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ANALYSIS AND DESIGN OF SINGLE FAMILY DWELLING USING CFS

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Abstract— **The present study reports the detailed analysis and design of single family dwellings using cold formed sections (CFS) for comparing the manual calculated deflection (in purlins & columns) with that calculated by Staad.pro V8i software. Material used in the present study is steel. Data used for the analysis is wind load pertaining to wind speed of Wind Zone IV. Location chosen for the analysis is Shimla. Design of Purlins & Columns has been done to examine the deflection as per steps & permissible limits of IS 801, 811. Deflection values are parameterised performing the analysis by Staad.pro V8i software. The study also gives a diagram of the present Indian construction regulations necessities and a gathering of flame and acoustic-appraised CFS congregations by which extra fire and acoustic congregations were recognized for future tests and appraisals. Study also reveals the saving in the cost of material by using CFS due to their light weight.**

Index terms: - Cold **formed sections; Staad.pro; dwellings; purlins.**

Notations:-
A = cross sectional area (mm^2)
b = width of the section (mm)
h = height of the section (mm)
t = thickness of metal (mm)
I_{xx} = moment of inertia about the X-X axis (mm^4)
I_{yy} = moment of inertia about the Y-Y axis (mm^4)
I_{uu} = moment of inertia about U-U axis (mm^4)
I_{vv} = moment of inertia about V-V axis (mm^4)
Z_{xx} = modulus of section about the X-X axis (mm^3)
Z_{yy} = modulus of section about the Y-Y axis (mm^3)
r_{xx} = radius of gyration about the X-X axis (mm)
r_{yy} = radius of gyration about the Y-Y axis (mm)
CFS= Cold Formed Sections
STAAD.Pro=Structural Analysis and Design for Professionals
V_b = Basic wind speed (m/sec.)
V_z = Designed wind speed at different heights (m/sec.)

P_z = Designed wind pressure at different heights (kN/m^2)

I. INRODUCTION

There are expanding requests for enhancements in measures of development quality, comfort and execution in dwelling. Cold formed steel area are widely utilized as a part of modern and numerous other non-Industrial developments around the world, it is generally another idea in India. An essential thought in numerous private development applications is flame and acoustical execution. Worldwide Cold framed steel have set up their nearness in India by neighbourhood promoting specialists and confirmed manufacturers. As the complete building bundle is supplied by a solitary seller, similarity of all the building segments and adornments is guaranteed. This is one of the real advantages of the Cold shaped building framework. The design compression strength of Indian (IS 811-1987).By using Cold formed system economy is achieved with completion of project in minimized time.

The design of dwelling structure is governed mainly by functional requirements and the need for economy of construction. In cross-sections these buildings will range from single or multi bay structures of larger span when intended for use as rent purpose to smaller span buildings. The main dimensions will nearly always be dictated by the particular operational activities involved, but the structural designer's input on optimum spans and the selection of suitable cross-sections profile can have an important bearing on achieving overall economy. Cold-formed steel has been widely used in commercial buildings, especially in non-load bearing (partitions) and curtain wall applications. Cold-formed steel sections are increasingly being used as primary structural members, such as beams, floor joists, and load-bearing walls in commercial and residential construction.

The content of all the papers included in the special issue is summarily outlined in the following sections. The LSB (Light

