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Cold-Formed Steel Z Purlins.

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Abstract:

Factory-made components are then assembled on-site at a PEB to the design's specifications. They were constructed of wood until recently. Five and six millimetre thick steel is offered. The design grew more difficult as a consequence. On these projects, keeping the cost of hot-rolled steel buildings under budget proved to be a serious obstacle. A common material for prefabricated construction components is cold-formed steel. In addition to reduced weight and tighter tolerances, cold-formed steel has a lower production cost as well. To save money, steel structures are used in their design. You can create pieces with optimised dimensions more easily using cold-formed steel. Purlins, a supplemental structural component, are used to transmit external loads to the primary frame of the vehicle. In the past, purlins were often constructed from angles, I-sections, and C-sections of hot-rolled steel. Cold rolled steel may take almost any shape. In recent years, interest in the C and Z portions of Purlins has risen. Buckling of the web and flange of purlin sections is a common issue. As soon as the flange is in place, the purlins may be hung perpendicular to the rafters. Z purlins are the most adaptable component in terms of torsional stability and ease of overlap and installation. Purlin design principles and cross-section design challenges are discussed here.

Cold formed steel (CFS) includes thin sections in addition to the galvanised ones (HDG).

INTRODUCTION

There have been many changes in all aspects of architecture, from building materials to techniques of construction. Today's economy necessitates the use of new construction methods. Metal construction technology have been credited with the rapid expansion of the metal building sector. Metal buildings are becoming increasingly popular due to their ease of construction, large spans, increased usable area, and ability to easily expand or move. Structural faults may be easily remedied... Maintenance and repair expenses are much lower for metal structures. Wood has been replaced by hot rolled metal in industrial building. In a growing number of production processes, cold formed steel is taking the place of hot rolled steel. Cold-formed steel and hot-formed steel may both be used to manufacture metal structures..

The CFS output is B

To make CFS, iron ore and carbon are the two most important ingredients. A phenomenon known as "hot bands" is produced when liquid steel is pressed against thin steel sheets. They become sheets when let to cool to ambient temperature. Cold rolled steel is the term used here. Coils" are the term used to describe the strips of material that make up this product. To begin the process of making "slit coils," you first need to cut the coil. Roll the slit coil to form the desired forms at room temperature. Rolling HRS needs a lot of heat. With each colour it undergoes, the steel takes shape. While driving, it is possible to install bolts and other hardware. Thus, the setup time has been greatly decreased as a consequence of this...

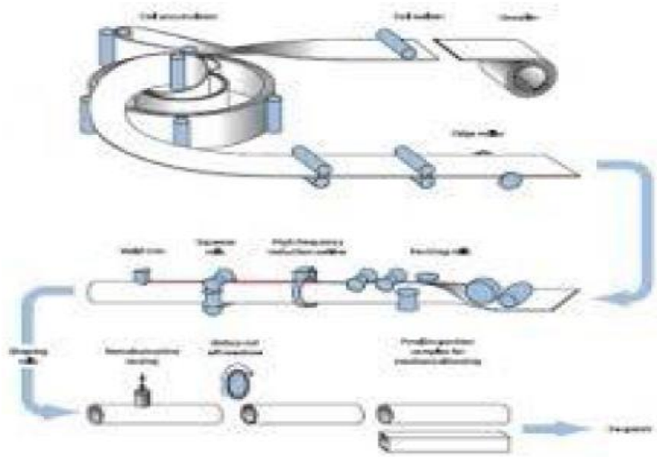

Fig - 1: Line diagram showing cold formed steel processing

Fig. 1 depicts the process of cold rolling. The thin metal sheet is made from hot rolled steel. To achieve the appropriate form, metal sheets are fed through a series of rollers of varied shapes and diameters. "Cold rolling" is the term used to describe this procedure Press brakes may also be used to provide the required sharp offsets in members.

