Die Storage Rack Analysis

Cross-members: 6"x6"x1/4" HSS tubing

Long. members: 6"x6"x1/4" HSS tubing
W6"x20#

Fixed end reaction for the cross members (dist. load w lbs./in.)

FEA = w*L/2

Fixed end moment for the cross members (dist. load w lbs./in.)

FEM = w*L2/12 beam fixed at ends

HSS tubing: sy = 46 ksi

L =	96	in.	
w =	250	lbs./in	
FEA =	12,000	lbs.	
FEM =	192,000	in-lbs.	
A =	5.24	in2	
Ix =	28.6	in4	
S =	9.54	in3	
sb =	20,126	psi	calculated bending stress at top
sa =	30,360	psi	allowable bending stress

Shear Stress:

Q =	2.91	in3	
t =	5,236	psi	calculated max. shear stress in side wall
Q =	2.02	in3	
t =	3,630	psi	calculated max. shear stress at corner
sb =	18,576	psi	calculated bending stress at corner

Combined Stress:

s =	19,260	psi	calculated stress at corner

Die Storage Rack Analysis

Cross-members: 6"x6"x1/4" HSS tubing

Long. members: 6"x6"x1/4" HSS tubing
W6"x20#

I-beam: sy = 36 ksi

L =	144	in.	
A =	5.87	in2	
Ix =	41.4	in4	
S =	13.4	in3	

Beam Forces and Moments:

P =	12,000	lbs.	from loading on cross-member
a =	35	in.	
b =	109	in.	
R1 =	10,218	lbs.	
R2 =	1,782	lbs.	

Bending moment from concentrated load:

M1 =	-240,645	in-lbs.	@ end of beam
Ma =	116,980	in-lbs.	@ intersection of cross-member and beam
Mc =	51,042	in-lbs.	@ center of beam
Mb =	-14,897	in-lbs.	@ intersection of cross-member and beam
M2 =	-77,271	in-lbs.	@ end of beam

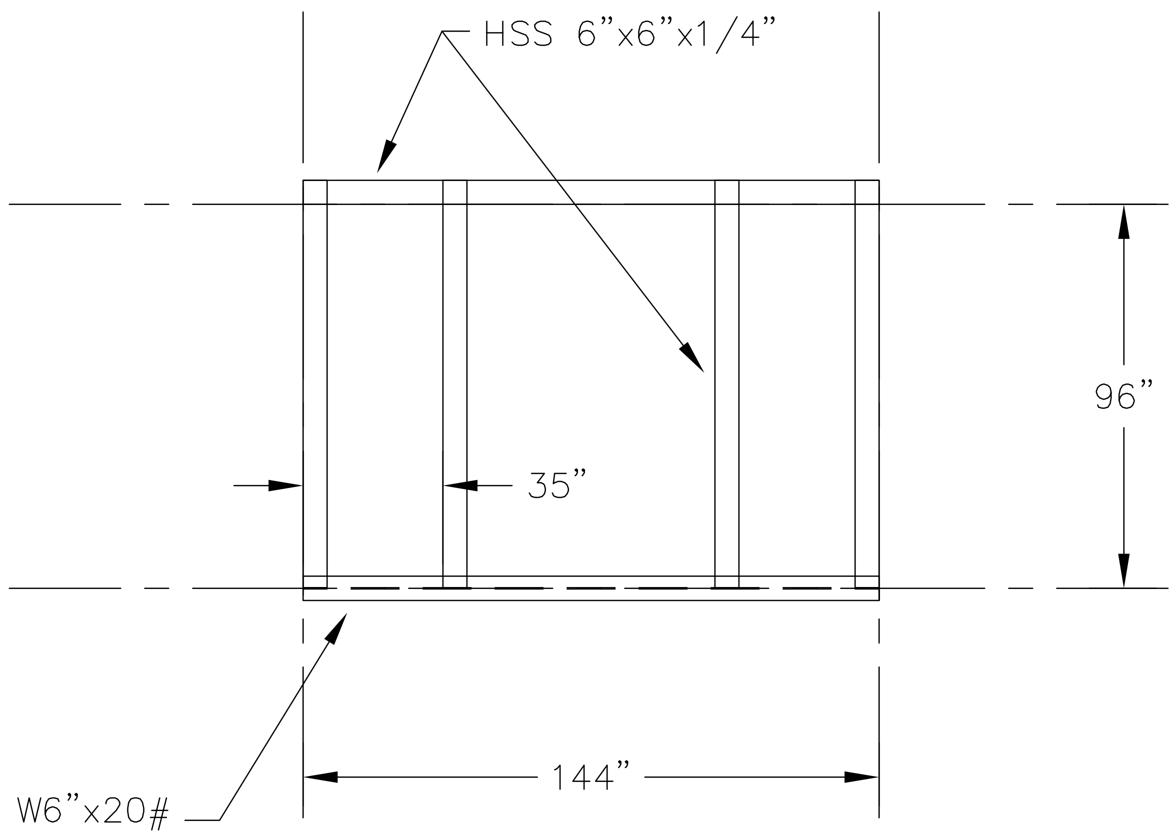
Bending moment from distributed load:

w =	0	lbs/in.	
M1 =	0	in-lbs.	@ end of beam
Ma =	0	in-lbs.	@ intersection of cross-member and beam
Mc =	0	in-lbs.	@ center of beam
Mb =	0	in-lbs.	@ intersection of cross-member and beam
M2 =	0	in-lbs.	@ end of beam

Combined Bending Moment:

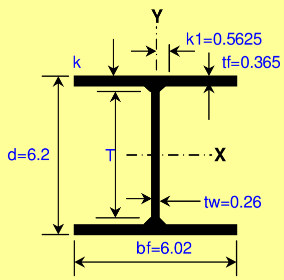
M1 =	-317,917	in-lbs.	@ end of beam
Ma =	102,083	in-lbs.	@ intersection of cross-member and beam
Mc =	102,083	in-lbs.	@ center of beam
Mb =	102,083	in-lbs.	@ intersection of cross-member and beam
M2 =	-317,917	in-lbs.	@ end of beam

sb =	23,725	psi	calculated bending stress at top flange
sa =	23,760	psi	allowable bending stress


HSS 6"x6"x1/4"
96"
35"
144"
W6"x20#

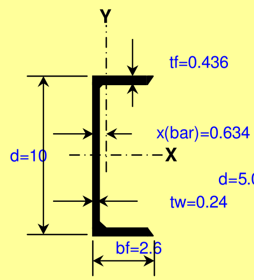
AISC 13th EDITION MEMBER DIMENSIONS AND PROPERTIES VIEWER

W, S, M, HP Shapes



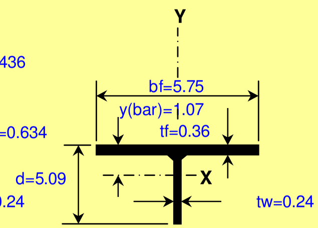
	W6X20	
A =	5.87	in.^2
d =	6.2	in.
tw =	0.26	in.
bf =	6.02	in.
tf =	0.365	in.
k(des) =	0.615	in.
k(det) =	0.875	in.
k1 =	0.5625	in.
T =	4.5	in.
gage =	3.5	in.
wt./ft. =	20	plf.
bf/(2*tf)	8.25	
h/tw =	18.7	
Ix =	41.4	in.^4
Sx =	13.4	in.^3
rx =	2.66	in.
Zx =	15	in.^3
Iy =	13.3	in.^4
Sy =	4.41	in.^3
ry =	1.5	in.
Zy =	6.72	in.^3
rts =	1.7	in.
ho =	5.84	in.
J =	0.24	in.^4
Cw =	113	in.^6
a =	34.92	in.
Wno =	8.78	in.^2
Sw =	4.82	in.^4
Qf =	3.07	in.^3
Qw =	7.38	in.^3

C, MC Shapes



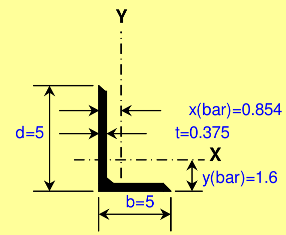
	C10X15.3	
A =	4.48	in.^2
d =	10	in.
tw =	0.24	in.
bf =	2.6	in.
tf =	0.436	in.
k =	1	in.
T =	8	in.
gage =	1.5	in.
rts =	0.869	in.
ho =	9.56	in.
wt./ft. =	15.3	plf.
eo =	0.796	in.
Ix =	67.3	in.^4
Sx =	13.5	in.^3
rx =	3.87	in.
Zx =	15.9	in.^3
Iy =	2.27	in.^4
Sy =	1.15	in.^3
ry =	0.711	in.
x(bar) =	0.634	in.
Zy =	2.34	in.^3
xp =	0.224	in.
J =	0.209	in.^4
Cw =	45.5	in.^6
a =	23.74	in.
ro(bar) =	4.19	in.
H =	0.884	

