International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Capacity Analysis of Post-tensioned Steel Structure in Column Removal

Jesidha S[1], Sadic Azeez[2]

[1]*Mtech Student, Computer Aided Structural Engineering, ICET, Mulavoor P.O, Muvattupuzha, Kerala, India*
[2]*Assistant Professor, Civil Department, ICET, Mulavoor P.O, Muvattupuzha, Kerala, India*

Abstract - *Post-tensioned (PT) steel structural frames have been successfully developed in the past decade as the novel earthquake-resistant structural system. Compared to old steel frames, a Post Tensioned steel frame which can demonstrates greater load bearing and seismic performance, notably when the minimum damages in main structural elements and the self-centering capability of a column under a design basis earthquake. The capacity of a post-tensioned steel frames subjected to a gradual increase in the vertical displacement along the line of column removed and it is systematically studied and analysed. On removal of a column from the ground portion, the entire system is been disturbed. In order to bring the system into a stable and safe position different methods are studied and incorporated. Finally, the corresponding safe modes are identified and the implications methods are suggested.*

Key Words: **Column removal, Structural capacity, self centring, Finite element analysis.**

1. INTRODUCTION

1.1 General Background

The recently introducing post-tensioned (PT) steel frames are highly potentially to an other alternative for a conventional steel moment resisting frames. Post Tensioned steel frames typically requires that the under a design basis earthquake, beams, columns, and Post Tensioned strands provide a primary sources of stiffness and strength and essentially remain elastic, while in-elasticity and damages due to seismic effects are concentrated within the replaced energy-dissipating elements. Thus, after the design basis earthquake, a Post tensioned steel building frame is expected to regain its original plumb position self-centering without incurring residual deformation in it's major structural elements.

Experimental studies have demonstrated that the comparison to conventional welded moment connections and the Post Tensioned steel connection inhibits a similar level of rotational strength, ductility and stiffness, while the repair of cost cracks in the welded structural components can be favorably decreased or even can eliminated to a certain extend. In addition to the experimental investigation high-fidelity finite element models have been developed to study the seismic response of Post Tensioned steel frames. In particular, by using the ANSYS software, a FE model can be conveniently built to generate a computer simulation of a vast amount of information on the deformation and internal forces of all components within a Post Tensioned steel structure.

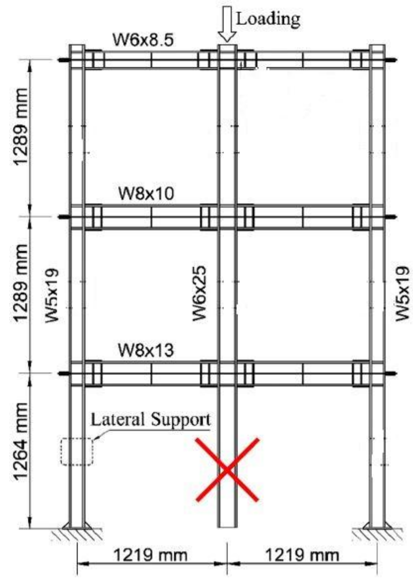

Fig -1: Experimental setup of a PT Steel frame under a vertical load

1.2 Objectives and Scope of the Study

The main objectives of this study are as follows:

- To compare the building frame with column and by removing a column.
- To determine the depth of beam by varying the depth and by using corrugations in web of I and H sections.
- To investigate measure of safety of circular, x, v, inverted-v and parallel bracings which are placed above the ground storey and to find the best model among them.
- To investigate the stability of the structure.

Scopes : Column to column length can be increased. To modify the existing buildings by column removal process. To have an overall safety control of the building.It can be used for rehabilitation and strengthening of structures.

2. NUMERICAL INVESTIGATION USING ANSYS WORKBENCH 16.1

2.1 Base Model

Development of Finite Elements models for both Post Tensioned steel beam to column connections and Post Tensioned steel frames that contains such connections, and a 9n order to validate these Finite Element models using a relevant benchmark of experimental data that is available in the literature point of view. The role of different structural elements which facilitate the load re-distribution on removal of column and identify the relevant implications for progressive collapse design. Numerical modelling of post tensioned steel with different frame sections was done using ANSYS 16.1 WORKBENCH, finite element software for mathematical modelling and analysis, SOLID 186 is used. The dimensions and material properties of all the models are same and as given in Table 1 and Table 2 respectively. The study reported in this paper aims to understand the behaviour and the capacity of a Post Tensioned steel frames under column removal that could lead to gravity-induced progressive collapse.