Merits of CFS over HRS

		CFS	HRS
Design	Considerations	Local, distortional and global buckling considered	Only global buckling considered
	Span	Designed as continuous span	Designed as simply supported span
	Longer span	Purlins are nested into one another	Open web sections are fabricated
Flexibility of Shapes		Flexible and unique shapes also possible	Standard and limited shapes
Connection		Simple (Standard bolted connections. Welding is avoided)	Complicated (Variable bolted and welded connections possible)
Galvanising		Pre – galvanising possible and preferred (Thin members distort during HDG)	Post – galvanising possible
Economy	Cost	Low cost of manufacturing.	High cost of manufacturing
	Span	Longer spans can be achieved by nesting members into one another.	

Table – 1: Merits of CFS over HRS

C. Classification of cross – section in HRS as per IS 800:2007

[9] In India, for the construction of steel structures, currently IS 800:2007 is being referred for HRS while IS 801:1975 is referred for CRS.

1) Class 1 (Plastic)
2) Class 2 (Compact)
3) Class 3 (Semi-Compact)
4) Class 4 (Slender)

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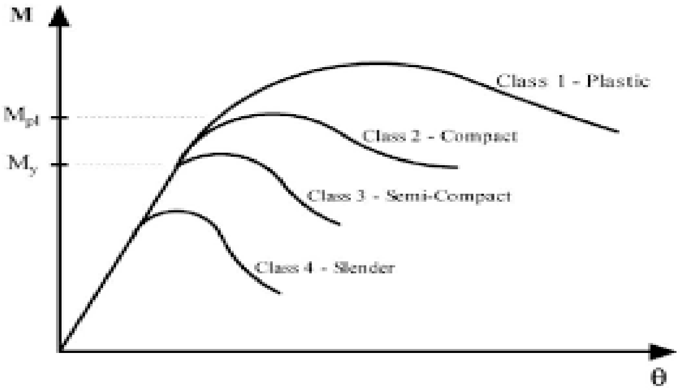

Fig - 2: Graph Showing Classification of Sections with respect to moment (M) and curvature (θ) as per IS 800:2007

From Fig - 2 we can predict that
Phase I – curve linear – section remains completely elastic
Phase II – curve non-linear – section partially elastic and partially
Phase III – curve non-linear – section completely plastic
Phase IV – curve parallel to curvature – plastic hinged mechanism
Cold formed sections are known for their thin gauges. Since these
defined as slender sections and are referred to be designed as per I

Overall depth (mm)	Width of flanges (mm)	Effective depth (mm)	Thickness (mm)	Sle (d/t)	(b/t)
200	60	191	1.5	127.33	34
200	60	190.4	1.6	119	31.5
200	60	189.2	1.8	105.11	27.33
230	60	218	2	109	24
230	60	216.8	2.2	98	21.27
250	70	235	2.5	94	22
250	70	232	3	77	17.33

Table – 2: Slenderness ratios of z purlins available in India.

Table 2 in IS 801:1975 specifies a maximum cross-sectional d/t ratio of 42 (internal compression flange) for the d/t ratio of the internal compression flange.

My name is PURLINS

In addition to the joists, purlins are part of the secondary structural system for supporting the roof. As the fundamental building framework, purlins provide structural support. Roof diaphragms need to be held in place by purlins. Purlins connect the building's core to the outside world by acting as a conduit. The cross-sectional forms of cold-formed purlins may be varied. Light gauge purlins with a depth ranging from 200 to 300 millimetres may have purlin lengths as long as 9.1 metres. The weight-bearing capacity of the roof panels dictates the purlin spacing. In 1961, Stran-Steel Corp. created Z purlins, which were the first of their kind. It's common to see Z and C sections in cold formed steel. Z purlins provide a number of benefits over other cross-sectional options. With Z purlins, high degrees of continuity may be attained. A seamless pattern may be created by glueing and overlaying several components. There is a book-like arrangement to the Z sections fashion. Each purlin component must have a minimum length of 300 mm. Longer distances between the major frames allow for an increase in this lap length.

