Comparative Study of Steel and R.C.C Residential Building

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Abstract- *The project involves analysis and design of an equivalent R.C.C structure frame so that a cost and strength comparison can be made between a Steel structure frame and an equivalent R.C.C. framed structure.The principle objective of this project is to analyze and design a R.C.C building frame by manual calculations and by using STAAD Pro. Steel building frame and R.C.C. building frame are considered for comparative study of G+15 storey residential building. The project also involves planning of residential building.Longer spans in R.C.Cbuildings increases the depth of beams and increase the dead loads also. We introduce the structural steel members as beam sections to reduce the dead loads, Quicker time of erection,Saving time and earlier completion of the building. The weight of steel structure is also less compared to R.C.C structure which helps in reduce the foundation cost. Steel structure gives more ductility to the structure as compared to the R.C.C. which is best suited under the effect of lateral forces. Cost of the R.C.C structure is economical compared to steel structure.Steel structures are best solutions for high raised building situated in earthquake zones with high intensityof earthquakes without considering the cost of building.*

Keywords- Steel frame, R.C.C frame, STAAD Pro, Time period, Deflection, Drift.

I. INTRODUCTION

Worldwide different types of RC and steel structures with various floor systems are being used for multistorey buildings. In the past, masonry structures were widely used for building construction. Day by day technology has developed. Later, steel structural systems were started for multistory buildings. With the introduction of reinforced concrete, RC structural systems started for multistory building construction. Due to failure of many multi-storied and low-rise RC and masonry buildings due to earthquake, structural engineers are looking for the alternative methods of construction. In the past mostly masonry and RC structures were being used. During last decade, steel structural systems are being popular. So, alternative structural systems are gradually developing to compete with RC structural systems. Now a day, use of masonry structure is very limited. So, comparative study is required to identify most effective structural system for a particular building.

Reinforced concrete multi-storied buildings are very complex to model as structural systems for analysis. Usually, they are modeled as two-dimensional or three-dimensional frame systems using finite beam elements. Steel is a material which has high strength per unit mass. Steel is a common building material used throughout the construction industry.Steel has many advantages when compared to other building materials such as concrete, timber, plastics and the newer composite materials. Steel is one of the friendliest environmental building materials. Steel is 100% recyclable material. Of all the structural building material in use today steel is perhaps the most universally acceptable as versatile material for engineering construction. Function of all the structure is to withstand stresses due to loads i.e., wind, earthquake etc. without failure or undue distress such as excessive deflections, dangerous vibrations etc. Steel as a building material has been studied and tested for many years.

The use of steel structure in India as compared to other countries is less, as India is developing country. In cities like Delhi and Mumbai, horizontal expansion is restricted therefore vertical growth of building becomes predominant.Reinforced Concrete (RC) has been the most popular construction material used worldwide in the desirable properties such as excellent insulation from environment, durability, low cost, ease of construction, ability to mould in any given shape to name a few. Even from structural aspects, reinforced concrete construction serves its intended purpose extremely well, if properly designed and constructed. As compared to the Reinforced cement concrete (RCC) the steel has got some important physical properties like the high strength per unit weight and ductility. The high yield and ultimate strength result in slender sections. Being ductile the steel structures give sufficient advance warning before failure by way of excessive deformations. These properties of steel are of very much vital in case of the seismic and wind resistant design. Thus, a comparative study is necessary to be done from the point of view of seismic and wind effect on the steel and R.C.C multistory buildings.

II. LITERATURE REVIEW

RAHUL PANDEY In research paper "Comparative study of analysis and design of R.C. and steel structures "a 3-D model was prepared for the frame analysis of building in ETABS for the earthquake zone 5 and the results were indicating the same thing that the storey drifts of steel structures are comparatively more than RC structures within the permissible limit. And RCC frame has the lowest value of storey drift because of its high stiffness, which indicates that as the value of stiffness increases, storey drift values decreases with it.

NITIN M. WARADE &P.J. SALUNKE is submitted a research paper "Comparative Study of Analysis and Design of R.C. and Steel Structures" it is concluded that base shear in steel structure is less than the R.C. structure because of the less seismic weight which gives better seismic response during earthquake. In this paper for the frame analysis a 3-D model was prepared in ETABS for the earthquake zone 5.The graphs for that are given below which show us that steel frame is having lesser values of base shear than RC frame due to its lesser weight. And bare frame is having lesser values of base shear than masonry infill frame due to its lesser weight.

SHASHI KALA. KOPPAD, DR. S.V.ITTI is submitted a research paper "Comparative Study of Analysis and Design of R.C. and Steel Structures" it is concluded that considered steel with RCC options for analyzing a B+G+15 building which is situated in earthquake zone III and earthquake loading is as per the guidelines of IS1893(part-I): 2002. The parameters like bending moment and maximum shear force were coming more for RCC structure than the steel structure. Their work suggested that steel framed structures have many benefits over the traditional RC structures for high rise buildings.

