IDENTIFICATION OF LATERAL TORSION/LATERAL RESTRAIN FOR FLANGE TO PREVENT BEAM FROM BUCKLING

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Abstract - The paper deals with the problem of lateral beam buckling of simply supported hot-rolled I-beams. Lateral stability of compression member/flange is very important factor in the design of PEB member, increasing the number of braced points thus decreasing the unbraced length of compression member/flange improves the performance of those member/flange under compression force and increases their compressive strength. when the compression flange is directly connected to roof purlins/wall girts the flange is considered braced at the points of intersection with those members, but when those members are connected with the opposite flange the flange with roof purlins/wall girts, the flange brace angle is required to connect the compression flange with roof purlins/wall girts, the flange brace system comprising flange brace angles and roof purlins/wall girts is providing lateral stability to compression flange. In Pre Engineering Building (PEB) structure to prevent lateral torsion bucking we have provided restrain, there is no Indian Standard clause available for preventing lateral torsion buckling of I Beam. According to metal building manufacturers association (MBMA), the standard distance for providing flange brace is 1.5m but in actual practice it's varies in that particular paper we have to study 1.5m distance is sufficient for restraining I beam using Ansys software.

Key Words: PEB, unbraced length.,

1. INTRODUCTION

Every structural system we have considered, except Butler's delta joist, requires lateral bracing of the rafter's compression flange for full structural efficiency. Under downward loads (dead, live and show), the top flange of primary members is mostly in compression. [1] Fortunately, this flange carries roof purlins, which provide the necceary bracing. Under wind uplift, however, it is the bottom flange that is mostly in compression. Lacking any help from secondary member, the bottom flange needs to be stabilized against buckling by flange bracing, consisting usually of bolted angle sections. [2]

Similar bracing is needed at needed at interior flange bracing by flange bracing, consisting usually of bolted angle section. Location of flange bracing are determined by the metal building manufacturer and need not concern the specifier. An absence of any flange bracing at all, however, warrants further inquiry. [3]

1.1 LATERAL TORSION BUCKLING

Lateral torsional buckling occurs when an applied load causes both lateral displacement and twisting of a member. This failure is usually seen when a load is applied to an unconstrained, steel I-beam, with the two flanges acting differently, one under compression and the other tension. 'Unconstrained' in this case simply means the flange under compression is free to move laterally and also twist. The buckling will be seen in the compression flange of a simply supported beam. [6]

1.2 WHAT IS LATERAL TORSIONAL BUCKLING?

Lateral torsional buckling may occur in an unrestrained beam. A beam is considered to be unrestrained when its compression flange is free to displace laterally and rotate. When an applied load causes both lateral displacement and twisting of a member lateral torsional buckling will occur. Figure shows the lateral displacement and twisting experienced by a beam when lateral torsional buckling occurs. [5]

1.3. WHAT CAUSES THE LATERAL DEFLECTION?

The applied vertical load results in compression and tension in the flanges of the section. The compression flange tries to deflect laterally away from its original position, whereas the tension flange tries to keep the member straight. The lateral movement of the flanges is shown in Figure. The lateral bending of the section creates restoring forces that oppose the movement because the section wants to remain straight. These restoring forces are not large enough to stop the section from deflecting laterally, but together with the lateral component of the tensile forces, they determine the buckling resistance of the beam. [5]

2. METHODOLOGY

2.1 HOW TO PREVENT LATERAL TORSIONAL BUCKLING

The best way to prevent this type of buckling from occurring is to restrain the flange under compression, which prevents it from rotating along its axis. Some beams have restraints such as walls or braced elements periodically along their lengths, as well as on the ends. This failure can also occur in a cantilever beam, in which case the bottom flange needs to be more restrained than the top flange. [8]

Fig1: -Torsion in Beam

The location of the applied load is a major concern. If the load is applied above the shear center of a section it is considered a destabilizing load, and the beam will be more susceptible to lateral torsional buckling. Therefore, loads applied at or below the shear center is a stabilizing load, with little risk of the buckling occurring. [8]