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steel beam) is a new cold-formed steel hollow flange channel section, which is produced by a conjunction of cold-forming and welding and used as floor joists and shifting beams in commercial, industrial, and residential buildings. The DSM(Direct strength method) is also used in the research presented in two papers; one by Casafont et al. Schafer used with the design rules assigned in Euro code 3 are introduced by Schfer B. M. and camotim D.[5] The flexural buckling strength of cold-formed steel columns was calibrated. consideration was given to the effect of some important parameters on the column strength, which cover the residual stress, the cross- sectional measurement, the yielding type (gradual or sharp yielding) of the stress- strain curve, and the forming method (press-braked or roll-formed) used to form the section by Weng C.C. and pekoz T. [6] Tests on stainless steel tubular column sections fabricated by cold-forming and welding. The purpose of the tests was to negotiate the compressive strength of stainless steel structural hollow sections and to develop a general rule for the design of these sections as structural members were used without modification by Rasmussen K.J.R. and Hancock G.J. [4] A number of proprietary fastening systems have been developed, essentially for use in semi or non-structural applications and primarily used in a variety of manufacturing industries such as automobile, heating and ventilating, and domestic appliances. There is considerable potential for the use of these techniques in cold-formed steel structures. The principal aim of this paper is to summarize an extensive experimental research program focused on the structural behaviour and application in cold-formed steel structures of a technique known as press joining by Pedreschi R.F, Sinha B.P and Davies R. [3] The losses base from present vulnerabilities in buildings and other structures and from the fact that these earthquakes occurred within or close to major town. Avoiding the potential for significantly greater losses in areas where the density of construction was higher. The intent of the Seismic Rehabilitation Guidelines is to promote public safety and welfare by reducing the risk of earthquake-induced damage in existing wood- frame residential buildings by Eguchi R.T. et al. [1] the seismic design of wood-frame single-family dwellings' (WFSFD) lateral force resisting systems (LFRS) requires determination of the stiffness of diaphragms and shear walls. Rigid diaphragm methods require extensive reanalysis for each rearrangement because the force distribution for the walls changes. Although WFSFD come in many configurations, design rules of thumb reduce the number of possibilities, so the effects of changes in opening size and location can be more readily evaluated by Kirkham W.J. [2].

The present study reveals the detailed analysis and design of single family dwellings using cold formed sections (CFS) for comparing the manual calculated deflection (in purlins & columns) with that calculated by Staad.pro V8i software. Data used for the analysis is wind load pertaining to wind speed of Wind Zone IV. Location chosen for the analysis is Shimla. Design of Purlins & Columns has been done to examine the deflection as per steps & permissible limits of IS 801, 811. Deflection values are parameterised performing the analysis by Staad.pro V8i software. The study also gives a diagram of the present Indian construction regulations necessities and a gathering of flame and acoustic-appraised CFS congregations by which extra fire and acoustic congregations were recognized for future tests and appraisals. Study also reveals the saving in the cost of material by using CFS due to their light weight.

II. METHODOLOGY

The methodology includes the methods, procedure and techniques used to collect all the relative data and analyze information. Before, dwelling outline had a tendency to be a more steady practice that advanced gradually, with each new dwelling structure somewhat adjusting past adaptations. The real "inventive" component of the outline procedure was considered by some to be one without technique, yet an instinctive procedure of 'learning by doing' that couldn't be depicted. As an outcome, different endeavors have been made to formally portray the procedure. Early recommendations suggested that the configuration approach was one of deteriorating an issue, taking care of the segments of the issue and afterward making these arrangements once again into an entirety. All the more as of late, the same vital explanatory point of view has portrayed outline as a procedure of; investigation, union and assessment.

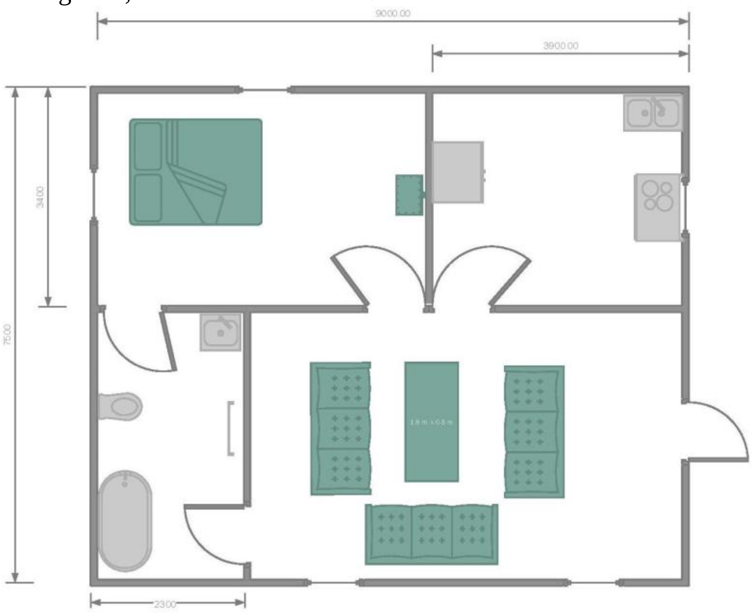

Figure-1: Plan of dwelling

Figure-1 shows plan of the dwelling structure (9.0m*7.5m) where one bed room, hall, kitchen, toilet and bathroom are attached which is comfortable for single family.