D.R. PANCHAL AND P.M. MARATHE In research paper "Comparative study of analysis and design of R.C. and steel structures it is concluded thata comparative method of study for RCC and steel options in a G+30 storey commercial building situated in earthquake Zone IV. For this they used Equivalent static method and used the software ETABS. The comparative study included size, deflections, material consumption of members in RCC sections as compared to steel sections was also studied closely and based on this study a cost comparison analysis was also performed.

D. R. PANCHAL AND P. M. MARATH In research paper "Comparative study of analysis and design of R.C. and steel structures As the results show the Steel option is better than R.C.C. The reduction in the dead weight of the Steel framed structure is 32 % with respect to R.C.C. framed structure Shear forces in secondary beams are increased by average 83.3% in steel structure as compared to R.C.C. framed structure while in main beams shear forces are increased by average 131% in steel structure as compared to R.C.C. framed structure. Bending moments in secondary beams are increased by average 83.3% in steel structure as compared to R.C.C. framed structure while in main beams bending moments are increased 131% in steel structure as compared to R.C.C. framed structure. Axial forces in column have been reduced by average 46% in steel structure compared to R.C.C. framed structure. Bending forces in X direction in column have been reduced by average 34% in steel structure as compared to R.C.C. framed structure while bending moments in Y direction in column have been reduced by average 25% in steel structure compared to R.C.C. framed structure.

III.METHODOLOGY

In this paper a 3-D model ion STAAD Pro has been developed to analyze the behavior ofreinforced concrete tall building & steel structure building under wind and earthquake loads. Our purpose is to analysis & design both the structure & study the effect on foundation & as well as the effect on costing of material for construction purpose. The model has been designed for 15 storied building & this comparison will guide us in choosing the type of structure for a 52.8m height building.

The building models are then analyzed by the software Staad Pro. Different parameters such as deflection, shear force & bending moment are studied for the models. 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): 2002 is the main code that provides outline for calculating seismic design force. Wind forces are calculated using code IS-875 (PART-3) & SP64.Design of both structures using Staad Pro. design software. Design of R.C.C building as per IS456.Design of steel building as per IS 800.

IV.BUILDING DETAILS

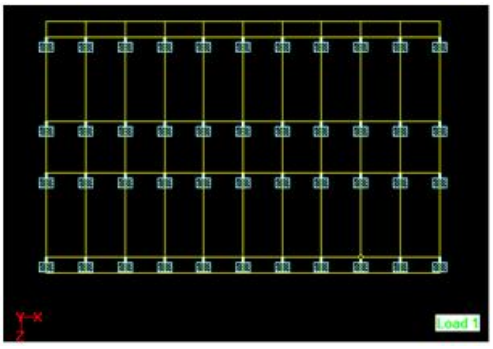


Fig.1 Plan showing typical floor

The building considered here is a residential building. The plan dimension is 40 mx24 m. The study is carried out on the same building plan for both Steel and R.C.C construction. The basic loading on both types of structures are kept same.

Table no:1 Data analysis for Steel and R.C.C structure

ANALYSIS DATA OF STEEL AND R.C.C		
DESCRIPTION	**R.C.C**	**STEEL**
Plan dimension	24mx40m	24mx40m
Total height of the	52.85m	52.85m
Height of each storey	3.3m	3.3m
Size of beams 8.0m	300x450mm	ISMB550
Size of beams 5.0m	300x375mm	ISMB400
Size of beams 4.0m	300x375mm	ISMB300
Size of beams 1.5m	300x450mm	ISMB250
Size of columns up	450x750mm	ISWB600H
Size of columns up	450x450mm	ISWB400
Thickness of slab	150mm	150mm
Thickness of external	230mm	230mm
Thickness of internal	115mm	115mm
Seismic zone	III	III
Wind speed	50m/s	50m/s
Soil condition	Hard soil	Hard soil
Importance factor	1.0	1.0
Zone factor	0.16	0.16
Floor finish	1.5kN/m2	1.5kN/m2
Live load at all floors	3.0kn/m2	3.0kn/m2
Grade of concrete	M30	M30
Grade of steel	Fe415	Fe250
Density of concrete	25kN/m3	25kN/m3
Density of brick	18kN/m3	18kN/m3
Damping ratio	5%	5%
Design software	STAAD Pro V8I	STAAD Pro V8I
Analysis type	Static analysis	Static analysis

