COMPARISON OF STATIC AND DYNAMIC RESPONSE OF CONVENTIONAL RC AND STAINLESS STEEL ENCASED CONCRETE COLUMN STRUCTURE

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Abstract: in modern period of technology to get maximum advantages of structural member under earthquake is the priority. Composite structure is one option to get the job done. Composite construction is increasing rapidly so the proper dynamic design should be needed to reduce the damage during the earthquake. In this study to fulfil the adjective of reducing the damage of the structure the composite column is used. The column is steel filled/encased concrete type composite column. And the material for steel casing is stainless steel 304 grade is used in modelling. Linear static and linear response spectrum analysis is carried out to study the response of the structure under. In this study the response of the conventional RC structure is compared with the response of the composite structure in which the stainless steel encased concrete column structure. For this analysis the FEM based ETABS software is used and the effect of this composite member is observed.

IndexTerms - Composite structure, composite column, stainless steel, response spectrum, response of building

I. INTRODUCTION

In this study the geometrically symmetric structure is taken under consideration. The structure are design as reinforced concrete (RC) structure and as well as the composite structure to study the response of the structure. Static and dynamic analysis is carried out. In composite structure only the columns are being taken as composite member. The composite column is steel encased concrete type of composite column. To get the batter response under earthquake excitation stainless steel is used as the casing material. Stainless steel is having higher tensile strength then other carbon or mild steel. So it gives good response in building under earthquake excitation.

In dynamic analysis linear response method is carried out. Linear response spectrum analysis gives good results of the structure. The linear spectrum analysis is carried out as per IS 1893-2002 for the conventional reinforced concrete structure and as per ASCE 7-10 for the composite structure. By doing the analysis as per IS 1893-2002 the site condition is taken as soft soil as a class c and in zone III, zone IV and zone V. And by doing same compare parameter for analysis as per ASCE 7-10 the site class taken as E as a soft soil and the location of the site is consider in Florida, Havaii and Alaska.

II. RESEARCH METHODOLOGY

In present work the building on a plane ground surface with G+ 12, G+17 and G+21 stories is modelled in FEM based ETABS software. The size of the beam got the RCC and Composite is same which is 300mm x 530mm, 230mm x 450mm at every floor. The beam placement is typical on every floor of the structure. The size of the column for RCC structure is 300mm x 825mm, 300mm x 750mm and 300mm x 675mm for G+12 structure, 375mm x 975mm, 300mm x 975mm, 300mm x 900mm for G+17 structure, 450mm x 975mm, 375mm x 975mm, 300mm x 975mm for G+21 structure. While for the composite structure the size of composite column (steel encased concrete) is 300mm x 825mm, 300mm x 750mm and 300mm x 675mm for G+12 structure, 375mm x 975mm, 300mm x 975mm, 300mm x 900mm for G+17 structure, 450mm x 975mm, 375mm x 975mm, 300mm x 975mm for G+21 structure. The external casing of composite column is provided of stainless steel grade 304. The thickness of the stainless steel casing is 15mm, 12mm, 9mm taken in modelling. Above mention dimension of the composite column section is including the thickness of the stainless steel casing.

The beams are loaded with the wall load of 5.681 kN/m and the terrace beams are loaded with parapet wall load of 4.6 kN/m. The live load on slab is 2 kN/m2. Static analysis has been carried out for the live and dead load of the structure.

Table 1. Seismic parameter for linear response spectrum analysis

Parameter	IS 1893-2002	ASCE 7-10
Zone	V	Alaska (00001)
Soil class	Soft soil	E(soft soil)
Importance factor	1	1
Response reduction factor (R)	5	6
System over-strength	-	3
Deflection amplification	-	5.5
Tube	-	15mm thick

Parameter	IS 1893-2002	ASCE 7-10
Zone	IV	Hawaii (96701)
Soil class	Soft soil	E(soft soil)
Importance factor	1	1
Response reduction factor (R)	5	6
System over-strength	-	3
Deflection amplification	-	5.5
Tube	-	12mm thick

Parameter	IS 1893-2002	ASCE 7-10
Zone	III	Florida (00041)
Soil class	Soft soil	E(soft soil)
Importance factor	1	1
Response reduction factor (R)	5	6
System over-strength	-	3
Deflection amplification	-	5.5
Tube	-	9mm thick

The necessary mass of the building are consider in the model analysis of the structure. The total number of modes are consider in such a way that model participation factor is more than 90% and model analysis consider 12 modes has been carried out.

The linear static response spectrum function is also applied in the ETABS software. As per IS 1893-2002 and ASCE 7-10 the response spectrum function are applied using following details.

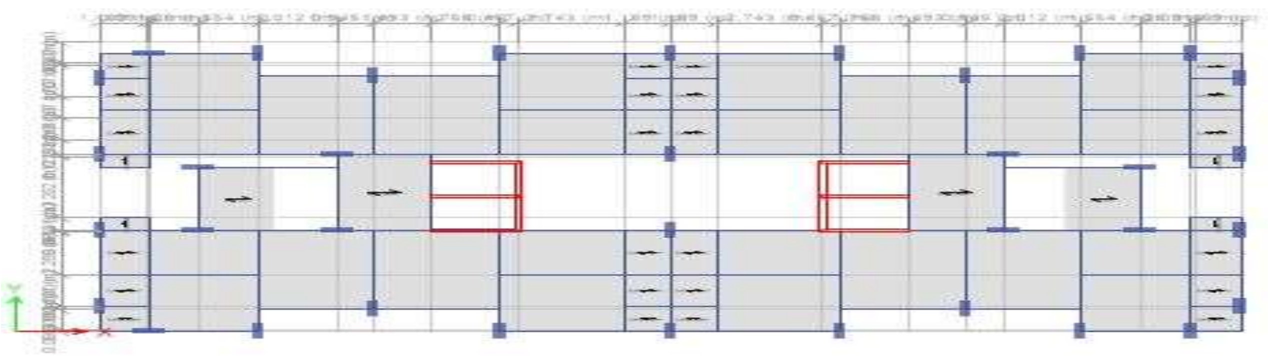

Fig 1 : Plan of structure in RCC and composite structure

For conventional and composite structure model the typical floor plan is shown in Fig 1. For both the structure the placement of above mention beams and columns section is same in model.

