Technical Circular T-14/04

Date: December 2, 2004

To: Director of Construction and Maintenance
Regional Paving Managers
Regional Project Managers
Managers, Field Services
Project Supervisors, Field Services

Subject: Use of Antistrip Additives

Purpose:

The purpose of this Technical Circular is to provide direction on the mitigation of moisture damage of asphalt pavements, with focus on the appropriate use of antistripping additives and to obtain consistency in requesting antistrip additives for provincial asphalt mix designs.

Background:

Asphalt cement is an excellent adhesive and water proofing agent to bind together aggregate particles in asphalt pavements. The asphalt cement adheres very well to most aggregates provided that they are clean, and dry. However, the presence of water can result in problems with the bond between the aggregates and the asphalt cement. Failure of the bond already formed, resulting in the displacement of the asphalt cement from the aggregate, is referred to as stripping. When this occurs, the asphalt pavement will lose rock particles under traffic loads and the result is raveling.

Aggregate rock type has a considerable influence on asphalt cement adhesion due to differences in affinity for asphalt cement. Aggregates with a high silica content (acidic aggregates, quartz rich) are more difficult to coat with asphalt cement and have therefore a higher stripping potential than aggregates with a high carbonate content (limestone or basic aggregates). The role of an antistripping additive is to improve the adhesion of the asphalt cement to the aggregate particles and resist raveling due to moisture action.

Moisture damage resulting in raveling of asphalt pavements is a serious durability problem in British Columbia and especially in areas such as Williams Lake, Smithers, Prince George and in parts of the Kootenays. It has been observed that aggregates from these areas have an inherent moisture susceptibility problem.

The use of antistrip does increase costs by approximately $2.00 per tonne of mix. It has been noted that there has been inconsistent concentrations requested for antistrip on Ministry contracts. Some contracts have requested that antistrip be added at rates varying from 0.25% to 1.0%. Some areas do not need antistrip as well but it has been noted that in some of these areas, antistrip has been requested. Also, our contracting methods have been noted as inconsistent in that some contracts have placed antistrip as incidental to the work while others have paid by the use of provisional sum.

The Benefits of Antistrip

The following conclusions were taken from a report, by P .S. Kandhal and I. J. Richards

1. Good pavement drainage is vital as it has been shown that saturation of asphalt is a primary cause of stripping
2. If subsurface drainage of pavement is inadequate, moisture and or moisture vapor can move upward due to capillary action and saturate the asphalt layer
3. If saturation of the asphalt exists, then stripping is likely and is caused by the mechanical scouring of the binder from the surface of the aggregate due to the extreme cyclic pore water pressure generated by heavy traffic. The potential for premature stripping is enhanced further if the HMA mixture consists of a stripping prone aggregate.
4. Use of an effective antistripping agent in the underlying bottom lift mix and the overlying surface mix is of benefit. Chemical antistrip additives to asphalt cement and also hydrated lime, used as a additive during the crushing operation, have been shown to be effective.
5. The pavement design engineer should evaluate the pavement structural design and condition of all existing pavement courses in terms of stripping and drainage before deciding about the depth of milling or the selection of new asphalt overlays (both type and thickness).

1. P .S. Kandhal and I. J. Richards. Premature Failure of Asphalt Overlays from Stripping: Case Histories, National Center for Asphalt Technology NCAT Report No. 2001-1, April 2001.

The following conclusions were obtained from the Transportation Association of Canada (TAC) report titled Moisture Damage of Asphalt Pavements and Antistripping Additives; Causes, Identification, Testing and Mitigation.

1. All asphalt mixes should be tested for stripping resistance, unless satisfactory performance has already been documented. Only in the case of known good field performance, with previous stripping test validation for the same mix type and components, (aggregates, asphalt cement, and antistripping additives, if any), should a mix be assumed to be satisfactory in stripping resistance (moisture susceptibility). Stripping resistance testing should be part of every agency's mix design procedures.

2. It is important to adapt all methods to mitigate moisture damage to asphalt pavements, particularly proper asphalt mix compaction and good asphalt pavement structural drainage.

