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ANALYSIS AND DESIGN OF PESTICIDE PROCESSING PLANT STRUCTURE AND COMPARATIVE STUDY ON RCC COLUMNS AND COMPOSITE COLUMNS

P Akash[1], C Sashidhar[2], B Sreenivas[3]

1 PG Scholar, Department of Civil Engineering, Jawaharlal Nehru Technological University Anantapur, Anantapuramu, India,
2 Professor, Department of Civil Engineering, Jawaharlal Nehru Technological University Anantapur, Anantapuramu, India
3 Managing Director of BUTLAS Consulting Engineers Pvt Ltd, Hyderabad, India

Abstract- In this paper a multi storied Pesticide Processing Plant structure is considered and it is analysed and designed with every one of the parameters. The analysis and design was done according to the standard specifications to the potential extend. Composite members are structural members composed of steel and concrete. It combines the advantages of both concrete and steel. In recent years, composite columns are gaining popularity over conventional reinforced concrete (RC) columns for high-rise construction because of its higher strength-to-weight ratios, better fire resistance, better ductility, structural integrity, durable finishes, dimensional stability and sound absorption. The analysis of RCC and steel structure was done using the software package "STADD PRO".V8i and the analysis of Composite columns was done using the software package E.TABS. All the structural components were designed using Staad pro, E.tabs and MS-excel. The detailed reinforcement was done in AutoCAD 2016. These multiple software's are used to saving time and to takes values on safer side than manual work. Composite individuals are auxiliary individuals made out of steel and cement. It joins the upsides of both cement and steel. As of late, composite sections are picking up fame over regular fortified cement (RC) segments for skyscraper development in light of its higher solidarity to-weight proportions, better imperviousness to fire, better malleability, auxiliary honesty, tough completions, dimensional steadiness and sound retention. The investigation of RCC and steel structure was finished utilizing the product bundle STADD PRO.V8i and the examination of Composite sections was finished utilizing the product bundle E.TABS. All the basic segments were structured utilizing Staad professional, E.tabs and MS-exceed expectations. The nitty gritty support was done in AutoCAD 2016. These different programming's are accustomed to sparing time and to takes esteems on more secure side than manual work.

Keywords: RCC columns, FEC Composite columns, story drift, typical load combinations.

1 INTRODUCTION

In Industrial Plants like Oil & Gas, Petrochemicals, Refinery etc. Process Industrial Building structures which carries major Equipment's and Pipes carryings liquids or gases from one Equipment to another Equipment, Cable trays with service platforms and walkways. Process Building Structures are important structures in Industrial Plants and hence detail planning and study are essential for any industrial projects. As the majority of material involves, there will be cost impact on the project and hence optimization is required. The structures with RCC Columns and Composite columns are studied and comparative study is carried out. In India, the majority of the structures are made with Reinforced Cement Concrete regardless of category or reason for the Building or Structures. But in event of Industrial structure, the scenario is different and they are constructed both with Reinforced Cement Concrete and Structural Steel. The structure in particular Pesticide preparing plant which involves the structural components foundation, columns, beams, slabs, trusses, pipe racks, staircase, steel sections, etc. Reviews and studies demonstrations that composite construction impressively decreases the gravity load as compare to RCC. composite is perfect and complimentary to each other; they have ideal combination as, steel in tension and concrete in compression, concrete protect the steel from corrosion as well as it gives thermal insulation to embedded Steel, though they have almost same thermal expansion. The comparison is made between RCC columns and composite columns.

2. STRUCTURE INFORMATION

2.1 General

Analysis has been carried out through STAAD Software and design is done by using IS:456-2000 Limit State Method[2]. STAAD model has been done by considering Plant North upward Direction (Along Z-axis). The building is combination of all aspects of construction. It is a G+3 RCC structure and on terrace the steel structure is located with combination of trusses, purlins and steel slabs. The height of RCC structure is 20 m and total height with steel structure is 36 m. The base area of the structure is 836 m^2. The structure system consists of RCC conventional beam slab arrangement. Following points are covered in this paper are given bellow.

