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Analysis of Base Shear and Displacement of Long, Short and Medium Steel Reinforced-Concrete Filled Tubular Column under Effect of Axial Concentrated Load

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Abstract

Nowadays, using concrete-filled tubular (CFT) columns has become common increasingly in the construction projects and this is to some extent because of excellent properties of seismic resistance. The limitation caused by the steel frame could improve concrete properties under a three axial mode and on the other hand, prevents inner buckling of the steel tube. The increased properties of the sections by the concrete could be expressed based on composite behavior of steel tube and concrete core. Hence, in this study, inelastic buckling behavior of short, medium and long columns under uniform loading is studied with regard to different buckling stiffness in form of anchor indication in peak of column using Abaqus software. The results obtained from the modeling show that with the analysis of the real time ideal ultimate load caused by the analysis and maximum strain values, maximum spring force equivalent for anchor indication, base shear, displacement, factors affecting buckling of composite columns such as column and anchor conditions affecting this field are undeniable and through comparing them, significant difference could be observed between ideal force tolerable by columns with real values caused by inelastic analysis in buckling of columns.

Keywords: base shear, displacement, long, short and medium concrete-filled columns, axial concentrated load, buckling behavior

Introduction:

In Composite columns filled in tubular form or steel tubes filled with concrete are called concrete filled tubes. The steel section usually contains structural rolled cans or steel tubes produced in large dimensions in Iran. in concrete core of the section, conventional or self-compacted concretes may be used. The composition of steel around the concrete core creates a composite section. Types of ceiling systems and steel beams are used in combination with these columns.

CFT columns have excellent properties including high tensile strength, high flexibility and high energy adsorption capacity. In addition to considerable increase in structural properties, CFT columns can reduce construction time significantly. Steel shell acts as longitudinal and transverse strengthener. Moreover, the shell provides confinement pressure for the concrete, which can apply stress on the concrete in all dimensions. In other words, steel shell retrofits the concrete core. This could prevent steel tube buckling and increase tensile stability and strength of steel column. In CFT columns, the place of steel wall around the section, where the bending and tensile stresses are effective, can increase stiffness of section significantly. Important property in the composite columns is the interaction between steel and concrete. Such system has important advantages of both materials ideally, so that it would be tried in the design to use leading properties of both materials [1]. Composite columns have been proposed as a fundamental solution to prevent total and positional buckling of steel columns and on the other hand, to prevent shear failure of concrete columns. Moreover, this form of structural element has high seismic resistance, stiffness, strength, flexibility and high energy adsorption capacity. Types of composite columns include [5]:

- Columns with steel profiled buried in concrete
- Concrete filled steel columns

Ghafuri (2016) has conducted a study on analyzing the nonlinear behavior of steel-reinforced concrete-filled steel tubular (SRCFST) under cyclic loading. In the study, numerical analysis of SRCFST under cyclic loading is presented based on finite element method. The feasibility and accuracy of this numerical method has been confirmed through comparing the calculated results with experimental studies. The curve of lateral load displacement and sectional stress are also measured. The results showed that SRCFST column has high stiffness, higher capability of tolerating lateral load and higher deformation capability than CFST columns because of presence of steel in tubular section. The parametric study included the effect of axial loading, the ratio of steel used in the section, the steel yield strength and concrete strength and the thickness of steel tubes under maximum lateral load.
Sakino et al (2015) conducted a study on 12 samples of composite steel tubular columns buried in concrete with lengths of 1, 2, 3 and 4m to achieve effect of yield strength structural steel (270Mpa). The results showed that increased strength of structural steel has insignificant effect on resistance of composite steel with relatively high thinness ratio because of the bending buckling mode; although use of high strength steel in short columns could considerable increase in composite column strength.
Dashti and Parsian (2016) have conducted a study to analyze buckling strength of CFT columns. In this study, the possibility of using reinforced concrete in CFT columns is investigated. Particularly, the effect of compressive strength of concrete on buckling strength of CFT is also measured. In the study, the emphasis was on comparison and experimental comparison of columns filled by concrete, conventional concrete and reinforced concrete. In this study, the author has tried to interpret and evaluate the results published from an experiment on this type of columns. Moreover, at the final section of the paper, to compare the test results, outputs of a computer model of the examined column were analyzed.

