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PARTIALLY RESTRAINED CONNECTIONS IN COLD-FORM BEAM COLUMN STEEL STRUCTURES

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Abstract - *The main objective of our current study is to increase the use of cold formed steel in steel construction by studying cold formed steel compounds. Typically, cold formed steel is only used wall panels without load carriers, partitions, floor coverings, etc. In this project, we have attempted to study the use of cold molded steel in the bolted connection of partially retained jet column determining its ability to load various connection configurations.The connection are designed based on BS-5950-5 1998.*

Key Words: **Light Gauge, Cold-Formed Steel, Hot-Rolled Steel, CATIA, HYPERMESH, ANSYS, Finite Element Analysis**

1. INTRODUCTION

Cold-formed sections of steel are lightweight materials suitable for the construction of buildings with high performance in structural behavior. Thickness usually ranges from 0.8 mm to 4.0 mm and section with yield strength of 250-450 N / mm2 are commonly available. Sections C and Z are commonly used in cold steel profiles as a secondary element in civil construction and are connected to the primary element through network latches as fixed or momentary connections.

In the last two decades, cold steel has increased its use as structural building material for multi-storey commercial buildings and residential buildings, due to its inherent characteristics, which overcomes the disadvantage of conventional products. Its strength, ease of production, non-combustibility, versatility, long-term durability, coupled with high yield capacity and high construction capacity have encouraged engineers, architects and contractors to use cold form steel products, which can improve structural function , appearance of construction and provide aesthetics appeal at a lower cost.

For typical application of cold steel profiles, there are many design recommendations for the available cold steel sections are available in AISI (1996), BS-5950 (1998) and Euro 3: spart1.3. In addition, the number of design guides and comments are available to help the design engineer design cold steel sections.

There is little practical guidance on the study of cold steel connections compared to hot rolled steel. Therefore, it is important to study the connections of cold steel profiles. High strength, rigid screw connections are essential in the safe and economical design and construction of cold formed steel sections.

In order to extend the effective use of cold steel in construction applications, it is essential to build secure and desirable moment structures, thus, the design of screw-bolted moment connections in the beam column, sub-frames with practical configuration is provided.

The study of connections in the structural member is of prime importance, because it is always desirable that the structural element fails first rather than connections. If structural connections fail before limb failure, it will always be a fragile and catastrophic failure. Stiffened and non-entangled compounds are two types of cold steel-steel compounds. In stiffened joint longitudinal edges along both webs support the element and in non-reinforced joints only one longitudinal edge supporting element and other parallel edge free to move.

2. MODELLING

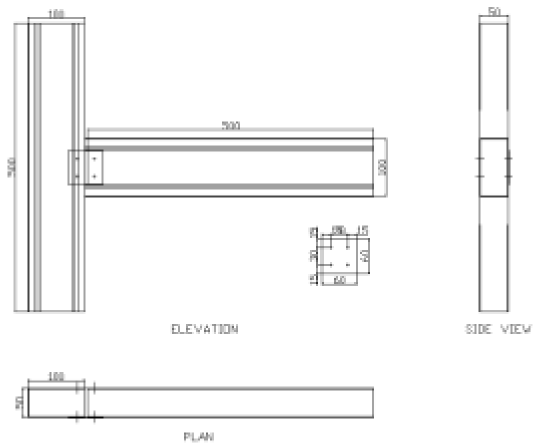
The connection are designed based on BS-5950-5 1998.

Table -1: Sectional Properties

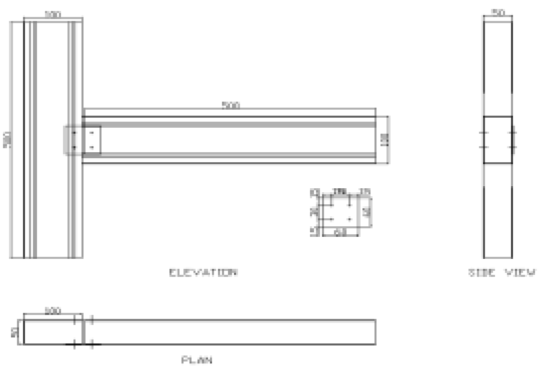
Web Depth	100 mm
Top and Bottom	50 mm
Lip Depth	15 mm
Thickness	1.05 mm, 1.5mm, 3mm
Full Sectional Area	459 mm^2
Grade	550 N/mm^2
Yield Strength	550 N/mm^2
Nominal Ultimate Strength U_s	654 N/mm^2
Design Strength D_s	550 N/mm^2
Centre of Gravity C_g	51 mm
Moment of Inertia I_{xx}	970048 mm^4
Moment of Inertia I_{yy}	193537 mm^4
Sectional Modulus Z_x	16.562 mm^3

2.1 : Model Considered for the Analysis.

