Moisture Susceptibility Behavior of Asphalt Concrete and Emulsified Asphalt Mixtures Using the Freeze-Thaw Pedestal Test

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Moisture-induced damage to asphalt concrete pavements, often attributable to stripping, is a recurrent problem because of the several variables involved. Many different tests are used to determine the moisture susceptibility of an asphalt mixture. Nevertheless, some are subjective and not suitable for evaluating individual aggregate components; whereas others have poor reproducibility, and no reasonable correlations with field performance can be obtained. At present many road test laboratories are using the Texas Boiling Test and Lottman's Tensile Strength Ratio. Plancher et al. have developed the Freeze-Thaw Pedestal Test, which is a simple laboratory test with a high degree of reproducibility. This test maximizes the effects of moisture at extreme temperatures and minimizes the effects of the mechanical properties of the mix (interlocking, density, gradation, etc.). Tests were conducted using different aggregates and types of bitumen: paving grade asphalt cement AC 70/100 and two types of asphalt emulsions—anionic slow-setting and cationic slow-setting. Results from these studies show the potential of this test in determining the susceptibility of cold and hot asphalt mixtures to moisture damage.

The durability of bituminous paving mixtures, such as hot asphalt concrete and emulsion paving mixtures, is influenced by securing and maintaining adhesion properties between the bitumen and the aggregates in the presence of water.

The stripping of bitumen from aggregate—that is, moisture-induced damage—is defined as the loss of the adhesive bond between asphalt and the aggregate surface resulting from the detrimental action of water. This damage may be more severe where freeze-thaw-heat cycles occur.

The effects of moisture and repeated freeze-thaw cycles on both hot and cold bituminous mixtures are analyzed with the Freeze-Thaw Pedestal Test (FTPT) developed by Plancher et al. (*1*). The FTPT is a water susceptibility test that indicates the susceptibility of asphalt-aggregate mixtures to repeated freeze-thaw cycles; it was developed for evaluating hot asphalt mixtures. In the present paper hot asphalt concrete and cold emulsified asphalt mixtures were evaluated using the FTPT with some modifications to original test procedures; the particular characteristics of cold asphalt mixes were taken into account.

The test variables of primary concern in this work are the type of binder, the type of aggregates and their gradation, the permeability of the briquets, the briquet thickness, asphalt content, the steps of briquet fabrication, mixing, compaction and curing, freezing temperatures, and length of the freeze-thaw cycle.

As a result of this study, hot and cold asphalt mixes can be evaluated using the FTPT from a point of view that takes into account moisture-induced damage. This test was found capable of distinguishing between stripping and nonstripping mixtures prepared with different aggregates for bituminous mixtures with asphalt cement or with emulsified asphalt.

GENERAL CONSIDERATIONS

The water susceptibility test (WST) proposed by Plancher et al. (*1*) was designed to evaluate the detrimental effects of moisture and repeated freeze-thaw cycles on bituminous mixtures. It is a simple laboratory test that shows a high degree of reproducibility if much care is taken during the fabrication of briquets.

This test maximizes the effects of moisture damage on bituminous mixtures and minimizes the effects of mechanical interlocking of the aggregate particles. The WST uses a miniature briquet that must be permeable to water. The properties of the specimen are primarily determined by the properties of the asphalt-aggregate bond if mechanical properties of the briquets are not present.

This test procedure has been applied to a variety of materials, including new and old pavement mixtures, and to the evaluation of the potential effectiveness of antistripping agents and emulsified asphalt types in cold mixtures.

Uniform aggregate size is used to produce a briquet with high voids permitting ready access by water to the asphalt-aggregate bond sites during repeated freeze-thaw cycles.

TEST PROCEDURES AND THEIR VARIABLES

In the FTPT, small cylindrical briquets measuring 41.33 mm (1.63 in.) in diameter and 19.05 mm (0.750 in.) in height are prepared from mixtures with aggregates produced by crushing to a size that passes the No. 20 (0.850-mm) sieve and is retained on the No. 35 (0.500-mm) sieve. This aggregate fraction is washed with distilled water and dried in an oven for 4 hr at 150°C before being coated with the bitumen. The asphalt is

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heated for 1 hr at 150°C. The mixture is mixed, reheated, and remixed three times; then cooled to room temperature.

