Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 14 (2016) 758 – 767

Transportation Research Procedia

www.elsevier.com/locate/procedia

6th Transport Research Arena April 18-21, 2016

Stiffness characterization of cold recycled mixtures

J. Valentin [a,*], Z. Čížková [a], J. Suda [a], F. Batista [b], K. Mollenhauer [c], D. Simnofske [c]

[a]*CTU in Prague Faculty of Civil Engineering, Thákurova 7, Praha 6, 166 29, Czech Republic*
[b]*LNEC, Avenida doBrasil 101,Lisboa, 1700-066, Portugal*
[c]*Universität Kassel, Faculty of Civil and Environmental Engineering, Mönchebergstraße 19, Kassel, 34109, Germany*

Abstract

One of the objectives within the European research project CoRePaSol (supported within the CEDR Transnational Program) was to summarize assessment and research of stiffness modulus of cold recycled mixes determined according to repeated indirect tensile stress test (IT-CY). In most cases the stiffness modulus values were compared to the values of indirect tensile strength (ITS), which is currently the most commonly used characteristic for proving the quality of a cold recycled mix. The first part of experimental measurements was focused on the standard cold recycled mixes, thus mixes whose aggregate skeleton is formed entirely by RAP and which contain either just the bituminous binder (bituminous emulsion or foamed bitumen), or a combination of one of these binders and a hydraulic binder (cement). Later also combinations with other types of recyclable materials were done and tested. Stiffness modulus and in most cases also the indirect tensile strength values were investigated from many points of view, e.g. the effect of different bituminous / hydraulic binder content on these characteristics, time-dependent progress in change of these characteristics, effect of testing temperature or the influence of fines addition on the stiffness modulus value. This paper therefore brings some summarization of the gained experience.

Peer-review under responsibility of Road and Bridge Research Institute (IBDiM)

Keywords: Stiffness modulus; indirect tensile strength; cold recycled asphalt mix; RAP; recycled conrete; influence of binder content

* Corresponding author. Tel.: +420-22435-3880.
E-mail address: jan.valentin@fsv.cvut.cz

Peer-review under responsibility of Road and Bridge Research Institute (IBDiM)
doi:10.1016/j.trpro.2016.05.065

1. Mix design and specimen production

Mix designs of four basic cold recycled mixtures, which were used for performing a large part of the experiments done within CoRePaSol project at CTU in Prague and presented in this paper are summarized in Table 1. Key different alternatives of cold recycled mixtures are addressed in this table. There is a mix containing bituminous emulsion and higher content of cement (mix A), mix with foamed bitumen and higher content of cement (mix B), as well as mixes containing solely bituminous emulsion (mix C) or foamed bitumen (mix D).

For the experimental studies almost all designed mixes contained the same type of screened reclaimed asphalt material (RAP) with 0/22 mm grading originating from the same source (hot mix asphalt plant Středokluky – see Fig. 1). Nevertheless the homogeneity of RAP was quite poor, which is typical for the Czech circumstances or more generally it is typical for these materials if selective cold milling for each construction site is not done. This fact influenced greatly the test results and makes final conclusions more difficult. The bitumen content was determined to be 5.6% by mass. Nevertheless this value should be considered as just approximate because the composition of RAP differed even within a single batch. Because of that it was very important to perform all measurements for each sub-study at once. Measuring of some related values later using specimens made from another batch is not recommendable because the RAP composition influences greatly the final mix characteristics.

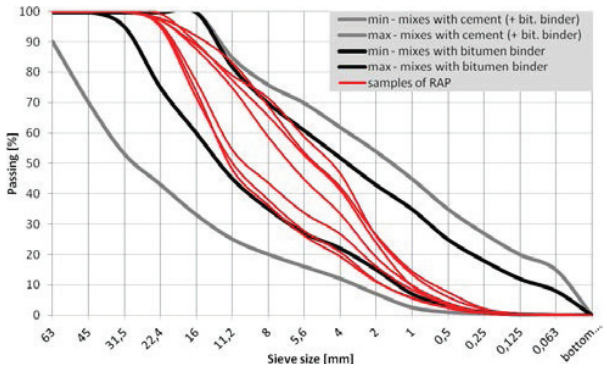

Fig. 1. Grading curves of used RAP 0/22 mm (location Středokluky, repeated analyses).

Part of the mixes described in the following chapters contained cationic slow-breaking bituminous emulsion C60B7 (according to the designation in [EN 13808:2013]) which is commonly used in the Czech Republic. Other mixes were based on the foamed bitumen using standard straight-run bitumen 70/100 according to [EN 12591]. When preparing the foamed bitumen, there was 3.8% of water added to the bitumen (the amount was determined in accordance with the procedure which is recommended for cold recycling technology by [Wirtgen Manual 2012]. Foamed bitumen was injected into the cold recycled mix under the temperature between 160 °C and 170 °C using the Wirtgen WLB10S laboratory equipment. For mixing twin-shaft compulsory mixer Wirtgen WLM 30 was used.

The cylindrical specimens usually with 150±1 mm diameter and 60 mm height were prepared by putting the cold recycled mix in cylindrical moulds and compacted by applying pressure of 5.0 MPa. The basic volumetric parameters were determined for the manufactured test specimens, and the indirect tensile strength according to (TP 208) was measured as well. For all test specimens data on stiffness modulus were collected. Unless otherwise stated, the measurements of ITS and stiffness modulus was performed at 15 °C.

Due to the important priority of the civil engineering practice to minimize the duration of laboratory tests, there is an effort to find an appropriate method to accelerate the process of specimens curing. Within the investigation performed during the CoRePaSol project, it was decided that it is possible to divide cold recycled mixes into two groups from the point of view of curing. The first group is formed by mixes with more than 1% of cement. The curing time of these mixes cannot be significantly shortened, because of the cement hydration process, which is absolutely