

# 2011 CANADIAN ASPHALT MIX EXCHANGE PROGRAM



Ministry of  
Highways and  
Infrastructure

## MARSHALL MIX DESIGN INSTRUCTIONS TO PARTICIPANTS

Please note that at the November 2005 CAMP technical meeting, it was agreed that only one test method for the Theoretical Maximum Specific Gravity is required. The test method shall follow AASHTO T 209. The samples as indicated below shall be mixed at 145°C and conditioned for four hours at 135°C.

### A. Mix Ingredients

The mix, consisting of processed aggregates, was used for the Saskatchewan Ministry of Highways and Infrastructure hot-mix paving project on Highway No. 1 east of Regina. The aggregates are from Saskatchewan Ministry of Highways and Infrastructure pit 721-234, a glacial gravel deposit. Asphalt cement samples are from the same batch supplied by Moose Jaw Refinery Inc. from Moose Jaw, Saskatchewan.

### B. Sample Container

Your Marshall Mix Design asphalt mix exchange participant package contains the following materials

- Seventeen (17) aggregate samples
- Two (2) asphalt cement samples

The aggregate samples are to be used as follows:

- Eight (8) 1,200.0 gram samples for Marshall briquettes.
- Three (3) 2,000.0 gram samples for Asphalt Mix Maximum Theoretical Density.
- Three (3) 2,000.0 gram samples for Coarse Aggregate Relative Density.
- Three (3) 1,000.0 gram samples for Fine Aggregate Relative Density.

#### **NOTE:**

- **The filler relative density is 2.700.**

Aggregate samples are ready for use with the following exceptions:

- a) The coarse aggregate relative density samples must be washed and sieved on the 5.0 mm sieve as specified by ASTM C127 Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.
- b) The fine aggregate relative density samples shall be tested according to ASTM C128 Standard Test Method for Specific Gravity and Absorption of Fine Aggregate. They must be washed on the 75 µm sieve.

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c) Aggregate Sieve Analysis

**Table 1: Aggregate Sieve Analysis**

Sieve	Percent Passing
16.0 mm	100.0
12.5 mm	100.0
9.0 mm	89.6
5.0 mm	64.9
2.0 mm	47.4
900 µm	35.8
400 µm	21.4
160 µm	8.5
75 µm	5.2

**C. Marshall Briquettes and Maximum Theoretical Density Samples**

Aggregate for the eight Marshall compaction briquettes have been labelled, "Marshall Briquette"

The aggregate samples have been pre-weighed to 1,200.0 grams. 68.4 grams of asphalt cement will be added to the aggregate samples to prepare the Marshall compaction briquettes. (5.70% asphalt content based on dry weight of aggregate or 5.39% asphalt content on a total mix basis).

Aggregate for the Maximum Theoretical Density (MTD) samples has been pre-weighed to 2,000.0 grams to which 114.0 grams of asphalt cement will be added to achieve an asphalt content of 5.70% based on the dry weight of aggregate. The test for MTD shall follow AASHTO T 209 Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures. **The only deviations from AASHTO T 209 are:**

- the 2000 g aggregate samples provided shall be mixed at 145°C, and
- the mix samples shall be conditioned for four hours at the compaction temperature of 135°C.

The results for this Theoretical Maximum Specific Gravity and Density test shall be used for determining the air voids of the Marshall briquettes and the percent asphalt absorption.

**NOTE:**

- If for some reason the aggregate mass varies from that specified, the

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**asphalt cement mass should be calculated based on the new aggregate mass to achieve an asphalt cement content of 5.70% by weight of dry aggregate.**

### D. Asphalt Cement

Two litres of 150/200A (penetration grade asphalt cement) have been provided. To ensure consistency, the following values should be used:

- Specific gravity 1.030
- Mixing temperature 145°C
- Compaction temperature 135°C

### E. Tests to be Performed and Reported

#### 1. Aggregate Relative Density and Water Absorption

Three determinations are to be made on each of the coarse and fine aggregates using the individual pre-weighed samples. The coarse relative density shall follow ASTM C127. The fine relative density shall follow ASTM C128. Aggregate relative density is to be reported to four (4) significant figures.

