A Multi-Purpose Tool for Small Farms

MECH-8003

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A Small Purpose Tool for Small Farms

By

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Advisor: Dr. Matthew Lawrence Date

Advisee: Matthew Messana Date

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Table of Contents

List of Figures and Tables

Abstract

The purpose of this project was to design a new agricultural cart for planting and harvesting on small farms. The current cart was an original design with nothing like it on the market presently was produced and being used currently but it was only constrained to be used for a couple of crops. The owner of the cart wanted to redesign the cart to improve the versatility of the cart to be used around the farm for more than just planting but for harvesting as well. The design objectives for the new cart were discussed with the owner and then applied to the concept drawings. The concept drawings were produced in AutoCAD 2010 and then a final design was agreed with the creation of assembly drawings. A solid rendering was produced to visualize what the cart will look like. The individual members of the cart were drawn up in detail drawings to aid in the fabrication of the cart. From there bending analysis was calculated for specific members to determine the integrity of the frame.

Introduction

The saying "time is money" can be related to any occupation in society but it can be truly seen in that of farmers. Farmers are always looking for ways to be more efficient with the daily tasks which will help them be more productive especially in difficult economic times. With the economy, hiring farm hands to help with the day to day operations is a daunting task with costs increasing. With having fewer workers around time management becomes an even more critical factor. From planting, harvesting and livestock, the manual labor and time spent on each can either make or break the season for the farmer with being on schedule for the seasons.

The implementation of a tractor drawn cart may be the solution to decrease the time spent in the fields planting and harvesting. Presently there is no cart that has the versatility to be used for the planting and harvesting process. The cart that was produced has limited ability to be changed to adequately be used for the various crops small farms deal with. To accomplish these tasks, a new cart would have to be designed for a fabricator to then fabricate and assemble for use.

Literature Review

Garlic is a crop that can be grown in many different climates. For cold climates it is planted in the ground in the fall with roughly six weeks before the soil freezes. The key to planting garlic is to have the pointed end of the garlic clove pointed up and at least two inches below the surface as seen in Figure 1. This requires the workers to be bent over and crawling on the ground for hours at a time until the crop is planted in the desired field. This can be seen in Figure 2.Then the garlic is left in the ground over the winter and is harvested in late spring. The harvesting process is similar to that of planting in the manner of being in the field on ones hands and knees which is time consuming to the farmer growing the crop.

Figure 1

Figure 2

Previous to the design the cart produced for Honey Hill Farms, there was no cart remotely close that resembled that same design. The cart was designed to be pulled behind a tractor. The frame design allowed a 4' x 8' piece of plywood to be laid in place as the cart bed and could be interchanged at anytime for different operations. This can be seen in Figure 3.The cart

Figure 3

design was a crude design with no working drawing specifications to have the cart be reproduced or be improved upon. The current cart can be viewed in Figure 4. The geometry of the cart limited the functionality to a few planting processes with garlic being the primary crop for use of the cart. The wheelbase of the cart was same width apart as the tractor that it was being pulled by with no option to adjust the wheel base of the cart. The wheels were mounted internally in the cart and restricted full availability of the full area of the plywood board for hauling of workers, planting and harvesting materials. Figure 5 shows the current carts wheel design. The tongue of the current cart runs through the center of the cart limiting available space in the center of the cart while providing stability of the geometry of the cart and support for the plywood board. Also the farmer of current cart would like to have the new cart be pulled being the potato harvester for a more efficient way that cuts down time spent collecting the potatoes after they have unearthed. Overall the new cart will be used for many more applications with the built in adjustability from the design ideas.

Figure 4

Figure 5

Engineering Principles

The new cart will be required to carry more weight than the previous cart for it can be used for a wide variety of tasks around the farm. With having an increased load, the structure of cart would have to be designed to hold sound with the weight being applied to it. The equations used for the frame of the cart were the bending equations for a cantilever beam and for a uniformly distributive load across a beam.

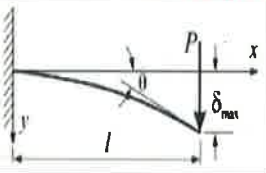
BEAM TYPE	SLOPE AT FREE END	DEFLECTION AT ANY SECTION IN TERMS OF x	MAXIMUM DEFLECTION
1. Cantilever Beam – Concentrated load P at the free end			
	$\theta = \frac{Pl^2}{2EI}$	$y = \frac{Px^2}{6EI}(3l - x)$	$\delta_{max} = \frac{Pl^3}{3EI}$

Table 1

The cantilever beam maximum deflection equation from Table 1 was applied to calculate the amount of deflection at the tongue of the cart. The load (P) was an estimated value from the design criteria for the new cart. The length of the tongue (L) can vary depending on the application the cart is being used for due to the adjustability design. The modulus of elasticity (E) for structural steel is 29×10^6psi. The moment of inertia (I) was calculated based upon the geometry of the member being looked at.

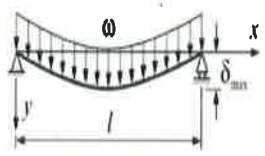
8. Beam Simply Supported at Ends – Uniformly distributed load ω (N/m)			
	$\theta_1 = \theta_2 = \frac{\omega l^3}{24EI}$	$y = \frac{\omega x}{24EI}\left(l^3 - 2lx^2 + x^3\right)$	$\delta_{max} = \frac{5\omega l^4}{384EI}$

Table 2

The uniformly distributed load equation for maximum deflection from Table 2 uses similar components to that of the cantilever beam equation for the modulus of elasticity, and determining the moment of inertia of the member being looked at. The load (ω) is distributed across the entire member uniformly. The length (L) of the member will vary according to the members being looked at.

Objectives

The purpose of the current agriculture cart is to assist in the planting of crops. With the current design, it is limited to a small range of crops with the primary crop being garlic. The new design will be more versatile with built in adjustability for the agriculture cart to be used for more than just planting. The new objectives of the new design will include:

1. Extendable tongue
2. Built in versatility
3. Adjustable wheel base
4. Installing a toolbar on the back of cart
5. Having a 4' x 4' opening in the center of cart
6. Desired weight load of 2000lbs

Methodology

The goals of this project are to design a newer version of the existing cart that will have more adjustability and versatility than the previous cart. This cart will implement the design criteria set forth from the owner and with the cart being cost effective. The material selection, geometry of the cart and the analysis of structural members will be carefully investigated to meet the project objectives.

At the start of the project a site visit to Honey Hill Farms in Livonia, New York took place in order to view the current cart. Dimensions were taken from the cart and preliminary discussions took place for the new cart. Drawings for the existing cart were created in AutoCAD and from those drawings the concept process for the new cart began. This process took the longest due to the changing ideas and conditions the owner of the existing cart wanted for implementation for new cart. The geometry of the cart basically stayed the same while addition support members were added to make the structure more rigid than the previous model. The material used for the cart followed along with the current material already used for the current cart. After implementing all the design conditions, a final design concept was created with assembly drawings and detail drawings for the individual members for the fabricator to produce the parts and fabricate the cart. A 3-D model was constructed to visually view the cart as a preview of the cart before being constructed. Once the final design met the criteria the owner desired the calculations for the frame were performed for selected members of the cart.

