TRENCH SHIELD TABULATED DATA

A COPY OF THIS SHEET MUST ACCOMPANY EACH CORRESPONDING TRENCH SHIELD AT EVERY JOB SITE

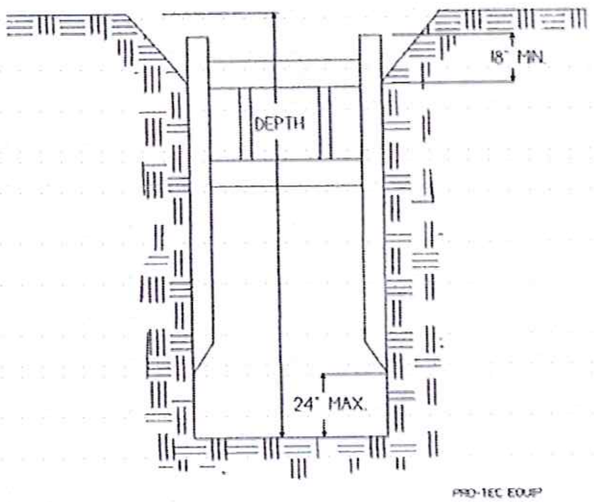
MODEL NUMBER: TSR PRO-4 820 KE

SERIAL NUMBER: 30962

SOIL	MAX DEPTH	PSF
TYPE A	46 - FT	*1320
TYPE B	27 - FT	
TYPE C60	22 - FT	
TYPE C80	17 - FT	

*Shield Capacity based on C60 soil at bottom of the excavation.

DATE MANUFACTURED: 03/27/15
SHIELD WEIGHT: 9,664 - LB
SHIELD SIZE: 8 - FT X 20 - FT
SPREADER SIZE: 8 IN SCH 80
MAX SPREADER LENGTH: 20 - FT



LIMITATIONS:

1. Soil above shield must be sloped according to OSHA Subpart P. Slope must begin no less than 18" below the top of shield.
2. Shield may be suspended no more than 2 feet above bottom of the trench and only if there is no possible loss of soil from behind or below bottom of shield.
3. A minimum of 2 spreader pipes are required on each end with manufacturer approved 2-in diameter pins and keepers.
4. Repairs and modifications shall be approved in writing by the manufacturer and a registered professional engineer.
5. Shields may be stacked as long as each is rated to the depth it is used and manufacturer approved stack connections are utilized.
6. Surcharge loads have not been included in the above depth ratings. The allowable working depth of the shield must be reduced to account for all surcharge loading which occurs adjacent to the trench. (Adjacent is defined as within a distance equal to the depth of the trench.)
7. The Soil Types A, B, and C - 80 are as defined in the OSHA Standard. Soil Type C - 60 is a moist, cohesive soil or a moist dense granular soil, which is not flowing or submerged and has an Equivalent Fluid Pressure (EFP) of 60 PSF per foot of depth. The competent person must monitor the excavation for signs of deterioration that may alter soil pressures and produce the Soil Type C - 80 condition. Such signs are indicated by, but not limited to, freely seeping water or flowing soil entering the excavation around or below the shield.
8. PRO-TEC trench shields have been designed by a registered professional engineer as required to comply with Occupational Safety and Health Administration (OSHA) standard 29 CFR Part 1926, Subpart P.
9. Maximum depths are based on shields being in structurally sound condition. Trench Shields should be inspected prior to each use for any damage or deterioration. If a shield has sustained major structural damage or permanent deformation of a structural member or connection, the Tabulated Data is void until repairs are made as specified by a registered professional engineer.

REGISTERED PROFESSIONAL ENGINEER
ADRIANUS J. VERMEULEN
No. 69082
CIVIL
STATE OF CALIFORNIA
4/2/15

TRINITY SHORING PRODUCTS, INC.
A TRINITY MINING & CONSTRUCTION EQUIPMENT, INC. COMPANY

JN 17929

Usage of trench shields other than specified could cause failure or cave-ins resulting in serious injury or death.

