International Association of Chinese Infrastructure Professionals
IACIP

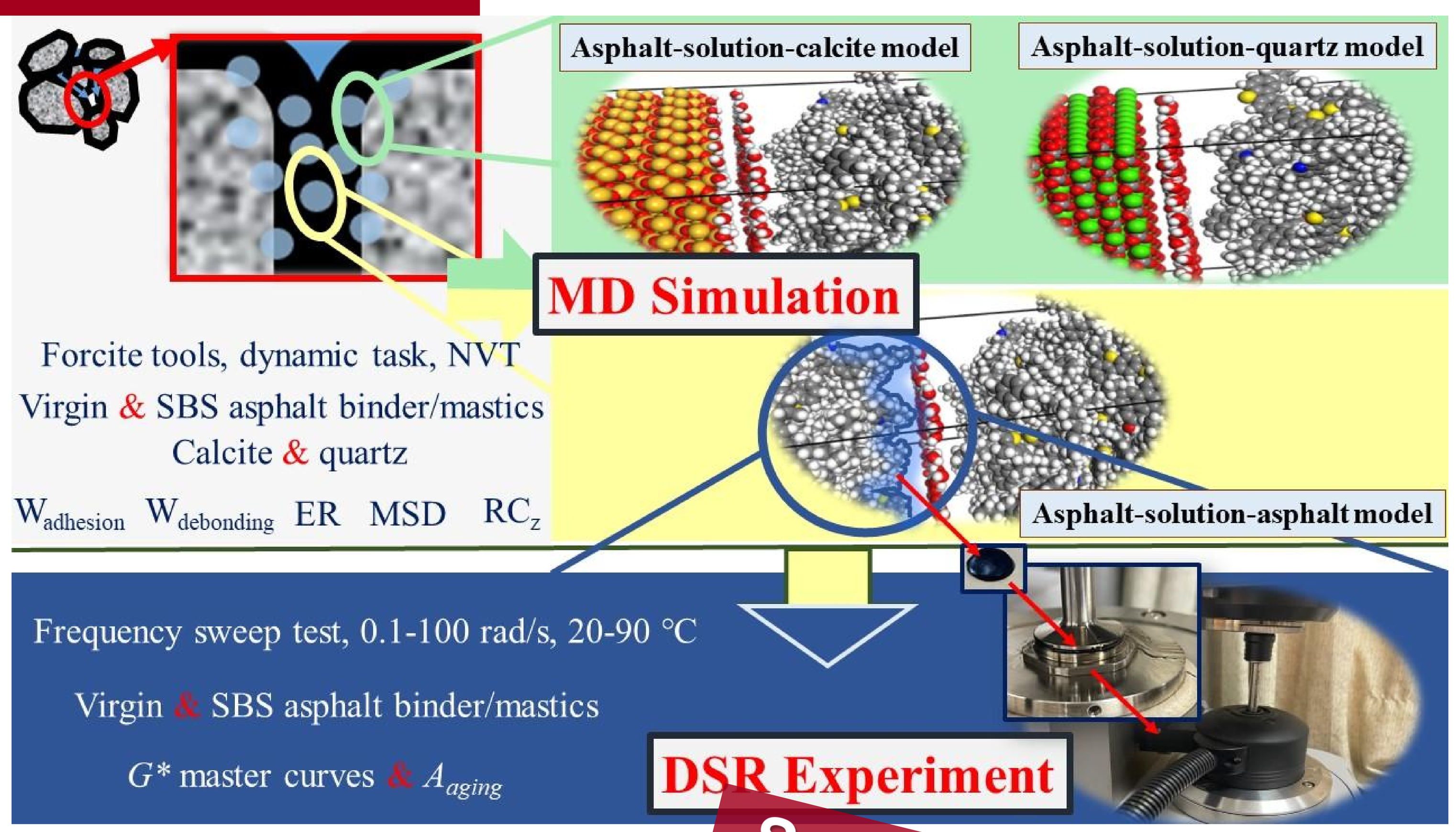
THE 13th IACIP Annual Workshop:
Adaptive Infrastructure under Climate Change

Investigation of the solution effects on asphalt-aggregate systems using molecular dynamic simulations and DSR test