The cross section of reinforced concrete column and stainless steel encased concrete column are shown in Fig 2 and Fig 3 respectively.

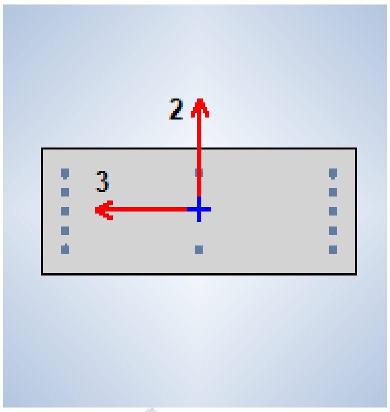

Fig 2 : Cross section of reinforced concrete column

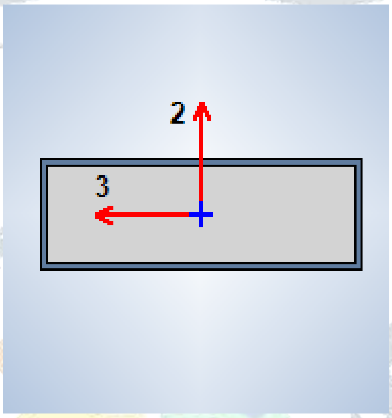

Fig 3 : Cross section of stainless steel encased concrete column

Here in this study stainless steel grade 304 [3] [4] material is used in casing material. Tensile strength of the stainless steel grade 304 is 515 Mpa and the yield strength is 205 Mpa. These properties of the stainless steel are higher than the other mild steel sections which are being used as structural steel in composite construction. According to these properties of the stainless steel it can be used in structural steel. Stainless steel casing provide confinement effect to the column.

According to the above mention modelling and data the static and dynamic analysis is carried out

III. RESULTS AND DISCUSSION

The linear static and linear response spectrum analysis has been carried out. Total base shear due to dead load and live load and the time period of the first 12 modes are plotted and shown in Fig. 4 and Fig. 5 respectively. Comparison of the response of the structure under bidirectional earthquake excitation is shown in graphical representation below in Fig 4 to Fig 21.

