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Comparative Study of Reinforced Concrete Frame Building and RC- Steel Composite Frame Building

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Abstract – **Steel industry is growing in almost all parts of the world. The use of steel structure in construction industry is less in India as compared to USA, EU and other developed countries. As well cities in India are amongs high densely inhabitants per square km. which restricts horizontal expansion therefore vertical growth of building becomes predominant. Concrete structures are massive and bestow more seismic weight while steel structure take more ductility and deflection. Composite construction consolidates the better properties of steel and concrete.**

In this study the static analysis under the provision of IS1893:2002 is carried out for three dimensional models RCC frame structure and RC-steel composite frame structure with the help of ETAB software. Comparative study of RCC frame structure and RC-steel composite frame structure for G+9 is included.

Subject headings: Composite structures, steel structure framed structure, seismic design, ETABS v18

1.INTRODUCTION

In the past , for the construction, the choice was normally between a concrete structure and a masonary structure. Failure of many masonary buildings and multistoried RCC buildings due to earthquake have necessitate structural engineers to look for the different method of construction.
Due to significant potential in improving the overall performance through rather modest changes in construction technology, use of composite frame structure is of particular intrest. There is great potential for increasing the volume of steel in construction. Especially the current development need in India. Use of steel, reinforced concrete, and composite steel concrete members which are functioning together such composite systems make use of each type of member in most efficient manner to maximize the structural and economical benefit.

2. ELEMENTS OF COMPOSITE STRUCTURE

2.1 Shear connector

Mechanical shear connectors are required at the steel-concrete interface. These connectors are designed to (a) transmit longitudinal shear along the interface and (b) prevent separation of steel beam and concrete slab at the interface.
There are three types of shear connectors as,

(a) Rigid type
(b) Bond or anchorage type
(c) Flexible type

2.2 composite deck slab

Composite deck slab consist of composite column(encased hot rolled I section), steel beam, steel jacketing.

2.3 composite beam

The steel beams are connected to the concrete slab in such a way that the two act as one unit, the beam is called as composite beam. Composite beams are similar to concrete T-beams where the flange of the T-beam is made of concrete slab and the web of the T-beam is made of the steel section.

2.4 Composite column

It is a compression member consisting either concrete encased hot rolled steel section embedded in concrete. At present there is no Indian standard code covering the design of composite column. The design method largely follows Euro code 4, which provides latest research on composite construction. IS 11384-1985 does not make any specific provisions to composite columns.

3. METHODOLOGY

RCC and steel-concrete frame models are analyzed. Seismic analysis of both RCC frame structure and composite frame structure are carried out using software tool ETAB v18. Different parameters such as shear force, storey stiffness, storey displacement, storey drift are discussed

3.1 Structural details

A typical plan of building is selected for comparative study of RCC and RC-steel composite having plan dimensions 25m x 16m as shown in figure.,
3-D model is being prepared for the frame analysis of building in ETABS. Following basic parameters are used for analysis and design of structures.

3.1.1 Material properties

Unit weight of masonary	19 kN/m^3
Unit weight of RCC	25 kN/m^3
Grade of concrete	M30
Grade of reinforcing steel	HYSD500
Grade of structural steel	Fe250
Modulus of elasticity for RCC	25 kN/m^2
Modulus of elasticity for steel	210 kN/m^2
Dead load	Self weight of structural elements
Live load	3 kN/m^2
Floor finish load	1 kN/m^2

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3.1.2 Earthquake parameters

Location	Pune, MH
Seismic zone	III
Soil type	Medium type II
Importance factor	1
Time period	Program calculated
Earthquake load in	X & Y direction
Type of diaphragm	Rigid

3.1.3 Model configuration

The methodology adopted for achieving the above-mentioned objectives is as follows:

Model M1- Modelling of regular G+9 R.C.C building
Model M2 - Modelling of G+9 building with composite steel beam and RCC column
Model M3 - Modelling of G+9 building with composite column(encased I section) and RCC beam
Model M4 - Modelling of G+9 building with composite steel beam and composite column.

