Decorah Eagle Project

A public art proposal for Decorah, Iowa
Sculpture design and rendering by Man Ho Cho

Materials: Steel / concrete base
Size: 30’w x 13’h x 7’d
Estimated materials cost: $28,353

In conjunction with the two-year partnership between the City of Decorah and the University of Iowa Initiative for Sustainable Communities (IISC), local residents collaborated with graduate students and faculty in the UI School of Art and Art History to design a public art piece, resulting in this proposal to install a unique sculpture abstractly depicting the image of an eagle. This proposal is intended to convey information about the design, the proposed location, as well as engineering specifications and materials costs.

ARTIST’S STATEMENT

“The abstract representation of an eagle calls attention to the area’s Native American history and culture and also celebrates the internationally famous Raptor Resource Project.

Using various elements of design, the sculpture plays with the viewer’s perception by enlarging the scale of the piece to a larger than life size. As people travel past the piece, it incites viewers to become interested in its presence and more apt to engage in questions about the use of the eagle and its history in connection to Decorah.”

Description

The sculpture, designed specifically for the City of Decorah at the proposed location, is comprised of 22 steel tubes sunk in a concrete base. The artist will adhere water jet/plasma cut steel panels to these poles so that from a specific angle, the shape of an eagle emerges. Safety and durability were considered in the design of the sculpture and selection of materials. Galvanized steel is recommended for the steel tubes and panels, and the panels will be painted with a non-reflective coating. Please see the attached engineering report for specifications.

Installation

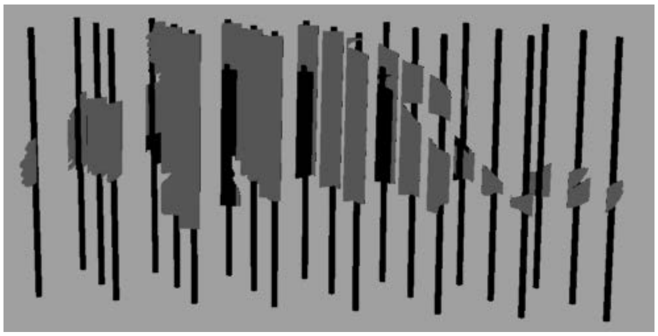
The artist can be contacted directly for additional details or to arrange installation. The artist will be responsible for transporting and installing the finished pieces.

Man Ho (Billy) Cho
Iowa City, Iowa
515 835 0547
Man-ho-cho@uiowa.edu

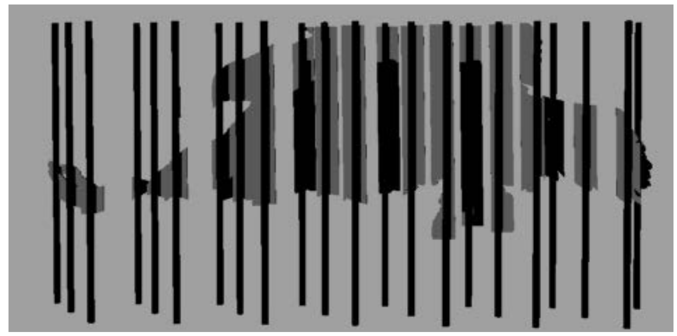
Schematic Design

These images illustrate the steel pole configuration and panel details to be used for the sculpture. A similar sculpture (conceptually) installed in South Africa is shown to further convey the concept.

