

Development of a Cold Formed Steel Housing System

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ABSTRACT: According to Indian Government vision to provide housing for all the people by the year of 2022 this project is undertaken. Cold Formed steel structures are used since it enhances easy and faster mode of construction and it is becoming very popular in India. To design and develop a G+2 cold formed steel housing system which is resistant against earthquake. The structure is designed using semi rigid connections. Each member are considered as a spring and the corresponding spring constant is found out and the structure is analyzed. The model is created using STAAD pro and the feasibility is checked. The design is based on a new method called Direct Strength method which is explicitly for cold formed steel structures. The design is based upon the buckling nature of the sections chosen and no other input parameters are provided. The buckling nature is found out using CUFSM software which is a finite strip method. The Comparison between a conventional steel building and the cold formed steel building is made by creating a model in STAAD pro to show the difference in weights, quantity of steel used and also in cost basis. Finally the materials for the wall panels or the wall claddings are to be discussed and the tests for the chosen section is to be carried out to check whether the section is safe.

KEYWORDS: Cold Formed Steel, Earthquake Resistant, Direct Strength Method, CUFSM software, Comparison of Conventional steel and Cold Formed Steel, Wall Panels.

I. INTRODUCTION

Cold-formed steel products are found in all aspects of modern life. The use of these products are multiple and varied, ranging from “tin” cans to structural piling, from keyboard switches to mainframe building members. Nowadays, a multiplicity of widely different products, with a tremendous diversity of shapes, sizes, and applications are produced in steel using the cold-forming process.

Cold-formed steel members are efficient in terms of both stiffness and strength. The use of cold-formed steel structures is increasing throughout the world with the production of more economic steel coils particularly in coated form with zinc or aluminium /zinc coatings. These coils are subsequently formed into thin-walled sections by the cold-forming process. They are commonly called “Light gauge sections” since their thickness has been normally less than 3 mm. However, more recent developments have allowed sections up to 25 mm to be cold-formed, and open sections up to approximately 8 mm thick are becoming common in building construction. The steel used for these sections may have a yield stress ranging from 250 MPa to 550 MPa (Hancock, 1997). The higher yield stress steels are also becoming more common as steel manufacturers produce high strength steel more efficiently. The use of thinner sections and high strength steels leads to design problems

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for structural engineers which may not normally be encountered in routine structural steel design. Structural instability of sections is most likely to occur as a result of the thickness of the sections, leading to reduced buckling loads (and stresses), and the use of higher strength steel typically makes the buckling stress and yield stress of the thin-walled sections approximately equal. Cold-formed shapes are usually made from hot-rolled sheet or strip steel, which costs less per pound than cold-rolled steel. The latter, which has been cold-rolled to desired thickness, is used for thinner gauges or where, for any reason, surface finish, mechanical properties, or closer tolerances that result from cold-reducing is desired. Manufacture of cold-formed shapes from plates for use in building construction is possible but is done infrequently. Cold-formed sections commonly have mono-symmetric or point-symmetric shapes, and normally have stiffening lips on flanges and intermediate stiffeners in wide flanges and webs. Usually, the depth of cold-formed sections for bar members ranges from 50 to 70 mm and 350 – 400 mm, with thickness from about 0.5 mm to 6 mm.

II. RELATED WORK

The use of slender material and cold-forming processes results in several design problems for cold formed steel construction dissimilar to those of heavy hot rolled steel construction. The next is a short argument of some problems usually joins in design (Yu, 2000). The three basic buckling modes of thin-walled cold formed steel members are given. Local buckling is a mode involving plate flexure alone without transverse deformation of the line or lines of intersection of adjoining plates, distortional buckling is a mode of buckling involving change in cross-sectional shape excluding local buckling, and the term global buckling embraces Euler (flexural) and lateral-torsional buckling of columns and lateral buckling of beams (Hancock, 2003). Cold formed open section steel members are more expected to go through torsional deformation due to their low torsional rigidity, resulting from their slender walls. Further, the sections are often loaded eccentrically from their shear centers and so are subject to considerable torque. The load-carrying capability and the buckling performance of compression components of beams and columns can be enhanced significantly by the use of edge stiffeners.

