Recommendation of RILEM TC237-SIB on Cohesion Test of Recycled Asphalt

Method to evaluate the presence of potentially active bitumen in reclaimed asphalt using indirect tension test.

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Abstract This recommendation describes how to evaluate the presence of potentially active bitumen in Recycled Asphalt (RA) materials through the cohesion test. The experimental protocol is designed according to the research performed by the RILEM Technical Committee 237-SIB ''Testing and characterization of sustainable innovative bituminous materials and systems'' with the purpose, to develop a new, simple and fast method for the characterization of RA while limiting the need for conventional rheological tests. The guidelines in this recommendation focus on the testing procedure including specimen preparation, data analysis and provide information on the preparation of a tests report.

Keywords: Recycled Asphalt (RA); Cohesion Test, Indirect Tensile Strength (ITS)

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1 Introduction

In the pavement industry, the use of reclaimed asphalt (RA) is a common practice, mainly because of its environmental and economical benefits [1]. RA is obtained from pavements which have exceeded their service life and therefore, this material is a product of milling or demolition processes. RA is composite material made of aggregates, bitumen, mastic, and in many instances a conglomerate of multiple aggregate particles. Given the complex characteristics of RA, it is critical to estimate the amount of RA bitumen that may be actively available when producing recycled asphalt mixtures (cold, warm, and hot mixtures for in-situ and plant production). This is especially important to develop reliable mix designs and to control mixture composition during production. In addition, the current experimental procedures to analyze the RA bitumen require time-consuming test procedures (bitumen extraction and recovery) [2, 3] coupled with sophisticated measurement methods and expensive devices (i.e. the dynamic shear rheometer) [4, 5] and complex modeling formulation that are not viable for routine mix design as well as for control of mix composition during production. Together with lack of simple experimental methods, RA consistency and representativeness, also in terms of bitumen, represent a challenge which requires use of test procedure that can provide a “fingerprint” of RA.

2 Scope

The present recommendation introduces a new experimental procedure capable of evaluating the capacity of bitumen from RA to actively contribute in blending process with virgin binder during the production of recycled asphalt mixture; specifically, the cohesion test is hereafter presented. Details on specimen preparation and test procedure, data analysis and tests reports are provided in the following section of this document.

The application of the proposed experimental procedure is part of a larger protocol, developed in different research efforts [6-8] and detailed in an upcoming RILEM recommendation, [9] with the purpose of RA characterization as well as for use in mix design procedures of asphalt mixtures that incorporate RA. The objective is to achieve a final product in field operation and construction site, which is comparable to the design performed in the laboratory. It must be stressed out that currently no alternative practical test procedures are available to easily determine the capacity of RA bitumen that can be reactivated.

The proposed procedure includes testing at different temperatures and, hence, the results provide insight on the availability of RA bitumen as function of temperature while also characterizing the influence of temperature on the evolution of particle size distribution. In addition, the cohesion test may contribute in the decision process regarding the selection of the specific recycling technology: hot, warm or cold. The present testing procedure is designed according to the protocol validated by round robin tests (RRT) conducted by the researchers of the TG6 of RILEM TC 237-SIB.

3 Referenced documents

The following section provides a list of international standards and documents linked to the present recommendation.

ASTM Standards

- ASTM D6925-15 (2015) Standard Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyratory Compactor. ASTM International, West Conshohocken, PA
- ASTM D6926-16 (2016) Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus. ASTM International, West Conshohocken, PA
- ASTM D6931-17 (2017) Standard Test Method for Indirect Tensile (IDT) Strength of Bituminous Mixtures. ASTM International, West Conshohocken, PA

EN Standards

- EN 12697-23 (2003) Bituminous Mixtures - Test methods for hot mix asphalt - Part 23: Determination of the Indirect Tensile Strength of Bituminous Specimens. European Committee for Standardization, Brussels, Belgium
- EN 12697-30 (2012) Bituminous mixtures - Test methods for hot mix asphalt - Part 30: Specimen preparation by impact compactor. European Committee for Standardization, Brussels, Belgium
- EN 12679-31 (2007) Bituminous mixtures - Test methods for hot mix asphalt - Part 31: Specimen preparation by gyratory compactor. European Committee for Standardization, Brussels, Belgium

RILEM recommendations

- Recommendation of RILEM TC237-SIB: Protocol for Characterization of Recycled Asphalt (RA) Materials for Pavement Applications

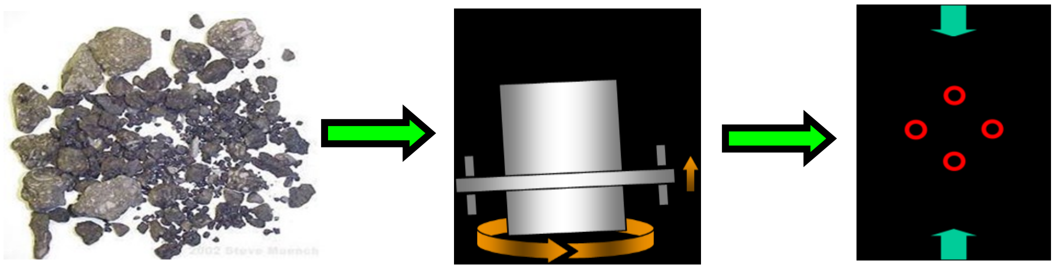
4 Definitions

Please refer to "Recommendation of RILEM TC237-SIB: Protocol for Characterization of Recycled Asphalt (RA) Materials for Pavement Applications" for definitions that are relevant to this recommendation.