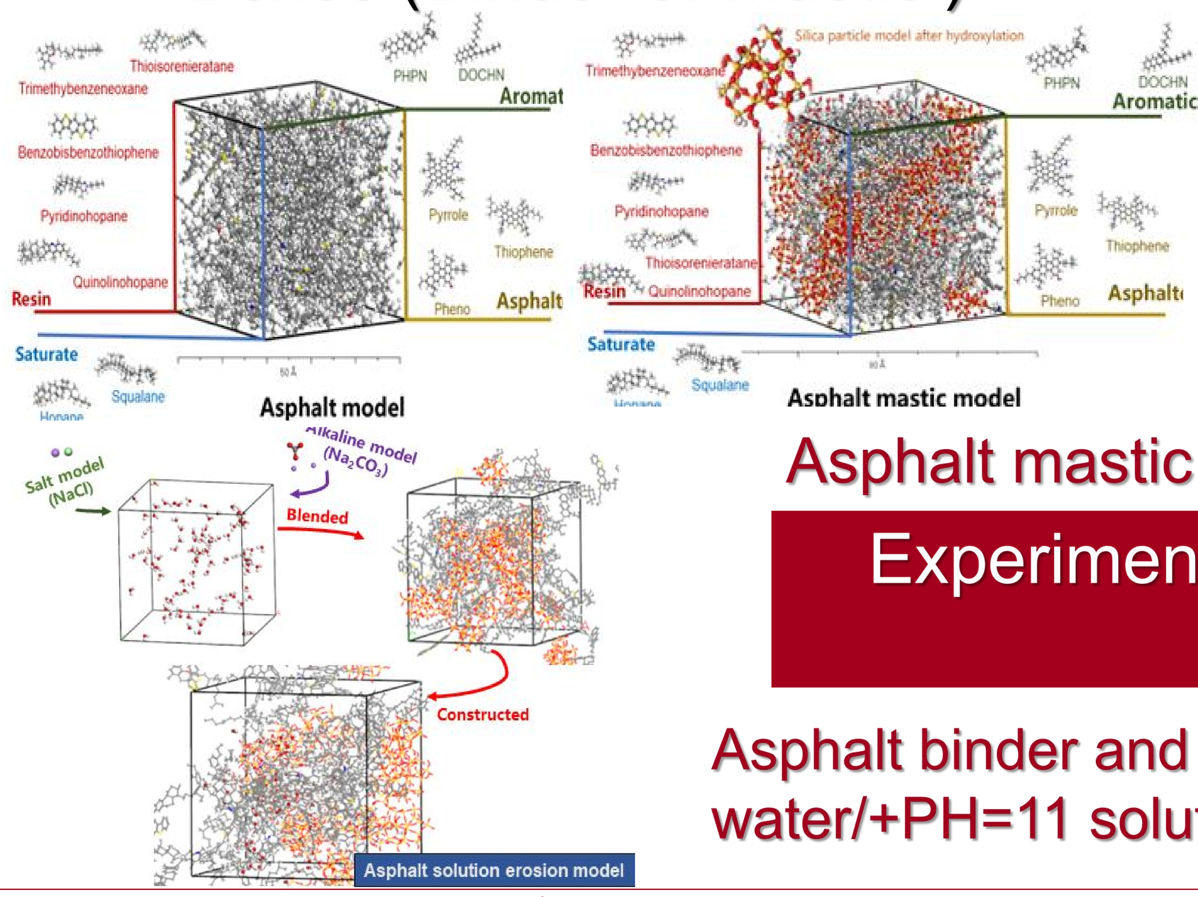
Chen Li 1, Key Laboratory Special Area Highway Engineering of Ministry of Education, Chang'an University;2018121140@chd.edu.cn
Feng Ma 2, Key Laboratory Special Area Highway Engineering of Ministry of Education, Chang'an University;mafeng@chd.edu.cn
Zhen Fu 3,School of Material and Science Engineering, Chang'an University; zhenfu@chd.edu.cn

Introduction

Interface



Boxes (Binder or Mastic)



