DESIGN OF ASPHALTIC CONCRETE FRICTION COURSE
(An Arizona Method)

Scope

1. This test method provides a means of determining the design bitumen content and the density of an asphalt concrete friction course.

Apparatus

2. The apparatus shall consist of the following:

(a) Oven - An oven capable of maintaining temperatures between 230° F. and 325° F.

(b) Testing Machine - 25,000 lb. capacity minimum, and capable of a head speed of 0.2 inches per minute.

(c) Molds - Molding cylinders, and top and bottom molding plungers; the cylinders shall be 4.000 ± 0.005 inches inside diameter by 6 inches in height. The top and bottom plungers shall be 3.990 ± 0.005 inches in diameter, the bottom plunger shall be approximately 2 inches in height and the top plunger shall be approximately 6 inches in height. A baseplate approximately 8" x 8" shall be provided to hold mold and plunger assembly.

NOTE: *Molding cylinders shall be marked with tare wt. to nearest 0.1 gram and inside diameter which has been determined to the nearest 0.001 inches.*

(d) Support Bars - Steel bars one inch square to raise mold cylinder during molding operation.

(e) Balance - A balance with a capacity of 5000 grams and a sensitivity of 1 gram.

(f) Miscellaneous spoons, spatulas, scoops, pans, etc.

Mineral Aggregate Requirements

3. The mineral aggregate for asphaltic concrete friction course shall be tested for compliance to the project requirements for:

(a) Gradation (ARIZ 201).

NOTE: *The mineral aggregate shall meet specified composite requirements.*

(b) Plasticity Index (AASHTO T90).

(c) Crushed Faces (ARIZ 212).

(d) Abrasion (AASHTO T96).

(e) Limestone Content (ASTM D 3042).

NOTE: *The above tests may be added upon or deleted as required by the specifications of the project.*

Aggregate Specific Gravities and Absorption

4. (a) The specific gravities (Bulk Oven Dry Basis (O.D.), Saturated Surface Dry Basis (S.S.D.) and Apparent Basis (App.)) and absorption of the fine and coarse mineral aggregate shall be determined in accordance with ARIZ 211 and AASHTO T85 respectively.

(b) The O.D., S.S.D., and App. Combined specific gravities are calculated by the following:

$$\text{Combined Specific Gravity} = \frac{P_1 + P_2}{\frac{P_1}{G_1} + \frac{P_2}{G_2}}$$

Where: P_1, P_2 = weight percent of coarse aggregate (plus No. 4) and fine (Minus No. 4) aggregate, respectively.

G_1, G_2 = specific gravity of coarse and fine aggregate, respectively.

Example:

$$\text{Combined O.D. Specific Gravity} = \frac{54 + 46}{\frac{54}{2.541} + \frac{46}{2.519}} = 2.531$$

Combined Absorption =

$$\frac{\left(\begin{matrix}\text{Combined S.S.D.}\\ \text{Sp. Gr.}\end{matrix}\right) - \left(\begin{matrix}\text{Combined O.D.}\\ \text{Sp. Gr.}\end{matrix}\right)}{\text{(Combined O.D. Specific Gravity)}} \times 100$$

Example: (Combined S.S.D. = 2.580, Combined O.D. = 2.531)

$$\text{Combined Absorption} = \frac{2.580 - 2.531}{2.531} \times 100 = 1.94\%$$

Determination of CKE Factor for Coarse Aggregate

5. The K_c value shall be determined in accordance with ARIZ 805.

Bitumen Content Determination

6. (a) Bitumen content will be determined as follows:

$$B = (1.5\ K_c + 3.5)\ \frac{2.650}{G_{ag}}$$

Where: B = bitumen content expressed as a percent of the total mix.

K_c = factor for coarse material from ARIZ 805.

G_{ag} = Combined O.D. specific gravity of the aggregate as determined in Section 4 of this procedure.

Preparation of Bulk Density Specimens

7. (a) Three samples of aggregate shall be prepared in the grading determined, each weighing 950 grams. The aggregate samples shall be heated to constant weight at the temperature required for the asphalt being used as shown in paragraph (b).