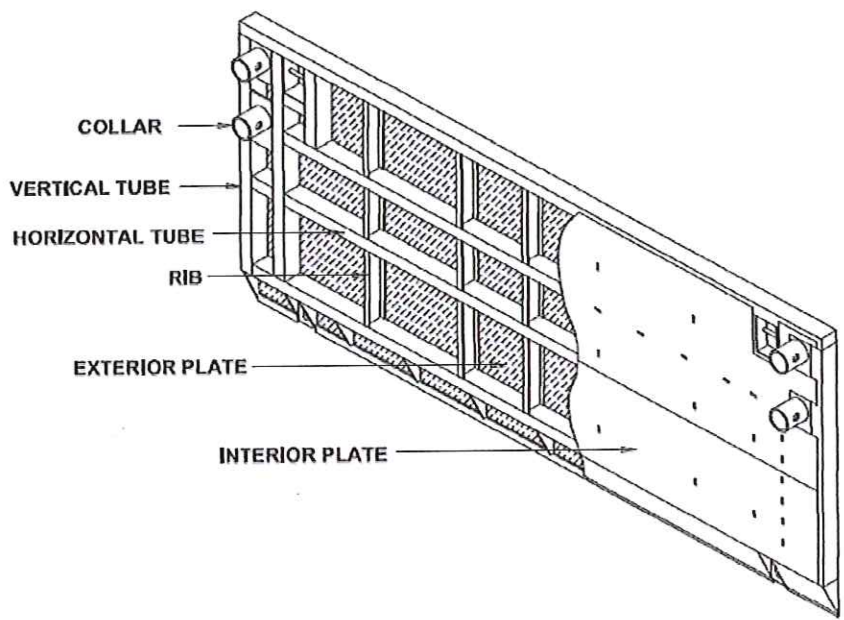
Phone (517) 827-3250 • 1-800-292-1225 • Fax (517) 827-3263
Pro-Tec Equipment • 4837 West Grand River Ave. • Lansing, MI 48906

Trinity Trench Shield Calculation Work Sheet

Model: TSR PRO-4 820 KE
Job Number: 17929
Date: 3/27/2015

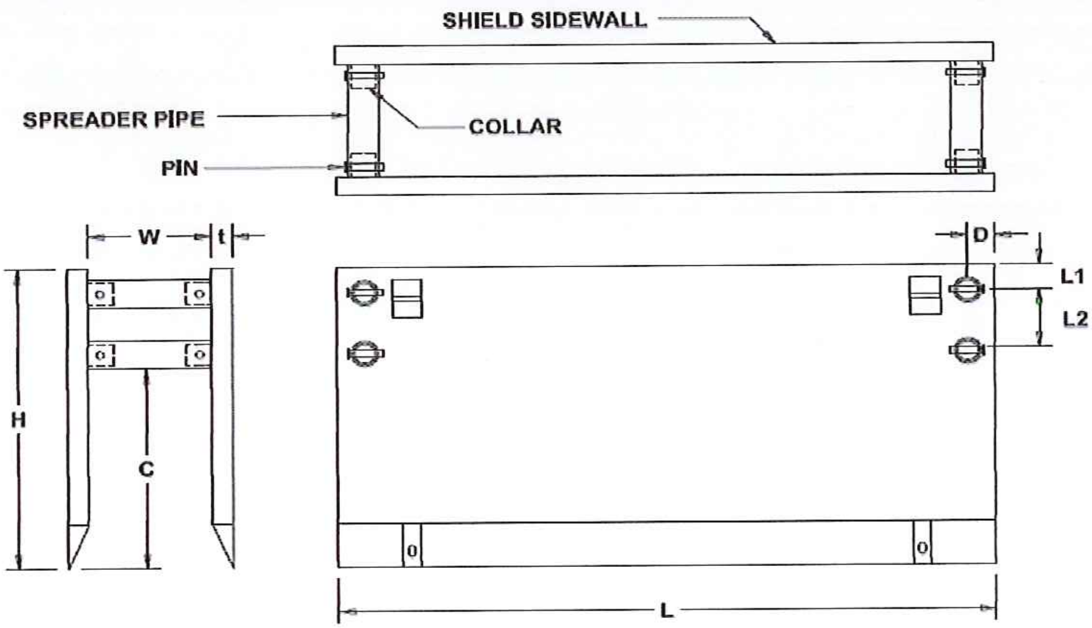
Trench Shields are designed in accordance with the *AISC Manual of Steel Construction - 13th edition* utilizing Allowable Stress Design and the following modifications:

Subject	Description	Reference
Allowable Stresses	1.33 increase for wall elements for Trench Shields	NBS / NIOSH 82 - 06 - M ASCE Geotechnical Special Publication No. 74
Moment Reduction	Reduce bending moments derived by soil pressure by 0.80	NBS / NIOSH 82 - 06 - M ASCE Geotechnical Special Publication No. 74
Effective Flange Width (be) for Horizontal and Vertical sections.	Maximum width to thickness ratios for compression in wall elements: b / t < 150	Manufacturer's testing data



Typical Trench Shield Structural Elements

Trinity Trench Shield Calculation Work Sheet



Trench Shield Dimensions

Trench Shield Geometry:

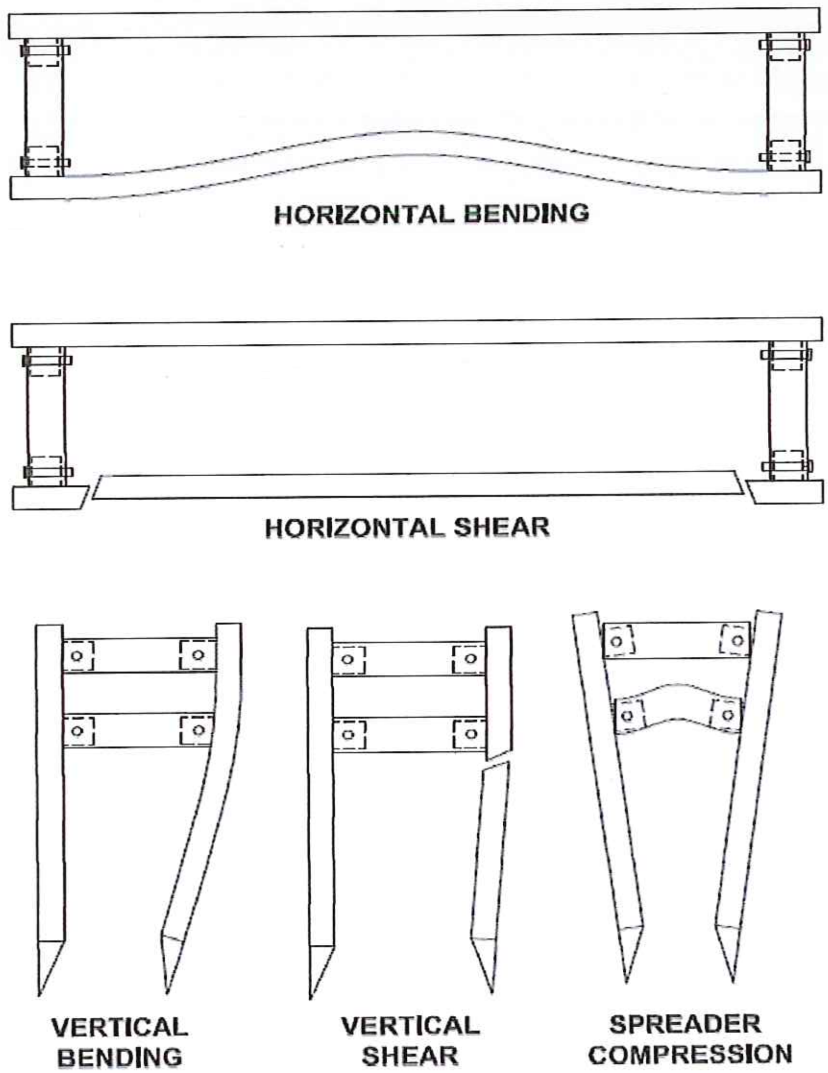
Height of Shield:	H = 8 ft	Pin Diameter:	d = 2. in
Length of Shield:	L = 20 ft	Spreader Size:	8 SCHD 80
Spreader Width:	W = 20 ft	Dimension D:	D = 8. in
Wall Thickness:	t = 4. in	Dimension L1:	L1 = 8.5 in
Pipe Clearance:	C = 65. in	Dimension L2:	L2 = 18.5 in

