COMPARATIVE DESIGN AND ANALYSIS OF MULTI-STOREY RCC AND COMPOSITE STRUCTURES

Submitted in partial fulfillment of the requirements

of the degree of

MASTER OF TECHNOLOGY

In

CIVIL ENGINEERING

by

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Transforming Education Transforming India

School Of Civil Engineering

LOVELY PROFESSIONAL UNIVERSITY, PHAGWARA

2017

DECLARATION

I, Ashutosh Pandey (11501846), hereby declare that this thesis report entitled **" Comparative Design And Analysis Of Multi-Storey RCC And Composite Structures "** submitted in the partial fulfillment of the requirements for the award of degree of Master of Technology in Civil Engineering, Lovely Professional University, Phagwara, is my own work. The matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree or honour.

Date: **Ashutosh Pandey**

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Place:

CERTIFICATE

Certified that this project report entitled **" Comparative Design and Analysis of Multi-storey RCC and Composite Structure "** submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

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ABSTRACT

Now a day the interest for construction of Multi-storey buildings is growing rapidly. The main aim behind it is the growing competition in the world and also to make it more economical and spacious in all forms. Theoretical calculations for such structures are very critical and hence the demand for faster and quick softwares is growing fastly.

This Project Report basically uses the computer programs like STAAD. ProV8i and ETABS for the designing and analysis of the Multi-storey building of 2 forms. The design code used is the Indian code of design. The structure taken is an RCC and Composite structure with G+20 storey. In all the two cases of Multi-storey buildings we will design and analyze and compare among all these structures.

STAAD. ProV8i & ETABS both are used for the concrete design, time history analysis,response spectrum analysis and p-delta analysis. The weight of Composite structure is 94.45% that of RCC structure. The P-Delta analysis result for both the structures it can be seen that storey drift for composite structure is 0.041667% higher that the RCC structure however it can be seen that the deflection is within the middle third of the columns. The Modal mass participation ratio in case of Response Spectrum analysis is greater than 90% which is the minimum required participation ration as per IS1893:2002. The Base shear ratio of linear and non linear case is approx. 91% which is greater than 85% of the desired ratio as per IS1893:2002.

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ABBREVIATION USED

%	Percentage
min	Minutes
mm	Millimeter
cm	Centimeter
m	Meter
sec	Second
Kg/m^3	Kilogram Per Meter Cube
MPa	Mega Pascal
Φ	Diameter
N	Newton
KN	Kilo Newton
Kn.m	Kilonewton Metre
3D	Three Dimensional
Etc	End Of Thinking Capacity
RCC	Reinforced Cement Concrete
FBD	Force Based Design
DBD	Displacement Based Design
Fig.	Figure
No.	Number
&	And

CHAPTER 1

INTRODUCTION

1.1 GENERAL

1.1.1 HISTORY BEHIND DEVELOPMENT OF MULTISTOREY BUILDING

Multi-storey buildings came to an existence after seeing the tall temples by Romans. The Romans were known for their arch design. Even 4000 years ago, ancient engineering was somewhat approached and allowed multi-storey buildings to be constructed examples can be found from all the path of South Europe to Central Asia. However approaches varied considerably, the result was same in all cases whether it was 2 or 3 storey houses/palaces etc. were made.

Fig 1.1 The Temple of Hercules Victor, in the Forum Boarium in Rome

Now a day's engineers and architects are moving towards the construction of various multi-storey buildings of RCC, Steel and Composite structure to make them as an economical, spacious and also to increase the engineering technologies and solutions.

Some of the Pictures of constructed multi-storey RCC and Composite structures are as follows:

Fig 1.2 The Wainwright Building,10-Storey Building In St. Louis, Missouri, Built In 1891

Fig 1.3 Multi-Storey, Steel-Framed Car Park, Milton Keynes in UK

1.1.2: MOTIVE BEHIND COMPARATIVE DESIGN AND ANALYSIS OF MULTISTOREY RCC & COMPOSITE STRUCTURE

With the development of technologies around the world, new and complex structures are being constructed and designed. Introduction of software in market has now made it easier to go for different shaped structures, also the work gets faster. So with the help of Staad.ProV8i & Etabs my aim is to design and analyse multi-storey Rcc and composite structure and then compare to make them more stable, spacious,earthquake resistant and safe.

1.1.3: ANALYSIS OF MULTISTOREY RCC AND COMPOSITE BUILDINGS

For the purpose of comparative designing and analysis a hypothetical 20 storey structure is being designed on Staad.ProV8i and Etabs with the various analysis like P-Delta analysis, time history analysis, Response spectrum analysis, etc are being done.

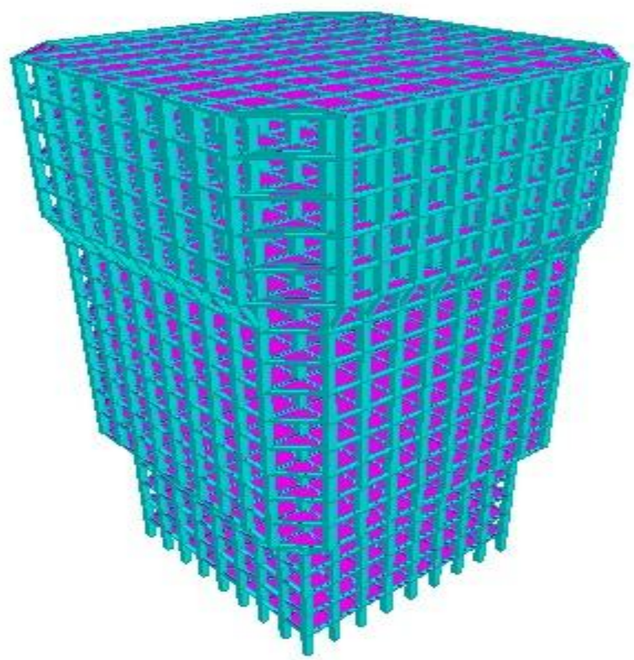

Fig 1.4 3D View

1.1. WORLD WIDE CURRENT SCENARIO

Currently Multi-storey buildings are becoming very popular world wide as a sign of technological advancement and capacity. On a Yearly basis 1000 number of multi-storey buildings are constructed worldwide. Few of the examples of Multi-storey building are Antilia of 27 storey (India), The Gargash Tower of 23 storey(Dubai)etc. However more and more works are done in this sector with the help of softwares like Staad.Pro, Etabs, Sap 2000 etc.

Fig 1.5 Antilia (Mumbai, India)

1.2: BENEFITS AND ADVANTAGES

As the area of land is decreasing day by day the requirement of Multi-storey buildings is getting higher. So the benefit of Multi-storey building is that more and more space can be covered with it. Also it serves as advancement in the modern era of new technology and shows the day by day growth of the nation. Also the main advantage of Multi-storey building is to serve it as official as well as residential purpose both and make it more spacious, stable, safe and economical.

CHAPTER 2

LITERATURE REVIEW

D.R. Deshmukh et al. (2016) studied the analysis and design of G+19 building using STAAD.PRO and found that STAAD.PRO is an powerful tool for the analysis and design of multistory buildings where manual calculation can be very cumbersome and complex.

Table 2.1 Structural Specifications (D. R. Deshmukh et al. 2016)

Particulars	Dimension
Column	.30m×.60m
Beam	.45m×.45m
Slabs	0.15m thick
Parapet Wall	.1m
Live load	2kn/m2
Floor Finish	1kn/m2
Grade of concrete	M30
Grade of steel	Fe415
Storey height	3.6m
Plan	33.6×18.8

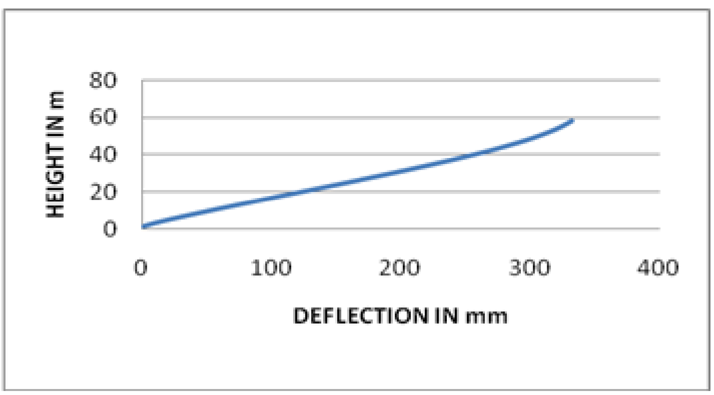

Fig 2.1 Height v/s Deflection (D.R. Deshmukh et al., 2016)

D.Ramya et al(2015) has done the comparative study on Design and Analysis of Multi-storey building (G+10) using STAAD.PRO and ETABS and she has also used the software to calculate forces,bending moment,stress,strain,deformation & deflection for a complex structure.

Table 2.2: Comparison between STAAD.PRO and ETABS

S.No	Point of Comparision	Softwares		Remarks
		STAAD.PRO	ETABS	
1	Time	It takes less time	It takes slightly more time.	STAAD is very easy to learn& work.
2	Accuracy	Less accurate	More accurate	STAAD is accurate for both analysis and design
3	Flexibility	User friendly	Learners choice	***
4	Present day status	Most of the designers are using this software	Not preferred like STAAD	STAAD is more preferred because of its flexibility and ease of workability
5	Steel	122.58 tons	111.24 tons	***
6	Concrete	1086 cum	1086cum	***

Chang-Hai Zhai et al. (2015) studied the effect of main shock, after shock on nuclear power plant and found that after shock imparts effect over structures. So, multiple shocks are to be determined and processed to get the response of structure.

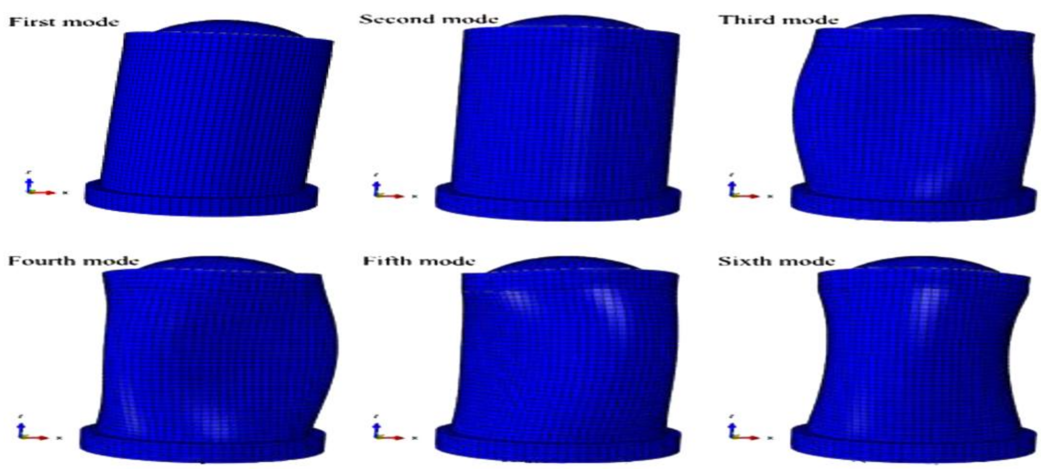

Fig 2.2 Mode Shape (Chang- Hai Zhai et al. , 2015)

Under sequential seismic load damage is greater than single seismic loading . The lateral displacement may raise upto 30 % at sequential load.