Table -1: Description of model

Number of bays in X direction	5
Number of bays in Y direction	4
Width of bays in X direction	5m
Width of bays in Y direction	4m
Height of typical storey	3m
Height of bottom storey	3.5m
Slab thickness	120mm
Shear wall thickness	250mm

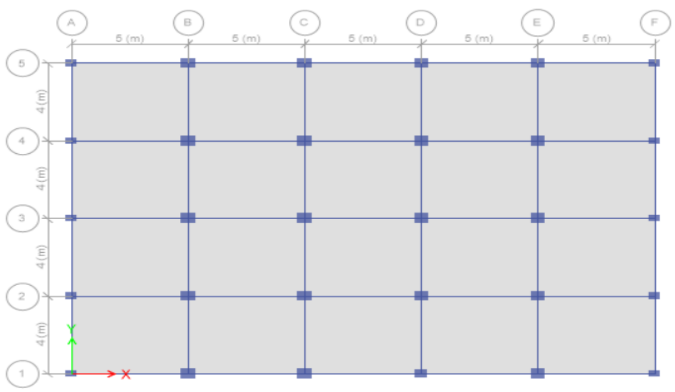

Fig 1: Plan

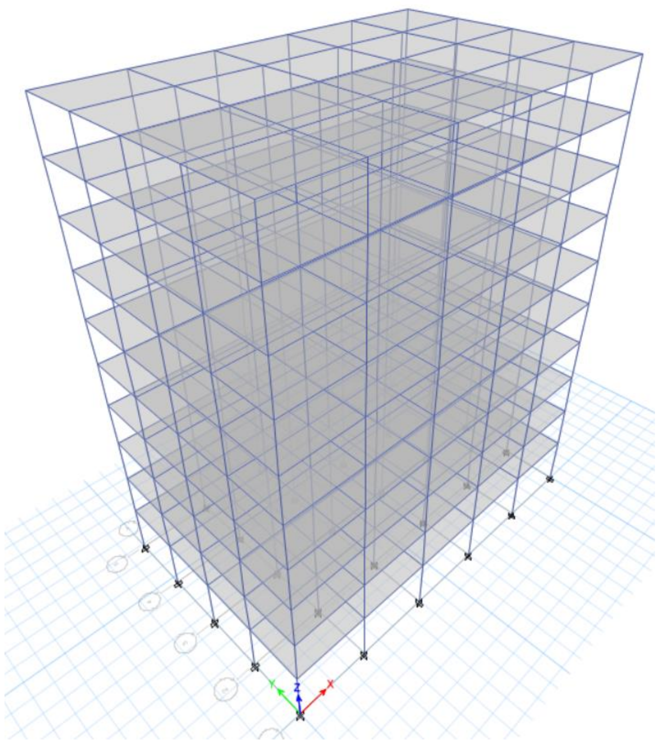

Fig. 3D view

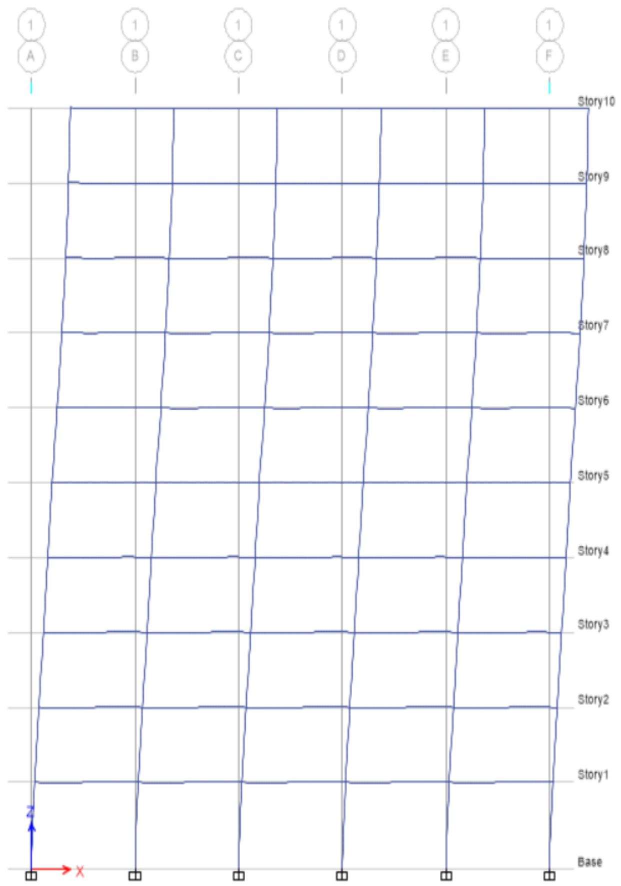

Fig 4. Deformed shape of G+9 storey building

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Due to lateral loading