Determining the purlin's cross-sectional area

When erecting purlins, one must decide whether to arrange angle, channel, and Zee sections with their flanges facing up- or down-slope. Cross section size, the availability of members, and the feasibility of section installation all contribute to this phenomena (here lapping).

B. The purlins' cross-sectional area

The cost of servicing a greater region increases linearly with its size. Cross-section area varies when the depth of a section is constant, as illustrated in Table 3. The final shape of cold-formed steel differs significantly from that of hot-rolled steel. This disparity is mostly attributable to the reduction in piece thickness. It is estimated that the space used by CRS is 70% lower than that of HRS.

Sr No	Shape Of Cross section	Depth	Nos	Area	Steel
		mm		mm^2	
1	L	100	2	1980	HRS
2	I	200	1	5200	HRS
3	C	200	1	3780	HRS
4	Z	200	1	540	CFS
5	C	200	1	540	CFS

Table – 3: Areas of different sections at constant depth

It is common in Indian purlins to utilise purlin portions, such as those referred to above. The graph below shows the highlighted locations. HRS made use of the LCQ's L, I, and C components. A vast variety of materials are used to construct the CRS. When it comes to CRS, sections C and Z are two of the most prevalent. We used little pieces of a steel table with the same depth for the comparisons. You may buy standards-compliant CRS sections from several different vendors. These sites provide access to both cross-sectional and net-sectional attribute data. Net section attributes are thus often employed in practise.
The cost of the truss is greatly influenced by the purlins. Purlin optimization might be a huge money-saver when it comes to truss costs. The depth of the web and the breadth of the flange are two important cross-sectional parameters to consider. A wide range of applications are possible..

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A. Importance of purlins in the economy of the structure

[9]Let s = spacing of the truss

t = cost of truss / unit area

p = cost of purlins / unit area

r = cost of roof coverings / unit area

x = overall cost of roofing system/unit area

$$\text{cost of trus} \propto \frac{1}{\text{spacing of truss}}$$

$$\text{cost of purlins} \propto (\text{spacing of truss})^2$$

$$\text{cost of roof coverings} \propto \text{spacing of truss}$$

Overall cost = OC = t+p+r then OC =

$$\frac{C_1}{s} + C_2 s^2 + C_3$$

For optimized section,

$$\frac{d(OC)}{ds} = 0$$

When it comes to total price, the purlins employed in the construction of the truss have a significant impact. Purlins may be made more efficient to save money on truss costs. Consideration must also be given to cross-sectional factors such as depth of web, flange width, and thickness of members. Alternatively, an iterative approach may be more effective.

This is Z PURLIN's design philosophy:

HRS is supported by a simple span.

HRS purlins are designed to sustain the basic span of the building. Figure 5 shows the BM and SF coefficients for a single-span, simply supported beam. For concrete-supported simple spans, the BM coefficient is larger than the BM coefficient for continuous spans (both are 0.125). There can be no merging of HRS components for the sake of uniformity. Sheer bond binds them together. The deflection of unsupported spans is greater. For supported beams, the end moment coefficients are not computed. Section depths increase when the beam's highest moment is dispersed throughout the core zone.

