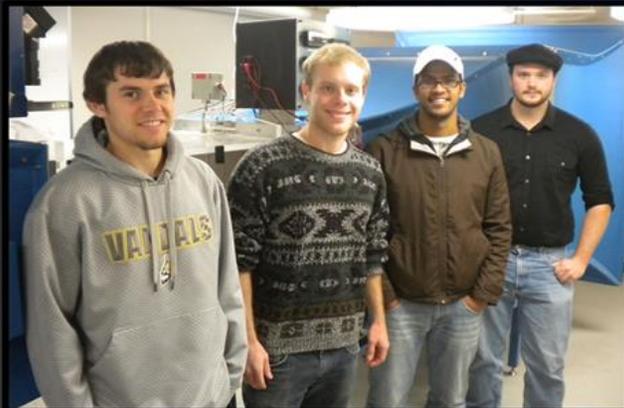




STAND YOUR GROUND



FROM LEFT TO RIGHT

STEPHEN VANPATTEN

KYLE MACLEAN

FAISAL ALAHMADI

CHRISTOPHER KREPS

Problem Statement

- The University of Idaho's high tunnel greenhouse team, Stand Your Ground, is tasked with designing a high tunnel for harsh environmental conditions. Current high tunnels have failed due to high wind load. The goal of this project is to design a high tunnel to prevent such damage.

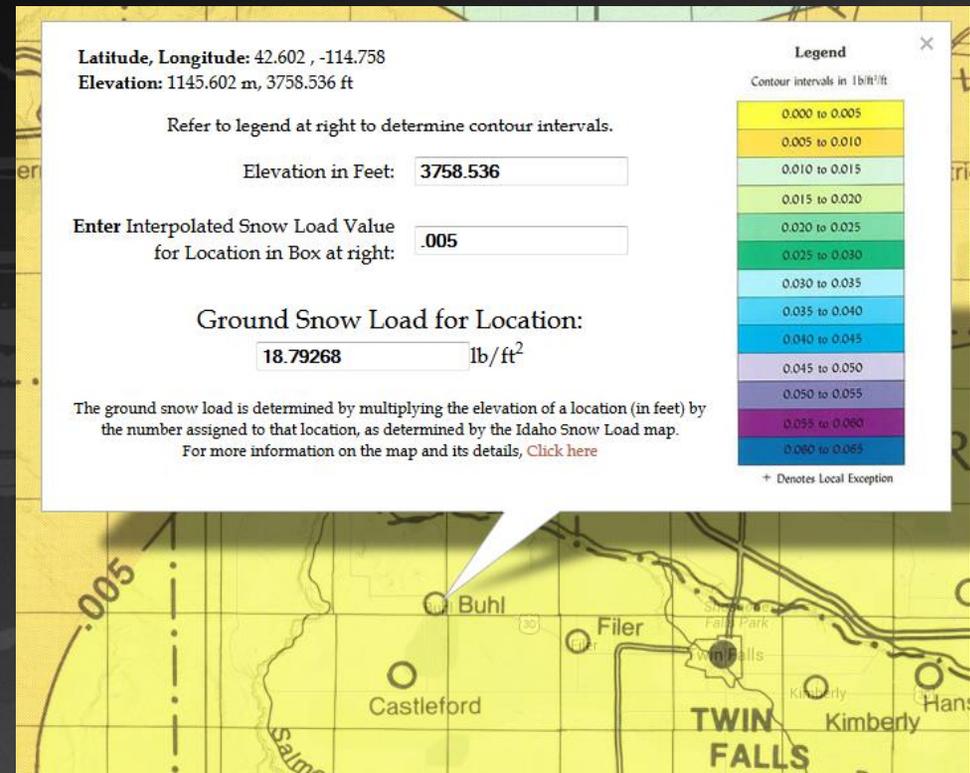


Design Specifications

High Tunnel Greenhouse		
Desired Specifications		
Variable	Design Goals	
Wind Speed	Customer: 65 mph	Worst Case: 105 mph
Snow Load	Avg. Snowfall=31.3"	Loading up to 20 lb/ft ²
Foundation Dimensions	Length=40ft	Width=24ft
Door Dimensions	Height=8ft (min)	Width=6ft (min)
Ventilation	Passive Roll-up Sides	
Orientation	Facing Wind	
Life Expectancy	10+ Years	
Cost	Budget=\$16,000	