The new cart includes features such as the angle bar that holds the plywood board in place being reinforced with 2" x 2" perforated steel tubing for added support

and for adding additional support members or other devices for planting and or harvesting within the 4' x 4' opening at the center of the cart. For applying the additional supports, a joist hanger system was being considered. A joist hanger is metal shape formed for hanging on the main beam to provide support for the end of a joist. This system would be used in the 4' x 4' opening. The hangers would attach to the perforated members by having the hanger either be wrapped around the perforated member or by being pinned to the member or even a combination of the two. Then the additional support member could drop into place at any location within the 4' x 4' opening.

Another feature is the addition of using telescoping perforated steel tube for the adjustable tongue for the cart. This will allow the user to determine the length of the tongue based upon what application the cart is being used for. The wider A-Frame that connects to the tongue member was widened for structural reasons of adding support and making the cart more rigid and functional reasons of being able to have workers stand or sit while the working in the fields.

Also the new addition of the 2.5" x 2.5" steel solid wall tube attached to the back of the cart as the toolbar is where the wheels and other agricultural attachments can be attached to the cart with ease. The wheel base of the cart can now be varied depending on the application the cart is being used for.

Results

Upon completing the drawings and computation of the calculations, the new version the cart encompasses the design objectives. The design of the cart is able to handle the load of 2000lbs with minimal deflection of the beam members. The adjustability and versatility are the main points of the cart and it will be able to perform various tasks. The materials used for the cart were then computed into total lengths for the weight and pricing for the materials could be calculated as seen in Table 3.

Material	Total Length (inches)	Total Length (feet)	Weight (lbs)	Cost	Total Cost
2"x2"x3/16" Square Tube	219.38	18.28	78.98	120.48/24'	$120.48
2"x2" Perforated Square Tube	411.50	34.29	82.85	180/24'	$360.00
1 3/4"x1 3/4"x1/8" Angle Bar	289.00	24.08	34.68	28.40/20'	$56.80
2.5"x2.5"x3/16" Square Tube	96.25	8.02	44.84	100.80/12'	$100.80
		Total Weight	241.34		$638.08

Table 3

There was no set price for the project and the cost values that were found were the lowest priced material found from research for the materials being used for fabrication of the cart. The fabrication of the cart was not a part of the project and the owner of the current cart will have a fabricator of his choosing to assemble the cart.

Conclusion and Recommendations

The new cart fulfills the all of the targeted objectives set forth for completing the project. The implementation of the design criteria significantly increases the versatility for use beyond just that of garlic planting but for planting and harvesting other crops on the farm as well. The additional supports can strengthen and introduce new uses for the cart as the ideas come along for newer and more efficient ways of farming. The current cart has shown that it is able to reduce work time spent in the field planting, thus reducing time spent planting and harvesting. Overall the new cart will be able to make planting and harvesting processes more efficient.

References

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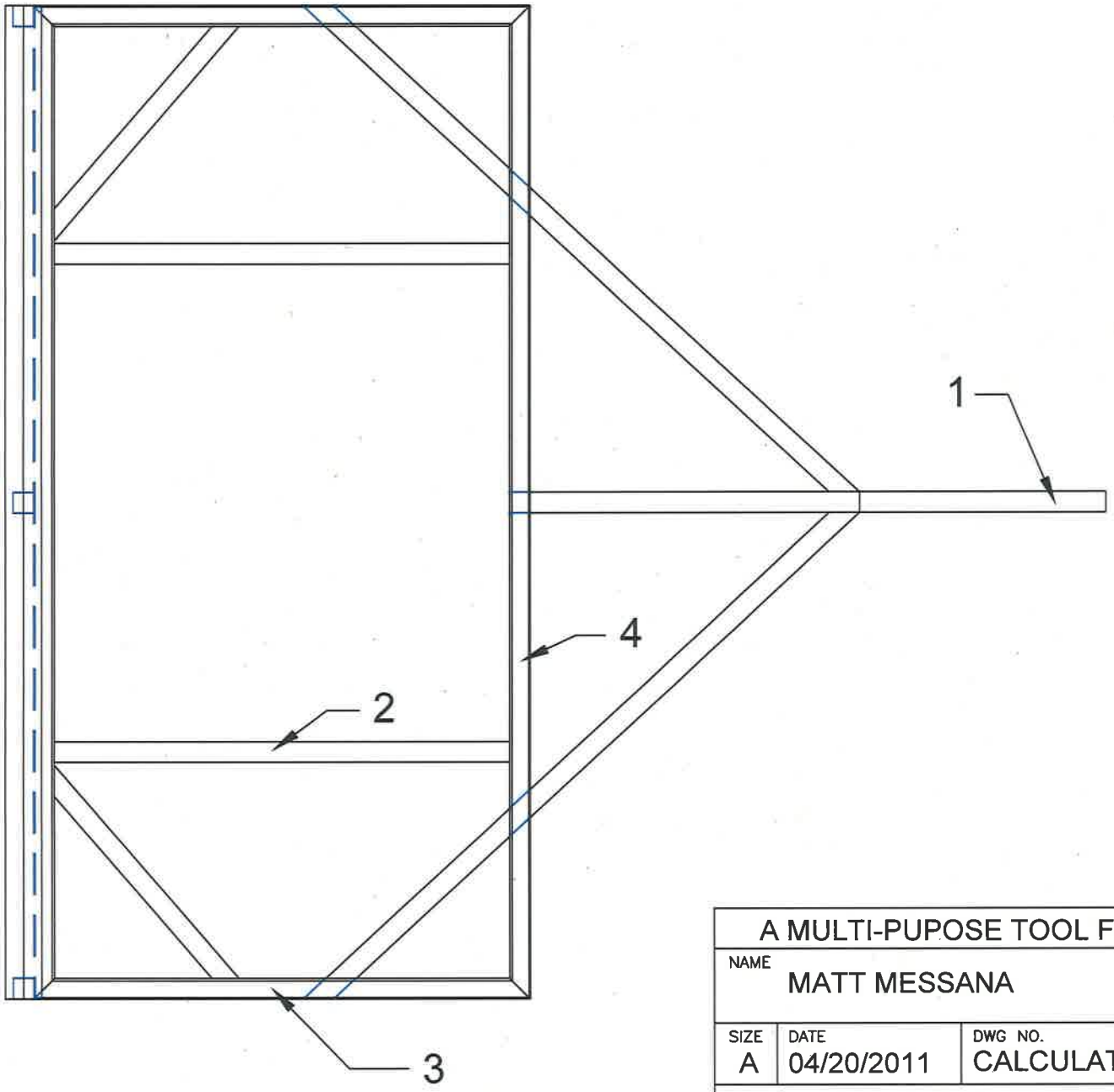
Appendix A