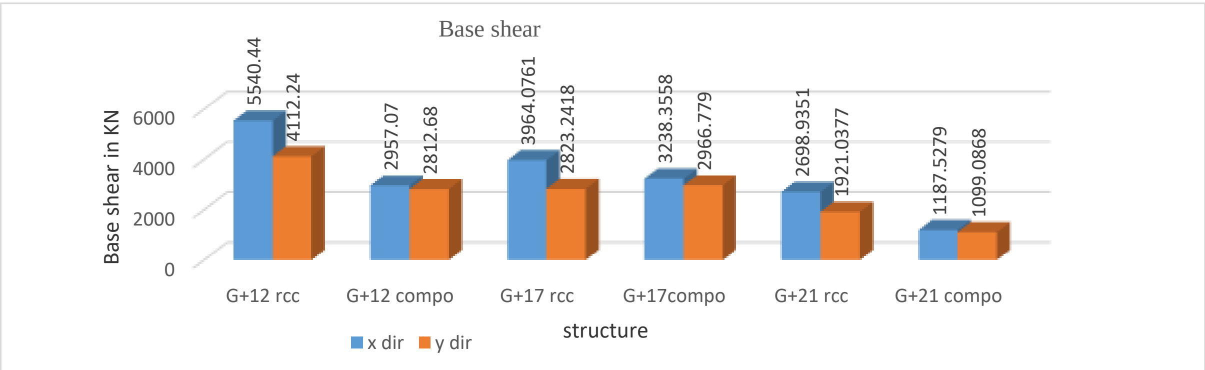

Fig 4 : Base shear comparison

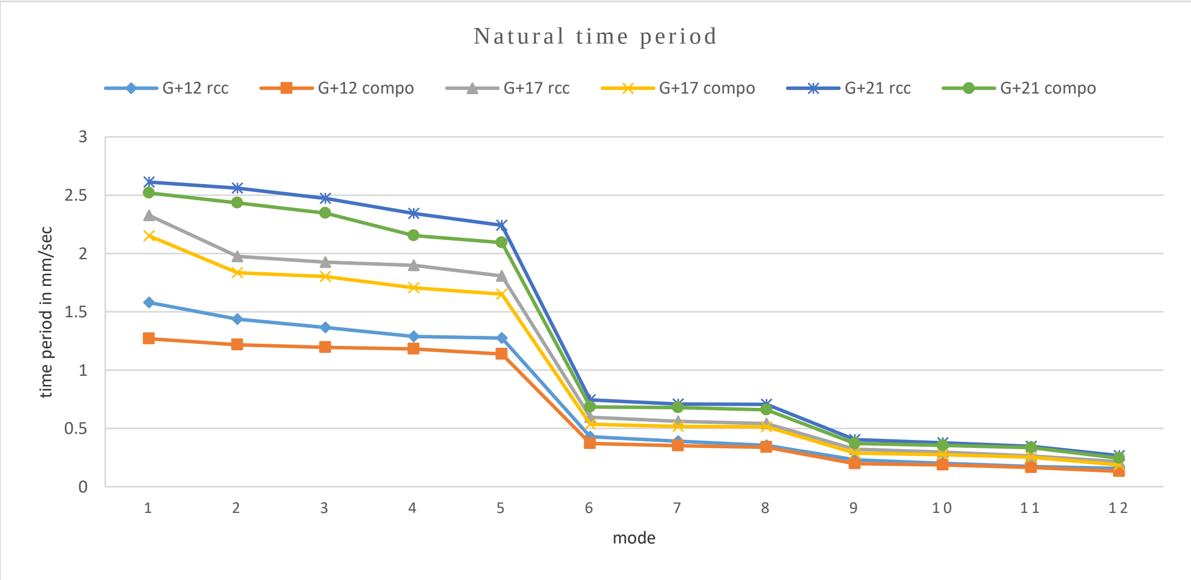

Fig 5 : Time period comparison

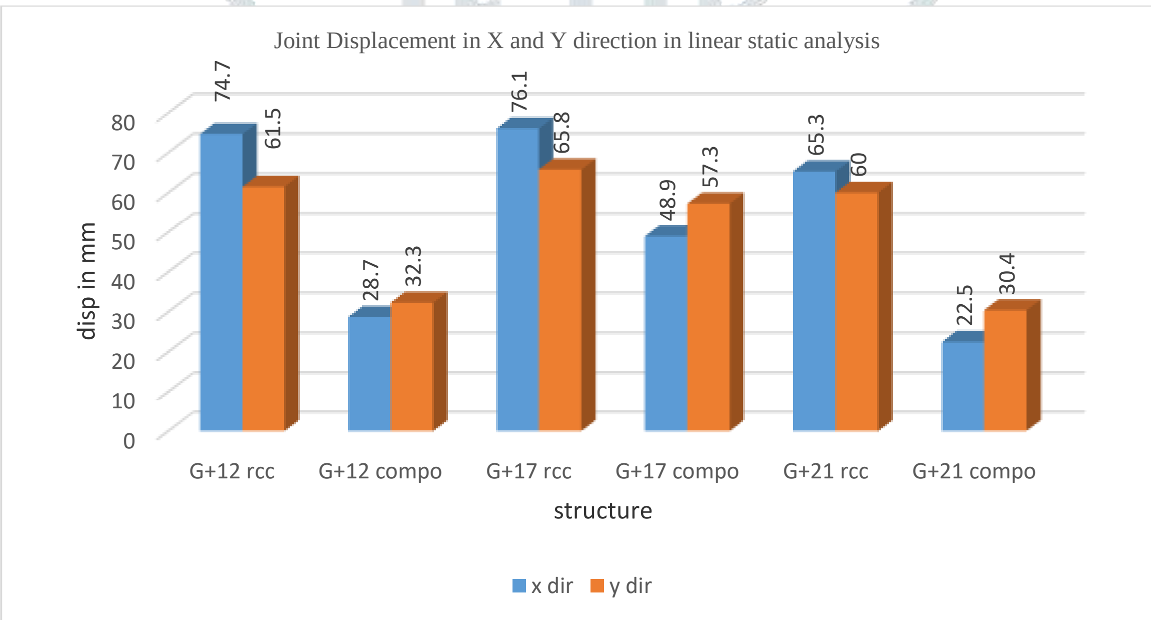

Fig 6 : Joint displacement in linear static analysis

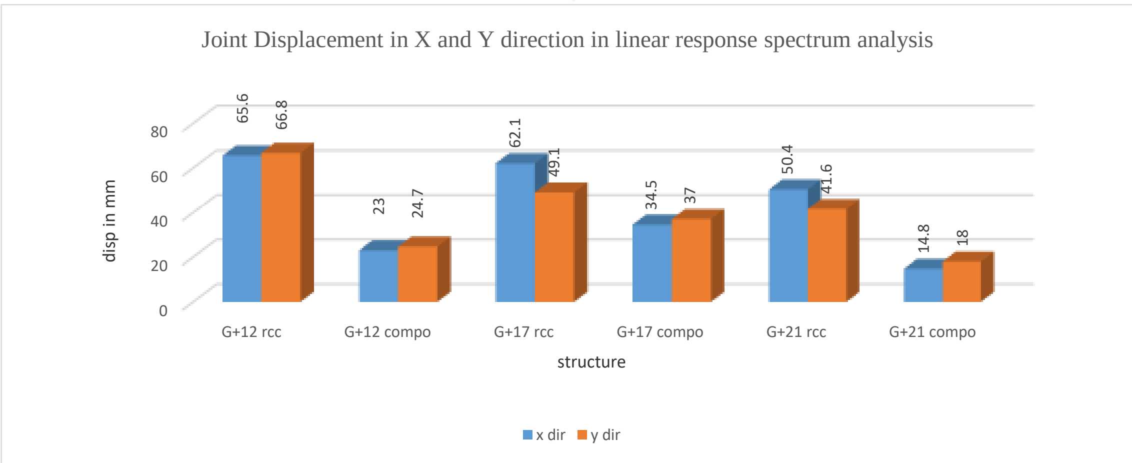

Fig 7 : Joint displacement in linear response spectrum analysis

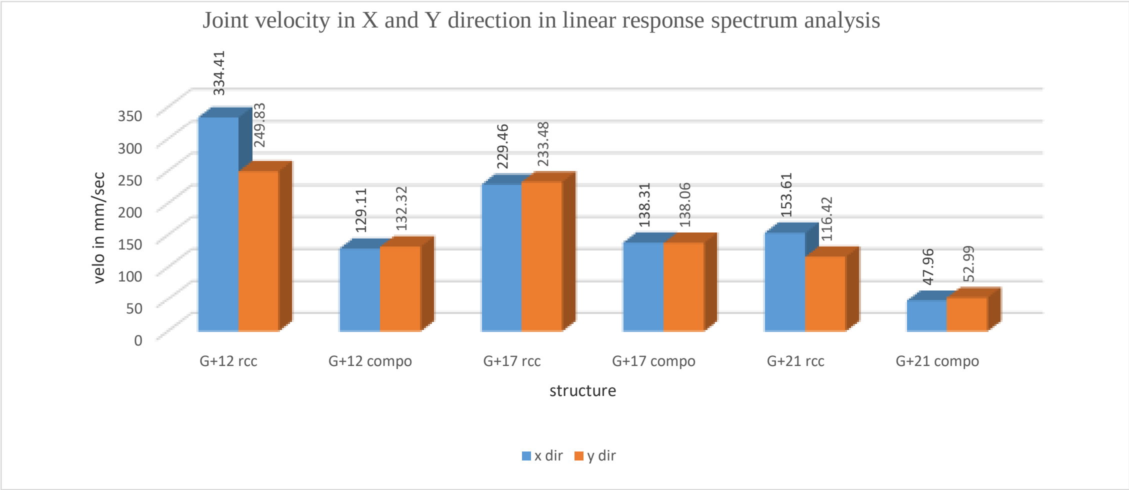

Fig 8 : Joint velocity comparison

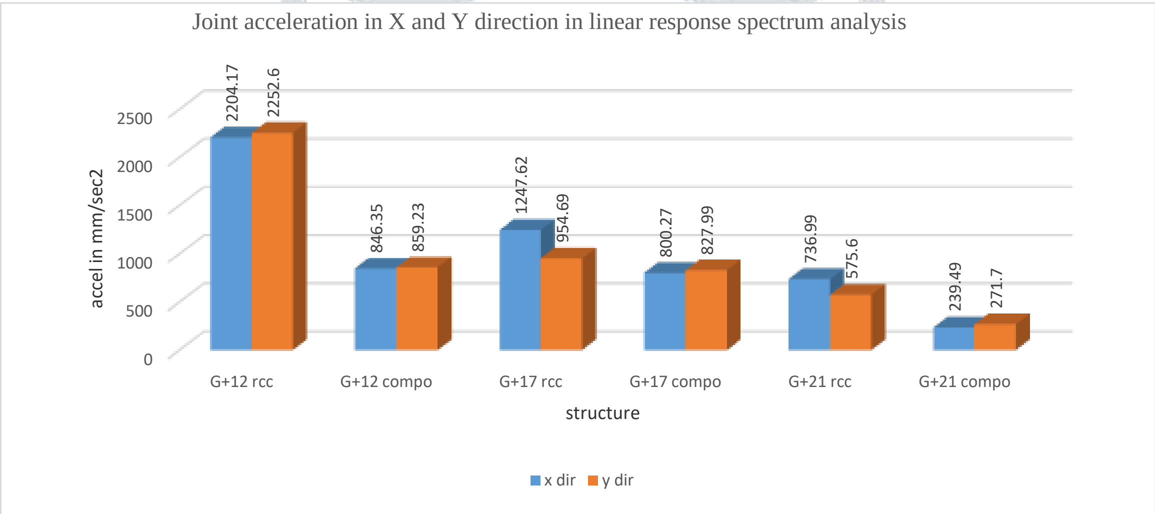

Fig 9 : Joint Acceleration comparison

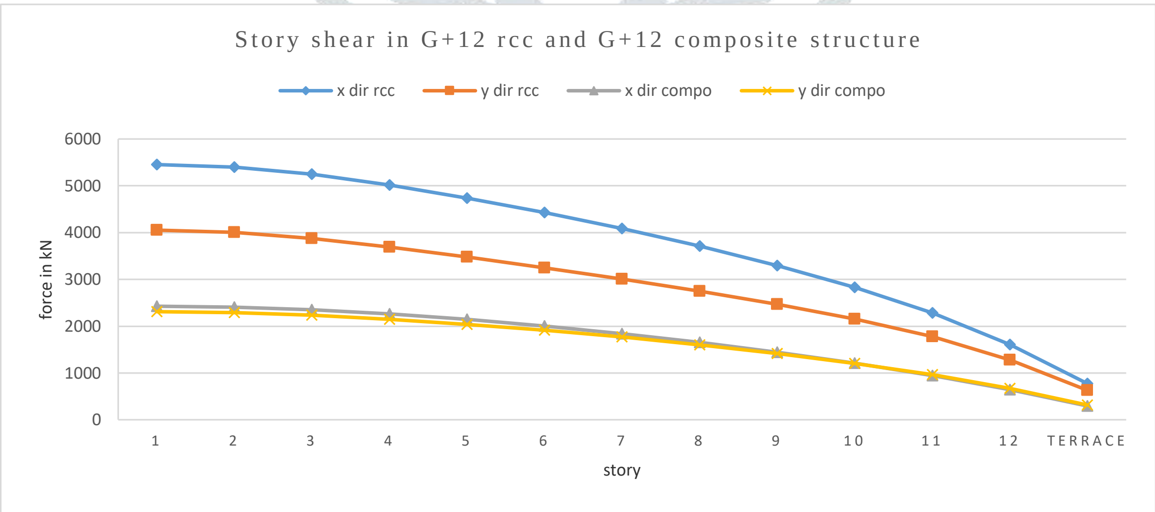

Fig 10: Story shear of G+12 RCC and G+12 Composite structure

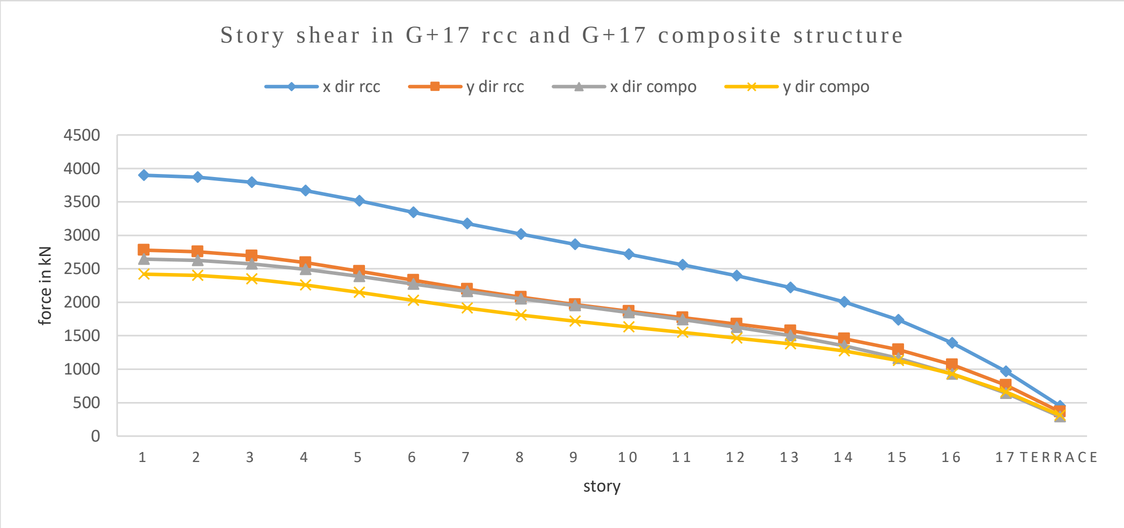

Fig 11: Story shear of G+17 RCC and G+17 Composite structure

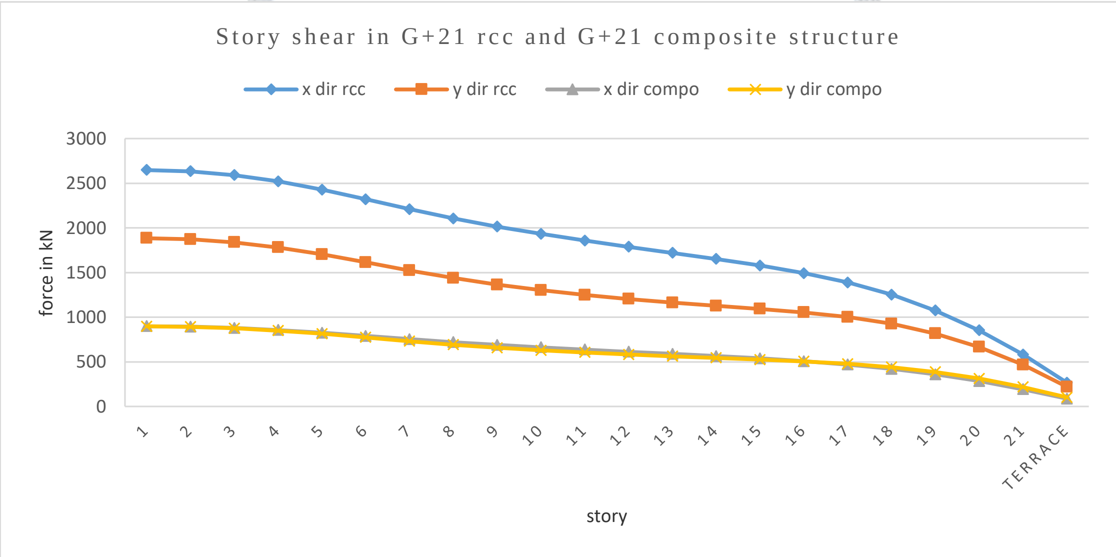

Fig 12: Story shear of G+21 RCC and G+21 Composite structure

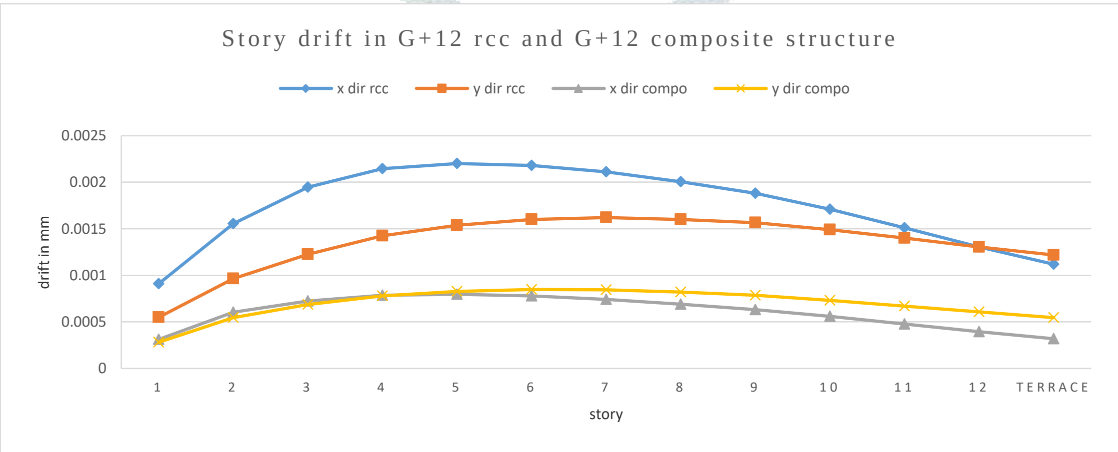

Fig 13: Story drift of G+12 RCC and G+12 Composite structure

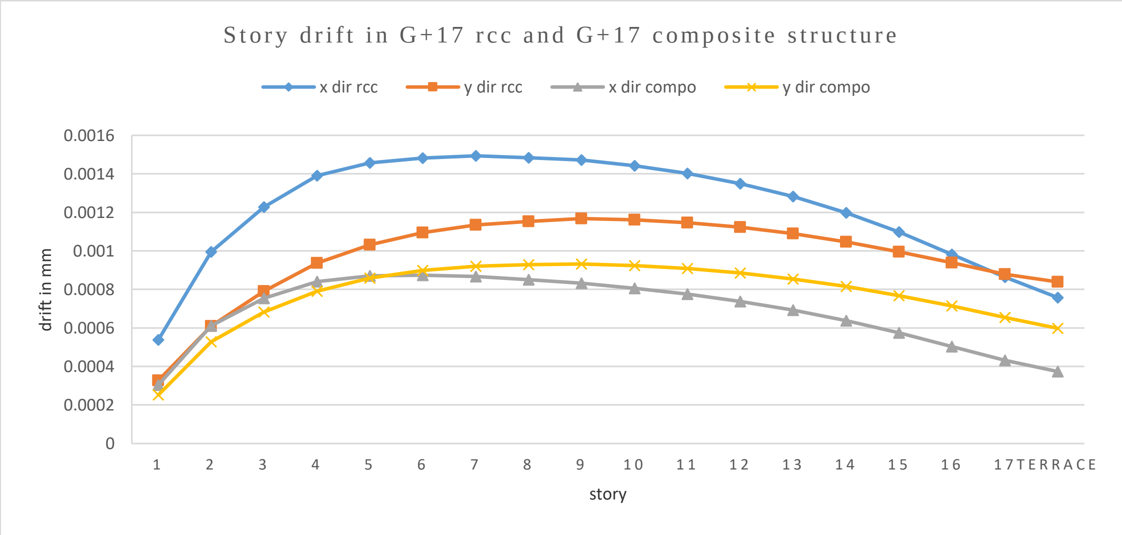