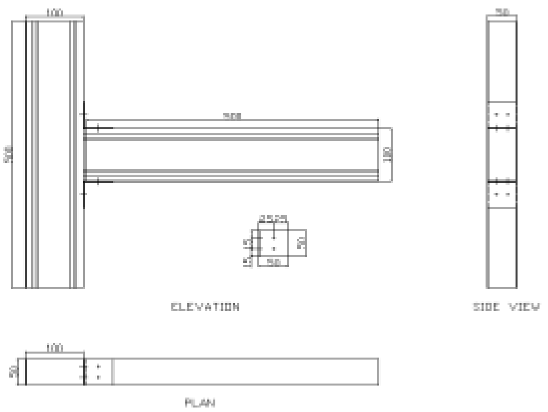
1. Connection With Gusset plate and Angle of 1.5mm thickness and 4 number of bolts on each plate(C1 1.5 mm)



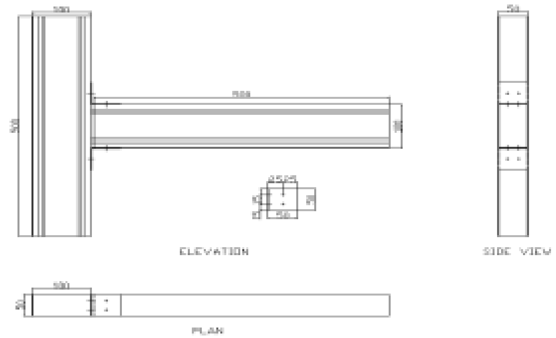
2. Connection With Gusset plate and Angle of 3.00 mm thickness and 4 number of bolts on each plate(C2 3.00 mm)



3. Connection With Cleat and Seat Angles of 3.00 mm thickness Angle With 4 Bolts on Each Angle (C3 3.0 mm)



4. Connection With Cleat and Seat Angles of 1.5 mm thickness Angle With 4 Bolts on Each Angle (C4 1.5 mm)



2.2 : Experimental Analysis

Fig-1: Experimental Setup

3. EXPERIMENTAL AND FEM RESULTS

3.1. Experimental result of connection with cleat and seat angle and 1.5mm gusset plate, and 4 numbers of screws on each plate.

Table 3.1

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.1	1.7	0.048	0.2029	0.00354
0.5	2.5	0.24	0.2984	0.00521
0.7	4.1	0.336	0.4894	0.00854
0.8	5	0.384	0.5968	0.01042
1	10	0.48	1.193	0.02083
1.2	11.2	0.576	1.3367	0.02333
1.4	15	0.672	1.78991	0.03124
1.6	17.6	0.768	2.0999	0.03665
1.8	22	0.864	2.6242	0.0458
2	28.3	0.96	3.3742	0.05889
2.2	38	1.056	4.52648	0.079
2.4	51.2	1.152	6.08853	0.10626
2.6	65.8	1.248	7.80564	0.13623
2.8	76	1.344	8.99714	0.15703
3	90	1.44	10.6196	0.18535
3.2	107.7	1.536	12.6463	0.22072
3.4	119.9	1.632	14.025	0.24478

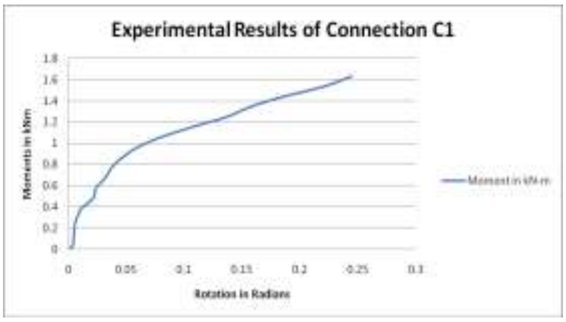


Chart 1- Moments v/s Rotation for Connection C1

3.2 Experimental result of connection with cleat and seat angle and 3mm gusset plate, and 4 number of screws on each plate.

