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Parametric Study of G+15 R.C.C , Steel and Steel Concrete Composite Building based on Seismic Analysis

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Abstract: Steel-Concrete composite constructions are nowadays very popular owing to their advantages over conventional Concrete and Steel constructions. concrete structures are bulky and impart more seismic weight and less deflection whereas Steel structures instruct more deflections and ductility to the structure, which is beneficial in resisting earthquake forces. Composite Construction combines the better properties of both steel and concrete along with economic, speedy construction, fire protection etc. Hence the aim of the present study is to compare seismic performance of a 3D G+15 storey RCC, Steel and Composite building frame situated in earthquake zone IV. All frames are designed for same gravity loadings.

The RCC slab is used in same all three cases, Sections are made of either RCC, Steel or Steel-concrete composite sections like that Beam and Column. In a Seismic analysis, Equivalent static method and Response spectrum method are used for G+15 Building in all three cases ETABS 2017 software is used and results are compared based on different parametric data, Maximum story displacement, story drift, story stiffness, Fundamental time periods, Base shear and weight for structures in all types of building frames is determined. Comparative study concludes that the composite frames are best suited for medium to High rise buildings among the RCC and Steel constructions in terms of increase stiffness and base shear of building with better seismic behaviour.

Keywords*: *G+15 buildings ETABS 2017, RCC, Steel and Steel concrete Composite frame building , Seismic analysis, Response spectrum method.

I. INTRODUCTION

The advance design and as per researched combination of construction materials is that of steel and concrete, with applications in low-rise to high-rise commercial buildings and factories, as well as in bridges. These essentially different materials Steel and Concrete are completely compatible and complementary to each other; They have an ideal combination of strengths with efficient material concrete in compression and the steel in tension. Concrete also gives against corrosion protection and thermal insulation to the steel and additionally can restrain slender steel sections from local or effect of lateral-torsional buckling. Now a days these two important building materials, steel and concrete, are promoted and constructed by two different material for industries. Since these industries are in direct competition with each other, sometimes difficult to promote the best use of these two materials.

Composite construction dominates the more efficient and economical in medium and high-rise building area . This has been the case for last twenty years. Its success is due to the strength and stiffness that can be achieved, with minimum use of materials. The reason why composite construction is often so good can be expressed in one simple way - concrete is good in compression and steel is good in tension. By joining the two materials together structurally these strengths can be exploited to result in a highly efficient and economical design.

II. COMPOSITE STRUCTURE

A steel-concrete composite column is a compression member comprising of a concrete filled tubular section of hot-rolled steel or a concrete encased hot-rolled steel sections, concrete filled and concrete encased column sections respectively. In a composite column, both the concrete and the steel interact together by friction and bond. Therefore, they resist external loading. Generally, in the composite construction, the initial construction loads are beared and supported by bare steel columns. Concrete is filled on later inside the tubular steel sections or is later casted around the I section. The combination of both steel and concrete is in such a way that both of the materials use their attributes in the most effective way. It is very convenient and efficient to erect very high rise buildings if we use steel-concrete composite frames along with composite decks and beams.

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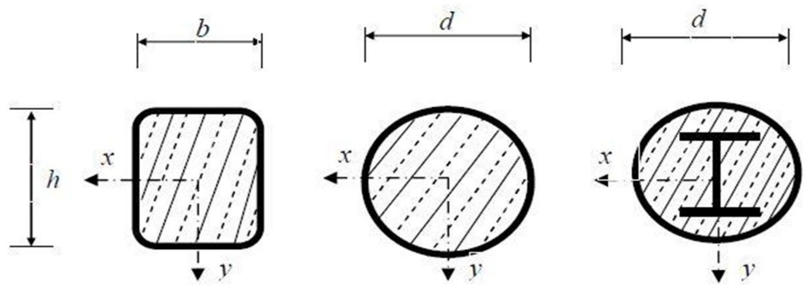

Figure 1. Steel encased (Composite) Concrete Column Sections

III. ANALYSIS METHOD USED

Each type of frame is analyzed separately by using Equivalent Static Load Method and Response spectrum method by ETABS 2017 Software.

The analysis is conducted for IS 1893(Part 1), 2016 specified combinations of loadings.

A. *Equivalent Static Analysis*

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design . It assumes that the building responds in its fundamental time period, and effect of earthquake on base shear and weight of structure as per seismic parameter IS 1893:2016. The applicability of this method is extended in many building codes by applying factors to values for higher buildings with some higher modes, and for low levels of twisting.

