Asphalt Compaction Mold
Four-Inch Thick Ingot Mold

Basic Mold Assembly and Operating Instructions

Principal Investigators: J. T. Harvey and C. L. Monismith
Design: M. Troxler
TABLE OF CONTENTS

Section 1: Description and General Overviews .............................................................................. 1
Section 2: Components and Sub-Assemblies .................................................................................. 6
Section 3: Assembly and Fabrication Prints .................................................................................. 18
Section 4: Multiple Section Operations for 8-Inch- and 12-Inch Thick Specimens .................. 36
Section 5: Accessory Equipment and Parts Lists ......................................................................... 48
Section 6: Operating Instructions for Asphalt Compaction Mold ................................................ 55
   1. Foreword .................................................................................................................................. 56
   2. Overview ................................................................................................................................. 57
   3. Base Plate ............................................................................................................................... 58
   4. Short Deck Plate ..................................................................................................................... 60
   5. Long Deck Plate ..................................................................................................................... 61
   6. Ramps .................................................................................................................................... 62
   7. Safety Guards Rails ................................................................................................................. 63
   8. Ingot Molds ............................................................................................................................ 64
   9. Using the Ingot Extraction Tool ............................................................................................ 66
  10. Additional Equipment to be Used for Making 8-Inch Thick, and 12-Inch Thick Specimens .................. 68
All measurements in inches unless otherwise noted.

Drawing Key:

- **Parts and components**
- **Dimension lines & text**
- **Hidden lines**
Section 1: Description and General Overviews
UNLESS OTHERWISE SPECIFIED

FINISH SPECIFICATIONS:
MACHINED SURFACES 125 \( \frac{1}{40} \) MAX
GROUND SURFACES 32 \( \frac{1}{16} \) MAX
DECIMAL TOL. \( \pm \frac{0.0005}{2} \) MAX
FRACTIONAL TOL. \( \pm \frac{0.010}{2} \)
ANGLE TOL. \( \pm 0.5\)°
REMOVE BURRS AND SHARP EDGES TO 0.015 MAX

DO NOT SCALE
UNLESS OTHERWISE SPECIFIED

PART NAME | BASE PANEL
MATERIAL | A-36
DESCRIPTION | STEEL
PART NUMBER | N/A

DO NOT SCALE

BASE PLATE FOR ASPHALT
COMPACTION FORM.

Angle iron bracket, to attach base panel sections together.
3.5" x 15" rectangular tube.
1875" wall, 72" long.

Detail "A".
Tube on one side, pin on the other, the base panel can be rotated 180°.

Hardened steel alignment pin, fits into adjoining tube socket.
2.5" x 3.5" square tube supports.

Alignment pin & socket 
see detail "A".

1/2-13NC threaded
holes for lifting 
eyes, 4 Each.

Tubes protrude from panel
to form mold supports.

4 Each, 1/2-13NC holes
for lifting eyes.

Bolt down point. 
See detail "B".

3 Each, guardrail mounts.

Ramp attachment, 2 each.

DETAIL A
Panel alignment points are a
combination of pin & socket. An
unlimited number of panels can be
stacked one on top of another.

DETAIL B
Panel bolt down points are
1" thru holes, with ½" thick
backing plates. Bolt heads are
recessed below top of panel.

ASPHALT COMPACITION MOLD PANELS

<table>
<thead>
<tr>
<th>PART NAME</th>
<th>ASPHALT COMPACITION PANELS</th>
<th>SCALE</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIAL</td>
<td>A-36 STEEL PLATE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRAWN BY</td>
<td>MPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHECKED BY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHANGED BY</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

UNLESS OTHERWISE SPECIFIED

F
E
D
C
B
A

NOT SCALE
Guardrails attach by pin and socket joints to the outer edges of both the long panels, and the base ramps.

<table>
<thead>
<tr>
<th>PART NAME</th>
<th>Guardrail Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCALE</td>
<td>n/a</td>
</tr>
<tr>
<td>DATE</td>
<td>12-23-02</td>
</tr>
<tr>
<td>DRAWN BY</td>
<td>MPT</td>
</tr>
<tr>
<td>SHEET BY</td>
<td></td>
</tr>
<tr>
<td>MATERIAL</td>
<td></td>
</tr>
<tr>
<td>NUMBER</td>
<td></td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td></td>
</tr>
<tr>
<td>PART NUMBER</td>
<td></td>
</tr>
</tbody>
</table>

Unless otherwise specified:
- Finish Specifications
- MACHINED SURFACES 185/MAX.
- GROUND SURFACES 38/MAX.
- ROLLER ROLL 280, 205, 206, 208, 2010
- PART NO. 740, 730
- PEG AND HAMMER ARE SHOWN EXACT TO SCALE.

GUARDRAILS ATTACH TO THE OUTER EDGES OF BOTH THE LONG PANELS AND THE BASE RAMPS.
Section 2: Components and Sub-Assemblies
Alignment pin B each are required for each section of mold assembly. AISI 4140 steel, welded into part #02, and then hardened through heat treatment.

### Isometric View

- Thru hole for alignment pin weld.

### Side View

- Diameter 0.005 (D) ± 0.002 (L)

### End View

- Diameter 0.005 (D) ± 0.002 (L)
Panel bolt-down opening.

Panel

Welding assembly for panel bolt-down point.

Part #02

Bottom View

Side View

Univer sit y of  Cal if or nia Pavem ent Resear ch Cent er , UC Davis & UC Ber kel ey

Univer sit y of  Cal if or nia Pavem ent Resear ch Cent er , UC Davis & UC Ber kel ey

University of California Pavement Research Center, UC Davis & UC Berkeley

Angle iron bracket. 8 each are required per section.
Heat-treated 4140 steel alignment pin, with lug. 2 each are required per base section, and 2 each (modified) are required for the base ramps.

