Analysis and Design of Airport Hangar

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Abstract— This paper describes about the planning, analysis and design of portable frame hangar to be built at Chennai. Normally lot of internal space is required for hangar, so it is preferable to build a portal frame. In this project analysis will be done both manually and by using STAADPro. The following components will be designed as per IS Standards Roof truss, purlin, columns, bases and footing will be designed. The hangar to be designed is a “FREE STANDING AIRCRAFT HANGAR”.

Keywords: Airport Hangar, Plastic Analysis, STAADPro

I. Introduction

A. General:

A hangar is a closed building structure to hold aircraft or spacecraft. Hangars are used for protection from the weather, direct sunlight, maintenance, repair, manufacture, assembly and storage of aircraft, aircraft carriers and ships. The primary function of a hangar is to provide an enclosure for servicing overhauling and doing repairs of the aircrafts. They are usually constructed of steel frames and covered with galvanised iron sheets. The shape of a hangar should be such that it covers minimum land area and yet provides educate space for storage and comfortable manoeuvring of aircrafts.

II. Aircraft Hanger Dimensions and Layout

A. Aircraft Dimension:

Boeing 747-200
Length = 68.6m
Height = 19.6m
Width = 59.6m

1) Hanger Dimension:

Length = 68.6m
Consider single bay as 6m
Provide 6 bays
12 x 6m = 72m
Provide length = 72m
Height = 19.6 + Free board
= 19.6 + 2.4
Height = 22m
Width = 3.2 + 59.6 + 3.2 (3.2m as clearance)
Width = 66m
Type of truss = Howe roof truss (North light roof truss)

B. Layout of Aircraft Hanger

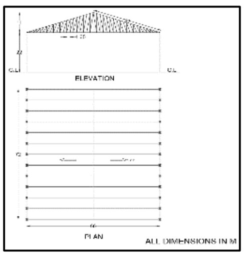


Fig. 1: Layout of aircraft hangar

III. Design Calculations

A. Total Load Acting on Truss:

Dead load W = 4 KN
W / 2 = 2 KN
Live load W = 5.75 KN
W / 2 = 2.875 KN
Wind load W = 23.25 KN
W / 2 = 11.625 KN

B. Design of Purlin

1) Bending Moment:

M_{xx} = 11.34 KNm
M_{yy} = 3.78 KNm
ISMC 200
$Z_p = 141.372 \times 10^3 \text{ mm}^2$ (Required)
Provided $Z_p = 181.6 \times 10^3 \text{ mm}^2$ (From steel table)
Z_p Required < Z_p Provided
$141.372 \times 10^3 < 181.6 \times 10^3$
Hence safe

2) Section Classification:

$b_f / t_f = 75 / 11.4 = 6.5 < 9.4$
$d_w / t_w = 165 / 6.1 = 27.04 < 42$
Hence the section is plastic

C. Design of Truss Member

1) Data’s to be collected for tension force:

Tension force T = 666.124 KN (member: 1750)
For ISA 180 X 180 X 15 Single angle

2) Gross section yielding:

$T_{dg} = A_g \times F_y / \gamma_{mo}$
$T_{dg} = 1176.13 \text{ KN} > 666.124$
Hence safe

3) Net section Rupture:

$T_{dn} = 0.9 A_{nc} F_u / \gamma_{m1} + \beta A_{go} F_y / \gamma_{m0}$
$T_{dn} = 1569.69 \text{ KN} > 666.12 \text{ KN}$
Hence safe

4) Block shear criteria:

$T_{db1} = A_{vg} F_y / \sqrt{3} \times \gamma_{mo} + 0.9 A_{tn} F_u / \gamma_{m1}$
$T_{db2} = 0.9 A_{vn} F_u / \sqrt{3} \times \gamma_{m1} + A_{tg} F_y / \gamma_{mo}$

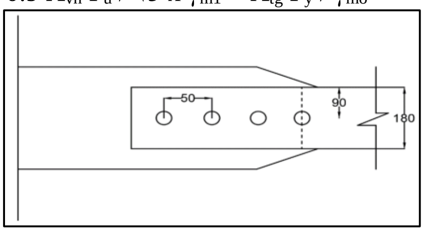


Fig. 2: Bolted connection

$T_{db1} = 712.958 \text{ KN} > 666.124 \text{ KN}$
$T_{db2} = 706.63 \text{ KN} > 666.124 \text{ KN}$
Hence safe

5) Data’s to be collected for compression force:

Compression force = 851.214 KN (member 1751)
For ISA 200 X 150 X 18

Single angle

6) Design compressive load:

P_d = A_e F_{cd}

P_d = 1284.2 x 10^3 N > 851.214 KN

Hence safe

D. Design of Column

1) Data's to be collected:

P = 243.28 KN

For section ISWB 500

2) Buckling class:

h / b_f = 500 / 250

= 2 > 1.2

t_f = 14.7 < 40

Hence the column belongs to Buckling class 'a' about zz axis

'b' about yy axis

P_d = F_{cd} A

P_d = 2562 KN > 243.285 KN

Hence safe

By interpolation for class 'b'

P_d = F_{cd} A

P_d = 584.28 KN > 243.285 KN

Hence safe

E. Design of Base Plate

Projected area

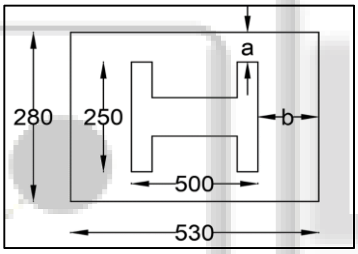


Fig. 3: Column located on base plate

a = 280 – 250 / 2

= 15mm

b = 530 – 500 / 2

= 15mm

1) Thickness of base plate:

t_s = 2.10mm

$t_s \ngtr t_f$

2.10mm $\ngtr$ 14.7mm

So, provide 15mm thickness of base plate

Connecting 530 x 280 x 15mm base plate to concrete foundation

Use 4 Nos of 20mm ø of anchorage bolt @ 500mm length

2) Connection details:

When the column hence a base plate having been cutter by machine for perfect bearing load from the column will be transfer to base plate by using welted connection.

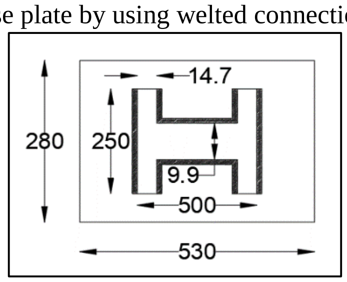


Fig. 4: Welted connection

Total length available = 2 (250 + 250 – 9.9 + 500 – 14.7)

= 1950.8mm

Strength of weld = 410 / √3 x 1 / 1.25

= 189.37 N/mm^2

The effective area of weld = 0.7 t L_e p

= 0.7 x 4 x L_e x 189.37

= 378.641 x 10^3

Use 4mm weld L_e = 714.09mm < 1950.8mm

Hence safe provide 4mm weld

F. Design of Footing

1) Check for one-way shear:

τ_v = V_u / bd

V_u = q_a b [B / 2 – L / 2 – d]

q_a = 94.44 x 1.5

q_a = 141.66 KN/m^2

V_u = 0.14166 (b) [2100 / 2 – 550 / 2 – d]

Assume percentage of steel as 0.15%

τ_v = V_u / bd

= 0.141 (b) [1050 – 275 – d] / b d

Consider τ_c as τ_v

τ_c = 0.28 for 0.15% of steel

0.28 d = 0.14 (1050 – 255 – d)

0.28 d = 111.3 – 0.14 d

d = 270mm

D = 325mm

2) Two-way shear (punching shear):

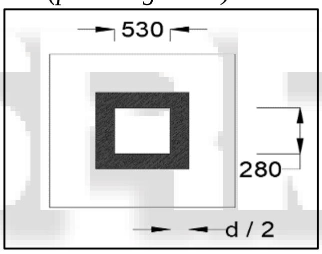


Fig. 5: Punching shear in footing

L_p = 2[d / 2+d / 2+530] +2 [d / 2+d / 2+280]

L_p = 2700mm

Permissible stress= 0.25 √Fck

= 0.25 x √30

= 1.36 N/mm^2

0.57 N/mm^2 < 1.36 N/mm^2

Hence safe

3) Reinforcement calculation:

A_{st} = Pt bd / 100

= 0.07 / 100 x 1000 x 270

A_{st} = 189mm^2

Minimum percentage of steel = 0.12% of bD

= 0.12 / 100 x 1000 x 325

A_{st} = 390mm^2

ast = π / 4 x 10^2

= 78.5mm^2

Spacing = ast / A_{st} x 1000

= 78.5 / 390 x 1000

Spacing = 201mm ~ 200mm

Provide 200mm C/C spacing of 10mm ø 0f bar

IV. PLASTIC ANALYSIS

A. Beam Mechanism:

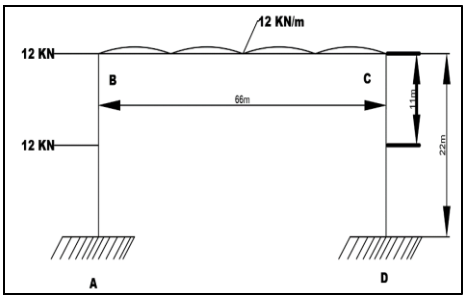


Fig. 6: Beam Mechanism

Mp = 2178 KNm

B. Column Mechanism:

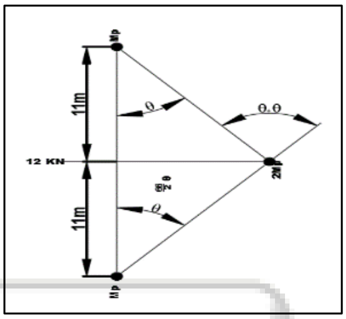


Fig. 7: Column Mechanism

Mp = 22 KNm

C. Sway Mechanism:

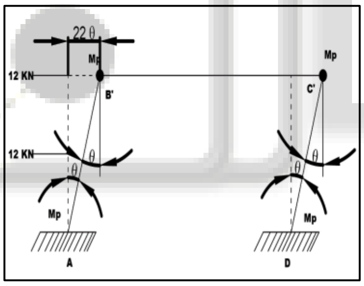


Fig. 8: Sway Mechanism

Mp = 99 KNm

D. Combined Mechanism:

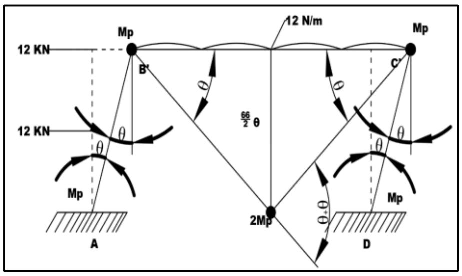


Fig. 9: Combined Mechanism

Mp = 1683 KNm

Hence the plastic moment of resistance, Mp = 2178 KNm

V. STAAD PRO ANALYSIS

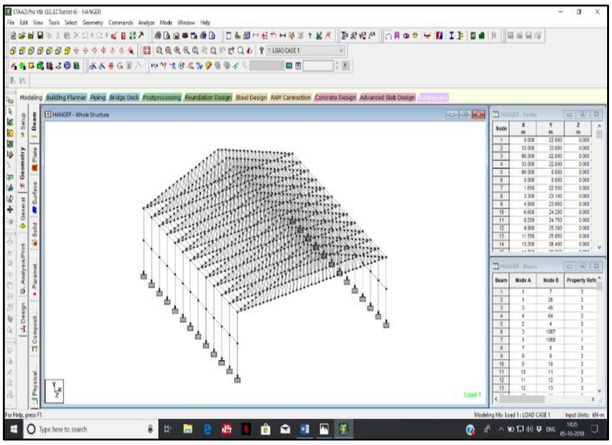
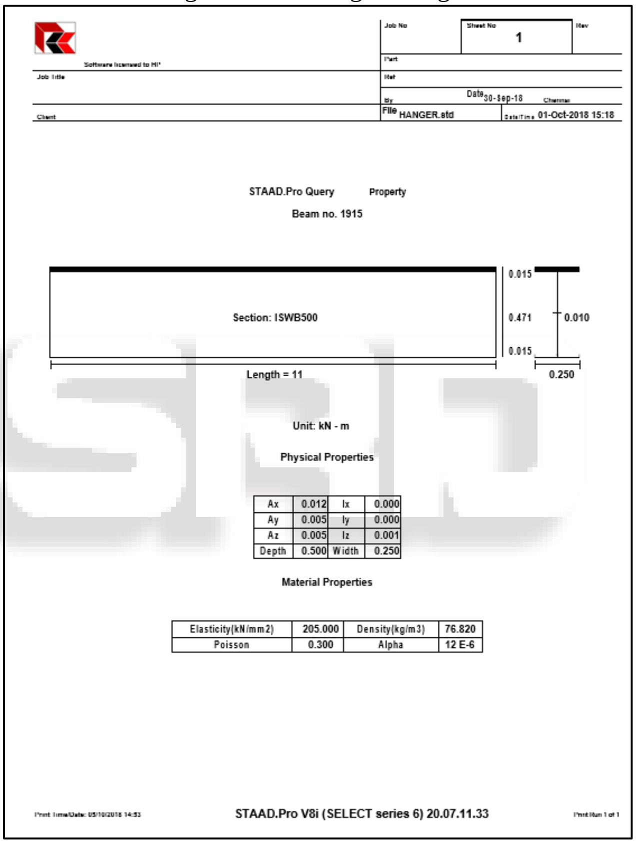


