Supplementary Information

Can crumb rubber modifier effectively replace the use of polymer modified bitumen in asphalt mixture?

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Alternative specimen preparation technique

For some of the experiments associated to the performance requirements described in the Swiss standards (i.e. water sensitivity and rutting), the SDA compacted samples, with higher CR and air void contents, were weighted down during cooling after compaction in order to prevent the expansion induced by the heat-mediated swelling and/or elastic recovery of rubber at temperatures of ca 130°C as recommended by the CR supplier based on their field experiences. As shown by Yu et al. (2014) the compaction temperature is known to affect the volummetric properties of dry process rubberized asphalt (*Yu, Miao & Wu, Guoxiong & Zhou, Jinchuan & Easa, Said. (2014). Proposed Compaction Procedure for Dry Process Crumb Rubber Modified Asphalt Mixtures Using Air Void Content and Expansion Ratio. Journal of Testing and Evaluation. 42. 20120337. 10.1520/JTE20120337*.). Furthermore, the amount of rubber added to the dense mixtures was limited due to the amount of virgin binder and we did not observe the elastic rebound in the AC mixtures.

ITS and ITSR Results

The SDA mixtures with CR were additionally tested after they were weighted down (designated as W) during the cooling process of sample preparation. The indirect tensile strength of the SDA weighted and non weighted samples are shown in **Figure S1**. The data shows an increase of strength in both dry and wet state as a result of this alternate specimen preparation method. The effect on dry strength seems to be even stronger for the samples with 1% CR (SDA3). This may be explained by the larger impact of swelling from higher content of rubber that was experienced by the SDA3 sample (without weighting) before complete cooling. The data also suggests, that with optimal processing, the maximum dry strenght of the modified mixture will be reached at higher CR-content. On the other hand, although the SDA3 samples (1% CR) would now fulffil the Swiss requirements regarding water sensitivity (ITSR>70%), the ITSR obtained by weighing the samples does not further increase in comparisson with SDA2 samples, indicating that the overall optimal content of CR for SDA lies below 1% (**Figure S2**). Unfortunately, no reference sample from SDA1 was weighted down in order to analyse the weighting down effect. If for any reason the wet ITS would also be increased by the alternated sample preparation, it could mean that overall still a negative trend for the ITSR values could be observed. It is also noteworthy that the dense AC mixtures showed a very low standard deviation in comparison to the semi-dense mixtures (see Section 3.2, Fig. 5 in main paper). Once the

samples are weighted down (indicated with a W) also the SDA samples show less deviation (**Figure S1**).

In conclusion, when samples are weighted down both types of CR modification surpass the dry and wet ITS values of polymer modified mixtures. This is an indication that indeed swelling and/or elastic recovery continue during the cooling process, having a direct effect on the strength development of the bulk material. An open point is, that CR addition to mixtures with higher porosity such as SDA could still go along with possible drawbacks in terms of water sensitivity. Therefore, future experiments should also include SDA reference samples that were weighted down during cooling.