Base alignment tube, with lug. 2 each required for base section. 8 2 each (modified) for base ramps.

Univer sit y of Cal ifor nia Pavem ent Re se arch C ente r, UC Davis & UC Berke ley
Base ramp alignment pin. Side & end views.

Base ramp alignment tube. Side & end views.

Table:

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Base Ramp Alignment Detail</th>
<th>Scale</th>
<th>Material</th>
<th>Description</th>
<th>Date</th>
<th>Rev</th>
<th>MFG</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>#03 &amp; #06</td>
<td></td>
<td>1/2</td>
<td>L-25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Part #03 print #013

Thru hole Ø.957

The 4½" void bolt-down guide is fabricated using part #03, and a 3" long section of schedule 40 black pipe. 4 each are needed for each ingot hold.
Steel stiffeners for rectangular tube, at base plate corners. 4 each are required per section.

Port H010 is a fabrication of 1.75" O.D. X 1" I.D. steel tubing, and 2"x2"x1/8" angle iron. 10 each are required per section.
Ramp guardrail mounts. Used on the base ramp only. Machined from 1/2" thick angle iron, 4 each are required.

Base Ramp Rib 10 each are required.
**Panel Ramp Angle Bracket**

- **用途**: 用于固定短斜坡到长面板，制作8' & 12'深试件。每段每部分需要4个。

<table>
<thead>
<tr>
<th>部件名称</th>
<th>额外角度</th>
<th>规格</th>
<th>数量</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel Ramp Angle</td>
<td>27&quot;x27&quot;x3&quot;</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

**长引导销**

- **用途**: 用于引导销和斜坡引导栏。材料: 碳钢。每段每部分需要10个，第二部分每段每部分需要6个。

<table>
<thead>
<tr>
<th>部件名称</th>
<th>引导销</th>
<th>涂层</th>
<th>数量</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guardrail Pin</td>
<td>1018</td>
<td>MPT</td>
<td>6</td>
</tr>
</tbody>
</table>

**短引导销**

- **用途**: 用于固定斜坡。每段每部分需要4个，无论构造多少部分。

<table>
<thead>
<tr>
<th>部件名称</th>
<th>引导销</th>
<th>涂层</th>
<th>数量</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guardrail Pin</td>
<td>1014</td>
<td>MPT</td>
<td>4</td>
</tr>
</tbody>
</table>
The long handle is for the outside of the long panel. The short handle is for the inside (facing the mold). 4 of each type are required per section.

| Part Name       | Long Panel Handles | 1/2-
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Alloy 1018</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>K-lin, steel bar</td>
<td></td>
</tr>
<tr>
<td>Part Number</td>
<td>018</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Lifting Eyes</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>K-19 Eyebolt</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part Number</td>
<td>019</td>
<td></td>
</tr>
</tbody>
</table>

Standard 1/2-13NC eyebolt. A minimum of 8 are recommended for each base/panel section.
Ingot extractor mounts are fabricated from 1.50 diameter, schedule 80 pipe, welded to a .750 high standoff. 4 each are required per ingot hold assembly.

Ingot Extractor Bar

The ingot extracting bar is made from .875 diameter, hardened alloy 4140 steel. There is a welded collar on one end, and a lock collar, (part #022) attaches to the other end. Two each are required.
Lock collars are for the ingot extractor bars. 2 each are required.

Angle iron and rectangular bar gussets for the panel and base ramps. 2 each per panel ramp, 4 each per base ramp.

Part Number | Lock Collar
---|---
2022 | Carbon Steel

Part Number | Ramp Gussets
---|---
623 | Low Carbon Steel

Unles otherwise specified:

Panel ramp only.

Charge: $0.00
Section 3: Assembly and Fabrication Prints
This is a 1/2-13NC nut, welded to underside of the base plate below the 4 ingot mold bolt-down points, to act as a reinforcement for the threads. Screw a 1" long, 1/2-13NC bolt through the base plate. Attach a 1/2-13 nut finger tight. Weld the nut to the underside of the base plate, and then remove the bolt.
Unless Otherwise Specified

Finish Specifications
Machined Surfaces: 125 Max.
Ground Surfaces: 32 Max.
Decimal Tol.: .010, .005, .002, .001
Fractional Tol.: .001
Remove Burr And Sharp Edges To .015 Max.

Do Not Scale

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Base Gusset Welds</th>
<th>Scale</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Number</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Part Number

Detail CC from drawing 031

Start weld at joint opposite of plate.

Gusset; 8 each

Start weld at joint opposite of plate.

Notes:
Outside dimensions of plate have been reduced from 25% 30% to allow clearance for nails and long deck plates.

2 Each are required per section.

Gusset; 8 each

Start weld at joint opposite of plate.

University of California Pavement Research Center, UC Davis & UC Berkeley

University of California Pavement Research Center, UC Davis & UC Berkeley

University of California Pavement Research Center, UC Davis & UC Berkeley
Long deck plate

Parts #01 & #02

Part #03

Univ. California Pavement Research Center, UC Davis & UC Berkeley

Welding Diagram

Part Number: 01, 02 & 03

Material: 1-1/4

Description: Weld

Checked by: MHE

Scale: 1/8

Welding detail for long panel guardrail mount, ramp angle, and rectangular tube stiffener.
Left and right short guardrails are identical, mirror images of each other. They attach to the base ramps. Two of each side are required.

Base ramps, 2 each are required.
Top View

Side View

Basic twin gang mold insert for 4" deep compacted asphalt concrete ingots. Mold sits flush with panels, and mounts with 4 each, 5/16-18NC bolts, 4½" long.

Tray assembly for 4" asphalt compaction molds. 1 Each is required per section.

