Dursun BAKIR
University of Bitlis Eren
Faculty of Engineering and Architecture

Ercan IŞIK
University of Bitlis Eren
Faculty of Engineering and Architecture

Mustafa ÜLKER
University of Bitlis Eren
Vocational School of Technical Sciences

A STUDY ON ECONOMIC LOSSES ACCORDING TO SELECTION OF STEEL CONSTRUCTION SYSTEMS

Keywords: *Frame System, Truss System, Steel Construction Systems*

Abstract

In order for any structure to resist against external factors in a safe way, all of the structural elements such as foundation, curtain walls, column, beam, flooring, which are formed to transport and transport the load, truss or carrier frame system is used in steel structures for the selection of the carrier system. As an example in this study, Industry structure with 20*30 m² selected. Frame systems consisting of trapezoidal truss system and steel I profile are used as the system. Bitlis province, central province was chosen as the snow load region. Snow load P_k=1,85 kN/m² is taken. In the trapezoidal truss system, equal-arm corners are chosen as cross-section. Two examples were resized with the SAP2000 program. According to the results obtained, the trapezoidal truss system is found to be more economical.

Introduction

Any structure is important in terms of structural cost of the carrier system. Steel structures usually use a frame system or a truss system. While the frame systems are being projected such that the knot points are bolted; truss systems are usually projected from welded joints. In this paper, the Ministry of Environment and Urban Planning unit price schedule of 2016 was used.

A variety of structural steel products are manufactured by steel plants for the construction of steel structures. The products available indifferent shapes and size to enable the structural engineer to select suitable sections to the requirements of the design (Ram, 2010).

When designing every building, cost should be considered together with safety. In this way, the building elements are sized according to the most economical section to provide the necessary safety. In our country, prefabricated reinforced concrete, which is preferred in industrial structures, is mainly used in steel construction and steel-reinforced concrete composite systems (Tastekin, 2007).

Central crossed frames are lateral force-resistant systems with high elastic stiffness, unlike the moment-resistant frames. The lateral force that provides rigidity in these systems is the strength of diagonal cross elements. The diagonal cross members and frame system fasteners form the basic units of a central crossed frame (Tuncel, 2015).

Loads that affect the system are dead loads, snow load and wind load. Dead loads consist weight of the roof cover, purlin, truss and wind connection. Snow load is taken from TS498 according to the area where the structure is located (Yilmaz and Sahin, 2013).

In this study, 20*30 m² industrial structure to be built in Bitlis was selected. This structure is modelled separately as frame system and truss system and were dimensioned under dead load and snow load.

Frame System Model

In this model, a frame system with 20% roof slope at an interval height of 20 m and a column height of 6 m was selected. The frames are projected at an interval of 6 m as shown fig. 1. 3D sample of the system is shown at fig. 2 below.

