NON LINEAR BUCKLING ANALYSIS OF RC-SIFCON COLUMN SUBJECTED TO LATERAL AND AXIAL LOADING

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Abstract - *Slurry Infiltrated Fibrous Concrete (SIFCON) is an extremely improved version of conventional Fiber Reinforced Concrete having high fiber content, a unique construction material having unique properties in the areas of strength, ductility, durability and toughness. The structural components like beams, columns; walls will exist in the different structures and bridges. It is necessary to understand the response of these structural components during loading action which is very important to develop an efficient and safe structure. Lot of work has been done in the field of SIFCON beams, beam column joints, slabs, wall joints etc. This paper reports on the non linear behavior of RC with SIFCON column with varying percentages of SIFCON. From the results it can be concluded that for the different slenderness ratios of the RC-SIFCON columns, the deflection was maximum for the column having minimum slenderness ratio and minimum for maximum slenderness ratio as the buckling takes places in the slender column. The load carrying capacity was maximum for the column having minimum slenderness ratio.*

***Key Words*: RC, SIFCON, COLUMNS, ANSYS, NON LINEAR BUCKLING ANALYSIS**

1. INTRODUCTION

In the construction of long span bridge, high rise building, offshore structures, and other mega structures requires materials, with increasingly improved properties, particular strength, stiffness, toughness, ductility, durability. In this view, simultaneous improvement in a combination of properties is needed. Such materials are called "High Performance Materials" and "Advanced Materials" and they are different from other conventional materials.

To improve performance characteristics of fiber reinforced concrete High Performance Fiber Reinforced Cement Composites (HPFRCC) was developed in the 1990's. In a unique HPFRCC application termed Slurry Infiltrated Fiber Concrete (SIFCON), the steel fibers are placed inside a mould and then infiltrated by a high strength, cementitious slurry. Even though SIFCON can achieve higher strength and energy absorption values under compression than plain concrete, this requires a relatively large amount of fibers, about 12% to 15% which is very difficult to achieve outside the laboratory.

1.1 SIFCON

SIFCON is a high-strength, high-performance material containing a relatively high volume percentage of steel fibers when compared to SFRC. It is often referred as 'high-volume fibrous concrete'. Prof. Lankard carried out extensive experiments in his laboratory in Columbus, Ohio, USA in 1979 and he proved that, if the percentage of steel fibers in a cement matrix could be increased considerably, then a material of very high strength could be obtained, which he named as SIFCON and thus SIFCON originated [2].

In conventional SFRC, the steel fiber content commonly varies from 1 to 3 percent by volume; it varies from 4 to 20 percent in SIFCON depending on the geometry of the fibers and the method of application. The method of making SIFCON is also different, due to its high steel fiber content. As in SFRC, the steel fibers are mixed with the wet or dry mix of concrete, before the mix being poured into the forms, SIFCON is made by infiltrating a low-viscosity cement slurry into a bed of steel fibers 'pre-packed' in forms/moulds.

SIFCON is a distinctive construction material having high strength as well as large ductility and excellent potential for structural applications when accidental (or) abnormal loads are encountered during services. SIFCON also exhibits new behavioral phenomenon, that of "Fiber lock" which is responsible for its excellent stress-strain properties.

1.2 SLENDERNESS RATIO

The ratio of the effective length of the column to the least radius of gyration of its cross section is called Slenderness ratio. Larger the slenderness ratio, lesser will be the strength of the column .This means that capacity decreases as the slenderness ratio increases. Higher slenderness ratio means lower critical stress which will cause buckling. Lower slenderness ratio results in a higher critical stress.

1.3 SHORT COLUMN AND LONG COLUMN

A column which has ratio of unsupported length to the least dimension of the cross section equal to or less than 12 is called Short column. If the ratio is greater than 12, then it is called Long or Slender column.

Column slenderness and length greatly influence a column's ability to carry the loads. Due to material failure, short column fail by crushing .Failure occurs once the stress exceeds the elastic limit of the material .Long slender columns fail by buckling – a function of column's dimensions and its modulus of elasticity. Failure occurs at a low stress level than the column's material strength due to buckling.

2. SOFTWARE USED FOR ANALYSIS

For the present study ANSYS software is used. For the non linear analysis ANSYS is a efficient non linear finite element package. ANSYS is a comprehensive general-purpose finite element computer program which contains over 100,000 lines of code. ANSYS has capability of performing static, dynamic, heat transfer, and fluid flow and electromagnetism analyses.