Boundary conditions were assigned to the models. Here 3 boundary conditions are given. The base of the column is fixed supported. A vertical displacement is provided at the middle portion from the top and a restrained lateral support at the side portion of the frame.

Table -1: Geometry of Sections

MEMBER	DIMENSIONS
DIMENSIONS OF THE I SECTIONS	W6X8.5
	W8X10
	W8X13
	W5X19

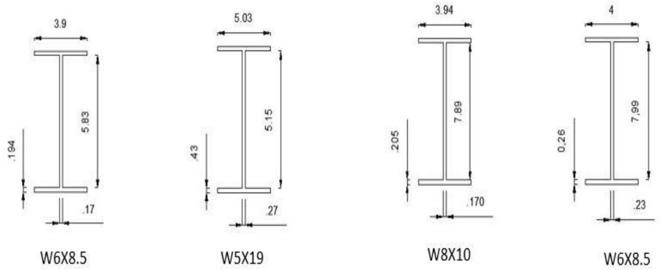

Fig -2: Various Geometric Sections.

Table -2: Material Properties of Steel.

Young's modulus of Steel (GPa)	200
Poisson's ratio of Steel (ν)	0.3
Yield stress of steel (MPa)	345

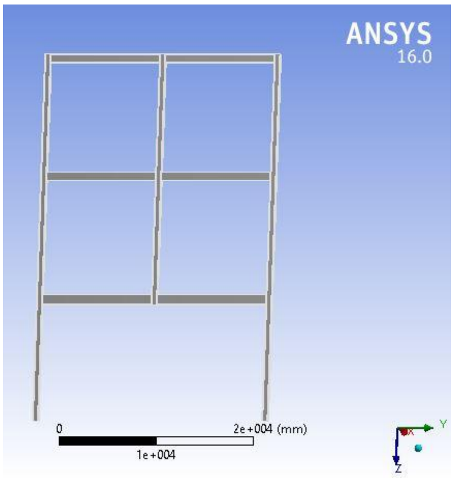

Fig -3: Modelled view when a column is removed.

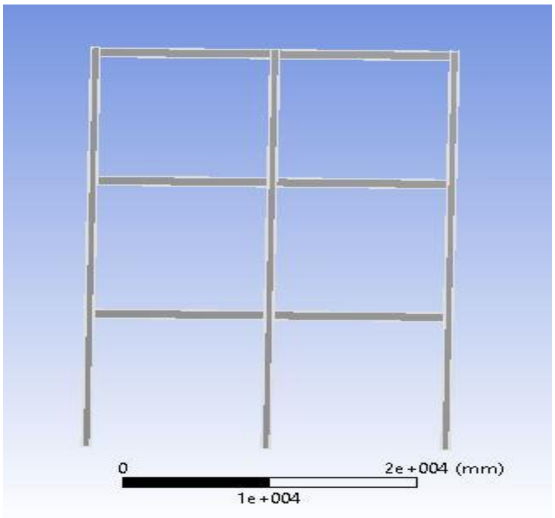

Fig -4: Modeled view with all the columns.

The building with the three columns can with-stand more force than when the column is removed. The maximum resultant force when the three column is placed is 4.92×10^7 N. Maximum resultant force when the middle column is removed is 3.23×10^7 N. The column is further modelled by providing corrugation, increase in the depth of the beam and also by providing various typed of bracing systems.

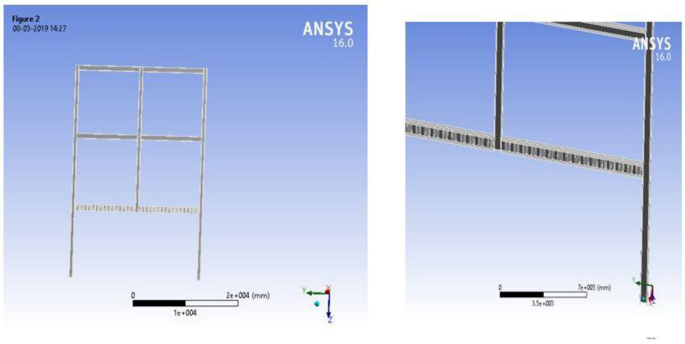

Fig -5: Modelled view corrugated section.

