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ANALYTICAL INVESTIGATIONS ON STRENGTH OF CFS GABLE FRAME

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Abstract-The main aim of our present study is to understand the behavior of Cold Formed Steel (CFS) structural components in Gable frame sections. Generally CFS are used only in purlins of roof truss, non-load bearing wall, partition walls, floor deck system etc. In this project, an alternative is made to study the usage of CFS sections in the column and rafter of a Gable frame for various spans. The moment carrying capacity, axial force and shear force are determined and compared in order to use various CFS sections in different applications. CFS lipped back-to-back channel section of size 350x96x32 mm of thickness 3 mm is used in the column and rafter of a gable frame for spans of 6 m, 9 m, 12 m, 15 m, 18 m, 21 m respectively . The global Analysis of the gable frame with CFS lipped back-to-back channel section is performed for spans 6 m, 9 m, 12 m, 15 m, 18 m and 21 m by using STADD.Pro V8i. The moment capacity, axial force and shear force of CFS lipped back-to-back channel section of size 350x96x32 mm for spans 6 m, 9 m, 12 m , 15 m, 18 m and 21 m are determined and a comparative study is made for their applications in future.

Keywords- Cold-Formed Steel (CFS), structural analysis, channel section, moment capacity, axial force, shear force, gable frame

I. INTRODUCTION

Cold formed steel sections are light-weight materials appropriate for building construction attributable to their high structural performance. The foremost common sections are lipped C and Z sections, the thickness usually ranges from 1.2 to 3.2 mm, and sections with yield strengths from 250 to 450 N/mm^2 are ordinarily on the market. The higher yield stress steels have become a lot of common as steel makers turn out high strength steel a lot of expeditiously.

CFS members have distinctive structural stability problems primarily owing to the massive width-to-thickness comparison part ratios, that isn't ordinarily the case with sections of hot-rolled steel. There is a large kind of welded and bolted connections of CFS structures. Bolted connections are regularly used on construction sites because of easier assembly. The foremost common fast association resolution has gusset plates for beam-to column joints and sleeve or over-lapped systems for beam-to-beam connections. The main advantages of thin-walled structures are lightweight weight, simple assembly on sites and risk of manufacture, which ends up in a very low price.

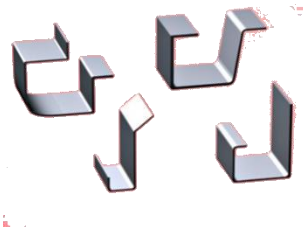

Fig.1 Cold Formed Steel sections (CFS)

However, there are some disadvantages, the most of that is that the lack of stability that causes local buckling and low ductility. This suggests that frames with thin-walled components cannot produce plastic hinges in CFS beams.

Gable frames are employed in single storey building with slanting sides and high rise. Once massive clear-span areas are needed for special industrial and engineering projects,the gable frame is usually the economical alternative particularly in industrial buildings. The portal frame is analyzed by considering two independent mechanisms viz., beam and sway mechanisms and one combined mechanism.

A gable frame is analyzed by considering three independent mechanisms viz., beam, gable and sway mechanisms and three combined mechanisms viz., beam-gable, beam-sway and gable-sway mechanisms. The beam section of the gable frame consists of two inclined members. The maximum moment and shear is taken for the beam design. Columns are vertical members utilized in building frames. The moments at the critical points are evaluated and also the column is intended supported the section modulus obtained from the critical moments.

II. LITERATURE REVIEW

Princychristina (2016) analysed the single bay gable frame of 14m span and 3m rise underneath each sway and non-sway condition. The uniformly distributed load is applied on each sloping sides of the member, wherever the column is given thrice of flexural rigidity than that of sloping sides. The member finish moments of those elements square measure iatrogenic from joint rotation and joint translation. The joints of corner are main connecting a part of gabled frames, of that the performance directly affects the integral behavior of its structure subject to UDL. The forces within the members and also the displacements of the joints are found using the theory of structural analysis by the moment distribution method, Kani's method and their bending moment values are compared.

Jin Cheng et al. (2016) investigated mechanical property of corner joint in gabled frames. Through static test and finite element analysis of comparing the panel zone with and without inclined stiffener. The load displacement curves show that the capacity of oblique nodes installed within stiffening rib components is enhanced i.e. 40% more than those without stiffening rib nodes. The results reveal that in the gabled frames, the corner node with the inclined stiffening rib can improve the bearing capacity of the specimens. When the extraterritorial flange is tension, the erection of the inclined stiffening rib can prevent structural failure and improve effectually the ductility of the structure.