Calculations

INPUTS				
app_load	load applied (W)	700	lbs	estimated
total_load	total load (W)	2000	lbs	estimated
mod_elas	modulus of elasticity (E)	29000000	psi	structural steel
ext_side	external side of solid tube	2	inches	measured
ext_side_2	external side of perforated tube	1.75	inches	estimated
wall_thck	wall thickness of perforated tube	0.105	inches	looked up value
lgth_tube_1	tube length 1 (L)	24	inches	estimated
lgth_tube_2	tube length 2 (L)	44.25	inches	actual
lgth_tube_3	tube length 3 (L)	48.25	inches	actual
lgth_tube_4	tube length 4 (L)	55.5	inches	actual
hght_angle_bar	height of angle bar	1.75	inches	actual
thck_angle_bar	thickness of angle bar	0.125	inches	actual
INTERMEDIATE CALCULATIONS				
int_side	internal side of solid tube	1.79	inches	=ext_side-(wall_thck*2)
int_side_p	internal side of perforated tube	1.54	inches	=ext_side_2-(wall_thck*2)
m_o_i	moment of inertia solid tube	0.478	in^4	=((ext_side^4)-(int_side^4))/12
m_o_i_L	moment of inertia angle bar	0.112	in^4	=1/3*(thck_angle_bar*(2/3*hght_angle_bar)+hght_angle_bar*(hght_angle_bar-(2/3*hght_angle_bar))^3-(hght_angle_bar-thck_angle_bar)*(hght_angle_bar-(2/3*hght_angle_bar)-thck_angle_bar)^3)
m_o_i_p	moment of inertia perforated tube	0.313	in^4	=((ext_side_2^4)-(int_side_p^4))/12
OUTPUTS				
deflect_tong	defection at tongue	0.233	inches	=((app_load*in_dist^3)/(3*mod_elas*m_o_i))
deflect_mem_2	defection at member 2	0.163	inches	=(5/384)*((total_load*lgth_tube_2^3)/(mod_elas*m_o_i))
deflect_mem_3	defection at member 3	0.085	inches	=(5/384)*((total_load/2*lgth_tube_3^3)/(mod_elas*(m_o_i+m_o_i_L)))
deflect_mem_4	defection at member 4	0.260	inches	=(5/384)*((total_load*lgth_tube_4^3)/(mod_elas*(m_o_i+m_o_i_L)))
deflect_tong	defection at tongue perforated	0.356	inches	=((app_load*lgth_tube_1^3)/(3*mod_elas*m_o_i_p))
deflect_mem_2	defection at member 2 perforated	0.249	inches	=(5/384)*((total_load*lgth_tube_2^3)/(mod_elas*m_o_i_p))
deflect_mem_3	defection at member 3 perforated and angle bar	0.119	inches	=(5/384)*((total_load/2*lgth_tube_3^3)/(mod_elas*(m_o_i_p+m_o_i_L)))
deflect_mem_4	defection at member 4 perforated and angle bar	0.361	inches	=(5/384)*((total_load*lgth_tube_4^3)/(mod_elas*(m_o_i_p+m_o_i_L)))



A MULTI-PUPOSE TOOL FOR SMALL FARMS			
NAME MATT MESSANA			
SIZE A	DATE 04/20/2011	DWG NO. CALCULATED MEMBERS	REV
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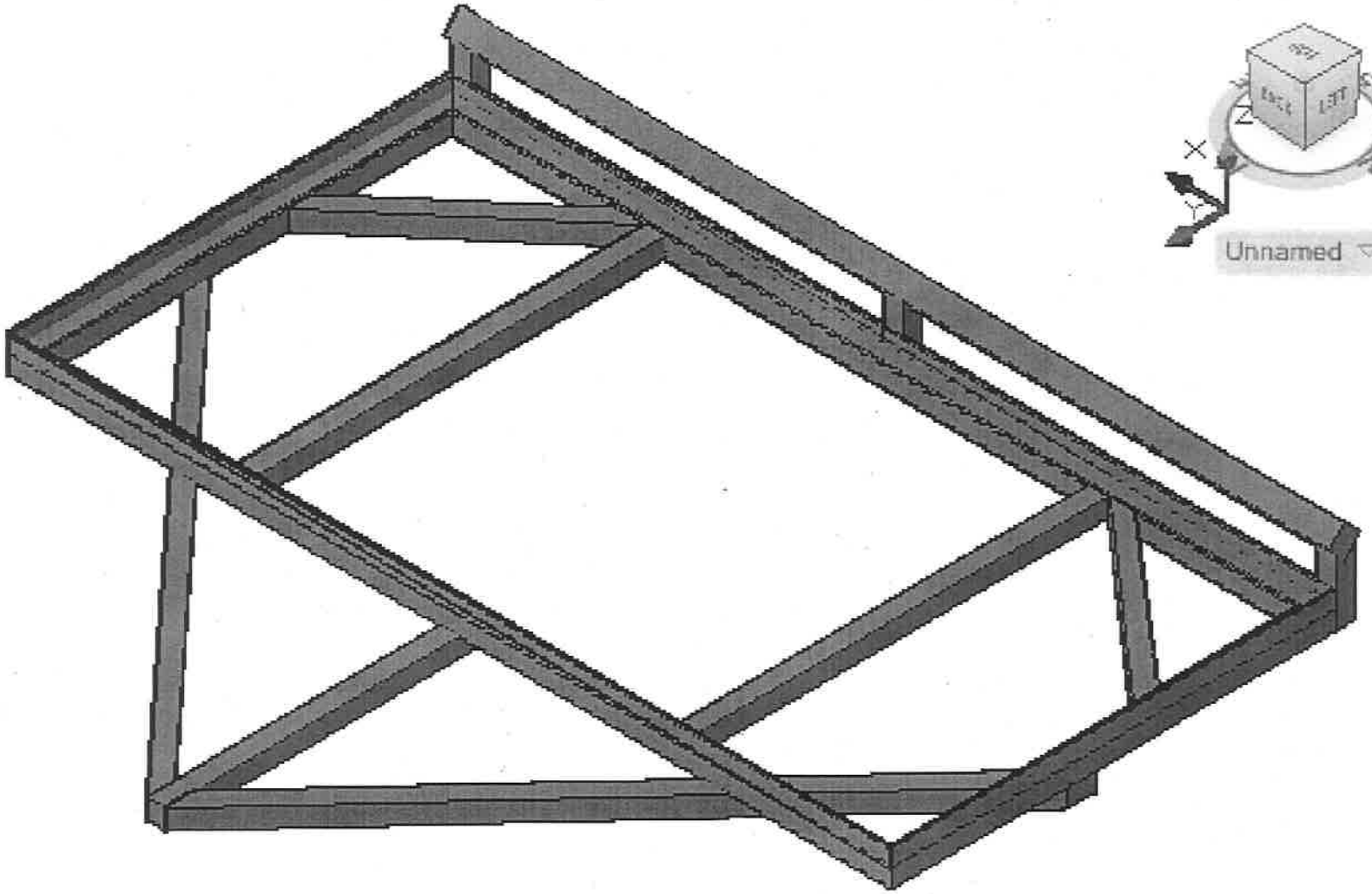
Appendix B

