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Comparative Analytical Study of Seismic Response and Cost of Multi-storey (G+12) RCC, Steel & Steel - Concrete Composite Building

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Abstract. *Engineers are familiar with the troubles that arise even as developing metallic or concrete structures, considering every fabric has its own set of traits. Because metallic components are often made up of thin plate factors, they are prone to buckling both locally and laterally. As a end result, they're examined for buckling and instability screw ups, at the same time as concrete contributors are usually thick and tough to buckle, but they're susceptible to creep and shrinkage over time. As a result, a steel-concrete composite construction has been industrialised to take advantage of each substance. Steel-concrete composite systems are the maximum value-effective solution to the numerous technical layout requirements for stiffness and electricity, combining the incredible traits of each metal and urban with lower costs, faster creation, and fire safety, amongst other blessings. In a number of locations. This kind of production has become a well-known issue in multi-tale metallic frame structures. A bare metallic frame with commonplace H-type section columns supports I-kind section beams, which in turn guide the overlying composite ground slab in the simplest form of composite structures. The composite floor slab, alternatively, is made of bloodless-shaped profiled steel sheets that serve as both the everlasting formwork and the vital tensile reinforcement for an in situ solid concrete slab. This powerful structural technique is suitable for systems that should face up to seismic forces. In this study, ETABS 2015 version 15.2.2 incorporated building layout software program was used to simulate all three sorts of systems defined above, namely steel, concrete, and composite multi-tale buildings. The Static seismic coefficient method and Dynamic Response spectrum evaluation technique are used to examine all three types of systems.*

For all fashions, the results are compared in terms of herbal length, frequency, storey displacement, storey going with the flow, storey shear, storey second, and storey stiffness. The number one

purpose of this research is to analyse the seismic behaviour of multi-tale RCC, steel, and composite structures.

***Keywords**: Steel, Concrete, Composites, ETABS.*

1. INTRODUCTION

The earth's systems are mostly exposed to two kinds of forces: static and dynamic. Static hundreds continue to be solid over time, at the same time as dynamic hundreds trade over time. The tremendous majority of civil structures are built on the basis that every implemented hundred is static. Because the structure is seldom exposed to dynamic masses, the impact of dynamic load is not taken into account.[2] However, consisting of it within the evaluation makes the solution more complicated and time-consuming. This feature of neglecting dynamic dynamics may every so often result in catastrophe. Especially on the occasion of an earthquake.[4]

An earthquake is a natural catastrophe that, unlike other calamities, including floods, offers little time for people to escape to more secure regions, resulting in a lack of lifestyles and assets.[8] As a result, the handiest viable option is to assemble our structures to face up to those seismic stresses. Each harm case take a look at has given essential data for enhancing layout and creation procedures which will shield constructing occupants. The code-primarily based technique for seismic analysis, the structural modelling idea, and the examiner's intention are all blanketed in this bankruptcy.[10]

2. DESIGN METHODOLOGY

IS 1893 adopted a design philosophy to ensure that structures possess minimum strength to

- Resist minor earthquakes (< DBE) without damage,
- Resist moderate earthquakes (DBE) without significant structural damage,
- Resist major earthquakes (MCE) without collapse.

The ductility is taken into account in the new code, which was published in 2002 as a response reduction factor (R). It suggests a number of important factors (I) that take into account the building's intended use. Both the Equivalent Static Load Method and Dynamic Analysis are recommended by the code as effective techniques of analysis. Using the equivalent static load technique, it is possible to calculate the design base shear of a structure.[9] In order to determine the design horizontal coefficient (A), it is necessary to use the seismic zone factor (Z). The significance of the factor (1) The response reduction factor (R) and spectral acceleration coefficient (Sa/g) were calculated from the response spectrum curve for the specified soil type and the specified fundamental time period of the structure, respectively.[11]

In zones IV and V, dynamic analysis is recommended for structures over 40 metres in height, as well as irregular buildings above 12 metres in height, as well as buildings over 40 metres in height.