Hossein Agha Beigi et al. (2015) studied about factors influencing repair cost of soft storey. They took an RC frame building and analyzed the seismic retrofit of it. It's found that soft storey with partial infill wall have greater tendency to collapse. Due to the soft storey formation at the first floor the deformation at the top floor gets increased hence by providing proper infill walls at first floor the deformation could be prevented to a greater extent. Amongst the three variants of structure viz. RC framed , partially infilled , fully infilled , the partial infill walls storey was most likely to deform under seismic loading .

Ima Muljati et al. (2015) studied the performance of displacement based design and force based design on concrete frame. They concluded that displacement based design is superior in predicting the seismic demand (storey drift) than force based design. The DBD designs structure for a particular performance while the FBD does several iterations to justify the codal provisions.

F. Cherifi et al. (2015) evaluated seismic vulnerability of structures. Location was Tizi Ouzou city in Algeria.

It was concluded that buildings made before 35 years are more susceptible to damage than buildings made after this period. The main reason could be the poor level of structure design and not following the codal provisions. ETABS software was used for the evaluation of damage.

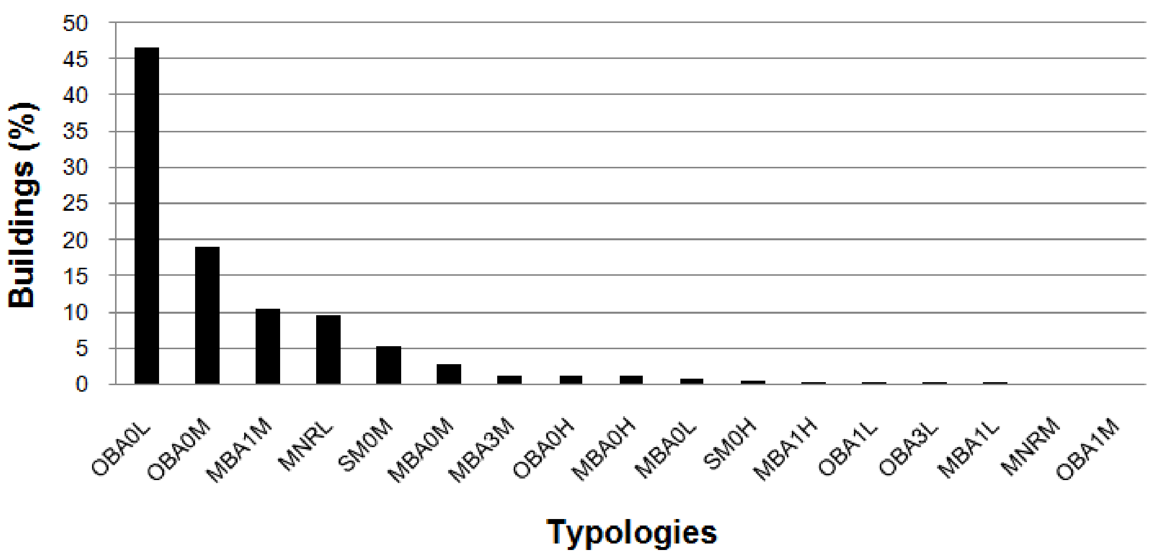

Fig 2.3 Topography V/S Buildings (F. Cherifi et al. , 2015)

The OBA0L topography (1- 3storey) has maximum buildings percentage. So the majority of buildings in the city are shorter in height.

Shweta A.Wagh et al.(2014) studied 4 various multi-storey buildings (RCC & Composite structures) of G+12,G+16,G+20,G+24 and then she designed and analyzed all these structures in STAAD.PRO and then she took the result and compared among these structures for cost and design comparision .

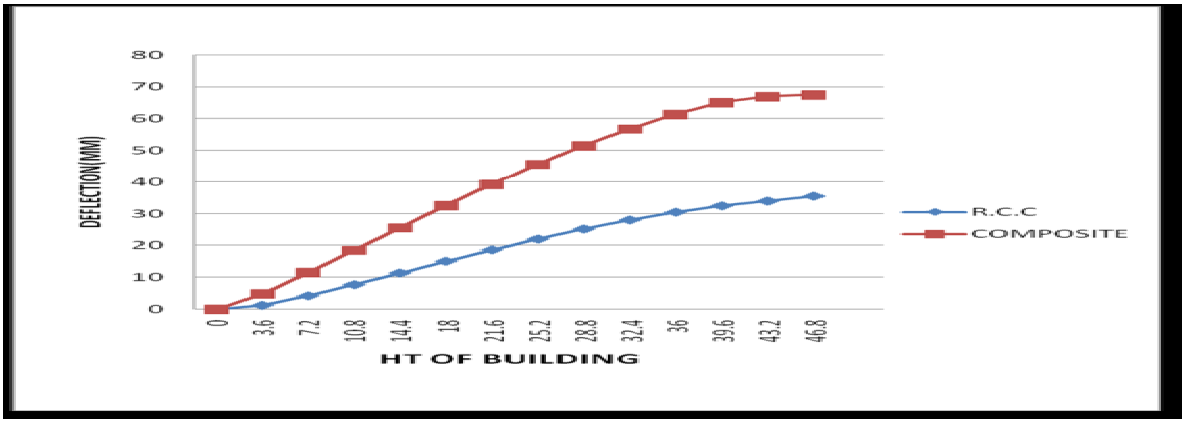

Fig: 2.4 Comparison Of Deflection

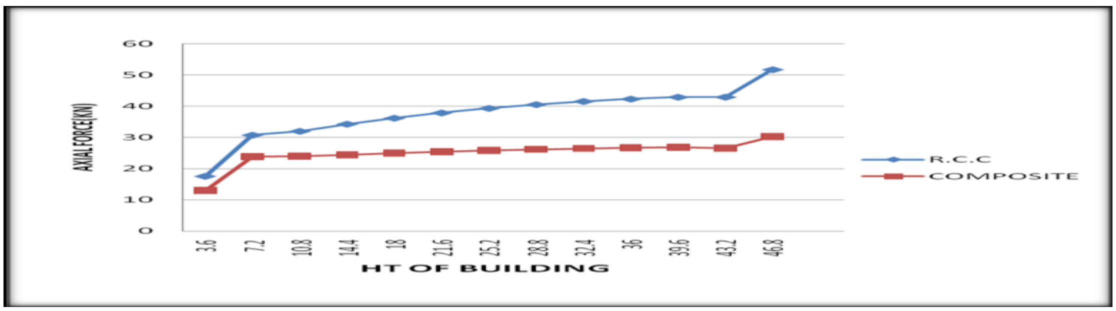

Fig: 2.5 Comparision Of Axial Force

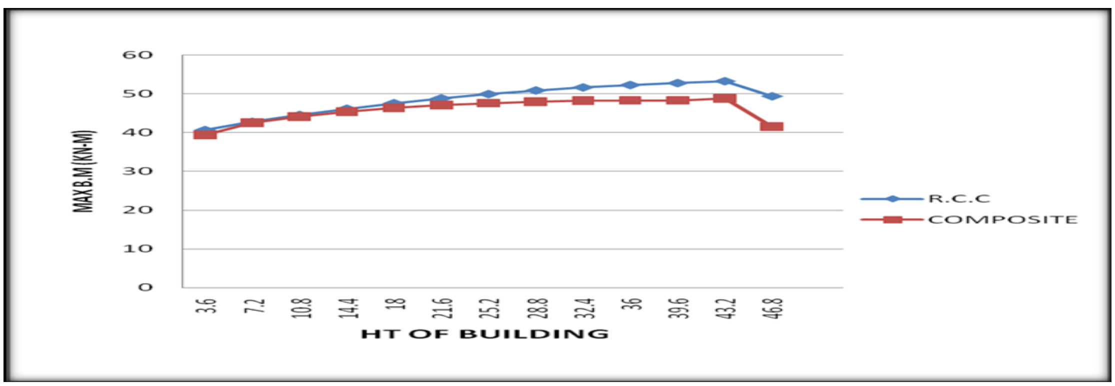

Fig: 2.6 Comparison Of Bending Moment

Table 2.3: Comparison Of Total Cost Between R.C.C Structure And Composite Structure

STORY	COST OF R.C.C STRUCTURE (Cr)	COST OF COMPOSITE STRUCTURE(Cr)	DIFFERENCE
G+12	5,67,20,409	5,66,57,375	-0.111
G+16	7,30,29,883	6,93,97,893	-5.23
G+20	9,57,76,019	8,67,20,187	-10.44
G+24	12,13,52,652	10,57,40,009	-14.77

Mohit Sharma et al. (2014) studied effect of static and dynamic load on multistoreyed rcc buildings. They took a G+30 building & analysed it using STAAD. Pro . It was found that axial force for building in seismic zone 2 and 3 under static and dynamic load in not much varying .

Table 2.4 Design Data (Mohit Sharma et al. , 2014)

S.no	Particulars	Dimension/size/value
1	Model	G+30
2	Seismic Zones	II , III
3	Floor height	3.6M
4	Depth of foundation	2.4M
5	Building height	114M
6	Plan size	25Mx45M
7	Total area	1125Sq.m
8	Size of columns	0.9Mx0.9M
9	Size of beams	0.3Mx0.50M
10	Walls	a)Internal wall 0.10m b)External wall 0.20m
11	Thickness of slab	125 mm
12	Earthquake load	As per IS-1893:2002
13	Type of soil	Type -II, Medium soil as per IS-1893
14	Ec	5000√fck N/ mm2(Ec is short term static modulus of elasticity in N/ mm2)

Also it’s concluded that torsion in beams for static load is negative while it’s positive during dynamic force. Dynamic force imparts more displacement to structure (17-28 %).

