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# Comparative analysis of LSM and WSM method of design of Roof truss

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**ABSTRACT:**
**In engineering, a truss is a structure that "consists of two-force members only, where the members are organized so that the assemblage as a whole behaves as a single object. External forces and reactions to those forces are considered to act only at the nodes and result in forces in the members that are either tensile or compressive. The top beams in a truss are called top chords and are typically in compression, the bottom beams are called bottom chords, and are typically in tension. The interior beams are called webs, and the areas inside the webs are called panels. For a safe design structure have four major objectives utility, safety, economical and elegance. This paper presents a study on behavior of Howe type roof trusses, channel section purlins by comparison of limit state and working stress method. In this paper the comparison will be of shear force, bending moment, deflection, and displacement. The data's are calculated using Indian Standard code IS 875-1975 (part III), IS 800 – 2007 using limit state method, IS 800-2007 using working stress method and the section properties of the specimens are obtained using steel table. The structure is designed under Wind loading with fixed supported condition. The main aim is to provide the method which is economical, high bending strength, more load carrying capacity and high flexural strength. The studies gives conclusion that the limit state method design is high bending strength, high load caring capacity, minimum deflection and minimum local buckling& distortional buckling compare to the working stress method.**

**Keywords:Truss, Purlin, flexure strength, Buckling, Distortional**

## I. INTRODUCTION

A truss consists of typically (but not necessarily) straight members connected at joints, traditionally termed **panel points**. Trusses are typically (but not necessarily) composed of triangles because of the structural stability of that shape and design. A triangle is the simplest geometric figure that will not change shape when the lengths of the sides are fixed. In comparison, both the angles and the lengths of a four-sided figure must be fixed for it to retain its shape. There are two basic types of truss:

- The pitched truss, or common truss, is characterized by its triangular shape. It is most often used for roof construction. Some common trusses are named according to their web configuration. The chord size and web configuration are determined by span, load and spacing.
- The parallel chord truss, or flat truss, gets its name from its parallel top and bottom chords. It is often used for floor construction.

In steel construction, the term **purlin** typically refers to roof framing members that span parallel to the building eave, and support the roof decking or sheeting. The **purlins** are in turn supported by rafters or walls. Structural engineering or building, a **purlin** (or historically purline, purloyne, purling, perling) is any longitudinal, horizontal, structural member in a roof except a type of framing with what is called a crown plate. In traditional timber framing there are three basic types of purlin: purlin plate, principal purlin and common purlin. Channel and angle sections are commonly used purlins. Cold formed steel purlins are the widely used structural elements in India. Practically „Z" sections are provided, where the span of the roof purlins is sloped and the length of the span is maximum. The main process of cold formed steel structural elements involves forming steel sections in cold state sheets at uniform thickness. The thickness of steel member ranges from 0.4 mm to 6.4mm. The cold forming operation increases the yield point and ultimate strength of the steel sections (1). Light gauge steel sections are also known as cold formed steel sections. These sections are made from thin sheets of uniform thickness without the applications of heat. The thickness of the sheet used is generally between 1mm and 8mm. These types of sections are extensively used in the building industry, as purlins girts, light struts roof sheeting, and floor decking.

King Post Truss
This particular truss is made out of wood most of the time, but it can also be built out of a combination of steel and wood. It all comes down to the architect and the building structure. The King Post Truss spans up to 8m, which makes it perfect for multiple types of houses, especially the smaller ones.

Pratt Truss
This is one of the most popular steel roof truss types and it is quite economical. This particular type of truss offers some interesting features mainly thanks to the fact that the vertical members provide tension, while the diagonal ones are bringing in compression. It's important to note that these trusses can be used for spans that range between 6-10m.
Queen Post Truss
The Queen Post Truss is designed to be a very reliable, simple and versatile type of roof truss that you can use at any given time. It offers a good span, around 10m, and it has a simple design which makes it perfect for a wide range of establishments.
Howe Truss
This type of truss is a combination of steel and wood, which makes it elegant, while also offering a very appealing design. Almost everything is made out of wood, however, the tension members or the vertical members are manufactured out of steel in order to offer extra support and reliability! One thing that makes the Howe Truss extraordinary is the fact that it has a very wide span, as it can cover anything from 6-30m. This makes it versatile and very useful for a wide range of project types.

