12-2011

Innovative Design: Design of a Press System and Molds to Produce a Skateboard Deck.

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Innovative Design:

Design of a Press System and Molds to Produce a Skateboard Deck

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A thesis

presented to

the faculty of the Department of Engineering Technology

East Tennessee State University

In partial fulfillment

of the requirements for the degree

Masters of Science in Technology

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by

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December 2011

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Keywords: Technology, Press, Molds, Skateboard

ABSTRACT

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Skateboarding is a passion for many people. Homemade skateboard machinery has been fabricated throughout the country. While the demand for skateboards is steady; there is a steady growth in the homemade skateboard deck market. The desire to create a one of a kind deck that expresses a person's individualism is growing. This applied research and development effort—designing and fabricating a fluid powered press system and 2-part mold assembly for forming glue up laminations for skateboard decks— is an attempt to gain understanding of the different phases of the product design process.

DEDICATION

This is dedicated to my family, especially Charlie Joe Elsea, who has inspired and continuously inspires me to pursue a better tomorrow.

"My contention is that creativity now is as important in education as literacy, and we should treat it with the same status."

-Sir Ken Robinson

ACKNOWLEDGEMENTS

The original idea for my product development research was sparked by the meaningful guidance of Dr. W. Andrew Clark, Dr. Paul Sims, William K. Hemphill, Dr. Mark Pollock, Sam Rowell, and Garth Ghearing. If it were not for their continued passion for excellence in education; my desire to research and design would not exist in its current state. I would like to make special acknowledgements for Sam Shafer and Chester Luther for their technical expertise.

CONTENTS Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This thesis encompasses the research and development process undertaken by the author in creation of a fluid-powered press system and two-part mold assembly for creating three dimensional laminated skateboard blanks. Industry standards were examined for product design, manufacturing methods, and quality expectations. Hobbyist designs were taken into consideration during the development of the press system. The goal was to produce a quality skateboard deck with a press and available machinery on East Tennessee State University's campus.

The press can be manually controlled and powered by a combination of pneumatics and hydraulics. The press's design is "Open Source" and available to the public for educational, entrepreneurial, and hobbyist use. The developed manufacturing methods will provide information in the materials, processes, and manufacturing fields. The development of the press system has also encompassed the elements of mechanical design and product development.

CHAPTER 2

BACKGROUND INFORMATION

Skateboarding History

Skateboarding is a sport that has seen a steady increase since the early 1950s. Skateboards have no definitive inventor and were a product of cultural innovation. This sport arose from the popular surfing culture in California. The idea manifested when surfers desired to continue their sport in the nonswimming seasons. They would take planks from old wooden crates from at the local ports and attach roller skate wheels to the bottom with wood screws. The first commercial skateboard was offered in 1959 by Makaha skateboards (White, 2011).

In the early 1960s multiple skateboard companies were formed and nearly 50 million skateboards were sold in 3 years. It was at this point the first skateboard contest was held in Hermosa Beach, California. Shortly after this spike in popularity the public opinion of skateboarding safety declined. While skateboarding had quickly lost its appeal to the general public, a passionate subculture endured. In the 1970s Larry Stevenson, the founder of Makaha, invented the kick tail. The kick tail is the portion of the deck that is bent upwards toward the end. In 1973 the Urethane wheel was invented along with a four-wheeled modular suspension system, called a truck, for more traction and stability. Skateboarding moved from flat to hilly terrain (Cave, 2011).

In the 1980s homemade ramps became a new way to experience skateboarding. Plywood and scrapped stud wood became the materials of choice for pipe and ramp building. The forces involved in skateboarding with ramps, vertically sloped pipes, and half pipes forced the evolution of deck design. Traditional solid wood decks evolved into pressed veneer decks that had the semirigid spring necessary to launch and endure large loads from sudden applications of dynamic forces. Between several companies multiple deck designs were created. Single kick tail boards were popular in the early 80s, but by the early 90s two tailed boards became the design of choice. The two tailed freestyle board consist of seven layers of Canadian Maple bonded with polyurethane glue; this was the industry norm until the present day (Cave, 2011).

Existing Board Designs

Skateboard deck designs have varied since the beginning of the sport. Modern skateboards vary in width and length depending on the intended riding environment. The faster the rider intends to ride, the longer the board will be. The average freestyle board is between 31 and 34 inches in length and nominally 7-1/2 inches wide with two kick tails that enable the rider to perform various tricks. The width of the board varies from 8-1/2 inches to 7-1/4inches. The use and size of the rider determines the most appropriate width to be used. Street riding generally requires a more narrow board. Ramp and pipe riding require a wider board for increased stability during a 180 degree turn (White, 2011).

Long boards are skateboards that have a greater length and broader wheel base than freestyle skateboards. Long board decks range in size from 34 to 59 inches long. The width varies from 7-1/2 to 10 inches. These sizes are determined by the rider’s size and intended speed. Longer and broader boards have the ability to maintain stability at much greater speeds than freestyle boards. The narrow class of long boards, also known as pin tails, is used for slower urban cruising speeds while larger longboards, known as bombers, are used for aggressive downhill riding. Pintails become unstable at 40 miles per hour and run the risk of a "death wobble" in which the rider loses balance and is thrown from the board. Bombers have been recorded of reaching speeds in excess of 80 miles per hour while riding down mountain passes (White, 2011).

Materials Used

Skateboards are typically made out of several layers of veneer. The premium wood veneer for skateboard making is Canadian Maple. Canadian maple has the necessary properties to withstand the abuse that a deck experiences while being ridden. Canadian maple has the strength, elasticity, and moisture resistance necessary to survive a long life of consistent abuse. Less expensive decks are made from Birch because of the wood's economic price. The tradeoff for economy is quality. Skateboard decks made from birch have neither the strength nor elasticity to withstand the abuse that is dealt by serious skaters. Veneer binding glues vary among different manufacturers. The common properties of the glues are that they are water and vibration resistant. Skateboard manufacturing glues are typically urethane based. The premium decks are bound together, or encased, by fiberglass-reinforced epoxy resin. Fiberglass-reinforced epoxy resin can also be referred to as F.R.E.R. The two skateboard manufacturers with good reputations for durability, Almost LLC of El Segundo California and Element Skateboards of Irvine California, use F.R.E.R. to bind their decks to increase strength and flexibility. Skateboarders commonly refer to these companies as Almost and Element (Moss, 2007a).

The F.R.E.R. also allows for fewer veneers to be used in order to make the deck lighter. Urethane glued decks typically use seven plies of veneer. F.R.E.R. decks typically use five to six plies of veneer. The difference between Almost's and Element's decks is that Almost puts a carbon fiber cloth on both sides of the core veneer sheet before applying the resin. This variable makes Almost's decks the premium choice for serious recreational and professional skaters (Moss, 2007a).

Press Designs

The gap between professional and recreational skateboard manufacturing is narrowing at an alarming rate. Any person with access to basic machinery and materials can develop a skateboard press system. There are different methods to produce a deck, each with its own individual strength and weakness. The most popular method of producing a skateboard deck for enthusiast is vacuum mold compression. The vacuum mold compression method uses a foam unibody mold that is made from high density foam. The veneer is glued and placed on the top of this mold. A high strength plastic sleeve is placed over the mold and veneer, then a vacuum removes the air compressing the veneer over the mold. (Moss, 2007b) This function can be seen in Figure 1.

This is the choice for hobbyist skateboard makers for its economy, simplicity, and ease of use. Additionally, the vacuum mold compression system does not require a large amount of equipment to complete the molding process. Another benefit to using a vacuum compression mold is that uniform distribution of the binding agent, such as glue or epoxy, which reduces the chance of large voids in the board (Schwartz, 2010). The problem with using a vacuum sealed compression system is that the necessary 20 tons of force for premium void removal and veneer shaping is not achieved. Another problem is that these molds and bags can only be used once making it impossible for entrepreneurs in the skate industry to mass produce decks. The nature of vacuum mold compression also makes it difficult for fiberglass to be used due to the high probability of resin overspill binding to the sealing bag and mold. This makes it difficult to prep the board for routering and sanding (Hunter, 2003).

Figure 1. Vacuum Mold Compression Device (Moss, 2007c)

Another method more popular for commercial skateboard manufacturers is the direct pressure method. The direct pressure method requires the building of a frame assembly and two matching molds. The molds are made from a variety of materials ranging from concrete to wood. The press's frame typically is made out of structural steel and is pressured by a hydraulic system as seen in Figure 2 (Moss, 2007c).

Figure 2. DIYSKATE.COM's Press Design Redesigned by Author in Solid Edge 3D (Moss, 2007c)

The purpose of this type of press system is to allow the production of multiple decks at one time (Moss, 2007c).

Existing Manufacturing Methods

The skateboard industry is a matured manufacturing sector with a several methods of manufacturing. The universal constant is the pressing and forming of laminated veneer to generate what is called a deck blank. Postpressing operations have slight differences based on the various manufacturers' standard operating practices. The manufacturing process can be reduced to eight operations.

The first operation is veneer prepping. This operation requires the press operator to sort between cross grain and long grain veneer, application of bonding agent, and placing of sacrificial material on the top and bottom of the blank stack (Moss, 2007c). The next operation is the loading of the veneer in the press and pressing the board to 120 pounds per square inch. The press is then heated to 250 degrees in order to cure the binding agent and held for 1 hour in the press. The deck is then unloaded and left to cure for 24 hours on an open faced rack. After curing for 24 hours the blank deck is mounted for drilling the holes that the truck hardware is mounted through. The machinery used differs from company to company. Some companies have a Computer Numerically Controlled gang drill press that drills all eight holes in one operation; other companies have jigs and fixtures that serve as a master template for traditional drill presses (White, 2011). Figure 3 shows a gang drill press that uses eight drill bits at one time.

Fig. 3 Gang Drill Press ("Used skateboard machinery,"2007)

The next operation is the rough cut. The blank deck is mounted to a template using the drilled hardware holes and then cut with a band saw. After this operation the rough cut deck is mounted to a final size template and routed to size with a shaper. The following operation is routing the round around the lip of the deck. This is done with a hand router. After routing the deck is dressed, taped, and assembled.

CHAPTER 3

PROBLEM STATEMENT

The need for developing simpler, more efficient ways of producing consumer goods drives the current market. Innovation at home and in the industrial sector will drive the future of industry by increasing output while reducing waste. Cross referenced insight from multiple industries and experience can drive innovative design. The drive for economical recreational equipment has spurred a new growth in multiple homebrewed manufacturing methods to develop and produce professional grade products at a fraction of the cost.