Dia Eddin Nassani (2014) studied the vibration period of steel structure using conventional methods and STAAD. Pro. It's concluded that the software gives better and faster result than the conventional methods and formulas proposed by various codes of practices.

A S Patil et al. (2013) did time history analysis of RCC buildings using various earthquake intensities. The software used was SAP 2000. It's found that for earthquake intensities V – X the response increased in accordance with the intensity.

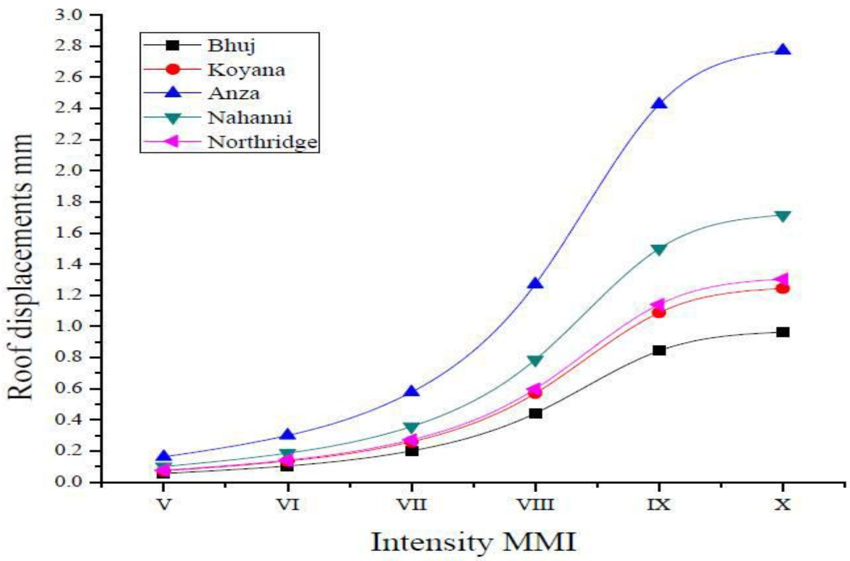

Fig 2.7 Intensity V/S Roof Displacement (A S Patil et al. , 2013)

The time history analysis provides a suitable way to provide check to the structure safety, the main reason could be being it's realistic input data.

Hendramawat A Safarizki et al. (2013) studied the effect of steel bracings over RCC buildings at seismic loading. It's found that steel bracing's couls be used as retrofit of earthquake forces. However the effect of steel member length couldn't be found out.

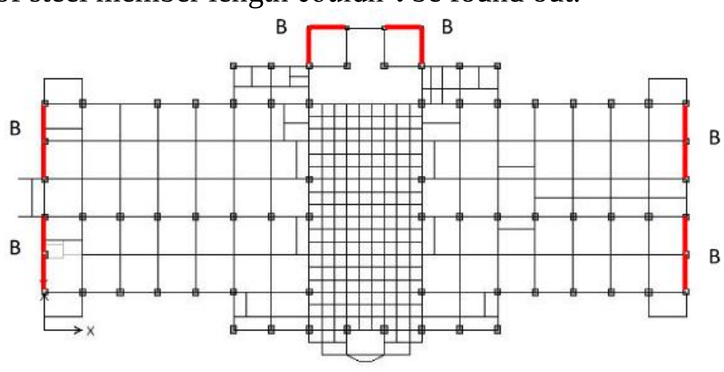

Fig 2.8 Steel Retrofit (Hendramawat A Safarizki et al. 2013)

Ketan Patel et al. (2013) studied effect of lateral force on CFT, STEEL and RCC buildings. It's found that the concrete filled steel tube building showed better performance that the rest two. Upto 30 storey RCC building lateral drift was permissible but beyond that it's not upto the mark. Load carrying capacity is greater in CFT structure by 1-8%.

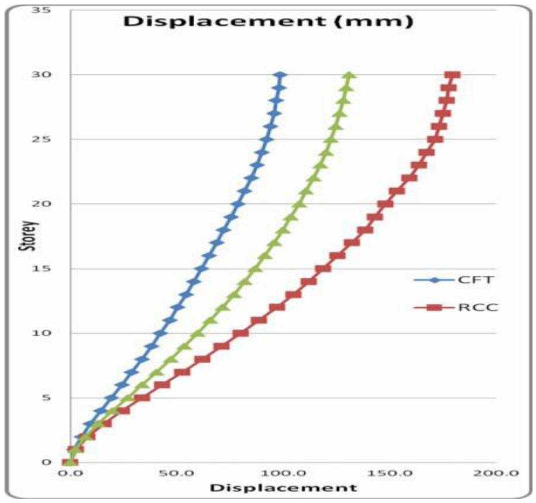

Fig 2.9 Storey V/S Displacement (Ketan Patel et al. , 2013)

Khushbu Jani et al. (2013) studied effect of diagrid on high rise steel buildings . It was found that lateral load was majorly taken by diagrid columns . while the gravity load was taken by all the columns . software used was ETABS , the building was 36 storey and 36*36 m's in plan .

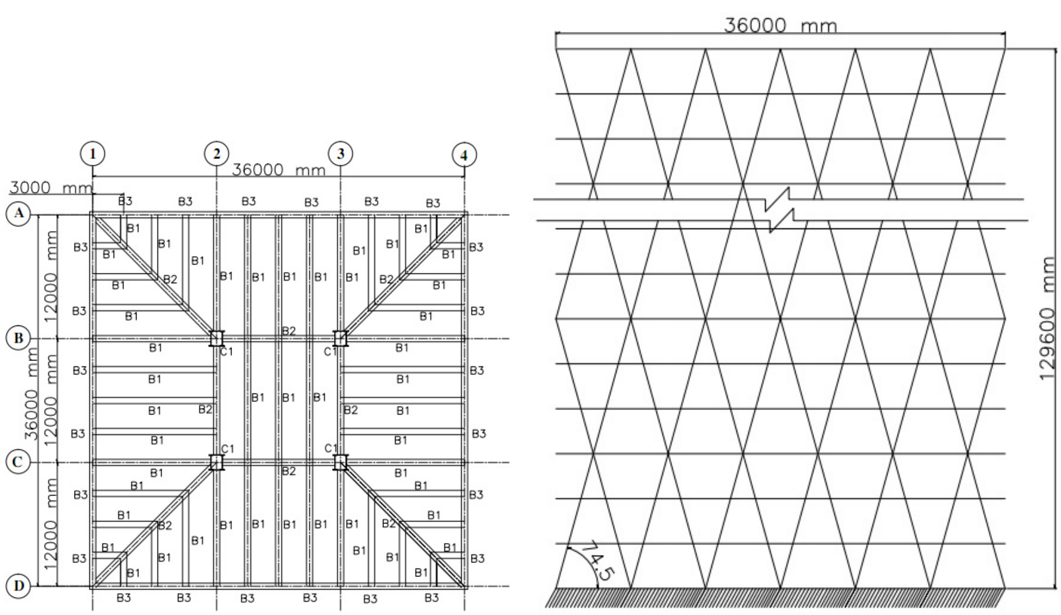

Fig 2.10 Plan Of Floor (Left **), Elevation(**Right **) (Khushbu Jani et al. 2013)**

B Suresh et al. (2012) studied behavior of a structure with and without earthquake forces. The building taken was 6 storeys. Conclusion obtained from the study using STAAD Pro was that for earthquake resistant construction the cost increases upto 3- 17 % of total cost . It's found that structure without lateral force consideration is highly prone to collapse during earthquake .

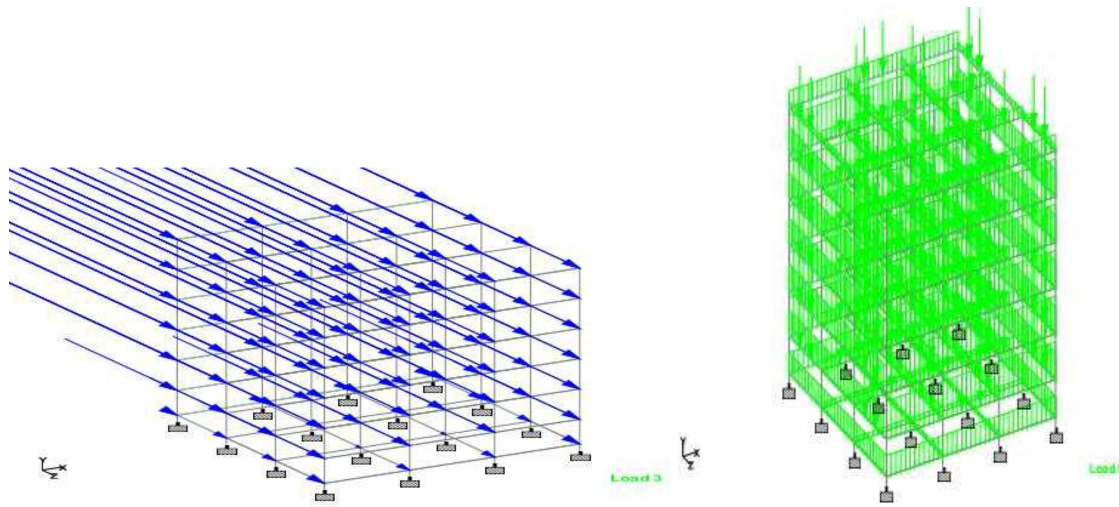

Fig 2.11 Earthquake And Vertical Load (B Suresh et al. , 2012)

Kai Hu et al. (2012) did comparative study of high rise RCC structure with oblique column in China using ETABS , SAAP 2000 , MIDAS and SATWE . Structure was 29 storey with 3 underground. Response spectrum result was similar in all softwares, however ETABS couldn't analyze the oblique columns. ETABS gave better time history result than all.

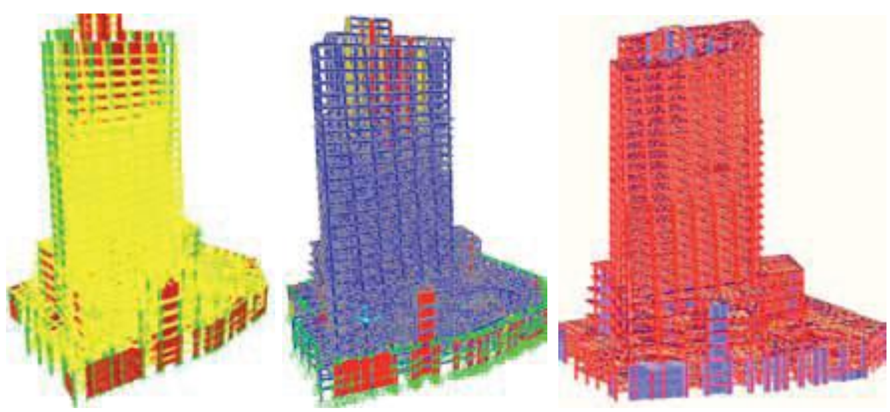

Fig 2.12 Model ETABS, SAP 2000, MIDAS (Kai Hu et al. 2012)

Mehmet Metin Kose (2009) studied the parameters affecting the fundamental period of RCC buildings with infill walls using ANN. Result obtained was that storey height/ no of floors have primary affect over period of vibration. Percentage of shear wall had second most importance.

