FATIGUE ANALYSIS OF DOUBLE CHANNEL COLD FORMED STEEL BEAM-COLUMN JOINT

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Abstract - *In steel construction, cold–formed structural members are becoming more popular and have a growing importance. Its growing popularity in building construction is due to its advantages over other construction materials such as lightness and consequent ease of erection and installation, economy in transportation and handling. Even though the static behaviour of cold-formed steel elements is well established, fatigue behaviour of these elements under fluctuating loads is still uncertain. Most of the codes of practice for usage of cold-formed steel sections in structural applications, deal only with static conditions of loading. Fatigue strength is important for cold-formed steel structural members and the probability of failure by fatigue is comparable with that of other Ultimate Limit State modes of failure. Hence the prospect of using cold-formed steel sections under dynamic conditions becomes attractive. Objective of this study is to examine the performance of cold formed steel beam column joint subjected to fatigue loading. Using ANSYS software, fatigue analysis of double channel beam column - joint with a bolted and a welded connection with varying thickness (2mm and 4mm) are planned to be studied. Within bolted connection, bolts only and cleat angle connections are studied. From this study, the best connection is flange and web cleat bolted connection.*

Key Words*:* Fatigue, cold-formed steel, fluctuating loads

1. INTRODUCTION

Cold formed steel structures are structural products that are made by forming plane sheets of steel at an ambient temperature into different shapes that can be used to convince structural and functional requirements. In steel construction, cold–formed structural members are becoming more popular and have a growing importance. Its growing popularity in building construction is due to its advantages over other construction materials such as lightness and consequent ease of erection and installation, economy in transportation and handling. In building construction, cold-formed steel products are mainly used as structural members, diaphragms, and coverings for roofs, walls and floors. There are varieties of cold-formed shapes available as structural members, which include open sections, closed sections, and built-up sections. Cee-, zee-, double channel I-sections, hat, and angle sections are open sections while box sections and pipes are closed sections.

Cold-formed steel elements are quality-assured materials that are suitable for mass construction. It exhibits a versatile nature which allows for the forming of almost any section geometry. These sections are usually thinner and can be subject to different modes of failure and deformation and therefore extensive testing is required to provide a guideline for the design of cold–formed thin–walled structural members.

Even though the static behaviour of cold-formed steel elements is well established, fatigue behaviour of these elements under fluctuating loads is still uncertain. Most of the codes of practice for usage of cold-formed steel sections in structural applications, deal only with static conditions of loading. Under dynamic situations cold-formed light gauge steel sections experience very low inertia forces as compared to the hot rolled sections because of their low mass. Hence the prospect of using cold-formed steel sections under dynamic conditions becomes attractive. Fatigue strength is important for cold-formed steel structural members and the probability of failure by fatigue is comparable with that of other Ultimate Limit State modes of failure. Two things become important when these sections are subjected to dynamic loads. Firstly, their low mass coupled with low stiffness makes their response and mode of failure complex. Secondly, the reversal of loading makes them highly susceptible to failure.

1.1 Research Significance

Joint is one of the weakest sections in a building. Cold formed steel members are widely used in all type of construction. Many researches where carried on static loading condition of beam column joint, while very limited amount of works are available for dynamic condition. so this study aims to present the fatigue analysis of cold formed steel beam column joint with different connections.

2. OBJECTIVES OF PRESENT STUDY

- To determine the fatigue life of double channel cold formed steel beam column joint with varying thickness.
- To determine the best connection in both the thickness.

3. STAGES INVOLVED IN FINITE ELEMENT MODELLING

3.1 Engineering Data

The material properties of cold formed steel section are explained here.

Young's Modulus	250GPa
Poisson's ratio	0.3
Yield strength	350MPa

3.2 Geometry

The sectional details of cold formed steel beam column joint are explained here. Double channel section with length of beam as 1000mm and length of column as 1500mm with a thickness variation of 2mm and 4mm.