B. *Response Spectrum Analysis*

This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following:

1) Square root of the sum of squares(SRSS).
2) Complete quadratic combination(CQC).

In our present study we have used the SRSS method to combine the modes. The consequence of a response spectrum analysis utilizing the response spectrum from a ground motion is commonly not quite the same as which might be computed from a linear dynamic analysis utilizing the actual earthquake data.

IV. BUILDING CONFIGURATIONS

The building considered here is G+15 storey office building located in seismic zone IV. The plan of building is shown in figure 2. The basic planning and the loading conditions are considered same for both RCC, Steel & Steel Composite Concrete Structure. In case of RCC structure, the structural members slab, beam and column are designed as per IS 456:2000 and in case of Steel Concrete Composite Structure, members are designed as per AISC-14 Composite beams are designed with structural steel section anchored to the steel deck slab with the connected of shear studs and columns are considered made of RCC having structural steel section in its core and reinforcement in the outside concrete

The explained 3D building model is analyzed using Equivalent Static Method and Response Spectrum Method. The building models are then analyzed by the software ETABS 2017. Different parameters such as maximum story displacement, story drift, base shear and fundamental time period are studied for the seismic loads. Seismic codes are unique to a particular region of country. In India, Indian standard criteria for earthquake resistant design of structures IS 1893 (Part-1): 2016 is the main code that provides outline for calculating seismic design force. For the analysis and design, following design data is considered:

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Table I. Design Data For Building

BUILDING DATA		
Foundation Depth	:	5 m below G.L
Foundation Type	:	Isolated footing
No of stories	:	15 stories
Walls	:	230 mm
lift	:	Centre Shaft
Lift Shaft	:	300 mm
Design Loads		
Slab Depth	:	125 mm
Live Load in office area	:	4 KN/sq m
Live load in Passage area	:	4 KN/sq m
Live load in urinals	:	2 KN/sq m
Floor Finish Load	:	1.0 KN/sq m
Staircase Loading	:	4 KN/sq m
Earthquake parameter		
Zone	:	IV
Soil Type	:	Hard Soil
Importance Factor	:	1.5
Time Period	:	As per 1893:2016
(Z)	:	5

Table II. Section Used in Structures

COLUMN SECTIONS			
Description Data	R.C.C	Steel	Composite
Foundation Up to Ground Floor	0.8 x 0.8 m	0.60 x 0.60	0.60 x 0.60
Grond Floor to 5th Floor	0.8 x 0.8 m	W33 x 354	0.6 x 0.6 m + (W18 x 60)
5th Floor to 10th floor	0.6 x 0.6 m	W24 x 370	0.6 x 0.6 m + (W18 x 60)
10th Floor to 15th Floor	0.4 x 0.4 m	W18 x 175	0.6 x 0.6 m + (W18 x 60)
BEAM SECTIONS			
Description Data	R.C.C	Steel	Composite
Foundation Up to Ground Floor	0.6 x 0.3 m	0.45 x 0.30 m	0.45 x 0.30 m
Ground Floor to 5th Floor	0.75 x 0.3 m	W24 x 76	W18 x 50
5th Floor to 10th floor	0.575 x 0.3 m	W24 x 76	W24 x 76
10th Floor to 15th Floor	0.45 x 0.3 m	W24 x 76	W24 x 76

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R.C.C , Steel and Composite Model has been made and different column sizes were selected along with different beam sizes. Were Structural member in analysed in AISC 14 in ETABS 2017 software with different section used in Steel and Composite model.