Fig 14: Story drift of G+17 RCC and G+17 Composite structure

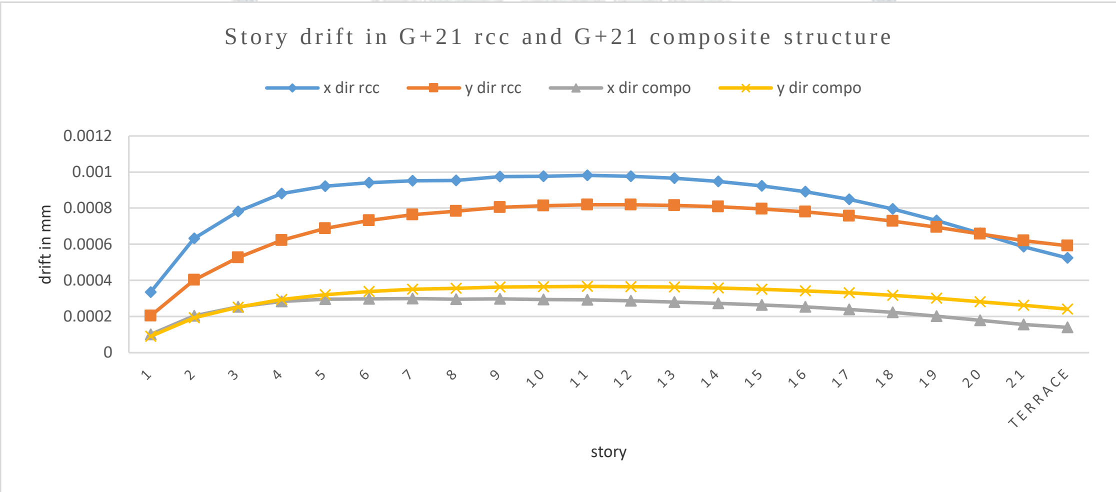

Fig 15: Story drift of G+21 RCC and G+21 Composite structure

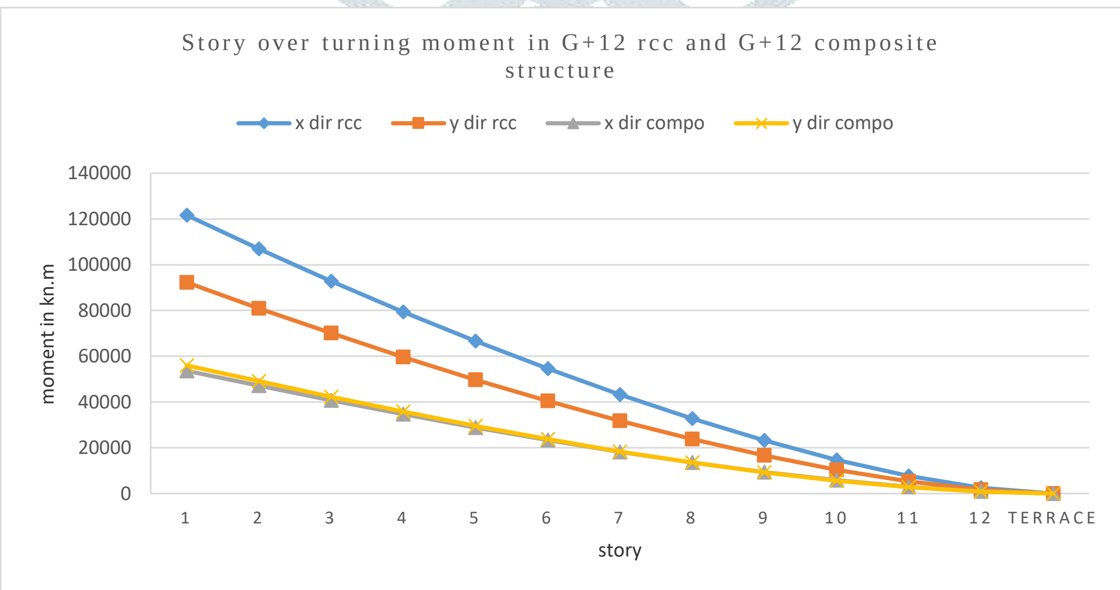

Fig 16: Story over turning moment of G+12 RCC and G+12 Composite structure

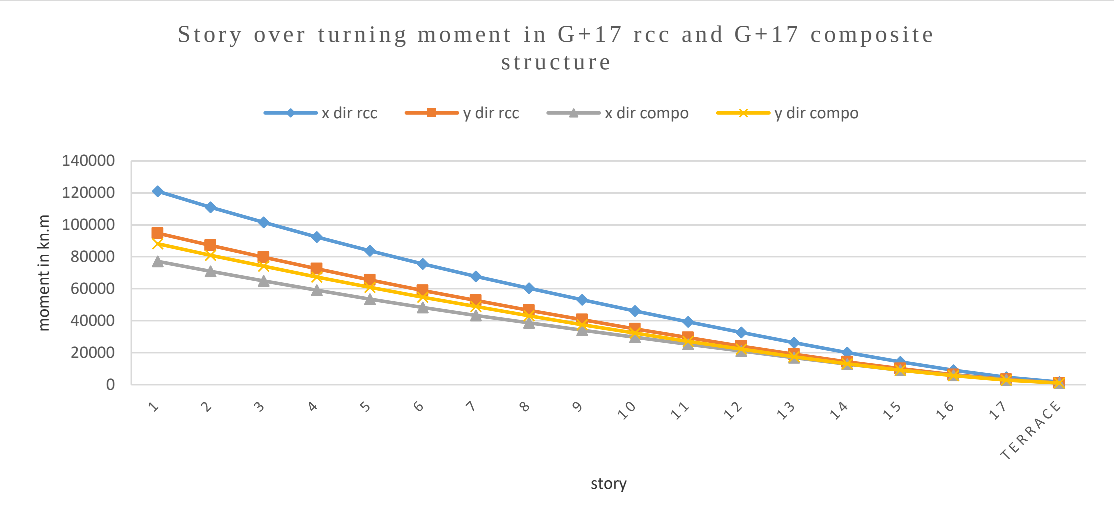

Fig 17: Story over turning moment of G+17 RCC and G+17 Composite structure

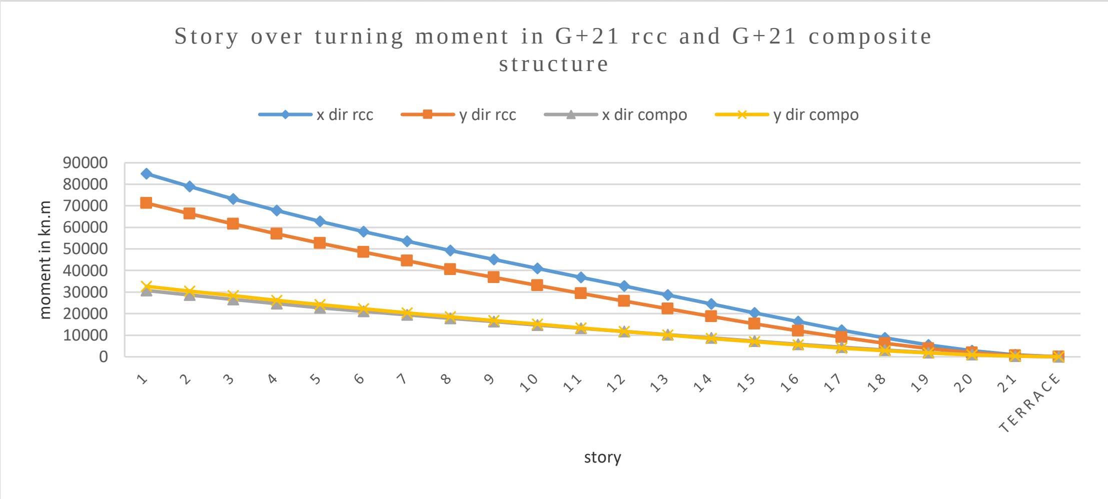

Fig 18: Story over turning moment of G+21 RCC and G+21 Composite structure

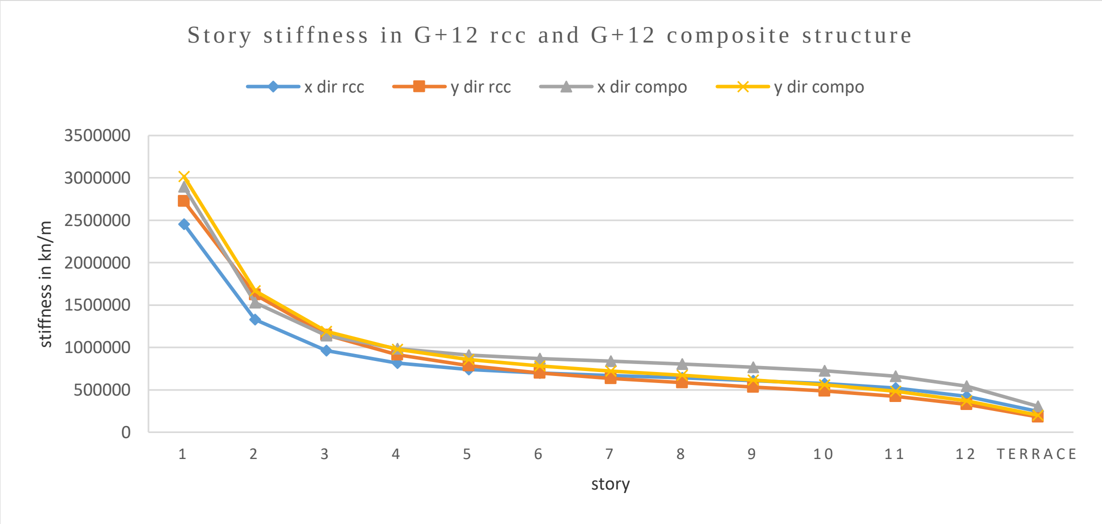

Fig 19: Story stiffness of G+12 RCC and G+12 Composite structure

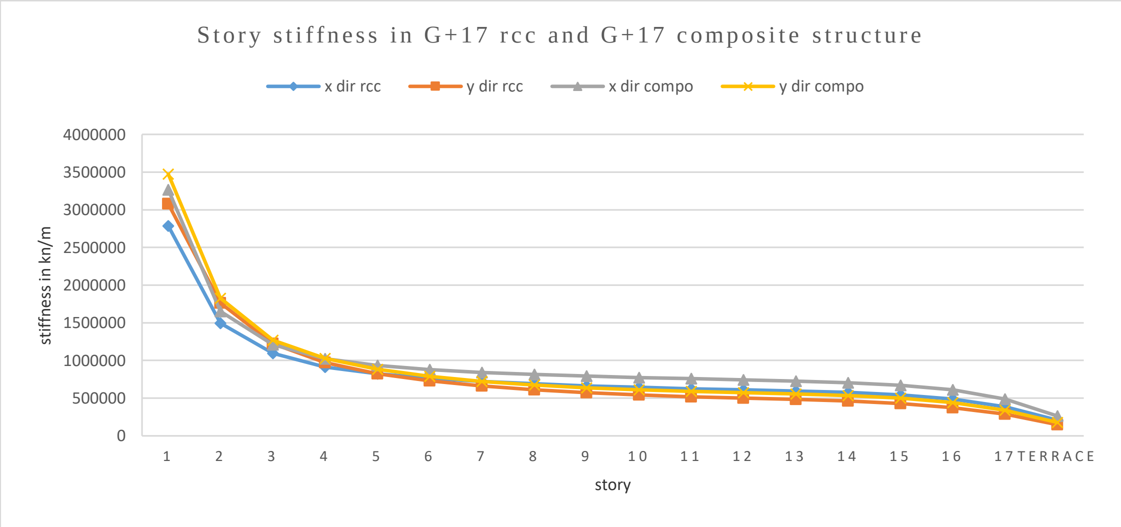

Fig 20: Story stiffness of G+17 RCC and G+17 Composite structure

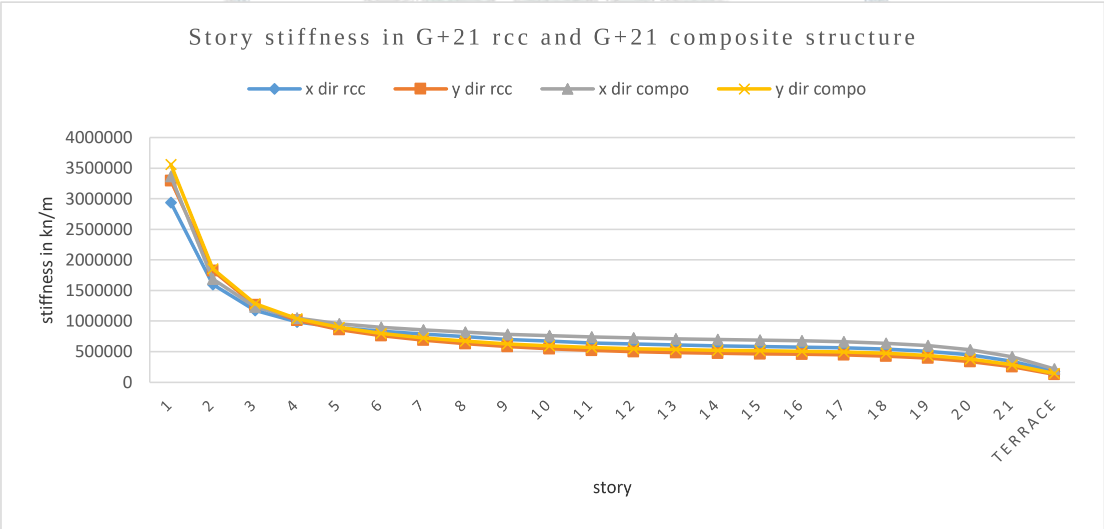

Fig 21: Story stiffness of G+21 RCC and G+21 Composite structure

IV. COST COMPARISON

Table 2 – Material list by G+12 structure

Element Type	Material	Pieces	Total Weight In R.C.C(kN)	Total Weight In CES(kN)