The mixture is then heated for 20 min, placed in a cylindrical mold, and compacted at a constant load of 6,200 lb (2,812 kg) for 20 min. The briquet is cured at ambient temperature for 3 days before being subjected to freeze-thaw cycling.

The briquet is then placed on a stress pedestal in a large, deep Pyrex dish covered with distilled water and is subjected to cycles of 24 hr at − 12°C followed by 24 hr at 60°C. At the end of each cycle the surface of the specimen is inspected to determine if the briquet presents cracks. The number of freeze-thaw cycles that briquets resist without cracking is used as a measure of their resistance to water damage.

Many variables are present in the test, and great care must be taken to determine that duplicate briquets fail on identical freeze-thaw cycles.

Mechanical interlocking, density, porosity, permeability, bitumen content, aggregate size and type, aggregate coating, compactive effort and temperature of compaction, briquet thickness, and freezing temperatures are the variables discussed below. In Figure 1 a cylindrical mold, a stress pedestal, and a briquet used in the FTPT can be seen.

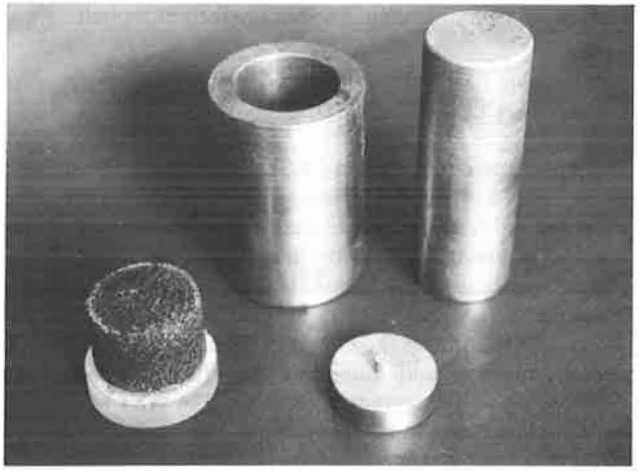

FIGURE 1 Cylindrical mold, stress pedestal, and cracked briquet used in freeze-thaw pedestal test.

EXPERIMENTAL

Materials: Aggregates and Binder Type

Aggregate type and size are most important variables since mineralogical composition, particle texture, and shape usually determine the aggregate-bitumen bond properties. In this work five different aggregates, each of four sizes, were examined from the moisture damage point of view.

Aggregate types and properties are given in Table 1. They are granite (high silica content), quartzite (high siliceous), basalt (medium siliceous), dolomite (high calcareous), and natural rounded gravel. The last aggregate presents plasticity. Additionally, aggregates from two field projects, crushed granite and crushed quartzite sands mixed with natural sand, were tested (Table 2).

Paving grade asphalt cement for hot mixes was an AC 70/100. Two types of emulsions were used in these tests. The first was anionic slow-setting emulsion SS-1; the second was cationic slow-setting emulsion CSS-1h. Properties of all binder types are given in Table 3. Generally both emulsions meet the requirements in ASTM specifications for cationic or anionic emulsified asphalts.

Test Data and Discussion of FTPT Procedures

As has already been pointed out, five mineral aggregates from different sources of Argentina that have been used extensively for asphalt concrete mixtures were tested by the FTPT in order to discover whether or not mixtures strip.

Two field projects (one that exhibited stripping and one that did not) were examined—first, with the materials combined in the proportions used in the field and then, with the individual components of an aggregate mixture—to determine their water susceptibility.