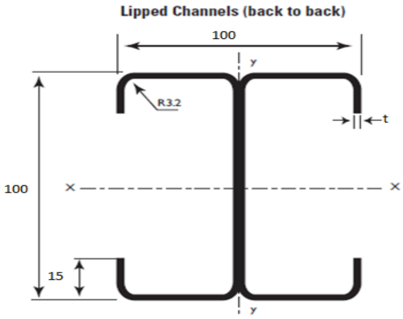

Fig-1: Details of double channel section

3.3 Modelling

Four models with different connection such as welded connection, bolted connection with web cleat angle connection, flange cleat angle connection, and web and flange cleat angle connection with variation in thickness 4mm and 2mm are used in this study.

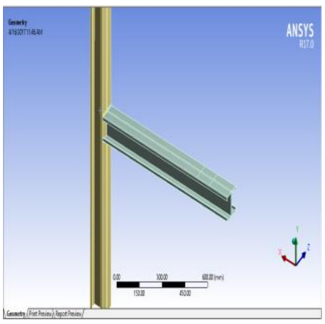

Fig-2: DC-WW-(4 and 2)

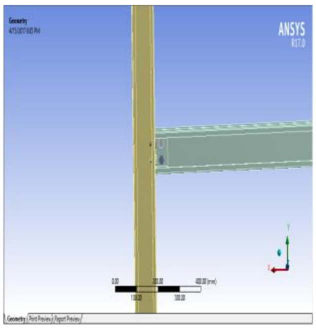

Fig-3: DC-WC-(4 and 2)

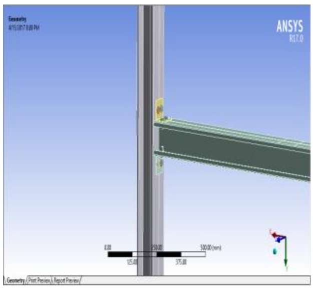

Fig-4: DC-FC-(2and 4)

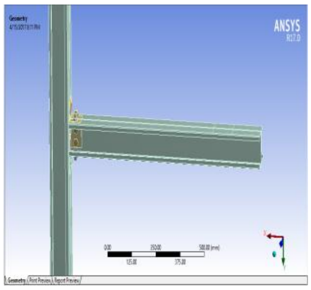

Fig-5: DC-FWC-(2 and 4)

3.4 Meshing

Here the model is divided into number of Finite elements called mesh. A mesh size of 5mm is provided for all the connection.

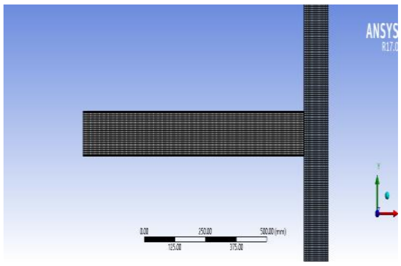

Fig-6: Meshed joint

3.5 Setup

In this case load and boundary conditions are applied to the ansys model. Here the support condition is fixed at both the ends of the column and load is provided in a region which is 1m from the free end of beam.

3.6 Solution

Here fatigue analysis results are obtained. The analysis type used is stress life, which is based on Stress-Cycle curves. In this study zero-based constant amplitude, proportional loading with a load ratio of 0 is assumed. Here force, fatigue life and damage are disused and comparing the values on the basis of varying thickness.

4. RESULT AND DISCUSSION

By applying fatigue analysis on beam column joint different values such as load, deformation, fatigue life and damage are obtained for varying thickness. The results are shown below:

1. Double channel beam column joint with 4mm and 2mm thickness is analyzed and the results are presented below.

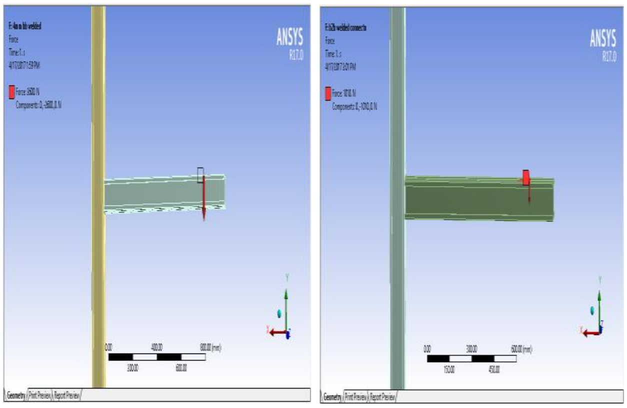

Fig-7 Load taken by 4mm and 2mm section

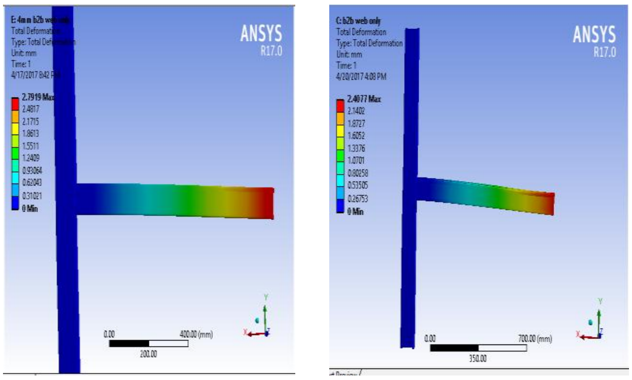

Fig-8 Deformation of 4mm and 2mm section

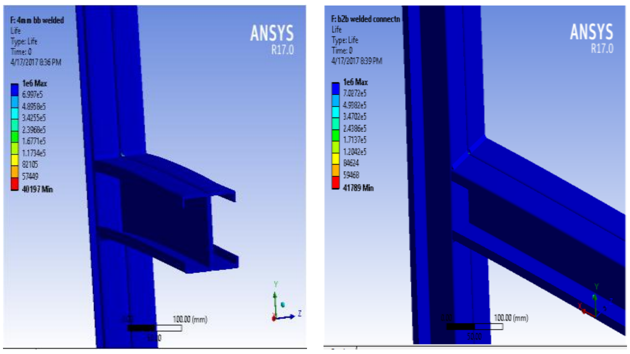

Fig-9 Fatigue life of 4mm and 2mm section

2 Double channel beam column joint with web cleat bolted connection is analyzed and presented below.

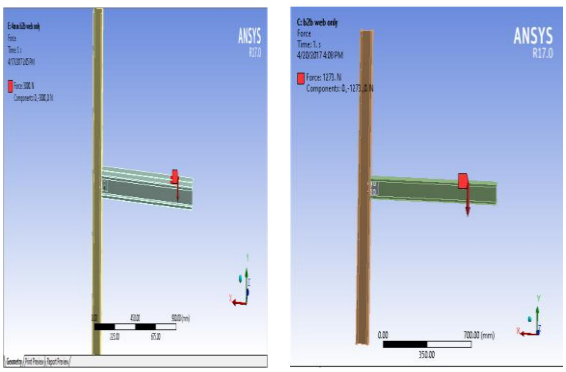

Fig-10 Load taken by 4mm and 2mm section

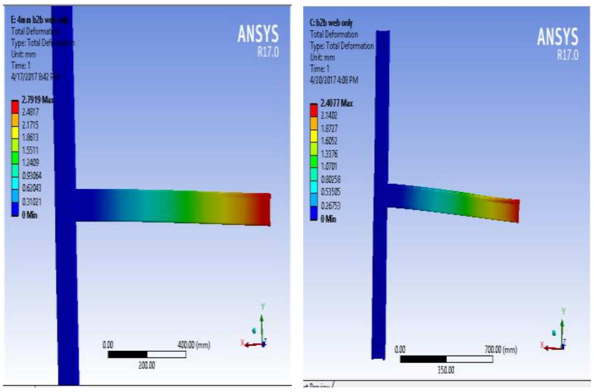

Fig-11 Deformation of 4mm and 2mm section

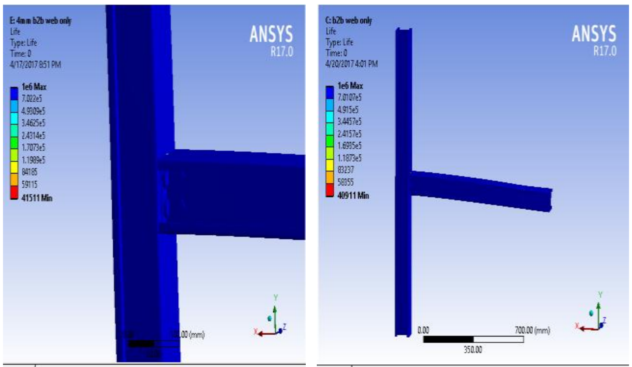

Fig-12 Fatigue life of 4mm and 2mm section

3 Double channel beam column joint with flange cleat bolted connection is analyzed and presented below.