The origin of the modern finite element method may be traced back to the early 1900s, when some investigation approximated and modeled elastic continua using discrete equivalent elastic bars. However, Courant (1943) has been credited with being the first person to develop the finite element method. The next significant step in the utilization of finite element methods was taken by Boeing in the 1950s when Boeing, followed by others, used triangular stress elements to model airplane wings. Yet it was not until 1960 that Clough made the term "finite element" popular. During the 1960s, investigation began to apply the finite element method to the areas of engineering, such as heat transfer and seepage flow problems. In 1971, ANSYS was released for the first time. [16]

ANSYS has been leading FEA program for well 20 years. Nowadays, we can find ANSYS in use in various engineering fields, including aerospace, automotive, electronics and nuclear. In a view to use ANSYS intelligently it is essential that one first understands the fundamental concepts and limitations of the finite element methods. ANSYS is a very powerful and impressive engineering tool which can be used to solve a variety of problems.

3. VALIDATION AND FE MODELING

Validation is done for the RC column with different percentages of SIFCON using FEM software ANSYS 14.5. Column dimension is taken as 1000mm length x100mm breadth x 100mm depth.

3.1 FE MODELING

3D modeling and 1D modeling of RC-SIFCON columns is done. The element used in this analysis is SOLID185 for 3D modeling and BEAM188 for 1D modeling.

3.2 MATERIAL PROPERTIES

The modulus of elasticity and Poisson's ratio details is as shown below:

Table -1: Material properties

Sl. No	RC (%)	SIFCON (%)	MODULUS OF ELASTICITY (N/mm^2)	POISSON'S RATIO
1	100	_	23158	0.15
2	_	100	20953	0.15
3	80	20	21349	0.15
4	70	30	32633	0.15
5	60	40	39067	0.15
6	50	50	28282	0.15

3.3 BOUNDARY CONDITION FOR THE COLUMN

The displacement boundary condition is needed to constrain the model to get the solution. Boundary condition is given for the column as one end fixed and other end free.

3.4 CRITICAL OR BUCKLING LOAD

The value of critical or buckling load is calculated manually by using the above formula for RC column with different percentages of RC and SIFCON and is compared with the critical buckling load of the same which is estimated using ANSYS software and validation process is carried out.

The manually calculated critical load and the critical load value got from the ANSYS software for 1D model and 3D model is tabulated as shown below:

Table-2: Critical load for column 100mmx100mmx1000mm

Sl no	RC (%)	SIFCON (%)	Manual calculated (kN)	1D (kN)	3D (kN)	% of Variation
1	100	_	476.167	475.285	447.612	5.99
2	_	100	430.811	430.030	404.992	5.99
3	80	20	438.95	438.158	412.646	5.99
4	70	30	670.962	669.745	630.750	5.99
5	60	40	803.250	801.794	755.110	5.99
6	50	50	581.502	580.447	546.651	5.99

