Report

OFS SEISMIC DESIGN

Obeya Seismic Anchorage

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PREPARED FOR

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1.0 Introduction

The Obeya product is a space-creating-architecture component designed by OFS that can be constructed with multiple bays in many different configurations. A single bay may consist of 42", 84", or 126" clear spans between posts.

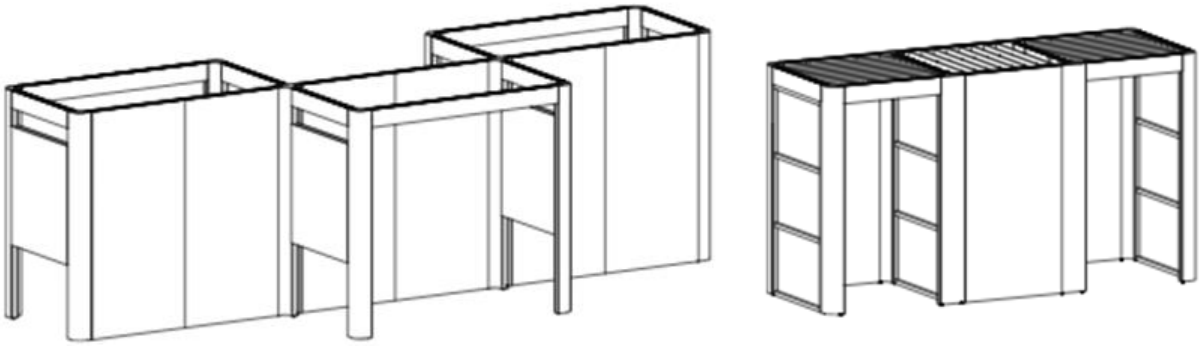


Figure 1-1: Sample Obeya product configurations.

The purpose of this report is to provide a single enveloping seismic anchorage solution for selected representative Obeya product configurations in order to comply with seismic provisions of the following building codes:

- 2018 International Building Code (IBC)
- ASCE 7-16, Minimum Design Loads for Buildings and Other Structures
- ACI 318-14, Building Code Requirements for Structural Concrete
- AISC 360-10, Specification for Structural Steel Buildings
- NDS 2015, National Design Specification for Wood Construction

The critical Obeya configurations used in this report are based on the drawing/documentation review and engineering judgment.

Note that this report does not provide a structural analysis of the Obeya product framing, panels or connections. The Obeya product framing, panels, and connections comply with ANSI / BIFMA X5.6-2016 standards per OFS Test Report OFSB-001932.

2.0 Seismic Anchorage

Two (2) bracket connections shall be installed for each corner post, three (3) bracket connections for each three-way post, and four (4) bracketed connections for each four-way post with the materials listed in Table 2-1. The installation process is as follows:

1. Attach the bracket to the bottom of the Obeya product's posts by inserting (4) #12 Wood Screw, 2" Long at the base of the interior solid wood rails.
2. Attach the bracket to the concrete slab by screwing in (1) ITW Redhead Tapcon+ 1/2"x3" Screw Anchor.

Table 2-1: Bill of materials for a single bracketed connection.

No	Item	Qt	Specification
1	ITW Redhead Tapcon+ 1/2"x3" Screw Anchor	1	Item LDT-1230 3/8"x3"
2	OFS Custom Bracket, 1/4" thick	1	ASTM A1011 GR 45
3	#12 Wood Screw, 2" Long	4	Steel GR 33

Refer to the design drawings for the code-compliant bill of materials and installation instructions.

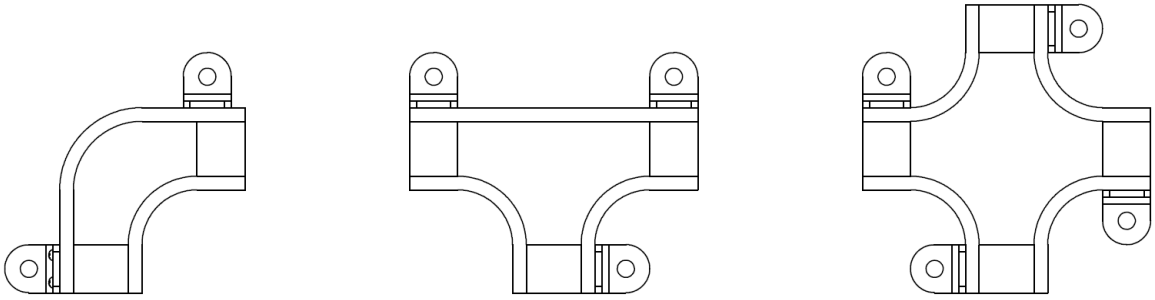


Figure 2-1: Required installation for a corner post, three-way post, and four-way post.

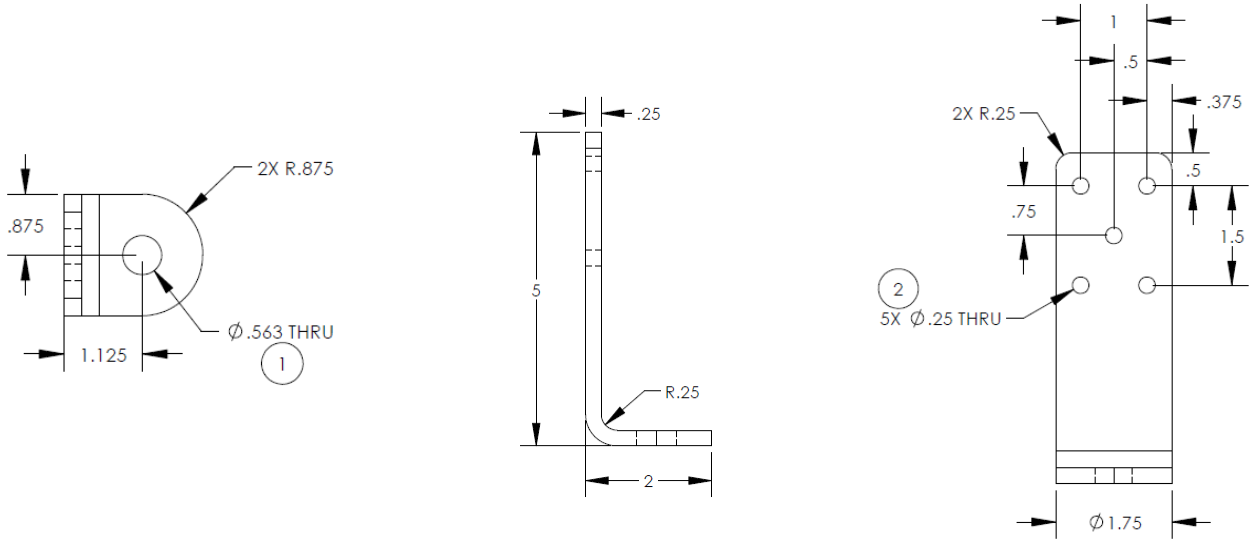


Figure 2-2: Item 2 dimensions.

3.0 Design Input

3.1 CLASSIFICATION

The Obeya product is considered a permanent nonstructural architectural component that falls within the scope of Chapter 13 of ASCE 7-16 because it is:

- Part of an architectural system within a building structure (ASCE 7-16 Sections 11.2, 13.1)
- Less than 25% of the effective seismic weight of the structure (ASCE 7-16 Section 13.1)
- A component whose collapse during an earthquake could result in blockage of the means of egress (ASCE 7-16 Section C13.1)
- Expected to remain in place for periods of a year or longer, even if it is designed to be movable (ASCE 7-16 Section C13.1)

The Obeya product has a component Importance Factor of 1.0, as it does not qualify under any of the conditions in ASCE 7-16 Section 13.1.3.

3.2 DESIGN CRITERIA

Section 1613 of the 2018 International Building Code (IBC 2018) regulates the seismic design of structures and nonstructural components attached to structures inside the United States. Section 1613.1 of IBC 2018 states that nonstructural components shall be designed to resist the effects of earthquake motions in accordance with ASCE 7.