Trench Shield Ratings:

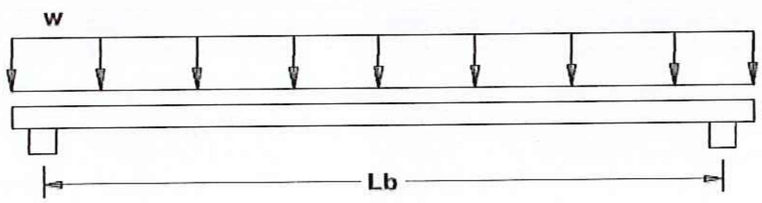
	Depth Ratings			
Shield Capacity (psf)	A25 (ft)	B45 (ft)	C60 (ft)	C80 (ft)
1,054	46	27	22	17

Estimated Trench Weight: 9,664 lb

Trench Shield Calculation Work Sheet



Trench Shield Failure Modes



Check Horizontal Bending:

Material and Geometric Properties:

Fy = 50. ksi

S = 88.51 in^3 ------------> (See Section Properties Calculations)

Required Flexural Strength:

Mr = (0.80)(w)(Lb)^2 / 8

w = (CAPACITY / 1000)(H)

w = (1,054 / 1000)(8) = 8.43 kips / ft

Lb = L - 2(D) / 12 = 20 - 2(8) / 12 = 18.67 ft

Mr = (0.80)(8.43)(18.67)^2 / 8 = 293.71 kip-ft

Available Flexural Strength:

Mn = (Fy)(S)(1/12) = 368.79 kip-ft (Eqn. F12-1)

Ω = 1.67 ---------------------> (Factor of Safety for Flexure)

Ma = (1.33)(Mn / Ω) = 293.71 kip-ft = Mr (o.k.)

Check Horizontal Shear:

Material and Geometric Properties:

Fy = 50. ksi

Aw = 15.5 in^2 ------------> (See Section Properties Calculations)

Required Shear Strength:

Vr = (w)(L) / 2

w = (CAPACITY / 1000)(H)

w = (1,054 / 1000)(8) = 8.43 kips / ft

Vr =(8.43)(20.) / 2 = 84.29 kips

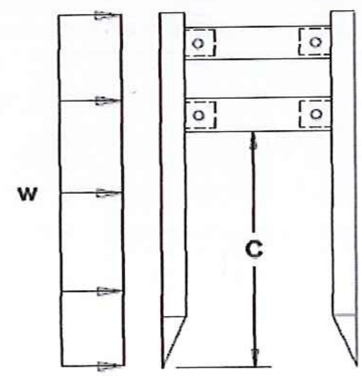
Available Shear Strength:

Vn = (0.60)(Fy)(Aw) = 465. kips (Eqn. G3-1)

Ω = 1.67 ---------------------> (Factor of Safety for Shear)

Va = (1.33)(Vn / Ω) = 370.33 kips > Vr (o.k.)

Check Vertical Bending:



Material and Geometric Properties:

Fy = 50. ksi

S = 39.11 in^3 -------------> (See Section Properties Calculations)

Required Flexural Strength:

Mr = (0.80)(w)(C / 12)^2 / 2

w = (CAPACITY / 1000)(L / 2)

w = (1054 / 1000)(20 / 2) = 10.54 kips / ft

C = 65 in

Mr = (0.80)(10.54)(65. / 12)^ 2 / 2 = 123.66 kip-ft

Available Flexural Strength:

Mn = (Fy)(S) = 162.94 kip-ft (Eqn. F12-1)

Ω = 1.67 ---------------------> (Factor of Safety for Flexure)

Ma = (1.33)(Mn / Ω) = 129.77 kip-ft > Mr (o.k.)

