Journal of Advanced Engineering Research
ISSN: 2393-8447
Volume 10, Issue 2, 2023, pp.235-241

SEISMIC PERFORMANCE OF COLD FORMED STEEL BEAM TO COLUMN EXTENDED ENDPLATE CONNECTION

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ABSTRACT

Cold-formed steel (CFS) is made by rolling or pressing thin sheets of steel at room temperature. This process of cold-working the steel allows it to be formed into a variety of shapes and profiles, while maintaining its strength and structural integrity. The resulting CFS sections can be used in a variety of construction applications, such as framing systems for buildings, bridges, and other structures. The protective coating that is applied to the CFS helps to prevent corrosion and extend the lifespan of the material. Overall, the good strength to cost ratio of CFS makes it an attractive option for many construction projects. While cold-formed steel (CFS) has many advantages in terms of strength-to-weight ratio and ease of construction, its use in seismic regions is limited by its low ductility and energy dissipation capacity. This is due to the low local/distortional buckling resistance of thin-walled CFS elements, which can lead to premature failure under seismic loading. Extended end-plate moment connections are commonly used in CFS beam-to-column connections in seismic moment-resisting frames. These connections are designed to be moment-resistant, which means they are able to resist the bending forces that occur during an earthquake or other seismic event.

Keywords – Cold formed steel, Extended end plate connection, Bolted connection

1. INTRODUCTION

GENERAL

Cold-formed steel (CFS) structures are becoming increasingly popular in construction due to their good strength-to-cost ratio. As you mentioned, CFS is made from thin strips of steel that are cold-rolled and formed into various shapes and profiles. The resulting sections are lightweight, easy to transport and install, and have good strength and durability. CFS structures are used in a variety of construction applications, including residential and commercial buildings, bridges, and other infrastructure projects. The use of CFS can help reduce construction costs and improve efficiency. compared to traditional construction methods, while still maintaining the necessary strength and performance.

Overall, the popularity of CFS structures is likely to continue to grow as the construction industry seeks more sustainable and cost-effective building solutions. Extended end-plate moment connections are commonly used in CFS beam-to-column connections in seismic moment-resisting frames. These connections are designed to be moment-resistant, which means they are able to resist the bending forces that occur during an earthquake or other seismic event.

1.2 COLD FORMED STEEL

Cold-formed steel (CFS) members are typically made from thin sheets of high-strength steel that are roll-formed into various shapes, including C-sections, Z-sections, and other profiles. The steel is not heated during the forming process, which is why it's called cold-formed steel.

The roll-forming process involves passing the flat sheet steel through a series of rollers that gradually shape the steel into the desired profile. The steel is often coated with a protective layer, such as galvanization, to help prevent corrosion and increase its lifespan. Cold-formed steel members have several advantages over other types of structural steel, including their high strength-to-weight ratio, ease of fabrication and installation, and ability to be produced in a wide range of shapes and sizes. These properties make CFS members a popular choice for a variety of construction applications, including framing systems for buildings, bridges, and other infrastructure projects.

1.3 BOLTED CONNECTION

Bolted connections are a common type of structural joint used to join steel structures together. These connections typically consist of bolts, nuts, and washers, which are used to clamp two or more structural elements together. Bolted connections offer several advantages over other types of connections, including their ability to be easily disassembled and reassembled, their high load-carrying capacity, and their relative ease of installation. They can also be used to connect dissimilar materials, such as steel and concrete, which can be useful in certain construction applications. However, bolted connections also have some disadvantages, such as the potential for corrosion, which can weaken the connection over time. To minimize the risk of corrosion, bolted connections are often coated with protective coatings, such as galvanization or other types of corrosion-resistant coatings. Overall, bolted connections are a versatile and widely used type of structural joint that can be found in many different types of steel structures, from buildings and bridges to industrial equipment and machinery.

1.4 EXTENDED END PLATE

An extended end-plate connection is a type of moment connection that typically consists of a steel plate welded to the end of a beam and bolted to the column. The extended end-plate provides a larger bearing surface for the bolts, which helps to distribute the forces more evenly and reduce the risk of premature failure. Overall, extended end-plate moment connections are a popular choice for CFS structures in seismic regions because they are able to provide the necessary strength and ductility to resist seismic forces while also being relatively easy to fabricate and install. An extended end-plate connection is a type of moment connection that typically consists of a steel plate welded to the end of a beam and bolted to the column. The extended end-plate provides a larger bearing surface for the bolts, which helps to distribute the forces more evenly and reduce the risk of premature failure. Overall, extended end-plate moment connections are a popular choice for CFS structures in seismic regions because they are able to provide the necessary strength and ductility to resist seismic forces while also being relatively easy to fabricate and install.