The average price of a professional grade, brand name, skateboard is $70.00 ("Ccs/decks/ccs," 2011). With proper tool development the production cost of these recreational products can be reduced drastically. The initial investment in equipment and time has the potential for a substantial return. This initial investment may be a deterrent for startups, but given the right resources and skill sets, a high quality product can be produced at a fraction of the cost ("Element product information," 2011).

Innovative design is driven by passion and creativity. The desire to invent and create may be driven not only by personal financial gain but a deeply rooted interest in creating a product or service. The production of this press system is driven by the author's personal interest in skateboards. The purpose of this study is to gain a meaningful understanding of the product development process by learning how skateboards are made.

CHAPTER 4

SOLUTION

Skateboard Design and Specifications

The skateboard selected for this project was the shortest and narrowest board that one could purchase. This choice was made to reduce material cost, and to keep the board within the capacities of the beam deflection gauge. A finished board size of 31 inches in length and 7.5 inches in width was chosen ("Element product information," 2011).

The board was designed with the intent to safely withstand the stress and rigor of general, extended use. The average skateboarder can take a board up to speeds of 13 mph and achieve an average height of three and a half feet during an aerial maneuver (Peters & Peters, 2004). The board's design was modeled on Siemens's Solid Edge 3-D design software as seen in Figure 4. This was done to determine possible clearance issues in the press design. A subsequent prototype board was made with the traditional build of seven sheets of Canadian Maple veneer and urethane glue. The following prototype was made with six Canadian Maple veneers and F.R.E.R. Solid Edge's finite Analysis analyzer was also used to determine the most likely points of failure on the deck in Figure 5.

Figure 4. Isometric View of Modeled Deck

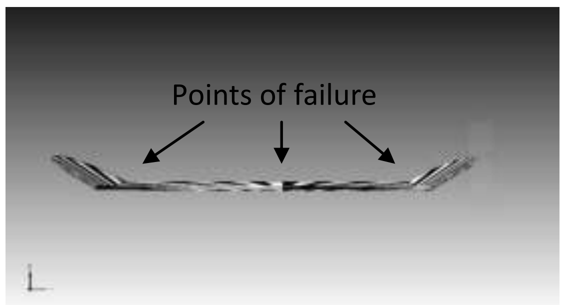

Figure 5. Finite Element Analysis

<u>Mold Design and Assembly</u>

Given the experience of other skateboard manufacturers, concrete was determined to be the most cost efficient material to make industrial grade molds. Other mediums such as wood and foam were insufficient for repeated industrial use. The original idea for the mold was conceived by DIYSkate.com. The inspirational designs used an open top box with an uncut blank deck to pour the cope and drag molds at separate times. The innovative method developed within this project was making both the molds simultaneously. The key to making accurate molds is having a master blank deck. The master blank deck for this project was obtained from skatepaige.com. After receiving the master blank deck, a box was built with ½ inch thick plywood as forms for the molds. At all of the box's joints silicone sealant was applied to prevent concrete from leaking out of the mold. (Moss, 2007b)

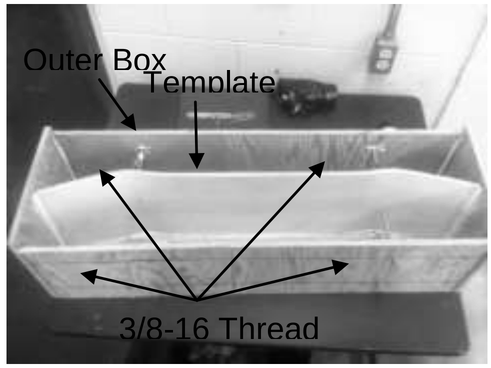

Figure 6. Pattern Deck and Mold Pouring Box

The pattern deck was placed in the center of the mold box, and a silicone bead was laid around the edges of the board to prevent seepage between the two sides of the board. Holes were drilled on both sides of the mold to mount (4) 3/8-16 threaded rods. Nuts were left on the threaded rod to give the concrete a better anchor geometry. The box halves are bound together with decking screws in order to prevent separation during the pouring. The molds required 230 pounds of high strength concrete in order to fill the mold (Moss, 2007b).

The concrete was mixed in a 5-gallon bucket according to manufacture specifications. Prior to pouring the concrete, all of the internal surfaces were coated with motor oil to prevent the binding of the concrete to the wood. Concrete was then slowly poured into the mold; making sure to dispense evenly from side to side to balance loading and reduced the likelihood of of voids that could compromise the integrity of the mold. A hand trawl was used to smooth the surface of the concrete, striking the concrete even with the top lip of pattern deck.

After the concrete cured for 5 days, it was ready for the halves to be mounted to the press system. The side panels were removed and the drag half from the box bottom, making sure to leave the wood panel with the thread rod connected to the mold. The pattern deck was removed cautiously in order to maintain the integrity of the cope half's pressing face. Figure 7 shows the disassembly process at the midpoint. After the cope and drag halves were separated they were left to cure an additional day.

Figure 7. Cope Mold After Separation.

After curing an additional day, the molds were inspected for protruding artifacts and surface voids. Needle nosed pliers and channel locks were used to remove artifacts by rocking them slowly making sure not to damage the molds surface. After thorough inspection and artifact removal, the molds were prepped and ready for mounting to the press system.

Press Design and Assembly

Given the various methods of applying force for producing a deck, a decision had to be made on which method was to be used. The goal was to produce a machine and method in which boards could be produced repeatedly, relatively inexpensive, and consistent is shape and strength. The foam mold immediately does not qualify because the mold is deformed and weakened after the initial pattern deck is made. The other issue with using a foam mold is if any adhesive bleeds out of the veneer, the mold will bind to the board and be damaged during deck removal. Consequently, the direct pressure method was chosen. Direct pressure molding offered several benefits including the necessary 20 tons of force can be achieved. The second benefit is that the molds can be made to make multiple boards at one time. Additionally, the molds can also handle seeping adhesives from the deck better than foam molds.

After correspondence with an engineer from Element Skateboards LLC, it was determined that best practice is to "generate 120 pounds per square inch of pressure for the veneer to maintain its shape." The largest deck that would be pressed would be 8.5 inches wide by 34 inches long. This would be 289 square inches of pressing area and would require 34,680 pounds of pressure to produce favorable results. So a minimum of a 20 ton press was necessary to generate the necessary force (White, 2011).

After researching various designs it was determined that the best design would be the press assembly that can be found on diyskate.com. The basic materials would be easily accessible and economical. The decision was made to derive the final design from this source with adjustments for size in order to save workspace and reduce material cost. Due to the precise nature of the design it was determined that three dimensional design software would be the best design platform for reducing errors in the manufacturing process. The entire press and board were modeled using 3-D modeling in Solid Edge ST2 as demonstrated in Figures 8 and 9.

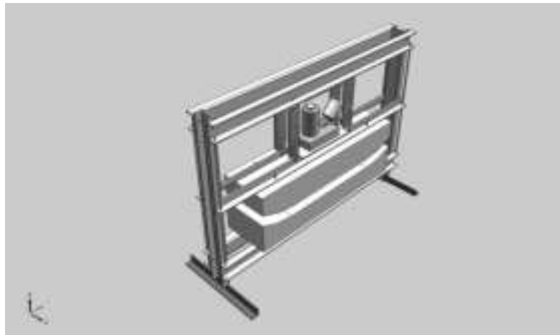

Figure 8. Isometric View of Modeled Press Assembly

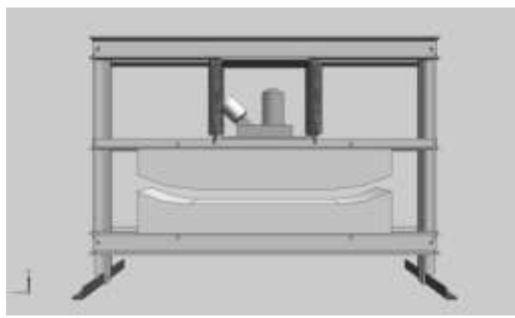

Figure 9. Front View of Modeled Press Assembly

The advantage of using three-dimensional modeling software was a significant reduction of design and fabrication created errors. Various dimension verifying tools allowed for predictions of tight fits during assembly. Figure 10 shows the minimum distance tool being used to determine mold spacing in order to calculate capacity. The press was designed to use repeatable tooling and to reduce the number of necessary fabrication operations. This also allows for repeatability in hardware use and to produce an easy to find center point on the press. Figure 10 demonstrates the dimension finding and simulating capabilities of Solid Edge ST2.

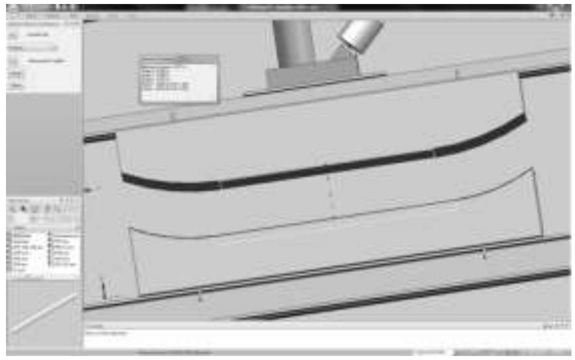

Figure 10. Dimension Verifier Being Used in Solid Edge ST2

The necessary materials are listed below in Table 1.

Table 1. List of Materials to Fabricate Press Assembly.

Quantity	Material and Size	Purpose in Assembly
4	4’ lengths of 3” x 1.5” x .25” C channel	Main Horizontal Supports
2	34.5” lengths of 3” x 1.5” x .25” C channel	Frame Uprights
2	18” lengths of 1.5” x 1.5” of .25” L bracket	Feet
2	4’ lengths of 1.5” x 1.5” x .25” L bracket	Top Die Mount
4	25” lengths of .5” cold rolled round stock	Guide Rods
1	7.75” x 5” X .25” steel plate	Bottle Jack Base Mount
1	3” x 6” x .25” steel plate	Bottle Jack Kick Plate
2	8” lengths of 1.5” x 1.5” of .25” L bracket	Inner Supports for Bottle Jack Kick Plate
1	20 ton Bottle Jack	Pressing device

The machines used during fabrication were a reciprocating band saw for rough cutting, vertical mill for precision cutting, drill press, and MIG welder. The cutters and drills necessary is a ¾” Diameter 4-flute end mill, ½” drill bit, 3/8” drill bit, and a #3 center drill. The first operation of press fabrication was cutting the stock C-channel sections to length. The reciprocating saw was the tool used for this as seen in Figure 11. The stock was mounted into the vice and measured with a tape measure. 0.120” is left on the stock for precision machining on the vertical mill.

