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Seismic Analysis and Comparison of RCC and Steel Framed Multi-story Structures

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A B S T R A C T

The research focused around Multi-story structures apllicable to residential and commercial uses in India and World around. Research paper work involved StaadPro analysis of various considered structures under seismic loading conditions. The structures were subjected to seismic zone IV and variation in number of story and structure frame type.G+10 and G+30 story RCC and steel framed structures were considered, modelled-analysed and compared for their results. Comparative parameters are deflection, shear force-bending moment, and reaction forces for all four models.. Results were traced in tabular format for all parameters value and comparision graphs were traced to achieve clear comparision of results obtained. Conclusion were made to describe the behavior and comparison of result values to set the platform for future policies for design engineers and researchers. It is also noted as a conclusion that the software can be utilised frequently which tends to save time and money for design professionals. Designer may rely on outcomes of the software to proceed for practical approach.

Keywords: Seismic, RCC structures, Steel Framed Structures, StaadPro, Displacement, Shear force-Bending moment, Stresses, Reactions.

1.Introduction

This study investigates about the RCC and steel framed structures which are now being popular in developing countries. For medium and high rise buildings RCC structure is no longer economical because of increase dead weight, span restriction, low natural frequency and hazardous formwork. Steel framed structures are becoming more popular nowadays and safe over its design life span. The steel framed constructions are best solution for modern buildings. In this paper we have discus the various results of the building construction for RCC and Steel framed structures considering different cases.

2. Objective

The main of present work is to analyze G+10 and G+30 storey buildings with RCC structure and Steel frame building against siesmic Zone IV.

The components of objectives are as follows :-

a) To design and evaluate the seismic behavior of RCC building having different heights / stories.
b) To design and evaluate the seismic behavior of Steel framed building having different heights / stories.
c) To compare RCC and steel structure for various heights under siesmic loading..
d) To obtain and analyze the various loads acting on the structure.

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3. Problem Formulation

3.1. Problem Case Formation

To achieve the objectives, structural modal of a G+10 and G+30 building has been prepared using STAAD Pro v8i software. A RCC framed structure has been formed for both G+10 and G+30 buildings. Again, following same plan, both steel structural systems has been formed. Then structural modeling and analysis have been performed by STAAD Pro software for all four models. Loads are assigned as per IS-875 & IS-1893-2002. RCC structural members are designed following IS-456-2002. Steel structural members, joints etc. are designed as non-composite following IS-800-2007. Complete information related to structural behavior is obtained.

3.2. Structural Parameters

Table 1: Buiding Description

Description	Structure Basic Details
Plan	30 mtr x 30 mtr
Bay Distance	6 Mtrs
Thickness of slab	150 mm
Height of floor	3 mtr

Table 2: Structural Loading Parameters

Parameter	Value
Live load	3 kN/m2
Dead Load	Self Weight of Structure
Earthquake	zone IV
Damping ratio	0.05
Type of soil	I
Response reduction factor	1
Importance factor	1

Table 3: Material Properties

Material	Concrete	Steel
Grade	M 25	Fe 500
Youngs Modulous (E)	2.17185e7 kN/m2	2.05e8 kN/m2
Mass Density	23.5616 kN/m3	76.8195 kN/m3
Poisson's Ratio	0.17	0.3

4. Methodology

In this present work the siesmic response is analysed for two category of buildings i.e. RCC and Steel framed structure. Two models for each category are modeled, Models are considered of G+10 storey and G+30 storey. The height of each floor is considered as 3 mtrs.

4.1. Case Formation

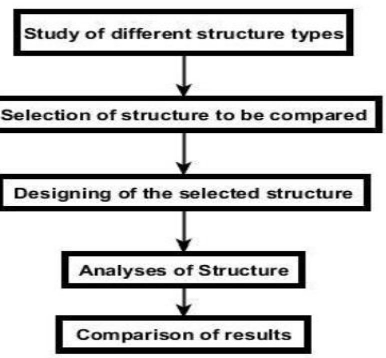
The models or cases are named as:

i. G+10 RCC Building Model.
ii. G+10 Steel Framed Building Model.
iii. G+30 RCC Building Model.
iv. G+30 Steel Framed Building Model.