- Planning of various components of a building.
- Study of design of various elements of building.
- Modelling of the building in the STAAD-Pro giving all boundary conditions (supports, loadings etc.,).
- Analysis and design of various structural components of the modal building.
- Designing a fully encased concrete Composite column and comparing with the R.C.C. column.
- Detailing of beams, columns, slab with section proportioning, structural steel and reinforcement.
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3. MODELING AND ANALYSIS OF THE BUILDING

3.1 General

For any engineering project, structural analysis is an integral part. For this process prescribed loading conditions are assigned to know the structure performance. The performance characteristics usually of interest in the design are

1. Stress or stress resultants (axial force, shears and bending moment)
2. Deflections
3. Support reactions

3.2 Soil Profile

In the construction site, after the results of lab tests and borehole log chart of boreholes 1, 2, 3 and 4 designate that the strata at the site are found to comprise of cohesive soil only. The cohesive type soil comprises of silty clay soil of medium plasticity and compressibility have its place to ‘‘CI’ group of IS classification and having 87 to 99 percent material finer than75 micron. The results of classification tests indicate that the natural soil stratum present at the Site is found to comprise of both fine-grained soils (clayey soil). According to the soil report, shallow foundations are not apt to this structure because of heavy column loads, very poor subsoil condition and high water table. Deep foundations are best for this condition of the soil. So for these structures, Pile-Raft foundation system is adopted.

3.3 Preliminary Design

In this condition, the preliminary dimensions of beams, columns and slabs are considered. Then the procedure for preliminary design of slabs, beams and columns are described briefly as follows.

3.4 Composite column:

“A steel-concrete composite column is a compression member, containing both of a concrete-encased hot rolled steel section or a concrete filled the hollow section of hot rolled steel”. They are generally utilized as a heap bearing member in a composite framed structure. Composite members are predominantly exposed to compression and twisting. At present, there is no “Indian standard code” covering the plan of the composite column. The strategy for structure in this report to a great extent pursues EC4, which joins the most recent research on composite construction.” Indian standard” for composite construction “IS 11384-1985” does not make any particular reference to composite columns. This strategy additionally the European bucking curves for steel columns as a basic of column design.

3.4.1 Composite column Advantages:

1. They increasing the strength for given cross-sectional measurements.
2. They increased stiffness, prompting to reduced slenderness and increased bulking opposition.
3. Good imperviousness to fire and corrosion resistance encased column.
4. Significant financial focal points over either unadulterated basic steel or fortified concrete options.
5. Identical cross areas with various load and minute protections can be delivered by shifting steel thickness, the concrete strength, and reinforcement. This permits the external elements of a section to be held consistent over various floors in a building, in this way disentangling the construction and architectural itemizing.
6. Erection of elevated structure in an exceptionally proficient way.
7. Formwork isn't required for concrete filled rounded areas.

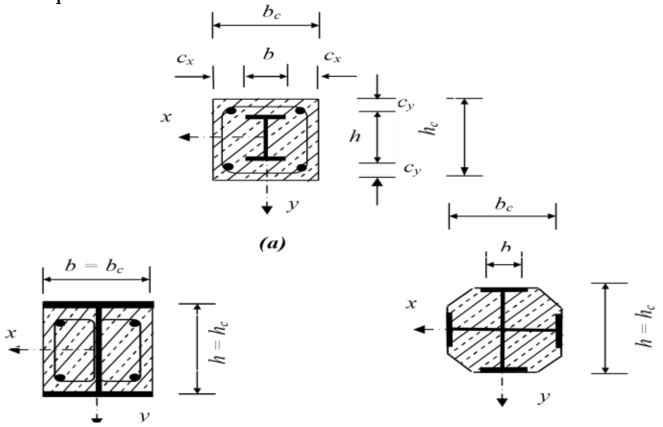

FIG 1: Typical cross - sections of fully and partially concrete encased columns

3.5 Specifying loads

The live loads and dead loads on the slabs were specified as floor loads, seismic loads were applied as nodal forces and wall loads were specified as member loads. All the equipment loads and pipe loads are applied on the slabs. Wind loads are defined in the Staad pro itself. According to IS codes all the load combinations were assigned. For analysis the various loads were considered

- Lateral Loads : As per the IS:1893 (part I): 2002 seismic loads are calculated and wind loads are from IS: 875 (part III)
- Vertical Loads : As per IS : 875 (part II)- 1987, the vertical loads of the building dead load and live load. Dead loads includes, self-weight of columns, beams, slabs, brick walls, floor etc.