Codes and Standards

- Frost depth
 - 24”
- Snow load – 18.8 lbf/ft²
- Engineering building code
 - Wind - ASCE 7-10
 - risk category I
 - 105 mph: 28 lbf/ft²



Project Learning

- High tunnel vs. greenhouse
- Structure type
- Frame material
- Ventilation
- Anchoring
- Weather Conditions
- Covering



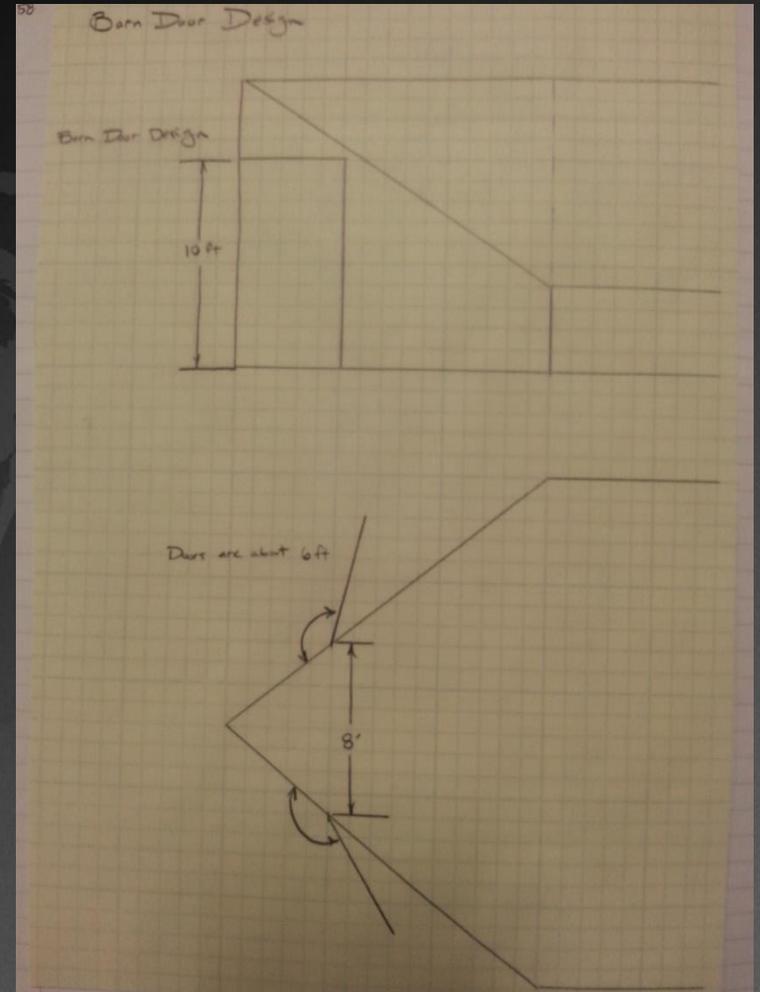
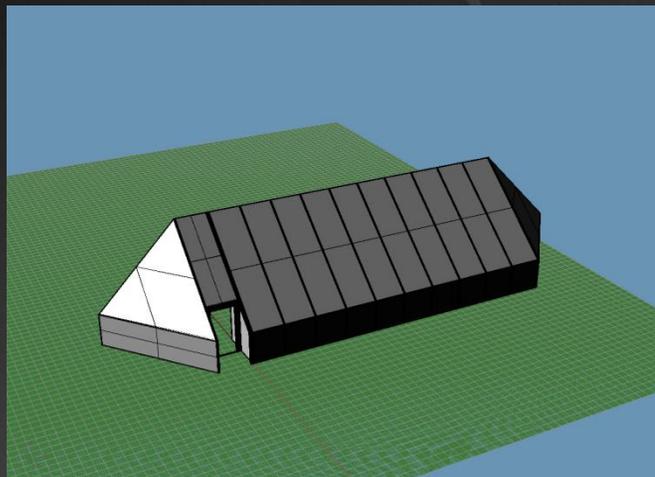
Gable/Gothic Style



Quonset Style

Design Considerations

- Windbreak mechanism
 - Natural
 - Attached
 - Geometry
- Door Types



Design Selection

Decision Matrix of Structure Type					
		Option One	Option Two	Option Three	Option Four
	Weight	Gothic Plain	Quonset Plain	Gothic Windbreak	Quonset Windbreak
Criteria					
Snow Load	4	5	3	5	3
Wind Load	5	3	3	5	5
Ease of Construction	2	4	5	3	2
Space Required	1	5	4	4	3
Cost	3	4	5	3	4
Total:		60	56	64	56

Grouping Information Using Tukey Method

EndType	N	Mean	Grouping
3	4	10.3450	A
1	4	8.9418	B
2	4	5.8900	C
4	4	4.3937	D

Means that do not share a letter are significantly different.