Drawings



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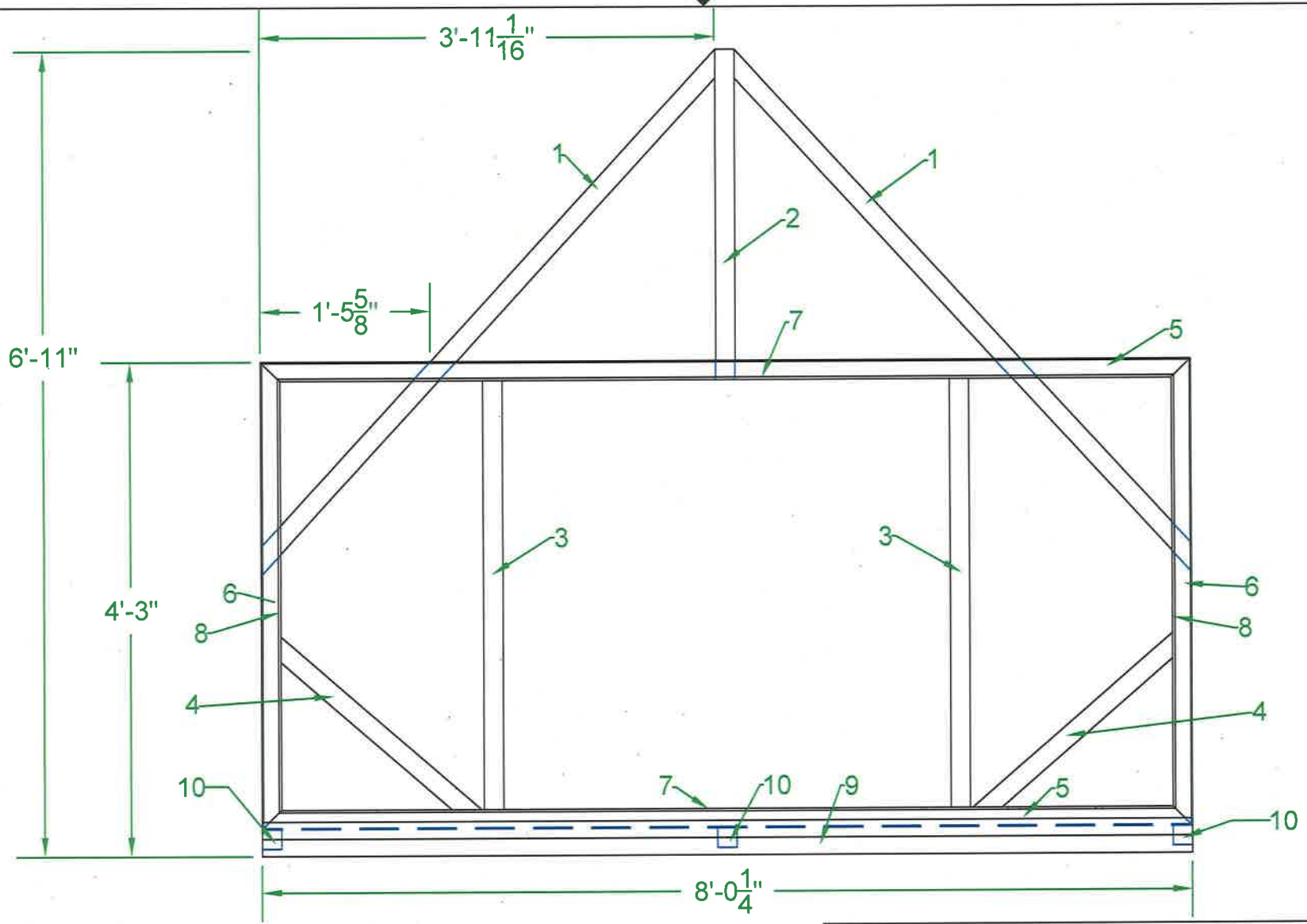

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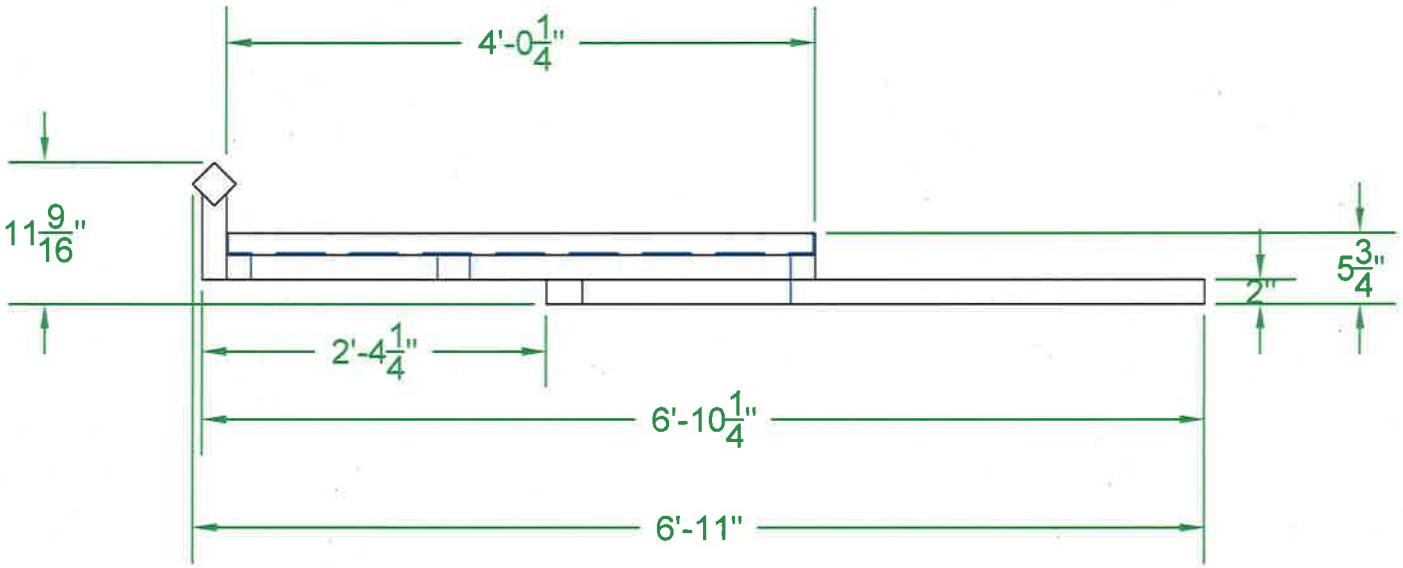