4.2. Software Application

Staad pro v8i has been used for modelling purpose. The analysis is mainly done for understanding the various aspects of RCC and Steel framed structure under siesmic / lateral loading. Frames are are considered with fixed joined and fixed base. Seismic Zone IV is considered for all the cases. Models are studied for comparative study like displacement, reaction force, shear force-bending moment and stresses etc. Comparative study is performed for codal provisions for RCC and Steel structure as per IS 1893 - 2002 and IS 456:2000 respectively.

4.3. Proposed Methodology Plan



5. Modelling, Analysis and Data Collection

5.1. *Case I. G+10 RCC Building*

5.2. *Case II. G+30 RCC Building*

5.3. *Case III G+10 Steel Framed Building*

5.4. *Case IV G+30 Steel Framed Building*

For all four cases I to IV rendered model as shown below are modelled using Staadpro software.

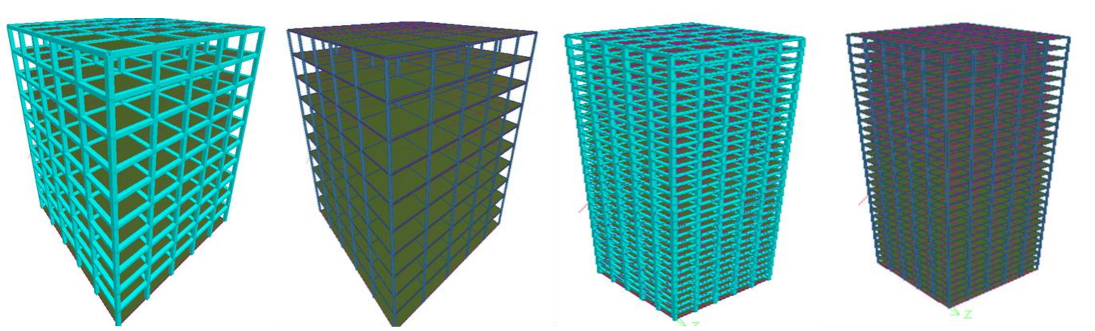


Figure 1 (a) G+10 RCC Model (b) G+10 Steel Framed Model (c) G+30 RCC Model (d) G+30 Steel Framed Model

Didplacement and shear force-bending moments were first analysed for all four cases I to IV applying siesmic loading under zone IV. The displacement and shear force-bending moment forces analysis result image results are found after StaadPro analysis is shown in figure below:

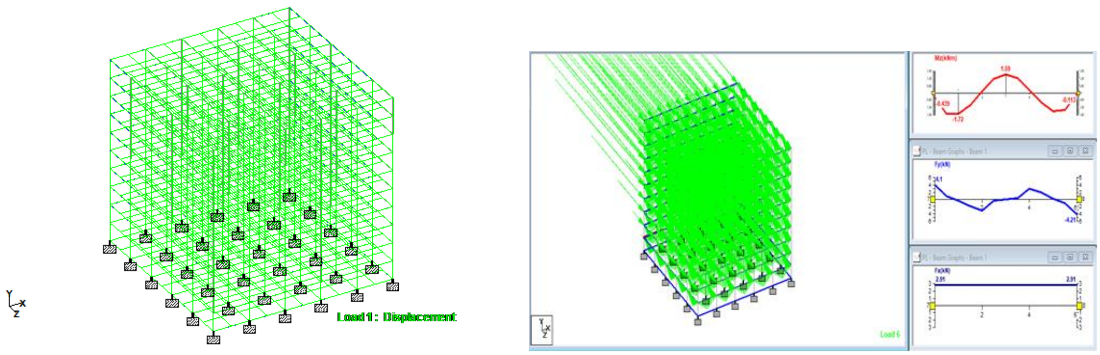


Figure 2 (a) Displacement Analysis (b) Shear force Bending moment Analysis

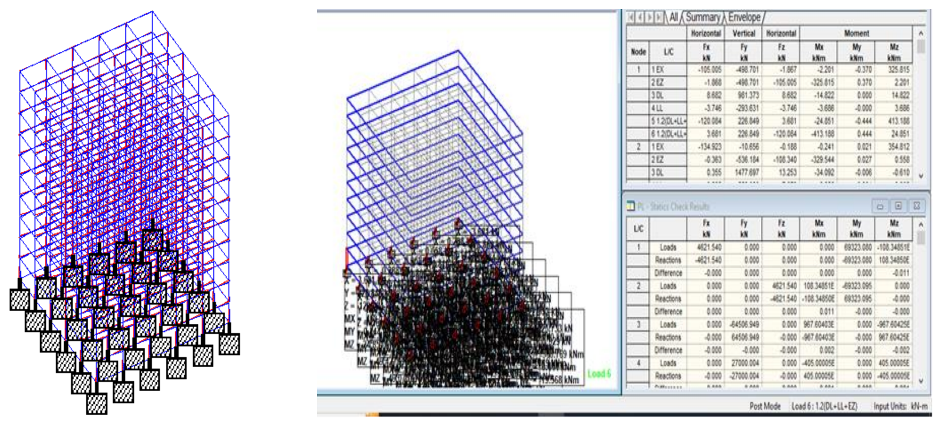


Figure 3 (a) Stress Analysis (b) Reaction Forces

6. RESULTS AND COMPARISION

Result comparison includes the comparison of displacement, SF/BM forces, Stresses, and reaction forces / moments of RCC vs Steel framed structure at different loading conditions such as seismic loading in X direction, seismic loading in Z direction, dead load, live load, and combined seismic load in X and Z direction. Graphical comparison is also presented for each case to look for diffrence in variety of result outcomes at each loading conditions. The pattern of RCC vs Steel framed displacement at each loading condition can also be only trace with the help of graphical comparison.

6.1. G+10 Displacement and SF/BM Comparison (RCC vs Steel Framed Building)

Displacement for G+10 RCC and Steel framed building is compared wih each other. The maximum displacement in civil building is found 83.167mm and in steel building maximum displacement is found 153.81mm. The displacement with steel building is greater then civil building.

The maximum shear force in civil building is found 2207.48 kN and in steel building maximum shear force is found 1341.933 kN. The SF with RCC building is greater then steel framed building building. The maximum bending moment in civil building is found 433.549 kNm and in steel building maximum bending moment is found 184.641 kNm. The BM with RCC building is greater then steel framed building.

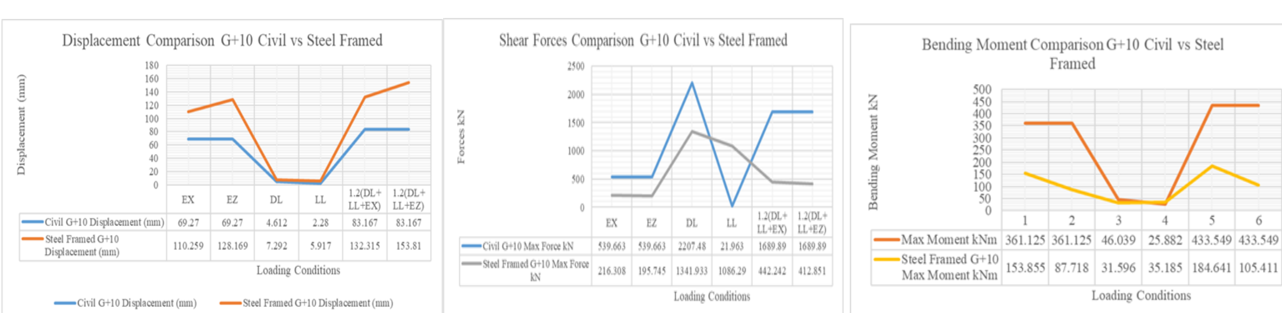


Figure 4 (a) Displacement Comparison Graph (b) SF/BM Comparison Graph

6.2. G+10 Stresses and Reaction Comparison (RCC vs Steel Framed Building)

Stresses for G+10 RCC and Steel framed building is compared wih each other. The maximum corner stresses in civil building is found 15.898 N/mm^2 and in steel building maximum corner stresses is found 291.279 N/mm^2. The corner stresses with Steel framed building is greater then RCC building. The maximum compressive stresses in civil building is found 15.898 N/mm2 and in steel building maximum compressive stresses is found 291.238 N/mm^2. The compressive stresses with Steel framed building is greater then RCC building. The maximum tensile stresses in civil building is found 14.9 N/mm^2 and in steel building maximum tensile stresses is found 291.279 N/mm^2. The tensile stresses with Steel framed building is greater then RCC building.