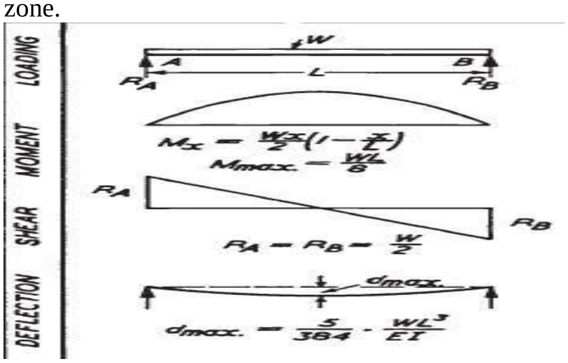

Fig – 3:imply supported beams - UDL as per Steel Designer's Manual – AISI

Continuous span for CRS

Purlins and beams have similar design ideas. Due to the Z A continuous purlin may be created by taking advantage of the purlin's tendency to overlap. In a continuous span analysis, the bending moment coefficients are less significant. Figure 6 displays the four-span continuous beam's BM and SF coefficients (see below). Is 801 – 1975 does not include continuous BM and SF coefficients, in contrast to AISI. The span BM coefficients of a continuous beam are 0.077. BM coefficients of -0.071 on Z purlin overlaps at supports triple the required cross-sectional area. When using a supported beam, the BM coefficient increases to 0.125. Additionally, these supports do not have Moment coefficients on either end. Structural stability is increased by using sag rod to support purlin. The purlins don't overlap at the end of the span, as they seem at first glance. All intermediate supports must be considered while designing purlins. To estimate the spacing of the sag rods, the length of the spans must be taken into account.

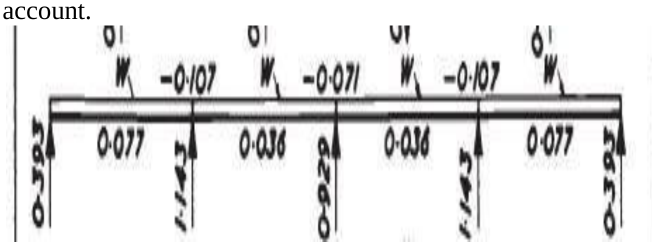

Fig - 4 Bending Moment and reaction Co-efficient - Equal span continuous beams – UDL as per Steel Designer's Manual – AISI

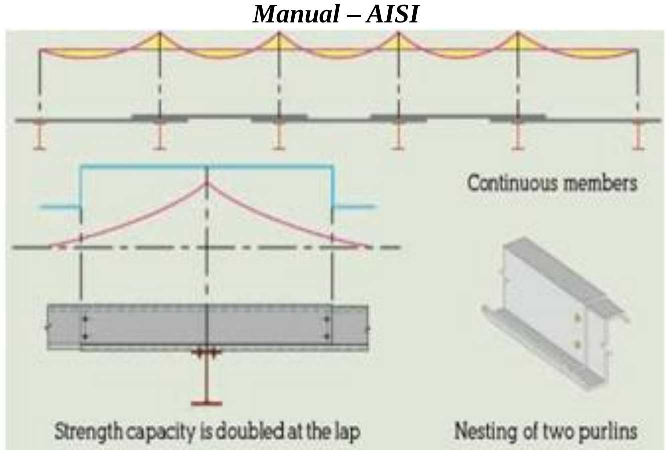

Fig – 5: Image courtesy: (Mr. Roshan S Satpute, et. al "Building Design Using Cold Formed Steel Section")

Wind Pressure

Load combinations considered are DL + LL (Deal load + Live load)

The gravity loads in this situation are not perpendicular to the axis of the Z purlin's cross-section. The top flange of the section is compressed, while the bottom flange is tensioned, as shown in Figure 6. The top flange is confined to the roof sheeting at regular intervals throughout its length.

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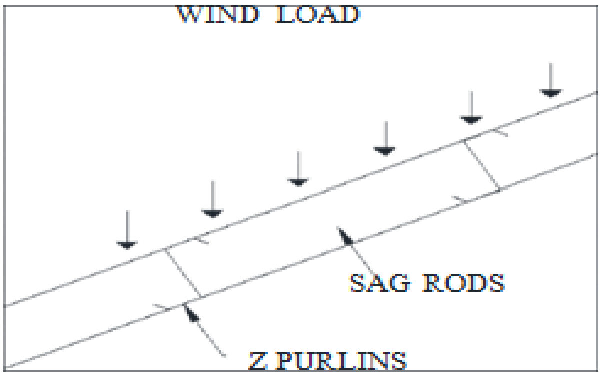

Fig - 6: Z Purlins under gravity load

DL + WS (Deal load + Wind Suction)

Fully enclosed and partially open constructions, the latter of which might be rather enormous, can both exhibit this behaviour. This is a very different situation than in the first example (case 1). Suction is shown in Figure 7 as a function of wind pressure. In this circumstance, the upper flange is constricted and the lower flange is compressed. Except for the supports, there is no constraint on the bottom flange. It's because of this that the bottom flange component has some buckles. For the section to give way, the values of Ix and Iy must be very dissimilar. The component that isn't braced has its length lowered as a result of this using sag rods.