The following interpretative revisions to ASTM C128 were agreed to at the 1989 Asphalt Mix Exchange. All participants should incorporate the following into their procedures:

1. The fine aggregate should again be washed after the 24 hour immersion period.
2. For the Cone Test, do not refill the cone after each tamping.

#### NOTE:

- **During the May 29, 1989 General Technical Meeting, most agencies indicated that a fan is being used to dry aggregate for determining bulk specific gravity, as allowed by ASTM.**

The following interpretative revisions to ASTM C128 were agreed to at the 1989 Asphalt Mix Exchange. All participants should incorporate the following into their procedures:

- The water absorption for the two aggregates shall be determined during the relative density testing in accordance with the respective ASTM procedures and reported.
- The combined percentage water absorption is based on a blend of 35.1% of the average held on the 5.0 mm sieve and 64.9% of the average passing the 5.00 mm sieve.

#### 2. Asphalt Absorption

Asphalt absorption determination shall follow ASTM D4469 Standard Test



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Method for Calculating Percent Asphalt Absorption by the Aggregate in an Asphalt Pavement Mixture.

#### **3. Asphalt Cement Content and Asphalt Mix Sample Preparation**

Eight (8) briquettes with an asphalt cement content of 5.70% (by weight of dry aggregate basis) are to be prepared separately by adding 68.4 g of asphalt cement.

Three MTD samples with an asphalt cement content of 5.70% (by weight of dry aggregate basis) are to be prepared by adding 114.0 g of asphalt cement.

The following procedures are to be followed to ensure uniformity in preparation of the asphalt mix samples:

#### Mixing

1. Aggregates shall be heated for 12 hours minimum at a temperature of  $110^{\circ}\text{C} \pm 5^{\circ}\text{C}$  prior to adding asphalt.
2. Mixing should be done at  $145^{\circ}\text{C}$  using a "**battered**" mixing pan. The mixing pan should not be totally clean but should contain the residue from previous mixing that is left after scraping with a spoon and/or spatula.
3. The asphalt cement added should be the percentage specified and no allowance should be made for asphalt cement that is left sticking to the sides of the mixing pan.
4. All mixing is to be done by hand using a spoon and a spatula.

#### Compaction

A total of eight (8) briquettes will be manufactured: four (4) by hand compaction and four by (4) mechanical compaction.

Hand compaction shall be **75 BLOWS** to each face at  $135^{\circ}\text{C}$ . Mechanical compaction should be based on the equivalent blow count to each face that your laboratory correlates to 75 blows of the hand hammer at  $135^{\circ}\text{C}$ .

1. The compaction pedestal shall follow specifications from AASHTO T245 Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus and shall be secured to a solid concrete slab.
2. For a bevelled compaction hammer, the thickest part of the compaction foot shall be placed toward the chain of the mechanical compactor at the start of compaction.
3. Briquettes are manufactured one at a time. Do not combine samples.
4. Manufactured briquettes will be air cooled for one hour before they are removed from the mould.



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5. The briquettes shall not be removed from the mould by applying blows to the face but rather by a constant applied pressure.

#### Marshall Mix Design Characteristics

1. Bulk specific gravity and density determination for briquettes shall be as specified in ASTM D2726 Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures.
2. Marshall stability and flow determination for briquettes shall be as specified in AASHTO T245.
3. Bulk specific gravity, Marshall stability and flow testing shall be performed 24 hours after the briquettes have been compacted.
4. Flow shall be measured using flow meters on each guide rod. The average flow value is recorded if hand flow meters are used. Please specify if some other method is being used.

#### To be reported:

The average bulk density of briquettes:

- 4 briquettes - Hand compacted, unsupported.
- 4 briquettes - Mechanically compacted.

Marshall stability (kN) and flow (mm) of briquettes:

- 4 briquettes - Hand compacted.
- 4 briquettes - Mechanically compacted.

#### Mechanical Compaction Equipment Data

- number of blows
- mass of compaction hammer (kg)
- drop of hammer (mm)
- type of spring in hammer
- thickness of compaction foot (mm) high and low thickness if bevelled
- base (rotating or stationary)
- type and trade name of mechanical compactor (e.g., home-made, Soiltest, Pine Instrument, double acting, etc.).

