Cold Form Steel Beam-Column Tube Connections

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Abstract: *The main aim of our present study is to increase the use of cold form steel in steel structure by studying cold form steel connections. Usually cold form steel is used only in purlins of truss, non-load bearing wall, partition walls, floor deck system etc. in this project we tried to study the application of cold form steel in partially restrained beam-column screwed connection by determining its load carrying capacity of various connection configurations.*

Keywords: **Light Gauge, Cold-Formed Steel, CATIA, Hypermesh, ANSYS, Finite Element Analysis**

1. INTRODUCTION

The use of steel structure nowadays is becoming more popular instead of RCC structures. The various advantages of steel structures over conventional structures are fast and easy erection and installation, high strength per unit mass, high speed of construction etc.

The structural steel is classified into two different categories based on the manufacturing process i.e. hot rolled steel sections and cold form light gauge steel section. In case of hot rolled steel sections they are manufactured under high temperature about 1400 ˚C whereas, cold-formed light gauge sections are manufactured in room temperature. Hot-Rolled sections have been successfully used for the construction of multi storey buildings, but their production is very costly to the environment and due to the limited number of section sizes they can be heavy and inefficient, whereas cold formed steel sections are easier to manufacture and offer a large variety of sections. This can lead to a more efficient design.

The thickness of the cold form structures varies from 1.2mm to 3.2mm. The yield strength varies from 230Mpa to 420Mpa.The cold form structures are manufactured by moulding the steel plates by the process of press braking, cold form rolling and bending brake operation. The most commonly available steel sections are lipped C and Z-sections. Connected onto primary structural members through web cleats as pinned or moment connections, cold-formed steel sections usually depend on the connection configurations as they act as secondary members. The cold form sheet is coated with zinc alloy and it completely covers the steel surface thus prevents the corrosion making it durable.

Cold form steel sections may be classified as stiffened or unstiffened connection. In case of stiffened connection the element is supported by the webs along both its longitudinal edges and in unstiffened connection the element is supported along one longitudinal edge only with other parallel edge free to move.

2. MODELING

The design of connection is done according to British code 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
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, P_y	550 N/mm^2
Center of Gravity, C_g	51mm
Moment of Inertia, I_{xx}	970048 mm^4
Moment of Inertia, I_{yy}	193537 mm^4
Sectional Modulus, Z_x	16.562 ^{3}