The asphalt cements were the same as those used for the construction of corresponding pavements. The materials used in the two field projects were combined in proportions corresponding to the design mixture and tested to determine their resistance to stripping. The stripping mixture was from R.P. 85 Guaminí-Salliqueló Road of the Province of Buenos Aires. The other project was from R.P. 88 Chivilcoy-Moll Road of the same province. The stripping materials cracked in less

TABLE 1 PROPERTIES OF MINERAL AGGREGATES

	Aggregate type				
Properties	Granite	Quartzite	Dolomite	Basalt	Gravel
Specific Gravity	2.63	2.67	2.82	2.97	2.67
Water absorption,%	0.70	0.91	0.33	0.56	0.75
Sand Equivalent,%	78.00	72.00	69.00	70.00	49.00
L.A.Abrasion Loss,%	25.00	42.00	18.00	19.00	29.00
CKE,%	3.1	4.2	4.6	2.8	3.8

TABLE 2 FIELD PROJECTS DATA

Road	Aggregate type	mix proportion,%	mix cycles	individual cycles
RP 88	crushed granite	69.9	12	11
	siliceous sand	14.2		10
	natural sand	10.9		4
	asphalt cement	5.1		
RP 85	crushed quartzite	76.9	2	1
	siliceous sand	18.0		10
	asphalt cement	5.1		

Note: the cycle length was 36hs, freezing at -12ºC for 12hs and thawing at 60ºC for 24hs.

than 2 cycles, whereas the nonstripping ones required more than 12 cycles to fail.

The stripping aggregate was a quartzite crushed sand, and the nonstripping one was a granite crushed sand; both were mixed with siliceous sand and natural rounded sand. In Table 2 materials and their proportions in the mixes are tabulated with the test results of each of the individual aggregates of the mixtures.

With regard to the five mineral aggregates cited earlier, replicate briquets of each one were tested. Asphalt concrete and bituminous cold mixtures were prepared with the different mineral aggregates. Test results are tabulated in Table 4 for hot mixes elaborated with the different aggregates. Nonstripping mixtures failed at more than 10 cycles, whereas mixtures that exhibit stripping cracked in fewer than 2 cycles.

Granite and basalt aggregates show good bonding properties with the AC 70/100 employed; however, quartzite, dolomite crushed sands, and natural rounded gravel exhibit poor adhesion with the asphalt cement. In these cases the addition of 1 percent hydrated lime was enough to restore the bonding properties of quartzite and dolomite sands. With natural rounded gravel, the addition of 0.5% amine additive was necessary to restore bonding properties.

As can be seen, the well-known and often quoted rule that acidic aggregates (high silica content) are vulnerable to stripping whereas basic aggregates (low silica content, high calcareous content) are not is quite wrong.

Briquet densities varied in a range of 1.84 g/cu cm (quartzite) to 2.10 g/cu cm (basalt), and the porosities (that is, the void content) varied between 17.8 and 21.7 percent with 2,812-kg load compaction in the different mixtures prepared.

A briquet thickness of 2.0 cm was adopted, but this thickness varied with the type of aggregate analyzed, as can be seen in Table 4.

Poor reproducibility of results between replicate briquets has been observed when the quantity and rate of heat loss varied during the oven and compaction times. In cold mixtures poor reproducibility has been detected when the fluid content at compaction in replicate mixtures varied slightly.

When emulsified asphalt mixtures were prepared with hydrophilic aggregates, they showed surprisingly good bonding properties. This may be partly explained by the beneficial effect of the emulsifier agents of the emulsions. Moreover, the number of cycles for failure of these briquets was higher than in the case of hot asphalt mixtures. This is discussed later.

With regard to the original test procedures with hot mixtures some modifications have been made. The aggregates were used without washing prior to mixing because field aggregates are not always washed prior to mixing and because surface coatings contribute to stripping.

The original procedure specified that the mix is mixed at 150°C, reheated and remixed two more times, and then cooled to room temperature. The mix is then reheated for 20 min, placed in a cylindrical mold, and compacted at 2,812 kg for 20 min. In this laboratory the mixtures were not reheated and remixed twice more because this procedure could lead to the unrealistic absorption of asphalt to particle aggregate.

