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Retrofitting of Existing Howe Truss for Additional Loads

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***Abstract*: Many of the steel structures i.e. steel truss roof buildings, industrial sheds with roof trusses got damaged due to recent heavy winds during cyclones. So, they need to be retrofitted by using external retrofitting or suitable materials. Many of the trusses are designed for less wind loads in the past. Such existing trusses should be analyzed with relatively high wind loads and should strengthen the failure members with suitable materials.**

Keywords – Steel truss, Retrofitting, Howe truss

I. INTRODUCTION

A famous conventional hall located in poranki, Vijayawada, India is being renovated with new false ceiling and air conditioning facilities. Previously, Thermocol sheets are used for this ceiling. Now, Gypsum sheets are being used as false ceiling with latest lights and chandelier. Previously, the truss is designed for less loads. But due to this renovation purpose approximately an additional load of 15 ton i.e. 153KN is being imposed on the truss.

In this paper we have considered this particular truss for retrofitting. The truss is designed for less loads. In order to sustain from the additional loads, it should be retrofitted with suitable materials.

The truss used for this structure is Howe truss. The truss is a welded pipe truss. PIPE 603.0M is used for top and bottom chord members. PIPE 337.0M is used for Vertical post members. PIPE 269.0M is used for Inclined braces. The I-sections used for existing columns is ISMB 200 x 100.

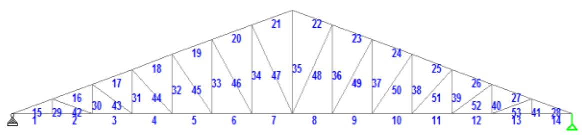


Fig 1 Steel Howe truss

Fig 1 shows the model of the truss and Fig 2 shows the original Steel truss hall

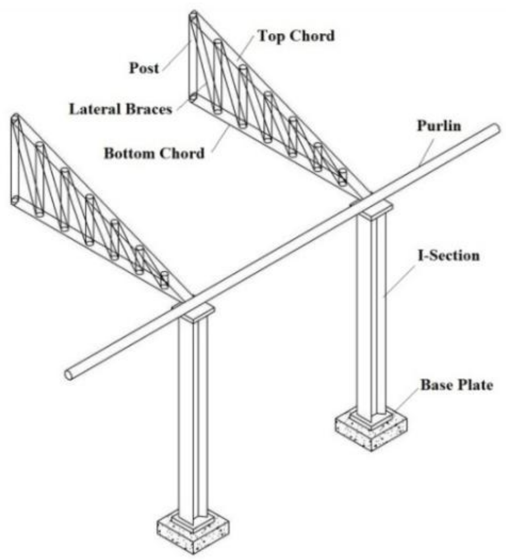
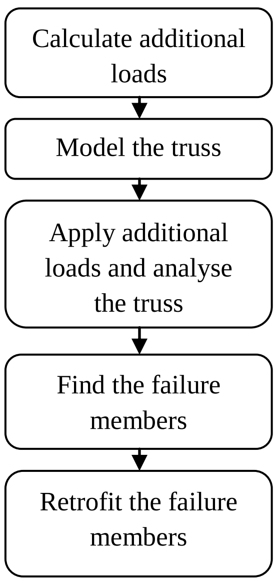


Fig 2 Original Steel truss structure

II. METHODOLOGY



LOADINGS

In the past, the truss is designed for less loads. So the provided sections are safe. But, due to recent cyclones, many of the steel structures are demolished due to heavy winds i.e. more than 200kmph. Even though the location of the structure is not located at the coast, but it is near to the coast. So, there may be chances of heavy winds in future. Hence, we should also consider wind loads. The following are the loads considered for the analysis:

Span = 17.68 m, Height = 2.59 m

No of bays along length = 7

Spacing of trusses = 3.66 m

Weight of sheeting = 170 N/m^2

Weight of purlin = 120 N/m^2

Size of each panel = 1.32 m x 3.66 m

Total Dead Load = 290 x 4.83 = 1.40 KN

Load on shoe: Taking 450mm roof protection load = 290 x (1.32/2 + 0.45) x3.66 = 1178.2 N ≈ 1.2KN