Fig. 1. 2D sample frame system

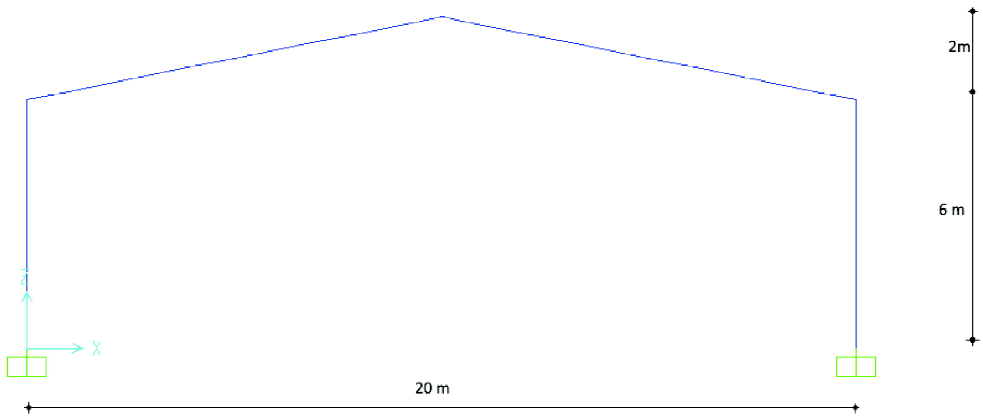
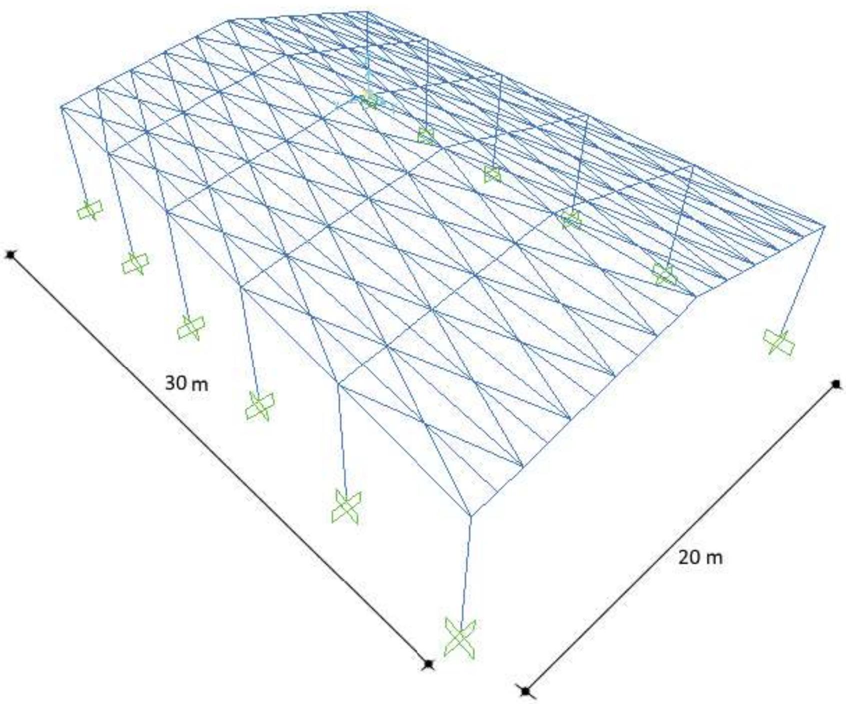


Fig. 2. 3D sample frame system



Load Analysis;

a) Dead load

Roof cover [Corrugated sheet] g = 0.25 kN/m^2 **(R.L.)**

$$g_1 = \frac{g}{cos\alpha} = \frac{0.25}{cos\alpha} = 0.27 \text{ kN/m}^2 \textbf{ (H.L.)}$$

Purlin self-weight= = 0.10 kN/m^2 **(H.L.)**

Wind and stability link shaft = 0.05 kN/m^2 **(H.L.)**

TOTAL g_2 = 0.42 kN/m^2 **(H.L.)**

Truss weight =0.08 kN/m^2 **(H.L.)**

TOTAL g_3 = 0.50 kN/m^2 **(H.L.)**

b) Snow Load

Snow load value (P_{ko}) was taken from Table 1 that prepared with the number of zones on the map by the snow height.

Table 1. Natural snow loads (P_{ko}) Values (kN/m^2)

	1	2	3	4	5
1	Yapı yerinin denizden yüksekliği	BÖLGELER			
	m	I	II	III	IV
	≤ 200	0,75	0,75	0,75	0,75
2	300	0,75	0,75	0,75	0,80
	400	0,75	0,75	0,75	0,80
	500	0,75	0,75	0,75	0,85
3	600	0,75	0,75	0,80	0,90
	700	0,75	0,75	0,85	0,95
	800	0,80	0,85	1,25	1,40
4	900	0,80	0,95	1,30	1,50
	1000	0,80	1,05	1,35	1,60
5	> 1000	1000 m'ye tekabül eden değerler, 1500 m'ye kadar %10, 1500 m'den yukarı yüksekliklerde %15 artırılır.			