Buckling in columns

In the Science of Strength of Materials, buckling refers to the behavior caused usually by the element under stress (column, shear wall, etc.). Moreover, it seems that in ancient Persian Language, the term "Tanbesh" used to be applied for the term "Buckling" (the words Tanban and Tanbak have been also made from this root). Compressed elements of a structure may face failure as a result of buckling before reaching maximum compressive strength and in fact, before failure under the effect of compressed yield stress. The longer the column is and the smaller the section surface is (thin column), the more the column would face yield buckling [1]. Buckling in columns is mostly depended on column thinness coefficient

(λ). Thinness coefficient refers to uncontrolled length ratio in column to the gyration radius. In ideal mode that no lateral load and no exit of axis are existed, the critical load amount of a steel column could be obtained as follows [1]:

Modeling

In this study, to model the concrete in the software, plastic damaged concrete model is used. In this model, it is assumed that the response to strain and negative uniaxial compression of strain stress is changed to the point of failure linearly and the stress is asymmetric with the beginning and extension of fine cracks in the concrete. After passing from the said point, the failures become observable in form of tangible cracks displayed as smoothing curve in the strain-stress space. This model has been embedded in types of structure in the software in order to model the concrete and other quasi-fragile materials. This model uses the concept of isotropic in linear limit and with the combination of isotropic tension and plastic pressure to show nonlinear behavior of concrete. Moreover, this model has the ability to model desirable loading conditions like cyclic loading and the elastic stiffness reduction could be explained with regard to plastic strain in both tension and compression. The proposed model for concrete in damaged mode is a continuous model based on plastic behavior and in the main mechanism of failure in this model; the cracks are caused by tension and failure in compressive section. Under uniaxial pressure, the response is elastic till reaching to flowing point and in plastic area; the behavior is generally expressed by the stiffness curve. Finally, after reaching to final stress point, the curves are smoothed. The proposed model could satisfy the main properties of concrete; although it is simple. In periodic loadings, decreasing behaviors are complicated and include opening and closing hair cracks previously formed and their interaction. It has been observed empirically that with change in loading direction, elastic stiffness is slightly increased, which could be an important property of concrete behavior while loading. The effect of this behavior becomes clear, when the loading is changed from tensile to compressive mode, which can cause the cracks closed and recover the compressive stiffness. In table 1, mechanical properties of modeled concrete ion software for all samples is presented.

Table 1: mechanical properties of modeled concrete

Parameters	Value
Ec	2200000kg/m3
U	0.3kg/m3
fy	3330kg/m3
γ_s	8770kg/m3

In these columns, power transmission between steel and concrete is done through contact between the two materials and its performance could be significantly effective in determining the column behavior and the friction coefficient between concrete and steel is to 0.3. In figure 1, the sample of fixed concrete filled steel section for all samples and the physical properties of modeled sections in software for all samples are presented in table 2.

