Comparative Study of Buckling and Wind Analysis by Changing Different Truss Parameter

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Abstract - *This paper summarizes the research work on the comparative study of buckling and wind analysis of steel roof truss by changing its truss parameter that is span, spacing and slope of A-type truss. The modelled steel roof trusses are analyzed by linear Euler buckling analysis and compared with the static wind analysis. ETABS 2015 is used for the modelling and analysis. Most economical design of the roof trusses is done by considering DCR. The objective is to find out which parameters results in most economical and light weight sections.*

Key Words: Truss parameter, A-type truss, Linear Euler buckling analysis, Wind analysis, ETABS, DCR

1. INTRODUCTION

For industries, warehouses, auditoriums etc. unobstructed space is needed. In order to provide that space we need to avoid columns. If RCC slab is used in this case, it consists of large areas, so it doesn't satisfy deflection criteria and becomes uneconomical. Therefore steel roof trusses are used.

A truss is a framed structure formed by joining various members in a particular pattern of triangles. The main reasons for using trusses are long span, light weight, reduced deflection and opportunity to support considerable loads. One disadvantage is that steel roof trusses can't take super imposed loads above it.

Steel roof of different spans (9m, 12m, 18m and 24m), different slopes (1:3, 1:4 and 1:5) and different spacing (4.5m, 5m and 6m) of A-type truss were modelled and analyzed in ETABS 2015. IS 875(Part I, II, III) are used to calculate the loads on the roof trusses. Buckling analysis is compared with the wind analysis in order to get desired results.

Buckling is very important mode of failure and it can happen suddenly without any prior warning. Buckling occurs physically when structure becomes unstable under a given loading. Buckling is characterized by an unexpected sideways deflection of a structural member.

Linear buckling analysis or Eigen value analysis predicts the theoretical buckling strength of a structure which is idealized as elastic. Buckling analysis brings out buckling load factors and the applied load is multiplied by these factors to obtain the buckling load.

Demand Capacity Ratio (DCR) for steel frame member indicates the acceptability of the member for the given loading. As per IS 800, 2007 clause 9.3.1.1 the DCR shouldn't exceed 1 because failure occurs. Normally DCR should be 0.8 to 0.9 for economic design of structures

1.1 Objective

1. To find out effect of buckling and wind load on different roof truss parameters.
2. Economic design of trusses with buckling loads by considering DCR.
3. Economic design of trusses with wind loads by considering DCR.
4. Comparing the analysis and design results.
5. Comparing the cost and weight of the truss.

2. SOFTWARE

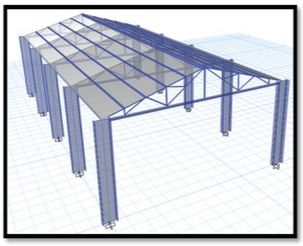
ETABS is a structural analysis and design software. It can be used for linear, non-linear, static and dynamic analysis and for the design and detailing of any type of building and its components.

3. MODELLING OF TRUSS

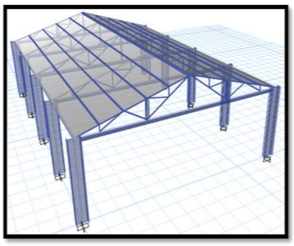
I-sections, Angle sections and rectangular tube sections made of mild steel (Fe250) are defined to model columns, truss members and the purlins of the roof truss respectively. A-type truss with different parameters are modelled in ETABS software for the analysis and design.

a) Trusses with varying spans that is 9m,12m,18m and 24m (slope 1:3, spacing 6m)
b) Trusses with varying slopes that is 1:3, 1:4 and 1:5 (span 12m, spacing 6m)
c) Trusses with varying spacing that is 4.5m,5m and 6m (span 12m, slope 1:3)

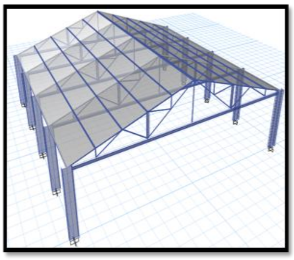
Figure 1, Figure2 and figure3 shows the truss with varying spans, slopes and spacing respectively