Note: This size ingot mold no longer used at UCPRC.
Completed mold and tray assemblies are welded together to form a single 4" deep gang mold. Each compacted ingot has a design weight of 80 lbs. The compaction mold weighs 84 lbs.
Top View

Side View

Tray assembly for UCPRC standard 4" deep compaction molds. 1 Each is required per section.
Standard size UCPRC ingot mold

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>UCPRC Mold Fabrication</th>
<th>SCALE</th>
<th>M4</th>
</tr>
</thead>
<tbody>
<tr>
<td>------------</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Material:**
- **Number:** 2203
- **Material:** HOT ROLL STEEL

**Part Number:** M4

Note: All dimensions are in inches. See welding notes below.

Welding notes:
- Weld the inside panel to both end panels and to the cross bar.
- Weld the end panels to the framework.

All dimensions are in inches. See welding notes. No additional information provided.
Repeated laboratory use has shown that reinforcing gussets are necessary on the ingot mold, to prevent failure of the mold flange welds when extracting asphalt specimens without the use of release agents. Typically 14 external, and 3 internal gussets are used on each ingot mold. These gussets were cut from 3” wide x 3/8” thick hotrolled steel flatbar.

**Universal Gusset**

3.3

1.36

5

External Gusset

9.375

1.43

Internal Gusset

9.375

.9375

.87

.9

.5

.5

.29

.14

.19

.11

.8

.7

.825

.825

6.75

6.75

7

8

10

23

TYPICAL GUSSET PLACEMENT:

Internal gussets: typically 3 each.

External gussets: typically 14 each.
Maximum sized single cavity Ingot mold. Produced for the warm mix asphalt project. Ingot dimensions are 3.875' deep, 20' x 20' at the top, and 24' x 20' at the base.
Section 4: Multiple Section Operations for 8-Inch- and 12-Inch Thick Specimens

8” Portland concrete cement specimen with 4” asphalt overlay.
8 Inch hot mix asphalt concrete compaction mold. Panels and mold for the 8 inch ingot are placed on top of the lower set of panels, which are used to produce 4 inch ingots.

UNLESS OTHERWISE SPECIFIED

<table>
<thead>
<tr>
<th>Finish Specifications:</th>
<th>Part Number</th>
<th>Scale</th>
<th>Date</th>
<th>Drawn by</th>
<th>Checked by</th>
<th>Date Change Eco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machined Surfaces 125 Max.</td>
<td></td>
<td>N/A</td>
<td></td>
<td>MPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Surfaces 32 Max.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle TOL. + 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fractional TOL. + .010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decimal TOL. + .010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Surfaces 32 Max.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machined Surfaces 125 Max.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finish Specifications:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A simi-exploded view of the panels, base plates, and ramps, showing the general arrangement of the asphalt compaction mold assembly.
Asphalt compaction mold configured for 4" deep specimens. First mold has been omitted to show mold supports. Ingot molds can be inserted in either straight, or 90 deg. orientations.

Panel ramp.

Asphalt compaction mold, configured for 8" deep ingot at the forth mold position.

<table>
<thead>
<tr>
<th>PART NAME</th>
<th>8&quot; ASPHALT COMPACTION FORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIAL</td>
<td>TYPE A-36 STEEL</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>N/A</td>
</tr>
<tr>
<td>MACHINED SURFACES</td>
<td>125 G</td>
</tr>
<tr>
<td>GROUND SURFACES</td>
<td>32 G</td>
</tr>
</tbody>
</table>

Do not scale
Asphalt compaction mold, configured for a row of 8" deep ingots at three mold positions. The 8" deep ingot molds can also be positioned in either straight or 90 deg. orientations.

### Asphalt Compaction Mold Specifications

**Gang Mold 8" Compaction Forms**

- Remove burrs and sharp edges to 0.015 max.
- Decimaltol. ± 0.010. ± 0.005. ± 0.0005 max.
- Angle tol. ± 1°.
- Unless otherwise specified.
- Angle tol. ± 1°.
- Fractional tol. ± 0.010.
- Ground surfaces 32.
- Machined surfaces 125.

### Finish Specifications

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Description</th>
<th>Number</th>
<th>Material</th>
<th>Scale</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gang Mold 8&quot; Compaction Forms</td>
<td>Type A-36 Steel</td>
<td>N/A</td>
<td>N/ A</td>
<td>None</td>
<td>21 Sep 03</td>
</tr>
</tbody>
</table>

**Asphalt Compaction Mold, configured with single 12" deep ingot mold at the center section. Either straight or 90 deg. orientations can be used.**

### Asphalt Compaction Mold Specifications

- 12" Asphalt Compaction Form
- Remove burrs and sharp edges to 0.015 max.
- Decimaltol. ± 0.010. ± 0.005. ± 0.0005 max.
- Angle tol. ± 1°.
- Ground surfaces 32.
- Machined surfaces 125.

### Finish Specifications

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Description</th>
<th>Number</th>
<th>Material</th>
<th>Scale</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot; Asphalt Compaction Form</td>
<td>Type A-36 Steel</td>
<td>N/A</td>
<td>N/ A</td>
<td>None</td>
<td>22 Sep 03</td>
</tr>
</tbody>
</table>

---

39
Typical ingot sizes produced by the asphalt compaction molds. 8” and 12” ingots may be either homogenous, or multi-layered.

6” and 8” shear and triaxle specimens, cut from 12” thick compacted hot mix asphalt ingots. Ingots can be either homogenous blocks, or can be built up by paving and compacting on top of 4” or 8” ingots. Composite, or three layer ingots can be built up by taking a 4” ingot, placing it in a 8” mold and paving over it. This ingot can then be placed in a 12” mold, and given a final lift, to make three layers.
8" Mold bolt-down guide is fabricated from part #03, and a 7" long piece of schedule 80 steel pipe.

12" Mold bolt-down guide is fabricated from part #03, and a 11" long piece of schedule 80 steel pipe.
Mold hold-down bolts for the 8" deep & 12" deep ingot molds are fabricated from grade B7 allthread, and 1/2-13NC nuts. The bolts for the 8" deep molds should have an OAL of 9.5". The bolts for the 12" deep molds should have an OAL of 13.5".