2.2 PROCEDURE OF ANSYS MODELLING

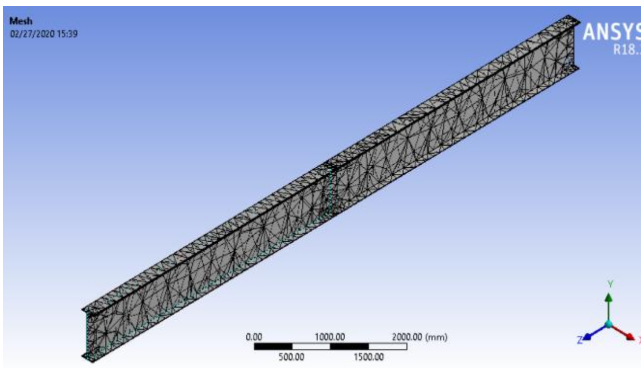

Fig 2: - Finite Element model of I section Beam

1. In static structure, we have edit property of material like young modulus, yield strength, Poisson ratio.
   - E=210GPa
   - Fy=345GPa
   - Poisson ratio:0.31 [4]
2. Then in geometry, we have created new sketch in xy plane, in that plane I section beam will have to make and one rectangular section have to make. The I section geometry is flange 180mm*10mm/200mm*10mm/220mm*10mm/240mm*10mm & web 700mm*6mm/750*6 and in YZ plane also create new sketch and drawing a straight line at a n^{th} distance point. Then extrude all this geometry and generate them. Those rectangular adjusted to I section which only for attaching spring to the I section flange. Which is fixed throughout the rectangular section. [7]

Table 1: Salient Features of I Section Beam

Type of Load acting on the beam	**Pressure loading**
Load capacity	**7.5KN/m² to 15KN/m²**
For Restrain	**Spring provided**
Stiffness of Spring	**0.5KN/mm to 2KN/mm**

3. RESULTS

1. The lateral torsion deflection (i.e. in X- direction Defection) for (180*10-700*6) mm I section of loading 50KN/m^2 is

Table 2: - X direction deformation on 180/200/220/240 mm flange with 7.5KN/m^2 loading

1. Loading :- 3 Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
121.15	14.398	15.9	11.994	21.462
210.26	24.398	30.47	34.595	23.401
243.77	28.023	52.452	37.958	24.032
213.09	25.948	38.196	36.515	26.202
124.55	16.759	21.433	17.751	21.886

Explanation: -

Case 1: - A beam with no restrain

Case 2: - A beam with all restrain at a distance of 1.5m c/c

Case 3: - A beam with restrain at a mid-span.

Case 4: - A beam with restrain at a 3,6 m resp.

Case 5: - A beam with restrain at a 1.5,4.5,7.5 m resp

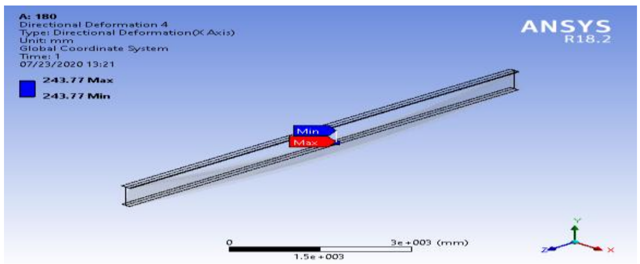

Fig1: - In beam when no restrain provided

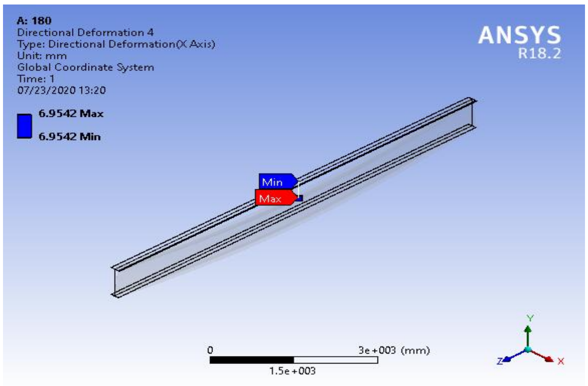

Fig 2: - when all the restrain provided at a distance of 1.5m c/c.