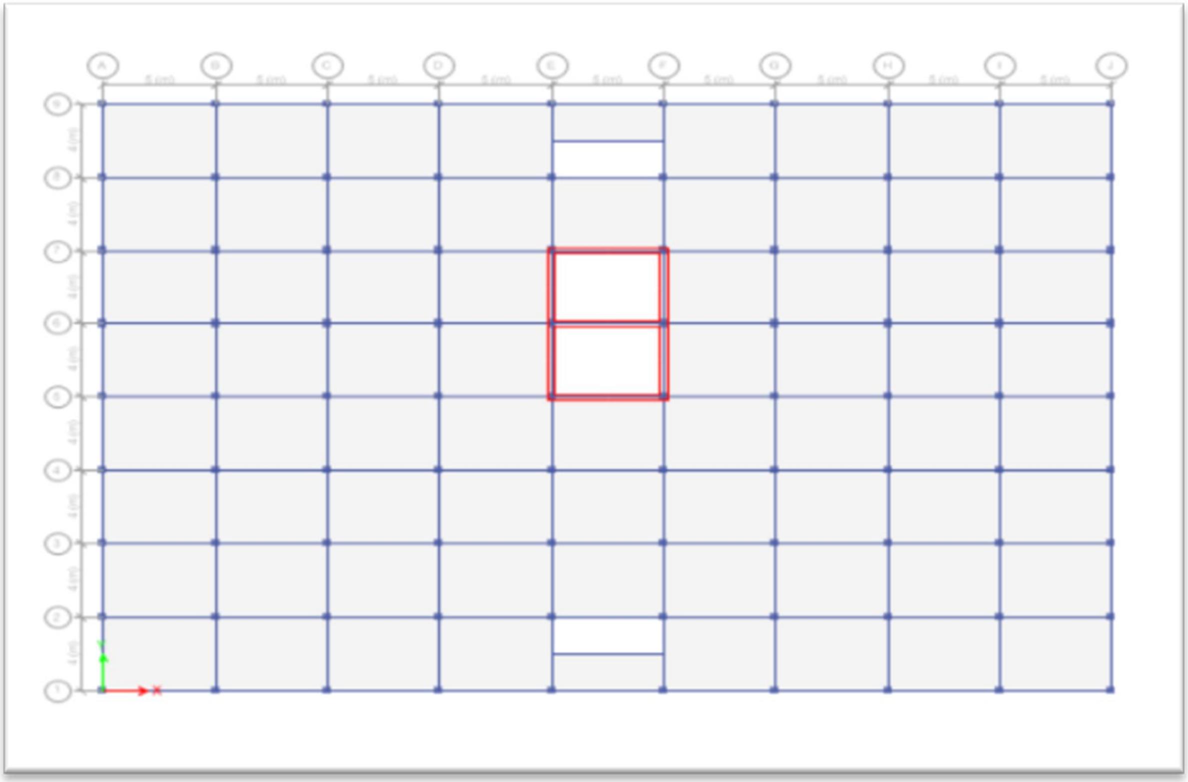

Figure 2. Plan of Building

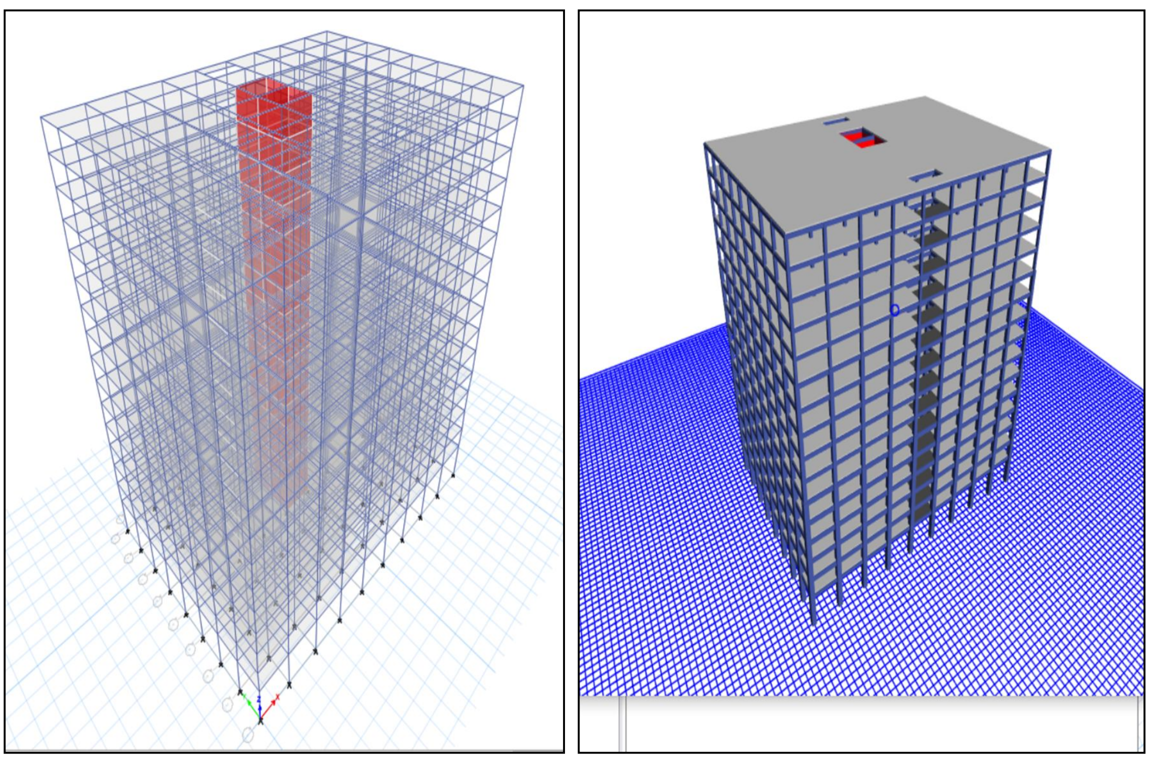

Figure 3. 3D-Rendering view of Building

V. RESULTS

Table III. Maximum Story Displacement (mm)

