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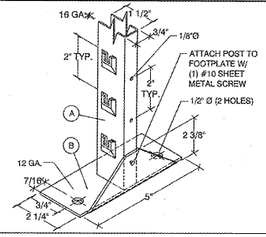
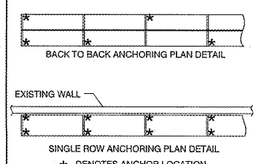
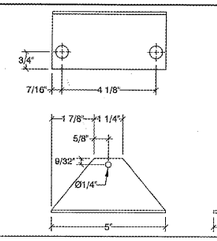
SPRINGFIELD, MO



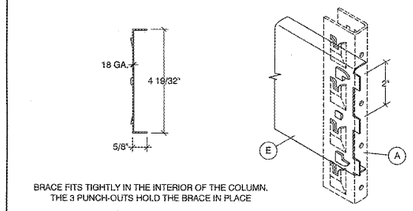
A COLUMN



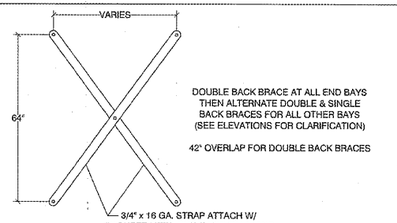
B FOOT PLATE



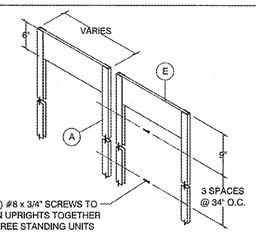
C ANCHOR



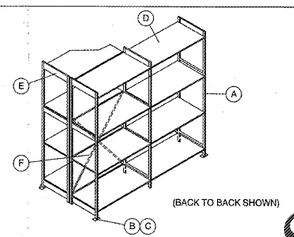
D SHELF



E HORIZONTAL BRACE

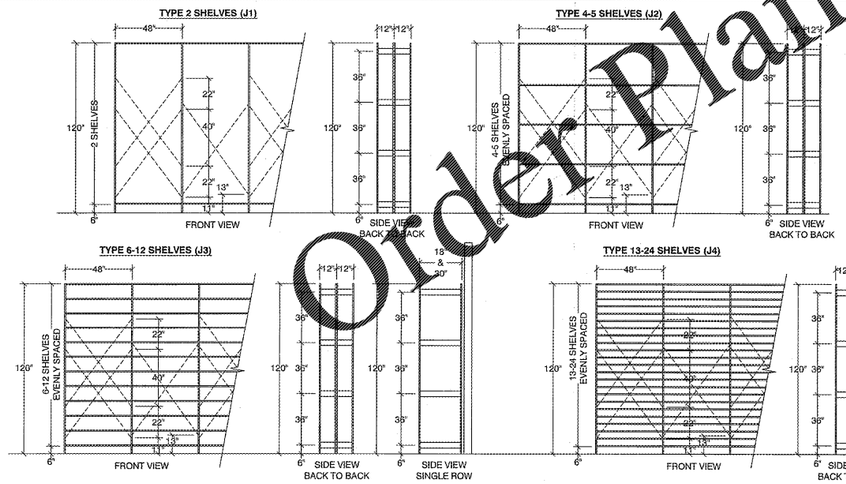


F REAR X-BRACE



G BACK TO BACK ASSEMBLY

H GENERAL CONFIGURATION



J LIGHT DUTY STORAGE FIXTURE ELEVATIONS (96" SIMILAR, MOST CRITICAL SHOWN)

1

LIGHT DUTY SHELVING ANALYSIS

SCOPE:
THE PURPOSE OF THIS ANALYSIS IS TO SHOW THAT THE FOLLOWING LIGHT DUTY STORAGE FIXTURE COMPLIES WITH SECTION 1613 OF THE 2012 IBC WHERE LATERAL FORCES ARE DETERMINED IN ACCORDANCE WITH SECTION 15.5 OF THE ASCE 7-10.