1/2-13NC Alloy steel threaded rod. ASTM A193 grade B7, AISI 4140. Minimum tensile strength: 125,000 PSI.

See note above

Size 1/2-13NC hex thin (jam) nut. Grade 8. ANSI/ASME B18.2.2 Width 3/4", Height 5/16"

Unless otherwise specified:

Panel Ramp Rib
5 each are required per ramp.

Base Ramp Rib
5 each are required per ramp.
Panel ramps are used when making 8' x 12' lifts. The ramps attach to the long panels by way of a set of angle iron brackets. 2 ramps are required for the 8' deep mold, and 4 are required for the 12' deep mold.
### Drawing Instructions

**8" Mold Fabrication**

**Scale:** N/A

<table>
<thead>
<tr>
<th>Material</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel</td>
<td>M4 T ( \times 1 )</td>
</tr>
</tbody>
</table>

**Parts Notes:**

- 4 Each 3/8" plate 8" X 12", welded on a 14 deg. angle.
- Weld both plates 90°.
- 4 Each part "A" weld all 4 pieces.
- 1-25/64" X 2" trays for the mold bolt guides.

**Assembly:**

Hand fit and weld inside panels at 14 deg. angle. All weld beads on the inside of the mold cavity.

**Notes:**

- DO NOT SCALE
### 12" Ingot Mold

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>060</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRAWING NO.</td>
<td>060</td>
</tr>
<tr>
<td>UNIVERSITY OF CALIFORNIA PAVEMENT RESEARCH CENTER, UC DAVIS &amp; UC BERKELEY</td>
<td></td>
</tr>
</tbody>
</table>

**Dimensions:**
- Width: 725
- Height: 20.5
- Depth: 1165
- Weld all 4 pieces.

**Notes:**
- Weld both place on both side panels.
- Hard fit and weld in 4 each 1/4" braces.

---

**Drawing Specifications:**

<table>
<thead>
<tr>
<th>PART NAME</th>
<th>12&quot; Ingot Mold</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCALE</td>
<td>N/A</td>
</tr>
<tr>
<td>DATE</td>
<td>10-11-07</td>
</tr>
<tr>
<td>MATERIAL</td>
<td>N/A</td>
</tr>
<tr>
<td>EDITION</td>
<td>MPT</td>
</tr>
<tr>
<td>DRAWN BY</td>
<td>N/A</td>
</tr>
<tr>
<td>APPROVED</td>
<td>MPT</td>
</tr>
</tbody>
</table>

---

**Notes:**
- Weld both place on both side panels.
- Hard fit and weld in 4 each 1/4" braces.

---

**University of California Pavilion Research Center, UC Davis & UC Berkeley**
Section 5: Accessory Equipment and Parts Lists
INGOT EXTRACTOR LINK. MADE FROM 1" THICK ALUMINUM PLATE. 2 EACH ARE REQUIRED.

MATERIAL: 6160-T6
DESCRIPTION: ALUMINUM
PART NUMBER: 025

DRAWING NO. PART NO.

PART NAME: Ingot Extraction Rail
SCALE: N/A

MATERIAL: C4534
DESCRIPTION: 2-36 Steel Channel
PART NUMBER: 025

MOLD ENF OF LINK WITH LARGER HOLE.
EXTRACTOR FRAME END OF LINK WITH SMALLER HOLE.

14.75
12.5
Ø1.25
12.5
Ø0.8125
2.25

2 Each, Grade 8 H/SL
Sides 3/8" x 3/8" long
with 1/4" x 20 tap
2 quick-disconnect 1/2 nuts.
10 ton hand operated hydraulic bottle jack.
Dummy ingots are used to fabricate the ingot molds. The dimensions of all of the ingot mold cavities have to be identical, so that each asphalt specimen will have the same volume, compaction density, and physical properties. Two dummy ingots are fabricated from 0.125" plate steel. Care should be taken with their dimensional accuracy, as it will be reflected in all the subsequent molds made afterwards.

<table>
<thead>
<tr>
<th>Material</th>
<th>Number</th>
<th>Description</th>
<th>Scale</th>
<th>Date</th>
<th>Drawn By</th>
<th>Checked By</th>
<th>Change</th>
<th>ECO Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 Plate Steel</td>
<td></td>
<td></td>
<td>N/A</td>
<td>10-12-07</td>
<td>MPT</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Finish Specifications
- Machined Surfaces: 125 Max.
- Ground Surfaces: 32 Max.

Decimal Tol. .010
Fractional Tol. .010

Angle Tol: 

Remove Burr's And Sharp Edges To .015 Max.

