COMPARISON OF SEISMIC ANALYSIS OF COMPOSITE STRUCTURE & IRREGULAR PLAN MULTISTOREY RESIDENTIAL RCC BUILDING WITH COST ANAYLSIS

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Abstract :-*Reinforced concrete structures are mostly used in India since this is the most suitable & economic system for low-rise buildings.Reinforcing schemes are generally designed to resist tensile stresses in particular regions of the concrete that might cause unacceptable cracking and/or structural failure. Modern reinforced concrete can contain varied reinforcing materials made of steel, polymers or alternate composite material in conjunction with rebar or not. Reinforced concrete may also be permanently stressed (concrete in compression, reinforcement in tension), so as to improve the behavior of the final structure under working loads. So the Structural engineers are facing the challenge of struggling for the most efficient and economical design solution. This paper is an attempt to calculate and compare the seismic performance of G+ 15 storey Irregular plan multi story residential building made of RCC and composite structures using ETABS software and cost comparison of with shear wall & without shear wall. A total of 10 models have been examined in ETABS software both RCC structures and composite structures located in the region of earthquake zone v on a medium soil. These parameters are consider Storey displacement, Storey drift, self-weight, Time period, Base shear to compare composite structures shows better performing than RCC.*

Key words: ***Composite Structures, Storey drift, Base shear, Time period, cost, ESA, RSA.***

I. Introduction

In India, most of the building structures fall under the category of low-rise buildings. So, far the structures are constructed using reinforced concrete members, because the construction becomes quite convenient and economical in nature. Due to rapid exponential increase of population in cities; non availability of land space is prevailed, so need for vertical growth of buildings are essential. Based on the overall shape, size and geometry, behavior due to earthquake needs to be checked to plan a high rise building. The storey shears at different storey heights in a building

need to be transferred down to the basement by the shortest path; any discontinuity in the structural members results in the change in the load path. So, for the fulfillment of this purpose a large number of composite elements are introduced for medium to high rise buildings nowadays. For the high-rise buildings it has been found out that the use of composite members in construction is more effective and economical than reinforced concrete members. There is a great potential for increasing the volume of Steel in construction, especially the current development needs in India and abroad. Comparative studies of RCC with Composite multistoried building are studied and the analysis results are compared. The parameters includes Storey shear, Displacement, storey Drifts, Time Period in composite building with respect to RCC Sections.

To analyses and design a multi storey building safe against earthquakes (siesmo-resistant) we need a

1. Good structural configuration.
2. Selection of lateral load resistant system
3. Dynamic characteristics
4. Construction quality

1) Structural configuration.

a. Regularity in horizontal and vertical plane
b. Irregularities in horizontal and vertical plans

2) Lateral load resistant system

a. Moment resisting building frames
b. Building with shear walls
c. Dual system (moment resisting frame + shear walls)

3) Dynamic characteristics:

It includes Natural frequency of vibration; Time period, dampness of material etc. are considered. To obtain a sesimo resistant building we need to have more dampness of material, less time period and more frequency of vibration.

4) Construction quality:

Quality of Materials should be maintained properly during construction to achieve designed strength. Structural analysis is mainly deals with finding out the behavior of a structure when subjected to some actions. The dynamic loads are wind, waves, traffic, earthquakes, and blasts. Any structure can be subjected to dynamic loads. Structural symmetry can be a major reason for

buildings poor performance under severe seismic loading, asymmetry contributes significantly to increased lateral deflections, increased member forces and ultimately the buildings collapse.

Concept of regular and irregular configuration

To perform well in an earth quake, a building should possess four main attributes namely simple and regular configuration, adequate lateral Strength, stiffness, ductility. The Present quake codes characterize basic setup as either normal or unpredictable regarding size and state of the building, arrangement of the structural and non-structural elements within the structure, appropriation of mass in the building and so on.