2.1 : Model Considered for the Analysis

1. Connection With Cleat and Seat Angles With 4 Bolts on Each Angle(C1)

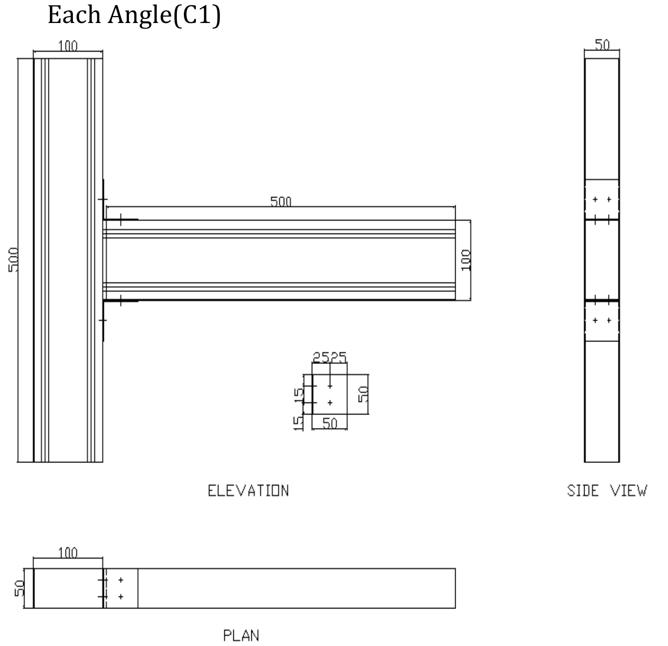

Fig.-1: Connection C1

2. Connection With Gusset Plate of 1mm Thickness With 8 Bolts on Each Plate(C4)

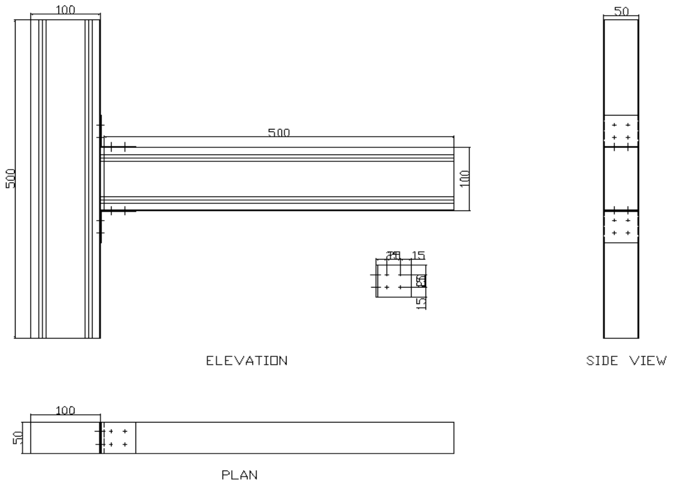

Fig.-2: Connection C2

3. Connection With Gusset Plate of 1mm Thickness With 4 Bolts on Each Plate(C3)

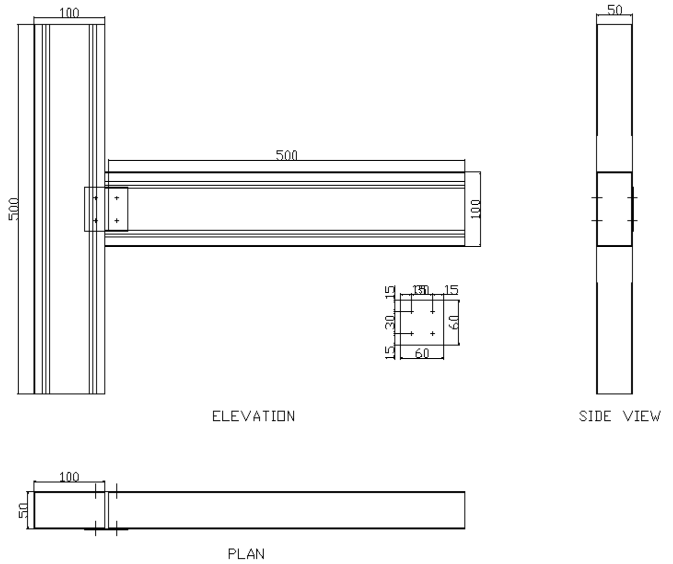

Fig.-3: Connection C3

4. Connection With Cleat and Seat Angles With 8 Bolts on Each Angle(C2)

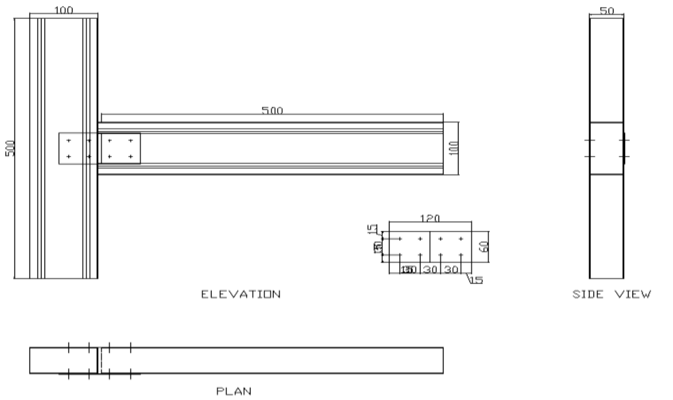

Fig.-4: Connection C4

2.2 : Experimental Analysis

Fig.-13: Experimental Setup

3. EXPERIMENTAL AND FEM RESULTS

3.1. Experimental result of connection with cleat and seat angle, and 4 number of screws on each angle.

Table No. 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	0.2028954	0.003542
0.4	2.8	0.192	0.33417826	0.005833
0.6	3.4	0.288	0.405785702	0.007083
0.8	7.8	0.384	0.930853781	0.01625
1	15.4	0.48	1.837371019	0.032083
1.2	37.6	0.576	4.478442391	0.078333
1.4	49.1	0.672	5.83980902	0.102292
1.6	59.8	0.768	7.100588505	0.124583