TABLE 1: STRUCTURE DETAILS

Particulars	RCC structure	Composite structure
Plan dimension	22m x 38m	22m x 38m
Total height	38 m	38 m
Size of beam	300mm x 450 mm 400mm x 600mm	300mm x 450 mm 400mm x 600mm
Size of column	600mmx600mm	Fully Encased Column 400mm x 450mm
Slab thickness	150 mm	150 mm
Dead load	4 KN/m^2	4 KN/m^2
Live load	5 KN/m^2	5 KN/m^2
Seismic zone	III	III
Response reduction factor	3.0	3.0
Importance factor	1.5	1.5
Zone factor	0.16	0.16
Soil type	Soft soil	Soft soil
Grade of concrete	M25	M25
Grade of reinforcing steel	Fe500	Fe500
Grade of structural steel	-----	Fe250
Density of concrete	25 KN/m^3	25 KN/m^3
Density of brick masonry	20 KN/m^3	20 KN/m^3
Damping ratio	5%	5%

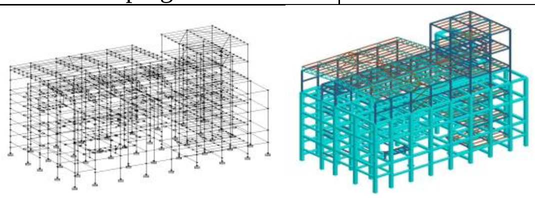

FIG 2: Isometric view and 3D view of the building

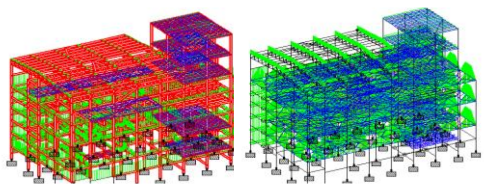

FIG 3: Dead load and Live load on all floors

3.5.1 Equipment operating load

- Equipment operating load considered as per Equipment load list provided by the Indian Pesticides Limit. And the equipment loads are analysed in three different conditions. They are
  1. Equipment Empty Load (EE)
  2. Equipment Operating Load (EO)
  3. Equipment Testing Load (ET)

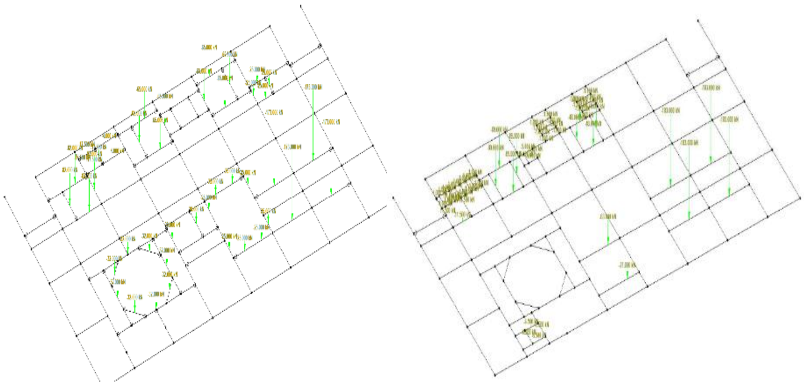

FIG 4: Equipment operating load at +7.00m and +14.00 level

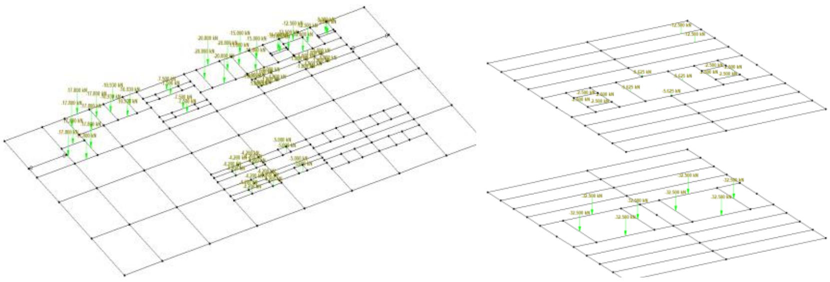

FIG 5: Equipment operating load at +20.00m and +25.00 level and +30.5

3.5.2 Pipe Load

In the analysis of pipe loads, the Pipe loads of the building is considered as follows

