To Study Optimization of Industrial Structure Using Light Gauge Steel Section

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***Abstract*- In recent decades the interest of the building sector is tending towards the lightweight construction so as to overcome the faults of the last decades. The light weight and faster construction is the demand of the era. This has led to the increase in the use of the light weight steel structure as they satisfy the demand of the light weight and faster construction. Though there are several advantages of the light gauge steel section they are partially obtained due to the unawareness of the designer about the behaviour of the section. Therefore it is necessary to study the behaviour of the light gauge section under loading which will help in achieving the good performance of the structure.**

Key Words:, light weight, behaviour , analysis, performance, demand.

I. INTRODUCTION

Structural engineers and designers are in the daily engineering praxis required to design the cheapest possible structures with the minimum amount of used material and technical equipment. The use of modern optimization methods thus becomes a great opportunity in the area of structural engineering. Single-storey industrial steel building structures are probably the most frequently built type of structures among various skeletal framed steel constructions. Many different optimization approaches have been proposed in the near past for the optimization of these structures. Performed a constrained non-linear cost optimization of steel portal framed building. A linear programming approach for the optimal design of pitched roof frames. Considered an optimum design of pitched roof steel frames with hunched rafters by using a genetic algorithm and using light gauge section in the structure. Industrial buildings, a sub-set of low-rise buildings are normally used for steel plants, automobile industries, light, utility and process industries, thermal power stations, warehouses, assembly plants, storage, garages, small scale industries, etc. These buildings require large column free areas. Hence interior columns, walls and partitions are often eliminated or kept to a minimum.

- **Failure Modes In Light Gauge Steel Section**
- ✓ **Local buckling**

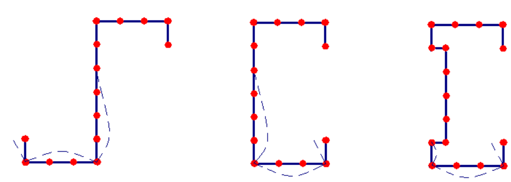

Figure No. 1.1: Local Buckling

Local buckling is characterised by ripples of relatively short half-wavelength of the order of magnitude of individual plate elements and the displacements are only perpendicular to plate elements while the fold lines remain straight.

- ✓ **Distortional Buckling**

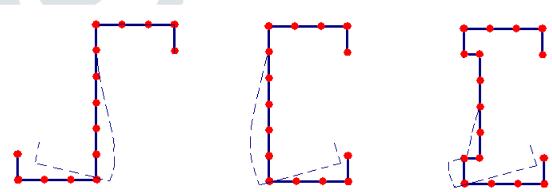

Figure No. 1.2: Distortional buckling

Distortional buckling occurs only in the structural members of open cross-sections. This buckling is characterised by the distortion of the cross-section of the structural member.

- ✓ **Lateral Torsional Buckling**

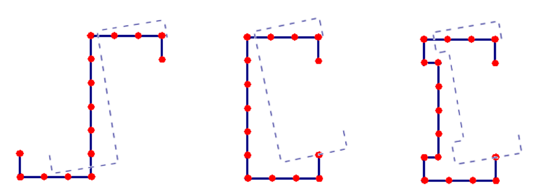

Figure No. 1.3: Lateral Torsional buckling

The buckling of a strut in compression or a beam in bending is called Euler buckling or lateral-torsional buckling; Lateral-torsional buckling usually occurs when a rigid body is bent to twist and translates to have lateral movements but do not have deformation in shape of cross-section.

II. LITERATURE REVIEW

1. Mufaiz Rehman and Rashmi Sakalle,(2019)

In this research work we will design Industry using analysis tool Staad.pro and use novel cold formed steel structure and compare it with general steel available in Indian market. Here we will compare both in terms of strength and weight of structure with bolted and welded connections. In present study comparative study is done on a 3-dimensional ware house for same loadings with different section to find out the best material either cold formed or general steel section which will be stable, good in stiffness, cost effective, economical and easily available.

2. Michal Stary, Frantisek Novotny, Marcel Horák, Marie Stara, Zdenek Vít,(2018)

The paper presents a method with high potential application for the production of plug welded structural frames. Both the experimental and the numerical simulation proved the interchangeability of the presented construction system with the common profile frame, provided that the specified rules were observed. In addition, the numerical simulation of stress fields in welded joints demonstrates the desirable effect of tightening. The main part of the paper describes the successful experimental optimization of joints in relation to used materials, i.e. steel and aluminium alloy.