Figure 11. C-Channel Being Cut to Length Using Reciprocating Saw

The next operation was milling the C-channel to final length. The C-Channel was mounted into the mill vice and supported at the longest end by an adjustable spacer. The ¾” DIA. 4-flute end mill was used to cut the stock to final length as seen in Figure 12. The first side is milled to achieve a square measuring surface then the other side is milled to final length. A Starret precision tape measure with 0.10” accuracy is used to measure final length. Blue Dykem is used to lay out the template for machining. Vernier height gages were used to mark the locations for the recess and holes. The recess for the foot is milled using the same ¾” DIA 4-flute end mill. A caliper is used to measure the distances for this operation.

Figure 12. C-Channel Being Milled to Final Length with Recess Being Milled into Surface

Once the part has been milled to final dimensions, the holes are drilled for assembly hardware. Figure 13 shows the drilling operation. The drill press was used for this operation. Half inch (0.500”) diameter and three-eighths inch (0.375”) diameter holes were drilled in their respective locations using the #3 center drill, 3/8” drill, and 1/2” drill. After the C-Channel was milled and drilled a file was used to de-burr the part as seen in Figure 14. After de-burring was complete, the part was cleaned with denatured alcohol to remove oils for painting. The C-Channel was primed and painted.

Figure 13. C-Channel receiving 3/8” Drill Holes after being Center Drilled.

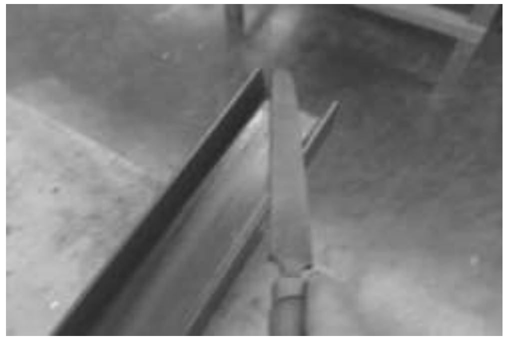

Figure 14. C-Channel being De-burred after Cutting and Drilling Operations

Following the C-Channel fabrication, the L-brackets were fabricated. In similar fashion, the L-bracket was prepared and machined using the same tools and machinery. The L-bracket was rough cut to the same 0.120” over size dimension then milled to final length. The L-bracket was then drilled and de-burred. The same tooling was used to achieved the necessary sizes and hole placements. The parts were then de-burred and prepped for painting.

The guide rods were turned from a piece of 3/8” cold rolled round stock. The round stock ends are turned to the ¼” Dia for a ¼-20 thread. The diameter and thread can be specified from a Starret Tap and Die chart. After the ends were turned and threaded, the guide rod was mounted into the lathe. They were sanded and polished to a mirror finish. The next operation was the machining of the press mounting plate and the press kick-plate. These were made from ¼” steel flat-stock. They were milled with the ¾” DIA 4-flute end mill to finished size.

After all of the parts were fabricated, the next operation was welding using the MIG welder. The top die brackets were welded to the press-plate support brackets using a quarter inch bead and ground to finish. The press kick plate was welded to the press support brackets, and the top kick plate was welded to the top cross braces. A low heat skip weld had to be used to connect the jack to the plate in order to prevent seal damage. Post-weld press and mount are seen in Figures 15 and 16.

Figure 15. Bottle Jack Welded to Top Die Kick Plate and Prepped for Welding to Top Mounts.

After the parts have been welded the assembly stage begins. The necessary hardware is listed in Table 2.

Table 2. Hardware Listing

Quantity	Hardware Description
8	3/8-16 x 1" bolts
8	3/8-16 nuts.
4	1/4-20 x ½" bolt
4	1/4-20 nuts
8	5/16-24 nuts

The 3/8"-16 bolts and nuts are used to assemble the frame. The ¼"-20 bolts and nuts are used to connect the legs to the frame.

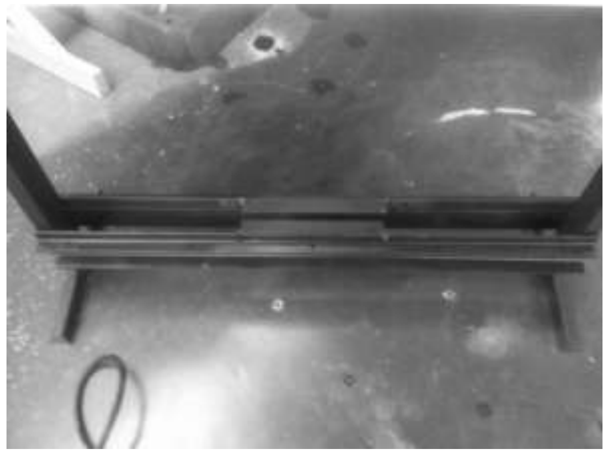

Figure 16. Cope Mold Mounting Brackets Attached to Kick Plate Brace Brackets

After the frame was completely assembled, the next operation was to attach the springs and mold halves. The springs serve as a balanced tensioning method that draws the cope mold up in order to release the skateboard blank. Each spring is nickel plated and rated for 100 pounds of continuous use. Four of them are used in order to handle the 150 pound cope mold that is under load for 24 hours at a time. The springs were mounted to the top frame bracket and cope mold mounts in their respective holes. After the springs were mounted, the next operation was to mount the mold halves. Two people were needed for this operation because the combined weight of the dies was 250 pounds. The drag mold was the first to be mounted. This was done by sliding the drag mold across the bottom braces until the thread rod slid into their respective holes. The 3/8"-16 nuts were tightened to 30 Foot/Pounds to reduce sliding from the press operation. Once the drag die was mounted and tightened, the cope die was mated to the drag die. The bottle jack was then engaged lowering the top mold mount while guiding the thread rod into the mounting holes. Once this was done, 3/8"-16 nuts and corresponding washers were installed and tightened to thirty foot/pounds of torque. Figures 17, 18, and 19 show the final steps of the press assembly process.

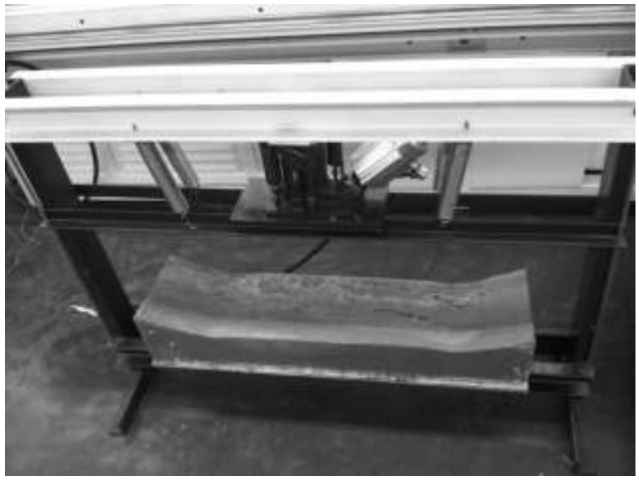

Figure 17. Drag Mold Mounted to Frame, and Springs Loaded in Respective Positions

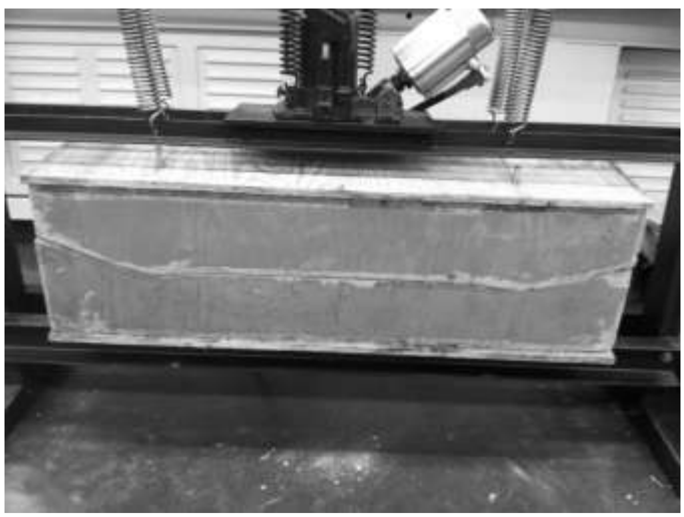

Figure 18. Cope Mold Resting on Bottom Die, Press down in Preparation of Connection

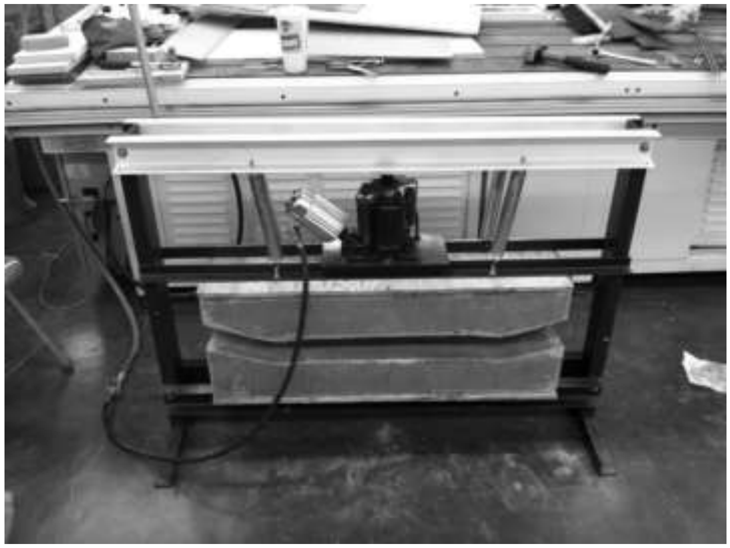

Figure 19. Press after Completed Assembly and Cope Mold Released

<u>Deviations from Original Design</u>

Given the experimental nature of this design and build process, deviations were expected for the press frame. All of the deviations occurred during the manufacturing phase. There were three notable deviations from the original design. The first deviation was the positioning of the mounting holes on the top die mounting bracket. The original intent was to use 1.5" L bracket and drill holes in their respective positions for die mounting. After searching for material, a 1.25" L bracket was discovered with predetermined holes that were equidistant in spacing. This allowed for easier manufacturing. The new distances are displayed in Figure 49.

The next deviation in design was the press mounting plate and brackets. Material access limitations forced an initial redesign of the press mounting plate. The original design called for a single ⅜" plate mounted on two L-brackets with a ¼" weld. The width of accessible material was half the needed width to accomplish the desired plate. Two 3" x 5" x 0.25" plates were welded together with the hopes of accomplishing the same purpose of mounting the hydraulic press as seen in Figure 20. The weld failed under pressure and required a quick adoption of the previous design. Material was purchased and the original design intent was carried out with success as seen in Figure 21.

