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Comparative Study of RCC Building with Composite Column and Steel Columns by ETABS

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Abstract
The majority of building structures are designed and constructed in reinforced concrete which is mainly depends upon availability of the constituent materials and the level of skill required in construction, as well as the practicality of design codes. R.C.C is no longer economical because of their increased dead load, hazardous formwork. However composite construction is a new concept for construction industry. The use of modern composite systems, allowing the erection of multi-story structural frames to proceed at pace, can make it economically prohibitive to delay the construction of each floor while concrete columns are cast. In Japan, however, the superior earthquake resistant properties of composite beam-columns have been long recognized and have become a commonly used for construction in that region. It was therefore necessary to develop seismic design criteria for typically used Indian structural systems, to advance the use of this efficient type of mixed construction. This Project shows comparison of various aspects of building.In this project a residential of G+30 multi-story building is studied for Pushover Analysis using ETABS, assuming that material property linear, static and dynamic analysis is performed. These non-linear analysis are carried out and different parameters like displacement, storey drift, Performance point, base shear are plotted. Now it is the demand of time that every structure must be analyzed and designed for lateral forces such as earthquake and wind forces. But generally it is found that the cross sectional area of RCC structural member comes out very heavy with large amount of constituent material such as steel & concrete, which takes large space in construction of multistory building. Under such circumstances composite structure is one of the best options, which not only takes care for earthquake forces but also gives less cross sectional area of structural member and provides large space for utilization in economical way.

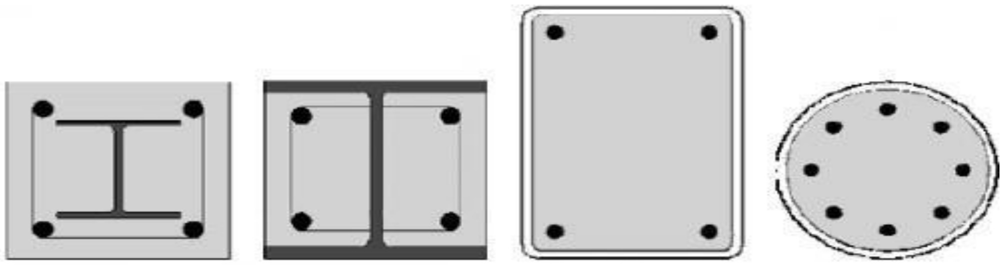
Index Terms: Pushover, ETABS, Performance Point, Non-linear.

I. Introduction

Structural engineers do not traditionally consider fire as a load on the structural frame. This is in contrast to other loads they must consider. Seismic design relies on modeling, risk analysis and changes to the structural stiffness. Wind design relies on additional structural members and wind tunnel tests. Fire design

relies on very simple, single element tests and adding insulating material to the frame. Thermal induced forces are generally not calculated or designed.
Natural disasters are inevitable and it is not possible to get full control over them. The history of human civilization reveals that man has been combating with natural disasters from its origin but natural disasters like floods, cyclones, earthquakes, volcanic eruptions have various times not only disturbed the normal life pattern but also caused huge losses to life and property and interrupted the process of development. With the technological advancement, man tried to combat with these natural disasters through various ways like developing early warning systems for disasters, adopting new prevention measures, proper relief and rescue measures. But unfortunately it is not true for all natural disasters. Earthquakes are one in all such disasters that's connected with in progress tectonic process; it suddenly comes for seconds and causes nice loss of life and property. So earthquake disaster prevention and reduction strategy is a global concern today. Hazard maps indicating seismic zones in seismic code are revised from time to time which leads to additional base shear demand on existing buildings

Composite columns:-
Composite columns may take a range of forms, as shown in the figure below. As with all composite elements they are attractive because they play to the relative strengths of both steel and concrete. This can result in a high resistance for a relatively small cross sectional area, thereby maximising useable floor space. They also exhibit particularly good performance in fire conditions.



Typical composite column cross sections

Steel building:-
Steel building is a metal structure fabricated with steel for the internal support and for exterior cladding, as opposed to steel framed buildings which generally use other materials for floors, walls, and external envelope. Steel buildings are used for a variety of purposes including storage, work spaces and living accommodation. They are classified into specific types depending on how they are used.