III. METHODOLOGY

❖ **Design Of The Channel Section As Per Is 801-1975**

Computation as per IS: 801-1975 of practice for use of cold formed light gauge steel structural member's in general building construction:

Material Properties: yield stress fy = 250 N/mm2

Computation of Sectional Properties:

Depth (d) = 100 mm

Width (w) = 40 mm

Depth of lip (D) = 20 mm

Thickness (t) = 2 mm

Area (A) = 424 mm^2

Span of length (L) = 1000 mm

Centroid: CG of section: X_{cg} = 14.623 mm

Z_{cg} = 37.103 mm

Moment of inertia: $I_{xx} = \frac{40X2^3}{12} + 40X2X49^2 + \frac{2X18^3}{12} + 18X2X40^2 + \frac{2X96^3}{12} + \frac{40X2^3}{12} + 40X2X49^2 + \frac{2X18^3}{12} + 18X2X49^2 = 0.649 \text{ X } 10^6 \text{ mm}^4$

$I_{zz} = \frac{2X40^3}{12} + 40X2X5.377^2 + \frac{2X40^3}{12} + 40X2X5.377^2 + \frac{18X2^3}{12} + 18X2X24.377^2 + \frac{96X2^3}{12} + \frac{18X2^3}{12} + 18X2X24.377^2 = 0.068832 \text{ X } 10^6 \text{ mm}^4$

Computation of effective width:

Checking of above section as per clause 5.2.2.1 IS 801-1975 (Page No: 6):

Effective width calculation of compression elements:

Flange is fully effective

if $\left(\frac{w}{t}\right) \leq \left(\frac{w}{t}\right)_{lim}$

Hence $\left(\frac{w}{t}\right) = \left(\frac{40}{.2}\right) = 20$

$\left(\frac{w}{t}\right)_{lim} = \frac{1435}{\sqrt{f_y}} = \frac{1435}{\sqrt{225}} = 95.667$

Hence $\left(\frac{w}{t}\right) < \left(\frac{w}{t}\right)_{lim}$

Therefore Entire area is effective.

Determination of safe load:

Section modulus $Z_e = \frac{I_{xx}}{Z_{cg}} = \frac{.648812 \text{ X } 10^6}{37.103} = 17530.721 \text{ mm}^3$

Allowable resisting moment = Z_e X f_y

= 225 X 12976.44

M = 2.912 x 10^6 Nmm

Let w be the load in N/mm

$\frac{w \text{ X } 1000^2}{8}$ = 2.912 X 10^6 N/mm

w = 23.296 N/mm

Check for web shear :

Maximum Shear force = V = $\frac{23.296 \text{ X } 1000}{2}$

= 11.648 X 10^3 N

Maximum average shear stress F_{max} = $\frac{V}{A}$

= $\frac{11.648 \text{ X} 10^3}{424}$

=27.472 N/mm^2

$\frac{h}{t} = \frac{100}{2}$

= 50

4590/$\sqrt{f_y}$ = 4590/$\sqrt{225}$

= 306

As per clause 6.4.1 IS 801-1975 (Page No: 15)

Since $\frac{h}{t}$ < 4590$\sqrt{f_y}$

Therefore the gross area of a flat web = F_v

= $\frac{1275\sqrt{f_y}}{\frac{h}{t}}$

= $\frac{1275\sqrt{225}}{50}$

F_v = 382.50 N/mm^2

F_v must not be greater than F_{vmax} = 0.4fy

= 0.4 X 382.50

F_{vmax} = 90 N/mm^2

Hence F_v = F_{vmax} =90 N/mm^2.

Thus, F_v = F_{vmax} = 90 N/mm^2 this is greater than the maximum Average shear stress of F_{max} = 27.472 N/mm^2. Thus the beam is therefore safe in shear.

Check for bending compression in web :

As per clause 6.4.2 IS 801-1975 (Page No: 16):

Actual compression stress at junction of flange and web:

f_{bw} = f_c X $\frac{40-2}{40}$

= 0.4 X 225 X $\frac{40-2}{40}$

= 85.5 N/mm^2

Permissible: F_{bw} = $\frac{36560000}{\left(\frac{h}{t}\right)^2}$ kg/cm^2

= $\frac{3585311.24}{(50)^2}$ N/mm^2

= 1433.152 N/mm^2

Since F_{bw} > f_{bw}. Hence safe in bending.

Combined Bending and Shear Stresses in Webs :

As per clause 6.4.2.3 IS 801-1975 (Page No: 16):

$$\sqrt{\left(\frac{f_{bw}}{F_{bw}}\right)^2 + \left(\frac{F_{max}}{F_v}\right)^2} \leq 1$$

Where, f_{bw}= actual compression stress at junction of flange and web;

F_{max} = actual average shear stress, that is, shear force per web divided b_v webs area;

F_v = allowable shear stress, except that the limit of 0.4f_y, shall not apply.

$$\sqrt{\left(\frac{85.5}{1433.152}\right)^2 + \left(\frac{27.472}{90}\right)^2} = .311$$

Since Combined Bending and Shear Stresses in Webs is less than unity.