III. METHODOLOGY

A Comparative study between the hot rolled steel and cold formed steel industrial building is compared and the difference in weight, quantity and cost is discussed. The Cold formed steel housing system model is created using the STAAD Pro software with the sectional property of cold formed steel structure. The framework is created using the software furthermore the design is carried out using direct strength method where the buckling load is determined using CUFSM software which uses finite strip method to determine the buckling loads of the member and compared with the prequalified members. With the help of buckling loads the section is designed and an effective section is chosen.

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IV. COMPARISON BETWEEN CONVENTIONAL STEEL AND COLD FORMED STEEL

Figures (a) , (b) shows the Conventional Steel frame and Cold formed steel frame which is created using STAAD pro software. The Specifications for the structure is given below.

Specifications for CSB and CFS

Structural Details	Single storey industrial structure
Total Bay Length	75m
Single Bay Length for CSB	3.75m
Single Bay length for CFS	7.5m
Span Width	22m
Clear Height	7.5m
Wind Speed	50m/s
CFS Roof slope	5.71°
CSB Roof Slope	13.3°

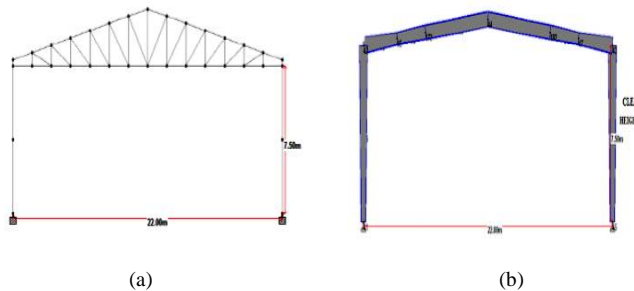


Fig. 1. Industrial Structure (a) Conventional Steel Frame (b) Cold Formed Steel Frame

Analysis & Design for the structure is taken default by the software

Dead Load : 1.125kN/m

Live Load : 0.75kN/sq.m

Wind Intensity : 50 m/s

CSB – ISMC 75

CFS – 200Z20

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The Comparison between CSB and CFS as per Steel consumption , weight comparison as per IS code, AISC code and also as per cost basis is given.