The third deviation was the abandonment of the use of guide rods. After final assembly the guide rods were buckling under pressure forcing a material failure at the thread. It was determined after operation that guide rods were not necessary for a successful pressing operation.

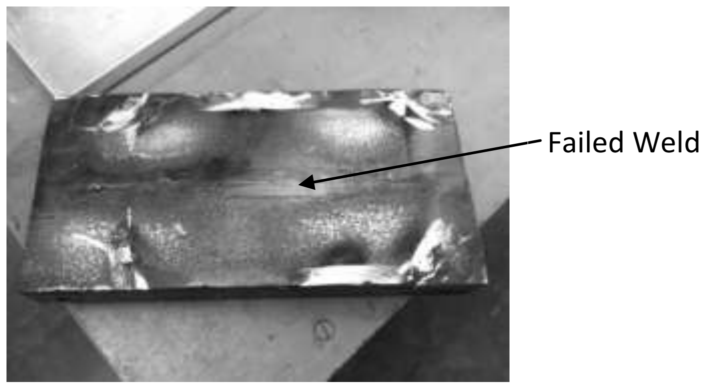

Figure 20. Deviated Press Mounting Plate with Bent Weld in Center

Figure 21. Successful Press Mounting Plate with Press Welded in Place

Manufacturing Methodology

The process chosen to manufacture the prototype skateboard was designed with the intent of emulating large scale manufacturers with the University's available equipment. The methodology was also designed to be able to support small lot production of skateboards. The process of producing one skateboard can be broken down into ten phases. The phases are:

1. Material selection
2. Material and epoxy resin prepping and laminate gluing
3. Pressing operation
4. Curing and removal
5. Locating and drill hardware holes
6. Rough cutting the contour
7. Shaping
8. Routing and rounding edges
9. Sanding
10. Dressing and Final Assembly

The material selection phase requires the operator to choose between five and seven different 0.058" Canadian Maple veneer sheets making sure to alternate grain patterns perpendicular between veneer faces. A longitudinal grain was chosen for the bottom veneer for aesthetic purposes, and then grain directions were alternated each layer. The number of veneers needed was determined by the adhesives used. Poly-Urethane glues, such as Gorilla Glue, required seven veneers in order to maintain strength under normal riding conditions. Fiberglass reinforced epoxy resin with carbon fiber sheets between the veneers only required five maple layers. Maple veneers with cracks and deformities should be discarded (Moss, 2007b).

Once the material and binding agents were selected, the prepping operation follows. The maple veneers were laid out in order from bottom to top. Once the veneer is laid out, the carbon fiber sheets are cut to size with a box cutter and laid beside each veneer to make ensure a proper layer sequence. Once these materials were laid out, the epoxy resin and hardener were mixed in a disposable cup according to manufacturer's recommendations. The epoxy resin was chosen for its strength and durability properties compared to polyurethane glue. A West Systems two-part epoxy was donated by a fellow student for prototyping purposes. Once the epoxy was activated the assembler has 25 minutes to coat the layers of veneer evenly and place the blank in the press. Figure 22 shows the epoxy resin and hardener prior to stirring in the demonstrated proportions that are one squirt of the resin to one squirt of the hardener.

Figure 22. Epoxy Resin and Hardener Prior to Stirring

The applicator for the epoxy was an inch oil paint brush as seen in Figure 23. After mixing the epoxy resin and hardener an even coat was spread over each side of the veneer until all surfaces are evenly coated on both sides. Once a surface is coated, the carbon fiber sheet was laid onto the wet surface and smoothed out using a spackle knife. Then the next veneer was coated and laid on top of the carbon fiber sheet.

Once this step was done, the next operation was loading the press. The stacked veneer laminate was squared until all four edges were flush around the stack. Sacrificial paper was placed on both sides of the blank stack in order to reduce scratching from the concrete mold surfaces. Paper was also placed under the press to catch any squeeze out from the pressing operation. Once loaded, the veneer was pressed until the press is fully engaged. This is indicated by a dramatic drop in tone and volume in the pneumatic cylinder on the press. The pneumatic cylinder runs at a high pitch that drops to a low and slow roar when maxed out. The maximum load condition is seen in Figure 24.

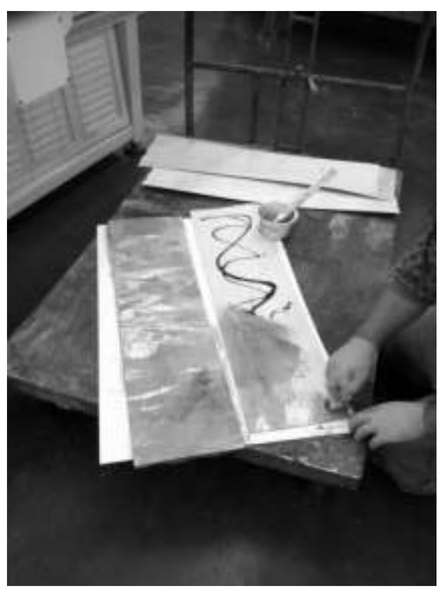

Figure 23. Epoxy Being Applied to Designated Veneers

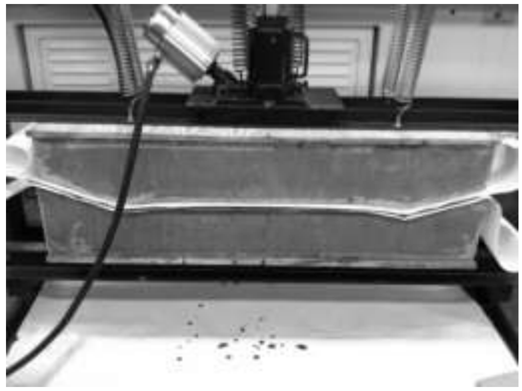

Figure 24. Veneer Laminate Blank Being Pressed

After the deck was loaded and pressed, it was left for 24 hours for the epoxy to cure. Once 24 hours had passed, the deck was unloaded and the paper removed from the deck surface. The deck was then left to cure in open air for another 24 hours before being shaped. The cured deck can be seen in Figure 25.

Once the deck was cured the master template deck blank was centered using a tape measure. The master deck was indicated in both the x and y coordinates, making sure to center the placement of the board tongues and board concave are mated accurately. The master template deck being centered is in Figures 26 and 27. The next step was using pressure clamps to stabilize the position of the master template deck relative to the blank deck. The deck was then drilled on the drill press using the master template deck's hardware mounting holes as a template. The drilling operation is shown in Figure 28.

Figure 25. Veneer Blank After Curing

Figure 26. Master Deck Being Mounted and Indicated on Blank Deck

Figure 27. Master Deck and Blank Deck Being Bound by Clamp

Figure 28. Drilling Operation Using Master Deck as Template

After drilling the holes in the master deck, the hardware from the master deck was used to keep the master template deck and blank deck together as seen in Figure 29. This prepared the blank deck for the rough cut. The band saw was used for this operation. The band block was adjusted to the height of the tongue in order to allow for clearance as seen in Figure 30. The rough shape was approximately 1/8” oversized. When the tongue enters the cutting area the deck was tilted down in order to reduce vibration. The rough sawn blank can be seen in Figures 31 and 32. The lip was checked post rough cut in order to determine if proper layering and epoxy penetration was completed. The visual inspection can be seen in Figure 33. The veneer should have perfect layering free of voids and cracking as determined by visual inspection.

Figure 29. Master Deck Mounted to the Blank Using Hardware

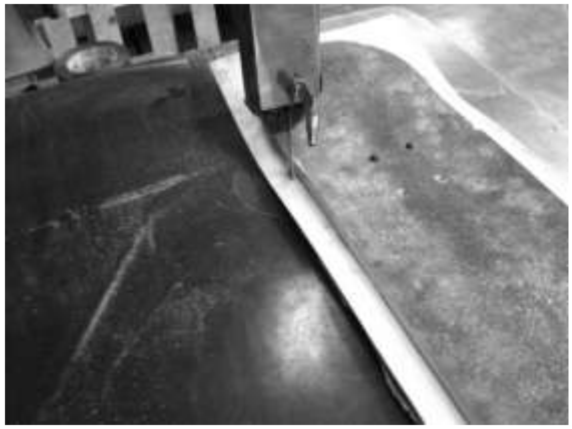

Figure 30. Deck Being Cut Out on Band Saw

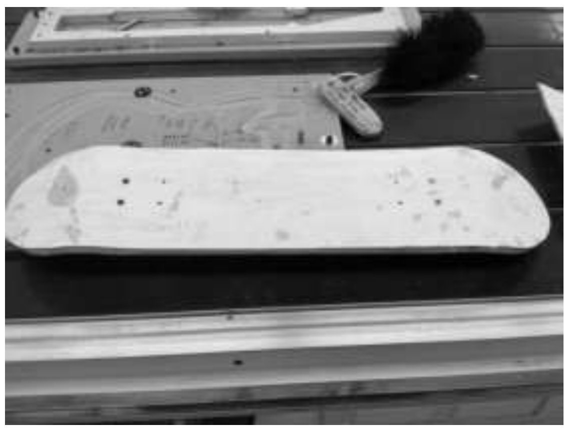

Figure 31. Deck Blank After Rough Cut

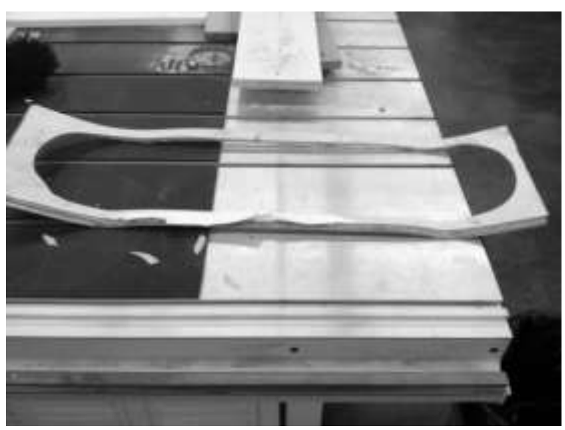

Figure 32. Deck Blank Scrap Post Rough Cut

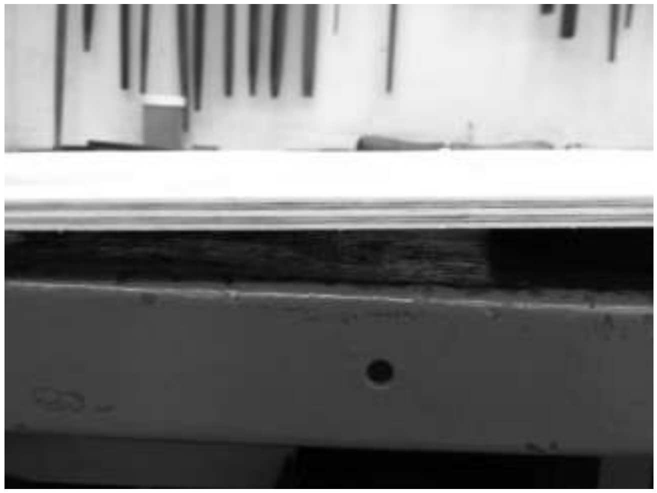

Figure 33. Inspection of Veneer Layering

After the rough cut operation the deck was ready for shaping. The shaping operation requires that the master deck was still bolted on as a guide. A router table with a ¼" DIA. flush router bit was used to shape the deck to final size. The router table and bit with top bearing guide are displayed in Figures 34 and 35. The rough cutting operation should not leave more than 1/8" material due to the possibility of bogging down the router. The routing started on the flat edge. As the tongue of the board approaches the router bit, the board was tilted to ensure the tongue remained parallel to the router bit axis.