Hence the section is safe.

Determination of deflection :

Deflection $\delta = \frac{5wL^4}{384EI} < \frac{L}{325}$

Where w = 150.4 kN/m = 150.4X103 N/mm

L = 1000 mm

E = 2.033×10^5 N/mm^2

I_{xx} = 505.1343×10^4 mm^4

$$\text{Hence } (\delta) = \frac{5X\ 23.296\ X\ (950)^4}{384\ X\ 2.033\ X\ 10^5 X\ 648.812X\ 10^3}$$

= 2.338 mm.

Permissible:

$$\frac{L}{325} = \frac{950}{325} \quad = 3.076 \text{ mm. Hence safe.}$$

IV. RESULTS AND DISCUSSION

4.1 Analytical results of Reaction of Model.

Table No 4.1:Comparison of Beam Force

Sr. No	Sections	Reactio n	Percentage Difference Steel & Light Gauge Steel	Percentage Difference between Light Gauge Steel
1	ISMB500	2607.2	-	-
2	40 X20	1788.1	45.80	-
3	40 X40	1791.7	45.51	0.19
4	60 X30	1806.7	44.30	0.83
5	80 X40	1817.8	43.42	0.61

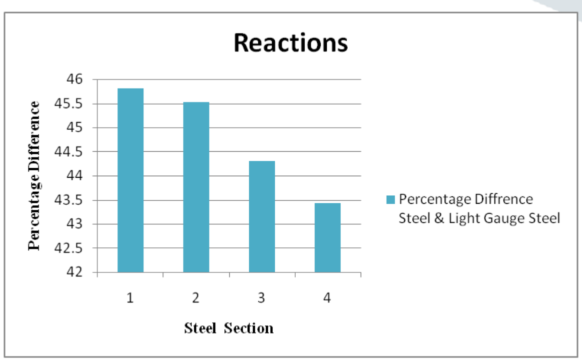

Figure No. 4.1: Percentage Difference Between Steel & Light Gauge Steel

Figure No. 4.2: Percentage Difference Between Light Gauge Steel

4.2 Analytical results for Beam Force

Table No 4.2: Comparison of Reaction

Sr. No	Sections	Beam Force	Percentage Difference Steel & Light Gauge Steel	Percentage Difference between Light Gauge Steel
1	Steel	6518.99	-	-
2	40 X20	4924.50	32.38	-
3	40 X40	4925.86	32.34	0.03
4	60 X30	4998.84	30.41	1.48
5	80 X40	5035.57	29.46	0.73

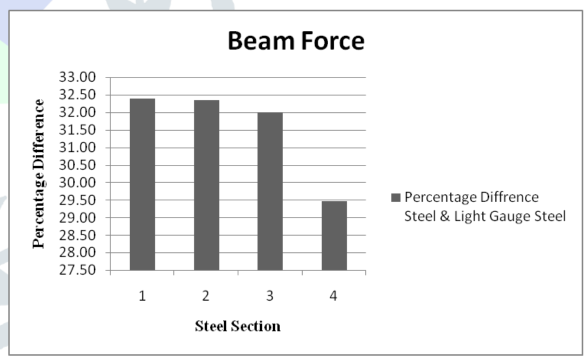

Figure No. 4.3: Percentage Difference Between Steel & Light Gauge Steel

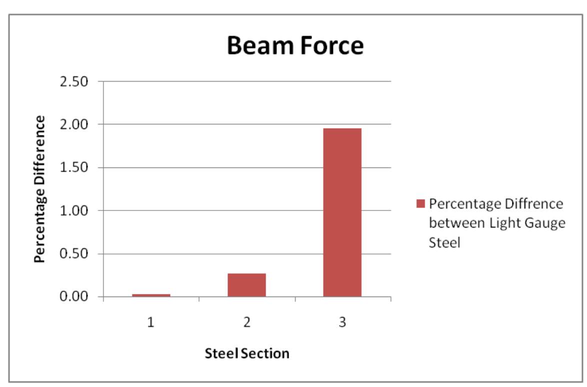

Figure No. 4.4: Percentage Difference Between Light Gauge Steel

4.3 Analytical results for Displacement of models

Table No 4.3:Displacement of Model

Sr. No	Light Gauge Steel Section	Displacement	Percentage Difference Steel & Light Gauge Steel	Percentage Difference between Light Gauge Steel
1	ISMB500	4678.6	-	-
2	40 X20	17950.9	73.93	-
3	40 X40	13320.02	64.87	34.76
4	60 X30	7387.345	36.66	80.30
5	80 X40	5514.762	15.16	33.95