Statistic Analysis on Wind Tunnel Results

Wind Tunnel Results

- More accurate scaled models
 - With windbreak
 - Without windbreak
- Two orientations
 - Head-on
 - Angled with wind toward flat end of windbreak
- Windbreak shows great improvement

Direction	Windspeed (mph)	Percent Reduction of Force
Head-On	35	27.4%
	60	27.7%
	103	31.5%
45 Degrees	35	33.0%
	60	25.5%



With windbreak

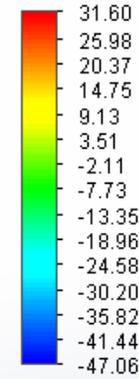
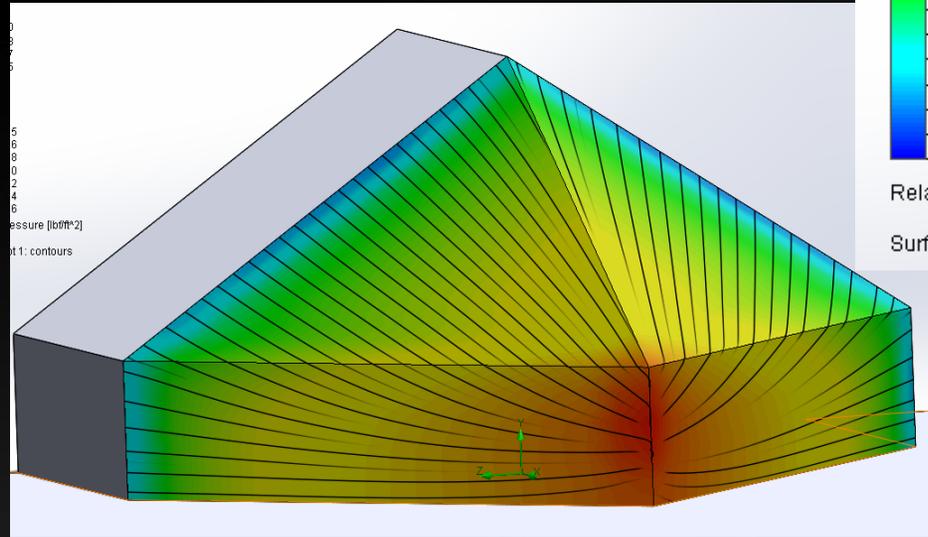