Story No.	R.C.C	Steel	Composite
15th	16.30	13.90	16.60
14th	15.40	13.30	16.00
13th	14.30	12.60	15.40
12th	13.10	11.80	14.70
11th	11.80	11.00	13.90
10th	10.50	10.10	13.00
9th	9.40	9.30	12.10
8th	8.30	8.40	11.10
7th	7.20	7.40	10.00
6th	6.10	6.50	8.90
5th	5.00	5.50	7.70
4th	4.20	4.50	6.40
3rd	2.40	3.60	5.00
2nd	2.70	2.70	3.80
1st	1.90	1.80	2.70
G.F	1.10	1.10	1.50

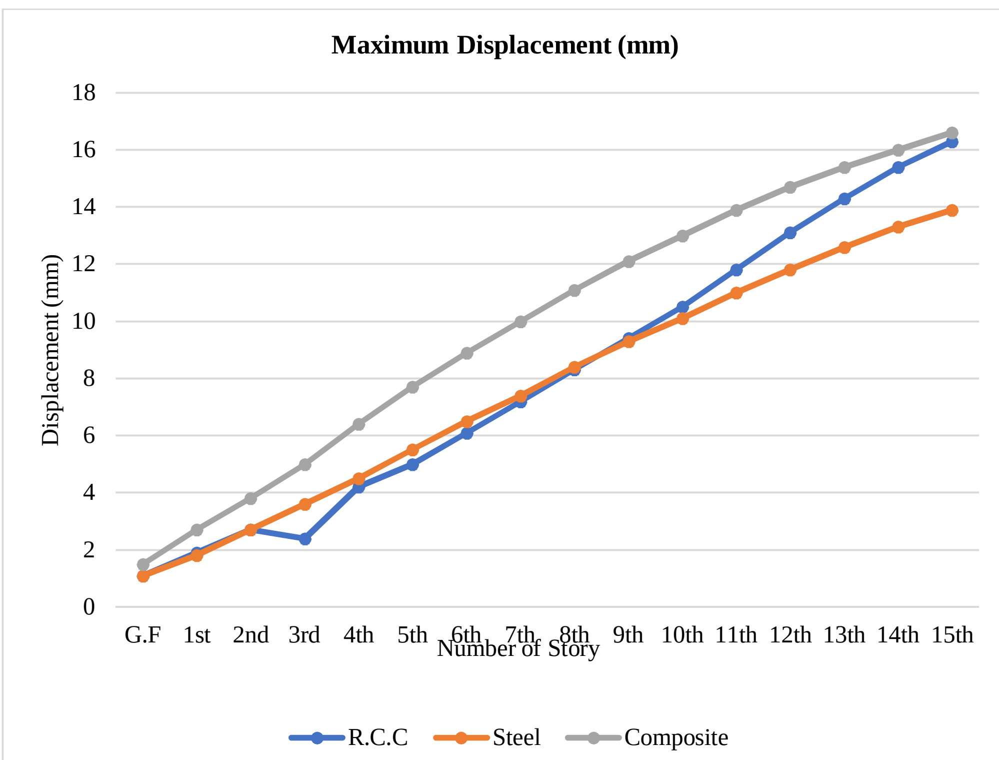

Figure 4. Maximum story Displacement VS number of Story

In a Graph of Story displacement VS number of Story ,The Value of Maximum reduction of the Story displacement under in composite structure 30.45% and 13.24% of the average value RCC and Steel structures.

