Development of Light Weight and Seismic Performance of Light Gauge Cold Formed Steel Structures by Different Types of Moment Resistant Steel Connection

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Abstract: Structural steel has many advantages over other construction materials by its high strength and ductility. It has a higher strength to cost ratio in tension and a slightly lower strength to cost ratio in compression when compared with concrete. This paper is intended to evaluate the beam column rolled and cold formed steel connection experimentally by moment resistant connection such as stiffened, un-stiffened and splice connection. At the present, in most of the countries, the use of light gauge cold formed steel section has been developed for economical and best seismic performance by different shape of cross sectional area and various types of connections are used. These results to study the seismic performance of cold form steel sections area using various moment resistance connections. Finally the report result the splice connection has best moment resistance connection, seismic resistant of structures, load carrying capacity is high and minimum weight compare with other types of connections. The splice connection has load carrying capacity is high, so we can reduced the size of section and prevent the base shear due to reduced the weight of structures.

Key words: cold formed steel, splice connection, stiffened connection, load deflection

1. INTRODUCTION

Moment resisting connections are used in multi-storey un-braced buildings and in single-storey portal frame buildings. Jerome F (et al). Connections in multi-storey frames are most likely to be bolted, full depth end plate connections or extended end plate connections. Where a deeper connection is required to provide a larger lever-arm for the bolts, a hunched connection can be used. However, as extra fabrication will result, this situation should be avoided if possible. For portal frame structures, hunched moment resisting connections at the eaves and apex of a frame are almost always used, as in addition to providing increased connection resistances, the haunch increases the resistance of the rafter. The paper presented seismic resistant, local web yielding and local flange bending using stiffening connection and also design seismic resistant of local bending , yielding and resistant of web buckling. Seyed Mohammad Mojtabaei (et al) presented, the leading failure mode of the cold formed steel bolted-moment connections is due to the local buckling of the cold formed steel beam sections close to the first row of the bolts. Curved and folded flange channels can post- pone the local buckling of the flange by creating in-plane stiffness through arching action and shifting the local buckling failure to the web. However, using bent flange channels (folded and curved) can only increase the moment capacity of the connections by up to 10%. on the other hand the moment capacity has 32% increased in square bolt arrangement compare then other type of connections and also the slenderness ratio increased about to 55%, to 45% and 30% higher ductility levels compared to the curved, fat and stiffened fat sections, respectively. The ductility developed in moment resistant connection by diamond or circular arrangement of bolt connection. M. Dundu (et al) reported that the cold formed steel sections and hot rolled angle section, the local buckling formed in cold formed channels sections and amount of bearing distortion was observed in the heavily loaded flange. The use of bolted angle cleats allows for a simple connection to be developed. Now day’s lot of technique developed for seismic resistance steel structures. Recently developed the splice connection is best control the vibration force, wherever occur in cyclic loading condition and seismic resistant in steel structures. A Jayaraman (et al) reported that the authors developed cold formed section with splice connection in experimental and theoretical investigation. In this report. In ISMC 100 mm for 1m length and 0.5 m length , the cold formed steel section both the connection with & without splice connection the load carrying capacity is 55.55 % & 46.67 % and 53.85% & 50.00 of less than the conventional steel section .In ISMC 75 mm for 1m length and 0.5 m length ,