If this burden increased 15% from Table 3 since the altitude of the location is about 1600 m;

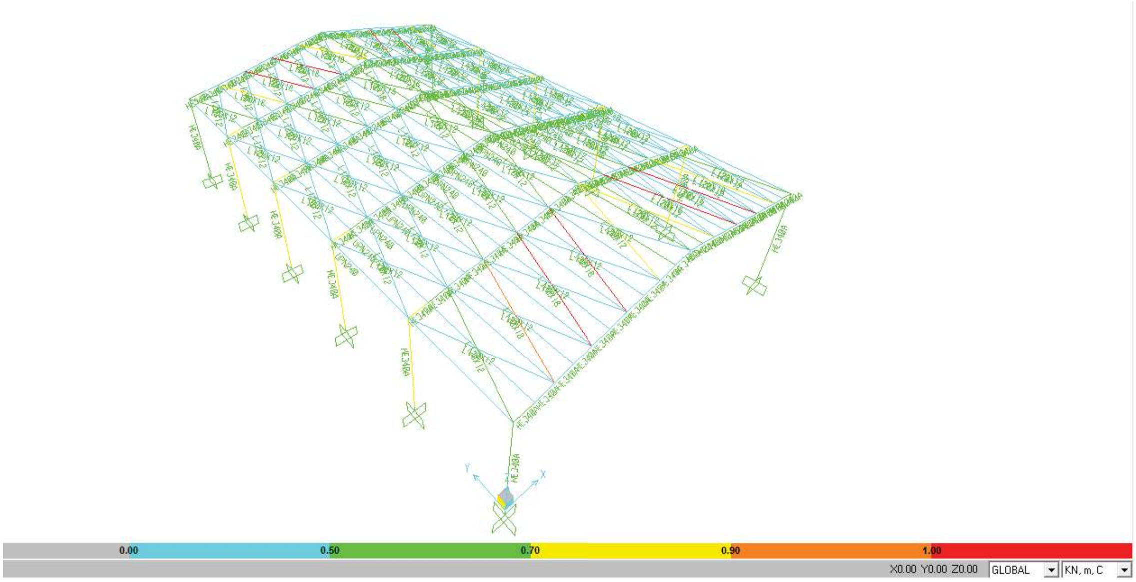
P_k = 1.60 x 1.15 = 1.85 kN/m^2

Structural analysis of the specified loads was performed in the SAP2000 program.

The calculations that is performed;

Frame beam, Columns, Purlins of Roof and Wind stability link shaft designed as HE340A, HE340A, UPN240, L120.12, respectively.

Fig. 3. 3D design results



Quantities of Structure:

As a result of the analysis of frame system model, 55.01 tons of steel profile was used as seen Table 2 below.

Table 2. Quantities

Profile name	Similar	Unit Weight(Kg/m)	Lengyh(m)	Amount(Kg)
HE340A	12	105	6	7560
HE340A	12	105	10.19	12839.4
UPN240	21	33.2	30	20916
L120.12	100	21.6	6.34	13694.4
		TOTAL		55009.8

Truss System Model

In this model, a trapezoidal truss system with 20% roof slope at 20 m roof height and 6 m column height was taken. The trusses are projected at an interval of 6 m.

Fig. 4. 2D sample trapezoidal truss system.

