

AIRPORT ENGINEERING

ATR-025

**AN INVESTIGATION OF THE
MODIFIED RICE TEST METHOD**

PROJECT 914222
MATERIALS TESTING REQUIREMENTS
AND PROCEDURES R&D
PHASE II

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1. INTRODUCTION

A review of Public Works and Government Services Canada (PWGSC) Architectural and Engineering (A&ES), Air Transportation, construction manual ASG-06¹ was carried out in 1995 by a Standards Review Board (SRB). The SRB consisted of members from the private sector and PWGSC, A&ES, Air Transportation. The purpose of the above noted review was to update the manual with current industry practices and developments in technology. Recommendations of the SRB were incorporated in the revised ASG-06 (September 1996) manual². Some of the recommendations were not included and it was agreed that further evaluation would be required before their implementation. The National Office of PWGSC, A&ES Air Transportation, requested assistance from the Atlantic Region to evaluate and report on these outstanding recommendations.

2. SCOPE OF WORK

The scope of work included the following three items:

- Investigation of the Modified Rice Test Method as put forward by the Canadian Asphalt Mix Exchange Program (CAMEP), compared to the test method for Maximum Specific Gravity of Bituminous Paving Mixtures (ASTM D2041-95)³.
- Review and evaluation of the Micro-Deval test. A report has been prepared and is submitted under separate cover (ATR-024).
- Evaluation of the test method ASTM D1557 and ASTM D4718 compared to "Laboratory Density Determination" as defined in section 2.4.1 of ASG - 06². A report has been prepared and is submitted under separate cover (ATR-026).

This report summarizes the literature search and review of the test methods to obtain the maximum specific gravity of bituminous paving mixtures which are recommended by PWGSC, CAMEP, several Provincial Highway Agencies, ASTM, AASHTO and the Asphalt Institute.

¹ ASG-06, Sept 1994. Pavement Construction Materials and Testing, Canadian Standards and Recommended Practices Airport Engineering, PWGSC, A&ES, Air Transportation.

² ASG-06, Sept 1996. Pavement Construction Materials and Testing, Canadian Standards and Recommended Practices Airport Engineering, PWGSC, A&ES, Air Transportation.

³ ASTM D2041-95. Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.

3. PWGSC AIRFIELD PAVEMENT ASPHALT MIXTURES

The PWGSC design methods and requirements for Airfield Pavement Asphalt Mixtures are defined in sections 2.4 and 2.5 of ASG-06². It states that "The Marshall method of mix design shall be used for design of hot mix asphalt concrete mixtures". Reference is made to the Asphalt Institute Manual MS-2⁴.

The Asphalt Institute Manual MS-24 delineates the required measurements needed for voids analyses. It states that the maximum specific gravity of the loose paving mixture should be obtained by carrying out test method ASTM D20413 and recommends that the Voids in Mineral Aggregate (VMA) values for compacted paving mixtures should be calculated in terms of the aggregate's bulk specific gravity. The effective specific gravity, or bulk specific gravity with an allowance for the portion of the asphalt binder lost by absorption into the aggregate particles, should be the basis for calculating the air voids in a compacted asphalt paving mixture.

The following excerpts taken from the Asphalt Institute Manual MS-2⁴ and ASTM D2041³ are highlighted for comparison purposes with the CAMEP Modified Rice Test Method:

- Section 5.05⁴ "Currently, there is no standardized or recommended procedure for aging or curing the mixture... A number of suggested methods have been proposed; however, a consensus of opinion has not yet been reached".
- Section 9.4³ states " Remove air trapped in the sample by applying gradually increasing vacuum until the residual pressure manometer reads 30 mm of Hg or less. Maintain this residual pressure for 5 to 15 minutes". Note 6 - Lean mixes require less and rich mixes require more time under vacuum, or more agitation, or both. In general, the minimum time needed to remove the air is best. Additional time under vacuum may introduce error due to water getting under the bituminous coating.
- Section 11³ "Supplemental Procedure for Mixtures Containing Porous Aggregates", contains special instructions for mixtures containing porous aggregate not completely coated. If the pores of the aggregates are not thoroughly sealed by an asphalt film, they may become saturated with water during the vacuum procedure thus influencing the calculation of the maximum specific gravity of the paving mixture, the effective specific gravity of the aggregate and the asphalt absorption into the aggregate. ASTM D2041³ recommends testing for the amount of absorbed water only if aggregate pieces exhibit visual evidence of absorbed water after the vacuum test.

