Evaluation of seismic behavior of Reinforced Concrete-steel Composite framed building

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***Abstract*—Most of the buildings are made up of RCC frame building. In addition to vertical loads, it is a great importance to design the buildings against lateral load produced due to wind, earthquake. The large social and economic impacts of recent earthquakes in the world have resulted in an increased awareness of the potential seismic hazard and the corresponding vulnerability of existing structures. Greater effort has been given to reasonable estimates, predictions and mitigation of the risks associated with this potential loss. In the present study, the seismic behavior on RC frame building and RC- steel composite frame building is carried out. For this purpose, linear analysis of RC-steel composite frame building and regular frame structure building has been carried out. The comparison is made based on base shear between RC framed building and RC-steel composite framed building. It is found that RC- steel composite structure has low base shear which will result in economical foundation design as well as RC-steel composite frame building has more ductility compared to conventional RC framed structure. Also, linear analysis of RC frame building and RC-steel frame building for G+4 storied structure and G+9 storied structure is carried out and compared both structure on the basis of cost.**

***INDEX TERMS* - Multi- Storey Building, Seismic Analysis, Storey Displacement, Storey Drift, Base Shear.**

a. INTRODUCTION

Construction activity is an integral part of infrastructure and industrial development of the anycountry. India is the fastest growing country across the world. In major cities of India cost of land is high so there is limitation of horizontal expansion of structure and we left with only solution is vertical expansion of structure. Generally, in India reinforced concrete structures are widely used for low rise building because it is economical and easy for construction. However,as height of structure increasing from medium to high rise the reinforced concrete structure is no longer economical also it is not easy for construction. As height of a structure increases, itsmass increases, overall stiffness of structure decreases and natural period of a building also increases. Also, there is restriction on span length and formwork is also hazardous. So structuralengineers facing challenges for effective and economical design of structure. For medium to high rise structure steel and concrete composite structure is common solution.

Innovative composite frame systems have developed in tall building design whereby structuralsteel and reinforced concrete have been combined to produce a building having the advantagesof each material. The use of these systems has advantages of both – i.e., the inherent mass, economy of reinforced-concrete and the speed of construction, long span capability, and light weight of structural steel.

b. LITERATURE REVIEW

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 currentdevelopment 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.

c. COMPOSITE STRUCTURE

Many students and practitioners of structural engineering think that composite frame construction is a construction practice but it began prior to the start of the 20^{th} century.

In the USA, composite frame construction first appeared in the year 1894 when building wasconstructed. A Viennese engineer named Joseph Melan obtained a patent for bending steel I- beams to the curvature of an arch and then casting them in concrete. He submitted calculationsto verify his composite design of the building Methodist Building in Pittsburgh constructed using concrete encased steel floor beams.

Shear connectors were recognized in this early composite construction as an effective means to enhance the natural bond between steel and concrete. In 1954, welded headed metal studs were first tested at the University of Illinois. In 1956, at the completion of the tests, a formulafor the design capacity of these connectors was published. The welded headed metal stud has become the dominant method of transferring shear between steel and concrete.

The components used in composite structure consist elements such as composite deck slab, composite beam, composite column, shear connectors

d. MODELLING AND ANALYSIS

To obtain and compare the seismic response of i) regular framed structure building, ii)steel beam and RC column frame building, iii)RC beam and composite column frame building andiv)steel beam and composite column frame building, different type of models are developed and analysis is carried out by using equivalent static method on using ETAB 2016.

A. Problem Data For Composite Structure Building And Regular Frame Building

Type of frame:	special moment resisting frame.
Seismic zone:	IV
Number of storey:	G+4 and G+9
Size of bay:	4m X 4m
Plan area:	20m X 20m
Storey height:	3.0m
Floor Finish:	1.5 KN/m^2
Live load:	3KN/m^2
Wall thickness	230mm
Density of bricks	20kN/m^3
Materials:	Concrete M30, Structural Steel Fe250,reinforcing steel-HYSD500
Density of concrete:	25KN/m^3
Type of Soil:	Medium
Damping of structure:	5%

B. Regular Frame Building and Composite Frame Building Model

A five storied and ten storied conventional RC frame building and composite frame buildingsituated in zone IV are taken for purpose of study. The plan area of a building is 20m X 20mwith storey having height as 3.0m. It consists of 5 bays of 4m each in X-direction and Y- direction. The building is considered as an ordinary Moment resisting frame. Damping of structure is assumed as 5% of critical damping.

The various G+4 building models are modelled with optimum design and they are listedbelow-

Model 1 - RC column, RC beam, RC slab (RC-RB) Model 2 – RC column, steel beam, RC slab (RC-SB)

Model 3 – Composite column (steel I section embedded in concrete casing), RC beam, RCslab.(CC-RB)

Model 4 – composite column (steel I-section embedded in concrete casing), steel beam, RCslab.(CC-SB)

The various G+9 building models are modelled with optimum design and they are listedbelow-

Model 5 - RC column, RC beam, RC slab(RC-RB) Model 6 – RC column, steel beam, RC slab(RC-SB)

Model 7 – Composite column(steel I section embedded in concrete casing), RC beam, RCslab.(CC-RB)

Model 8 – composite column(steel I-section embedded in concrete casing), steel beam, RCslab.(CC-SB)

C. Modelling: Linear analysis.

Analysis has been performed using ETAB 2016, which is a structural analysis program forstatic and dynamic analysis of structures. In the study, ETAB 2016 linear Version 16 has been used for performing seismic analysis. The columns are assumed as fixed to the ground. All the floors are assumed to be rigid inplane. All joints are considered as rigid.

For seismic analysis equivalent static method is used is equivalent static method**:**

The equivalent static lateral force method is a simplified technique to substitute the effect of dynamic loading of an expected earthquake by a static force distributed laterally on a structure for the design purposes. The total applied seismic force V is generally evaluated intwo horizontal directions parallel to the main axes of the building. It assumes that the building responds in its fundamental lateral mode. For this to be true, the building must be low rise and must be fairly symmetric to avoid torsional movement underground motions. The structure must be able to resist effects caused by seismic forces in either direction simultaneously.