Chapter 13 of ASCE 7-16 provides the seismic design requirements for nonstructural components, and all seismic loads are determined in accordance with this chapter. Note that ASCE 7-16 states that:

- Anchors in concrete shall be designed in accordance with Chapter 17 of ACI 318, which provides the capacities for concrete anchors.
- Structural steel shall be designed in accordance with AISC 360.
- Wood connections shall be designed in accordance with AWC NDS 2015.

The general requirement of the seismic anchorage design is for the anchors and connections to have a capacity that can withstand the seismic demand, following the procedures outlined in Chapter 13 of ASCE 7-16.

3.3 SEISMIC DESIGN CATEGORY

All Obeya products placed in a building structure that falls in Seismic Design Category C, D, E or F are subjected to the provisions of Chapter 13 of ASCE 7-16 and therefore require seismic bracing.

Obeya products placed in a building structure that falls within Seismic Design Category A or B are exempt from these requirements per Sections 11.7 and 13.1.4 of ASCE 7-16. The hazard maps created by the United States Federal Emergency Management Agency (FEMA) provided in Appendix A of this report may be used as a guide for determining the Seismic Design Category. If an Obeya product is to be exempted from seismic anchorage, the Seismic Design Category must be confirmed by building's construction documents or the authority having jurisdiction.

3.4 STRUCTURE & LOCATION

This seismic anchorage design is for any Obeya product housed in a structure that is:

- Located within the continental United States, Alaska, Puerto Rico, Virgin Islands, and American Samoa. Note that this does not include Hawaii, Guam, and the Northern Mariana Islands.
- Designed for commercial use (classified by ASCE as 7-16 as Risk Category I or Risk Category II).
- Not resting on Soil Class Site F as defined by ASCE 7-16. Note that Site Class F is a rare classification and the building owner and the authority having jurisdiction should generally be aware if the structure falls within this class.

This seismic anchorage design is for any Obeya product placed:

- At any height within a temperature-controlled structure, in an area that is protected from the elements.
- At least 8 inches from a slab edge.
- On a slab that is a minimum of 6 inches thick and constructed of structural reinforced concrete (may be cracked or uncracked) with a compressive concrete strength of at least 3000 psi.

3.5 PRODUCT ASSUMPTIONS

This seismic anchorage design applies to any Obeya product with one or more bays, where one bay has:

- A maximum weight of 1900 pounds for a bay with a minimum horizontal dimension of 4 feet.
- A maximum weight of 2900 pounds for a bay with a minimum horizontal dimension of 11 feet.
- A maximum center of gravity of 4.5 feet above the top of slab.
- Less than 100 pounds of additional attachments not mentioned in the product specification
- Posts with solid wood rails comprised of Walnut, White oak, or Beech species.

It is assumed that the frame, connections, and paneling of the Obeya product, which complies with BIFMA X5.6-2016, are structurally sound and are sufficient to carry the seismic load to the anchorage assembly for all critical load cases.

4.0 Calculation

4.1 SPECTRAL ACCELERATION

The Risk-Targeted Maximum Considered Earthquake short period spectral acceleration, Ss, for all US States and Territories are displayed on the maps provided in Chapter 22 of ASCE 7-16. The maximum design spectra acceleration for the selected US States/Territories discussed in Section 3.4 herein, is determined using Section 11.4 of ASCE 7-16 and summarized in Table 4-1. Conservatively, the largest acceleration is used to determine the demand on the anchorage. Note that Site Coefficient, Fa, must be greater than 1.2 when default Site Class D is assumed.

Table 4-1: Maximum design spectral accelerations for US States/Territories covered in this report.

Area	Country	Class	Ss	Fa	Sms	Sds
Continental US	US	D	2.00	1.2	2.40	1.60
Alaska	US	D	2.00	1.2	2.40	1.60
Puerto Rico	US	D	1.39	1.2	1.67	1.11
Virgin Islands	US	D	1.39	1.2	1.67	1.11
American Samoa	US	D	0.45	1.4	0.63	0.42
					Max	**1.60**

Area = Area
Country = Country
Class = Site Class
Ss = Maximum MCEr short period spectral acceleration [g]
Fa = Site coefficient wrt Site Class
Sms = Site-adjusted MCEr short period spectral acceleration [g]; =Fa*Ss
Sds = Design site-adjusted MCEr short period spectral acceleration [g]; =2/3*Sms

4.2 SEISMIC FORCES

The anchorage for a nonstructural component must consider the horizontal force, Eh, in one direction (considering overstrength, Ωo, for brittle limit states) and the vertical force, Ev, acting concurrently per Section 13.3 of ASCE 7-16. The LRFD combination 7 in ASCE 7 is the controlling case:

$$\varphi U \geq 0.9*D - Ev + (\Omega o)*Eh$$

The seismic forces on the Obeya product are calculated using the two critical configurations shown in Table 4-2.

Table 4-2: Critical Obeya configurations.

Config	Control	Description
Obeya T1	Tension	top loaded overturning scenario, two bays side-by-side
Obeya V1	Shear	heaviest loaded sliding scenario sans friction, two bays side-by-side

A front loaded and less heavy configuration has been considered in Appendix C (Obeya T2), however it is deemed not to control over the Obeya T1 configuration. Also note that overturning in the front-to-back in the front direction is not a concern for configurations with multiple bays stacked in the front-to-back direction due to the restoring moment provided by the adjacent bays. Therefore, multiple bay configurations stacked in the front- to-back direction are not considered critical scenarios. This assumes that the Obeya product structure remains intact.

Obeya T1

Obeya T1 is a critical overturning configuration that considers a two bays with:

- A long span in the side-to-side direction
- A short span in the front-back direction
- Seismic loading in the front-back direction
- The maximum possible weight added to the top (top heaviest)

Conservative design forces are calculated below:

Design Input					
Configuration	Config	=	Obeya T1		
Country	Location	=	Cont US		
Height within structure to total height	z/h	=	1.00		
Importance factor	Ip	=	1.00		ASCE 7-16 Section 13.1.3 does not apply
Amplification factor	ap	=	2.50		ASCE 7-16 Table 13.5-1, high deforming component
Response modification factor	Rp	=	3.50		ASCE 7-16 Table 13.5-1, high deforming component
Overstrength factor	Ωo	=	2.50		ASCE 7-16 Table 13.5-1, high deforming component
Configuration Input					
Number of bays	bays	=	2		
Number of tension resisting brackets	nbt	=	7		
Number of shear resisting brackets	nbv	=	14		
Weight	Wp	=	1994	lb	Appendix C
Support spacing	s	=	48.00	in	Appendix C
Front-back eccentricity	ey	=	24.00	in	Appendix C
Vertical eccentricity	ez	=	54.11	in	Appendix C
Demand					
Short period spectral acceleration	Sds	=	1.60	g	Section 4.2
Min horizontal acceleration	ahmin	=	0.48	g	=0.3*Sds*Ip
Max horizontal acceleration	ahmax	=	2.56	g	=1.6*Sds*Ip
Horizontal acceleration	ah	=	1.37	g	=MAX(ahmin,MIN(ahmax,0.4*ap*Sds/(Rp/Ip)*(1+2*z/h)))
Vertical acceleration	av	=	0.32	g	=0.2*Sds
Factored Demand					
Horizontal force	Fh	=	5469	lb	=bays*ah*Wp
Vertical force	Fv	=	-2313	lb	=bays*(av-0.9)*Wp
Overturning moment	Mot	=	20038	lb-ft	=MAX(0,Fh*ez/12+Fv*ey/12)
Bracket tension	Tb	=	716	lb	=Mot/(s/12)/nbt
Bracket shear	Vb	=	391		=Fh/nbv
Design Demand with Overstrength					
Horizontal force	Fmh	=	13673	lb	=bays*Ωo*ah*Wp
Overturning moment	Mmot	=	57033	lb-ft	=MAX(0,Fmh*ez/12+Fv*ey/12)
Bracket tension	Tmb	=	2037	lb	=Mmot/(s/12)/nbt
Bracket shear	Vmb	=	977	lb	=Fmh/nbv