II.RELATED WORK

1) Proposed the concept of response spectra for design engineers not familiar with their significance and to summarize a variety of uses that can be applied for purposes such as rapid evaluation for a large inventory of buildings, performance verification of new construction, evaluation of existing structures for seismic vulnerability, and post-Earthquake estimates of potential damage of buildings. When earthquake ground motion data is available, the use of response spectra can be very useful in understanding how buildings perform and to identify deficiencies and damage potential. Response spectrum techniques allow engineers to visually imagine how buildings will perform during major damaging earthquakes. It is recommended that researchers and design professionals put more effort into detailed examinations of individual building response records.

2) Ravikumar C M et al,"Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings" (2012). The present paper made an attempt to study two kinds of irregularities in the building models namely plan irregularity with geometric and diaphragm discontinuity and vertical irregularity with setback and sloping ground. These irregularities are created as per clause 7.1 of IS 1893 (part1)2002 code. In Oder to identify the most vulnerable building among the models considered, the various analytical approaches are performed to identify the seismic demands in both linear and nonlinear way. It is also examined the effect of three different lateral load patterns on the performance of various irregular buildings in pushover analysis.

3) Mahesh Suresh Kumawat, "Analysis and design of multistory building using composite structure "(2014). Steel concrete composite development implies the concrete slab is associated with the steel beam with the assistance of shear connectors, so they go about as a solitary unit. In the present work steel concrete composite with RCC alternatives are considered for near investigation of G+9 story commercial building which is arranged in seismic tremor zone-III and for earthquake loading, the arrangements of IS: 1893 (Part1)-2002 is considered. A three dimensional demonstrating and examination of the structure are

completed with the assistance of SAP 2000 software. Equivalent Static Technique for Examination and Response spectrum investigation strategy are utilized for the examination of both Composite and RCC structures. The outcomes are thought about and found that composite structure more practical).

4) Ajay Singh Gulshan proposed the fundamental structural response characteristics and technological issues of composite steel and concrete systems. It assesses the pros and cons of composite structural systems and investigates the efficacy of beam-column members. Design rules for composite constructions are presented and discussed in details in order to get deep insight into their background. Composite steel and concrete systems are a viable alternative to both bare steel and reinforced concrete structures. They exhibit enhanced stiffness, strength and ductility. Composite frames benefit of the improved performance of steel and concrete columns; beams are generally in bare steel to yield at an early stage in compliance with the capacity design rules.

Review from Literature survey /Related Work:

1) Greater the height of the structure, higher will be the Storey Displacement.
2) In medium high rise buildings provision of providing shear wall is found to be effective in enhancing the overall seismic capacity of the structure.
3) Building model which is made of complete shear walls is best model because there is small amount of Story displacement and storey drift is obtained and more lateral load capacity.
4) In composite structure the self-weight of the frame is less and therefore substantial reduction in cost of the foundation.
5) Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the composite frame.

III. METHODOLOGY

A. Buildings

Buildings are formed by different structural elements made of concrete or steel standing more or less permanently in one place. They can also be constructed as single or multi-storey for residential, commercial and industrial building. As per IS 1893 (Part 1): 2016, buildings are classified into two types as regular and irregular based on various size, shape and function as per architectural requirements.

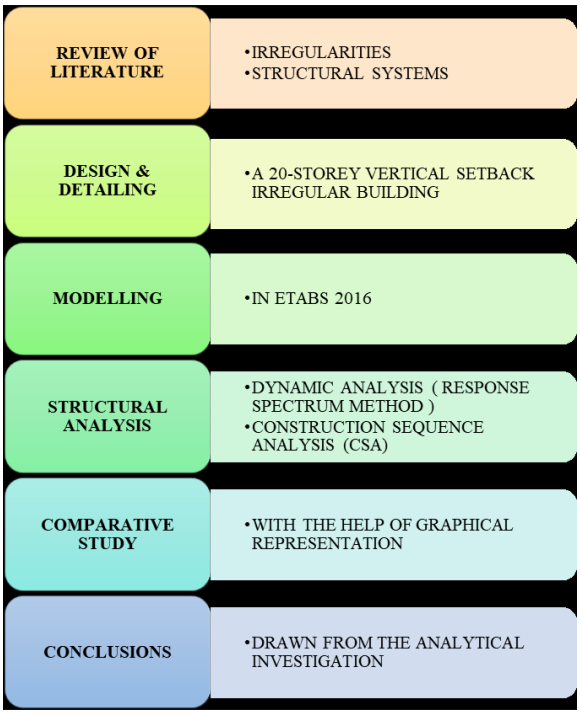


Figure.1 Conceptual framework of this research

1) Regular building

Buildings with simple regular geometry and uniformly distributed mass and stiffness in plan and elevation are said to be regular building. This type of building suffers much less damage during earthquake.