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Table IV. Maximum Story Drift

Story No.	R.C.C	Steel	Composite
15th	0.000348	0.000211	0.000215
14th	0.000379	0.000255	0.000243
13th	0.000429	0.000276	0.000266
12th	0.000469	0.000295	0.000290
11th	0.000480	0.000324	0.000312
10th	0.000371	0.000299	0.000332
9th	0.000385	0.000315	0.000351
8th	0.000392	0.000326	0.000369
7th	0.000391	0.000333	0.000386
6th	0.000357	0.000337	0.000422
5th	0.000272	0.000328	0.000455
4th	0.000269	0.000321	0.000457
3rd	0.000265	0.000306	0.000445
2nd	0.000262	0.000285	0.000421
1st	0.000274	0.000274	0.000389
G.F	0.000213	0.000214	0.000302

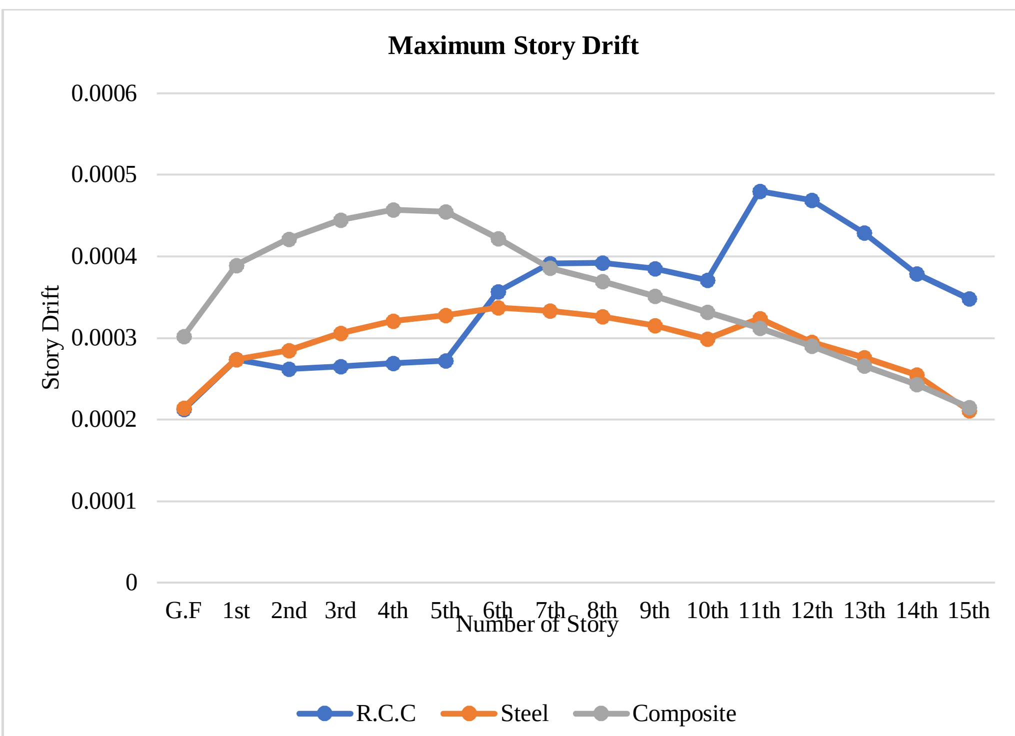

Figure 5. Maximum story drift VS number of Story

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Table IV. Maximum Story Stiffness (KN/m)

Story No.	R.C.C	Steel	Composite
15th	715136.13	1291682.89	1099997.22
14th	1246121.21	1972552.83	1898949.46
13th	1546116.84	2457827.07	2373965.34
12th	1728692.88	2752012.27	2613483.93
11th	1899049.21	2822155.49	2724561.39
10th	2491606.46	3370291.71	2779499.79
9th	2644129.92	3460697.72	2819862.14
8th	2874476.19	3594010.66	2861273.04
7th	3160583.09	3753155.56	2905401.50
6th	3690361.27	3937349.51	2807708.82
5th	5002727.52	4257246.62	2766303.63
4th	5535845.84	4570233.28	2931753.50
3rd	6199980.55	5012394.73	3199974.92
2nd	6916638.85	5586570.76	3612260.24
1st	7334147.69	602560.02	4195114.79
G.F	3174664.40	5095786.89	3662420.95