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NAME MATT MESSANA			
SIZE A	DATE 04/20/2011	DWG NO. SIDE VIEW OF CART	REV
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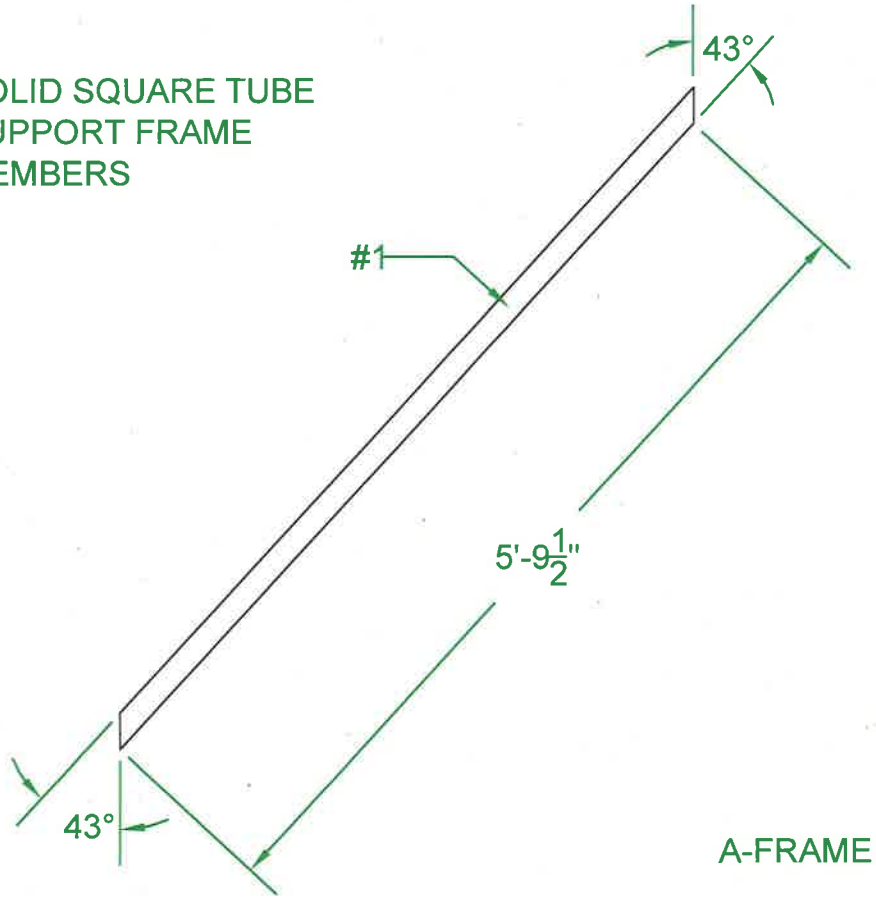
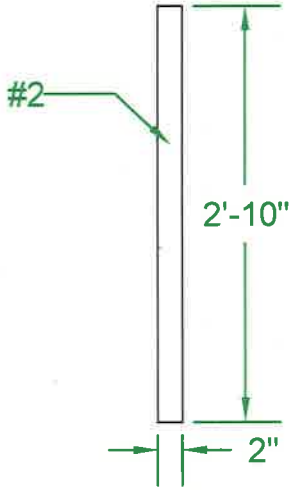
SOLID SQUARE TUBE
SUPPORT FRAME
MEMBERS



A-FRAME MEMBERS



PERFORATED SQUARE TUBE
SUPPORT FRAME
MEMBERS

A MULTI-PUPOSE TOOL FOR SMALL FARMS			
NAME MATT MESSANA			
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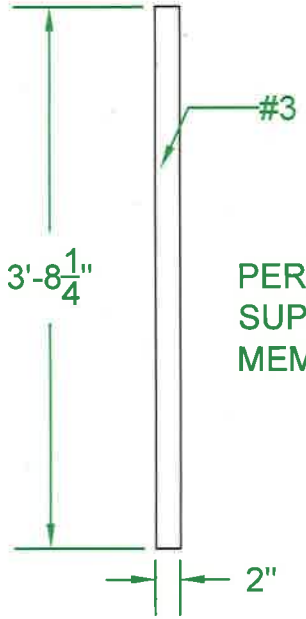

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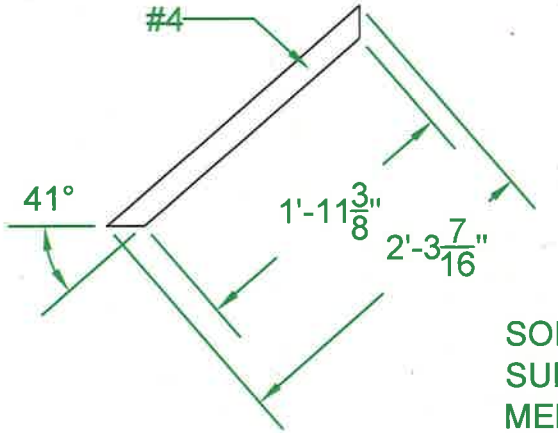
SUPPORT FRAME
MEMBERS