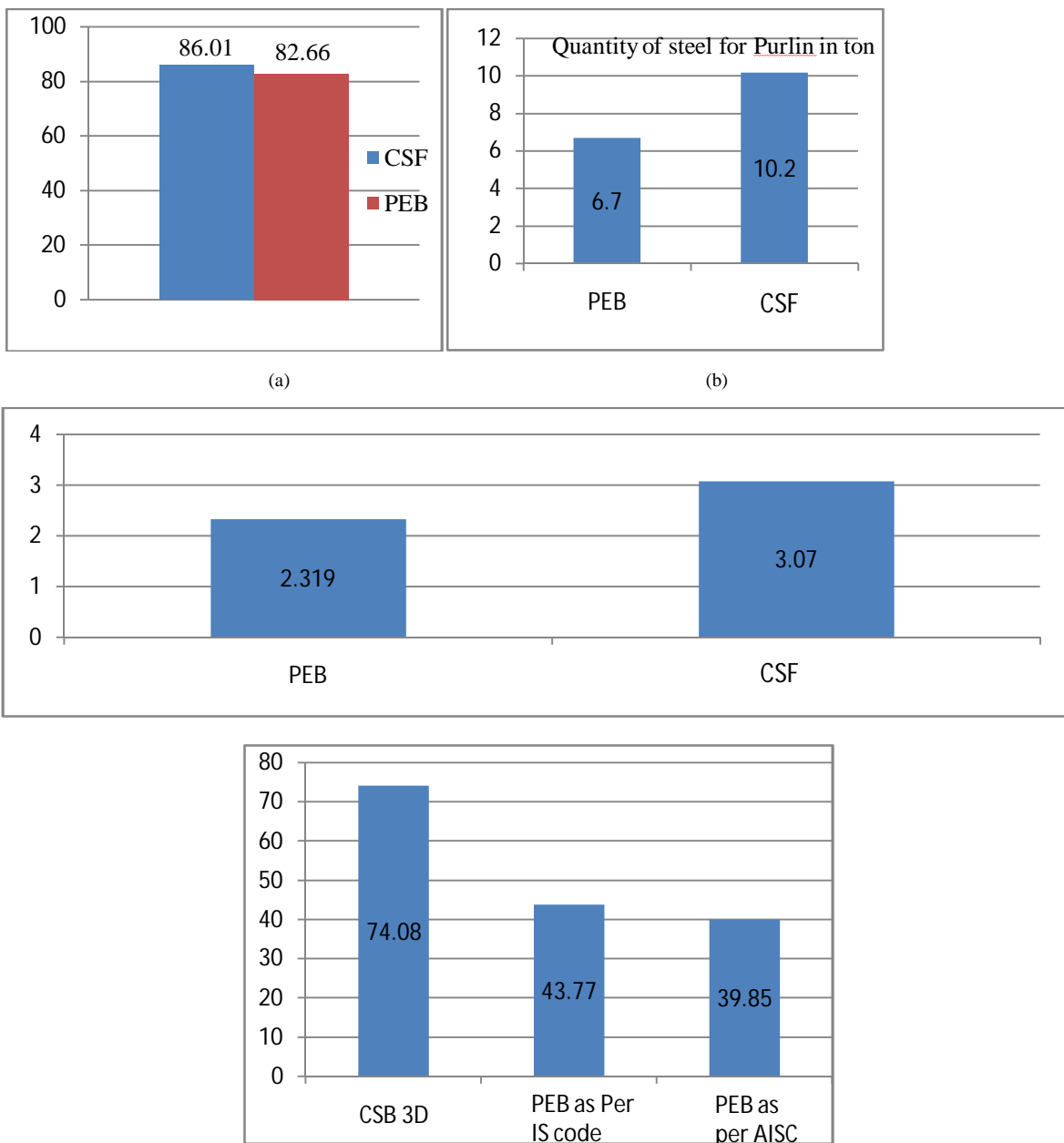


Fig. 2 Text Detection and Inpainting (a) Steel Consumption (b) Quantity of steel for purlin (c) Weight Comparison for 2D frame (d) Weight Comparison as per IS code and AISC code

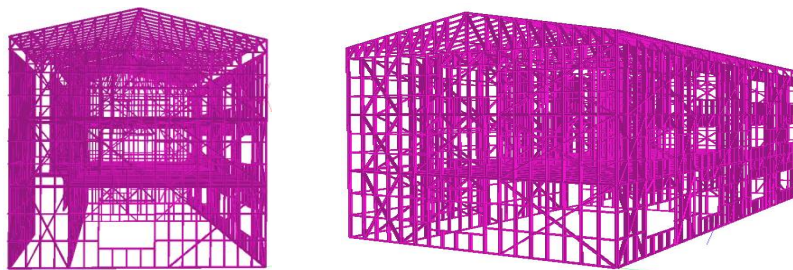
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Cost As per the steel Consumed for the entire structure including the sub structure works around Rs.2500 to Rs.3000 per Sq.ft area for Conventional steel Building.Incase of Cold formed steel building including the sub structure works the cost comes around Rs.1650 to Rs.1850 per Sq.ft area. The cost per tonnage of conventional steel building is Rs.26,800 and also the cost per tonnage for Cold formed steel building is Rs.32,400. The structure to be designed comprises of Cold formed steel roofing, cross beams, framework, columns, foundation, and connection. It is a structure whose length is 21.5m , and height is 11.4 m.



(a) (b)
Fig. 3 (a) and (b) G+2 Housing System

The loads constructed in the analysis of the project are dead load, live load and wind load. The magnitude of each load is specified below.

Dead Load	Self Weight of the structure
Live Load	2 kN/m ²
Wind Intensity	50 m/s

Direction	Dead Load Reaction			Live Load Reaction			Wind Load Reaction		
	x	y	z	x	y	z	x	y	z
Load	0.00	1279.7	0.00	0.00	1400.10	0.00	7.28	-215.64	-194.53
Moment	6556.3	0.00	14050.38	7087.92	0.00	15475.38	-2407.17	1994.86	-2337.63
Displacement	0.34	-0.14	2.35	0.348	-0.17	2.84	0.77	9.52	2.527