CHAPTER 3
FUTURE SCOPE & OBJECTIVE OF STUDY

3.1 FUTURE SCOPE OF STUDY

In this project “Comparative design and analysis of Multi-storey Buildings” various analysis like P-Delta analysis, time history analysis,response spectrum analysis are done on a RCC and Composite structure and the results are compared and the best suited structure is taken into consideration for practical implementation. The result of this project work can be used in future for the design of safest structure amongst RCC and Composite.

3.2 OBJECTIVE OF STUDY

- To study the concrete design of structure for two different structures.
- To locate the center of gravity of the structures from Staad.pro.
- To find out the storey drift using P-Delta analysis for two different structures.
- To find out the frequencies of the structure using time history analysis in Staad.pro
- To perform the response spectrum analysis for both cases.
- To find out the most economical and safe structure amongst the two different structures.

CHAPTER: 4

EXPERIMENTAL PROGRAMS

Table 4.1: Structural Details

S.NO	PARTICULARS	DIMENSION/VALUE/SIZE
1	PLAN(Up to 5 floors)	32m*32m
2	PLAN(Up to 15 floors)	40m*40m
3	PLAN(Up to 20 floors)	44m*44m
4	FLOOR HEIGHT	4m
5	COLUMN SIZE	.60m*.60m
6	BEAM SIZE	.40m*.40m
7	FOUNDATION DEPTH	10m
8	TYPE OF SOIL	HARD
9	ZONE TYPE	3
10	GRADE OF CONCRETE	M25
11	GRADE OF STEEL	Fe415

Various Designs and Analysis to Be Carried Out

Table 4.2: Design and Analysis Details

S.No	RCC	COMPOSITE
1	Total weight of structure	Total weight of structure
2	P delta analysis	P delta analysis
3	Time history analysis	Time history analysis
4	Response Spectrum analysis	Response Spectrum analysis
5	Locating C.G.	-

P Delta Analysis:

When a structure is loaded, there is a deflection in the members of structure and it causes secondary moments and due to these members in the end may not be in vertical in deflected position. To overcome these effects number of iterations is done for the each storey drifting and thus these process is known as P Delta Analysis.

P Delta Analysis is done by STAAD.PROV8i (For RCC) & ETABS Software (For both) by number of iterations.

Time History Analysis:

Time History Analysis is based on Realistic earthquake data which occurred in past and then the response of the structure is determined.

Time History Analysis is done by STAAD.PROV8i (For RCC frequency & Period) & ETABS software (For RCC& Composite Base Fx & Time-period) by inserting the previous seismic data.

Response Spectrum Analysis:

Response Spectrum Analysis is a kind of linear analysis which contains graph of Period Vs Acceleration or Period Vs Displacement. Based on the Earthquake data the response of the structure is obtained.

Response spectrum Analysis is done by ETABS Software.

CHAPTER: 5

RESULT AND DISCUSSIONS

Results According to Staad.Pro V8i for RCC structure is given below:

5.1: CONCRETE DESIGN

The Result for the Concrete Design of the structure obtained is given below:

TOTAL VOLUME OF CONCRETE = 8688.7 CU.METER

Table 5.1 Concrete Design

Bar Dia	Weight (N)
8	1012450
10	579209
12	2866185
16	859424
20	857444
25	687725
32	28654
40	61928
Total	6953019

The result obtained above is for Reinforcing Steel in beams and columns, However Reinforcing steel in Plates is not included in above obtained result.

5.2: Locating the Centre of Gravity

The centre of gravity has been calculated using Staad.Pro and the results are given below:

Table 5.2 CG Locations

Particulars	CG(m)
X	15.9988
Y	41.7437
Z	15.9988

TOTAL SELF WEIGHT = 291745.3125 (KN UNIT)

Clearly it can be seen that the centre of gravity of the structure is get shifted slightly towards the centre of the structure

5.3: P-DELTA ANALYSIS RESULT

The values of p-delta analysis is most critical in the case of seismic loading , values for the displacement , moment and reactions are given in the table below ,

Table 5.3 P-Delta Result

DIRECTION	MAX. LOAD (TOTAL)	MAX. REACTION	MAX. DISPLACEMENT	NODE NO.	MOMENT AT ORIGIN
X	280.06KN	-280.06KN	4.95228E-01	2364	
Y	0	0	4.48435E-02	1594	
Z	0	0	1.74822E-03	326	
MX					0.00
MY					-4480.90KNm
MZ					16384.81KNm

Beam End Force Summary

The signs of the forces at end B of each beam have been reversed. For example: this means that the Min Fx entry gives the largest tension value for an beam.

				Axial	Shear		Torsion	Bending	
	Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
Max Fx	8729	2380	6:GENERATEI	12.4E+3	-258.890	4.837	-2.485	8.175	1.37E+3
Min Fx	8729	4	2:LOAD CASE	-3.16E+3	216.465	-4.755	2.070	10.819	-309.661
Max Fy	916	276	5:GENERATEI	3.64E+3	448.784	-80.535	3.511	108.406	669.806
Min Fy	964	324	6:GENERATEI	3.64E+3	-439.531	80.821	3.269	-108.926	-667.865
Max Fz	1445	409	6:GENERATEI	6.05E+3	32.845	243.671	-1.239	-655.999	191.661
Min Fz	1523	487	5:GENERATEI	5.98E+3	-50.779	-241.960	-1.218	653.855	-191.317
Max Mx	1112	328	5:GENERATEI	2.11E+3	-132.101	-69.180	54.011	140.767	-480.241
Min Mx	1109	325	5:GENERATEI	2.08E+3	-134.281	71.264	-54.133	-143.384	-483.325
Max My	886	327	5:GENERATEI	11.1E+3	30.432	238.172	-35.663	673.772	-149.958
Min My	884	325	6:GENERATEI	11.1E+3	-66.939	-239.507	-37.309	-675.009	157.975
Max Mz	8782	2433	6:GENERATEI	4.38E+3	-324.486	0.000	-0.000	-0.009	1.47E+3
Min Mz	8781	2432	5:GENERATEI	4.36E+3	324.664	0.000	-0.000	-0.003	-1.47E+3

Fig 5.1 Data for Shear, Torsion and Bending and Axial Force

From the above result it can be seen that the max base shear occurs at the base floor column no. 8729. Also, the minimum shear force is produced in the inner column no. 8729 at the base floor.

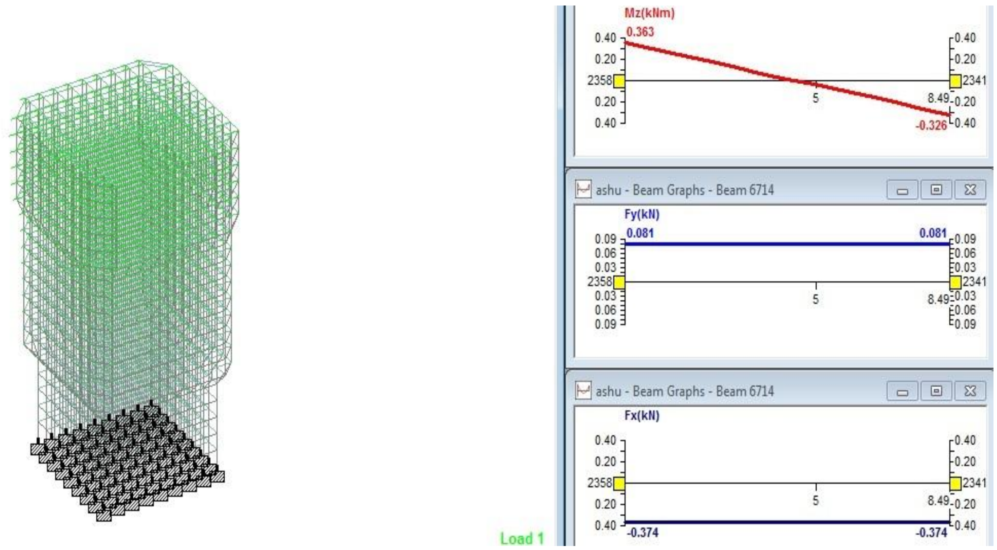

Fig 5.2 SF & BM Diagram For A Beam Member

5.4: TIME HISTORY ANALYSIS RESULT

Table 5.4: Time History Analysis Result

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	3.521	0.28404
2	3.522	0.28390
3	4.349	0.22995
4	4.511	0.22167
5	4.858	0.20586
6	5.012	0.19553

ACTUAL WEIGHT OF THE STRUCTURE = 291722.656 KN
From the above it is clear that as the time is increasing the frequency is getting decreased.