Introduction to ETABS:-
ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS features an intuitive and powerful graphical interface coupled with unmatched modeling, analytical, and design procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of geometrical nonlinear behaviors, making it the tool of choice for structural engineers in the building industry (Computers and structures Inc. 2003)

II. LITERATURE REVIEW

This paper provides complete guide line for manual as well s software analysis of seismic coefficient method. The effective design and the construction of earthquake resistant structures have much greater importance in all over the world. In this paper, the earthquake response of symmetric multistoried building is studied by manual calculation and with the help of ETABS 9.7.1 software. The method includes seismic coefficient method as recommended by IS 1893:2002. The responses obtained by manual analysis as well as by soft computing are compared.

III. METHODOLOGY AND TYPES OF LOADS CONSIDERED

EVALUATION OF SEISMIC ISOLATION SYSTEMS

Seismic isolation is a technology that was developed in order to minimize the earthquake damage. It is a design method that is based on the principle of decreasing the earthquake energy affecting the structure by extending the structure period instead of increasing the resistance capacity of the building against the earthquake. In the buildings that are constructed by using this technology, the elastic behaviour of the building is ensured even during major earthquakes. Initially, the purpose was to prevent the collapsing of the buildings during an earthquake, but today, the designs that aim to maintain comfort in addition to earthquake security are on the foreground.

As it is known, the modern regulations of today aim providing the life security in addition to elimination of the damages in buildings caused by major earthquakes. Therefore, here we have a situation in which the building would become unusable after a major earthquake that is probable only once during the life of the building or its reinforcement would not be economical. This situation can also bring a huge financial and work loss. Although the application of seismic control systems increases the project-related cost to a certain degree, these losses can be escaped at a great scale with the correct design. Especially in case of reinforcement of the public buildings and the buildings, which contain valuable equipment, when the expenses of their reconstruction, loss of function and destruction of the equipment after an earthquake are considered, it will be seen that this increase in cost is negligible

EARTHQUAKE REGULATIONS AND DESIGN GUIDES:

In the developed countries where intensive seismic activity is observed, various seismic isolation types are widely applied. Some earthquake regulations have special conditions regarding the seismic isolation and passive energy dissipating systems. In particular, the regulations in the USA and Japan are the most detailed ones in this field. In the USA, many researches and applications have been performed since 1980's. These works were evaluated in scientific gatherings such as ATC, ASCE Structural Congress, EERI Spectra, US and World Conferences on Earthquake Engineering

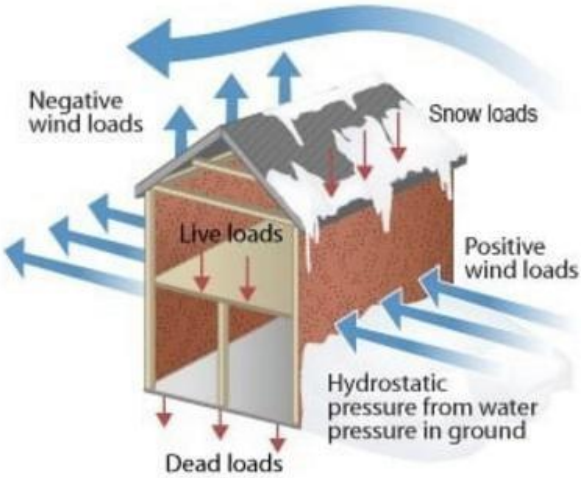
METHODOLOGY

Response Spectrum Analysis:- This method is also known as modal method or mode superposition method. It is based on the idea that the response of a building is the superposition of the responses of individual modes of vibration, each mode responding with its own particular deformed shape, its own frequency, and with its own modal damping

Types of loads considered

Different types of loads acting on the structure

The types of loads acting on structures for buildings and other structures can be broadly classified as vertical loads, horizontal loads and longitudinal loads. The vertical loads consist of dead loads, live load and impact load. The horizontal loads comprises of wind load and earthquake load. The longitudinal loads i.e. tractive and braking forces are considered in special case of design of bridges, gantry girders etc.



