Kurdistan Regional Government-Iraq

Kurdistan Engineers union

Report Title

Steel Truss Design.

By

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2025-2024

Abstract

This study examines the design principles, materials, construction methods, and applications of steel trusses in modern architecture. It emphasizes the value of load distribution, material selection, and structural analysis while demonstrating how steel trusses provide dependable and efficient solutions for large-span constructions. The research provides an overview of the design processes, including everything from basic inspiration to detailed analysis and optimization using state-of-the-art software and analytical methodologies. Steel trusses are beneficial and advantageous in a variety of architectural scenarios, as demonstrated by case studies.

Contents

1 Introduction

Steel trusses are an essential part of civil engineering and architectural projects because of their great load-bearing capability and ability to span huge distances with little material consumption. These structures are perfect for applications like roofs, towers, and bridges because they are made of linked triangle components that distribute stresses efficiently. The purpose of this paper is to present a thorough review of steel truss design and analysis, with an emphasis on important concepts, materials, techniques, and practical applications.

2 METHODOLOGY

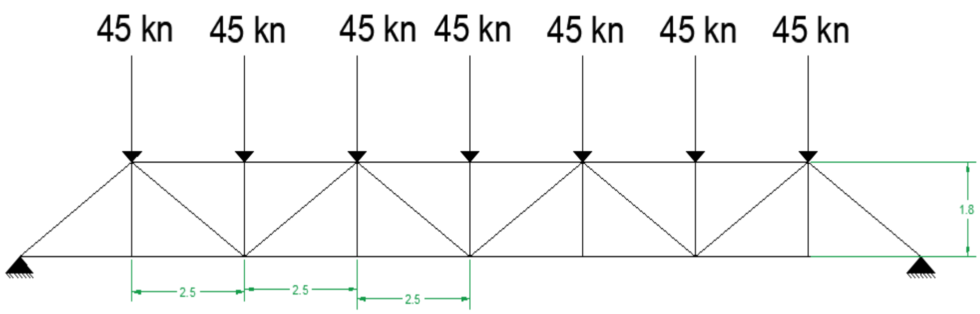
Numerous crucial processes are involved in the design of steel trusses, such as comprehensive structural analysis, member selection, load analysis, and connection design. The following is the report's methodology:

1. Literature Review: Examining current studies and recommendations, such as those issued by the American Institute of Steel Construction (AISC), to identify best practices.
2. Load analysis: figuring out what kinds of loads (live, dead, wind, seismic) and how much of each the truss needs to support.
3. Preliminary Design: Creating preliminary member sizes and truss layouts in accordance with load calculations and architectural specifications.
4. Member and Connection Design: To guarantee strength and stability, the right steel sections should be chosen, and joints should be designed.
5. Analytical Methods: For initial force estimates, use techniques like the method of joints and method of sections.

6 Computational Analysis: Employing software tools (e.g., SAP2000, STAAD.Pro, ANSYS) for extensive modeling and analysis.

7. Optimization: Adapting the design to attain structural performance and material economy.
8. Case Studies: Examining particular instances of steel truss usage to highlight design concepts.

3 Case studies



truss from 8 spans each span 2.5 m length, height of truss is 1.8 m ,load

Design of the truss

1 first step analysis of the members

By analyses this truss we found this date for each member

member no	member length m	exile load in kn
1	2.5	-125
2	2.5	-125
3	2.5	125
4	2.5	125

5	2.5	125
6	2.5	125
7	2.5	-125
8	2.5	-125
9	3.08058	-269.551
10	2.5	-375
11	2.5	-375
12	2.5	-500
13	2.5	-500
14	2.5	-375
15	2.5	-375
16	3.08058	-269.551
17	1.8	0
18	3.08058	192.537
19	3.08058	-115.522
20	0	38.507
21	3.08058	38.507
22	0	-115.522
23	3.08058	192.537
24	0	-45
25	1.8	0
26	0	-45
27	0	0
28	1.8	-45
29	0	0

This date analyzed by sap 2000

Biggest member in compression is 500 kn

Biggest member in tension is 192.537 kn

Convert KN to kips

500Kn =112.4Kips

192.537 KN =43.28kips

2Design

Design of compression member:

Pu =112.4kips

The section we chose (Double Angle Section) with

equal legs according to AISC specifications with (1/4`` thickness).as shown in fig no 3