ETABS Results for RCC Structure:

5.5: General Material Properties

Element Type	Material	Total Weight kN	# Pieces	# Studs
Column	M25	83351.3796	2316	
Beam	A992Fy50	9445.489	2840	0
Beam	M25	25414.5593	1580	0
Brace	A992Fy50	355.5893	72	
Floor	4000Psi	134366.3447		
Floor	M25	6264.1497		

Fig: 5.3 Material list by element type

Name	Type	E MPa	v	Unit Weight kN/m³	Design Strengths
4000Psi	Concrete	24855.58	0.2	23.5631	Fc=27.58 MPa
A615Gr60	Rebar	199947.98	0.3	76.9729	Fy=413.69 MPa, Fu=620.53 MPa
A992Fy50	Steel	199947.98	0.3	76.9729	Fy=344.74 MPa, Fu=448.16 MPa
HYSD415	Rebar	200000	0	76.9729	Fy=415 MPa, Fu=485 MPa
M25	Concrete	25000	0.2	24.9926	Fc=25 MPa

Fig: 5.4 Material Properties Summary

Story	Element Type	Material	Total Weight kN	Floor Area m^2	Unit Weight kN/m^2	# Pieces	# Studs
SUM	Column	M25	83351.3796	30440	2.7382	2316	
SUM	Beam	A992Fy50	9445.489	30440	0.3103	2840	0
SUM	Beam	M25	25414.5593	30440	0.8349	1580	0
SUM	Brace	A992Fy50	355.5893	30440	0.0117	72	
SUM	Floor	4000Psi	134366.3447	30440	4.4141		
SUM	Floor	M25	6264.1497	30440	0.2058		
TOTAL	ALL	ALL	259197.5115	30440	8.515	6808	0

Fig: 5.5 Material List Summary

5.6: Response Spectrum Analysis:

Table 5.5: Base Reactions

Load Case	FX kN	FY kN	FZ kN	MX kN-m	MY KN-m	MZ kN-m
Dead	0	0	259197.5115	5702345	-5702345	0
eq Max	315543.9398	315543.9398	0	0	13638831	0.003
eq Min	0	0	0	-13638831	0	0
rs Max	347887.5074	347887.5074	0	20151115	20151115	10823719

Mode	Period	UX	UY	UZ	RX	RY	RZ	Modal Mass	Modal Stiffness
	sec	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m-s^2	kN-m
1	3.318	0	0	0	0	0	2.70325	1.00E-06	3.59E-06
2	3.178	5.90E-05	-0.00014	0	1.112492	0.46515	0	1.00E-06	3.91E-06
3	3.178	0.000142	5.90E-05	0	-0.46515	1.112492	0	1.00E-06	3.91E-06
4	0.896	-8.00E-06	-4.40E-05	0	-3.15	0.570597	0	1.00E-06	5.00E-05
5	0.896	4.40E-05	-8.00E-06	0	-0.5706	-3.15	0	1.00E-06	5.00E-05
6	0.81	0	0	0	0	0	-0.46573	1.00E-06	6.00E-05
7	0.458	-1.70E-05	-3.00E-06	0	-0.13614	0.72519	-1.45E-08	1.00E-06	0.00019
8	0.458	3.00E-06	-1.70E-05	0	-0.72519	-0.13614	5.53E-09	1.00E-06	0.00019
9	0.408	0	0	0	3.52E-08	4.09E-08	-0.22833	1.00E-06	0.00024
10	0.323	-6.00E-06	1.20E-05	0	0.703132	0.367825	1.36E-08	1.00E-06	0.00038
11	0.323	1.20E-05	6.00E-06	0	0.367825	-0.70313	-7.31E-09	1.00E-06	0.00038
12	0.298	0	0	0	-4.02E-08	-6.75E-08	0.201402	1.00E-06	0.00044
13	0.246	-1.00E-05	-4.00E-06	0	-0.17012	0.439482	0	1.00E-06	0.00065
14	0.246	4.00E-06	-1.00E-05	0	-0.43948	-0.17012	0	1.00E-06	0.00065
15	0.238	0	0	0	2.18E-08	5.89E-08	-0.12688	1.00E-06	0.0007
16	0.191	4.00E-06	-3.00E-06	0	-0.18574	-0.25877	6.53E-09	1.00E-06	0.00108
17	0.191	-3.00E-06	-4.00E-06	0	-0.25877	0.18574	0	1.00E-06	0.00108
18	0.182	0	0	0	0	2.14E-08	-0.06574	1.00E-06	0.00119
19	0.153	2.00E-06	-4.00E-06	0	-0.16543	-0.08691	0	1.00E-06	0.00168
20	0.153	4.00E-06	2.00E-06	0	0.086909	-0.16543	-1.72E-08	1.00E-06	0.00168
21	0.144	0	0	0	-2.15E-07	2.27E-08	0.059582	1.00E-06	0.00191
22	0.131	1.00E-06	4.00E-06	0	0.227449	-0.08524	2.80E-08	1.00E-06	0.00231

23	0.131	4.00E-06	-1.00E-06	0	-0.08524	-0.22745	-6.21E-08	1.00E-06	0.00231
24	0.124	0	0	0	-3.19E-08	1.86E-07	0.062859	1.00E-06	0.00258
25	0.117	4.00E-06	-5.81E-08	0	-0.00285	-0.18399	4.05E-08	1.00E-06	0.00291
26	0.117	-5.81E-08	-4.00E-06	0	-0.18399	0.002847	-6.65E-08	1.00E-06	0.00291
27	0.111	0	0	0	-2.44E-07	-1.75E-07	0.046537	1.00E-06	0.00318
28	0.101	-2.00E-06	2.00E-06	0	0.095435	0.093645	4.86E-08	1.00E-06	0.00391
29	0.101	2.00E-06	2.00E-06	0	0.093645	-0.09544	-4.41E-08	1.00E-06	0.00391
30	0.096	0	0	0	7.13E-08	0	0.029638	1.00E-06	0.00429