2.1 An overview of composite construction

Traditionally, when it came to building design, the choice was typically between a concrete structure and a masonry one. Structure engineers, however, have been obliged to seek another mode of manufacture as a result of the collapse of numerous multi-story and occasional-rise R.C.C. and masonry buildings as a result of earthquakes.[3] The usage of composite or hybrid materials is of particular relevance because of the enormous potential for improving ordinary overall performance by making just a few minor adjustments to manufacturing and building procedures. Many consulting engineers in India are cautious about including the usage of composite metal-concrete systems in their designs because of the unfamiliarity and complexity of the analysis and layout. When properly designed, composite steel-concrete systems may also provide incredibly cost-effective structural solutions that are both very durable and quick to construct while also providing superior seismic performance. In composite manufacturing, two different materials are bonded together by means of shear studs with a shallower intensity at their interface, which results in a significant reduction in fabric costs.[8] The thermal growth of concrete and steel is about equal (coefficient of thermal expansion). This results in no induction of varied thermal strains inside the segment as a consequence of temperature variations within the segment. Systems of steel-concrete-composite construction are constructed by joining metal beams to concrete slabs or profiled deck slabs using mechanical shear connectors, enabling the slab and beam to act as a single, unbroken unit. It's a terrific opportunity to learn about the behaviour and reactions of composite textile materials.[4]

2.2 Objective of the study

- To assess the seismic response of multistory buildings constructed of various materials, such as concrete, steel, and composite materials, so that the best option with excellent seismic performance and low cost may be chosen.
- Understanding the building's response during an earthquake is accomplished through the use of the dynamic response spectrum method, and the response of the structure is compared for all types of models in terms of time period and frequency as well as deflections, shear, storey

displacement, storey drift, modal participation factor, and peck ground acceleration.

- Identify and calculate the material costs for each of the three types of construction.

3. METHODOLOGY

It is proposed in this study to compare reinforced concrete, steel, and composite frame structures for use in earthquake-prone areas. A G+12 multi-story building with a plan dimension of 24 metres by 42 metres has been modelled and analysed using the Etabs 2015 integrated building design software, version 15.2.2. On the structure, an equivalent static analysis as well as a dynamic response spectrum analysis were carried out.

Three different kinds of buildings are modelled in the following sections:

1. Steel building

2. Conventional RCC building

3. Composite building (with composite column, steel beam & profiled steel deck)

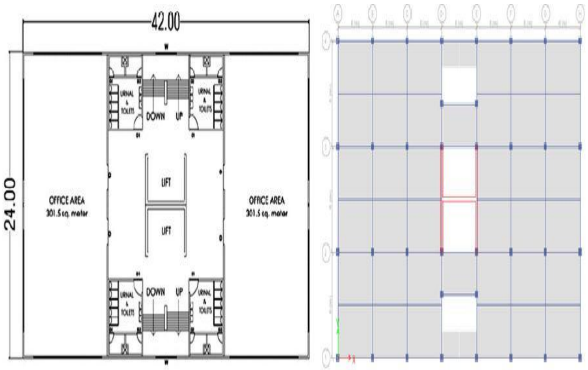


Figure 1. plan view

Material data

Table 1. Materials data

Material	Weight (KN/M³)	M.O.E. (E) (KN/M²)	Shear modulus (G)	oisson ratio	Co effi. Of thermal expansion
Steel ($f_e = 415$)	78.5	2 x 10^8	76884615	0.3	11.7 x10^{-6}
Steel ($f_e = 345$)	76.9	2 x 10^8	80769230	0.3	11.7 x10^{-6}
Concrete ($f_{ck} = 25$)	25	25 x 10^6	10416666.7	0.2	9.9 x10^{-6}
Masonry	20	11 x 10^6	521739.13	0.15	07 x10^{-6}

Geometrical Data

Table 2. Geometrical Data

Type of building	Commercial building
location of building	Hyderabad
Height of building	50 m (including foundation depth 4.5 m)
Storey Height of building	3.5 m

Earthquake Data

Table 3. Earthquake data

Frame	Special moment resisting frame
Location	Hyderabad
Zone factor	0.16 (zone III)
Importance factor	1.5
Response reduction factor	5
Soil type	Medium (type 2)

4. Analysis, Results and Discussions

A combination of equivalent static analysis and response spectrum analysis is utilised in this research to examine the seismic responses of reinforced concrete, steel, and composite construction.

Among the most significant variations between similar static and dynamic studies is the magnitude and spatial distribution of lateral forces throughout the whole height of the structure.

A simple formula in IS 1893-2002 provides an estimate of the fundamental period and force distribution, which is used to calculate the quantity of forces in the equivalent lateral force technique.