- Pipe rack load considered as 3.5 KN/m^2
  Spacing of the support = 5m
  Load on the member due to pipe rack = 3.5x5 = 17.5KN/m
- Cable tray load considered as 2.5 KN/m^2
  Spacing of the support = 5m (Approx. for loading
  Load on the member due to pipe rack = 2.5x5 = 12.5KN/m

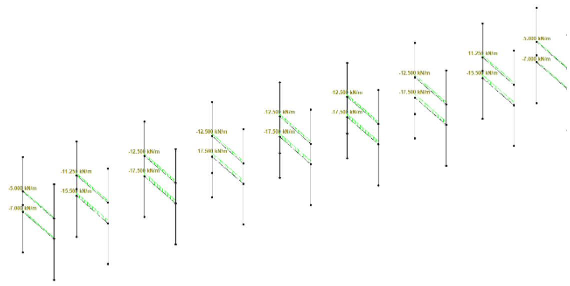

FIG 6: Pipe rack and cable tray load

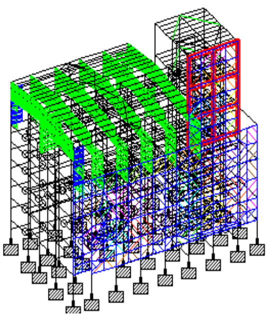

FIG 7: Wind loads in Z direction on all floors

3.5.3 Wind Loads

Wind load calculations calculated as per IS: 875-1997 part III,
Basic wind speed Vb = 47 m/s (Lucknow)
The Design wind pressure (Pz) shall be obtained by the following relationship between wind pressure and wind speed:

$$P_z = 0.6 \times V_z^2$$

Where:
Vz = Design Wind Speed in m/s at height Z.

The design wind speed (Vz), mathematically expressed as follows:

$$V_z = V_b * k_1 * k_2 * k_3$$

Where:
Vb= Basic wind speeds in m/s (Appendix A, IS: 875-1997 part III)
K1= Probability factor or risk coefficient. (Table-1, IS: 875-1997 part III)
K2= Terrain, height and structure size factor. (Table-2, IS: 875-1997 part III),
(Consider Terrain category 2 and Class B)
K3= Topography factor. (Cl. 5.3.3.1, IS: 875-1997 part III)

TABLE 2: CALCULATIONS OF WIND SPEED AND WIND PRESSURE

S.No	Height (m)	Basic wind speed (Vb) m/s	k1	k2	k3	Design wind speed, (Vz = Vbxk1xk2xk3) m/s	Design wind pressure, $P_z = 0.6V_z^2$ (kN/m^2)
1	10	47	1.00	1.00	1.00	46.06	**1.27**
2	15	47	1.00	1.05	1.00	47.94	**1.38**
3	20	47	1.00	1.07	1.00	49.35	**1.46**
4	30	47	1.00	1.12	1.00	51.70	**1.60**
5	36.2	47	1.00	1.14	1.00	52.17	**1.63**

External pressure co-efficient (Cpe) for walls of Rectangular clad buildings,
Height of the building h, = 36.20m
Width of the building w, = 22.0m
Length of the building l, = 38.0m
Building height ration = h/w = 36.2/22 = 1.645 > 1.5 and < 6
Building plan ratio = l/w = 38/22 = 1.72 > 1.5 and < 4
Internal pressure co-efficient (Cpi) considered as ±0.7 since the openings area is greater than 20% of total wall area.