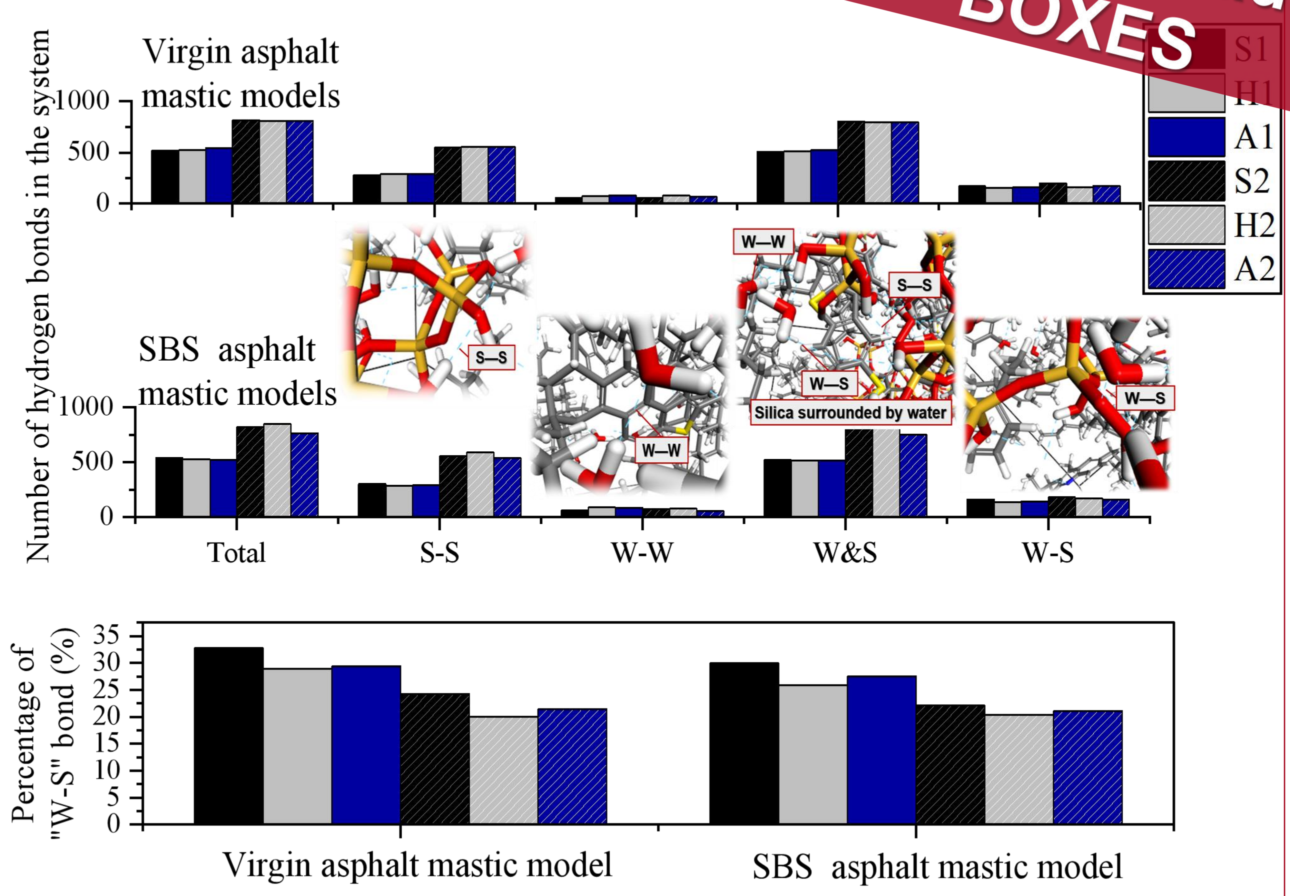
Establishment of models

Asphalt-solution-asphalt model
Asphalt-solution-aggregate model
Asphalt solution erosion model
Virgin asphalt/ SBS asphalt model
Asphalt mastic model with 0.8/1.2 filler/binder ratio

Experiment of solution erosion of asphalt binder and mastic

Asphalt binder and mastic film + *6*、*12*、*18* days Distilled water/+PH=11 solution/+10% NaCl solution **Via** DSR test

