# BCAL Module Construction Procedures

(includes pictures)
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WRITTEN: JUNE 22, 2010 → VERSION 1 (PRODUCTION MODULES)

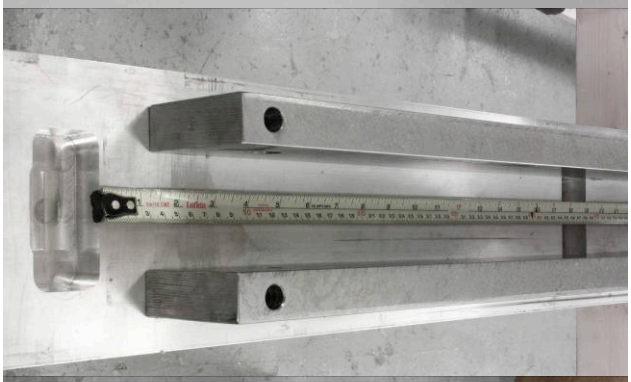
**Proper safety procedures, clothing, equipment, and materials must be used during the entire construction and all measuring equipment must be properly calibrated before use.**

## Preparing Base Plate

1. Clean the bottom of base plate with a water soluble degreaser followed by ethanol.

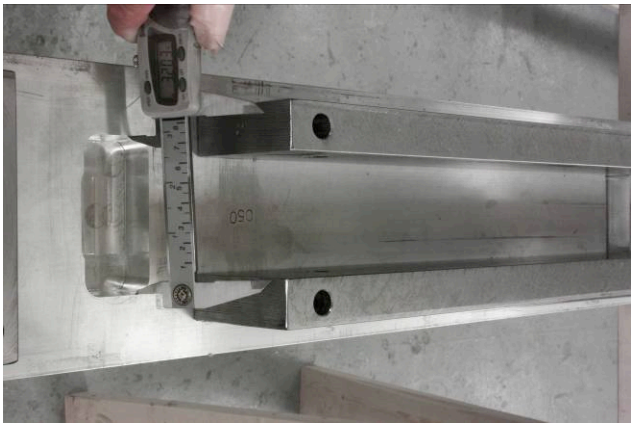
2. Check that the inserts (two sets of four) have been properly installed. Position is checked at Ross Machine Shop using the gauges that the UofR has provided.

3. Using a calibrated tape measure check the position of the bolt hole pockets, and report only out of specification measurements on the traveller for that specific base plate.



4. Measure the width of each bolt hole pocket with calibrated digital callipers at the top of the draft, and report only out of specification measurements on the traveller for that specific base plate.

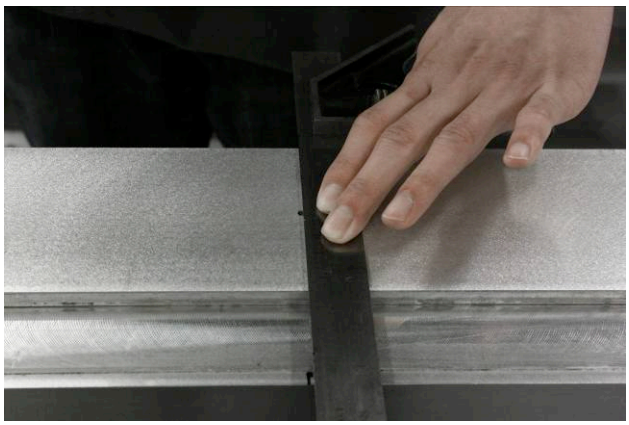
5. Measure the length of each bolt hole pocket with calibrated digital callipers at the top of the draft, and report only out of specification measurements on the traveller for that specific base plate.



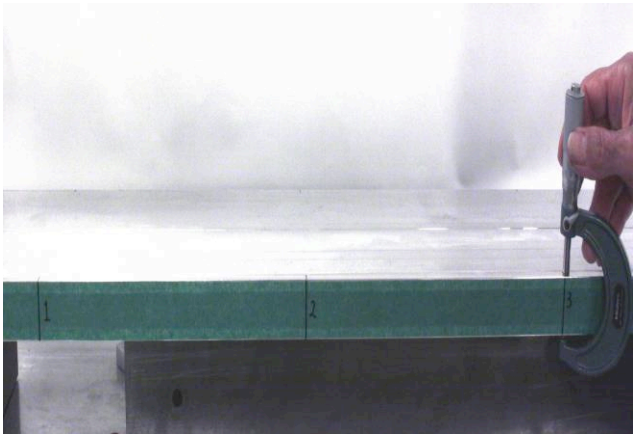
6. Measure the depth of each bolt hole pocket with calibrated digital depth gauge, and report only out of specification measurements on the traveller for that specific base plate.


7. Turn plate up-side-down and clean the top and side of plate.

8. Label 16 points on the side of the plate: Facing the machine side (front side), point 1 is on the left; stamp is near point 16. Either use the drill holes on a top plate as a guide, transferring them to the base plate as shown here or measure the position using tape measure. Center to center spacing is 10 inches. Point 8 and point 9 are centered on the length of the plate.

