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Review on Comparative Study of Steel and AluminiumAlloy Roof Truss

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Abstract: ***The aluminium element was discovered 200 years ago. After an initial period of technological development, aluminium alloys were used in many structural applications, including the civil engineering field. Aluminium is the second most widely specified metal in building after steel, and is used in all sectors from commercial building to domestic dwelling. This paper contains complete overview of use of aluminium in roof truss construction. How it is beneficial in modern roof truss construction. This paper also contains the properties, advantages and results.***

Keywords: Aluminium alloy, steel, unit weight, comparison, angle sections

1. Introduction

A comparison between the two metallic materials, aluminium and steel, is necessary in order to emphasize the specific characteristics and the advantages, as well as sometimes the disadvantages, of aluminium alloys as structural material. Pure aluminium dose not have yield strength and tensile strength .However the addition of alloying elements like manganese, silicon, copper and magnesium can increase the strength properties of aluminium. This comparison can lead to identify the design criteria which must be followed in order to make the use of aluminium alloys friendly and actually competitive with steel in the range of structural design There are many reasons for the selection of a material for structural applications, but the determinant issue is that the product must be affordable, i.e. its cost must be acceptable to the customer. Generally, aluminium is attractive in many applications, because of a favorable life-cycle cost, which is given by the sum of the initial cost of the finished product, the cost of operating or maintaining the product over its life and the cost of disposing of or recycling it after its useful life. In addition, aluminium has sustained and increased its use in many fields.

Aluminium and steel are different materials but design problems usually are similar. Aluminium differs from steel in its physical properties (low mass weight, stiffness and linear expansion) and in its mechanical properties (strength and elongation), the latter as a result of alloy hardening. A designer should make use of the advantages of aluminium in particular its light weight, extrudability and corrosion resistance and find adequate solutions for the disadvantages such as its low stiffness, resulting in stability being a more predominant design aspect, and its lesser fatigue and fire resistance behavior, when compared to steel.

1.1 Design Philosophies (Working stress method)

The aim of analysis and design of aluminium structure and steel structure is to compare the strength, and unit weight. The properties of aluminium alloy are near about same as that of steel.

So that the structure being designed will perform satisfactorily during its intended life. With an appropriate degree of safety the structure should

- Sustain all loads expected on it.
- Sustain deformations during and after construction.
- Structure should be stable and have alternate load paths to prevent overall collapse under accidental loading.

1.2 Configuration of Truss

1.2.1 Pitched Roof Trusses

Most common types of roof trusses are pitched roof trusses wherein the top chord is provided with a slope in order to facilitate natural drainage of rainwater and clearance of dust/snow accumulation. These trusses have a greater depth at the mid-span. Due to this even though the overall bending effect is larger at mid-span, the chord member and web member stresses are smaller closer to the mid-span and larger closer to the supports.

1.2.2 Analysis of Aluminium and Steel Roof Trusses: -

Aluminium and steel structure are analysed on the basis of their unit weights. In the analysis I was considered the number of forces acting on the structure such as dead load, live load, and wind loads with three load combinations {1.[(DL+LL)x1.5], 2. [(DL+LL+WL) x 1.2], 3.[(DL+WL) x 1.5]}.

1.3 Design Problem

In this work, a typical warehouse truss problem has been considered for analysis and design by working stress method of both aluminium and steel roof truss. Span of truss is taken as 10m, 14m, 17m, and 20 m with spacing of truss in between 4 m to be built near Pune. Class of Building assumed as class 1 and terrain category 3. Width of Building: 10m, 14m, 17m, and 20 m Height of eve level is considered as 10 m. Permeability of structure is assumed as normal with span of Purlins taken as 1.425m. Rise of truss is 1/4 of span. Assume the weight of purlin. Type of truss is simple Pratt truss.

