COMPARATIVE STUDY OF A STEEL STRUCTURE BUILDING WITH REINFORCED CONCRETE STRUCTURE UNDER SEISMIC FORCES WITH RESPONSE SPECTRUM ANALYSIS

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Abstract - *Building is common in modern times, especially for home growth. Because it serves the entire people, building construction is crucial to these endeavors. Each building needs stability. Country-specific building codes for various construction materials were influenced by weather, geology, and topography. With Nepal and India being neighbors, steel and RCC structures are commonly utilized. Here the analysis of steel and reinforced concrete buildings were compared through ETABS". In this study a six-story skyscraper. Construction uses RCC, steel, and ETABS V18. The main parameters investigated were axial force stiffness, shear force, and bending moment diagram. These metrics are compared using the Regular floor plan for reinforced concrete (RCC) and steel (G+6) buildings in this research.*

Key Words: Steel Structures, Reinforced Concrete Structures, ETABS V18, Axial Force Stiffness, Shear Force Analysis, Bending Moment Diagram.

1.INTRODUCTION

The development of reinforced concrete (RC) structures has numerous challenges in terms of construction timeline, financial investment, and prospective economic benefits. Hence, it is beneficial to opt for geographically strategic sites, such as hills and plains, when choosing locations for the construction of vital facilities like hospitals, educational institutions, hospitality establishments, and office complexes that utilize reinforced concrete framing methods. In earthquake-prone areas, such constructions experience greater shears and torsion than traditional construction. Depending on the local foundation material, behaviors may differ. The selection factor for RC structure or Steel structure building is dependent upon the available material as well as budget of the project and also time period for the completion of project is essential. Now days due to may aspect like return value of the structural material after long period steel structure are widely in use. It is light in weight rather than RC structure which reduces the base reaction for soil and gives economic foundation size for the construction. It also reduces transportation and wastage of construction material like aggregate, formworks, reinforcement bending & placing etc. Today, Steel structure have return value as well as less tedious and quick in construction rather than RC structure. Every consumer aspect is different which makes special challenges to Engineer. Now a day's steel structure buildings give different attraction and design then RC structure which gives eye pleasing moment for viewers. The main objective in this paper is to analyze Steel Structure Building with Reinforced Concrete Structure under Seismic Forces with Linear Dynamic Analysis.

2. LITERATURE REVIEW

In a study conducted by Sameer and Dahake, 2017, they evaluated G+10 and G+15 buildings in seismic zones III and IV. The study focused on comparing reinforced concrete (R.C.C.) and composite structures, with a specific emphasis on column importance, story drift, displacement, and self-weight control outcomes. While both types of structures can withstand seismic forces, composite buildings differ from R.C.C. structures due to their use of steel and concrete together. Composite constructions are appealing because they are faster and cost-effective. Steel-concrete connections play a vital role in bonding steel and concrete in composite building systems.

Wagh and Waghe, 2014 discussed the widespread use of steel-concrete composite construction globally as an alternative to traditional steel and concrete structures. They pointed out that India, compared to other developing nations, uses less steel in its buildings. The study highlighted the potential for India to expand its steel usage for construction due to its availability and cost-effectiveness. The research focused on four multistory commercial buildings (G+12, G+16, G+20, and G+24) and used STAAD-Pro and MS-Excel for design and cost estimation to compare R.C.C. with composite constructions.

Srivastava et al., 2023 examined the growing popularity of modern light steel framing over traditional RCC construction. Light steel structures are advantageous due to their seismic performance and ductility, offering improved building safety. The study also explored the benefits of combining RCC and steel structures to enhance fire protection and construction speed. They conducted a seismic analysis of a G+3 residential building in Earthquake Zone II using the Equivalent Static Method and compared individual 3D models for RCC, composite, and light steel buildings. ETABS 2016 software was used to analyze results, including tale drift, maximum story displacement, shear force, and bending moment, as well as material cost.

Divya and Murali, 2021 discussed the importance of time in modern construction and highlighted the efficiency of fast-erection steel structural buildings. Their study aimed to assist in selecting the most suitable construction method based on specific conditions and functional requirements. The primary focus was on column span, a critical factor influencing structural design, analysis, and cost. The research compared the design, analysis, and construction costs of RCC and steel structures with long and short columns. G+8 RCC and Steel Structures were designed and analyzed using ETABS-2018 software.

