Springer Verlag London Limited (1993).
9. C.P. Providakis "Effect of LRB Isolators and Supplemental Viscous Dampers on Seismic Isolated Buildings Under Near-Fault Excitations" @ Elsevier (2008).
10. Dhanaraj M. Patil, Keshav K. Sangle "Seismic Behaviour of Different Bracing Systems in High Rise 2-D Steel Buildings" @ Elsevier (2015).
11. Dhara Panchal, Sharad Purohit "Dynamic Response Control of a Building Model using Bracings" @ Elsevier (2013)
12. Dimos C. Charmpis, Petros Komodromos and Marios C. Phocas "Optimized Earthquake Response of Multi-Storey Buildings with Seismic Isolation at Various Elevations" @ John Wiley and Sons Earthquake Engg Struct. Dyn. (2012).
13. Donato Cancellara & Fabio De Angelis), "Dynamic assessment of base isolation systems for irregular in plan structures: Response spectrum analysis vs nonlinear analysis" @ Elsevier (2019).