Seismic Behaviour and Strength of Tubed Steel Reinforced Short Column

Aswathy Ananthan
M Tech student,
Department of Civil Engineering
Amal Jyothi College of Engineering
Kerala, India

Soumya Anand
Assistant Professor,
Department of Civil Engineering
Amal Jyothi College of Engineering,
Kerala, India

***Abstract* — A tubed Steel Reinforced Short columns is a special SRC column where Reinforcement is in the cage of a outer thin steel tube but the steel tube does not pass through the beam–column connection and is shorter than concrete core. In areas that suffered earthquakes, the short columns are vulnerable to brittle shear failure. Tubed SRC short Columns are widely used in bridges, High rise Buildings and factories. Experiment Studies shows that the shear strength, plastic deformation capacity, ductility index and energy dissipating capacity of tubed SRC short column were much higher than those of the SRC column and normal RCC column. The main aim of this study is to develop a nonlinear finite element model for CTSRC and RCC column and to compare their behavior during an earthquake. This study also helps to understand the short column effect in a structure and also the latest strengthening methods of short column. Modelling was done using ANSYS WORKBENCH 14.5.**

Keywords— Short column, Circular steel tubed reinforced Concrete, Harmonic Analysis, Time History Analysis

I. INTRODUCTION

Columns are considered very critical members in structural moment resisting frames. The collapse of a column or a group of columns may lead to a partial if not a total collapse of the frame. Columns are even more critical in structural frames in zones of high seismicity where they must exhibit good ductility during an earthquake.

A tubed steel reinforced concrete (SRC) column as depicted in is a special SRC column where reinforcement cage is in the form of an outer thin steel tube. The outer circular or square tube does not pass through the beam-to-column connection, therefore no axial load is directly applied on the steel tube and the tube con- fines the core concrete more effectively. This leads to an efficient use of the steel tube in preventing the concrete cover from spalling off and the longitudinal steel from buckling. At the same time, the strength and ductility of the concrete core will increase owing to the confinement of the steel tube. This approach leads to a pro-nounced enhancement in both strength and ductility of the overall column behaviour. A serious structural member crossed through the construction of building is called short column. A column is considered to be short when the ratio of its effective length to its least lateral dimension does not exceed 12. Short columns are frequently encountered in high rise structures in virtue of their high axial load and they are seen able in power station structure in virtue of their complicated manufacturer requirement. There are a large number of short columns in many other kind of buildings. These columns are designed as slender columns, while partials supporting walls, which created short columns are later constructed as vulnerable to brittle shear failure during earthquake. Brittle shear failure reduces the ductility, post elastic and deformation capacity of the columns. One of the significant method to enhance the properties and behaviour of short columns is casting the fresh reinforced concrete in to thin wall tube but this tube should be thinner than the core column.

To the knowledge of authors no has been published on the analysis and behaviour of tubed SRC short column. Only limited researchers have been carried out in this area. Xuhong Zhoua[3] conducted an experimental study on the strength and behaviour of tubed SRC short column. The objective of this research was to find out the seismic behaviour and strength of tubed SRC short column. This study was experimentally conducted by testing eight specimens which is subjected to constant combined axial load and lateral cyclic load. The test result indicate that shear strength plastic deformation capacity and ductility index of tubed SRC short columns were much higher than those of the SRC column with same steel ratio and axial compressive load. Xuhong Zhou [2] conducted experimental and analytical studies on the behaviour of square tubed SRC columns subjected to eccentric compression. Eight square TSRC columns were tested to investigate the effects of eccentricity ratio of the compression force, width-to-thickness ratio (B/t) of the steel tubes, and use of shear connector studs on the steel sections. The test results indicated that local buckling of the square tubes was delayed effectively since axial load was not directly applied on the steel tube. A nonlinear finite element (FE) model was developed using ABAQUS, in which the nonlinear material behaviour and initial geometric imperfections were included. Good agreement was achieved between the predicted results using the proposed FE model and the test results.

Numerical modeling can provide better understanding of the behaviour of tubed SRC short columns. Therefore, the present paper is thus an attempt to study seismic behaviour of tubed SRC short columns and RCC columns. The main objectives of this paper were

[1] To develop a nonlinear finite element model for TSRC and RCC short columns and study their behaviour during an earthquake.

