Analysis of A High Rise Building Farme Considering R.C.C, Steel and Composite Material under Seismic Zone III

Dushyant Patel[1] Prof. Vinay Kumar Singh Chandrakar[2] Dr. Gyanendra Singh[3] Prof. Praveen Singh Tomar[4]
[1]M.Tech. Scholar [3]Director [4]Head of Dept
[2,4]Department of Civil Engineering
[1,2,4]Patel Institute of Engineering & Science (PIES), Bhopal, Madhya Pradesh, India [3]PGOI Bhopal

Abstract— Steel-Concrete composite constructions are nowadays very popular owing to their advantages over conventional Concrete and Steel constructions. Concrete structures are bulky and impart more seismic weight and less deflection whereas Steel structures instruct more deflections and ductility to the structure, which is beneficial in resisting earthquake forces. Composite Construction combines the better properties of both steel and concrete along with lesser cost, speedy construction, fire protection etc. Hence, the aim of the present study is to compare Structural Parameters and cost of (G+12) storey RCC, Steel and Steel-Concrete Composite building frame situated in earthquake zone III. All frames are designed for same gravity loadings. Equivalent static method and Response Spectrum method are used. A 3D Modelling and analysis of the structures are carried out with the help of ETAB 2015 software and results are compared. The result is compare in terms of natural period, frequency, story displacement, story drift, story shear, story moment, story stiffness, bending moment, shear force and axial force for all three models. Cost effectiveness is only based on material cost for all types of building frames are determined.

Key words: Structural Analysis, Comparative Study, Composite Structure, Seismic Load

I. INTRODUCTION

Structures on the earth are generally subjected to two types of load i.e. static and dynamic. Static loads are constant with time while dynamic loads are time varying. In general majority of the civil structures are designed with the assumption that all applied loads are static. The effect of dynamic load is not being considered because the structure is rarely subjected to dynamic loads, more its consideration in the analysis makes the solution more complicated and time consuming. This aspect of neglecting dynamic forces may sometimes become the cause of disaster. Particularly in case of earthquake.

Bhavin H. Zaveri, Bhargav K. Panchotiya, Smit U. Patel, Pratik A. Bilimoria (Aug. 2016) they did parametric study of RCC, steel and composite structures under seismic loading. For that they modeled and analyzed the low rise (g+5) storey RCC, steel and composite buildings for the same grid pattern and same external loads. RCC building elements are determined using is 456 and that of steel structure are determined using is 800. For composite building, due to unavailability of Indian codes, sections are determined using ANSI codes. They did analysis on ETABS v.15. They compare beam forces, column forces, joint displacements, storey accelerations, storey drifts, storey maximum displacements, storey stiffness and storey shear. After analysis they come to know that for given seismic conditions and low rise buildings, RCC construction can be better. Because composite construction is much stiffer so resulted into attracting large amount of seismic forces and so it is not suitable for these conditions. And Steel construction is showing comparatively more deformations and very less stiffness resulting into less convenient construction.

Rajendra R. Bhoir, Prof. Mahesh Bagade (July 2016)In this papertwo residential g+15 storied composite and RCC structure are analyzed and designed in ETAB software with two different story heights 3m and 4m. It is found that the depth of beams in composite structure is lesser than of RCC structure, which results to also reduce the sizes of columns in composite structure. it is also seen that the concrete and steel consumption in composite structure is less but as they are using hot rolled sections the structural steel consumption is increased. They conclude that composite action increases the load carrying capacity and stiffness by factors of around 2 and 3.5 respectively. They conclude that composite structure proved more economical.

II. OBJECTIVE

To understand the response of the building under earthquake, dynamic response spectrum method is used, and the response of the structure in terms of time period, frequency, deflections, story shear, story displacement, story drift, modal participation factor, peck ground acceleration is compared for all types of models.