Without windbreak

CFD Analysis

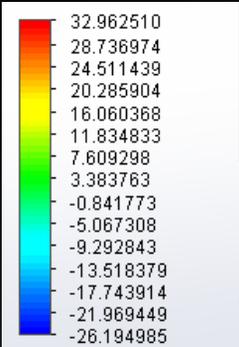


CFD Analysis



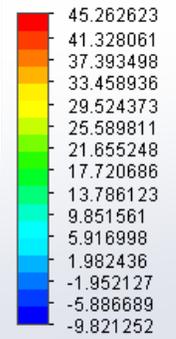
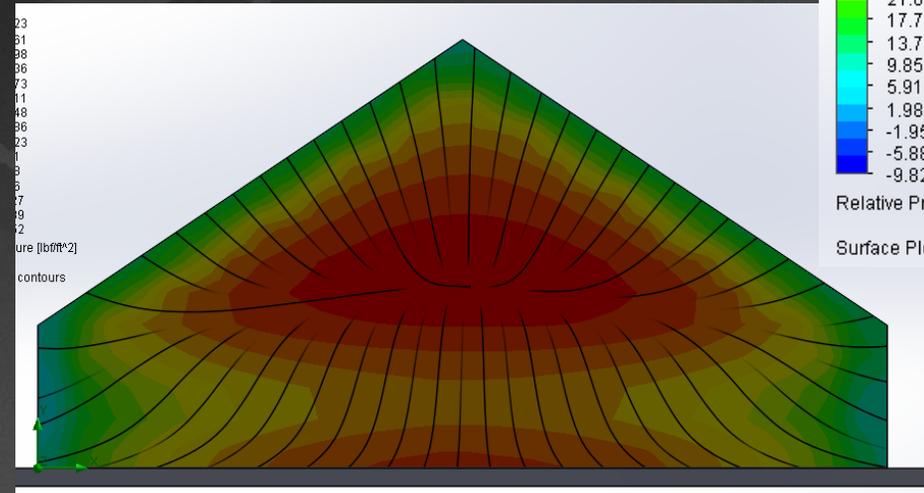
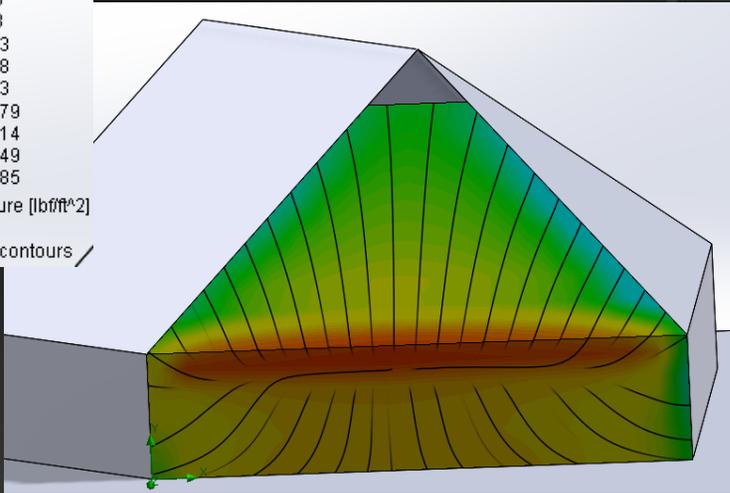
Relative Pressure [lb/ft²]

Surface Plot 1: contours



Relative Pressure [lb/ft²]

Surface Plot 1: contours

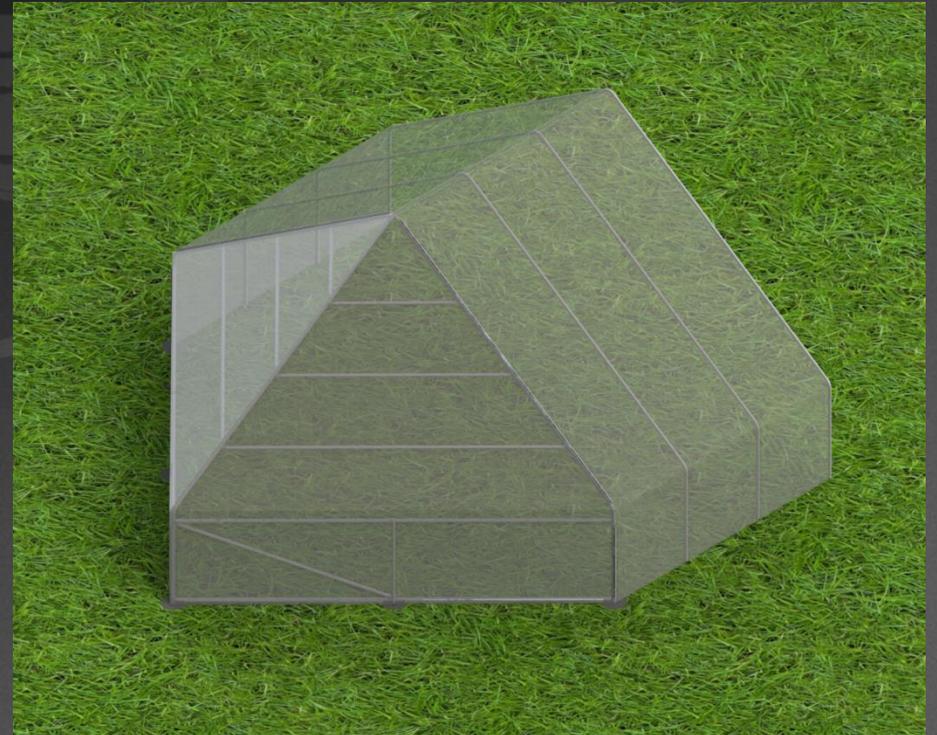


Relative Pressure [lb/ft²]