Twenty minutes of compactive effort were considered excessive. After 10 min the mixture was cooled in the mold and the briquet was then removed. No difference in results was observed with either 10 or 20 min of compaction.

The original test procedure specified that the aggregate should be crushed to produce a material passing a No. 20 (0.833-mm) Tyler Series sieve and retained on the No. 35 (0.417-mm) Tyler Series sieve. In the present work material between the No. 20 (0.840-mm) U.S. Standard Series sieve and the No. 40 (0.420-mm) U.S. Standard Series sieve was used because those sieve openings are quite similar and the Tyler Series sieve is not currently used in this country.

A Study of the Test Variables

The FTPT procedure presents many significant variables: aggregate grading, asphalt content and type, briquet thickness, freezing temperatures and length of freeze-thaw cycles,

TABLE 3 ASPHALT CEMENT AND EMULSIFIED ASPHALT PROPERTIES, AC 70/100 PAVING ASPHALT CEMENT

Penetration,25°C,100g,5sec	82
Ductility,25°C,5cm/min,cm	150+
Specific gravity	1.025
Solubility in Trichloroethylene,%	99.7
Viscosity,60°C,Poises	2012
Viscosity,135°C,cSt	415
Ash Content,%	0.33
Rostler	
Asphaltenes,%	15.1
Nitrogen Bases,%	22.4
1st Acidaffins.%	25.4
2nd Acidaffins,%	25.4
Paraffins,%	11.7
Parametral relationship	1.29

Emulsion grade	CSS-1h	SS-1
Viscosity,Saybolt Furol,25°C	54	19
Settlement,5-day,%	0.4	1.6
Cement mixing test,%	0.4	0.1
Sieve Test,%	0.03	0.01
Residue,%	62.5	58.5
On the residue		
Penetration,25°C,100g,5sec	74	143
Ductility,cm	150+	150+
Solubility in Trichloroethylene,%	99.4	99.6
Viscosity, 60°C, Poises	2475	636
Viscosity,135°C,cSt	460	247

mixing, compaction, and permeability of briquets. They are now discussed.

Aggregate Grading

Four different aggregate gradings used in this study were tested to determine if results obtained using gradings other than those specified by the test could give similar results. Some differences emerged in the results from specimens prepared with material passing the No. 8 (2.32-mm) sieve and being retained on the No. 16 (1.19-mm) and material passing the No. 16 sieve and being retained on the No. 30 (0.590-mm) sieve, with materials between No. 20 (0.840-mm) and No. 40 (0.42-mm) sieves, and with materials between No. 40 and No. 80 (0.177-mm) sieves (see Table 5).

Mixtures with an aggregate size between the No. 8 and No. 16 sieves and between the No. 16 and No. 30 sieves in hot mixes cracked in fewer than 2 cycles with nonstripping aggregates, whereas mixtures prepared with a grading between the No. 20 and No. 40 sieves, and between the No. 40 and No. 80 sieves, required more than 10 cycles to fail.

When using a gradation between the No. 40 and No. 80 sieves, a greater percentage of asphalt cement was needed, the mix results were more dense, and their permeability decreased. The 40-80 fraction is a useful tool, however, to evaluate finer materials present in the mixture design.

TABLE 4 FREEZE-THAW PEDESTAL TEST RESULTS, IN HOT MIXTURES

	Granite	Quartzite	Basalt	Dolomite	Gravel
Cycles.................	10	2/16	14	2/13	1/14
Thickness,cm...........	2.3	2.3	2.0	2.1	2.3
Briquet weight,gr......	60	60	60	60	60
Asphalt content,* %....	7	8	7	8	8
Density,gr/cm^3.........	1.91	1.87	2.10	2.04	1.93
Voids content,%........	19.1	20.8	19.8	17.8	19.2
Hydrated lime,%........	0	0/1	0	0/1	0
Amine additive,%.......	0	0	0	0	0/0.5

Note: *asphalt content by weight of mix. Quartzite,Dolomite and Gravel sands resist 2 cycles without any addition. With the addition of 1% of hydrated lime on Quartzite and Dolomite the resistance is more than 13 cycles. With the addition of 0.5% of an amine additive on gravel,its resistance was more than 13 cycles. Total cycle length was 36hs.