III. METHODOLOGY& PROBLEM FORMULATION

Stepwise Procedure for Modeling of Building in Etabs

1) Step 1: Define Storey data like storey height, no of storey etc.
2) Step 2: Select Code preference from option and then define material properties.
3) Step 3: Define Frame Section from Define menu like column, beam.
4) Step 4: Define Slab Section
5) Step 5: Draw building Elements from draw menu.
6) Step 6: Give the support conditions.
7) Step 7: Define load cases and load combination
8) Step 8: Assign load
9) Step 9: Define mass source
10) Step 10: Give the structure auto line constraint.
11) Step 11: Give renumbering to the whole structure.
12) Step 12: Select analysis option and run analysis

A. *Material Data*

material	Weight (KN/M³)	Modulus of elasticity (E) (KN/M²)	Shear modulus (G)	Poisson ratio	Coeffi. Of Thermal Expansion

Steel(fe = 415)	78.5	2×10^8	76884615	0.3	11.7×10^{-6}
Steel (fe = 345)	76.9	2×10^8	80769230	0.3	11.7×10^{-6}
Concrete (fck = 25)	25	25×10^6	10416666.7	0.2	9.9×10^{-6}
Masonry	20	11×10^6	521739.13	0.15	7×10^{-6}

Table 1: Material Data

B. Geometrical Data

Type of building : Commercial building
Type of building : Surat
Height of building: 50 m (including foundation depth 4.5 m)
Storey Height of building : 3.5 m

C. Loading Data

Live load: on ground floor 10 KN/M² (parking area)
: on office area 4 KN/M²
: on passage area 4 KN/M²
: on urinal area 2 KN/M²
: On stairs 4 KN/M²
Floor finish: 1.5 KN/M²
Water proofing: 2.5 KN/M² (terrace)

D. 5.1.4 Earthquake Data

Frame : Special moment resisting frame
Location: Surat
Zone factor : 0.16 (zone III)
Importance factor: 1.5
Response reduction factor : 5
Soil type: medium (type 2)
Load combination:

RCC	Composite	Steel
1.5 (DL + LL)	1.35 DL + 1.5 LL	1.5 (DL + LL)
1.2 (DL + LL ± EQX)	1.35 DL + 1.5 LL ± 1.05 EQX	1.2 (DL + LL ± EQX)
1.2 (DL + LL ± EQY)	1.35 DL + 1.5 LL ± 1.05 EQY	1.2 (DL + LL ± EQY)
1.2 (DL ± EQX)	1.35 DL + 1.05 LL ± 1.05 EQX	1.5 (DL ± EQX)
1.2 (DL ± EQY)	1.35 DL + 1.05 LL ± 1.05 EQY	1.5 (DL ± EQY)
0.9 DL ± 1.5 EQX	1.5 (DL ± EQX)	0.9 DL ± 1.5 EQX
0.9 DL ± 1.5 EQY	1.5 (DL ± EQY)	0.9 DL ± 1.5 EQY

Table 2: Load Combination

Load combination are taken from IS: 875 (part III) and for earthquake IS: 1893 – 2002. Earthquake load is applied in both x and y direction.

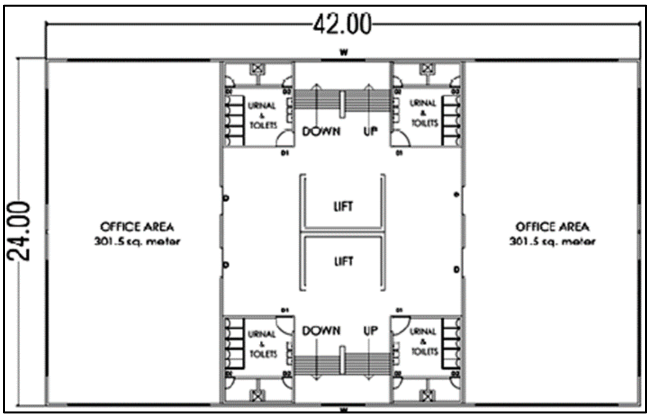

Fig. 1: Plan View of Building

IV. COMPARISON OF RESULTS

storey	story shear		story displacement		story drifts	
	manual	Etabs	manual	Etabs	manual	Etabs
7	480	469.28	79.43	80.80	7.23	7.02
6	860	845.96	72.20	73.81	12.19	12.03
5	1104	1091.95	60.01	61.78	15.68	15.69
4	1242	1231.29	44.33	46.09	17.58	17.79
3	1304	1294.04	26.75	28.30	17.26	17.89
2	1320	1310.22	9.49	10.43	9.08	10.58
1	1320	1310.90	0	0	0	0

