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Seismic Analysis of Multistorey Building using Steel Beam and Concrete Columns

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***Abstract* - In structural engineering, the pursuit of innovative solutions that balance performance, efficiency, and sustainability continues to evolve. Within the context of high-rise construction, hybrid structural systems have gained attention for their potential to combine the strengths of different materials. One promising approach is the integration of steel beams with concrete columns, leveraging the advantages of both materials to form a unified and adaptable high-rise structure. This study investigates the seismic performance of a G+20 multistorey building using the Response Spectrum Method and Linear Time History Analysis based on the Bhuj earthquake. Four structural models were developed for comparison. Model 1 represents a conventional RCC frame, serving as a baseline. In Model 2, internal RC beams (between shear walls and columns) are replaced with steel beams. Model 3 involves the substitution of external RC beams (between peripheral columns) with steel beams. In Model 4, all RC beams throughout the structure are replaced with steel beams. Key parameters such as storey stiffness, storey displacement, storey drift, storey shear, and overturning moment were evaluated across the models. The results indicate that substituting RC beams with steel significantly enhances structural stiffness, leading to noticeable reductions in storey displacement, drift, base shear, and overturning moment. Additionally, the higher strength-to-weight ratio of steel contributes to a substantial decrease in the overall dead load of the structure.**

***KeyWords:* Seismic Analysis, Steel beam, concrete column, Response Spectrum Method, Multi-story Buildings, Comparative Analysis.**

INTRODUCTION

The rise of urbanization has directed in an era where towering skyscrapers dominate city skylines, symbolizing human progress and achievement. High-rise buildings have become representative of modern architectural prowess, reshaping urban landscapes and accommodating the growing global population. However, the construction and engineering challenges associated with erecting these colossal structures are equally formidable. The very essence of a high-rise building's design revolves around optimizing space, functionality, and efficiency within a confined vertical footprint. The taller a building climbs, the more pronounced the challenges become, ranging from wind and seismic forces to vertical transportation logistics and environmental considerations. Traditional construction materials and methods, while effective, often necessitate substantial resources and exhibit limitations in addressing these challenges. It is within the context of these challenges that innovative structural solutions emerge as essential catalysts for high-rise building evolution. As buildings strive to touch the sky while adhering to stringent safety, sustainability, and economic requirements, the spotlight turns to new paradigms in structural engineering. In the realm of structural engineering, the quest for innovative solutions that harmonize performance, efficiency, and sustainability remains an ongoing pursuit. As the demands placed upon our built environment become increasingly diverse and complex, traditional construction methods and materials often fall short in meeting the evolving needs of modern society. It is within this context that the concept of steel-concrete hybrid structures emerges as a compelling avenue for exploration and advancement. The inherent strengths and weaknesses of steel and concrete have long been acknowledged in the construction industry. Steel possesses exceptional tensile strength, enabling it to bear significant loads across extended spans. Conversely,

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concrete excels in compressive strength and durability, providing resilience against environmental and fire-related challenges. The convergence of these attributes opens up a world of possibilities for combining these materials in ways that transcend their individual limitations. 1 Standing at the intersection of tradition and innovation, the investigation into steel-concrete hybrid structures exceeds the domain of academic pursuit, evolving into a pragmatic response to the contemporary challenges of our time. The pursuit of this knowledge bears the potential to revolutionize the conceptualization, design, and construction of structures, driving humanity towards a future wherein the built environment seamlessly integrates with the natural world, all the while catering to the demands of an adaptable and evolving society. Through this report, we aim to shed light on the principles, benefits, and challenges of steel-concrete hybrid structures, contributing to the collective pool of knowledge that drives the evolution of structural engineering. In the dynamic landscape of high-rise construction, the pursuit of innovative solutions that combine efficiency, strength, and sustainability has led to the exploration of hybrid structural systems. One such intriguing approach is the integration of steel beams and concrete columns, where the unique properties of each material are harnessed to create a cohesive and versatile high-rise structure. This fusion offers the potential to optimize load- bearing capacities, enhance architectural freedom, and address the challenges inherent to tall buildings.

AIM AND OBJECTIVES

The specific objectives of the research are:

1. To study the seismic behaviour of multi-storeyed building with steel beam-concrete column HYBRID structure by Response spectrum method and Time history method.
2. To compare storey stiffness, storey displacement, storey drift, storey shear and overturning moment of both buildings using ETABS software.

LITERATURES REVIEW

S Morino (2014), studied the situation of hybrid structure development, design and construction in recent times and details of several selected hybrid structural systems are discussed like steel reinforced concrete structure, concrete filled tubular column system, reinforced concrete column, steel beam structural system and hybrid wall system. After the study the researcher reached the conclusion that concrete filled tubular column, reinforced concrete column and steel beam element hybrid structure have attained a sufficient level of application in buildings. However, smooth stress transfer is even a challenging work due to lack of knowledge in connection of element in hybrid structure.[1]

Shahrooz et. al. (2014), provided a comprehensive exploration of design considerations pertaining to hybrid structures featuring reinforced concrete central core walls combined with perimeter steel frames. It delves into a range of design possibilities, including the utilization of steel or steel-concrete composite coupling beams and their associated connections to core walls, as well as the connections between outrigger beams and core walls. The study also introduces practical design guidelines, which are assessed based on prior experimental data from tests conducted by the authors. By adhering to the recommended design methodologies outlined in this paper, it becomes feasible to achieve desirable cyclic behavior with regard to both strength and energy dissipation characteristics in such hybrid structures.**[2]**