TABLE 5 EFFECT OF AGGREGATE GRADATION ON NUMBER OF CYCLES REQUIRED TO BRIQUET FAILURE

Gradings between sieves,	Granite	Quartzite	Basalt	Dolomite	Gravel
Nº 8 - Nº16	1	1	1	1	1
Nº16 - Nº30	4	1	3	2	1
Nº20 - Nº40	10	13*	14	14*	13*
Nº40 - Nº80	9	14*	13	13*	15*

Note: mixtures compacted at 2812Kg, 150ºC with 7% asphalt content.

*1% hydrated lime added.

Total cycle length: 36hs, freezing at -12ºC for 12hs and thawing at 60ºC for 24hs.

Bitumen Content

An asphalt cement content determined from the optimum of the Marshall mixture design is recommended in the original FTPT (*1*). Kennedy et al. (*2*) found that an additional 2 percent asphalt content beyond the Marshall or Hveem optimum was needed to solve the aggregate coating problem because of the large surface area of the finer aggregates normally used in the test.

It is considered that to maximize asphalt-aggregate bond effects, uncoated mineral aggregate particles are undesirable. Consequently, a larger percentage of asphalt cement was adopted to achieve a total aggregate coating.

From the results assembled in Table 4 with asphalt mixtures prepared with different aggregates, the optimum asphalt content seems to be between 7 and 8 percent for a 20-40 aggregate size with granite and basalt, and with the previous addition of 1 percent hydrated lime for quartzite and dolomite and a 0.5 percent amine additive for natural gravel. Any other asphalt content resulted in a smaller number of cycles for cracking the briquets (Table 6). At high asphalt content the briquet cracking is probably due to the loss of cohesion of the asphalt cement.

Briquet Thickness

This variable, tabulated in Table 7, shows that thicker briquets, with 7 percent of asphalt content and various types of aggregates, are more resistant to the freeze-thaw cycles than thinner briquets. A 2-cm thickness was adopted in spite of its variation with the type of aggregate.

Plancher suggests the use of greater thickness in briquets that without stripping fail at only one cycle. However, a bri-

TABLE 6 EFFECT OF ASPHALT CONTENT

Asphalt content by wt.of mix,%	Granite	Quartzite*	Basalt	Dolomite*	Gravel*
5.0	2	1	1	1	1
7.0	10	5	14	2	1
8.0	10	14	16	13	18
9.0	8	15	15	12	14
11.0	5	6	9	7	5
17.0	1	1	1	1	1

Note: briquets weight of 60gr; *1% hydrated lime added. 36hs total cycle length.

TABLE 7 EFFECT OF BRIQUET THICKNESS

Weight,gr	thick,cm	Granite	Quartzite*	Basalt	Dolomite*	Gravel*
45	1.9	4	2	3	2	1
50	2.0	10	16	14	13	12
55	2.1	11	17	12	13	14
60	2.2	13	17	15	16	15
70**	2.6	16	20	17	18	17

Notes: mixtures prepared with 7% of AC 70-100, *1% hydrated lime added. **Mixtures compacted with double-plunger static load.

Total cycle length of 36hs, freezing at -12ºC for 12hs and thawing at 60ºC for 24hs.

quet thickness greater than 2.3 cm produces a deficient compaction with a 2,812-kg single-plunger static load. A 2,812-kg, double-plunger static load would be needed to obtain reliable values in these cases on the FTPT results.

Freezing Temperatures and Freeze-Thaw Cycle Length

A set of briquets was frozen at different temperatures between −7°C and −18°C, and no noticeable differences were detected in the results (Table 8). The minimum temperature necessary to freeze the water within the specimens seems to be enough to conduct a water susceptibility test.

