877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

STRUCTURAL ENGINEERING CALCULATIONS

FOR

DDB UNLIMITED®

POLE AND PAD MOUNTING SHELF (PMS)

WALL ANCHORAGE

ACME CELLULAR SOLUTIONS

CONTROL ROOM

AUSTIN, TEXAS XXXXX

PROJECT: 012345

ENGINEER: CHRISTOPHER J. CASTLE, P.E.

STATE OF TEXAS
CHRISTOPHER JUNFIN CASTLE
96522
LICENSED
PROFESSIONAL ENGINEER

DESIGN CRITERIA:

- IBC BUILDING CODE
- ASCE 7-16

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

TABLE OF CONTENTS

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

PROJECT CONTACTS

Engineering Team:

Christopher J. Castle, P.E. (Engineer)
Douglas D. Hardin, P.E. (Peer Review)
2225 E Murray
Holladay, UT 84117
877-697-9269

Client:

ACME Cellular Solutions
John Smith
XXXX Riverside Dr.
Austin, TX XXXXX
XXX-XXX-XXXX

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

PROJECT SCOPE

Provide ***Client*** with structural engineering anchorage calculations for the PMS to a supporting wall in accordance with the latest edition of CBC and any local jurisdiction amendments. Structurally related drawings will be provided by ***Client*** to ***SolidBox*** for review purposes. Calculations and stamped drawings will be provided to the ***Client*** for submittal to the local jurisdiction. Calculations to include seismic analysis, and anchorage. Environmental conditions, such as wind and snow loads are not consider, as this an interior installation.

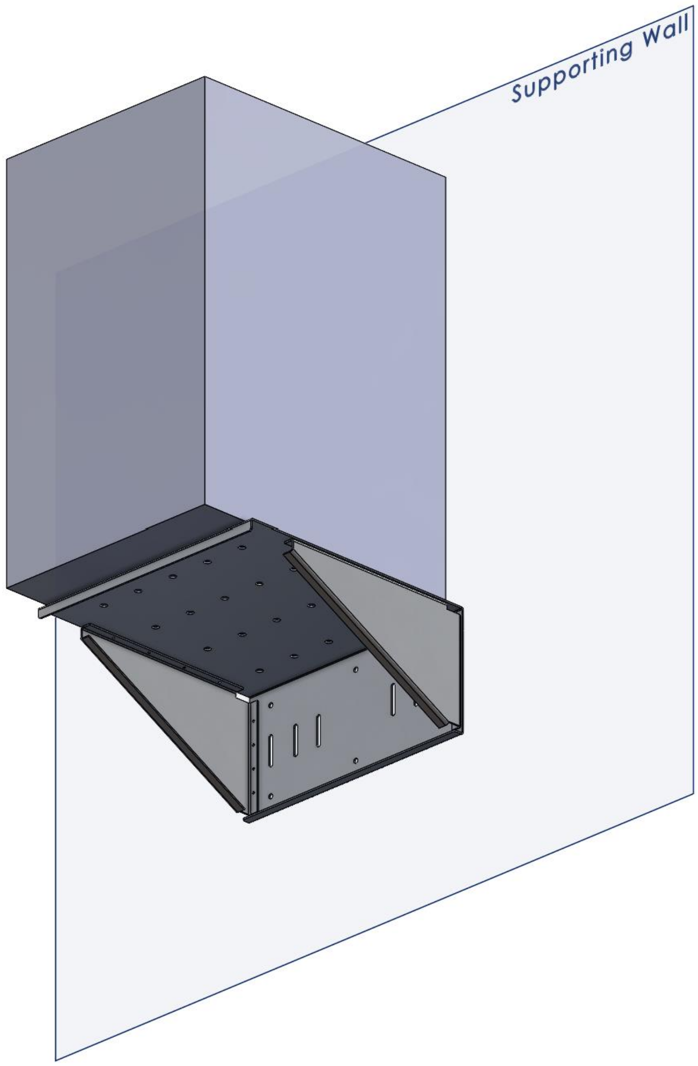


Figure 1: Pole and Pad Mounting Shelf (PMS) with Enclosure Load, anchored to Standard Wall