1.8	71.8	0.864	8.506313322	0.149583
2.0	88.2	0.96	10.41060317	0.18375
2.2	94.6	1.056	11.147712	0.197083
2.4	101.9	1.152	11.98392406	0.212292
2.6	115.2	1.248	13.49398362	0.24
2.8	121.8	1.334	14.23643883	0.25375
3.0	127.3	1.44	14.85145418	0.265208

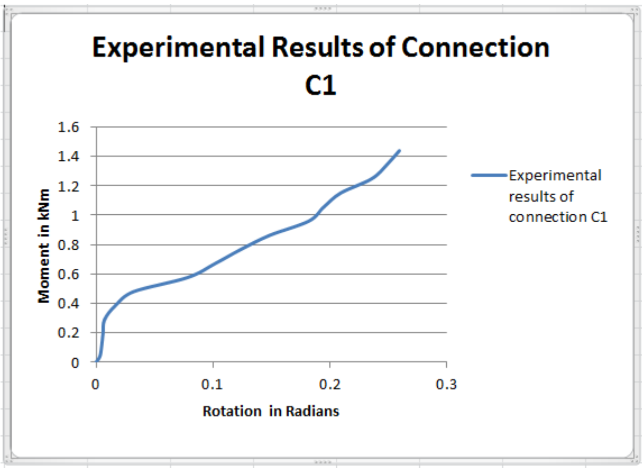

Chart -1: Experimental Results of Connection C1

3.2. Experimental result of connection with cleat and seat angle, and 8 number of screws on each plate C_2

Table No. 3.2.

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.1	0.5	0.048	0.0596	0.00104
0.2	1.7	0.096	0.2029	0.00354
0.4	5.9	0.192	0.704	0.0123
0.6	8.7	0.288	1.0382	0.018
1.0	17.9	0.48	2.1354	0.0373
1.2	22.7	0.576	2.707	0.047
1.4	31.3	0.672	3.7304	0.0651
1.6	39.3	0.768	4.68	0.0817
1.8	44.7	0.864	5.32	0.093
2.0	49.7	0.96	5.911	0.103
2.2	69.6	1.056	8.25	0.144
2.4	73.6	1.152	8.716	0.152
2.6	85.6	1.248	10.11	0.176
2.7	87.7	1.296	10.35	0.18

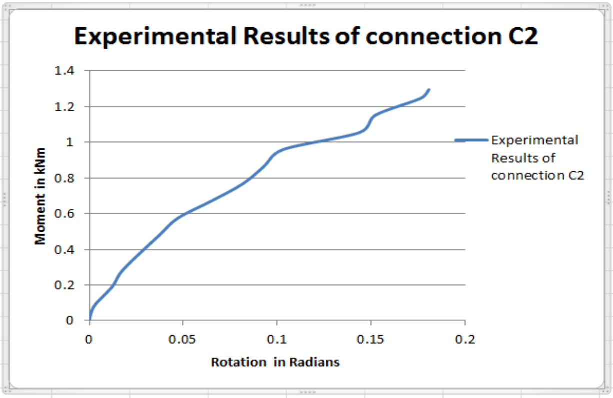

Chart -2: Experimental Results of Connection C2

3.3. Experimental result of the connection with 1mm thick gusset plate, with 4 number of screws on each plate C_3

Table No. 3.3.