Figure 34. Router Table Used to Shape Deck

Figure 35. 3/8” Flush Router Bit with Top Oriented Bearing Used for Shaping

The next operation was hand routing the round on the bottom and top lips of the deck. A hand rotary tool was used with a ¼” dia. round router bit to shape the board around the entire lip. The smaller routing space was used in order to better mount while routing around the curvature of the tongue. The Dremel router with multipurpose guide attachment used is displayed in Figure 36.

Figure 36. Dremel Tool Hand Router Configuration

Once the routing was completed, the deck was ready for sanding. The progression for sanding was 120 grit, 220 grit, and 400 grit sandpaper. The sanding was performed with an orbital hand sander. All surfaces were sanded until all surface nonconformities were removed. The edge rounds were also sanded in order to achieve an even rounding from top to bottom of the deck. The dressed completed deck is displayed in Figure 38. Grip tape was applied to the board and hardware was ready to be installed.

Figure 37. Completed Deck Prior to Dressing and Application of Grip Tape

Deck Testing on August 1st,2011

After contacting World Industries Skateboards, several technical specifications were gathered to determine deck quality and strength. The engineering representative explained that the majority of deck failures occur at the center and tongue regions of the deck. These failures are a result of direct loading while landing from an airborne state. The required load ratings for the deck to pass inspection are 3,200 lbs at the center, and 2,700 lbs at the tongue. The common testing tool used in industry is a beam deflection gauge loaded with a 2 x4 block that was six inches in length used to simulate a foot at the respective points. Failure was considered full material fracture at the respective test areas. Natural veneer separation was not considered because the deck will experience a natural separation of veneer from consistent use, and in a majority of cases will still be considered a usable deck. A beam deflection gauge was used because the deck is a beam that has variable support and points. The worst case loading scenarios that were chosen to determine deck quality were a direct load on the center of the deck, and a direct load on a single tongue of the deck.

ETSU's beam deflection gauge was used to test the board in the same conditions. A sample size of three decks was used in order to generate an accurate average of sustainable pressure. A larger sample of testing decks would have been ideal but was beyond the scope of this project. According to faculty, the beam deflection gauge was in calibration at time of use. Simple supports were placed over the hardware holes in order to simulate the placement of the trucks and wheels. The Neutral position with no load can be seen in Figure 38. Once loaded, a continuous load was place on the center of the deck until failure was reached. Once the center test point failed the deck was mounted on two simple supports and clamed using a C-clamp in order to hold the center down while pressing the center of the tongue. The three load results were recorded in Table 3.

Table 3. Deck Load Results from Beam Deflection Testing.

Deck #	Center Load Failure (LBS)	Tongue Load Failure (LBS)
1	5,200	3,700
2	5,000	3,500
3	5,200	3,600

The average center pressure rating was 5,133.33 lbs. The deck at the loaded position can be seen in Figure 40, and the deck made an audible crack at 3,000 pounds, which is seen in Figure 41. The audible crack was heard shortly before absolute failure occurred. The average tongue pressure rating is 3,600 lbs. The comparison of the thesis deck to the professional deck showed startling results. The center’s pressure rating was 60% above industry average. The tongue’s pressure rating was 33.4% above industry average. This can be attributed to the use of high quality epoxy and carbon fiber sheets over the entire surface of the center veneer layers.

Figure 38. Deck Mounted in The Beam Deflection Gauge Ready for Testing

Figure 39. Deck at 5,000 Pounds Experiencing 1-3/4” Deflection

Figure 40. Deck Tongue Rating Reading Nearly 3,000 Pounds Prior to Failure

Given the rating and construction, this skateboard deck can be considered a competitive design for commercial use. The use of durable materials and experimental use of carbon fiber produced a deck that was light, strong, and provided the necessary “pop” for a safe and exceptional riding experience.

The deck was also tested for voids using an ultrasonic thickness tester. The most likely points for voids lie around the outer edge of the deck and at the angular transitions. The acoustic velocity of maple had to be determined. To calibrate the thickness tester, the acoustic velocity of maple is 4110 meters per second (Schwarts, 2002). The nominal thickness of the deck is 0.370” with minus 0.074” tolerance. The 0.074” tolerance was used because that is the exact thickness of one veneer. The meter reading of the nominal reading is shown in Figure 41.

Figure 41. Ultrasonic Thickness Tester Reading at Nominal Thickness

Fifty readings were taken around the parameter of the deck and at the fold where the tongue meets the base of the deck. All points showed no signs of voids.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The skateboard press, material selection, and manufacturing methodology are still being refined. The first generation of prototype boards are completed and tested. Experimental use of various woods, such as bamboo and acetated wood, will be of profound interest. Templates will be made out of more durable materials such as aluminum and pickled oiled steel. Stronger considerations for design efficiency can be made as research and development continues.

The press design did not need guide rods; subsequent press system designs could use the uprights to guide the upper mold mount. Another point of redesign for molds should be made from high pressure hydraulic fluid resistant concrete. The current press cost $300.00 for materials with an additional $120.00 for assembly materials for the deck. The total project cost was $420.00. It is recommended, if this research is to be replicated in any way, that a budget minimum of $600.00 be used. A great deal of material was scavenged scrap metal, and the bottle jack was purchased at a heavily reduced price. The bottle jack was originally $129.00 at Harbor Freight tools, and was purchased on closeout for $59.99.

The opportunities for expansion into other board sports using this press are making it an ongoing personal project. The press will be used for skateboard decks, snowboard decks, snow skis, and luge decks. The press also has the capability to demonstrate to students that engineering and design technology is a more entertaining field than commonly perceived. It could be used as a means to attract high school students into the product development and engineering fields.

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APPENDIX: SUPPLAMENTAL FIGURES

Item Number	Document Number	Title	Quantity
1	PRESS_UPRIGHT_1	PRESS UPRIGHT	2
2	BOTTOM_DE_MOUNT_CROSS_BRACE	BOTTOM DE MOUNT CROSS BRACE	2
3	KICK_PLATE_BRACE_1	KICK PLATE BRACE	2
4	PRESS_GUIDE_ROD_1	PRESS_GUIDE_ROD	4
5	PRESSURE_PRESS_PLATE_1	PRESS PRESSURE PLATE	1
6	PURCHASED JACKSTAND	PURCHASED JACKSTAND	1
7	PRESS_LEG_1	PRESS LEG	2
8	TD_1	TOP DE	1
9	BD-1	BOTTOM DE	1
10	TPP	TOP PRESS PLATE	1
11	TOP_DE_GUIDE_MOUNT_1	TOP DE GUIDE MOUNT	2
12	20-4358	ACTION SPRING	4