Design base shear is calculated by using, $V_B = A_h \times W$

Where

A_h = design horizontal seismic coefficient W = seismic weight of building

Z = zone factor

I = importance factor

R = response reduction factorSoil type = medium soil Damping coefficient = 0.05

D. Step By Step Procedure of Analysis In ETAB 2016.

Define Material Properties:

The material properties of concrete and steel are given. for concrete properties like weight perunit volume, modulus of elasticity, poisons ratio must be given. For M30 grade, the above properties are 25kN/m^3, 5000/fck, 0.2, 20000 kN/m^2 respectively. For steel minimum yield strength is required and for Fe415, it is 415000kN/m^2

Define Section Properties

he frame section properties of column size and beam size are given. For column and beam width and depth has given. For column the reinforcement details are clear cover, longitudinaland confinement bar size, number of longitudinal bars are provided and confinement spacingshould be given. For beam the reinforcement details are clear cover to top and bottom has been given.

Define Area Section Properties:

For slab the reception properties are given. Shell element is used for slab and thickness ofslab is given.

Develop The Model And Assign The Joint Restraints:

In this step, preparing model by adding frame objects and area objects with the associated column, beam and slab. Once the model is prepared next step is assigning joint restraints. Forbuilding frame the joint restraints is fixed joint

Develop Load Pattern And Assign To Frame :

In this step, the load patterns like dead load, dead wall, floor finish, live load are defined. Theloading is given to the frame. The mass source is defined the all dead load are considered 100% and live load must be considered as 25% (because live load= 3 kN/m^2). Then all joints are making rigid by joint constraints. The loading combinationsare given.

Run The Analysis :

The value for shear force and bending moment for every element must be check. The designcheck for column must be taken i.e. the reinforcement provided a sufficient or not.

Verify All Members Are Passed:

Verify every element of structure is passed through check.

Design the section for optimum design:

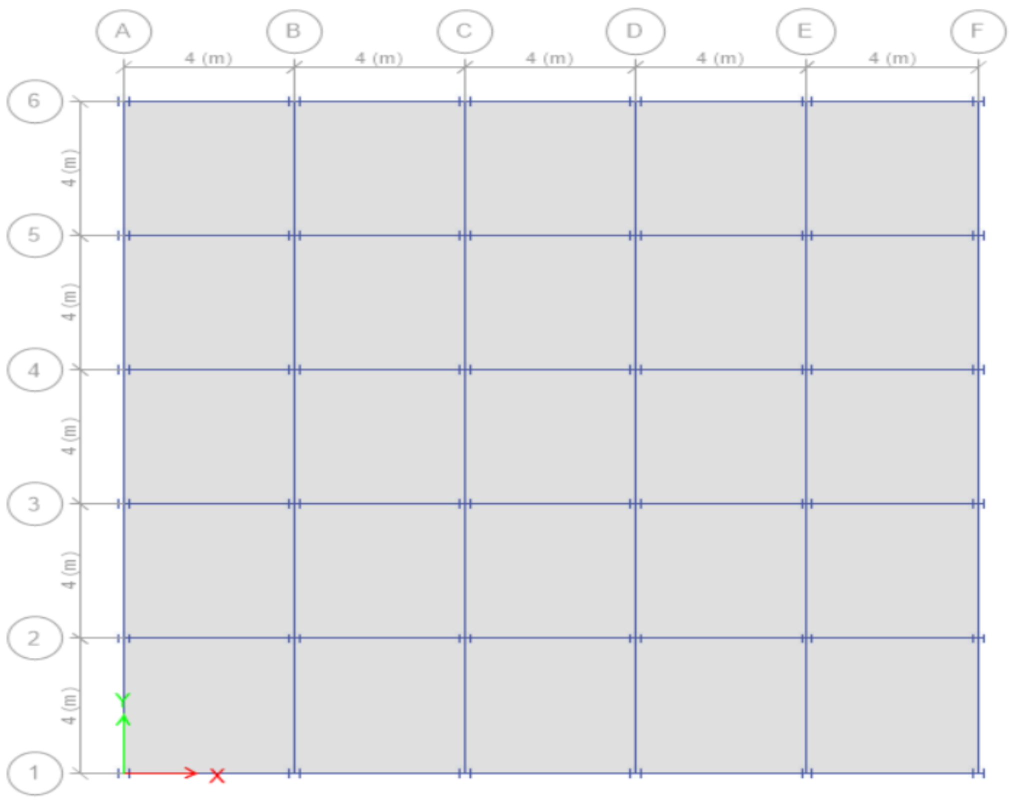


Fig 1. Plan

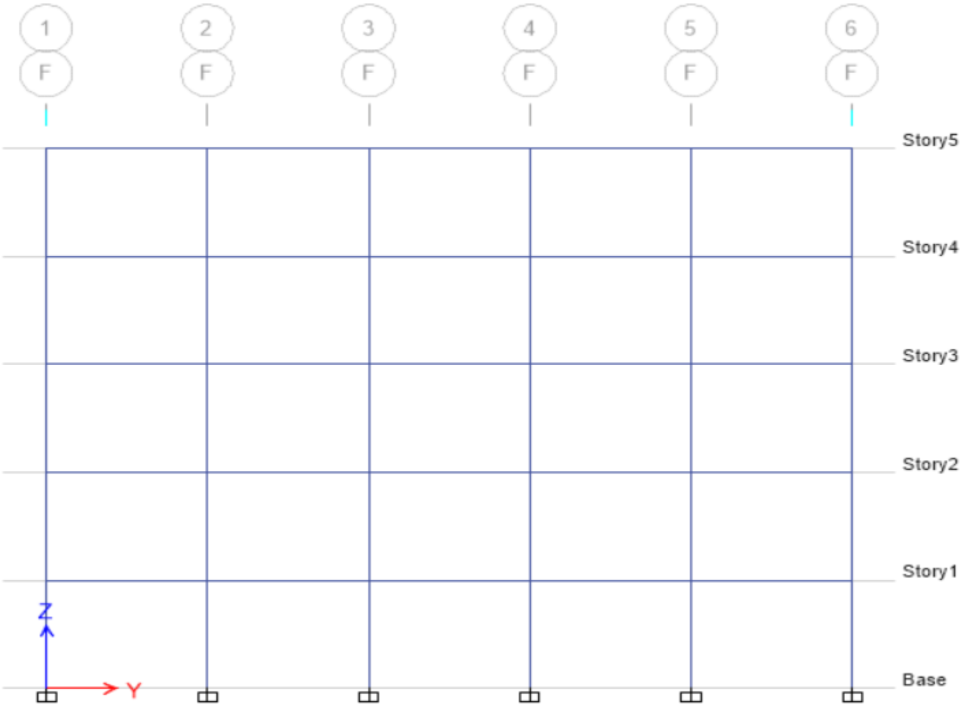


Fig.2. Typical elevation of G+4 storied building

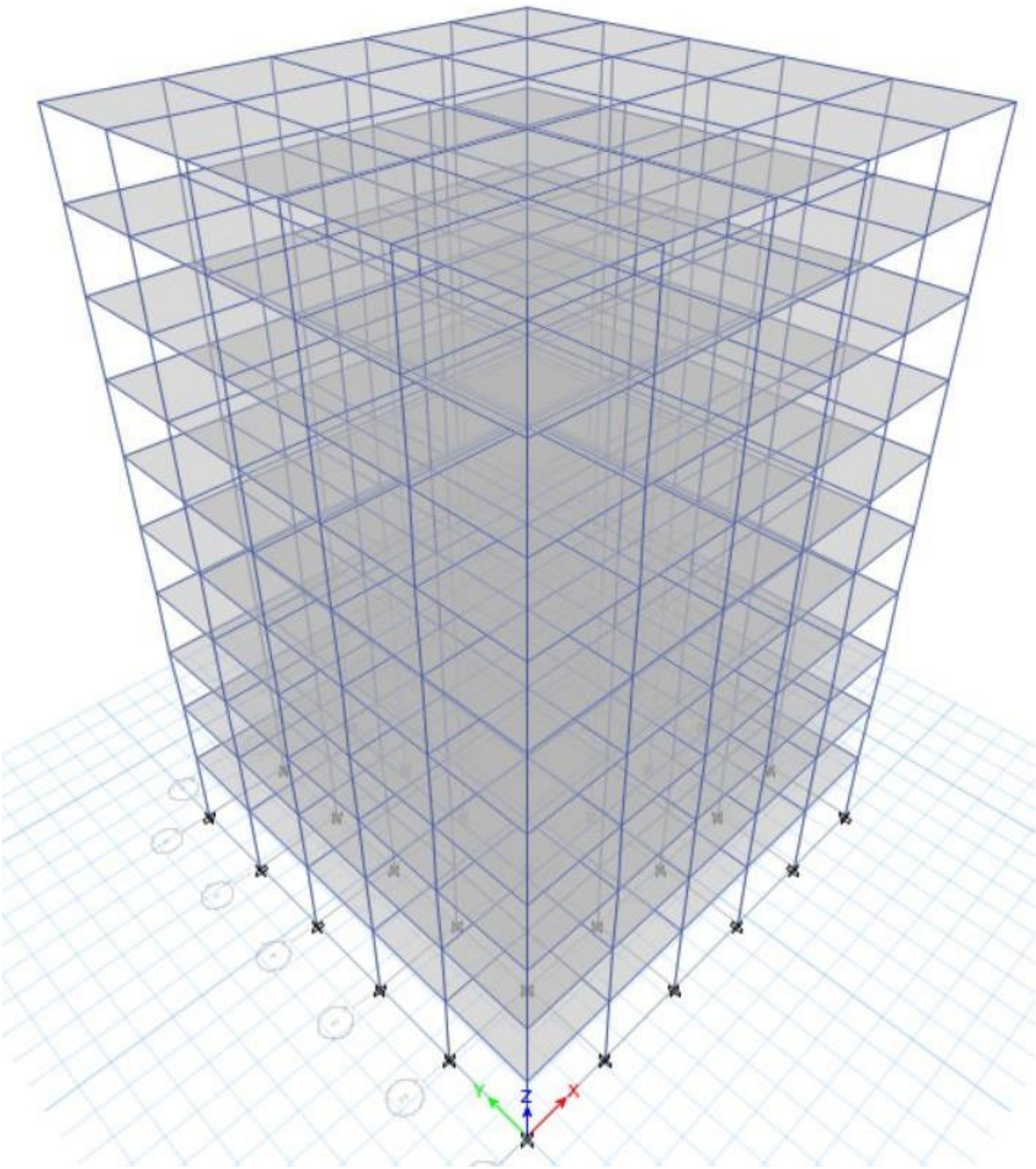


Fig 3. 3D view of building

e. RESULTS AND DISCUSSION

This chapter generally represents the results of analysis of rc conventional frame andcomposite frame building. Analysis has been done by using ETABS 2016 software.

Notations:

Model 1 **RC-RB** : RCC COLUMN & RCC BEAM
Model 2 **RC-SB** : RCC COLUMN & STEEL BEAM
Model 3 **CC-RB** : COMPOSITE COLUMN & RCC BEAM
Model 4 **CC-SB** : COMPOSITE COLUMN & STEEL BEAM

A. For G+4 storied building:

a. Maximum Storey Displacement(Mm):

Table no. 1 shows the max. storey displacement due to earthquake in X- direction. The maxstorey displacement for model 1, model 2, model 3, model 4 are 8.491mm, 11.254mm, 11.933mm, 17.563mm respectively.