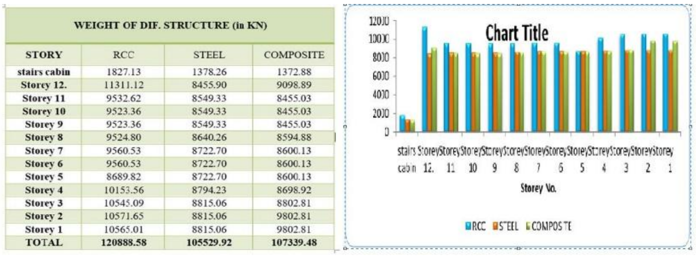
A building's natural vibration modes have characteristics that influence how lateral forces are applied during the dynamic analysis process. The features of the natural vibration modes are controlled by the distribution of mass and stiffness throughout its height.

The maximum sagging and hogging bending moments, shear force, and axial force for each column and beam are calculated and shown in the table below. Storey drift, base shear distribution, seismic stress, storey displacement, and time period are all calculated and compared as well as other variables.

4.1 Seismic weight

Seismic weight of the RCC, steel and composite building is 120888.58 KN, 105529.92 KN, and 107339.48 KN respectively. So, seismic weight of steel building is 12.70 %, 11.20 % lower than seismic weight of the RCC building.

Seismic weight of the building is calculated by considering self-weight of slab, column, beam, floor finish, wall and 50% of live load.



WEIGHT OF DIF. STRUCTURE (in KN)

STORY	RCC	STEEL	COMPOSITE
stairs cabin	1827.13	1378.26	1372.88
Storey 12.	11311.12	8455.90	9098.89
Storey 11	9532.62	8549.33	8455.03
Storey 10	9523.36	8549.33	8455.03
Storey 9	9523.36	8549.33	8455.03
Storey 8	9524.80	8640.26	8594.88
Storey 7	9560.53	8722.70	8600.13
Storey 6	9560.53	8722.70	8600.13
Storey 5	8689.82	8722.70	8600.13
Storey 4	10153.56	8794.23	8698.92
Storey 3	10545.09	8815.06	8802.81
Storey 2	10571.65	8815.06	9802.81
Storey 1	10565.01	8815.06	9802.81
TOTAL	120888.58	105529.92	107339.48

Figure 2. Weight of the structure

4.2 Storey shear and moment

Aspects of the magnitude of the lateral force that affects each floor level of the structure include the mass of the building at each floor level, the stiffness distribution over height, and the Storey displacement in a particular mode.

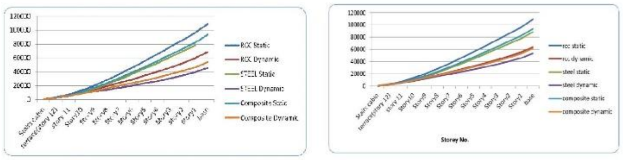


Figure 3. Storey moment for static and dynamic analysis in x-y direction

4.3 Storey displacement

Storey drift is determined from the Storey displacement; a greater amount of Storey displacement suggests a construction with less rigidity.

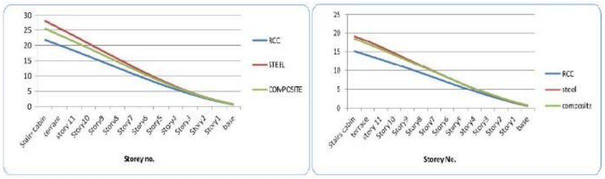


Figure 4. Maximum storey displacement for static and dynamic analysis in x-y direction

4.4 Storey stiffness

In order to calculate the stiffness of a structure, it is assumed that the supports are fixed and that the load is applied at floor level. It is necessary