[2] To develop finite element model for a short column structure Behaviour Originated from the Level Difference on Sloping Lots during Earthquake.
[3] To obtain necessary information for designing and construction practises to avoid short column Failure during earthquake**.**

The purpose of this study is to investigate the improvement of strength of a structure by adding tubed SRC columns.

The overall scope of the work is to study the behaviour of tubed SRC and RCC columns during an earthquake, 4 storey structure with tubed SRC column and another a RCC column structure.

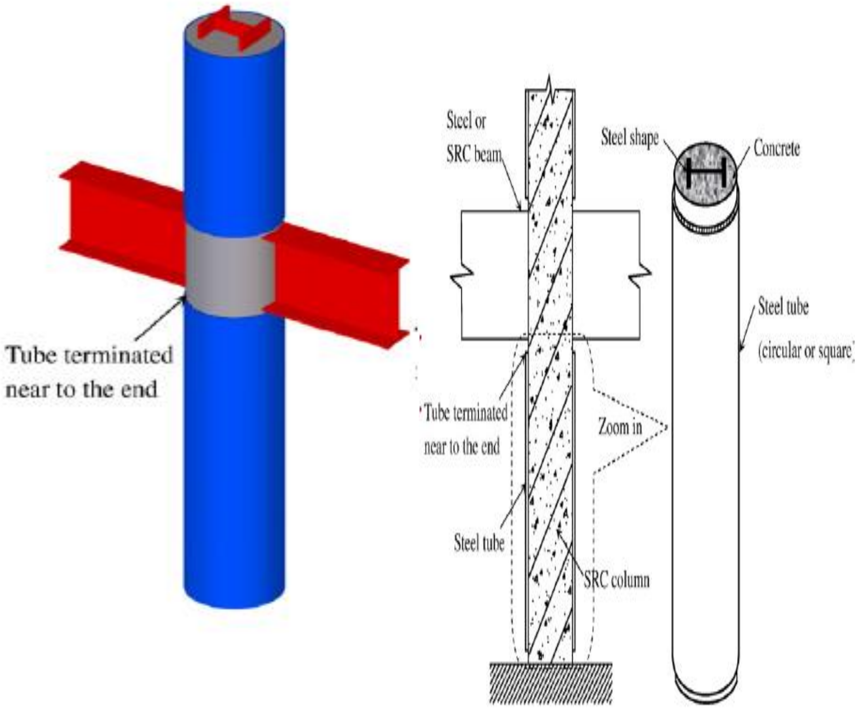


Fig. 1. Tubed SRC in a Structural Frame

II. MATERIAL MODELLING

A nonlinear 3 dimensional (3D) FEM was carried out using Ansys work bench in order to simulate the RCC and TSRC columns.

The TSRC column model was developed using the testing procedure of Xuhong Zhoua.The CTSRC columns were only consisted of circular tube, steel shape and concrete; neither longitudinal nor transverse ties were used in the CTSRC columns. The steel shapes used in the CTSRC columns were 150mm high and 85mm wide. The flange thickness of the steel shape was 10mm. The web thickness of steel shape was 3mm.The length L of the column was 680mm for the circular.

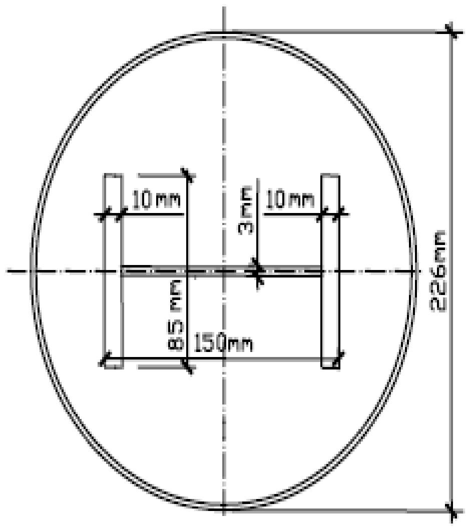


Fig. 2. Details of CTSRC column

A RCC column model was developed similar CTSRC column with length L. Nominal cover used for RCC column was 40mm. Stirrups at suitable spacing were used in the RCC column.

ISSN: 2278-0181
NCRACE-2015 Conference Proceedings

Four storey structures on a varying floor height were modelled with equal no of beams and columns. Beam and column size used were 150mm.

Different mesh sizes were considered to select the reasonable mesh that provides accurate results with lesser computational time. It was found that a mesh size of 20 mm is the appropriate one.