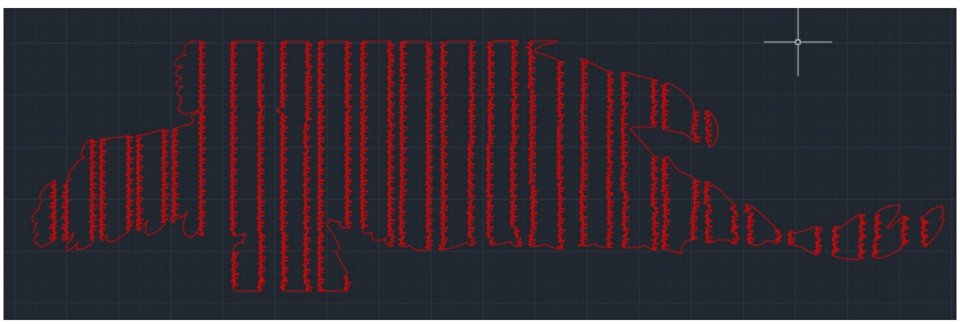
Conceptual drawing:
front of sculpture



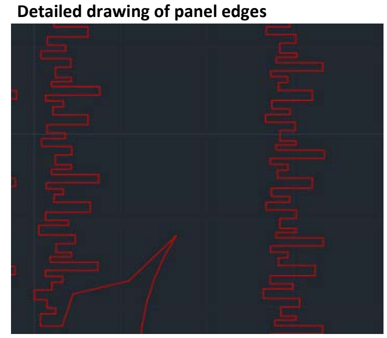
Conceptual drawing:
back of sculpture



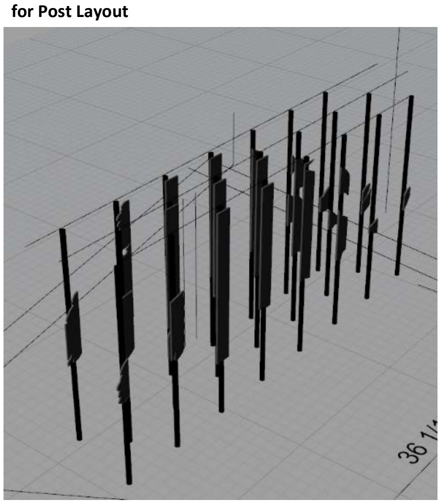
Conceptual drawing:
panels to adhere to steel posts



Conceptual drawing:
Detailed drawing of panel edges



Schematic Design
for Post Layout



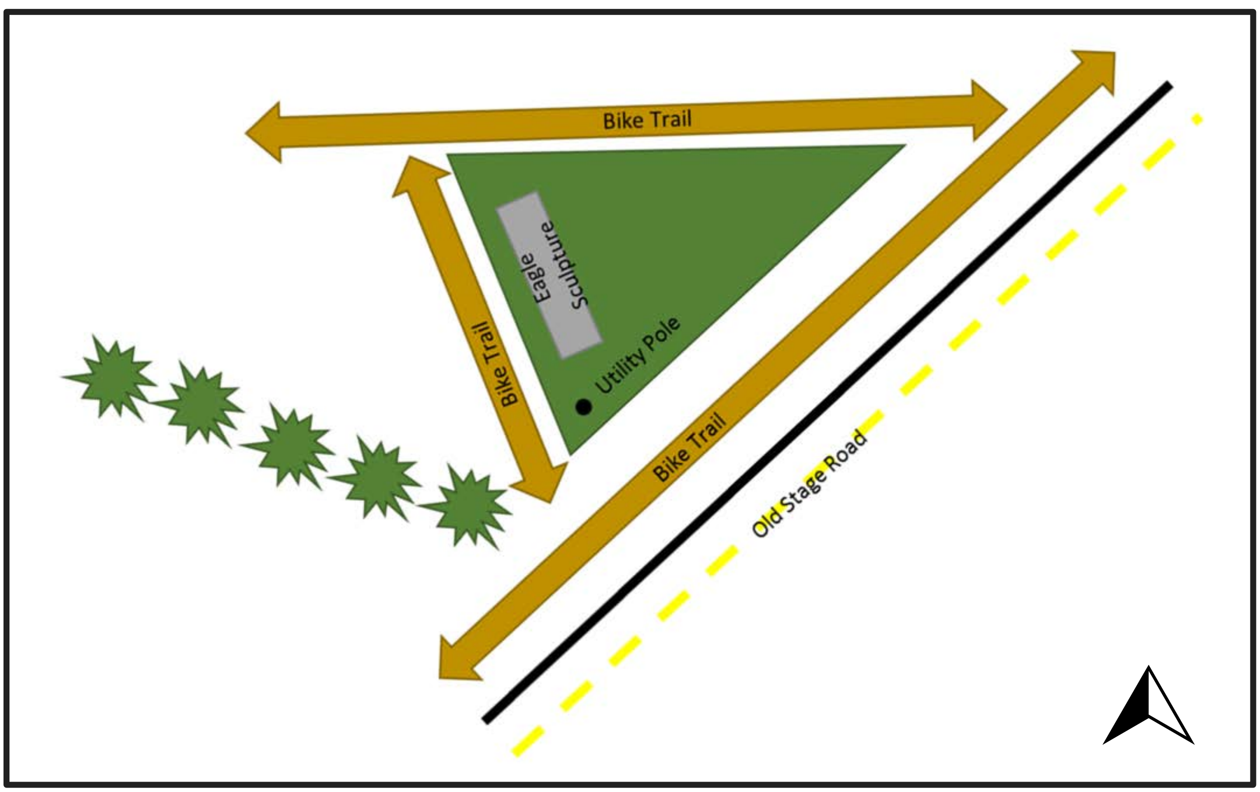
Example of Concept:
Nelson Mandela Sculpture