PARAMETERS:
STABILITY OF THE LIGHT DUTY STORAGE FIXTURE UNITS IS PROVIDED BY METAL SPRINGER BRACES IN THE TRANSVERSE DIRECTION AND X-BRACES IN THE LONGITUDINAL DIRECTION.

STORAGE FIXTURES WILL BE ANALYZED UTILIZING THE FOLLOWING FORMULA:
LATERAL FORCE:
V = Cs * Ws WHERE Cs = S_{DS}/(R/I)
= [(2/3) * Fa * Ss * I/R] * Ws

SPECIFICATIONS:
- MAIN STEEL — Fy = 36000 PSI MIN. YIELD STEEL
- BOLTS — A307 (UNLESS OTHERWISE NOTED)
- ANCHORS — 3/8"Ø x 2-1/2" MIN. EMBED, HILTI KH-EZ SCREW ANCHOR (ICC ESR-3027) OR 3/8"Ø x 2-1/2" MIN. EMBED, POWERS POWER STUD SD2 (ICC ESR-2502) **PERIODIC SPECIAL INSPECTION REQUIRED FOR ANCHOR INSTALLATIONS.**
- SLAB — 4 IN (minimum required) x 2500 PSI (minimum required)
- SOIL — 1000 PSF

MAXIMUM PERMISSIBLE STORAGE LOAD:
1440 LB MAX. PER BAY
240 LB MAX. PER SHELF

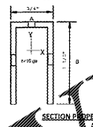
SHELVING PROFILES:

TYPES	LEVELS	MAX. PER BAY
1. TYPE 2 SHELVES	2	480 LB
2. TYPE 4-5 SHELVES	4-5	960 LB
3. TYPE 6-12 SHELVES	6-12	1440 LB
4. TYPE 13-24 SHELVES	13-24	1440 LB

CRITICAL CONFIGURATIONS:
12" DEEP SINGLE ROW
(2) 12" DEEP BACK-TO-BACK ROWS

SAMPLE ANALYSIS ON CRITICAL CONFIGURATIONS.

COLUMN ANALYSIS: TYPE 6-12 SHELVES (SINGLE ROW) (SEE DETAIL A)
TRANSVERSE DIRECTION
ANALYZED PER AISI COLD FORM STEEL MANUAL.
(1+0.115$_{DS}$) Pstatic + 0.75 Pseismic= 910 LB
0.75 Mcol= 173 IN-LB
KxLx/rx = 1*31.5 IN/0.4756 IN
= 66.2
KyLy/ry = 1*22.8 IN/0.3272 IN
= 69.7 <=== (KL/r)max
AXIAL
Fe= π^2E/(KL/r)max^2
= 60.0 KSI
Fy/2= 18.0 KSI
SINCE, Fe > Fy/2
THEN, Fn= Fy[1-Fy/4Fe)
= 36 KSI*[1-36 KSI/(4*60 KSI)]
= 30.6 KSI
Pn= Ae*Fn
= 5,806 LB
Ω= 1.92
Pa= Pn/Ωc
= 5809.1/1.92
= 3,024 LB
P/Pa= 0.30 > 0.15
FLEXURE
CHECK: P/Pa + (Cmx*Mx)/(Max*μx) ≤ 1.0
P/Pa0 + Mx/Max ≤ 1.0
Pno= Ae*Fy
= 0.19 IN^2 *36000 PSI
= 6,831 LB
Pao= Pno/Ωc
= 6831 LB/1.92
= 3,558 LB
Myield=My= Se*fy
= 0.0581 IN^3 * 36000 PSI
= 1910 IN-LB
Mxo= My/Ωb
= 1910 IN-LB/1.67
= 1144 IN-LB
λ= (KL/r)√(Fy/E)
= √(36 KSI/29500 KSI * 0.043 IN^4 /(1*31.5 IN)^2
= 1.1 <=== 1.49
μx= [1-(Pa/Pe)]/[1-(Pa/Pn)]
= [1-(3,024 LB/910 LB*12594 LB)]^-1
= 1.56
Pstatic= # OF LEVELS*(wPL + wDL)
= 6 LEVELS * (240 LB + 10 LB)/2
= 750 LB
Pseismic= Σ (Fi*hn)/depth=(Movt/d)
= 192 LB