⁴ Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types, MS-2, Sixth Edition, Asphalt Institute.

4. MODIFIED RICE TEST METHOD (CAMEP)

The Canadian Asphalt Mix Exchange Program (CAMEP) is part of the Canadian Asphalt And Mix Program (CAMP) and is presently hosted by Saskatchewan Highways and Transportation (SHT). Participation in the program is voluntary. A total of 43 laboratories from across Canada including 14 government agencies and 29 Consultant Engineering Firms participated in the 1995 exchange.

The exchange provides an opportunity for participants to compare their laboratory procedures and test results. The exchange evaluates the volumetric and mechanical properties of an asphalt mixture using the Marshall Mix procedures.

The Modified Rice Test Method as set forth by CAMEP is based on ASTM D-2041³ with three modifications. The three modifications are highlighted for discussion purposes:

- CAMEP recommends "... the oven curing of test specimens for at least 4 hours at 143⁰ C (290⁰F) in order to account for maximum absorption of asphalt cement in porous aggregates... will ensure the computation of realistic values for the amount of asphalt absorbed by the aggregate and void properties of the mix"
- CAMEP recommends to gradually increase vacuum until the residual pressure manometer reads 30 mm of Hg (instead of 30 mm or less) and
- CAMEP recommends maintaining this residual pressure for 15 minutes (instead of for 5 to 15 minutes).

CAMEP has found that by using a combination of a residual pressure of 30 mm Hg and a vacuuming time of 15 minutes, the need for running the supplementary procedure Section 11³, can generally be avoided when thoroughly coated mixes are used.

5. OTHER AGENCIES

Several Provincial Highway Agencies were contacted to inquire if they have implemented the CAMEP Rice Test Method modifications in their standards. The following will summarize the interviews:

5.1 Ministry of Transportation of Ontario (MTO)

Contact: Anil Virani, Victor Mata Lab Supervisor (416-235-3723).

MTO have their own test standard, LS-264⁵, for obtaining the maximum specific gravity of loose asphalt mix. Their standard is based on ASTM D2041³. They have adopted a four hour oven curing at 143⁰ C of the test samples during the mix design stage. The vacuum test is carried out by applying gradually increased vacuum until the residual pressure manometer reads 30 mm of Hg plus or minus 1 mm. The residual pressure is maintained for 15 minutes.

The supplemental test procedure, Section 11³, to determine the amount of absorbed water in the aggregate is routinely carried out at their central lab however it is not always carried out at their regional labs.

5.2 Ministry of Transportation of Quebec (MTQ)

Contact: Pierre Langlois/ Denis Proteau (418-644-0181).

MTQ have their own test standard NQ 2300-045⁶ for obtaining the maximum specific gravity of loose asphalt mix. Their standard is also based on ASTM D2041³. They do not oven cure the test samples during the mix design stage. The test is carried out by applying gradually increased vacuum until the residual pressure manometer reads 30 mm of Hg or less . The residual pressure is maintained for 5 to 10 minutes. The supplemental test procedure Section 11³ to determine the amount of absorbed water in the aggregate is not routinely carried out at the mix design stage.

5.3 Department of Transportation of New Brunswick (DOTNB)

Contact: Andy Leger (506-453-2619).

DOTNB specifies ASTM D2041³ for obtaining the maximum specific gravity of loose asphalt mix. They do not oven cure test samples during the mix design stage. The test is carried out by applying gradually increased vacuum until the residual pressure manometer reads 30 mm of Hg or less. The residual pressure is maintained for 5 to 15 minutes

⁵ LS-264 (1995). Method of Test for Theoretical Maximum Relative Density of Bituminous Paving Mixtures, MTO Laboratory Testing Manual.

⁶ NQ 2300-045 (1987). Melanges Bitumineux, Determination de la densite Maximale, Bureau de Normalisation du Quebec.

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(usually 15). The test procedure Section 11³ for determining the amount of absorbed water in the aggregate is not routinely carried out at the mix design stage.

5.4 Department of Transportation of Prince Edward Island (DOTPEI)

Contact: Ron Chinery (902-368-4740).

