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# Comparative Analysis of Multistorey Building RCC Vs Steel Vs Composites

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**ABSTRACT:** The goal of this work is to study the behaviour of a typical ordinary moment-resisting framed structure with composite columns and traditional steel columns during an earthquake and to look at the most important design issues. This study looks at how a typical 10-story concrete and steel structure responds to earthquakes using the equivalent static method of analysis as described in IS: 1893:2002 for moderate seismic zone 4th using the ETABS software package. The analyses are done on regular 3D space models with steel and concrete columns that can resist bending. The analysis is done, and the results are compared in terms of important earthquake response parameters like base shear, storey drifts, roof displacements, and storey overturning moments. A comparison of how three different kinds of multistory framed buildings react to earthquakes. The main goal is to compare three different models that were all put through the same load and other tests. The first model is supposed to be made of normal RC structures, the second is made of steel, and the third will be made of a composite frame. Dynamic Analysis and Response spectrum were also done so that the results and similar conditions and criteria could be compared. At last, a sample analysis of Pushover has been done to find out where the column failed. By means of E-TABS values. In the end, we found that the displacement for RCC and steel is higher than that for composites. So, if displacement is the most important thing, the performance of a composite structure is better. The story drifts of composite structures are less than those of RC structures, but they are still within the limits of what is allowed. So, composite structures are a better choice again when there is story drift, which happens under each floor. Due to the way steel is made, this structure was found to be more resistant to shear than the other models. For the second choice, composite structures are much better than RCC structures.

**KEYWORDS:** ETABS, RCC, Dynamic Analysis, Static Analysis.

## I. INTRODUCTION

### 1.1 GENERAL

In India, buildings are mostly made of RCC, and steel structures are only used in industrial buildings and, more recently, in multistorey buildings, which have become more popular because they use composite structural elements. But recently, composite columns are becoming more popular for use in multistorey buildings. This is because they have great static and earthquake-resistant properties, such as a lower mass, high strength, rigidity, and stiffness, significantly high toughness and ductility, and a large energy dissipation capacity. In addition to these benefits, they are easy to set up and install on-site, which can save money on labour and foundation costs. They also resist buckling better than RCC columns and cost less to maintain and fireproof than steel columns. Also, composite systems weigh about 20–40% less than construction made of concrete. So, the composite system is a better way to build a building than using just steel or reinforced concrete elements. When using a composite section, important design parameters include the amount of structural steel, reinforcing steel, and concrete area, as well as the shape and position of the three materials. In fact, there are a lot of different ways to put things together, which makes the design flexible. Because of these things, composite members are becoming more important in the building of skyscrapers, the growth of infrastructure, and especially high-rise buildings in places where there are earthquakes.

A steel concrete composite column is a compression member made of either a concrete-encased hot-rolled steel section or a hot-rolled steel tubular section filled with concrete. It is usually used as a load-bearing member in a composite-framed building. Composite columns can hold more weight than the bare reinforced column and the structural steel column that are part of the system.



## 1.2 Composite Beams and columns

Multistory buildings that are not homes are mostly made of composite materials. This has happened for more than twenty years. It works well because it can be made strong and stiff with a small amount of materials.

Concrete is good at being compressed, and steel is good at being stretched. This is why composite construction is often so good. By structurally joining the two materials together, these strengths can be used to make a design that is both very strong and light. Because composite elements weigh less on their own, the forces in the parts that hold them up, like the foundations, are also less. Composite systems can also help speed up the building process. When using composite construction, you can reduce the depth of the floors, which can save you a lot of money on service costs and the building envelope.

This article talks about composite beams, composite slabs, composite columns, and composite connections, among other things. While beams and slabs are very common in UK construction, composite columns and connections are not used as often.

### 1.2.1 Types

#### Concrete Encased I Section

Steel beams that are covered in concrete have been used a lot in building bridges and buildings for a long time. Investigations showed that these composite beams led to a decrease in both the weight of the structure and the deformations that came from it. In this paper, the nonlinear three-dimensional finite element method and the general-purpose computer programme DIANA are used to make an accurate model of concrete-encased steel beams. The analysis takes into account how the steel and concrete work together to make a good model of how the encased beams will behave. The analysis has been done for both stages that are linear and stages that are not linear. The results of this work are compared to similar results from other experimental works that have already been done. The comparison showed that the current model can give a good representation of the concrete.

#### Concrete filled steel tubes

The CFT structural member is better than an equivalent steel, reinforced concrete, or steel-reinforced concrete member in a number of ways. The cross section is as strong and stiff as it can be because of how the steel and concrete are placed. The steel is at the outside edge, where it has the best tension and bending moment resistance. Also, the CFT is much stiffer because the steel, which has a much higher modulus of elasticity than the concrete, is farthest from the center, where it contributes the most to the moment of inertia. In most cases, the concrete forms an ideal core that can handle the compressive loads, and it delays and often stops the steel from buckling in localised areas, especially in rectangular CFTs. Also, it has been shown that the steel tube holds the concrete core together, which makes the circular CFTs stronger and the rectangular ones more flexible. Because of this, it is best to use CFTs for columns that have to deal with a lot of compression. Unlike reinforced concrete columns with transverse reinforcement, the steel tube also keeps the concrete from cracking and keeps the reinforcement from crowding in the connection area. This is especially important for seismic design.

### 1.3 Objectives

Following are the objective of the present study are.