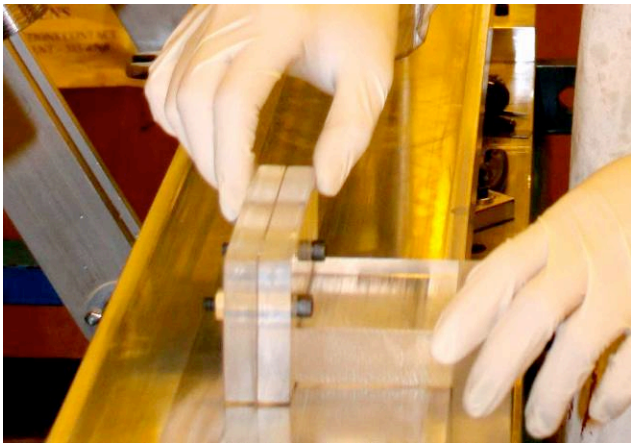


9. Measure and log the thickness of the plate at each of the 16 points. Two measurements on each side (front and back) are needed – from the bottom to the top of plate, and from the bottom of the plate to the top of recess. Enter all measurements into a digital spread sheet.



10. Using an orbital sander, abrade the top of the plate using 80 grit sand paper to improve epoxy bonding characteristics.

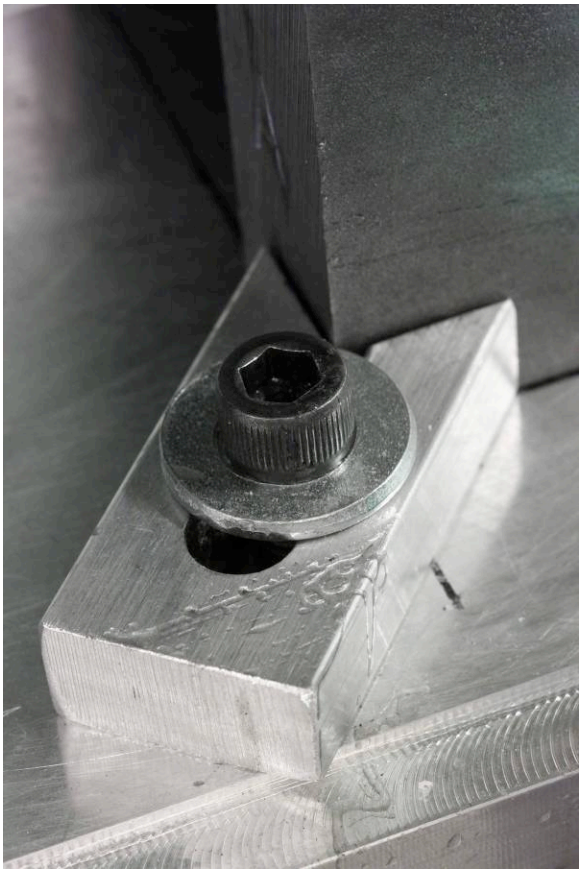
11. Using the groove cutting and cleaning tool rework the alignment groove if necessary to ensure the minimum depth is 0.024 inches. Ethanol may be used as a lublricant.



12. Set up alignment posts and wire, and set guides 0.5 mm above the top of the plate.

13. Move the base plate with rails attached on to the press, level, shim if necessary, center and align the groove parallel to the wire.

14. Fix base plate into place using four corner brackets pressed tight against the rails.



15. Clean the plate using appropriate solvents. Mask the side, ends and top recess of the plate using green masking tape. Transfer numbers onto tape.

**First Build**

- Layer 0 is glued to the base plate using industry epoxy, layers 1 and 2 using BC-600 optical epoxy.
- Two more layers are built on top of Layer 0 so that there is enough height for the epoxy to flow down. This minimizes the amount of epoxy that goes on top of the lead sheet.

1. Measure and dispense only in separate cups, Araldite 2011 industry 100 g epoxy resin and 80 g hardener and cover cups with plastic wrap. Do Not Mix.
2. Measure and dispense only in separate cups, 150 g Bicron BC-600 Optical Epoxy Resin and 42g hardener, only in separate cups, cover cups with plastic wrap. Do Not Mix.

3. Sort two bundles of 95 fibres each.
4. Take off the guide wire. Place a fibre to act as a guide, in the groove of the abraded and pre-cleaned base plate.

5. Note the length of a clean rolled up 13cm sheet of swaged lead. Set its end where the unrolled length will be centered on the length of the base plate. Align and place, setting the center most groove of the lead sheet onto the fibre in the base plate. Slowly unroll the lead carefully following the fibre under it, making sure the fibre remains in the groove.