Qing-Sheng Yang et. al. (2015), represented the interfacial stresses of FRP-RC hybrid beams by analytical methods. An approximate model of the hybrid beam was developed and a closed-form solution for interfacial shear stress was derived out. Then the finite element calculations were carried out for validation of the analytical solution. The 8 comparisons between present solution and other ones in existing literatures were also performed. It is shown that the analytical solution for the interfacial shear stress is agreed well with the corresponding finite element result. He concluded that the interfacial stresses in FRP-RC hybrid beam by analytical method. The numerical examples show that the analytical and numerical results have good agreements. The comparisons of present solution and others are carried out. Present solution can be used to predict the interfacial stress and failure and to consider the parametric effects of the FRP-RC hybrid beams**.[3]**

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Jiang Jun et al. (2015), presented the seismic design of a super high-rise hybrid structure on a background of project by using linear elastic analysis and nonlinear elasto-plastic analysis. The hybrid structure consists of concrete shear walls, steel reinforced concrete (SRC) columns, concrete-filled square steel tubular (CFSST) columns, SRC beams and steel beams. Firstly, comparing steel structure and hybrid structure on seismic behavior and construction cost. Then, two structural design programs are utilized for elastic response spectrum analysis combined with elastic time-history analysis, and the results of two programs are quite close. Thirdly, static nonlinear analysis (pushover analysis) and dynamic nonlinear analysis (elasto-plastic time-history analysis) are performed to evaluate the seismic performance of the hybrid structure. Moreover, the important parts, such as strengthened part at bottom and hotel lobby at middle, are analyzed carefully to ensure the key columns are in elastic state under fortifiable earthquake. Conclusion can be drawn that the super high-rise hybrid structure achieves the earthquake performance objective, and the seismic design of the building can satisfy the inspection due to out-of-codes. He introduced the design procedure of a super high-rise hybrid structure. Elastic analysis including response spectrum method and elastic time-history analysis including static and dynamic procedures are conducted. There are some conclusions he drawn from the study. The results of elastic response spectra analyses calculated by two structural programs show the correctness of the calculating model. And the results of elastic time-history are basically identical with that of response. Nonlinear elasto-plastic analyses under fortifiable and severe earthquake are performed to indicate the behavior of structure. The results show that the hybrid structure has well seismic performance and achieves the performance objective.**[4]**

hajehpour et. al. (2021), studied the design of hybrid structure with cross laminated timber (CLT). Moderately ductile moment resisting frames are common for lateral load resist, but become uneconomical for high rise structure due to large member sections to satisfy the drift requirement. In the research, 3 hybrid buildings 8 storey, 12 storey and 16 storey tall for seismicity of Vancouver, Canada and their performance was with benchmark steel moment frame buildings. Ductile connections were used to join the CLT panel and steel frame. Non-linear static and time history analyses were carried out to evaluate the structure's seismic performance. With this study the researcher concluded that the stiffness of hybrid structure was increased and modal period of structure were reduced. The use of steel in hybrid structure was also reduced as compared to steel moment frames.**[11]**

SYSTEM DEVELOPMENT

The system development phase of this dissertation project encompasses the design, implementation, and evaluation of a computational framework for the seismic analysis of a G+20 RCC framed structure and Steel Beam-Concrete Column Hybrid Frame Structure, with a particular focus on the replacement of RCC beams with steel beams. This phase is critical in achieving the overall research objectives, which are to assess the seismic performance, structural integrity, and comparative advantages of these two structural systems. For seismic analysis of high-rise structure, the two methods are used which are response spectrum method and time history method and which are linear dynamic methods. In high-rise structures, time history analysis should be performed because it gives the most accurate results than the response spectrum method. The data required for analysis of structure and models for this study are explained below.

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Type of structure	SMRF
No. of storeys	G+20
Overall height of building	73.5m
Floor dimensions	22m x 22m
Grade of Steel	Fe500
Grade of Concrete	M40
Column dimensions	500mm x 650mm and 500mm x 500mm
Beam dimensions	300mm x 650mm and 300mm x 700mm
Slab thickness	150mm
Steel beam dimension	ISLB550
Shear wall thickness	230mm
External wall thickness	230mm
Internal wall thickness	150mm
Bottom storey height	4.5m
Typical storey height	3.5m

Table 3.1: Geometric parameters of model

Sr. No.	Design load combinations for zone 3	Design load combinations for zone 4 and zone 5
1	1.5DL+1.5LL	1.5DL+1.5LL
2	DL+LL	DL+LL
3	1.2[DL+LL±EQX] 1.2[DL+LL±EQY]	1.2[DL+LL±(EQX±0.3EQZ)] 1.2[DL+LL±(EQY±0.3EQZ)]
4	1.5[DL±EQX] 1.5[DL±EQY]	1.5[DL±(EQX±0.3EQZ)] 1.5[DL±(EQY±0.3EQZ)]
5	0.9DL±1.5(EQX) 0.9DL±1.5(EQY)	0.9DL±1.5(EQX±0.3EQZ) 0.9DL±1.5(EQX±0.3EQZ)

Table 3.2: Load combinations considered for seismic analysis

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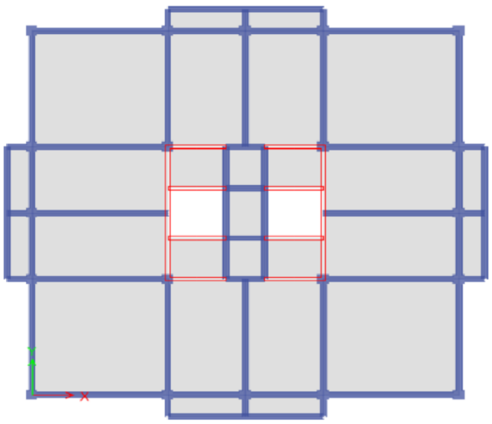