1. Comparison of seismic behavior of three types of multistory framed structures consisting.
2. The main aim is to Compare Three different Models which is subjected same load and other conditions.
3. First Model is supposed to be Normal RC structures, second Model is Steel Structure and third will be Composite frame structure.
4. Dynamic Analysis and along with this Response spectrum carried in order to compare the results and similar conditions and criteria.
5. Comparison done for three Different models and finding out the required results under Displacement, Autolateral, Shear.
6. Comparing the major parameters finding out the best model which is suitable in each and every result output, and suggesting the best model.



## II. RELATED WORK

Dr. D. R. Panchal In 2014, they show a simpler way to design composite slabs, beams, and columns, and they make VB.NET software with pre- and post-processing tools. All of the most important design checks are built into the software. Also taken into account are the full and partial shear connections and the need for transverse reinforcement.

D. R. Panchal and P. M. Marathe compared steel concrete composite, steel, and R.C.C. for a commercial building with 30 floors in earthquake zone IV. People use the Equivalent Static Method. ETABS software is used to model composite, steel, and R.C.C. structures, and the results are compared. It turns out that composite structures are cheaper. In all of the choices, the values of the story displacements are within the limits set by the code. Steel and composite structures are more flexible than R.C.C. structures, which are best when side forces are acting on them.

LIU Jingbo and LIU Yangbing made the CL-CFST (composite beam-concrete filled square tubular column), SLCFST (steel beam-concrete filled square tubular column), CLETRC (composite beam-equivalent stiffness RC column), SLETRC (steel beam-equivalent stiffness RC column), and RC frame structures in 2008. Then the spectrum of response and the inelastic

Chapman talked about how a simple composite section and a shear connector behave. He said that, for the design of the ultimate load, the composite section's relatively large shape factor is a good thing. The limited rotational ductility of the composite section, on the other hand, needs restrictions. It was made clear how important the standard testing procedure for the shear connectors is. He also said that the spacing between the shear connectors can be the same in most cases of load.

Chapman and Balakrishnan looked at how seventeen composite I beams behaved when static concentrated and distributed loads were put on the beam's axis. Changes were made to the amount of shear connection within the range that could be considered for design, and the effect of interface slip on elastic and ultimate load behaviour was studied. They said that the shear connection should be made so that it can handle the horizontal shear force in the beam when it is loaded to its maximum capacity. For this purpose, it was suggested that 80 percent of the shear connectors' maximum strength, which was found through experiments, should be used.

Vallenilla and Bjorhovde said that the beam span, the width of the slab, and the amount of shear connection have the most impact on how much a composite beam with a formed steel deck bends. They also said that the way the AISC Specification figures out the effective width gives beam stiffness properties that are too high. So, beams made this way tend to have less deflection than they actually have. The effective width test results were found to be in good agreement with the proposed formula. If the suggested method is used, it gives the designer a better way to figure out how the strength and behaviour of a composite beam with a formed steel deck are affected by a partial shear connection.

D.R. Panchal et.al, (2011): This paper looked at how Steel-concrete composite systems have become popular in the field of civil engineering because they are better than other ways of building. Based on the results, steel structure is better than RCC, but composite is the most cost-effective choice for a high-rise building. Compared to an RCC structure, a steel structure's dead load can be cut by 32%, and a composition structure's can be cut by 30%. Compared to RCC structure, the axial load on a column can be cut by 46% in a steel structure and by 7% in a composite structure.

Renavikar Aniket V et.al, (2013): For analysis in this study, STAAD.Pro software is used. Most of these problems with medium- to high-rise buildings can be solved with a steel-concrete composite frame system that is both effective and inexpensive. Due to the smaller size of the steel members, the cost of a steel structure can be less than that of an RCC structure. When compared to a steel composite structure, RCC has more axial forces, bending moments, and deflections. This causes the cost to go up. Because it's easy to connect the members, the structure can be finished quickly. Because of its natural flexibility, Steel's concrete structure will perform best compared to RCC structures in the event of an earthquake.

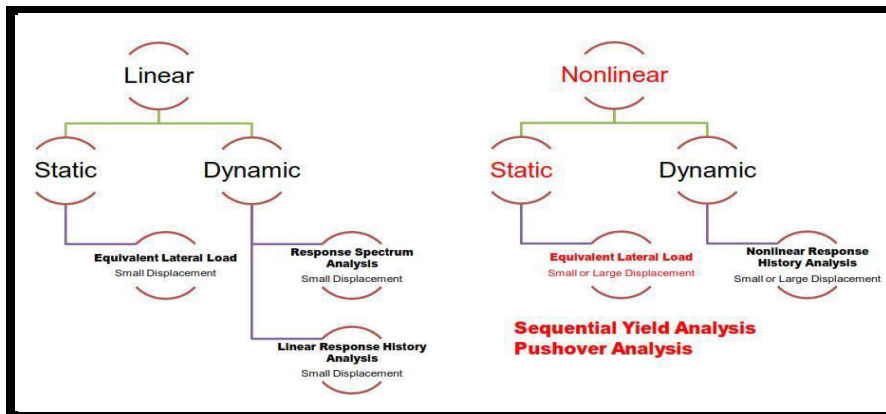
Shashikala. Koppad et.al, (2013): RCC structures are no longer cost-effective for medium-rise and high-rise buildings because they are dangerous to work on, aren't as stiff, have shorter spans, and have more dead weight. Instead, composite structures are best for cost-effective building. Local and lateral buckling can happen to structural members made of steel. Most of the time, RCC members are bigger and less likely to buckle, but they can still creep and shrink



when they're loaded. Steel and concrete are two common building materials that are often used together. The improved overall performance of construction technologies has made steel-concrete construction more cost-effective.