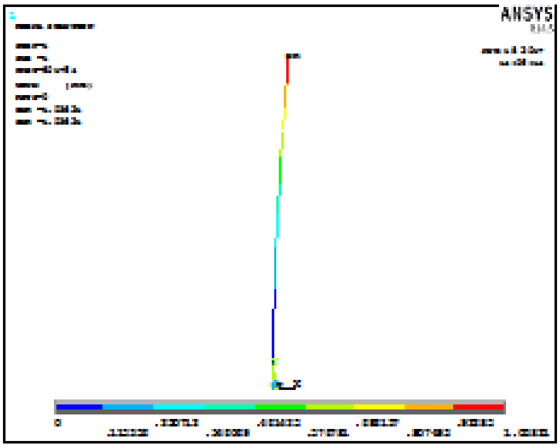

Fig -1: Critical load for 60%RC-40%SIFCON column model 1D

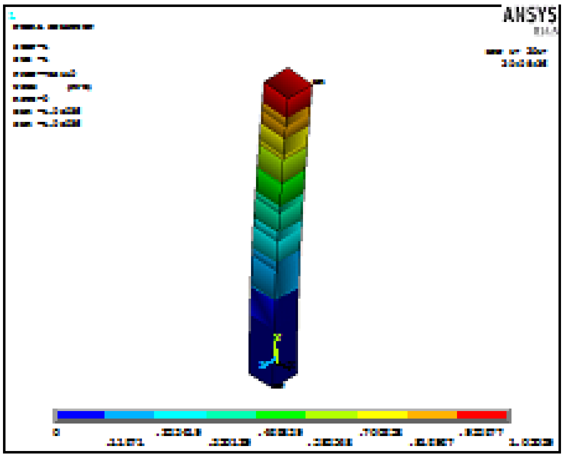

Fig -2: Critical load for 60%RC-40%SIFCON column model 3D

3.5 NONLINEAR FE MODELING

After finding the critical load, non linearity is introduced in the analysis by applying the lateral loads for post buckling analysis. Here Non linear buckling analysis is performed by incremental application of axial loads on columns for RC with SIFCON column models with varying percentages of SIFCON for different slenderness ratios.

Finite element column models are developed to simulate the behavior of Reinforced concrete with SIFCON in the columns using ANSYS program. Comparisons were made with the non linear buckling response of the RC columns with varying percentages of SIFCON and slenderness ratios.

3. RESULTS AND DISCUSSIONS

Inference drawn from the FE modeling of RC-SIFCON columns is shown by using graphs.

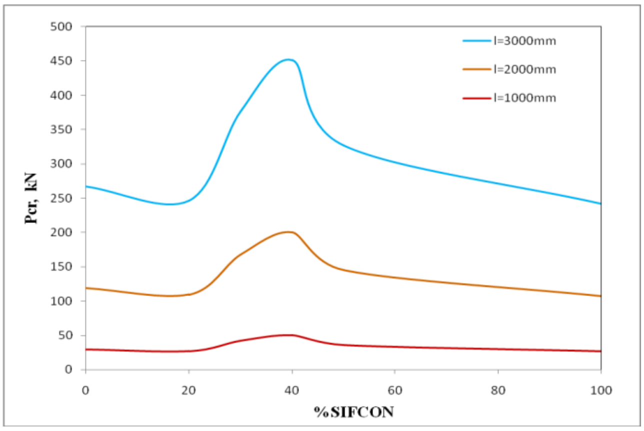

Chart-1: Critical load versus % of SIFCON for constant slenderness ratio

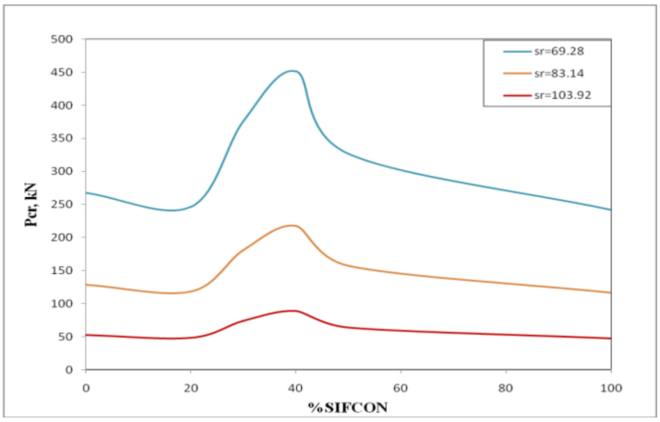

Chart-2: Critical load versus % of SIFCON for varying slenderness ratio

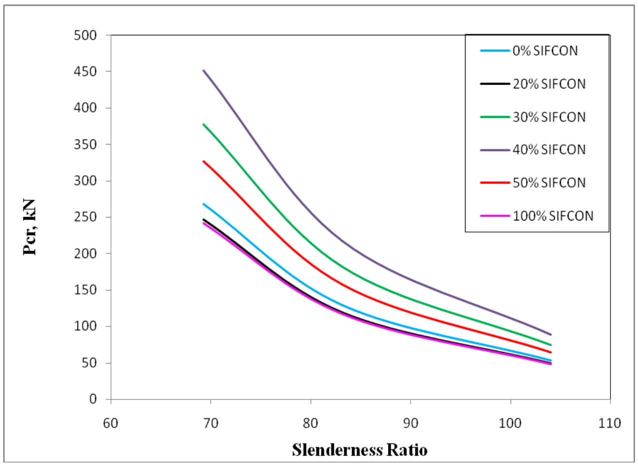

Chart-3: Critical load versus Slenderness ratio for different percentage of SIFCON