#### Calculated Data

The calculated Marshall Mix Design characteristics for percent voids in the mineral aggregate (VMA), percent air voids and percent voids filled is to be reported for each of the four hand compacted briquettes and the four mechanically compacted briquettes.



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The calculations shall be done using the bulk density of the aggregate, the bulk density of the compacted mixture and the maximum theoretical density of the asphalt-aggregate mixture that your laboratory has submitted.

#### Data

All tests and calculation sheets shall be submitted for a review. In those cases where calculations are prepared by a computer, a copy of the printout shall be submitted.

#### F. Submission of Data

##### Submission Date

**All data must be returned by March 25, 2011.**

##### Submission

Please submit completed test results sheet and direct all questions to:

**Magdy Beshara, P.Eng.**  
**Saskatchewan Ministry of Highways and Infrastructure**  
**1610 Park Street**  
**REGINA SK S4N 2G1**  
**Phone: (306) 787-4922**  
**Fax: (306) 787-4582**  
**Our web site address: [www.highways.gov.sk.ca/camp/](http://www.highways.gov.sk.ca/camp/)**

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### FORMULAE



#### VOIDS IN MINERAL AGGREGATE (VMA), by dry weight of aggregate:

$$VMA = 100 - \left( \frac{G_{mb}}{G_{sb}} \times \frac{100}{100 + P_b} \right) \times 100$$

#### AIR VOIDS:

$$AV = 100 \times \left( 1 - \frac{G_{mb}}{G_{mm}} \right)$$

#### VOIDS FILLED WITH ASPHALT:

$$VF = \left( \frac{VMA - AV}{VMA} \right) \times 100$$

#### % WATER ABSORPTION

$$\text{Water Absorption} = \left( \frac{B - A}{A} \right) \times 100$$

- Where: .....(Units)
- $G_{mb}$  = bulk density of compacted mixture ..... (g/cm<sup>3</sup>)
  - $G_{sb}$  = bulk density of aggregate ..... (g/cm<sup>3</sup>)
  - $P_b$  = asphalt (% by weight of aggregate) ..... (%)
  - $G_{mm}$  = MTD maximum theoretical density of paving mixture (no air voids) ..... (g/cm<sup>3</sup>)
  - $B$  = weight of saturated surface dry aggregate ..... (g)
  - $A$  = dry weight of aggregate ..... (g)

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### DATA COLLECTION AND SUBMISSION FORMS

#### **A. PARTICIPANT DOCUMENTATION**

Agency/Company \_\_\_\_\_  
\_\_\_\_\_  
Address \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
Contact Person \_\_\_\_\_  
Telephone No. \_\_\_\_\_  
Fax No. \_\_\_\_\_  
E mail \_\_\_\_\_

#### **B. SAMPLE DOCUMENTATION**

Date Samples Received \_\_\_\_\_  
Date Testing Commenced \_\_\_\_\_  
Dated Testing Completed \_\_\_\_\_

#### **C. PARTICIPANT COMMENTS**

Please provide any comments which may be of value to this or future exchanges:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

#### **D. SUBMISSION OF DATA**

Please submit all Data Collection and Test Forms and direct any questions to:

Magdy Beshara, P.Eng.  
Saskatchewan Ministry of Highways and Infrastructure  
1610 Park Street  
REGINA SK S4N 2G1  
Phone: (306) 787-4922  
Fax: (306) 787-4582

**2011 Canadian Asphalt Mix Exchange Program Data**

**Lab Name:**

**Briquette Data**

Method of Compaction	Briquette Number	Bulk Density (g/cm <sup>3</sup> )	Marshall Stability (kN)	Flow (mm)	V.M.A. (%)	Air Voids (%)	Voids Filled with Asphalt Cement (%)
Hand 75 Blows (@135°C)	1						
	2						
	3						
	4						
	Average						
Mechanical _____ Blows (@135°C)	1						
	2						
	3						
	4						
	Average						