Shooshtari et al. (2014) performed free vibration analysis of a gabled frame with elastic support and semi-rigid connections by using a program in OpenSees software. Natural frequencies and mode shape details of frame are obtained for two states, which are semi-rigid connections and elastic supports, separately. The members of this structure are analyzed as a prismatic nonlinear beam-column element in software. The mass of structure is considered as two equal lumped masses at the head of two columns in horizontal and vertical directions and the mode shapes of frame are achieved. Conclusively, the effects of connections and supports flexibility on the natural frequencies and mode shapes of structure are investigated.

Wenfeng Du et al. (2012) designed of a light-weight steel structure with three-span gabled frames and discussed the solution of the large suspended loads. By taking the steel quantity as the target, the depth calculations and statistical analysis for reasonable value of the column spacing were carried out. It was concluded that the large suspended loads should be imposed in the form of live load and when the column spacing is about 8m, the steel quantity is the lowest.

III. MODELING OF CFS GABLE FRAME

The length of the CFS gable frame considered as 6 m, 9 m, 12 m, 15 m, 18 m and 21 m and the total width is 25 m. The major structure adopts the light-weight steel structure. There are 5 frames in total. The higher rise point is at 9 m with slope of 36.9°.The material is steel based on EN 10326 standard of Grade S350GD+Z, which is a continuous hot dip zinc coated carbon steel sheet of structural quality of yield strength f_{yb}=350 N/mm^2 and ultimate strength f_u=420 N/mm^2.

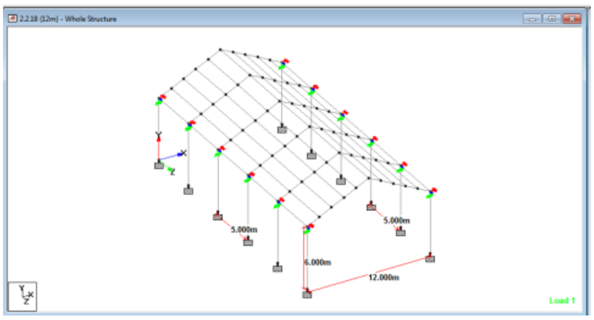

Fig.2 Entire view of CFS Gable Frame of span 12 m

A. Section Properties

The CFS lipped channel section of size 350x96x32 mm is connected back-to-back, which is used in the column as well as in the rafter of the gable frames.

The section properties of CFS channel section are

Section Grade = S350GD+Z

The width of flange = 192 mm

The depth of web = 350 mm

The depth of lip = 32 mm

Thickness = 3 mm

B. STADD.Pro Modeling

The section is modeled in section wizard of STADD.Pro and it is assigned to the entire CFS gable frame.

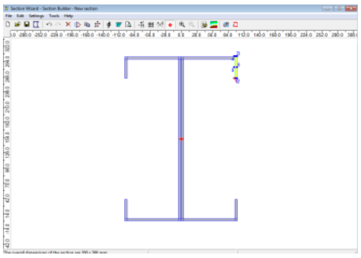

Fig.3 CFS lipped back-to-back channel section of size 350x96x32 mm of thickness 3 mm

IV. ANALYSIS OF CFS GABLE FRAME

A single CFS gable frame is analyzed in STADD.Pro under two cases of load conditions (i) Dead Load and Live Load (DL+LL), (ii) Dead Load, Live Load and Wind Load (DL+LL+WL) for various spans of 6 m,9 m, 12 m, 15 m, 18 m and 21 m.