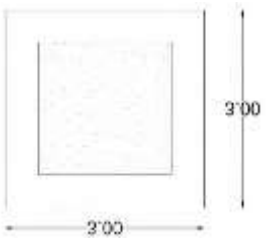


Figure 1: concrete filled steel fixed section

Table 2: physical properties of modeled sections

Index	Size
Width	360mm
Thickness	360mm
Length	6mm

According to sameness of all physical properties of section and to consider different thinness modes in the modeling process, thinness coefficients in short, medium and long columns are used to calculate lengths of modeled sections with thinness coefficients respectively to $\lambda 1 = 19$, $\lambda 2=58$ and $\lambda 3= 92$. Hence, different lengths of sections are equal to L1=1.93, L2=5.22 and L3=8.30. Moreover, each length includes following stiffness values with regard to limiting indication in one end of the column and the other side, is assumed with absolutely clamped beam. The stiffness (k) is considered to 0, 25, 50, 75 and 100 for each length. Hence, in the modeling, 15 samples have been modeled with 5 different lengths and other properties such as steel properties, concrete properties, loading style and other information are assumed fixed. Now for the column, (k) is calculated as an equivalent and 5 coefficients of 0%, 25%, 50%, 75% and 100% of the stiffness are allocated to the spring connected on the column. In table 3, the values of compressive strength of concrete and ultimate strength of modeled steel in software are presented for all samples.

Table 3: values of compressive strength of concrete and ultimate strength of modeled steel in software for all samples

Title	Value (kg/cm2)
Fc	220
FU	260

Applied software in this study is Abaqus software. Although Abaqus provides wide range of capabilities of using software for the user, it is almost simple. The most complicated problems could be modeled in this software easily. For example, the problems including more than one element could be modeled through creating geometric model and the ratio of behavior of material related to each element and assemblage of different elements. In most modeling processes, even models with high nonlinearity degree, the user should determine just the engineering data such as geometry of problem, behavior of material, boundary conditions and loading of the problem. Abaqus can select the amount of growth of load and convergence tolerances automatically in a nonlinear analysis and adjust them during the analysis to achieve a true answer. As a result, the user should rarely determine controlled parameters of numerical problem solving in Abaqus [6]. In figure 2, a 3-D view of the column modeled in software is presented.

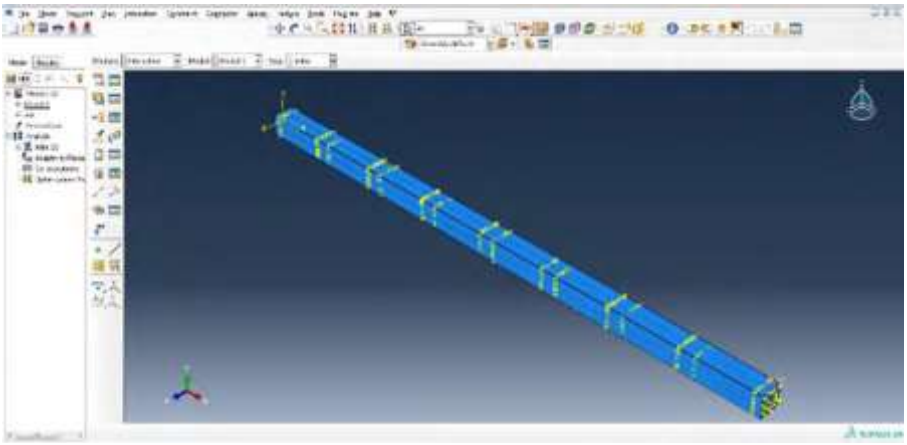


Figure 2: 3-D view of the column modeled in Abaqus software

Results

The results obtained from modeling on 3 desired concrete filled tubular columns are as follows:

Results related to short column:

In the table 4, maximum strain, maximum force of base shear values and displacement and ideal values are presented for each column with length of 1.93. Moreover, in figure 3, the accumulated diagram for the column with length of 1.93m with values of (k)=0, (k)=25, (k)=50, (k)=75 and (k)=100 is illustrated.

Table 4: maximum strain values in column for length of 1.93m

Spring stiffness ratio (K)	Maximum strain	Maximum force	Base shear values		Displacement	pcr
0	56443	8/7658E-009	1/27E+0/6	98054	9/93843E-009	92452000
25	43556	5465/10	35546	34216	9/9043E-07	2992100
50	43567	3223/9	67439	39780	9/99963E-07	29913500
75	42923	33492/80	17684	53909	9/62483E-007	2914200
100	42114	33412/8	36579	56121	9/63493E-007	2914200