Zafar Mujawar et.al, (2015): In Steel-concrete composite structures, faster-connecting technology has been used a lot. This saves a lot of time during construction and makes it easy to finish the structure in the least amount of time. Compared to an RCC structure, there is more space inside a composite structure, which also makes it more likely to last longer. From the results of the experiment When compared to RCC structures, composite structures have 29% less base shear and 29% less composite structure. Compared to RCC structures, steel structures have 48% less axial force and composite structures have 50% less. Based on the results, it can be said that a lower axial force on the footing will lead to a smaller footing and that a composite structure can be finished in a short amount of time.

### III. METHODOLOGY



#### 3.1 METHODS OF SEISMIC ANALYSIS OF STRUCTURE

Different approaches for conflicting obstacle have been generated for the seismic inspection of structures. They can be termed below

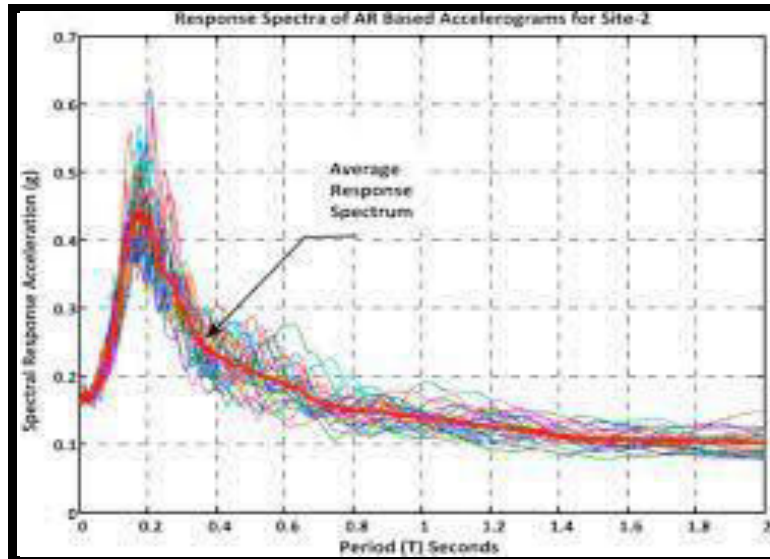
- Static analysis
- Non Linear Static Analysis

#### 3.2 RESPONSE SPECTRUM ANALYSIS (RSA)

It is a linear dynamic statistical analysis method that measures how much each natural mode of vibration contributes to show the likely maximum seismic response of a structure that is mostly elastic. Response spectrum analysis gives information about dynamic behaviour by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping. It is possible to wrap response spectra so that the peak response for each realisation of the structural period is shown by a smooth curve. Response spectrum analysis is helpful for making design decisions because it shows how choosing the type of structure affects how it moves. Structures with shorter periods have more acceleration, while structures with longer periods have more displacement. During preliminary design and response spectrum analysis, the performance goals of the structure should be taken into account.

A response spectrum is a graph of the peak or steady-state response (displacement, velocity, or acceleration) of a group of oscillators with different natural frequencies that are set in motion by the same base vibration or shock. If you know the natural frequency of oscillation of a linear system, you can use the resulting plot to figure out what it will do. One way it is used is to figure out how buildings react at their worst during earthquakes. Scientists who study strong ground motion may be able to use some values from the ground response spectrum, which is calculated from seismograph recordings of surface ground motion, to figure out how seismic damage is caused.

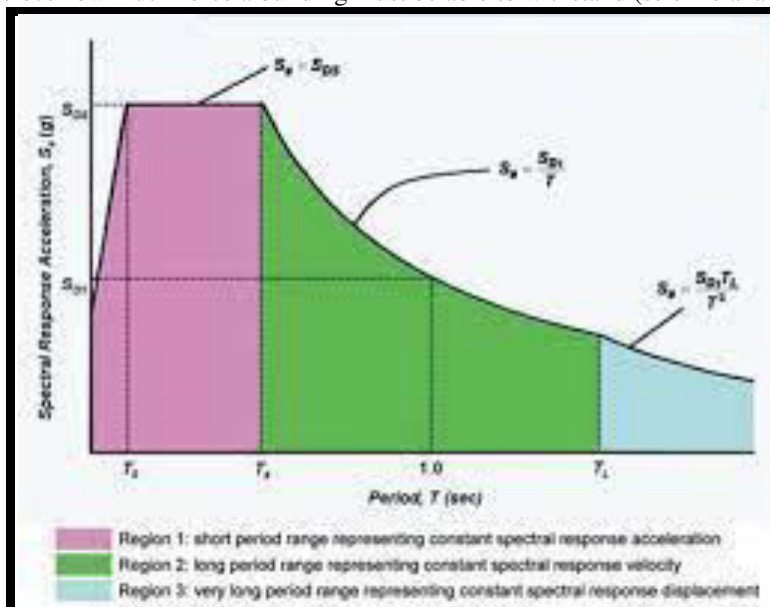
If the input used to calculate a response spectrum is steady-state periodic, then the steady-state result is recorded. If there is no damping, the response will be infinite. For inputs that change over time, like seismic ground motion, the peak response is given. Most of the time, some level of damping is assumed, but even if there is no damping, a value will be found.