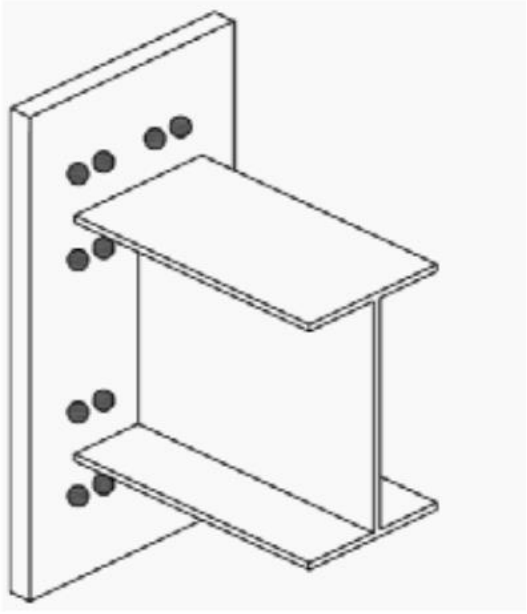


Fig1: Extended end plate

Fig 2: geometry of connection

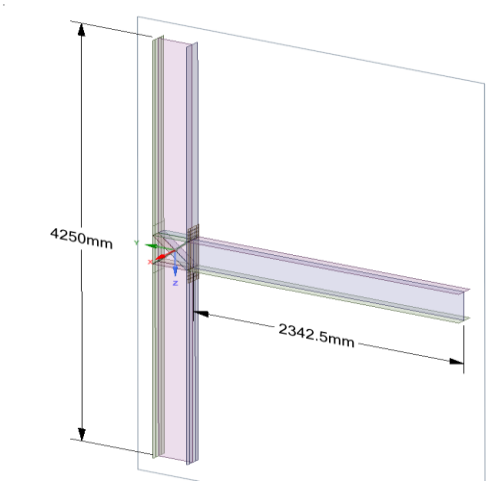
2. METHODOLOGY

2.1 SYSTEM INFORMATION

Journal articles provided the information and data needed for the structural model study. Journal papers are used to gather information on the values to be entered into the ANSYS software. The cyclic loading of the cold formed beam to column connection is taken from several journal papers in which the cyclic analysis of cold formed steel is conducted.

2.2 GEOMETRY OF MODELS

The creation of a finite element model for evaluating seismic performance of cold formed steel beam to column connected by extended end plate. x-shaped stiffeners are provided to improve the stiffness of the beam-column joint. thickness of x-shaped stiffener is 8 mm. length of column is 4250mm and length of beam is 2342.5mm. flange width of column and beam are 150mm.web width of column and beam are 200 mm. flange thickness and web thickness are 5mm and 10 mm respectively. Extended end plate with different number of bolts is modeled. Six, eight and ten number of bolt models were created. There is a model pictures from ANSYS software are given below.



Stiffeners are secondary plates or sections which are attached to beam webs or flanges to stiffen them against out of plane deformations. The biggest advantage of the stiffeners of the structure with a minimum of additional material, which makes these structures stiffen. X-shape stiffeners are used in beam-column connection.

