Engineering Structures 254 (2022) 113835

Contents lists available at ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

# Resilient steel beam-column connection with bolted compact hollow structural steel damper

Redhwan M. Algobahi [a,b], Mohamed Abdel-Basset Abdo [a], Mohamed F.M. Fahmy [a,c,d,*]

[a] Civil Eng. Dept., Faculty of Eng., Assiut Univ., Assiut, Egypt
[b] Civil Eng. Dept., Faculty of Eng., Thamar Univ., Dhamar, Yemen
[c] International Institute for Urban Systems Engineering, Southeast Univ., Nanjing 210096, China
[d] Sustainable Architectural Program, Egypt-Japan University of Science and Technology (E-JUST), Alexandria 21934, Egypt

ARTICLE INFO

*Keywords:*
Resilience
Resilience based design
Self-centering
Post-tensioning
Compact section
Steel tube
Seismic
FEM

ABSTRACT

This study proposes a resilience-based design approach that considers the correlation between the resilience response of self-centering post-tensioned (SCPT) steel beam to column connections and the inelastic performance of the required energy dissipation (ED) system. A compact circular hollow steel tube (CHST) is proposed as a replaceable ED system. On the basis of existing experimental results, a detailed three-dimensional finite element modeling (3D-FEM) was carried out to identify the response of the compact CHST under half cyclic loading. A large number of numerical works ended with the extraction of design charts to determine the axial strain (ΔL/L) of the ED system before encountering post-yield buckling and/or excessive strength degradation. Accordingly, in a numerical validated reference SCPT connection, several predesigned ED systems were implemented for simulation. As a result, according to the design charts, the optimum selection of proper inherent depth to thickness (D/t) ratio and length to depth (L/D) ratio of the CHST-ED system can increase the resilience of modern self-centering steel structures. In addition, the improvement of the entire connection resilience is associated with the development of satisfactory energy dissipation capacity. Furthermore, the superior performance of the connection under sequential cyclic loading promotes the application of the proposed SCPT-ED connection in a resilient structural system.

## 1. Introduction

During the Northridge earthquake in 1994 in the United States, welded joints suffered unexpected premature failure due to their limited inelastic deformation capacity. This response was mainly attributed to the less ductility of the connections causing several detrimental failure modes on columns and connecting beams [more details can be referred to FEMA-355 D [28]]. Although more works have been devoted to developing seismic provisions and specifications of national design codes to enhance the connection seismic response, they cannot protect the main components from significant inelastic deformations during strong earthquakes and permanent post-earthquake deformations and increase the construction cost. Therefore, in recent years, self-centering post-tensioning (SCPT) connections have been considered to be reliable attractive moment-resisting connections using conventional materials and well-known construction techniques. SCPT connections can achieve high ductility and deformability based on their geometry rather than the material ductility (usually forming plastic hinges at the beam ends), which is more attractive for comprehensive research. At present, the international demand is getting higher and higher, which requires resilience performance in various structures. From the structural point of view, resilience is the elasticity shown by limiting the damage to the main components of the structure (restoration of the entire system function without repair works) [11]. The SCPT system is a promising seismic-resisting system, which can be designed to avoid major damage during an earthquake and restore the plumb position of the structure after the earthquake, so as to ensure the functionality of the structure and reduce the potential risk to human life. Therefore, many researchers suggest the SCPT system being an alternative for traditional welding moment connections in modern resilient steel structures, e.g., the moment-resisting frame (MRF) system [10,9,31,34], among others]. However, the energy dissipation (ED) capability of the SCPT connections depends on the hysteretic response of an additional system through yielding or frictional mechanisms, which must be incorporated into the connection structure to achieve this goal.

* Corresponding author at: International Institute for Urban Systems Engineering, Southeast Univ., Nanjing 210096, China.
*E-mail addresses:* algobahi@eng.aun.edu.eg (R.M. Algobahi), abdo14@aun.edu.eg (M. Abdel-Basset Abdo), m.fahmy@aun.edu.eg (M.F.M. Fahmy).

https://doi.org/10.1016/j.engstruct.2021.113835
Received 16 December 2020; Received in revised form 22 December 2021; Accepted 30 December 2021
Available online 13 January 2022
0141-0296/