**Bulk Density of Aggregates**

Aggregate (ASTM C127) (+5.00 mm) (g/cm <sup>3</sup> )	Trial Number 1	Trial Number 2	Trial Number 3	Average
Aggregate (ASTM C128) (- 5.00 mm to +75 μm) (g/cm <sup>3</sup> )	Trial Number 1	Trial Number 2	Trial Number 3	Average
Filler (ASTM D854) (-75 μm) (g/cm <sup>3</sup> )				Average
				2.700
Bulk Aggregate Density based on 35.1% Coarse, 59.7% Fine, 5.2% Filler (g/cm <sup>3</sup> )				

**Water Absorption**

Average (+5.00 mm) (ASTM C127) (%)	Trial Number 1	Trial Number 2	Trial Number 3	Average
Average (- 5.00 mm) (ASTM C128) (%)	Trial Number 1	Trial Number 2	Trial Number 3	Average
Combined Water Absorption (35.1 Coarse / 64.9 Fine) %				
Maximum Theoretical Density (g/cm <sup>3</sup> )	Trial Number 1	Trial Number 2	Trial Number 3	Average

Asphalt absorption using the theoretical maximum specific gravity of the asphalt aggregate mixture shall be determined as specified in ASTM D4469 Standard Test Method for CALCULATING PERCENT ASPHALT ABSORPTION BY THE AGGREGATE IN AN ASPHALT PAVEMENT MIXTURE.

Asphalt cement absorption (%)

**MECHANICAL COMPACTOR DATA**  
(include photo - optional)

Mass of Compaction Hammer (s) – kg \_\_\_\_\_

\_\_\_\_\_

Drop of Hammer (s) - mm \_\_\_\_\_

\_\_\_\_\_

Type of Spring in Hammer \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Thickness of Compaction Foot - mm (high and low thickness of bevel) \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Base - Rotating or Stationary \_\_\_\_\_

Type and Trade Name of Mechanical Compactor \_\_\_\_\_

\_\_\_\_\_

Other Comments: \_\_\_\_\_

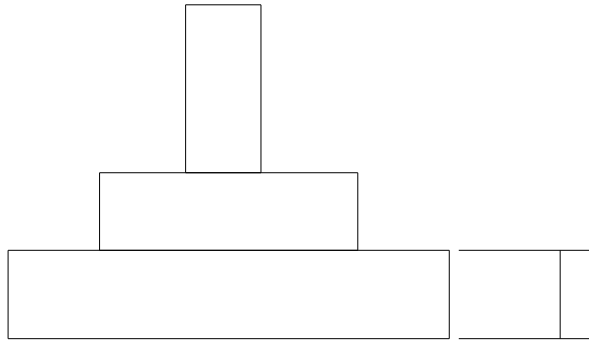
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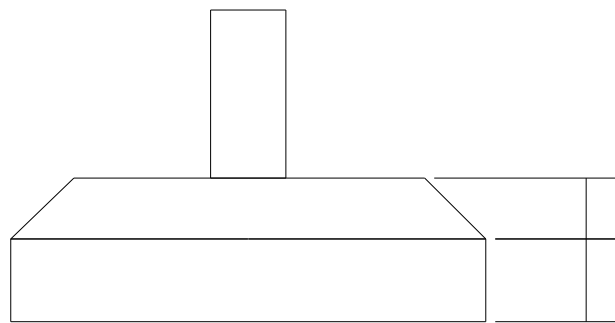
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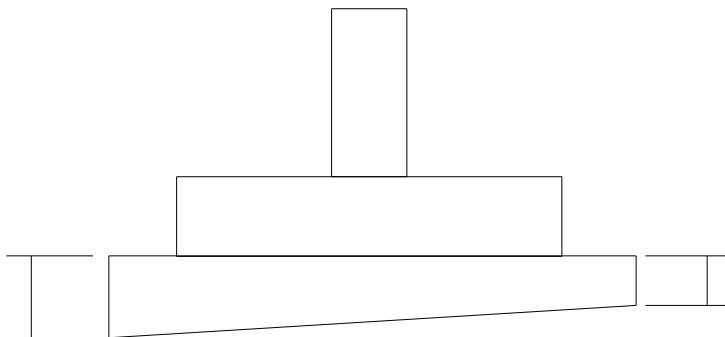
# Thickness of Compaction Foot



Remarks:



Remarks:



Remarks:

Enter dimensions (millimeters) of applicable compaction foot.