In honor of South African politician Nelson Mandela and to mark the 50th anniversary of his arrest, artist Marco Cianfanelli was commissioned to produce a sculpture to stand in Howick, South Africa, on the exact unassuming spot that he was captured.

When viewed from the right angle, the quietly powerful sculpture forms a profile portrait of Mandela.

Proposed Location

The sculpture was designed for the specific location shown below.



About Iowa Initiative for Sustainable Communities

The Iowa Initiative for Sustainable Communities is a campus-wide, engaged learning program housed in the Provost's Office of Outreach & Engagement at the University of Iowa. IISC pursues a dual mission of enhancing the sustainability of Iowa's communities while transforming teaching and learning at the university. Through projects that address community priorities while engaging students in high-impact experiences, IISC addresses Iowa's economic, environmental, and socio-cultural challenges in ways that build a more sustainable future for the state, and more successful, community-engaged futures for our students. IISC partnered with the City of Decorah for the 2014-15 and 2015-16 academic years. To learn more about IISC and the partnership, visit http://iisc.uiowa.edu.

THE UNIVERSITY OF IOWA

COLLEGE OF ENGINEERING
Civil & Environmental Engineering
4105 Seamans Center
for the Engineering Arts and Sciences
Iowa City, Iowa 52242-1527
319-335-5647 *Fax* 319-335-5660
www.cee.engineering.uiowa.edu

Date: October 24, 2016

TO: Richard Fosse

FROM: Adam Kueny

RE: Decorah Art Project Structural Analysis

Per your request, the structural analysis was completed for twenty-two square tubing poles that will be up to thirteen feet in height above the ground. The poles must be able to support the art design, withstand wear and tear, and survive the weather conditions of the area. The design is to have a limited budget by using standard materials and construction techniques. Based on the design work outlined in this report, I recommend using a 6" X 6" steel tubing with a 3/8" wall thickness as the primary structural support. The supports will require an 8.65' deep footing that is 2' in diameter and filled with concrete. For durability, the steel tubing should be galvanized and have a welded cap on the top and a ½" weep hole drilled 1" above the top of the footing. The steel tube and the art piece will also need to have a plastic protector in between the two pieces to prevent corrosion.