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TIME PERIOD (in SEC.) AND FREQUENCY						
MODE	**RCC**		**STEEL**		**COMPOSITE**	
	Time period	**Frequency**	**Time period**	**Frequency**	**Time period**	**Frequency**
1	2.22	0.45	2.57	0.39	2.25	0.44
2	1.37	0.73	1.83	0.55	1.64	0.61
3	1.25	0.80	1.58	0.63	1.46	0.68
4	0.68	1.47	0.83	1.20	0.74	1.35
5	0.37	2.71	0.44	2.27	0.42	2.41
6	0.37	2.73	0.41	2.47	0.39	2.57
7	0.30	3.32	0.39	2.56	0.38	2.64
8	0.23	4.31	0.28	3.58	0.28	3.64
9	0.18	5.46	0.20	5.01	0.20	4.90
10	0.17	6.06	0.19	5.38	0.18	5.43
11	0.14	7.12	0.17	5.96	0.17	5.98
12	0.13	7.96	0.15	6.55	0.16	6.24

to measure horizontal displacement at the floor level in order to calculate lateral stiffness, which is calculated by dividing the horizontal displacement by the lateral load. In other words, stiffness is defined as the amount of force necessary to create a unit displacement, which is determined by the slope of the force-displacement relationship between the two forces.

A system's strength is defined as the amount of force it can withstand.

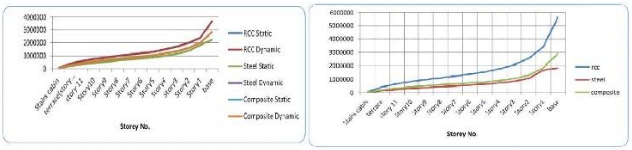

Figure 5. Storey stiffness for static and dynamic analysis inx- y direction

4.5 Time period

The time period has an impact on the technique of analysis chosen. The ground velocity governs the reaction of flexible structures over a longer time period. The natural period of a stronger structure is shorter, and its reaction is controlled by ground acceleration; most structures fall into this group. Flexible structures, such as broad span bridges, have a longer natural period and their reaction is controlled by ground displacement.

Table 4. time periods and frequency

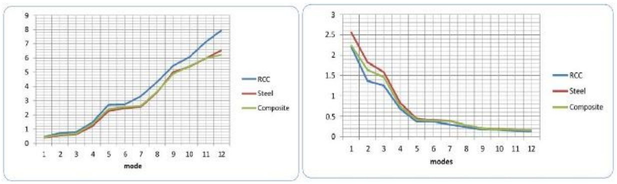

Figure 6. Time period and frequency for different modes

4.6 Storey drift

When one level of a multi-story building moves in relation to the level below it, this is referred to as "storey drift." A measure of inter-story drift is the difference in displacement between the roof and floor displacements of a building's first and second floors as it sways during an earthquake, normalised by the building's height. Drift is the movement of an item from one side to the other. When the interstory drift is 0.10, for example, it means that the roof is shifted one foot in relation to the floor below it for a storey that is ten floors high.

The amount of storey drift is related to the stiffness of the structure. The stronger the stiffness of the structure, the lower the drift and the larger the lateral forces on the structure.

The greater the amount of drift, the greater the possibility of harm.

Peak inter-story drift values....

1. 0.06 indicate severe damage.

2. > 0.025 indicate that the damage could be serious enough to pose a serious threat to human safety.

3. > 0.10 indicate probable building collapse.

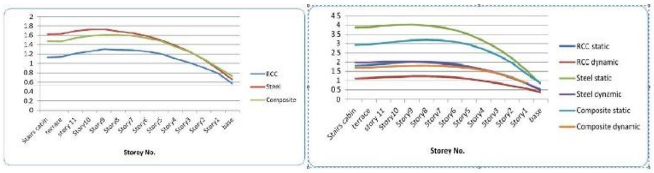

Figure 7. Storey drift for static and dynamic analysis in x-y direction

4.7 Peak ground acceleration (PGA)

Peak ground acceleration (PGA) is the maximum acceleration of the ground in the given direction of the ground shaking. Means acceleration of mass relative to the base can be determined by PGA.

RCC BUILDING			
Concrete	4700 m3	4200 ` per m3	1,97,40,000 `
Reinforcement	1018000 kg	62 ` per kg	6,31,16,000`
Total			**8,28,56,000`**

COMPOSITE BUILDING			
Concrete	1245 m3	4200 ` per m3	52,29,000 `
Reinforcement	112900 kg	62 ` per kg	69,99,800`
Structural steel	1010200 kg	65 ` per kg	6,56,63,000`
Total			**7,78,91,800`**

