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Experimental Analysis of Cold Formed Steel Purlin and Comparison of C and Z Section Using Ansys

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Abstract

Nowadays the application of cold form steel elements in construction is becoming very popular in roof construction, due to advantages like Fast construction, high strength to weight ratio, dimensional stability. It is vulnerable to different types of buckling, crippling, tensional failure and also leads to fire resistance. The purlin members are thin walled cross section subjected to roof loading either in upward or downward direction. The Z purlin is the most commonly used cold formed steel section for roofing system because of lapping ability, continuity, thickness of the material at support region leads to greater performance and results in economical design. The experimental investigation of the behaviour of cold formed steel roof trusses does not over a prior knowledge about either the member will fail first or the capacity of the whole truss. The aim is to investigate the overall behaviour of CFS roof truss member using finite element analysis and to predict the failure location in the truss assembly and its cause by calculating the demand to capacity ratio. Initially, industrial building is created in STAAD on basis of IS codes for selection of sections. The C and Z are the most commonly used section in the field for purlin based on the economical property. The numerical investigation of the member i.e., the non-linear analysis of element by Ansys.

Keywords: ***Purlin, cold form Steel, roofing system, connection, numerical modelling.***

1. Introduction

In growing world, many construction techniques are invented and practiced. The main aspect of these techniques is to develop sustainable structure in less period of time. steel is the important component in construction industry. There are two types of steel based on the manufacturing process i.e., Hot Rolled and Cold Formed steel. **Cold-formed steel** (**CFS**) is the common term for steel products shaped by cold-working processes carried out near room temperature, such as rolling, pressing, stamping, bending, etc. Stock bars and sheets of **cold-rolled steel** (**CRS**) are commonly used in all areas of manufacturing. cold-formed steel is light weight, extremely strong, non-combustible and it has dominated the market for interior works (non-loadbearing walls) and roofing systems. Panelised systems are used in CFS for structural applications in mid-rise and multi-housing building. It is actually formed by roll forming the steel through a series and no heat is required. CFS members are rarely used as individual beams or columns but typically form part of a more complex structural system in which the interaction of the various components, including the fastening arrangements, results in significantly better performance than would be predicted by considering the single member acting on its own. The development of the high strength cold form steel led to an increase of steel purlin in the usage of both industrial and commercial purpose. CFS is an excellent alternative to timber in terms of moisture and insect resistance. The advantage of thin-walled cold-formed steel profiles used as a carrying member in building structures is their low weight, which results to both material savings and simple assembly. The design disadvantages because of their large slenderness, which influence the local and global stability [1]. The finite element modelling and optimisation techniques have improved strength to weight ratio by increasing the section's strength through the use of stiff eners in the section webs [2].The experimental investigation of the behaviour of cold formed steel (CFS) roof trusses does not off er a prior knowledge about either which member will fail first or the capacity of the whole truss. This research aims to investigate the overall behaviour of CFS roof truss to predict the failure location in the truss assembly[3]. Anaggregate of 20 examples of single-length purlin rooftop gatherings considering inspire wind load were tried to examine the auxiliary conduct of cold-framed steel Z-purlins (4). The comparative study on cold form purlin sections under distortional buckling behaviour and is made up of steel sheets, thickness ranges from 0.8mm to 5mm and formed by cold process. In this study, an analysis has been made to understand the behaviour of cold formed "C" purlins for gravity and wind load conditions. In this uniformly distributed load was applied and vertical and lateral deflection was measured (5). Cold shaped steel purlins are the broadly utilized basic components in India. The potential methods of disappointment of the individuals. The Effective Width Method disregards between component (e.g., between the spine and the web) harmony and similarity in deciding the flexible clasping conduct, fuse of contending clasping modes, for example, distortional clasping can be unbalanced, bulky cycles are required to decide even fundamental part quality, and deciding the viable area turns out to be progressively increasingly confused as endeavours to improve the segment are made (6). In a pre-engineered building of larger bay span two purlins are connected in such a way that it acts as a continuous member. The purlins are connected either by overlapping them or by bolting a short sleeve member that holds and connects the purlins. This study aims in determining the capacities of bolted overlapped and sleeved connections for z and other section having same depth and thickness (7).The sleeve examples were tried under three-point loading for various parameters, for example, the length of channel segments, length, and thickness of sleeve connector and number of jolts. Nearby clasping disappointment was watch racket the purlin segment contiguous the finish of the sleeve for all the sleeve example sand at the mid-length for control examples. a decline in 0moment resistance by about11%and13% for span length of 3.0m and 3.6m regarding 2.4mspan (8). A total of 60 tests of two different depths and three different thickness have been performed in the above series, while 42 tests were conducted with straps at the loading points, the remaining 18 tests were tested without straps (9). Nine cold-formed steel Z sections with different connection arrangements were tested in bending. The tests revealed the failure mechanism of sleeved and overlapped connections lateral forces introduced by the member undergoing distortional buckling amplify web imperfections of the neighbour cross-section and therefore reduces the strength of the arrangement. An analytical solution and a beam model for vertical displacement prediction were presented. On the other hand, traditional design practice considers simple flexure stress distribution on the cross-section, whereas tests revealed that this assumption is only correct for continuous sections (10).