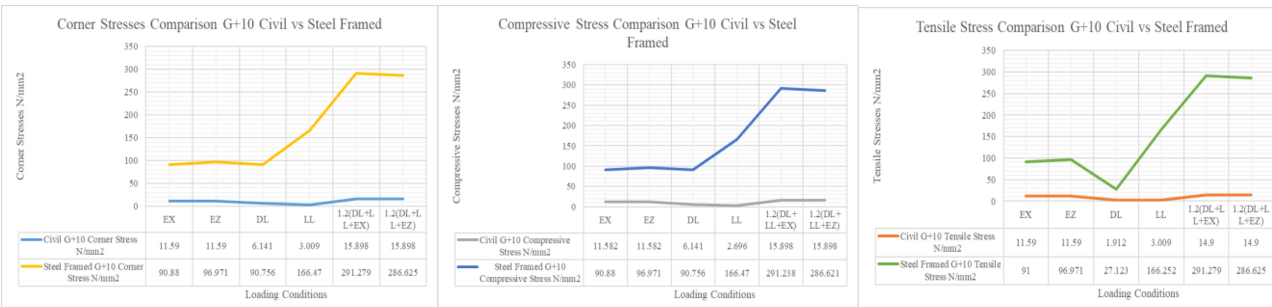


Figure 5 (a) Corner Stresses Comparison Graph (b) Compressive Stresses Comparison Graph (c) Tensile Stresses Comparison Graph

Reactions for G+10 RCC and Steel framed building is compared wih each other. The maximum corner stresses in civil building is found 15.898 N/mm^2 and in steel building maximum corner stresses is found 291.279 N/mm^2. The corner stresses with Steel framed building is greater then RCC building. The maximum compressive stresses in civil building is found 15.898 N/mm^2 and in steel building maximum compressive stresses is found 291.238 N/mm^2. The compressive stresses with Steel framed building is greater then RCC building. The maximum tensile stresses in civil building is found 14.9 N/mm^2 and in steel building maximum tensile stresses is found 291.279 N/mm2. The tensile stresses with Steel framed building is greater then RCC building.

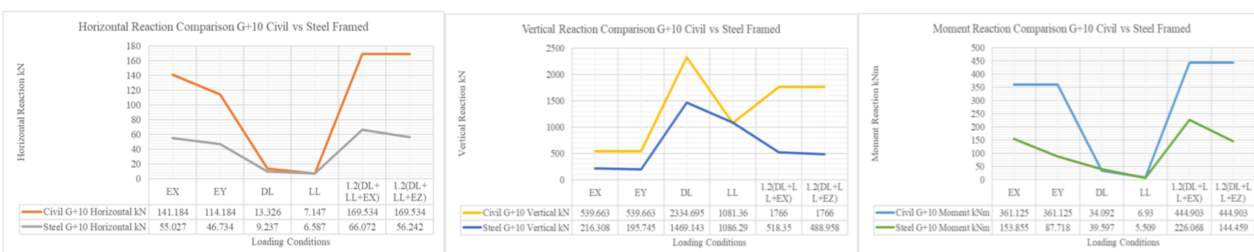


Figure 6 (a) Horizontal Reaction Comparison Graph (b) Vertical Reaction Comparision Graph (c) Moment Reaction Comparison Graph

6.3. G+30 Displacement and SF/BM forces Comparison (RCC vs Steel Framed Building)

Displacement for G+10 RCC and Steel framed building is compared wih each other. The maximum displacement in civil building is found 185.51 mm and in steel building maximum displacement is found 452.669 mm. The displacement with steel building is greater then civil building.

The maximum shear force in civil building is found 7981.904 kN and in steel building maximum shear force is found 3962.81 kN. The SF with RCC building is greater then steel framed building building. The maximum bending moment in civil building is found 767.6 kNm and in steel building maximum bending moment is found 223.542 kNm. The BM with RCC building is greater then steel framed building.