3. The mitigation of moisture damage for asphalt pavements requires the following:

    1. adequate pavement drainage

2. proper selection and use of aggregates
3. proper mix design optimized for rutting resistance, fatigue endurance, thermal cracking resistance and durability
4. use of antistripping additives as necessary to provide adequate stripping resistance and
5. quality control and assurance at all stages for asphalt pavement construction.

Policy:

All asphalt mixes including top and bottom lifts, must be tested for stripping resistance, unless satisfactory performance has already been documented. Only in the case of known good field performance, with previous stripping test validation for the same mix type and components (aggregates, asphalt cement and antistripping additive, if any), should a mix be assumed to be satisfactory in stripping resistance (moisture susceptibility). Stripping resistance should be part of the mix design procedure. The recommended test to determine the need for antistrip additives is titled the Standard Test Method for Effect of Water on Compressive Strength of Compacted Bituminous Mixtures, ASTM D-1075 as noted below. The minimum test value, for a mix not to require antistrip additive, is an Index of Retained Marshall Stability (IRMS) value of 85.

If an antistrip additive is determined to be required by the above test, then a product must be chosen from the Recognized Products List. For consistency, the concentration of the product will be noted **as 0.3% additive by weight**. It is noted that the manufacturer's recommendations, in the case of Redicote C 2914, is a range from 0.25% to 0.75% additive by weight of asphalt cement. If hydrated lime can be included as part of the crushing operation, then this is an effective strategy to mitigate potential stripping problems. Also and in addition to antistrip additive, liquid silicones in very low dosage such as Dow Corning DC-200, can be used to mitigate moisture damage and to suppress slumping and tearing of the hot mat during compaction. It is recommended that the use of silicon for this purpose be encouraged.

If the Ministry is aware that an antistrip additive is required, then it shall be specified in the Special Provisions, the Contractor will supply and the cost will be incidental to the works. The Contractor's bid would reflect the cost of antistrip. The antistrip application rate will be 0.3% by weight of asphalt cement.

If the Ministry is not sure if an antistrip additive is required, then the Ministry will require that the winning Contractor perform, as part of the mix design process, the test for the requirement of antistrip (ASTM D 1075). If in the mix design process, it is determined that an antistripping additive is required by the Contractor's tests, then the Contractor will supply and the costs will be paid for by Provisional Sum. The Contractor's bid in this case, would not reflect the cost of antistrip.

Also, if the Contractor's test results show that antistrip is not be required but the test results are marginal (i.e. the tests results slightly greater than 85 IRMS), the Ministry may desire to increase the confidence in the mix. The Ministry may then

request the addition of antistrip to the mix and the Ministry would pay by use of Provisional Sum.

Also, for Hot In Place contracts, Antistrip in the admix, will be required and the Contractor shall supply and the cost will be incidental to the works.

<u>Test Procedure:</u>

The following test procedure shall be used to determine the need for antistrip in asphalt mixes. Please note that this method is based on ASTM D1075 (copy inserted) and is the method of choice to determine the susceptibility of asphalt mix to moisture damage. It should be noted that there are other test methods that are more appropriate to evaluate and determine the optimal antistrip concentration to be used in a proposed mix.

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<u>Attachments:</u>

- Test Procedure

Standard Test Method for Effect of Water on Compressive Strength of Compacted Bituminous Mixtures ASTM D-1075

ASTM Designation: D 1075 – 96 (Re approved 2000)
American Association State Highway and Transportation Officials Standard AASHTO No.: T165

1. Scope

1.1 This test method covers measurement of the loss of compressive strength resulting from the action of water on compacted bituminous mixtures containing asphalt cement. A numerical index of reduced compressive strength is obtained by comparing the compressive strength of freshly molded and cured specimens with the compressive strength of duplicate specimens that have been immersed in water under prescribed conditions.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D 1074 Test Method for Compressive Strength of Bituminous Mixtures

D 2726 Test Method for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

3. Significance and Use

3.1 This test method is useful as an indicator of the susceptibility to moisture of compacted bitumen-aggregate mixtures.