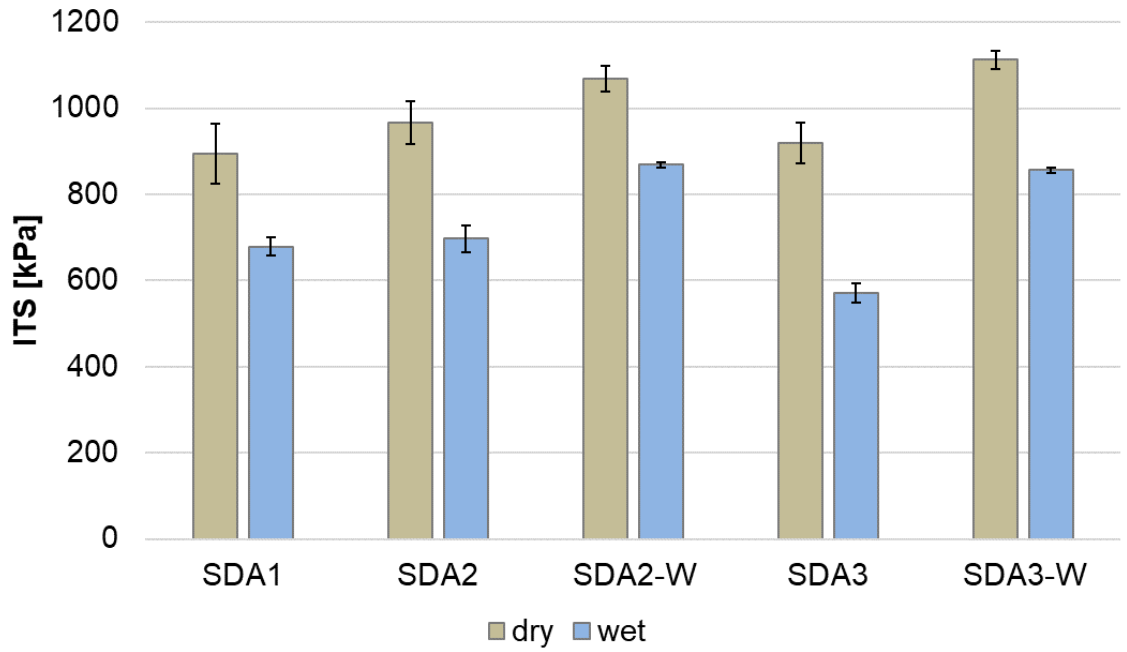

Figure S1 Indirect tensile strength of SDA samples in wet and dry state and weighted (W) and non-weighted samples

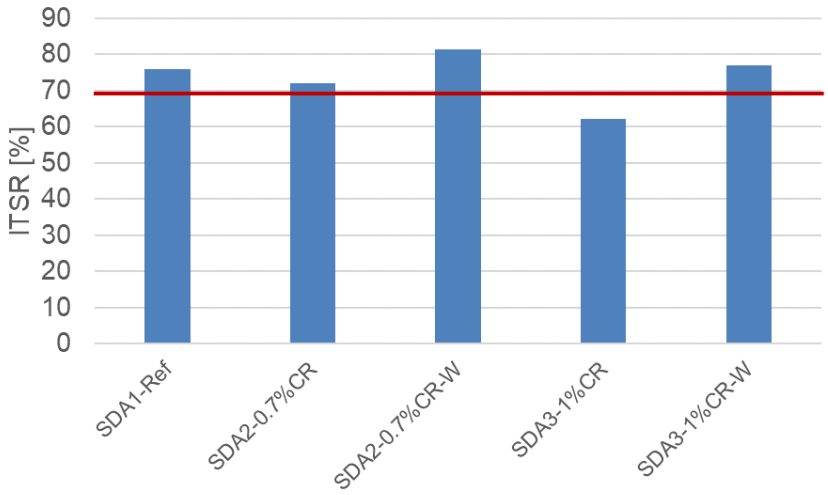

Figure S2 Indirect tensile strength ratio, ITSR values for weighted (W) and non-weighted samples

French rutting test

Regarding the response against permantent deformation of SDA mixtures, again a significant effect of the weighing down of the samples can be seen as shown in **Figure S3** and **Figure S4**. Once the samples were weighted down for SDA3 (1%CR) very similar performance to the polymer modified reference can be seen (SDA1). SDA2 results were slightly better than the reference PmB but not repeatable. Regarding the rate of rutting that shows the development over time the weighing down had a positive effect (**Figure S4**).

In conclusion: the processing during cooling of samples containing CR is important. This needs to be taken into account when implementing the product into plant production and road construction work.