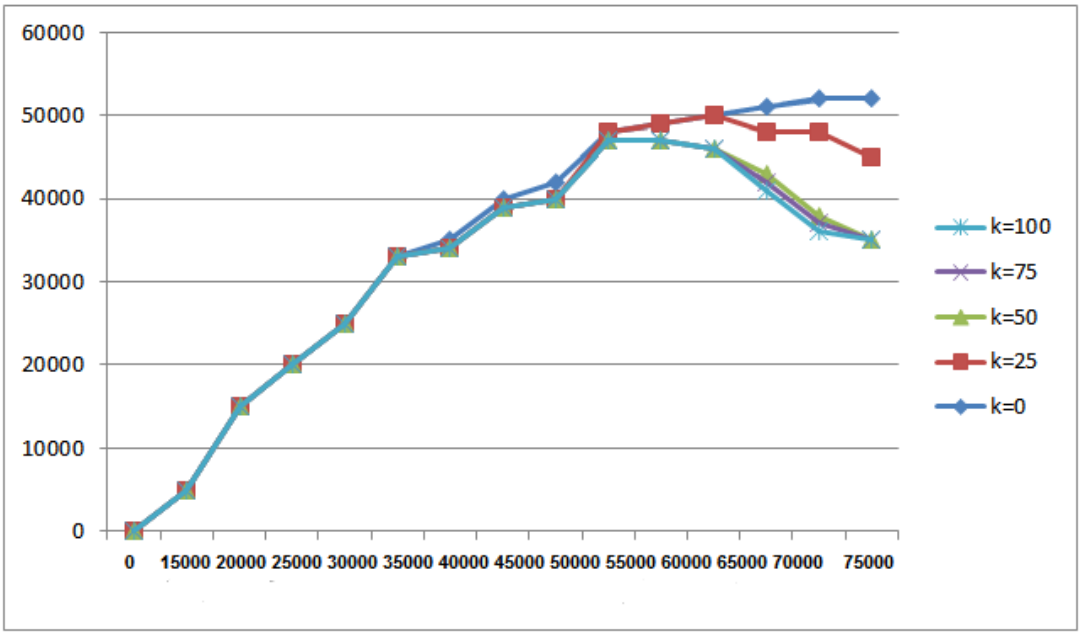


Figure 3: accumulated diagram for short column

Results related to medium column

In table 5, maximum strain, maximum force of base shear values and displacement and ideal values are presented for each column with length of 5.22. Moreover, in figure 4, the accumulated diagram for the column with length of 1.93m with values of (k)=0, (k)=25, (k)=50, (k)=75 and (k)=100 is illustrated.

Table 4: maximum strain values in column for length of 1.93m

Spring stiffness ratio (K)	Maximum strain	Maximum force	Base shear values		Displacement	pcr
0	36443	9/9958E-009	60453	25612	8/62843E-006	587452000
25	35556	17435/10	56445	18452	9/9443E-05	64553000
50	34567	3273/9	50654	37665	9/93963E-005	63320600
75	34423	2042/85	41980	20786	9/934483E-005	63312000
100	34123	2912/8	36999	12332	9/99893E-005	63325500