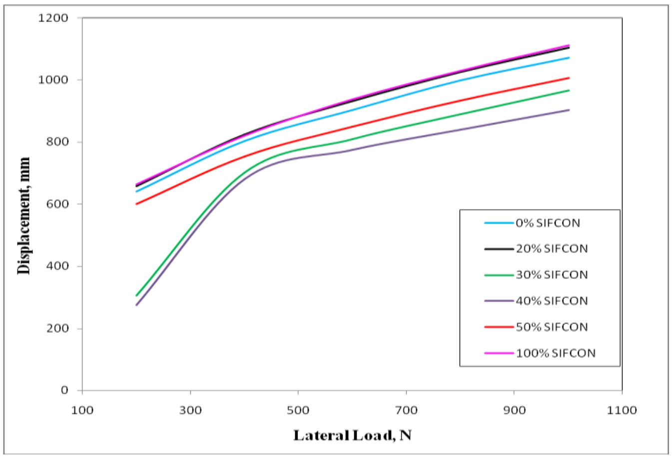

Chart-4: Lateral load versus Displacement for slenderness ratio=69.28

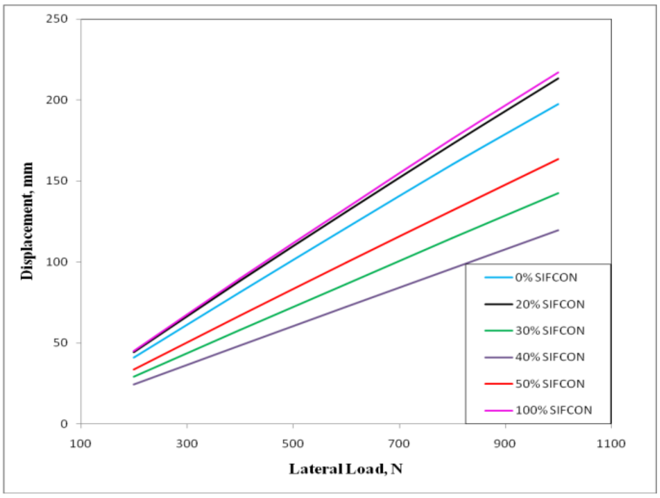

Chart-5: Lateral load versus Displacement for slenderness ratio=83.14

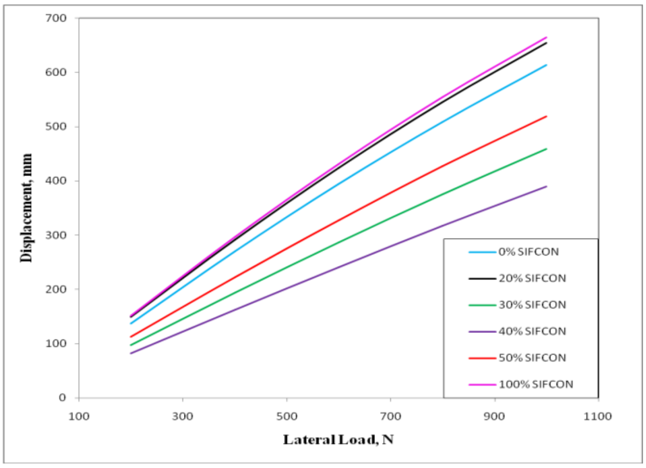

Chart-6: Lateral load versus Displacement for slenderness ratio=104

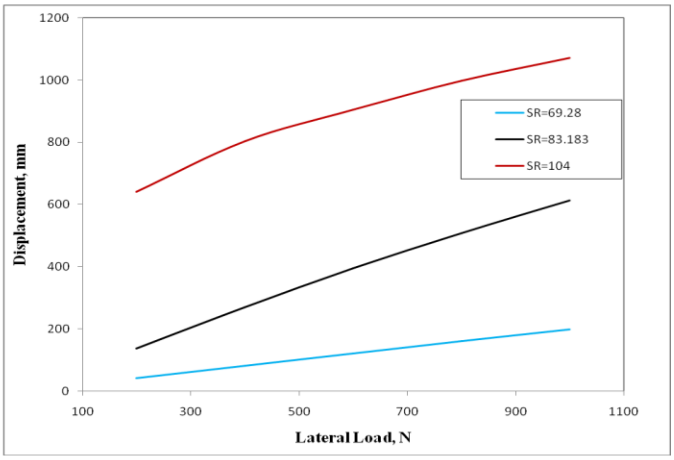

Chart-7: Lateral load versus Displacement for 0% SIFCON

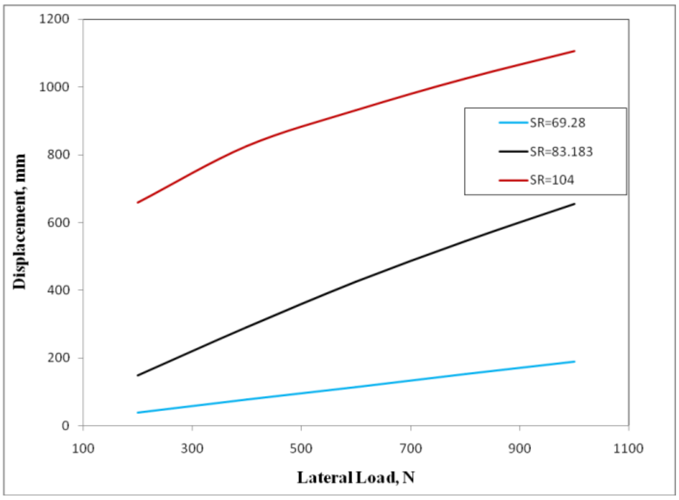

Chart-8: Lateral load versus Displacement for 20% SIFCON

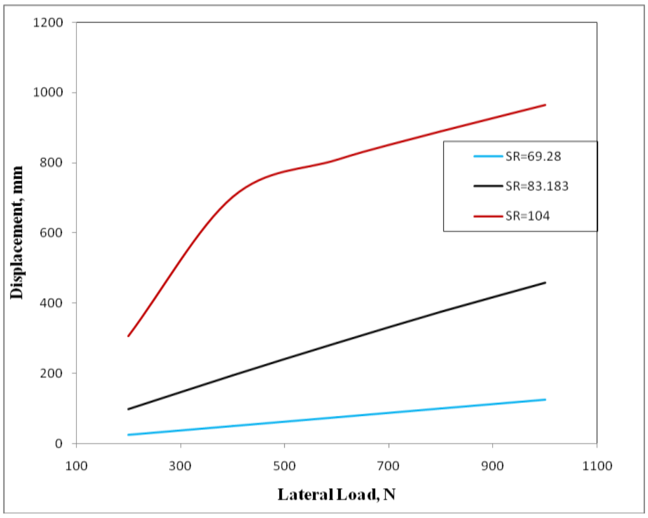

