To Study The Strenghthning of Steel Truss By Prestressing

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Abstract*-The need of rehabilitation of existing steel truss is a growing concern in many countries. Although rehabilitation of a steel truss includes all of its components such as substructure, superstructures, the present study will treat only truss portion of the superstructures by adopting prestressing. Use of prestressing is one of the technical advancement in the field of construction. In structurally deficient steel truss there is need to strengthen the members of truss in order to fulfill the present and future loading. In the present study the behavior of truss element is observe under different load and without dismantling the whole structure the strengthen of steel truss is carried out, prestressing is done to the tension member and compression member which are unsafe is modified with preferable one.*

Keywords-Truss, Tendon, Prestressing ,Staad pro.

I. INTRODUCTION

Steel is the most important construction material due to its light weightiness ,the presences of high elastic modulus ,energy absorption in seismic condition and because it provide high construction speed .prestressing means inducing the tensile force in the tendon or wire and anchored to the member being prestressed .so steel having low tensile strength can behave as a high tensile strength can behave as a high tensile strength after prestressing it increases the load carrying capacity of steel structures .prestressing mainly use for rehabilitation of the steel structure ,for strengthening the structure or member by providing confining forces.casson (1971) and Torr (1964) discuss and illustrate Egyptian boats built approximately 3500 years ago, in which the hull, posts and ropes formed structures to prevent 'hogging' .These boat structures were prestresed by twisting ropes the same technique is used to Prestress the blade in a traditional bucksaw. Historically the concept of prestressing was employed long before the word was coined so therefore the word was coined so therefore the concept of prestressing is used in everyday object .generally, the overcome tensile strength of the concrete and steel prestressing is done to increase the load carrying capacity of the load carrying capacity of the prestressed steel structure is more than that of without prestressing steel structure. The objective of project is to study the load carrying capacity of steel truss after prestressing

II. METHODOLOGY

D.L and L.L acting on joints of truss are considered for model M1.The loads are increased by 10% for model M2, 20% for model M3 .Models in which the members have been found to be unsafe in compression have been modified with appropriate section. The models in which the members have been found to be unsafe in tension have been modified with prestressing technique.

III. PROBLEM STATEMENT

Loading calculation:

1. Size of truss ; Roofing material – G.I sheets; Span of trusses- 4m; ϴ = 18.43^0

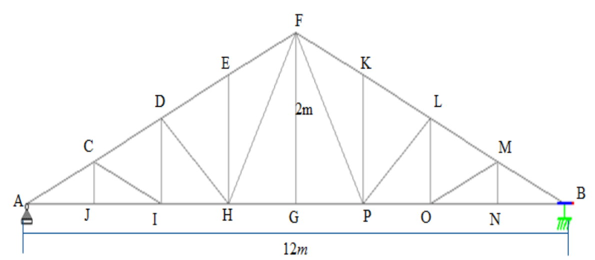


Figure 1 Pratt truss

The loads acting on the truss members are Dead load and Imposed load .The dead load comprises of dead load from G.I sheets, purlins and dead load of the truss itself. The load calculation is given below:

Dead load: Dead load of G.I sheet=0.827
Self-weight of the truss= 2.3808
Dead load of bracing=
Dead load from purlin = 6.144
Load on each intermediate panel due to dead load = =26.5kN
Load on end panel =13.25kN

Imposed load :As per Is code 875:1987 (part 2) If the slope of the roof is greater than then formula for I.L is =0.75-0.02(-)Here Therefore, Load on each intermediate panel due to imposed load =3.671kN Load on end panel =1.835 kN

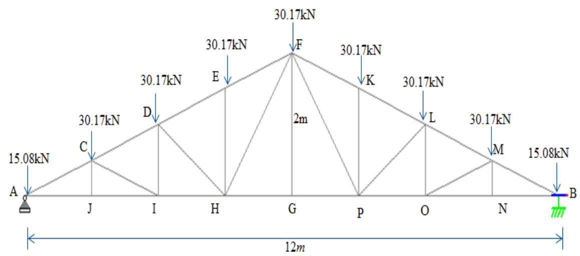


Figure 2 Assigning D.L+L.L for Model M1

By using method of joint forces in member is calculated and design for truss member is performed.

Selection of section:
Design of compression member for maximum force =334kN.