6. Set up the guide wire. Use the polyethylene runner to check that the lead sheet is straight. If necessary, "massage" the lead sheet back and forth gently to straighten, align and ensure it is parallel with the guide wire and guide fibre. Feel the top of the lead sheet to confirm that the fibre is still in the base plate groove. If not, roll up the lead and repeat step 5.
7. Roll up about ¾ of the lead sheet from one end on a core. The other ¼ of the lead sheet should remain on the base plate to ensure the position and alignment remains unchanged.
8. Mix the industry epoxy resin and hardener together.
9. Mix the optical epoxy resin and hardener together.
10. Using a 18 pitch hacksaw blade as a notched trowel, spread the industry epoxy evenly on the base plate keeping the epoxy a minimum of 3 mm away from the fibre to avoid forming a high spot in the center, caused by epoxy getting squeezed and trapped under the guide fibre.
11. Unroll the lead sheet onto the epoxy again using the fibre as a guide.
12. From the opposite end roll up about ¼ of the lead sheet until the epoxy is exposed making sure that the epoxy doesn't contact the top of the rolled up lead.
13. Use the saw blade to spread the industry epoxy evenly on the remaining surface of the base plate.
14. Unroll the remaining lead sheet following the guide fibre.
15. Set up the guide wire to check that the lead sheet is straight and parallel to it.
16. Inspect the top of the lead using your fingers to ensure the guide fibre is set in the base plate groove.

**NOTE: If conditions in steps 15 or 16 can not be satisfied, DO NOT CONTINUE to step 17;** the lead must be repositioned or removed and the process started over.

17. Build two layers of 13-cm lead sheets and optical fibres in all grooves using optical epoxy, inspect each for alignment and press.

**Preparing Fibres**

1. Make sure the copper-covered fibre table is grounded.
2. Take a box of fibres from the crate onto the fibre table.
3. Open the box at one end. There are two large bags of fibres in each box. One person holds the bags and keeps the fibres on the table, while another person pulls the box out.
4. Cut the end of the large bags. There are 12 small bags of fibres in each large bag. One person holds the small bags, while another person pulls the large bag out.
5. Cut one end of the small bag. Be careful not to damage the fibres. Also cut a small portion of the side of the bag. This will allow a person to hold on to the fibres. Another person will pull the bag out.

6. Separate the fibres into bundles. The number of fibres in each bundle will depends on the width of the lead sheet to be used in the construction:
   - 13cm – 96-97 fibres
   - 12cm – 88 -89 fibres
   - 11cm – 80-81 fibres
   - 10cm – 73-74 fibres
7. Line up all the fibres in the same bundle.

**Preparing Epoxy**

1. Check and recalibrate the weighing scale if necessary using the 100g weight.
2. Cover the scale with plastic wrap.
3. Put a plastic cup on the scale. Zero (tare) the scale.
4. Measure the resin and hardener separately in clean new 10 ml. plastic cups.
5. The ratios are as follows:

| | |
|---|---|
| Bicron Optical Epoxy: | 100.0g resin<br>28.0g hardener |
| Arldtite 2011 Industry Epoxy: | 100.0g resin<br>80.0g hardener |

6. **Do not mix** the epoxy until it is ready to be used. Cover the resin and hardener with plastic wrap until such time.
7. When the epoxy is ready to be used, add the hardener to the resin. Stir and fold with a mixing stick for one minute in the original cup and then transfer mixed contents to the center of a clean new cup and continuing mixing for a total minimum time of 4 minutes.

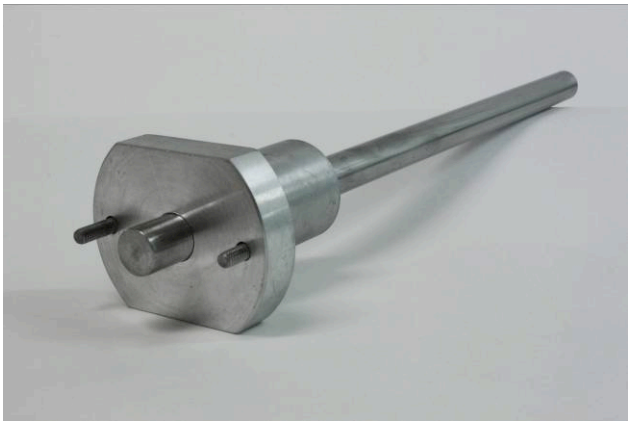
**Setting up the post and guide wire**

1. Ensure that the aluminum plates that the posts sit on are clean and flat. If you are unsure contact the Construction Manager before proceeding.