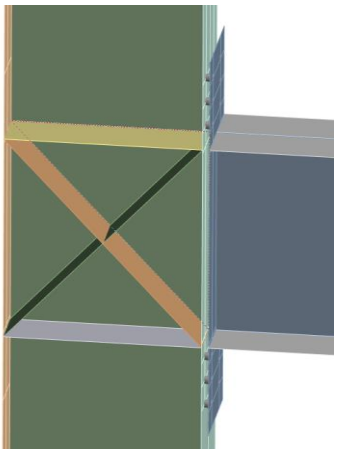


Fig 3: x-shaped stiffeners are provided

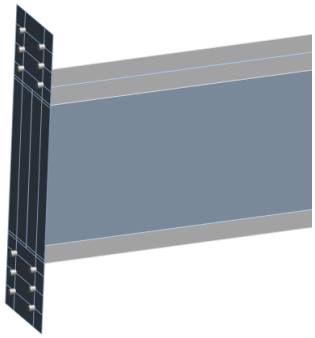


Fig 4: extended end plate with six sets of bolts

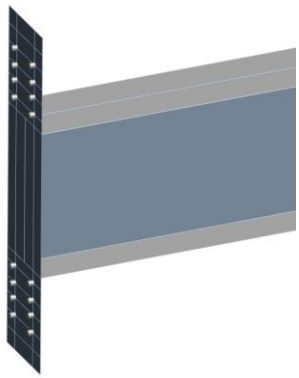


Fig 5: extended end plate with eight sets of bolt

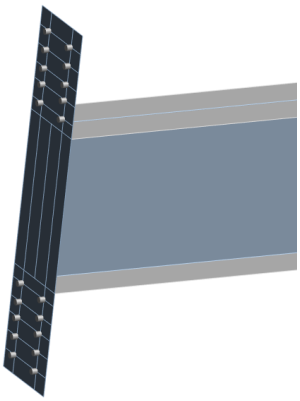


Fig 6: extended end plate with ten sets of bolts

2.3 MATERIAL PROPERTIES

The main material of beam is cold-formed structural steel. extended end plate material is steel. These engineering properties are given below,

- ❑ Steel beam
  - Poisson's ratio - 0.3
  - Compressive yield strength- 372.35 mpa
- ❑ Steel plate
  - Poisson's ratio - 0.3
  - Compressive yield strength- 368.73 mpa

2.4 BOUNDARY CONDITIONS AND LOADING

Two pin joints are A and B. here six degree of freedom and four-point load where RX is free and is pin supported on both edges. Then cyclic load applied on the end of beam at Z direction. Cyclic loading applied based on loading pattern and cycle vs deformation curve.

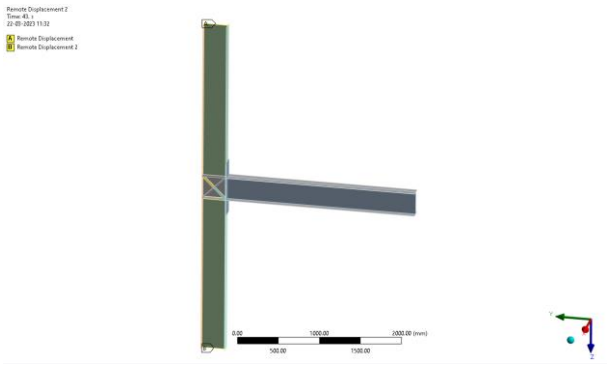


Fig 7 loading

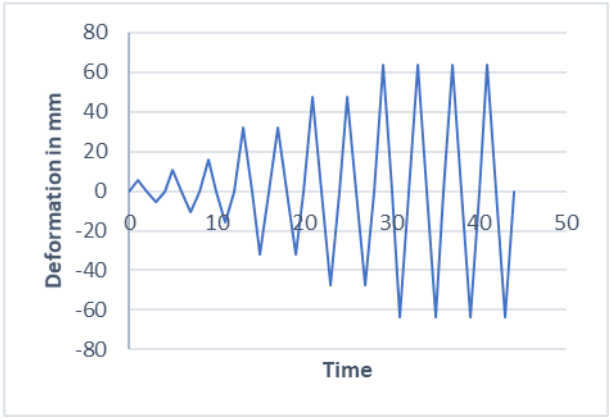


Fig 8 cyclic loading pattern

2.5 MESH MODEL

ANSYS meshing capabilities are a valuable tool in reducing the time and effort required to obtain accurate simulation results. Meshing, which involves generating 2D or 3D grids by dividing complex geometries into smaller elements, is an essential step in the finite element analysis process. However, meshing can be time-consuming and challenging, as it requires careful consideration of element types, mesh density, and refinement techniques. 20 mm size of mesh is used. Element type is Quad 4 and element order is linear.

Fig 9 mesh model

Degrees of freedom	X	Y	Z	RX	RY	RZ
A. Pin joint	0	0	0	Free	0	0
B Pin joint	0	0	0	Free	0	0
LOADING at BEAM END	Free	Free	Loading	-	-	-

3 RESULTS

ANSYS software is used to analyze cold formed beam to column connection. Cold formed steel beam of 2342.5 mm is connected to the column of 4250 mm by extended end plate connection. The maximum load carrying capacity of beam column connection is determined from hysteresis curve.