WT, ST, MT Shapes



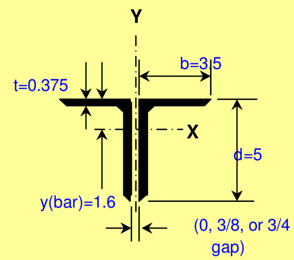
	WT5X11	
A =	3.24	in.^2
d =	5.090	in.
tw =	0.240	in.
bf =	5.750	in.
tf =	0.360	in.
k(des) =	0.6600	in.
k(det) =	0.9375	in.
gage =	2.75	in.
wt./ft.	11.00	plf.
bf/(2*tf)	7.990	
d/tw	21.200	
Ix =	6.88	in.^4
Sx =	1.72	in.^3
rx =	1.46	in.
y(bar) =	1.070	in.
Zx =	3.02	in.^3
yp =	0.282	in.
Iy =	5.71	in.^4
Sy =	1.99	in.^3
ry =	1.33	in.
Zy =	3.05	in.^3
Qs(50) =	0.837	
J =	0.12	in.^4
Cw =	0.107	in.^6
a =	1.53	in.
ro(bar) =	2.16	in.
H =	0.830	

Single Angles



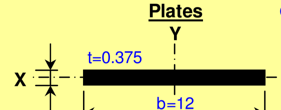
	L5X3-1/2X3/8	
A =	3.05	in.^2
d =	5	in.
b =	5	in.
t =	0.375	in.
k =	0.8125	in.
wt./ft. =	10.40	plf.
eo =	0.31	in.
Ix =	7.75	in.^4
Sx =	2.28	in.^3
rx =	1.590	in.
y(bar) =	1.600	in.
Zx =	4.090	in.^3
yp =	0.933	in.
Iy =	3.15	in.^4
Sy =	1.19	in.^3
ry =	1.020	in.
x(bar) =	0.854	in.
Zy =	2.120	in.^3
xp =	0.305	in.
Iz =	1.74	in.^4
Sz =	0.67	in.^3
rz =	0.755	in.
TAN(α) =	0.485	
Qs(36) =	0.983	
J =	0.15	in.^4
Cw =	0.217	in.^6
a =	1.94	in.
ro(bar) =	2.45	in.
H =	0.000	

Double Angles



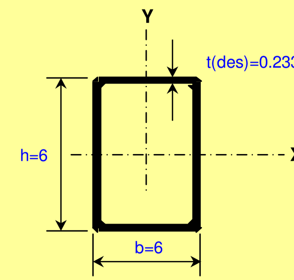
	2L5X3-1/2X3/8LLBB	
A =	6.1	in.^2
d =	5	in.
b =	3.5	in.
t =	0.375	in.
wt./ft. =	20.8	plf.
Ix =	15.5	in.^4
Sx =	4.56	in.^3
rx =	1.59	in.
y(bar) =	1.6	in.
Zx =	8.18	in.^3
yp =	0.93	in.
ry(0) =	1.33	in.
ry(3/8) =	1.46	in.
ry(3/4) =	1.59	in.
Qs(0) =	2.51	
Qs =	2.58	
ro(bar)(0) =	2.66	in.
H(0) =	0.683	
ro(bar)(3/8) =	0.7	in.
H(3/8) =	0.718	
ro(3/4) =	1	in.
H(3/4) =	0.983	

Plates



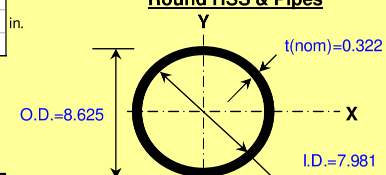
t =	0.375	in.
b =	12	in.
wt./ft. =	15.31	plf.
A =	4.500	in.^2
Ix =	0.053	in.^4
Sx =	0.281	in.^3
rx =	0.108	in.
Iy =	54.000	in.^4
Sy =	9.000	in.^3
ry =	3.464	in.
J =	54.053	in.^4