SECTION PROPERTIES
A= 0.75 IN
Ix= 1.5 IN
Ix = 0.060 IN
Iy = 0.150 IN^2
ry = 0.043 IN^4
Sx = 0.065 IN^3
rx = 0.476 IN
Iy = 0.020 IN^4
Sy = 0.054 IN^3
ry = 0.327 IN
Kx = 1.0
Lx = 31.5 IN
Ky = 1.0
Ly = 22.8 IN
Fy= 36 KSI
E= 29,500 KSI
Ωb= 1.67
Cmx= 0.85
Cb= 1.0

(910 LB/3024 LB) + (0.85*173 IN-LB)/(1144 IN-LB*0.86) = 0.45 < 1.0 OK
(910 LB/3558 LB) + (173 IN-LB/1144 IN-LB) = 0.41 < 1.0 OK

OVERTURNING ANALYSIS: TYPE 6-12 SHELVES (SINGLE ROW) (SEE DETAIL C)
DEPTH OF SINGLE UNIT = 12 IN
TOP SHELF HEIGHT = 120 IN
LEVELS= 6 LVL
(A) FULLY LOADED:
Vtotal = 27 LB
Mot = Σ(Fp*h)*0.75
= 1,774 IN-LB
Mst = Σ[(0.6-0.115$_{DS}$)wDL +0.75*(0.6-0.145$_{DS}$)*0.67wPL] x Depth / 2
= 2,723 IN-LB
Puplift = (Mot - Mst)/D
= 0 LB <= NO UPLIFT
(B) TOP SHELF LOADED
Vtop = 8 LB
Mot = Σ(Fp*h)*0.75
= 693 IN-LB
Mst = Σ[(0.6-0.115$_{DS}$)wDL + 0.75*(0.6-0.145$_{DS}$)wPL] x Depth / 2
= 835 IN-LB
Puplift = (Mot - Mst)/D
= 0 LB <= NO UPLIFT
ANCHOR:
QUANTITY= 1 PULLOUT = 750 LB SHEAR = 800 LB
OCCURRENCE = 2
Ps/Pt + Vs/Vt ≤ 1.2
COMBINED STRESS(A) = (0 LB/(1*750 LB)) + (28 LB/(1*800 LB))
= 0.03 < 1.2 OK
COMBINED STRESS(B) = (0 LB/(1*750 LB)) + (8 LB/(1*800 LB))
= 0.01 < 1.2 OK
USE (1) 3/8"Ø x 2-1/2" MIN. EMBED. HILTI KH-EZ SCREW ANCHOR (ICC ESR-3027) PER FOOT PLATE
ANCHORAGE REQUIRED AT EVERY OTHER BAY
USE 3/8"Ø x 2-1/2" MIN. EMBED. POWERS POWER STUD SD2 (ICC ESR-2502) AS AN OPTION.
(PULLOUT CAPACITY=750 LB, SHEAR CAPACITY=800 LB, OK BY SIMPLE REVIEW)

2

LOADS & DISTRIBUTION: TYPE 6-12 SHELVES (SINGLE ROW) (SEE DETAIL J SIDE VIEW)
ANALYZE PER SECTION 1613 OF THE 2012 IBC WHERE LATERAL FORCES ARE DETERMINED IN ACCORDANCE WITH SECTION 15.5 OF THE ASCE 7-10:

SITE CLASS = D
V = Cs * Ws WHERE Cs = S_{DS}/(R/I)
AND Ws = OPERATING WEIGHT
S_{DS} = 2/3*Fa*Ss WHERE Fa = 1.6 & Ss = 0.142
= 0.151
I = 1.00 <=== NO PUBLIC ACCESS
R = 4
REDUCTION = 0.7 <=== WORKING STRESS
NO. OF LEVELS = 6 LVL
PRODUCT LOAD, wPL = 240 LB **(1440 LB MAX. PER BAY)**
DEAD LOAD, wDL = 10 LB
DEPTH= 12 IN
HEIGHT= 120 IN