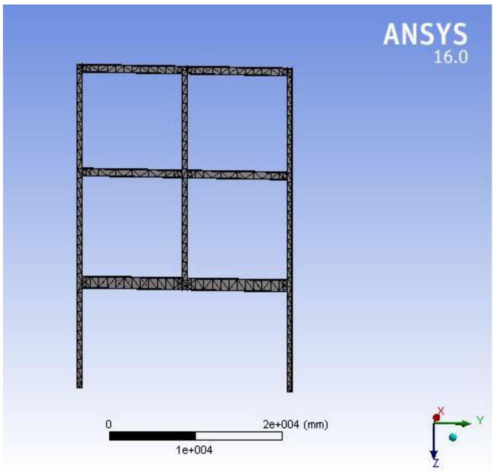

Fig -6: Modelled view of increase in the beam section.

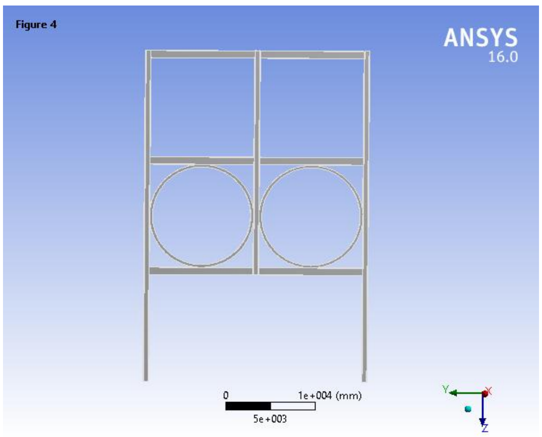

Fig -7: Modelled view with circular bracings in the section.

3. RESULTS AND DISCUSSIONS

The deformations and corresponding force reaction of steel frame with sections geometries were obtained. The force vs displacement graph of the all types of section was shown below in Figure 6 and 7 respectively. Deformation, stress strain of different sections is also obtained.

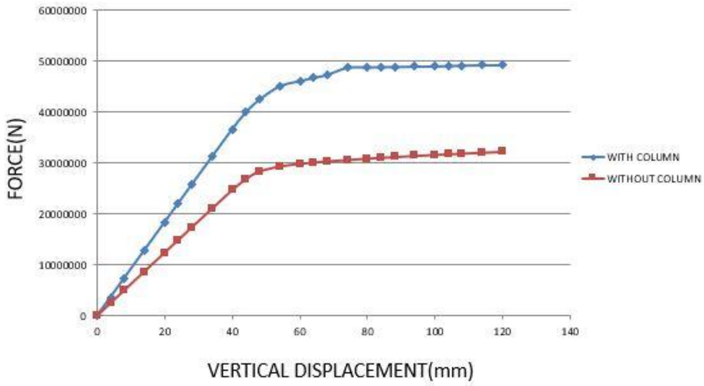

Fig -8: Force vs displacement graph of different sections.

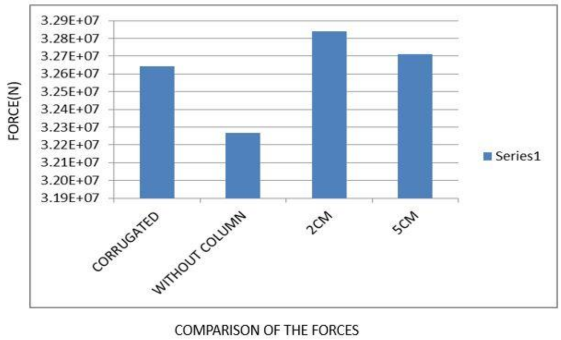

Fig -9: Comparison of Forces

Figure 9 to Figure 13 shows the total deformation of all the models obtained from ansys analysis. And Figure 14 to Figure 18 shows the equivalent von mises stress of all the models from ansys.

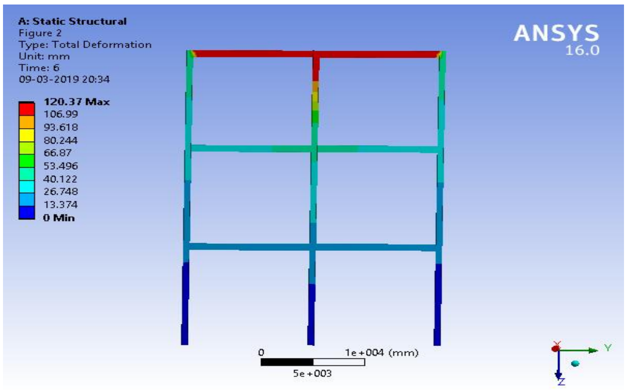

Fig -9: Total deformation of column placed section.