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

ICC EVALUATION, PRODUCT SPECIFICATION LITERATURE, AND DESIGN AIDS

- ASCE 7-16 – MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES
- AISC – STEEL CONSTRUCTION MANUAL 14TH ADDITION
- ALUMINUM ASSOCIATION 1997 EDITION OF THE ALUMINUM DESIGN MANUAL

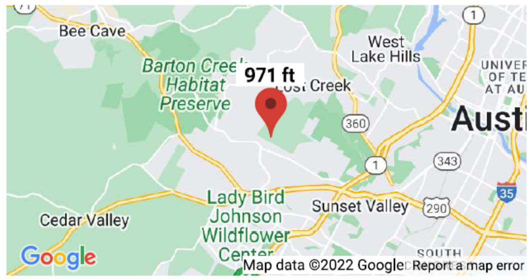
877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

LOCATION DETAILS

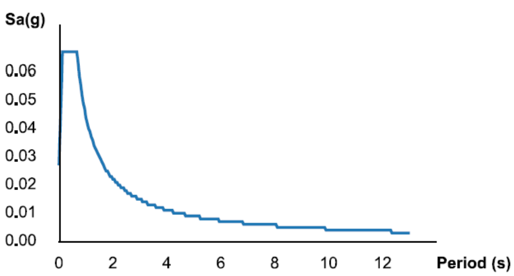
ATC Hazards by Location

Search Information

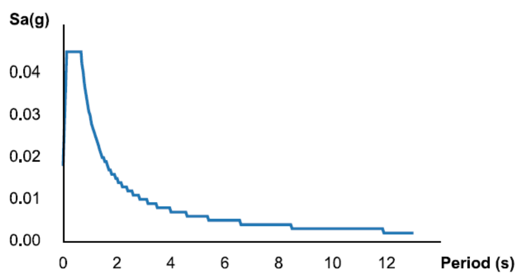
Address:	Austin, TX, USA 78735
Coordinates:	30.2573497, -97.86127669999999
Elevation:	971 ft
Timestamp:	2022-07-28T22:25:51.625Z
Hazard Type:	Seismic
Reference Document:	ASCE7-16
Risk Category:	III
Site Class:	C



MCER Horizontal Response Spectrum



Design Horizontal Response Spectrum



Basic Parameters

Name	Value	Description
S_S	0.052	MCE_R ground motion (period=0.2s)
S_1	0.03	MCE_R ground motion (period=1.0s)
S_{MS}	0.067	Site-modified spectral acceleration value
S_{M1}	0.044	Site-modified spectral acceleration value
S_{DS}	0.045	Numeric seismic design value at 0.2s SA
S_{D1}	0.03	Numeric seismic design value at 1.0s SA

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

STRUCTURAL CALCULATIONS

Structural Requirements

The ASCE 7-16 code (Minimum Design Loads and Associated Criteria for Buildings and Other Structures) provides guidelines for protection against failure in building structures. The following structural requirements are used as they are directly applicable to the structure designed by DDB Unlimited, for these general conditions:

Risk Categorization:

This structure falls under Risk Category II (All buildings and other structures except those listed in Risk Categories I, III, and IV).

Wind:

N/A

Seismic:

Seismic analysis is not required for the structure, as the Spectral Response Acceleration parameter S_S is less than 0.4, and Seismic Design Category is category C, for the location where this PMS will be installed.

Snow:

N/A

Standard Engineering Practices (In addition to ASCE):

Factor of Safety (based on von Mises) in Mechanical Joints > 1.2 (relative to allowable stress, not yield)

Load Definitions

Castle Consulting PLLC utilizes the “Load Combinations for Allowable Stress Design” method detailed in the ASCE 7-16 code to validate the structural integrity of the structure. The loads listed herein consider the most conservative loads that would produce the most unfavorable effects on each structural member within the structure. Any load combinations that are not applicable, due to environmental conditions, are removed.