2) Irregular building

Buildings with different plan and in geometry will come under the category of irregular. Building is considered as an irregular when any of the conditions given in Table 5 and 6 of IS 1893 (Part 1):2016 satisfies. Irregular building is further classified into two types as,

Plan irregularity: Plan irregularity is further classified into five types as torsional irregularity, re-entrant corners, diaphragm discontinuity, out-of-plane offsets and non-parallel lateral force system.

Vertical irregularity: Vertical irregularity is further classified into six types as stiffness irregularity, mass irregularity, vertical geometric irregularity, strength irregularity-weak storey, floating or stub column and irregular modes of oscillation in two principal plan directions.

B. Structural system

Building with structural systems is usually designed to cope up with vertical gravity loads and lateral forces caused by wind and earthquake load. The structural system which is used to resist the lateral force is known as lateral load resisting system. Different structural system used for lateral resisting load systems are classified into,

- Braced frame structural system
- Rigid frame structural system
- Shear wall-frame system (Dual system)
- Shear wall system
- Core and outrigger structural system

IV.PROPOSED WORK

The present work deals with the evaluation of seismic characteristics for multi-storey residential reinforced concrete and composite building. The main focus of attention is to find out the behavior of buildings (RCC and Composite) with different locations of shear walls using Equivalent static analysis and Response spectrum analysis and cost comparison of with shear wall & without shear wall.