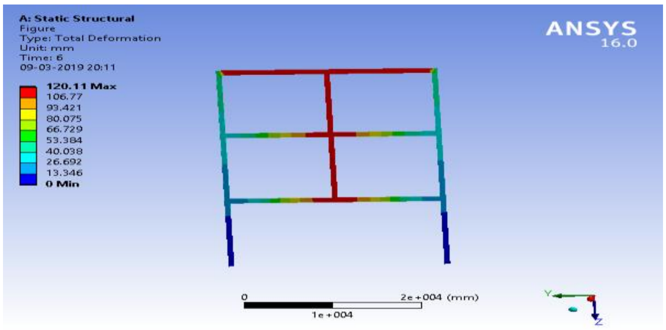

Fig -10: Total deformation by removing a column.

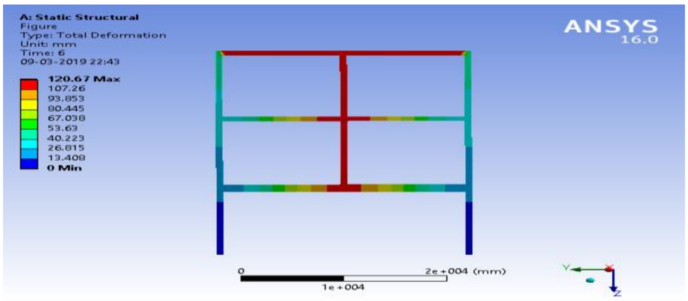

Fig -11: Total deformation of section by increasing the size of beam.

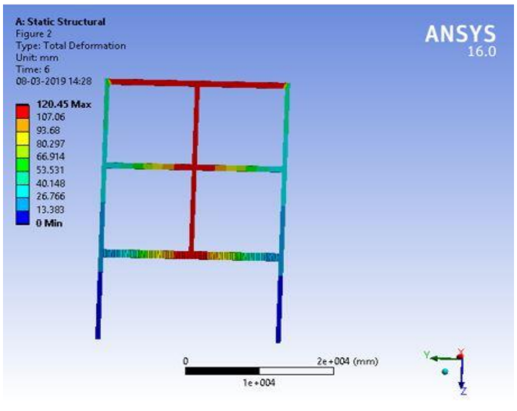

Fig -12: Total deformation of section by providing corrugations.

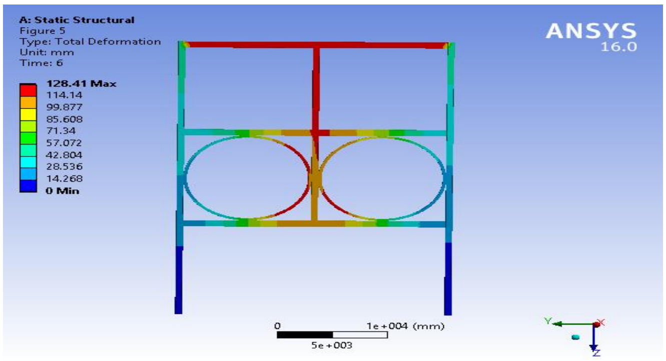

Fig -13: Total deformation of the frame section by providing circular bracings.

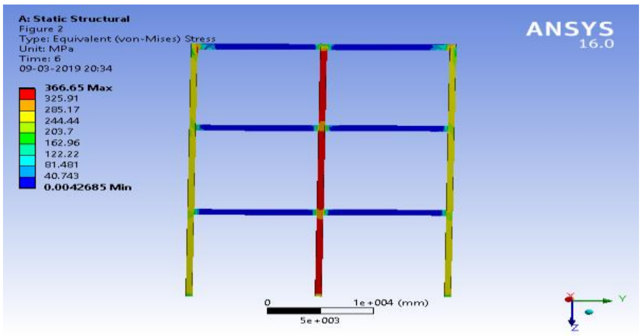

Fig -14: Equivalent von mises stress column placed section.