Response spectra can also be used to measure the response of linear systems with more than one way to oscillate (systems with more than one degree of freedom), but they are only accurate for low levels of damping. Modal analysis is used to find the modes, and from the response spectrum, the response in that mode can be chosen. The total response is then estimated by adding up all of these peak responses. If the modal frequencies are not close together, the square root of the sum of the squares (SRSS) is a common way to combine them. Since phase information is lost in the process of making the response spectrum, the result is often different from what would be calculated directly from the input.

The main problem with response spectra is that they can only be used for linear systems in general. Response spectra can be made for non-linear systems, but they only work for systems with the same level of non-linearity. However, people have tried to make non-linear seismic design spectra that can be used for a wider range of structures. This means that the results can't be put together directly to get a multi-mode response.

Response spectra are very useful in earthquake engineering for figuring out how buildings and other things work during quakes, since many of them act mostly like simple oscillators (also known as single degree of freedom systems). So, if you can figure out the structure's natural frequency, you can estimate the building's peak response by reading the value for that frequency from the ground response spectrum. In most building codes in areas prone to earthquakes, this number is used to figure out how much force a building must be able to withstand (seismic analysis).

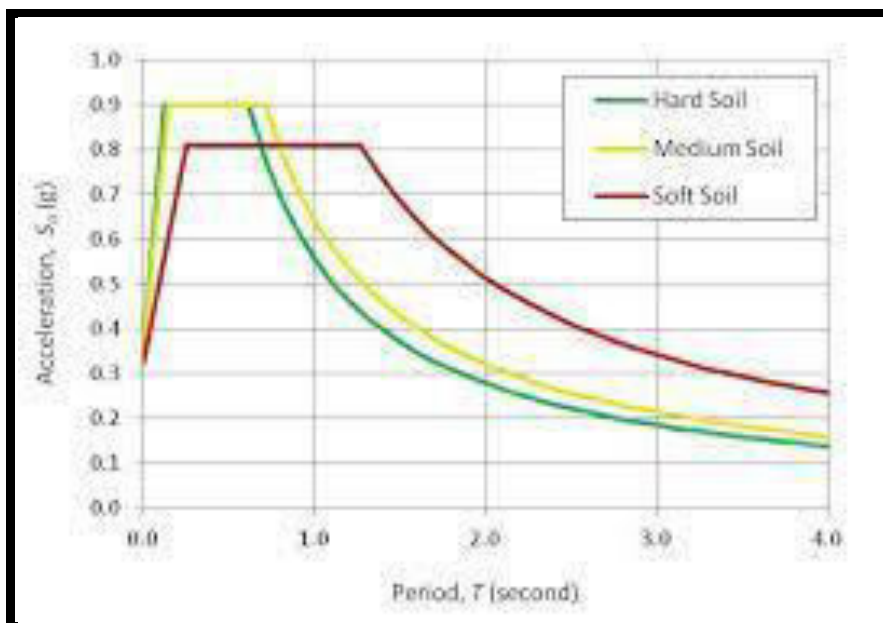




As was already said, the ground response spectrum is the plot of the response at the earth's free surface. If the building's response is "in tune" with parts of the ground motion (resonance), which can be seen in the response spectrum, it could cause a lot of damage. This was seen in the 1985 Mexico City Earthquake[1], when the deep-soil lake bed moved at the same rate as mid-rise concrete buildings. This caused a lot of damage. Shorter (stiffer) and taller (more flexible) buildings

In the 1982 EERI Monograph on "Earthquake Design and Spectra,"[2] Newmark and Hall explain how they made an "idealized" seismic response spectrum based on a range of response spectra made from earthquake records. This was then made into a design response spectrum for use in building design, and this basic form (with some changes) is now the basis for building design everywhere in the world where there is a risk of earthquakes. A nominal level of damping (5% of the critical level of damping) is assumed.

For "regular" low-rise buildings, the structural response to earthquakes is characterised by the fundamental mode (a "waving" back and forth), and most building codes allow design forces to be calculated from the design spectrum based on this frequency. However, for more complex structures, it is often necessary to combine the results for many modes (calculated through modal analysis). When buildings are too oddly shaped, too tall, or important to a community during a disaster, the response spectrum approach isn't enough. Instead, a more complex analysis is needed, such as a non-linear static or dynamic analysis, as in the seismic performance analysis technique.



As isolation devices against earthquakes, double concave friction pendulum bearings are put between the bridge deck and the piers and abutments. A curved bridge is chosen to show how seismic isolation can be used. The bridge in question has three spans and a superstructure made of cast-in-place concrete box girders supported by reinforced concrete columns on drilled shafts and integral abutments on steel pipe piles. Also, the bridge is built on a site with a deep deposit of material that doesn't stick together. The equivalent soil springs method is used to model the drilled shaft-soil system, which is also part of the finite element model. The soil is connected to the drilled shaft at even distances by what looks like a series of springs.

- The multi mode method of analysis is typically implemented in a computer program capable of performing response spectrum analysis. The response spectrum specified for the analysis is the 5%-damped spectrum modified for the effects of the higher damping. Each isolator is represented by its effective horizontal stiffness with a linear link element.
- As seen from the results of the outlined analysis, usage of the isolation devices offers some advantages for the internal forces on the deck for the considered curved bridge as per the non-isolated curved bridge.
- The response spectrum analysis is substantially required to make a decision of the displacement capacity of the double concave friction pendulum bearings used in the study.



### 3.3 Modelling and Analysis

The FEM based structural software is used for modelling and analysis of the building. The analysis is carried out using ETABS software.

