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18 March 2012

TRIANGULAR LIFT BEAM DESIGN

The beam shown in figure 1, sheet 3 could be rotated up 180° where the single connection could be hooked to a crane and the two twin connections could be hooked to a load. But it is best suited for transferring a load from one crane to another crane in the air. Note in figure 1 that each crane is carrying half of the load. By letting down on the left hand crane until its sling is slack (about 30°), the crane on the right takes the total load. Thus the load transfer in the air.

Several months ago, I sent a sketch of this beam out for your information. Michael Harrison has since asked me if I had some details that could be used for fabricating a beam that could carry 96 kips. Following is a simple design that can be used for fabrication. I designed the beam for 121 kips to fully utilize the selected shackle. A larger beam can be designed by following the same steps.

SHACKLE SELECTION:

A 55 Te shackle, Crosby G2130, was used.

The SWL of the 55 Te metric shackle is 121.33 kips > 96 kips ===➔ GOOD
The design load is then 121k*1.8 S.F ≈ 218 kips. ≈ means approximately

A 55 Te shackle was selected for use at the three connection points. This way, any leg of the beam can be used as the top horizontal leg.

PIPE SELECTION:

Pipe with a yield stress Fy = 36 ksi was used for the legs.

<u>Allowable Tension Load With One Leg Vertical (see figure 2):</u>

The allowable tension stress Ft = 0.6*Fy = 0.6*36 = 21.6 ksi Therefore, the area of the metal required = 218/21.6 = 10.1 sq. in. The AISC table, page 3-37 shows where an 8” ϕ Extra Strong (XS) pipe, 0.5” wall, has an area of metal = 12.8 sq. in. See sheet 6.

Using this pipe size, the max. allowable tension = 12.8*21.6 ≈ 276 k > 218 k ===➔ GOOD

<u>Allowable Compression Load With One Leg Horizontal (see figure 1):</u>

The compression in the top leg = 60.5 k/Tan(60°) = 34.9 k.
The design compression load is 35*1.8 ≈ 63 k.

The AISC table, page 3-37, shows the SWL of an 8" ϕ Extra Strong pipe in compression where KL = 10' equals 243 k > 63 k ===➔ GOOD.

LUG PLATE DESIGN:

The end area for the lug plate for each connection was found by going to the Spreader Bar program with lugs top and bottom on my website, opening the pre-designed lugs, selecting a 55 Te shackle, which shows a lug radius of 5", a pad radius of 4.5", a lug thickness of 2" and the pad thickness of 0.5". The Fy = 36 ksi. Or go to the Pad Eye program, select a 55 Te shackle and enter the above values. See sheet 4 for a layout of the lug plate and sheet 7 for a printout of the Pad Eye program. Each square on sheet 4 = 1".

LUG PLATE DETAILS:

After the shackle size, the pipe size and lug end area were determined, the next step was laying out the connection of the pipes to the lug plates **to scale** to determine how close the ends of the pipes could be positioned to the centerline of the lug hole and how far the lug plate needed to be extended back into the pipes to provide enough weld length. See sheet 4 for the layout.

Knowing that the pipes are at 60° to each other, one leg was laid out horizontally with both pipe centerlines meeting at the centerline of the lug hole. The lug and the 55 Te shackle were then laid out **to scale** with the bail of the shackle in the vertical and again with the bail at 30° to the right. 1" of clearance was used between the shackle and the end of the pipe. From this it was found that the closest that the pipes could be located to the center of the lug hole was 5".

Now with a little experimenting, it was found that if the far end of the lug plates were located 15" from the center of the lug hole, then this would provide enough weld length. See the weld calculations below. Note that one pipe will have to be trimmed to avoid interference with the other one.