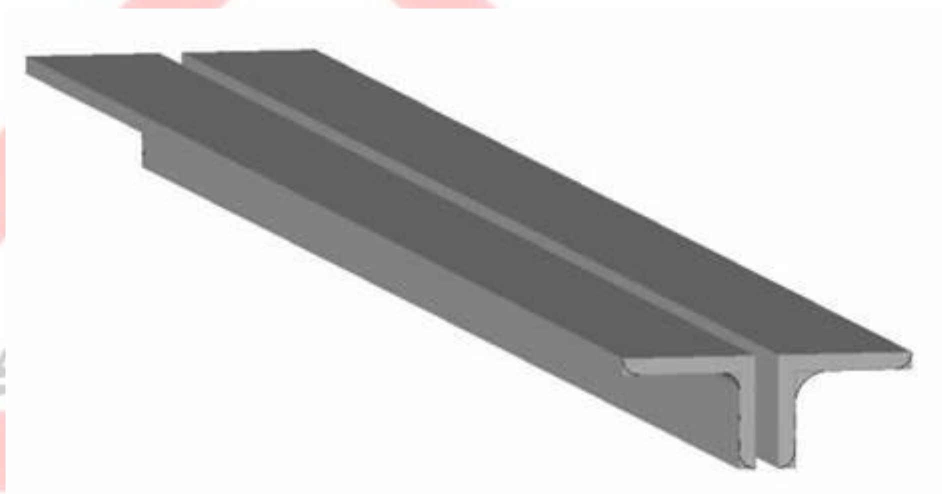


Fig no 3 double angel section

Because all joints are pin so (K)= 1

Section 2L 4x4 ¼

$$L = \frac{2.5}{0.3048} = 8.2ft \quad , K = 1$$

$$KL = 1 * 8.2 = 8.2$$

From table 4-8

Section 2L 4x4 ¼ $2L4 * 4 * \frac{1}{4} \rightarrow \emptyset Pn = 89.5 < 112.4 \quad \therefore not\ OK$

Section 2L 4x4 3/8 $\emptyset Pn$ =134

Check the section from table 4-22

From table 4-22 $\frac{KL}{r} = 80$, $Fy = 36$

$\emptyset cFcr = 22.7 \rightarrow \emptyset pn = \emptyset cFcr * Ag$

$\emptyset pn = 22.7 * 5.72 = 129.8 > 112.4kips \quad \therefore OK$

$$\frac{KL}{r} = 80 < 4.71\sqrt{\frac{E}{Fy}} \rightarrow 4.71 * \sqrt{\frac{29000}{36}} = 133.68 ; \frac{KL}{r} = 80 < 133.68$$

Ok

$$\therefore use\ Fcr = (0.658)^{\frac{fy}{Fe}} * Fy \quad ; Fe = \frac{\pi^2 * E}{(KL/r)^2} = Fe = \frac{\pi^2 * 29000}{(80)^2} = 44.67$$

$Fcr = (0.658)^{36/44.67} * 36 = 25.69$

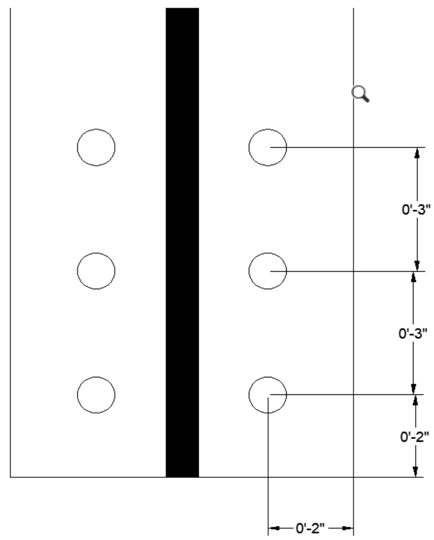
$\emptyset cPn = \emptyset cFcr * Ag = 0.9 * 25.69 * 5.72 = 121.8$>112.4 $\quad \therefore OK$

$\frac{KL}{r} = 80 < 200 \quad \therefore OK$

Check the local buckling: -

The shape (2L4*4*3/8) is not slender (there is not footnote in the dimensions and properties indicate that it is) so local buckling does not have to be investigated.