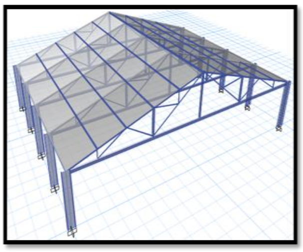
9m span



12m span

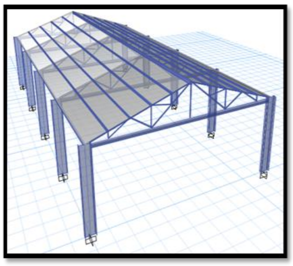


18m span

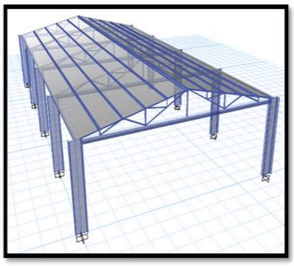


24m span

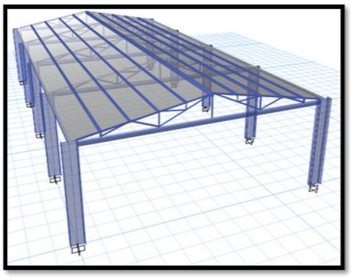
Fig -1: Trusses with varying spans



1.3 slope

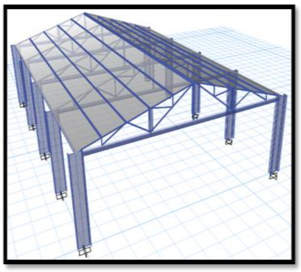


1:4 slope

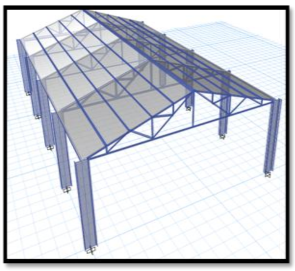


1:5 slope

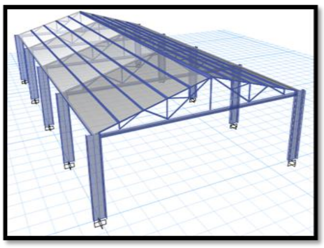
Fig -2: Trusses with varying slopes



4.5m spacing



5m spacing



6m spacing

Fig -3: Trusses with varying spacing

4. ANALYSIS

4.1 Buckling Analysis

Linear Euler buckling analysis calculates buckling load factor (BLF) for different mode shapes of the structure. From the buckling load factors available, the one which is greater than 1 is selected and it is multiplied by the applied load to get the buckling load magnitude.

The load combinations used are

- 1.5 (DL+LL)
- BLF (DL+LL)

The results of buckling analysis of truss by changing different parameters are as follows

Table -1: BLF for different truss parameter

Varying parameter		Euler buckling load factor(BLF)
Span in m	9	1.079
	12	1.141
	18	1.744
	24	1.764
Slope	1:3	1.141
	1:4	1.124
	1:5	1.110
Spacing in m	4.5	1.117
	5	1.132
	6	1.141

From above table shows that 9m span, 1:5 slopes and 4.5m spacing have least buckling load factor.

4.2 Wind Analysis

Static wind analysis is done for different types of steel truss geometries. The analysis is carried out by the ETABS software. Wind loads are calculated by the IS 875 Part 3.

5. RESULT AND DISCUSSION

Result of buckling and wind analysis for different truss spans, slopes and spacing of A-type truss. This analysis result is compared to get the most effective and economic design as per DCR.

5.1 Trusses with Varying Spans

From the analysis results is shown in the table 2. Chart 1 and chart 2 shows the member weight and cost of varying truss spans. Chart 3 and chart 4 shows the total weight and cost of varying truss spans. It is shown that 9m span have less weight and cost. Span increase weight and cost increase. Buckling analysis is less than the wind analysis. Column has more weight in buckling analysis than the other members. Truss member has more weight in wind analysis.