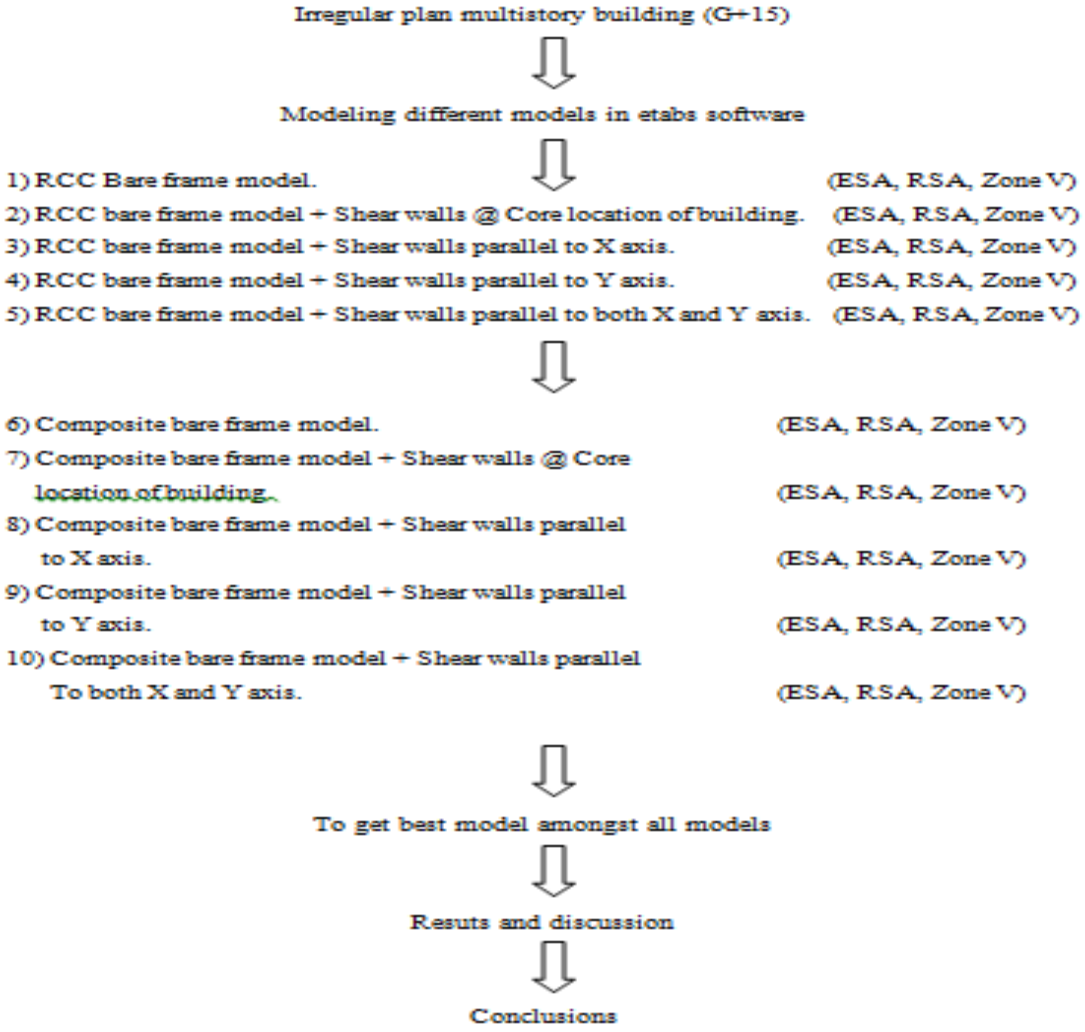
V.IMPLEMENTATION

It is an attempt to investigate the effect of Irregular plan configuration for multistoried reinforced concrete building model. This project mainly emphasizes on analysis of a multi-storey building (G+15) which is irregular both in plan. Modeling of 15 storeyed R.C.C. framed building will be done on the ETABS 2015 software for analysis. Post analyses of the structure such as Maximum Storey Displacement, Base Shear, Storey Drift, Maximum base reactions, Self weight are computed and then compared for all the analyzed cases.

VI. DESCRIPTION OF THE MODEL

1. Here in this study we have considered ten models for the study.
2. Conventional RCC building with beams and columns (Bare frame model).
3. Bare frame model + Shear walls @ Core location of building.
4. Bare frame model + Shear walls parallel to X axis.
5. Bare frame model + Shear walls parallel to Y axis.
6. Bare frame model + Shear walls parallel to both X and Y axis.
7. Composite building with beams and columns (Bare frame model).
8. Composite Bare frame model + Shear walls @ Core location of building.

9. Composite Bare frame model + Shear walls parallel to X axis.
10. Composite Bare frame model + Shear walls parallel to Y axis.
Composite Bare frame model + Shear walls parallel to both X and Y axis.



VII. RESULT AND ANALYSIS

Fundamental Time period:

From the chart it is seen that, the Fundamental Time Period is highest for the bare frame model (Model 1) less for the model 10 i.e., Composite bare frame model with Shear walls provided parallel to X and Y direction. The Fundamental Time Period is found to be decrease when the influence of shear wall is considered. The Fundamental Time Period is highest for the RCC model 5 with shear walls parallel to X and Y axis and less for the Composite model 10 with Shear walls parallel to X and Y direction. The percentage decrease in Time period for model 10

is 61.68% when compared to model 5 (RCC Bare frame model with shear walls parallel to X and Y axis).

From the chart it is observed that, the maximum storey displacement is more for model 1 and less for model 10. The permissible Maximum displacement as per IS code is given by L/500=53130/500=106.26mm where L is total height of the building. Model 1, Model 2 exceeds permissible limits in ESA and RSA. Whereas other 3 models are within the permissible limits**.** The Storey displacement is maximum for model 5 i.e., RCC bare frame model with shear walls provided parallel to X and Y axis compared to Composite Bare frame model with shear walls parallel to X and Y axis (model10). The percentage decrease in displacement for ESA and RSA are 72.22% and 90.88% in X direction and Y directions respectively for model 10 when compared to model 5. The reduction in storey displacement shows that the model 10 is stiff and less flexible.