Unit weight of materials

Sl. No	Material	Weight (kN/m^3)
1	Brick masonry	18.8
2	Stone masonry	20.4 – 26.5
3	Plain concrete	24
4	Reinforced cement concrete	24
5	Timber	5 - 8

Earthquake loads (EL)

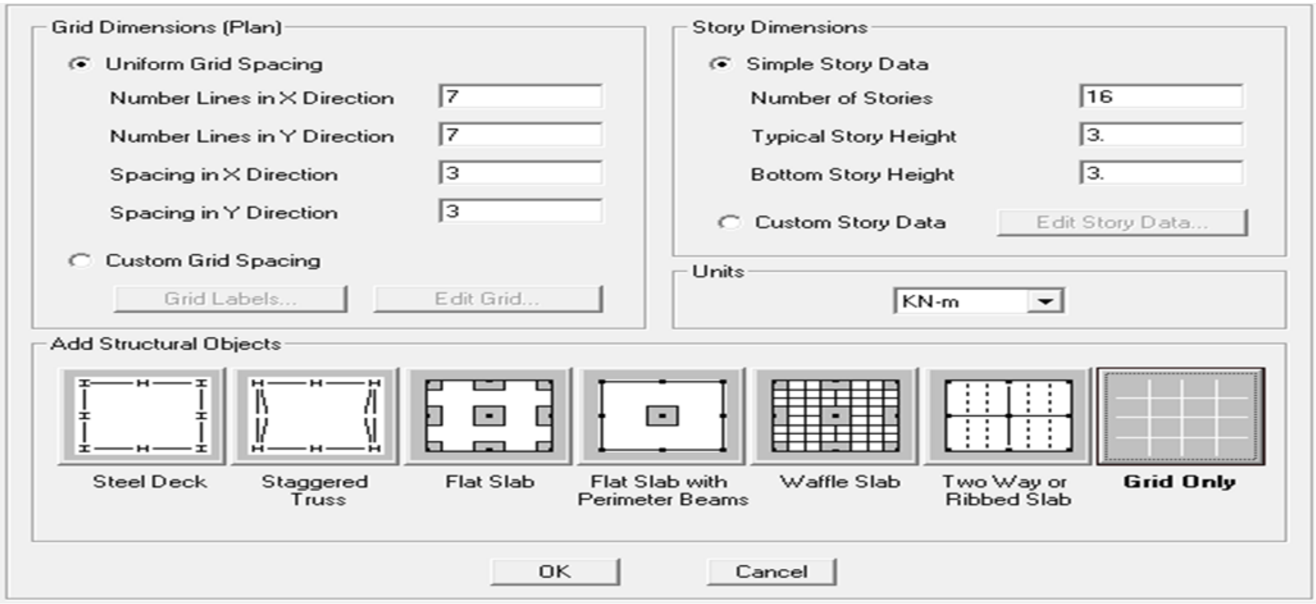
.The structure is exposed to both vertical and level quake stresses. The whole vibration produced by a tremor might be partitioned into three commonly opposite headings: one vertical and two even (DonatoCancellara, et al, 2016).