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

Loads Combinations

Table 1: ASCE Load Combinations for Allow Stress Design

Load Case	Load Combination
1	D
2	$D + L$
3	$\cancel{D + S}$
4	$\cancel{D + 0.75L + 0.75(L_r or\ S\ or\ R)}$
5	$\cancel{D + (0.6W)}$
6	$\cancel{D + 0.75L + 0.75(0.6W) + 0.75(L_r or\ S\ or\ R)}$
7	$\cancel{0.6D + 0.7W}$
8	$\cancel{D + 0.7E_v + 0.7E_h}$
9	$\cancel{D + 0.525E_v + 0.525E_h + 0.75L + 0.75S}$
10	$\cancel{0.6D - 0.7E_v + 0.7E_h}$

$D =$ Dead Load. The dead load considers the weight of all materials and the static payload of the enclosure (950 lbs)

$L =$ Live Load (ASCE minimum is 5 psf, per ASCE 7-16 Table 4.3-1)

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

Analysis Method

Finite Element Analysis Software (Numerical Method)

The FEA and CFD software used in this analysis is SOLIDWORKS Simulation version 2020 SP5.0. This is a commercially available FEA code.

Study Types

The “elastic stress analysis method” is used to satisfy all the design by analysis requirements set forth in ASCE code. Static and Buckling analyses are done for all primary and secondary structure. Static analysis is done for all mechanical joints and validated with hand calculations. Fatigue analysis is not performed, as the allowable stress are below the infinite life of the materials. Thermal, resonance, dynamic, and non-linear studies were also not required.

FEA Elements

In each FEA study performed in this analysis, a mixed mesh (solids, beams, and shells) is used to most accurately represent the components of the design. Solid tetrahedral elements represent the “solids” that cannot be represented by beam or shell elements. The tetrahedral element has 10 nodes; 6 at its vertices, and 4 at its mid-sides. Each node on the tetrahedral element has 3 translational degrees of freedom. Shell elements are represented by triangles with 6 nodes; 3 at its vertices, and 3 at its mid-sides. Each node on the triangular shell element has 3 translational and 3 rotational degrees of freedom. Beam elements represent the slender structural components that have a uniform cross section throughout their length. Within SOLIDWORKS, beam elements capture the detailed cross-section properties of the CAD model, and utilize those properties to calculate moments of inertia, neutral axes, and the distances of the extreme fibers, from the neutral axes.

Mesh Quality

In each FEA study performed in this analysis, a uniform density mesh is applied globally to keep error below 5%. However, in areas of fillets, “mesh control” is applied. The locally refined mesh is typically 10-25% of the global mesh size. In the analyses of specific high-stress regions of the casting, the mesh is refined locally until a 5% von Mises convergence criterion is satisfied.

Bolted Connections

Bolt connectors are used to simulate the stresses found at bolted joints. The bolt connectors allow the bolt preload to be applied on the appropriate bearing area and include the effects of the bolt’s elasticity.

Model Simplification

The CAD model is simplified to represent only primary and secondary structure. This simplified model is used in the FEA. All mechanical joints, e.g., splices, hardware, and anchoring points are analyzed individually within their own FEAs and through hand-calculations to ensure compliance with standard engineering practices.

FEA Boundary Conditions & Connections

Anchor Points: A virtual “hinge” is applied where the truss and gable legs of the structure connect to the baseplates that are bolted to concrete foundation. The concrete foundation is assumed to be infinitely rigid.

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

Section & Material Properties

Table 2: Section & Material Properties

Component	Material	Density	Modulus	Tension Ultimate/Yield	Compression Yield	Shear Ultimate/Yield	Bearing Ultimate/Yield
Sheet Metal	Aluminum 5052-H32	0.097 lb/ft^3	10,152 ksi	40/28 ksi	21 ksi	28/14 ksi	78/38 ksi
Hardware	Stainless Steel	0.290 lb/ft^3	27,500 ksi	70 ksi	N/A	N/A	N/A

The allowable stress value for each material is listed in Table 3. Castle Consulting PLLC utilizes a factor of safety (FOS) of 1.25 for extrusions and hardware, in combination with the primary and secondary structures' yield strength and ASCE combined loading, to create a conservative allowable stress for the analysis. The yield stress values are obtained from the manufacturers' material specification sheets and crosschecked against values established by the *Aluminum Association 1997 edition* of the *Aluminum Design Manual*. The most conservative values are used throughout the analysis.