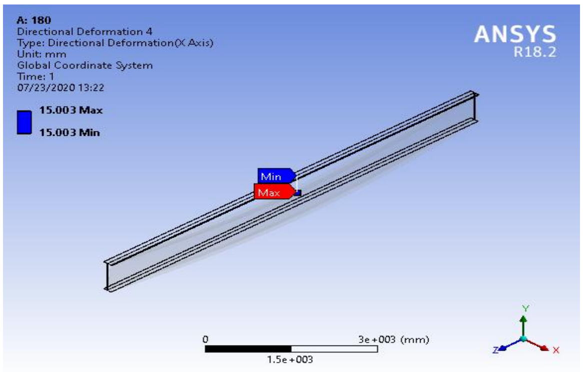

Fig 3: - when only one restrain provided at midpoint

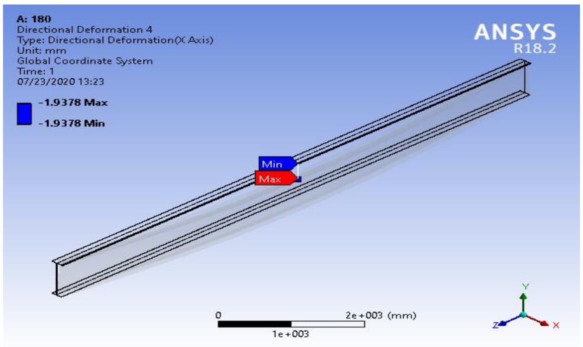

Fig 4: - when two restrain provided at 3,6 m resp.

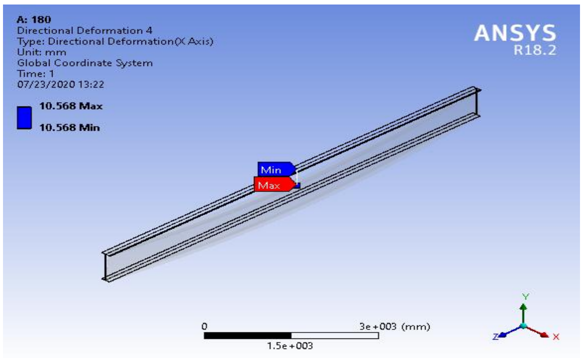

Fig 5: - when three restrain provided at 1.5,4.5,7.5 m resp.

2. Loading- 2.7Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
76.105	12.619	11.907	10.118	17.821
131.91	21.583	23.886	28.81	19.651
152.78	24.912	42.177	29.372	33.344
133.47	22.889	29.535	30.196	21.642
78.01	14.564	15.703	14.408	17.953

3. Loading:- 2.45Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
82.001	15.801	19.859	16.148	22.41
141.91	27.062	36.531	36.914	29.615
164.14	30.234	53.613	44.626	42.654
143.23	28.316	41.156	38.164	31.258
83.606	17.585	22.998	19.752	22.555

4. Loading :- 2.25Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
68.123	19.596	22.156	19.18	24.139
117.04	29.638	40.068	36.443	33.509
134.68	29.778	52.191	33.003	26.824
117.1	27.286	37.119	36.466	30.73
68.221	18.788	20.75	19.239	22.939

Table 3: - X direction deformation on 180/200/220/240 mm flange with 10KN/m² loading

1. Loading: - 4Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
161.53	10.105	5.705	3.4253	15
280.34	16.759	13.262	24.291	8.9614
325.03	18.866	38.174	31.564	27.928
284.12	18	23.62	26.182	12.561
166.07	12.366	13.073	10.532	16.062
538.39	475.61	490.29	484.93	486.48

2. Loading:- 3.6Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
101.47	8.8552	3.6484	3.156	13.172
175.88	14.914	10.281	20.495	7.969
203.71	16.96	41.215	26.141	23.597
177.96	16.024	17.873	21.917	10.59
104.01	10.779	8.7219	8.5226	13.284
487.62	422.18	453.73	451.77	450.71

