Investigation of the effects of Retrofitting the Connection of Steel Beam to Concrete-Filled Steel Tube Column with Bidirectional Bolts by Haunch plates

Khadijeh Ghanbari Soumeha [1], Hossein Parvini Sani[2*]

[1]M.Sc. Structural Engineering, Department of Civil Engineering, Zanjan Branch, Islamic Azad University, Zanjan, Iran.

[2]Assistant Professor, Structural Enginnering, Department of Civil Engineering, Zanjan Branch, Islamic Azad University, Zanjan, Iran.

ABSTRACT

So far, a lot of research has been done on concrete filled tubes (CFT) columns and their connections in different countries and several alternatives have been proposed for their connections, however, most of the proposed connections are associated with executive problems and have not been able to create rigid connection conditions. On the other hand, in these connections, the load enters the concrete indirectly and the concrete core does not mobilize well against the applied loads. For steel moment frames that columns are of CFT type, new and suitable methods have been proposed to improve the behavior of their fixed connections. Among them are bidirectional bolted connections that in this study, the effect of strengthening this type of connection using haunch plated is surveyed. In these models, the main variables are haunch plates and column plate thickness. The results showed that by examining the formation of the position of the plastic hinge, it can be said that in the model without the haunch plate, plastic hinges and maximum strains are formed almost at the connection and on the face of columns. In most models retrofitted by haunch plates, however, the location of plastic hinge is in the off-connection area, approximately 20 cm side of the column. It has been seen that the CFT connections retrofitted by haunch plates, energy absorption has increased by 22.62% and the moment capacity bearing has increased by 3%.

KEYWORDS

Connection in CFT columns, local buckling, haunch plate, plastic strain, plastic hinge.

* Corresponding Author: Email: hossein.parvini_sani@iauz.ac.ir

1. Introduction

During the occurrence of earthquakes in the last two decades, significant economic and human losses have occurred due to the collapse of structures [1,2,3]. So, extensive studies have been conducted on the behavior of rigid flexural connections in concrete filled tube (CFT) columns under cyclic loading over the past decades, which has resulted in the development of new types of connections and the establishment of relevant regulation [4]. Most current studies on steel beam to concrete-filled steel tube column connections with bidirectional bolts or other proposed connections are based on analytical and experimental tests and it has been shown that the bidirectional bolted beam-to-column connection has excellent seismic resistance, and this structural system can perform well as expected and be put into practice [5-12]. Given the results of the previous studies regarding fixed connections in CFT columns and the existence of extensive studies in this regard, seismic design regulations and connections will go through further developments and evolution over the next decades which highlights the significance of conducting further studies on CFT connections and their frames [13]. Although the conduction of large-scale experiments might not be feasible due to the limitation and shortage of experimental equipment as well as financial reasons, it appears necessary to conduct further analysis and experimental studies in this field since the finite element method does not perform a complete simulation of seismic impacts, especially in the case of rare earthquakes [14,15].

The present study examines the effect of using haunch plates in CFT connections through studying variables of haunch plate and column plate thickness. The examination of these variables mainly aims to obtain the extent of the haunch plate's effect on the models strain, the energy absorption, the location of plastic hinges, and the moment-carrying capacity.

2. Methodology

In this study, Li-yan Wu et al.'s [6] beam-to-CFT-column connection has been used as the validation model to examine modeling validation by finite element modeling. The aforementioned connection relates to a structure with a span of 6m and a height of 3m. The beams were made out of H-shaped steel with a grade of A36 steel and a cross-section of H500* 200* 10* 16, and a plate in the size of 720mm* 400mm* 25mm was welded to the end of the beam. A490 steel with a diameter of 30mm was used as the bolts. In order to validate the finite element modeling, one of the connection models (FSB-8) was modeled in Abaqus software based on the conditions mentioned in Li-yan Wu et al.'s [6] study. The Solid element with eight nodes was used to model all the elements of beams, steel tubes, triangular stiffener, flange widening plates, and the end plate, the passing bolt, and the concrete core in the model. The Von-Misses strain criteria and considering the strain hardening were used to define the mechanical properties of the steel and the plastic damage and plastic failure criteria was used for concrete in the software modeling. Since the present thesis is not concerned with the examination of welding micro-behaviors, the optimal welding condition (complete continuity and no rupture in the weld during loading) was assumed, and the "Tie" constraint was used in the loading model to model the connection of the welding edges of all elements. The constraint of "Hard Contact" was used to define the behavior of the surfaces in contact with one another (passing bolt surfaces and the concrete, screw surfaces and the steel cover of the column, and the steel cover surfaces with the concrete core) [6]. The type of analysis selected for this model is a dynamic analysis, and fixed support were defined at both ends of the column. Linear continuous elements with reduced integration (C3D8R) were used for mesh modeling (Figure 1).

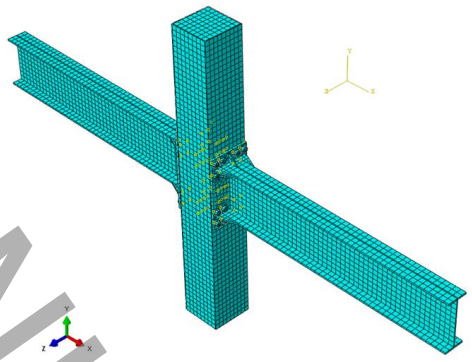

Figure 1. The final meshed model in abaqus

3. Results and discussion

The moment carrying capacity has increased due to the increase in plate thickness, so that the model with a thickness of 16mm was 2.44% and 3% more capable in terms of moment-bearing compared to the models with thickness of 12mm and 8mm, respectively. A comparison of the impact of adding haunch plates on the performance of the models indicates that the model without a haunch plate undergo local buckling approximately between 0.015 and 0.03 rotations. In terms of moment-bearing capacity, the use of plates proved to increase this capacity by 3%. Examination of the location of plastic hinge creation indicates that the

model without haunch plates created a plastic hinge and maximum strain in the proximity of the connection and side of the column, while most of the models incorporating haunch plates created plastic hinges outside the connection location and almost 20cm away from the side of the column. Increasing the column plate thickness has revealed to be effective to some extent; and in higher thicknesses, large increases in thickness bring about almost smaller changes in moment bearing capacity. The use of thick column plates has increased the load-bearing capacity by an average of 20.7% compared to the models with no haunch plates. A comparison of the models with a haunch plate with the models lacking haunch plates indicates an increased energy absorption of around 22.62%. The comparison of the impact of column plate thickness increase in models with haunch plates versus models lacking haunch plates indicates an average of 93.7% increase in the amount of energy absorption.

4. Conclusion

In this study, the effect of using reinforcing haunch plates in the connections of steel beams to concrete filled tube columns of the type of bidirectional bolts in the form of variables of haunch plate thickness and column plate thickness has been investigated. The main purpose of these variables is to obtain the effect of haunch plate on the amount of stress, strain, energy absorption and bearing capacity of the samples. It has been shown that increasing the plate thickness from 8mm to 12 and 16mm increased energy absorption by 13.4% and 7%, respectively. A comparison of the models with a haunch plate with the models lacking haunch plates indicates an increased energy absorption of around 22.62%. The model without haunch plate created the plastic hinge and the maximum strain around the connection and side of the column, while most of the models incorporating haunch plates created plastic hinges on the 20-50 cm side of the column.

5. References

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