Kennedy recommends a cycle consisting of freezing at −12°C for 12 hr and thawing at 49°C for 12 hr in order to shorten the original cycle length of 48 hr. See Table 9 for effects of cycling durations.

A series of briquets was tested at freeze-thaw cycles with lengths of 24 hr, 36 hr, and 48 hr. Table 10 shows that results are quite similar with freeze-thaw cycles of 36 hr and of 48 hr. It is important to note that 12 hr seems to be enough for a freezing cycle, but a heating cycle cannot be shorter than 24 hr for such similarity in results to be obtained.

The briquets always failed at the end of a heating cycle. Here is where differences were encountered because with a 12-hr heating cycle, some briquets did not present cracks or were faintly cracked and the water damage resistance of the briquet seemed to be higher, as a large number of cycles was required.

Consequently, a freeze-thaw cycle of 36 hr consisting of 12 hr of freezing at −12°C followed by 24 hr of thawing at 60°C, has been adopted for the evaluation of asphalt mixtures for water damage at extreme temperatures.

FREEZE-THAW PEDESTAL TEST APPLIED ON EMULSIFIED ASPHALT MIXES

Paving mixtures using emulsified asphalts are being used for both new construction and in the rehabilitation of existing pavements for diverse reasons, including environmental concerns, energy conservation, and ease of construction. The adhesion phenomenon and water effects in these particular mixtures are complex.

The original FTPT was developed for mixtures of aggregates with hot asphalt cement. In cold mixes manufactured

TABLE 8 EFFECT OF FREEZING TEMPERATURES

Freezing Temperature, ºC	Granite	Quartzite*	Basalt	Dolomite*	Gravel*
- 7	10	15	13	12	14
-10	9	16	13	11	14
-12	11	16	14	13	12
-15	10	14	13	12	12
-18	11	15	13	11	13

Notes: mixtures prepared with 7% AC by wt.of mix, weighing 60gr.
*Mixtures with 1% of hydrated lime.
Total cycle length: 36hs.

TABLE 9 EFFECT OF CYCLING LENGTH

Cycle length,hs.							
Freeze	Thaw	Total	Granite	Quartzite*	Basalt	Dolomite*	Gravel*
12	12	24	6	7	9	7	8
12	24	36	10	15	14	13	14
24	24	48	10	14	16	12	13

Notes: mixtures prepared with 7% AC by wt. of mix, weighing 60gr.
*Mixtures with 1% of hydrated lime added.
Total cycle length: 36hs.

TABLE 10 FREEZE-THAW PEDESTAL TEST RESULTS, IN COLD MIXTURES

	Granite	Quartzite	Basalt	Dolomite	Gravel
Cycles................	10	19	20	16	15
Thickness,cm..........	2.0	2.0	1.9	1.9	2.1
Briquet weight,gr.....	50	50	50	50	50/
Residual AC,*%........	7.5	7.5	7.5	8	8
Premix water,%........	2.0	3.0	2.0	2.0	3.0
Density,gr/cm^3........	2.0	1.88	2.26	2.20	2.04
Voids content,%.......	17.7	19.5	15.8	16.1	16.4

Note: *Residual asphalt content by wt.of the dry aggregate weight.
Total cycle length of 36hs, freezing at -12ºC for 12hs ahd thawing at 60ºC for 24hs.

with emulsified asphalt some cautions must be observed when preparing the briquets.

Briquet preparation mixing wetted aggregates and asphalt emulsions is conducted at ambient temperature. The first condition is that the permeability of the emulsified briquets must be similar to that of the hot asphalt briquets; that is, the water must get into the emulsified asphalt mixture briquet easily.

Briquets prepared from No. 16–No. 30 sieve aggregate-size particles are more suitable for obtaining a permeability similar to that of the hot asphalt mixes because a greater void content is needed because of the normally higher fluid content these mixtures present.

Emulsion mixture variables are aggregate premix water, aggregate coating, emulsion content, fluid content at compaction, compaction load, and curing procedure. The amount of added mixing water needed for good dispersion and the optimum emulsion content for good coating are estimated from trial-and-error tests.

