Bio-Sand Filtration

Mould Construction Guidelines
Introduction

On the following pages, you will find an illustrated construction guide that takes you step-by-step through the process of building a mould that will allow you to cast your own concrete bio-sand filters. Note that a separate illustrated filter construction guide is available from www.biosandfilter.org.

Much of the information in this document was collected by the author during a project that was financed and implemented by Medair in Kenya, in 2000. Check www.medair.org for more information on the humanitarian programmes implemented by this organization.

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Madagascar

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Casting procedure

Construction of a mould is not difficult. It can be made in most small metal workshops, even in developing countries. However, a good level of accuracy is required. A lathe and rolling machine (three-roll bender) are needed, besides a welding machine, drill and grinder.

List of Materials

The following materials are needed for the construction of 1 mould:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Where used</th>
<th>Manufacturing process</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For the Outer Shell:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Plate 1113mm x 950mm x 2mm</td>
<td>Outer shell body</td>
<td>Roll tube to 350mm diameter</td>
</tr>
<tr>
<td>1</td>
<td>Flat iron 50mm x 6mm 1415mm long</td>
<td>Outer shell bottom ring</td>
<td>Roll to I.D. 354mm</td>
</tr>
<tr>
<td>1</td>
<td>Flat iron 50mm x 6mm 1415mm long</td>
<td>Outer shell top ring</td>
<td>Roll as above, drill as per drawing</td>
</tr>
<tr>
<td>4</td>
<td>Flat iron 50mm x 6mm x 938mm long</td>
<td>Outer shell locking flats</td>
<td>Drill as per drawing</td>
</tr>
<tr>
<td>1</td>
<td>M12x 50 bolt &amp; nut</td>
<td>P.V.C pipe lock</td>
<td>Drill shell, weld nut to shell</td>
</tr>
<tr>
<td>1</td>
<td>Plate 265 mm x 265mm x 2mm</td>
<td>Nose</td>
<td>Cut and bend as per drawing</td>
</tr>
<tr>
<td>1</td>
<td>Plate 110mm x 180mm x 6mm</td>
<td>Nose plate</td>
<td>Cut &amp; shape as per drawing</td>
</tr>
<tr>
<td>1</td>
<td>Flat iron 25mm x 6mm x 40mm long</td>
<td>Nose plate lock</td>
<td>Drill and weld M12 nut</td>
</tr>
<tr>
<td>2</td>
<td>Flat iron 25mm x 3mm x 25mm long</td>
<td>Nose plate aligners</td>
<td>Weld to nose plate</td>
</tr>
<tr>
<td>1</td>
<td>M12 x 75 bolt &amp; nut</td>
<td>Nose plate lock</td>
<td>Weld nut to flat</td>
</tr>
<tr>
<td>2</td>
<td>Bright mild steel shaft 40mm x 50mm long</td>
<td>Puller supports on shell</td>
<td>Drill 17mm and weld to shell</td>
</tr>
<tr>
<td><strong>For the Inner Core:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Plate 945mm x 253 mm x 2mm</td>
<td>Cone A</td>
<td>Roll to 300mm (top) and 290mm (bottom)</td>
</tr>
<tr>
<td>1</td>
<td>Plate 850mm x 655mm x 2 mm</td>
<td>Cone B</td>
<td>Roll to 270mm (top) 250mm (bottom)</td>
</tr>
<tr>
<td>1</td>
<td>Plate 290mm x 290mm x 2 mm</td>
<td>Cone A bottom</td>
<td>Cut to 286mm diameter</td>
</tr>
<tr>
<td>1</td>
<td>Plate 250mm x 250 mm x 2mm</td>
<td>Cone B bottom</td>
<td>Cut to 246 mm diameter</td>
</tr>
<tr>
<td>1</td>
<td>Plate 450mm x 450mm x 6mm</td>
<td>Top plate for core</td>
<td>Cut to 450mm diameter</td>
</tr>
<tr>
<td>1</td>
<td>M25 nut</td>
<td>Core puller nut</td>
<td>Weld to top plate</td>
</tr>
<tr>
<td>1</td>
<td>Plate diameter 100mm x 10mm thick</td>
<td>Core puller nut support</td>
<td>Weld to top plate with nut</td>
</tr>
<tr>
<td>2</td>
<td>Square tube 50mm x 50mm x 3mm x 300mm long</td>
<td>Top stands</td>
<td>Weld as per drawing</td>
</tr>
<tr>
<td><strong>For the Puller:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Flat iron 50mm x 6mm 50mm long</td>
<td>Puller support plates</td>
<td>Weld to puller bush</td>
</tr>
<tr>
<td>1</td>
<td>Square tube 50mm x 50mm x 3mm x 600 long</td>
<td>Puller top</td>
<td>Drill as per drawing</td>
</tr>
<tr>
<td>2</td>
<td>Angle iron 50mm x 50mm x 6mm 600 long</td>
<td>Puller reinforcements</td>
<td>Drill and weld to above</td>
</tr>
<tr>
<td>2</td>
<td>Bright mild steel shaft 16mm x 360mm long</td>
<td>Puller legs</td>
<td>Weld to above</td>
</tr>
<tr>
<td>1</td>
<td>Bright mild steel shaft 25mm x</td>
<td>Puller bolt</td>
<td>Thread M25 250 long</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Function</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------</td>
<td>---------------------------</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>300mm long Bright mild steel shaft 40mm x 50mm long</td>
<td>Puller bolt head Drill 20mm and weld to bolt</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>300mm long Bright mild steel shaft 40mm x 10mm long</td>
<td>Puller legs stopper Drill 16mm &amp; weld to legs</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Pipe 1&quot; class 'B' 900mm long</td>
<td>Puller handle Weld to shaft</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Bright mild steel shaft 18mm x 150mm long</td>
<td>Puller handle front Weld to above 50mm in pipe</td>
<td></td>
</tr>
</tbody>
</table>