SOLID SQUARE TUBE
SUPPORT FRAME
MEMBERS

INTERNAL FRAME SUPPORT
MEMBERS

A MULTI-PUPOSE TOOL FOR SMALL FARMS			
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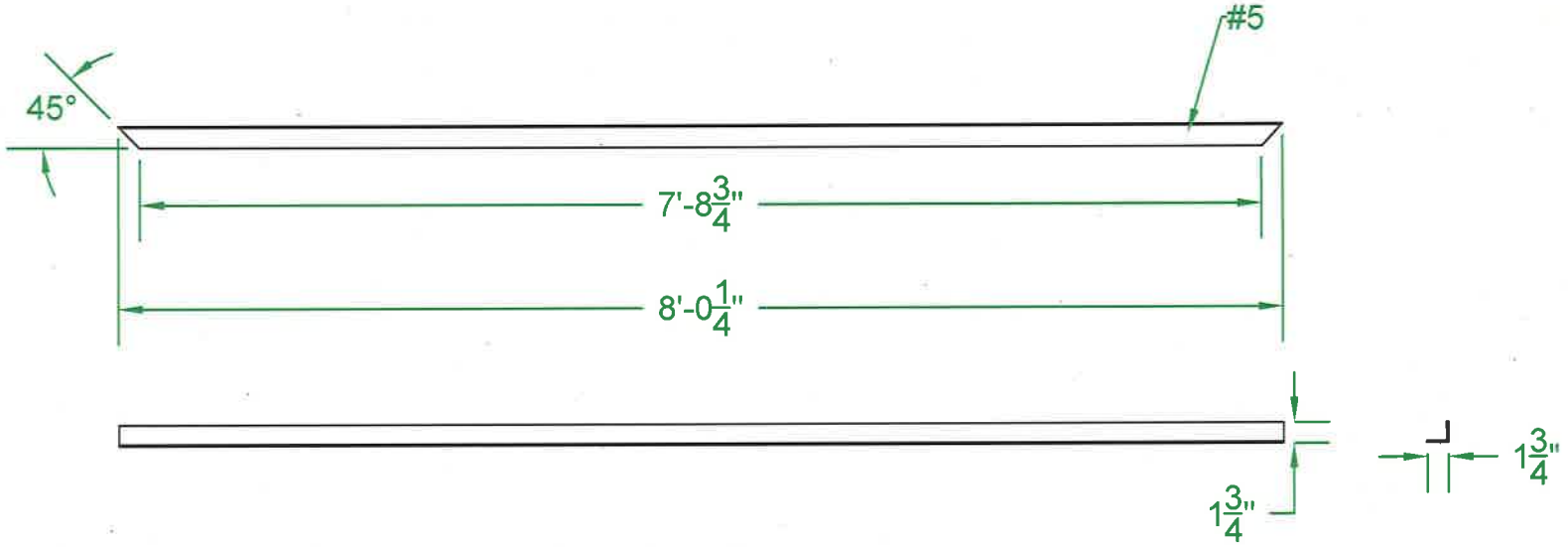

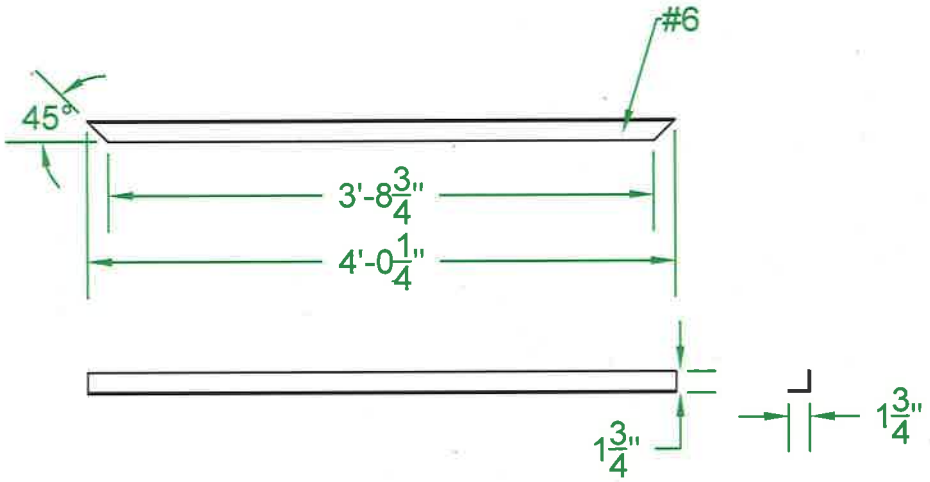

A MULTI-PUPOSE TOOL FOR SMALL FARMS

NAME: MATT MESSANA			
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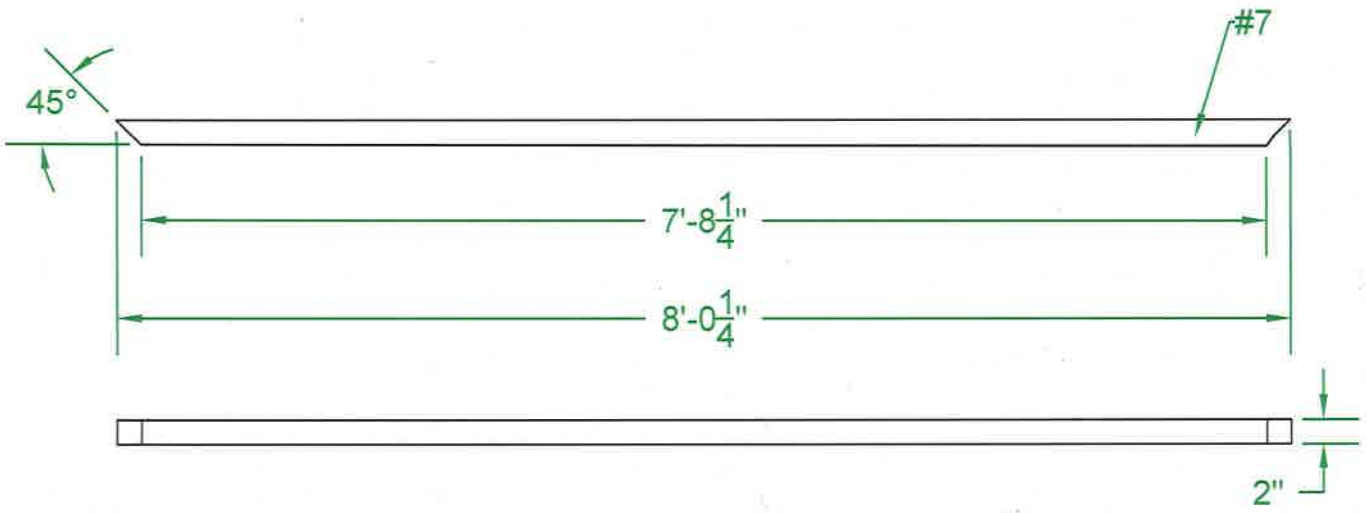