Table 3: Allowable Stresses for Materials

Stress Type	Maximum Allowable Stress
Sheet Metal (Aluminum 5052-H32)	28 ksi
Hardware (Stainless Steel)	70 ksi

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

Loads & Anchorage

The PMS is loaded with a standard OD (DDB) enclosure. The enclosure is anchored to the top surface of the PMS via 4 anchor bolts. The validation of fastening system between the enclosure and the PMS is outside the scope of this analysis. The payload of the enclosure is 950 lbs.

The PMS is mounted to a standard wall that meets the ASCE minimum requirements, i.e., the ability to withstand a 1,000 lbs concentrated load, via 6x ½"-13 UNC hardware, including oversized flat washers.

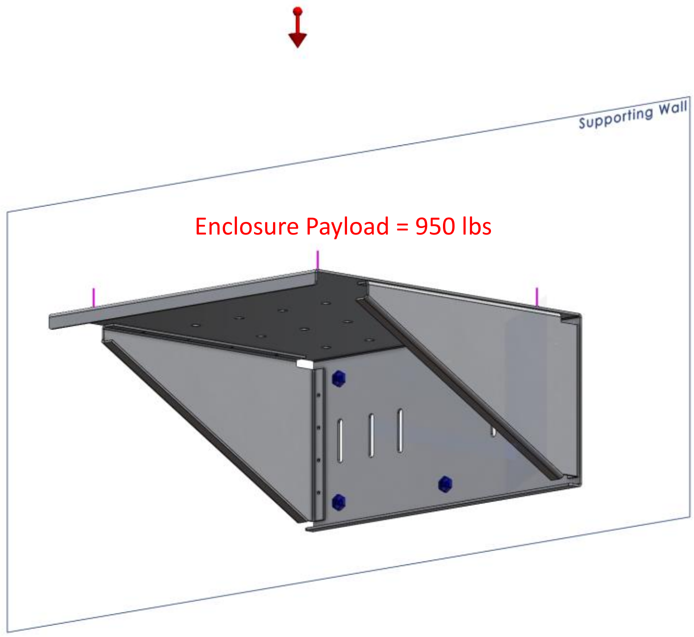


Figure 2: PMS Loading Scenario, anchored to Standard Wall (Payload 950 lbs plus 1.2x dead load)

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

RESULTS

Stress

The FEA results illustrate the distribution of von Mises stress throughout the sheet metal structure. The peak values of stress are well below the allowable stress, Figure 3. The plot in Figure 4 illustrates the Factor of Safety (FOS) distribution. Any locations that fall short of the 1.2 FOS requirement would appear in a red color.