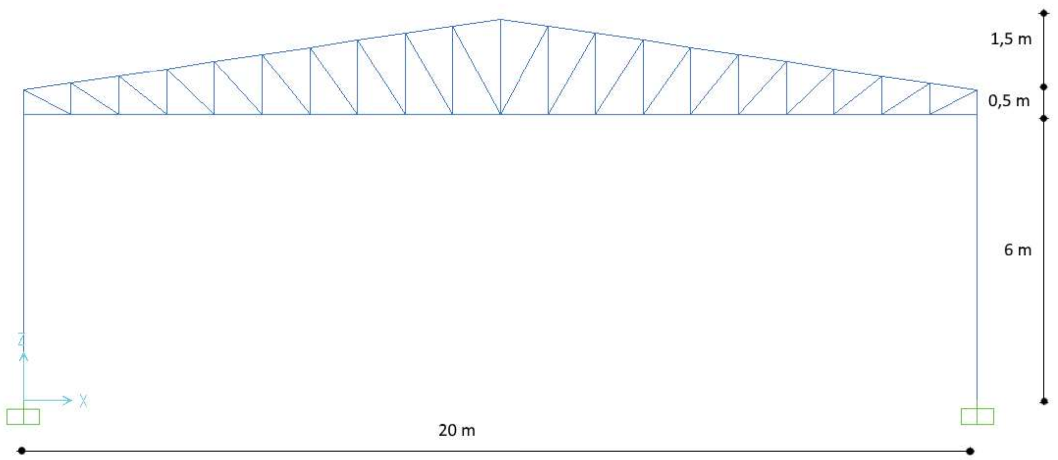
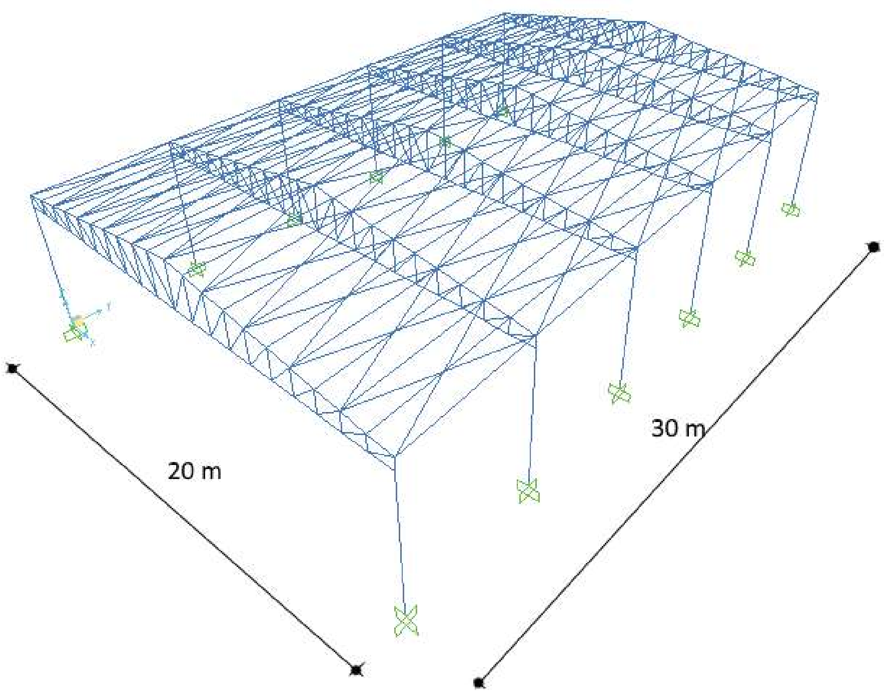


Fig. 5. 3D sample trapezoidal truss system.



Load Analysis;

a) Dead load

Roof cover [Corrugated sheet] g = 0.25 kN/m^2 **(R.L.)**

$$g_1 = \frac{g}{cos\alpha} = \frac{0.25}{cos\alpha} = 0.27 \text{ kN/m2 } \textbf{(H.L.)}$$

Purlin self weight = 0.10 kN/m^2 **(H.L.)**

Wind and stability link shaft = 0.05 kN/m^2 **(H.L.)**

TOTAL g_2 = 0.42 kN/m^2 **(H.L.)**

Truss weight = 0.08 kN/m^2 **(H.L.)**

TOTAL g_3 = 0.50 kN/m^2 **(H.L.)**

b) Snow Load

Snow load value (P_{ko}) is taken from Table 2 that prepared with the number of zones on the map by the snow height.

Table 2. Natural snow loads (P_{ko}) Values (kN/m^2)

	1	2	3	4	5
1	Yapı yerinin denizden yüksekliği	BÖLGELER			
	m	I	II	III	IV
	≤ 200	0,75	0,75	0,75	0,75
2	300	0,75	0,75	0,75	0,80
	400	0,75	0,75	0,75	0,80
	500	0,75	0,75	0,75	0,85
3	600	0,75	0,75	0,80	0,90
	700	0,75	0,75	0,85	0,95
	800	0,80	0,85	1,25	1,40
4	900	0,80	0,95	1,30	1,50
	1000	0,80	1,05	1,35	1,60
5	> 1000	1000 m'ye tekabül eden değerler, 1500 m'ye kadar %10, 1500 m'den yukarı yüksekliklerde %15 artırılır.			