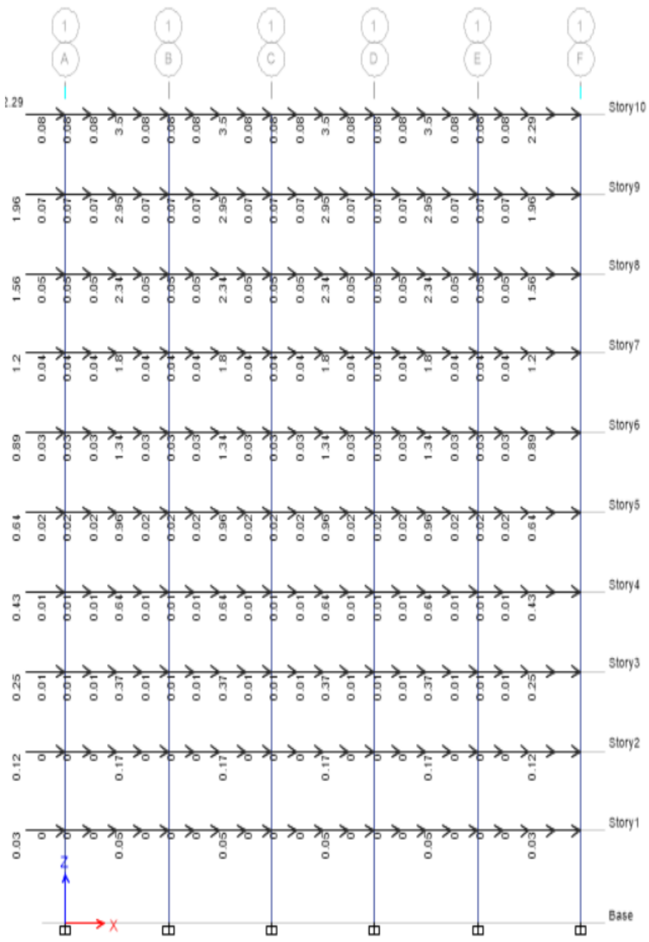


Fig 5. Joint load due to lateral loading.

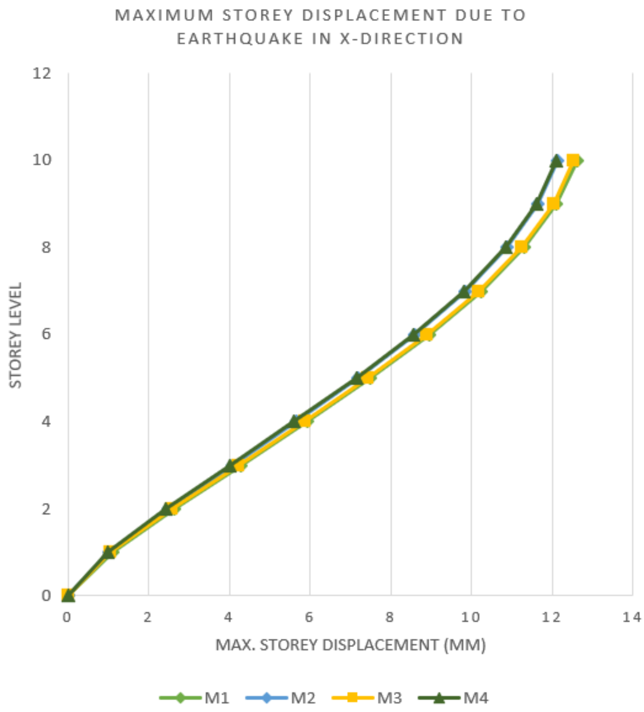
4. RESULTS

4.1 Max. Storey displacement

4.1.1 Max Storey Displacement due to earthquake in X-direction

Table no. 1

Storey	M1	M2	M3	M4
0	0	0	0	0
1	1.094	1.005	1.056	0.972
2	2.632	2.47	2.575	2.421
3	4.282	4.063	4.218	4.01
4	5.923	5.655	5.857	5.604
5	7.497	7.184	7.43	7.136
6	8.954	8.598	8.886	8.553
7	10.245	9.847	10.173	9.803
8	11.313	10.879	11.238	10.835
9	12.106	11.645	12.028	11.603
10	12.609	12.136	12.533	12.099