Table 1: Time period of Various RCC and Composite models.

Time eriod in seconds	
Model No.	ETABS Analysis
1	3.327
2	3.14
3	2.792
4	2.8
5	1.305
6	3.073
7	2.94
8	2.692
9	2.582
10	0.5

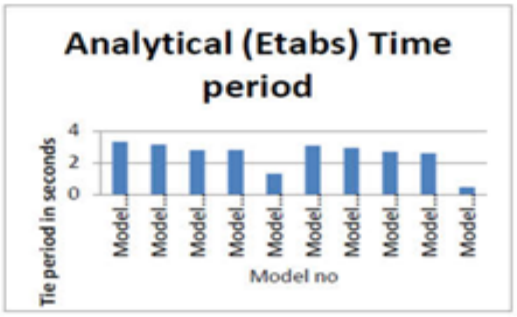


Chart 1: Time periods of various RCC and Composite models.

Maximum storey displacement

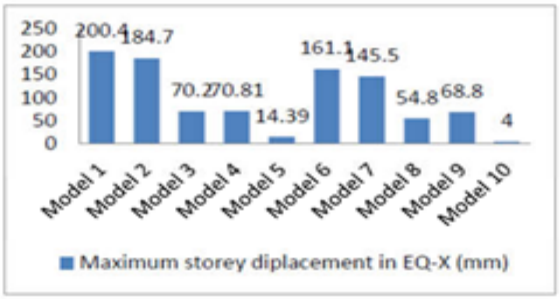


Chart 2: Maximum storey displacement of RCC & Composite models for ESA along EQ-X

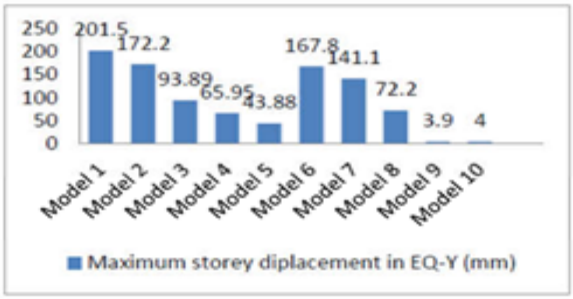


Chart 3: Maximum storey displacement of RCC & Composite models for ESA along EQ-Y

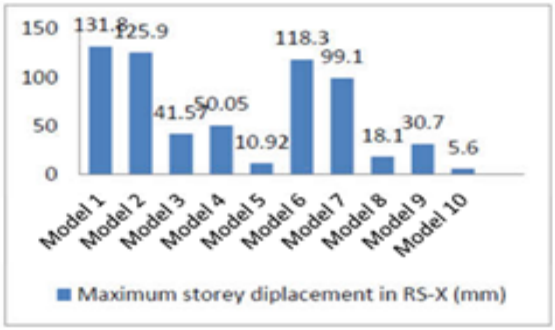


Chart 4: Maximum storey displacement of RCC & Composite models for RSA along EQ-X

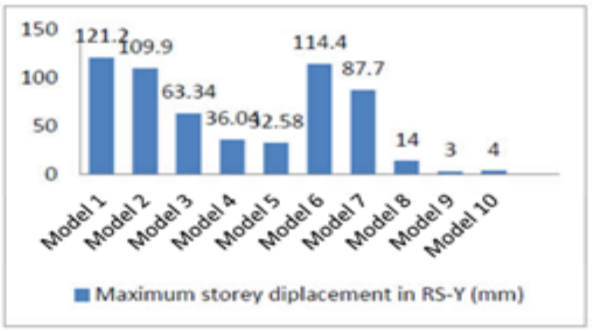


Chart 5: Maximum storey displacement of RCC & Composite models for RSA along EQ-Y

The story displacement results are summarized as follows:

Table 2 : Maximum storey displacement of RCC and Composite models.