The first calculation completed was for the wind forces on the pole in order to find the correct design. Those calculations are in Appendix D. The wind force was calculated by using the ASCE standard for the maximum wind velocity of 90 mph. For the soil sample, Terracon of Iowa City was contacted to see if there were any soil samples taken at the location. The closest sample was one mile away so that data could not be used. The Soil Survey of Winniesk County was also taken into account but did not provide enough reliable information. The soil capacity was assumed to be 0.15 ksf/ft due to no previous accurate records existing. With that information known, the footing depth could be calculated using the Flag Pole Design Calculator shown as Source 1 in Appendix B. Multiple diameters of the pole were used to test for depth of the pole and are shown in Table 1. The assumption made for future calculations was assumed to be a 2 ft diameter and 8.65 ft deep. The footings will be also filled with concrete and the yardage required for each length is provided in Table 1. Although it is likely that the footing depth requirements could be reduced if better soils data were available, it is unlikely that the construction cost savings would be sufficient to justify the cost of a soils report.

Depth (ft)	Diameter of Pole Footing (ft)	Concrete yardage
11.26	1	7
9.62	1.5	14
8.62	2	22
8	2.5	32
7.39	3	43

Table 1: Diameter of Pole Footing vs. Depth of Footing

Next, the correct sizing of the pole had to be determined to see if it would withhold the bending moment and deflection of the pole. The Guide Specifications for the Design of Flagpoles was used for those calculations shown in Source 2 of Appendix B. Most of the pole designs after the 4" X 4" pole were able to withstand the bending moment. Besides bending moment, the deflection had to be taken into account. Multiple sizes of base and width were used as well as wall thickness. The wind force calculated previously was divided over the length of the pole since the wind will be spread throughout the pole. From this, the deflection was calculated for fourteen pole types and is shown in Table 2.

Size of Steel (in X in)	Wall Thickness (in)	Unit Weight (lbs/ft)	Deflection (in)	Passing
6 X 6	1/8	8.16	4.456	No
6 X 6	1/5	14.65	3.017	No
6 X 6	1/4	19.02	2.299	No
6 X 6	3/8	27.48	1.582	Yes
6 X 6	1/2	35.24	1.224	Yes
6 X 6	5/8	42.3	1.011	Yes
7 X 7	1/4	22.42	1.435	No
7 X 7	3/8	37.7	0.983	Yes
7 X 7	1/4	42.05	0.757	Yes
8 X 8	1/5	19.63	1.258	No
8 X 8	1/4	26	0.955	Yes
8 X 8	3/8	37.7	[redacted]	Yes
8 X 8	1/2	49	[redacted]	Yes
8 X 8	5/8	59.32	[redacted]	Yes

Table 2: Poles Sizes and deflection

From the list of fourteen, nine poles were able to pass. The lightest pole that passed from the 6" X 6", 7" X 7", and 8" X 8" were then used to get a price estimate. The final pole that was chosen was to be the 6" X 6" tube. Hawkeye Weld and Repair quoted the 8" X 8" as the cheapest pole due to its unit weight and size. The 7" X 7" would be more expensive due to its odd size and the 6" X 6" used more steel which increased cost. The 6" X 6" was decided on because of its visual impact on the structure.

After that, the total length of steel was to be calculated. Each piece was measured from the base of the hole (8.65 ft) to about the top of each art piece. These lengths are shown in Table 4. The final total length of the steel was calculated to be 401.7 ft. When buying the steel the lengths will have to be taken into consideration. The lengths of tubing that Hawkeye Weld and Repair can order are 18 ft, 20ft, 24 ft, and 48 ft. Hawkeye Weld and Repair stated the lengths don't affect in the cost of the steel but some steel will be wasted and could increase the cost a small amount.

Another thing that was looked at was a basic design matrix shown in Table 3. One being the best possible option and three being the worst possible option. The obstruction is referring to how much the tube will take away from the art project do to its size. The workability is referring to how much the tube weighs and how long it would take to move around at the construction site. The deflection may also need to be considered depending on the material for the actual art so that it does not break.