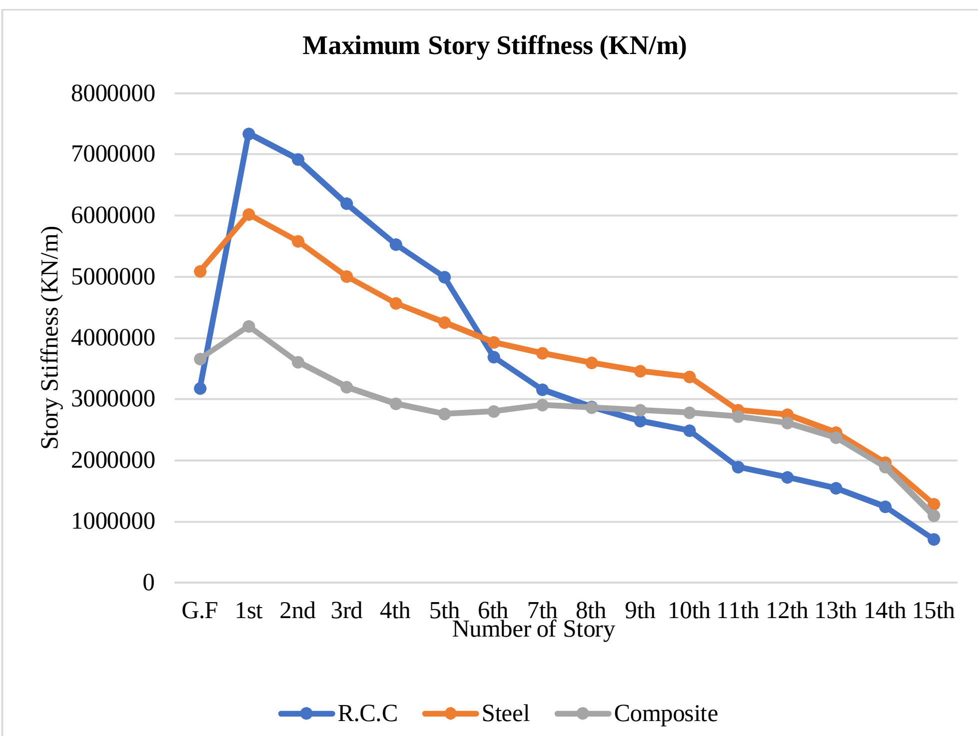

Figure 6. Maximum story Stiffness VS number of Story

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Table V. Fundamental Time Period (S)

Mode	R.C.C	Steel	Composite
1	0.957	1.114	1.341
2	0.867	0.998	1.101
3	0.833	0.927	1.002
4	0.379	0.386	0.388
5	0.302	0.274	0.292
6	0.267	0.270	0.263
7	0.225	0.228	0.235
8	0.148	0.157	0.159
9	0.145	0.138	0.142
10	0.130	0.134	0.128
11	0.117	0.122	0.120
12	0.092	0.098	0.094

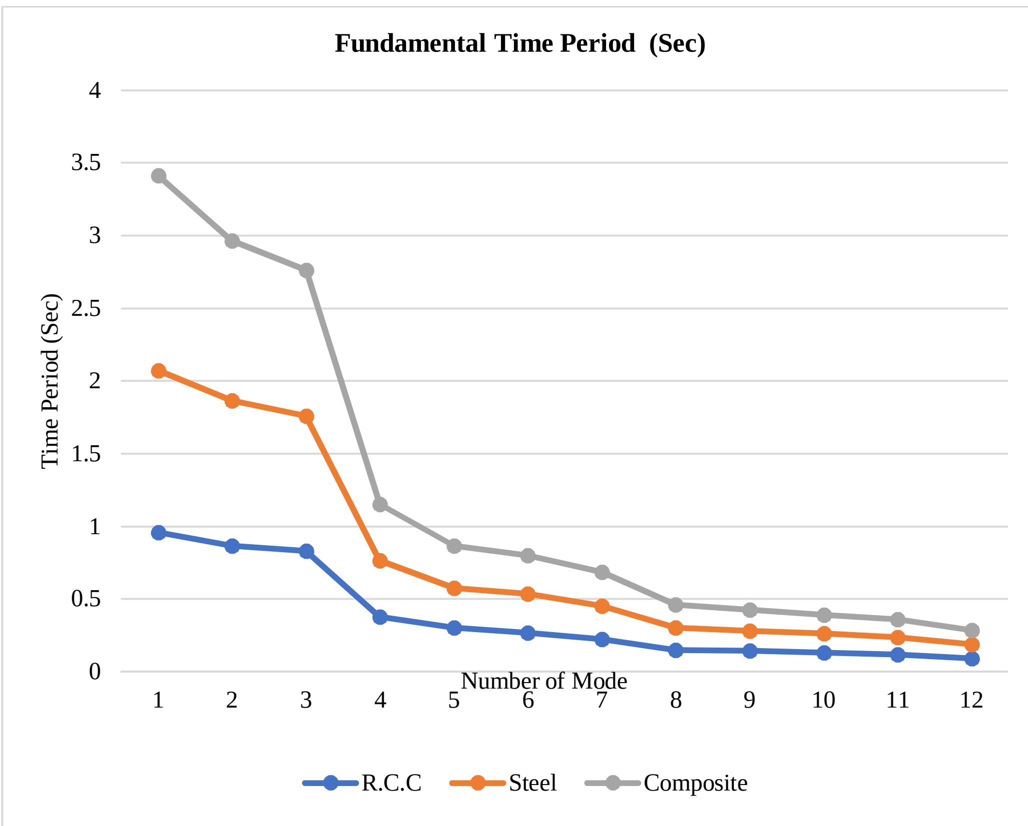

Figure 7. Time Periods (S) VS number of modes

Table VI. Maximum Base Shear (KN)