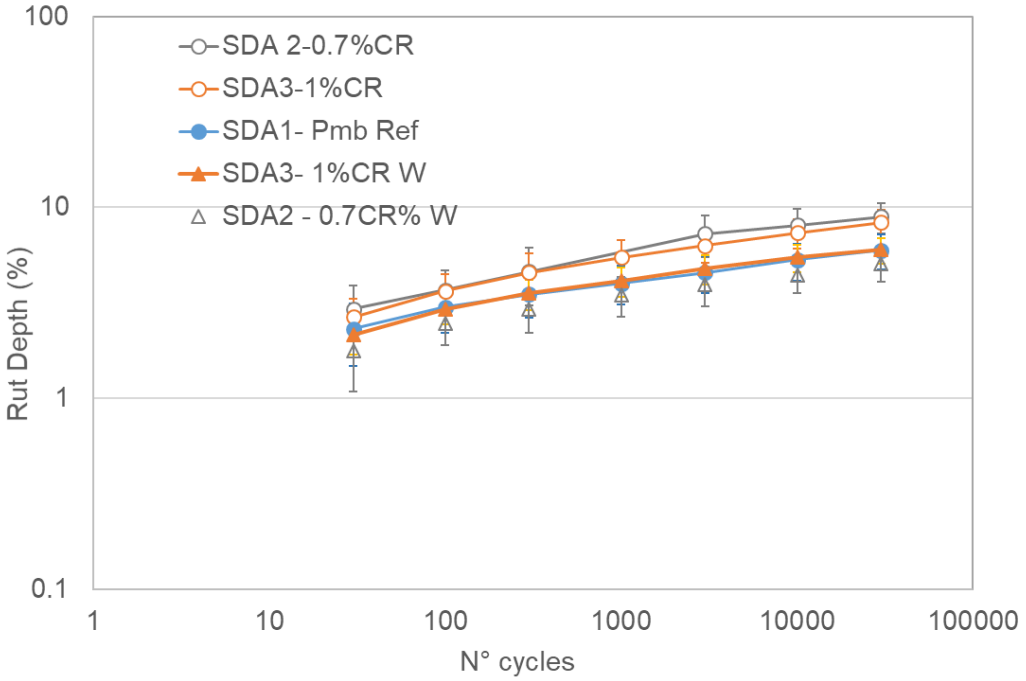

Figure S3 Rutting test results of conventional and weighted (w) samples of SDA mixtures

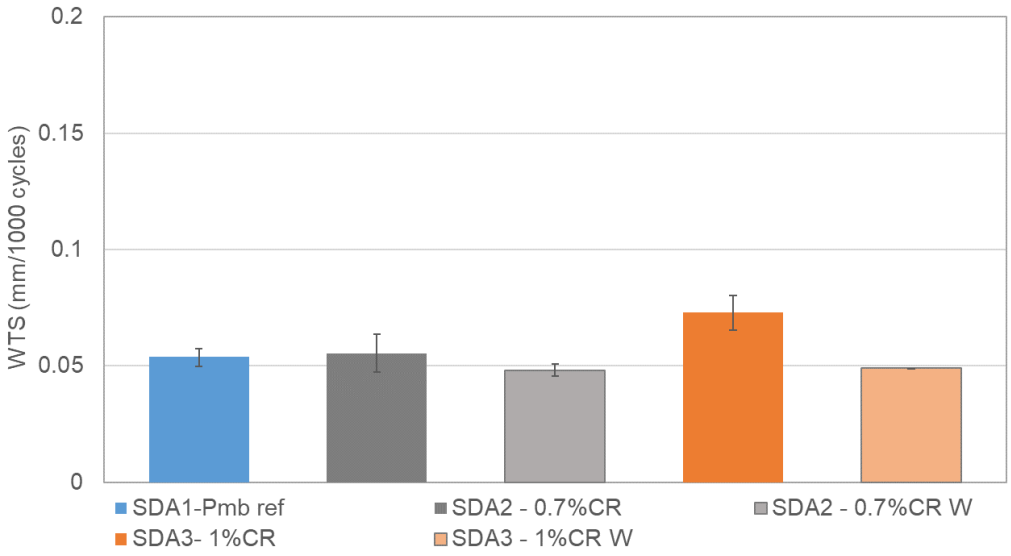

Figure S4 Rutting test slope results of conventional and weighted (w) samples of SDA mixtures