Member AC; $\tan\alpha = \frac{0.5}{1.5}$; α=$18.43^0$; Length of member AC=1.58m
Let us assume effective length L=l ; L=1.58m
$f_y = 250mpa$; Allowable compressive stress=60mpa;Cross sectional area required =5566 mm^2
Let us consider 2ISA $80\times80\times10mm$; Area provided =3010 mm^2; $r_{\min} = 24.4mm$

$$\lambda = \frac{l}{r_{\min}} = \frac{1580}{24.4} = 64.75mm\langle 180$$, Hence ok

From I.S code 800:1984 for $\frac{l}{r} = 64.75$; $\sigma_{ac} = ?$, therefore by interpolation
$\sigma_{ac} = 117.25N/mm^2$; Capacity of member =353 kN

Design of Tension member for maximum force=316.86kN

Member AJ; Length of member AJ=1.5m; Allowable tensile stress, $\sigma_{at} = 150mpa$

Net area required =2112 mm^2 ; Increase net area by 40%
Gross cross sectional area required=1.4× 2112 =2956.8 mm^2
Let us consider 2ISA $80\times80\times10mm$; Area provided =3010 mm^2; $r_{\min} = 24.4mm$
Net area of angle = $3010 - 2\times24.4\times10 = 2528mm^2$

$$\lambda = \frac{l}{r_{\min}} = \frac{1500}{24.4} = 61.47mm\langle 180$$, Hence ok; Capacity of member =379kN

In Model M2 member AC=MB is provided with 2ISA and having capacity 353 kN which is unsafe, so after redesign this section is replace by 2ISA of capacity 422 kN .Now all member are safe.In model M3 member AC=MB is provided with 2ISA and having capacity 353 kN which is unsafe, so after redesign this section is replace by 2ISA of capacity 422 kN .and member DH=LP is provided with 2ISA of capacity 62.52 kN and is replace by 2ISA of capacity 89 kN.Member AJ=NB and JI=ON are strengthen by using prestressing.

Sr.no	Members	Force in kN	Section selected	Capacity in kN	Weight of member in kg	Remark
1	AC=MB	334(C)	2ISA $80\times80\times10mm$	353(C)	74.576	SAFE
2	CD=ML	286.45(C)	2ISA $80\times80\times10mm$	353(C)	74.576	SAFE
3	DE=KL	238.71(C)	2ISA $80\times80\times10mm$	353(C)	74.576	SAFE
4	EF=KF	238.70(C)	2ISA $80\times80\times10mm$	353(C)	74.576	SAFE
5	AJ=NB	316.86(T)	2ISA $80\times80\times10mm$	379(T)	70.8	SAFE
6	JI=ON	316.86(T)	2ISA $80\times80\times10mm$	379(T)	70.8	SAFE
7	IH=OP	271.53(T)	2ISA $80\times80\times10mm$	379(T)	70.8	SAFE
8	HG=PG	181.02(T)	2ISA $80\times80\times10mm$	379(T)	70.8	SAFE
9	CJ=MN	0	2ISA $20\times20\times4mm$	0	2.2	SAFE
10	CI=OM	47.78(C)	2ISA $50\times50\times5mm$	62.52(C)	24.016	SAFE
11	DI=LO	15.105(T)	2ISA $25\times25\times5mm$	56(T)	7.2	SAFE
12	DH=LP	54.42(C)	2ISA $50\times50\times5mm$	62.52(C)	27.36	SAFE
13	EH=KP	30.16(C)	2ISA $50\times50\times5mm$	62.52(C)	22.8	SAFE
14	HF=PF	75(T)	2ISA $50\times50\times5mm$	120(T)	38	SAFE
15	FG	0	2ISA $20\times20\times4mm$	0	4.4	SAFE