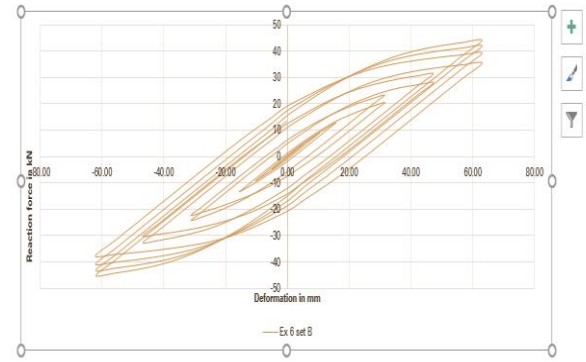


Fig 10 hysteresis curve of 6 sets if bolts

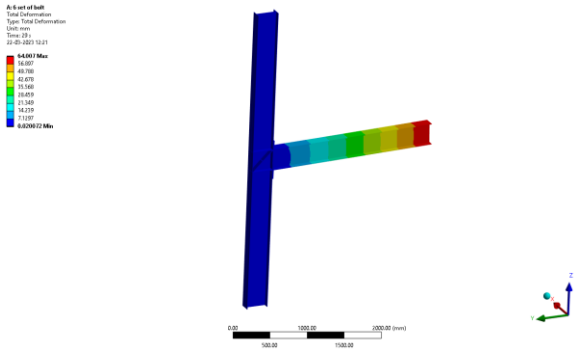


Fig 8 total deformation of 6 sets of bolts

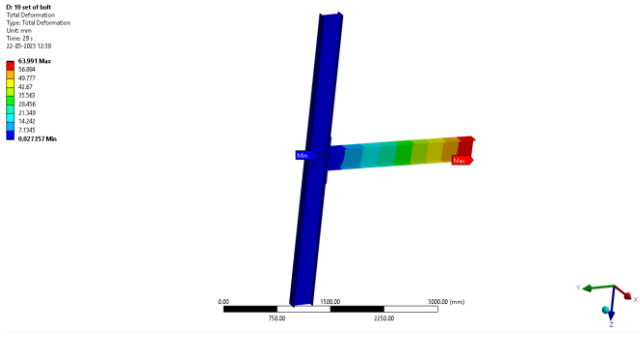


Fig 11 Total deformation of 8 sets of bolts

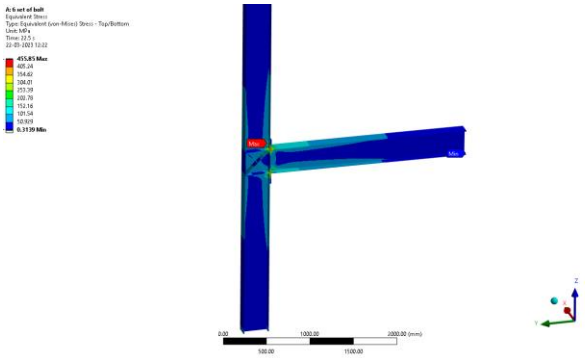


Fig 9 Equivalent stress of 6 sets of bolts

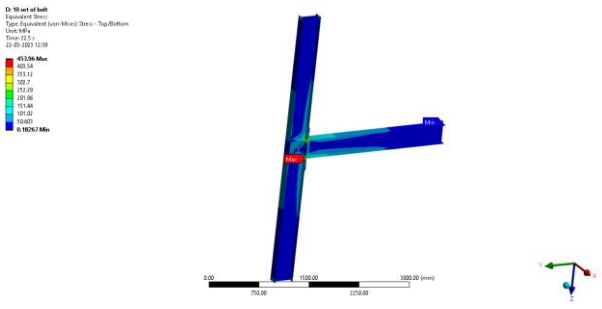


Fig 12 Equivalent stress of 8 sets of bolts

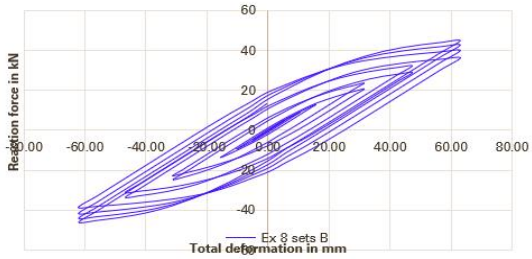


Fig 13 hysteresis curve of 8 sets of bolts

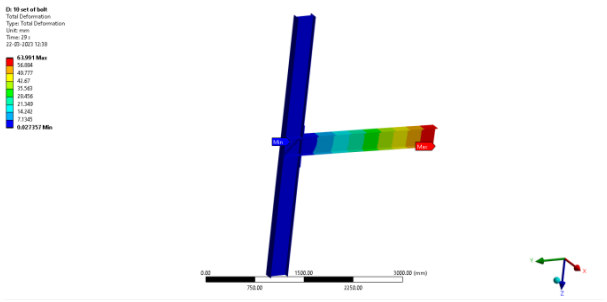


Fig 14 Total deformation of 10 sets of bolts

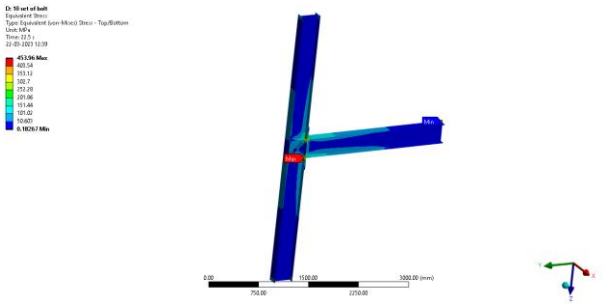


Fig 15 Equivalent stress of 10 sets of bolts

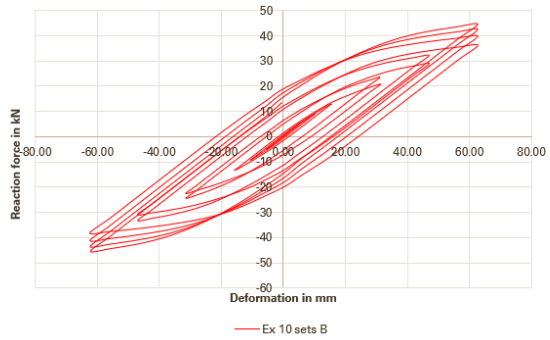


Fig 16 hysteresis curve of ten sets of bolts