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the cold formed steel section both the connection with & without splice connection the load carrying capacity is 42.85.55 % & 77.77 % and 68.08 & 49.10 % of lesser than the conventional steel section. In cold formed steel section both the connection with & without splice connection the deflection is 53.70 % & 52.94 % and 56 % & 54.16 % of lesser than the conventional steel section ISMC100 mm and ISMC 75 mm. The cold formed steel section both the connection with & without splice connection the total member weight and total weight of structures is 66.60 % & 70.00% & 88.88 % and 51.22% of lesser than the conventional steel section. In cold formed steel section both the connection with and without splice connection the total cost estimation is 88.46 % and 83.66 % of lesser than the conventional steel section. In cold formed steel section both the connection with and without splice connection the base shear is 51.79 % and 54.46 % of lesser than the conventional steel section. R. B. Kulkarni (et al) reported that increase the load carrying capacity in which cold formed steel sections at the joints with single and multiple number of bolted connection by effect of infilled different grade conventional concrete and Geopolymer concrete. The ultimate load carrying capacity of the bolted connection percentage is increases vary from 8.95% to 57.25%. By infilling conventional concrete or geopolymer concrete at the joints only. The performance of connections any with conventional concrete or geopolymer concrete infilled at joints is nearly same and small variations are observed. The cold formed steel sections is better moment resistance vary from 36 % to 97% of measured by bolted moment connections feasibility and economically. Furthermore developed cold formed steel channel section back to back connection using medium and large span structures by M F Wonlf. Pervious literature survey studied K.K. Sangle (etal) suggested the bracing system used in steel structures prevented the lateral displacement at roof level, to control the seismic behaviour of structures and control the vibration of the system. The displacement reduces about 43% to 60% of at the roof level bracing system, time period is also reduced up to 65 %. The effective and economical design of bracing system obtained by diagonal B – style bracing system. Cold-formed steel (CFS) structural elements have seen a dramatic expansion in the range of applications over the past decade. CFS systems are currently used in structural, mechanical and aeronautical engineering. Compared to their hot-rolled counterparts, CFS members are often more economical and efficient due to their light weight, ease and speed of construction and a greater flexibility in manufacturing. However, the inherently low buckling resistance of thin sections results in relatively low strength and ductility in CFS structural elements, which may limit their performance under extreme loading events such as strong earthquakes. While the seismic performance of CFS structures has been previously investigated majority of these studies have focused on the behaviour of shear wall panels as the main lateral load- bearing system. However, using moment-resisting CFS frames can reduce the reliance on the fixed shear wall panels and therefore provide higher flexibility for space planning and future alterations.

II. AIM OF THE PROJECT

The main objective is development of light weight and seismic performance of the light gauge cold formed steel structures by different types of moment resistant steel connection.

III. CONNECTION DETAILS

1. Development of light weight of structures by light gauge cold formed steel section in

   - Un stiffened, stiffened and splices connection.

2. Development of seismic and earthquake resistant of structures by light gauge cold formed steel

   - Un stiffened, stiffened and splice connection.

3. Low cost, economical, strength and durability of the structures by light gauge cold formed steel

   - Un stiffened, stiffened and splice connection. Some of the main advantages of cold rolled sections, as compared with their hot-rolled counterparts are as follows:
     - Cross sectional shapes are restricted to close versatilities and these can be reliably repeated for whatever timeframe that required.
     - Cold rolling can be utilized to pass on any pined for shape to any required length.
     - Pre-blended or pre-anchored metals can be formed, with the target that high protection from use, other than a connecting with surface complete, can be refined.
     - They are generally light making it simple to transport and erect.

3.1 Splice connection:

   - The splice joint is used when the material being joined is not available in the length required.
   - It is an alternative to other joints such as the butt joint and the scarf joint.

![Figure 1. Splice connection](image)

![Figure 1(a). Experimental set up for loading of rolled steel bolted splice connection](image)
3.2 Un stiffened connection
The seated connection is a horizontal angle with its horizontal leg at its top is used to receive the beam on it, in such a case it is called unstiffened seat connection.

![Un stiffened connection](image)

**Figure 2. Un stiffened connection**

3.3 Stiffened Seat Connections
In addition to the seat angle, a web cleat is provided when the beam is connected to a beam and a flange cleat is used when the beam is connected to a stanchion. The angle cleats are essential because they keep the beam stable in a vertical position and prevent it from lateral buckling.

![Stiffened seat connections](image)

**Figure 2 (a)** Experimental set up Stiffened seat angle bolted connection

**Figure 2 (b)** Experimental set up Un stiffened seat angle bolted connection

**Figure 2 (c)** Experimental set up Un stiffened seat angle welded connection

**IV. EXPERIMENTAL PROCEDURE**
In this research it is proposed to carry out the experiential investigation moment resistant connection of conventional steel as well as the cold formed steel structures using stiffened, unstiffened and splice connections. Splices are therefore most often used when the structural element is required in longer length and also resistant the seismic force in structural elements. Moment resistant connection is experimentally done for both conventional and cold formed steel as per codal provisions. Consider the rolled steel channels section and cold formed steel section ISMC100 & ISMC75. A 1m, 1.5m 2m length of ISMC100 and ISMC75 is taken respectively. The corresponding sections are reduced to 0.5m length and their bolted connections are made with splice plates. The testing is carried out in computerized universal testing machine of capacity 1000kN. The result is occupied as a load carrying capacity and deflection of the rolled steel section, cold formed steel section and their properties are compared with the sections with and ordinary and moment resistant connection of rolled steel and cold formed steel sections.