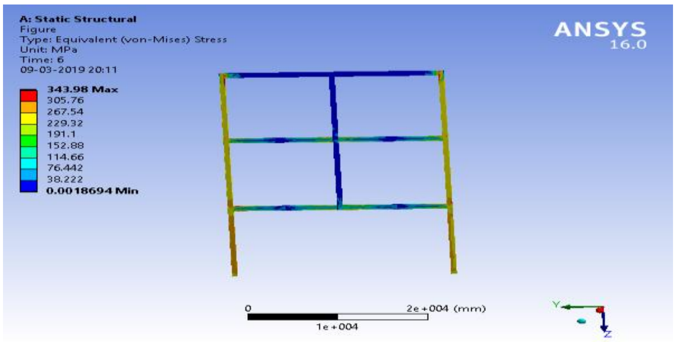

Fig -15: Equivalent von mises stress by removing a column.

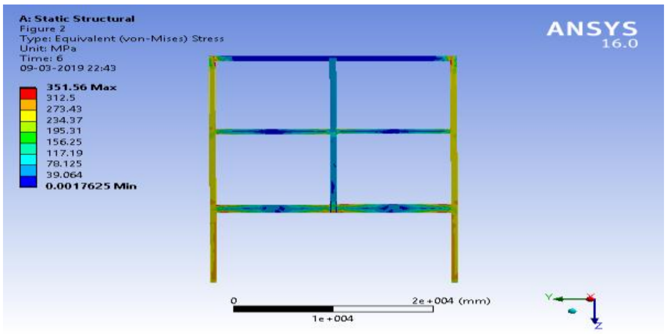

Fig -16: Equivalent von mises stress by increasing the size of beam.

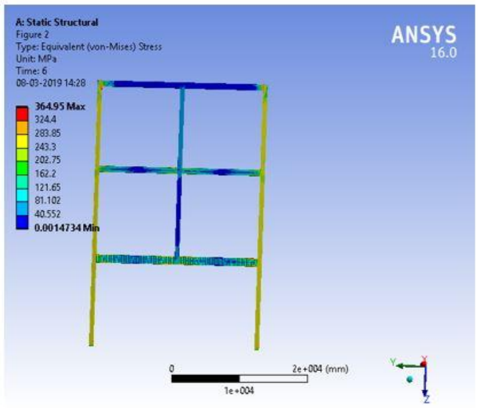

Fig -17: Equivalent von mises stress section by providing corrugations.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

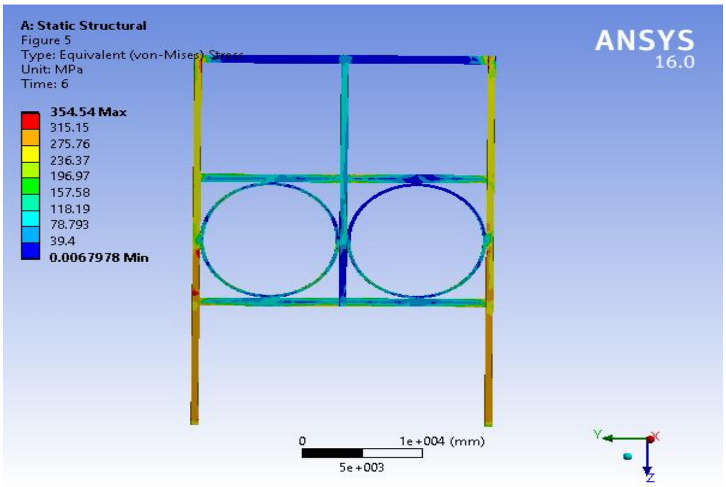

Fig -18: Equivalent von mises stress of the frame section by providing circular bracings.

Graph representing maximum force and displacement of various sections and wall panels were illustrated below.