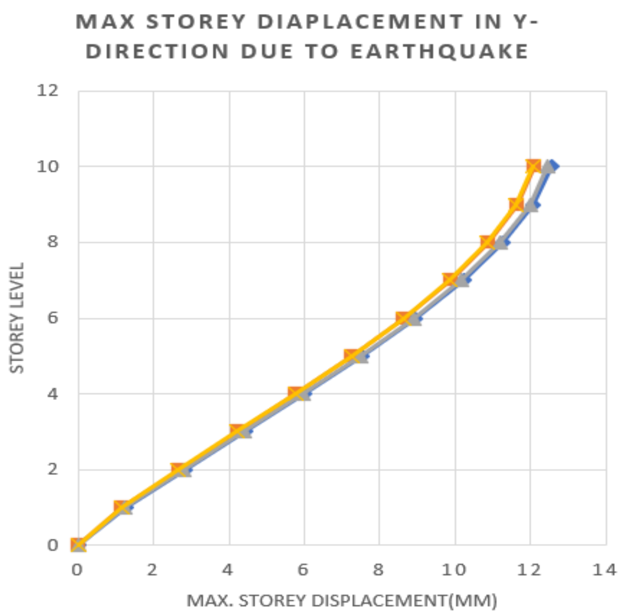


Graph no.1 Max. storey displacement in X-dir. Due to earthquake

4.1.2 Max. storey Displacement due to earthquake in Y-direction

Table no. 2

Storey	M1	M2	M3	M4
0	0	0	0	0
1	1.269	1.165	1.246	1.147
2	2.825	2.667	2.796	2.645
3	4.433	4.235	4.4	4.214
4	6.019	5.785	5.982	5.765
5	7.542	7.271	7.499	7.251
6	8.959	8.651	8.909	8.629
7	10.222	9.877	10.163	9.851
8	11.276	10.896	11.206	10.863
9	12.063	11.652	11.982	11.612
10	12.549	12.12	12.459	12.074



Graph no.2 Max. storey displacement in Y-dir. Due to earthquake

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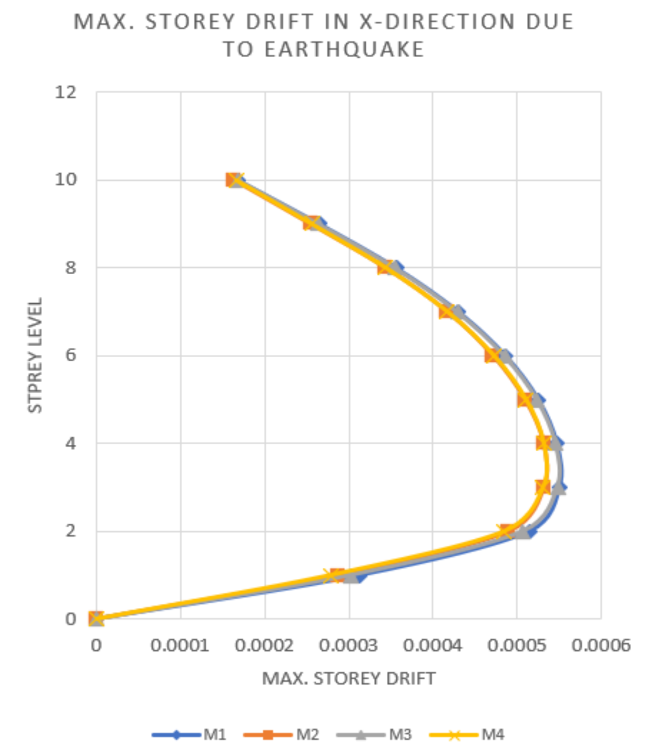
4.2 Max. storey drift

Table no. 3

4.2.1 Max. storey drift in X-direction due to earthquake

Storey	**M1**	M2	M3	M4
0	0	0	0	0
1	0.000313	0.000287	0.000302	0.000278
2	0.000514	0.000489	0.000507	0.000484
3	0.00055	0.000531	0.000548	0.00053
4	0.000547	0.000531	0.000546	0.000531
5	0.000525	0.000509	0.000524	0.00051
6	0.000486	0.000471	0.000485	0.000472
7	0.00043	0.000417	0.000429	0.000417
8	0.000356	0.000344	0.000355	0.000344
9	0.000265	0.000255	0.000264	0.000256
10	0.000168	0.000164	0.000168	0.000166