Design Matrix	Cost	Deflection	Obstruction	Workability
6” X 6”	2	2	1	2
7” X 7”	3	1	2	3
8” X 8”	1	3	3	1

Table 3: Decision Matrix

With all of this information, the budget was calculated. The other thing that had not been considered was the cost of labor. The cost of labor, painting vs. galvanizing, and all specifics of the budget are in Appendix C. The cost of labor came from a local construction company, TD Builders. The pricing for the auger came from ABC Rentals website seen in Source 3 of Appendix B. The fours different options for poles are shown below in Table 5. The final budget was calculated to be $28,358 using a 6” X 6” galvanized tube.

Piece	Length of Footing (ft)	Steel Length Above Ground (ft)	Total Length (ft)	Sum of Lengths (ft)
1	8.65	6.3	14.9	14.9
2	8.65	8.3	16.9	31.8
3	8.65	8.4	17.0	48.8
4	8.65	8.8	17.4	66.3
5	8.65	13.0	21.7	87.9
6	8.65	13.0	21.7	109.6
7	8.65	13.0	21.7	131.2
8	8.65	13.0	21.7	152.9
9	8.65	13.0	21.7	174.5
10	8.65	13.0	21.7	196.2
11	8.65	13.0	21.7	217.8
12	8.65	13.0	21.7	239.5
13	8.65	13.0	21.7	261.1
14	8.65	11.7	20.3	281.5
15	8.65	11.2	19.8	301.3
16	8.65	10.6	19.2	320.5
17	8.65	6.2	14.9	335.4
18	8.65	4.5	13.1	348.5
19	8.65	3.8	12.5	361.0
20	8.65	4.7	13.3	374.3
21	8.65	5.1	13.7	388.0
22	8.65	5.1	13.7	401.7
			Total (ft)=	401.7

Table 3: Steel Lengths

Decorah Art Project Strutural Support Budget Comparsion				
	6" X 6" X 3/8" Galvanized	6" X 6" X 3/8" Painted	8" X 8" X 1/4" Galvanized	8" X 8" X 1/4" Painted
Strutural Design	200	200	200	200
Steel	16150	9350	15242	8442
Painting	0	1625	0	1625
Construction Costs	8305	8305	8305	8305
Contingency: 15%	3698	2922	3562	2786
Total:	28353	22403	27309	21358

Table 5: Total Budget

Lastly, some additional notes that were not mentioned previously. Steel was ruled as the best material initially since it is both stronger and cheaper than aluminum, and cheaper than stainless steel. The steel will also be capped at the top so that water will not get inside of the structure and cause blowouts. For additional safety there will be ½" weep holes about 1" above the ground line to prevent blowouts. The steel was also measured from the bottom of the footing to the top of art design. If the art design has self-strength then the steel wouldn't need to go all of the way to the top of the design and would reduce the cost. The cost of the actual art design was not included and could be another significant cost since it will have to be cut using a CNC machine as well as the actual cost of the materials for the design. To go along with the cost of the art design, the price of shipping for both the structural steel and art design were not considered. The actual source of everything is not known and will greatly affect the shipping cost. Another thing that was considered was painting vs. galvanizing. Galvanizing would be the best long-term solution to do its longevity and lack of maintenance. If galvanizing is used there will have to be ¼ in. pieces of plastic separating the art piece from the poles to reduce corrosion. The price of painting was also researched and is shown in Appendix C. TK Paints was contacted for a rough estimate on the price of painting and contact information is in Appendix C along with the other costs for each item. The future outlook of the project would have to be considered for either consideration.