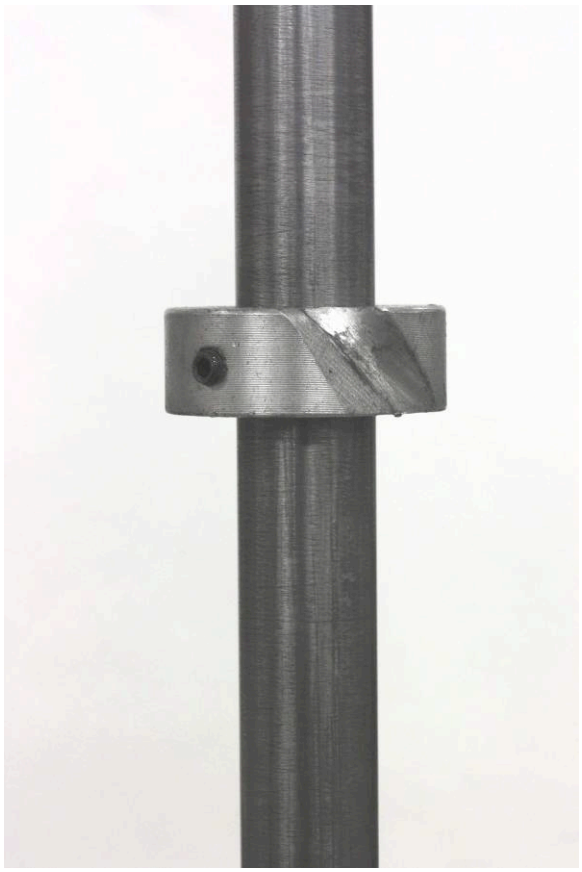
2. Using the Lufkin #59 level placed on the above plates check that both ends of the press are level within three divisions of level, if more than three divisions contact the Construction Manager to re-level the press before proceeding.


3. Brush off any particles and any high points underneath the post. Repeat Step #1.

4. Install the posts at each end of the press. There is a number stamped on each post on the blue press (Press 1) and letters on the red press (Press 2). Make sure that the stamp on each post matches the one on the press. Tighten the screws evenly with an Allen wrench.



5. Put the aluminum alignment wire guide on Post # 1 (or Post D for Press 2). Adjust the height so that the top of the guide is about 1mm above the module. Tighten the set screw lightly to lock the position.

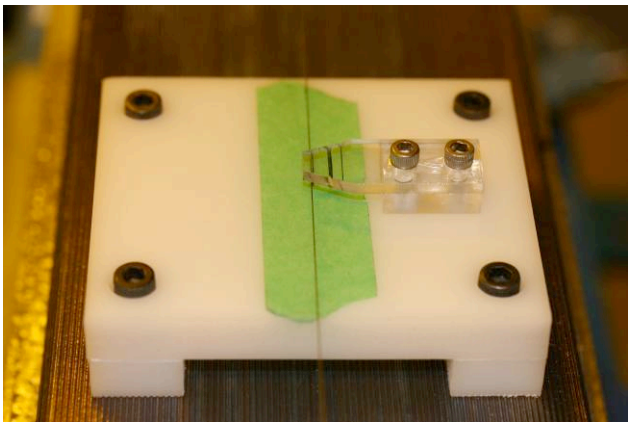


6. When not in use put the wire on the plastic drums at the top of the press.

7. Wrap the wire around the pole so that the wire is on the side along the center line.

8. Put the other end of the wire on top of the aluminum guide and wrap around the post. Attach a weight to pull the wire taunt and straight.

9. The alignment of the grooved lead sheets can be checked by setting the alignment wire height 1 mm above the cart and then running the polyethylene runner along the grooves on top of the module from one end to the other while viewing directly from above. The mark on the cart stays aligned with the wire if the module is straight.



**Construction**

*Preparation*

While two crew members are preparing for the constructions with the following steps, the other two should prepare fibres and optical epoxy.

1. Open the press and clean up the top of the BCAL module. Using custom built re-grooving and groove grooming tools remove any epoxy that might have migrated into the grooves on the sides and ends of the module.
2. Remove the tape on the top sides of the base plate recess. Measure and log the height of the module at each of both the front and back positions of the 16 labelled points. These points correspond to the 16 #8-32 holes spaced at 10.0 in. centers on the top aluminum plate.
3. Enter the data into an electronic spreadsheet.
4. Tape the top sides of the recesses of the base plate to prevent epoxy running onto it.
5. From the schematics and the height data, determine the appropriate width of lead sheet to be used.
6. Set up the posts and wire. The wire represents the center of the module. Use either a calliper or gauge plates with appropriate width to outline where the lead should be positioned.

*Build Process*

Once the preparation is done, mix the optical epoxy. Write the time when the epoxy is first mixed in the log book. Pour a small sample of the mixed epoxy into a clean up as a reference for epoxy viscosity. Within two hours after the epoxy is first mixed, build up alternate layers of optical fibres and lead on the BCAL module. The procedures for building one layer are as follows.