Table -2: Design of varying truss spans

Span		Column	Truss				Purlin
			Horizontal	Inclined	Vertical	Top	
9m	BA	ISLB 75	ISA 100X100X8	ISA 20X20X3	ISA 20X20X3	ISA 20X20X3	ISB 50X50X2.6
	WA	ISWB 150	ISA 200X200X15	ISA 35X35X3	ISA 40x40x3	ISA 45X45X3	ISB 50X50X2.6
12m	BA	ISWB 350	ISA 150X150X10	ISA 45X45X4	ISA 30X30X3	ISA 75X50X6	ISB 72X72X3.2
	WA	ISWB 350	ISA 200X200X25	ISA 45X45X5	ISA 65X65X5	ISA 65X65X5	ISB 72X72X3.2
18m	BA	ISJB 175	ISA 200X200X25	ISA 65X65X5	ISA 65X65X5	ISA 75X75X8	ISB 72X72X3.2
	WA	ISWB 300	ISA 200X200X25	ISA 65X65X5	ISA 65X65X5	ISA 70X70X8	ISB 72X72X3.2
24m	BA	ISWB 350	ISA 200X200X25	ISA 65X65X5	ISA 65X65X5	ISA 100X100X10	ISB 72X72X3.2
	WA	ISWB 350	ISA 200X200X25	ISA 65X65X5	ISA 130x130x10	ISA 90X90X12	ISB 72X72X3.2

*BA-Buckling Analysis
*WA-Wind Analysis

Chart 1 and 2 show the member weight and cost of all the four truss spans.

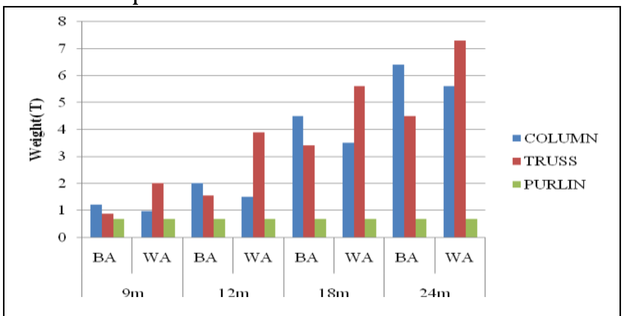


Chart -1: Member weight for varying truss spans

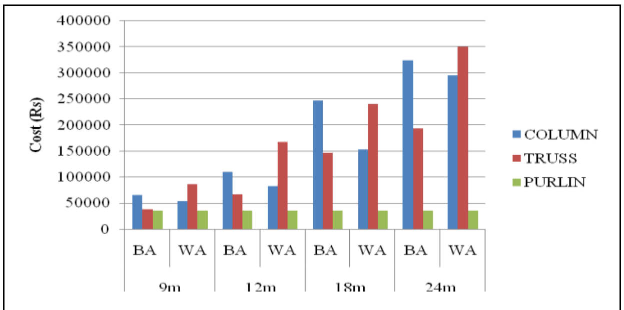


Chart -2: Member cost for varying truss spans

Chart 3 and 4 shows the total weight and cost of all the four truss spans.

Chart -3: Total weight for varying truss spans

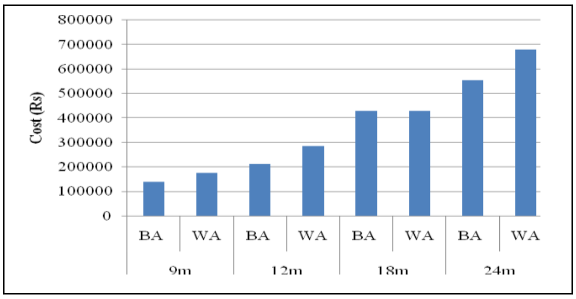


Chart -4: Total cost for varying truss spans

5.2 Trusses with Varying Slopes

From the analysis results is shown in the table 3. Weight and cost estimation is calculated as per steel table. Chart 5 and chart 6 shows the member weight and cost of varying truss slopes. Chart 7 and chart 8 shows the total weight and cost of varying truss slopes. It is shown that 1:5 slopes have less weight and cost. Slopes increases weight and cost reduces. Buckling analysis is less than the wind analysis. Column has more weight in buckling analysis than the other members. Truss member has more weight in wind analysis.