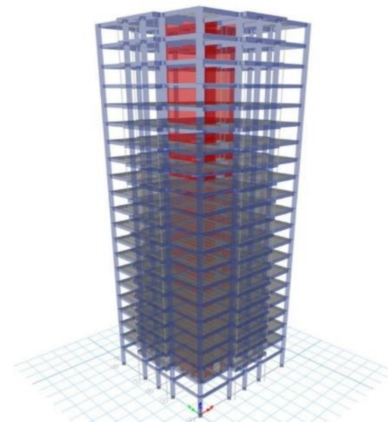

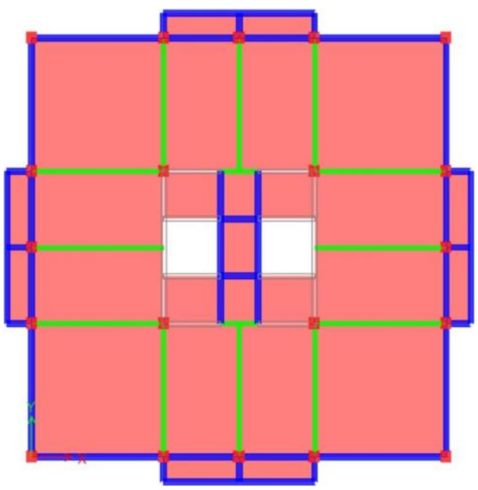

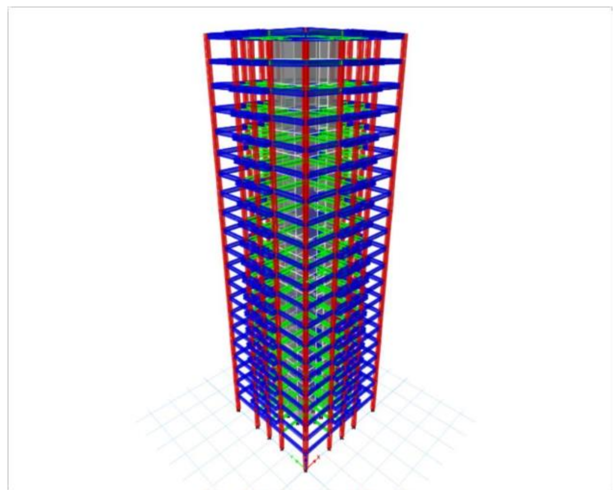

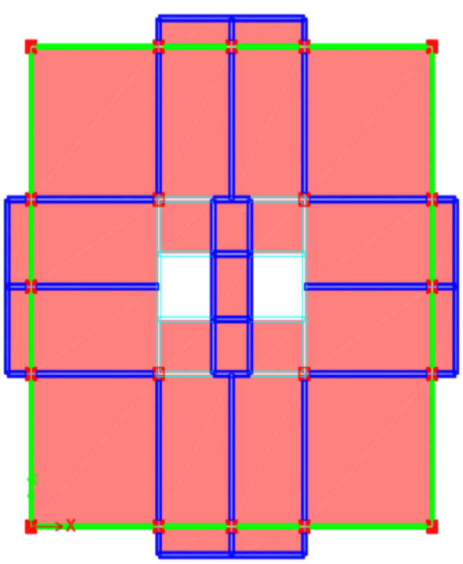

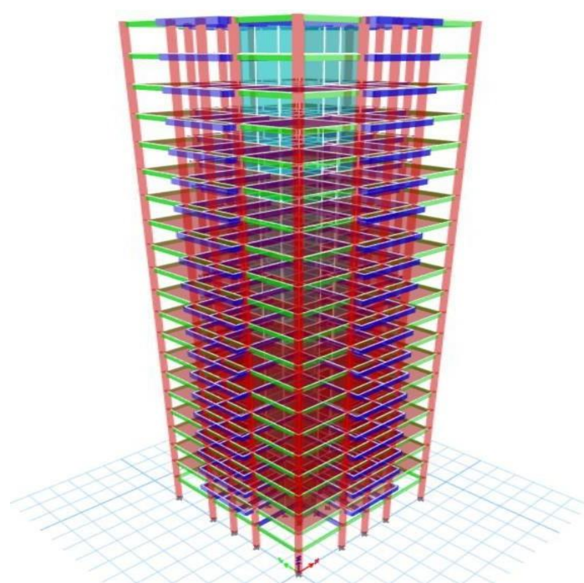

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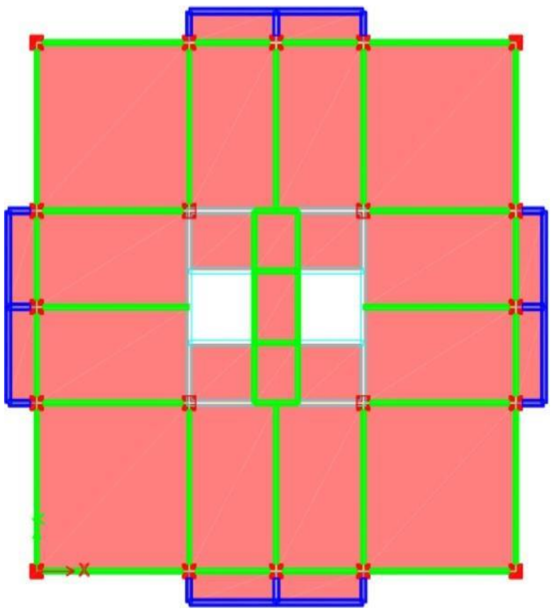
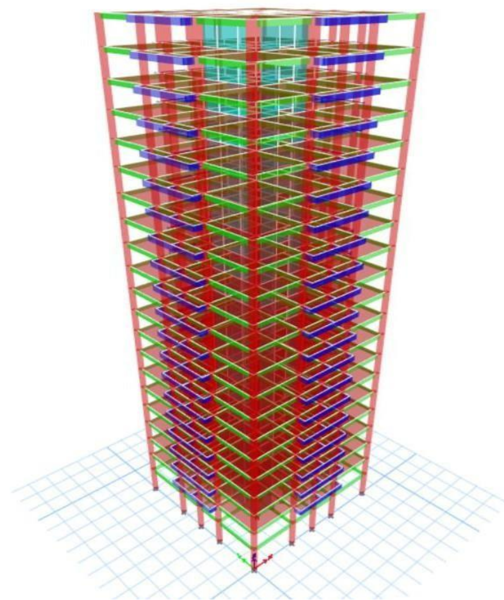