1.3.1 Loading

For analyzing the roof truss I was considered the following loads,

1) Dead load:- Various types of Dead loads acting on roof truss such as weight of Sheet which is used for covering, self weight of all the members either steel members or aluminium members, weight of fixtures, self weight of purlins, etc. All the unit weightsare taken from IS 875 (Part-1) and IS 8147-1976.
   a) Consider unit weight of AC sheet is 0.13 KN/m^2.
   b) Consider unit weight of purlin for aluminium and steel are 30 N/m and 100 N/m respectively.
   c) Consider unit weight of fixtures for both materials is 0.05 KN/m^2.
   d) Consider unit weight of rafter bracing for aluminium and steel are 0.05 KN/m^2 and 0.1 KN/m^2respectively.
2) Live load: - Live load is taken from IS 875 (part-2).
3) Wind load: - Wind load is taken from IS 875 (part-3).

1.3.2 Selection of aluminium alloy

The four aluminium alloy most commonly used in general and structural engineering.

1) Principal alloy 64430 (H30):- For general use, particularly in bolted or riveted frame structures this alloy is the normal choice on the ground of strength, durability and economy. It is supplied as plates, extruded sections (both solid and hollow), sheet, tube and forgings. It is weldable but with considerable reduction of strength near the welds.
2) Principal alloy 65032 (H20):- This alloy is the medium strength alloy and has similar applications as 64430 (H30) in general structures.
3) Principal alloy 63400 (H9):- This alloy combines moderate strength with high durability and good surface finish that response well to anodizing. Like 64430 (H30) its also losses parts of its strength on welding.
4) Principal alloy 54300 (N8):- This alloy is highly durable and strong for weldable structures and plate work. It shows less reduction in strength after welding.

For analysis and design of aluminium roof truss we are using first alloy 64430 (H30) and analyzing the same in staad pro and we got following results.

Table 1: Panel point loads on truss

Span in m	Load	Number of panel point	Panel Point Load in KNFor Aluminium roof truss		Panel Point Load in KN For Steel roof truss	
			Intermediate	**End**	**Intermediate**	**End**
10m	Dead load	8	1.697	0.848	2.407	1.203
	Live load		1.395	0.697	1.395	0.697
	Wind load		4.220	2.110	4.220	2.110
14m	Dead load	12	1.696	0.848	2.358	1.179
	Live load		1.302	0.651	1.302	0.651
	Wind load		3.940	1.970	3.940	1.970
17m	Dead load	14	1.934	0.967	2.603	1.301
	Live load		1.355	0.677	1.355	0.677
	Wind load		4.101	2.051	4.101	2.051
20m	Dead load	16	2.036	1.018	2.71	1.354
	Live load		1.395	0.697	1.395	0.697
	Wind load		4.22	2.11	4.22	2.11

Table 2: Design forces of truss members by using staad pro

Span in m	Member	Design forces (Aluminium) in KN		Design forces (Steel) in KN	
		Tension	Compression	Tension	Compression
10	Principle Rafter	27.5625	36.303	19.2135	44.634
	Tie Member	32.466	20.394	39.921	12.939
	Inclined Strut	10.275	10.0425	12.6315	7.677
	Vertical Strut	8.9445	9.1545	6.8385	11.2545
14	Principle Rafter	36.6885	55.3155	24.4695	67.5285
	Tie Member	49.467	28.842	60.39	17.919
	Inclined Strut	13.281	12	16.2135	9.0675
	Vertical Strut	11.2755	12.48	8.52	15.2355
17	Principle Rafter	40.8855	71.715	26.3055	86.2905
	Tie Member	64.1355	32.439	77.181	19.3935
	Inclined Strut	17.2695	13.917	20.7825	10.404
	Vertical Strut	13.3305	16.5405	9.966	19.905
20	Principle Rafter	46.8855	86.3085	29.9295	103.2645
	Tie Member	77.1975	37.6905	92.3625	22.5255
	Inclined Strut	20.8845	16.323	24.987	13.5
	Vertical Strut	15.8175	20.238	11.841	24.2145