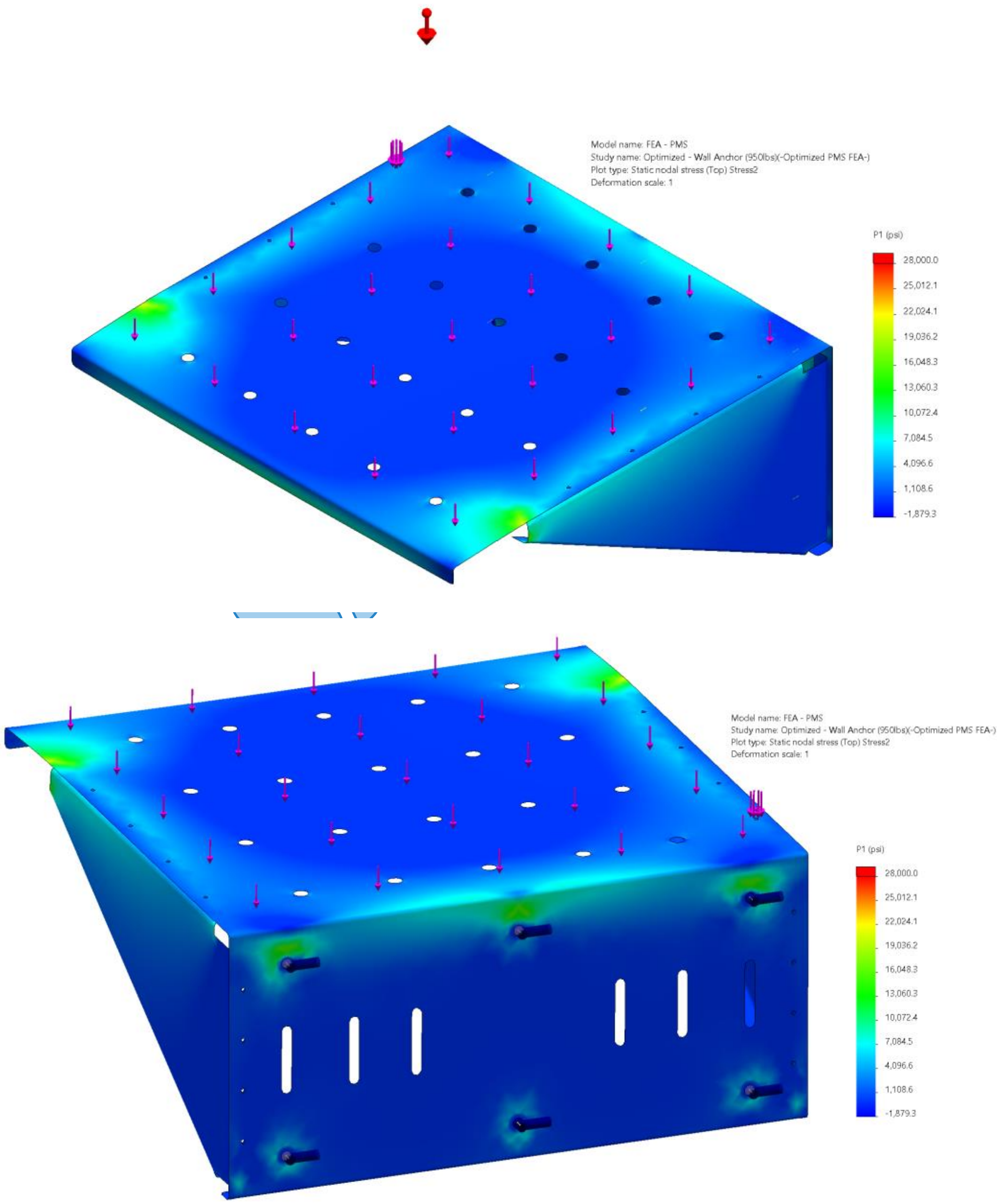


Figure 3: von Mises Stress Contour Plot (ISO 1 & 2 Views)

