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SEISMIC ANALYSIS OF COLD FORMED STEEL WALL PANEL

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Abstract— Earthquake standards around the world are positively moving towards adopting a new and suitable performance based seismic design approach, providing the guideline's for the newer innovative seismic force resisting systems and codifying the seismic performance already use in structural systems. The Cold-formed Steel (CFS) gained the recognition in previous few years because of its advantages in less weight, capacity for providing lateral stability and most significantly cost effectiveness. These research summaries analytical studies on CFS wall panel with Fiber cement Board (FCB) Sheathing. The study shows that there are several factors which directly influence the behavior of CFS shear wall panel such as section of cold-formed steel, thickness of CFS, spacing of screw connecting sheathing to CFS wall stud and type of sheathing board. From the study it was observed that existence of diagonal strap inside of CFS wall panel determine cause slightly higher load capacity. Though it had been the satisfactory performance by CFS structure for one or two story in seismic prone area encourage the CFS construction.

Keywords— Cold Form steel, Bracing strap, Fiber cements Board, Ansys.

I. Introduction

Cold –Formed Steel (CFS) wall system, which have the advantage of being environmentally green and easy to construct, are commonly utilized as load-bearing structural components in low and mid-rise CFS structures and non-load bearing structural components in other residential, commercial and industrial building. Currently, many theoretical and experimental studies are conducted to research the influence of various parameters, including the screw spacing, stud section and spacing, kind of sheathing, number of layers of sheathing, hole of stud web and height of wall stud on the load capacity and therefore the failure modes of such system. For successful adoption and field implementation of LGSF technology to stakeholders and society it's not only necessary the planning /design / cost / steel consumption / connection, but to understand and improve the technology in terms of fireplace safety / Thermal comfort / Durability / Life cycle costing / Acoustics / Energy efficiency etc. as well. The objective of the work is the achievement of an acceptable probability that the residential and commercial structure and with Sheathed Cold-formed Steel (CFS) Panel will perform satisfactorily for the intended purpose during the design life.

II. LITRATURE REVIEW

Regarding the experimental and analytical studies by Eray Baran, Cagatay Alica [1] focused on the behavior of cold formed steel panel under monotonic horizontal loading by using different thickness of sheathing, [2] have conducted experimental on the various configuration using screw spacing and thicknesses, [3-5] analyses the design planning criteria of full scale wall panel for steel connection for higher velocity loadings, monotonic and cyclic test on full scale shear panel, test on connection detail, [6] investigated and indicated a major reduction in stiffness of bolted links as compared with conventional links. Moreover, interventions for repair of the structure tormented by a moderate to strong earthquake are limited to replacing the bolted links, [7-8] introduced four variety of sustainable mixed building technology, which combine steel and timber within the framing and different material's for cladding, [9] summaries short members of thin-walled cold-formed (TWCF) steel sections, in compression and bending, fail by forming local plastic mechanisms, [10] conclusion that the response of the truss is influenced not only by the rotational stiffness, but also by the axial stiffness of joints, in the direction of the axial forces of web members, [11] this review paper has targeting on those developments, which have appeared in the leading journals in the area, [12-13] simple straightforward, is being adapted for building large FE models of steel structural connections, [14] they concluded with the experiment that Phase I specimens exhibited sudden tear failure at the ultimate load in all the specimens, [15-16] the experimental and design results indicate that the additional need for steel bracing will be eliminated with the accurate consideration of sheathing effects in the design, [17] research aims to research the overall behavior of CFS roof trusses using finite element analysis and to predict the failure location in the truss assembly, [18] The importance of this paper was to summaries and reviews the main research developments of numerical research associated with lateral performance, [19-21] concluded that the LWS floors employed in traditional constructions could add up partially the seismic resistance of building reckoning on the diaphragm action them to develop, [22] demonstrate that the flexural rigidity increases with the rise in fastener stiffness, the amount of fastener rows along the length, [23] The experiment shows increasing the screw spacing slightly decreased the maximum load for the 9 mm boards while the effect was negligible for the 12 mm boards, [24] introduced concept and structural benefits of pre-stressing cold-formed steel beams are explored in the present paper, [25] investigate the moment-rotation behavior of floor-to-wall connections utilized in ledger-framed cold-formed steel building construction with full-scale experiments, [26] presented the results of an experimental study on the behavior and strength of the cold- formed steel shear wall paneling, [27] determined that the sleeve stiffeners, in their current design, have minimal impact on frame ultimate vertical loads resulting in less than 5% increase, [28] remainder of the model employs rigid sheathing panels, beam–column elements for framing, semi-rigid rotational springs for stud-to-track connections, and springs for hold-downs, [29] Experiment shows an improved design equation for the clip angle connection has been proposed and compared with the experiments, [30-31] Experimented test results on screw connections between wood- or gypsum-based panels and cold-formed steel stud profiles are presented also presented the results of an extensive parametric non linear dynamic analysis, (32-37) experimented an investigation on gypsum sheathed cold-formed steel (CFS) panels with different sheathing configurations was conducted under four-point bending, A comprehensive analytical study on the stiffness offered by the sheathing to the CFS panel was conducted to be used in design equations, [38] it concluded that in the full bearing condition (when the system is placed at the center of concrete slab or there's enough distance to the edge), the slab can keep the load distribution uniform, [39] presented the numerical investigation into the structural behavior of sheathed cold-formed steel C-lipped columns (studs) subjected to compression, [40] presented the results of monotonic and reversed cyclic gypsum shear wall tests and discusses wall performance intimately, [41] had provided an summary of computational modeling, both elastic buckling and nonlinear collapse analysis, for cold-formed steel members, [42] presented detailed results on the shear behavior of 2.44 m by 2.44 m light-gauge steel stud walls for 3 different shear resisting systems: framed walls with 20 gauge flat strap X-bracing on the face-type, [43] shows the experimentally establish the shear behavior of cold form SWPs with FCB and its response compared to other forms of conventional sheathing materials, [44] separated the source of this translational stiffness into two parts: local and diaphragm, [45] presented a research project aimed to feature shear strength values for 0.686 mm, 0.762 mm, and 0.838 mm steel sheet sheathed CFS shear walls with aspect ratios of 2:1 or 4:1.