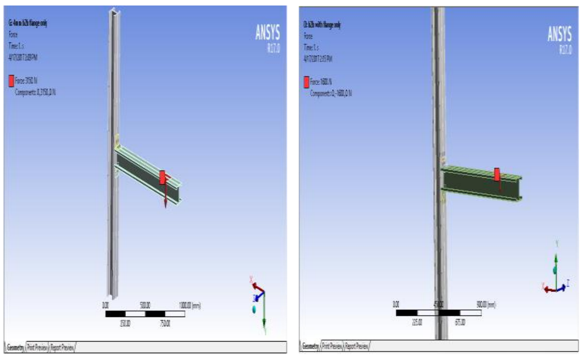

Fig-13 Load taken by 4mm and 2mm section

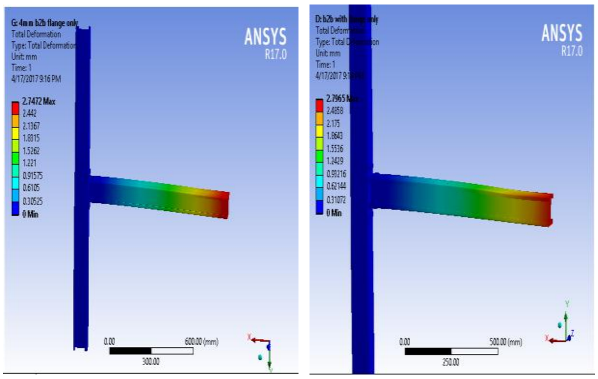

Fig-14 Deformation of 4mm and 2mm section

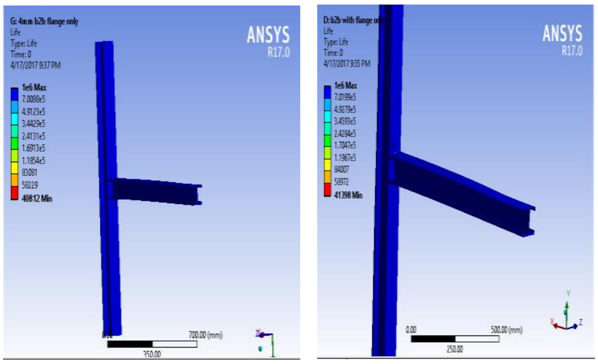

Fig-15 Fatigue life of 4mm and 2mm section

4 Double channel beam column joint with flange and web cleat bolted connection is analyzed and presented below.

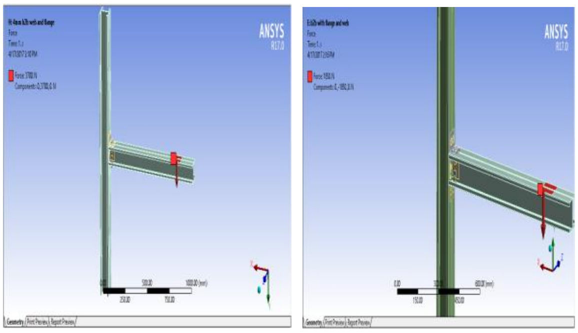

Fig-16 Load taken by 4mm and 2mm section

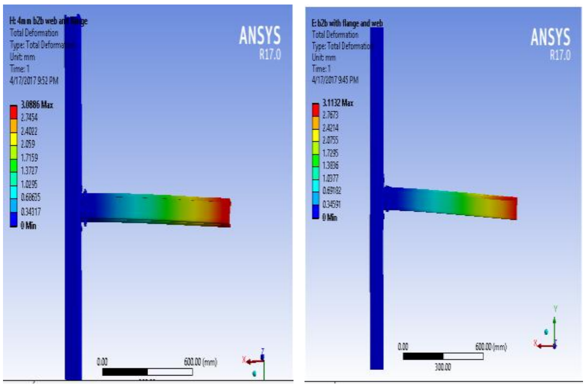

Fig-17 Deformation of 4mm and 2mm section

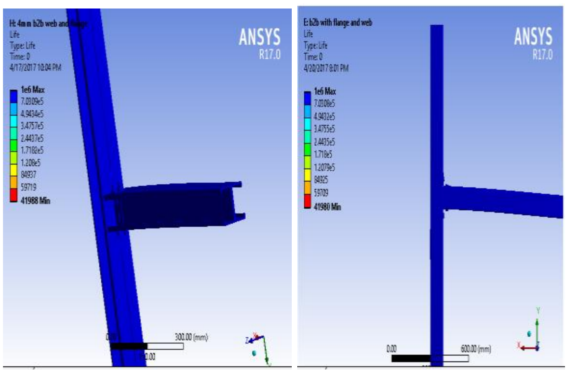

Fig-18 Fatigue life of 4mm and 2mm section

Table below shows the result of fatigue analysis of cold formed steel beam column joint with different connection at varying thickness.

5 Stress-Cycle curve (S-N curve) obtained for the given cold formed steel section is given below.