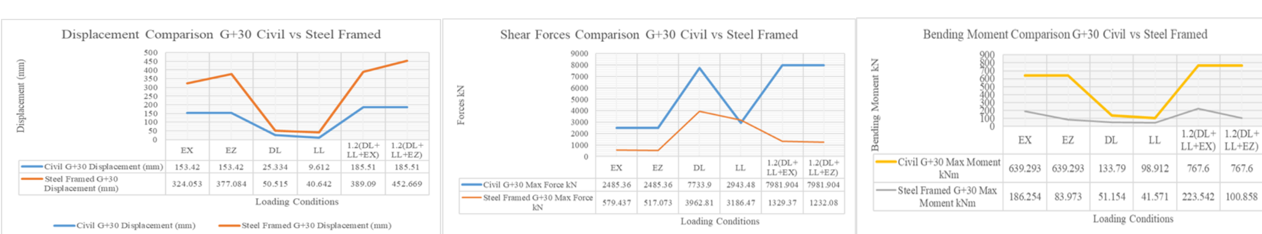


Figure 7 (a) Displacement Comparison Graph (b) SF/BM Comparison Graph

6.4. G+30 Stresses and Reaction forces Comparison (RCC vs Steel Framed Building)

The maximum corner stresses in civil building is found 20.85 N/mm^2 and in steel building maximum corner stresses is found 289.204 N/mm^2. The corner stresses with Steel framed building is greater then RCC building. The maximum compressive stresses in civil building is found 20.85 N/mm^2 and in steel building maximum compressive stresses is found 289.197 N/mm^2. The compressive stresses with Steel framed building is greater then RCC building. The maximum tensile stresses in civil building is found 13.173 N/mm^2 and in steel building maximum tensile stresses is found 289.204 N/mm^2. The tensile stresses with Steel framed building is greater then RCC building.

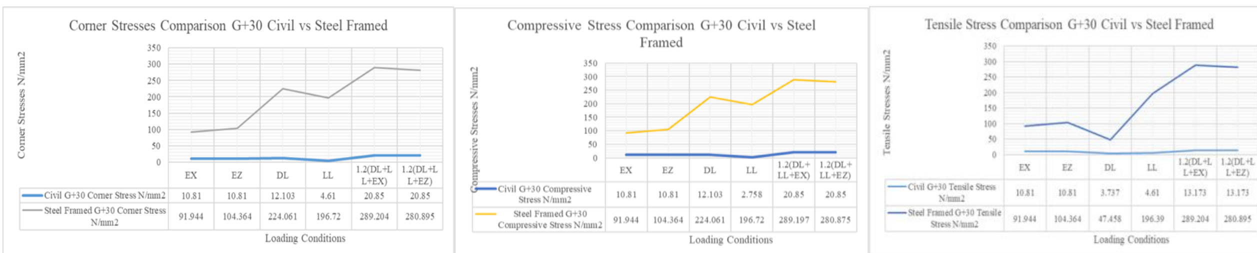


Figure 8 (a) Corner Stresses Comparison Graph (b) Compressive Stresses Comparison Graph (c) Tensile Stresses Comparison Graph

The maximum reaction forces horizontally in civil building is found 286.937 kN and in steel building maximum reaction forces horizontally is found 60.931 kN. The reaction forces horizontally with RCC building is greater then Steel framed building. The maximum reaction forces vertically in civil building is found 8058.011 kN and in steel building maximum reaction forces vertically is found 4090.021 kN. The reaction forces vertically with RCC building is greater then Steel framed building. The maximum reaction moment in civil building is found 767.585 kN and in steel building maximum reaction moment is found 268.176 kN. The reaction moment with RCC building is greater then Steel framed building.

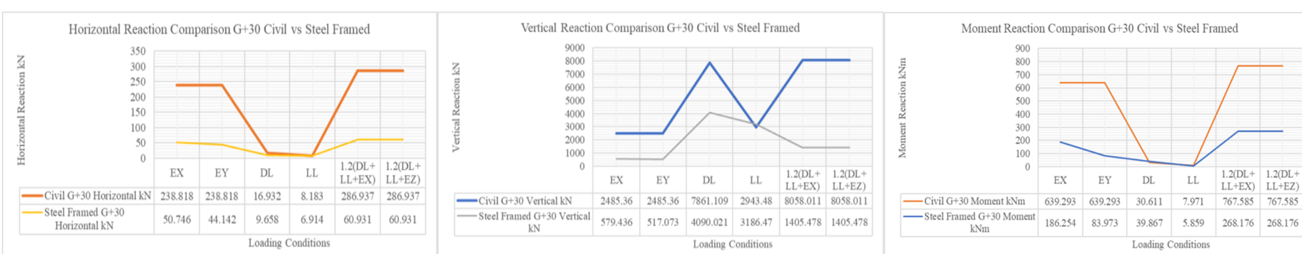


Figure 9 (a) Horizontal Reaction Comparison Graph (b) Vertical Reaction Comparision Graph (c) Moment Reaction Comparison Graph