#### 3.3.1 Introduction to ETABS

EXTENDED 3D ANALYSIS OF BUILDING SYSTEM (ETABS) could be a stand-alone structural research system for a high-quality approach to structural design and analysis of building frameworks. ETABS is easy to use and understand, and it does a great job of covering the full range of tasks from claiming to shape analysis and configuration. ETABS could be a package for figuring out if a building is suitable for more than one story. The person's whole story could be told graphically or by writing clear English instructions. It is made with complicated advertising calculations and images of the country's uniqueness, making it very easy to understand nature's domain.

#### Brief History

ETABS is a programme that was made just for building frameworks. [R. W. Clough, et al., 1963]: The idea of purpose tasks for building type systems may have been around for more than 35 years. But the most unusual reason programs, like ETABS, have never been more clear. Likewise structural unique architects set nonlinear static Also, changing the way exams are done under the act and using the more powerful computers available today will make big, more unpredictable explanation models.

With ETABS, making and improving a model, running analysis, designing, and updating the model's configuration would all be done through a single interface that is fully integrated into Microsoft Windows. Graphical representations of the results, as well as a real-time display of the time records that were moved, are processed. Revealed output, which can go to a printer, specific parts, or at certain points, is also definitely converted. This project gives. A huge step forward in the way models are made, changed, broken down, and planned. The ability to explain ETABS is just as good, and I'd like to know more about the latest look into finished numerical methods and result calculations.

#### Facilities

ETABS would possibly make a champion around the one's ones that complete degree large element effective the component that is an extra quantity well known structural constructing result. It's far tremendous regarded with its clean with catch interface, fit contraptions to demonstrating what is more notable loading, want offices. Deliver us examine towards to the span of those specific business settings to be had In ETABS from that angle of a structural engineer.

- Model generating facilities
- Model verification facilities
- Load generation capabilities
- Finite elements capabilities
- Dynamic/seismic capabilities
- Analytical capabilities
- Concrete design capabilities
- Steel design capabilities
- Post analysis capabilities

#### 3.3.2 MODELING

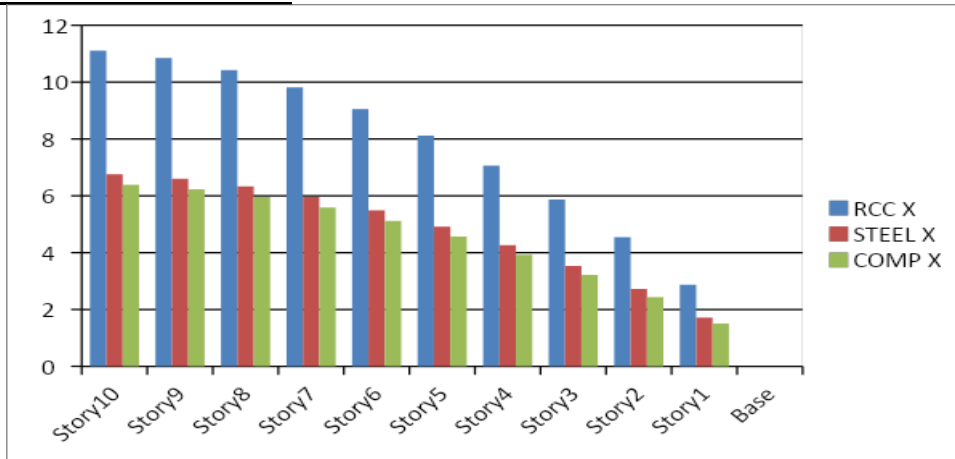
Just for this look, three models could be made: one with a cement structure and a straight span for many supporting structures, with a straight width of about 6 meters; the other could be shaped like a G+12 memories skyscraper, with different configurations for supporting structures. ETABS programming would break down every last part of these models. Also, the results need to be narrowed down, and figuring out the length's balance and doing a similar investigation "around the frames for seismic tremor will be done. These are the most important parameters to consider as of the show. The focus is on the displacement, flow, seismic, Pushover, and pivot effects of the systems. The models will look at the same static analysis to find the right supporting structures to withstand the earthquakes well and also to compare the responses from braced and unbraced buildings that were put through point or parallel stacking.