Table 3.2

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.2	2	0.096	0.23873	0.00417
0.4	3.2	0.192	0.38197	0.00667
0.6	5.2	0.288	0.62068	0.01083
0.8	6	0.384	0.71616	0.0125
1	8.6	0.48	1.02644	0.01792
1.2	15.3	0.576	1.82568	0.03188
1.4	21	0.672	2.50509	0.04375
1.6	23.4	0.768	2.79096	0.04875
1.8	32	0.864	3.81407	0.06667
2	35.9	0.96	4.27728	0.07479
2.2	41	1.056	4.88216	0.08542
2.4	46.5	1.152	5.53326	0.09688
2.6	55	1.248	6.53663	0.11458
2.8	59.8	1.344	7.10151	0.12458
3	70	1.44	8.29714	0.14583
3.2	74	1.536	8.7641	0.15417
3.4	84.5	1.632	9.98414	0.17604

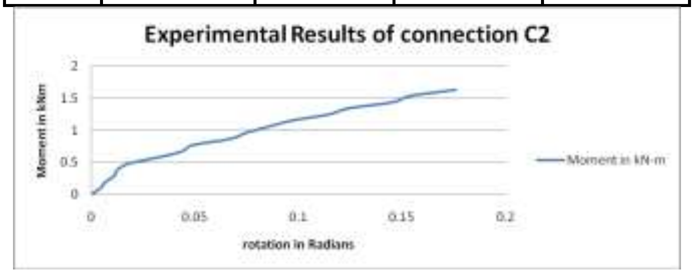


Chart 2- Moments v/s Rotation for Connection C2

3.3 Experimental result of connection with 3mm Cleat and seat angle with 4number of screws on each plate.

Table 3.2

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.2	6.5	0.096	0.775833	0.013542
0.4	15.2	0.192	1.81376	0.031667
0.6	21.2	0.288	2.52892	0.044167
0.8	24.9	0.384	2.969557	0.051875
1	30.1	0.48	3.588224	0.062708
1.2	38.9	0.576	4.63322	0.081042
1.4	55	0.672	6.536634	0.114583
1.6	63.2	0.768	7.500798	0.131667

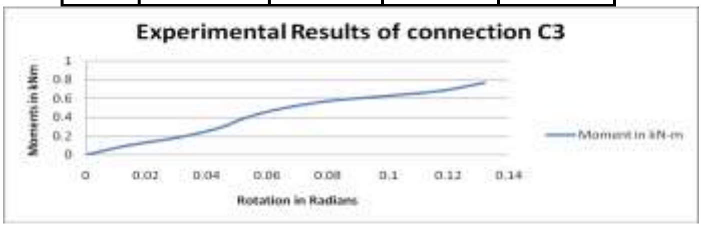


Chart 3- Moments v/s Rotation for Connection C3

3.4 Experimental result of connection with 1.5mm Cleat and seat angle with 4number of screws on each plate.

Table 3.2

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.5	4.5	0.24	0.537132197	0.009375
0.7	8.5	0.336	1.014506726	0.017708333
0.9	38.3	0.432	4.562060351	0.079791667
1.1	61.6	0.528	7.312986245	0.128333333
1.3	75.3	0.624	8.915612248	0.156875
1.5	89.3	0.72	10.53891542	0.186041667
1.7	99.4	0.816	11.69963129	0.207083333
1.9	110.5	0.912	12.9641009	0.230208333
2.1	114.5	1.008	13.41670155	0.238541667

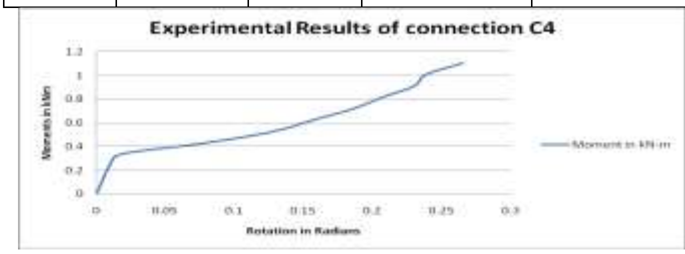


Chart 4- Moments v/s Rotation for Connection C4

3.5. FEM result of connection with Gusset plate and cleat and seat angle with 1.5 mm thickness, and 4 number of screws on each angle.

Table 3.5

LOAD kN	DISPLACEMENT mm	MOMENT IN kN-m	ROTATION IN DEGREE	ROTATION IN RADIANS
0	0	0	0	0
0.1	2.55	0	0.3	0.00524
0.5	12.7629	0.02	1.6	0.02793
0.8	20.4192	0.03	2.6	0.04538
1	25.5182	0.04	3.2	0.05585
1.2	30.6249	0.05	3.8	0.06632
1.4	35.7316	0.05	4.5	0.07854
1.6	40.8306	0.06	5.1	0.08901
1.8	45.9373	0.07	5.7	0.09948
2	51.0441	0.08	6.4	0.1117
2.2	56.1431	0.08	7	0.12217
2.4	61.2498	0.09	7.7	0.13439
2.6	66.3565	0.1	8.3	0.14486
2.8	71.4555	0.11	8.9	0.15533
3	76.5623	0.11	9.6	0.16755
3.2	81.669	0.12	10.2	0.17802
3.4	86.768	0.13	10.9	0.19024