Source: TS 498

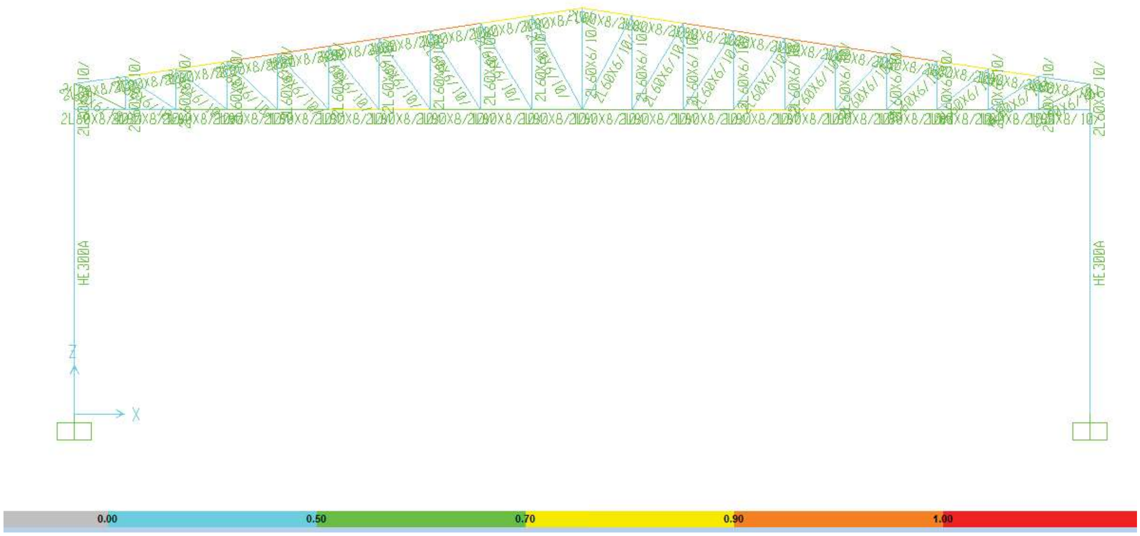
If this burden increased 15% from Table 3 since the altitude of the location is about 1600 m;

$$P_k = 1.60 \times 1.15 = 1.85 \text{ kN/m}^2$$

Structural analysis of specified loads was done using SAP2000 program. According to calculations made;

The system is designed as truss subheading as 2L80.8/10, upper flange as 2L80.8/10, vertical rot and diagonals as 2L60.6/10 columns as HE340A, purlins of roof as UPN240 and wind stability links as L120.12.

Fig. 6. 3D Truss System



Quantities of Structure:

Table 4. Quantities

Profile name	Similar	Unit Weight	Lengyh	Amount
2L80.8/10	6	19.32	20	2318.4
2L80.8/10	12	19.32	10.19	2362.45
2L60.6/10	6	10.84	56.88	3699.475
HE300A	12	88.3	6	6357.6
UPN240	21	33.2	30	20916
L120.12	100	21.6	6.34	13694.4
				49348.32

As a result of analysis of frame system model, it was observed that 49.35 tons of steel profiles were used.

Results

Static analysis of the SAP2000 program with respect to the loads specified in both systems showed that the results of the structural metrics resulted in less steel profiles are being used in the trapezoidal truss system. This proves that the trapezoidal steel truss are more economical. The trapezoidal truss system required 5.66 tons less material than the frame system.

According to the unit price of the Ministry of Environment and Urban Planning in 2016, the cost of a ton of steel is 3.605,91 TL/tons (ÇŞB, 2016). According to that unit price, if the trapezoidal truss system is selected in the structure, the construction costs will be 20.409,45 TL ($ 5,647.00) which is more economic.

REFERENCES

[1] ÇŞB, 2016. Çevre ve Şehircilik Bakanlığı 2016 Birim Fiyatları.

[2] Ram Sai K.S. 2010. *Design of steel structures*. Pearson Education India.

[3] SAP2000 V14. Structural Analysis Program.

[4] Taştekin M. S. 2007. *Sanayi Yapilarinin Maliyetinde Etkin Parametrelerin İrdelenmesi*. J. Fac. Eng. Arch. Selcuk Univ 22.4.

[5] TS 498. Turk Standartlari.

[6] Tunçel U. 2015. *Merkezi Çaprazlı Çelik Çerçeve Sistemlerin Dbybh 2007 Yönetmeliğine Göre Tasarımı*. Diss. Fen Bilimleri Enstitüsü.

[7] Yilmaz O., Şahin A. 2013. *Educational Software Development For Desing Of Steel Structures Lesson*. Sigma 31, 571-581.