**V. RESULTS AND DISCUSSION**

3.4.1 Load carrying capacity of bolted and welded connections

| S.N | Different types of Bolted Connection | Rolled Section | Cold Formed Steel Section |
|-----|--------------------------------------|----------------|----------------------------|
| 1   | Ordinary                             | 3.8            | 3.0                        |
| 2   | Un stiffened                         | 8.5            | 9.7                        |
| 3   | Stiffened                            | 8.3            | 9.7                        |
| 4   | Splice connection                    | 10.6           | 11.5                       |

Table 1. Load carrying capacity bolted connections
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By experimental investigation, the load carrying capacity of rolled steel un stiffened, stiffened and splice bolted connections are increased with 55.29 %, 54.21 % and 64.15% compare with ordinary bolted connection. By experimental investigation, the load carrying capacity of cold formed steel un stiffened, stiffened and splice bolted connections are increased with 69.07 %, 69.07 % and 73.91% compare with ordinary bolted connection. The experimental investigation of rolled steel, unstiffened, stiffened and splice bolted connection are found to be 14.11 %, 16.86 % and 8.49 % . It is observed that the load carrying capacity of cold formed steel section is decreased compared with ordinary connection. In the rolled steel and cold formed steel section, the load carrying capacity is more or less same in ordinary connection.

By experimental investigation, the welded rolled steel unstiffened and splice welded connections are found to be 11.09 % and 33.00 % and 64.15%. It is observed that the load carrying capacity is increased compared with ordinary bolted connection, and also the load carrying is decreased about 12.28 % stiffened welded connection compared with ordinary connection.

By experimental investigation, the load carrying capacity of cold formed steel unstiffened, stiffened and splice welded connections are increased with 62.17 %, 45.62 % and 68.47% compare with ordinary welded connection. The experimental investigations of rolled steel welded unstiffened and splice welded connection are found to be 4.34 % and 10.86 %. It is observed that the load carrying capacity is decreased compared with light cold formed steel sections. The rolled steel and cold formed welded connection, the load carrying capacity is more or less same in stiffened welded connection. The load carrying capacity is increased ordinary welded rolled steel section, it is found to be 52.30% compare with light gauge cold formed steel section.

### Table 2. Load Carrying Capacity of welded Steel section

| S.No | Ordinary | Rolled Section | Cold Formed Steel Section |
|------|----------|----------------|--------------------------|
| 1    | 9.12     | 4.35           |                          |
| 2    | 11       | 11.5           |                          |
| 3    | 8        | 8              |                          |
| 4    | 12.13    | 13.8           |                          |

### Table 3. Weight of section in bolted connection

| S.No | Different types of Bolted Connection | Rolled Section | Cold Formed Steel Section |
|------|--------------------------------------|----------------|--------------------------|
| 1    | Ordinary                             | 26.38          | 21.86                    |
| 2    | Un stiffened                         | 12.52          | 10.76                    |
| 3    | Stiffened                            | 12.84          | 10.94                    |
| 4    | Splice connection                    | 12.6           | 10.82                    |

### Table 4. Weight of section in welded connection

By experimental investigation, the welded rolled steel unstiffened and splice welded connections are found to be
By experimental investigation of rolled steel, unstiffened, stiffened & splice bolted and welded connection have minimum weight compare with ordinary bolted and welded connection and is found to be 7.78 %, 6.15 % & 17.36 % and 13.63 %, 11.81 % & 17.27 %. By experimental investigation of light gauge cold formed steel, unstiffened, stiffened & splice bolted and welded connection have minimum weight compare with ordinary bolted and welded connection and is found to be 50.77 %, 49.95 % & 50.50 % and 42.68 %, 70.35 % & 79.32 %. The weight of rolled steel ordinary, unstiffened, stiffened and splice bolted and welded connection are found to be 17.13 %, 14.05 %, 14.79 % & 14.12 % and 14.33 %, 19.76 %, 19.50 % & 14.12 %, the weight is increased compare with cold formed steel section in both bolted and welded connection.