1. Two people paint optical epoxy evenly on the top lead layer of the module.
2. One person with clean gloves (no epoxy) should lift one end of a bundle of fibres from the grounded copper covered fibre sorting table so that another person can hold the fibres

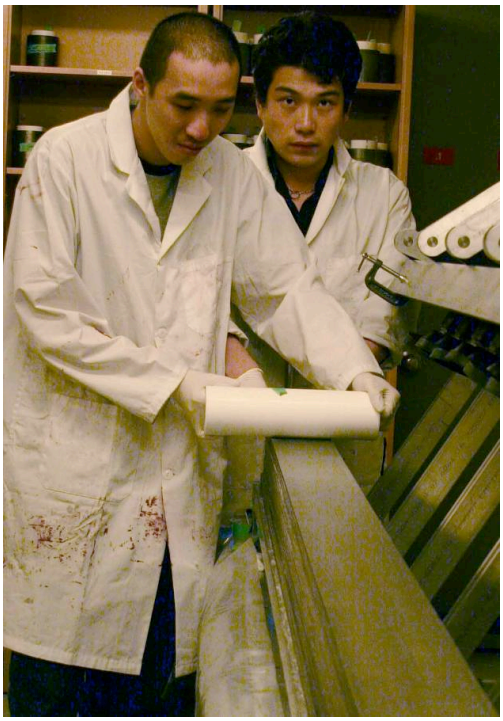
from that end. Repeat this at the middle of the bundle and at the other end. Three people carry the fibres to the module.

3. Line up the fibres on the top lead sheet so that they extend evenly past both ends.

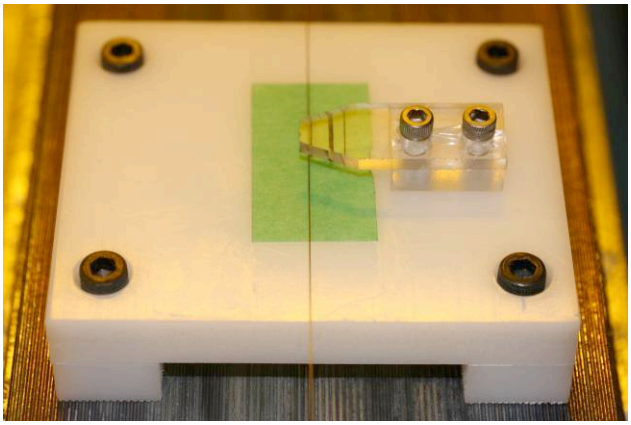
4. Placing the fibres into the grooves: One person rolls and massages the fibres into the grooves at the middle of the lead sheet while two people using their fingers comb, untangle and slide the fibres into the proper grooves along the rest of the length of the lead sheet to the ends. At this point all fibres should be seated in their grooves and be parallel to each other.

5. If additional fibres are needed, the person with clean gloves will count and lift them for the other three people. If there are too many fibres in the bundle which has been in contact with the epoxy, place the extra fibres on a piece of clean poly and use them for next layers. Once all fibres are seated and the quantity is known, record the batch number of the fibres and number of fibres used for that layer in the log book.
6. Slide fingers gently over the top of the fibres to feel for irregularities in fibre height. Irregularities may be caused by particles underneath the fibres, or there may be irregularity on the lead sheet. Use a toothpick to remove any particles underneath the fibres. If the grooves of the lead sheet are deformed or if you are unable to seat the fibres properly in the grooves, inform the Construction Manager before proceeding.
7. Two people paint a thin coat optical epoxy evenly on the fibres, cross checking each other's work.
8. One person centers, on the fibres, and unrolls a lead sheet of appropriate width on the module slowly. (Alternating Type 1 and Type 2.) Another person "massages" the lead back and forth gently to ensure the grooves lock onto the fibres.

9. With one person holding the lead sheet from moving another rolls the lead sheet flat using a Teflon roller, first cleaned using ethanol.



*Alignment*



To ensure that the placement of the lead sheet is correct install the wire on the posts and guides and use a weight at one end to pull the wire taught. Using the polyethylene runner, check that the lead sheet is straight and aligned with the wire. If not, roll up the lead sheet on a core (spool) and reseat the fibres, if it is on the last layer of the day and has epoxy on the top side of the lead sheet, discard it and re-apply a coat of epoxy and use a clean lead sheet. All discarded lead sheets must be documented in the log book. When checking for straightness of the build put the brass wire guide on the appropriate post, Post 2 for Press 1 (Post C for Press 2). Adjust the height so that it is about 1mm above the runner. Lightly tighten the set screw to lock the position. Position the aluminum guide at the same level on the opposite side.

Note: the guide wire is made using 11gr musical wire fastened to this guide with a loop tied at the other end for weighting purposes. If substantial kinks develop in the wire it be must be changed.

*Last Layer of the Day*

- Change to clean gloves with no epoxy on them. Clean the Teflon roller and traveling cart using ethanol.

- Use a lead sheet that is 1cm wider and approximately 6 cm. longer than other layers you built that day. (If you are building 13cm, use 13cm for the last layer since there is no 14cm lead.)
- Lift the PVC core slightly while unrolling the lead sheet. If there is any fibre not in the groove, the person "massaging" the lead sheet will feel it more easily.