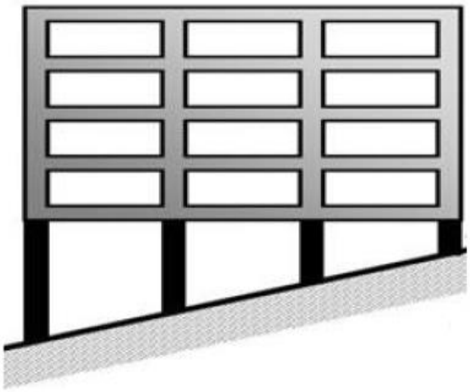


Fig. 3. Plan of four storey Structure in a Flat lot

III. FINITE ELEMENT MODELING

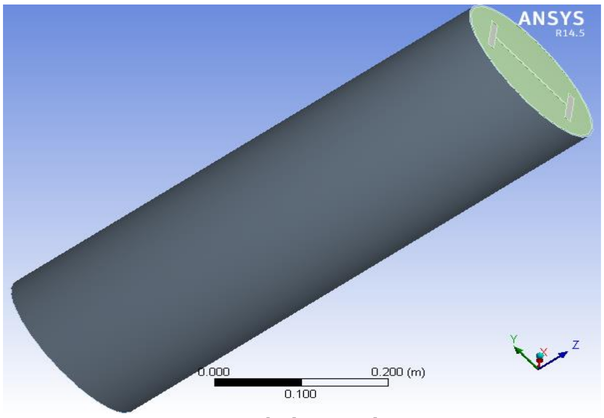
Modelling was done using ANSYS WORKBENCH (14.5).

Element type- Solid 65 was selected as the element type for the non linear analysis. Solid 65, an eight node solid element, is used to model the concrete with or without reinforcing bars. The solid element has eight nodes with three degrees of freedom at each node translations in the nodal x, y, and z directions.

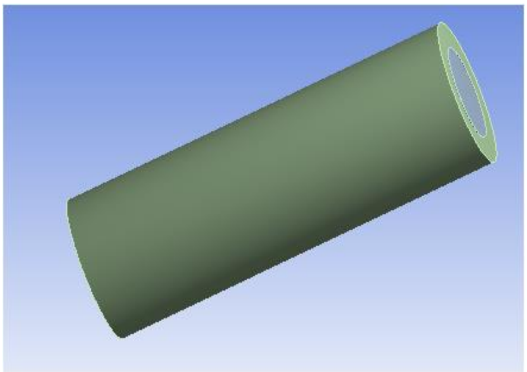
Material properties – The Solid65 element requires linear isotropic and bilinear isotropic material properties to model a structure. The characteristics strength of the concrete considered was 40 N/mm^2

The Concrete and Steel properties used were given in the table 1 and 2.

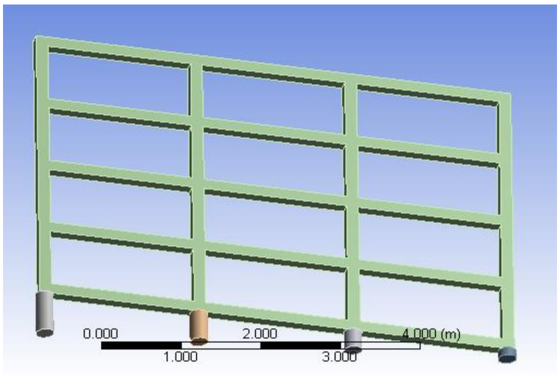
Loading and Boundary Condition- Axial load was applied using the hydraulic jack. Displacement was given at the both ends The bottom end of the specimen was fully fixed to the ground, while the top end was free to move.



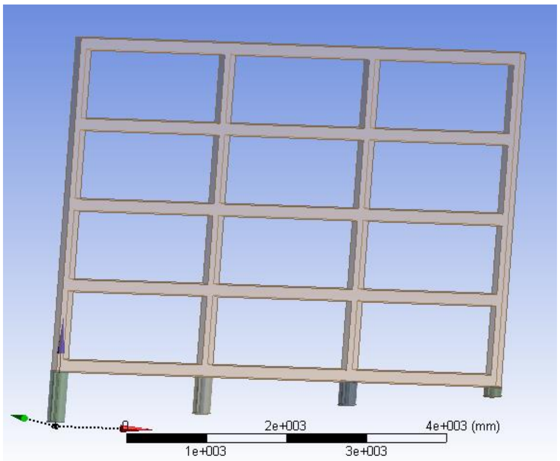
a.Tubed SRC Column



b. RCC Column



c. Position of RCC column on a slopping lot



d. Position of Tubed SRC column on a slopping lot

Fig .4. Finite Element Modelling

TABLE1. CONCRETE PROPERTIES

Material	Material Model	Modulus of Elasticity MPa	Poisson's ratio
Concrete	Linear Elastic	31622	0.15