Appendix A: Contacts

Name	Phone	Email
Hawkeye Weld and Repair	319-354-9353	
Terracon Iowa City	319-688-3007	
TK Paints	319-631-2525	
TD Builders	319-841-5051	
Richard Fosse		Rick-Fosse@uiowa.edu
Billy (Art Designer)		Man-Ho-Cho@uiowa.edu
Adam Kueny (Structural Analysis)	319-533-6441	Adam-Kueny@uiowa.edu
Chris Stoakes (Assoc. Professor)		Christopher-Stoakes@uiowa.edu

Appendix B: Sources

1. http://www.engineersedge.com/calculators/flagpole-base-design-calculator.htm
2. http://www.acmelingo.com/flagpoles/FP1001-07.pdf
3. http://www.abceqrental.com/category.php?id=107

Appendix C: Specific Budgets

Galvanized Steel Tubes Budget

8" X 8" Steel Tubes Galvanized

Item	Quantity	Units	Unit Price	Units	Other	Total
Design						
Strucutral Design	20	hr	10	$/hr		200
				Section Total:		200
Steel						
Steel 8" X 8" Tubes	22	Sec.	NA	NA		5600
Galvanizing	22	Sec.	NA	NA		4400
Freight for Galvanizing	1	Trips				750
Labor	1					1650
				Section Total:		15242
Construction Costs						
Labor	128	Man hrs.	35	$/hr		4480
Rental of Auger	4	days	82.5	$/day		330
Concrete (105%)	24	yd^3	120	$\$/yd^3$		2880
Profit	8	%	615.2			615.2
				Section Total:		8305
Total Costs						
				Subtotal:		23747
				Contingency: 15%		3562
				Total:		27309

6" X 6" Steel Tubes Galvanized

Item	Quantity	Units	Unit Price	Units	Other	Total
Design						
Strucutral Design	20	hr	10	$/hr		200
				Section Total:		200
Steel						
Steel 6" X 6" Tubes	22	Sec.	NA	NA		5600
Galvanizing	22	Sec.	NA	NA		4400
Freight for Galvanizing	1	Trips				750
Labor	1					1650
				Section Total:		16150
Construction Costs						
Labor	128	Man hrs.	35	$/hr		4480
Rental of Auger	4	days	82.5	$/day		330
Concrete (105%)	24	yd^3	120	$\$/yd^3$		2880
Profit	8	%	615.2			615.2
				Section Total:		8305
Total Costs						
			Subtotal:			24655
			Contingency: 15%			3698
				Total:		28353

Painted Steel Tubes Budget

8" X 8" Steel Tubes Painted

Item	Quantity	Units	Unit Price	Units	Other	Total
Design						
Strucutral Design	20	hr	10	$/hr		200
				Section Total:		200
Steel						
Steel 8" X 8" Tubes	22	Sec.	NA	NA		8442
				Section Total:		8442
Painting						
Paint	5	gallons	80	$/gal		400
Primer	5	gallons	25	$/gal		125
Head Painter	20	hours	40	$/hr		800
Assistant	9	hours	20	$/hr		180
Profit		8%				120
				Section Total:		1625.4
Construction Costs						
Labor	128	Man hrs.	35	$/hr		4480
Rental of Auger	4	days	82.5	$/day		330
Concrete (105%)	24	yd^3	120	$\$/yd^3$		2880
Profit	8	%	615.2			615.2
				Section Total:		8305
Total Costs						
				Subtotal:		18573
				Contingency: 15%		2786
				Total:		21358

6" X 6" Steel Tubes Painted

Item	Quantity	Units	Unit Price	Units	Other	Total
Design						
Strucutral Design	20	hr	10	$/hr		200
				Section Total:		200
Steel						
Steel 6" X 6" Tubes	22	Sec.	NA	NA		9350
				Section Total:		9350
Painting						
Paint	5	gallons	80	$/gal		400
Primer	5	gallons	25	$/gal		125
Head Painter	20	hours	40	$/hr		800
Assistant	9	hours	20	$/hr		180
Profit		8%				120
				Section Total:		1625
Construction Costs						
Labor	128	Man hrs.	35	$/hr		4480
Rental of Auger	4	days	82.5	$/day		330
Concrete (105%)	24	yd^3	120	$\$/yd^3$		2880
Profit	8	%	615.2			615
				Section Total:		8305
Total Costs						
				Subtotal:		19481
				Contingency: 15%		2922
				Total:		22403