2.1 Parameter of single family dwelling

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Location	Wind zone IV
Utility	Residential building
Building width	7.5 meters
Building length	9.0 meters
Slope of roof	1:10
Area covered	7.5 m * 9.00 m
Span of purlin	7.5m
Spacing of purlin	1.26m

2.2 Application of proposed methodology:

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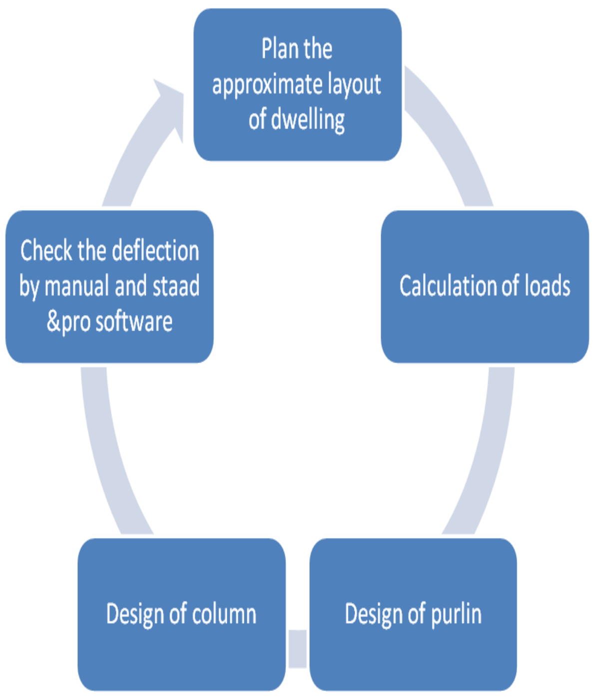

Figure 2: Cyclic procedure of present work

Figure-2 shows the cyclic procedure of the work. Starting from the plan the approximate layout of the dwelling till the design of the dwelling all the steps mention in this cyclic figure.

Each design procedure is remarkable, and this non specific regulated manual for the design procedure is characteristic as it were. The quantity of steps shifts relying upon the multifaceted nature of the task and whether you are building another home, revamping or basically making a couple of little home changes.

III. RESULTS AND DISCUSSION

3.1 Wind speed calculation

As per IS 875 (part3) for location zone IV

$V_z = V_b * K_1 * K_2 * K_3$

$K_1 = 1$ coefficient from table 1 of IS 875 (part3)

$K_2 = 0.88$ from table 2 of IS 875 (part3)

$K_3 = 1$ topography factor

$V_z = 42.3$ m/sec and $P_z = 0.6*Vz^2 = 1.073$ kN/m^2

3.2 Design of purlin

3.2.1 Dead load

Unit wt/m of A.C sheeting @ 0.09 KN/m
= 0.09*1.26
= 0.1134 KN/m

Unit wt /m or self wt of purlin = 0.07KN/m

Total DL/m on each purlin = 0.1834 KN/m

3.2.2 Live load

Total imposed load/m on each purlin = 0.75*1.26
= 0.945 KN/m

3.2.3 Wind load

Max wind load/m on each purlin

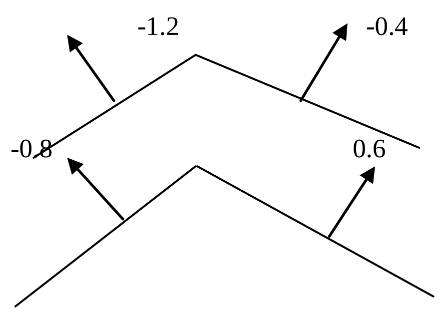

Figure- 3: Wind angle along purlin

Total wind load = [(-1.2*2.66) + (-0.4*2.66)]
= - 4.256 KN/m

3.2.4 Load combination-1

DL+LL
= 1.1284 KN/m

3.2.5 Load combination-2

DL+WL
= 3.8385 KN/m

$M_z = 14.97$ KN-m

$M_y = 14.74$ KN-m

Choose Z section with lip (140*60*20*2.55)

Checking the above section based on IS 801

W/t = 21.52

Min overall depth required as per clause no 5.2.2.1 of IS-801

$$= 2.8\, t^6 \sqrt{\left(\frac{w}{t}\right)^2} - \sqrt{281200/}$$

= 15mm

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This is less than the lip 20mm