Obeya V1

Obeya V1 is the critical shear configuration that considers a single bay with:

- A long span in the side-to-side direction
- A long span in the front-back direction
- Seismic loading in either major horizontal direction
- The maximum possible weight that can be added

Conservative design forces are calculated below:

Design Input					
Configuration	Config	=	Obeya V1		
Country	Location	=	Cont US		
Height within structure to total height	z/h	=	1.00		
Importance factor	Ip	=	1.00		ASCE 7-16 Section 13.1.3 does not apply
Amplification factor	ap	=	2.50		ASCE 7-16 Table 13.5-1, high deforming component
Response modification factor	Rp	=	3.50		ASCE 7-16 Table 13.5-1, high deforming component
Overstrength factor	Ωo	=	2.50		ASCE 7-16 Table 13.5-1, high deforming component
Configuration Input					
Number of bays	bays	=	2		
Number of tension resisting brackets	nbt	=	7		
Number of shear resisting brackets	nbv	=	14		
Weight	Wp	=	2948	lb	Appendix C
Support spacing	s	=	132.00	in	Appendix C
Front-back eccentricity	ey	=	66.00	in	Appendix C
Vertical eccentricity	ez	=	54.64	in	Appendix C
Demand					
Short period spectral acceleration	Sds	=	1.60	g	Section 4.2
Min horizontal acceleration	ahmin	=	0.48	g	=0.3*Sds*Ip
Max horizontal acceleration	ahmax	=	2.56	g	=1.6*Sds*Ip
Horizontal acceleration	ah	=	1.37	g	=MAX(ahmin,MIN(ahmax,0.4*ap*Sds/(Rp/Ip)*(1+2*z/h)))
Vertical acceleration	av	=	0.32	g	=0.2*Sds
Factored Demand					
Horizontal force	Fh	=	8086	lb	=bays*ah*Wp
Vertical force	Fv	=	-3420	lb	=bays*(av-0.9)*Wp
Overturning moment	Mot	=	18012	lb-ft	=MAX(0,Fh*ez/12+Fv*ey/12)
Bracket tension	Tb	=	234	lb	=Mot/(s/12)/nbt
Bracket shear	Vb	=	578		=Fh/nbv
Design Demand with Overstrength					
Horizontal force	Fmh	=	20215	lb	=bays*Ωo*ah*Wp
Overturning moment	Mmot	=	73242	lb-ft	=MAX(0,Fmh*ez/12+Fv*ey/12)
Bracket tension	Tmb	=	951	lb	=Mmot/(s/12)/nbt
Bracket shear	Vmb	=	1444	lb	=Fmh/nbv

4.3 ANCHORAGE ASSEMBLY CHECKS

Connecting Brackets

The connecting brackets shall be made of A1011 SS of at least Grade 45 (yield strength of 45ksi and tensile strength of 60ksi). The wood screws shall be made of steel of at least Grade 33. The following are considered controlling limits for the connecting bracket and are checked in this section on the following pages:

- Wood screw lateral loading, NDS Sec. 11.3.1
- Bracket bending, AISC 360 Eq. F11
- Bolt prying, AISC 360 Eq.9-20a
- Bracket bearing at bolt hole, AISC 360 Eq. J3-6a

Note that:

- The analysis considers 1.5 brackets per post resisting tension (3-way post)
- Other limit states, such as steel bracket bearing at screw holes, have been considered not to control over the limit states above.
- Wood screw lateral loading check per NDS 2015 includes the single shear limits states of the wood member, steel screw, and the side member (steel bracket).
- Wood screw withdrawal, lateral, and combined strengths are conservatively checked against the resultant of the screw tension and shear to ensure all connections can transfer the loads to the brackets.
- The post rail wood species that controls the lateral design value is Walnut, which has the minimum specific gravity, G, per Table 4-3.
- The following properties are met so the reference lateral design values for wood screws given NDS 2015 Table 12M can be used:
    - Dowel bearing strength Fe > 61,850 psi
    - Dowel bending yield strength Fyb > 70,000 psi for wood screw diameters of 0.236" < D ≤ 0.273"

Table 4-3: Specific gravity wood species.

Species	G	Reference
Beech-Birch-Hickory	0.71	NDS 2015 Table 12.3.3A
White Oak	0.73	NDS 2015 Table 12.3.3A
Walnut	0.55	Wood Handbook Table 5-3a

Concrete Anchors

Anchorage shall consist of ITW Redhead Tapcon+ 1/2"x3" Screw Anchors as specified in Section 2.0. The concrete anchors are qualified for the seismic demand of Obeya T1 and Obeya V1 one and two bay configurations in in **Error! Reference source not found.** per the ASD provisions of ACI 318-14 and ESR-3699 using the data in A ppendix B. Note that the anchorage is controlled by the bracket plastic moment formation (see Tmb' in the following tables). Because this is a ductile limit state, it is used in lieu of the overstrength tension value, per ACI 318 Section 17.2.3.4.3(b).

Obeya T1

Bracket Input					
Configuration	Config	=	Obeya T1		
Steel designation	Steel	=	A1011 SS		
Steel grade	Grade	=	Grade 45		
Bracket steel yield strength	Fy	=	45000	psi	
Bracket steel ultimate strength	Fu	=	60000	psi	
Bracket width	B	=	1.750	in	
Bracket thickness	t	=	0.250	in	
Bracket moment arm	a	=	1.125	in	
Bolt hole diameter	dh	=	0.563	in	
Clear distance, bolt to bracket edge	lcb	=	0.594	in	=(1.75-dh)/2
Wood Screw Input					
Wood species	Species	=	Walnut		Controlling species
Number of wood screws	nw	=	5		
Wood screw number	No	=	12		
Screw diameter	D	=	0.216	in	No 12 screw
Screw penetration	p	=	2.000	in	
Thread penetration	pth	=	1.500	in	
Unity factors, Cm*Ct*Ceg*Cdi*Ctn	C1	=	1.000		
Anchor Input					
Manufacturer	Man	=	Redhead		
Product	Product	=	Tapcon+		
Size	Size	=	1/2"x3"		
Anchor diameter	da	=	0.500	in	
Effective length	hef	=	2.17	in	
Concrete strength	f'c	=	3000	psi	
Tension allowable	Ta	=	1854	lb	
Shear allowable	Va	=	2990	lb	
Bolt spacing	s	=	9.90	in	
Edge distance	e	=	8.00	in	
Backet Demand					
Bracket tension	Tb	=	716	lb	Section 4.2
Bracket shear	Vb	=	391	lb	Section 4.2
Bracket tension with overstrength	Tmb	=	2037	lb	Section 4.2
Bracket shear with overstrength	Vmb	=	977	lb	Section 4.2
Bracket section plastic modulus	Zb	=	0.027	in^3	=B*t^2/4
Bracket tension at hinge development	Tby	=	1538	lb	=1.25*Fy*Zb; ASCE 41 Table 9-6
Overstrength bracket tension at yield	Tmb'	=	1538	lb	=MIN(Tmb,Tby)
Wood Screw Demand					
Wood screw tension	Tw	=	195	lb	=Vmb/nw
Wood screw shear	Vw	=	308	lb	=Tmb'/nw
Wood screw shear, combined case	Vwc	=	364	lb	=SQRT(SUMSQ(Tw,Vw))
Angle between surface and load	α	=	1.01	rad	=IF(Tw=0,0,ATAN(Vw/Tw))
Bracket Bending					
Plate moment due to bolt tension	Mb	=	805	lb-in	=Tb*a
Bracket section bending strength	ϕMb	=	1107	lb-in	=0.9*Fy*Zb; AISC360-10 F11-1
Bracket bending utilization	βm	=	73%		=Mb/ϕMb
Bracket Bearing at Bolt Hole (Bolt in Shear)					
Bracket bearing at bolt hole strength	ϕRb	=	8016	lb	=0.75*MIN(1.2*lcb,2.4*da)*t*Fu; AISC360 J3-6a
Bracket bearing at bolt hole utilization	βb	=	12%		=Vmb/ϕRb