Fig: 5.6 Modal Participation Factor

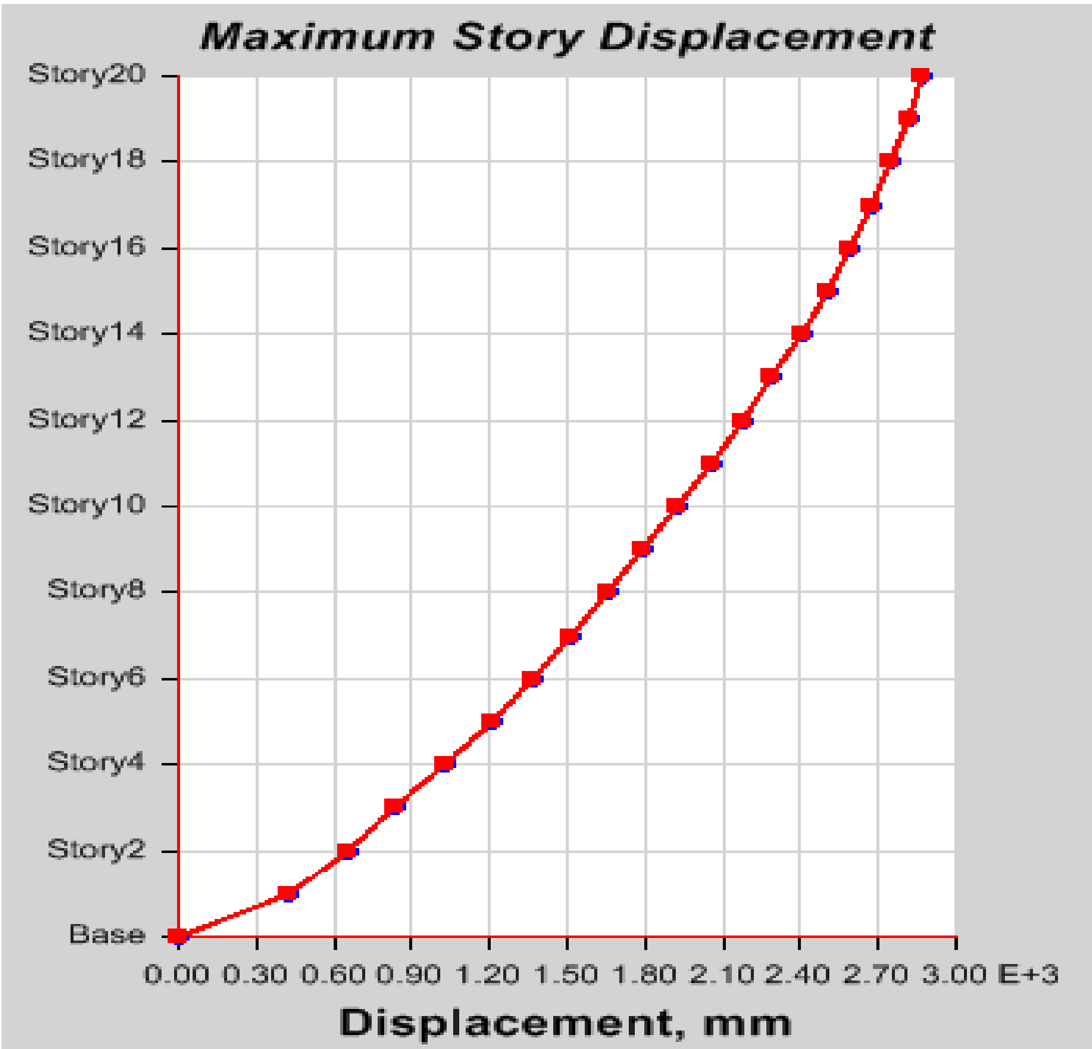

Fig: 5.7 Response Plot

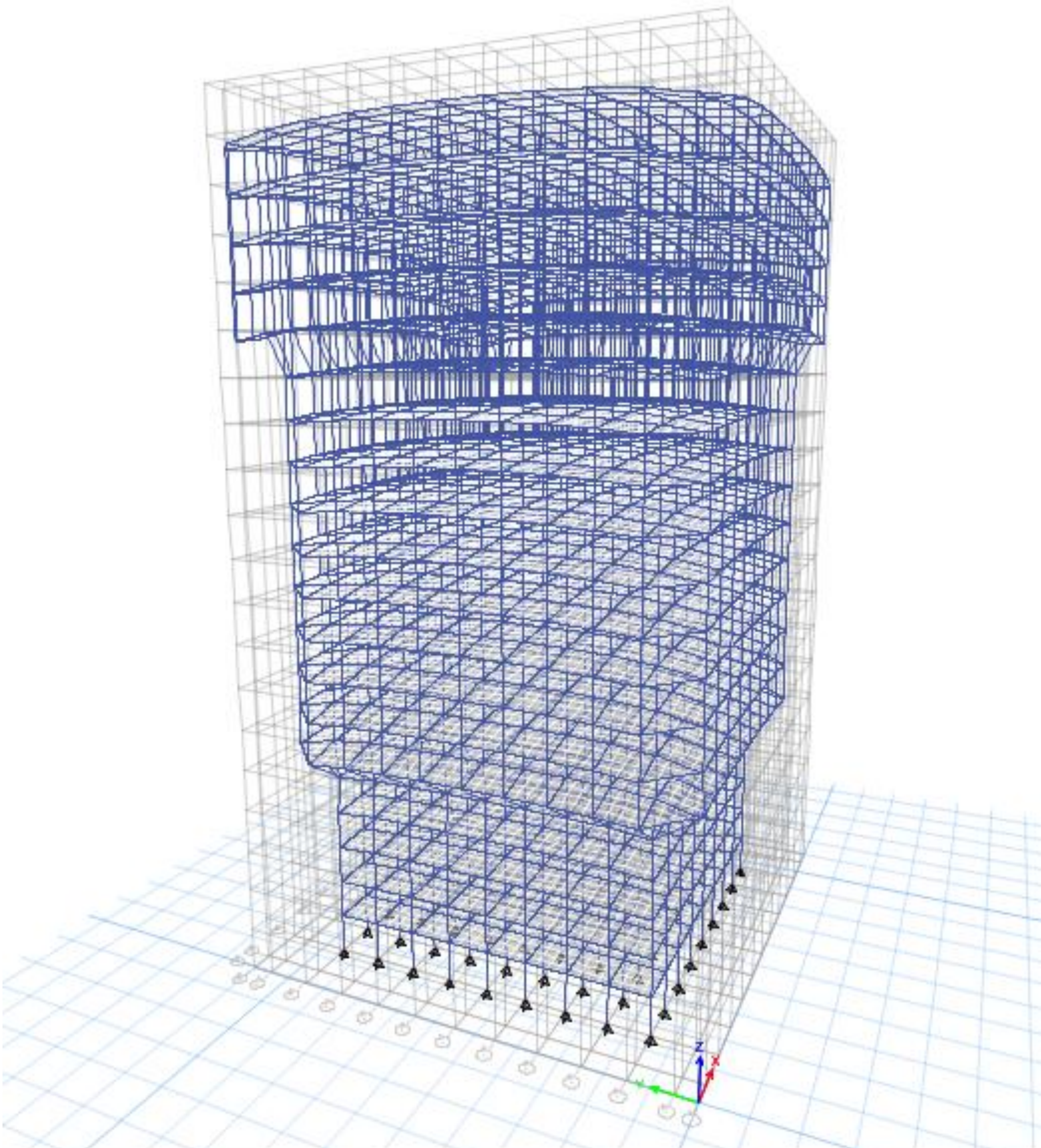

Fig: 5.8 Deformed Shape

5.7: Time History Analysis

Table: 5.6 Time history values

S.No	Time in sec	Value
1	0	-0.013
2	0.16	-0.00897
3	0.32	-0.00969
4	0.64	-0.0145
5	1.12	-0.0867
6	1.44	-0.0134
7	2.08	-0.0147
8	2.72	-0.00673
9	3.2	-0.02
10	3.5	0.00306
11	5.6	-0.00683
12	6.72	0.0502

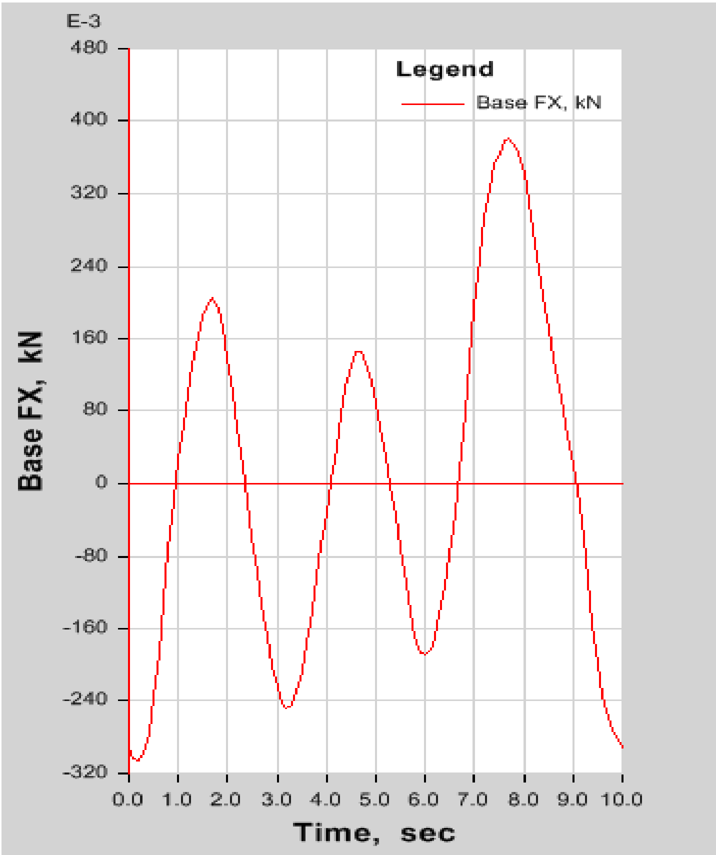

Fig: 5.9 Time plot

5.8: P-delta Analysis:

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	0	0	259197.5115	5702345	-5702345	0
Live	0	0	259197.5115	5702345	-5702345	0
eq Max	285543.9398	285543.9399	0	0	13638831	0.003
eq Min	0	0	0	-13638831	0	0
rs Max	214099.2387	214099.2382	0	12961218	12961218	6661205

Fig: 5.10 Base reactions

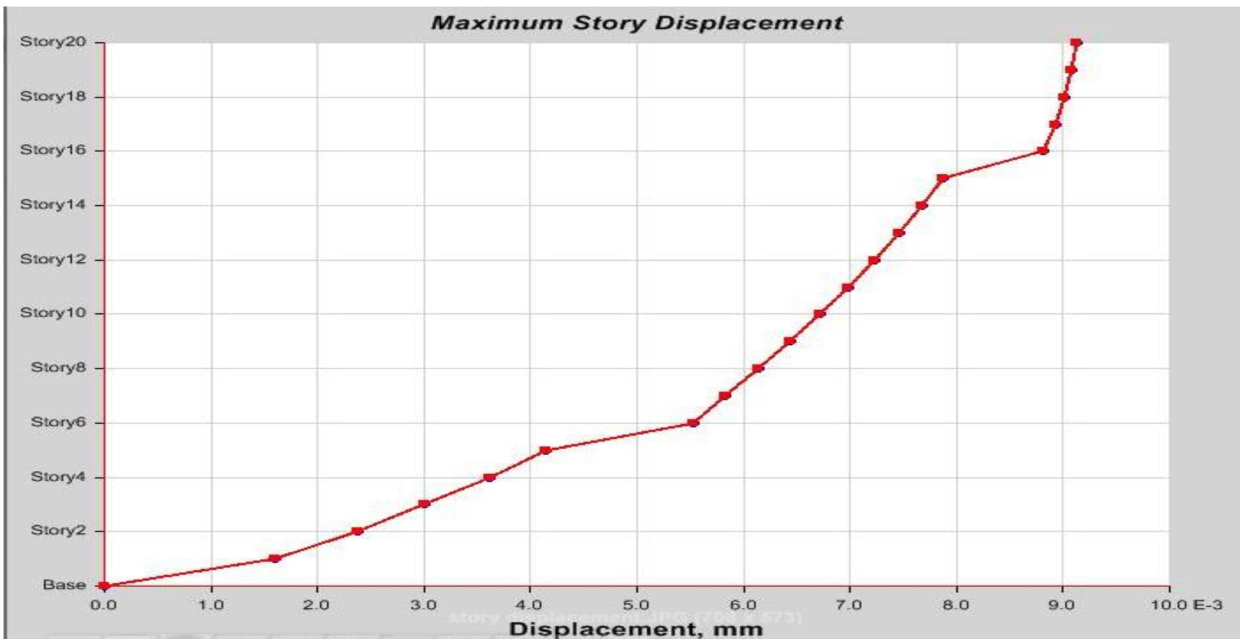

Fig: 5.11 Story displacements

Case	Item Type	Item	Static %	Dynamic %
Modal	Acceleration	UX	100	100
Modal	Acceleration	UY	100	100
Modal	Acceleration	UZ	0	0

Fig: 5.12 Modal load participation ratios

ETABS Result for Composite Structure:

5.9: General Material Properties

Element Type	Material	Total Weight kN	# Pieces	# Studs
Column	M25	83351.3796	2316	
Beam	Fe345	14360.5077	4423	0
Brace	M25	3280.8237	72	
Floor	4000Psi	117891.0101		
Floor	M25	25042.6029		
Metal Deck	N.A.	882.7588		

Fig: 5.13 Material lists by element type

Name	Type	E MPa	v	Unit Weight kN/m³	Design Strengths
4000Psi	Concrete	24855.58	0.2	23.5631	Fc=27.58 MPa
A615Gr60	Rebar	199947.98	0.3	76.9729	Fy=413.69 MPa, Fu=620.53 MPa
A992Fy50	Steel	199947.98	0.3	76.9729	Fy=344.74 MPa, Fu=448.16 MPa
HYSD415	Rebar	200000	0	76.9729	Fy=415 MPa, Fu=485 MPa
M25	Concrete	25000	0.2	24.9926	Fc=25 MPa

Fig: 5.14 Material Properties Summary

Story	Element Type	Material	Total Weight kN	Floor Area m²	Unit Weight kN/m²	# Pieces	# Studs
SUM	Column	M25	83351.3796	33032	2.5234	2316	
SUM	Beam	Fe345	14360.5077	33032	0.4347	4423	0
SUM	Brace	M25	3280.8237	33032	0.0993	72	
SUM	Floor	4000Psi	117891.0101	33032	3.569		
SUM	Floor	M25	25042.6029	33032	0.7581		
SUM	Metal Deck	N.A.	882.7588	33032	0.0267		
TOTAL	ALL	ALL	244809.0829	33032	7.4113	6811	0

Fig: 5.15 Material list Summary

5.10: Response Spectrum Analysis:

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	0	7443	236426.0318	4861138	-5201399	163746.0001
Live	0	0	236426.0318	5201338	-5201399	0
wind 1	0	0	283711.2381	6241605	-6241679	0
wind 2	0	0	283711.2381	6241605	-6241679	0
seismic Max	0	0	283711.2381	6492474	-6241679	87836.0552
seismic Min	-3992.5895	-3992.5666	283711.2381	6241605	-6492549	-87837.1622
RS Max	129549.3919	129549.11	0	6953711	6953717	4030656