Table 5. Response Spectrum Accelerations

Response spectrum accelerations (in x direction) (m/sec²)							
structure		RCC		STEEL		COMPOSITE	
spectrum	mode	period	acceleration	period	acceleration	period	acceleration
RSAX	1	2.22	0.128	2.57	0.119	2.25	0.114
RSAX	2	1.37	0.206	1.83	0.166	1.64	0.196
RSAX	3	1.25	0.226	1.58	0.192	1.46	0.219
RSAX	4	0.68	0.432	0.83	0.368	0.74	0.446
RSAX	5	0.37	0.520	0.44	0.560	0.42	0.589
RSAX	6	0.37	0.520	0.41	0.560	0.39	0.589
RSAX	7	0.30	0.520	0.39	0.560	0.38	0.589
RSAX	8	0.23	0.520	0.28	0.560	0.28	0.589
RSAX	9	0.18	0.520	0.20	0.560	0.20	0.589
RSAX	10	0.17	0.520	0.19	0.560	0.18	0.589
RSAX	11	0.14	0.520	0.17	0.560	0.17	0.589
RSAX	12	0.13	0.520	0.15	0.560	0.16	0.589
RSAX	13	0.12	0.520	0.12	0.560	0.16	0.589
RSAX	14	0.10	0.512	0.12	0.560	0.13	0.589
RSAX	15	0.09	0.485	0.10	0.560	0.11	0.589
RSAX	16	0.09	0.473	0.09	0.552	0.11	0.589
RSAX	17	0.08	0.463	0.09	0.532	0.10	0.582
RSAX	18	0.07	0.425	0.08	0.514	0.10	0.570

Cost analysis

Costing of each building is based on material only. In case of steel and composite building steel required for joints and connection is added in structural steel.

Table 6. cost analysis

STEEL BUILDING			
Concrete	1600 m3	4200 ` per m3	67,20,000`
Reinforcement	97300 kg	62 ` per kg	60,32,600`
Structural steel	1028000 kg	65 ` per kg	6,68,20,000`
Total			**7,95,72,600`**

Table 7. comparison of building

PARAMETERS	RCC	STEEL	COMPOSITE
Seismic weight	maximum	Minimum	In-between
Storey shear	maximum	Minimum	In-between
Storey displacement	Minimum	maximum	In-between
Storey drift	Minimum	maximum	In-between
Time period	Minimum	maximum	In-between
Storey stiffness	maximum	Minimum	In-between

Storey stiffness	maximum	Minimum	In-between

5. Conclusions

Following the static and dynamic analysis of steel, RCC, and composite buildings, it was discovered that dynamic analysis not only provides a better knowledge of structural behaviour but also allows for the formulation of the following conclusions:

- ➢ The maximum seismic weight of an RCC structure is ten thousand pounds. Steel and composite buildings have a seismic weight that is 12.70% and 11.21% less than reinforced concrete buildings, respectively.
- ➢ Storey shear in composite buildings is 14 percent lower than in RCC buildings, while steel buildings are 18 percent lower.
- ➢ RCC construction has the highest storey stiffness because it has a less flexible structure than other structures. When compared to reinforced concrete structures (RCC), steel buildings have a 26% lower storey stiffness and composite buildings have a 23% lower storey stiffness.
- ➢ The stiffer the material, the less displacement will occur. The highest storey displacement is seen in steel buildings. The steel structure has a 26 percent greater storey displacement than the RCC building, whereas the composite building has a 22 percent greater storey displacement than the RCC building.
- ➢ The amount of storey drift that occurs is directly proportional to the rigidity of the structure. The greater the stiffness, the less drift there is. With this in mind, a steel structure has the greatest amount of story drift. When compared to an RCC building, a steel building has a 43.54 percent greater storey drift and a 30.35 percent greater floor drift.
- ➢ When it comes to RCC construction, it is quite rigid and requires a shorter construction time period. Consequently, when compared to the other two types of structures, RCC construction requires the least amount of time. Steel buildings have a time period of 15.77 percent, whereas composite buildings have a time period of 2 percent.
- ➢ The modal participation factor demonstrates that mass contributes significantly in the first four modes, whereas the contribution of the higher mode is minimal in the structure.
- ➢ The peak ground acceleration (PGA) of steel buildings is greater than that of composite buildings.
- ➢ Based on the element sections, we may deduce that composite structures not only result in decreased dead weight, but they also result in reduced dimensions. This provides an additional working area as well as extra headroom.
- ➢ The average storey shear for RCC, steel, and composite buildings is reduced by 33%, 27%, and 23%, respectively, when dynamic analysis is performed.