Wood Screw Factors					
Format conversion factor	Kf	=	3.32		NDS Table 11.3.1
Group action factor	Cg	=	1.00		=IF(D<1/4,1); NDS 11.3.6
Geometry factor	CΔ	=	1.00		=IF(D<1/4,1); NDS 12.5.1
Penetration factor	Cp	=	0.93		=IF(p<6*D,0,MIN(1,p/(10*D))); NDS Table 12M
Wood specific gravity	Gw	=	0.55		NDS Table 12.3.3A
Wood Screw Withdrawal					
Ref withdrawal design value (per in pen)	W/p	=	186	lb/in	NDS Table 12.2B
Withdrawal design value	W	=	279	lb	=W/p*pth
Withdrawal strength	ϕW	=	602	lb	=0.65*Kf*C1*W; NDS 11.3.1
Withdrawal utilization	βww	=	32%		=Tw/ϕW
Wood Screw Lateral					
Ref lateral design value	Z	=	218	lb	NDS Table 12M wrt Gw, t
Lateral strength	ϕZ	=	436	lb	=0.65*Z*Kf*C1*Cp*Cg*CΔ; NDS 11.3.1
Combined load design value	ϕZα	=	543	lb	=ϕW*ϕZ/(ϕW*COS(α)^2+ϕZ*SIN(α)^2)
Lateral utilization	βwz	=	84%		=MAX(Vwc/ϕZ,Vw/ϕZα)
Anchor Tension/Shear					
Tension utilization	T/Ta	=	83%		=Tmb'/Ta
Shear utilization	V/Va	=	33%		=Vmb/Va
Utilization	βa	=	96%		=IF(T/Ta<0.2,V/Va,IF(V/Va<0.2, T/Ta, T/Ta+V/Va)/1.2)
Check - Anchor Prying					
Moment arm	b'	=	0.875	in	=a-da/2
Bracket tributary width	pb	=	1.750	in	=MIN(B,2*a)
Min thickness for no anchor prying	tmin	=	0.24	in	=SQRT(4*Tmb'*b'/(0.9*pb*Fu)); AISC360 9-20a
No bolt prying	NoPry	=	TRUE		=tmin<t
Check - Breakout Area					
Min spacing for max breakout area	smin	=	6.51	in	=3*hef
Min edge distance for max breakout area	emin	=	3.26	in	=1.5*hef
Has full capacity	FullCap	=	TRUE		=AND(s>smin,e>emin)
Utilization					
Utilization	β	=	96%		=MAX(βwz,βm,βww,βwz,βb,βa)
Status	Status	=	OK		

Obeya V1

Bracket Input					
Configuration	Config	=	Obeya V1		
Steel designation	Steel	=	A1011 SS		
Steel grade	Grade	=	Grade 45		
Bracket steel yield strength	Fy	=	45000	psi	
Bracket steel ultimate strength	Fu	=	60000	psi	
Bracket width	B	=	1.750	in	
Bracket thickness	t	=	0.250	in	
Bracket moment arm	a	=	1.125	in	
Bolt hole diameter	dh	=	0.563	in	
Clear distance, bolt to bracket edge	lcb	=	0.594	in	=(1.75-dh)/2
Wood Screw Input					
Wood species	Species	=	Walnut		Controlling species
Number of wood screws	nw	=	5		
Wood screw number	No	=	12		
Screw diameter	D	=	0.216	in	No 12 screw
Screw penetration	p	=	2.000	in	
Thread penetration	pth	=	1.500	in	
Unity factors, Cm*Ct*Ceg*Cdi*Ctn	C1	=	1.000		
Anchor Input					
Manufacturer	Man	=	Redhead		
Product	Product	=	Tapcon+		
Size	Size	=	1/2"x3"		
Anchor diameter	da	=	0.500	in	
Effective length	hef	=	2.17	in	
Concrete strength	f'c	=	3000	psi	
Tension allowable	Ta	=	1854	lb	
Shear allowable	Va	=	2990	lb	
Bolt spacing	s	=	9.90	in	
Edge distance	e	=	8.00	in	
Backet Demand					
Bracket tension	Tb	=	234	lb	Section 4.2
Bracket shear	Vb	=	578	lb	Section 4.2
Bracket tension with overstrength	Tmb	=	951	lb	Section 4.2
Bracket shear with overstrength	Vmb	=	1444	lb	Section 4.2
Bracket section plastic modulus	Zb	=	0.027	in^3	=B*t^2/4
Bracket tension at hinge development	Tby	=	1538	lb	=1.25*Fy*Zb; ASCE 41 Table 9-6
Overstrength bracket tension at yield	Tmb'	=	951	lb	=MIN(Tmb,Tby)
Wood Screw Demand					
Wood screw tension	Tw	=	289	lb	=Vmb/nw
Wood screw shear	Vw	=	190	lb	=Tmb'/nw
Wood screw shear, combined case	Vwc	=	346	lb	=SQRT(SUMSQ(Tw,Vw))
Angle between surface and load	α	=	0.58	rad	=IF(Tw=0,0,ATAN(Vw/Tw))
Bracket Bending					
Plate moment due to bolt tension	Mb	=	263	lb-in	=Tb*a
Bracket section bending strength	ϕMb	=	1107	lb-in	=0.9*Fy*Zb; AISC360-10 F11-1
Bracket bending utilization	βm	=	24%		=Mb/ϕMb
Bracket Bearing at Bolt Hole (Bolt in Shear)					
Bracket bearing at bolt hole strength	ϕRb	=	8016	lb	=0.75*MIN(1.2*lcb,2.4*da)*t*Fu; AISC360 J3-6a
Bracket bearing at bolt hole utilization	βb	=	18%		=Vmb/ϕRb