Wind load, F = (Cpe-Cpi) x A x Pd

Where,
Cpe = External pressure coefficient
Cpi = Internal pressure coefficient
A = Surface area of structural element or cladding unit, and
Pd = Design wind pressure

3.5.4 Load Combinations

Design of the structures would have become highly expensive in order to maintain either serviceability and safety if all types of forces would have acted on all structures at all times. Accordingly the concept of characteristics loads has been accepted to ensure at least 95 percent of the cases, the characteristic loads considered will be higher than the actual loads on the structure. However, the characteristic loads are to be calculated on the basis of average/mean load of some logical combinations of all loads mentioned above. IS 456:2000 and IS 1893 (Part1):2002 stipulates the combination of the load to be considered in the design of the structures.

Load combinations for Serviceability	**Load combinations for Strength**
1.0DL+1.0EO+1.0PO	1.5DL+1.5EO+1.5PO
1.0DL+1.0LL+1.0EO+1.0PO	1.5DL+1.5LL+1.5EO+1.5PO
1.0DL+1.0LL+1.0EO+1.0PO+1.0TL +VE	1.2DL+1.2LL+1.2EO+1.2PO+1.2TL +VE
1.0DL+1.0EO+1.0PO+1.0WL +X	1.5DL+1.5EO+1.5PO+1.5WL +X
1.0DL+1.0EO+1.0PO+1.0WL +X+1.0TL +VE	1.2DL+1.2EO+1.2PO+1.2WL +X+1.2TL +VE
1.0DL+1.0EO+1.0PO+1.0WL +X+1.0TL –VE	1.2DL+1.2EO+1.2PO+1.2WL +X+1.2TL –VE
1.0DL+1.0LL+1.0EO+1.0PO+1.0WL +X	1.2DL+1.2LL+1.2EO+1.2PO+1.2WL +X
1.0DL+1.0LL+1.0EO+1.0PO+1.0WL +X+1.0TL +VE	1.2DL+1.2LL+1.2EO+1.2PO+1.2WL +X
1.0DL+1.0LL+1.0EO+1.0PO+1.0WL +X+1.0TL –VE	1.2DL+1.2LL+1.2EO+1.2PO+1.2WL +X+1.2TL –VE
0.9DL+0.9EO+0.9PO+1.0WL +X	0.9DL+0.9EO+0.9PO+1.5WL +X
1.0DL+1.0EO+1.0PO+1.0EQ +X	1.5DL+1.5EO+1.5PO+1.5EQ +X
1.0DL+1.0EO+1.0PO+1.0EQ +X+1.0TL +VE	1.2DL+1.2EO+1.2PO+1.2EQ +X+1.2TL +VE
1.0DL+1.0EO+1.0PO+1.0EQ +X+1.0TL –VE	1.2DL+1.2EO+1.2PO+1.2EQ +X+1.2TL –VE
1.0DL+1.0LL+1.0EO+1.0PO+1.0EQ +X	1.2DL+1.2LL+1.2EO+1.2PO+1.2EQ +X
1.0DL+1.0LL+1.0EO+1.0PO+1.0EQ +X+1.0TL +VE	1.2DL+1.2LL+1.2EO+1.2PO+1.2EQ +X+1.2TL +VE
1.0DL+1.0LL+1.0EO+1.0PO+1.0EQ +X+1.0TL –VE	1.2DL+1.2LL+1.2EO+1.2PO+1.2EQ +X+1.2TL –VE
0.9DL+0.9EO+0.9PO+1.0EQ +X	0.9DL+0.9EO+0.9PO+1.5EQ +X