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

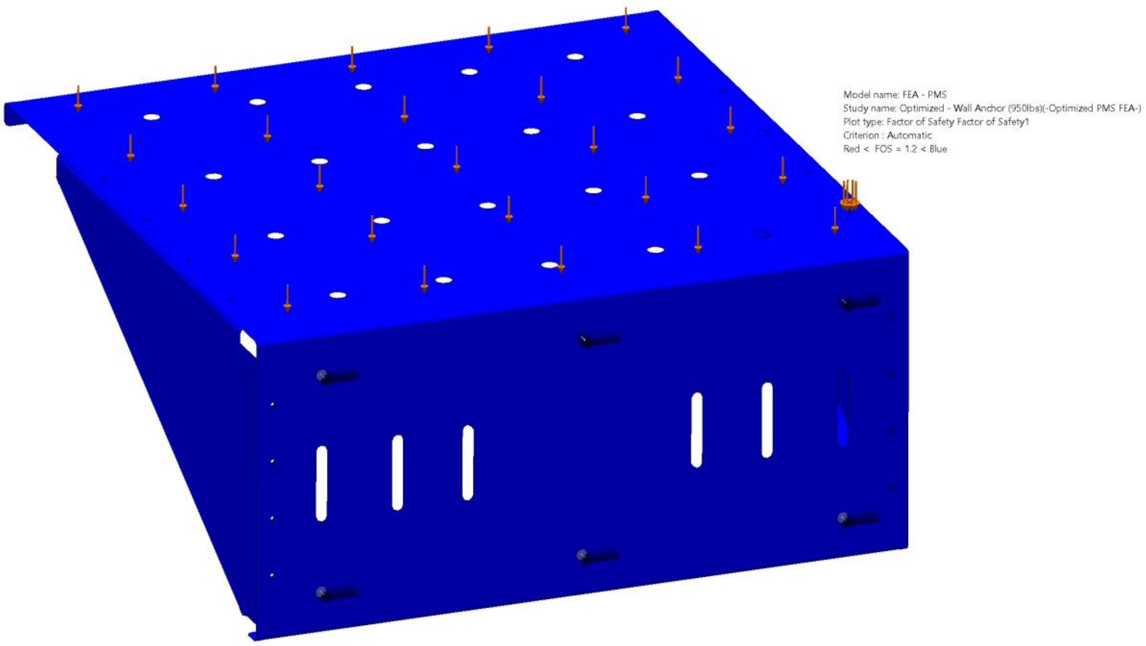


Figure 4: Factor of Safety Plot (Blue indicates a FOS > 1.2)

877-697-9269

sales@mysolidbox.com

2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

Fastener Check

All fasteners are cross-checked, through the FEA software and hand-calculations. The following methodology is used to calculate the safety of each bolt:

Bolt Connector - Safety Check

You can determine if a bolt connector in an assembly can safely carry the applied loads, or if it fails.

The software calculates the bolt strength factor of safety (SF) based on the combined load ratio a connector withstands and compares it with the user-defined factor of safety.

Axial load ratio, Ra	Ra is the maximum of: • SF * F / (At * S) • Pre-load / (At * S)	
	SF	Bolt strength factor of safety calculated by the software. SF is the unknown of the combined load ratio equation. The software calculates the factor of safety SF twice: SF1 is calculated based on the first bulleted value of the axial load ratio Ra and SF2 based on the second value of Ra. • If (SF1 * F / (At * S)) > (Pre-load / (At * S)), then the first value of SF1 is considered for the pass/no pass criterion. • If (Pre-load / (At * S)) > (SF1 * F / (At * S)), then the second value of SF2 is considered for the pass/no pass criterion.
	F	Axial load calculated by the software
	At	Tensile area
	Pre-load	Bolt pre-load
	S	Strength value of connector's material or grade (could be yield or ultimate tensile strength based on application). This is the user-defined value for **Bolt Strength**
Bending load ratio, Rb	Rb = SF * D * M / (2 * S * I)	
	SF	Bolt strength factor of safety calculated by the software
	M	Bending moment calculated by the software
	D	Nominal shank diameter
	S	Strength value of connector's material or grade (could be yield or ultimate tensile strength based on application). User-defined value for **Bolt Strength**.
	I =0.25*π*r^4	
Shear load ratio, Rs	Rs = SF * V / (0.5 * At * S)	
	SF	Bolt strength factor of safety calculated by the software
	V	Shear load calculated by the software
	At	Tensile area
	S	Strength value of connector's material or grade (could be yield or ultimate tensile strength based on application). User-defined value for **Bolt Strength**
	The factor of 0.5 is applied to the material yield strength (or ultimate tensile strength) to account for the material shear strength. The calculation of the shear load ratio is more accurate when the yield strength of the material is considered. It is a conservative estimate, when the ultimate tensile strength of the material is considered.	
Combined load ratio	(Ra + Rb)^2 + Rs ^3 <=1 The solution of the third order equation yields the unknown bolt strength factor of safety SF. Only the positive roots or the SF are considered.	

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

The bolt check plot, Figure 5, reveals that each anchor bolt meets the 1.2 FOS requirement. Table 4 list the final combined load ratio for the weakest anchor bolt in the series (upper right corner in Figure 5). The combined load ratio is below the limitation of 1 (max allowable load ratio when using a 1.2 FOS value).