Table 01: Maximum storey displacement in mm due to earthquake in x- direction:

Story	RC-RB	RC-SB	CC-RB	CC-SB
1	1.507	1.658	2.327	2.652

2	3.68	4.505	5.359	7.119
3	5.753	7.357	8.201	11.555
4	7.442	9.709	10.517	15.199
5	8.491	11.254	11.933	17.563

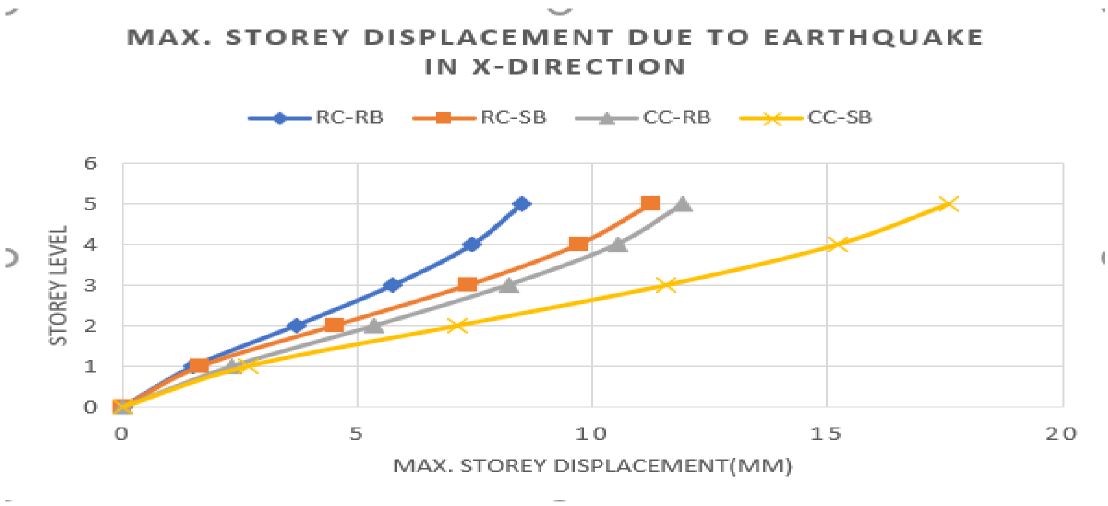


Fig. 4 Maximum story displacement due to earthquake in x-direction

Table no. 1 shows max. storey displacement due to earthquake in Y-direction. The max storeydisplacement for model 1, model 2, model 3, model 4 are 8.491mm, 11.254mm, 12.115mm, 17.751mm respectively.

Table 02: Maximum storey displacement due to earthquake in Y- direction**:**

Story	RC-RB	RC-SB	CC-RB	CC-SB
1	1.507	1.658	2.388	2.722
2	3.68	4.505	5.461	7.25
3	5.753	7.357	8.339	11.723
4	7.442	9.709	10.683	15.389
5	8.491	11.254	12.115	17.751

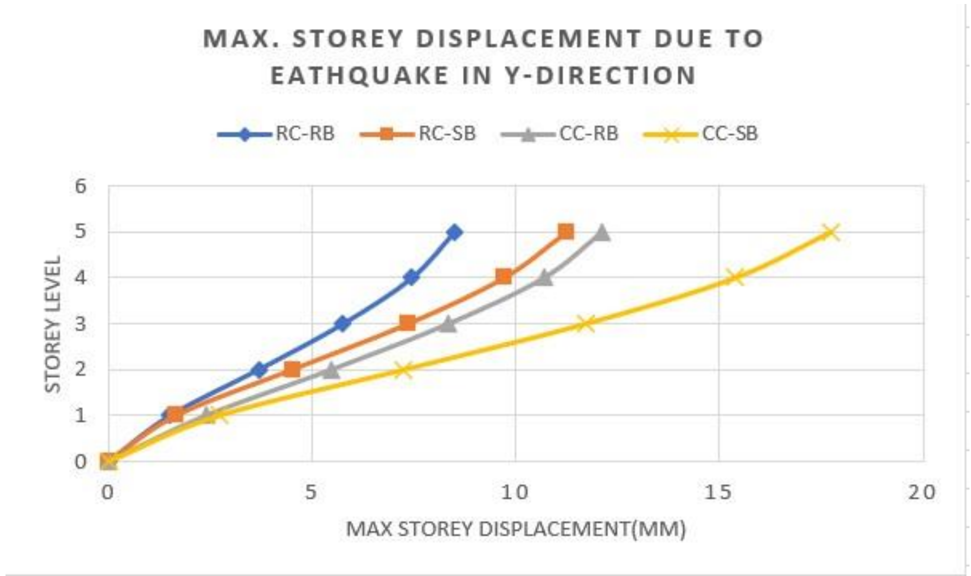


Fig. 5 Max. storey displacement due to earthquake in Y- direction

b. *Base Shear*:

Table no. 03 shows base shear due to earthquake in X-direction. Base shear for model 1, model2, model 3, model 4 are 766.19kN, 551.5694kN, 518.0177kN, 339.7307kN respectively.

Table 03: Base shear (kN) due to earthquake in X- direction:

Story	RC-RB	RC-SB	CC-RB	CC-SB
1	766.1942	551.5694	518.0177	339.7307
2	752.0465	541.3723	508.5064	333.4889
3	695.4557	500.5838	470.4611	308.5216
4	568.1264	408.8098	384.8592	252.3453
5	341.7632	245.6559	232.6779	152.4761