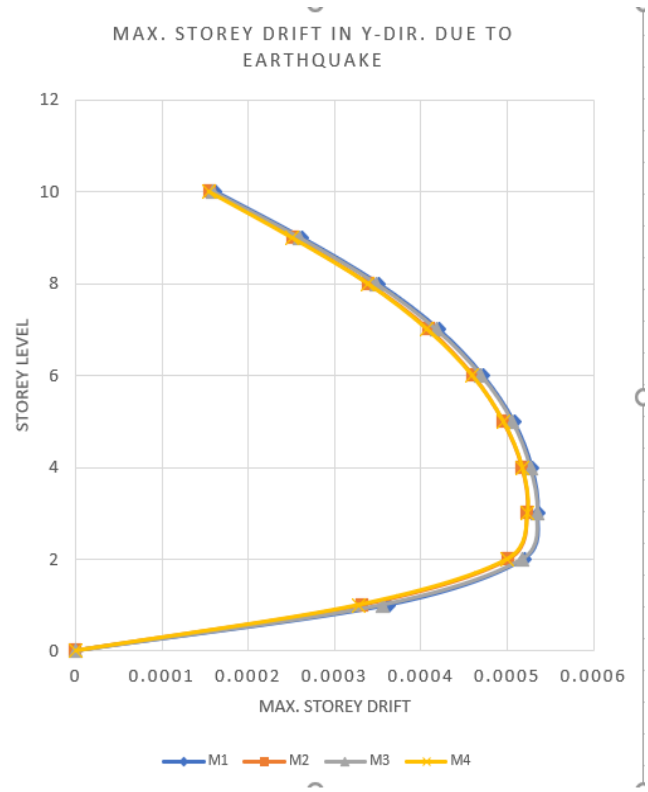


Graph no.3 Max. storey drift in X-dir. Due to earthquake

Table no.4

4.2.2 Max. storey drift in Y-direction due to earthquake

Storey	**M1**	M2	M3	M4
0	0	0	0	0
1	0.000363	0.000333	0.000356	0.000328
2	0.00052	0.000502	0.000518	0.0005
3	0.000536	0.000523	0.000535	0.000523
4	0.000529	0.000517	0.000527	0.000517
5	0.000508	0.000495	0.000506	0.000495
6	0.000472	0.00046	0.00047	0.000459
7	0.000421	0.000409	0.000418	0.000407
8	0.000351	0.000339	0.000348	0.000338
9	0.000262	0.000252	0.000259	0.00025
10	0.000162	0.000156	0.000159	0.000154



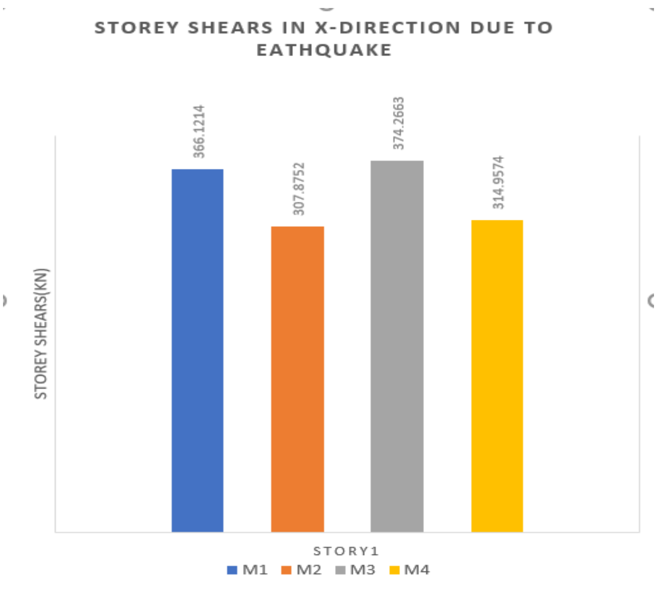
Graph no.4 Max. storey drift in Y-dir. Due to earthquake