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.2	3.3	0.096	0.3938	0.0068
0.4	15.4	0.192	1.8373	0.0321
0.6	34.4	0.288	4.098	0.0715
1.0	57.6	0.48	6.8419	0.11943
1.2	70.4	0.576	8.343	0.14563
1.4	80.2	0.672	9.4843	0.1656
1.6	89.6	0.768	10.572	0.1845
1.8	99.4	0.864	11.698	0.2042
2.0	112.6	0.96	13.2	0.230
2.2	131.2	1.056	15.285	0.267
2.3	149.6	1.104	17.3083	0.3021

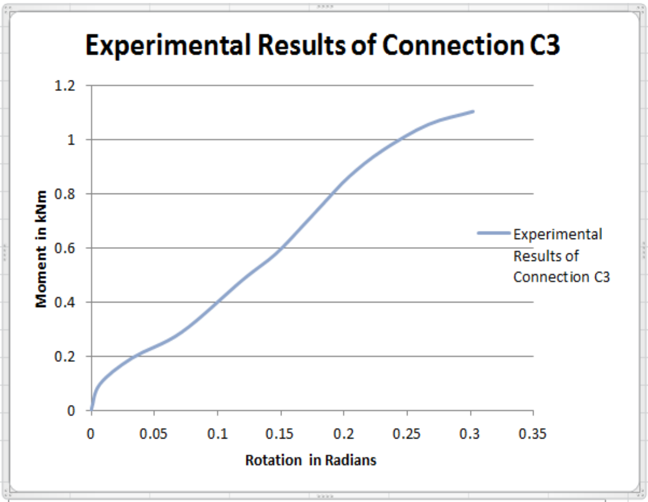

Chart -3: Experimental Results of Connection C3

3.4. Experimental result of the connection with 1mm thick gusset plate, with 8 number of screws on each plate C_4

Table No. 3.4.

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.2	8.0	0.096	0.954	0.0167
0.4	15.4	0.192	1.8374	0.0321
0.6	23.2	0.288	2.7668	0.0483
1.0	38.2	0.48	4.5497	0.0795
1.2	43.0	0.576	5.1184	0.089
1.4	47.4	0.672	5.639	0.098
1.6	53.2	0.768	6.3236	0.1104
1.8	58.4	0.864	6.936	0.121
2.0	64.6	0.96	7.664	0.1338
2.2	73.2	1.056	8.67	0.151
2.4	83.2	1.152	9.8323	0.1716
2.5	90.4	1.2	10.6644	0.186

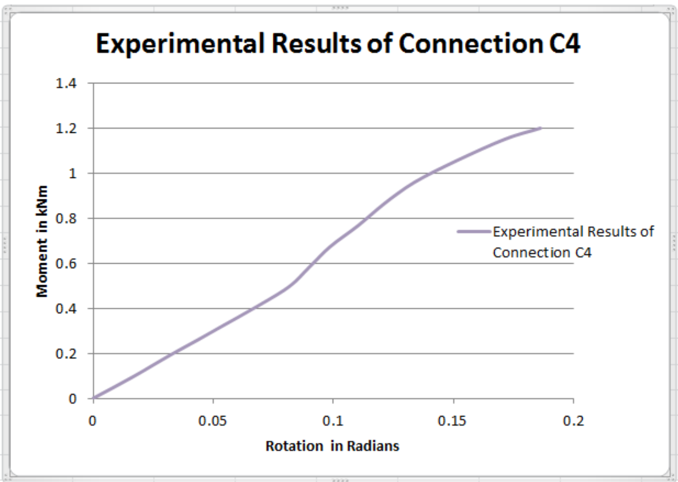

Chart -4: Experimental Results of Connection C4

3.5. FEM result of connection with cleat and seat angle, and 4 number of screws on each angle.

Table No. 3.5.

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.1	11.34	0.0223	1.97	0.0344
0.4	45.55	0.09125	7.92	0.138
0.6	68.19	0.1366	11.85	0.2068
0.8	90.02	0.1803	15.65	0.27318
1.0	113.74	0.2279	19.77	0.3451
1.2	136.38	0.27305	23.71	0.4139
1.4	159.12	0.3187	25.66	0.448
1.6	182.75	0.366	31.77	0.554
1.8	204.57	0.4098	35.56	0.6208
2.0	227.21	0.4552	39.5	0.6895
2.2	250.12	0.5011	43.48	0.759
2.4	272.76	0.5464	47.42	0.8278
2.6	294.58	0.5901	51.21	0.894
2.8	319.13	0.6393	55.48	0.968
3.0	340.95	0.68305	59.27	1.0346