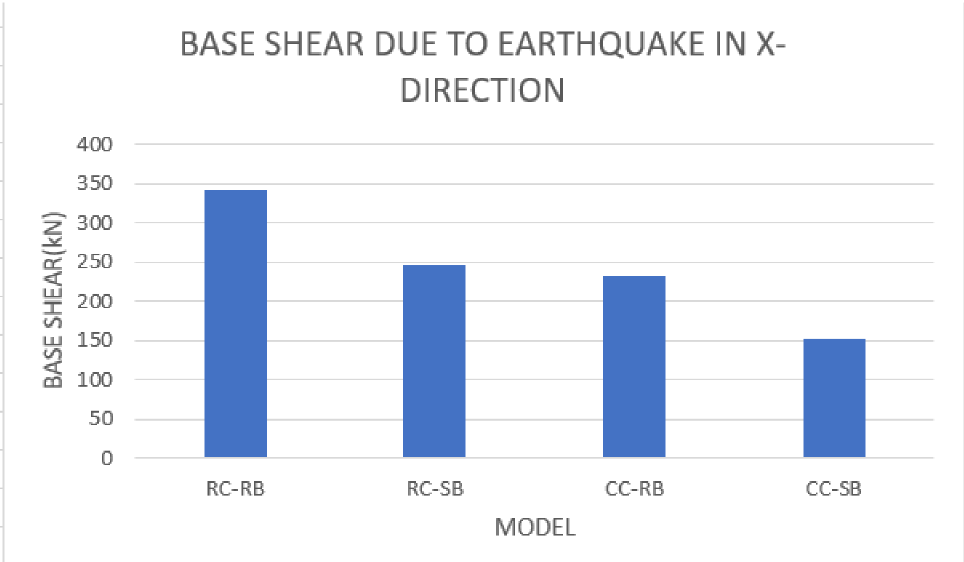


Fig. 6 Base shear due to earthquake in x- direction

Table no. 4 shows base shear due to earthquake in X-direction. Base shear for model 1,model 2, model 3, model 4 are 766.19kN, 551.5694kN, 518.0177kN, 339.7307kN respectively

Table 04 : Base shear(kN) due to earthquake in Y- direction:

Story	RC-RB	RC-SB	CC-RB	CC-SB
1	766.1942	551.5694	518.0177	339.7307
2	752.0465	541.3723	508.5064	333.4889
3	695.4557	500.5838	470.4611	308.5216
4	568.1264	408.8098	384.8592	252.3453
5	341.7632	245.6559	232.6779	152.4761

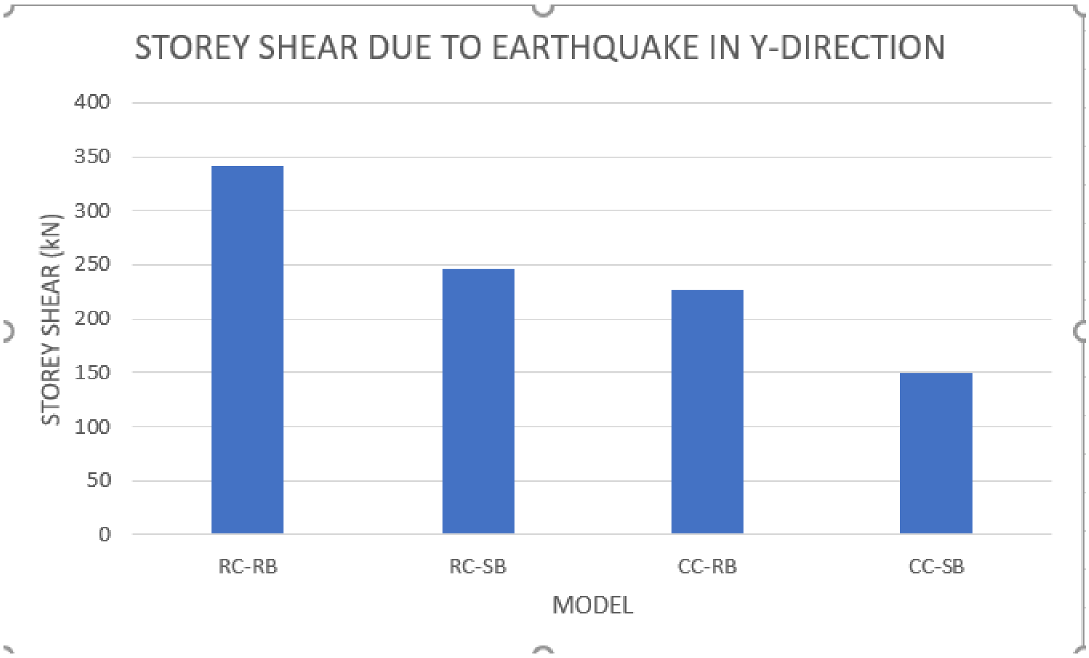


Fig. 7 Base shear due to earthquake in Y- direction:

B. For G+9 storied building:

a. ***Maximum Story Displacement (Mm):***

Table 05: Maximum story displacement due to earthquake in x- direction:

Story	RC-RB	RC-SB	CC-RB	CC-SB
1	1.812	1.697	1.773	2.07
2	4.171	4.2	4.112	5.636
3	6.644	6.952	6.573	9.846
4	9.09	9.738	9.009	14.237
5	11.439	12.449	11.346	18.536
6	13.624	14.996	13.519	22.555
7	15.57	17.286	15.452	26.135
8	17.195	19.213	17.064	29.144
9	18.414	20.678	18.271	31.5
10	19.183	21.647	19.032	33.236