4.3 Base shear

Table No.5

4.3.1 Storey shear in X-dir. Due to earthquake

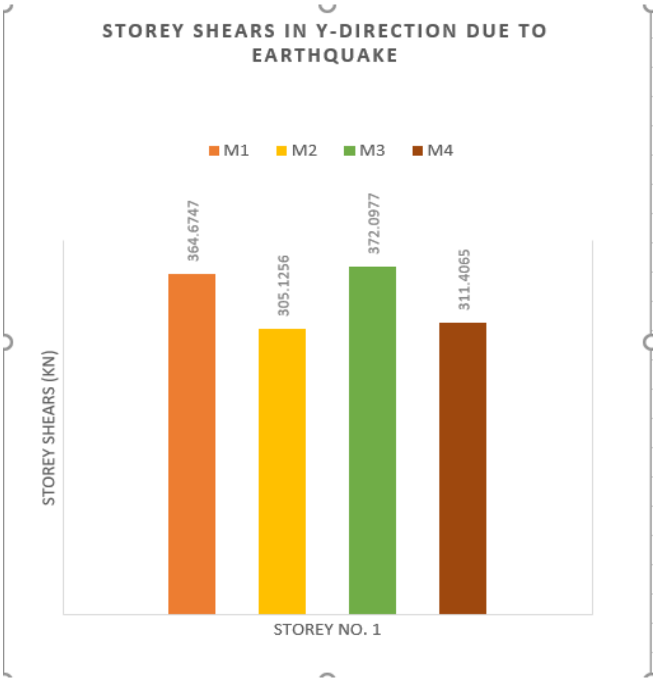
Storey	**M1**	M2	M3	M4
1	366.1214	307.8752	374.2663	314.9574
2	364.8312	306.7787	372.9444	313.8327
3	360.457	303.0763	368.4665	310.0389
4	351.1134	295.1676	358.9014	301.9348
5	334.9367	281.4752	342.3413	287.9041
6	310.0634	260.4218	316.8784	266.3306
7	274.63	230.4301	280.605	235.5979
8	226.7728	189.9225	231.6134	194.0896
9	164.6285	137.3219	167.996	140.1895
10	86.3333	71.0508	87.8448	72.2812



Graph.5 Base shear in X-dir. Due to earthquake

Table No.6
4.3.1 Storey shear in Y-dir. Due to earthquake

Storey	M1	M2	M3	M4
1	364.6747	305.1256	372.0977	311.4065
2	363.3897	304.0389	370.7834	310.2945
3	359.0328	300.3695	366.3315	306.5434
5	349.7261	292.5315	356.8218	298.5306
6	333.6133	278.9614	340.3576	284.6582
7	308.8383	258.096	315.0422	263.3279
8	273.5449	228.3721	278.9791	232.9417
9	225.8768	188.2264	230.2714	191.9014
10	163.978	136.0955	167.0225	138.609



Graph.6 Base shear in Y-dir. Due to earthquake

RESULTS

Graph no. 1 and 2 shows that, the structure having steel beam with composite column shows more rigidity compared to RCC beam and column framed structure. The storey displacement of Model no. 4 is 5 % less compared to model no. 1. Max. storey displacement differs in x-direction and y-direction due to rectangular geometry and orientation of column.

The permissible limit for displacement is H/500 where H is height of building. Total building height is 30.5m that means permissible limit for displacement is 61mm. Permissible limit for storey drift according to IS 1893(part1):2016 is 0.004 times the storey height which is 0.1220, all models are safe in drift criteria. Max. storey drift for all frame structure is within permissible limit.Storey stiffness differs in X-direction and Y-direction owing orientation column

From chart 5 and 6 it is seen that, Storey shear for steel beam with composite column frame structure has reduced by 15% compare to that of reinforced concrete structure. Base shear for steel beam with RCC column frame is 16% less compared to RC framed structure.

CONCLUSIONS

- By keeping same specification and loading, we designed smaller section composite structure For the same bending moment, axial forces .
- Because of inherent ductility characteristic steel-concrete composite structure under earthquake consideration steel-concrete composite structure performs better
- As compared to RCC frame structure steel beam with RC column frame structure and steel beam with composite column frame structure require less construction time due to quick errction of the steel beam and ease of formwork of concrete
- Including the construction period as a function of total cost in the cost estimation will result in increased economy for the composite structure
- Steel beam with composite column frame structure has less base shear which gives economic foundation design, construction period for steel beam with composite column frame structure is less. Also requirement of construction worker is reduced. Also due to inherent ductility of steel-RC composite structure it performs better in earthquake prone regon
- According to analysis and my study on that I conclude that steel-beam with composite column frame structure is superior over RCC frame structure, steel beam with RC column frame structure, and Composite column frame structure amongs all

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