Do Not Scale
asphalt compaction mold

4 Inch HMA Gang Mold

List of Materials

1 each, \( \frac{1}{2} \)" thick A-36 steel plate, 72" X 72".
2 each, \( \frac{3}{8} \)" thick A-36 steel plate, 72" X 36".
2 each, \( \frac{3}{8} \)" thick A-36 steel plate, 72" X 21".
2 each, \( \frac{3}{8} \)" thick A-36 steel plate, 30" X 21".
24 feet of \( \frac{3}{4} \)" X 6" hot rolled steel flat bar.
10 feet of \( \frac{1}{4} \)" X 4" hot rolled steel flat bar.
3 feet of \( \frac{3}{8} \)" X 1 \( \frac{1}{2} \)" hot rolled steel flat bar.
6 feet of \( \frac{3}{8} \)" X 1 \( \frac{3}{4} \)" hot rolled steel flat bar.
6 feet of \( \frac{3}{8} \)" X 4" hot rolled steel flat bar.
1 foot of \( \frac{1}{2} \)" X \( \frac{1}{2} \)" cold rolled steel square bar.
1 foot of \( \frac{1}{2} \)" X \( \frac{3}{4} \)" cold rolled steel flat bar.
1 foot of \( \frac{1}{2} \)" X 1 \( \frac{1}{2} \)" hot rolled steel flat bar.
1 foot of \( \frac{3}{4} \)" X 1" cold rolled steel flat bar.
5 feet of 2" X 2" X \( \frac{3}{8} \)" angle iron.
2 feet of 2 \( \frac{1}{2} \)" X 2 \( \frac{3}{4} \)" X \( \frac{1}{2} \)" angle iron.
1 foot of 3" X 3" X \( \frac{1}{2} \)" angle iron.
10 feet of \( \frac{1}{2} \)" diameter 1018 steel round stock.
6 feet of 1" diameter 1018 steel round stock.
1 foot of 2" diameter 1018 steel round stock.
6 feet of 1" diameter 4140 steel round stock.
4 feet of 1\( \frac{1}{2} \)" O.D. X 1" I.D. steel D.O.M. tubing.
2 feet of 1\( \frac{1}{4} \)" O.D. X 0.5625" I.D. steel D.O.M. tubing.
6 feet of 1\( \frac{3}{4} \)" O.D. X 1" I.D. steel D.O.M. tubing.
20 feet of C8X13.75 channel iron.
70 feet of 3\( \frac{1}{2} \)" X 2\( \frac{1}{2} \)" rectangular steel tube, .188" wall.
20 each, \( \frac{1}{2} \)"-13 NC bolts, 4\( \frac{1}{2} \)" long, grade 5 or higher.
4 each, \( \frac{1}{2} \)"-13 NC bolts, 2" long, grade 8, with locknuts.
asphalt compaction mold

8 inch HMA Mold
List of Materials

3 each, $\frac{1}{2}''$ thick A-36 steel plate, 72'' X 72''.
4 each, $\frac{3}{8}''$ thick A-36 steel plate, 72'' X 36''.
8 each, $\frac{3}{8}''$ thick A-36 steel plate, 72'' X 21''.
8 each, $\frac{3}{8}''$ thick A-36 steel plate, 30'' X 21''.
30 feet of $\frac{3}{4}''$ X 6'' hot rolled steel flat bar.
50 feet of $\frac{1}{4}''$ X 4'' hot rolled steel flat bar.
6 feet of $\frac{3}{8}''$ X 1 1/2'' hot rolled steel flat bar.
12 feet of $\frac{3}{8}''$ X 1 3/4'' hot rolled steel flat bar.
3 feet of $\frac{3}{8}''$ X 3'' hot rolled steel flat bar.
16 feet of $\frac{3}{8}''$ X 4'' hot rolled steel flat bar.
2 feet of $\frac{1}{2}''$ X 1 1/2'' cold rolled steel square bar.
2 feet of $\frac{1}{2}''$ X 3 1/4'' cold rolled steel flat bar.
10 feet of $\frac{1}{2}''$ X 1 1/2'' hot rolled steel flat bar.
5 feet of $\frac{3}{4}''$ X 1'' cold rolled steel flat bar.
14 feet of 2'' X 2'' X $\frac{3}{8}''$ angle iron.
4 feet of 2 1/2'' X 2 1/2'' X 1 1/2'' angle iron.
2 feet of 3'' X 3'' X $\frac{1}{2}''$ angle iron.
35 feet of $\frac{1}{2}''$ diameter 1018 steel round stock.
16 feet of 1'' diameter 1018 steel round stock.
4 feet of 2'' diameter 1018 steel round stock.
10 feet of 1'' diameter 4140 steel round stock.
10 feet of 1 1/4'' O.D. X 1'' I.D. steel D.O.M. tubing.
6 feet of 1 1/4'' O.D. X .5625'' I.D. steel D.O.M. tubing.
8 feet of 1 1/2'' O.D. X 1'' I.D. steel D.O.M. tubing.
16 feet of C4X7.25 channel iron.
16 feet of C8X13.75 channel iron.
14 feet of 1/2-13NC alloy 4140 threaded rod.
8 feet of $\frac{1}{4}''$ X 8'' hot rolled steel plate.
6 feet of $\frac{3}{8}''$ X 8'' hot rolled steel plate.
6 feet of 1'' diameter, schedule 80 pipe.
1 foot of 1 1/2'' diameter, schedule 80 pipe.
250 feet of $\frac{3}{16}''$ X 2 1/2'' rectangular steel tube, .188'' wall.
54 each, $\frac{1}{2}''$-13NC bolts, 4 1/2'' long, grade 5 or higher.
8 each, $\frac{1}{2}''$-13NC bolts, 2'' long, grade 8, with locknuts.
asphalt compaction mold

12 inch HMA Compaction Mold
List of Materials

5 each, 1/2" thick A-36 steel plate, 72" X 72".
18 each, 3/8" thick A-36 steel plate, 72" X 36".
18 each, 3/8" thick A-36 steel plate, 72" X 21".
6 each, 3/8" thick A-36 steel plate, 30" X 21".
80 feet of 3/4" X 6" hot rolled steel flat bar.
85 feet of 1/4" X 4" hot rolled steel flat bar.
12 feet of 3/8" X 11/2" hot rolled steel flat bar.
10 feet of 3/8" X 3" hot rolled steel flat bar.
26 feet of 3/8" X 4" hot rolled steel flat bar.
2 foot of 1/2" X 1/2" cold rolled steel square bar.
2 foot of 1/2" X 3/4" cold rolled steel flat bar.
10 feet of 1/2" X 1 1/2" hot rolled steel flat bar.
12 feet of 3/4" X 1" cold rolled steel flat bar.
30 feet of 2" X 2" X 3/8" angle iron.
10 feet of 2 1/2" X 2 1/2" X 1/2" angle iron.
2 foot of 3" X 3" X 1/2" angle iron.
75 feet of 1/2" diameter 1018 steel round stock.
22 feet of 1" diameter 1018 steel round stock.
10 feet of 2" diameter 1018 steel round stock.
20 feet of 1" diameter 4140 steel round stock.
30 feet of 1 1/2" O.D. X 1" I.D. steel D.O.M. tubing.
20 feet of 1 1/4" O.D. X .5625" I.D. steel D.O.M. tubing.
30 feet of C4X7.25 channel iron.
20 feet of C8X13.75 channel iron.
60 feet of 1/2-13NC alloy 4140 threaded rod.
20 feet of 1/4" X 8" hot rolled steel plate.
10 feet of 1/4" X 12" hot rolled steel plate.
20 feet of 3/8" X 8" hot rolled steel plate.
30 feet of 1" diameter, schedule 80 pipe.
1 foot of 1 1/2" diameter, schedule 80 pipe.
510 feet of 3 1/2" X 2 1/2" rectangular steel tube, .188" wall.
100 each, 1/2" 13NC bolts, 4 1/2" long, grade 5 or higher.
10 each, 1/2" 13NC bolts, 2" long, grade 8, with locknuts.
Section 6: Operating Instructions for Asphalt Compaction Mold