TABLE 2. STEEL PROPERTIES

Material Model	Linear Elastic
Elastic Modulus E_s	200GPa
Poisson's ratio	0.3
Yield strength, f_y	250 MPa

IV. FINITE ELEMENT ANALYSIS

The analysis has been carried out for the columns and structures - subjected to earthquake loading. The analysis was carried out with acceleration time history data of past earthquake by mentioning the number of data points and time intervals.

V. RESULTS AND DISCUSSION

The present study is to compare the seismic performance of tubed SRC column and RCC column and also to compare the short column behaviour of tubed SRC column and RCC column structure. The analysis were carried out for different models.

A. Failure Mode of Columns

Failure pattern of TSRC and RCC columns are shown in the fig 7. There was severe bond failure between the concrete and the flanges of steel section. The concrete cover spalled off, and then the main reinforcement buckled after the peak lateral load since the ties cannot prevent the main reinforcement bars from buckling after the cover spalling off.
From the fig 7 it is clear that TSRC can withstand load up to 1.518 sec, after that load value goes on decreasing. Max deformation corresponding to time 1.518 sec is 56.792.But for RCC column, up to 0.77208sec the load value (P) goes on increasing, after tat it suddenly decreases. Maximum deformation obtained is 11.94 which is less than CTSRC column.