Surface Plot 1: contours

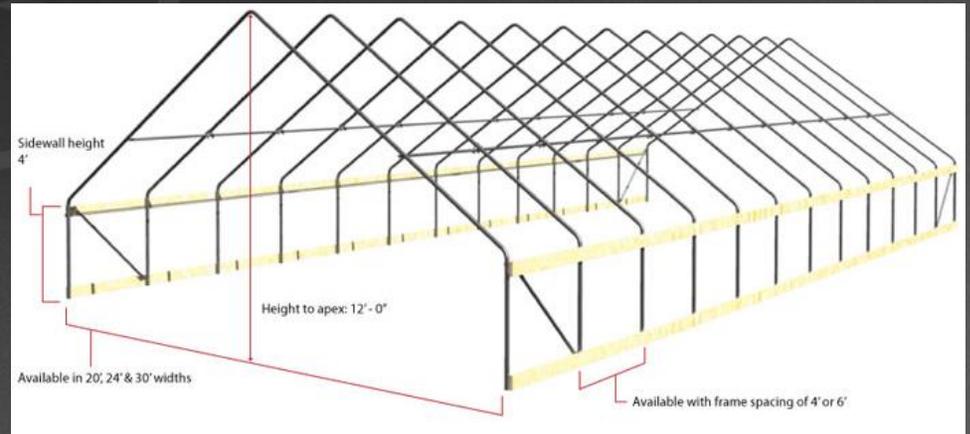
Final Design Overview

- Install specified kit
- Build designed windbreak onto kit
 - On the side common to high winds
 - Opposite side has door



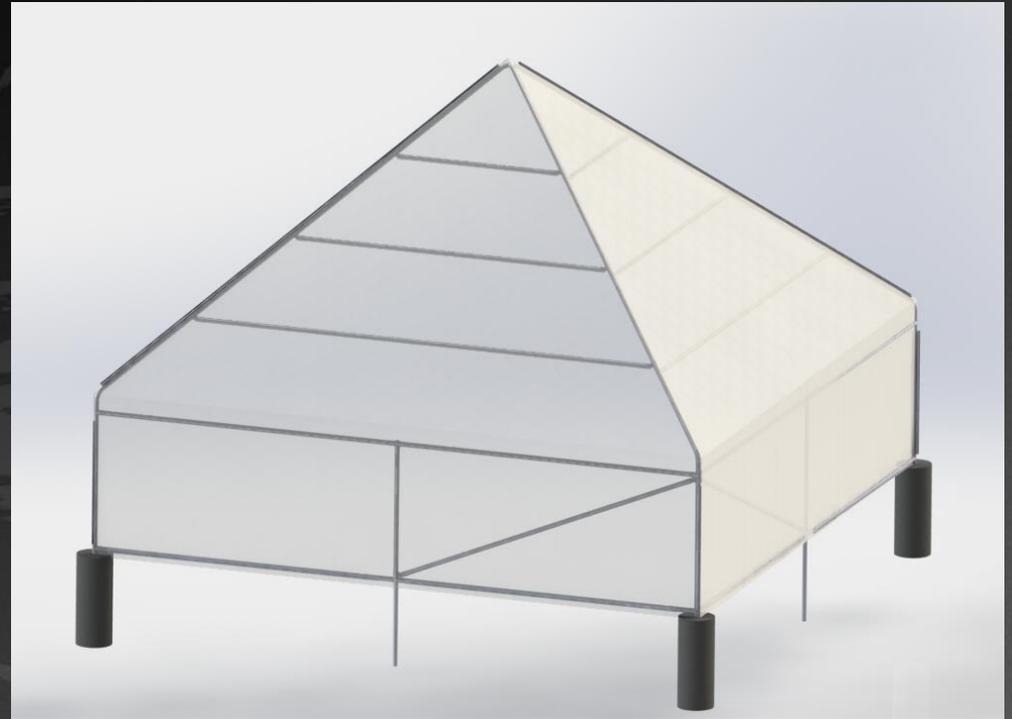
Suggested Kit

- Poly-TEX
 - USDA NRCS approved vendor
- 24' wide by 40' long
 - 4' sidewalls
- Roll-up sides
- 8' x 8' roll-up door
- 14 gauge galvanized steel