	Equivalent Static Analysis (mm)		Response Spectrum Analysis (mm)	
Model No.	EQ-X	EQ-Y	RS-X	RS-Y
1	200.4	201.5	131.8	121.2
2	184.7	172.2	125.9	109.9
3	70.20	93.89	41.57	63.34
4	70.81	65.91	50.05	36.04
5	14.39	43.88	10.92	32.58
6	161.1	167.8	118.3	114.4
7	145.5	141.1	99.1	87.7
8	54.8	72.2	18.1	14
9	68.8	3.9	30.7	3
10	4	4	5.6	4

Storey Drift

Table 3 : Storey Drift of RCC and Composite models

	Equivalent Static Analysis (ESA)		Response Spectrum Analysis (RSA)	
Model No	EQX	EQY	RSX	RSY
1	0.003555	0.006144	0.004937	0.005042
2	0.003802	0.003339	0.003814	0.002168
3	0.005321	0.002723	0.000067	0.002007
4	0.001947	0.00143	0.00257	0.00022
5	0.000674	0.00067	0.000141	0.000142
6	0.00389	0.00427	0.00257	0.00275
7	0.00322	0.003043	0.001365	0.000787
8	0.0009946	0.001995	0.000458	0.001204
9	0.00259	0.00009	0.00194	0.000084
10	0.000097	0.000101	0.000079	0.000085

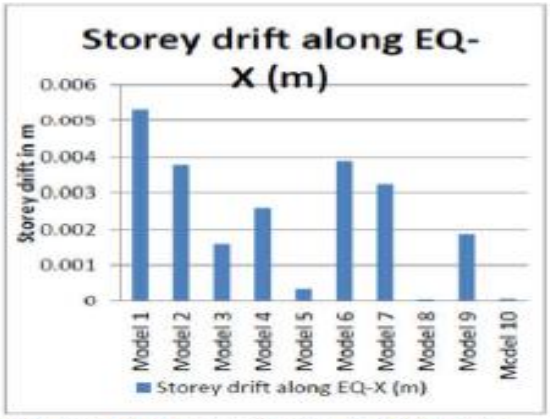


Chart 6 : Storey drift of RCC and Composite models for

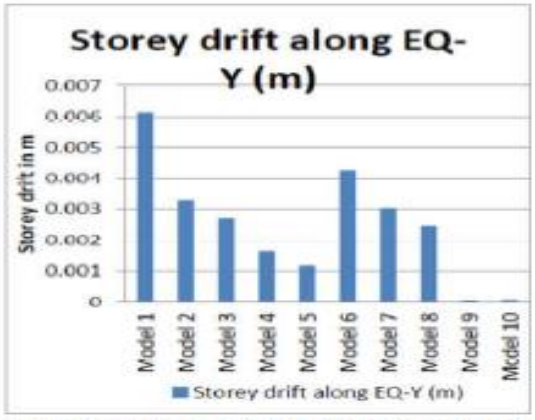


Chart 7 : Storey drift of RCC and Composite models for

ESA along X- direction



Chart 8 : Storey drift of RCC and Composite models for RSA along X- direction

ESA along Y- direction



Chart 9: Storey drift of RCC and Composite models for RSA along Y- direction

Cost comparison between with shear wall and without shear wall.

Calculation for 9" concrete shear wall (0.75" thickness)

Consider 1" * 1" *0.75" =0.75"cft

But as per mix design of M_{20} grade concrete quantities of different ingredients are as follows

	Water	cement	F.A.	C.A.
Quantity in/Kg	180.42	360	584	1223.8
Ratio	0.5	1	1.62	3.4

We know,

$1m^3 = 35.29$ cft

Quantities required for 1cft, M_{20} grade concrete

Water= $\frac{180.42}{35.29}$ =5.11 lit

Cement = $\frac{360}{35.29}$ =10.20 kg

F.A. = $\frac{584}{35.29}$ = 16.55 kg

C.A. = $\frac{1223.8}{35.29}$ = 34.68kg

But we need to calculate the quantities for 0.75m3

Water = 3.83 =4kg* 0.10 =Rs 0.40/-

Cement = 7.65 = 8kg * 7 =Rs 56/-

F.A.(Sand) = 12.41 =12.5.1.5 = Rs 18.75 /-

C.A. (20mm) =26.01kg =26 *0.65 = Rs 169/- =Rs17

Total material cost for 9" M20 concrete shear =92.15/sqft

If we consider 8mm bar @ 108mm spacing then per running feet we require 3-8mm bars. for 1sqft we require 6-8mm bars (3-horizontal & 3 vertical)