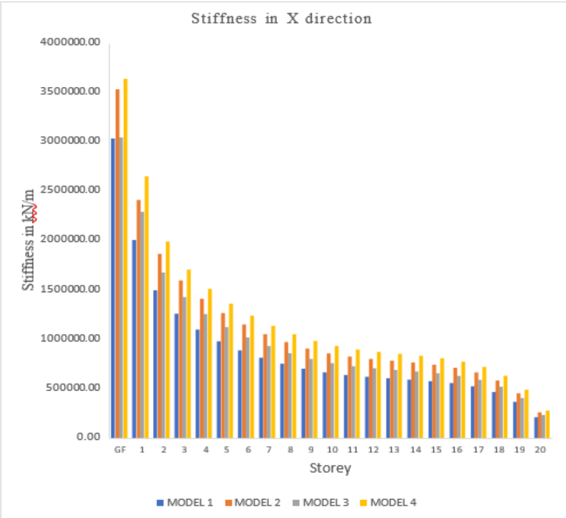


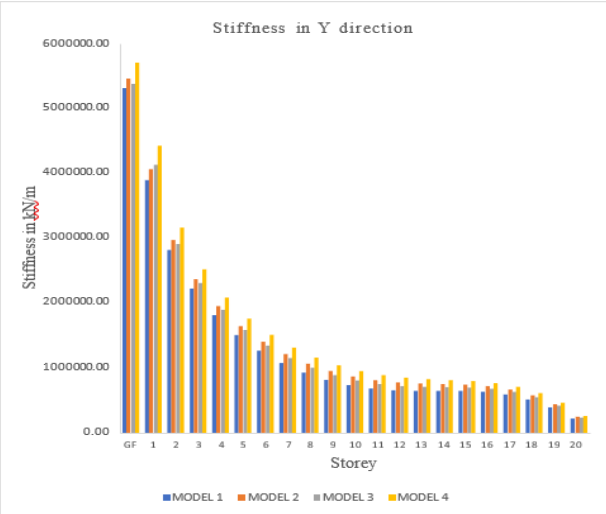
RESULTS AND DISCUSSION

In the present work G+20 multistorey RCC framed structure is modelled using ETABS software according to IS 1893:2016 and IS 16700:2017. The element sizes are changed according to the design requirements. The model is analysed with two different framed system i.e., one is RCC framed structure and in another model RC beams are replaced by steel beams and keeping concrete column and shear wall same. For the present analysis response spectrum analysis under seismic zone III, IV and V, and time history analysis by considering Bhuj earthquake data. The framed structure considered for the analysis are RCC framed structure and HYBRID framed structure, in which all internal beams connecting shear wall and periphery columns are replaced by steel beams in one model, all external beams connecting periphery columns are replaced with steel beams and all the beams are replaced with beams in model 2, 3 and 4 respectively, and columns and shear walls are kept as same as RCC framed structure.The various seismic parameters like storey stiffness, storey displacement, storey drift, storey shear and overturning moment are compared for both type of structures, graphical comparison is carried out for each parameter as shown below.

1.1.1.1 Storey stiffness in X direction:

The storey stiffness of RCC framed structure and HYBRID structures in X direction are compared and presented in tabulated form and also represented in graphical format. The results for storey stiffness are shown in figure 4.1.





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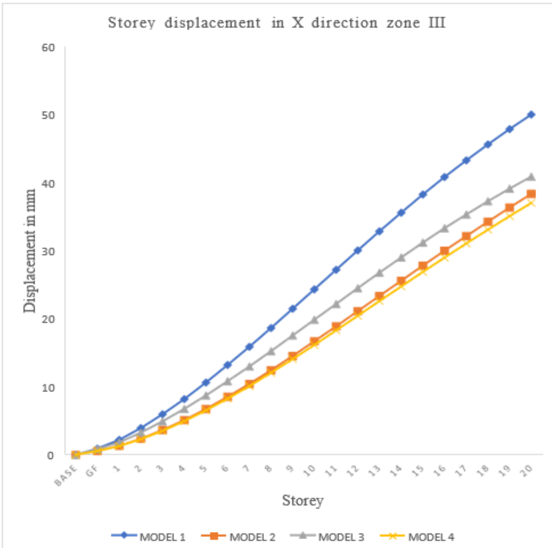