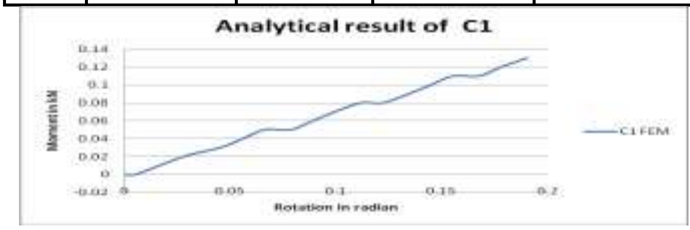


Chart 5- Moments v/s Rotation for Connection C1(FEM)

3.6. FEM result of connection with Gusset plate and cleat and seat angle with 1.5 mm thickness, and 4 number of screws on each angle.

Table 3.6

LOAD kN	DISPLACEMENT mm	MOMENT IN kN-m	ROTATION IN DEGREE	ROTATION IN RADIANS
0	0	0	0	0
0.2	4.9227	0.01	0.6	0.01052
0.4	9.838	0.01	1.24	0.02166
0.6	14.7609	0.02	1.86	0.0325
0.8	19.6837	0.03	2.48	0.04334
1	24.5991	0.03	3.1	0.05416
1.2	29.5219	0.04	3.72	0.06493
1.4	34.4446	0.05	4.35	0.07592
1.6	39.36	0.05	4.97	0.08666
1.8	44.2828	0.06	5.59	0.09749
2.2	53.1209	0.07	6.83	0.11921
2.4	59.437	0.08	7.45	0.13003
2.6	63.9665	0.08	8.07	0.14085
2.8	68.8819	0.09	8.69	0.15169
3	73.8046	0.1	9.31	0.16253
3.2	78.7274	0.1	9.93	0.17331
3.4	83.6428	0.11	10.55	0.18415

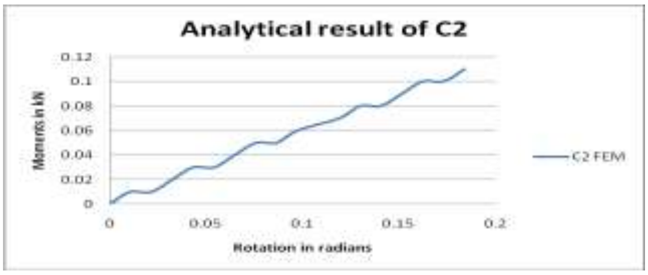


Chart 6- Moments v/s Rotation for Connection C2 (FEM)

3.7. FEM result of connection with 3.0 mm Cleat and seat angle with 4number of screws on each plate C3.

Table 3.7

LOAD kN	DISPLACEMENT mm	MOMENT IN kN-m	ROTATION IN DEGREE	ROTATION IN RADIANS
0	0	0	0	0
0.2	5.58681	0.02	3.45	0.06026
0.4	11.1803	0.05	6.91	0.12058
0.6	16.7671	0.07	10.36	0.18085
0.8	22.354	0.09	13.82	0.24112
1	27.9475	0.12	17.27	0.30144
1.2	33.5343	0.14	20.72	0.3617
1.4	39.1211	0.17	24.18	0.42197
1.6	44.7416	0.19	27.63	0.48229

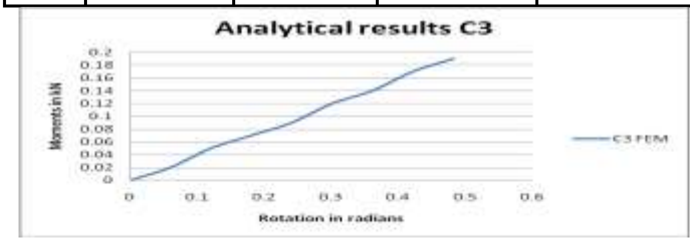


Chart 7- Moments v/s Rotation for Connection C3 (FEM)