WELD DESIGN:

<u>Pipe To Lug Plate Weld Calculations:</u>

Assumptions:
1. Use LH70 weld rod with an allowable of 14.85 k/in/in, ie, a 1" weld leg, 1" long.
2. Use a maximum of 0.5" fillet weld as the pipe thickness is 0.5"
3. Use a partial pent weld just to insure that the 0.5" fillet weld is achieved
4. Length of the fillet weld = (10" + 8")*2 sides of the lug plate = 36"

Therefore, the weld capacity of each connection with the loaded leg in the vertical = 14.85*0.5" weld*36" of weld length = 267 k > 218 k. ===➔ GOOD

MAXIMUM REACH

CALCULATIONS and SKETCHES

DATE 16 MAR 2012
CONT. NO.
BY KEG CHK'D

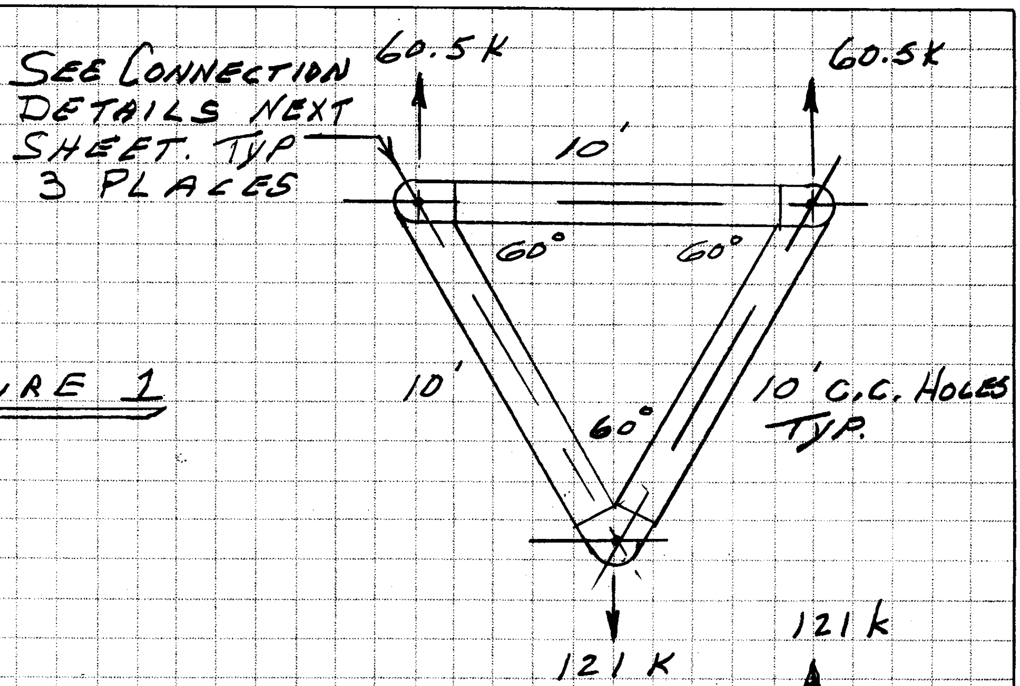


FIGURE 1

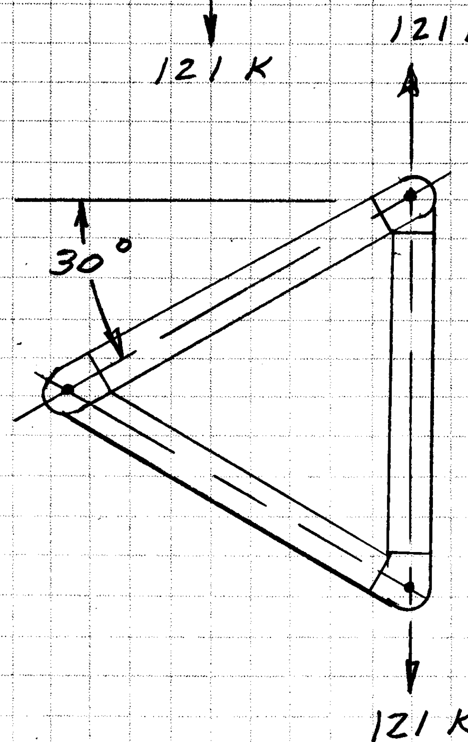
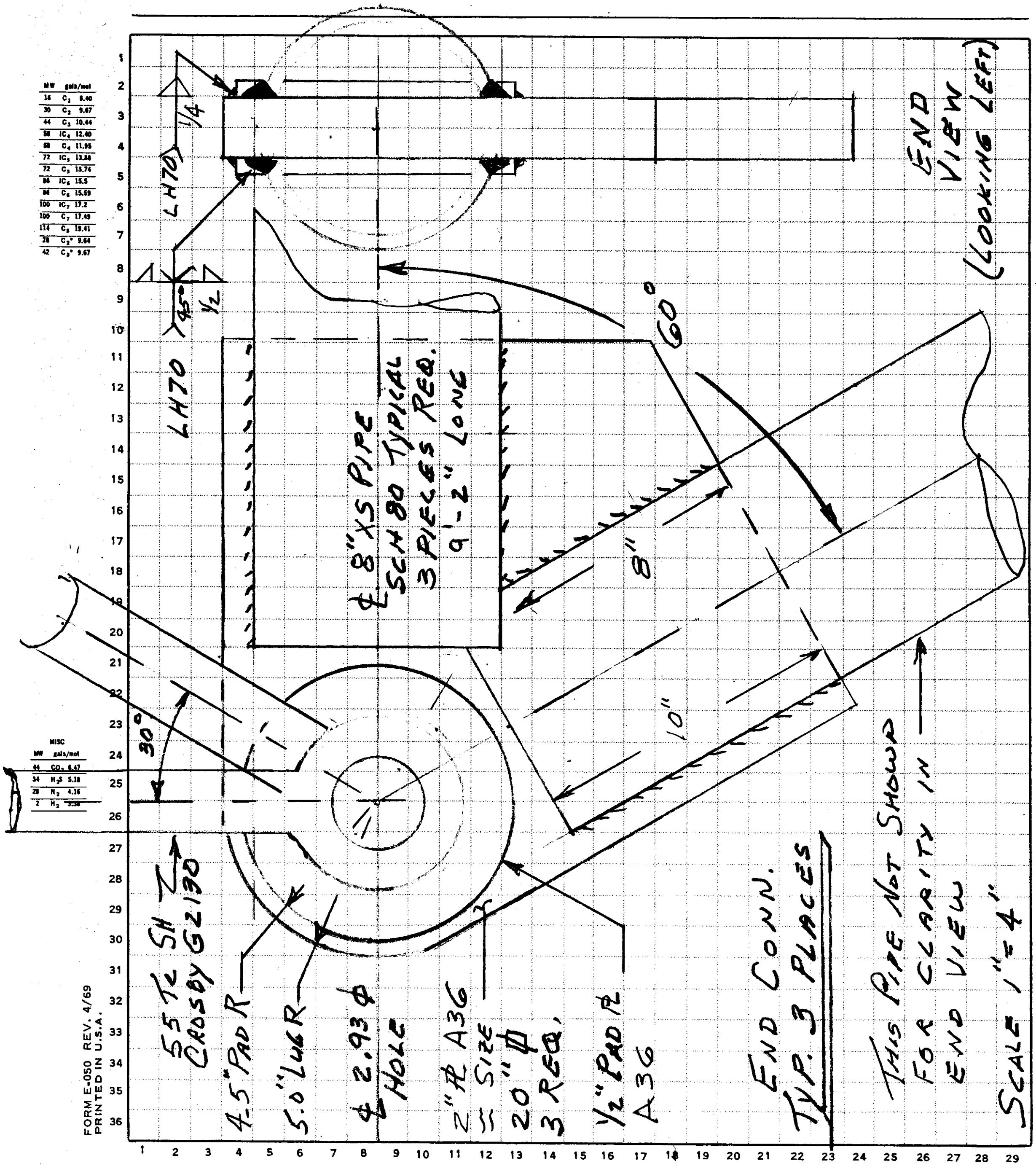


FIGURE 2

DATE 16 MAR 2012
CONT. NO.
BY KEG CHK'D
SHEET NO. 4 OF 7
REV 1
ADDED PAD DETAILS

TRIANGULAR LIFT BEAM



Manual of

STEEL CONSTRUCTION

Allowable Stress Design

NINTH EDITION

(312) 670-2400

American Institute of Steel Construction, Inc.
1 East Wacker Drive, Suite 3100
Chicago, Illinois 60601