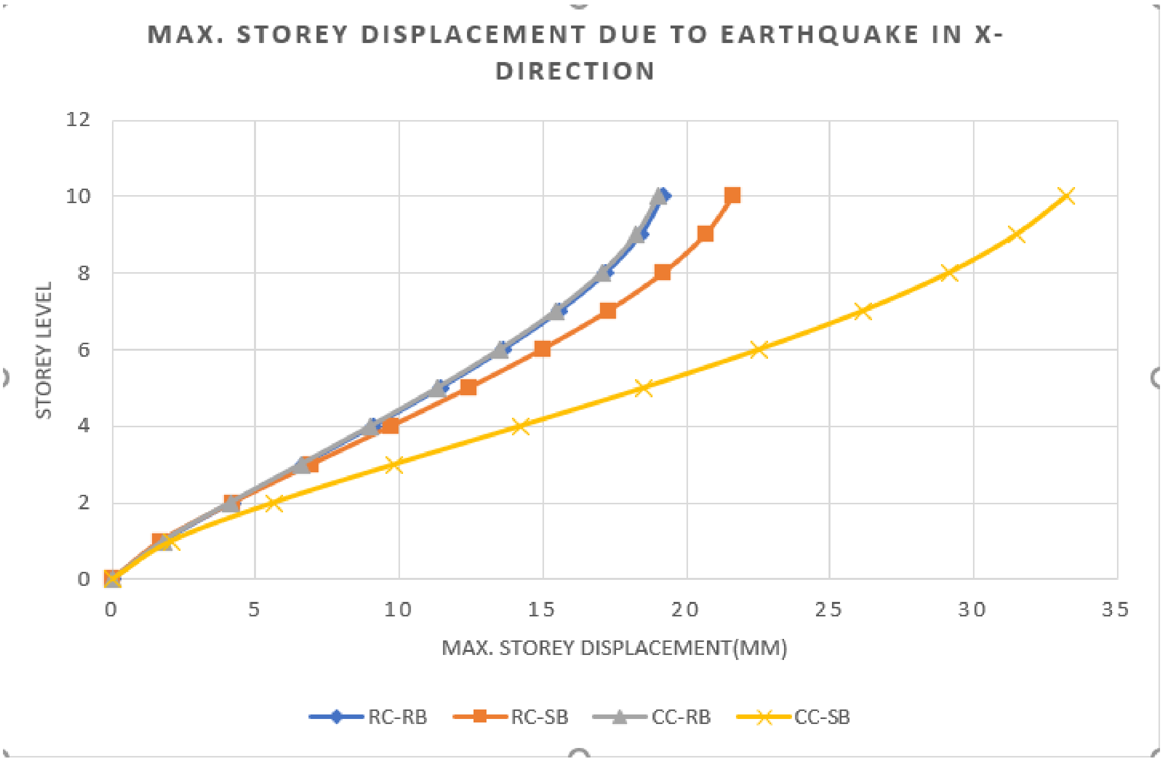


Fig.08 maximum storey displacement due to earthquake in x-direction

Table no. 5 shows max. storey displacement due to earthquake in X-direction. The max storey displacement for model 1, model 2, model 3, model 4 are 19.183mm, 21.647mm, 19.032mm,33.236mm respectively.

Table 06: Maximum storey displacement due to earthquake in Y- direction

Story	RC-RB	RC-SB	CC-RB	CC-SB
1	1.812	1.697	1.773	2.07
2	4.171	4.2	4.112	5.636
3	6.644	6.952	6.573	9.846
4	9.09	9.738	9.009	14.237
5	11.439	12.449	11.346	18.536
6	13.624	14.996	13.519	22.555
7	15.57	17.286	15.452	26.135
8	17.195	19.213	17.064	29.144
9	18.414	20.678	18.271	31.5
10	19.183	21.647	19.032	33.236

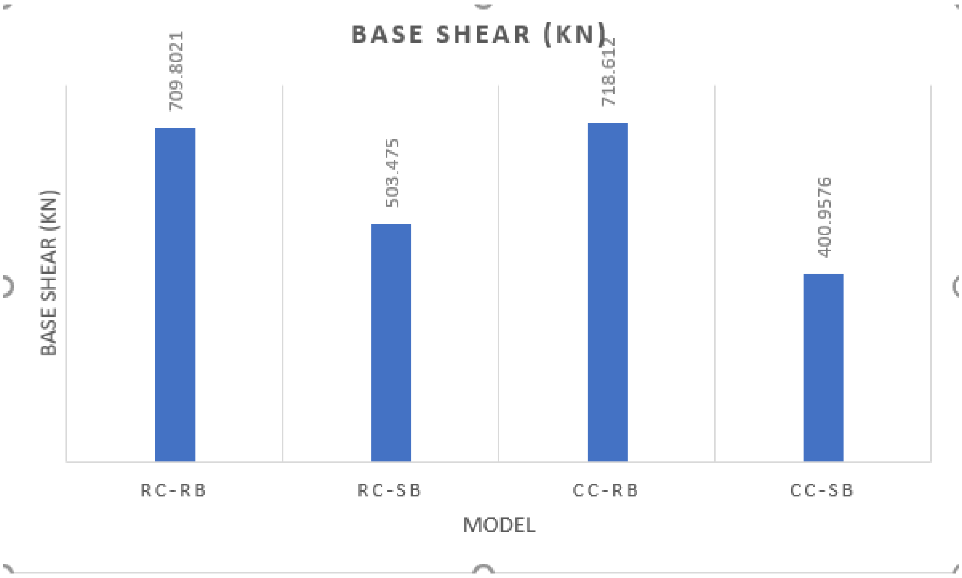
Fig.09 Max. story displacement due to earthquake in Y- direction

Table no 6. shows max. storey displacement due to earthquake in Y-direction. The max storeydisplacement for model 1, model 2, model 3, model 4 are 19.183mm, 21.647mm, 19.032mm,33.236mm respectively.

b. ***Maximum Story Displacement (Mm):***

Table 07: Base shear(kN) due to earthquake in X- direction:

Story	RC-RB	RC-SB	CC-RB	CC-SB
1	709.8021	503.475	718.612	400.9576
2	707.3649	503.475	716.1426	399.578
3	699.0184	501.6854	707.6884	394.8572
4	681.1894	494.5272	689.6294	384.7731
5	650.3221	478.4212	658.3638	367.3144
6	602.8605	449.7884	610.2898	340.4699
7	535.2487	405.0496	541.8056	302.2284
8	443.9308	340.6257	449.3095	250.5787
9	325.3509	252.9377	329.1996	183.5094
10	175.953	138.4063	177.8741	99.0095



Graph no.07 Base shear due to earthquake in x- direction

Table no. 7 shows base shear due to earthquake in X-direction. Base shear for model 1,model 2, model 3, model 4 are 709.8021kN, 503.475kN, 718.612kN, 400.9576kN respectively.