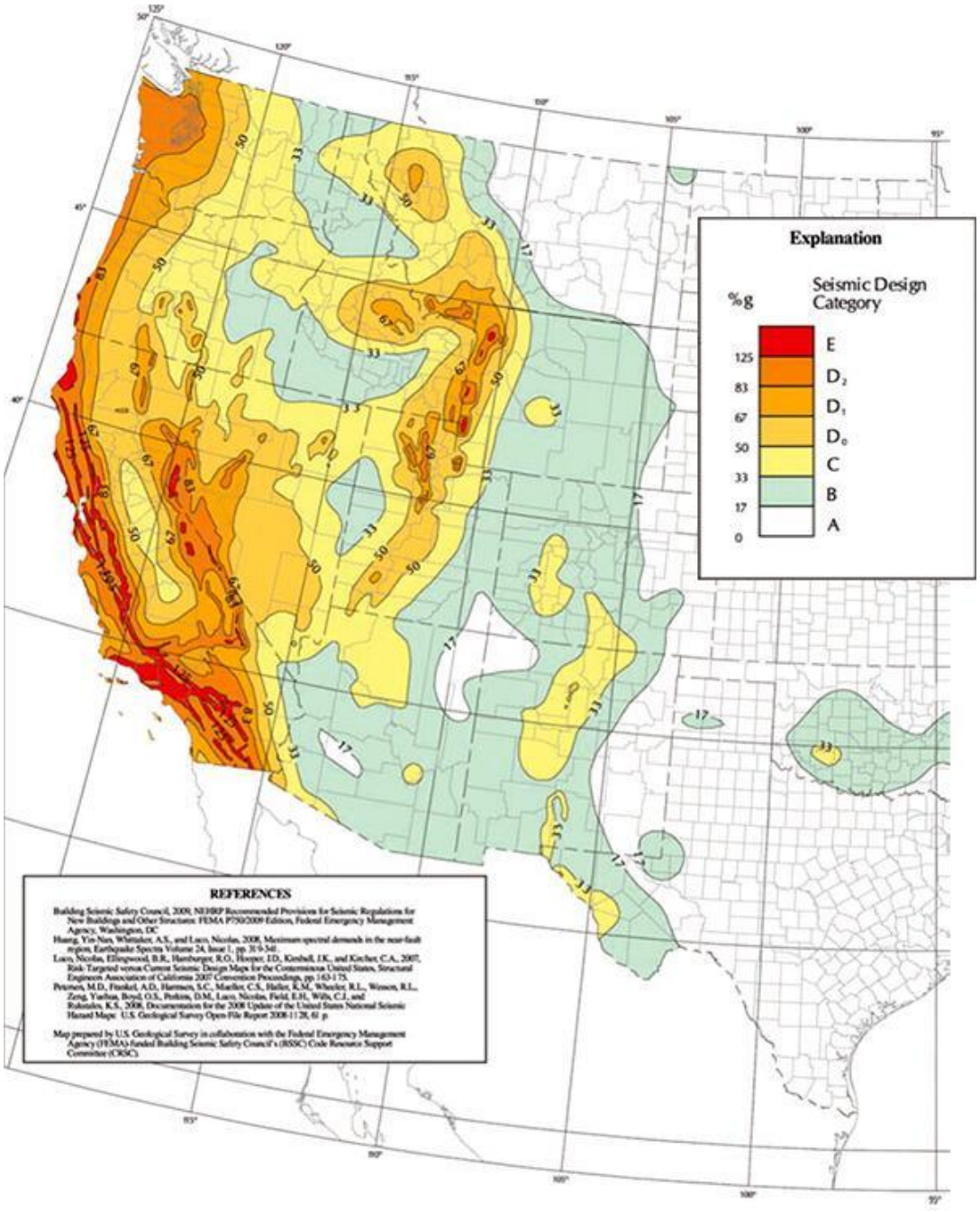
Wood Screw Factors					
Format conversion factor	Kf	=	3.32		NDS Table 11.3.1
Group action factor	Cg	=	1.00		=IF(D<1/4,1); NDS 11.3.6
Geometry factor	CΔ	=	1.00		=IF(D<1/4,1); NDS 12.5.1
Penetration factor	Cp	=	0.93		=IF(p<6*D,0,MIN(1,p/(10*D))); NDS Table 12M
Wood specific gravity	Gw	=	0.55		NDS Table 12.3.3A
Wood Screw Withdrawal					
Ref withdrawal design value (per in pen)	W/p	=	186	lb/in	NDS Table 12.2B
Withdrawal design value	W	=	279	lb	=W/p*pth
Withdrawal strength	ϕW	=	602	lb	=0.65*Kf*C1*W; NDS 11.3.1
Withdrawal utilization	βww	=	48%		=Tw/ϕW
Wood Screw Lateral					
Ref lateral design value	Z	=	218	lb	NDS Table 12M wrt Gw, t
Lateral strength	ϕZ	=	436	lb	=0.65*Z*Kf*C1*Cp*Cg*CΔ; NDS 11.3.1
Combined load design value	ϕZα	=	475	lb	=ϕW*ϕZ/(ϕW*COS(α)^2+ϕZ*SIN(α)^2)
Lateral utilization	βwz	=	79%		=MAX(Vwc/ϕZ,Vw/ϕZα)
Anchor Tension/Shear					
Tension utilization	T/Ta	=	51%		=Tmb'/Ta
Shear utilization	V/Va	=	48%		=Vmb/Va
Utilization	βa	=	83%		=IF(T/Ta<0.2,V/Va,IF(V/Va<0.2, T/Ta, T/Ta+V/Va)/1.2)
Check - Anchor Prying					
Moment arm	b'	=	0.875	in	=a-da/2
Bracket tributary width	pb	=	1.750	in	=MIN(B,2*a)
Min thickness for no anchor prying	tmin	=	0.19	in	=SQRT(4*Tmb'*b'/(0.9*pb*Fu)); AISC360 9-20a
No bolt prying	NoPry	=	TRUE		=tmin<t
Check - Breakout Area					
Min spacing for max breakout area	smin	=	6.51	in	=3*hef
Min edge distance for max breakout area	emin	=	3.26	in	=1.5*hef
Has full capacity	FullCap	=	TRUE		=AND(s>smin,e>emin)
Utilization					
Utilization	β	=	83%		=MAX(βwz,βm,βww,βwz,βb,βa)
Status	Status	=	OK		