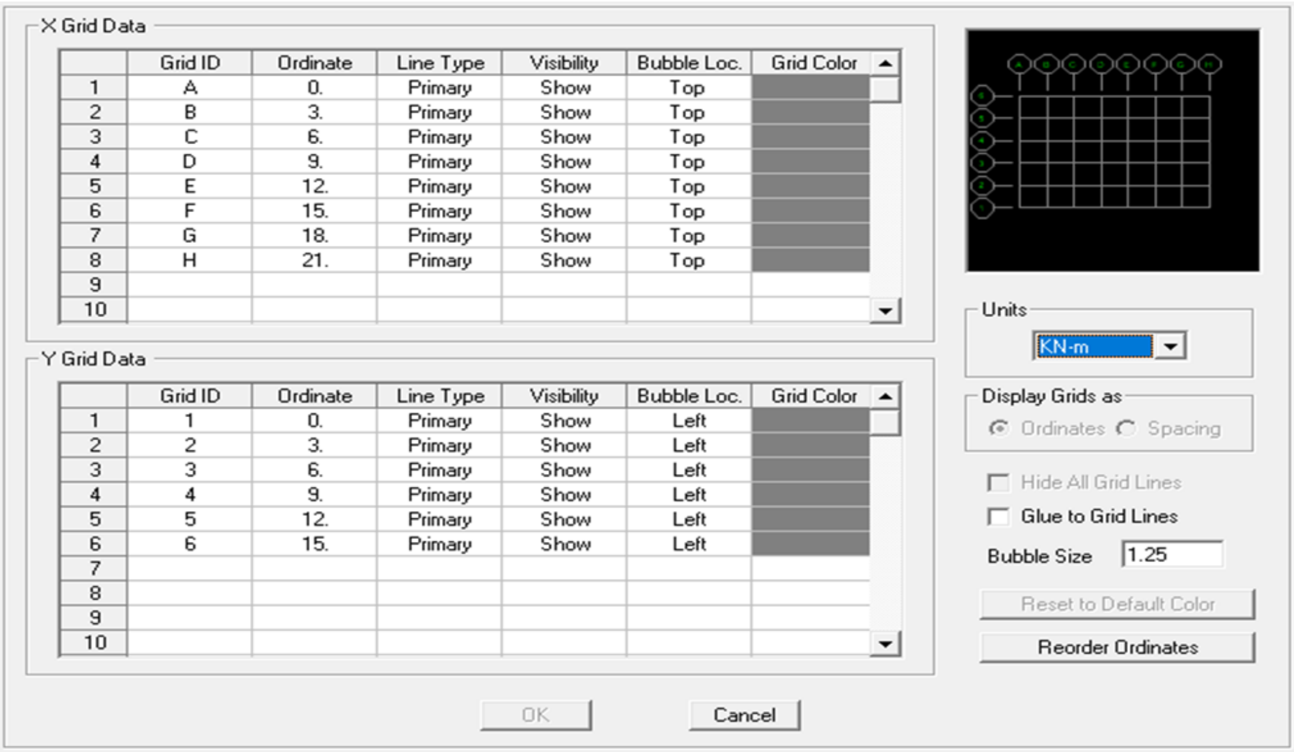
IV. MODELING OF BUILDING IN ETABS SOFTWARE

Problem statement

1. Grade of concrete : M40
2. Grade of Reinforcing steel : HYSD Fe500
3. Dimensions of beam : 230mmX460mm
4. Dimensions of column : 690mmX690mm
5. Thickness of slab : 180mm
6. Steel column :ISWB500
7. Composite column :0.69X0.69 with angle section
8. Height of bottom story : 3m
9. Height of Remaining story : 3m
10. Live load : 5 KN/m^2
11. Dead load : 2 KN/m^2
12. Density of concrete : 25 KN/m^3
13. Seismic Zone : Zone IV
14. Site type : II
15. Importance factor : 1.5
16. Response reduction factor : 5
17. Damping Ratio : 5%
18. Structure class : B
19. Basic wind speed : 44m/s
20. Risk coefficient (K1) : 1.08
21. Terrain size coefficient (K2) : 1.14
22. Topography factor (K3) : 1.36
23. Wind design code : IS 875: 1987 (Part 3)

Building Modeling in ETABS Software


Grid Dimensions (Plan)
Uniform Grid Spacing
Number Lines in X Direction 7
Number Lines in Y Direction 7
Spacing in X Direction 3
Spacing in Y Direction 3
Custom Grid Spacing
Grid Labels...
Edit Grid...
Story Dimensions
Simple Story Data
Number of Stories 16
Typical Story Height 3.
Bottom Story Height 3.
Custom Story Data
Edit Story Data...
Units
KN-m
Add Structural Objects
Steel Deck
Staggered Truss
Flat Slab
Flat Slab with Perimeter Beams
Waffle Slab
Two Way or Ribbed Slab
Grid Only
OK
Cancel