Sl no	Specimen	Ultimate load in kN	Total deformation (mm)
1	EX 6sets B	43.18	63.09
2	EX 8sets B	45.046	62.84
3	EX 10 sets B	45.8	62.89

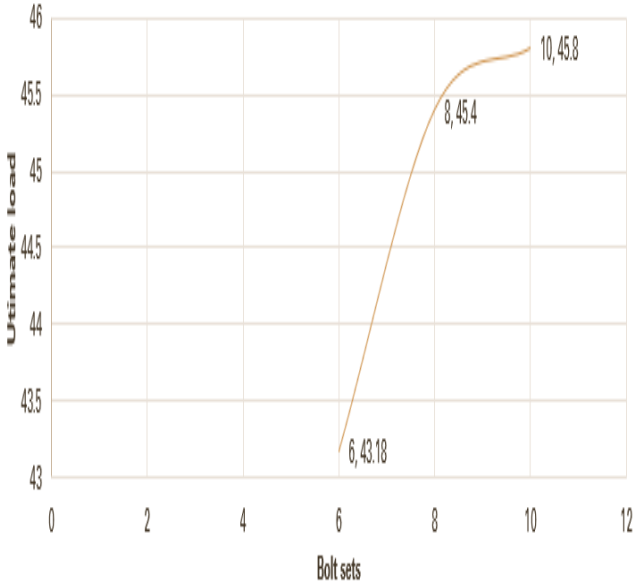


Fig 17 bolt sets vs ultimate load

4 CONCLUSIONS

Extended end-plate moment connections are used in a CFS beam-to-column connections in seismic moment resisting frames. Extended end plate is a moment resistant connection. Eight bolt sets are most suitable for cold formed beam to column connection. Because, after eight bolt sets there is no change in ultimate load. Here ultimate loads are constant. So, it is best bolt sets for this connection. extend end plate has good energy dissipation capacity and it is used for moment resisting connections.

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