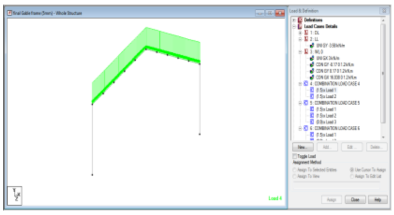

Fig.4 CFS Gable frame under DL+LL condition for span of 12 m

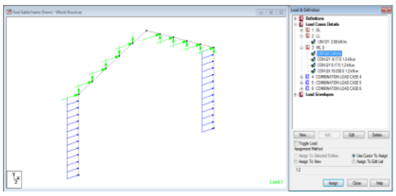

Fig.5 CFS Gable frame under WL condition for span of 12 m

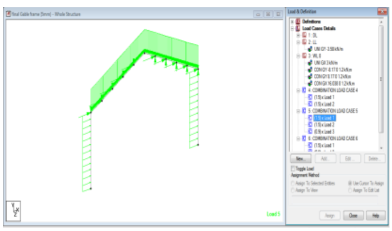

Fig.6 CFS Gable frame under DL+LL+WL condition for span of 12 m

V. RESULTS

The moment capacity of the CFS gable frame of span 6 m, 9 m, 12 m, 15 m, 18 m and 21 m are determined using STADD.ProV8i analysis. The strength of CFS gable frame for various spans are presented in table 1 to 5 and graphically plotted in Figs.7 to 11 below.

TABLE 1

MOMENT CAPACITY OF CFS GABLE FRAMES AT BASE

SPAN (m)	BASE MOMENT M_B (kNm)	
	DL+LL	DL+LL+WL
6	2.756	3.212
9	6.001	3.272
12	11.023	10.302
15	18.01	15.26
19	27.076	29.036
21	38.287	43.755

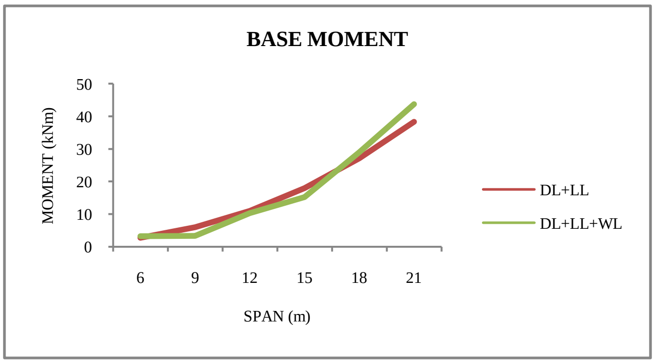

Fig.7 Moment Capacity of CFS Gable Frames at Base

TABLE 2
MOMENT CAPACITY OF CFS GABLE FRAMES AT EAVES

SPAN (m)	EAVES MOMENT M_E (kNm)	
	DL+LL	DL+LL+WL
6	7.545	14.643
9	14.099	15.374
12	22.804	29.883
15	33.649	33.649
19	46.607	46.607
21	61.64	61.64

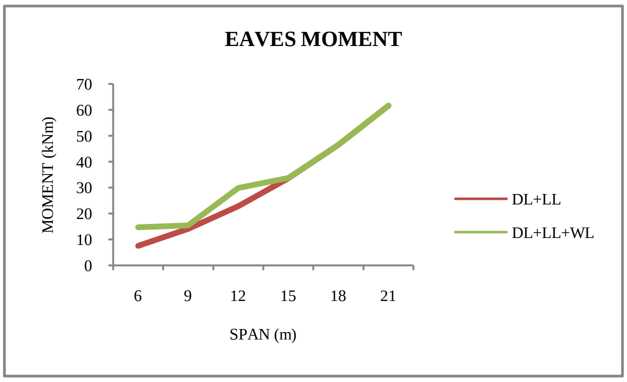

Fig.8 Moment Capacity of CFS Gable Frames at Eaves

TABLE 3

MOMENT CAPACITY OF CFS GABLE FRAMES AT RIDGE

SPAN (m)	RIDGE MOMENT M_R (kNm)	
	DL+LL	DL+LL+WL
6	2.756	17.475
9	6.001	23.507
12	11.023	45.489
15	18.01	55.561
19	27.076	83.551
21	38.287	113.456

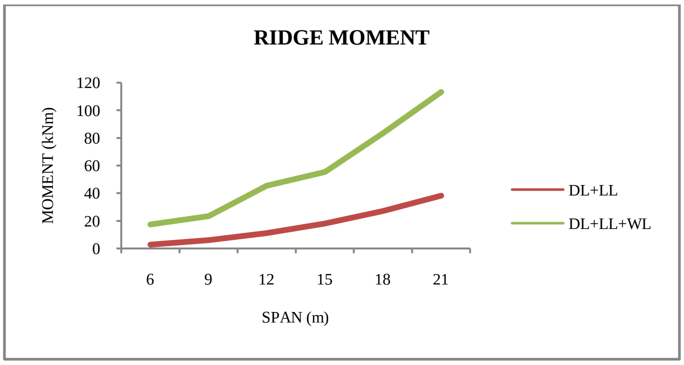

Fig.9 Moment Capacity of CFS Gable Frames at Ridge

TABLE 4

SHEAR FORCE OF CFS GABLE FRAMES

SPAN (m)	SHEAR FORCE F_y (kN)	
	DL+LL	DL+LL+WL
6	7.555	41.836
9	11.528	43.014
12	15.611	53.389
15	19.773	58.007
19	23.992	70.335
21	28.252	79.278