After mixing water was incorporated, emulsified asphalt was added in an amount to give 7.5 percent residual asphalt and was mixed for 0.5 min. Mixtures were qualitatively evaluated for ease of mixing, complete coating, and excess water in the mixture. In the present work 3 percent mixing water for cold mixtures elaborated with cationic emulsions and 2 percent for mixes elaborated with anionic emulsions were found to be the optimum proportions (Table 10).

The proper fluid content at compaction is the same as that for mixing and coating. Pore water pressures that are developed during laboratory compaction help to obtain high void space in spite of the higher fluid content at compaction.

So properties of such briquets were largely determined by properties of the asphalt-aggregate bond. Then the mixture is compacted at 2,812 kg for 10 min or until the water loss cannot be seen through the bottom mold. Immediate extrusion after compaction and oven curing for 1 day at 60°C or until constant weight is reached was adopted.

In Table 10 the results from application of the FTPT to emulsified mixtures elaborated with different aggregates are tabulated. It can be seen that the number of cycles for cracking the briquets is higher than for hot mixtures. The cracks in the briquet surface occur slowly and during 2 or 3 days or more before the briquet fails. Evidently the emulsifying agents of the emulsion have a beneficial effect on the water susceptibility resistance of the mixtures.

Note that hydrated lime was not needed for stripping aggregates when these were integrated with emulsified mixtures with the appropriate emulsion type.

The thawing cycle at 60°C in an oven has a beneficial effect in the residual asphalt emulsion distribution on the aggregate particles, improving aggregate coating. This is probably another factor that contributes to the aggregate-asphalt bond.

SUMMARY AND CONCLUSIONS

1. Five different mineral aggregates that are used extensively for hot and cold asphalt mixtures and two field projects, with stripping and nonstripping materials, were tested using the Freeze-Thaw Pedestal Test to evaluate the water susceptibility of those aggregates when integrated with bituminous mixtures, such as asphalt concrete and emulsified asphalt mixtures. Results from the FTPT provide a good method to evaluate water damage in asphalt mixtures.
2. For hot asphalt mixtures the FTPT should be performed using (a) aggregate sizes in the interval between the No. 20 (0.840-mm) and No. 40 (0.420-mm) U.S. Standard sieves, (b) a compaction load at 2,812 kg for 10 min, (c) a cycle of freezing at −12°C for 12 hr and thawing at 60°C for 24 hr, (d) a total cycle length of 36 hr, and (e) an asphalt content for maximum aggregate coating up to 2 percent higher than the Marshall design, as a guide, but that may vary with aggregate type.
3. For emulsified asphalt mixtures the FTPT should be performed using (a) aggregate sizes in the interval between the No. 16 (1.19-mm) and No. 30 (0.590-mm) U.S. Standard series sieves to obtain ready access of water into the briquets; (b) a compaction load at 2,812 kg at ambient temperature, with 100 percent fluid content, for 10 min, (c) a freeze-thaw cycle of 36 hr, and (d) an emulsified asphalt content that will bring maximum coating of aggregate particles. This content can be estimated by trial-and-error tests on briquets with different emulsion contents and by visually inspecting the aggregates before mixing.
4. The FTPT can be used to evaluate individual aggregates in a mix and the effectiveness of antistripping agents, as well as to select the more appropriate type for each aggregate from the water susceptibility point of view.
5. The aggregate interval between the No. 40 (0.42-mm) and No. 80 (0.177-mm) sieves can be used when individual fine aggregates are present in the mix design and do not fall into the interval between the No. 20 and No. 40 sieves.
6. Further experience is required, including a wider range of aggregates, asphalts, emulsions, and antistripping agents, for studying water damage and understanding the effects of briquet thickness and the mechanistic factors that determine the cycles for failure in the wetness susceptibility test.
7. On the other hand, it is necessary to complement the FTPT with a mechanical structural procedure to take into account the effects of traffic on asphalt-aggregate bond properties.

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