**Miscellaneous:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Bolts &amp; nuts M10 x 25</td>
<td>Top plate, shell locks Tighten top plate &amp; shells</td>
</tr>
<tr>
<td>2</td>
<td>Bolts &amp; nuts M10 x 40</td>
<td>Outer shell top locks Locks shells top bolt</td>
</tr>
<tr>
<td>2</td>
<td>Spanners # 17</td>
<td>Top and outer shell Tightening &amp; opening bolts</td>
</tr>
<tr>
<td>1 kg</td>
<td>Welding rods</td>
<td>welding Weld where applicable</td>
</tr>
</tbody>
</table>
Construction Process Step-by-Step
Kindly refer to the blueprints in the Annexes in order to obtain the correct specifications.

**Step 1 – Bending Outer Shell Plate**

Measuring the plate as per the instructions on the blueprint (see Annex).

Cutting the plate for the outer shell to the right size.

In a three-roll bender roll the plate for the outer shell (1113 x 950 x 2mm).

Produce a cylinder of approximately 354mm diameter x 950mm length. Refer to the Annexes for exact measurements.

Measuring the diameter of the outer shell after bending.
Step 2 – Bending Inner Core plate
In the same bender, roll the cone B to major diameter of 300mm and minor diameter of 290mm. Finally, roll cone D to major diameter of 270mm and minor diameter of 250mm.

Important:
The plates for the cones must be cut to the exact shape as shown in the drawings in order to get a proper conical shape. Refer to the Annexes for the correct measurements. Note that you get the apex angle you connect the two short edges of the metal plate to one point that should be 7.2 degrees. The simplest way to do that is as follows:

1. Take a rope and tie 2 nails at each end. The distance between the nails should be 7500mm (7.5metres). Then draw a arc;
2. From the same centre draw another arc of 7250mm (7.25mts);
3. Draw a line from the centre to the first arc;
4. Take a standard protractor. Place it on the centre out 7.2 deg and draw a line to the first arc.

The area between the two lines is your template.
The other way is follow steps 1-3 then with a tape measure. Measure 942.5mm on the outer circle, follow the radius at that point connect it to the centre. The area in the centre is your template.