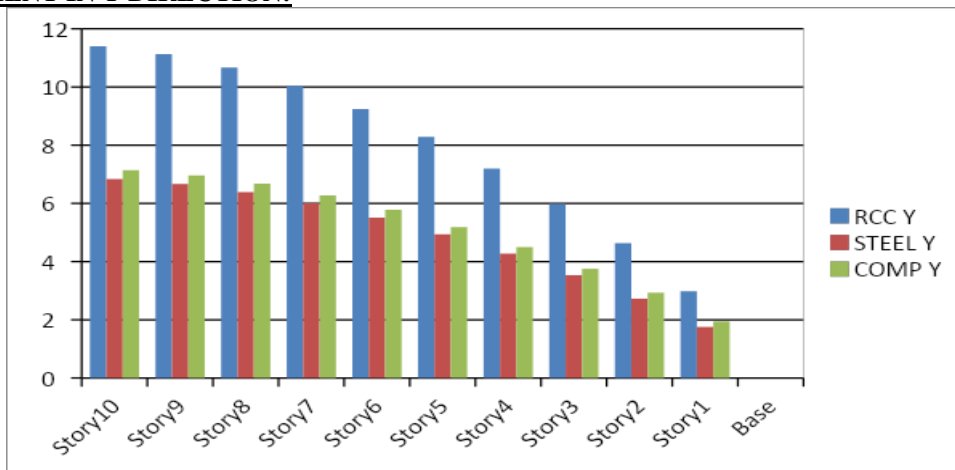


IV. EXPERIMENTAL RESULTS

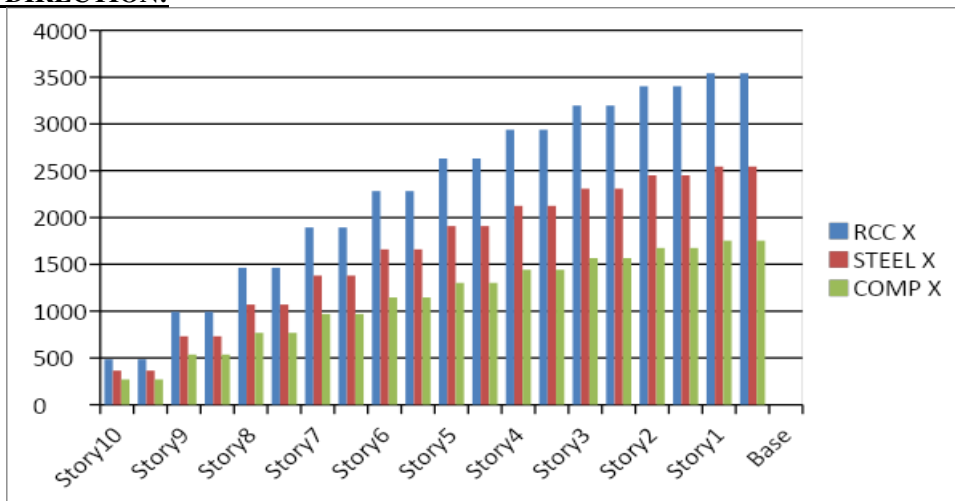
**DISPALCEMENT IN X DIRECTION:**



**DISPALCEMENT IN Y DIRECTION:**

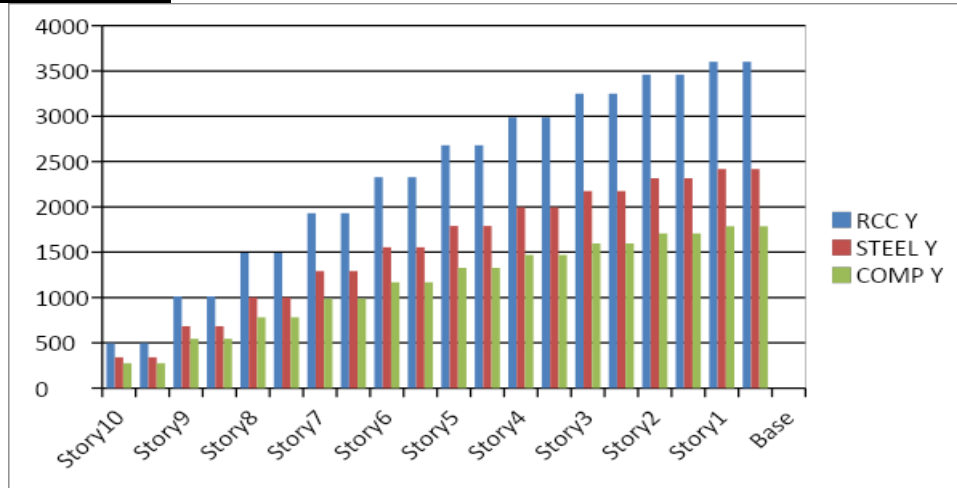


**SHEAR IN X DIRECTION:**

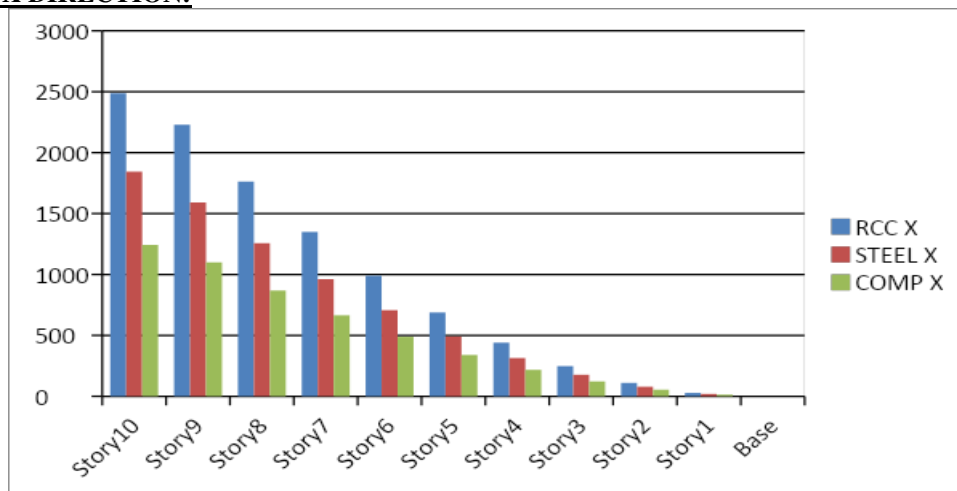




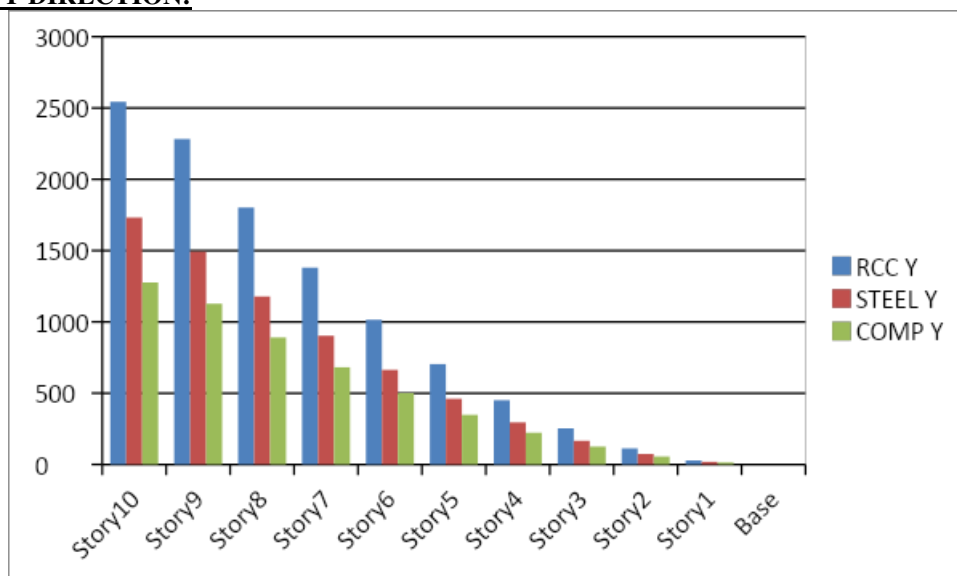
**SHEAR IN Y DIRECTION:**



**SEISMIC IN X DIRECTION:**



**SEISMIC IN Y DIRECTION:**

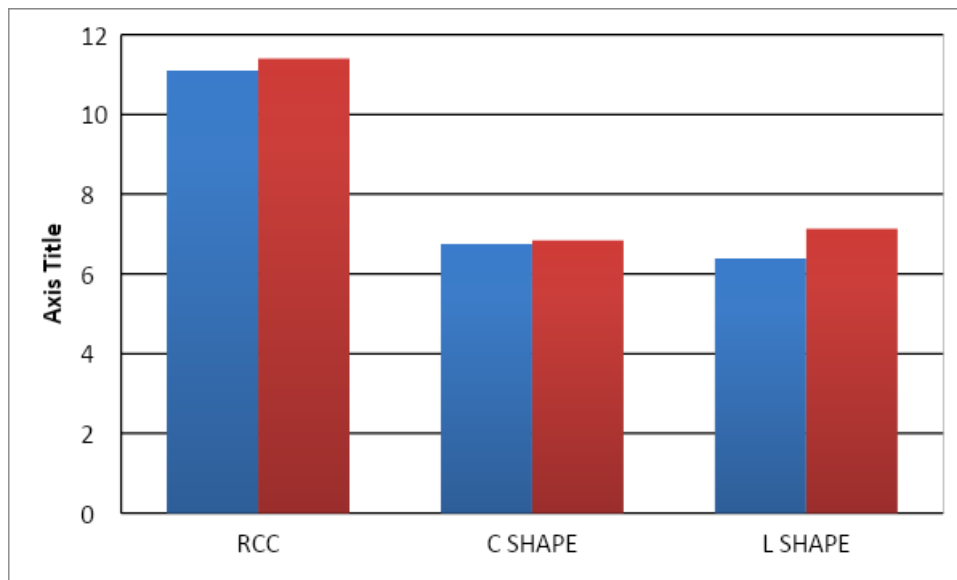




1. Considering RCC the maximum story displacement of the story is found to be around 11.105 in X direction and 11.4 in Y direction and it is found to be the displacement is little bit maximum at Y direction .
2. Considering Rcc the maximum story shear is found to be around 485.092 in X direction and 494.864 in Y direction and it is found to be the shear is little bit maximum at Y direction .
3. Considering RCC the maximum story Seismic is found to be around 2486.652 in X direction and 2544.7805 in Y direction and it is found to be the Seismic is little bit maximum at Y direction .
4. Considering Steel structure the maximum story displacement is found to be around 6.755 in X direction and 6.84 in Y direction and it is found maximum at Y direction.
5. Considering Steel structure the maximum story shear is found to be around 364.7512 in X direction and 340.2366 in Y direction and it is found maximum at X direction.
6. Considering Steel structure the maximum story Seismic is found to be around 1845.098 in X direction and 1731.037 in Y direction and it is found maximum at X direction.
7. Considering composite structure the maximum story displacement is found to be around 6.387 in X direction and 7.135 in Y direction and it is found maximum at Y direction.
8. Considering composite structure the maximum story shear is found to be around 270.4228 in X direction and 274.382 in Y direction and it is found maximum at Y direction.
9. Considering composite structure the maximum story seismic is found to be around 1244.0277 in X direction and 1276.0692 in Y direction and it is found maximum at Y direction.