5 Specimen preparation

RA can be classified as “active” or “inactive”, depending on the capacity of the residual bitumen to glue the particles together after compaction. For this reason, the cohesion test is performed on 100% RA without additional bitumen with a maximum aggregate size to be less than or equal to 1/5th of the smaller mould dimension. Before testing, RA has to be dried at 30°C until the weight loss within 24 hours is less than 1% (Figure 1a). Then, the material is compacted into cylindrical samples (Figure 1b). For this purpose, a Superpave Gyratory Compactor (SGC) with a mould having a 150mm diameter can be used to impose 30 gyrations to the RA material according to ASTM D6925-15 or EN 12697-31 [10, 11]. Quantity of material should be selected to produce specimen of dimensions required by ASTM D6931-12 or EN 12697-23 [14, 15]. During compaction, the evolution of the air voids content is recorded. Alternatively, Marshall Compaction according to ASTM D6926-10 or EN 12697-30 [12, 13] can be used to produce specimens with a diameter of 101.6 mm, however use of gyratory compactor is recommended.

Specimens needs to be compacted at three different temperatures: 20, 70 and 140°C. Before determining the cohesion value through the Indirect Tensile Strength (ITS) [14, 15]. Six replicates need to be produced for each of the selected testing temperatures. Each of the six samples is divided into two sub-groups where one is tested in dry condition while the other set is conditioned in water at 25°C for 24 hours prior to testing.



(a) **(b)** **(c)**

Fig. 1 Procedure and apparatus used in the cohesion test

6 Test procedure

The ITS testing procedure detailed in the ASTM D6931-12 or EN 12697-23 [14, 15] is used to evaluate the degree of cohesion (Figure 1c). Table 1 shows typical cohesion test results obtained from the RRT conducted by the TG6 of RILEM TC 237-SIB.

Table 1 Example of cohesion test results

Source of RAP	**A**
Temperature 20°C	
ITS at 25°C (dry) [kPa]	*N/A*
ITS at 25°C (wet) [kPa]	*N/A*
Air voids level	*N/A*
Source of RAP	A
Temperature 70°C	
ITS at 25°C (dry) [kPa]	*389*
ITS at 25°C (wet) [kPa]	*61*
Air voids level	*23.0*
Source of RAP	A
Temperature 140°C	

ITS at 25°C (dry) [kPa]	811
ITS at 25°C (wet) [kPa]	765
Air voids level	18.2

N/A.: it was not possible to test the compacted specimens, as they fell apart during the demoulding process

7 Data analysis

This section is based on the analysis performed during the RRT campaign of the TG6 of RILEM TC 237-SIB. All the manufactured samples are subjected to ITS test as described in Section 6. Figures 2 and 3 provide an overview of the results obtained from the RRT as an example. The average air voids value of each group of tested samples is reported in brackets in the graphs.