Kumar and Maru, 2021 observed that developing countries are increasingly adopting composite constructions due to the limitations of medium and high-rise RCC structures, such as dead weight, span restrictions, low natural frequency, and complex formwork requirements. The study compared a G+25 story commercial building in Earthquake Zone IV using equivalent static analysis. E-tabs software was used to model steel, R.C.C., and composite structures, emphasizing the affordability of composite constructions.

3. OBJECTIVES

- To compare the performance Steel structure with RC frame structure with their behavior on seismic zone.
- To study displacement, story drift, base shear, story shear, time period, axial force, shear force, and bending of RC frame and steel structures.
- To Study Response spectrum analysis both RC an Steel as per code (1893:2016) for medium soil type.

4. GEOMETRY CONFIGURATION:

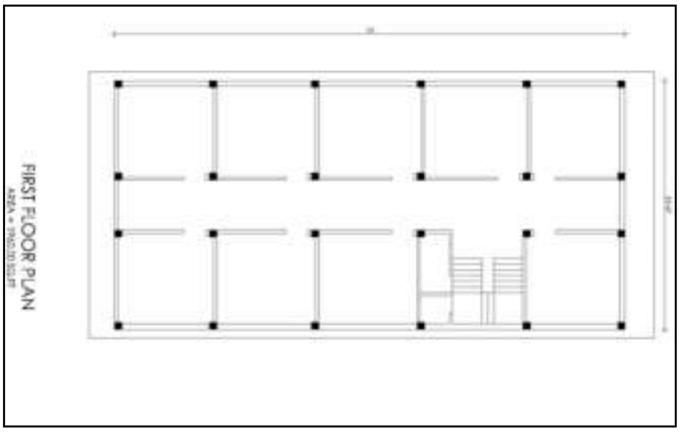
In this project, we have selected the G+5 floor building whose ground condition is medium soil. For this project, RC structure & Steel structure design was compared in terms of its response and performance.

Table -1: Geometry Data

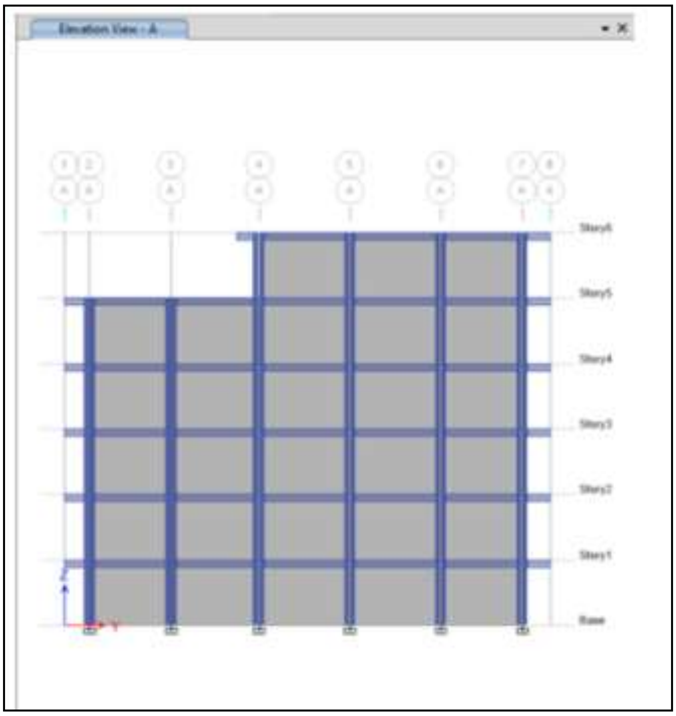
DATA	Steel Structure	RC structure
Plan	10.5m x 23.622m	10.5m x 23.622m
Typical story Hight	3.175m	3.175m
Thickness of slab	125mm	125mm
Beam size	300mmX500mm	ISMB350
Column size	IS2MB600	450mmX450mm
External wall thickness	250mm	
Floor finish	1.2KN/m^2	
Live load	3KN/m^2	
Quake zone	Medium soil zone III Importance of 1.5 and Response Reduction of 5. Damping=0.05.	
Concrete grade	M-20	
Steel grade	Fe345 & HYSD500	

4.1 Defining Plan & Elevation:

PLAN:



ELEVATION:



4.2 Modelling in ETABS:

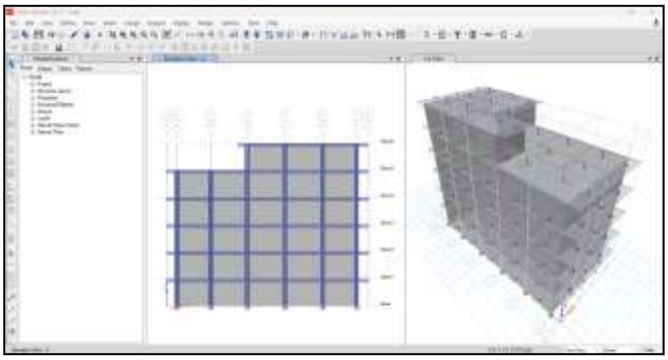


Fig -1: ETABS Modelling of G+5 steel structure.