2. ANALYTICAL INVESTIGATION

The difference between the practical difficulties and analytical values the comparison and the study is made to find the exact values. Initially the sections are designed assumed structure and found values is used for numerical modelling.

2.1 Building design using STAAD.Pro.vi8

Industrial building is designed based on the IS code 800, 875, 456 and purlin is designed in cold form steel using is codes 801, 811 in STAAD. Analysis is done based the Coimbatore region. The Pratt roof truss is used and it is made of hot rolled steel, only purlin is made up of cold form steel section. By trial and error method we have arrived the purlin section for both C and Z.

2.2 Types of connection and its section properties

There are various types of steel connections and sections are available in the field. Based on the requirement we can alter the size of the section. We have chosen two connection types, they are

- Sleeved connection
- Overlapped connection

In an Over lapped type of connection purlins are provided with an extra length called overlapping length and it is lapped with adjacent purlin and Screwed together. Lap length is distance between centre to centre of the edge bolts / Screws.Lap length for a purlin connection depends on parameters like span of the beam and depth of the purlin section. The failure of an overlapped connection is directly proportional to the length ratio, which is the ratio of the lap length to beam span. In practice the normal lap length adopted is 12.5% of the bay span. In this study the span of the beam may be assumed as 1.5 meters and the lap length is 0.5 meters. In sleeved connection a short cold-formed steel member similar to the purlin that holds and connects both purlins. The sleeve length adopted here is 0.5m as that for lapped connection for better analysis and comparison. The thickness of the sleeve adopted here is 3mm. Both the connection is applied for both C and Z lipped sections. The lipped section is more economical and carries most load when the section is subjected to buckling. Here we have arrived two sections based on the STAAD pro. Analysis further procedure will be followed with these sections.

Z SECTION WITH LIPPED:

H = 200 mm
B = 60 mm
D = 20 mm
T = 3.15 mm

The same section properties are chosen for C section and its values are calculated based on IS 811 code. Identical section type is chosen for the comparison of the elements in numerical and experimental analysis.

3. Preliminary non-linear finite element analysis

The numerical analysis is done find the exact deflection in each point and to compare the difference between analytical and experimental model. In this studydensity, boundary conditions, material models and initial imperfections. The numerical modelling is done in workbench 16.0.

Table.1 Thickness of cold formed steel

SECTIONS	Z TYPE	C TYPE
Length of the each purlin	200 mm	200 mm
Length of the purlin specimen	1.5 m	1.5 m
Lip length	20 mm	20 mm
Screw Thickness	3 mm	3 mm
Thickness of the purlin	3.15 mm	3 mm

3.1 ANSYS model for Z, C purlin for sleeved and overlapped connections

Three-dimensional finite element model was developed and validated to simulate the realistic collapse of CFS Purlin specimen.Classical metal plasticity theory with isotropic hardening is used along with linear elastic material behaviour with E=29,500 ksi and ν=0.3. The screw is used for connecting specimen and the total length of the section is considered as 1.5 m. The end condition is assumed as simply supported.