X Grid Data
Grid ID Ordinate Line Type Visibility Bubble Loc. Grid Color
1 A 0. Primary Show Top
2 B 3. Primary Show Top
3 C 6. Primary Show Top
4 D 9. Primary Show Top
5 E 12. Primary Show Top
6 F 15. Primary Show Top
7 G 18. Primary Show Top
8 H 21. Primary Show Top
9
10
Y Grid Data
Grid ID Ordinate Line Type Visibility Bubble Loc. Grid Color
1 1 0. Primary Show Left
2 2 3. Primary Show Left
3 3 6. Primary Show Left
4 4 9. Primary Show Left
5 5 12. Primary Show Left
6 6 15. Primary Show Left
7
8
9
10
Units
KN-m
Display Grids as
Ordinates Spacing
Hide All Grid Lines
Glue to Grid Lines
Bubble Size 1.25
Reset to Default Color
Reorder Ordinates
OK
Cancel

	Label	Height	Elevation	Master Story	Similar To	Splice Point	Splice Height
17	STORY16	3.	48.	Yes		No	0.
16	STORY15	3.	45.	No	STORY16	No	0.
15	STORY14	3.	42.	No	STORY16	No	0.
14	STORY13	3.	39.	No	STORY16	No	0.
13	STORY12	3.	36.	No	STORY16	No	0.
12	STORY11	3.	33.	No	STORY16	No	0.
11	STORY10	3.	30.	No	STORY16	No	0.
10	STORY9	3.	27.	No	STORY16	No	0.
9	STORY8	3.	24.	No	STORY16	No	0.
8	STORY7	3.	21.	No	STORY16	No	0.
7	STORY6	3.	18.	No	STORY16	No	0.
6	STORY5	3.	15.	No	STORY16	No	0.
5	STORY4	3.	12.	No	STORY16	No	0.
4	STORY3	3.	9.	No	STORY16	No	0.
3	STORY2	3.	6.	No	STORY16	No	0.
2	STORY1	3.	3.	No	STORY16	No	0.
1	BASE		0.				