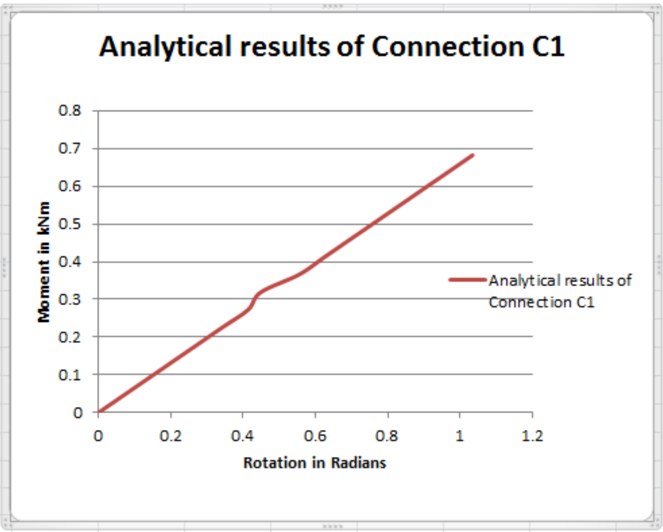

Chart -5: Experimental Results of Connection C1

3.6. FEM result of connection with cleat and seat angle, and 8 number of screws on each plate C_2

Table No. 3.6.

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.1	7.31	0.00164	11.44	0.015228
0.2	34.9	0.03286	22.9	0.0726
0.4	56.24	0.06575	45.78	0.1166
0.6	81.75	0.09861	68.68	0.1687
0.8	102.6	0.1315	114.475	0.2106
1	117.98	0.16434	137.37	0.241
1.2	137.56	0.19725	160.265	0.28
1.4	153.42	0.2302	173.52	0.31
1.6	170.56	0.263	183.16	0.341
1.8	197.64	0.296	206.055	0.3906
2	211.21	0.3287	228.95	0.414
2.2	229.8	0.3615	251.845	0.446
2.4	247.79	0.3943	274.74	0.4765
2.6	268.46	0.4273	297.63	0.51
2.7	290.61	0.4934	309.08	0.545

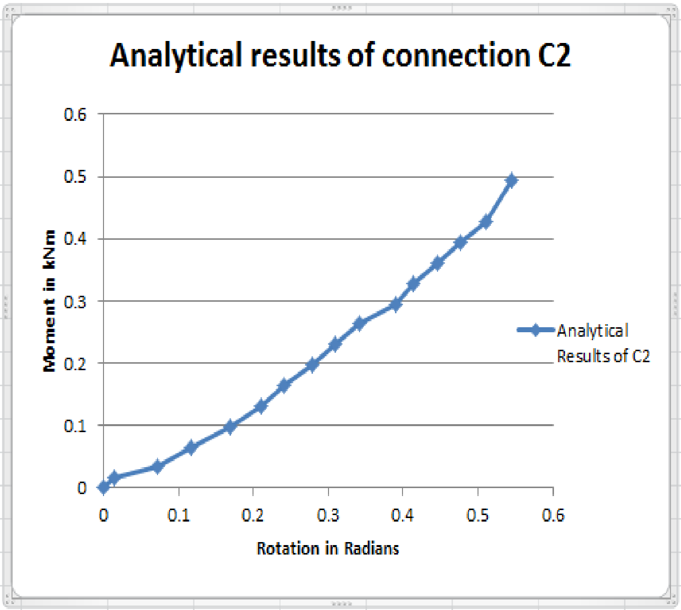

Chart -6: Experimental Results of Connection C2

3.7. FEM result of the connection with 1mm thick gusset plate, with 4 number of screws on each plate C_3

Table No. 3.7.