LONGITUDINAL & TRANSVERSE DIRECTION

FULLY LOADED
V = 0.7*[0.151*1*(0.67*1440 LB + 60 LB)/4]
= 27 LB

LATERAL FORCE DISTRIBUTION

h	LEVEL	WEIGHT	HEIGHT	W x H	Fi	Mot
6.0 IN	1	171 LB	6.0 IN	1026.8 IN-LB	0.4 LB	2.5 IN-LB
22.8 IN	2	171 LB	28.8 IN	4919.0 IN-LB	2.1 LB	59.6 IN-LB
22.8 IN	3	171 LB	51.6 IN	8813.3 IN-LB	3.7 LB	191.3 IN-LB
22.8 IN	4	171 LB	74.4 IN	12707.5 IN-LB	5.3 LB	397.8 IN-LB
22.8 IN	5	171 LB	97.2 IN	16601.8 IN-LB	7.0 LB	679.9 IN-LB
22.8 IN	6	171 LB	120.0 IN	20496.0 IN-LB	8.6 LB	1034.8 IN-LB
120.0 IN				Σ = 64562 IN-LB	27 LB	2365 IN-LB

TOP SHELF LOADED ONLY
Vtop = 0.7*[0.151*1*(240 LB + 60 LB)/4]
= 8 LB

LATERAL FORCE DISTRIBUTION

h	LEVEL	WEIGHT	HEIGHT	W x H	Fi	Mot
6.0 IN	1	10 LB	6.0 IN	60.0 IN-LB	0.0 LB	0.1 IN-LB
22.8 IN	2	10 LB	28.8 IN	288.0 IN-LB	0.1 LB	2.0 IN-LB
22.8 IN	3	10 LB	51.6 IN	516.0 IN-LB	0.2 LB	6.5 IN-LB
22.8 IN	4	10 LB	74.4 IN	744.0 IN-LB	0.2 LB	15.4 IN-LB
22.8 IN	5	10 LB	97.2 IN	972.0 IN-LB	0.3 LB	29.1 IN-LB
22.8 IN	6	250 LB	120.0 IN	30000.0 IN-LB	7.3 LB	878.7 IN-LB
120.0 IN				Σ = 32580 IN-LB	8 LB	932 IN-LB

TRANSVERSE MOMENT CONNECTION ANALYSIS: TYPE 6-12 SHELVES (SINGLE ROW) (SEE DETAIL E)
Mconn,max= 0.75 Mconn
= 315 IN-LB
(A) MOMENT CAPACITY OF METAL STRINGER
Mconn,max / Sx
= 315 IN-LB / 0.065 IN^3
= 4,846 PSI
fb/Fb = fb/(0.6*Fy)
= 11% < 1.000 PSI
= 0.06 < 1.0 OK
MAXIMUM LOADS ON TABS
Pmax = Mconn,max/Tab Distance
= 1050 LB
(B) SHEAR CAPACITY OF CONNECTOR TABS:
Area = 2 * t1 * d
= 0.1 IN * 0.285 IN
= 0.028 IN^2
Pallow = Area * (0.4Fy)
= 410 LB > Pmax, OK
(C) BEARING ON COLUMN:
Fu= 58,000 PSI
16ga column, t = 0.06 IN
Abrg,= 2 * t1 * t
= 0.1 IN * 0.06 IN
= .006 IN^2
Pallow = Area * fbearing
= 348 LB > Pmax, OK

Sx = 0.065 IN^3
Fy= 36,000 PSI

TAB PROPERTIES
Height, h = 0.281 IN
Depth, d = 0.285 IN
Thickness, t1 = 0.05 IN
Tab Distance = 4.0 IN