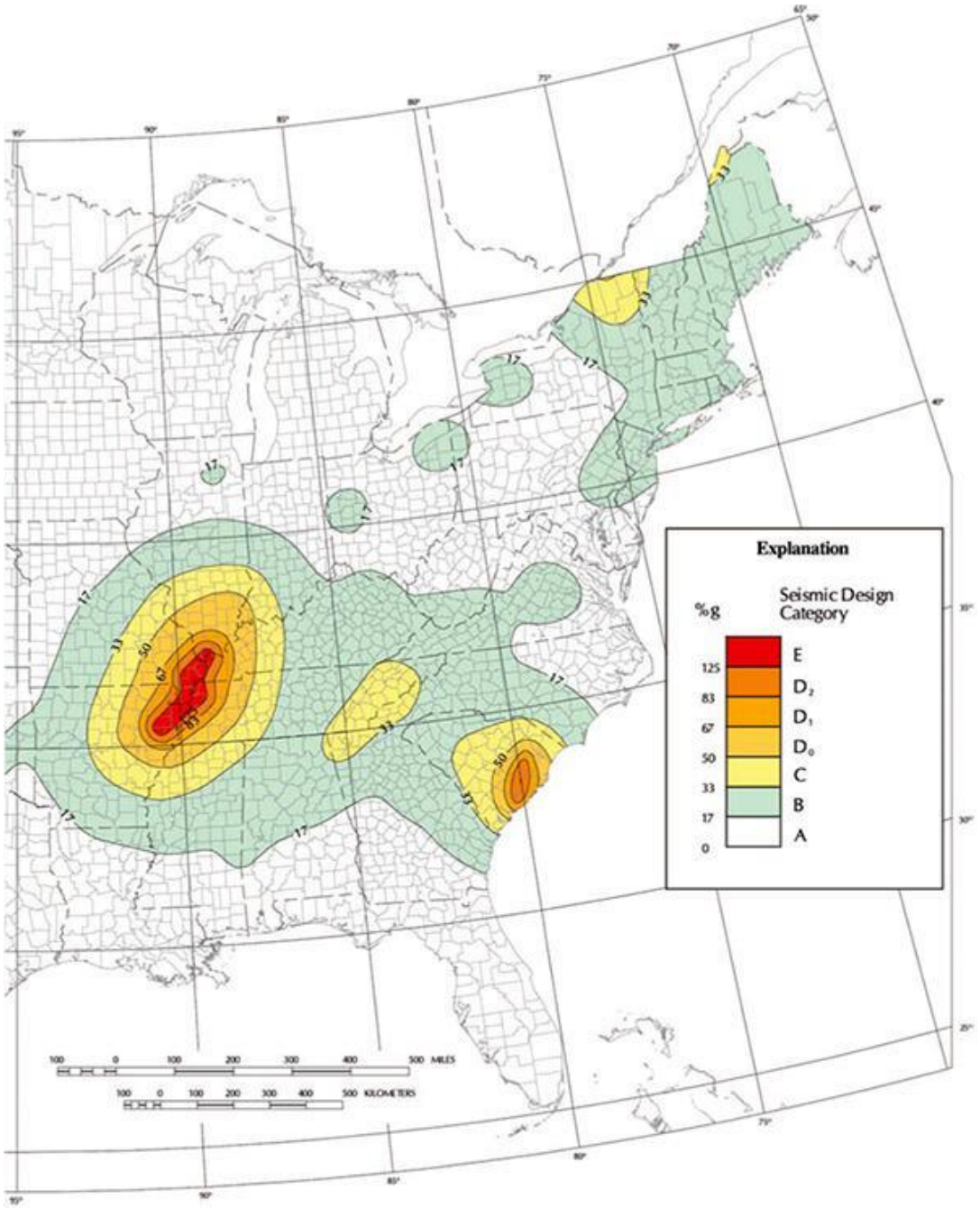
5.0 References

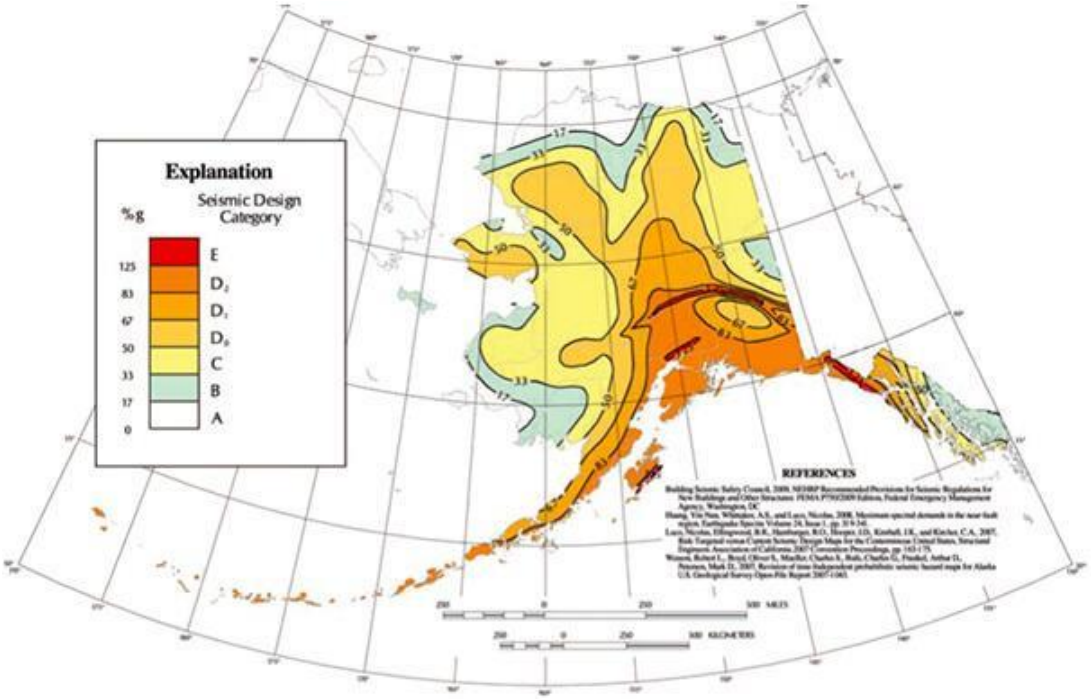
1. ACI 318-14, Building Code Requirements for Structural Concrete, 2014.
2. ANSI/AISC 360-10, Specification for Structural Steel Buildings, 2010.
3. ASCE/SEI 7-16, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, 2016.
4. ASCE/SEI 41-17, Seismic Evaluation and Retrofit of Existing Buildings.
5. AWC NDS 2015, National Design Specification for Wood Construction.
6. FEMA Earthquake Hazard Maps, https://www.fema.gov/earthquake-hazard-maps, Last Updated: 1/14/2019 - 07:40.
7. ICC ESR-3699, Tapcon+ Screw Anchors and Sammys Threaded Rod Anchors for Use in Cracked and Uncracked Concrete
8. IBC 2018, International Building Code, 2018.
9. OFS Report OFSB-001932
10. SAD001.001 - Seismic Anchorage Details Sheet 1 Rev 0.
11. SAD001.002 - Seismic Anchorage Details Sheet 2 Rev 0.
12. USDA Wood Handbook, Wood as an Engineering Material, 2010.

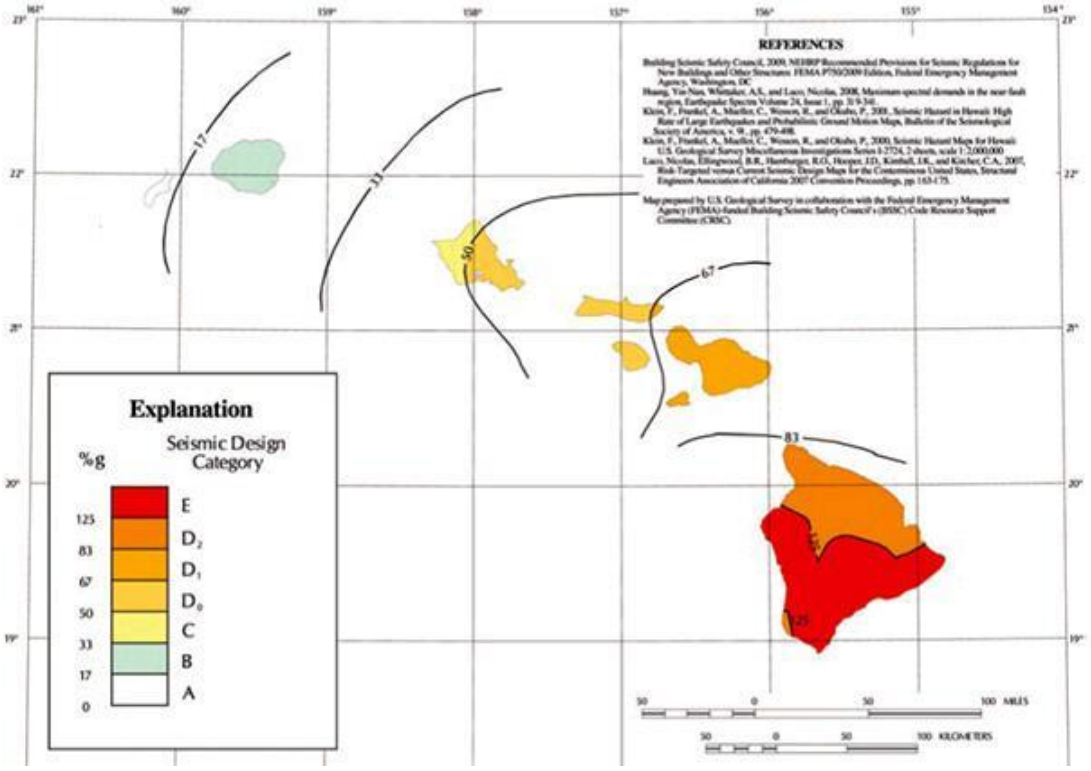
Appendix A – Seismic Design Category Maps

The following Seismic Design Category Maps for Default Site Class D are retrieved from the United States Federal Emergency Management Agency (FEMA) website at the following url: https://www.fema.gov/earthquake-hazard-maps. Seismic Design Category designations of A or B shall be confirmed by the building's construction documents.




Explanation
Seismic Design Category
%g
125
83
67
50
33
17
0
E
D2
D1
D0
C
B
A
100 0 100 200 300 400 500 MILES
100 0 100 200 300 400 500 KILOMETERS


Explanation
Seismic Design Category
%g
125
83
67
50
33
17
0
E
D2
D1
D0
C
B
A
REFERENCES


REFERENCES
Explanation
Seismic Design Category
%g
125
83
67
50
33
17
0
E
D2
D1
D0
C
B
A

Appendix B – Tapcon+ Performance Data

Retrieved from https://www.tapcon.com/products/heavy-duty-tapcon-plus on 10/15/2019. Allowables are taken as 25% of ultimate capacities.

ULTIMATE PULLOUT (IN CONCRETE)		
Anchor Diameter	Embedment Depth	Concrete Compressive Strength
		3,000 psi
5/16"	1-3/4"	2,785 lbs.
3/8"	2-1/2"	5,445 lbs. 10% higher than wedge 28% higher than sleeve
1/2"	3"	7,415 lbs. equal to wedge 22% higher than sleeve

ULTIMATE SHEAR (IN CONCRETE)		
Anchor Diameter	Embedment Depth	Concrete Compressive Strength
		3,000 psi
5/16"	1-3/4"	3,045 lbs.
3/8"	2-1/2"	5,955 lbs. 10% higher than wedge 28% higher than sleeve
1/2"	3"	11,960 lbs. equal to wedge 22% higher than sleeve

A safety factor of 4:1 or 25% of ultimate pullout/shear value is generally accepted as a safe working load.