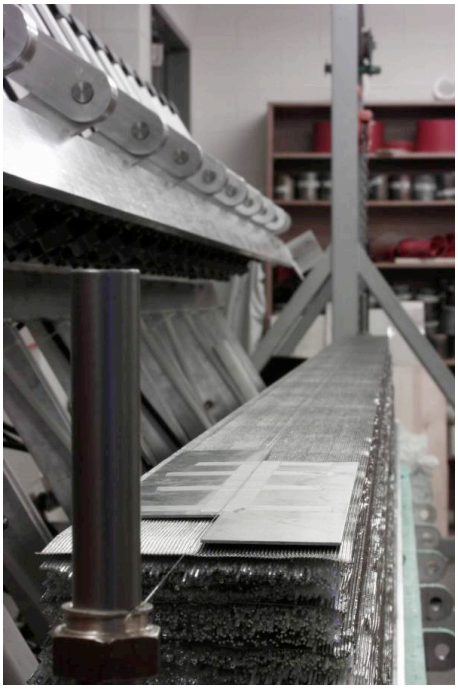
**Last Build of Each Step**

1. Reference drawing Stepwedge.pdf (posted on the bulletin board) to determine the minimum height needed to complete the step.

2. Using a digital depth gauge measure the height of the build from the top of lead sheet to the top of base plate step at positions 1-16, both at the front and back edge. Enter the data into a spread sheet which will automatically add the thickness of the base plate that was measured at each of the 32 points. The sum of the two will equate to the distance from top of the lead to the bottom of base plate.

3. Use the point where the smallest total distance was measured to determine the number of layers needed at that point to finish to the minimum required height for each step.

4. After a build is pressed and cured, use the guide wire and alignment templates to center the next build.

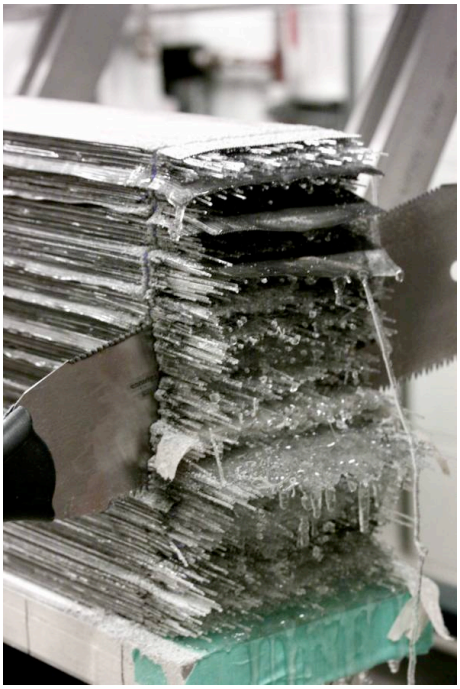


5. The total fibre/ lead height should be as close as possible to 253.7 mm, but should never exceed 254.0mm measured from bottom base plate to top of lead sheet.

6. If the lead sheet is above 253.7 mm it must be shaved off using a custom made guide and joiner plane with a sharp blade set to the correct depth.

## Top  Aluminum Plate Installation

***Preparing the Module and Plate***



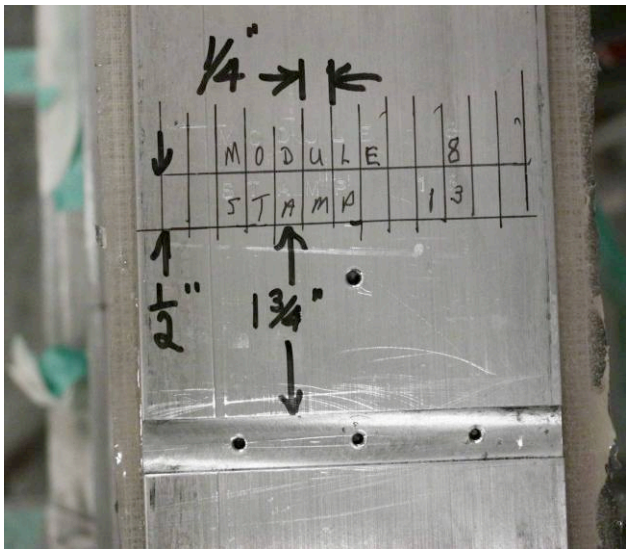
1. Trim off both ends of the cured module using a pull saw.

2. Clean all surfaces of the top aluminum plate using water based industrial cleaner followed with ethanol.

3. Abrade the inside surface of the top plate using an orbital sander with 80 grit sandpaper as done with the base plate.