4. RESULTS AND DISCUSSION

4.1 Comparison of story Drift of FEC composite with RCC

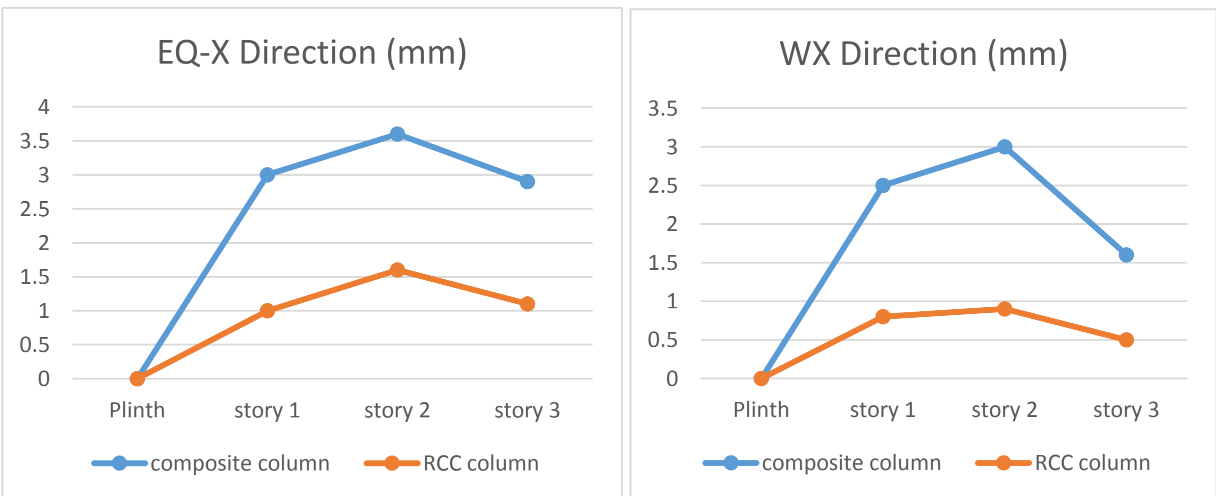

FIG 8: Maximum Story Drift of FEC Composite column structure and RCC column structure

The story drift for FEC column and RCC columns are compared in the above graphs. The comparison shows the variation of drift along the storey height. It is seen that story drift is more in case of wind load and less in case of earthquake load. Story drift in case of RCC columns structure is more than composite column structure to both loads. RCC frame is better than FEC composite in case of storey drift.

TABLE 6: COMPARISON BETWEEN RCC COLUMN AND COMPOSITE COLUMN STRUCTURE ON A PERTICULAR SELECTED COLUMNS

S.No	DESCRIPTION	SELF WEIGHT (kN)	MOMENTS (kN-m)	AXIAL LOAD (kN)	COST (Rs)
1	Composite columns Structure	5740 k N	116.7195 KN m	484.710 k N	25,00,000.00
2	RCC columns Structure	6950 KN	223.70 KN m	1317.220 KN	40,00,000.00
3	Difference Between RCC & Composite	1210 KN	106.98 k N m	832.5 k N	15,00,000.00
4	No of times RCC over Composite	1.21	1.9	2.71	2.6
5	% Difference	22%	91%	172.90%	60 %