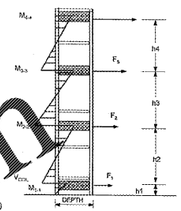
OVERTURNING ANALYSIS: TYPE 6-12 SHELVES (BACK-TO-BACK ROWS) (SEE DETAIL C)
DEPTH OF BACK-TO-BACK UNIT = 24 IN
TOP SHELF HEIGHT = 120 IN
LEVELS= 6 LVL
(A) FULLY LOADED:
Vtotal = 54 LB
Mot = Σ(Fp*h)*2 UNITS]*0.75
= 3,548 IN-LB
Mst = Σ[(0.6-0.115$_{DS}$)wDL +0.75*(0.6-0.145$_{DS}$)*0.67wPL] x Depth / 2
= 10,892 IN-LB
Pupllft = (Mot - Mst)/D
= 0 LB <= NO UPLIFT
(B) TOP SHELF LOADED
Vtop = 16 LB
Mot = Σ(Fp*h*2 UNITS)*0.75
= 1,386 IN-LB
Mst = Σ[(0.6-0.115$_{DS}$)wDL +0.75*(0.6-0.145$_{DS}$)wPL] x Depth / 2
= 3,340 IN-LB
Pupllft = (Mot - Mst)/D
= 0 LB <= NO UPLIFT
ANCHOR:
QUANTITY= 1 PULLOUT = 750 LB SHEAR = 800 LB
OCCURRENCE = 2
Ps/Pt + Vs/Vt ≤ 1.2
COMBINED STRESS(A) = (0 LB/(1*750 LB)) + (54 LB/(1*800 LB))
= 0.07 < 1.2 OK
COMBINED STRESS(B) = (0 LB/(1*750 LB)) + (16 LB/(1*800 LB))
= 0.02 < 1.2 OK
USE (1) 3/8"Ø x 2-1/2" MIN. EMBED. HILTI KH-EZ SCREW ANCHOR (ICC ESR-3027) PER FOOT PLATE
ANCHORAGE REQUIRED AT EVERY OTHER BAY AND AT ENDS, PERIMETER POST ONLY
USE 3/8"Ø x 2-1/2" MIN. EMBED. POWERS POWER STUD SD2 (ICC ESR-2502) AS AN OPTION.
(PULLOUT CAPACITY=750 LB, SHEAR CAPACITY=900 LB, OK BY SIMPLE REVIEW)

3

TRANSVERSE SEISMIC LOADS: TYPE 6-12 SHELVES (SINGLE ROW) (SEE DETAIL J SIDE VIEW)
THE FRAME SHALL BE ANALYZED AS A BRACED FRAME IN THE LONGITUDINAL DIRECTION, AND A MOMENT RESISTING FRAME IN THE TRANSVERSE DIRECTION, UTILIZING MOMENT RESISTING SPREADER TO COLUMN CONNECTIONS.

Vtrans= 27 LB
Vcol= 14 LB

TRANSVERSE SEISMIC
F1 @ 6" = 1 LB
F2 @ 42" = 5 LB
F3 @ 78" = 9 LB
F4 @ 114" = 12 LB



TRANSVERSE ELEVATION

$M_{1,1}$= Vcol * h1
= 13.6 LB * 6 IN
= 81 IN-LB
$M_{2,2}$= [Vcol-(F1/2) * h2/2
= (13.6 LB - (1.5 LB/2)*(36 IN)/2
= 231 IN-LB
$M_{3,3}$= [Vcol-(F2/2)-(F1/2)] * h3/2
= [13.6 LB - (1.5 LB/2) - (5 LB/2)]*(36 IN)/2
= 189 IN-LB
$M_{4,4}$= [Vcol-(F3/2)-(F2/2)-(F1/2)] * h4/2
= [13.6 LB - (9 LB/2) - (5 LB/2) - (1.5 LB/2)]*(36 IN/2)
= 108 IN-LB

CONNECTION MOMENT
$M_{conn,1}$ = [$M_{1,1}$ + $M_{2,2}$]
= 313 IN-LB
$M_{conn,2-3}$ = [$M_{2,2}$ + $M_{3,3}$]
= 420 IN-LB

h1= 6.0 IN
h2= 36.0 IN
h3= 36.0 IN
h4= 36.0 IN
depth= 12.0 IN

ADEQUACY OF CONNECTION
Mconn = 420 IN-LB
VERIFY ADEQUACY OF COLUMN
Mcol= 231 IN-LB

LONGITUDINAL BRACING ANALYSIS: REAR X-BRACE (BACK-TO-BACK ROWS) (SEE DETAIL F & J)
BRACING CAPACITY IS GOVERNED BY TENSION CAPACITY OF CROSS BRACING, AND SHEAR CAPACITY OF CONNECTION SCREW.