Design of Tension members:



Pu =192.537 KN =43.28kips

$Fy = 36kips\ ; \quad Fu = 58kips$

Use double angle section

$2L4 * 4 * \frac{3}{8}\ ; \quad Ag = 5.72in^2$

$1)\emptyset pn(yield) = 0.9 * Fy * Ag = 0.9 * 5.72 * 36 = 185.32kips$

$\boldsymbol{Fracture\ Strength}$

$A_n = A_g - 2\left(Area\ of\ one\ bolt\ + \frac{1}{8}\right) * \ Thickness$

$An = 5.72 - \left(2\left(\frac{7}{8} + \frac{1}{8}\right)\right) * \frac{3}{8} = \ 4.97\ inch^2$

From table 1.7

$x' = 1.13 \quad , \ u = 1 - \frac{1.13}{6} = 0.81$

$Ae = 4.97 * 0.81 = 4in^2$

$2)\emptyset pn(ultimate) = 0.75 * Fu * Ae = 0.75 * 58 * 4 = 174 > 43\ \therefore OK$

Check for block shear

$Ag(v) = 8 * \frac{3}{8} * 2 = 6in^2$

$A(n)(v) = 6 - \left[2.5\left(\frac{7}{8} + \frac{1}{8}\right) * \frac{3}{8} * 2\right] = 4.125in^2$

$Ag(t) = 2 * \frac{3}{8} * 2 = 1.5in^2$

$An(t) = 1 - \left[0.5 * \frac{3}{8} * 2\right] = 1.125in^2$

1) $\emptyset(0.6 * fy * Ag(v) + Fu * An(t)) =$
2) $\emptyset(0.6 * Fu * An(v) + Fy * Ag(t)) =$
3) $\emptyset(0.6 * Fu * An(v) + Fy * Ag(t)) =$

1) $0.75(0.6 * 36 * 6 + 58 * 1.125) = 146.13kips$

2)$0.75(0.6 * 58 * 4.125 + 58 * 1.125) = 156.6kips$

4) $\emptyset(0.6 * 58 * 4.125 + 36 * 1.125) = 138.1kips$

$\therefore All\ of\ this\ results\ > Pu = 43kips \quad \therefore OK$

$L/r = \frac{3.06/0.3048}{1.23} = 100 < 300 \quad \therefore OK$

Discussion and Result

From the result of the analysis and design of the members the section 2L4x4 3/8 it is suitable for all members and its best type according to the load on the member economical and safe

Below shown same date from analyzed truss by SAP200 that we used.

Table: Active Degrees of Freedom

Table: Active Degrees of Freedom

UX	UY	UZ	RX	RY	RZ
Yes	Yes	Yes	Yes	Yes	Yes

Table: Analysis Options, Part 1 of 2

Table: Analysis Options, Part 1 of 2

Solver	SolverProc	Force32Bit	StiffCase	GeomMod	HingeOpt	NumAThreads	MaxFileSize	NumDThreads
Advanced	Auto	No	None	None	In Elements	0	0	0

Table: Analysis Options, Part 2 of 2

Table: Analysis Options, Part 2 of 2

NumRThreads	UseMMFiles	AllowDiff
0	Program Determined	No

Table: Auto Wave 3 - Wave Characteristics - General

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WaveChar	WaveType	KinFactor	SWaterDepth m	WaveHeight m	WavePeriod Sec	WaveTheory
Default	From Theory	1.	45.	18.	12.	Linear

Table: Case - Modal 1 - General

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Case	ModeType	MaxNum Modes	MinNum Modes	EigenShift Cyc/sec	EigenCutoff Cyc/sec	EigenTol	AutoShift
MODAL	Eigen	12	1	0.0000E+00	0.0000E+00	1.0000E-09	Yes

Table: Case - Static 1 - Load Assignments

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Case	LoadType	LoadName	LoadSF
POINT LOAD	Load pattern	POINT LOAD	1.

Table: Connectivity - Frame, Part 1 of 2

Table: Connectivity - Frame, Part 1 of 2

Frame	JointI	JointJ	IsCurved	Length m	CentroidX m	CentroidY m	CentroidZ m
1	1	2	No	2.5	1.25	0.	0.
3	2	4	No	2.5	3.75	0.	0.
4	4	5	No	2.5	6.25	0.	0.