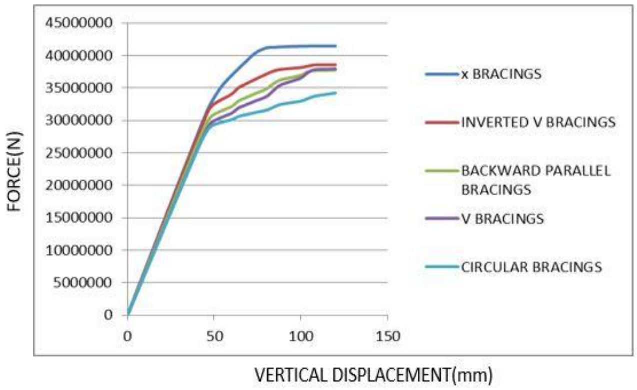

Fig -19: Maximum force and displacement of different sections

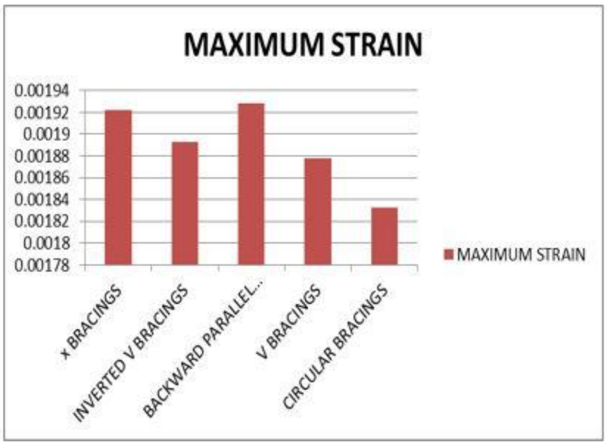

Fig -20: Maximum strain

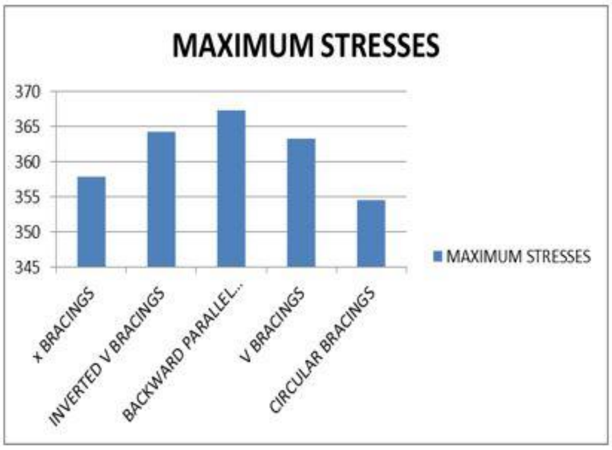

Fig -21: Maximum stress

4. CONCLUSIONS

This study proposed a new configuration of circular bracing in column removal scenario and their application in multi storey structure, the conducted analytical study on post tensioned steel under column removal result in following conclusions:

A column is removed from the ground storey and in order to ensure the stability, different methods are proposed and analysed.

- Increasing the depth of the beam up to a certain limit will improve the load carrying capacity of the structure, but further increase will not give a satisfactory result.
- Providing corrugation is also found to be less effective as compared to increase in the depth of the beam.
- Providing bracings is found to be more satisfying method.
- Here a new bracing system is introduced-ie. circular bracing system.
- On comparing the building frames, more stability is observed for x bracing and circular bracing.
- By providing circular bracing it is found that the structure can carry the load coming on it without transferring it to the ground.
- The stress and strain experienced in circular bracings is much smaller as compared to all other method.
- The load carrying capacity is also increased by providing circular bracings.
- Hence it concludes that providing circular bracing is a good method in column removal process.

ACKNOWLEDGEMENT

I wish to thank the Management, Principal and Head of Civil Engineering Department of Ilahia College of Engineering and Technology, affiliated by Kerala Technological University for their support. This paper is based on the work carried out by me (Jesidha S.), as part of my PG course, under the guidance of Mr. Sadic Azeez (Assistant Professor, Ilahia College of Engineering and Technology, Muvattupuzha, Kerala). I express my gratitude towards him for his valuable guidance.

REFERENCES

[1] Akbar Pirmoz, Min LIU. (2016), "Finite element modelling and Capacity Analysis Of Post Tensioned Steel Frames Against Progressive Collapse" Engineering Structures Journal doi:.2016.

[2] Wang D. Numerical and experimental studies of self-centering post-tensioned steel frames PhD Thesis. State University of New York at Buffalo; 2007.

[3] Robert G. Driver,Hossein Daneshvar, " Modeling Benchmarks For Steel Shear Connections In Column Removal" Alexandria Engineering Journal Vol. 56, Pg. No: 251 – 262;2017.

[4] Sadek F, Main J, Lew H, El-Tawil S. Performance of steel moment connections under a column removal scenario. II: Analysis. J Struct Eng 2012;139(1):108–19.

[5] AISC. Seismic provisions for structural steel buildings (ANSI/AISC 341-05). Chicago, IL: American Institute of Steel Construction, Inc; 2005.

[6] Amir Hossein Arshian et al., "Three-dimensional progressive collapse analysis of reinforced concrete frame structures subjected to sequential column removal". Engineering Structures Journal, Vol. 105, Pg. No: 139 – 150;2016.