COLUMN	M20	468	7807.4438	-
COLUMN	SS-304	468	-	9765.738

According to the comparison of results, the cost of total weight of composite structures is significantly increased by 25.08% than the RCC structure in G+12 structures.

V. CONCLUSIONS

- According to the comparison of results, the base shear of the composite structures is significantly reduced by 46.62%, 18.30%,60% than the base shear of the RCC structure in X direction respectively in G+12,G+17 and G+21 structures.

- According to the comparison of results, the base shear of the composite structures is significantly reduced by 31.60%, 5.08%,42.78% than the base shear of the RCC structure in Y direction respectively in G+12,G+17 and G+21 structures.
- No significant changes are observed in natural time period of different modes of the structure.
- Results comparison in linear static analysis shows that under the same seismic parameter for the both type of structures, the reduction in response of joint displacement obtained are 61.57%,35.74%,65.54% in G+12,G+17 and G+21 story structure respectively in X direction.
- Results comparison in linear static analysis shows that under the same seismic parameter for the both type of structures, the reduction in response of joint displacement obtained are 47.47%,12.91%,49.33% in G+12,G+17 and G+21 story structure respectively in Y direction.
- Results comparison for joint displacement in linear response spectrum analysis shows that there is about 64.93%, 44.44%,70.63% reduction in maximum joint displacement in G+12,G+17,and G+21 story composite structures than the RCC structure in X direction respectively.
- Results comparison for joint displacement in linear response spectrum analysis shows that there is about 63.02%, 24.64%,56.73% reduction in maximum joint displacement in G+12,G+17 and G+21 story composite structures than the RCC structure in y direction respectively.