R.C.C	Steel	Composite
4267.88	3803.26	4306.66

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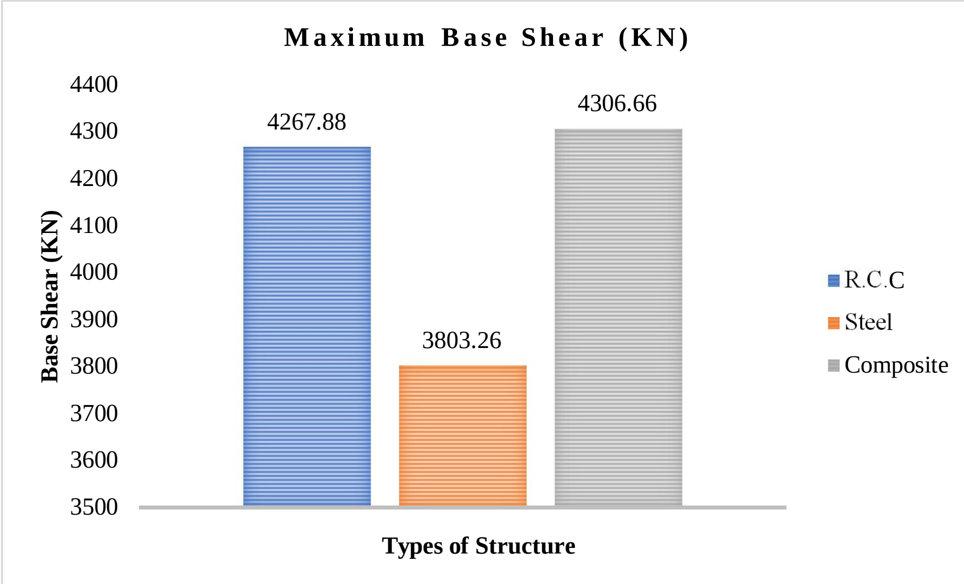

Figure 8. Maximum Base shear VS Types of Structures

Table VII. Maximum Weight (KN)

R.C.C	Steel	Composite
167185.39	148985	168704.56

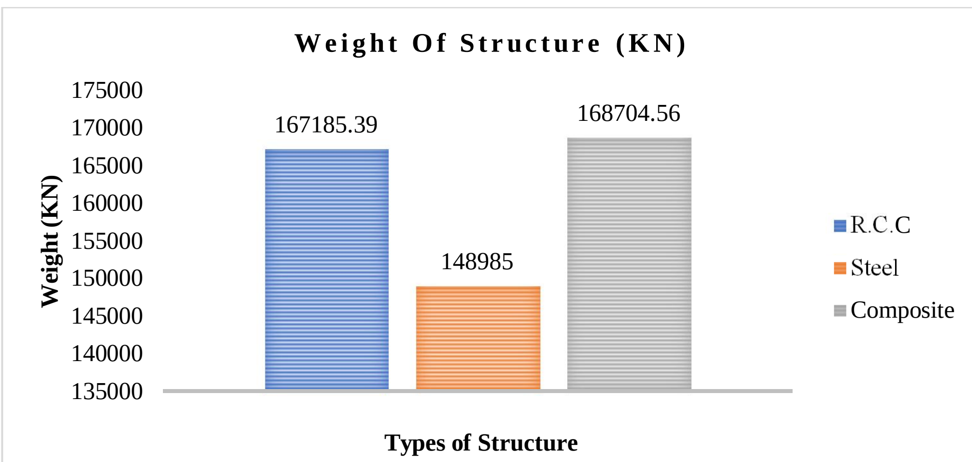

Figure 9. Maximum Weight VS Types of Structures

VI. CONCLUSIONS

A. In a Comparative, Maximum reduction of the Story displacement under in composite structure 30.45% and 13.24% of the average value RCC and Steel structures.