Live Load = 500 N/m^2

LL on intermediate panel points = 500 x 1.32 x 3.66 = 2415.6 N = 2.4 KN

LL on shoe = 500 x (1.32x0.5 + 0.45) x 3.66 = 2031.3 N = 2.00 KN

Wind pressure on windward side = -1.872 KN/m^2

Wind pressure on leeward side = -1.636 KN/m^2

Wind load on panel points on windward side:

a) Intermediate panels = -1.872 x 1.32 x 3.66 = -9.04 KN
b) At crown joint = -4.52 KN
c) At shoe = -1.872 x ((1.32+0.45)/2) x 3.66 = 6.06KN

Wind load on panel points on leeward side:

a) Intermediate panel = -1.636 x 1.32 x 3.66 = -7.90 KN
b) At crown joint = -.3.95 KN
c) At shoe = -1.636 x ((1.32 + 0.45)/2) x 3.66 = 5.3 KN

III. ANALYSIS

The analysis is done both manually and using STAAD.pro software. Working stress method is adopted for the analysis of the members of the truss. The values are similar in both cases. The members of the truss are to be analysed in both cases i.e. under compression and tensile forces. Each member is checked and additional area is calculated according to the procedure. The following is the procedure for members failed in compression:

Member: 1

Maximum Compressive force = 51.22 KN

Maximum Tensile force = 109.45 KN

Length of the member = 1.26 m

Effective length = (0.7 x 1260) = 882 mm

PIPE 603.0M was used

Area, A = 510 mm^2, Radius of gyration, r = 22.65

Slenderness ratio, L/r = 882/22.65 = 38.94

From table 2, IS: 806-1968, clause 5.2

Permissible axial stress in compression,

σ_{ac} = 130.82 N/mm^2

Safe permissible load, Aσ_{ac} = 66.72 KN>51.22 KN

Hence, the member is safe in compression

According to IS: 806-1968, Table 1, Clause 5.1

Permissible tensile stress for Fe250 grade steel = 150 N/mm^2

Tensile stress = (109.45x 10^3) / 510 = 214.61 N/mm^2 > 150 N/mm^2

Hence, the member is not safe in tension

Area required for tension = (109.45 x 10^3) / 150 = 729.67 mm^2

Additional area of steel required = 729.67 – 510 = 219.67 mm^2

The following is the procedure of members failed in Tension:

Member: 15

Maximum Compressive force = 114.06 KN

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Maximum Tensile force = 52.96 KN

Length of the member = 1.32 m

Effective length = (0.7 x 1320) = 924 mm

PIPE 603.0M was used

Area, A = 510 mm^2, Radius of gyration, r = 22.65

Slenderness ratio, L/r = 924/22.65 = 40.790

From table 2, IS: 806-1968, clause 5.2

Permissible axial stress in compression,

σ_{ac} = 129.92 N/mm^2

Safe permissible load, Aσ_{ac} = 66.259 KN < 114.06 KN

Hence, the member is not safe in compression

According to IS: 806-1968, Table 1, Clause 5.1

Permissible tensile stress for Fe250 grade steel = 150 N/mm^2

Tensile stress = (52.96 x 10^3) / 510 = 103.84 N/mm^2 < 150 N/mm^2

Hence, the member is safe in tension

Area required for compression = (510 / 66.259) x 114.06 = 877.93 mm^2

Additional area of steel required = 877.93 – 510 = 367.93 mm^2

IV. RESULTS & DISCUSSIONS

The following is the tabular form of the details regarding member forces, failure members and additional area required:

The abbreviations used for Table 1: Mem – Member, CF – Maximum Compressive Force, TF – Maximum Tensile Force, PSL – Permissible Safe Load in Compression, TS – Tensile Stress, AST – Additional Area Required, P – Pass, F – Fail