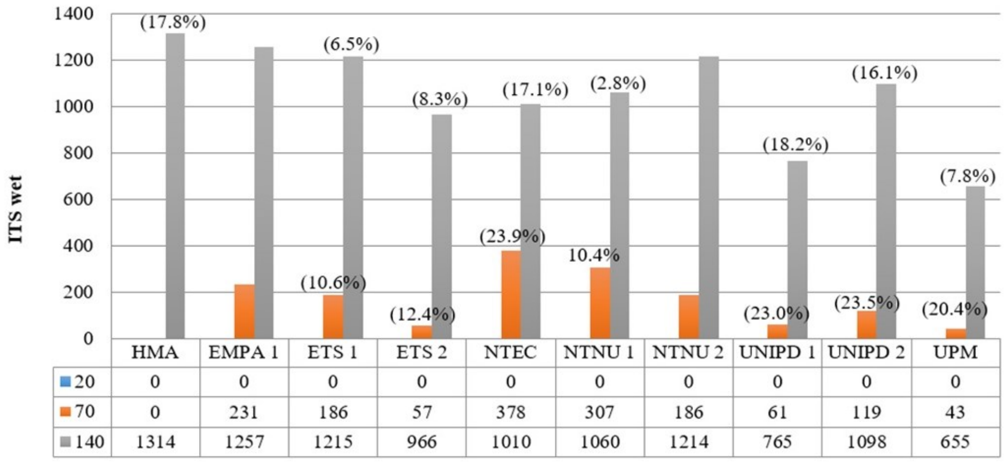


Fig. 2 Cohesion test results - WET condition

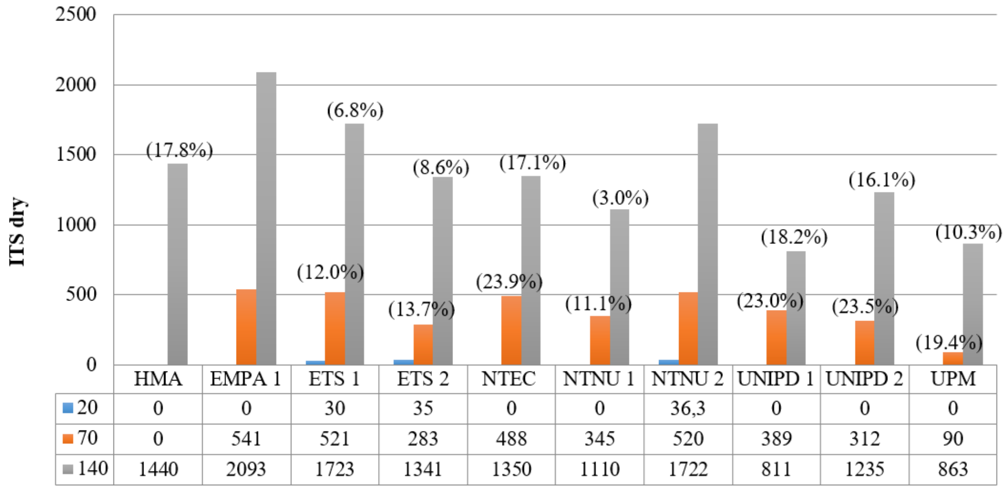
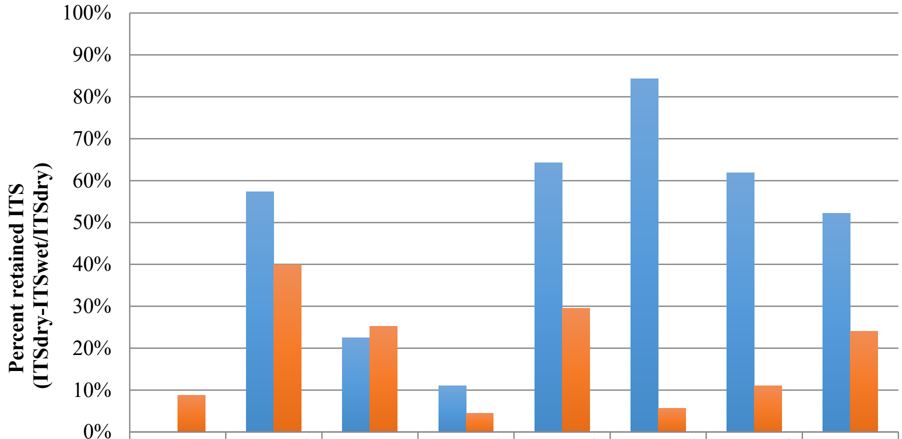


Fig. 3 Cohesion test results - DRY condition

With respect to the proposed example, RA samples compacted at 20°C did not hold in most of the cases. Nevertheless, in all other cases, regardless if in dry or in wet condition, the values exceeded 100 kPa indicating that all RA can be classified to have bitumen or mastic with potential cohesive contribution. After water bath conditioning, the results of ITS test on 100% RA samples vary significantly (Figure 4); while differences for hot mixes are less noticeable, using a classification in wet conditions might be more meaningful for half-warm mix applications.



	HMA	EMPA 1	NTEC	NTNU 1	NTNU 2	UNIPD 1	UNIPD 2	UPM
70	0.00%	57.30%	22.54%	11.01%	64.23%	84.32%	61.86%	52.22%
140	8.75%	39.94%	25.19%	4.50%	29.50%	5.67%	11.09%	24.10%

Fig. 4 Reduction of ITS value due to 24h water soaking

8 Closing remark and test report

The cohesion test presented in this RILEM recommendation provide as simple procedure to estimate the presence of active binder in RA materials. The RA material can be considered to have no cohesive contribution from bitumen or mastic (inactive) if the tested specimen at 20, 70 or 140°C is unable to support self-weight and the shape of the compacted specimen is not maintained at the testing time at designated test temperature, or if the ITS value in wet condition is less than 100kPa at 70°C. The specimen self-supporting requirement is made in context of gyratory compacted specimens of 150 mm diameters, while using Marshall procedure for compaction, the 100kPa strength based limit should be used. The procedure requires equipment which widely used and commonly available in laboratories and at asphalt plants. Based on the present document the test report should contain:

- Relevant information on the tested RA, such as origin, storing, maximum aggregate size and potential conditioning;
- The description of the test setup, including: mould size, compaction temperatures and mode, specimen conditioning;
- The ITS values measured for each compaction temperature and corresponding air voids values, for wet and dry conditions as well as the corresponding variation between the two measured values in percentage.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

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