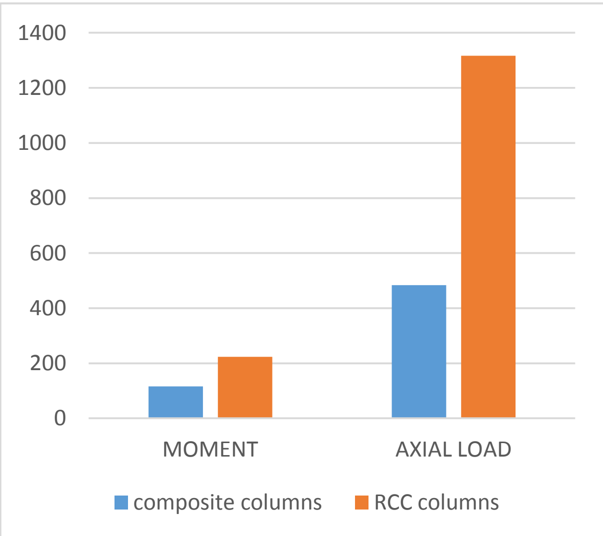

FIG 11: Moment and axial loads for typical columns

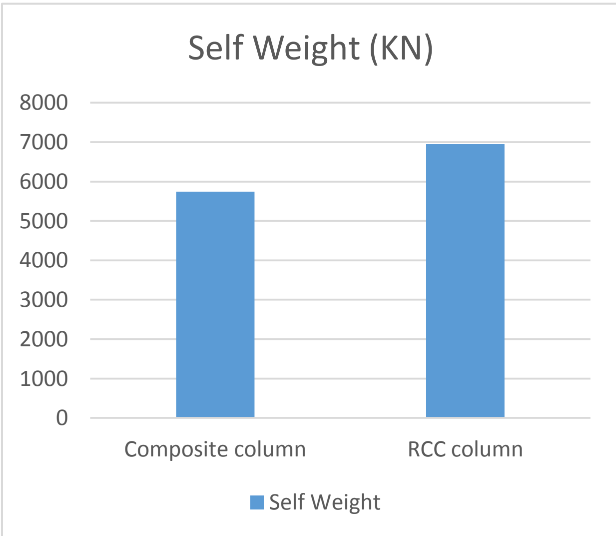

FIG 12: Self weight of columns

The weight of the composite structure is quite low as compared to RCC structure, which helps in reducing foundation cost. The axial load and moment is less in composite columns compared to RCC columns.

- An average reduction of 91% is seen in moment of composite column than R.C.C.
- An average reduction of 172% is seen in axial load of composite column than R.C.C.

5. CONCLUSION

- Composite column structure is advanced over RCC construction in case of Strength, Ductility, Durability, Light weight. Composite column structure having some advantage compared to Reinforced Cement Concrete structures and they are (i.e. RCC Structures having Self Weight 1.21 times more , Axial Load 2.71 times more, Moment 1.9 times more, Cost of selected columns 2.6 times more that of Composite column structure)
- In case of Industrial Structures, Structural with composite columns is preferred in view of high Strength which leads resistance to unexpected wind loads and more utilization of space.
- The story drift of FEC RCC is considerably better as compared with Composite columns.
- In composite structure, the column size is lesser than the RCC structure which also reduces the volume of concrete. As concrete reduces, the reinforcing steel also reduced.
- The fire protection is more in RCC structure than compare with FEC composite column.

6. REFERENCES

[1].IS 800:2007-General Construction in steel – Code of Practice.
[2] IS 456:2000 – Plain and Reinforced concrete – Code of Practice.
[3] IS 875:1997 - Code of practice for design loads (other than earthquake) for buildings and Structures (PART - I, III,V).
[4] IS 1893(Part 1):2002 – Criteria for Earthquake resistant design of structures.
[5] K.C. Jain, “Design for RCC Slabs - A Ready Reckoner”, lakshmi publications, new Delhi- 2002.
[6] S. S. Bhavikatti, “Design Of R.C.C. Structural Elements, Volume 1”, new age international publications, new Delhi, 2005
[7] SP 16: 1980, Design Aids for Reinforced Concrete to IS: 456-1978, Bureau of Indian Standards, New Delhi.
[8] SP 34: 1987, Hand Book on Concrete Reinforcement and Detailing, Bureau of Indian Standards, New Delhi.
[9] IS 11384: Code of Practice for Composite Construction in Structural Steel and Concrete
[10] Advanced Design of Composite Steel-Concrete Structural element by Dr. D. R. Panchal -ISSN: 2248-9622, Vol. 4, Issue 7(Version 2), July 2014, pp.124-138
[11] ANSI/AISC 360-05, An American National Standard Specification for Structural Steel Buildings March 9, 2005.
[12]Comparative Analysis of RCC and Steel-Concrete-Composite (B+G+ 11 Storey) Building Mr. Nitish A. Mohite, Mr. P.K.Joshi, Dr. W. N. Deulkar IJSR, Volume5, Issue 10, October 2015 ISSN 2250-3153
[13] Composite Structures of Steel and Concrete (Beams,slabs, columns, and frames) for buildings Third Edition By R.P. JOHNSON (2004)
[14] Eurocode 4: Design of composite steel and concrete structures - Part 1-1: General rules and rules for buildings
[15] Comparative Study Of Performance Based Plastic Design of R.C And Composite (Cfrst) Moment Resisting Frames Based On Inelastic Response Analysis G.S.Hiremath, Kushappa M Kabade- IJARSE, Vol. No.3, Issue No.8,August 2014 ISSN-2319-8354(E).
[16] Comparison of R.C.C. And Composite Multi-storied Buildings by Anish N. Shah, Dr. P.S. Pajgade- Vol. 3, Issue 2, March -April 2013, pp.534-539.