Finally, take note that rolling pressures has to be different when rolling taper cones on a standard three roll bender. Therefore, make sure to tighten the rollers uneven.

Step 3 – Welding of rolled plates
Tack-weld the edges and roll them again for roundness. If the bender does not allow for this process (most benders have a loose top roll where a welded job can be re rolled) then hammer it all round using a rubber mallet.

Step 4 - Welding and finishing inner core

Fully weld the edges on the cones inside and outside, and then grind the outer weld to a smooth finish. Next, check the surface of the cones for dents and roundness. If any dents are found make sure you remove them.

This is very important, as it will be next to impossible to remove the concrete filter from the mould if dents are present.

Once the above process has been completed take the flanges C & E. Machine them on a lathe to 286mm (C) & 246mm diameter (E). Machine the top plate A to 450mm diameter. Mark the centre lines for drilling holes on plate A, then draw a circle of 400mm and divide the circle into 10 equal parts. Subsequently drill 11mm holes at the divisions. In the middle of any division, drill a 13mm hole (this is the locating hole normally a odd one either a square or bigger round with a pin welded). On the opposite side draw a circle of 300mm this is the locating mark for welding the cone B to plate A. Drill a 28mm hole in the centre of plate A.
Step 5 – Welding
Weld cone D to flange E, check for distortions and rectify them.
Weld cone B to flange C, check for distortions and rectify them.
Weld cone D to flange C, finish by welding the cone assembly to plate A.
Grind and smoothen all welds.

The inner core and the outer shell halfway through construction.

Detail of the inner core. Inside, the reinforcement flanges are still visible before the top plates are welded to the cone.

Important:
Make sure that the cone assembly is aligned properly to Plate A. This is necessary to allow proper removal of the core from the concrete cast.

Step 6 - Top and Bottom Rings for outer shell
Take the flat iron (50 x 6 x 1415). In a roll bender fix the ring bending rollers and bend a ring to 450mm outside diameter x 350mm-inside diameter. Alternatively, if this facility is not available in the bender, then from a 6 mm plate cut a ring of the above size.

Step 7 - Outer Shell Locks
Take flat iron 50 x 6 x 938mm (4 pieces). Tack-weld 2 pieces at the edges to ensure drilled holes line up perfectly. Mark and drill 11 mm holes as per the drawings (top and bottom holes at 33 mm from the top to centre, the rest at 110 mm centre to centre). After drilling, grind away the tack-welds to separate the two pieces. Repeat this for the other pair.

Drill holes in the side plates for bolts.
Step 8 – Splitting the Shell

Take the rings that were made in step 6 and fit them to the top and bottom of the cylinder made in step 1.

Next, take the two flats made in the step seven and tack weld one on either side (the side of the joint and right opposite).

Proceed to split the cylinder to produce the two shell halves, using a grinder or a jigsaw. Once split, join the 2 shells with 10 mm bolts.

Step 9 – Fitting Inner Core

Take the core and place in the shells and centralize. Tack-weld the core and the shells together and proceed to drill 11mm holes as per the top plate. Remove the tack-welds and bolt the centre core to the shells.

Step 10 – Nose assembly and PVC pipe locking bolt

For the nose plate, take the 10 x 180-x 6-mm plate. Cut the nose bottom plate size as per the drawing.

Drill a 22-mm hole. Next weld the aligners (flat iron 25 x 3 x 25long). These ensure that the nose plate fits well to the nose itself.

For the nose itself, take the 265mm x 265mm-x 2mm plate. Draw and cut as per template. Fold in centre and grind to shape.
Next, take one of the outer shells. Tack-weld the nose and mark its position with a scriber. Make sure to position the bottom of the nose in the correct position measured from the top as per the drawings. Proceed to remove the tacks using a grinder or jig saw. In the outer shell, cut away the marked position of the nose. Having opened the mould, place the nose in position from the inside and weld both inside and outside. Take care to grind the inner side to a smooth finish.

Take the flat for the nose plate lock (25 x 6 x 40 long). Drill a 13-mm hole and weld a M12 nut as per the drawing.