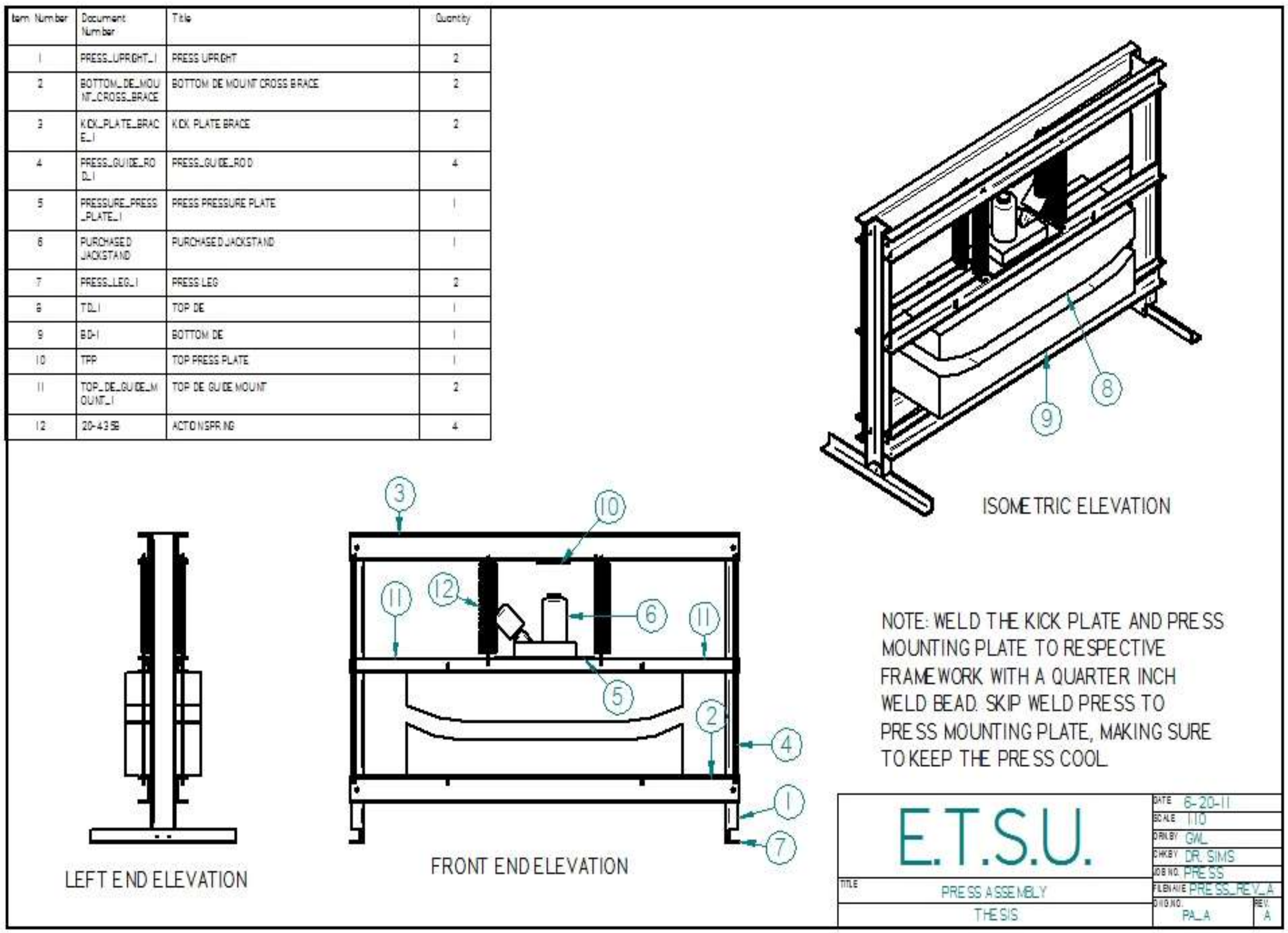

Figure 42. Press Assembly Drawing

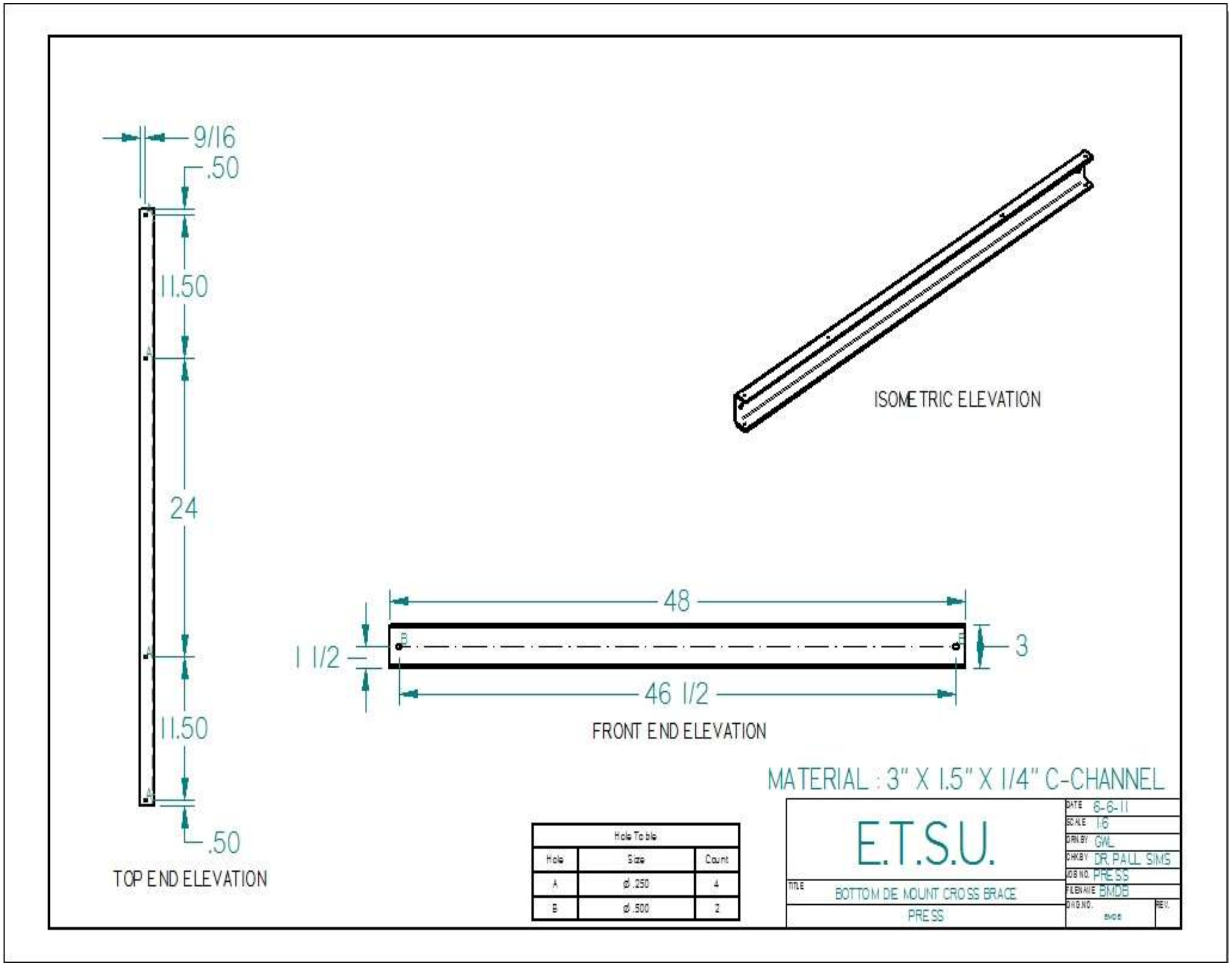

Figure 43. Bottom Die Mount Design

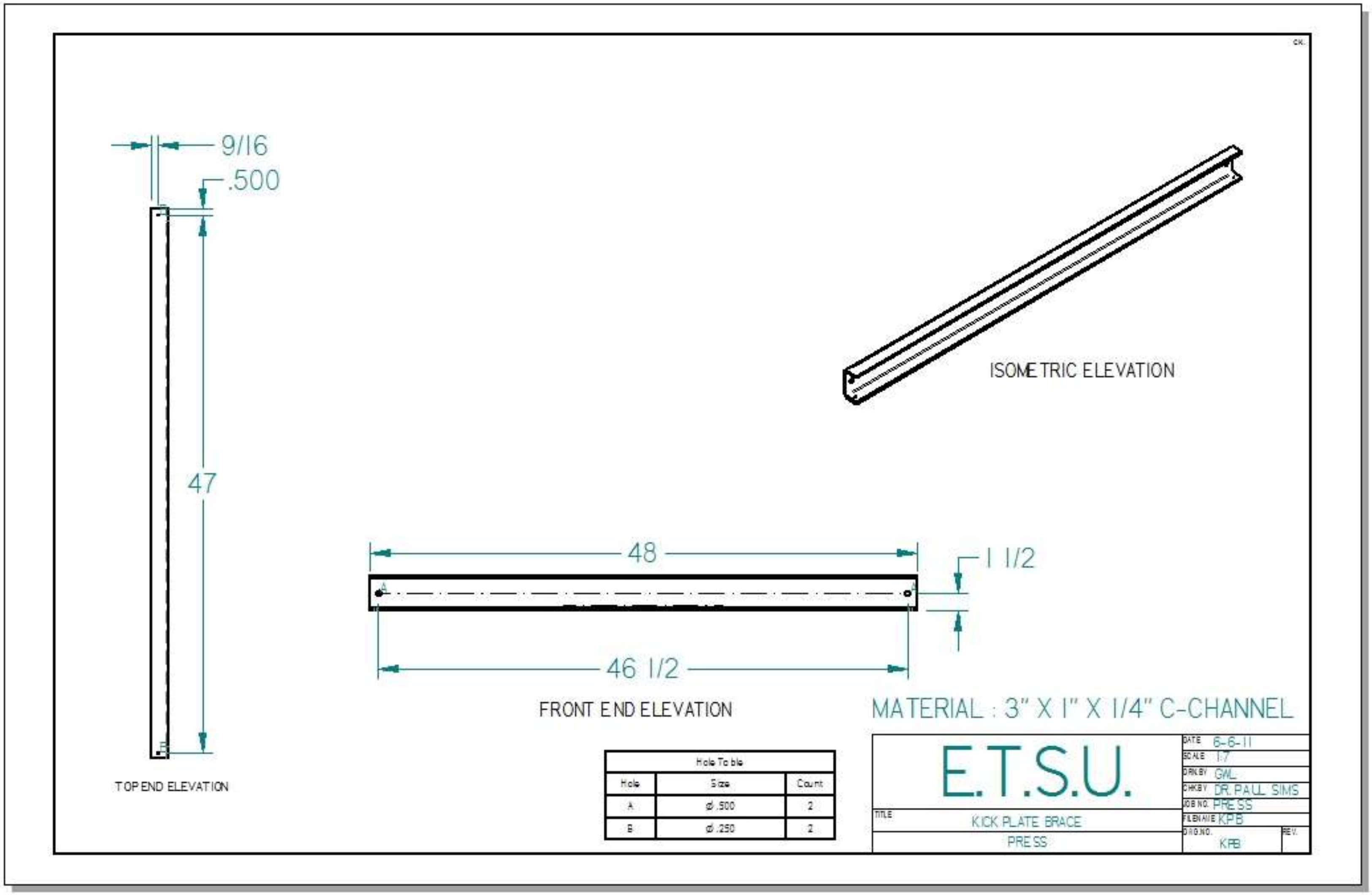

Figure 44. Original Kick Plate Brace Drawing