TABLE 1 Additional Area required for Failure Members

Mem	Compression			Tension			AST mm^2
	CF KN	PSL KN		TF KN	TS N/mm^2		
BOTTOM CHORD							
1	51.22	66.72	P	109.45	214.61	F	**219.67**
2	51.22	66.72	P	109.45	214.61	F	**219.67**
3	46.05	66.72	P	101.1	198.24	F	**164.0**
4	40.89	66.72	P	92.73	181.82	F	**108.20**
5	35.74	66.72	P	84.34	165.37	F	**52.27**
6	30.6	66.72	P	75.94	148.90	P	-
7	25.47	66.72	P	67.52	132.39	P	-
8	24.12	66.72	P	67.52	132.39	P	-
9	27.89	66.72	P	75.94	148.90	P	-
10	31.67	66.72	P	84.34	165.37	F	**52.27**
11	35.46	66.72	P	92.73	181.82	F	**108.20**
12	39.26	66.72	P	101.1	198.24	F	**164.00**
13	43.07	66.72	P	109.46	214.63	F	**219.73**
14	43.07	66.72	P	109.46	214.63	F	**219.73**
TOP CHORD							
15	114.06	66.26	F	52.96	103.84	F	**367.92**
16	105.36	66.26	F	49.34	96.75	F	**300.96**
17	96.64	66.26	F	45.74	89.69	F	**233.84**
18	87.90	66.26	F	42.16	82.67	F	**166.57**
19	79.14	66.26	F	38.57	75.63	F	**99.14**
20	70.37	66.26	F	35.01	68.65	F	**31.64**
21	61.58	66.26	P	31.45	61.67	P	-
22	61.58	66.26	P	31.57	61.90	P	-
23	70.36	66.26	F	33.93	66.53	F	**31.56**
24	79.13	66.26	F	36.31	71.20	F	**99.07**
25	87.88	66.26	F	38.7	75.88	F	**166.42**
26	96.63	66.26	F	41.09	80.57	F	**233.77**
27	105.35	66.26	F	43.5	85.29	F	**300.88**
28	114.07	66.26	F	45.93	90.06	F	**368.0**
VERTICAL POSTS							
29	-	42.96	P	1.02	2.00	P	-
30	0.82	39.36	P	3.5	6.86	P	-
31	2.33	35.56	P	5.97	11.71	P	-
32	3.83	29.97	P	8.45	16.57	P	-
33	5.33	22.55	P	10.93	21.43	P	-
34	6.82	16.91	P	13.43	26.33	P	-
35	14.9	12.61	F	30.78	60.35	P	**56.44**
36	4.83	16.91	P	13.43	26.33	P	-
37	3.73	22.55	P	10.93	21.43	P	-
38	2.64	29.97	P	8.45	16.57	P	-
39	1.53	35.56	P	5.97	11.71	P	-
40	0.43	39.36	P	3.5	6.86	P	-

41	-	42.96	P	1.02	2.00	P	-
INCLINED BRACES							
42	8.7	16.97	P	5.39	26.68	P	-
43	9.71	14.83	P	5.98	29.60	P	-
44	11.18	11.93	P	6.86	33.96	P	-
45	12.96	9.14	F	7.92	39.21	P	**84.35**
46	14.95	6.88	F	9.11	45.10	P	**236.80**
47	17.08	5.2	F	10.36	51.29	P	**461.82**
48	17.08	5.2	F	7.62	37.72	P	**461.82**
49	14.95	6.88	F	6.7	33.17	P	**236.80**
50	12.96	9.14	F	5.83	28.86	P	**84.35**
51	11.18	11.93	P	5.05	25.0	P	-
52	9.71	14.83	P	4.41	21.83	P	-
53	8.7	16.97	P	3.98	19.70	P	-

The below are the pictures of retrofitted members. Fig 3 shows the inclined braces welded with 20mm and 16mm diameter bars.

Fig 3 Inclined braces welded with 16mm and 20mm dia. Bars

There is a scope for analysing the truss after retrofitting by using finite element analysis applications like Ansys and can assess the capacity of the truss until which loads it can withstand.

V. CONCLUSIONS

The following conclusions can be obtained from the study:

- One third of the bottom chord members of the truss failed due to tension.
- One third of the top chord members of the truss failed due to compression.
- Most of the horizontal members are safe.
- Half of the inclined members failed due to compression
- Additional area can be provided to the failed members by welding the members with additional steel sections.
- The truss can be retrofitted economically by provided calculated additional area.

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