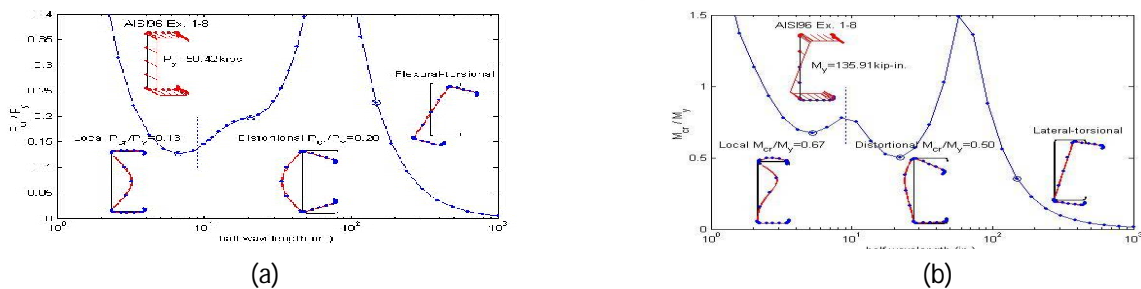


Fig.4 (a) Buckling mode shape in Compression (b) Buckling mode shape in Bending

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	Formula*	FSM model	
A =	0.881	0.880	in. ² $M_y = 112.82 \text{ Kip.in}$
$I_x =$	10.3	10.285	in. ⁴ $M_{cr1} = 0.86 M_y M_{cr1} = 97.03 \text{ kip.in}$
$x_c =$	0.612	0.610	in. $M_{crd} = 0.65 M_y M_{crd} = 73.33 \text{ kip.in}$
$I_y =$	0.698	0.695	in. ⁴ $P_y = 46.55 \text{ kip}$
m =	1.048	1.036	in. $P_{cr1} = 0.16 P_y P_{cr1} = 7.488 \text{ kip}$
$x_o =$	-1.660	-1.646	in. $P_{crd} = 0.27 P_y P_{crd} = 12.569 \text{ kip}$
J =	0.00102	0.00102	in. ⁴ Design Strength = 60.63 kip.in
$C_w =$	11.9	11.1	in. ⁶ Allowable Design Strength = 40.34 kip.in

Predicted capacity is less than the prequalified member. The DSM predicts local buckling and will control distortional buckling is presumed not to interact with long column buckling.

V. WALL PANELLING

Exterior walls can be finished with a wide array of materials and techniques. Exterior wall finishes can produce significant savings for the contractor as well as for the building. Cement Plaster board or Gypsum board panelling could be done.

Interior Wall panelling such as, when a high degree of sound absorption is desired, acoustical panels can be a good choice.

- fabric type
- core material
- Hydrophobic fabrics do not absorb and retain moisture.
- These include polyester, acetates, nylon.
- Hydrophilic fabrics absorb and retain moisture.

Stone used as a finished wall surface can be achieved using two different approaches

- Tiles: thin, small, modular, pieces, typically no larger than 12" x 12".
- panels/slabs: 3/4" up to 4" thick.
- Wall Flats are Inhabit's take on a modern, eco-friendly wallpaper. Wall Flats are made from 100% bamboo pulp, one of the world's most renewable resources. They are a sustainable wall covering that is free of chemicals and will not be a burden to the environment at the end of its lifecycle, since the tiles are 100% bio-degradable.

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VI. CONCLUSION

- For 3D CFS structure weight is 35 % lesser than the weight of CSB structure. The Reason for higher weight in IS code compared to AISC is limiting ratio of the section.
- Weight of CFS depends on the bay spacing with the increase in bay spacing up to certain spacing , the weight reduces and further increase makes weight heavier.
- One of the main reason to increase in weight in IS code is Serviceability Criteria. Deflection limits by IS code is (H/150) are higher than deflection limits by AISC (H/60).
- Pre-engineered structure cost is 15% lesser than the cost of conventional steel structure. Pre-engineered structure offers low cost, strength, durability and recyclability.
- The comparative study on conventional and Pre-engineered building leads to the conclusion that CFS proves to be relevant and beneficial for warehouses equipped with cranes. Hence Pre-engineered frames must be preferred over conventional frames.

The loads considered for the structure were the dead load, live load and wind load (wind speed of 50m/s). Analysis of the structure by STAAD PRO results in a dead load of magnitude of 1279.71kN , live load of magnitude of 1400.10kN and a wind load of magnitude of 215.64kN. In the analysis of the model response spectrum analysis is also carried out as the site comes under earthquake and vibration prone zone.

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