Solution invaded BOXES

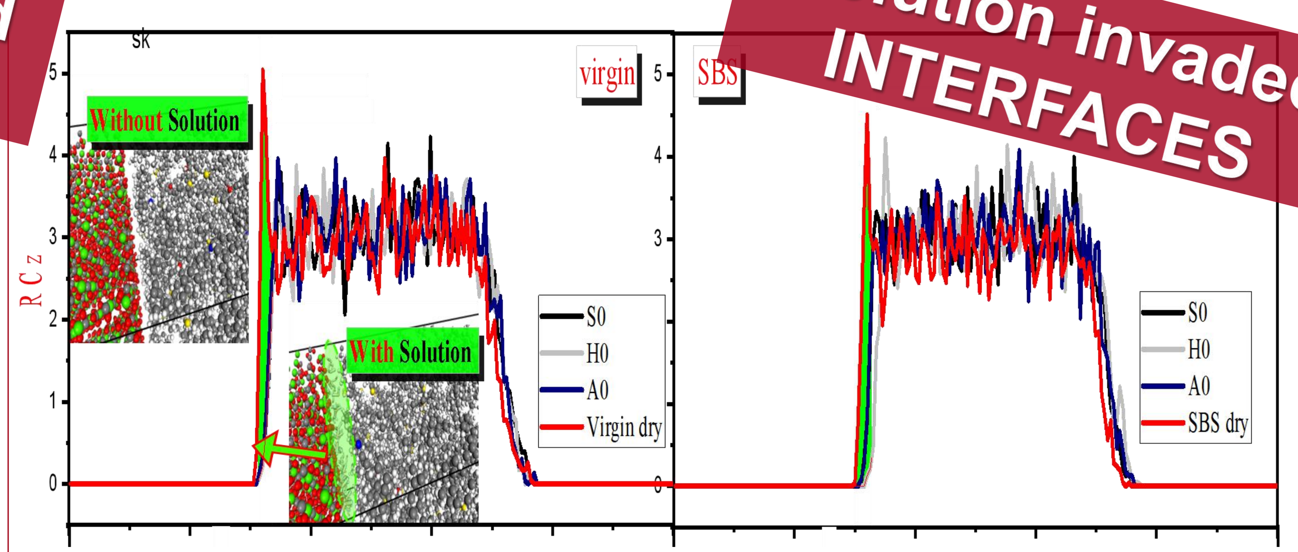


The saline-alkali solute helps to shorten the adsorption distance between water and the surface of SiO_2, thus performing a stronger hydrogen bond effect;

The W-S percentage in the SBS model is slightly lower than that of the virgin one, which may be due to the existence of long-chain of the SBS polymer affecting the water distribution, where the water clusters are more likely to form;

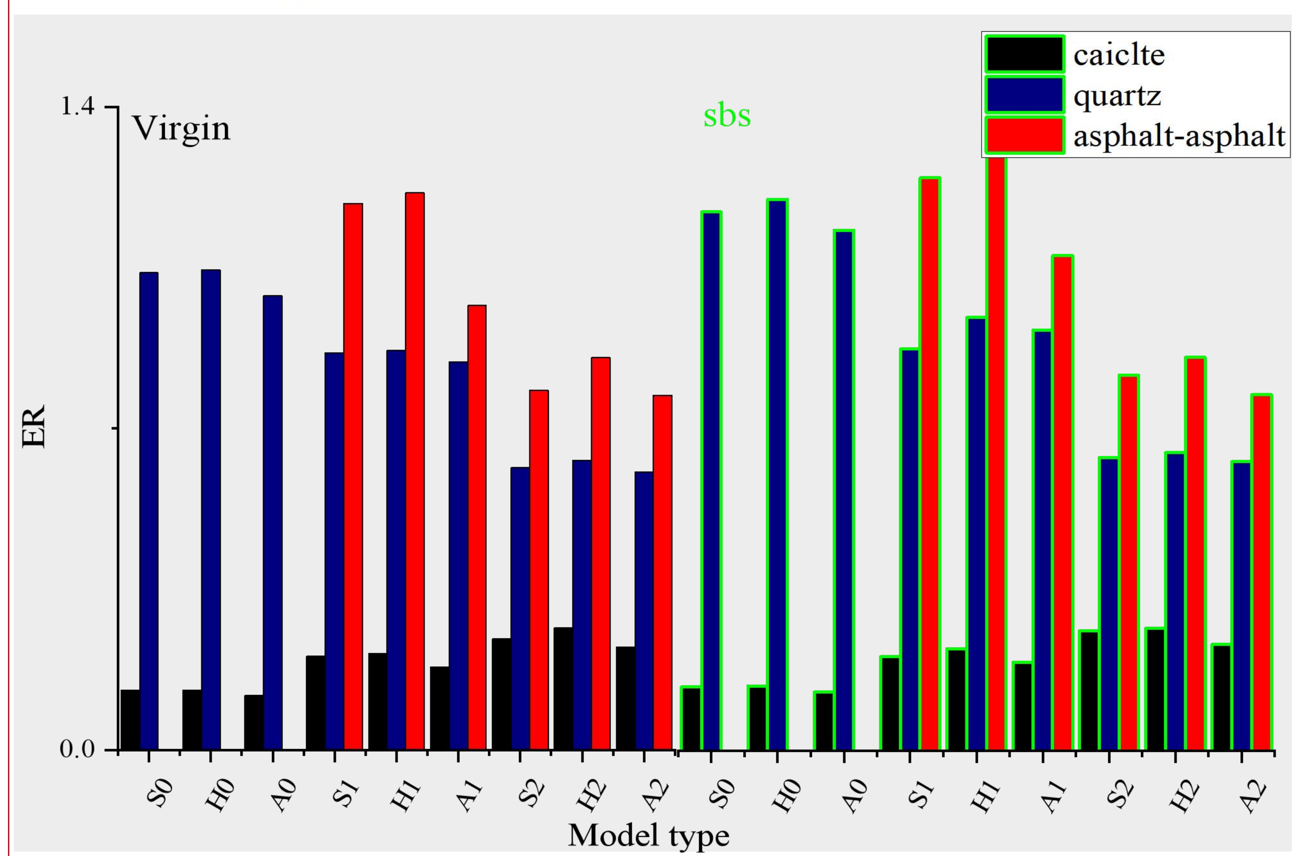
The asphalt mastic with a high filler/binder ratio is not easily affected by water.