Rectangular HSS



	HSS6X6X1/4	
A =	5.24	in.^2
h =	6	in.
b =	6	in.
t(des) =	0.233	in.
wt./ft. =	18.99	plf.
Ix =	28.6	in.^4
Sx =	9.54	in.^3
rx =	2.34	in.
Zx =	11.2	in.^3
Iy =	28.6	in.^4
Sy =	9.54	in.^3
ry =	2.34	in.
Zy =	11.2	in.^3
h(flat) =	4.875	in.
b(flat) =	4.875	in.
J =	45.6	in.^4
C =	15.4	in.^3
A(surf) =	1.93	ft^2/ft

Round HSS & Pipes



	Pipe8STD	
A =	7.85	in.^2
O.D. =	8.625	in.
I.D. =	7.981	in.
t(nom) =	0.322	in.
t(des) =	0.3	in.
wt./ft. =	28.60	plf.
Ix = Iy =	68.1	in.^4
Sx = Sy =	15.8	in.^3
rx = ry =	2.95	in.
Zx = Zy =	20.8	in.^3
J =	136	in.^4
C =	---	in.^3

Reference:
The shapes contained in this database are taken from the AISC Version 13.0 "Shapes Database" CD-ROM Version (12/2005), as well as those listed in the AISC 13th Edition Manual of Steel Construction (12/2005).

NOMENCLATURE FOR AISC VERSION 13.0 MEMBER PROPERTIES AND DIMENSIONS:

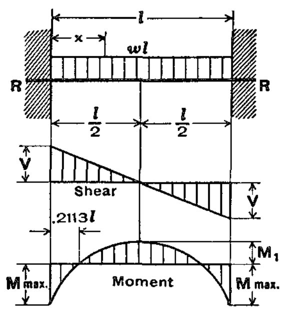
A = Cross-sectional area of member (in.^2)
d = Depth of member, parallel to Y-axis (in.)
h = Depth of member, parallel to Y-axis (in.)
t_w = Thickness of web of member (in.)
b_f = Width of flange of member, parallel to X-axis (in.)
b = Width of member, parallel to X-axis (in.)
t_f = Thickness of flange of member (in.)
k = Distance from outer face of flange to web toe of fillet (in.)
k_1 = Distance from web centerline to flange toe of fillet (in.)
T = Distance between fillets for wide-flange or channel shape = d(nom)-2*k(det) (in.)
gage = Standard gage (bolt spacing) for member (in.) *(Note: gages for angles are available by viewing comment box at cell K18.)*
I_x = Moment of inertia of member taken about X-axis (in.^4)
S_x = Elastic section modulus of member taken about X-axis (in.^3)
r_x = Radius of gyration of member taken about X-axis (in.) = SQRT(I_x/A)
I_y = Moment of inertia of member taken about Y-axis (in.^4)
S_y = Elastic section modulus of member taken about Y-axis (in.^3)
r_y = Radius of gyration of member taken about Y-axis (in.) = SQRT(I_y/A)
Z_x = Plastic section modulus of member taken about X-axis (in.^3)
Z_y = Plastic section modulus of member taken about Y-axis (in.^3)
r_{ts} = SQRT(SQRT(I_y*C_w)/S_x) (in.)
x_p = horizontal distance from designated member edge to plastic neutral axis (in.)
y_p = vertical distance from designated member edge to plastic neutral axis (in.)
h_o = Distance between centroid of flanges, d-t_f (in.)
J = Torsional moment of inertia of member (in.^4)
C_w = Warping constant (in.^6)
C = Torsional constant for HSS shapes (in.^3)
a = Torsional property, a = SQRT(E*C_w/G*J) (in.)
E = Modulus of elasticity of steel = 29,000 ksi
G = Shear modulus of elasticity of steel = 11,200 ksi
W_{no} = Normalized warping function at a point at the flange edge (in.^2)
S_w = Warping statical moment at a point on the cross section (in.^4)
Q_f = Statical moment for a point in the flange directly above the vertical edge of the web (in.^3)
Q_w = Statical moment at the mid-depth of the section (in.^3)
$x_{(bar)}$ = Distance from outside face of web of channel shape or outside face of angle leg to Y-axis (in.)
$y_{(bar)}$ = Distance from outside face of outside face of flange of WT or angle leg to Y-axis (in.)
e_o = Horizontal distance from the outer edge of a channel web to its shear center (in.) = (approx.) t_f*(d-t_f)^2*(b_f-t_w/2)^2/(4*I_x)-t_w/2
x_o = x-coordinate of shear center with respect to the centroid of the section (in.)
y_o = y-coordinate of shear center with respect to the centroid of the section (in.)
$r_{o(bar)}$ = Polar radius of gyration about the shear center = SQRT(x_o^2+y_o^2+(I_x+I_y)/A) (in.)
H = Flexural constant, H = 1-(x_o^2+y_o^2)/$r_{o(bar)}$^2)
LLBB = Long legs back-to-back for double angles
SLBB = Short legs back-to-back for double angles
$h_{(flat)}$ = The workable flat (straight) dimension along the height, h (in.)
$b_{(flat)}$ = The workable flat (straight) dimension along the width, b (in.)
$A_{(surf)}$ = The total surface area of a rectangular or square HSS section (ft.^2/ft.)
STD = Standard weight (Schedule 40) pipe section
XS = Extra strong (Schedule 80) pipe section
XXS = Double-extra strong pipe section