1. Foreword
2. Overview
3. The Base Plate
4. Short Deck Plate
5. Long Deck Plate
6. Ramps
7. Safety Guard Rails
8. Ingot Molds
9. Ingot Extraction Tool
10. Additional Equipment for Making 8-inch Thick, and 12-inch Thick Specimens.

Figure 1. Basic 4” asphalt compaction mold assembly. Forward panel safety guard, and ramp guard, removed for clarity.
1. Foreword

The Asphalt Compaction Mold is designed to be user friendly, safe, and have maximum versatility. Many of its components are modular, and interchangeable. The ingot molds themselves are designed to be used in multiple orientations, and multiple styles of molds can be used to make many different sizes of specimens. The overall system has many redundant features, to provide for the safest level of operation, and ease of use.

Even though the mold was designed to be used with a smaller riding compactor, the strength of the assembly allows it to accommodate weights of up to 22,000 pounds safely. The safety guards allow the use of a rolling wheel up to 36” wide to make edge of wheel to center of mold passes, with 2” clearance on either side.

The operating instructions for the Asphalt Compaction Mold, (ACM), are presented along three main topics: a discussion about the function of each of the major components, the assembly procedures for each of the components, and a description of the use or operation of the components. These instructions are written to describe the basic, single unit, 4” lift mold. The last chapter discusses the additional equipment used when expanding the mold to accommodate ingot molds for both 8” and 12” lifts.
2. Overview

In use, the operation of the ACM is quite simple. The mold is preheated prior to compacting an ingot. In standard practice this is usually accomplished through the use of heat lamps affixed inside a wooden box placed over the mold. Once the mold has been preheated, a sample of hot mixed asphalt concrete is placed into the ingot mold. Then a power driven, or manual rolling compactor is used to compress the sample into the ingot mold. The rolling compactor may be allowed to travel back and forth the full length of the ACM without danger.

Once the asphalt sample has cooled, the ingot mold assembly can be unbolted from the rest of the ACM, and lifted free by use of a set of eyebolts. Once the mold has been removed, it can be inverted by use of a steel bar, inserted through tubes under the mold assembly. When the ingot mold is turned upside down, the asphalt specimens usually fall free of the mold. If the ingots stick in the mold, then an ingot extractor tool can be used to free them.
3. Base Plate

The base plate forms the foundation of the entire compaction mold. Made from ½” thick steel plate, it performs multiple functions. A tube and socket connection underneath the base plate allows a row of base plates to be linked up in series. This is useful, either when producing multiple simultaneous specimens, or when making lifts of 8” or 12” depth. Each base plate is secured to the next by ½” bolts, passed through angle iron flanges at the corners. If needed, the correct spacing between base plates can be maintained by thick spacer washers placed in-between the flanges on each of these bolts.

A pattern of threaded holes provides the attachment points for all of the deck plates, and the mold assembly, which are fastened by long bolts from above the base plate. A series of through holes act as alignment guides for positioning pins on the long and short deck plates. The combination of guide holes and bolt holes makes it easy to assemble the panels in the correct orientation. All of the holes are mirrored on each half of the base plate, so even when the base plates are rotated 180 degrees, these hole patterns are designed remain the same. All the base plates are identical, and interchangeable.

For proper operation, the base plate should be places on a level concrete surface, of sufficient strength to support the rolling compactor which will be used. It is not absolutely necessary that the floor be perfectly level, but it is always most desirable to have the ACM set directly upon smooth concrete, to attain proper surface contact. If the support surface is slightly uneven, then ¾” thick plywood sheets may be placed together to form a continuous flooring surface between the concrete and the base plate. The weight of the rolling compactor should settle the ACM into the wooden flooring with repeated use.

You should never attempt to level individual base plates with wedges, shims or small pads. These will not provide full surface contact, and may cause localized loading and stress concentrations which may cause bending of the ACM under high loads.
If it is anticipated that additional base plate segments will be attached to facilitate a set of gang molds, then the original base plate should be positioned in a location which will accommodate further expansion. Once the base plate has been placed in position, it will be time to install the deck plates.
4. Short Deck Plate

The deck plates form the surface upon which the rolling compactor will travel. Both the long and short deck panels surround the ingot mold, and support the rolling compactor as it compresses the asphalt into the mold.

The short deck plates have a set of alignment pins which fit into corresponding holes in the base plate. This assures proper alignment. Each short deck plate has a set of sockets directly above the alignment pins, which are designed to accept the alignment pins of yet another short deck plate. In this way, several short deck plates may be stacked upon each other, and will still retain the correct alignment.