4. Clean abraded surface with ethanol.

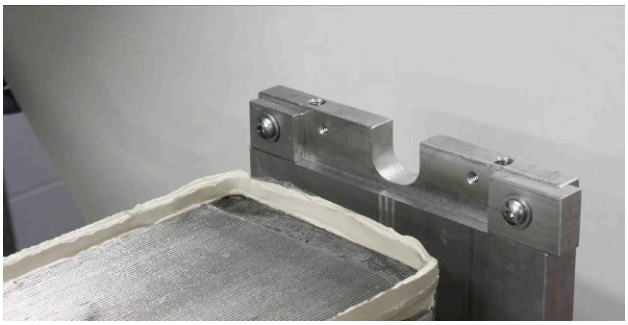
5. With the machined front sides facing you stamp the top right hand side of the plate.




*Setting the Top Plate into Position*

1. Measure only and place 300g of industrial epoxy resin and 240g of hardener in separate cups. Measure and place two of each, 100g of industrial epoxy resin and 80g of hardener in separate cups. Do Not Mix.

2. Wrap 1 layer yellow sealant tape around the top of the top of the module. It is important that the top edge is slightly below the top of the lead layer even when it is compressed from the side.

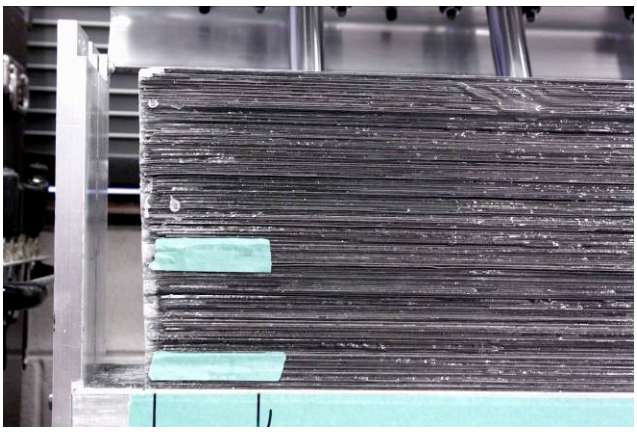


3. Remove the paper from the previous tape and wrap another layer of tape on top of it leaving the top edge forming a dam 2 mm above anticipated glue height.

4. Wrap two layers of packing around the sealant tape to support it.

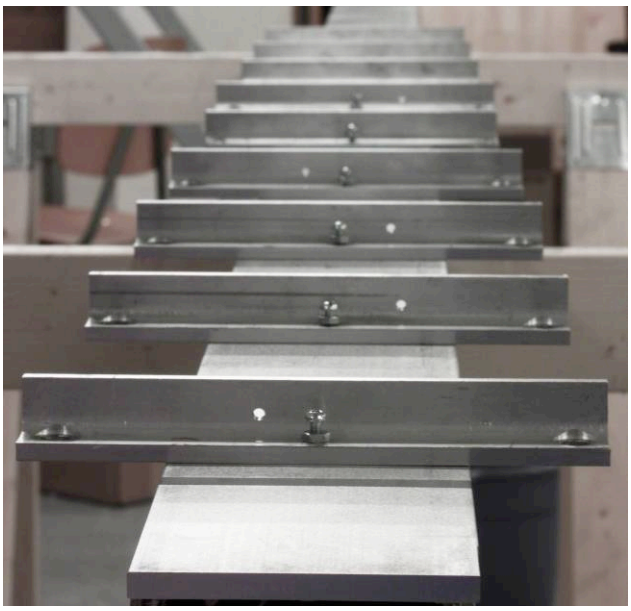
5. Cut the corners of the tape to allow the top plate to fit inside.

6. Bolt the alignment/height plates at both ends of the base plate using two - 5/16 socket head cap screws and washers with the fixed top plate stop facing the front of the module. The front edge should be flush with the front edge of the base plate and the bottom step should be pulled down tight to the top of the base plate, using the three bottom screws on the bottom clamp.



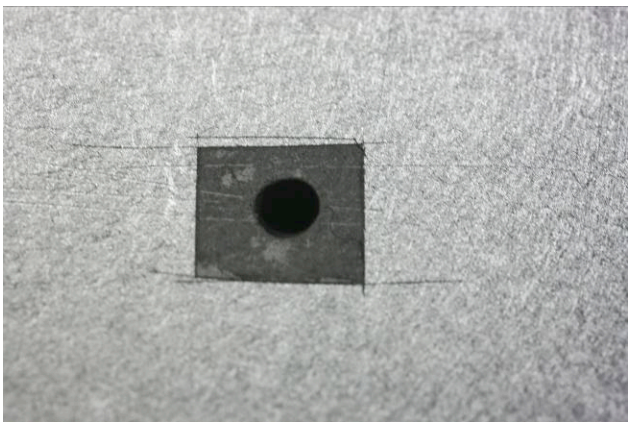
7. Set up the 16 stand-offs along the back side of the base plate.