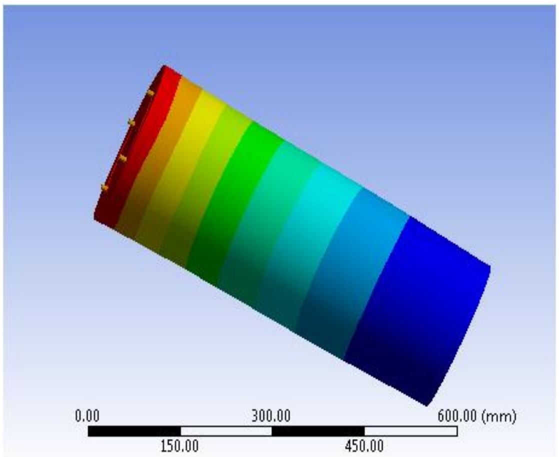


Fig .5. Deformation of RCC

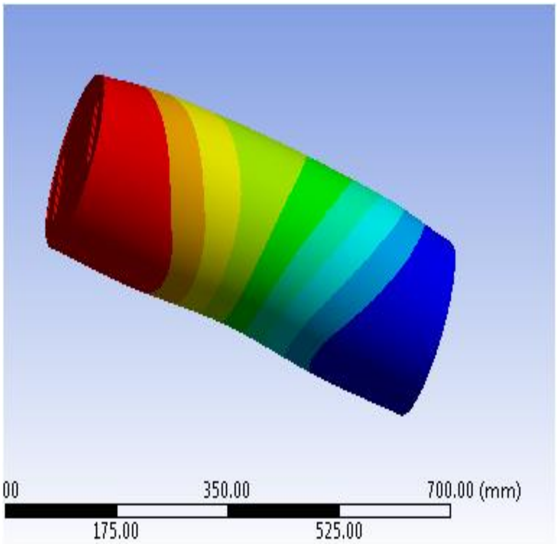


Fig. 6. Deformation of CTSRC

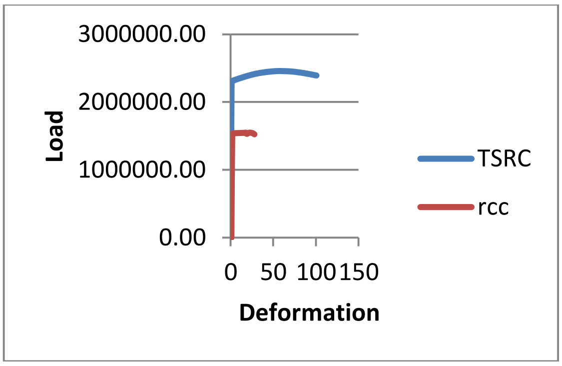


Fig. 7. Deformation versus load

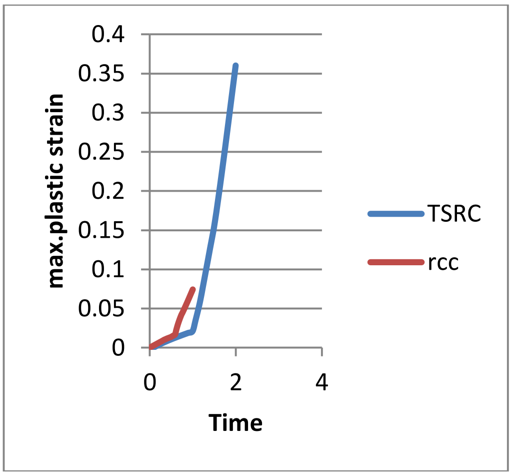


Fig .8. Max Plastic Strain

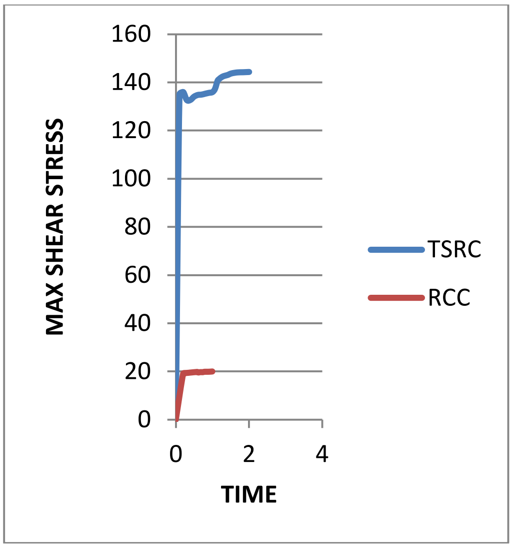


Fig. 9. Max Shear Stress

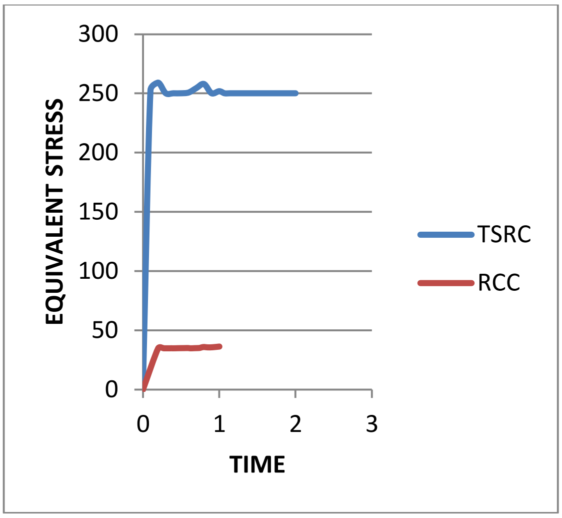


Fig .10. Equivalent Stress

A. Natural Frequency

The term natural frequency is defined as the frequency at which a system oscillates when not subjected to continuous or external force. The term frequency depends upon mass and stiffness. When stiffness increases frequency also increases. As the stiffness of the tubed SRC is higher than the RCC structure, its frequency goes on increasing compared to RCC structure.

B. Harmonic Analysis

Harmonic Analysis, mathematical procedure for describing and analyzing phenomena of a periodically recurrent nature. From the fig 10 and fig 11it is clearly understood that the for a same frequency, amplitude of RCC structure is 25 times higher than the tubed SRC structure.