Fig: 1 Type of Roof Trusses
Fan Truss
Just like you can see from many roof truss types pictures, the Fan Truss comes with a very simple design and it's made out of steel. In this particular situation, the trusses form a fink roof truss. On top of that, the main characteristic here is that the top chords are split into smaller lengths, as this allows the build to obtain purlin support. Also, you get a medium span with this type, around 10-15m, which is more than enough for most projects.
North Light Roof Truss
The North Light Roof Truss is suitable for the larger spans that go over 20m and get up to 30m. This happens because it's cheaper to add a truss that has a wide, larger set of lattice girders that include support trusses. This method is one of the oldest, as well as most economical ones that you can find on the market, as it allows you to bring in proper ventilation. Plus, the roof has more resistance too because of that.
If you are looking for types of roof trusses design that bring in durability and versatility, this is a very good one to check out. You can use it for industrial buildings, but this truss also works for drawing rooms and in general those spaces that are very large.
Quadrangular Roof Trusses
These are used for large spans, and this is why you can encounter then in larger spaces, which include auditoriums or even railway sheds.
Parallel Chord Roof Truss
These types of trusses are created specifically for those of us that want to engage in a roof construction without having a large budget to begin with. These are made out of wood and the best part about using them is that they don't require any beam nor bearing wall. Instead, they opt for full pieces of wood and thus lower the amount of labor necessary for working with them. It does require more space in the attic and the span might not be the best, but the price might justify opting for it if you are on a budget.
Scissor Roof Truss
A Scissor Roof Truss can particularly be found in cathedrals. It doesn't require beams or bearing walls, however it doesn't leave that much space for insulation which makes its energy efficiency very poor. On the other hand, the upside here is that the ceiling gets vaulted and you receive more space in the attic.

## II. OBJECTIVE OF THE PAPER

The main objective of the study provides which is the economical method and , high bending strength, more load carrying capacity and high flexural strength by analysis of both working stress and limit state method in STAAD Pro software.

## III. MATERIALS USED FOR ANALYSIS

Density of steel: 7850 kg/m$^3$
Poisson ratio: 0.3
Modulus of rigidity: 0.769x10$^5$N/mm$^2$
Coefficient of thermal expansion: 12 x 10$^6$

IV. COMPONENT OF ROOF TRUSS

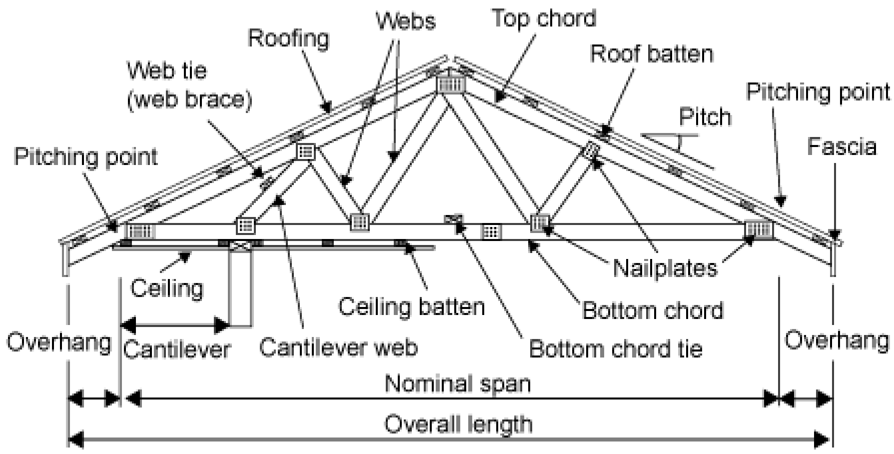


Fig: 2 Components OF ROOF TRUSS [Ref no. 9]

- **Slope** Is the measure of how "steep" a roof is. For example, if a roof is "4 in 12", the roof rises 4 inches for every horizontal run of 12 inches. The pitch of the roof is a big factor in determining the kinds of materials that can be used and the longevity of the roof. Usually, a steeper roof (higher pitch) will last longer due to its better drainage capabilities.
- **Top Chord** - Main member of a truss running along the underside supporting the decking.
- **Bottom Chord** - Main member of a truss running along the lower side between supports.
- **Peak** The highest part of the truss.
- **Overhang** That portion of the roof truss structure that extends beyond the exterior walls of a building.
- **Cantilever** - a beam anchored at one end projecting into space.