3.4.3 Base shear in bolted and welded connection

Through experimental investigation of rolled steel, unstiffened, stiffened & splice bolted and welded connection are found to be 56.25 %, 43.75 % & 17.36 % and 53.89 %, 45.76 % & 59.32 %. It is investigated that the base shear is decreased compare with ordinary bolted and welded connection. Through experimental investigation of light gauge cold formed steel, unstiffened, stiffened & splice bolted and welded connection are found to be 50.77 %, 49.95 % & 50.50 % and 42.68 %, 70.35 % & 79.32 %. It is investigated that the weight of the structure is minimum compare with ordinary bolted and welded connections. The base shear is decreased for rolled steel ordinary, unstiffened, stiffened & splice bolted and welded connections, it is found that 7.813 %, 2.857 %, 11.11 % & 11.11 % and 16.61 %, 24.47 %, 36.170 % & 49.41 % compare with cold formed steel section in both bolted and welded connection.
3.4.4 Deflection in bolted and welded connection

Table 7. Deflection in bolted connection

| S.No | Different types of Welded Connection | Rolled Section | Cold Formed Steel Section |
|------|-------------------------------------|----------------|---------------------------|
| 1    | Ordinary                            | 38             | 41                        |
| 2    | Un stiffened                        | 35             | 34                        |
| 3    | Stiffened                           | 30             | 42                        |
| 4    | Splice connection                   | 21             | 33                        |

By experimental investigation of rolled steel unstiffened, stiffened and splice bolted connection the deflection capacity are found to be 13.51 %, 18.75 % and 17.30 % and is increased compare with cold formed steel sections and also ordinary rolled steel bolted connection as 13.46% the deflection value is decreased compare with cold formed steel section in both welded and bolted connections.

Table 7. Deflection in welded connection

| S.No | Different types of Welded Connection | Rolled Section | Cold Formed Steel Section |
|------|-------------------------------------|----------------|---------------------------|
| 1    | Ordinary                            | 38             | 41                        |
| 2    | Un stiffened                        | 35             | 34                        |
| 3    | Stiffened                           | 30             | 42                        |
| 4    | Splice connection                   | 21             | 33                        |

Through the experimental investigation of rolled steel, unstiffened, stiffened and splice welded connection, it is found to be 7.29 %, 21.05 % and 44.73 %. It is observed that deflection is minimum compare with ordinary bolted connection. By experimental investigation of cold formed steel, unstiffened and splice welded connections, it is found to be 17.07 % and 19.51 %. It is observed that deflection is minimum compare with ordinary bolted connection and also found to be the deflection is more or less same in ordinary and stiffened welded connections. The deflection is increased about 7.89 %, 28.57 % and 36.36 %, compare with cold formed steel sections in ordinary connection, stiffened and splice welded connection. The rolled steel and cold formed section, the deflection is more or less same in stiffened welded connection.

VI. CONCLUSIONS

- Development of light weight structures by light gauge cold formed steel section in both welded and bolted unstiffened, stiffened and splice connection.
- Development of seismic and earthquake resistant of structures by light gauge cold formed steel in both welded and bolted unstiffened, stiffened and splice connection.
- Low cost, economical, strength and durability of the structures by light gauge cold formed steel in both welded and bolted unstiffened, stiffened and splice connection.
- Load carrying capacity has high in welded connection compare with bolted connection in both the rolled and cold formed section.
- The splice connection has load carrying capacity is high, in both welded and bolted connection compare with stiffened and un stiffened connection.
- The combination of claim 5 further including, the splice connection has load carrying capacity is high, so we can reduced the size of section and prevent the base shear due to reduced the weight of structures.
- The splice connection has best seismic performance in both cold formed steel and rolled steel section compare with other types of connections.

REFERENCE

1. S. K. Duggal“ Limit State Design of Steel Structures “.
2. N. Subramanian “Design of Steel Structures based on Limit state Method of design as per standardized code IS: 800: 2007.
3. S.S Bhavikatti “Design of steel structure by limit state method as per IS: 800: 2007”.
4. IS: 801:1975 Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members in General Building Construction. 5. IS 811: 1987 Specification for Cold Formed Light Gauge Structural Steel Section.
5. IS 800 Code of Practice for General Construction in Steel , Bureau of Indian Standards, New Delhi .2007
6. IS 1893 -2002 “ Criteria for Earthquake Resistance and Construction of Buildings”Bureau of Indian Standards, New Delhi.
7. A Jayaraman (etal) “Seismic Performance of Cold Formed Steel and Conventional Steel of Industrial Structures Using Splice Connections” International Journal of Recent Technology and Engineering” ISSN: 2277-3878, Volume-7 Issue-4S2, December 2018.
8. JEROME F (etal) “Continuity Plate Detailing for Steel Moment-Resisting Connections” ENGINEERING JOURNAL”, September-2003.
9. Seyed Mohammad Mojtabaei (etal) “Efficient design of cold-formed steel bolted-moment connections for earthquake resistant frames” Thin-Walled Structures ISSN 0263-8231 January 2019.
10. M. Dundu (etal ) “Angle Cleat Base Connections”20th International Specialty Conference on Cold-Formed Steel structures November 2010