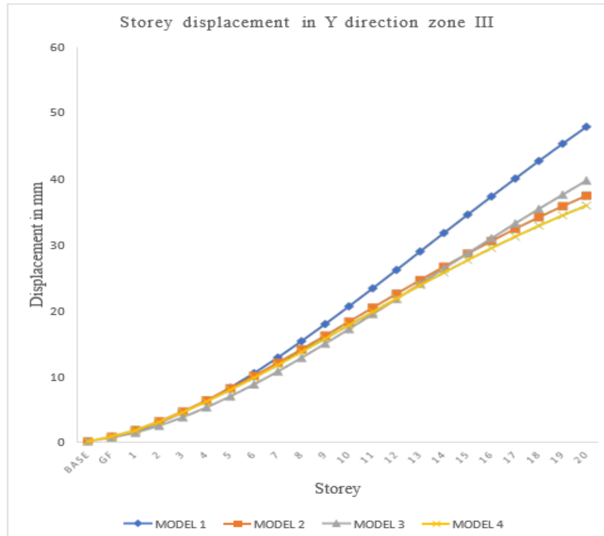

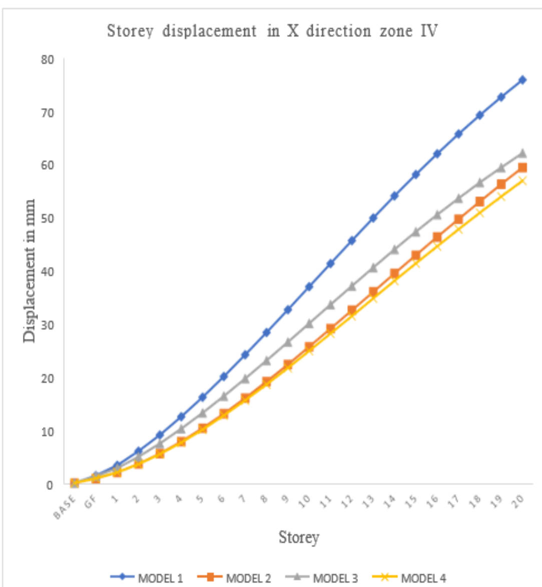

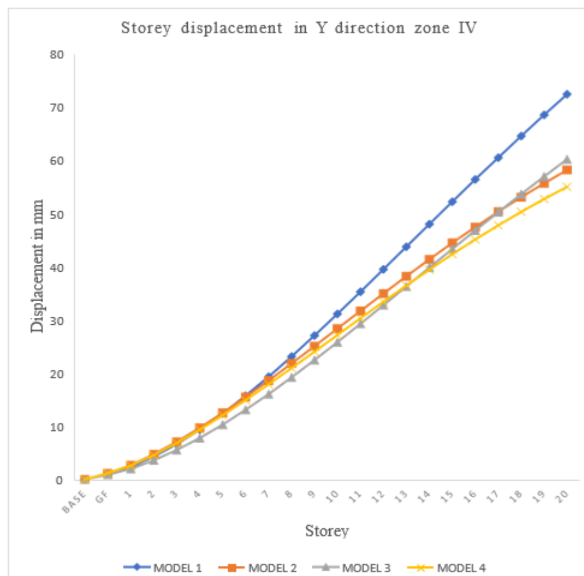

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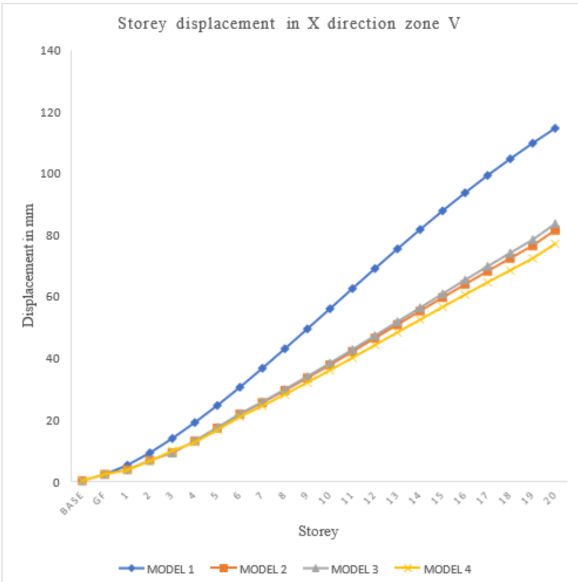