3.8. FEM result of connection with 1.5 mm Cleat and seat angle with 4number of screws on each plate C4.

Table 3.8

LOAD kN	DISPLACEMENT mm	MOMENT IN kN-m	ROTATION IN DEGREE	ROTATION IN RADIANS
0	0	0	0	0
0.1	5.7672	0.02	1.64	0.02854
0.5	28.8087	0.1	8.16	0.14247
0.7	40.3293	0.14	11.43	0.19944
0.8	46.0966	0.16	13.06	0.22794
0.9	51.8639	0.18	14.69	0.25646
1.1	63.3846	0.22	17.96	0.31343
1.3	74.9053	0.25	21.22	0.37039
1.5	86.4398	0.29	24.49	0.42741
1.7	97.9065	0.33	27.75	0.4844
1.9	109.481	0.37	31.02	0.54138
2.1	121.016	0.41	34.2865	0.59841

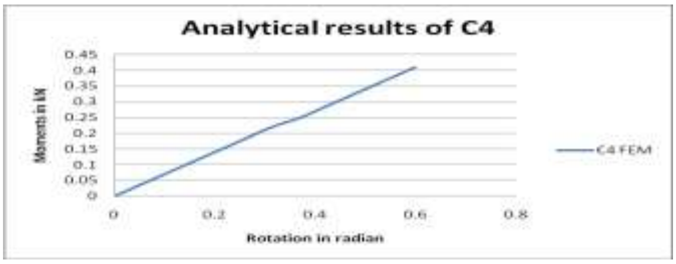


Chart 8- Moments v/s Rotation for Connection C4 (FEM)

4. CONCLUSION AND DISCUSSIONS

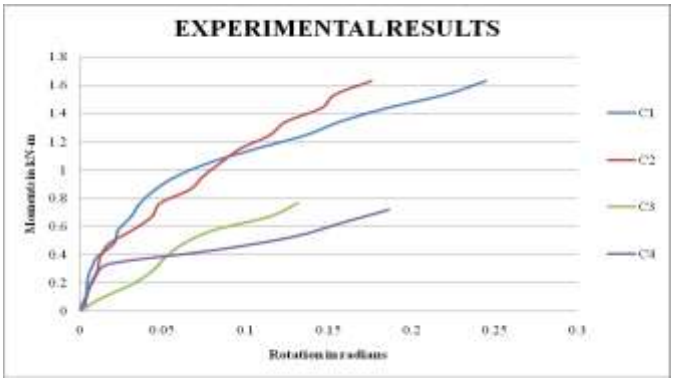


Chart 9- Experimental Results of all the connections C1, C2, C3 and C4

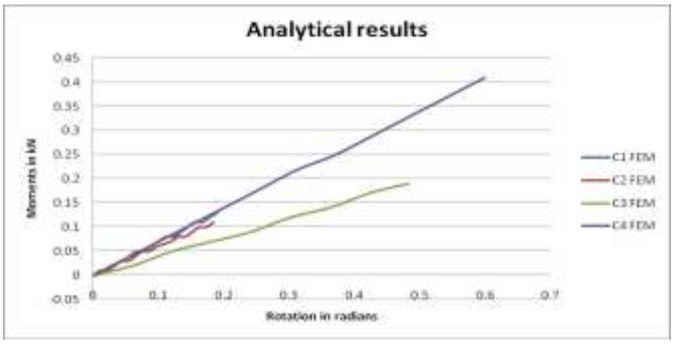


Chart 10- FEM Results of all the connections C1, C2, C3 and C4

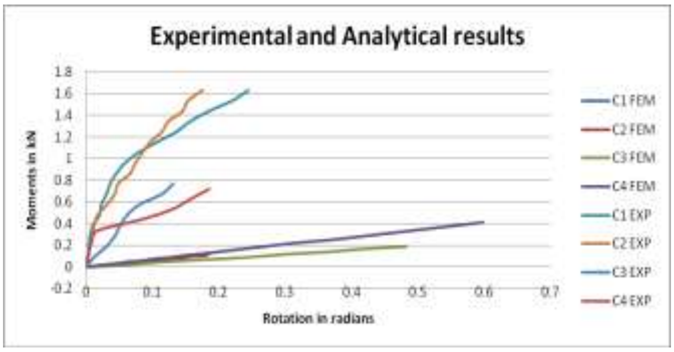


Chart 11- Experimental and FEM Results of all the connections C1, C2, C3 and C4

5. CONCLUSIONS

1) Due to the presence of the angular plates in the connections C3 and C4, the buckling failure by twisting is greater.
2) Connection C1, C2 and C3 has almost identical initial stiffness, while the initial stiffness of connection C4 is much lower.
3) C1 and C2 has maximum moment capacity of the connection as compared to the other two connections.
4) By providing the angled plate and increasing the number of screws, increases the rigidity of the connection.
5) There are variations in FEM analysis compared to the experimental analysis due to rigid conditions and other factors.
6) FEM analysis can be used to predict the behavior of compounds.

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