Appendix D: Calculations

Part 1: Foundation Depth

$Area := 1.2998\ ft \cdot 12\ ft = 15.598\ ft^2$ Largest section of the design

$Windvelocity := 90\ mph$ ASCE standard

$Soilcapacity := 150\ \frac{psf}{ft} = 0.15\ \frac{ksf}{ft}$ Less than 50% are underlain by soils with abunant clay

$H := 13\ ft$ Height of the tallest member

$Pressure := \frac{.00256 \cdot slug}{ft^3} \cdot Windvelocity^2 = \left(2.136 \cdot 10^3\right)\ Pa$

$Cd := 2$ Drag for flat plate $FS := 1.6$

$Windforceart := Area \cdot Pressure \cdot Cd \cdot FS = 2.226\ kip$

$Areapole := 4\ in \cdot 5\ ft = 1.667\ ft^2$

$Windforcepole := Areapole \cdot Pressure \cdot Cd = 0.149\ kip$

$Windforce := Windforcepole + Windforceart = 2.375\ kip$

$Depth := 7.92\ ft$ $Diameter := 2.5\ ft$ The entire structure would be a trench

Part 2: Material and Pole Size

$M1 := Windforceart \cdot (H - 6\ ft) = 15.585\ kip \cdot ft$

$M2 := Windforcepole \cdot 2.5\ ft = 0.372\ kip \cdot ft$ Bending Moment

$MT := M1 + M2 = 15.956\ (kip \cdot ft)$

No Torsional Moment. Project is center

$OD := 8\ in$ Outer dimension $UnitWeight := 19.63 \cdot \frac{lbf}{ft}$
$WT := 0.1875\ in$ Wall thickness

$fa := \frac{UnitWeight \cdot H}{\left(\left(OD^2\right) - (OD - WT)\ (OD - WT)\right)} = 0.086\ ksi$ Compressive Stresses

$S := \frac{\left(OD^4 - WT^4\right)}{6 \cdot OD} = 85.333\ in^3$

$fb := \frac{MT}{S} = 2.244\ ksi$ $\blacksquare \le \blacksquare$ 22 Bending Stresses fc: Shear stress would be neglible compared to bending stresses?

$$Ib := OD \cdot \frac{OD^3}{12} - \frac{(OD - WT)^4}{12} = 30.892\ in^4$$

$$E := 29000\ ksi$$

$$CA := 1 - \frac{\left(\frac{0.38 \cdot UnitWeight \cdot H^3}{2.46 \cdot E \cdot Ib}\right)}{0.52} = 0.998$$

$$CSR := \frac{fa}{0.6 \cdot 50\ ksi} + \frac{fb}{CA \cdot 50\ ksi \cdot 0.66} = 0.071$$

<=1

$$FA := \frac{\left(3.14^2 \cdot E\right)}{1.95 \left(\frac{(2 \cdot H)}{\left(\left(\frac{Ib}{\left(OD^2 - (OD - WT)^2\right)}\right)^{\frac{1}{2}}\right)}\right)^2} = 15.695\ ksi$$

Part 3. Deflection

$$OD := 8\ in \qquad WT := \frac{1}{4}\ in \qquad E := 29000\ ksi$$

$$Ib := OD \cdot \frac{OD^3}{12} - \frac{(OD - WT)^4}{12} = 40.708\ in^4$$

$$Deflection := \frac{\left(Windforce \cdot H^3\right)}{3 \cdot E \cdot Ib} = 2.546\ in$$

Point Load

$$w := \frac{Windforce}{H} = 182.696\ \frac{lbf}{ft}$$

$$Deflection := \frac{w \cdot H^4}{8\ E \cdot Ib} = 0.955\ in$$

Distributed Load

$$Deflection := \frac{H}{120} = 1.3\ in$$

Allowance