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Abstract

Filler Effect on Moisture Resistance of Cold Recycling Materials †

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1. Overview and Novelty

Cold recycling materials (CRM) with bitumen emulsion are getting increasingly important aiming at highly efficient road infrastructure and tackling energy consumption as well as its further consequences on climate change. Normally, cement is added to get improved strength, but its usage leads to risk again mixture performance such as brittleness behavior and drying shrinkage [1], [2]. The objective of the present study is to analyze how eco-friendly by-product fillers affect the moisture resistance as well as the stiffness of CRM.

2. Methodology and Results

The aggregate blend of the mortars was obtained by removing the coarse aggregate (larger than 2 mm) CRM granulate. The emulsion and filler content was fixed to 5% emulsion content and filler content of 3 %. Cationic slow-setting bitumen emulsion was used. Various fillers were selected to provide an extensive overview of the effect of fillers on the mechanical properties and water sensitivity of CRM materials: Cement (CE), ladle slag (LD), silica fume (SF), Ettringite binder (ET:70%LD+30%gypsum), geopolymer (GO:55% LD 35%Fly ash+10% SF). Two different methods were used to assess the water sensitivity which are Rolling Bottle Test (RBT) and Shaking Abrasion Test (SAT). Dynamic Modulus derived from, and Ultrasonic Pulse Velocity (UPV) tests were performed to validate RBT and SAT method results.

In general, Figure 1 shows that the curing time has a clear influence on the coating ability, abrasion resistance, and dynamic modulus especially at the initial stage of curing (within 28 days). Figures 1 a and b show that the used fillers improved the bitumen coverage for both basalt and limestone aggregate compared with CE as a control filler, except SF which exhibited poor bitumen covering ability. It is worth noting that bitumen affinity to basalt aggregate is higher, especially at an early age, this finding is lined up with. When compared with CE, ET filler improved the bitumen coating ability after water erosion due to the early formed crystallin that increases the interlocking force between bitumen and aggregate surface, which improves adhesion between the mastic and the aggregate surface. In contrast, the bitumen coating ability of the CE specimen was considerably low. In the CE blended aggregate, the rigid hydration products improve the stiffness properties of the bitumen which in turn increases the stiffness of the mortar as shown in Figure 1 c, which improves the cohesion considerably but the adhesion slightly, and since the stripping resistance mostly depends on adhesion. Generally, all used fillers showed comparable abrasion resistance in 90 days of observation except SF. However, CE has slightly higher abrasion resistance on the first days of curing. Considering the effect of fillers on E, mortars with CE and ET exhibited the highest long-term and short-term performances, respectively. SF mortar performed the worst.

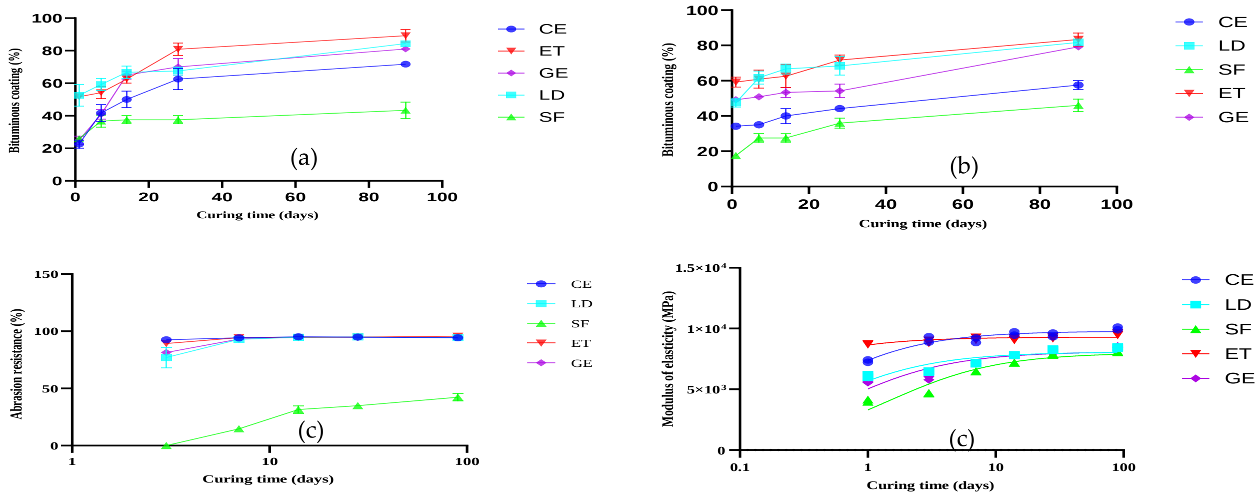

Figure 1: a) Results of RBT test for the Basalt, (b) Results of RBT test for the limestone, (c) Results of SAT (d) Results of UPV

3. Conclusions and Recommendations

- Adding the active fillers provided a higher bitumen coverage and abrasion resistance than the SF, resulting in better affinity and moisture resistance, especially ET.
- The effect of filler on moisture sensitivity was found to be higher than the effect of aggregates.
- Adding ET filler provided higher E values at an early age, while the CE led to higher stiffening behavior in long term.
- LD and GO allowed for general lower stiffness and higher bitumen coverage and comparable abrasion resistance compared with CE.
- The result of the E test is generally correlated with abrasion resistance.
- Applying those methods and tests will provide a more comprehensive view for evaluating the moisture resistance of the CRM mixtures.

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