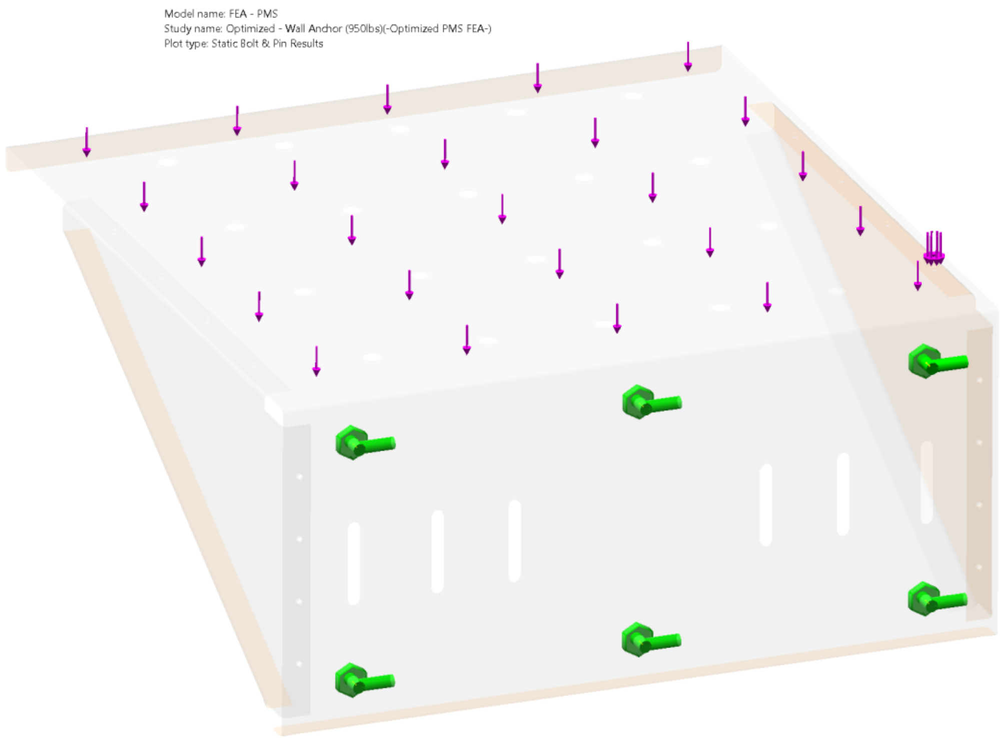


Figure 5: Bolt Check Plot (Green Hardware Passes the 1.2 FOS Requirement)

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

Table 4: Bolt Check Calculation Sheet

	Input	Value
SFd	Desired Factor of Safety	1.2
D	Nominal Shank Diameter (in)	0.5
S	Allowable Bolt Strength (psi)	70000
Fpre	Bolt Pre-Load @ 60% of S (lbs)	7500
At	Tensile Area (in2)	0.196
	SW Calculated Forces & Bending Moment	**Value**
V	Shear Force Resultant (lbs)	264
Fa	Axial Force (lbs)	7346
M	Bending Moment Resultant (in-lbs)	132
SF	Factor of Safety	1.99
	Cross-Check Output	**Value**
	Axial Load Ratio	
Ra	MAX of Axial Load Ratio = SF*Fa/(At*S)	0.64
	or = Fpre/(At*S)	0.55
	Bending Moment Ratio	
Rb	Rb = SF*D*M / (2*S*I) where I = 0.25*PI*r^4	0.18
	0.003	
	Shear Load Ratio	
Rs	Rs = SF*V / (0.5*At*S)	0.05
	Combined Load Ratio	
Rt	Rt = (Ra + Rb)^2 + Rs^3	0.68
	Rt <= 1 (Y/N)	Y

CONCLUSION

Castle Consulting PLLC has performed a detailed structural analysis on the primary and secondary of the PMS when anchored to a standard wall that is able to support a minimum concentrated load of 1,000 lbs. The analysis confirms that the the system is able to support the 950 lbs payload requirement while meeting the requirements set forth by IBC and ASCE 7-16 code, and additional criteria developed by Castle Consulting PLLC.

877-697-9269
sales@mysolidbox.com
2225 E MURRAY HOLLADAY RD
#105 HOLLADAY, UT 84117

DRAWINGS