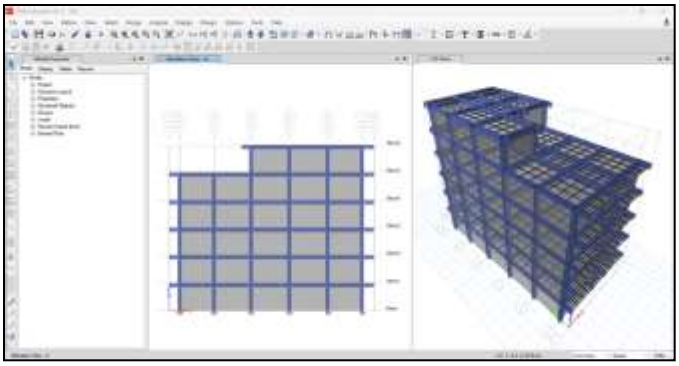


Fig -2: ETABS Modelling of G+5 RCC structure.

5. RESULTS & DISCUSSIONS:

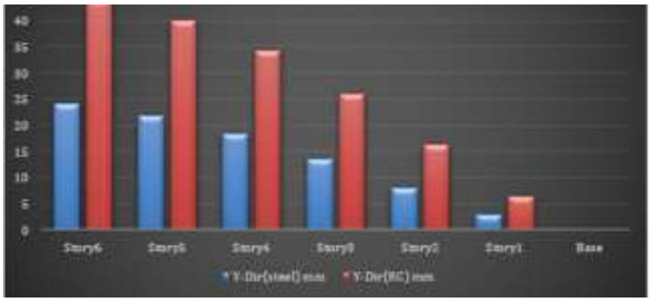
RC building with different type of slab resting on Plain ground have been analyzed by dynamic analysis. The seismic applied in X- direction and Y- direction independently. Results have been obtained from static & dynamic analysis for RC building & Steel Building with seismic zone V using ETABS software.

5.1. Story displacement of both structure with response analysis:

Chart -1: Displacement of both building in X- direction in response spectrum analysis.

Table -2: Displacement along X- Direction of RC Building and Steel Building

Storey Level	Displacement	
	RC	STEEL
6	58.629	28.803
5	53.692	25.237
4	45.148	20.417
3	33.938	14.516
2	21.246	8.218
1	8.451	2.7
0	0	0



. **Chart -2**: Displacement of both building in Y- direction in response spectrum analysis.

Table -3: Displacement along Y- Direction of RC Building and Steel Building

Storey Level	Displacement	
	RC	STEEL
6	43.961	24.137
5	40.049	21.664
4	34.228	18.228
3	25.989	13.515
2	16.277	8.024
1	6.37	2.79
0	0	0

Response analysis reveals maximum displacement in RC structure buildings compared to steel structures, roughly double in X-Direction and over 80% in Y-Direction when design check is met. Response analysis reveals maximum displacement in RC structures compared to steel structures, roughly double in X-Direction and over 80% in Y-Direction when design check is met.

5.2. Drift of both structure with response analysis:

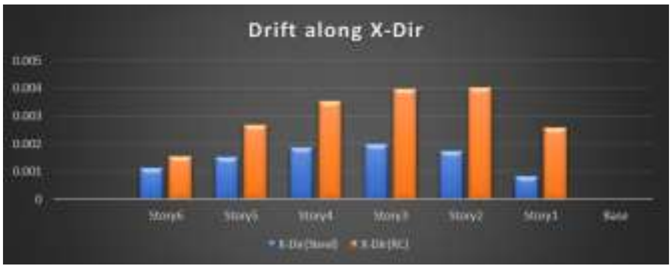


Chart -3: DRIFT of both building in X- direction in response spectrum analysis.

Table -4: Drift along X- Direction of RC Building and Steel Building.

Storey Level	Drift	
	RC	STEEL
6	0.001555	0.001123
5	0.002691	0.001518
4	0.003531	0.001859
3	0.003998	0.001983
2	0.00403	0.001738
1	0.002571	0.00082
0	0	0

Chart -4: DRIFT of both building in Y- direction in response spectrum analysis.