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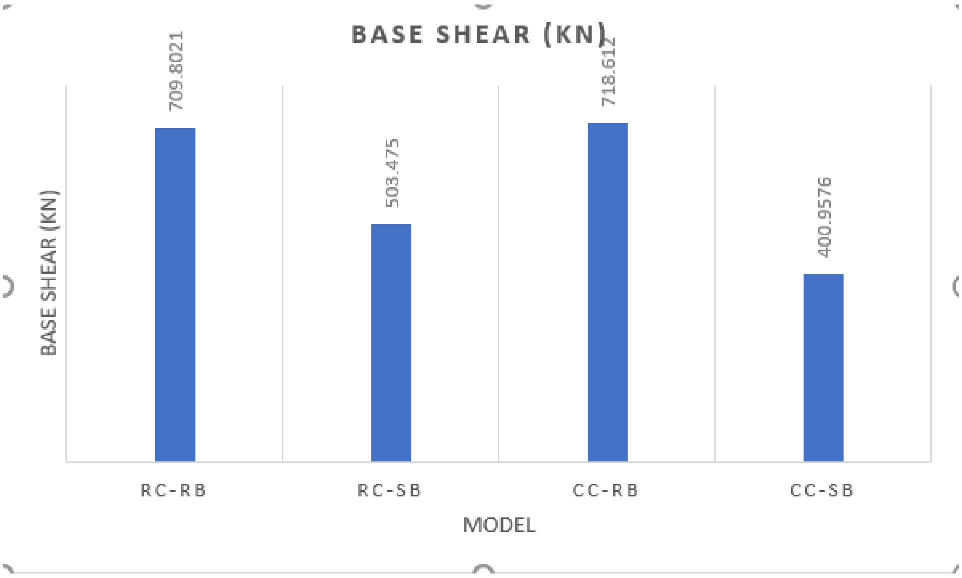
Table 08: Base shear(kN) due to earthquake in Y- direction:

Story	RC-RB	RC-SB	CC-RB	CC-SB
1	709.8021	503.475	718.612	400.9576
2	707.3649	503.475	716.1426	399.578
3	699.0184	501.6854	707.6884	394.8572
4	681.1894	494.5272	689.6294	384.7731
5	650.3221	478.4212	658.3638	367.3144
6	602.8605	449.7884	610.2898	340.4699
7	535.2487	405.0496	541.8056	302.2284
8	443.9308	340.6257	449.3095	250.5787
9	325.3509	252.9377	329.1996	183.5094
10	175.953	138.4063	177.8741	99.0095



Graph no.08 Base shear due to earthquake in Y- direction

Table no 9. shows base shear due to earthquake in X-direction. Base shear for model 1,model 2, model 3, model 4 are 709.8021kN, 503.475kN, 718.612kN, 400.9576kN respectively.

C. REINFORCEMENT DETAILS:

a. *G+4 STORIED STRUCTURE:*

Table 09: Model no. 1 (RC-RB):

Sr. No.	sections	Reinforcement details
1	column 400X400	Main reinforcement: 8bar-16mm ϕ
		Links- 8mm ϕ @ 120 mm c/c
2	Beam 230x380	main reinforcement: top- 2#12mmϕ bottom- 12mm ϕ#2 curtailment: top- 3#12mm ϕ up to L/4 distance from support bottom- 1#12mm ϕ
		Stirrups 8mm ϕ@150mmc/c

Table 10: Model no. 2- (RC-SB):

Sr. no.	sections	Reinforcement details
1	Column 400x400	Main reinforcement 12#16mm ϕ
		Links- 8mm ϕ@120mmc/c
2	Beam	ISMB 300

Table 11: Model no. 03- (CC-RB)

Sr. No.	Sections	Reinforcement details
1	column 300X300	Embedded ISHB150
		confinement bars: 4#12MM ϕ

2	Beam 230x380	main reinforcementtop- 12 mmϕ#2 bottom- 12mm ϕ#2curtailment: top- 3#12mm ϕ bottom- 1#12mm ϕ
		Stirrups 8mm ϕ@150mmc/c

Table 12: Model no. 04- (CC-SB)

Sr. No.	sections	Reinforcement details
1	column 300X300	embedded ISHB150
		confinement bars: 4#12MM ϕ
2	Beam	ISMB200

b. ***G+9 STORIED STRUCTURE***

Table 13: MODEL NO. 1 (RC-RB):

Sr. No.	sections	Reinforcement details
1	column 450X450	Main reinforcement: 12#20mmϕ
		Links- 8mm ϕ @ 100 mm c/c
2	beam 230x380	main reinforcement:top- 12 mmϕ#2 bottom- 12mm ϕ#2 curtailment: top- 3#12mm ϕ bottom- 1#12mm ϕ
		Stirrups: 8mm ϕ@100mmc/c

Table 14: Model no. 2- (RC-SB):

Sr. no.	sections	Reinforcement details
1	column 450x450	Main reinforcement 14#25mm ϕ
		Links- 8mm ϕ@100mmc/c
2	Beam	ISMB 300

Table 15: Model no. 03- (CC-RB):

Sr. No.	sections	Reinforcement details
1	COLUMN 450X450	Embedded ISHB200
		confinement bars: 4#12MM **ϕ**
2	Beam 230x380	main reinforcement:top- 2#12mmϕ bottom- 2#12mm ϕ curtailment: top- 3#12mm ϕ bottom- 1#12mm ϕ
		Stirrups: 8mm ϕ@100mmc/c

Table 16: Model no. 04- (CC-SB)

Sr. No.	sections	Reinforcement details
1	COLUMN 450X450	Embedded ISHB200
		confinement bars: 4#12MM **ϕ**
2	Beam	ISMB 300

D. COST ANALYSIS:

Quantity of concrete, reinforcing steel, & structural steel for one beam and onecolumn

a. ***For G+4 storied structure:***

Table 17: Model 1(RC-RB)

Sr no.	Material	Quantity		Total quantity for one beam and one column	rate	Cost in INR
		Beam	column			
1	Concrete (m^3)	0.35	0.48	0.83	5400	4482/-
2	Reinforcing steel (kg)	40.215	56.692	97	38	3686/-
3	Structural steel (kg)	-	-	-	-	-
Total cost (in INR)		3418/-	4764/-			8168/-