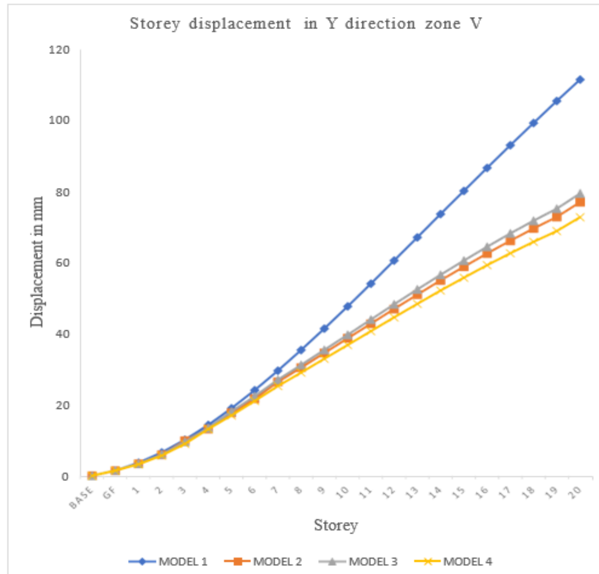

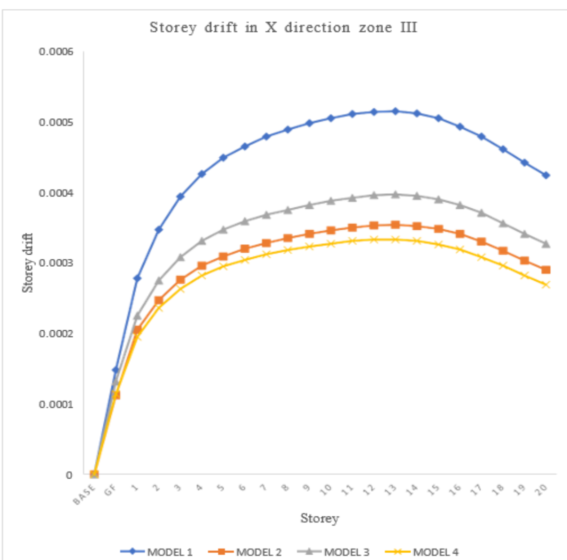

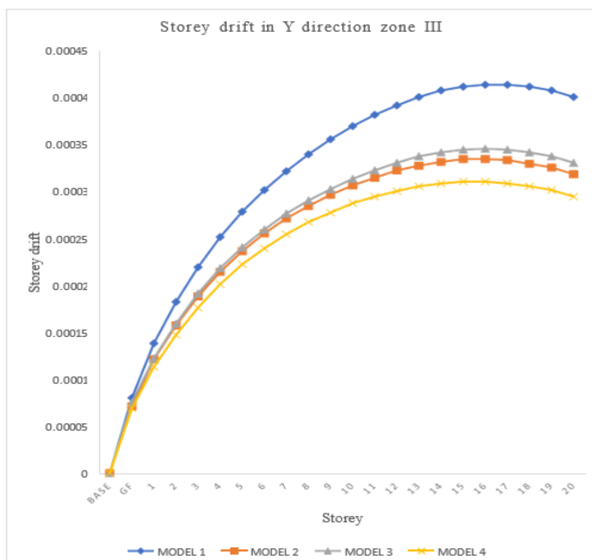

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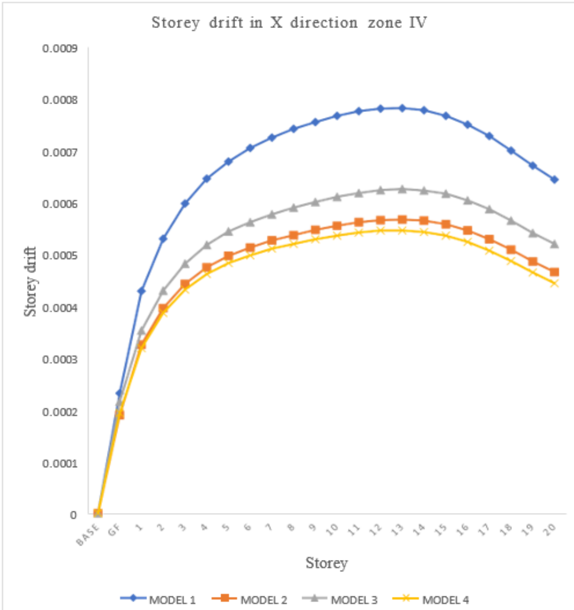