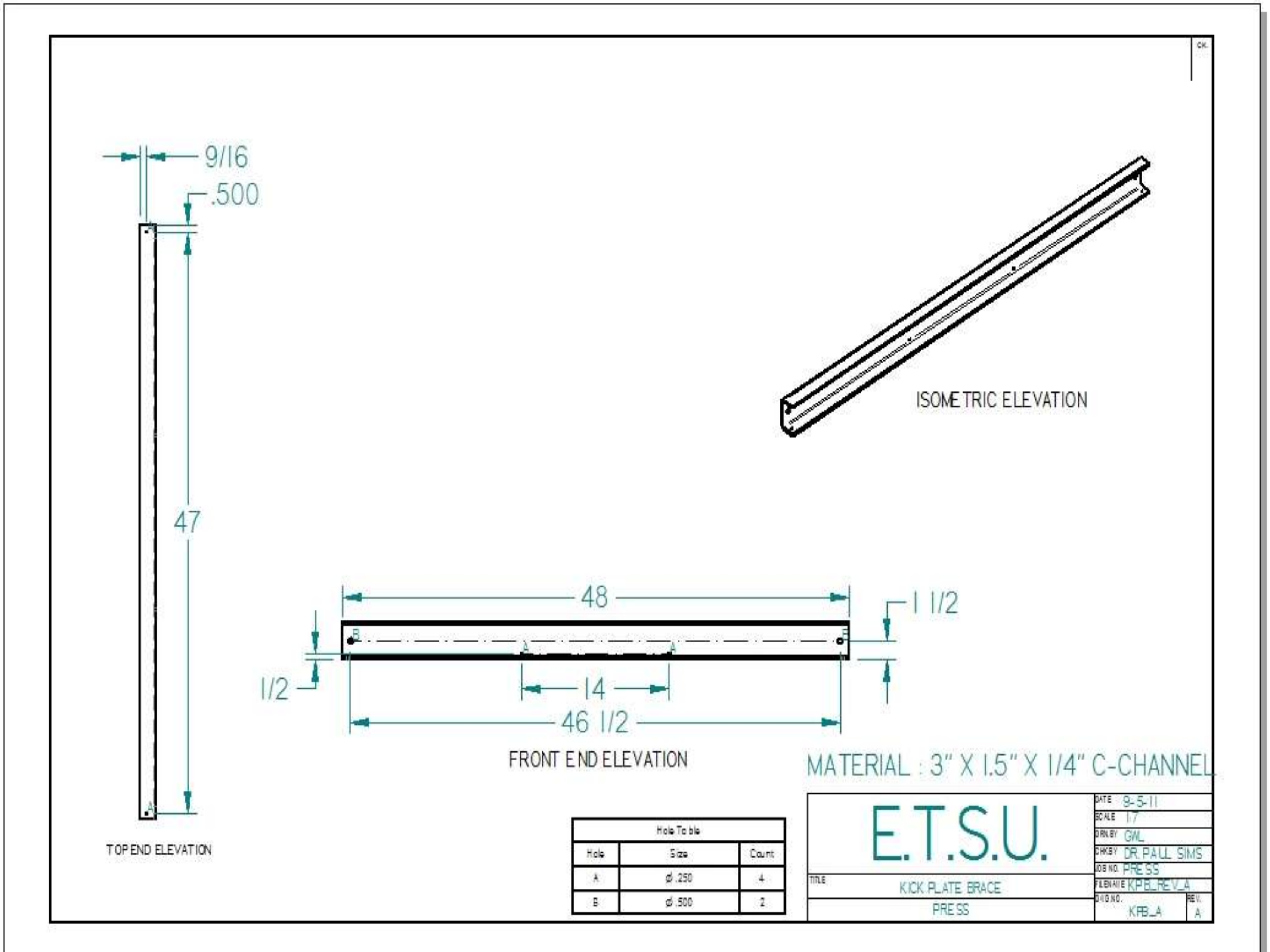

Figure 45. Revision of Kick Plate Brace Drawing

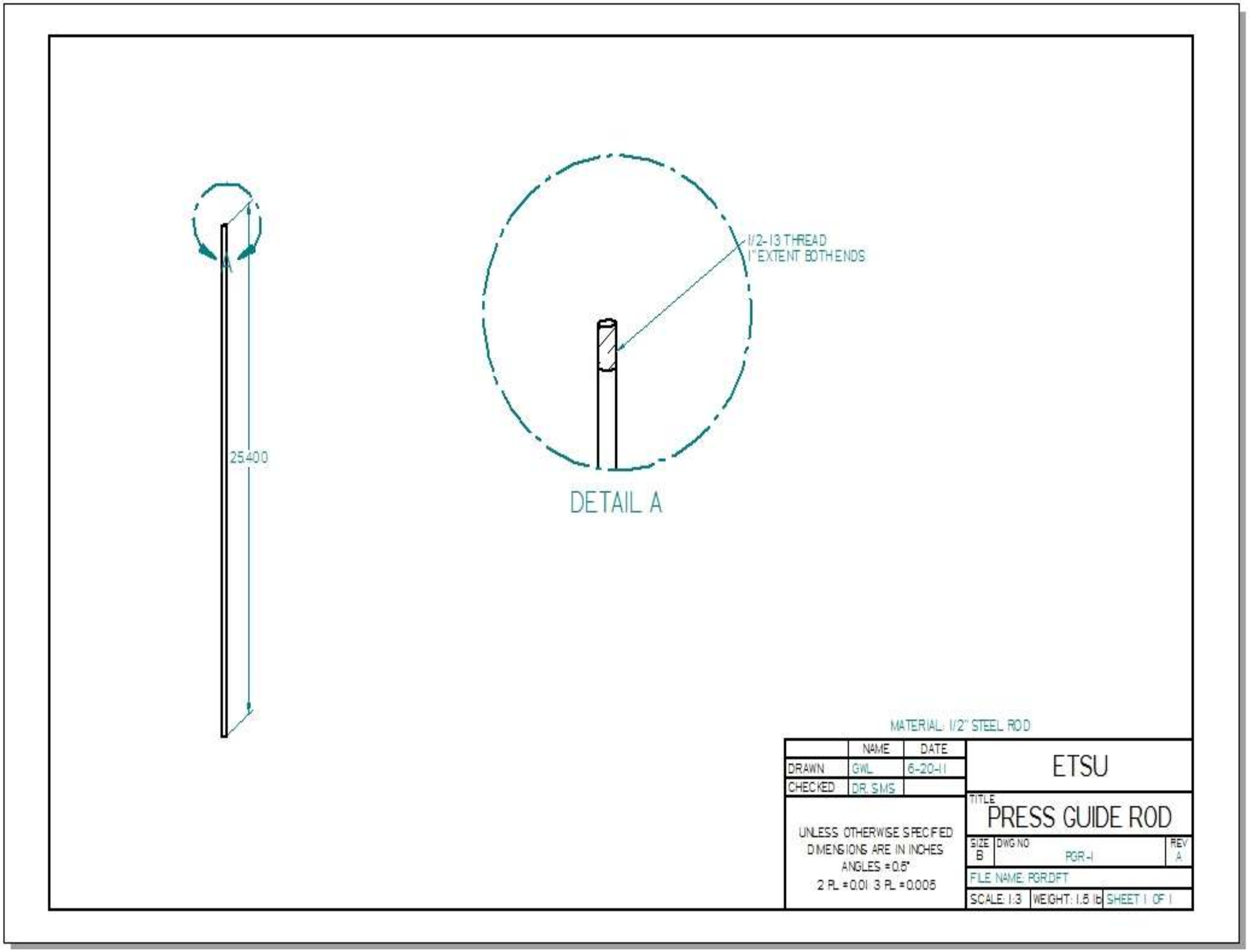

Figure 46. Press Guide Rod Drawing

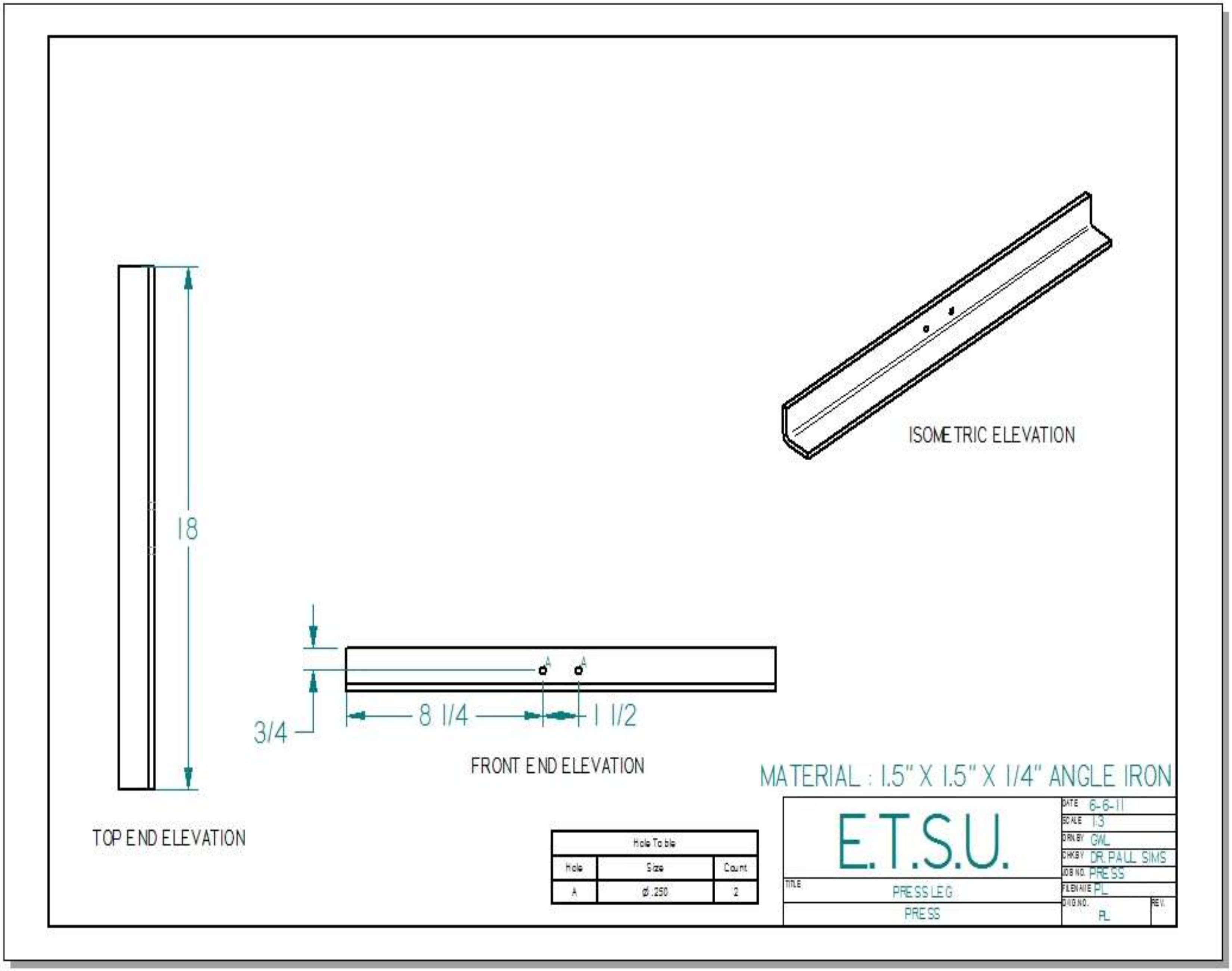

Figure 47. Press Leg Drawing

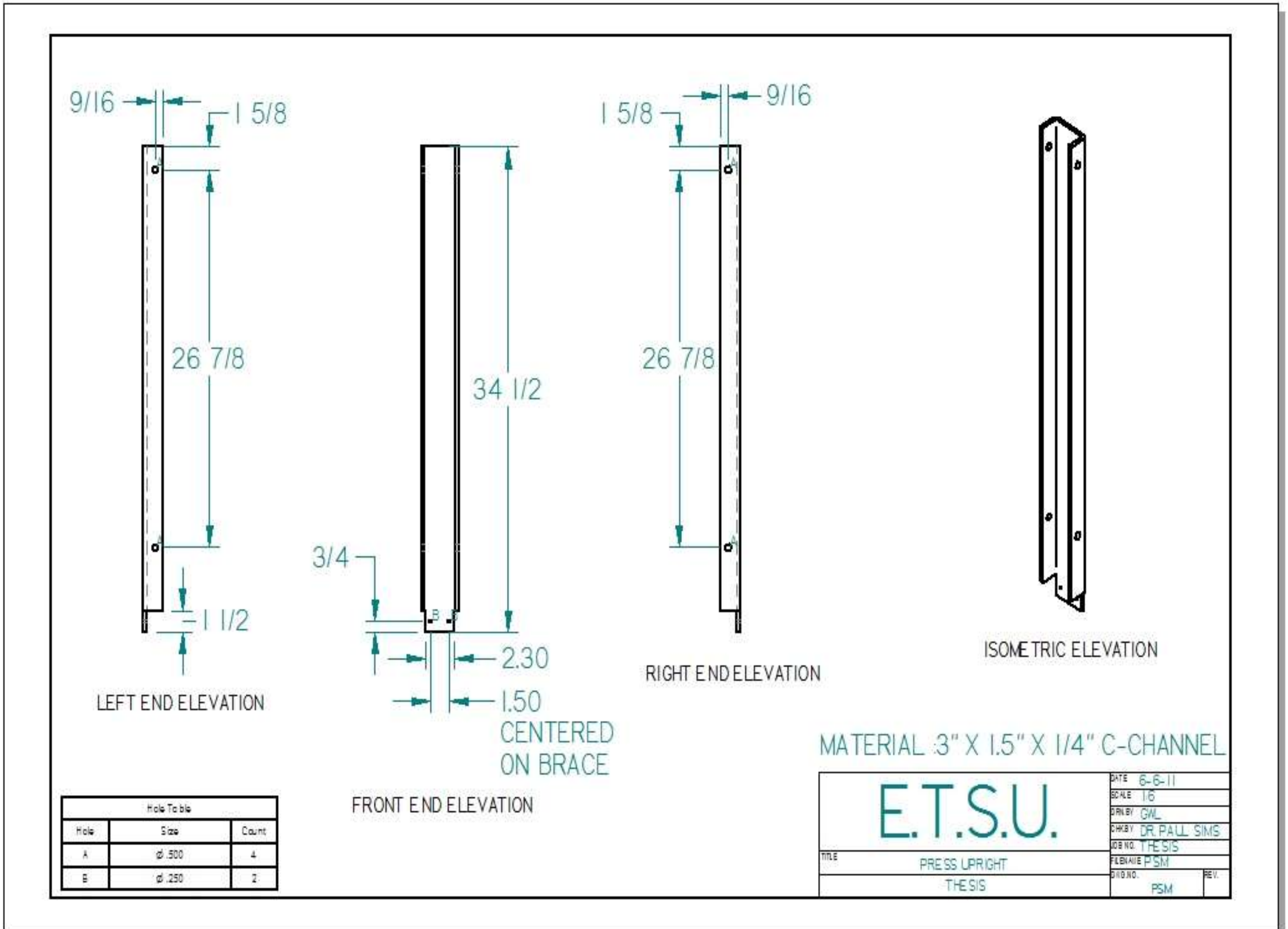