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.1	1.22	0.0051	1.22	0.021295778
0.2	2.46	0.0102	2.46	0.042940667
0.4	4.89	0.0204	4.89	0.085357667
0.6	7.34	0.031	7.34	0.128123778
1.0	12.23	0.0512	12.23	0.213481444
1.2	14.68	0.0614	14.68	0.256247556
1.4	17.13	0.072	17.13	0.299013667
1.6	19.57	0.082	19.57	0.341605222
1.8	22.02	0.092	22.02	0.384371333
2.0	24.48	0.102	24.48	0.427312
2.2	26.91	0.1126	26.91	0.469729
2.4	29.36	0.123	29.36	0.512495111

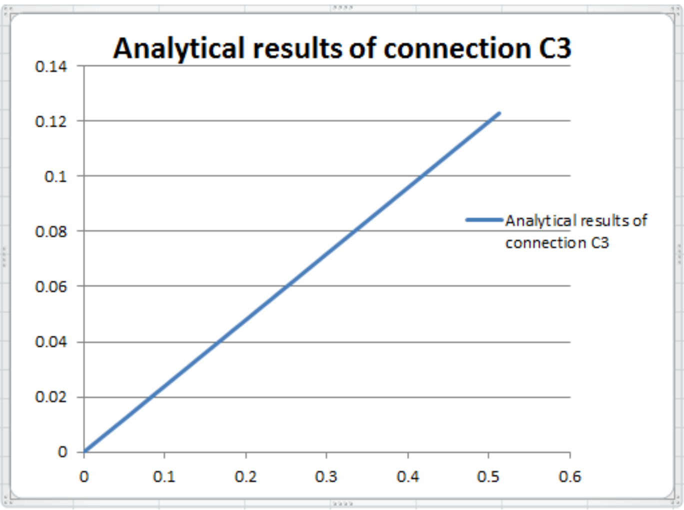

Chart -7: Experimental Results of Connection C3

3.8. FEM Experimental result of the connection with 1mm thick gusset plate, with 8 number of screws on each plate C_4

Table No. 3.8.

Load in kN	Deflection in mm	Moment in kN-m	Rotation in degree	Rotation in radian
0	0	0	0	0
0.2	1.77	0.011	5.37	0.093736333
0.4	3.55	0.022	10.75	0.187647222
0.6	5.33	0.0326	16.12	0.281383556
1.0	8.88	0.0545	26.87	0.469030778
1.2	10.66	0.0653	32.24	0.562767111
1.4	12.44	0.0762	37.62	0.656678
1.6	14.22	0.088	42.99	0.750414333
1.8	15.99	0.098	48.37	0.844325222
2.0	17.77	0.11	53.74	0.938061556
2.2	19.55	0.12	59.12	1.031972444
2.4	21.33	0.13	64.49	1.125708778
2.5	22.22	0.136	67.18	1.172664222