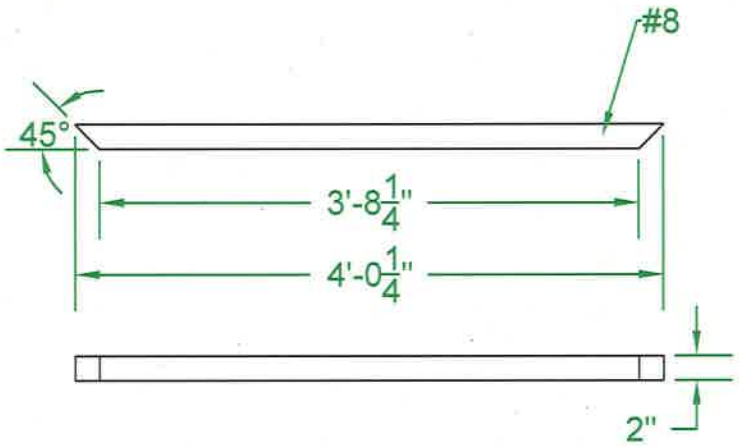

BASE FRAME MEMBERS

A MULTI-PUPOSE TOOL FOR SMALL FARMS			
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SIZE A	DATE 04/20/2011	DWG NO. 2"x2" PERFORATED SQ TUBE	REV
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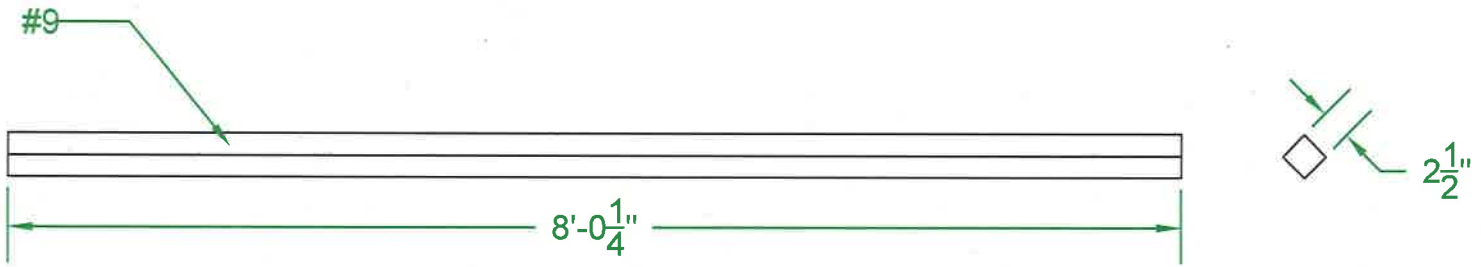
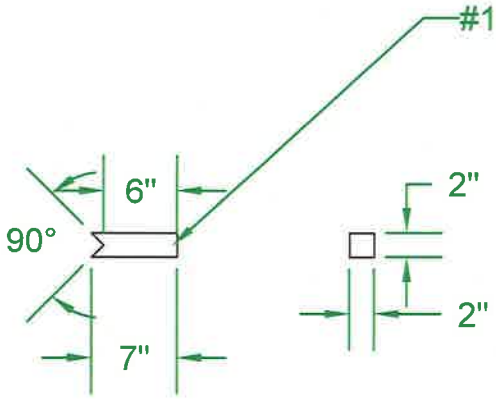
SOLID SQUARE TUBE
TOOLBAR





SOLID SQUARE TUBE
TOOLBAR SUPPORT
MEMBER

A MULTI-PUPOSE TOOL FOR SMALL FARMS			
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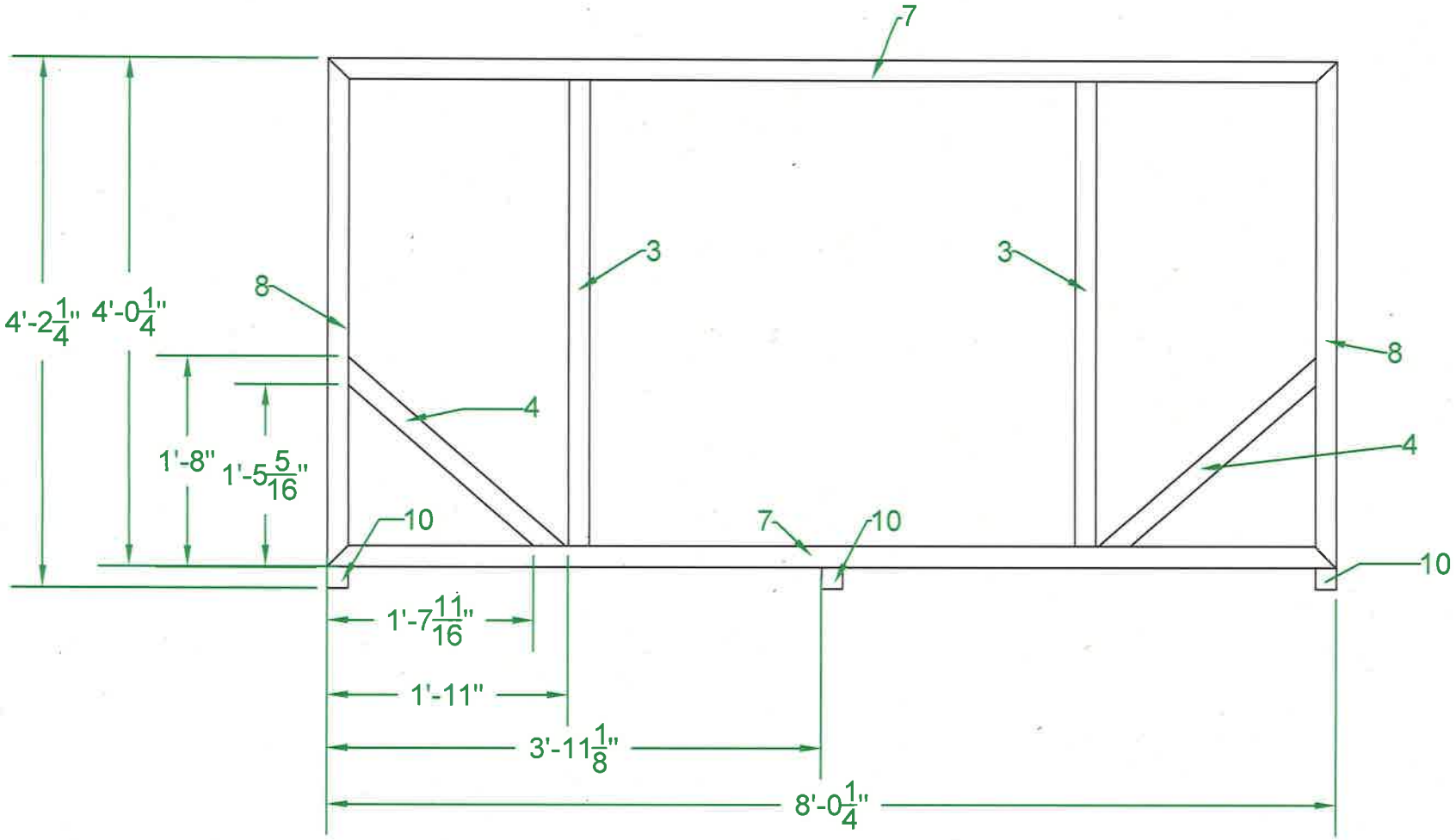

A MULTI-PUPOSE TOOL FOR SMALL FARMS			
NAME MATT MESSANA			
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Appendix C