Load increase by 10% for **Model M2**

Sr.no	Members	Force in kN	Section selected	Capacity in kN	Weight of member in kg	Remark
1	AC=MB	367.4(C)	2ISA $80\times80\times10mm$	353(C)	74.576	UNSAFE
2	CD=ML	315.09(C)	2ISA $80\times80\times10mm$	353(C)	74.576	SAFE
3	DE=KL	262.58(C)	2ISA $80\times80\times10mm$	353(C)	74.576	SAFE
4	EF=KF	262.58(C)	2ISA $80\times80\times10mm$	353(C)	74.576	SAFE
5	AJ=NB	348.54(T)	2ISA $80\times80\times10mm$	379(T)	70.8	SAFE
6	JI=ON	348.54(T)	2ISA $80\times80\times10mm$	379(T)	70.8	SAFE
7	IH=OP	298.68(T)	2ISA $80\times80\times10mm$	379(T)	70.8	SAFE
8	HG=PG	199.12(T)	2ISA $80\times80\times10mm$	379(T)	70.8	SAFE
9	CJ=MN	0	2ISA $20\times20\times4mm$	0	2.2	SAFE
10	CI=OM	52.55(C)	2ISA $50\times50\times5mm$	62.52(C)	24.016	SAFE
11	DI=LO	16.61(T)	2ISA $25\times25\times5mm$	56(T)	7.2	SAFE
12	DH=LP	59.862(C)	2ISA $50\times50\times5mm$	62.52(C)	27.36	SAFE
13	EH=KP	33.176(C)	2ISA $50\times50\times5mm$	62.52(C)	22.8	SAFE
14	HF=PF	82.5(T)	2ISA $50\times50\times5mm$	120(T)	38	SAFE
15	FG	0	2ISA $20\times20\times4mm$	0	4.4	SAFE

Load increase by 20% for **Model M3**

Sr.no	Members	Force in kN	Section selected	Capacity in kN	Weight of member in kg	Remark
1	AC=MB	400.8(C)	2ISA 80×80×10*mm*	353(C)	74.576	UNSAFE
2	CD=ML	343.74(C)	2ISA 80×80×10*mm*	353(C)	74.576	SAFE
3	DE=KL	286.45(C)	2ISA 80×80×10*mm*	353(C)	74.576	SAFE
4	EF=KF	286.45(C)	2ISA 80×80×10*mm*	353(C)	74.576	SAFE
5	AJ=NB	380.23(T)	2ISA 80×80×10*mm*	379(T)	70.8	UNSAFE
6	JI=ON	380.23(T)	2ISA 80×80×10*mm*	379(T)	70.8	UNSAFE
7	IH=OP	325.83(T)	2ISA 80×80×10*mm*	379(T)	70.8	SAFE
8	HG=PG	217.22(T)	2ISA 80×80×10*mm*	379(T)	70.8	SAFE
9	CJ=MN	0	2ISA 20×20×4*mm*	0	2.2	SAFE
10	CI=OM	57.33(C)	2ISA 50×50×5*mm*	62.52(C)	24.016	SAFE
11	DI=LO	18.126(T)	2ISA 25×25×5*mm*	56(T)	7.2	SAFE
12	DH=LP	65.304(C)	2ISA 50×50×5*mm*	62.52(C)	27.36	UNSAFE
13	EH=KP	36.192(C)	2ISA 50×50×5*mm*	62.52(C)	22.8	SAFE
14	HF=PF	90(T)	2ISA 50×50×5*mm*	120(T)	38	SAFE
15	FG	0	2ISA 20×20×4*mm*	0	4.4	SAFE

IV. CALCULATION FOR PRESTRESSING

Member AJ in model M3 were observed unsafe in tension so, this member is analyzed by prestressing.

Tensile force in member AJ $F_1 = 380.23kN$

Cross sectional area of member AJ= $3010mm^2$

Length of member AJ= $1.5m$

Bottom chord member AJ is prestressed by using tendon.

Tendon:-Tendon is made up of 4 wires of 2.5mm dia. And cross sectional area of each wire is $4.908mm^2$ .Therefore, overall cross sectional area of tendon

$$A_t = 4 \times 4.908 = 19.632mm^2$$

The increase of the prestressing force in the tendon will be found by equillbring the elongation of the bottom chord to elongation of the tendon.

Elongation of Member AJ (Δl_1)

$$\Delta l_1 = \frac{F_1 - n_1 \Delta X}{EA_1}$$

Elongation of Tendon (Δl_t)

$$\Delta l_t = \frac{n_1 \Delta X}{E_t A_t}$$

Where,

F_1 =Tensile force in member AJ

ΔX=Increase force in tendon after prestressing

EA_1= Stiffness of member

E_t =Modulus of elasticity of tendon

A_t =Cross section of tendon

n_1 =Number of panel

$$\Delta l_1 = \Delta l_t$$

$$\frac{F_1 - n_1 \Delta X}{EA_1} = \frac{n_1 \Delta X}{E_t A_t}$$

$$\Delta X = \frac{\frac{F_1}{EA_1}}{\frac{n_1}{E_t A_t} + \frac{n_1}{EA_1}}$$

We have,

$F_1 = 380.24kN$

$E = 2 \times 10^5 N/mm^2$

$A_1 = 3010mm^2$

$E_t = 1.95 \times 10^5 N/mm^2$ -(As per IS:1343-1980 table no. 1-7.4)

$A_t = 19.63mm^2$

$n_1 = 1$

By substituting above value in $eq^n 3$ we get,

$\Delta X = 2402.79kN$

The permissible force in one tendon consisting of 4 wires of 2.5 mm dia.