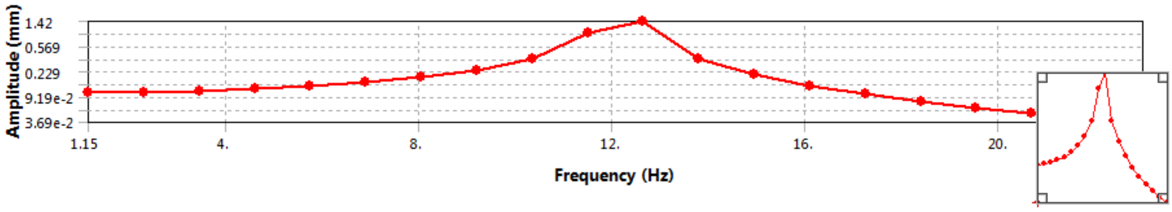


Fig 11: Frequency versus amplitude of tubed SRC structure

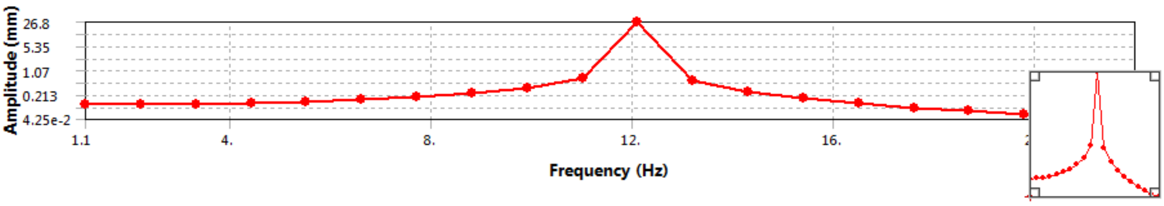


Fig 12: Frequency versus amplitude of RCC structure

A. Time History Analysis

In time history analyses the structural response is computed at a number of subsequent time instants. In other words, time histories of the structural response to a given input are obtained ad a result. Here the analysis is carried out based on the acceleration values obtained from the past earthquake. The structural response of deformation and stress produced due to acceleration is computed.

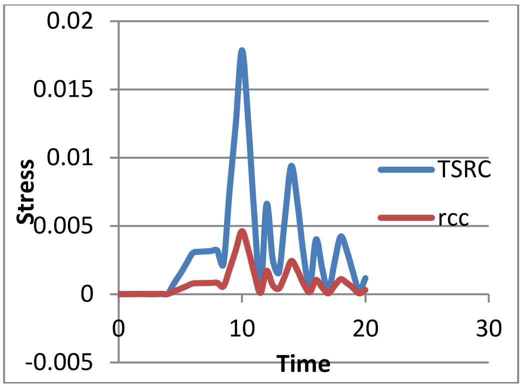


Fig 13: Structural response of a column

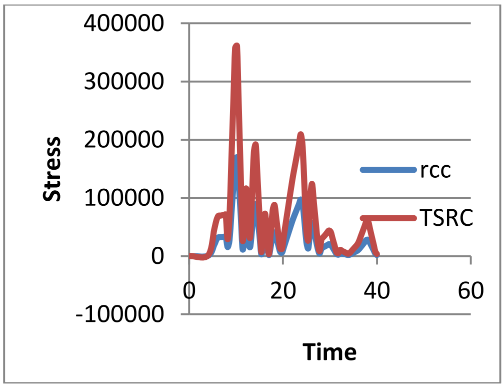


Fig 14: Response of a structure

VI. CONCLUSION

In this study an effort was taken to analyse the seismic behaviour of tubed SRC Short column and RCC short column. Following are the conclusion obtained from the graph and other results.

1) Strength of tubed SRC short columns was excellent due to the effective confinement of the outer thin steel tube to the core concrete.
2) Tubed SRC column can withstand load higher than the RCC column due to its outer thin steel tube.
3) The result indicate that shear stress, plastic deformation capacity, equivalent stress were much higher than those of the RCC column.
4) Amplitude of tubed SRC structure is 25 times less than the RCC structure for the same frequency.
5) Frequency of the tubed SRC structure is higher than the RCC structure, as the stiffness increases.

REFERENCES

[1]Vipulkumar Ishvarbhai Patel a, Qing Quan Liang b, Muhammad N.S. Hadi (2014) 'Nonlinear analysis of axially loaded circular concrete-filled stainless steel tubular short columns' *Journal of Constructional Steel Research*

[2] Sumei Zhang, Jiepeng Liu (2007) 'Seismic behavior and strength of square tube confined reinforced-concrete (STRC) columns' *Journal of Constructional Steel Research* ;63(9):1194207.

[3] Xuhong Zhoua, Jiepeng Liu 'Seismic behavior and strength of tubed steel reinforced concrete (SRC) short columns' (2010) *Journal of Constructional Steel Research* 66 885 – 896.

[4] M. Morettia,, T.P. Tassiosb 'Behaviour of short columns subjected to cyclic shear Displacements Experimental results' (2007) *Engineering Structures* 29 2018–2029.

[5] Keyvan Ramin, Foroud Mehrabpour (2014) 'Study of Short Column Behavior Originated from the Level Difference on Sloping Lots during Earthquake (Special Case: Reinforced Concrete Buildings)' , *Open Journal of Civil Engineering*, 4, 23-34 .