Table -3: Design of varying truss slopes

Slope		Column	Truss				Purlin
			Horizontal	Inclined	Vertical	Top	
1 in 3	BA	ISWB 350	ISA 150X150X10	ISA 45X45X4	ISA 30X30X3	ISA 75X50X6	ISB 72X72X3.2
	WA	ISWB 350	ISA 200X200X25	ISA 45X45X5	ISA 65X65X5	ISA 65X65X5	ISB 72X72X3.2
1 in 4	BA	ISWB 250	ISA 150X150X10	ISA 50x50x4	ISA 40x40x3	ISA 90X90X6	ISB 72X72X3.2
	WA	ISWB 225	ISA 200X200X25	ISA 50X50X6	ISA 65X65X5	ISA 65X65X5	ISB 72X72X3.2
1 in 5	BA	ISMB 250	ISA 150X150X10	ISA 50X50X4	ISA 75X75X5	ISA 125X75X8	ISB 72X72X3.2
	WA	ISWB 150	ISA 200X200X25	ISA 50X50X6	ISA 65X65X5	ISA 75X75X8	ISB 72X72X3.2

*BA-Buckling Analysis
*WA-Wind Analysis

Chart 5 and 6 show the member weight and cost of all the three truss slopes.

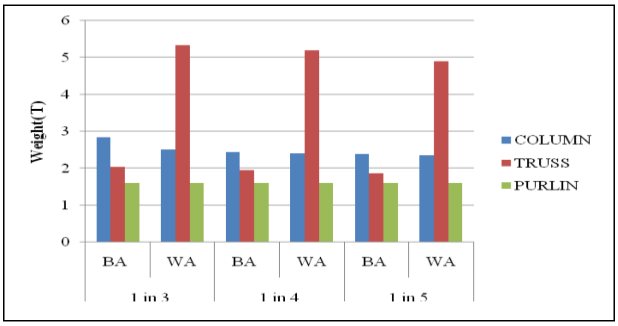


Chart -5: Member weight for varying truss slopes

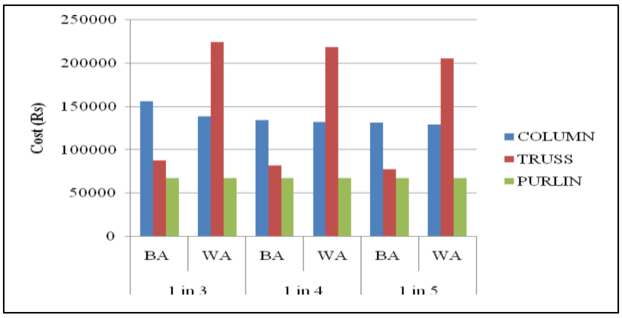


Chart -6: Member cost for varying truss slopes

Chart 7 and 8 shows the total weight and cost of all the three truss slopes.

Chart -7: Total weight for varying truss slopes

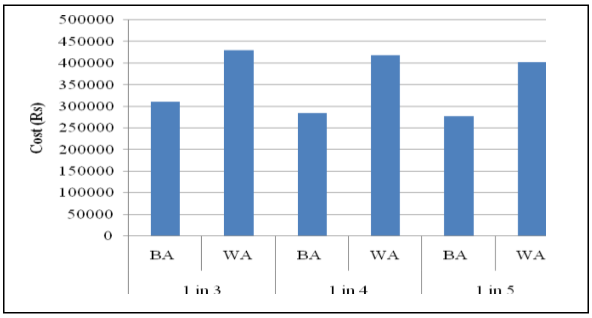


Chart -8: Total cost for varying truss slopes

5.3 Trusses with Varying Spacing

From the analysis results is shown in the table 4. Weight and cost estimation is calculated as per steel table. Chart 9 and chart10 shows the member weight and cost of varying truss spacing. Cha11 and chart 12 shows the total weight and cost of varying truss spacing. It is shown that 4.5m spacing have less weight and cost. Spacing increase weight and cost increases. Buckling analysis is less than the wind analysis. Column has more weight in buckling analysis than the other members. Truss member has more weight in wind analysis.