**FINAL COMAPRIOSN MAXIMUM DISPLACEMENT**

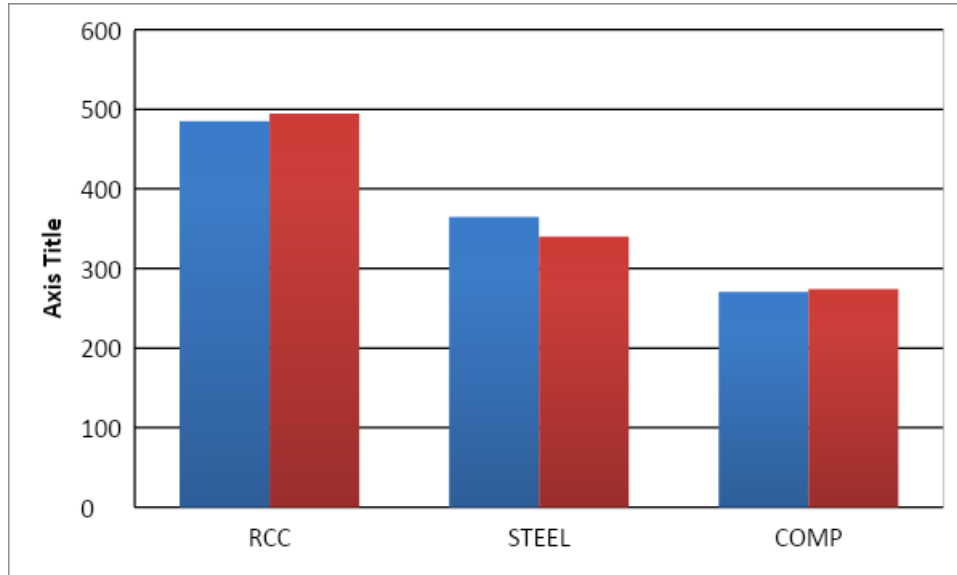
TYPE	X	Y
RCC	11.105	11.4
STEEL	6.755	6.84
COMPOSITE	6.387	7.135



From above comparison it’s found that the displacement gradually reduce from RCC to steel and finally composite shows better performance in the reduction of the displacement in the Composite structure.

**MAXIMUM SHEAR**

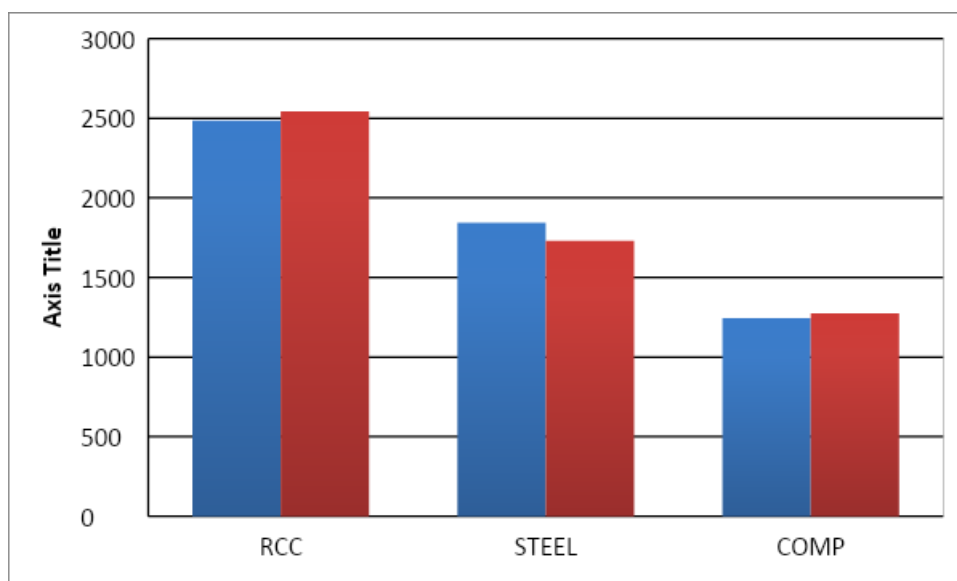
TYPE	X	Y
RCC	485.092	494.864
STEEL	364.7512	340.2366
COMPOSITE	270.4228	274.382



From above comparison its found that the shear gradually decreases from RCC to steel and but finally at composite shows better performance in the reduction of the Shear when compared with that of all other model.

**AUTOLATERAL LOADS**

TYPE	X	Y
RCC	2486.652	2544.7805
STEEL	1845.0982	1731.0373
COMPOSITE	1244.0277	1276.0692



From above comparison it's found that the Seismic gradually reduce from RCC to steel But at composite shows better performance in the reduction of the of shear, while the Composite holds good.



**RESPONSE SPECTRUM**

MODEL	SCALE FACTOR	BASE>85%	RRF>90%
RCC	916	85	99.4
STEEL	902	85	99.43
COMP	896	85	99.4

Under the response spectrum analysis all model has been passed the base reaction value which is greater than 85 % and also the response reduction factor using the modal participating mass ratio is found to be for all model above 90%. Hence the base reaction and the response reduction factor passes all the criteria according to the highest standard and also the scale factor is found to be around nominal conditions validating all the required criteria.

**V. CONCLUSION**

1. From comparison it's found that the displacement gradually reduce from RCC to steel and finally composite shows better performance in the reduction of the displacement in Composite When compared with all other structure.
2. From comparison it's found that the shear gradually Increases from RCC to reduces to steel and but finally at composite shows better performance in the reduction of the Shear in Composite.
3. From comparison it's found that the Seismic gradually reduce from RCC to steel But at composite shows better performance in the reduction of the of shear, Hence here also Composite show better Performance.
4. We Conclude that the Composite is showing better Performance in when compared whit all other models. In future any kind of retrofitting method can be used to improve the performance of the model as well.
5. Under the response spectrum analysis all model has been passed the base reaction value which is greater than 85 % and also the response reduction factor using the modal participating mass ratio is found to be for all model above 90%.
6. Hence the base reaction and the response reduction factor passes all the criteria according to the highest standard and also the scale factor is found to be around nominal conditions validating all the required criteria.

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