Chart-9: Lateral load versus Displacement for 30% SIFCON

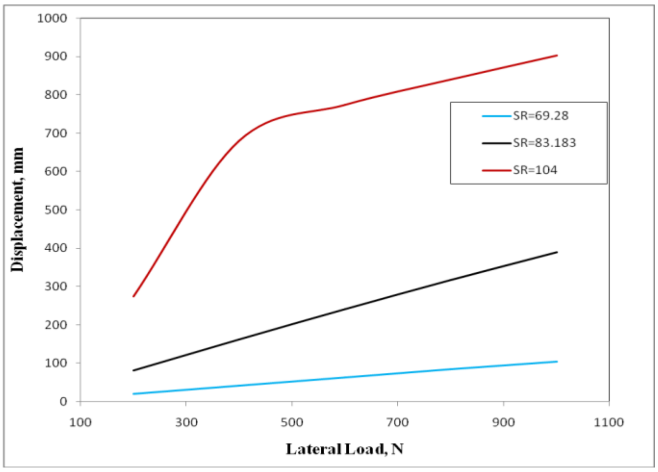

Chart-10: Lateral load versus Displacement for 40% SIFCON

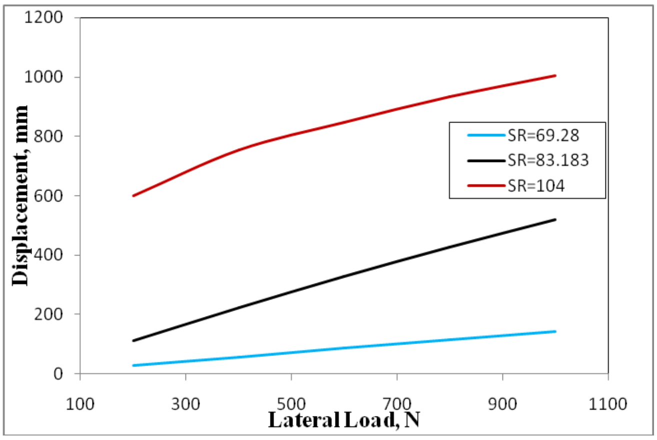

Chart-11: Lateral load versus Displacement for 50% SIFCON

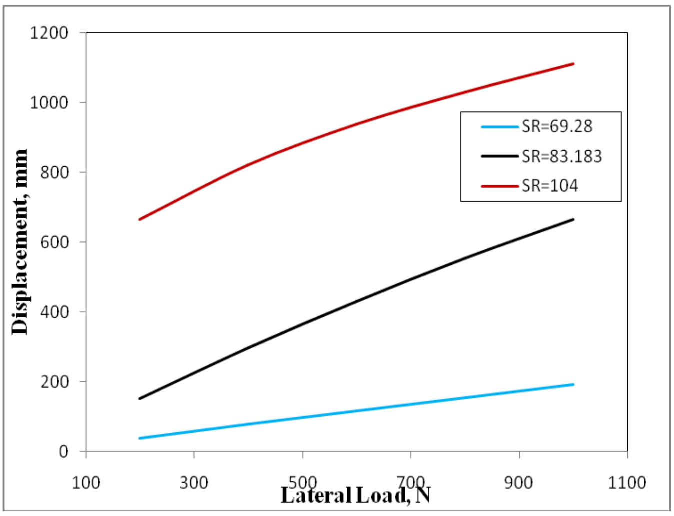

Chart-12: Lateral load versus Displacement for 100% SIFCON

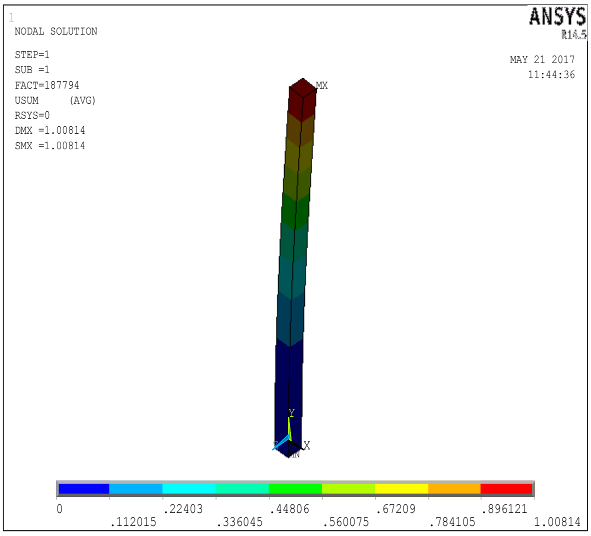

Fig -3: Critical load for 40%SIFCON column of for slenderness ratio=69.28

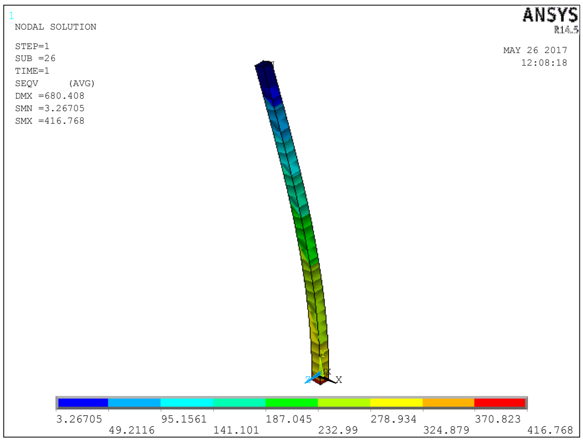

Fig -4: Displacement for 100% SIFCON column for slenderness ratio 104

4. CONCLUSIONS

In the investigation of non linear buckling analysis of RC-SIFCON columns, following conclusions were listed.

1. When the percentage of SIFCON varies from 0 to 100%, critical buckling load is maximum for 40%SIFCON column for varying slenderness ratio and was found maximum for the lesser slenderness ratio

2. Keeping slenderness ratio constant with varying length of the column , critical buckling load was maximum for the higher length of the column and for 40%SIFCON column for all the length of the column.