$4 \times 4.908 = 19.63mm^2$

$2010 \times 19.63 = 39456.3N$

As per IS code 1785-1983 (part 1) the permissible stress for 2.5 mm dia of wire is

$$X_0 = X + \Delta X = 39456.3$$

$$X = 39456.3 - 2402.79$$

$$X = 37053.51N$$

The prestressing force is $X = 37.05kN$

Stress in tendon

$$F_t = \frac{X + \Delta X}{A_t}$$

$$= \frac{39456.3}{19.63}$$

$$= 2010N/mm^2$$

Capacity of tendon $= F_t \times A_t$

$$= 2010 \times 19.63$$

$$= 39.45kN$$

After prestressing total capacity becomes

= member capacity+ tendon capacity

$$= 379 + 39.45$$

$$= 418.45kN$$

Hence member is safe now.

V.OBSERVATION AND RESULT

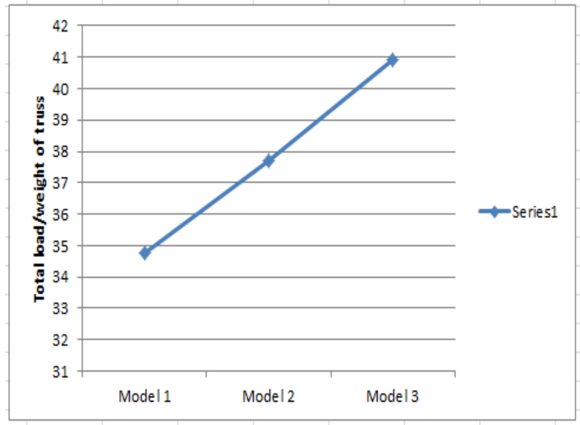
By doing all the calculation for the Model M1, Model M2 and Model M3, it is observed that the load carrying capacity of the truss is increases by modifying the compression member and applying prestressing to the tension member .Ratio of total load to weight of truss and weight of truss to span of truss is calculated for Model M1, Model M2, Model M3.

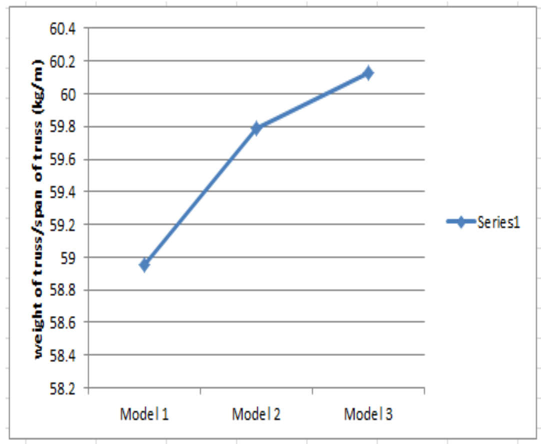
Sr.no	Model M1	
1	Total load /weight of truss	34.78
2	Weight of truss /span of truss(kg/m)	58.95

Sr.no	Model M2	
1	Total load /weight of truss	37.72
2	Weight of truss /span of truss(kg/m)	59.79

Sr.no	Model M3	
1	Total load /weight of truss	40.92
2	Weight of truss /span of truss(kg/m)	60.13

Comparison by Graph: Following comparison is done in between Total load to weight of truss and weight of truss to span of truss for Model M1, Model M2, and Model M3





VI. CONCLUSION

By adopting prestressing in steel structure one can achieve

1. Prestressing increases the load carrying capacity of the structure.
2. By doing prestressing of the steel structure about 12-17 % material can be saved.
3. In the present study, Analysis of truss is carrying out by prestressing due to which the number of trusses reduces.
4. The present study conclude that without dismantling the whole truss ,the capacity of truss can be increases by modifying and applying prestressing to the members of truss .
5. The same analysis can be done in future for purlin span and many other component of truss with dynamic analysis and by changing properties of section.
6. The same concept can be applied to the different types of truss having large span.

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