- When dynamic analysis is performed on an average storey of RCC, steel, and composite buildings, displacement is reduced by 26.91 percent, 27.94 percent, and 24.08 percent, respectively.
- When dynamic analysis is performed on the average storey level, drift is reduced by 38%.
- When compared to RCC and steel construction, the cost of composite construction is 17.05 percent and 3.05 percent lower, respectively.
- The effects of dynamic analysis on storey shear, displacement, and drift are reduced, among other things; this illustrates that dynamic analysis improves force estimations, resulting in more accurate and cost-effective building analysis results.
- The lateral stiffness of a structure should be adequate to provide superior seismic performance. Deformation and strains caused by low lateral stiffness are severe, and non-structural component deterioration and occupant discomfort are common consequences.
- Despite the fact that a stiff structure attracts more seismic force, it has survived better in prior earthquakes, such as the one that occurred in 1893. (Part-I).
- Composite construction reduces both the cross-sectional area of the element and the amount of steel that is utilised in its construction. As a consequence, the foundation's operating costs will be significantly decreased. Therefore, composite structures are one of the best options for multistorey building construction as well as earthquake protection.

REFERENCES

[1] Abhishek Sanjay Mahajan & Laxman G. Kalurkar, “performance analysis of RCC and steel concrete composite structure under seismic effect”, International Journal of Research in Engineering and Technology, Volume 5 Issue 4 Apr-2016.

[2] Anamika Tedia & Dr. Savita Maru, “Cost, Analysis and Design of Steel-Concrete Composite Structure RCC Structure”, IOSR Journal of Mechanical and Civil Engineering, Volume 11, Issue 1, Jan. 2014.

[3] Aniket Sijaria, Prof Anubhav Rai & Prof Y.K. Bajpai, “Cost comparison between r.c.c. beam& steel composite beam structure of g+5 storeyed building the overall plan dimension of the building is 56.3 m x 31.94m”, International Journal of Computational Engineering Research, Volume 4, Issue 6, June 2014.

[4] A. Sattainathan Sharma, R. Anjughap Priya, R. Thirugnanam and P. Rathna Priya, “Comparative Study on Multi-Storey Structure of R.C.C and Composite Material”, Indian Journal of Science and Technology, Volume 9, Issue 2, January 2016.

[5] Bhavin H. Zaveri , Bhargav K.Panchotiya & Smit U. Patel, “parametric study of rcc, steel and composite structures under

seismic loading", International Journal of Civil Engineering and Technology ,Volume 7, Issue 4, July-August 2016.

[6] Bhavin H. Zaveri, Jasmin A. Gadhiya & Hitesh K. Dhameliya, "A Review on the Comparative Study of Steel, RCC and Composite Building", International Journal of Innovative Research in Science Engineering and Tech., Vol. 5, Issue 1, January 2016.

[7] Deepak M Jirage, Prof. V.G. Sayagavi & Prof. N.G. Gore, "Comparative Study of RCC and Composite Multi-storeyed Building", International Journal of Scientific Engineering and Applied Science, Volume 1, Issue 6, September 2015.

[8] D. R. Panchal & P. M. Marathe, "comparative study of RCC, steel and composite (G +30 Storey) building", institute of technology, Nirma University, 08-10 December 2011.

[9] Mahesh Suresh Kumawat & L G Kalurkar, "analysis and design of multistory building using composite structure", Indian Journal of Science and Technology, Volume 3, issue No. 2, May 2014.

[10] Murtuza S. Aainawala, " behavior of g+15 RCC and composite structure", International Journal of Innovative and Emerging Research in Eng., Volume 3, Sp. Issue 1, 2016.

[11] Nitish A. Mohite, P. K. Joshi & Dr. W. N. Deulkar, "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.

[12] Nitin m. Warade & P. J. Salunke, "comparative study on analysis and design of composite structure", International Journal of Advance Research in Science and Engineering, Volume No.2, Issue No.12, December, 2013.

[13] Jeeva K, & Prof. G. Augustine Maniraj Pandian, "Study of Behavior of Steel and Steel-Concrete Composite Multi-Storey Moment Resistant Frames Using Pushover Analysis", International Conference on Engineering Trends and Science & Humanities page no. 17 to 21, 2015