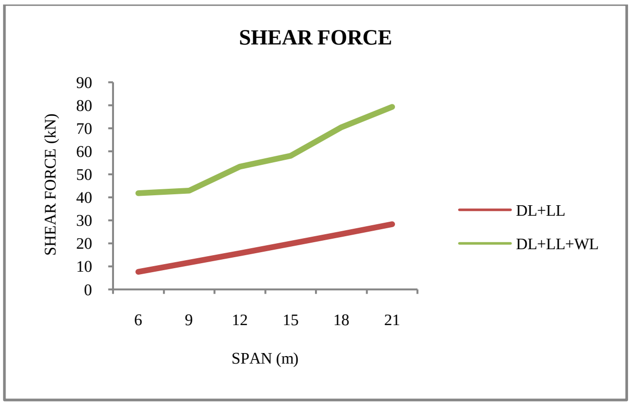

Fig.10 Shear Forces of CFS Gable Frames

TABLE 5

AXIAL FORCE OF CFS GABLE FRAMES

SPAN (m)	AXIAL FORCE F_z (kN)	
	DL+LL	DL+LL+WL
6	27.179	49.13
9	39.151	62.272
12	55.613	104.56
15	76.478	116.33
19	101.69	166.17
21	131.22	209.87

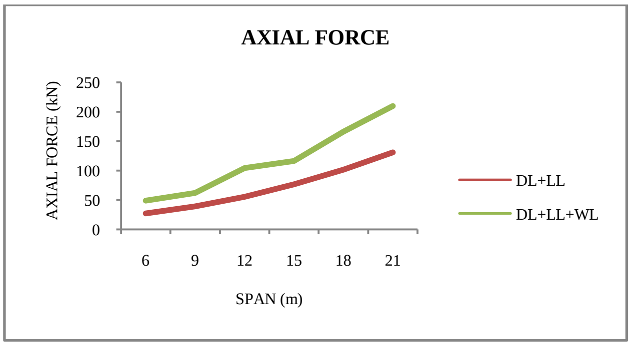

Fig.11 Axial Forces of CFS Gable Frames

Based on the above results, the following equations are obtained, which gives a relationship between span and strength of the gable frames.

TABLE 6

EQUATIONS FOR FINDING THE STRENGTH OF CFS GABLE FRAMES

	LOAD COMBINATIONS	EQUATIONS
BASE MOMENT	DL+LL	$M_B = 0.111 L^2 - 0.639 L + 2.658$
	DL+LL+WL	$M_B = 0.199 L^2 - 2.658 L + 11.87$
EAVE MOMENT	DL+LL	$M_E = 0.117 L^2 + 0.425 L + 0.736$
	DL+LL+WL	$M_E = 0.129 L^2 - 0.332 L + 11.10$
RIDGE MOMENT	DL+LL	$M_R = 0.111 L^2 - 0.639 L + 2.658$
	DL+LL+WL	$M_R = 0.284 L^2 - 1.3 L + 14.73$
SHEAR FORCE	DL+LL	$F_y = 1.381 L - 0.862$
	DL+LL+WL	$F_y = 0.092 L^2 + 0.109 L + 36.87$
AXIAL FORCE	DL+LL	$F_z = 0.243 L^2 + 0.361 L + 16.20$
	DL+LL+WL	$F_z = 0.010 L^3 - 0.044 L^2 + 5.977 L + 11.18$

where, L = Span of the gable frame

VI. SUMMARY AND CONCLUSIONS

This paper introduces the design of CFS gable frames and discusses the solution of the large suspended loads as well as wind loads. Based on the above results, the CFS lipped back-to-back channel of size 350x96x32 mm can be used upto the span of 21 m for storage houses, ware houses and conveyor systems etc. The equations proposed in this paper can be used to find the base moment, eaves moment, ridge moment, shear force and axial force for gable frames with spans between 6 and 21 m.

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