V. RESULTS AND DISCUSSION

Analysis of all two types ofbuildings is done and the results are as follows

Table 2: Comparisons of R.C.C. And steel buildings

COMPARISON OF R.C.C & STEEL STRUCTURES			
S.N	**FACTOR**	**R.C.C BUILDING**	**STEEL BUILDING**
1	Time period	1.46 sec	1.66 sec
2	Maximum nodal displacement	181.5 mm	427.3 mm
3	**Maximum support reaction**		
	FY (D.L)	1810kN(C23)	552kN(C44)
	FY(L.L)	1240kN(C13)	1260kN(17)
4	**Story drift**		
	x-direction	0.57 cm	1.067 cm
	z-direction	1.705 cm	3.067 cm
5	Base shear	672.8 kN	42.1 kN
6	Dead loads	20939kN	9274kN

Table 3: Comparisons of columns w.r.t axial force

AXIAL FORCE OF COLUMNS			
HEIGHT	COLUMN NO.	(FY). 1.5(D.L+L.L) (KN)	
		R.C.C	STEEL
0.0	1	2369.5	1378.2
3.3	160	2211.3	1282.6
6.6	319	2053.9	1188.9
9.9	478	1896.3	1095.5
13.2	637	1730.2	1003.6
16.5	796	1582.8	912.75
19.8	955	1426.8	822.4
23.1	1114	1270.9	735.2
26.4	1273	1114.2	648.6
29.7	1432	975.2	565.1
33.0	1591	835.2	482.5
36.3	1750	695.7	400.8
39.6	1909	557.2	319.8
42.9	2068	417.3	238.9
46.2	2227	278.1	157.9
49.5	2386	139.7	80.2

Table 4: Comparisons of columns w.r.t deflection

DEFLECTION		
HEIGHT	R.C.C	STEEL
0.0	0.0	0.0
3.3	8.4	25.9
6.6	24.4	55.3
9.9	42.3	84.3
13.2	60.0	112.8
16.5	76.8	139.9
19.8	92.4	166.5
23.1	106.8	193.5
26.4	120.0	218.6
29.7	132.6	244.4
33.0	143.7	270.4
36.3	153.1	296.5
39.6	160.9	322.6
42.9	167.2	348.5
46.2	171.8	371.6
49.5	175.0	389.5
52.8	176.7	400.4

Table 5: Comparisons of columns w.r.t drift

DRIFT				
HEIGHT	X-DIRECTION		Z-DIRECTION	
(M)	R.C.C	STEEL	R.C.C	STEEL
0.0	0.0	0.0	0.0	0.0
3.3	0.23	0.41	0.87	3.07
6.6	0.48	0.85	1.66	3.33
9.9	0.56	1.01	1.83	3.18
13.2	0.57	1.06	1.80	3.01
16.5	0.55	1.06	1.70	2.81
19.8	0.52	1.05	1.59	2.70
23.1	0.48	1.03	1.46	2.71
26.4	0.45	0.97	1.33	2.60
29.7	0.49	0.95	1.28	2.56
33.0	0.42	0.91	1.11	2.57
36.3	0.36	1.00	0.95	2.53
39.6	0.30	0.77	0.80	2.50
42.9	0.24	0.84	0.63	2.42
46.2	0.18	0.75	0.47	2.18
49.5	0.12	0.55	0.31	1.83
52.8	0.06	0.35	0.18	0.95

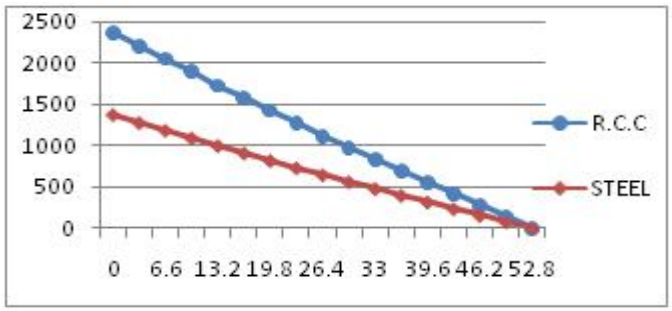
Table 6: Comparisons of columns w.r.t cost

COST ANALYSIS				
STRUCTURE TYPE	MATERIALS	QUANTITY USED	RATE OF MATERIAL	AMOUNT
R.C.C	CONCRETE	1570 CUM	8500/CUM	13345000
	STEEL	179 MT	52000/MT	9308000
TOTAL AMOUNT				22653000
STEEL	STRUCTURAL STEEL	675 MT	55000/MT	37125000
TOTAL AMOUNT(Rs)				37125000

- Through STAAD Pro, values of the time period of structures are extracted.The maximum time period is of steel building, it means it is more flexible to oscillate back and forth when lateral forces act on the building. Also results show that R.C.C building has least time period which says it is very less flexible among the steel structures.
- From table 2 it is clear that, node displacements in steel structure is more compared to RCC structure. This is because , steel structure is more flexible as compared to RCC structure.
- From table 5, the storey drift i.e the displacement of one level relative to the other level above or below, is double in steel building in comparison with Steel buildings in both X and Z directions. Steel structure gives more ductility to the structure as compared to the R.C.C. which is best suited under the effect of lateral forces.
- From table 3 it is clear that the axial forces in R.C.C. column is maximum and nearly twice then steel column. This is because, RCC sections are bulky in size thus their self-weight as compared to thin steel section is more. This results in the higher axial force on the columns in case of RCC frame structure.
- From table 1 it is clear that the base shear of steel structure is very less compared to R.C.C structure. Why because dead weight of a steel structure is less compared to an R.C.C. Structure , it is subjected to fewer amounts of forces induced due to the earthquake.