The study aims to Evaluation of "Sheathed Cold-formed Steel (CFS) Framed Structures" and their use in residential and commercial construction. The software used for the analysis is Ansys R19.2 and numerically by ASCE07-10 (Minimum Design Loads and Associated Criteria for Buildings and Other Structures). After the analysis both the results are compared.

III. PROBLEM STATEMENT

Reducing the weight of the building is very important now-a-days but without compromising with the lateral stability of structure. Also reducing the construction time by removing tedious work gives the benefits in construction cost. The western construction industry is booming with the fast, light and stable construction solution for low-rise and mid-rise buildings which comes as a cold-form steel structure. By removing the strap bracing and using properties of sheathing of wall for lateral stability.

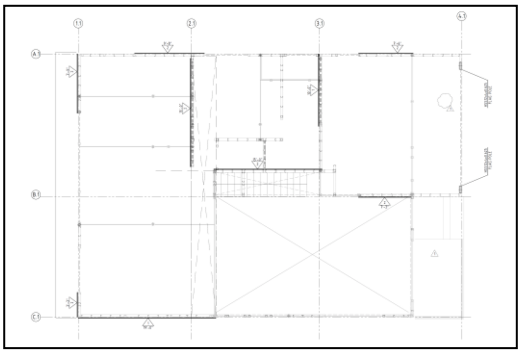

Figure 1: Floor Plan

IV. FEM ANALYSIS

A double storey cold formed steel structure of dimension length 18m and width 12m with floor height of 10ft subjected to gravity and lateral load is designed. The shear panel modeling is done by using ANSYS R19.2 software. Load assigned to model were self weight gravity load of 2.0 Mpa and lateral force of 77 KN. Loads and the load combination are considered as per minimum design loads and associated criteria for building and other structures (ASCE 07-10). The cold formed steel panel was sheathed with 15mm thick fiber cement board on both sides. The section used for cold formed steel wall panel is 350S162-54 mils.

The analysis model was done by using ANSYS 19.2. The working procedure in ANSYS 19.2 starts with the initialization of project to study. Following to this drafting of model has to done in ANSYS for better understanding and better results. After finalizing the model important part is to define different parameters like material properties, section properties, load pattern and load combination etc to model. Once the properties assign to the model input parameters like axial loads and lateral loads has to be given to model for required results. After all inputs the model has set run on analysis part. After analysis we get the results for our model. Following are the step by step presentation of analytical analysis procedure.

V. NUMERICAL ANALYSIS

Numerical analysis is carried out using ASCE (Minimum Design Loads and Associated Criteria for Buildings and Other Structures).