Reset Selected Rows

Height 3. Reset

Master Story No Reset

Simlar To NONE Reset

Splice Point Reset

Splice Height 0 Reset

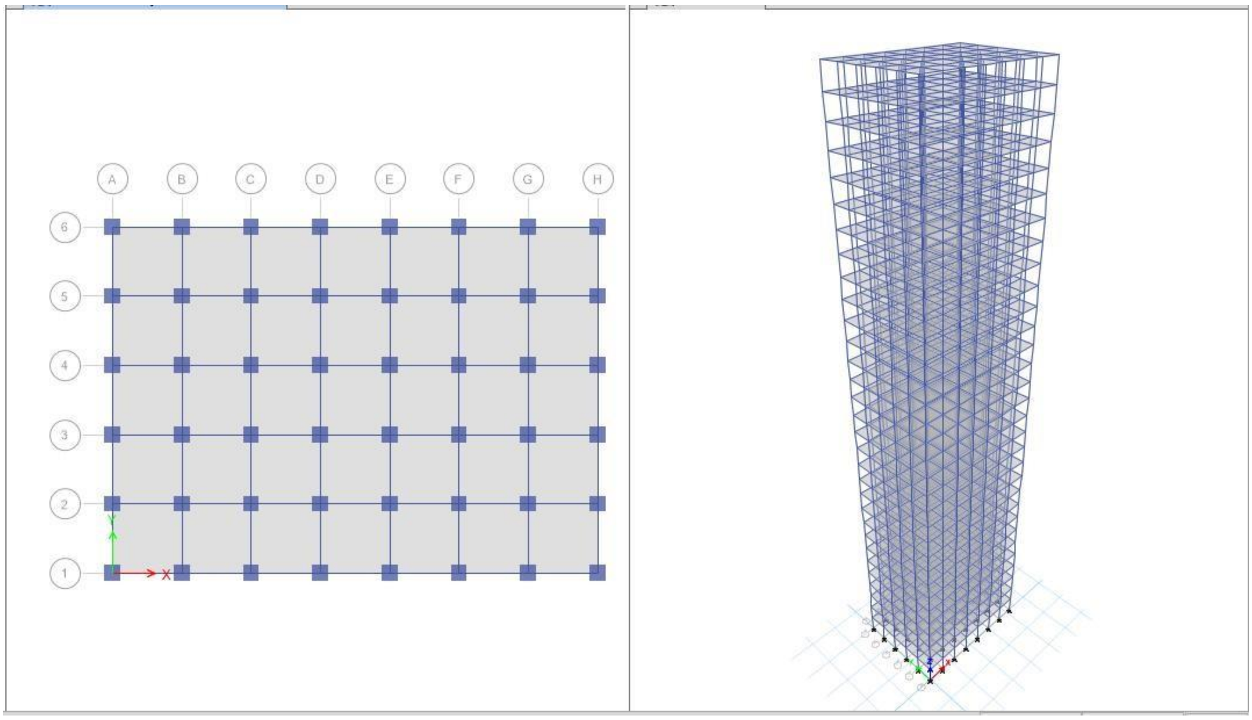
Units

Change Units KN-m

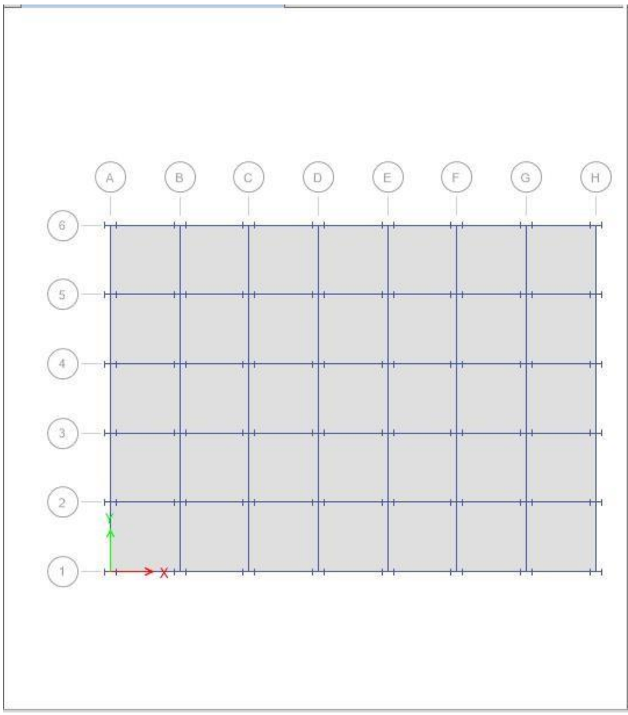
OK Cancel

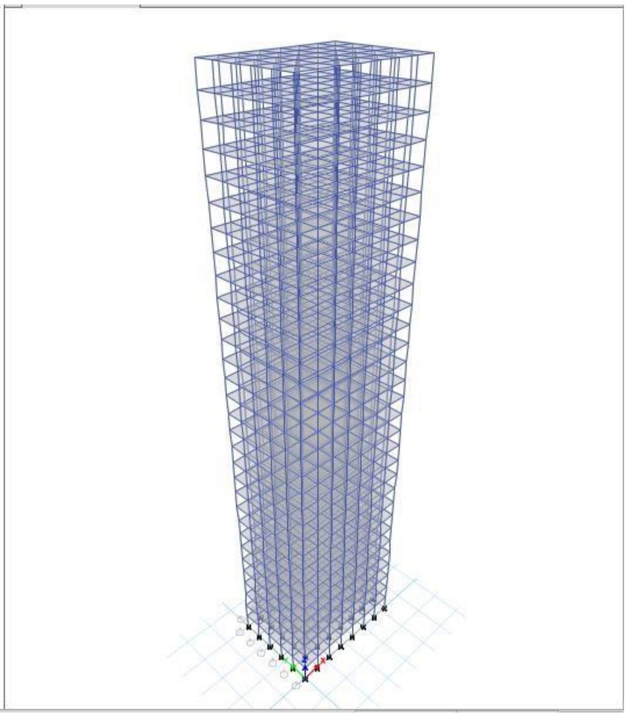
Models in ETABS

RCC Column Building



Steel Column Building

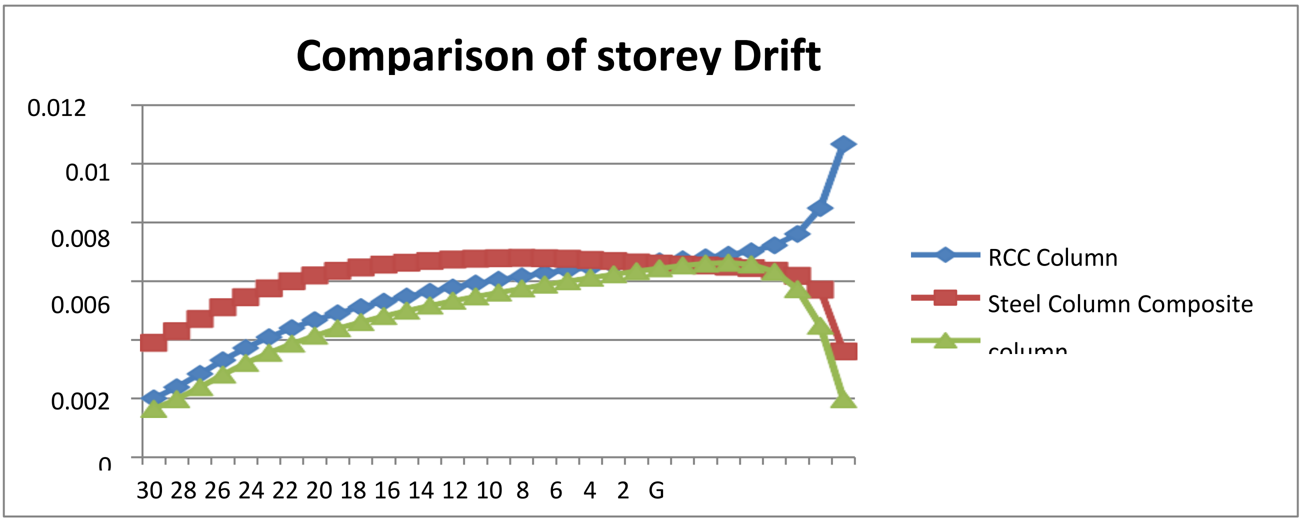




Seismic loading in X Direction Results

Story number	RCC Column	Steel Column	Composite column
30	0.002014	0.003902	0.001655
29	0.002391	0.004298	0.001982
28	0.00285	0.004717	0.002395
27	0.003307	0.005109	0.002818
26	0.003724	0.005457	0.003213
25	0.004091	0.005755	0.003565
24	0.004405	0.006001	0.003875
23	0.004675	0.006197	0.004147
22	0.004909	0.006349	0.00439
21	0.005117	0.006467	0.00461
20	0.005305	0.006557	0.004812
19	0.005478	0.006628	0.004998
18	0.005638	0.006685	0.005169
17	0.005786	0.006731	0.005328
16	0.005923	0.006765	0.005476
15	0.006048	0.006786	0.005616
14	0.006165	0.006792	0.00575

13	0.006273	0.006783	0.005879
12	0.006372	0.00676	0.006002
11	0.006462	0.006724	0.00612
10	0.006542	0.006682	0.00623
9	0.006613	0.006639	0.006336
8	0.006677	0.006598	0.006435
7	0.00674	0.006563	0.006527
6	0.00681	0.00653	0.0066
5	0.006897	0.006493	0.00663
4	0.007019	0.006442	0.006567
3	0.007216	0.006355	0.006323
2	0.007602	0.006186	0.005733
1	0.008481	0.005709	0.004485
G	0.010662	0.003607	0.001985



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CONCLUSISONS

1. The values of story Drift in both X and Y load case is observed as less values for the steel building model than other models (RCC Building and Composite column Building). And the maximum values are obtained from composite column buildings.

2. The values of shear and bending moment and building twist are increases for 30th to bottom story. For the steel column building has less shear and bending values are obtained than the RCC buildings and composite column structures.

3. The maximum values of Base shear is obtained for composite column building than the RCC column and Composite column models in both X direction and Y Direction push over load.

4. For the above points the steel column building has less values of Shear, Bending, Torsion, Story Drift and other factors than the RCC column building, Composite column building..

5. Storey drift in Analysis in X-direction is more for Steel frame as compared to Composite and RCC frames.
6. The differences in storey drift for different stories along X and Y direction are owing to orientation of column sections. Moment of inertia of column sections are different in both directions.
7. Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the steel and the composite frame. Base shear gets reduced by 40% for Composite frame and 45% for Steel frame in comparison to the RCC frame.

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