Table -5: Drift along Y- Direction of RC Building and Steel Building.

Storey Level	Drift	
	RC	STEEL
6	0.001232	0.000779
5	0.001833	0.001082
4	0.002595	0.001484
3	0.003059	0.00173
2	0.00312	0.001648
1	0.002006	0.000879
0	0	0

The response analysis method shows that Drift is maximum in RC structure Building than Steel Structure where it is negligible for steel structure at design check condition.

5.3. Storey shear of both structure with response analysis:

Chart -5: Storey Shear of both building in X- direction in response spectrum analysis.

Table -6: Storey Shear along X- Direction of RC Building and Steel Building.

Storey Level	Storey Shear	
	RC	STEEL
6	-269.0711	-182.2899
5	-762.5333	-477.17
4	-1132.167	-789.1966
3	-1340.086	-964.7116
2	-1432.4944	-1042.7183
1	-1455.5969	-1062.2244
0	0	0

Chart -6: Storey Shear of both building in Y- direction in response spectrum analysis.

Table -7: Storey Shear along Y- Direction of RC Building and Steel Building.

Storey Level	Storey Shear	
	RC	STEEL
6	-269.0711	-182.2899
5	-762.5333	-477.17
4	-1132.167	-789.1966
3	-1340.086	-964.7116
2	-1432.4944	-1042.7183
1	-1455.5969	-1062.2244
0	0	0

The response analysis method shows that Storey Shear is maximum in RC structure Building than Steel Structure Building which is nearly 40% in X-Direction and nearly 40% in Y-Direction when structure satisfied the design check.

5.4. Base shear of both structure with response analysis:

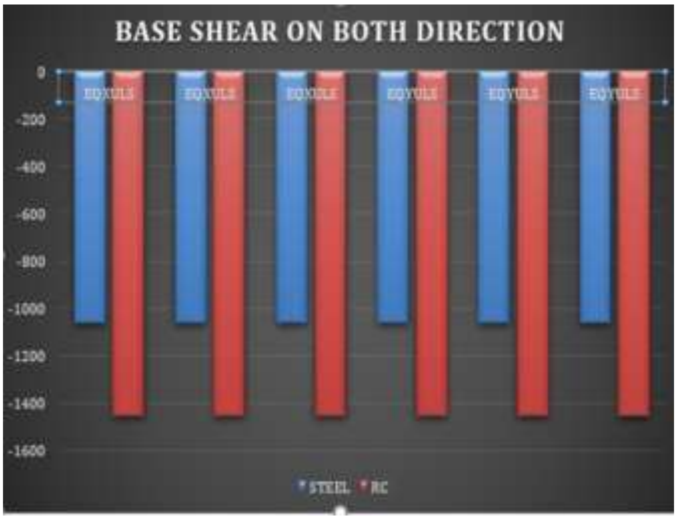


Chart -7: Base Shear of both building in response spectrum analysis.

Based on response studies, RC structures have higher Base Shear than steel structures, with about 40% in X-Direction and 40% in Y-Direction when meeting design checks.

5.5. Time period of both structure with response analysis:

Chart -8: Time period of both building response spectrum analysis.

Table -8: Time Period along Both Direction of RC Building and Steel Building.

Modal	Time Period	
	RC	STEEL
1	1.035	0.765
2	1.005	0.72
3	0.898	0.622
4	0.336	0.241
5	0.33	0.214
6	0.293	0.18
7	0.197	0.134
8	0.194	0.106
9	0.181	0.101
10	0.144	0.086
11	0.14	0.071
12	0.132	0.063

Time required for undamped system to complete one cycle of free vibration is the natural time period of vibration of system in unit of second. The response spectrum analysis is observed that maximum time period in RC building.

6. CONCLUSIONS:

Based on response spectrum analysis of both buildings, the following conclusion are drawn:

- The Performance of Both Buildings in Seismic excitation proved Steel Structure building is more suitable.
- When applied in equivalent static & response spectrum analysis the displacement is maximum in RC building.

- There is a least difference between the time periods of both buildings. But time period is maximum in RC building.
- The column portion section is huge in steel building than RC building.
- Base shear value of RC building is more.
- Response spectrum analysis reveals higher axial, shear, torsion, and bending moment values in RC buildings.
- In addition, RC building can be elongated to high-rise level rather than steel section due to its sectional availability.

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