VI. RESULT AND DISCUSSION

A. FEM Result

The results after evaluating the system are as follows:

Table 1: Analytical behavior Cold formed steel wall panel

Results	Minimum	Maximum	Units
Equivalent stress	1.1076e-006	43.1	Mpa
Total Deformation	0.2	2.0403	Mm

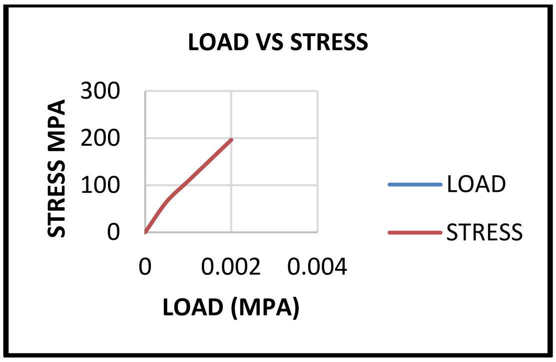

Fig 1: Load vs Stress

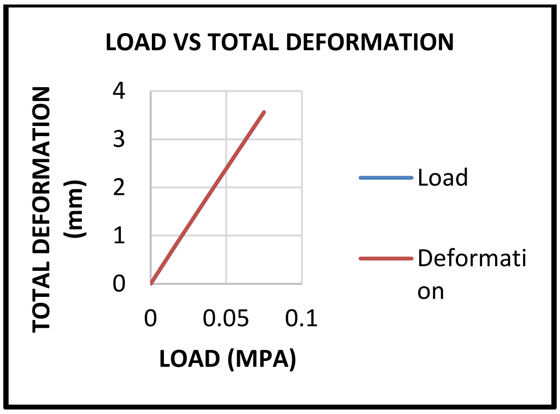

Fig 2: Load vs Total deformation

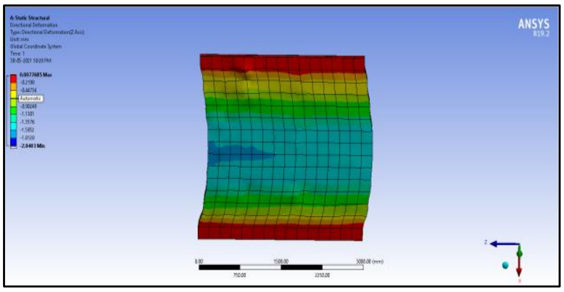

Fig 3: Deformation of cold formed steel wall panel

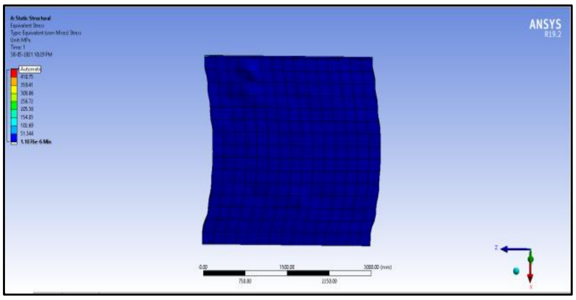

Fig 4: Equivalent Stress in cold formed steel wall panel

B. Numerical Result

Table 2: Numerical behavior of Cold formed steel wall panel

Results	Minimum	Maximum	Units
Equivalent stress	0.0	26.51	Mpa
Total Deformation	0.0	1.016	Mm

C. Comparison of FEM and Numerical Result

The comparison between the Numerical and analytical results were carried out in table 3.

Table 3: Comparison of Analytical and Numerical analysis for shear wall 1VC

Results	Analytical		Numerical		Allowable
	Mini.	Max	Mini	Max	Max
Equivalent stress	1.1076e-006	43.1	0.0	26.51	196.2 MPa
Total Deformation	0.2	2.0403	0.0	1.016	3.56 mm

Fig 5: Load vs Stress

VII. CONCLUSION

Considering above result following conclusion may be drawn:

1. The study shows the satisfactory performance by CFS structure for one or two story in seismic prone area.
2. Using 15 mm FCB thickness resulted in larger lateral load capacity when the diagonal struts were not used in the CFS frame.
3. Regarding the effect of screw spacing, the analytical results shows that increasing the spacing of screws from 150 mm to 250 mm at the boundary framing members reduces the lateral load and deformation capacity of CFS wall.
4. Seismic response of light-gauge steel framing can be significantly improved if shear walls are used to resist horizontal forces.

ABBREVATIONS

- CFS – Cold Formed Steel
- TWCF – Thin Wall Cold Formed
- LGSF – Light Gauge Frame wall
- FCB – Fiber Cement Board

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