15mm<20mm

4.8 t = 4.8 * 2.55
= 12.24
12.24<15
Hence ok

3.2.6 Design of laterally unbraced beam

Clause 5.2.2.1 of IS 801
W = 41.4 * 2.55
= 105.57
= (60-2 * 2.55)
= 54.9
105.57>54.9

Hence ok

Hence full flange is effective in compression referring to clause no 6.3. (b) IS 801

$$(L^2 * S_{xc}/d*I_{yc})$$

Where,
L = Unbraced Length of the member
$S_{xc} = Zxx$
$I_{yc} = I_y/2$

$= 2.3^2*30.5/14*29.4$
$= 3920$……………..… (1)
$(0.18\pi 2Ec*b)/fy = (0.18*3.14^2*2*10^6*1)/(3450)$
$= 1030$ …………….. (2)
$(0.9\pi 2Ec*b)/fy = (0.9*3.14^2*2*10^6*1)/34504$
$= 5150$ ………………… (3)

Hence,
Equation (1) is greater than equation (2)
(1) > (2)
Equation (1) is less than equation (3)
(1) < (3)
Hence,
$[L^2 * S_{xc}/d*I_{yc}] > [(0.18\ \pi 2Ec*b)/fy] < [(0.9\ \pi 2Ec*b)/fy]$
$F_b = (2/3)\ f_y - (f_y^2/2.7\ \pi^2 Ecb)\ (l^2Sxc/dlyc)$
$= (2/3)\ 3450 - (3450^2/\ 2.7*\ \pi^{2*}2*10^6*1)\ (3920)$
$= 142.55\ N/m^2$
Referring clause 6.1 at IS 801-1975
F_b= Laterally Unbraced Beam.
F = basic design stress
= 0.6fy
= 0.6* 3450
= 2070 kg/cm
Hence safe = 207 N/mm^2
Since here wind load condition is critical
F_b = 1.33* 142.55
= 189.59
F_b act = M/Zxx
$= 14.94/30.55*10^3$
= 48.90 <189.59; **OK**

3.2.7 Check for deflection

Permissible deflection due to imposed load on purlin as per IS code

$\Delta_{max} = (5wl^3) / (384\ EI) = 1.131$ mm
$\Delta_{lim} = L/360 = 5.20$ mm
Hence, Deflection limits greater than max deflection i.e. 5.20 > 1.131; **OK**

3.3 Column design

Wind Load on End wall Column due to Wind influence area
= wind load area * wind load * factor
= (2.3*3.2) * (-4.0219) *(-1.25)
= 37 KN
Dead load:-
Compression = (18.09+0.11)
= 18.20 kN
Choose a C with lip section (180*80*25*4)
Taking all the relatives properties from IS 811
M = (load * l)/8
= (37*3.2)/8= 14.8 kN-m

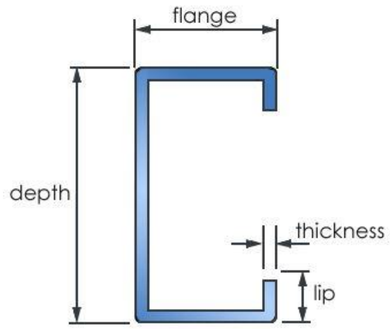

Figure-4: C section with lip

As per clause no of IS 801;
$KL/r_{xx} = (1*320)/ (7.04)$
= 45.45<200
$KL/r_{yy} = (1*320)/ (2.89)$
= 110.7<200

Finding out Fa i.e. permissible average compression stress as per clause no 6.6.1.1 of IS 801
Cc =
$E = 2*10^6\ N/mm^2$
Cc = 107
Calculation of effective design width of compression element as per clause 5.2.1.1 of IS 801
$(w/t)_{lim} = 321$

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Max $(KL/r_y) = (1*320)/ (2.89)$
$= 110.7$
As, $KL/r_{yy} \geq Cc$
According to clause no 6.6.1.1 (b) IS 801
$Fa_1 = (12\,\pi^2\, E)/23(KL/r_{yy})^2$
$= (10680000)/ (110.7)^2$
$= 87.15\ N/mm^2$
Permissible axial compression stress $= (1820)/ (14.2*10^2)$
$= 1.28\ N/mm^2$