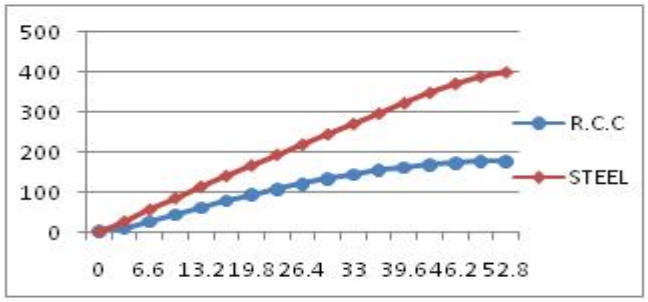
GRAPHS

AXIAL FORCE



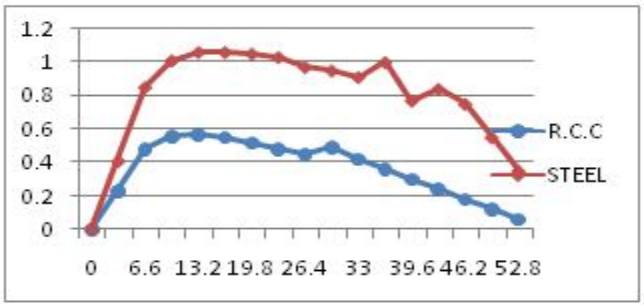
Graph: 1

DEFLECTION



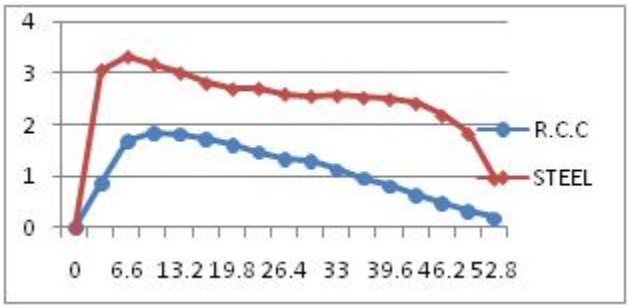
Graph: 2

DRIFT IN X-DIRECTION



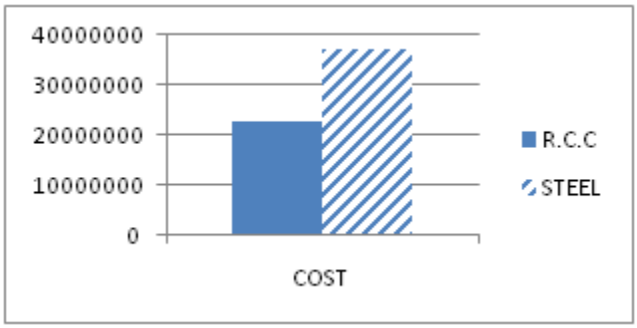
Graph: 3

DRIFT IN Z-DIRECTION



Graph: 4

COST ANALYSIS



Graph: 5

VI. CONCLUSION

Analysis and design results of G+15 storied R.C.C and Steel buildings are given in chapter. The comparison of results of building shows that:-

1. The deflection Steel structures are nearly twice then the R.C.C structure but within the limit. This is because, steel structure is more flexible as compared to RCC structure.
2. The graph shows that there is significant reduction in bending moments of columns in Z Direction from R.C.C to steel structure.
3. The graph shows that there is no significant difference in bending moments of columns in X Direction in R.C.C and steel structure.
4. Axial Force in R.C.C. structure is on higher side than that of steel structure.
5. Weight of steel structure is quite low as compared to RCC structure which helps in reducing the foundation cost.
6. R.C.C structures are more economical than that of steel structure.
7. 7. Speedy construction facilitates quicker return on the invested capital & benefit in terms of rent. In this point of view steel structure is economical then R.C.C structures.
8. Base shear of steel structure is very less compared to R.C.C structure. This is because; steel structure is best suited under the effect of earthquake zones.
9. The storey drift in Steel structures are nearly twice then the R.C.C structure but within the limit. This is because; steel structure is more flexible as compared to RCC structure.
10. Steel structure gives more ductility to the structure as compared to the R.C.C. which is best suited under the effect of lateral forces.

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