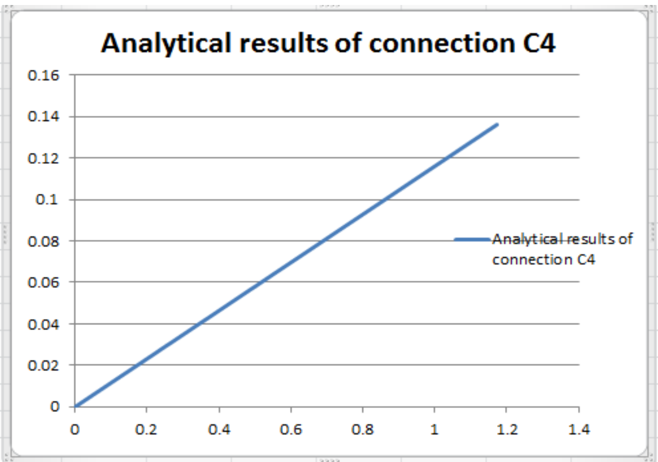

Chart -8: Experimental Results of Connection C4

4. CONCLUSION AND DISCUSSIONS

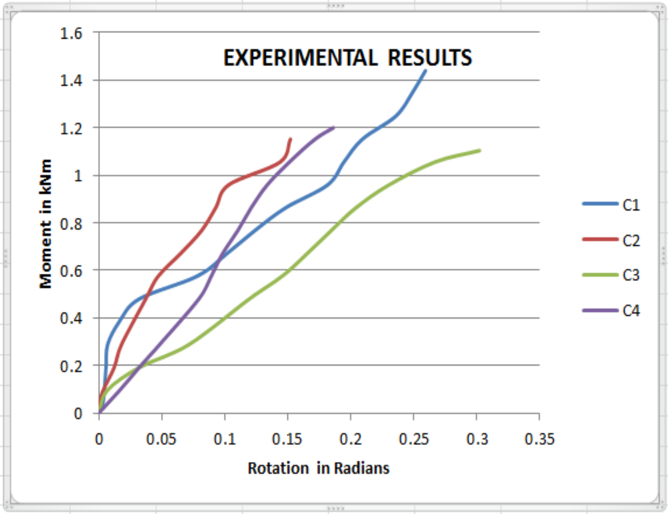

Chart -9: Experimental Results of all connections

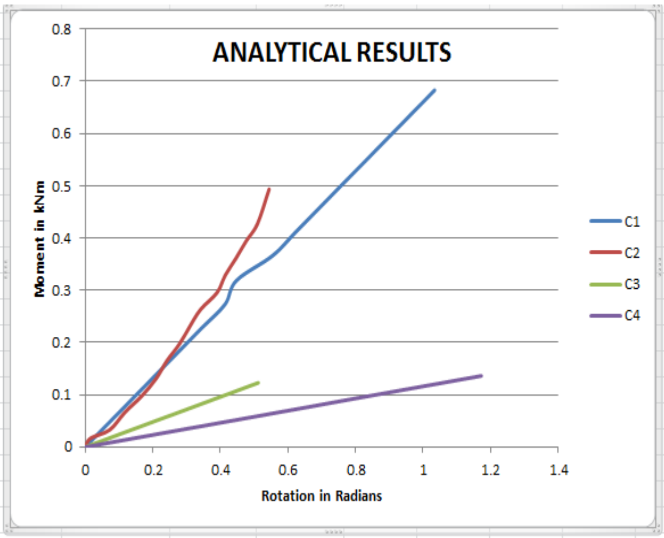

Chart -10: Analytical Results of all connections

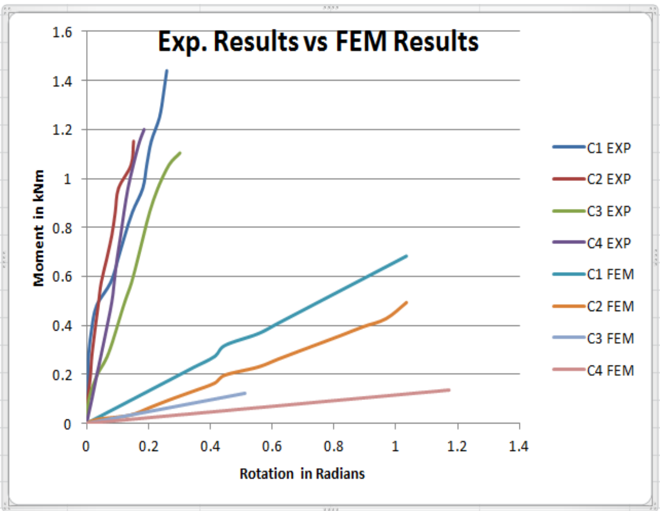

Chart -11: Experimental and FEM Results

5. CONCLUSIONS

Following conclusions are drawn from the present study-

1) Connection C3 is rotating excessively when compared with other connections.
2) Due to the presence of the angle plates in connection C1 and C2, the torsional buckling failure is at a higher load.
3) The connection C1, C2 and C4 has almost similar initial stiffness, whereas the initial stiffness of the connection C3 is very less.
4) The ultimate moment capacity of the connection C2 is more as compared to the other connections.
5) By providing the angle plate and increasing the number of screws increases the stiffness of the connection.
6) There are variations in FEM analysis when compared to the experimental analysis due to rigid condition and other factors.
7) The FEM analysis can be used to predict the behaviour of the connections.

From graph it can be observed that the connection C1 and C2 has high ultimate moment capacity as compared to that of other connections, connection C2 has high initial stiffness as compared to that of C1, C3 and C4.

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