Miscellaneous

	BILL OF MATERIALS		
ITEM	QTY	DESCRIPTION	MATERIAL
1	2	A-FRAME ANGLE MEMBER	2" x 2" SOLID WALL SQUARE TUBE STEEL
2	1	A-FRAME MIDDLE MEMBER	2" x 2" PERFORATED SQUARE TUBE STEEL
3	2	FRAME VERTICAL MEMBER	2" x 2" PERFORATED SQUARE TUBE STEEL
4	2	FRAME ANGLE MEMBER	2" x 2" SOLID WALL SQUARE TUBE STEEL
5	2	LONG ANGLE BAR	1.75" x 1.75" ANGLE BAR STEEL
6	2	SHORT ANGLE BAR	1.75" x 1.75" ANGLE BAR STEEL
7	2	LONG BASE FRAME MEMBER	2" x 2" PERFORATED SQUARE TUBE STEEL
8	2	SHORT BASE FRAME MEMBER	2" x 2" PERFORATED SQUARE TUBE STEEL
9	1	TOOLBAR	2.5" x 2.5" SOLID WALL SQ. TUBE STEEL
10	3	TOOLBAR SUPPORTS	2" x 2" SOLID WALL SQUARE TUBE STEEL

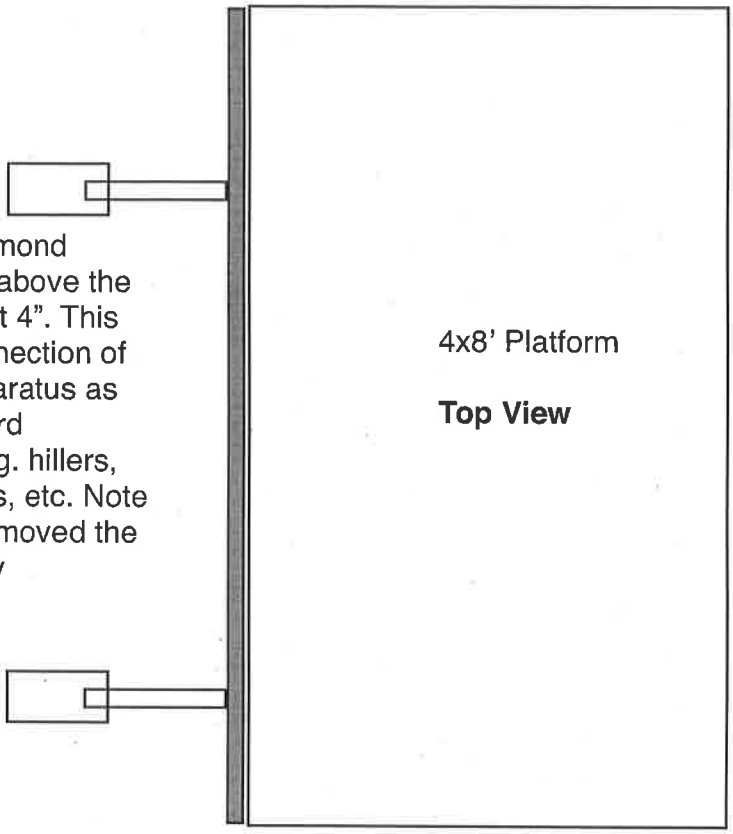
A MULTI-PUPOSE TOOL FOR SMALL FARMS

NAME MATT MESSANA

SIZE	DATE	DWG NO.	REV
A	04/20/2011	BILL OF MATERIALS	

SCALE 1.00=1.00 SHEET 1 OF 1

Not to scale

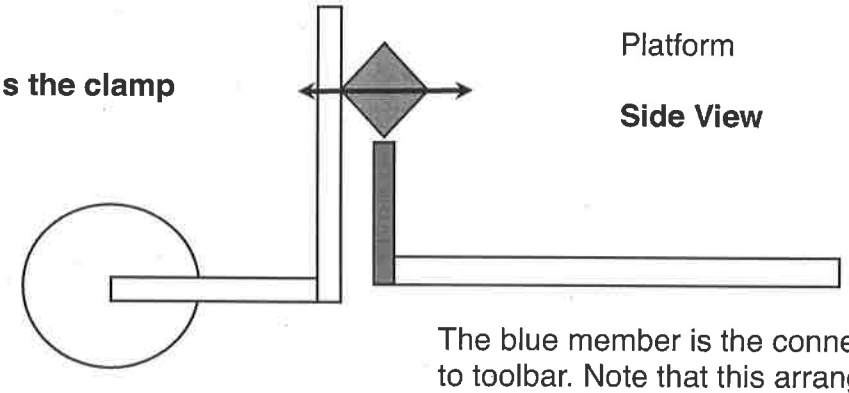


Green indicates a 2.5" diamond toolbar elevated as below above the frame of the platform about 4". This conveniently provides connection of wheels and any other apparatus as commonly used in standard agricultural applications e.g. hillers, shanks, furrowers, seeders, etc. Note that the wheels are easily moved the width of the platform in any configuration.

4x8' Platform

Top View

The arrow is the clamp



Platform

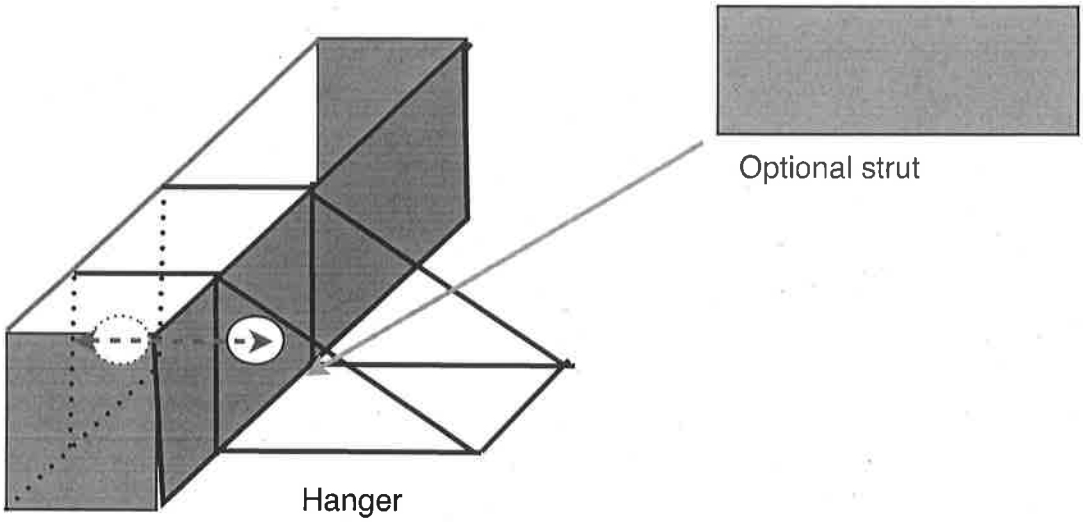
Side View

The blue member is the connector from main frame to toolbar. Note that this arrangement permits platform elevations (from soil) @ zero to n at low cost and with common components.

I have calculated platform load at ~1500# thus each wheel at 750#. (known uses). Design should accommodate this at a minimum.

Further improvements to follow

Bolt securing the hanger



This is the best I can do to Illustrate using text editing!!