DOTPEI specifies ASTM D2041³ for obtaining the maximum specific gravity of loose asphalt mix. They do not oven cure test samples during the mix design stage. The test is carried out by applying gradually increased vacuum until the residual pressure manometer reads 30 mm of Hg or less . The residual pressure is maintained from 5 to 15 minutes. The supplemental test procedure Section 11³ for determining the amount of absorbed water in the aggregate is not routinely carried out at the mix design stage.

5.5 Department of Transportation of Newfoundland (DOTN)

Contact: Don Brennan (709-729-2441).

DOTN specifies ASTM D2041³ to obtain the maximum specific gravity of loose asphalt mix. They have implemented the oven curing of test samples for 4 hours at 143⁰ C during the mix design stage. The test is carried out by applying gradually increased vacuum until the residual pressure manometer reads 30 mm plus or minus 1 mm. The residual pressure is maintained from 5 to 15 minutes. The supplemental test procedure Section 11³ for determining the amount of absorbed water in the aggregate is not routinely carried out at the mix design stage.

5.6 Department of Transportation of Nova Scotia (DOTNS)

Contact: Paul Arsenault (902-860-2999).

DOTNS specifies ASTM D2041³ for obtaining the maximum specific gravity of loose asphalt mix. They do not oven cure test samples during the mix design stage. The test is carried out by applying gradually increased vacuum until the residual pressure manometer reads 30 mm of Hg or less . The residual pressure is maintained from 5 to 15 minutes. The supplemental test procedure Section 11³ for determining the amount of absorbed water in the aggregate is not routinely carried out at the mix design stage.

5.7 Saskatchewan Highways and Transportation (SHT)

Contact: Randy Smith, (306-787-4935).

SHT specifies ASTM D2041³ for obtaining the maximum specific gravity of loose asphalt mix. They do not oven cure test samples during the mix design stage. The test is carried out by applying gradually increased vacuum until the residual pressure manometer reads 30 mm of Hg or less . The residual pressure is maintained from 5 to 15 minutes.

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The test procedure Section 11³ for determining the amount of absorbed water in the aggregate is not routinely carried out at the mix design stage.

5.8 Manitoba Department of Transportation (MDOT)

Contact: Doreen Burdey, (204-945-1371).

MDOT specifies ASTM D2041³ for obtaining the maximum specific gravity of loose asphalt mix. They do not oven cure test samples during the mix design. The test is carried out by gradually increasing vacuum until the residual pressure manometer reads 30 mm of Hg. This pressure is maintained for 15 minutes. Section 11³ for determining the amount of absorbed water in the aggregate is not routinely carried out at the mix design stage however MDOT are considering specifying it mandatory in the future.

5.9 AASHTO Standard Test Method T209-94

The AASHTO test method T209-94⁷ for determining the maximum specific gravity of bituminous mixtures is relatively identical to ASTM D2041. It does not include any provision for aging the sample for mix design and production control purposes. The standard recommends that a vacuum of 30 mm of Hg or less residual pressure be applied for 15 +/- 2 minutes.

5.10 AASHTO Provisional Standard Test Method TP39-94

The AASHTO provisional standard test method TP39-94⁸ for determining the maximum specific gravity of bituminous mixtures is also relatively identical to ASTM D2041 but it includes sample aging for mix design and production control purposes. This aging consists of curing the sample in an oven at 143⁰ C for at least 4 hours. The standard also recommends that a vacuum of 30 mm of Hg or less residual pressure be applied for 15 minutes. It is stated in the standard that by using this combination of residual pressure (30 mm Hg) and vacuuming time (15 minutes), the need for running the supplementary procedure can generally be avoided when a thoroughly coated mix is used.

⁷ AASHTO T209-94. Standard Test Method for Maximum Specific Gravity of Bituminous Paving Mixtures.

⁸ AASHTO TP39-94. Standard Test Method for Determining the Maximum Specific Gravity of Bituminous Paving Mixtures.

6. DISCUSSION

PWGSC standards and guidelines for Canadian Airfield Pavements specify that asphalt mixtures should be designed following the Marshall Method MS-2⁴. The eight Provincial Agencies also confirmed the use of the Marshall Mix Design Method⁴. Several Provincial Agencies are also verifying the performance of their asphalt mixes by the new Asphalt Institute SUPERPAVE Mix Design Method (SP-2)⁹, based on the Strategic Highway Research Program (SHRP). Of the eight Provincial Agencies interviewed, only two have adopted some of the modifications proposed by CAMEP (Modified Rice Test Method). It is evident that a consensus has not been reached by Provincial Agencies on adopting the modifications as proposed by CAMEP.