3. As the load increased, deflection in the RC-SIFCON columns also increased. However, the deflection value is minimum for 40%SIFCON-60%RC column in all cases when compared to other percentages of SIFCON columns.

4. 100%SIFCON column showed the maximum deflection for increase in the load when compared with the other percentages of the SIFCON column.

5. When the percentage of SIFCON varies from 0 t0 100%, critical buckling load is maximum for 40%SIFCON column for increase in slenderness ratio and was found minimum for 100%SIFCON column.

6. While comparing the deflection of the RC-SIFCON columns for different slenderness ratios, the deflection was maximum for the column having minimum slenderness ratio and minimum for maximum slenderness ratio as the buckling takes places in the slender column.

7. Overall we can conclude that, the analytical study on different type of columns with and without SIFCON shows the better results for 40%SIFCON - 60%RC composite column.

REFERENCES

[1] Amen Saleh, Ahmad Fathy Abdelaziz ,Amr H.Zaher ,Bassem Bahy Awad(2015), “Strengthening of RC beam column joint under seismic loads using of recent material”, International Journal of Application or Innovation in Engineering and Management,Vol .4.

[2] Antony Jeyasehar C and Balamuralikrishnan R. (2012), “Strengthening of structures by HPFRCC laminates”, Asian Journal of Civil Engineering, vol.13, pp. 29-42.

[3] Balaji S, Thirugnanam (2014) , “Study on cyclic behaviour of exterior beam column joints strengthened with precast SIFCON laminates” , Journal of Engineering and Technology ,Vol.4, pp.65-69.

[4] Bryan Thane Wood (2001). “Use of slurry infiltrated fibre concrete in hinge regions of earthquake resistance structures”, Dissertation Abstracts International, vol.62-12, pp.12-29.

[5] D Anandhi ,M Sivakumar(2015) , “Study on reinforced concrete exterior beam column joint with partial replacement of cement by SIFCON”,International Research journal in Advanced Engineering and Technology ,Vol.1,pp.217-222.

[6] Dr.P.Thamilselvi (2012).“Behaviour of exterior beam column joints using SIFCON”, International Journal of Engineering Research and Technology, Vol.1.

[7] Harish R. (2012), “Study on flexure behavior of slurry infiltrated fibrous concrete (SIFCON)”, International Journal of Computer & Organization Trends, Vol. 2, pp. 2946.

[8] H K Sharma,R K Sharma,Shashikant(2015),“Behaviour of high performance fibre reinforced beam column joints”, International Conference on Transportation and Civil Engineering,pp108-115.

[9] I S Misir, S Kahraman (2013), “Strengthening of non-seismically detailed reinforced concrete beam–column joints using SIFCON blocks” ,Indian Academy of Sciences ,Vol.38,pp.69-88.

[10] Jayashree.S.M, Rakul Bharatwaj R,Dr.Helen Santhi M(2013), “Flexural Behaviour of SIFCON Beams”, International Journal of Engineering Research and Technology ,Vol.2.

[11] Kuldeep Dagar(2012), “Slurry Infiltrated Fibrous Concrete (SIFCON)”,International journal of Applied Engineering and Technology ,vol.2,pp.99-100.

[12] M Jamal Shannag, Nabeela Abu-Dyya, Ghazi Abu-Farsakh (2005). “Lateral load response of high performance fibre reinforced concrete beam column joints”, Journal of construction and building materials, Vol.19, pp.500-508.

[13] N Ganesan. P.V.Indira, Ruby Abraham (2007). “Steel fibre reinforced high performance concrete beam column joints subjected to cyclic loading”,ISET Journal of Earthquake Technology ,Vol.44, pp.445-456.

[14] Pradeep Singh,Abhishek Mishra,Arpit Kulshreshtha(2016), “Finite element analysis of Reinforced concrete beam using ANSYS”, International Journal of Current Engineering and Scientific Research,vol.3.

[15] P Thamilselvi , P.Devadas Manoharan(2008). “Study of behaviour of reinforced concrete frames with slab using SIFCON in beam column joints”, Journal of Engineering and Applied Sciences, pp.104-108.

[16] Saeed Moaveni (1999), “Finite Element Analysis, Theory and application with ANSYS”.

[17] S.S.Bhavikatti , “Strength of materials”, S.Chand Publishing.