Table: Connectivity - Frame, Part 1 of 2

Frame	JointI	JointJ	IsCurved	Length	CentroidX	CentroidY	CentroidZ
				m	m	m	m
5	5	6	No	2.5	8.75	0.	0.
6	6	7	No	2.5	11.25	0.	0.
7	7	8	No	2.5	13.75	0.	0.
8	8	9	No	2.5	16.25	0.	0.
9	9	10	No	2.5	18.75	0.	0.
10	10	11	No	3.08058	18.75	0.	0.9
11	11	12	No	2.5	16.25	0.	1.8
12	12	13	No	2.5	13.75	0.	1.8
13	13	14	No	2.5	11.25	0.	1.8
14	14	15	No	2.5	8.75	0.	1.8
15	15	16	No	2.5	6.25	0.	1.8
16	16	17	No	2.5	3.75	0.	1.8
17	17	1	No	3.08058	1.25	0.	0.9
18	2	17	No	1.8	2.5	0.	0.9
19	17	4	No	3.08058	3.75	0.	0.9
20	4	15	No	3.08058	6.25	0.	0.9
21	15	6	No	3.08058	8.75	0.	0.9
22	6	13	No	3.08058	11.25	0.	0.9
23	13	8	No	3.08058	13.75	0.	0.9
24	8	11	No	3.08058	16.25	0.	0.9
25	4	16	No	1.8	5.	0.	0.9
26	5	15	No	1.8	7.5	0.	0.9
27	6	14	No	1.8	10.	0.	0.9
28	7	13	No	1.8	12.5	0.	0.9
29	8	12	No	1.8	15.	0.	0.9
30	9	11	No	1.8	17.5	0.	0.9

Table: Frame Output Station Assignments

Table: Frame Output Station Assignments

Frame	StationType	MinNumSta	MaxStaSpcgm	AddAtElmInt	AddAtPtLoad
1	MaxStaSpcg		0.5	Yes	Yes
3	MaxStaSpcg		0.5	Yes	Yes
4	MaxStaSpcg		0.5	Yes	Yes
5	MaxStaSpcg		0.5	Yes	Yes
6	MaxStaSpcg		0.5	Yes	Yes
7	MaxStaSpcg		0.5	Yes	Yes
8	MaxStaSpcg		0.5	Yes	Yes
9	MaxStaSpcg		0.5	Yes	Yes
10	MinNumSta	3		Yes	Yes
11	MaxStaSpcg		0.5	Yes	Yes
12	MaxStaSpcg		0.5	Yes	Yes
13	MaxStaSpcg		0.5	Yes	Yes
14	MaxStaSpcg		0.5	Yes	Yes
15	MaxStaSpcg		0.5	Yes	Yes
16	MaxStaSpcg		0.5	Yes	Yes

Table: Frame Output Station Assignments

Frame	StationType	MinNumSta	MaxStaSpcg m	AddAtElmInt	AddAtPtLoad
17	MinNumSta	3		Yes	Yes
18	MinNumSta	3		Yes	Yes
19	MinNumSta	3		Yes	Yes
20	MinNumSta	3		Yes	Yes
21	MinNumSta	3		Yes	Yes
22	MinNumSta	3		Yes	Yes
23	MinNumSta	3		Yes	Yes
24	MinNumSta	3		Yes	Yes
25	MinNumSta	3		Yes	Yes
26	MinNumSta	3		Yes	Yes

RAMPTH	4.	1.
UNIFTH	0.	1.
UNIFTH	1.	1.

Table: Grid Lines, Part 1 of 2

Table: Grid Lines, Part 1 of 2

CoordSys	AxisDir	GridID	XRYZCoord m	LineType	LineColor	Visible	BubbleLoc
GLOBAL	X	A	0.	Primary	Gray8Dark	Yes	End
GLOBAL	X	B	2.5	Primary	Gray8Dark	Yes	End
GLOBAL	X	C	5.	Primary	Gray8Dark	Yes	End
GLOBAL	X	D	7.5	Primary	Gray8Dark	Yes	End
GLOBAL	X	E	10.	Primary	Gray8Dark	Yes	End
GLOBAL	X	F	12.5	Primary	Gray8Dark	Yes	End
GLOBAL	X	G	15.	Primary	Gray8Dark	Yes	End
GLOBAL	X	H	17.5	Primary	Gray8Dark	Yes	End
GLOBAL	X	I	20.	Primary	Gray8Dark	Yes	End
GLOBAL	Y	1	0.	Primary	Gray8Dark	Yes	Start
GLOBAL	Z	Z1	0.	Primary	Gray8Dark	Yes	End
GLOBAL	Z	Z2	1.8	Primary	Gray8Dark	Yes	End

Table: Grid Lines, Part 2 of 2

Table: Grid Lines, Part 2 of 2

CoordSys	AllVisible	BubbleSize m
GLOBAL	Yes	0.4375
GLOBAL		
GLOBAL		
GLOBAL		
GLOBAL		
GLOBAL		
GLOBAL		
GLOBAL		
GLOBAL		