Directly below and in line with the nose plate lock, drill a 13-mm hole 90mm from the bottom side of the mould and weld a M12 nut (see arrow for approximate position).

Insert a suitable bolt: when making a filter this bolt will be used to press the PVC pipe flush with the inner core.

**Step 11 - Puller**

Take the 50 x 50 x 3mm square tube and drill a 30mm hole in the centre, as well as two 16.5mm holes on each side as per the drawing. Then take the 25 diameter x 300mm B.M.S rod and thread 250mm. Take the 40 diameter x 50 long B.M.S and drill a 20mm hole in the centre. Proceed to weld this to the threaded shaft (this is the puller bolt).
Take the 16 diameter x 360mm B.M.S and taper the front ends slightly, next drill with a 16mm-drill bit the 2 pieces of 40 diameter x 10 long and weld as per drawing.

Finally, take the two 40mm diameter x 50 mm long shafts and drill a 17mm hole. Take the 50 x 6 x 50mm long flats and drill an 11mm hole in the centre, then weld one each to the bush as per the drawing.

Shown here is the completed puller.

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**Step 12 - Testing the mould**

The completed core including the top stands made from square tubing. Next to it the outer shells.

The outer shells detached.
A finished mould consists of the following parts:

- Rear half shell;
- Front half shell with nose;
- Nose Plate;
- Bolt M12 x 75;
- Bolt M12 x 50;
- Centre core;
- Puller;
- Handle;
- Bolts & nuts M10 x 25;
- Bolts & nuts M10 x 25, M10 x 40.

It is advisable to test the mould by making one or more filters while still in the workshop. This way, problems can be easily rectified. For instructions on how to build a filter, please refer to the Filter Construction Guidelines, also available on www.biosandfilter.org.

Additional information:
This mould is also available ready-made. For more information, email info@biosandfilter.org.

Credits:
This mould was designed by Jitu Jawahar Patani and Adriaan Mol in Nairobi, Kenya in 2000 with funding from Medair.
Annex 1: All Components

Opening handle (8)  

Center core (6)  

Rear Half (1)  

Puller (7)  

M10 x 25 (9)  

Front Half (2)  

With nose  

Nose Plate (3)  

M12 x 50 (6)  

M12 x 75 (4)  

Fasten M10 x 25  
Top M10 x 40 (10)  

Mould Parts  
Page one (1)  
Drawn by J Patani  
email: jawaharpatani@hotmail.com
Annex 2: Inner Core template 1

Cone B (Top)
Radius on Major Curve = 75.00
Radius on Minor Curve = 72.50
Apex angle = 7.2 degrees
Annex 3: Inner Core Template 2

Cone D (Bottom)
Radius on Major curve = 8775
Radius on Minor curve = 8125
Apsis angle = 5.53 degrees
Annex 4:

[Diagram showing welding positions and procedures]

Welding Procedure (Page 2)

1. Drill holes in top plate as per drawing.
2. Align cone B to center of Plate A
3. Draw a circle and tack to outside of cone.
4. Place flange C to top of cone A and tack with edges.
5. Place flange B to cone B and tack to marking.
6. Place flange E to cone D and tack.
7. Check for straightness and weld all around.
8. Weld on opposite sides to avoid distortion to cones.

Plan A, B, C, D, E

Plan A without Plate C welded

Plan C 2mm thick

Plan D without plate E welded

Plan E 2mm thick
Annex 5: Where to pour concrete

Materials Required
- Portland cement: 10 kgs
- Dry clay-free building sand: 30 kgs
- Ballast (6 - 10 mm): 40 kgs
- Water: approximately 5 - 8 hrs
- PVC pipe: ¼" approx 800 mm
- PVC elbow: ¼" 3 pcs
- PVC glue
Annex 6: Puller drawing 1
Annex 7: Puller drawing 2

[Diagram of puller drawing 2]
Annex 8: Insert PVC pipe

Cross section

Cast filter with 20 mm P.V.C pipe
Annex 9: Bottom and top views of Outer Shells

- Plan Top
- Plan Bottom
- Hole for locating pin