Check Vertical Shear:

Material and Geometric Properties:

Fy = 50. ksi

Aw = 3.5 in^2 ---------> (See Section Properties Calculations)

Required Shear Strength:

Vr = (w)(C) / 2

w = (CAPACITY / 1000)(H)

w = (1,054 / 1000)(8) = 10.54 kips / ft

Vr =(10.54)(20.) / 2 = 57.07 kips

Available Shear Strength:

Vn = (0.60)(Fy)(Aw) = 105. kips (Eqn. G3-1)

Ω = 1.67 ---------------------> (Factor of Safety for Shear)

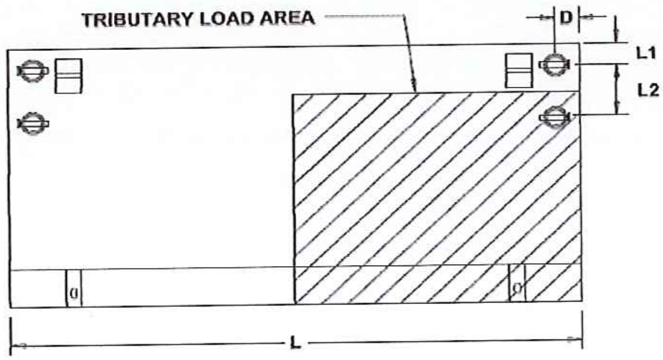
Va = (1.33)(Vn / Ω) = 83.62 kips > Vr (o.k.)

Trench Shield Calculation Work Sheet

Check Spreader Pipe for Combined Forces:

Material and Geometric Properties:

8 SCHD 80
Fy = 35. ksi
E = 29,000 ksi
Weight = 43.4 lb / ft
Ag = 11.9 in ^2
Z = 31 in ^3
I = 99.39 in^4
r = 2.89 in
L = W = 20. ft
K = 1



Required Compressive Strength:

Pr = (CAPACITY / 1000)((H)(12) - L1 - L2 / 2) / 12)(L / 2)
Pr = (1,054 / 1000)((8)(12) - 8.5 - 18.5 / 2) / 12)(20) / 2 = 68.71 kips

Required Flexural Strength:

Mr = (Weight / 1000)(L)^2 / 8
Mr = (43.4 / 1000)(20)^2 / 8 = 2.17 kip - ft

Determine Moment Magnification: (Section C2.1b)
B1 = Cm /(1 - (α)(Pr / Pe1)) (Eqn. C2-2)
Cm = 1 and α = 1.6
Pe1 = π^2(E)(I) / (KL)^2 = 493.88 ksi (Eqn. C2-5)
B1 = 2.11

Magnified Required Flexural Strength:
Mrt = (B1)(Mr) = 4.57 kip -ft (Eqn. C2-1a)

Available Compressive Strength:

(K)(L) / r = (1.0)(20)(12) / 2.89 = 83.04
Fe = π^2(E) / ((K)(L) / r)^2 = 41.5 ksi (Eqn. E3-4)
(K)(L) / r < 4.71(E / Fy)^0.5 = 135.58 (Use Eqn. E3-2)
Fcr = (0.658 ^ (Fy / Fe))(Fy) = 24.59 ksi (Eqn. E3-2)
Pn = (Fcr)(Ag)= 292.63 kips (Eqn. E3-1)
Ω = 1.67 ---------------------> (Factor of Safety for Compression)
Pa = Pn / Ω = 175.23 kips

Check Spreader Pipe for Combined Forces cont.:

Available Flexural Strength:

Mn = (Fy)(Z)(1/12) = 90.42 kip-ft (Eqn. F2-1)