(b) The temperature of the asphalt at the time the mixing begins shall be in accordance with the following:

Grade	Temperature Range Degree F.	(Degree C.)
AR-2000	250 (121)	275 (135)
AC-20, AR-4000	275 (135)	300 (149)
AC-30	300 (149)	325 (163)
AC-40, AR-8000	300 (149)	325 (163)

(c) Place a large mixing bowl which has been heated to 230° F. on the balance and tare, transfer the heated aggregates to the bowl and add a small amount of -#4 "blend" material to bring weight to 950 grams.

(d) Pour the required amount of asphalt, as determined in Section 6, on the aggregate.

(e) Hand mix thoroughly with a heated spoon.

(f) Place the mixed sample into a 230° ± 5° F. oven until a constant temperature is attained (approximately one hour). Also place a mold and bottom plunger for each mixture into oven and heat to 230° ± 5° F.

(g) Remove bottom plunger and mold cylinder from oven, place mold assembly on baseplate (bottom plunger in place with mold cylinder supported on the two steel bars). Place paraffin coated disc on bottom plunger to prevent material from adhering to plunger. Place all of the mixture into molding cylinder and spade mixture vigorously with heated spatula or similar flat object, 15 times around the edge of the mold and 10 times at random into the mixture, penetrating mixture to the bottom of the mold. The top of the mixture should be slightly rounded to aid in firm seating of the upper plunger.

(h) Place a paraffin coated disc and then the upper plunger (which has been preheated) on the sample and compress the mixture under an initial load of 150 psi, to set it against the sides of the mold. Remove the support bars and permit full double-plunger action. Apply the load to the mixture at a rate of 0.2 inch per minute until a load of 2000 psi is reached. Hold the load at 2000 psi for 2 minutes.

(i) After compaction the top plunger is removed along with the paraffin disc leaving the bottom plunger in place to support specimen until cool as specified in paragraph (k).

(j) Repeat the procedure as described in paragraphs (c) through (i) above, for the other two samples.

(k) Allow specimens to cool in the mold with bottom plunger in place until they can be handled easily with the bare hand.

NOTE: *Cooling may be achieved by the use of 77° F. air bath, or if more rapid cooling is desired fans may be used.*

Bulk Density Determination

8. (a) After the specimens have cooled, remove the bottom plunger and paraffin disc and determine the weight of each mold with specimen to the nearest 0.1 gram. The weight of each specimen is calculated by subtracting the tare weight of the corresponding mold cylinder.

(b) While the specimens are still in the molds, the heights of the three specimens are determined to the nearest 0.001 inch.

(c) The inside diameters of the three molds used are determined and recorded to the nearest 0.001 inch.

(d) The bulk density is determined for each specimen by the following:

$$BD = \frac{W}{\left(\frac{d}{2}\right)^2 (h)\ (51.49)} \times 62.3$$

Where:

BD = Bulk Density of the specimen, expressed in pounds per cubic foot

W = Weight of specimen, grams

h = Height of specimen, inches

d = Inside diameter of mold, inches

(e) The average bulk density of the three specimens is then determined and recorded.

(f) Extrude specimens from molds and clean apparatus.

Example and Report

9. An example of the calculations is shown in Figure 1. The composite grading of the aggregate, results for specific gravity/absorption, K_c determination, calculations for the asphalt content and the results of the average bulk density determination shall be reported on the Bituminous Mixture Design Laboratory Card as shown in Figure 2.

Mold #	Tare Wt.	Inside Dia.	$(d/2)^2$
1	3694.8	4.001	4.002
2	3709.1	3.999	3.998
3	3702.6	4.003	4.006

Equation for Bulk Density:

$$BD = \frac{\text{Wt. of Spec.}}{(d/2)^2 (\text{Ht. of Spec.})(51.49)} \times 62.3$$

Date	Lab No.	% Asph.	Mold / Spec. No.	Inside Dia. of Mold	Height of Spec.	Wt. of Spec. & Mold	Wt. of Mold	Wt. of Spec.	Bulk Density lbs/cu.ft.	Avg. Bulk Density lbs/cu.ft.	Int.
12/25/88	88-9999	5.7	1	4.001	2.469	4682.9	3694.8	988.1	121.0	121.4	J.T.
			2	3.999	2.470	4703.5	3709.1	994.4	121.8		
			3	4.003	2.462	4693.0	3702.6	990.4	121.5		

FIGURE 1

†●44-2901 R7/81

☐ INITIAL ☐ FINAL ☐

MATERIALS SECTION
LABORATORY BITUMINOUS MIXTURE DESIGN

Pit No. DIXON & VIXON GRAVEL
Blend
Asphalt Source ARTIC REFINERY

Received 12-13-88	Test Commenced 12-13-88	Material MA-ACFC
Identification	Sampled 12-10-88	Lab. No. 88-9999
Submitted by	Sampled by CLAUS	Project No M-222-333
Source of Sample STOCKPILES	Quantity	
Location of Supply DIXON AND VIXON GRAVEL		
Project Name NORTH POLE LANE - ELF DRIVE	Contractor ICE CAP PAVING	
Specifications Governing	Mix Design Request No.	