8. Screw the 16 angle brackets facing up, on top plate using #8-32 screws.



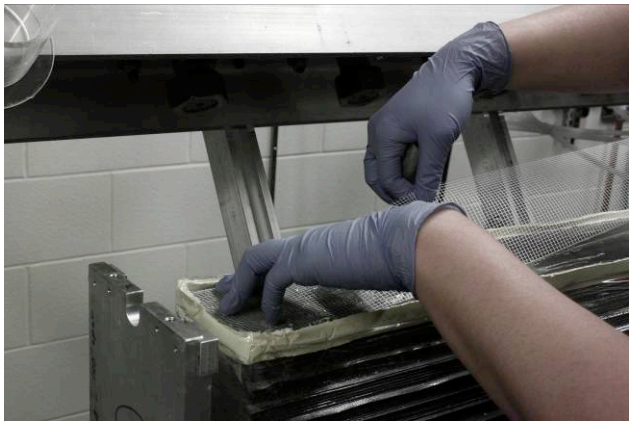
9. Move the top plate with brackets attached to the solvent room, abraded side up, don appropriate safety clothing and equipment and degrease abraded surface with degreasing solvents. Leave the plate in the room for minimum 5 minutes.

10. Tape all holes on the abraded side of the plate using 2 layers of transparent tape approx. 8mm sq. being careful not to touch the cleaned surface any more than necessary.



11. Mix up the 300g batch of industrial epoxy and coat the top surface of the module.

12. Referencing the last build total measurement chart lay in 4” wide (or 2” if necessary) fibreglass tape to bring up to a level 0.5 mm under 253.7 mm.

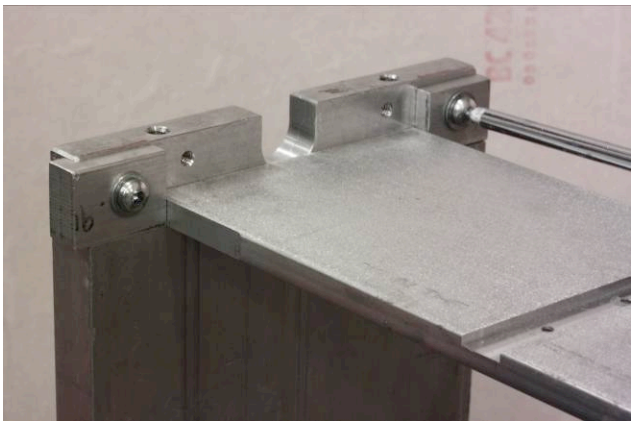


13. Fill the dam level to about 254.7with mixed epoxy, more of the measured epoxy may be needed, but mix only as needed.

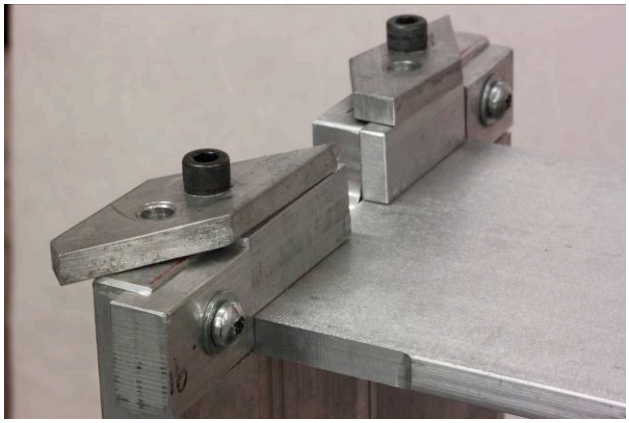
14. Set up the 16 stand-offs at the front of the base plate.

15. Install the cleaned and degreased top plate with angle brackets installed making sure that the top plate doesn’t contact the sealant tape.

16. Press the adjustable top edge clamps forcing the top plate machined front edge against the fixed stops at both ends and fix in place by tightening screws. Fixed stop is on the left side.
    i. Note: In this and the following diagram the module is removed for clarity.



17. Clamp both ends of the top plate down to the alignment plate using spacer blocks. Excess epoxy should squeeze out.



18. Attach the 16 brackets to the stand-offs using 3/8” socket head machine screws.

19. Adjust all screws and nuts to fix the top plate at the proper height. Excess epoxy should squeeze out.
20. Continue to adjust all screws and nuts as epoxy squeezes out.
21. As the epoxy squeezes out pressure is released so check and readjust all screws at least four times before leaving.
22. Let epoxy cure overnight.
23. Remove brackets, stand-offs and alignment plates.
24. Remove sealant tape and excess cured epoxy.
25. Scrape top and sand using orbital sander.
26. Debur all holes.
27. Trim off ends of top plate and paint module ends with two coats of black chalkboard paint.
28. Undo clamps, hoist module into crate using the A-frame hoist, and fasten into place.
29. Place cover on crate and screw down with four wood screws, mark the position of the screws with a felt pen, label crate cover indicating both module and stamp number and prepare crate for shipping to Ross Machine Shop.