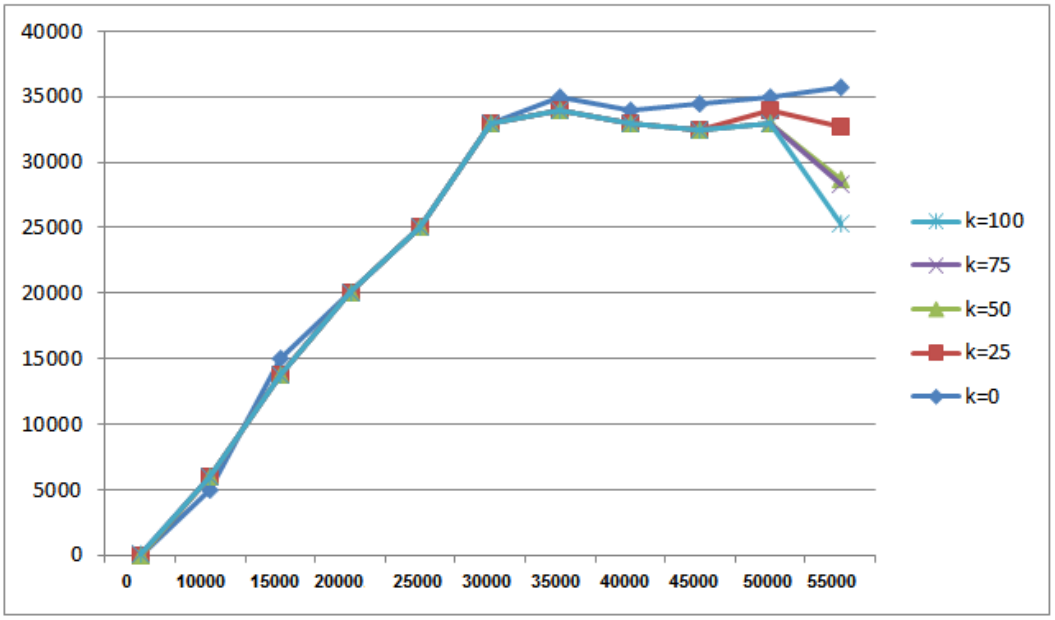


Figure 4: accumulated diagram for medium column

The results related to long column

In table 6, maximum strain, maximum force of base shear values and displacement and ideal values are presented for each column with length of 8.30. Moreover, in figure 5, the accumulated diagram for the column with length of 1.93m with values of (k)=0, (k)=25, (k)=50, (k)=75 and (k)=100 is illustrated.

Table 4: maximum strain values in column for length of 1.93m

Spring stiffness ratio (K)	Maximum strain	Maximum force	Base shear values		Displacement	pcr
0	35243	9/9921E-009	300865	56657	9/95843E-006	26149700
25	35184	59/9867	303223	54557	9/9743E-006	26355200
50	33567	59/5463	665680	54229	9/43963E-006	26524800
75	33433	59/3432	300876	17349	9/97543E-006	26893200
100	32022	62/2311	300321	51134	9/87893E-006	26685700