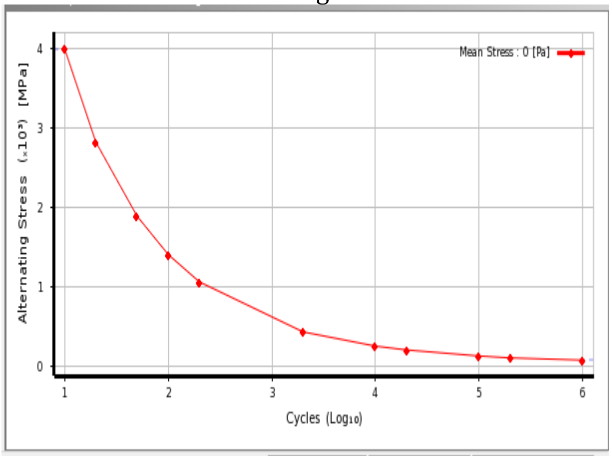

Chart-1 S-N Curve for Cold Formed Steel Section

Table-1 Fatigue results of double channel section

Type of connection	Force(N)	Deformation (mm)	Life (cycles)
DC-WW-4	2000	2.451	40197
DC-WW-2	1010	1.9	41789
DC-WC-4	3000	2.79	41511
DC-WC-2	1273	2.407	40911
DC-FC-4	3150	2.747	40812
DC-FC-2	1600	2.79	41398
DC-FWC-4	3700	3.089	41988
DC-FWC-2	1850	3.113	41980

From this table following graphs can be drawn

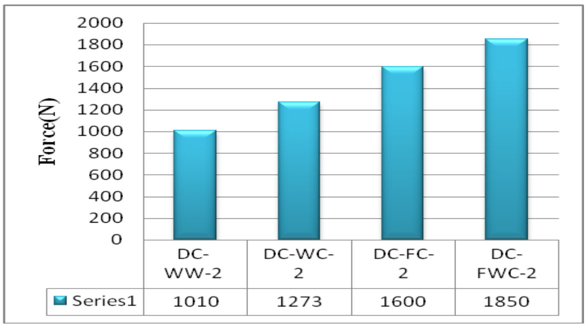

Chart-2 Comparing the value of force in 2mm thick section

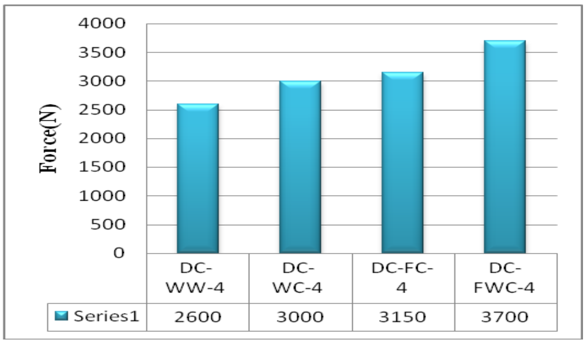

Chart-3 Comparing the value of force in 4mm thick section

Maximum force is taken by double channel beam column joint with flange and web cleat bolted connection and minimum is for welded connection in case of 2mm thickness and for 4mm thickness.