Table 18: Model 2(RC-SB)

Sr no.	Material	Quantity		Total quantity for one beam and one column	rate	Cost in INR
		Beam	column			
1	Concrete (m^3)	-	0.48	0.48	5400	2592
2	Reinforcing steel (kg)	-	86.108	86.108	38	3272
3	Structural steel (kg)	184	-	184	45	8280
	Total cost (in INR)	8280/-	5864/-			14144/-

Table 19: Model 3 (CC-RB)

Sr no.	Material	Quantity		Total quantity for one beam and one column	Rate in INR	Cost in INR
		Beam	column			
1	Concrete (m^3)	0.35	0.27	0.62	5400	3348
2	Reinforcing steel (kg)	40.215	10.68	50.90	38	1934.20
3	Structural steel (kg)	-	108.40	108.40	45	4878
	Total cost (in INR)	3418/-	6741/-			10160/-

Table 20: Model 4(CC-SB)

Sr no.	Material	Quantity		Total quantity for one beam and one column	rate	Cost in INR
		Beam	column			
1	Concrete (m^3)	-	0.27	0.27	5400	1458
2	Reinforcing steel (kg)	-	10.68	10.68	38	405.84
3	Structural steel (kg)	96.80	108.40	205.20	45	9234
	Total cost (in INR)	4356/-	6741/-			11097/-

b. ***For G+9 storied structure:***

Table 21: Model 1(RC-RB)

Sr no.	Material	Quantity		Total quantity for one beam and one column	rate	Cost in INR
		beam	column			
1	Concrete (m^3)	0.35	0.5961	0.9461	5400	5108.94
2	Reinforcing steel (kg)	39.01	200.0461	239.0561	38	9084
3	Structural steel (kg)	-	-	-	45	-
	Total cost (in INR)	3372/-	10820/-			14192/-

Table 22: Model 2(RC-SB)

Sr no.	Material	Quantity		Total quantity for one beam and one column	rate	Cost in INR
		Beam	column			
1	Concrete (m^3)	-	0.5868	0.5868	5400	3168.5400
2	Reinforcing steel (kg)	-	216	216	38	8208
3	Structural steel (kg)	176.80	-	176.80	45	7956
	Total cost (in INR)	7956/-	3168/-			19332/-

Table 23: Model 3(CC-RB)

Sr no.	Material	Quantity		Total quantity forone beam and one column	rate	Cost in INR
		Beam	column			
1	Concrete (m^3)	0.35	0.5932	0.9432	5400	5093.28
2	Reinforcing steel (kg)	39.01	10.67	49.68	38	1887.84
3	Structural steel (kg)	-	111.90	111.90	45	5035
	Total cost (in INR)	3372.38/-	8644/-			12016.12/-

Table 24: Model 4(CC-SB)

Sr no.	Material	Quantity	Total quantity	rate	Cost in INR

		Beam	column	for one beam and one column		
1	Concrete (m^3)	-	0.5932	0.5932	5400	3203.28
2	Reinforcing steel (kg)	-	10.67	10.67	38	405.46
3	Structural steel (kg)	176.80	111.90	288.70	45	12991.50
	Total cost (in INR)	7956/-	8644/-			16600/-

E. **OBSERVATIONS**

Table 25: G+4 Storied building:

Models	Base Shear (KN)	Max storey displacement (mm)	Total cost for one beamand one column (INR)
Model 1 RC-RB	766.19	8.491	8168/-
Model 2 RC-SB	551.5694	11.254	14144/-
Model 3 CC-RB	518.0177	11.933	10160/-
Model 4 CC-SB	339.7307	17.653	11097/-

Table 26: G+9 Storied building:

Models	Base Shear (KN)	Max storey displacement (mm)	Total cost for one beamand one column (INR)
Model 1 RC-RB	709.8021	19.183	14192/-
Model 2 RC-SB	503.475	21.647	19332/-
Model 3 CC-RB	718.612	19.032	12016/-
Model 4 CC-SB	400.9576	33.236	16600/-

The comparison shows that,

base shear for model 4 i.e. (composite column and steel beam frame building) has reduced by 45% to 55% compared to that of the model 1 (reinforced concrete frame building).

Max. storey displacement for model 4(composite column and steel beam) has increased by 75% to 85% compared model 1(RCC column and RCC beam)

From table 25, In G+4 storied building Material cost for one beam and column for model no.01(RC-RB) is lowest among all, and 20% less compared to model 3(CC-RB)

From table 26, In G+9 storied building material cost for one beam and one column for model 03(CC-RB) is lowest among all, and 15% less compared to model 01(RC-RB) i.e., conventional RC frame building.

***F.* CONCLUSION**

Analysis and design of building can be done and comparison can be made between them and from that conclusions can be drawn out are as follows:-

For G+4 storied structure the cost of model 1 (RC-RB) i.e., conventional RCC frame building is 20% to 25% less compared to model 3 (CC-RB) and model 4 (CC-SB) i.e., composite frame structure. Therefore concluded that for low rise building up to 5 storey from performance and economic point of view conventional RCC frame building is better than RC-steel composite structure.

For G+9 storied building the cost of CC-RB is 15% less compared to conventional RC frame building. For 10 storied structure RC-steel composite structure is economical over conventional RC frame building.

Composite column and steel beam frame structure has light in weight as compared to conventional RCC frame structure which will give economical foundation design.

Under earthquake consideration because of inherent ductility characteristics, Steel-concrete composite structure performs better than conventional RCC frame structure.

As compared to conventional RCC framed structure, composite structures less construction time due to quick erecting of the steel frame and ease of formwork of concrete. Including the construction period as a function of total cost in the cost estimation will certainly result in increased in economy for the composite structure.

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List and number all bibliographical references in 10-point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets, for example: [1]. Where appropriate, include the name(s) of editors of referenced books. The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in "[3]"—do not use "Ref. [3]" or "reference [3]". Do not use reference citations as nouns of a sentence (e.g., not: "as the writer explains in [1]").

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