Figure 48. Press Upright Drawing

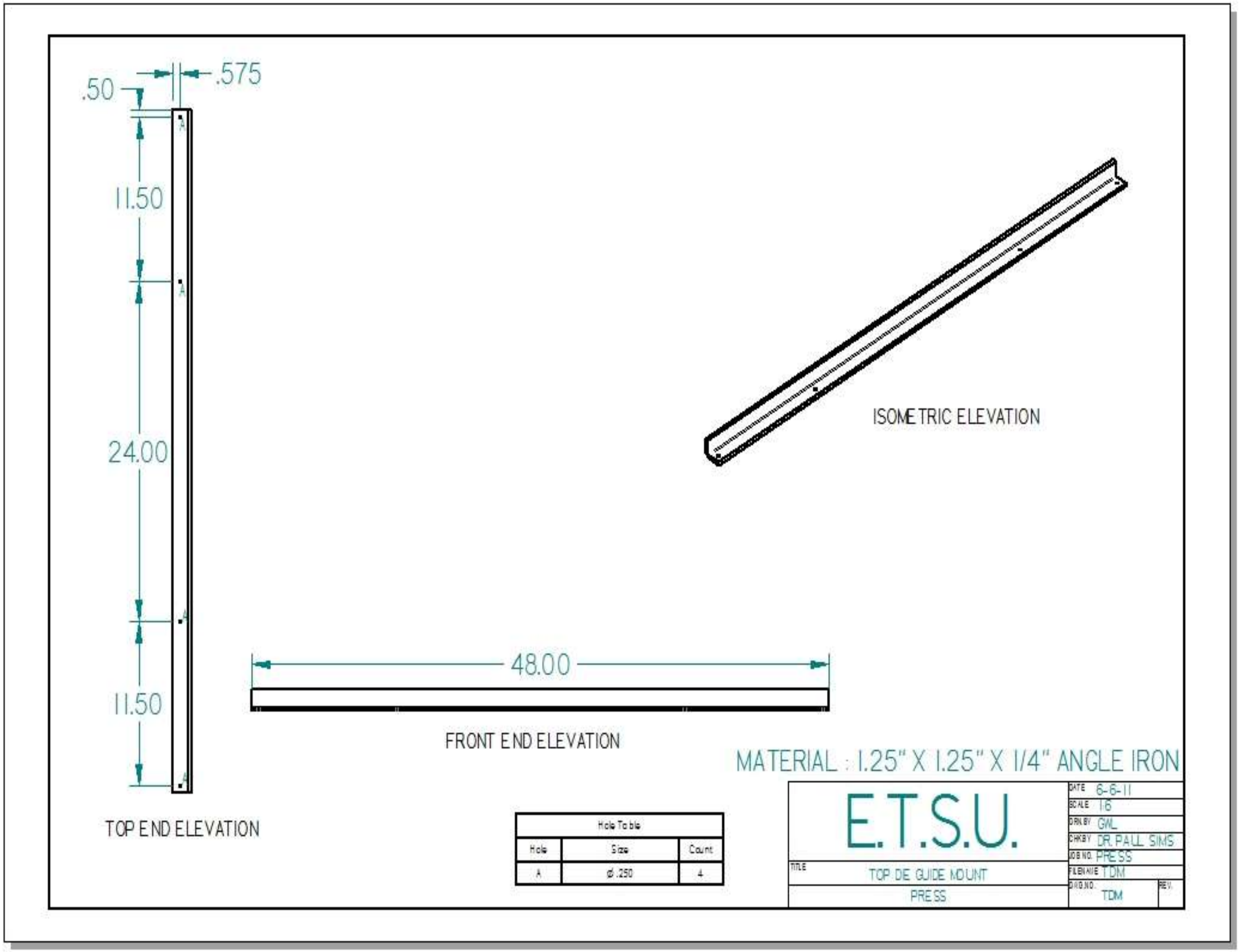

Figure 49. Top Die Mount Drawing.

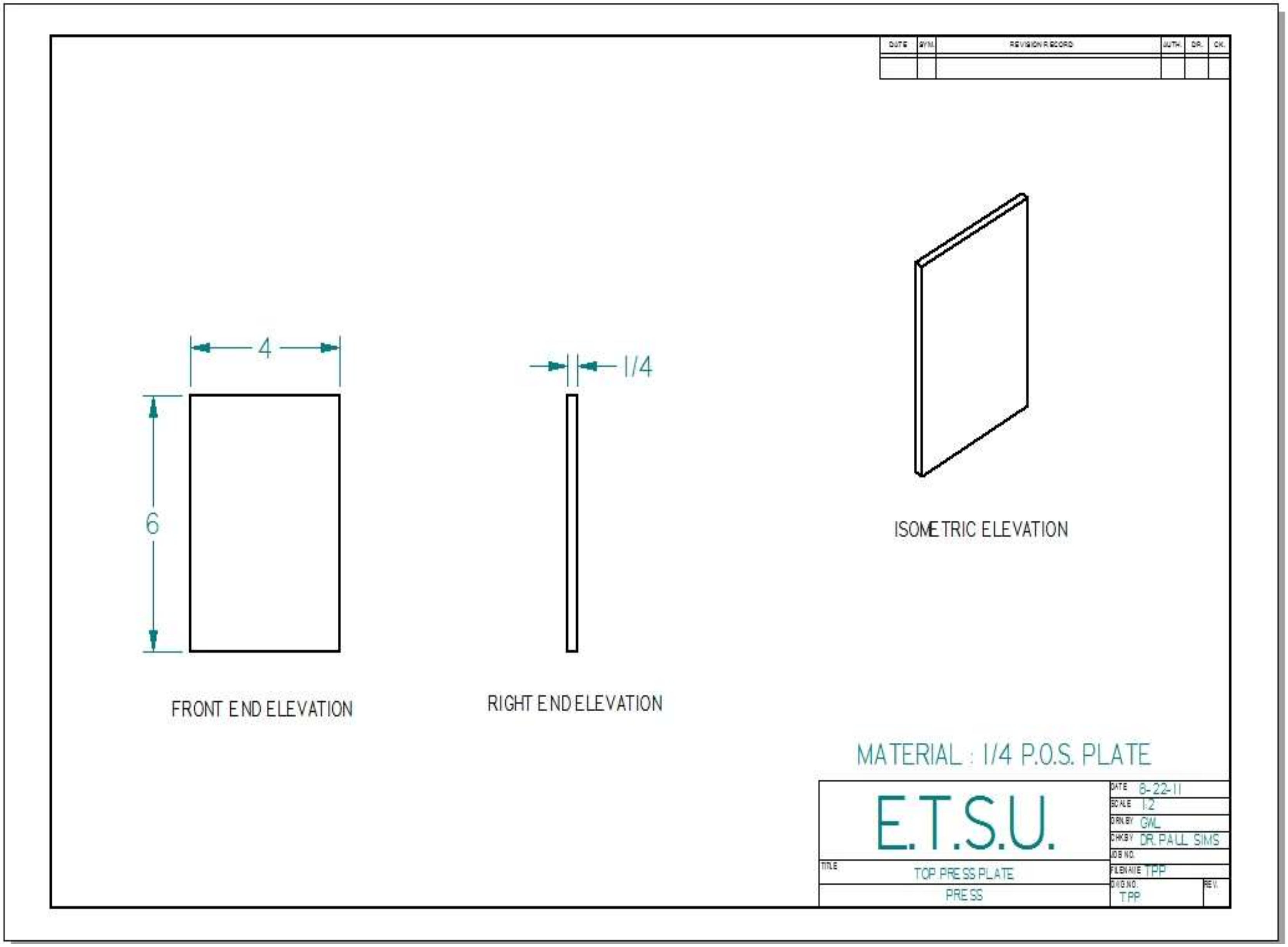

Figure 50. Top Pressure Plate Drawing

VITA

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