Appendix C – Obeya Weight Calculations

Itemized Weights

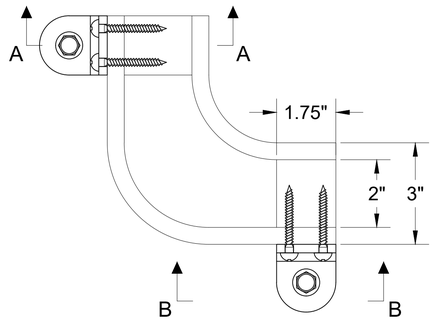
Itemized weights for each configuration are listed below in units of pounds and inches

Config	Item	Location	W1	qty	x	y	z	W	Wx	Wy	Wz
Obeya T1	Corner post	Front left	35	1	0.00	0.00	48.00	35	0	0	1680
Obeya T1	Corner post	Front right	35	1	132.00	0.00	48.00	35	4620	0	1680
Obeya T1	Corner post	Back right	35	1	132.00	48.00	48.00	35	4620	1680	1680
Obeya T1	Corner post	Back left	35	1	0.00	48.00	48.00	35	0	1680	1680
Obeya T1	Double wall panel & rail kit	Front	200	3	66.00	0.00	48.00	600	39600	0	28800
Obeya T1	Double wall panel & rail kit	Right	200	1	132.00	24.00	48.00	200	26400	4800	9600
Obeya T1	Double wall panel & rail kit	Back	200	3	66.00	48.00	48.00	600	39600	28800	28800
Obeya T1	Double wall panel & rail kit	Left	200	1	0.00	24.00	48.00	200	0	4800	9600
Obeya T1	Ceiling & misc. weight	Top	154	1	66.00	24.00	96.00	154	10164	3696	14784
Obeya T1	Additional attachments	Top	100	1	66.00	24.00	96.00	100	6600	2400	9600
Obeya T2	Corner post	Front left	35	1	0.00	0.00	48.00	35	0	0	1680
Obeya T2	Corner post	Front right	35	1	132.00	0.00	48.00	35	4620	0	1680
Obeya T2	Corner post	Back right	35	1	132.00	48.00	48.00	35	4620	1680	1680
Obeya T2	Corner post	Back left	35	1	0.00	48.00	48.00	35	0	1680	1680
Obeya T2	Double wall panel & rail kit	Front	200	3	66.00	0.00	48.00	600	39600	0	28800
Obeya T2	Short beam	Top right	22	1	132.00	24.00	96.00	22	2904	528	2112
Obeya T2	Long beam	Top back	66	1	66.00	48.00	96.00	66	4356	3168	6336
Obeya T2	Short beam	Top left	22	1	0.00	24.00	96.00	22	0	528	2112
Obeya T2	Ceiling	Top	154	1	66.00	24.00	96.00	154	10164	3696	14784
Obeya T2	Additional attachments	Top	100	1	66.00	24.00	96.00	100	6600	2400	9600
Obeya V1	Corner post	Front left	35	1	0.00	0.00	48.00	35	0	0	1680
Obeya V1	Corner post	Front right	35	1	132.00	0.00	48.00	35	4620	0	1680
Obeya V1	Corner post	Back right	35	1	132.00	132.00	48.00	35	4620	4620	1680
Obeya V1	Corner post	Back left	35	1	0.00	132.00	48.00	35	0	4620	1680
Obeya V1	Double wall panel & rail kit	Front	200	3	66.00	0.00	48.00	600	39600	0	28800
Obeya V1	Double wall panel & rail kit	Right	200	3	132.00	66.00	48.00	600	79200	39600	28800
Obeya V1	Double wall panel & rail kit	Back	200	3	66.00	132.00	48.00	600	39600	79200	28800
Obeya V1	Double wall panel & rail kit	Left	200	3	0.00	66.00	48.00	600	0	39600	28800
Obeya V1	Ceiling	Top	154	2	66.00	66.00	96.00	308	20328	20328	29568
Obeya V1	Additional attachments	Top	100	1	66.00	66.00	96.00	100	6600	6600	9600

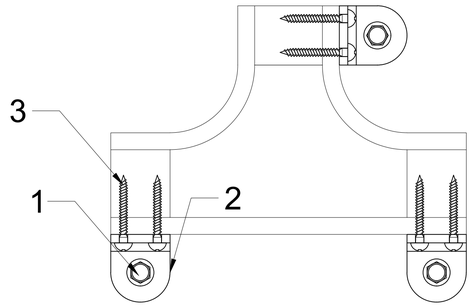
Total Weights and Eccentricities

Total weights and eccentricities are listed below for each configuration in units of pounds and inches.

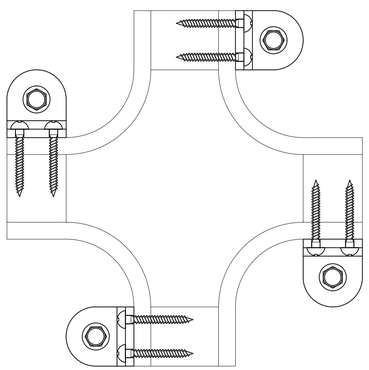
Config	Lx	Ly	Lz	W	Wx	Wy	Wz	xcg	ycg	zcg
Obeya T1	132.00	48.00	96.00	1994	131604	47856	107904	66.00	24.00	54.11
Obeya T2	132.00	48.00	96.00	1104	72864	13680	70464	66.00	12.39	63.83
Obeya V1	132.00	132.00	96.00	2948	194568	194568	161088	66.00	66.00	54.64



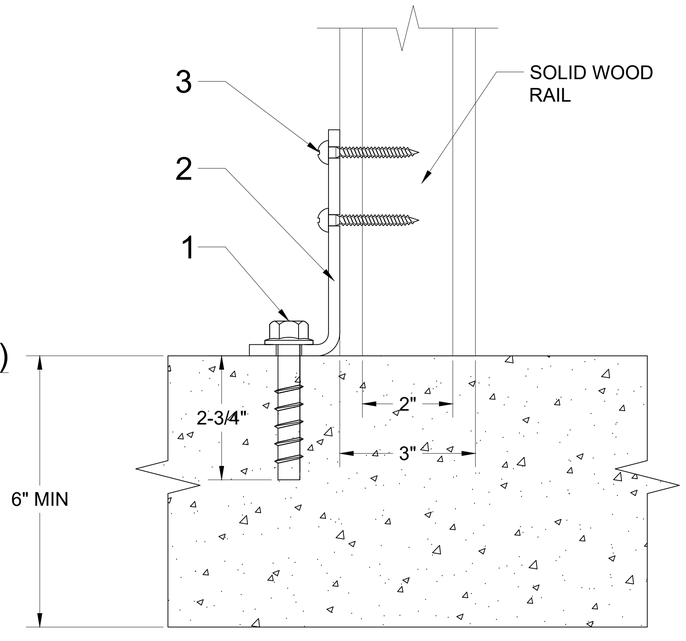
TOP VIEW: CORNER POST (SCALE: 6" = 1'-0')



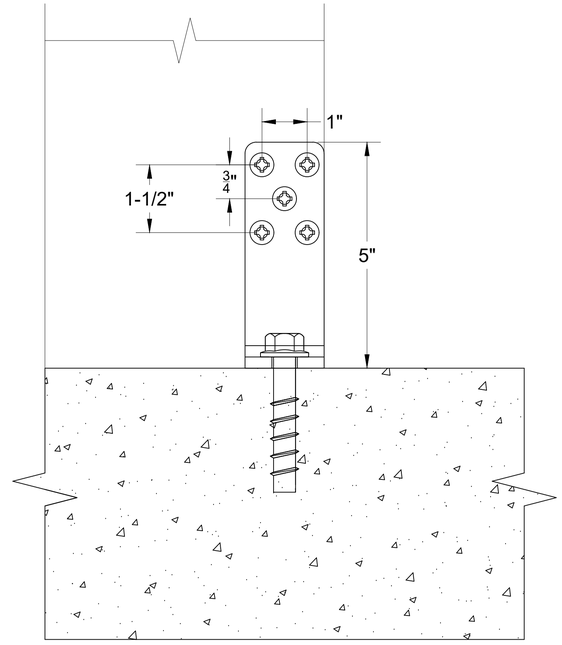
TOP VIEW: 3-WAY POST (SCALE: 6" = 1'-0')