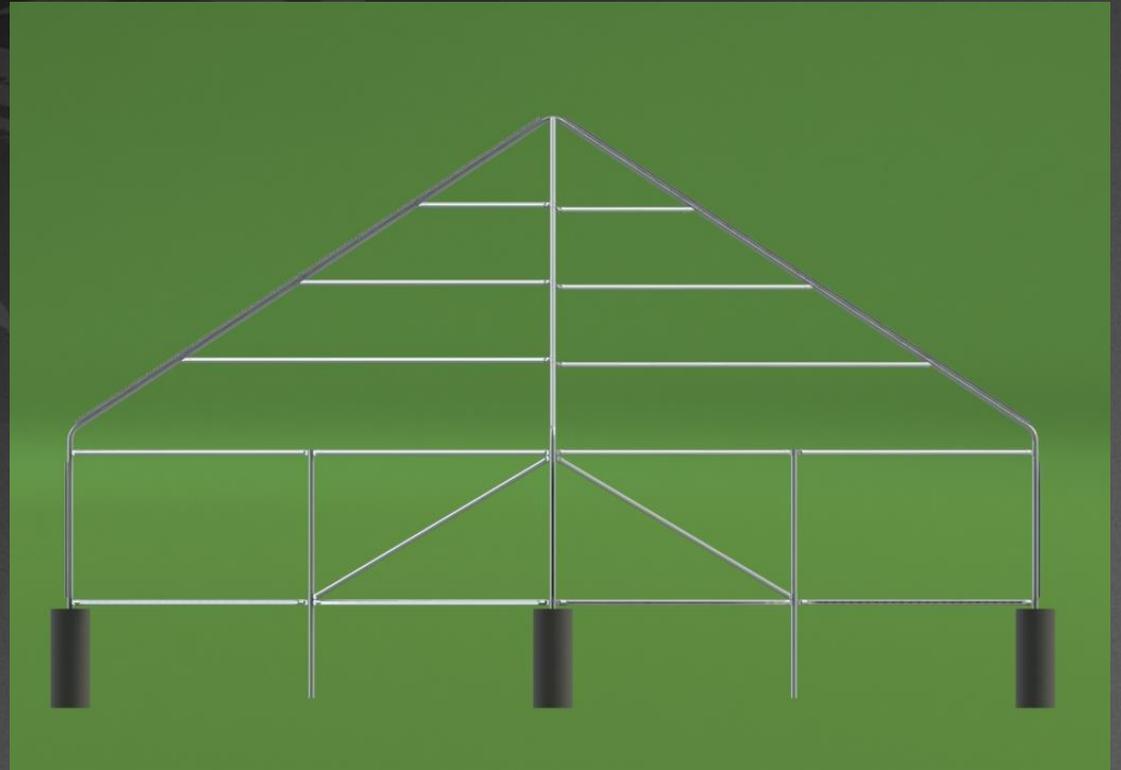
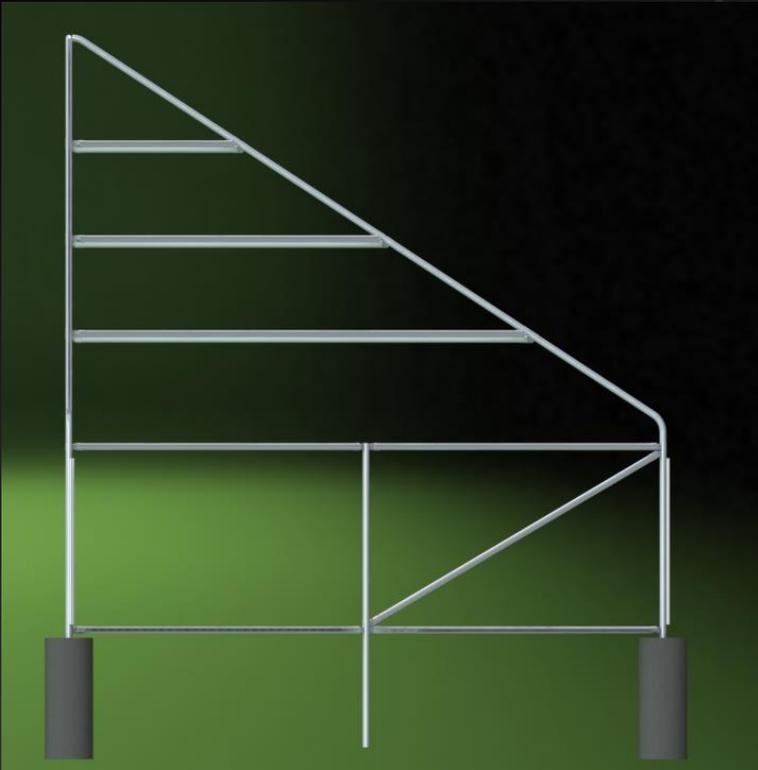
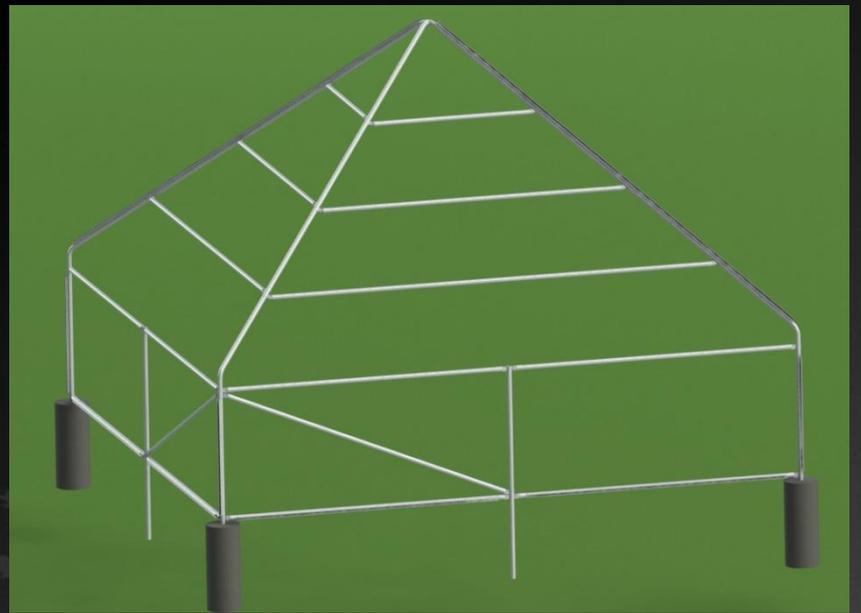