DOTN and MTO have implemented a four hour oven curing of the asphalt test samples during the mix design stage. It would appear that the CAMEP's recommended four hour oven curing was put forth to ensure a uniform testing procedure for mix exchange purposes however it is not clear if it takes into account different aggregate porosities and asphalt cement contents. If conditioning of asphalt samples at the mix design stage is to be carried out, it should reflect as much as possible the same conditioning as during plant production.

The Asphalt Institute SUPERPAVE Level 1 Mix Design Manual (SP-2)⁹ recommends a four hour oven aging at 135⁰ C prior to carrying out AASHTO T209 / ASTM D2041 to determine the maximum theoretical specific gravity of the mixture. However the Asphalt Institute has not yet included oven aging in their MS-2 Manual⁴. It is understood¹⁰ that the Asphalt Institute is not planning a seventh edition of MS-2 until later in 1999.

Six of the Agencies interviewed require that the vacuum be applied 5 to 15 minutes as specified in ASTM D2041³. Technician experience in preparing the loose sample, the use of wetting agents and different asphalt / aggregate mix combinations can influence the release of entrapped air thus affecting the required vacuum time. MTO and MDOT are the only Agencies specifying a 15 minute vacuum period.

Si of the Agencies interviewed specify 30 mm or less of Hg as specified in ASTM D2041³. Only DOTN and MTO have specifically set the residual pressure value at 30 mm of Hg . It is however understood that most Agencies (including PWGSC Atlantic Region) apply a vacuum of 30 mm of Hg in any event.

None of the eight Provincial Agencies interviewed, except for MTO, routinely carries out the supplemental test procedure Section 11³ for determining the amount of water absorbed into the aggregates after the vacuum procedure. Each Agency was asked if any studies were carried out to investigate the presence, if any, of absorbed water in aggregates of moderate to low porosity after an asphalt sample was subjected to vacuum as specified in ASTM D2041³ ; no reports or studies were identified during the

⁹ Superpave Level 1 Mix Design, Series No 2, SP-2, Asphalt Institute.

¹⁰ Ross Benson (606-288-4960), Asphalt Institute, Lexington, KY, USA.

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interviews. Most Agencies did indicate that, if a porous aggregate did show evidence of water absorption after vacuum, the supplemental Section 11³ would be carried out. Historically PWGSC Atlantic Region has routinely carried out the supplemental Section 11³ to accurately calculate the asphalt absorption into the aggregates. This is based on the assumption that significant water absorption can occur even with moderately porous aggregates if they are not perfectly coated prior to the vacuum test¹¹.

7. CONCLUSIONS

In conclusion, it is recommended that PWGSC continue specifying that the void properties of asphalt mixes be determined in accordance with chapter 4 of MS-2⁴ which stipulates that the maximum specific gravity of the loose paving mixtures be determined in accordance with ASTM D2041.

Insufficient data has been found during this study to support implementation of the modified Rice method. It however appears that the proposed changes would improve testing repeatability. No data has been found which would indicate that the modified Rice method would result in more realistic values for the computation of the amount of asphalt absorbed and the air void content of asphalt mixes. Few provincial agencies have adopted the modified Rice method.

Comparative laboratory testing would be useful in providing PWGSC with an indication of the benefit of instituting these modifications. A collection of test results with and without these modifications would allow for a comparison of the two test methods. Any regional office with upcoming paving projects that are interested in collecting such information should contact the Airport Engineering National Centre of Expertise (NCOE) to co-ordinate the collection and recording of data and to ensure that the experience gained is distributed nationally.

A new guideline could be inserted in ASG-06 to describe the modified Rice method as an **alternative test method**, especially for use in areas with porous aggregates. The guideline should also state that the method is experimental and comparative data should be collected and co-ordinated with the NCOE.

A new guideline in ASG-06 should also be created to stipulate that in the absence of sufficient historical data, supplementary procedure 11 should be routinely performed when carrying out ASTM D2041 for each asphalt mix design and plant Marshall test.

¹¹ J.A.A. Lefebvre, Research Department, Imperial Oil Ltd., Sarnia, Ontario