7. Conclusion

Result conclusion is the considered as last phase of thesis or dissertation. We here will make note on final outcomes remarks and scope covered with understanding of presented research's main findings. We will aim to brief heiglights of the research findings, the final concluded remarks are summarized as follows:

1. Displacement is analysed and compared for all four cases conidered, it can be clearely seen that for both G+10 and G+30 building models displacement in case of steel framed building is much heigher then RCC building. Steel is ductile in nature and having heigher tensile properties which allows steel structure to withstand safe under heigher seismic loading caonditions. Now a days in India, engineers are recommending steel framed structure in seismic sensative zones.

2. Conclusion for SF/BM forces results first need to clearify that the self load or we can say dead load of the RCC structure is always too much heigher than steel framed buildings. Here, for both G+10 and G+30 buiding cases shear force and bending moment both are at heigher side in case of RCC building. This RCC aspect of being heavy tends RCC to fail prior to similar steel structure under similar seismic loadings. Again it is recommendd to go for steel framed structure in seismic sensative zones.

3. Steel is stable under both stress and compression and thus has high compressive and tensile strength. Concrete is low in compression and thus has high compressive strength.

   The ultimate compressive strength of steel varies from 800 to 1200 N/mm2 and in present results for any of the four cases, compressive stress in steel is maximum found 291.238 N/mm2 which is 36.40% of allowable compressive stresses. While in RCC the compressive strength of concrete is 25 N/mm^2, compressive stress in RCC is maximum found 20.85 N/mm^2 which is 83.4% of allowable compressive stresses. Hence, steel is prooved safier compairing percentage compressive stress generated against ultimate values.

The ultimate tensile strength of steel varies from 520 to 720 N/mm^2 and in present results for any of the four cases, tensile stress in steel is maximum found 291.279 N/mm^2 which is 56.01% of allowable tensile stresses. While in RCC the ultimate tensile strength of concrete can be achieved equals to compressive strength 25 N/mm^2, tensile stress in RCC is maximum found 14.9 N/mm^2 which is 59.6% of allowable compressive stresses. Hence, steel is prooved safier compairing percentage tensile stress generated against ultimate values.

4. Reaction forces or simply reactions are the forces and moments which hold or constrain an object or structural system in equilibrium. They are called the reactions because they react when other forces on the system change. Reactions decides the footing strength to be design for any height with any material of building. It is concluded that RCC reactions are always found heigher hence need much hevier footing design, RCC itself as a structure is costlier than steel frames. This makes RCC buildings costlier than steel frame buildings by 30-35% cost.

8. Future Scope

Now a days many composits application is increasing in demand which are lighter in weight and stronger with properties. Many composits offers economic construction of compatible strength and even helps to complete project in short time duration which ultimately reduces cost of project. The complete cost analysis can be done, keeping in view all the factors like slab, footing, shear studs, connections , cost of formwork, labour , machinery cost etc. and complete results can be calculated so that there is better and clear idea about the cost included in construction.

Different irregular Plans of buildings can be designed for various heights to get more clearance about building safety. Time history analysis can be also included with seismic design to reach closer approximation. Wind load and analysis can also be performed using pushover analysis for heigh-rise structures or buildings. Pushover analysis using different types of encased and in filled concrete composite section can also be performed.