Windbreak Details

- 12' long to the point
 - Use half of a kit frame
- Concrete anchor points
- 4' high sidewalls
- Frame
 - Secured by pipe fittings
- Wiggle wire

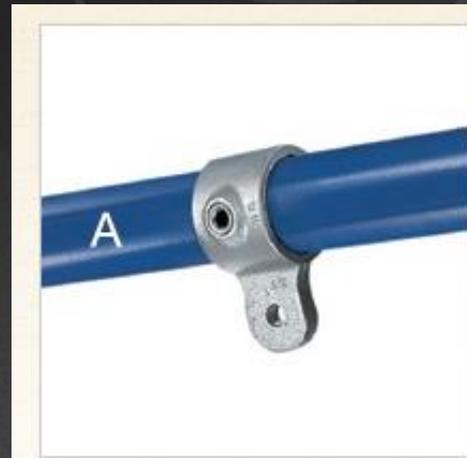
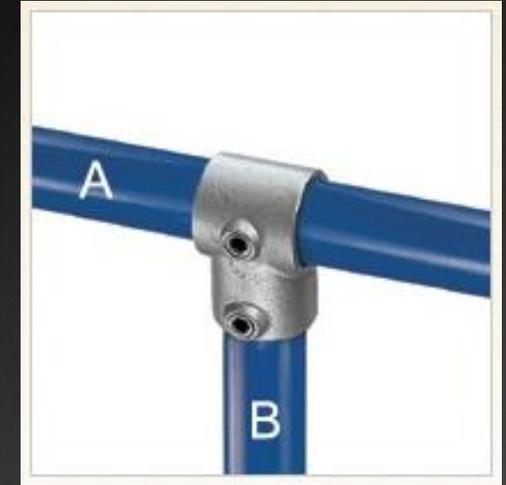