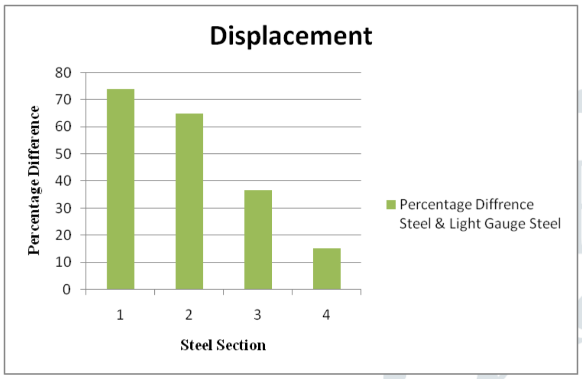

Figure No. 4.5: Percentage Difference Between Steel & Light Gauge Steel

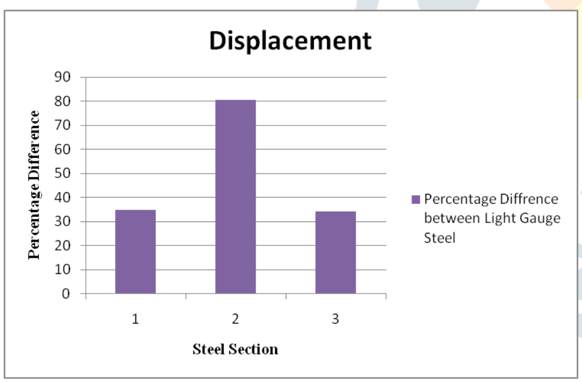

Figure No. 4.6: Percentage Difference Between Light Gauge Steel

4.4 Analytical results for Compression of models

Table No 4.4: Maximum Compression

Sr. No	Steel Section	Maximum Compression	Percentage Difference Steel & Light Gauge Steel	Percentage Difference between Light Gauge Steel
1	ISMB500	444138	-	-
2	40 X20	578148	30.17	-
3	40 X40	160436	49.07	72.25
4	60 X30	157952	63.87	39.79
5	80 X40	96598	64.43	38.84

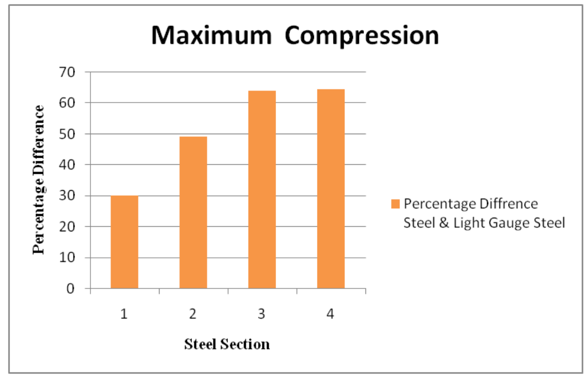

Figure No. 4.7: Percentage Difference Between Steel & Light Gauge Steel

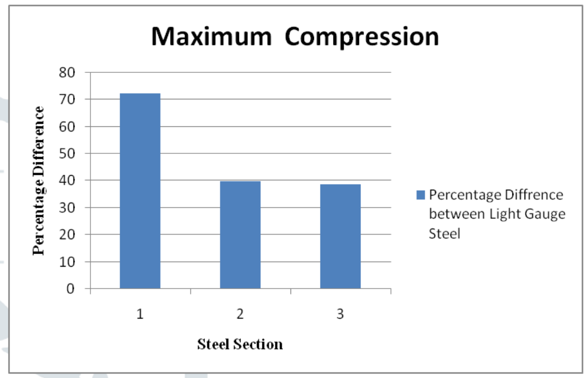

Figure No. 4.8: Percentage Difference Between Light Gauge Steel

V. CONCLUSION

The optimization of industrial structure by maximum using light gauge steel sections in whole structure. In addition, the performance of the innovative optimized sections subject to shear and web crippling action were also investigated using analysis.

- There are a great range of systems and products catering to this type of construction.
- It is easy to change or modify this Structure fabrication at any point in its lifespan.
- It is able to shape itself to any form, and can be clad and insulated with a wide range of materials.
- From the analysis the software models the section change, reaction and displacement also change its incensing with respective to node point.
- From the results concluded that the percentage between steel and light gauge steel are decreases with the section. Percentage difference between light gauge sections maximum 0.61% and minimum 0.19% bare shows from the results.
- From the results concluded that the percentage of compression and tension between steel and light gauge steel are increases with the section. Percentage

difference between light gauge sections is decreases with the different section.

- From the results concluded that percentage of beam force between steel and light gauge steel are decreases with the section. Percentage difference between light gauge sections maximum 1.48% and minimum 0.03% are shows from the results.
- It is determined in this study that light gauge steel is better ion resisting load, and unbalanced forces.
- Here it is concluded that deflection in light gauge steels sections are relatively less.
- It can be determine that stress and support reaction of light gauge steel is comparatively less than the steel.

VI. REFERENCES

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