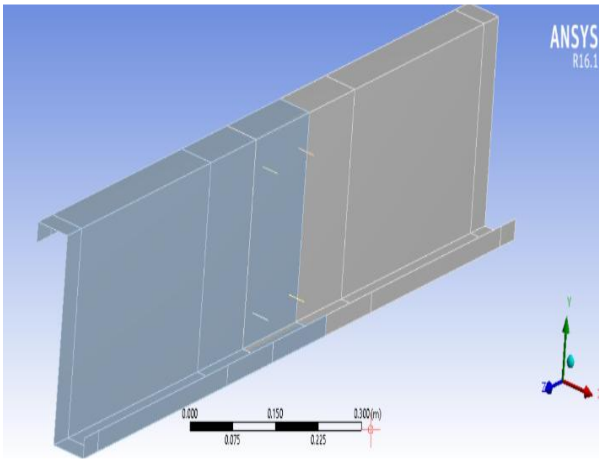

Fig.1.overlapped connection

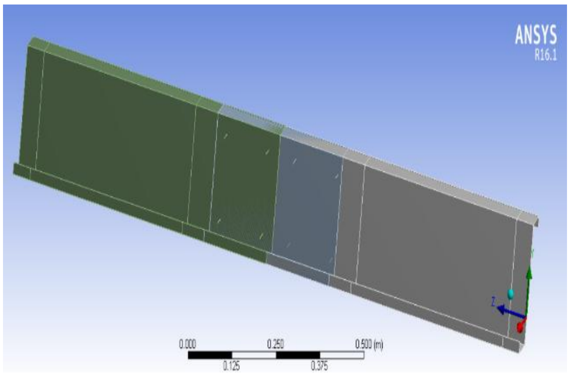

Fig.2.Sleeved connection

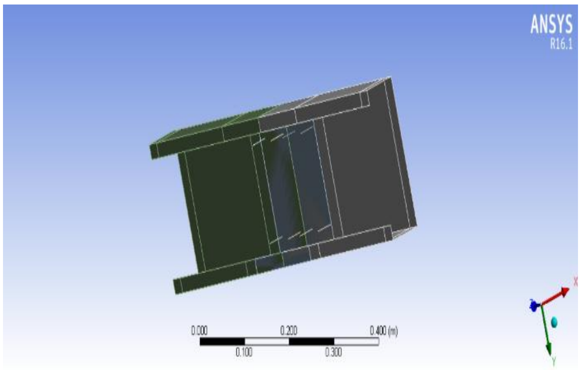

Fig.3.overlapped connection

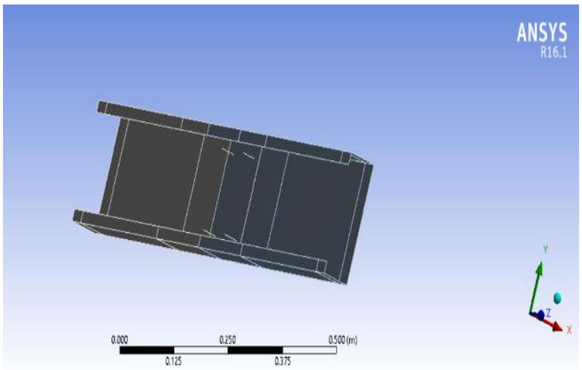

Fig.4.Sleeved connection

3.2 EXPERIMENTAL TESTING OF PURLIN SECTIONS

The experimental testing is mainly used to find the variation between actual and the field. The gravity loading and three-point loading test are used to find deflection of the section. The extracted value is compared with the numerical model value to found the optimized section. The study will be carried out in the next part of the paper.

4. RESULTS AND DISCUSSION

Codes offer only the design of components not systems. So if all components of the structural system are safe and whole system will be safe. An example of structural system is roof truss that consists of many components that interact with each other's. The strength of the whole purlin cannot be predicted without testing or finite element modelling system.

4.1 Test Results for Dynamic Properties of Z and C purlin

4.1.1 Z section connection

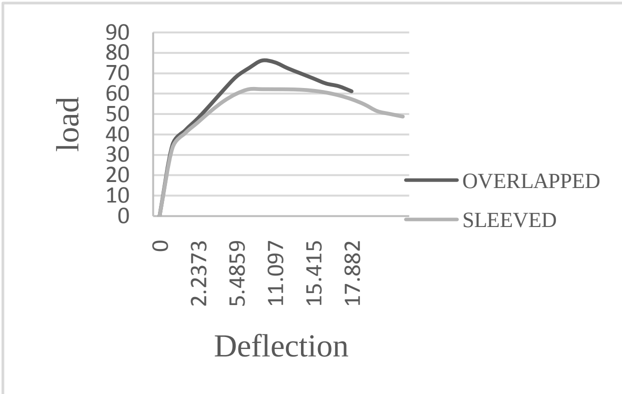

Chart.1 comparison of overlapped and sleeved connection for Z

4.1.2 C Section Connection

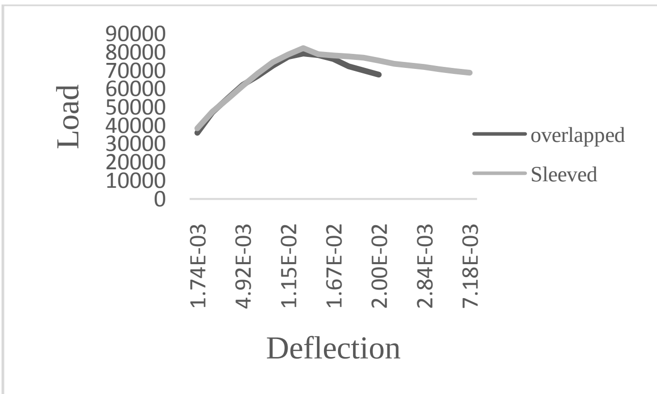

Chart.2 comparison of overlapped and sleeved connection for C

Conclusions

From the analytical work carried out and the analysis of the results following conclusions seem to be found that Z with lipped section is more economical the c section with lipped

- The early study suggests the deformation of the Z purlin is cost efficient.
- The results show that z section with overlapped connection carries more load than other connection specimen.
- From our experimental work we found that Z section with overlapped connections is optimum
- Further investigation and experimental comparison will be carried out in the next phase

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