The short deck plates are fastened to the base plate via a pair of ½” diameter bolts. The heads of these bolts rest in a recess, below the top surface of the short deck plate. This allows the rolling compactor to travel over the panel surface, without contacting the bolt heads. All of the short deck plates are identical, and interchangeable. Though they can be placed on either end of the base plate, their attachment hole and alignment pin configuration prevents them from being installed incorrectly.

Three of the under ribs of the short deck plate extend 1” beyond the edge of the panel surface. These act as supports for the flange around the top of the ingot mold.
5. Long Deck Plate

The long deck plates function much the same as the short deck plates, but have several additional features. Like the short deck plates, the long deck plates have a set of alignment pins and sockets. This allows up to three deck plates to be stacked atop each other, to accommodate the mold for a 12” lifting ingot.

The long deck plates have the same type of recessed-head bolt attachment as the short deck plates, but with five bolt holes instead of two. Only the one central under-ribs of the long deck plate extends beyond the panel. This extended rib also acts as a support for the ingot mold flange.

Because it is longer, and heavier, the long deck plate has four lifting handles to make installation and removal easier. On the outer edge of the long deck plate are three mounting sockets for the safety guard rail. The angle iron flanges on the outside corners of the long deck plates are to facilitate the mounting of the ramps that are used as approaches by the rolling compactor. If several ACM segments are joined in series, and the greatest possible rigidity is desired, then these angle iron flanges may be used to secure the long panels on one segment to those on the next. (This is not generally required.)

Both the long and short deck plates may be removed or installed individually, and in no particular order. To remove, the plates are simply unbolted, and lifted off of the base plate.
6. Ramps

There are two types of ramps employed with the ACM. A higher ramp is used as an approach on both ends of the ACM, or on both ends of a series of ACM segments. Ramps which are half as high are used when additional layers of deck plates have been stacked up to facilitate either 8” or 12” liftingots. The shorter ramps are not used with the 4” liftingot mold configuration.

The higher ramps have the same type of pin and socket alignment equipment as the base plates, and will interconnect with them. An angle iron flange on the higher ramps will mate with the flange on the corner of the base plates, and the two will be joined using ½” bolts. The higher ramps have socket mounts to accept ramp safety guard rails. These higher ramps are used at either end of the ACM, to drive the rolling compactor up off the floor, and onto the ACM.

The shorter ramps do not have alignment pins or sockets, and have no provision for mounting safety guards. The angle iron flanges on the short ramps mate with the flanges on the ends of the long deck plates. The short ramps are secured to the long deck plates with ½” bolts. The short ramps are used when several layers of deck plates are employed. The short ramps are placed on one level of deck plate, and allow the rolling compactor to move up to the next level of plates. When using an 8” liftingot mold, the deck plates are stacked two high, and two short ramps are used. When using a 12” liftingot mold, the deck panels are stacked three high, and four of the short ramps are employed to allow the rolling compactor access to the mold.
7. **Safety Guards Rails**

When using the ACM, especially when making 8” and 12” lifts, great care must be taken not to allow the rolling compactor to fall off the side of the compaction mold assembly, as the rolling compactor may tip over, causing great mechanical damage, and danger to the operator and bystanders.

The ACM is equipped with a robust safety guard rail on either side of the assembly. This guard rail is made of ¾” thick steel, 6” high, and is held in position by 1” diameter steel pins.

There are two types of safety guard rails used on the ACM; panel guards, and ramp guards. The panel guard rails are straight, have three attachment pins, and are 70” long. They attach to the mounting sockets on the outside edge of the long deck plates. The panel guards are identical, and are interchangeable.

The ramp guard rails are shorter, and trapezoid in shape. They have two attachment pins; one of standard length, and one stub pin. The ramp guard rails mount to the higher “end” ramps only, and are not interchangeable. One ramp guard will fit on the left side of the ramp, and the other will fit on the right.

(Though they offer a degree of safety, no safety feature is full proof. It would be very difficult to do, but a large industrial rolling compactor can be driven over the top of these guards! The Asphalt Compaction Mold should only be used by competent personnel, trained in the proper use of a rolling compactor.)
8. Ingots Molds

The ingot molds are the heart of the ACM. There are three different configurations. The basic mold has two cavities, and will produce two 4” deep ingots at a time. The molds which produce 8” and 12” deep ingots are both single cavity. All of the ingot molds have a symmetrical mounting bolt pattern, and can be rotated at 90 degree intervals in the ACM.

Even though the three sizes of ingot molds have different size ingot trays, and different width mold flanges, there are many features which all the molds have in common. All of the ingot molds bolt down to the base plate using ½” bolts, in a square pattern 25” on a side. All of the ingot molds feature six ½” threaded holes, which may be used for either attaching lifting eyes, or for use with jacking bolts.

All of the ingot molds have four slots arranged along their perimeter, to be used as prying points when lifting the mold assembly out of the ACM. All of the ingot molds have four tubes, positioned beneath the flange, to facilitate both inverting the mold assembly, and attaching the ingot extracting tool.

Once the deck plates are bolted to the base plate, the ingot mold assembly can be inserted into the recess this creates in the center of the compaction mold. Four ½” bolts are inserted into the bolt guides on the ingot mold assembly. These guide tubes also act as standoffs, providing additional support for the ingot mold. The heads of the bolts are in recesses, below the level of the surface of the ingot mold. Once the bolts are tightened, the ingot mold is in place, and ready to be used.

The ingot molds are preheated, and hot asphalt concrete is placed into the mold cavities. The asphalt is compacted while hot, and is then allowed to cool. Once the asphalt ingots have cooled, it is time to remove the ingot mold from the base and deck plates.

The four bolts which retain the ingot mold are loosened, and removed. It is recommended that four ½” eyebolts be screwed into the threaded holes near the corners of the ingot mold flange. The ingot
mold, with the asphalt specimens still inside, can then be lifted free from the rest of the assembly using a crane, forklift, hoist, lifting bar, or some other contrivance.