Fig: 5.16 Base reactions

Mode	Period sec	UX kN-m	UY kN-m	UZ kN-m	RX kN-m	RY kN-m	RZ kN-m	Modal Mass kN-m-s²	Modal Stiffness kN-m
1	2.971	-1.992E-08	9.474E-09	0	-7.8E-05	-0.000163	-2.556829	1E-06	4.472E-06
2	2.881	-4.3E-05	-0.00014	0	1.075818	-0.32933	-6.6E-05	1E-06	4.755E-06
3	2.881	0.00014	-4.3E-05	0	0.329324	1.075804	-0.000379	1E-06	4.755E-06
4	0.824	-1.5E-05	-4E-05	0	-2.843142	1.062362	0.000121	1E-06	6E-05
5	0.824	-4E-05	1.5E-05	0	1.062367	2.843163	-5E-06	1E-06	6E-05
6	0.74	0	8.902E-09	0	0.000713	-0.000204	0.44945	1E-06	7E-05
7	0.428	8E-06	1.5E-05	0	0.548319	-0.282322	-3.3E-05	1E-06	0.00022
8	0.428	-1.5E-05	8E-06	0	0.282273	0.548266	1.1E-05	1E-06	0.00022
9	0.38	0	0	0	8.1E-05	5.6E-05	-0.219239	1E-06	0.00027
10	0.3	4E-06	-1.1E-05	0	-0.646771	-0.265658	-2.5E-05	1E-06	0.00044
11	0.3	1.1E-05	4E-06	0	0.265668	-0.646772	2E-06	1E-06	0.00044
12	0.272	0	0	0	-5E-06	-2.7E-05	-0.181915	1E-06	0.00053
13	0.227	-2E-06	1E-05	0	0.430483	0.072738	-0.000157	1E-06	0.00076
14	0.227	1E-05	2E-06	0	0.072682	-0.43055	1.3E-05	1E-06	0.00076
15	0.216	0	-1.388E-08	0	-0.000662	-0.000114	-0.123511	1E-06	0.00084
16	0.18	4.868E-07	-5E-06	0	-0.292581	-0.028842	0.000248	1E-06	0.00122
17	0.18	5E-06	4.866E-07	0	0.028869	-0.292448	8E-06	1E-06	0.00122
18	0.17	0	1.692E-08	0	0.000966	0.000162	0.060502	1E-06	0.00137
19	0.142	-2.609E-07	3E-06	0	0.144508	0.011382	-0.000193	1E-06	0.00196
20	0.142	-3E-06	-2.607E-07	0	-0.011337	0.144521	-4E-06	1E-06	0.00196
21	0.133	0	-1.467E-08	0	-0.00067	-2.9E-05	-0.048279	1E-06	0.00222

22	0.119	-2.192E-07	4E-06	0	0.229343	0.012631	-0.000159	1E-06	0.00278
23	0.119	-4E-06	-2.193E-07	0	-0.012654	0.229371	-2E-06	1E-06	0.00278
24	0.113	0	-1.064E-08	0	-0.000606	-7.8E-05	-0.063939	1E-06	0.00311
25	0.109	-2.171E-07	4E-06	0	0.178966	0.010164	-9.7E-05	1E-06	0.00333
26	0.109	-4E-06	-2.168E-07	0	-0.010148	0.178878	-1E-05	1E-06	0.00333
27	0.103	0	0	0	-0.000125	-1.8E-05	-0.046479	1E-06	0.00376
28	0.094	4.011E-08	-2E-06	0	-0.112954	-0.002191	8.1E-05	1E-06	0.00444
29	0.094	-2E-06	-4.014E-08	0	-0.002179	0.1129	-5E-06	1E-06	0.00444
30	0.089	0	5.677E-09	0	0.000286	1.6E-05	0.025045	1E-06	0.00499

Fig: 5.17 Modal Participation Factor

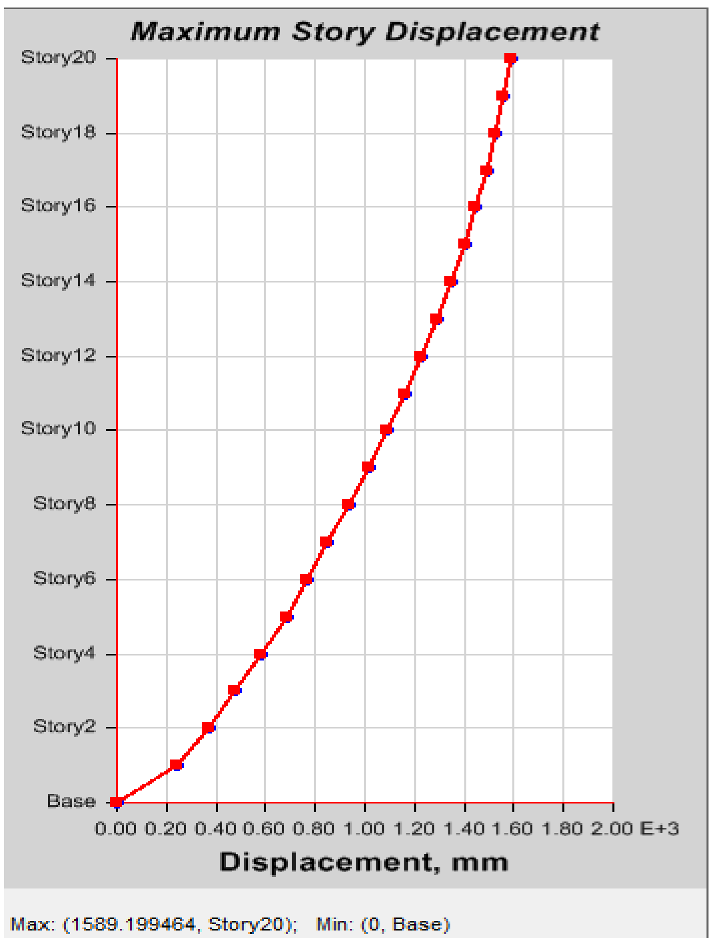

Fig: 5.18 Response plot

5.11: Time history Analysis

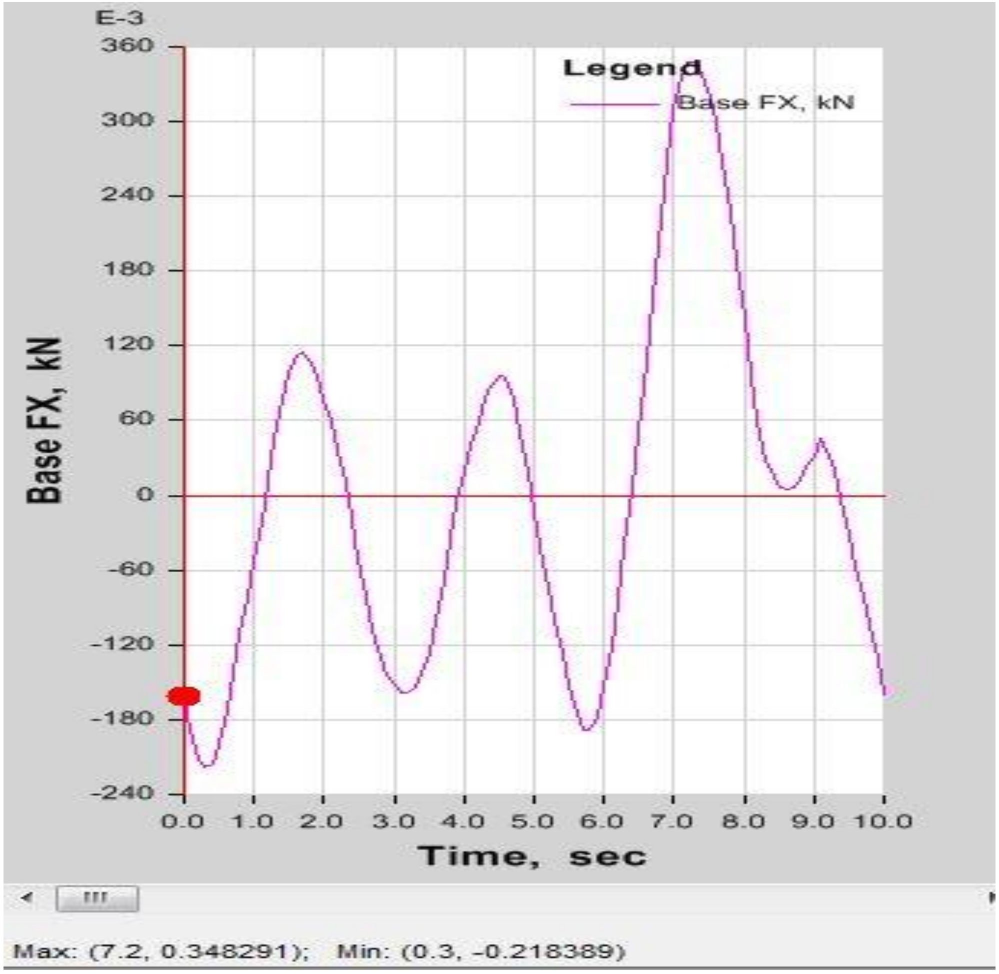

Fig: 5.19 Base shear Vs Time Plot

5.12: P-delta Analysis

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	0	7443	236426.0318	4830539	-5201399	163746.0388
Live	0	0	236426.0318	5201347	-5201399	0.0544
seismic Max	0	0	283711.2381	6478535	-6241679	82973.5432
seismic Min	-3771.5639	-3770.7363	283711.2381	6241605	-6478661	-82956.8559
rs Max	109031.4485	109121.5158	0	6316735	6311437	3408294
DCmpD1	0	7443	236426.0318	4830539	-5201399	163746.0388

Fig: 5.20 Base Reactions

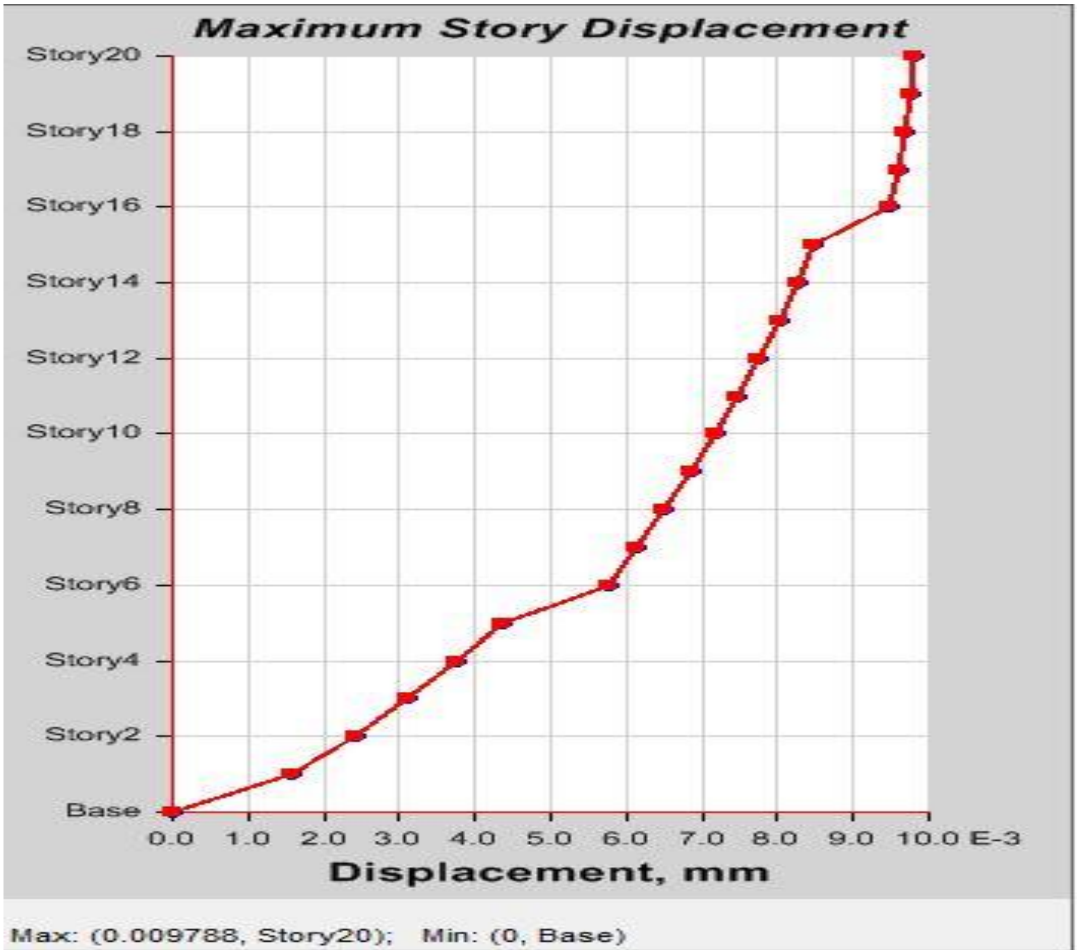

Fig: 5.21 Story Displacement

Case	Item Type	Item	Static %	Dynamic %
Modal	Acceleration	UX	100	99.81
Modal	Acceleration	UY	100	99.81
Modal	Acceleration	UZ	0	0