Table 3: Comparison of Software Verification Result

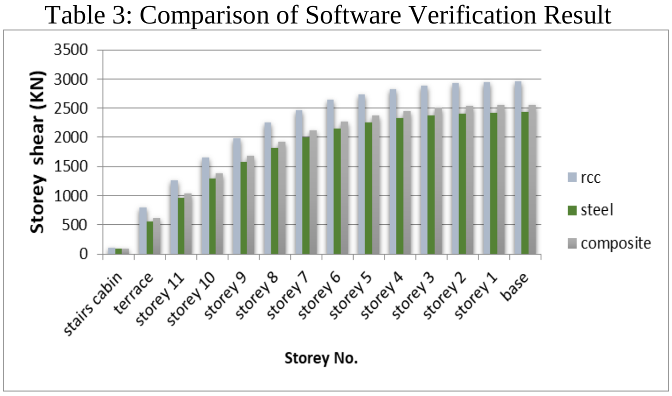

Fig. 2:

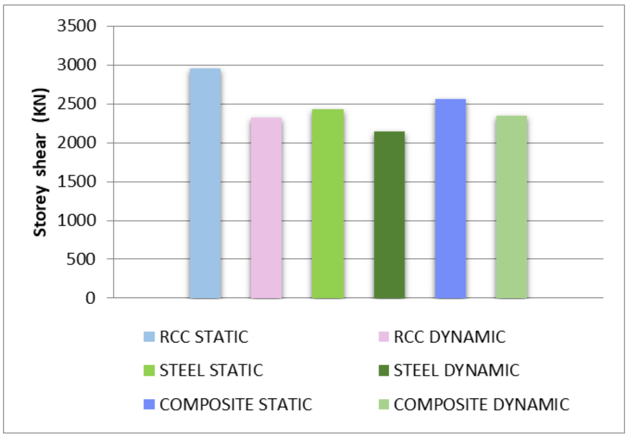

Fig. 3:

Storey	RCC	Steel	Composite
Stairs cabin	*-16	6.04	3.74
terrace(story 12)	-22.43	-4.73	-5.15
story 11	-27.69	-14.51	-13.01
Story10	-32.74	-23.48	-20.89
Story9	-36.82	-30.63	-27.15
Story8	-39.77	-35.77	-31.33
Story7	-41.22	-38.56	-33.45
Story6	-40.91	-38.82	-33.57
Story5	-39.81	-36.71	-31.73
Story4	-36.92	-32.72	-28.20
Story3	-32.78	-27.60	-23.55
Story2	-28.34	-22.25	-18.59
Story1	-24.46	-17.56	-14.19
base	-21.45	-11.87	-8.35

Table 4: Comparison of Storey Shear for Static and Dynamic Analysis (In %)

V. Conclusion

1) RCC building has maximum seismic weight. Steel and composite building has 12.70 % and 11.21% lesser seismic weight than RCC.
2) Composite building has average 14% and steel building has average 18% lower storey shear than RCC building.
3) As RCC structure has less flexible structure, RCC structure has maximum Storey stiffness. The storey stiffness of steel building is 26% and composite building is 23% less as compare to RCC building.
4) Higher the stiffness; displacement will less. Steel building has a highest storey displacement. Steel building has 26% and composite building has 22% more storey displacement then the RCC building.
5) Storey drift is directly related to the stiffness of the structure. The higher the stiffness; lowers the drift. With the view to this, steel building has maximum storey drift. As compare to RCC building; steel building has 43.54% and 30.35% more storey drift.
6) As far as RCC building is considered, it is relatively stiff and it has less time period. So, RCC building has minimum time period as compare to other two type buildings. Steel building has 15.77% and composite building has 2% more time period.
7) Modal participation factor shows that mass is contributing majorly in first four mode higher mode contribution is negligible in structure.
8) Steel building has higher peck ground acceleration (PGA) than composite.
9) From the element sections we can conclude that composite structure not only gives reduced dead weight but also gives reduced dimension. This allows more working space and clear headroom.
10) When dynamic analysis is performed average storey shear is decreased by 33%, 27% and 23% for RCC, steel and composite building respectively.
11) When dynamic analysis is done average storey displacement is decreased by 26.91%, 27.94%, and 24.08% for RCC, steel and composite building respectively.
12) When dynamic analysis is done average storey drift is decreased by 38%.

Parameters	RCC	Steel	Composite
Seismic weight	maximum	Minimum	In-between
Storey shear	maximum	Minimum	In-between
Storey displacement	Minimum	maximu m	In-between
Storey drift	Minimum	maximu m	In-between
Time period	Minimum	maximu m	In-between
Storey stiffness	maximum	Minimum	In-between
Storey stiffness	maximum	Minimum	In-between

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