3) WP and DL A combination of (Deal load + Wind Pressure)

The bottom flange is also stressed, while the top flange is compressed. As a result of how a building is oriented, the wind might change direction. Because of this, the user's knees buckle. As you can see, the beam has a propensity to bend in this way. The use of sag rods between the webs of successive purlins across the rafter prevents this from happening. With the compressed bottom flange visible in Figure 8, sagging rod holes may be observed on the purlin.

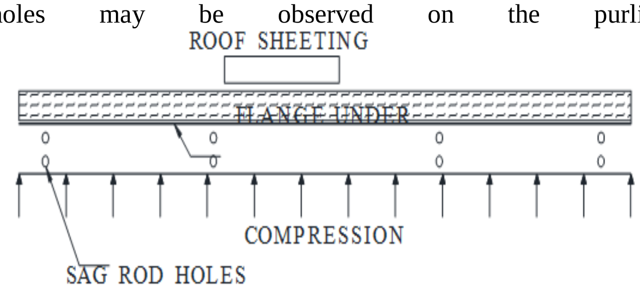

Fig - 8: Bottom flange of the purlin under compression

Figure 8 shows how the positive internal wind pressure compresses the bottom of the roof. This compressive force is absorbed by the purlins. As a result of its lack of bracing, the purlin's bottom flange fails under high compressive pressures.

Deformities in the Z-Purlin

Under stress, slender materials that are suitable for cold forming deform. Deformations such as buckling, both local and distortional, may take place. Local buckling and lateral torsional buckling may be seen in the web of the Z purlin section.

Local buckling does not result in any deformation of the member's axis. In a longitudinal direction, the member deflects. FIGURE 9 depicts an L-section with local buckling in both of its legs. To be clear, the cross-section shape hasn't changed at all.

Torsional distortion-induced buckling

Ludwig von Mises' distortional theory may be tested using purlin sections. The rafter's outer flange is attached to the purlins at an angle. When the member is tilted, it buckles, resulting in the distortional buckling. The purlin's unbraced length is affected by buckling of the bottom flange. The roof diaphragm buckles with time, resulting in uneven roof surfaces and, in extreme circumstances, complete roof collapse.

Because the flanges are at risk of slipping out of the pipe if they are not secured. Maximum lateral displacements of the top flange with regard to the purlin reaction points shall not exceed the length divided by 360, according to the 1996 AISI Cold Formed Specification for Cold Formed Steel.