Ω = 1.67 ---------------------> (Factor of Safety for Flexure)

Ma = Mn / Ω = 54.14 kip-ft

Unity Check:

Pr / Pa = .39 > 0.20 (Use Eqn. H1-1a)

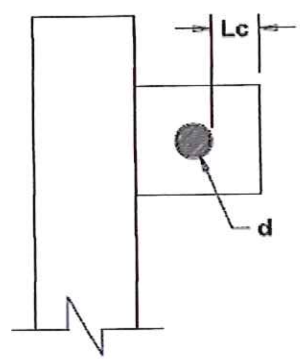
Pr / Pa + 8 / 9(Ma / Mrt) = .47 < 1.0 (o.k.)

Check Spreader Connection:

Design connection for an axial tensile force of 50% of the required compressive strength of the spreader pipe. (Section J1.4b)

Required Tensile Strength of the connection:

Rr = (0.5)(Pr) = 34.35 kips



Material and Geometric Properties of Pin:

Fu = 60. ksi

d = 2. in

Ap = 3.14 in^2

Material and Geometric Properties of Collar:

Fu = 58. ksi

t = .5 in

Available Pin Shear Strength:

Fv = 0.50(Fu) = 30. ksi (Table J3.2)

m = 2 --------------------> (Number of Shear planes)

Rnp = (m)(Ap)(Fv) = 188.5 kips

Ω = 2. ---------------------> (Factor of Safety for Connections)

Rap = Rnp / Ω = 94.25 kips > Rr (o.k.)

Check Spreader Connection Cont.:

Determine Required Clear Distance based on Bearing Strength:

Rn = (m)(1.5)(Lc)(t)(Fu) (Eqn. J3-6b)

m = 2 ---------------------> (Number of Shear planes)

Ω = 2. ---------------------> (Factor of Safety for Connections)

Rn = (Ω)(Rr)

Solve for Minimum Clear Distance (Lc):

Lc = (Ω)(Rr) / (m)(1.5)(t)(Fu)

Lc = .79 in

Determine Required Clear Distance based on Shear Rupture:

Rn = (m)(0.6)(Fu)(Asf) (Eqn. J4-4)

Asf = (2)(t)(a + d / 2)

m = 2 ---------------------> (Number of Shear planes)

Ω = 2. ---------------------> (Factor of Safety for Connections)

Rn = (Ω)(Rr)

Solve for Minimum Edge Distance (a):

Lc = (Ω(Rr) / ((2)(t)(m)(0.6)(Fu)) - d / 2

Lc = -.01 in

Determine Shield Deflection:

Material and Geometric Properties:

E = 29,000 ksi

I = 198.53 in^4 (Horizontal) -------------> (See Section Properties Calculations)

I = 85.55 in^4 (Vertical) --------------> (See Section Properties Calculations)

Calculate Horizontal Deflection:

w = (CAPACITY / 1000)(H) / 12 = (1,054 / 1000)(8) / 12 = .7 Kips / in

Lb = L - 2(D) / 12 = 20 - 2(8) / 12 = 18.67 ft

Δh = 5w((Lb)(12))^4 / 384(E)(I) = 5(.7)((18.67(12))^4 / 384(29,000.)(198.53) = 4. in

Calculate Vertical Deflection:

w = (CAPACITY / 1000)(L / 2) = 1054 / 1000)(20 / 2) = .88 kips / in

C = 65 in

Δv = w(C)^4 / 8(E)(I) = (.88)((65.)^4 / 8(29,000.)(85.55) = .79 in

Total Deflection:

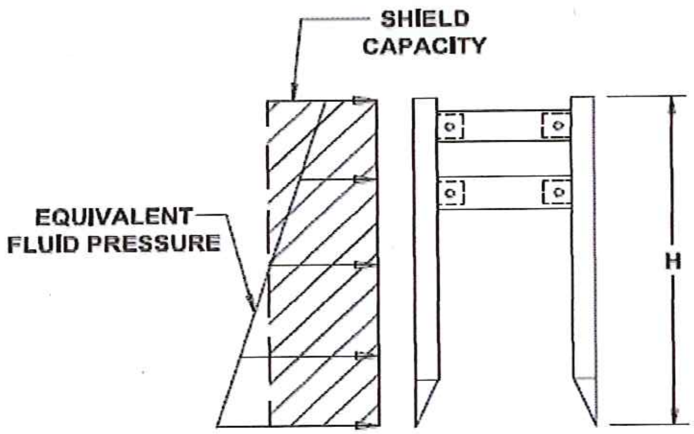
Δ = Δh +Δv = 4.79 in

Trench Shield Calculation Work Sheet

Determine Depth Ratings:

Calculate shield depth ratings based on soils with the following equivalent fluid pressures:

Soil Type	EFP (psf / ft of depth)
A	25
B	45
C60	60
C80	80



$$\text{DEPTH RATING} = \frac{\text{SHIELD CAPACITY}}{\text{EQUIVALENT FLUID PRESSURE}} + \frac{H}{2}$$

A25 Soil: Depth Rating = CAPACITY / EFP + H / 2 = 1,054 / 25 + 8. / 2 = 46 ft
B45 Soil: Depth Rating = CAPACITY / EFP + H / 2 = 1,054 / 45 + 8. / 2 = 27 ft
C60 Soil: Depth Rating = CAPACITY / EFP + H / 2 = 1,054 / 60 + 8. / 2 = 22 ft
C80 Soil: Depth Rating = CAPACITY / EFP + H / 2 = 1,054 / 80 + 8. / 2 = 17 ft

Comments:

Capacity at bottom of shield in C60 soil:

CAPACITY(C60) = 22(60) = 1320 psf

CALCULATION OF SECTION PROPERTIES

3/27/2015

JN 17929 TSR PRO-4 8 KE SECTION PROPERTIES

HORIZONTAL SECTION

ELEMENT	DESCRIPTION	A	x	Ax	Iy	dx	Adx^2
1	(2)TS 4 X 2 X 1/4	5.180	2.188	11.331	8.220	-0.055	0.016
2	TS 4 X 6 X 3/8	6.580	2.188	14.394	15.600	-0.055	0.020
3	TS 4 X 6 X 3/8	6.580	2.188	14.394	15.600	-0.055	0.020
4	TS 4 X 6 X 3/16	3.520	2.188	7.700	9.320	-0.055	0.011
5	0.1875 Plate x 94	17.625	0.094	1.652	0.052	2.038	73.223
6	0.1875 Plate x 85.75	16.078	4.281	68.834	0.047	-2.149	74.269
7	Triangle 8.25 x 4.1875	17.273	1.583	27.350	16.827	0.549	5.200
8	Triangle 7.880597 x 4	-15.761	1.521	-23.970	-14.010	0.611	-5.887
		57.075		121.685	51.656		146.872

SECTION PROPERTIES	
Depth (in)	4.375
Area (in^2)	57.075
x1 (in)	2.132
x2 (in)	2.243
Iy Total (in^4)	198.528
Sy1 (in^3)	93.118
Sy2 (in^3)	88.510
Aw (in^2)	15.500

VERTICAL SECTION

ELEMENT	DESCRIPTION	A	x	Ax	Iy	dx	Adx^2
1	TS 4 X 4 X 1/4	3.590	2.188	7.853	8.220	0.000	0.000
2	TS 4 X 4 X 3/16	2.770	2.188	6.059	6.590	0.000	0.000
3	0.1875 Plate x 43	8.063	0.094	0.756	0.024	2.094	35.344
4	0.1875 Plate x 43	8.063	4.281	34.518	0.024	-2.094	35.344
		22.485		49.186	14.857		70.689

SECTION PROPERTIES	
Depth (in)	4.375
Area (in^2)	22.485
x1 (in)	2.187
x2 (in)	2.188
Iy Total (in^4)	85.546
Sy1 (in^3)	39.107
Sy2 (in^3)	39.107
Aw (in^2)	3.500