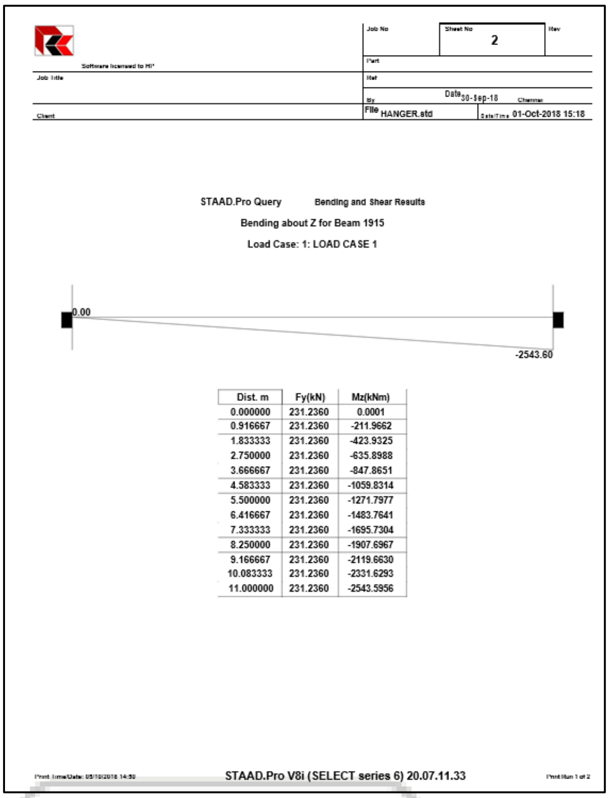
Fig. 10: Modelling of hangar



Ax	0.012	Ix	0.000
Ay	0.005	Iy	0.000
Az	0.005	Iz	0.001
Depth	0.500	Width	0.250

Elasticity(kN/mm2)	205.000	Density(kg/m3)	76.820
Poisson	0.300	Alpha	12 E-6

Fig. 11: Property



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Job Title

Client

STAAD.Pro Query Bending and Shear Results

Bending about Z for Beam 1915

Load Case: 1: LOAD CASE 1

Dist. m	Fy(kN)	Mz(kNm)
0.000000	231.2360	0.0001
0.916667	231.2360	-211.9662
1.833333	231.2360	-423.9325
2.750000	231.2360	-635.8988
3.666667	231.2360	-847.8651
4.583333	231.2360	-1059.8314
5.500000	231.2360	-1271.7977
6.416667	231.2360	-1483.7641
7.333333	231.2360	-1695.7304
8.250000	231.2360	-1907.6967
9.166667	231.2360	-2119.6630
10.083333	231.2360	-2331.6293
11.000000	231.2360	-2543.5956

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Fig. 12: Bending and Shear Results

VI. STAAD PRO DESIGN RESULTS

Group No	Group Name	Member number	Original section	Design section	Member spec	slenderness check	Axial check	combination of axial & bend check	Shear along y check	Shear along z check
G1	Design Grc	M1	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M2	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M3	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M4	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M5	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M6	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M7	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M8	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M9	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M10	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M11	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M12	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M13	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M14	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M15	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M16	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M17	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M18	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M19	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M20	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M21	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M22	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0
		M23	ISWB500	ISWB500	BEAM	PASS	N/A	PASS	PASS	PASS
						0	N/A	0	0	0

Table 1:

VII. CONCLUSION

In our project we have analyzed and designed "Free standing aircraft hangar" both in staad pro as well as manually based on the dimensions of "Boeing 747-200" aircraft. From this project we have learnt that for a portable frame structure free standing hangar is suitable. This project we have designed steel structures such as truss, purlin, column, beam, and base plate from code books of IS standards on Indian conditions. So overall comparing manual calculations and staad pro out puts staad pro analysis and design is more essential and time saving and more over all sections for beams and columns are automatically selected by the software based on best preference or satisfying all conditions economically. We have learnt how to make use of code books to design steel structures and how to complete a project.

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