Once clear of its recess, the ingot mold may be placed upon the surface of the deck plates. The lifting eyes are now removed, and a steel bar passed through a set of the tubes under the ingot mold flange, on one side of the mold only. A sling, chain or hoist is attached to both ends of this bar. By lifting the ingot mold using this bar, the entire assembly will travel over center as soon as the ingot molds are lifted clear of the deck plates. The ingot molds may now be lowered, and will settle in a position upside-down from the one from which they were lifted.

The ingots should come free from the mold as it is being lowered into the upside-down position. To form a cushion to prevent possible damage to the ingots as they come out of the ingot mold, the mold may be lowered onto layers of burlap, a thick sheet of foam, or some other suitable material. If the ingots do not come free from the mold, the bottom of the mold, which will now be facing up, is open, exposing the bottom of the asphalt ingot. Because of its tapered configuration, a pressure applied to the bottom of the asphalt ingot should force it from the mold assembly.

Should the ingots become stuck in the mold cavities, an ingot extraction tool can be used to remove them. This consists of a strong back with two links, two steel bars, and a hydraulic jack.
9. Using the Ingot Extraction Tool

The mold, with the stuck ingots in it, is inverted and placed on a raised surface so that the ingots will have room to fall free of the mold. Usually the mold is placed upside-down on a pair of wood two by four.

Next a flat piece of metal plate is placed on the bottom of the asphalt ingot, to spread out the force of the extracting tool. A 10 ton hand operated hydraulic jack is then placed on top of the metal plate. The strong back with links is positioned over the hydraulic jack, and the links are attached to the mold body by passing steel bars through both the extraction tool mounts on the mold, and the holes on the end of the links.

With the ingot extraction tool now installed, the jack is cranked by hand until enough force is exerted on the asphalt ingot to extract it from the mold cavity.
10. Additional Equipment to be Used for Making 8-Inch Thick, and 12-Inch Thick Specimens

The modular design of the ACM allows several base plate & deck plate assemblies to be linked together. If only one or two of these assemblies are linked in a row, they can only be used to make the 4” deep asphalt ingot molds. However, when three sets of plates are linked together, a second layer of deck plates can be stacked on top of the center panel. This configuration will permit the use of an 8” deep ingot mold. When five sets of plates are linked together, the three center panels can be stacked two high, and the centermost panel can be stacked with a third set of deck plates to accommodate the use of a 12” deep ingot mold.

To set up an 8” deep ingot mold, first bolt together three, (or more), base plate assemblies. The long and short deck plates for these may be set in place, but only the deck plates on the first and last set are bolted down. Do not place any bolts into the deck plates on the center section. A set of the higher base ramps is bolted to both ends of this series of plates.

Either 4” deep asphalt ingot molds may be bolted into position on the first and third set of plates, or these positions may be left empty. A second set of deck plates is stacked up on the center panel. This double high stack of deck plates is bolted down with special 9½” long, high strength bolts, which will pass through both layers of panels. A set of the shorter panel ramps is bolted to each end of this second set of deck plates on the center panel. Now there should be ramps allowing the rolling compactor access on and off the ACM, and also up to the second layer of deck plates.

The single cavity, 8” deep asphalt ingot mold may now be inserted into its recess in the center panel. The mold is also bolted down with the same 9½” long high strength bolts.

Once the mold is bolted down, the guards are ready to be installed. Simply line up the steel pins in the guards with the socket mounts on the sides of the long deck plates, and set the guards into position. The ramp
guards install in the same manner into socket mounts on the base ramps, but there are left hand and right hand guards. The left hand guards will only insert into the left side of the ramp and the right hand guards into the right. No guards are needed on the panel ramps.

The ACM with the 8” deep ingot mold is now ready to use. The mold may either be preheated, and asphalt placed into the mold to be compacted into an 8” deep specimen, or a duel layer specimen may be produced. To make an 8” specimen using two different types or layers of asphalt, place a 4” deep asphalt ingot into the bottom of the 8” mold, and compact an additional lift on top of it. Once the ingot has cooled, the mold is unbolted, lifted out and inverted with the same process as the 4” ingot mold.

To produce 12” ingots, at least five base plate and deck plate assemblies need to be linked together. All five sections will have a layer of long and short deck plates installed, but the center three sections are not to be bolted down. Installing ingot molds is optional. As always, a set of base ramps is placed at either end of the mold segments.

A second layer of deck plates is installed on top of the center three plate assemblies. The 9½” long high strength bolts are used to fasten down the second layer of deck plates on the second and forth in the series of plates, but the center plate, (the third in the series of plate assemblies), is left unbolted. Then a third layer of deck plated is placed on the center plate assembly, and is bolted down using 13½” long high strength bolts.

Four of the panel ramps are now used. Two of the panel ramps are places at either end of the third level of deck plates on the center plate assembly. Another set of panel ramps are attached to the ends of the second set of deck plates, on the second and forth set of plates. A total of six ramps are now employed to lift the rolling compactor from floor level up to the 12” ingot mold, and back again.

Now the ramp and panel guard rails are inserted, the same as they were on the 8” mold ACM. Finally the 12” deep single cavity asphalt ingot mold is inserted into the recess in the center panel assembly. The
mold is bolted down using the 13½” high strength bolts. The 12” ACM is now ready to be used.

A single homogenous ingot, 12” deep may be produced, or different combinations of multiple layer ingots can be made. An 8” deep ingot may be placed in the 12” mold, and a 4” lift added. Or, a double layer ingot, produced by placing a 4” ingot into an 8” mold, may be placed into the 12” mold and given a third lift. If a concrete mold is made to simulate an 8” deep ingot, then this specimen can be placed in the 12” deep mold, and a 4” asphalt overlay can be added.

Once the ingot cools, it may be unbolted, lifted and inverted in the customary manner. Caution is advised when handling the 12” ingots and mold, as the 12” deep specimens are very heavy.