TOP VIEW: 4-WAY POST (SCALE: 6" = 1'-0')



SECTION A-A (TYP.)
(SCALE: 6" = 1'-0')



SECTION B-B (TYP.)
(SCALE: 6" = 1'-0')

NOTES:

1. Obeya configurations shall consist of posts placed where the outer dimensions are more than than 4'-0" apart and less than 11'-0" apart.
2. Obeya configurations shall have a center of gravity less than 4'-6" above top of slab.
3. Obeya configurations shall have a maximum weight of 1900 pounds for a bay with a minimum horizontal dimension of 4'-0".
4. Obeya configurations shall have a maximum weight of 2900 pounds for a bay with a minimum horizontal dimension of 11'-0".
5. The solid wood rails of the posts shall be a full 2" X 1-3/4" cross section consisting of of Walnut, White Oak, or Beech wood species.
6. Two (2) bracket connections shall be installed for a corner post, three (3) bracket connections shall be installed for a three-way post, and four (4) bracket connections shall be installed for a four-way post.

BILL OF MATERIALS (PER BRACKETED CONNECTION)

ID	ITEM	Spec.	Quant.
1	ITW Redhead Tapcon+ 1/2”x3” Screw Anchor	ESR-3699	1
2	OFS Custom Bracket, 1/4” thick	ASTM A1011 GR 45	1
3	#12 Wood Screw, 2" Long	Steel GR 33	4

JENSEN HUGHES
Advancing the Science of Safety
100 Quannapowitt Parkway
Suite 401
Wakefield, MA 01880
O: 781-270-5200 | F: 781-229-2922
www.jensenhughes.com

NO.	REVISION	DATE
0	Original Issue	10/18/2019

KEY PLAN

NORTH

SEAL

PROJECT
OFS OBEYA
SEISMIC ANCHORAGE
DESIGN

ADDRESS
Not Applicable

PROJECT NO
1CMH00002.000

DATE
October, 15 2019

DESIGN	DRAWN BY	CHECKED BY
CMH	TAD	KO

SCALE
See on views, details, and sections when applicable.

TITLE
SEISMIC ANCHORAGE
DETAILS

NUMBER
SAD001

SHEET
1 of 2

REVDATE: FILE NAME: C:\Users\chendrix\AppData\Local\Temp\AcPublish_19928\1CMH00002-SAD001.dwg LAYOUT NAME: Sheet_1 PLOTTED: Friday, October 18, 2019 - 1:43pm

DESIGN NOTES:

The values listed below are defined for a conservative analysis of an architectural component per ASCE 7-16, Chapter 13.

1.	Risk category:	I or II
2.	Seismic design category:	F (see explanation above)
3.	Seismic importance factor: I_e=	1.0
4.	Mapped Spectral Accelerations	
4.1.	S_s=	2.00g
4.2.	S_1=	Not used
6.	Soil Class:	D (unknown by ASCE 7-16, Section 11.4.3)
7.	Soil Class Coefficients:	
7.1.	F_a=	1.2
7.2.	F_v=	Not used
8.	5% Damped Design Spectral Response Acceleration	
8.1.	S_{DS}=	1.60g
8.2.	S_{D1}=	Not used
9.	Component Response modification:	
9.1.	a_p=	2.5
9.2.	R_p=	3.5
9.3.	Ωo=	2.5

GENERAL

1. Typical details and sections shall apply where specific details are not shown.
2. The contractor shall verify all site conditions and dimensions. If the actual conditions differ from those shown in the contract drawings, the contractor shall immediately notify the architect/engineer/manufacturer before proceeding with the fabrication, construction or installation of any affected elements.
3. Omissions or conflicts between the contract drawings and/or specifications shall be brought to the attention of the architect/engineer/manufacturer before proceeding with any changes, substitutions or modifications. Any work done by the contractor before receiving written approval will be at contractor risk.

POST-INSTALLED ANCHORS

1. Do not install mechanical anchors or screw anchors in concrete less than 7 days old. Contractor must obtain written approval from the engineer to install prior this time period. Do not apply full load to anchors until concrete has reached 28-day compression strength.
2. The anchors specified in the details shall be installed. Alternative anchors may be used if the contractor provides calculations demonstrating that the alternative can achieve the performance values of the specified product.
3. Follow the manufacturer's recommendations and certification testing reports for anchor installation.
4. No anchor shall be installed within 1.5 anchor rod diameters of an abandoned hole that has been filled with non-shrink grout; increase distance to 3 anchor rod diameters.
5. For concrete, the mechanical anchor shall be Tapcon+ 1/2"x3" Screw Anchor (ICC-ES ESR-3699) by ITW Redhead (structural engineer to confirm).
6. The anchors shall be installed at a minimum distance of 8 inches from the reinforced concrete slab edges.
7. The reinforced concrete slab shall be a minimum of 6 inches thick and constructed of structural reinforced concrete (may be cracked or uncracked) with a compressive concrete strength of at least 3000 psi.
8. Spacing requirements:
   - 8.1. Minimum spacing of 9" between screw anchors
   - 8.2. Minimum edge distance of 8"

POST-INSTALLED ANCHORS INSPECTIONS

ITEM FOR VERIFICATION & INSPECTION	INSPECTION FREQUENCY		COMMENTS
	CONTINUOUS	PERIODIC	
Post Installed Anchors and Reinforcing Bars (2018 IBC Table 1705.3)			
Mechanical Anchors and Screw Anchors	-	X	Special inspection shall be provided per manufacturer's requirements and approved ICC-ES report noted in POST-INSTALLED ANCHOR section above prior to installation of mechanical or screw anchors.

a. Reference Code is ACI 318-14
b. Specific requirements for special inspection shall be included in the research report for the anchor issued by an approved source in accordance with 17.8.2 in ACI 318, or other qualification procedures. Where specific requirements are not provided, special inspection requirements shall be specified by the registered design professional and shall be approved by the building official prior to the commencement of the work.

NOTICE TO THE APPLICANT / OWNER / OWNER'S AGENT / ARCHITECT or ENGINEER OF RECORD

1. By using this permitted construction drawings for the construction/installation of the work specified herein, you agree to comply with the requirements of the Authority Having Jurisdiction for special inspections, structural observations, construction material testing, and off-site fabrication of building components, contained in the statement of special inspections and as required by the California construction codes.

NOTICE TO THE CONTRACTOR / BUILDER / INSTALLER / SUB-CONTRACTOR / OWNER-BUILDER

1. By using this permitted construction drawings for the construction/installation of the work specified herein, you acknowledge and are aware of, the requirements contained in the statement of special inspections. You agree to comply with the requirements of the Authority Having Jurisdiction for special inspections, structural observations, construction materials testing, and off-site fabrication of building components, contained in the statement of special inspections and, as required by the California construction codes.

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NO.	REVISION	DATE
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KEY PLAN

NORTH

SEAL

PROJECT
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SEISMIC ANCHORAGE
DESIGN

ADDRESS
Not Applicable

PROJECT NO
1CMH00002.000

DATE
October, 15 2019

DESIGN	DRAWN BY	CHECKED BY
CMH	TAD	KO

SCALE
See on views, details, and sections when applicable.

TITLE
SEISMIC ANCHORAGE
DETAILS

NUMBER
SAD001

SHEET 2 of 2

REV/DATE: FILE NAME: \\EpiryteDrive_jh\Shared\Legacy\US\WKFD\Proj\JensenHughes\Chris Hendrix\1CMH00002.000 OFS Seismic Anchorage\Drawings\1CMH00002-SAD001.dwg LAYOUT NAME: Sheet_2 PLOTTED: Friday, October 18, 2019 - 2:39pm