Pictures

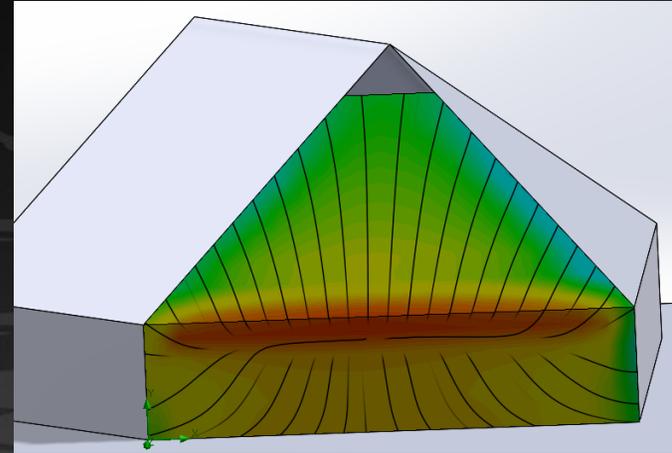
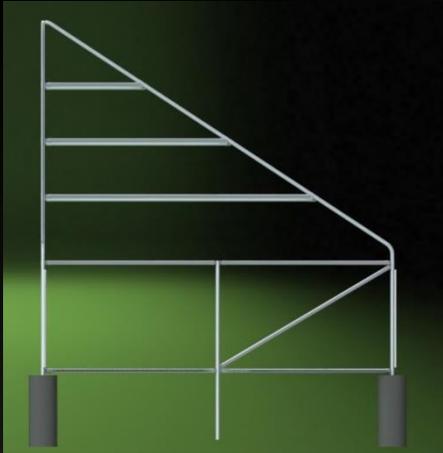


Purlin Connections

- Specialty Pipe Fittings
 - Ordered from Simplified Building
 - 2000 lb. axial load rating (2:1 safety factor)
 - Galvanized steel



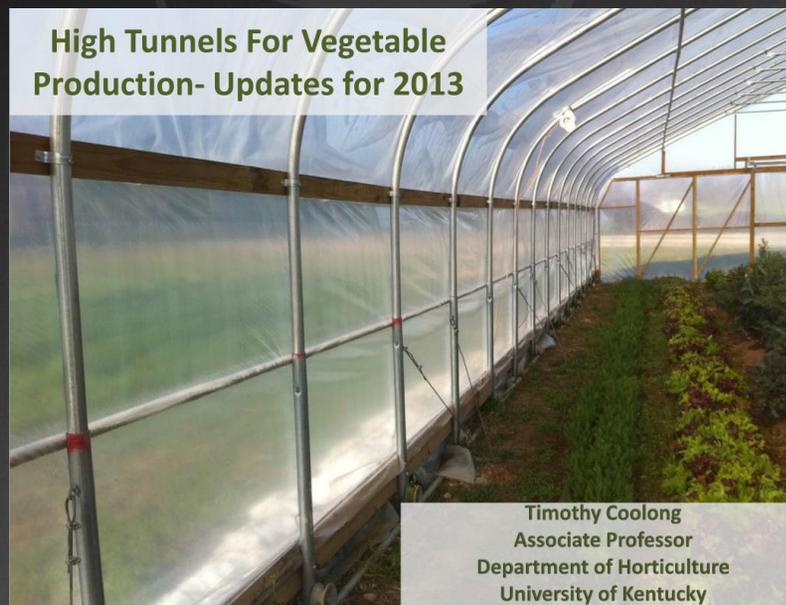
Frame Analysis



Indirect Wind Stress Calculation	
Wind Speed = 105 mph	
Load Status	Pipe Characteristics
Total Wind Load [lb]	Outer Diameter [in]
1135.5	1.66
Moment Acting on Each Support [lb*ft]	Moment of Inertia [in^4]
763.75	0.121508922
Stress [psi]	Ultimate Strength [psi]
62604.0447	63800
Safety Factor	
1.019103483	

Anchor Analysis

High Tunnel	Size	Wind	Lift force	Structure Weight	Contact Points	lbs/Contact	Earth Anchors Contact
UK	22' x 100'	80 mph	22000 lbs	--	--	--	--
UK	30' x 72'	80 mph	16000 lbs	3000 lbs	36	360	--
UI	24' x 52'	80 mph	13000 lbs	--	23	565	1500 lbs



High Tunnels For Vegetable Production- Updates for 2013

Timothy Coolong
Associate Professor
Department of Horticulture
University of Kentucky

Cost Analysis

Cost Analysis Overview	
Kit Cost	\$4500
Windbreak Poly	\$125
Windbreak steel	\$220
Windbreak Extras	\$95
Windbreak frame fittings	\$500
Lumber	\$205
Concrete	\$115
Total Cost	\$5760

Future Work

- Building the high tunnels
 - One with windbreak
 - According to our instruction manual
 - One without windbreak
- 10+ years of use and testing
 - Plastic sheeting comparisons
 - Sagging
 - Strength
 - Tearing
 - Replacement periods
 - Structure stability

Questions/Comments?