## V. LOAD ON ROOF TRUSS

**Dead load**

Dead load on the roof trusses in single storey industrial buildings consists of dead load of claddings and dead load of purlins, self weight of the trusses in addition to the weight of bracings etc. Further, additional special dead loads such as truss supported hoist dead loads; special ducting and ventilator weight etc. could contribute to roof truss dead loads. As the clear span length (column free span length) increases, the self weight of the moment resisting gable frames (Fig. 2.2b) increases drastically. In such cases roof trusses are more economical.
In the Project the dead load are applied as:
Self weight
Member Load = -12 KN/m
Floor Load = -2 KN/m

**Live load**

The live load on roof trusses consist of the gravitational load due to erection and servicing as well as dust load etc. and the intensity is taken as per IS:875-1975. Additional special live loads such as snow loads in very cold climates, crane live loads in trusses supporting monorails may have to be considered.
In the Project the Live load are applied as:
Member Force= - 6 KN/m

**Wind load**

Wind load on the roof trusses, unless the roof slope is too high, would be usually uplift force perpendicular to the roof, due to suction effect of the wind blowing over the roof. Hence the wind load on roof truss usually acts opposite to the gravity load, and its magnitude can be larger than gravity loads, causing reversal of forces in truss members. The calculation of wind load and its effect on roof trusses is explained later in this chapter.
In the Project the Wind Load are applied as:
WL in X direction
WL in Z direction
Load combination:

1. 1.5 (DL+LL+WL)
2. 1.2(DL+LL+WL)

## VI. NUMERICAL DATA OF ROOF TRUSS

The Building is located in Industrial Area Jaipur. Both ends of the truss are fixed.
1. Span of the roof truss = 12m

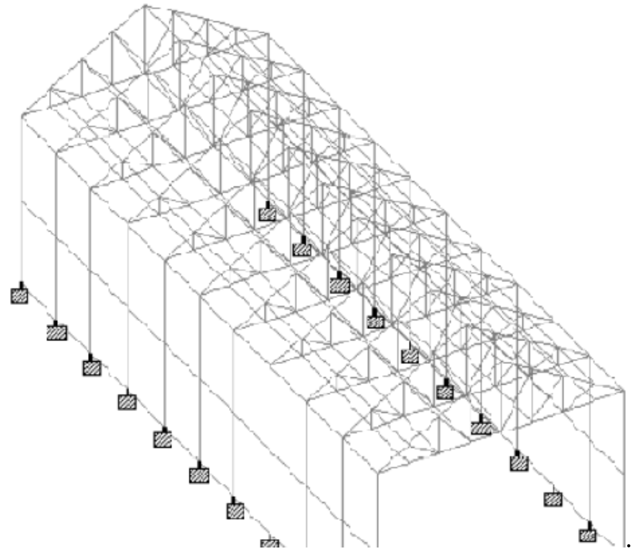

Fig: 3 Structure of roof truss from STTAD Pro [ Refer from STAAD Pro]

2. Spacing of the truss = 3m
3. Height of the building = 12m
4 Length of the building = 20 m
5. Rise of the truss= 3m
6. Pitch of the truss = 1 in 4

## VII.SPECIFICATIONS OF MEMBER

1. ISMC250

2. ISA65X65X6

3. ISA50X50X6

## VIII. ANALYSIS:

Comparative Table

Table: 1 Comparative analysis of Different parameter of LSM and WSM Method

| S.No. | LSM | | | WSM | | |
|---|---|---|---|---|---|---|
| 1. Shear Force | Maxx Fx | Maxx Fy | Maxx. Fz | Maxx Fx | Maxx Fy | Maxx. Fz |
| | 931.319 | 73.737 | 26.431 | 1035.306 | 51.404 | 30.861 |
| 2. Bending Moment | Maxx Mx | Maxx My | Maxx. Mz | Maxx Mx | Maxx My | Maxx. Mz |
| | 931.319 | 73.737 | 26.431 | 1035.306 | 51.404 | 30.861 |
| 3. Reaction | X | Y | Z | X | Y | Z |
| | 20.7 | 719.281 | 16.497 | 20.399 | 694.379 | 16.599 |

## IX. RESULTS

Two methods were used for the analysis and the comparison of various parameters like Shear force, bending moment, Reaction, Weight of the structure done. The data's are calculated using Indian standard code IS 800 WSM and IS 800 LSM, Steel Table and IS 875 Part III Using Calculation of wind load recommended. The results of the limit state method of bending moment and load carrying capacity is higher than working stress method.

## CONCLUSIONS

In this paper work the total roofing load configuration is same in both the limit state and working stress method. The results show that the load carrying capacity of limit state method is higher than the working stress method. Actual deflection and bending stress is same in both the method. The study reveals that the limit state method design is high bending strength, high load carrying capacity, minimum deflection and minimum local buckling and distortional buckling compare to the working stress method.

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