0.75*Vlong= 0.75 * Vlongit * 2 BAYS/1 X-BRACE
= 20.25 LB * 2 BAYS/1 X-BRACE SETS
= 41 LB <=== 2 BAY TRIBUTARY TO X-BRACES.
Vdiag= Vtot(diag/Uhoriz)
= 58 LB <=== SEISMIC LOAD IN TENSION

TENSION CAPACITY OF STRAP
Tallow= 0.6 * Fy * AREA(gross)
= 972 LB > Vdiag OK IN TENSION
OR
Tallow= 0.5 * Fu * AREA(net)
= 1018 LB > Vdiag OK IN TENSION

SHEAR CAPACITY OF #8 SHEET METAL SCREW, TAKEN AS LEAST OF Pns:

Pns= 4.2*(t2*3*d)^0.5*Fu2
= 4.2 * ((0.06 IN)^3 * 0.165 IN)^0.5 * 58000 PSI
= 1,454 LB
Pns= 2.7*t1*d*Fu1
= 2.7 * 0.06 IN * 0.165 IN * 58000 PSI
= 1,550 LB
Pns= 2.7*2*d*Fu2
= 2.7 * 0.06 IN * 0.165 IN * 58000 PSI
= 1,550 LB

Pns-eff/Ω= (1454 LB/3)
= 485 LB > 58 LB Vdiag OK IN SHEAR

(3/4"x16 GA. STRAP)
AREA(gross)= 0.0450 IN^2
AREA(net)= 0.0351 IN^2
Uhoriz= 48.0 IN
Vvert= 48.0 IN
Vdiag= 67.9 IN
Fu= 58,000 PSI
Fy= 36,000 PSI
Fu= 58,000 PSI
Fy= 36,000 PSI

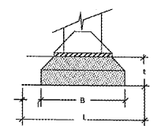
ASD safety factor for screw, Ω= 3

4

5

6

SLAB & SOIL ANALYSIS: TYPE 6-12 SHELVES (SINGLE ROW)
(1.2+0.2S_{DS})DL+(0.85+0.2S_{DS})*PL+1.5*EL= 966 LB
(A) PUNCTURE
Pmax= 966 LB
BASE PLATE WIDTH (W)= 5.00 IN
BASE PLATE DEPTH (B)= 2.25 IN
fpunct = 2.66*sqrt(f'c)
= 133 PSI
Apunct = (W+B+t)*2*t
= 90. IN^2
fv/Fv = Pmax/(Apunct * fpunct)
= 0.03 < 1.0 OK
(B) SLAB TENSION
Asoil = Pmax * 144/fsoil
= 139.2 IN^2
L = (Asoil)^.5
= 11.8 IN
B = sqrt(B*W) + t
= 7.4 IN
l = (L-B)/2
= 2.2 IN
Mconc = wl^2/8 = (fsoil*l^2) / (144*2)
= 17.1 IN-LB
Sconc = 1 in * t^2 / 6
= 2.67 IN^3
fconc = 5β* sqrt(f'c) WHERE β=0.55
= 138 PSI
fb/Fb = Mconc/(Sconc*fconc)
= 0.05 < 1.0 OK



SLAB:
t = 4.0 IN
f'c = 2,500 PSI
β = 0.55
SOIL:
fs = 1,000 PSF

7

8

9

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1130 E. Cypress St.
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91724
Tel.(909)869-0989

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DATE: 10/18/18
LAST REV. BY:
REV. DATE:
TYPE: LOZ
SCALE: N.T.S.
APPVD BY: SAL E. FATEEN

COMMONWEALTH OF VIRGINIA
SAL E. FATEEN
No. 30770
PROFESSIONAL ENGINEER
EXPIRES
02-28-2019

DESCRIPTION:
LIGHT DUTY STORAGE (FIXTURE #1A)

DRAWING NUMBER:
18-2387-A