- On comparing joint velocity response at G+12,G+17 and G+21 story, the reduction in joint velocity obtained are 61.39%,39.72%,68.77% respectively in X direction.
- On comparing joint velocity response at G+12, G+17 and G+21 story, the reduction in joint velocity obtained are 47.03%,40.86%,54.48% respectively in Y direction.
- On comparing joint acceleration response at G+12,G+17 and G+21 story, the reduction in joint acceleration obtained are 61.60%,35.85%,67.50% respectively in X direction.
- On comparing joint acceleration response at G+12, G+17 and G+21 story, the reduction in joint acceleration obtained are 61.85%,13.27%,52.79% respectively in Y direction.
- According to the comparison of the story shear results, in composite structure the story shear are reduced by 55.50% to 43%, 32.11% to 12.90% and 66% to 52.31% in X and Y both direction than the result of conventional structure and story drift results, in composite structure the story drift are reduced by 63.75% to 46.13%,41.96% to 18.87%,70.36% to 55.25% in X and Y both direction than the result of story drift in conventional reinforced concrete structure.
- On comparing Story over turning moment response at G+12,G+17 and G+21 story, the Story over turning moment obtained are reduced by 55.91%,36.17%,63.79 and reduced by 39.14%,7.02%,54.11% respectively in X and Y direction.
- On comparing Story stiffness response at G+12,G+17,G+21 story, the increase in Story stiffness obtained are 17.92%,17.31%,14.77% and 10.63%,12.80%,8.10% respectively in X and Y direction.

From above statements we can conclude that the composite structure with stainless steel encased concrete column significantly have better seismic response than the conventional reinforced structure under bidirectional earthquake excitation. It will give excellent response in severe earthquakes.

VI : ACKNOWLEDGEMENT

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