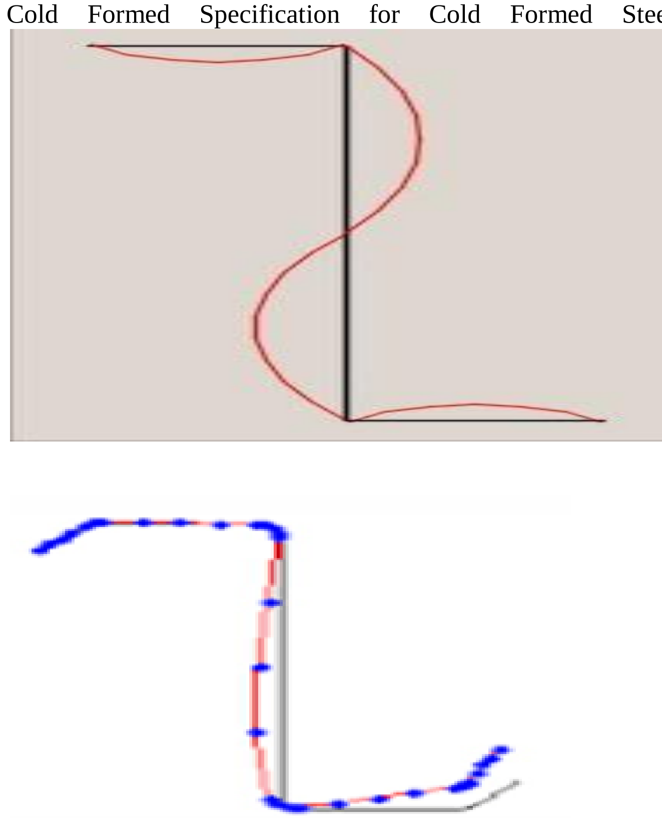

Fig 9 (a): LOCAL BUCKLING Beam deflects laterally Fig 9 (b): DISTORSIONAL BUCKLING Beam twists and deflects laterally

Lateral torsional buckling

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In this case, the beam twists and deflects laterally. Fig – 10 shows a Z sections with flanges and web laterally deformed and a distorted cross section. To avoid this type of buckling sag rods are placed in the web of the purlins. Sag rods reduces the unbraced length of the purlin.

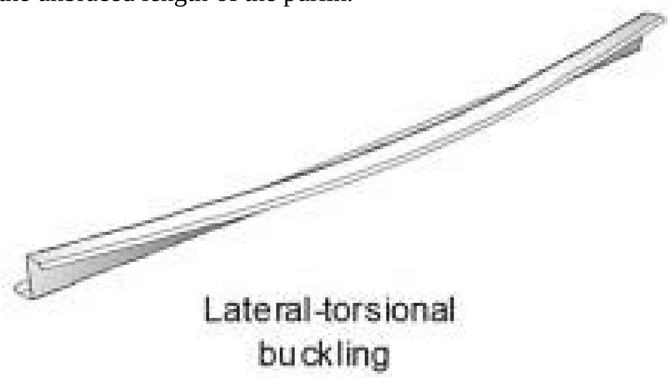

Fig - 10: Lateral torsional buckling of Z section

Distance from the lateral supports to the compression plate (boundary conditions), type and location of loads, material qualities, initial flaws of geometry and loading are all variables that impact lateral-torsional buckling strength.

B. Cross-sectional choice.

As opposed to HRS, CRS does not come with a user guide. Consequently, mathematical models are utilised to determine the section's properties. Section 5.2.1 of IS 801:1975 allows for the evaluation of b/t ratios.

Dimensions are taken into consideration and considered in line with the AISI Manual.

A compression flange's maximum flat-width-to-thickness ratio is 60. Using compression flange stiffener provisions may help. W/T ratios greater than 250 result in substantial deflection throughout a whole design length, although members' ability to provide sufficient strength remains unharmed.

It is permitted to have a maximum web depth to thickness ratio of 150 for cold formed sections with unreinforced web. A 200:1 web depth-to-thickness ratio is used for members that can efficiently transfer concentrated loads and/or reactions into the web.

For a continuous span beam, the moment calculations are the same. A purlin's weight must be taken into consideration while constructing one. The depth of a purlin in an architectural design is crucial.

A maximum permitted design stress of 0.06Fy is required for the net section and extreme fibres of tension and compression members. Typically, the yield stress of cold-rolled steel is 345 MPa. The IS801:1975 standard also tackles a slew of architectural concerns.

CONCLUSION

There are several advantages to using cold-formed roof diaphragms. Z purlins are the most suited sections in all design parameters. In the case of Z purlins, lower BM coefficients may be used since the purlins overlap at the moment of the overlap. Distortional buckling in Z purlins is a common cause of roof diaphragm collapse. In purlin analysis and design, the studies outlined here will be of use.

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