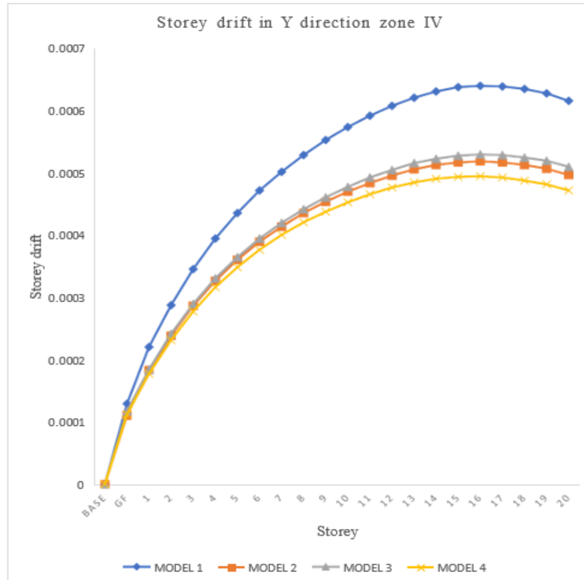

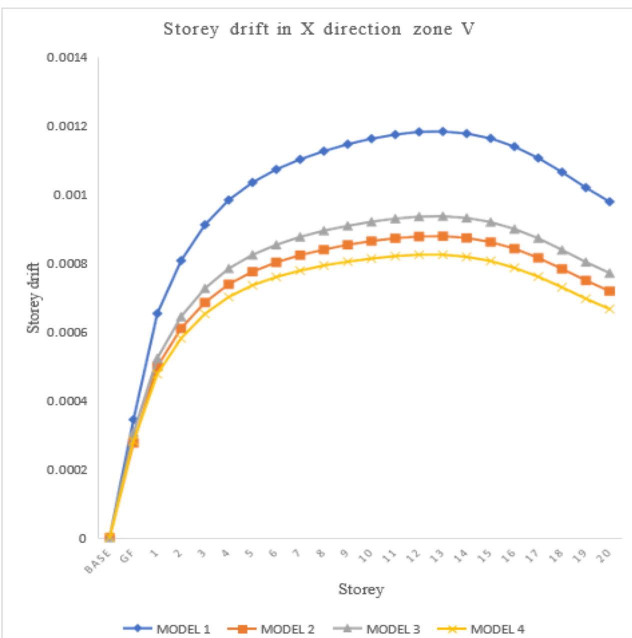

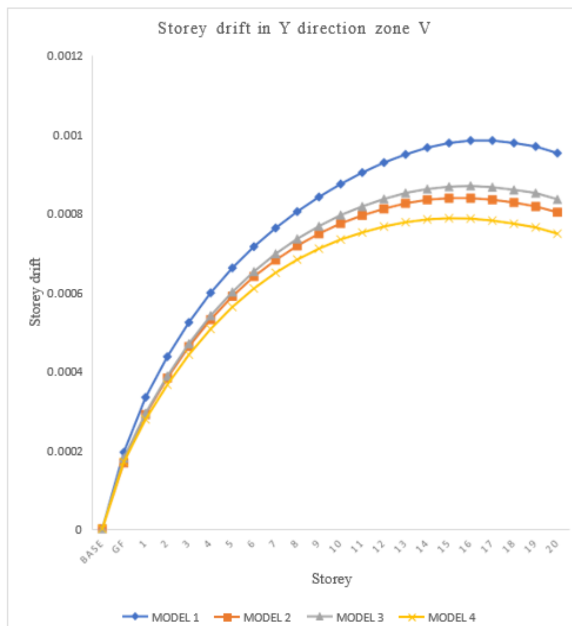

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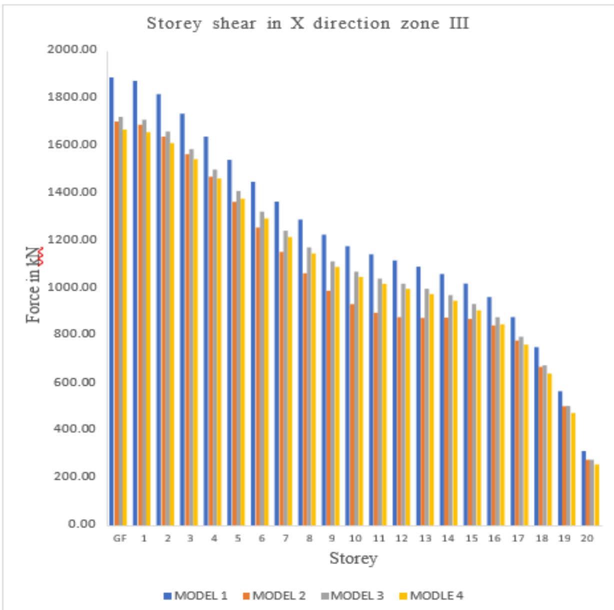

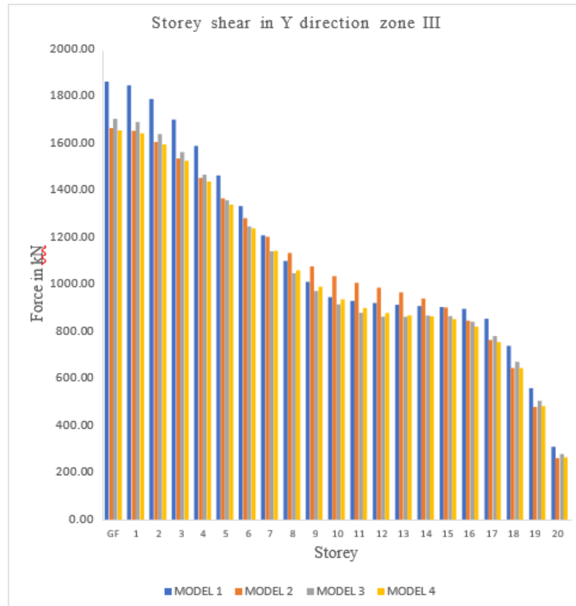

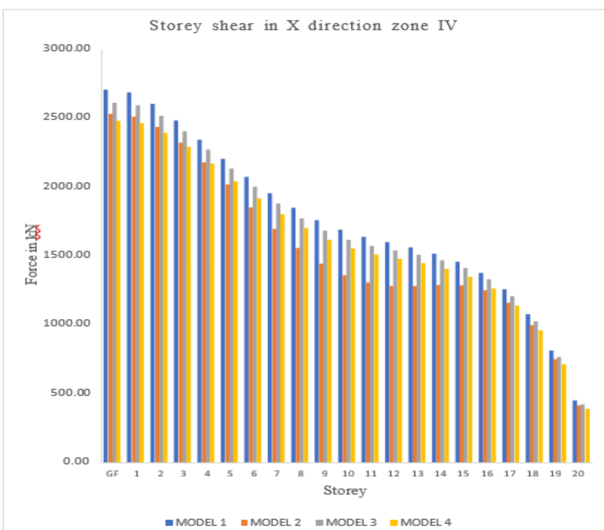

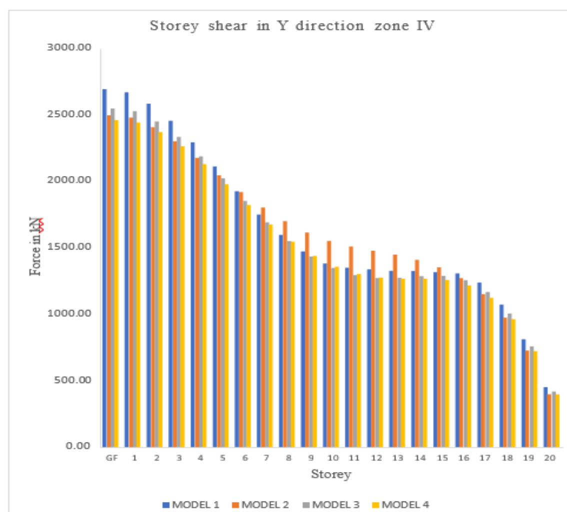

CONCLUSIONS

In the present work, G+20 multistorey building is modeled using ETABS software as per IS 1893-2016 and IS 16700-2017. Four models are considered. Model 1 is ordinary SMRF RCC framed structure as baseline for comparison. In model 2 all internal beams connecting between shear wall and periphery columns are replaced by steel beams. In model 3 all external beams between periphery columns are replaced by steel beams and in model 4 all the RC beams are replaced by steel beams. The result of various parameters like storey stiffness, storey displacement, storey drift, storey shear and overturning moment are compared and following conclusions are drawn.

1) The stiffness of the structure increases in HYBRID structure as compared to RCC framed structure. However, model 4 shows the maximum increase in stiffness.

2) While the HYBRID structure with all steel beams (Model 4) represents the maximum reduction in displacement, the difference between model 2 and model 4 is very less in all zones and in time history method also.

3) The storey drift in model 4 decreases drastically when compared to model 1. While the difference in storey drift in model 2 and model 4 is minimal under zone III, IV and V.

4) Models 2, 3, and 4 consistently exhibit lower base shear values than Model 1, under zone III, IV and V and in time history method also, indicating comparatively reduced seismic forces or lesser structural stress in these models.

5) Model 4 consistently demonstrates notably lower overturning moments under seismic zone III, IV and V and using time history method compared to Model 1. This indicates a considerable reduction in the potential for structural overturning or instability in Model 4 when compared to Model 1.

6) The section sizes required will be less due to higher strength to weight ratio of steel ultimately reducing the dead load of the structure.