Table 3: Comparison of Unit Weight and sections of Aluminium and Steel

Span in m	Member	Aluminum Truss Member		Steel Truss Member	
		Section	Unit Weight in KN/m	Section	Unit Weight in KN/m
10	Principle Rafter	2ALE 50 X 50 X 5	1.9	2ISA 45 X 45 X 4	**2.7**
	Tie Member	2 ALE 45 X 45 X 4	0.95	2ISA 40 X 40 X 4	**2.4**
	Inclined Strut	ALE 60 X 60 X 4	1.28	ISA 35 X 35 X 5	**2.6**
	Vertical Strut	ALE 60 X 60 X 4	1.28	ISA 40 X 40 X 6	**3.5**
14	Principle Rafter	2 ALE 60 X 60 X 4	1.28	2ISA 45 X 45 X 6	**4**
	Tie Member	2 ALE 50 X 50 X 4	1.06	2ISA 45 X 45 X 5	**3.4**
	Inclined Strut	ALE 60 X 60 X 4	1.28	ISA 35 X 35 X 6	**3**
	Vertical Strut	ALE 60 X 60 X 4	1.28	ISA 45 X 45 X 5	**3.4**
17	Principle Rafter	2 ALE 60 X 60 X 5	1.58	2ISA 50 X 50 X 6	**4.5**
	Tie Member	2 ALE 60 X 60 X 4	1.28	2ISA 50 X 50 X 6	**4.5**
	Inclined Strut	ALE 60 X 60 X 5	1.58	ISA 45 X 45 X 4	**2.7**
	Vertical Strut	ALE 60 X 60 X 5	1.58	ISA 45 X 45 X 6	**4**
20	Principle Rafter	2 ALE 60 X 60 X 6	1.88	2ISA 55 X 55 X 6	**4.9**
	Tie Member	2ALE 50 X 50 X 6	1.54	2ISA 55 X 55 X 6	**4.9**
	Inclined Strut	ALE 60 X 60 X 6	1.88	ISA 45 X 45 X 5	**3.4**
	Vertical Strut	ALE 70 X 70 X 5	1.86	ISA 50 X 50 X 6	**4.5**

2. Review of Literature

Stefania Arangio, Chiara Crosti, Marco Zampetti:-
In this paper some specific aspects related to the design of aluminium structures for the entertainment industry have been presented. The structural features of aluminium elements depend on both the mechanical properties of the material and the temporary use of the structures. In the early days trusses for the entertainment industry were often fabricated.

R. Gitter (2008) "Design of Aluminium Structures: Selection Of Structural Alloys":
State that, the main reason for the use of aluminium in structural engineering is still its good corrosion behavior. No coating is necessary under most atmospheric conditions. And the costs and environmental problems which exist when renewing organic coatings are still underestimated. We have many structural applications, where, due to the functionality given by the use of extruded sections, the structure is economically competitive.

Federico M. Mazzolani (2006) "Structural Applications of Aluminium in Civil Engineering":-
States that, the success of aluminium alloys as constructional material and the possibility of a competition with steel are based on some prerequisites which are connected to the physical properties, the production process and the technological features.

By Prof. Madhuri K. Rathi, Mr.Ajinkya K. Patil:-
States that, Aluminium, while it has a relatively high initial energy cost, offers unparalleled manufacturing flexibility, the broadest ranges of finishes, an excellent strength-to-weight ratio, and unlimited recyclables and has a far better environmental profile than many specifiers believes. Above all, it offers architects the most elegant and satisfying design solutions. For many contemporary designers there are simply no alternative to Aluminium the form dictates the material and the material facilitates the form. This fact alone will ensure the continued growth of Aluminium in construction.

3. Conclusion

On the basisof study of steel roof truss and aluminium alloyroof truss mainly we conclude that all the members of aluminium alloy roof trusses are light weight compare to steel roof trusses for different spans and we observed that material consumption is more in aluminium roof trusses. Aluminium alloy roof truss can also suitable where heavy rainfall areas because aluminium is corrosion less so durability of truss may be increases.

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