Calculation for permissible compression building stress as per clause of IS 801-1975
$F_b = 0.6fy$
$= 207N/mm^2$
Under wind load combined $F_b = 1.33*207$
$= 275.31$
Calculation for permissible compressive stress as per clause 6.3 of IS 801−1975 referring to Clause no.6.3 (a) of IS: 801-1975. L = 1.6m is Unbraced Length

$(L^2Sxc)/ (dlyc)$
Where,
L = Unbraced Length of the member
$S_{xc} = Zxx$
$I_{yc} = I_y/2$
$= (1.6^2 *78.2)/ (18*95.2)$
$= 1168.2$ …………….. (4)
$(0.36\pi^2ECb)/ (fy) = (0.36*3.14^2*2*10^6*1)/ 3450$
$= 2060$ ……………. (5)
$(1.8\,\pi^2ECb)/ fy = (1.8*3.14^2*2*10^6*1)/ (3450)$
$= 10299$ ………………… (6)
(4) < (5)
(4) < (6)

Hence
$F_b = 148.04\ N/mm^2$
$F_{bact} = 143.22$
143.22 < 148.04
Hence ok

3.3.1 Check for deflection

$\Delta_{max} = 5wl^3/ 384EI = 5.51$ mm
$\Delta_{lim} = L/360 = 8.84$ mm
Hence, **8.84>5.51; OK**

3.4 Check for deflection by staad.pro

From the stadd.pro we get the deflection of the dwelling and following table is given below which is comes from the different node and get the vertical deflection.

Table 1: Deflection values

Node	Load	Vertical deflection
18	1 DL	-8.483
10	1 DL	-7.383
11	1 DL	-6.957
4	1 DL	-6.483
75	1 DL	-5.414
52	1 DL	-7.383
67	1 DL	-6.957
2	1 DL	-5.117
22	1 DL	-.117
9	1 DL	-1.804
1	1 DL	-0.167
7	1 DL	-0.167
15	1 DL	-0.167
21	1 DL	-0.167
29	1 DL	-0.167
35	1 DL	-0.167
43	1 DL	-0.167
49	1 DL	-0.167
57	1 DL	-0.167
63	1 DL	-0.167

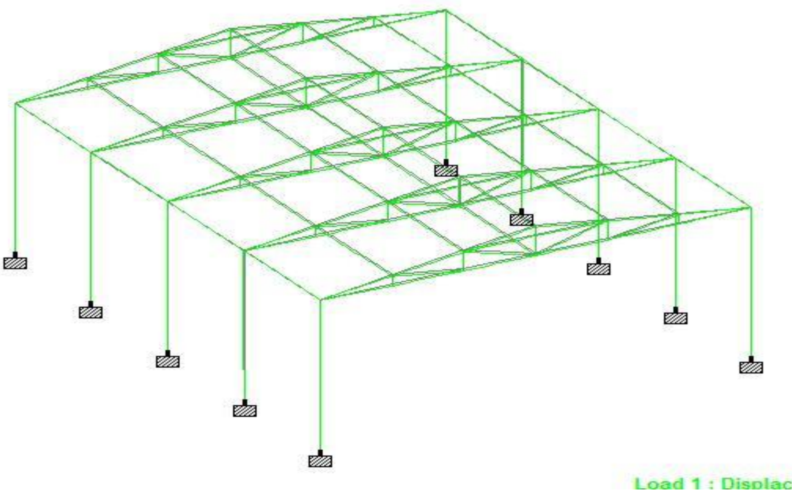

Figure 5: Displacement of dwelling

Figure-5 shows the deflection on the dwelling which is safe according to the staad.pro V8i software. Both manual calculation and software data get the approximate deflection which means it is safe structure.

IV. CONCLUSIONS

In the present work an attempt has been made for the detailed analysis and design of single family dwellings using cold formed sections (CFS) for comparing the manual calculated deflection (in purlins & columns) with that calculated by Staad.pro V8i software. Based on the present study, the following conclusions are drawn:-

- Study gives a diagram of the present Indian construction regulations necessities and a gathering of flame and acoustic-appraised CFS congregations by which extra fire and acoustic congregations were recognized for future tests and appraisals.
- Study reveals the saving in the cost of material by using CFS due to their light weight.
- In the single family dwelling the material and the cost of dwelling is minimized in case of cold formed section while in case of conventional building it was higher.

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