Table: Grid Lines, Part 2 of 2

CoordSys	AllVisible	BubbleSize
		m
GLOBAL		
GLOBAL		
GLOBAL		

Table: Groups 1 - Definitions, Part 1 of 3

Table: Groups 1 - Definitions, Part 1 of 3

GroupName	Selection	SectionCut	Steel	Concrete	Aluminum	ColdFormed	Stage
ALL	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table: Groups 1 - Definitions, Part 2 of 3

Table: Groups 1 - Definitions, Part 2 of 3

GroupName	Bridge	AutoSeismic	AutoWind	SelDesSteel	SelDesAlum	SelDesCold	MassWeight
ALL	Yes	No	No	No	No	No	Yes

Table: Groups 1 - Definitions, Part 3 of 3

Table: Groups 1 - Definitions, Part 3 of 3

GroupName	Color
ALL	Red

Table: Groups 3 - Masses and Weights

Table: Groups 3 - Masses and Weights

GroupName	SelfMass	SelfWeight	TotalMass X	TotalMass Y	TotalMass Z
	KN-s2/m	KN	KN-s2/m	KN-s2/m	KN-s2/m
ALL	0.87	8.521	0.87	0.87	0.87

Table: Joint Coordinates, Part 1 of 2

Table: Joint Coordinates, Part 1 of 2

Joint	CoordSys	CoordType	XorR	Y	Z	SpecialJt	GlobalX
			m	m	m		m
1	GLOBAL	Cartesian	0.	0.	0.	No	0.
2	GLOBAL	Cartesian	2.5	0.	0.	No	2.5
4	GLOBAL	Cartesian	5.	0.	0.	No	5.
5	GLOBAL	Cartesian	7.5	0.	0.	No	7.5
6	GLOBAL	Cartesian	10.	0.	0.	No	10.
7	GLOBAL	Cartesian	12.5	0.	0.	No	12.5
8	GLOBAL	Cartesian	15.	0.	0.	No	15.
9	GLOBAL	Cartesian	17.5	0.	0.	No	17.5
10	GLOBAL	Cartesian	20.	0.	0.	No	20.
11	GLOBAL	Cartesian	17.5	0.	1.8	No	17.5
12	GLOBAL	Cartesian	15.	0.	1.8	No	15.
13	GLOBAL	Cartesian	12.5	0.	1.8	No	12.5
14	GLOBAL	Cartesian	10.	0.	1.8	No	10.
15	GLOBAL	Cartesian	7.5	0.	1.8	No	7.5
16	GLOBAL	Cartesian	5.	0.	1.8	No	5.
17	GLOBAL	Cartesian	2.5	0.	1.8	No	2.5

Table: Joint Coordinates, Part 2 of 2

Table: Joint Coordinates, Part 2 of 2

Joint	GlobalY m	GlobalZ m	GUID
1	0.	0.	77f10cb4-75c1-4d4c-b7b5-d831129fd35d
2	0.	0.	6d9752b7-86b8-45ad-88d7-bda2e6fdc196

Conclusion

For this type of truss that we designed the compression member controlled the truss because the load on the compression member larger than the tension so chosen the section 2L4x4 3/8 that controlled all members

Reference

Steel Bridge Competition 2018 Rules, 1st ed., ASCE / AISC, 2017.
American Iron and Steel Institute North American Specification for the Design of Cold- Formed Steel Structural Members, 2016.
Steel building design: Introduction to the Eurocodes (P361) The Steel Construction Institute, 2009 Steel building design: Concise Eurocodes (P362) The Steel Construction Institute, 2009 Steel building design: Design data (P363) The Steel Construction Institute and The British Constructional Steelwork Association, 2009 Steel building design: Worked examples – open sections (P364) The Steel Construction Institute, 2009 Handbook of Structural Steelwork (Eurocode Edition) (P366) The British Constructional Steelwork Association and The Steel Construction Institute, 2009 Steel building design: Worked Examples - hollow sections (P374) The Steel Construction Institute, 2009 Steel building design: Fire resistant design (P375) The Steel Construction Institute, 2009 Steel building design: Worked examples for students (Without National Annex values) (P376) The Steel Construction Institute, 2009 Architectural Teaching Resource Studio Guide – Second Edition (P167) The Steel Construction Institute, 2003