	MATERIALS SURVEY (PE) PRELIMINARY DESIGN GRADING						AS PRODUCED (CONSTRUCTION) FINAL ADJUSTED DESIGN GRADING				
	ORIG. PIT AVERAGE		CRUSHED GRADATION		ADJ. CRUSH GRADATION		AS CRUSHED ON PROJECT COMPOSITE		AS ADJ. IN LABORATORY COMPOSITE		SPEC. LIMITS
Sieve	% Ret	% Pass	% Ret	% Pass	% Ret	% Pass	% Ret	% Pass	% Ret	% Pass	
3" Slot									COARSE 85 %		
3"									FINE 15 %		
2½"									%		
2"									%		
1½"									%		
1"											
¾"											
½"											
⅜"									0	100	100
¼"									26	74	
No. 4									28	46	30-60
8									36	10	7-15
10									2	8	
16									2	6	
30									1	5	
40									0	5	
50									1	4	
100									1	3	
200									0	2.6	0-4.0

O.D. SP. GR. COARSE	2.541	O.D. SP. GR. FINE	2.519	O.D. SP. GR. COMB.	2.531	
S.S.D. SP. GR. COARSE	2.584	S.S.D. SP. GR. FINE	2.575	S.S.D. SP. GR. COMB.	2.580	
APP. SP. GR. COARSE	2.655	APP. SP. GR. FINE	2.667	APP. SP. GR. COMB.	2.661	
ABSORP. COARSE AGGR.	1.70 %	ABSORP. FINE AGGR.	2.21 %	ABSORP. COMB. AGGR	1.94 %	

	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	SAND EQUIV.
NATURAL FINES				
CRUSHED FINES			NP	
COMBINED FINES				

ABRASION (A, B, C, D): 100 REV. 4 % LOSS 500 REV. 19 % LOSS CRUSH.FACES 92 % LIMESTONE 0.13 %

REMARKS

$B = (1.5\ K_c + 3.5)\ 2.650 / G_{AG} = (1.5 \times 1.3 + 3.5)\ 2.650 / 2.531 =$
$= 5.7\%$

BD = 121.4 lbs. / CU. FT.

DESIGN DATA
(SEE BACK FOR CHARTS)

SPECIMEN	A	B	C	D	E	F	DESIGN SPEC
BIT.GRADE/SPECIFIC. GRAVITY	AC 20						
% OF BIT.	5.7						
BULK DENSITY LBS. PER CU. FT.	121.4						
MARSHALL STABILITY							
FLOW							
HVEEM STABILITY							
COHESION							
% AIR VOIDS							
% V.M.A.							
% AIR VOIDS FILLED							
% EFFECT ASPHALT TOTAL MIX							

SAMPLE	AIR PSI	H_2O PSI	RETENTION	ARIZ 802 MINIMUM RETENTION % / H_2O PSI MINIMUM 150
No. 1			%	% ASPHALT
No. 2			%	%
No. 3			%	%
No. 4			%	%
No. 5			%	%
No. 6			%	%

MAX. DENSITY LBS. PER CU. FT @ % ARIZ 806 (RICE TEST)

ASPHALT ABSORP. ON DRY AGGREGATE %

AGG. SURFACE AREA- SQ.FT./LB. FILM THICKNESS MICRONS

C.K.E. VALUES - ARIZ 805 F = F(CORR.)= C = 3.1 C(CORR)= 3.0

Kf = Kc = 1.3 Km =

BIT GRADE RECOMMENDED BITUMEN %

RECOMMENDED BITUMEN CONTENT CONSIDERING ALL TEST DATA 5.7 %

MIX DESIGN GRADATION TARGET VALUES

Sieve	% Pass
1"	100
¾"	
½"	
⅜"	
No. 4	
8	
40	
200	

FIGURE 2