4. Apparatus

4.1 One or more automatically controlled water baths shall be provided for immersing the specimens. The baths shall be of sufficient size to permit total immersion of the test specimens. They shall be so designed and equipped as to permit accurate and uniform control of the immersion temperature within plus or minus 1°C. They shall be constructed of or lined with copper, stainless steel, or other non reactive material. The water used for the wet storage of the specimens shall be either distilled or otherwise treated to eliminate electrolytes and the bath shall be emptied, cleaned, and refilled with fresh water for each series of tests.

4.2 A manually or automatically controlled water bath also shall be provided for bringing the immersed specimens to the temperature of 25 plus or minus 1°C for the compression test. Any convenient pan or tank may be used provided it is of sufficient size to permit total immersion of the specimens.

4.3 A balance and a water bath with suitable accessory equipment will be required for weighing the test specimens in air and in water in order to determine their densities, the amount of absorption, and any changes in specimen volume resulting from the immersion test.

4.4 A supply of flat transfer plates of glass or other non-reactive material will be required. One of these plates shall be kept under each of the specimens during the immersion period and during subsequent handling, except when weighing and testing, in order to prevent breakage or distortion of the specimens.

5. Test Specimens

5.1 At least six 101.6 by 101.6-mm (4 by 4-in.) cylindrical specimens shall be made for each test. The procedures described in Test Method D 1074 shall be followed in preparing the loose mixtures and in molding and curing the test specimens.

NOTE 1—This test method was developed to measure the loss of compressive strength due to water for specimens designed at approximately 6 % air voids by the compaction procedures of Test Method D 1074. When used with mixtures designed by other test methods, it is possible that the specimens will be compacted to some other void level which may influence the results. Some agencies have established an air void or percent density target to which the specimens should be compacted. This is accomplished by adjusting the loading in the Molding and Curing Test Specimens Section of Test Method D 1074.

6. Determination of Bulk Specific Gravity of Test Specimens

6.1 Allow each set of six test specimens to cool for at least 2 h after removal from the curing oven described in Test Method D 1074. Determine the bulk specific gravity of each specimen in accordance with the procedure (thoroughly dry specimens) and calculation (bulk specific gravity) sections of Test Method D 2726.

7. Procedure

7.1 Sort each set of six test specimens into two groups of three specimens each so that the average bulk specific gravity of the specimens in Group 1 is essentially the same as for Group 2. Test the specimens in Group 1 as described in 7.1.1. Test the specimens in Group 2 as described in 7.1.2 unless the alternative procedure described in 7.1.3 is specified.

7.1.1 *Group I*—Bring the test specimens to the test temperature 25 plus or minus 1°C, by storing them in an air bath maintained at the test temperature for not less than 4 h and determine their compressive strengths in accordance with Test Method D 1074.

7.1.2 *Group 2*—Immerse the test specimens in water for 24 h at 60 plus or minus 1°C. Transfer them to the second water bath maintained at 25 plus or minus 1°C and store them there for 2 h. Determine the compressive strength of the specimens in accordance with Test Method D 1074.
7.1.3 *Group 2, Alternative Procedure*—Immerse the test specimens in water for four days at 49 plus or minus 1°C. Transfer them to the second water bath maintained at 25 plus or minus 1°C and store them there for 2 h. Determine the compressive strength of the specimens in accordance with Test Method D 1074.

8. Calculation

8.1 Calculate the numerical index of resistance of bituminous mixtures to the detrimental effect of water as the percentage of the original strength that is retained after the immersion period as follows:

Index of Retained Stability (IRMS), % = $(S_2/S_1) \times 100$

where:
S_1 = compressive strength of dry specimens (Group 1), and

S_2 = compressive strength of immersed specimens (Group 2).

9. Precision and Bias

9.1 *Single-Operator Precision*—The single-operator standard deviation has been found to be 6 % (see Note 2). Therefore, results of two properly conducted tests by the same operator on the same material should not differ by more than 18 % (see Note 2).
NOTE 2—These numbers represent, respectively, the (1s) and (d2s) limits as described in ASTM Practice C 670.
9.2 *Multilaboratory Precision*—The multilaboratory standard deviation has been found to be 18 % (see Note 2). Therefore, results of two properly conducted tests from two different laboratories on identical samples of the same material should not differ by more than 50 % (see Note 2).

10. Keywords

10.1 bituminous paving mixtures; compression testing; moisture; water