BEAM DIAGRAMS AND FORMULAS

For various static loading conditions

For meaning of symbols, see page 2 - 293

15. BEAM FIXED AT BOTH ENDS—UNIFORMLY DISTRIBUTED LOADS



Total Equiv. Uniform Load . . . . . $= \frac{2wl}{3}$

R = V . . . . $= \frac{wl}{2}$

V_x . . . . $= w\left(\frac{l}{2} - x\right)$

M max. (at ends) . . . . $= \frac{wl^2}{12}$

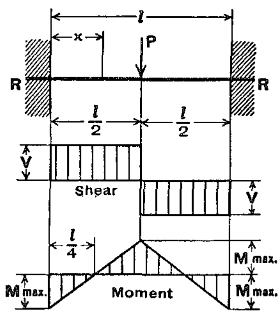
M_1 (at center) . . . . $= \frac{wl^2}{24}$

M_x . . . . $= \frac{w}{12}(6lx - l^2 - 6x^2)$

Δmax. (at center) . . . . $= \frac{wl^4}{384EI}$

Δx . . . . $= \frac{wx^2}{24EI}(l - x)^2$

16. BEAM FIXED AT BOTH ENDS—CONCENTRATED LOAD AT CENTER



Total Equiv. Uniform Load . . . . . = P

R = V . . . . $= \frac{P}{2}$

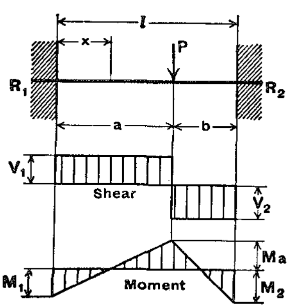
M max. (at center and ends) . . . $= \frac{Pl}{8}$

M_x $\left(\text{when } x < \frac{l}{2}\right)$ . . . . . . $= \frac{P}{8}(4x - l)$

Δmax. (at center) . . . . $= \frac{Pl^3}{192EI}$

Δx $\left(\text{when } x < \frac{l}{2}\right)$ . . . . . . $= \frac{Px^2}{48EI}(3l - 4x)$

17. BEAM FIXED AT BOTH ENDS—CONCENTRATED LOAD AT ANY POINT



$R_1 = V_1$ (max. when a < b) . . . . $= \frac{Pb^2}{l^3}(3a + b)$

$R_2 = V_2$ (max. when a > b) . . . . $= \frac{Pa^2}{l^3}(a + 3b)$

M_1 (max. when a < b) . . . . $= \frac{Pab^2}{l^2}$

M_2 (max. when a > b) . . . . $= \frac{Pa^2b}{l^2}$

M_a (at point of load) . . . . $= \frac{2Pa^2b^2}{l^3}$

M_x (when x < a) . . . . . . $= R_1x - \frac{Pab^2}{l^2}$

Δmax. $\left(\text{when } a > b \text{ at } x = \frac{2al}{3a + b}\right)$. $= \frac{2Pa^3b^2}{3EI\,(3a + b)^2}$

Δa (at point of load) . . . . $= \frac{Pa^3b^3}{3EIl^3}$

Δx (when x < a) . . . . . . $= \frac{Pb^2x^2}{6EIl^3}(3al - 3ax - bx)$