3. Loading:- 3.272Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
109.34	11.214	11.528	8.6501	16.842
189.22	18.96	22.345	26.942	16.942
218.86	21.66	50.892	30.163	31.011
190.97	20.112	28.584	28.285	19.104
111.48	13.049	15.728	13.203	16.963

463.51	413.13	425.7	422.26	422.25

3. Loading :- 3Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
90.831	15.491	15.51	13.274	19.024
156.05	21.703	28.713	27.31	22.192
179.58	19.662	50.787	39.324	31.435
156.14	19.049	24.678	27.331	18.651
90.961	14.861	13.581	13.344	17.655
452.82	413.79	426.91	417.39	422.91

Table 4: - X direction deformation on 180/200/220/240 mm flange with 12.5KN/m² loading

1. Loading:- 5Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
201.91	8.6564	10.926	1.3319	13.65
350.43	14.135	3.7373	20.555	1.1334
406.29	15.603	42.815	27.952	23.472
355.15	15.18	16.713	22.432	55.426
207.59	10.909	9.0664	7.1258	14.014
672.99	593.31	610.65	605.07	606.41

2. Loading:- 4.5Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
126.84	7.5712	1.3108	0.7597	11.517
219.85	12.596	2.495	17.421	5.553
254.63	14.095	47.004	29.802	19.939
222.45	13.567	12.014	18.868	4.8089
130.02	9.5162	5.0366	5.6624	11.622
609.52	551.61	565.34	563.22	561.89

5. Loading :- 4.09Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
136.67	9.6157	6.9227	4.7327	14.794
236.52	16.072	14.73	23.128	10.445
273.57	19.143	55.797	40.821	36.503
238.71	17.14	22.566	24.537	13.128
139.34	11.504	12.181	10.199	14.907
579.39	514.77	529.33	525.61	525.6

4. Loading :- 3.75Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
113.54	14.25	12.117	10.583	17.201
195.07	18.898	23.087	23.739	16.689
224.47	15.608	46.059	32.739	26.824
195.17	15.99	17.99	12.097	12.448
113.7	13.81	9.6768	10.666	15.717
567.28	515.49	530.77	519.41	526.25

Table 5: - X direction deformation on 180/200/220/240 mm flange with 12.5KN/m² loading

1. Loading:- 6Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
242.29	7.9382	4.739	5.0414	12.635
420.51	12.823	3.5892	18.625	4.8759
487.55	13.908	46.007	29.756	26.136
426.19	13.721	11.998	20.495	0.34511
249.1	10.214	6.3052	4.7695	12.989
807.59	711.25	731.4	726.84	726.65

2. Loading :-5.4Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
152.21	6.9339	5.301	3.8195	10.689
263.82	11.431	3.5819	15.82	3.803
305.56	12.597	44.776	32.786	27.003
266.94	12.293	7.8586	17.284	5.551
156.02	8.9155	2.3194	3.6489	10.79
731.43	662.25	677.36	674.97	673.73

3. Loading :- 4.909Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
164.04	8.8216	3.467	8.614	13.761
283.88	14.606	9.1426	21.115	5.7476
328.36	16.292	53.059	43.519	34.088
286.51	15.599	18.57	22.572	8.9515
167.25	10.771	9.7837	8.2221	13.869
695.41	616.84	633.53	629.47	629.45

4. Loading :- 4.5Pa

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
136.25	13.757	9.7673	8.856	16.334
234.08	17.509	19.298	21.836	12.924
269.37	13.284	53.473	38.017	33.271
234.21	14.374	13.146	21.858	8.0145
136.44	13.505	6.8202	9	14.767
680.74	617.54	635.05	621.81	629.98

Conclusions

1. The lateral torsion buckling deformation for different loading is varying.
2. The maximum allowable deflection is 30mm (i.e. L/300) and all the values are less then 30mm. therefore it is accepted.
3. We can change restraining position from 1.5m to 3m by these study.

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