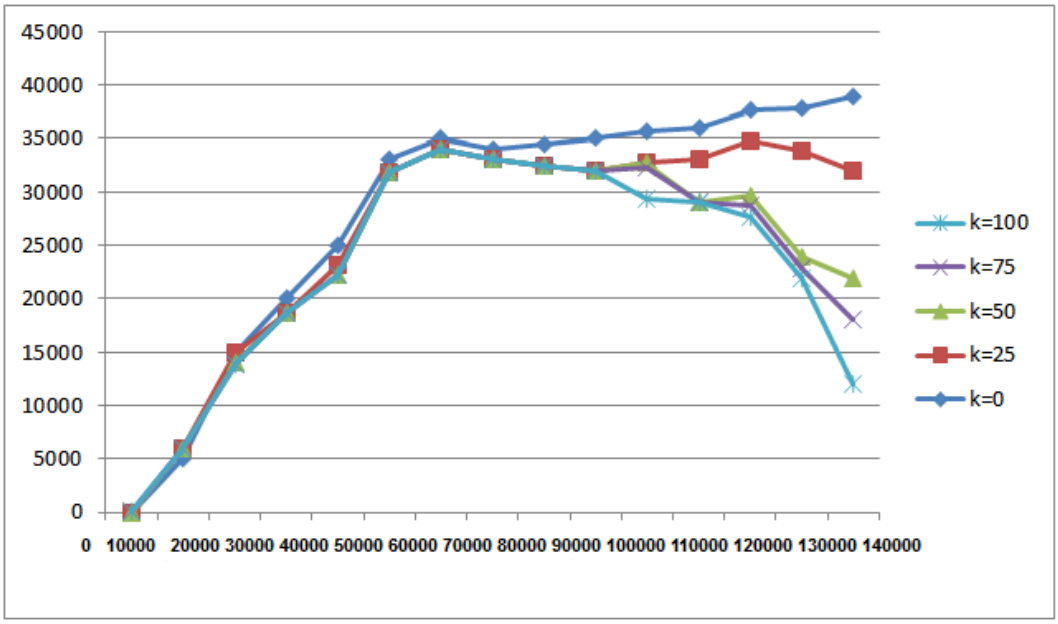


Figure 4: accumulated diagram for long column

Conclusion

In this study that is conducted to evaluate inelastic buckling behavior of columns with concrete filled steel tubular columns, the results showed that for column with length of 1.93 for different k values, it could be found that with the increase in k value in head of column, the maximum strain is decreased and if the ratio of k=0 to k=100 for maximum strain is decreased to 17% and if for the column with length of 5.22m, maximum strain of ratio of k=0 to k=100 is 11 to 4% and for the column with length of 8.23m, if the maximum strain for ratio of k=0 to k=100 is decreased to 8%, it could be mentioned that increased k value in the head of column has caused total decrease in maximum strain in column. Moreover, according to analysis of the ideal pcr and real pcr, caused by risk analysis diagrams, it could be found that ideal pcr is relatively same for all samples with length of 1.93m; although real pcr for each k is about 840 times less than ideal mode. Moreover, ideal pcr is same for all samples with length of 5.22; although real pcr for each k is about 1870 times less than its ideal mode. Also, ideal pcr is relatively same for all samples with length of 8.22; although the real pcr separated for each k is about 759 times less than its ideal mode. Moreover, it could be found from the results obtained from diagrams of real pcr that in general mode, increase in k value of pilaster spring could lead to increase in tolerable pcr by the column and this value could be decreased with the increase in column length. Through studying the results obtained from maximum forces on the spring, it could be found that increase in k value in pilaster, the spring force equivalent of pilaster is decreased. Moreover, with the increase in length of column, reduction of spring force is significant and the ratio of length of 8.30 to 1.93m has been declined about 450 times and the ratio of length of 5.19 to 1.93m is declined about 160 times. Increase in pilaster stiffness could result in reduction of displacement of pilaster. This value reaches to approximate value of 2% in column with length of 1.93m and is 0.06% for the column with length of 5.22m and to 0.05% for the column with length of 8.30. Through comparing the results obtained from maximum strain in tables, it could be found

that in general mode, increase in k value of pilaster could result in reduction of maximum strain, so that increase in column length has also led to more reduction of the strain.

References

Boniadin, Mirghaderi, A., 2016, loading capability studs filled with concrete columns, Proceedings of the Seventh Congress of Civil Engineering, Faculty of Engineering Shahid Nikbakht, Iran, 11 to 17 May.

Dashti Rahmatabadi, MA and M. Parsaeian, 2016, the buckling strength of CFT columns, Scientific Congress on new horizons in the field of civil engineering, architecture, culture and urban management, Tehran, Association for the Development and Promotion of Science and Technology

Ghafuri, E. and M. Ghafuri, 2016, non-linear behavior of steel beams reinforced with steel sections SRCFST under cyclic loading, the second international conference on new research in civil engineering, architecture and urban management, Tehran, International Federation of Inventors Associations (IFIA), University of Applied Sciences,

Jerome F. Hajjar, Aleksandr Molodan. "A Distributed plasticity model for cyclic analysis of concrete filled steel tube beam-columns and composite frames." Engineering structures, Vol. 20, No. 4-6, pp. 398-412, 1998.

Johansson , M. and Gylltoft , k.(2011) , "structural behavior of slender circular steel concrete composite columns under various means of load application

Sakino, K., and Ishibashi, H., (2015). "Experimental Studies on Concrete Filled Square Steel Tubular Short Columns Subjected to Cyclic Shearing Force and Constant Axial Force.", Transaction of the Architectural Institute of Japan (Tokyo), No. 353, 81-89.