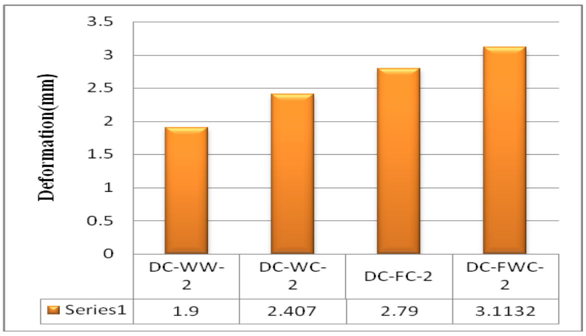

Chart-4 Comparing the value of deflection in 2mm thick section

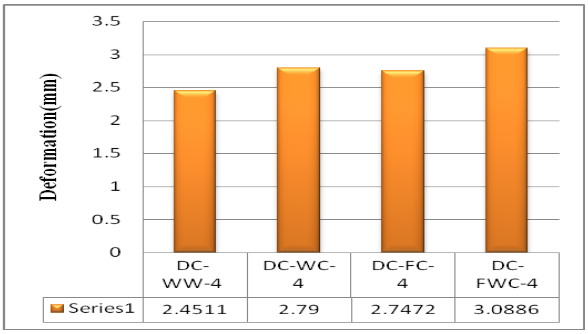

Chart-5 Comparing the value of deflection in 4mm thick section

Deflection has somewhat slight variation in all the connection with variation in thickness.

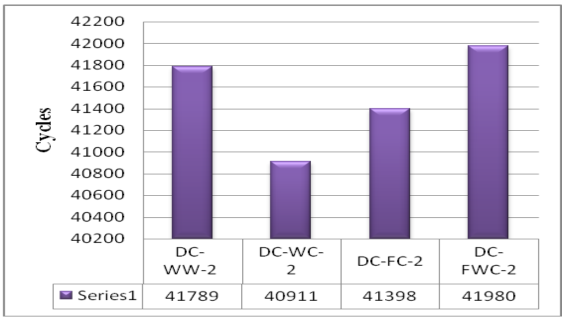

Chart-6 Comparing the value of cycles in 2mm thick section

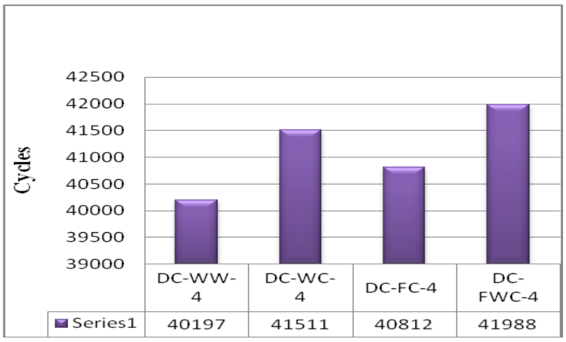

Chart-7 Comparing the value of cycles in 4mm thick section

Maximum fatigue life is for flange and web bolted connection and minimum is for welded connection for both the thickness.

5. CONCLUSIONS

The main conclusion drawn from this study is summarized below:

- The analysis type used is stress life, which is based on Stress-Cycle curves
- The load corresponding to yield stress of cold formed steel section is given as fatigue load for each of the connections.
- The fatigue life defined in this study was between 10^4 and 10^6 cycles.
- The endurance limit of cold formed steel section is 86.2 MPa
- In case of double channel section, the maximum load is taken by flange and web cleat connection(3.7kN and1.85kN) for both the thickness and minimum of 2.6kN and 1.01kN is for welded connection with 4mm and 2mm thickness.
- Maximum fatigue life is for flange and web connection (41988 cycles) for 4mm thickness and (41980 cycles) for 2mm thickness.

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