B. Comparative studies of International standards demonstrate that AISC and different standards estimate 4 % and 6% higher value of flexural resistance respectively, as compared to Indian standard stress block.

C. Neutral axis factors are developed to verify under-reinforced section theoretically. Steel grade of 365 MPa is optimum for analyzed deck. Whereas use of 450 MPa steel grade makes the section over - reinforced, which can trigger brittle failure.

D. In a Comparative Base shear for Steel-concrete composite structure is on higher side compare to other building configuration because weight of composite structure more than other RCC and Steel structures.

E. The presented story wise drift reduction in composite structure among the RCC and Steel building configurations.

F. The story stiffness of composite structures is high compare to RCC and Steel Structures.

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VII. ACKNOWLEDGMENT

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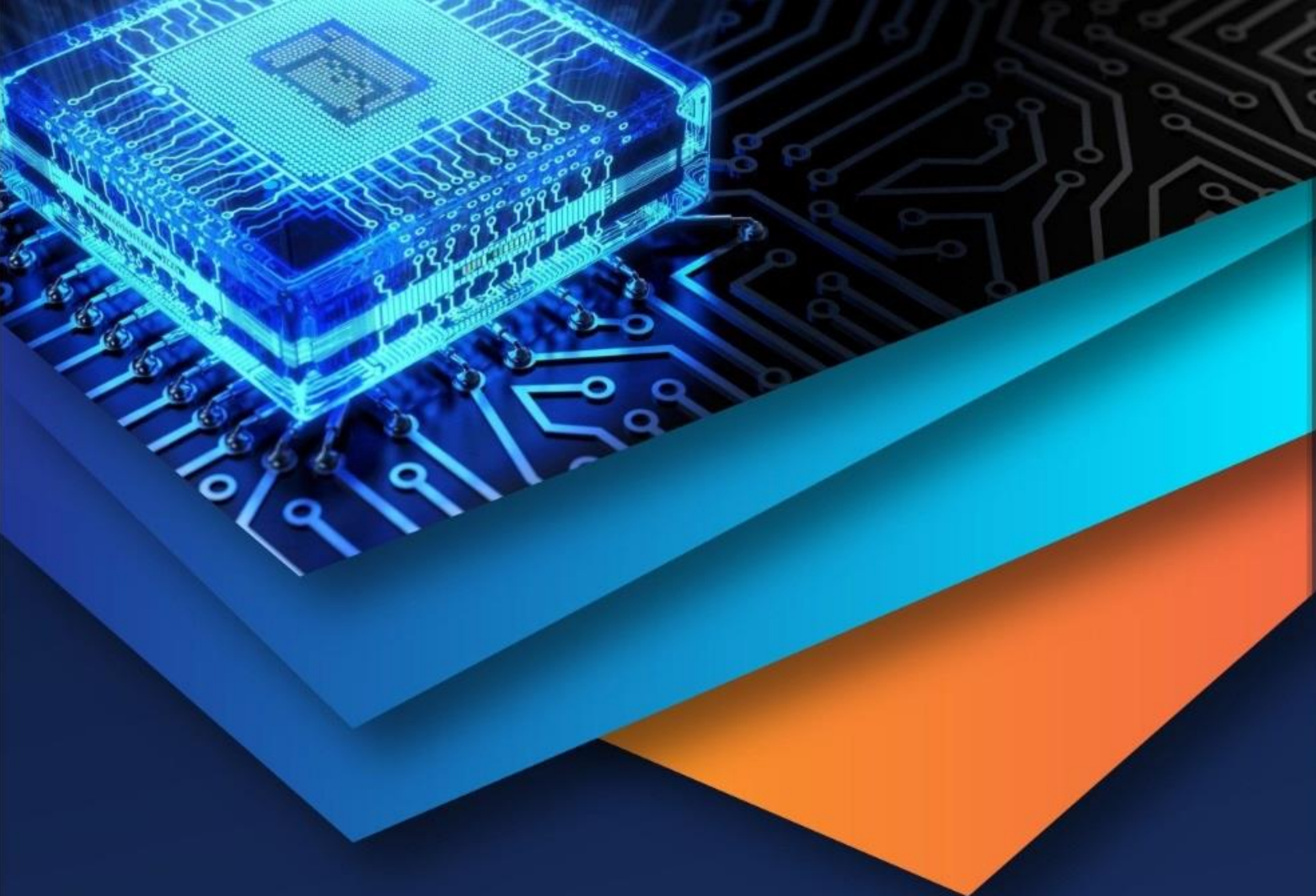

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