REFERENCES

1) S. Morino, "Recent developments in hybrid structures in Japan-research, design and construction", Engineering Structures, Volume 20, pp: 336-346, Elsevier (Scopus) 2014.
2) Bahram M Shahrooz, Bingnian Gong, Gokhan Tunc, Jeremy T Deason, "An overview of reinforced concrete core wall-steel frame hybrid structure", Progress in Structural Engineering and Materials, Volume 3, Issue 2, pp: 149-158, 2014.
3) Qing-Sheng Yang, Yun Cui, Lian-Hua Ma, "Analytical and numerical investigation of interfacial stress in FRP-RC hybrid structures", Engineering, Science, Construction and Operations in Challenging, Earth and Space, pp:1-8, ASCE 2015.
4) Jiang Jun, You Bing, Hu Ming, Hao Jiping Li Yangcheng, "Seismic design of a super high-rise hybrid structure", 14th World Conference on Earthquake Engineering, 2015.
5) Maria Antonietta Aiello, "Structural Performances of Concrete Beams with Hybrid „Fiber-Reinforced Polymer-Steel Reinforcements", ASCE, Volume 10, pp 133-140, 2015.
6) Lei Pang, "Design Propositions for Hybrid FRP-Steel Reinforced Concrete Beams", ASCE, Volume 10, pp 180-189, 2015.
7) Ze-liang Yao, Fa-ning Dang, Guo-liang Bai, "Seismic response analysis on a steel- concrete hybrid structure", Tenth International Conference of Chinese Transportation Professionals, pp: 3001-3007, ASCE 2016.
8) M. A. Bezabeh, S. Tesfamariam, M. Popovski, K. Goda, S. F. Stiemer, "Seismic base shear modification factors for timber-steel hybrid structure: Collapse risk assessment approach", Journal of Structural Engineering, Volume 143, Issue 10, ASCE 2017.
9) Mohammad Hamid Elmy, "Static and seismic behaviours of innovative hybrid steel reinforced concrete bridge", Elsevier (Scopus), Volume 138, pp 701-713, 2017.
10) André Plumier, "An Analytical Design Method for Steel-Concrete Hybrid Walls", Elsevier (Scopus), Volume 9, pp 185-199, 2017.
11) J. Ding, "Experimental study of structural fire behaviour of steel beam to concrete filled tubular column assemblies with different types of joints", Elsevier (Scopus), Volume 29, Issue 12, pp 3485-3502, December 2017.
12) Alessandro Zona, Luca Tassotti, Graziano Leoni Andrea Dallasta, "Nonlinear seismic response analysis of an innovative steel and concrete hybrid coupled wall system", Journal of Structural Engineering, Volume 144, Issue 7, ASCE 2018.
13) Chris P. Pantelides, "Structural Performance of Hybrid GFRP/Steel Concrete Sandwich Panels", ASCE, Volume 12, pp 570-576, 2018.
14) Piotr Lacki, "Comparison of steel-concrete composite column and steel column", Volume 202, pp 82-88, October 2018.
15) Xiaoge Ren, Shungeng Gong, Yong Lu, "Performance evaluation of seismic strengthened irregular RC-steel hybrid frames", Journal of Performance of Constructed Facilities, Volume 33, Issue 1, ASCE 2019.
16) He Zhang, Pingzhou Ca, Kai Wu, Lijian Ren, Chao Xu, "Two step seismic calculating method and seismic features of SRC-RC hybrid frame structure", Journal of Performance of Constructed Facilities, Volume 33, Issue 5, ASCE 2019.
17) V. M. Venghiac, M Budescu, S. A. Baetu, "Design of a high-rise building with hybrid steel-concrete structural elements", Computational Civil Engineering Conference series: Material Science and Engineering, pp: 586-593, 2019.
18) Zahra Hajirahimi, "Hybrid structures in time series modeling and forecasting: A review", Elsevier (Scopus), Volume 86, pp 83-106, 2019.
19) Huanjun Jiang, "Study on seismic performance of a super-tall steel–concrete hybrid structure", Wiley Online Library, Volume 12, 2019.
20) Eiichi Inai, "Behavior of Concrete-Filled Steel Tube Beam Columns", ASCE, Volume 10, 2019.
21) Mehdi Khajehpour, Yuxin Pan, Thomas Tannert, "Seismic analysis of hybrid steel moment frame CLT shear walls structures", Journal of Performance of ʻconstructed Facilities, Volume 35, Issue 5, ASCE 2021.
22) Omid Parvizi, "Numerical study of steel beam to reinforce concrete column (RCC) connection with through-plate and buckling-restrained steel plates", Elsevier (Scopus), Volume 23, September 2024.
23) Chin-Tung Cheng, "Seismic behavior of steel beam and reinforced concrete column connections", Elsevier (Scopus), Volume 61, Issue 5, pp 587-606, May 2024.
24) J. Beutel, "Cyclic behaviour of concrete filled steel tubular column to steel beam connections", Elsevier (Scopus), Volume 24, Issue 1, pp 29-38, January 2024.
25) Vishal Misal, "Hybrid Structure: Combining Steel and Concrete for Optimal Performance", International Journal on Science and Technology, Volume 16, Issue 2, April-June 2025.
26) IS 456-2000 Code of practice Plain and Reinforced concrete. Bureau of Indian Standards, New Delhi.
27) IS 875 (Part-1):1987 Code of practice for design of loads of building & structures Part-I. Dead loads. Bureau of Indian Standards, New Delhi.
28) IS 875 (Part-2):1987 Code of practice for design of loads of building & structures Part-II. Live loads. Bureau of Indian Standards, New Delhi.
29) IS 1893:2016 (Part-1) Criteria for Earthquake Resistant Design of Structures sixth revision, Bureau of Indian Standards, New Delhi.
30) IS 16700:2017 Criteria for Structural Safety of Tall Concrete Buildings first revision, Bureau of Indian Standards, New Delhi.