Table -4: Design of varying truss spacing

Spacing		Column	Truss				Purlin
			Horizontal	Inclined	Vertical	Top	
4.5m	BA	ISMB 250	ISA 150X150X12	ISA 45X45X5	ISA 50X50X4	ISA 60X60X5	ISB 50X50X2.6
	WA	ISWB 225	ISA 200X200X25	ISA 45X45X4	ISA 50x50x4	ISA 60X60X5	ISB 50X50X2.6
5m	BA	ISWB 250	ISA 150X150X10	ISA 45X45X5	ISA 75X50X5	ISA 75X50X6	ISB 50X50X2.6
	WA	ISWB 300	ISA 200X200X25	ISA 45X45X5	ISA 50x50x4	ISA 65X65X5	ISB 72X72X3.2
6m	BA	ISWB 350	ISA 150X150X10	ISA 45X45X4	ISA 30X30X3	ISA 75X50X6	ISB 72X72X3.2
	WA	ISWB 350	ISA 200X200X25	ISA 45X45X5	ISA 65X65X5	ISA 65X65X5	ISB 72X72X3.2

*BA-Buckling Analysis
*WA-Wind Analysis

Chart 9 and 10 show the member weight and cost of all the three truss spacing.

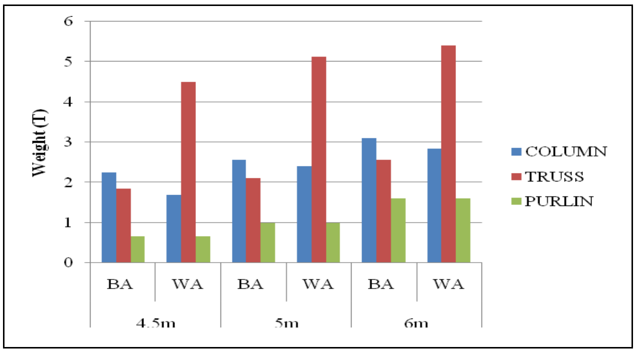


Chart -9: Member weight for varying truss spacing

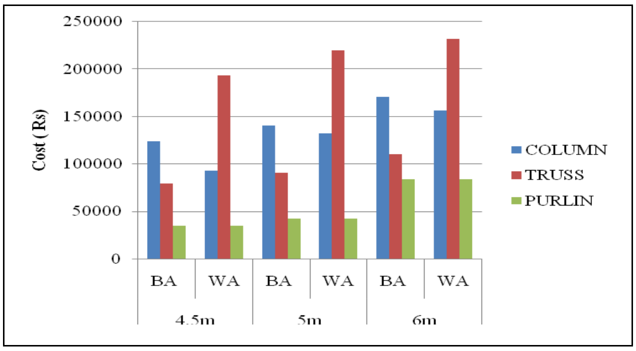


Chart -10: Member cost for varying truss spacing

Chart 11and 12 shows the member weight and cost of all the three truss slopes.

Chart -11: Total weight for varying truss spacing

Chart -12: Total cost for varying truss spacing

6. CONCLUSIONS

- When span and spacing of the truss increases, buckling, cost and weight also increases
- When slope increases, buckling cost and weight reduces.
  - As per SP-38, Increase in the deflection can result in reduction in the slope of roof
- The ratio of weight per square metre of 6.0 m spacing to 4.5 m spacing of trusses is generally in the range of 1.04 to 1.2.

  - Smaller weight per square metre ratio indicates steeper slopes of roof truss
  - Larger weight per square metre ratio indicates flatter slopes of roof truss
- Design of the trusses with respect to DCR results in highly economical sections with less out of plane buckling. Out of plane buckling is less for
  - I-sections in case of columns
  - Angle sections in case of truss members
  - Rectangular tube sections in case of purlins

So local buckling of the truss is controlled by the selection of accurate sections

- Buckling analysis results in heavy column sections because buckling is the sideway deflection of the compression members. So when an excitation occur column buckles more since it is the most compressible member.
- Wind analysis results in heavy truss section because the wind pressure acts on the asbestos sheet and which in turn apply more load on the truss members.
- Buckling Analysis results in light weight and economical sections than wind analysis. Do wind analysis only when the horizontal dimension is comparatively less than vertical dimension of the truss structure. Otherwise it will be uneconomical
- In both analysis purlins consumes less weight since it does not carries much load but acts as connections between bays of truss. Purlins weight constitutes between 20 to 29 percent of the truss system only

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