REFERENCES

1. Harish Soundalgekar and Kshitij S Patil, Comparative Study of Reinforced Cement Concrete and Steel Structures, International Advanced Research Journal in Science, Engineering and Technology, Vol. 10, Issue 5, May 2023. PP 476-478.
2. Md.Yaser and Ajith Kumar Dey, Comparative Cost Analysis And Dynamic Analysis Of RCC, Steel And Steel-Concrete Composite Frame Of Low, Medium & High Rise Buildings, Journal of Engineering Sciences, Vol 13, Issue 10, 2022, PP 301-309.
3. Jadhav Gorakhnath S, et. al, Comparative Analysis of RCC And Steel-Concrete Composite Multistoried Building, Journal of Information, Knowledge and Research in Civil Engineering, Volume 4, Issue 2, 2022, PP 398-404.
4. Sayyed Faizuddin Hashmi and Hemant.B.Dahake, Comparative Study of R.C.C, Composite and Steel Structure Under Dynamic Condition, International Journal of Scientific Development and Research, Volume 6 ,Issue 6, June 2021, PP 2019-228.
5. Raghuvaran Komati and Battu Jaya Uma Shanker, A Review on Comparative Pushover Analysis on Different Frame Structures, International Journal of Current Engineering and Technology, Special Issue-9, Aug 2021, PP 18-22.
6. Bhanu Prakash et. al., Review on Comparative Study on RCC and Steel Structure for Different Criteria's, International Journal of Multidisciplinary Educational Research, Volume:10, Issue:4(2), April 2021, PP 1-4.
7. Mitaali Jayant Gilbile and S. S. Mane, A Review on Comparative Study on the Structural Analysis and Design of Pre-Engineered Building [PEB] with Conventional Steel Building [CSB], International Journal of Engineering Research & Technology, Vol. 9 Issue 09, September-2020, PP 56-58.
8. Ankush Dod and Prof. V. M. Sapate, Comparative Analysis of RCC and Steel Building Using STAAD Pro, International Journal for Research in Applied Science & Engineering Technology, Volume 8 Issue V May 2020, PP 1291-1299.
9. Sumit Shah and S.Saranya, Comparative Study of Reinforced Cement Concrete (RCC) and Steel Structure, International Journal of Science and Research, Volume 9 Issue 1, January 2020, PP 1548-1551.
10. G.Hemalatha et. al., Comparative Analysis of Steel and RCC Frame Structure of a Commercial Building, International Journal of Constructive Research in Civil Engineering, Volume 6, Issue 4, 2020, PP 10-13.
11. Hemanthkumar.S.K and A.R.Pradeep, A Study on the Analysis and Design of the Steel Warehouse, Journal of Interdisciplinary Research, Vol.1(2), 2020, pp. 28-35.
12. Ishwor Thapa et. al. Comparative Study of Structural Analysis between Reinforced Cement Concrete Structure and Steel Framed Structure, International Research Journal of Engineering and Technology, Volume 07, Issue 08, Aug 2020, PP 3633-3637.
13. Surya Nand and Sumit Sharma, Comparative Study on Steel Framed and Reinforces Concrete Buildings- A Review, Journal of Engineering Analysis Design, Volume 2 Issue 3, 2020, PP 1-3.
14. Anil S. Savadi and Dr. Vinod Hosur, Comparative Study of RCC, Steel And Composite Structures for Industrial Building, International Journal Of Advance Research And Innovative Ideas In Education, Vol-5, Issue-4, 2019, PP 637-647.
15. Mayank B. Patel, Comparison of STEEL Structure and RCC Structure, Journal of Emerging Technologies and Innovative Research, February 2019, Volume 6, Issue 2, PP 427-433.
16. Anurag Saraogi et. al. A Comparison between RCC and Steel Structure, International Journal of Research in Engineering, Science and Management, Volume-1, Issue-4, April 2018, PP 106-108.
17. Tolga Celik and Saeed Kamali, Multidimensional, Comparison of Lightweight Steel and Reinforced Concrete Structures: A Case Study, Technical Gazette 25, Issue 4, 2018, PP 1234-1242.
18. Jyothi D N, Comparative Analysis of RCC and Steel Structure, International Research Journal of Engineering and Technology, Volume 05, Issue 02, Feb-2018, PP 345-347.
19. Mohd Tauseef and V.G.Meshram, Comparative Study of Wooden, R.C.C and Steel Framed Structure Under Seismic Loading Part-I, International Journal of Innovative Research & Studies, Volume 8, Issue IV, April 2018, PP 404-411.

20. Isha Bedi et. al., Comparative study of RCC Frame Structures using Staad.Pro, ETABS, and SAP, International Journal of Advance Research in Science and Engineering, Volume 6, Issue 9, Sep 2017. PP 1005-1013.
21. Bhavin H. Zaveri et. al. A Review on the Comparative Study of Steel, RCC and Composite Building, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 1, Januray 2016, PP 354-365.
22. IS 1893:2002 (part1) Criteria for earthquake resistant design of building.
23. IS 875 (part 1) Code of practice for design deal load.
24. IS 875 (part2) Code of practice for design live load.