Fig: 5.22 Modal load Participation Ratios

5.13: Comparison Graph for Response Plot from Response Spectrum Analysis:

We are comparing RCC and Composite response plot for 5th,10th, 15th&20th story and it is found that RCC structure is having the more displacement value and line graph. Horizontal axis represents story and Vertical axis represents Displacement in E+3 mm

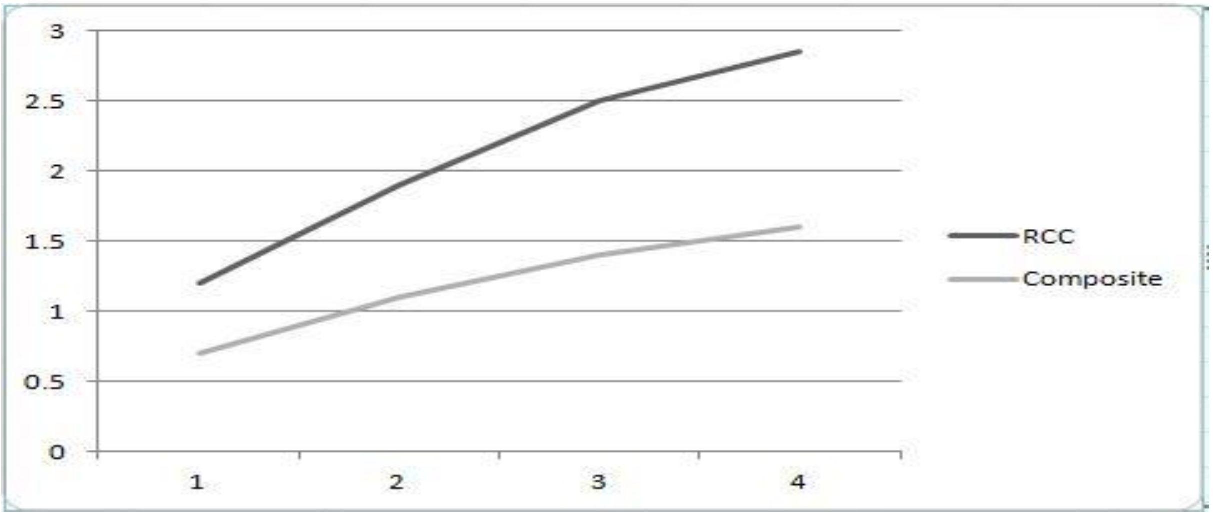

Fig: 5.23 Response plot comparison graph

5.14: Comparison Graph for Time history Analysis:

We are comparing RCC and Composite Structures for first 10 seconds and it is found that RCC structure is having the more Base Fx value as the time is increasing. Horizontal axis represents time in sec and Vertical axis represents Base fx in E-3 Kn.

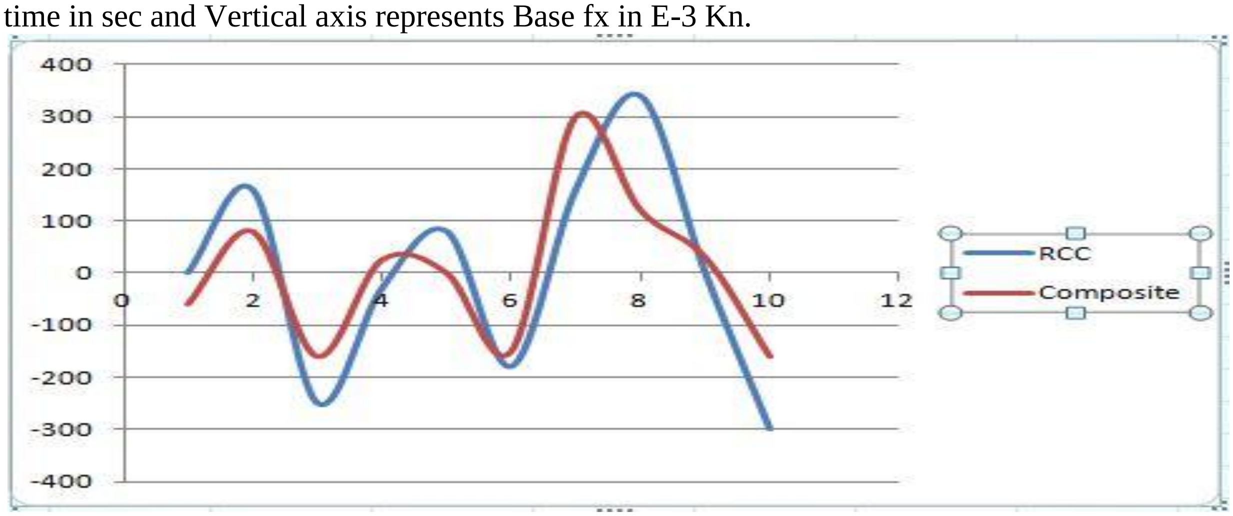

Fig:5.24 Time history plot comparison graph

5.15: Comparison Graph for Maximum Displacement /Story Drifting from P-delta Analysis:

We are comparing RCC and Composite modal plot for 5th,10th,15th&20th story and it is found that Composite structure is having the more displacement value and line graph. Horizontal axis represents story and Vertical axis represents Maximum Displacement in E-3 mm

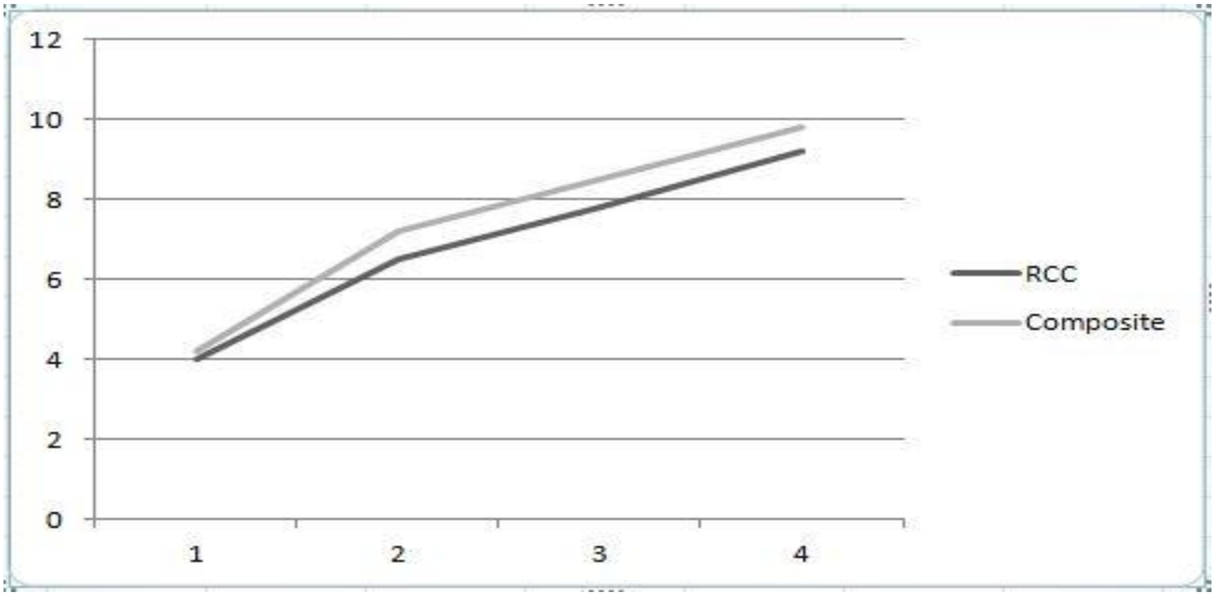

Fig:5.25 P-delta comparison graph

CHAPTER 6
CONCLUSIONS

Following conclusions can be derived from the analytical results obtained till now :-

1- From the concrete design obtained, it can be seen that the quantity of reinforcement & concrete required for Rcc. is in permissible limit but for composite structures we will conclude in future
2- Also the construction of 20 floor Multi-storey building is feasible.
3- The C.G. is get shifted towards the centre of the structure.
4- The p-delta analysis of the columns showed that the structure is safe and storey drift is within the permissible limit.
5- Weight of RCC structure is 259197.5KN & of Composite structure is 244809KN as per Etabs result.
6- The weight of Composite structure is 94.45% that of RCC structure.
7- Base shear of RCC structure is more than that of composite structure as per Etabs results for the Time history analysis.
8- From the P-Delta analysis result for both the structures it can be seen that storey drift for composite structure is 0.041667% higher that the RCC structure however it can be seen that the deflection is within the middle third of the columns.
9- The Modal mass participation ratio in case of Response Spectrum analysis is greater than 90% which is the minimum required participation ration as per IS1893:2002
10- The Base shear ratio of linear and non linear case is approx. 91% which is greater than 85% of the desired ratio as per IS1893:2002.
11- From the various analysis performed and the results obtained it can be seen that the Composite structure is better in terms of self weight however in case of storey drift the Composite structure if inferior than RCC structure due to the Tensile nature of the Steel members used in the Columns.

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