6* 1" =6" = 1.83m *0.4 =0.732 kg

Quantity of steel required for 1 sqft 9" concrete wall is 0.732kg

Cost of steel =0.732* 50= Rs 36.6 = (approx.) 37/-

Now .as per general market rates in Maharashtra the labour rate for 9" concrete shear wall construction is Rs 65/sqft

Total cost of 1sqft 9" concrete shear wall = cost of concrete required + cost of steel required + labour cost

Total cost of 1sqft 9" concrete shear wall per sqft= 92.15+37+65 = Rs194 approx.

CONCLUSIONS

The maximum storey displacement, storey drift, Base shear and Time period is more for the RCC Bare frame model when compared to the Composite bare frame model. The maximum storey displacement, Storey drift, Base shear and Time period is more for model 5 i.e., RCC Bare frame model with shear walls provided parallel to X and Y direction and less for model 10 i.e., Composite Bare frame model with shear walls provided in both X and Y directions.

The Fundamental Time Period, maximum storey displacement, Storey drift and Base shear for model 10 is less compared to all other models which show that the model 10 is stiff, less flexible to vibrate against lateral force. The self-weight of Composite structure is less as compared to RCC structure which helps in reducing the foundation cost. The Base shear for composite structure is less as compared to RCC structure because the self-weight of RCC structure is more as compared to composite structure.

REFERENCES

1. *Dhiraj.V.Narkhede "Performance of Shear Wall Building at Various Positions by Using Pushover Analysis" International Journal of Research in Advent Technology (IJRAT) (EISSN:2321-9637) Special Issue National Conference "CONVERGENCE 2016", 06th- 07th April 2016*

2. *Lakshmi K.O. "Effect of shear wall location in buildings subjected to seismic loads"ISOI*

Journal of Engineering and Computer science Volume 1 Issue 1; Page No. 07-17.

3. *Kasliwal N. An "Effect of Numbers and Positions of Shear Walls on Seismic Behaviour of Multistoried Structure "International Journal of Science, Engineering and Technology Research (IJSETR) Volume 5, Issue 6, June 2016.*

4. *Fazal U RahmanMehrabi, "Effects of Providing Shear wall and Bracing to Seismic Performance of Concrete Building "International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056Volume: 04 Issue: 02 | Feb -2017*

5. *Ravikumar C M et al, "Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings" Architecture Research 2012, 2(3): 20-26 DOI: 10.5923/j.arch.20120203.01.*

6. *Mahesh Suresh Kumawat, "Analysis and design of multistory building using composite structure "International Journal of Structural. & Civil Engineering Research. ISSN 2319-6009 Vol. 3, No. 2, May 2014.*

7. *Murtuza S. Aainawala "Behaviour of G+15 RCC and composite structure" International Journal of Innovative and Emerging Research in Engineering Volume 3, Special Issue 1,ICSTSD 2016.*

8. *Suryanarayana M "Analysis of G+15 RCC and Composite structure having soft storey at ground level by response spectrum and equivalent static methods using ETABS 2013" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 02 Issue: 03 | June-2015*

9. *Nitish A. Mohite "Comparative Analysis of RCC and Steel-Concrete-Composite (B+G+11 Storey) Building" International Journal of Scientific and Research Publications, Volume 5, Issue 10, October 2015 1 ISSN 2250-3153.*

10. *Varsha Patil "Comparative Study on Dynamic Analysis of Composite, RCC & Steel Structure" International Journal of Engineering Technology, Management and Applied Sciences August 2015, Volume 3, Issue 8, ISSN 2349-4476.*