F_y = 36 ksi

COLUMNS
Extra strong steel pipe
Allowable concentric loads in kips

SCHEDULE 80 UP TO 8" ⌀

Nominal Dia.		12	10	8	6	5	4	3½	3
Wall Thickness		0.500	0.500	0.500	0.432	0.375	0.337	0.318	0.300
Wt./ft		65.42	54.74	43.39	28.57	20.78	14.98	12.50	10.25
F_y		36 ksi							
Effective length in ft *KL* with respect to radius of gyration	0	415	348	276	181	132	95	79	65
	6	400	332	259	166	118	81	66	52
	7	397	328	255	162	114	78	63	48
	8	394	325	251	159	111	75	59	45
	9	390	321	247	155	107	71	55	41
	10	387	318	243	151	103	67	51	37
	11	383	314	239	146	99	63	47	33
	12	379	309	234	142	95	59	43	28
	13	375	305	229	137	91	54	38	24
	14	371	301	224	132	86	49	33	21
	15	367	296	219	127	81	44	29	18
	16	363	291	214	122	76	39	25	16
	18	353	281	203	111	65	31	20	12
	19	349	276	197	105	59	28	18	11
	20	344	271	191	99	54	25	16	
	21	337	265	185	92	48	22	14	
	22	334	260	179	86	44	21		
	24	323	248	166	73	37	17		
	26	312	236	152	62	32			
	28	301	224	137	54	27			
	30	289	211	122	47	24			
	32	277	197	107	41				
	34	264	183	95	36				
	36	251	168	85	32				
	38	237	152	76					
	40	223	137	69					
Properties									
Area *A* (in.^{2})		19.2	16.1	12.8	8.40	6.11	4.41	3.68	3.02
I (in.^{4})		362	212	106	40.5	20.7	9.61	6.28	3.89
r (in.)		4.33	3.63	2.88	2.19	1.84	1.48	1.31	1.14
B Bending factor		0.339	0.408	0.521	0.688	0.822	1.03	1.17	1.36
$a/10^6$		53.6	31.6	15.8	6.00	3.08	1.44	0.941	0.585

Note: Heavy line indicates *Kl/r* of 200.

PROGRAM TO DESIGN A PAD EYE TYPE LIFTING LUG v.02

COMPANY: Maximum Reach **PROJECT:** Triangular Lift Beam
ITEM NUMBER: Design Of Lug Plate

Crosby G2130x55 ▾		Select a metric shackle from the lookup table based on the force on the lug or click the SHACKLE button to enter your own	
4.13	in	Shackle Inside Width at Pin	
5.69	in	Shackle Eye Diameter	
2.80	in	Shackle Pin Diameter	
2.93	in	Lug Pin Hole Diameter	Recommend hole be 0.13" or > than shackle pin dia.
5.00	in	Lug Radius	
2.00	in	Lug Plate Thickness	
10.00	in	Lug Plate Width at Base	Minimum value of 2*radius of lug
.50	in	Lug Pad Thickness	Input zero if pads are not required
4.50	in	Lug Pad Radius	Input zero if pads are not required
4.50	in	Lug Eccentricity	
121.00	kips	Force on the Lug	
90.00	deg	Angle of the Force on the Lug	Measured from the horizontal
36.00	ksi	Yield Stress of the Lug Material Fy	
14.85	kips/in	Allowable Force on the Weld	Use 10.91 for LH60 or 14.85 for LH70
1.80		Impact factor, IF	Recommend that a minimum 1.8 impact factor be used

OUTPUT:

Checking combined stress of the lug plate

20.00	in^2	Area of Lug Plate at Base
33.33	in^3	Section modulus of the lug plate at the base
0.00	ksi	Bending stress of the lug plate fb, actual
10.89	ksi	Tension stress of the lug plate ft, actual
21.60	ksi	Allowable bending and tension stress, Fb & Ft
0.50		Combined stress of the lug plate. Must be less than 1.0

Checking the lug weld size, with the weld treated as a line

20.00	in	Area of the weld
33.33	in^2	Section modulus of the weld
10.89	kips/in	Resultant Force on the weld
0.73	in	Minimum weld size ← N/A LUG ℘ WELDED TO PIPES

Checking bearing at the pin hole

38.89	ksi	Bearing stress of the lug without pads
25.93	ksi	Bearing stress with pads attached
32.40	ksi	Allowable bearing stress
20.17	kips	Load per pad
0.13	in	Pad weld size, min. ← USE 1/4"

Checking end area of the lug across the pin hole

13.44	in^2	End area required across the pin hole
4.59	in	Maximum effective lug radius. Used to calculate the max. allowable end area
14.06	in^2	Maximum effective end area

Checking end area of the lug past the pin hole

8.96	in^2	Area required past the pin hole
10.10	in^2	Actual end area
9.29	in^2	Maximum allowable end area

Calculated by www.maximumreach.com 3/17/2012