Solution invaded INTERFACES



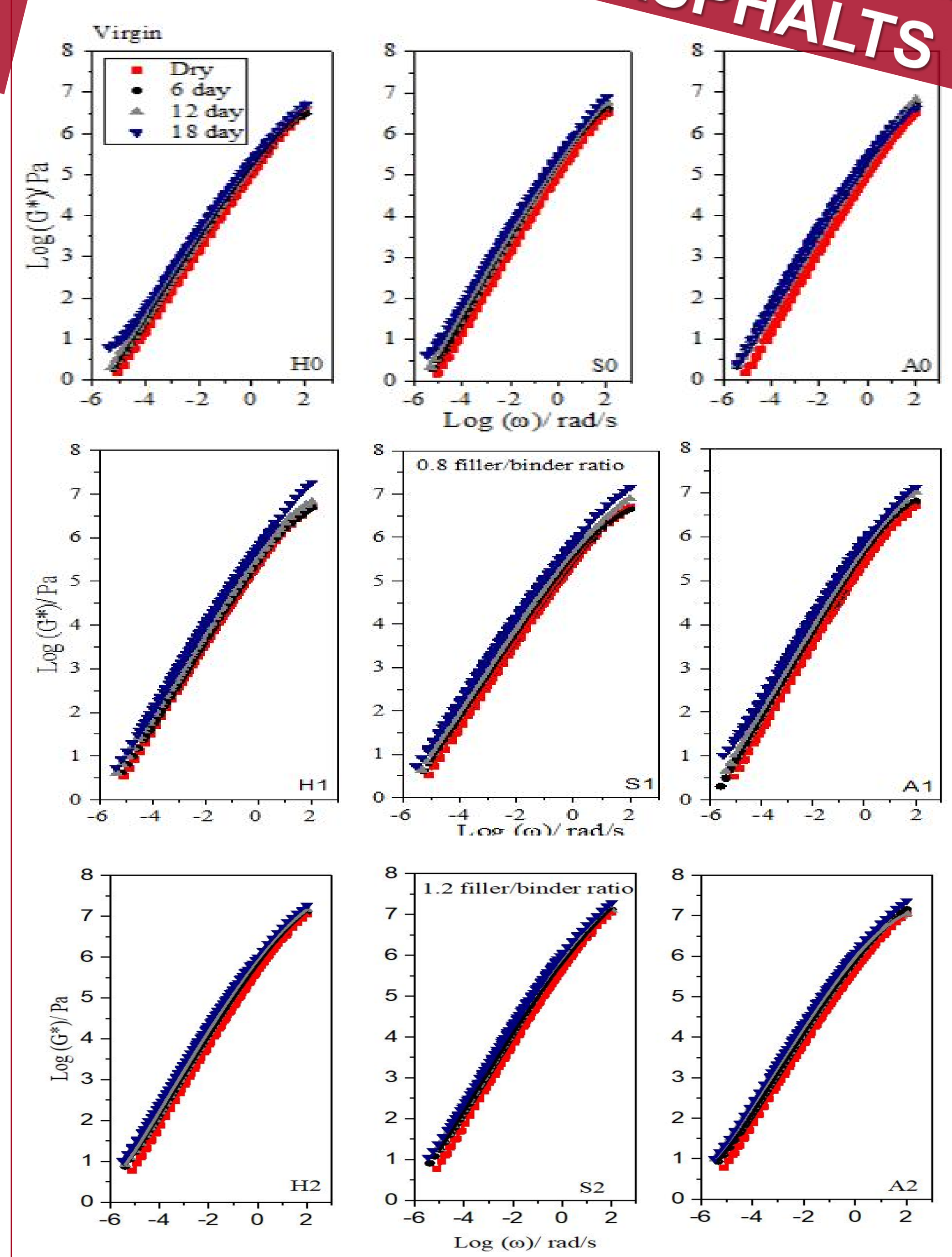
$$W_{debonding} = (\Delta W_{\alpha-wa} + \Delta W_{agg-wa} + \Delta W_{R(\alpha-agg)} - \Delta W_{\alpha-agg}) / A$$

$$ER = \frac{W_{adhesion}}{W_{debonding}} \quad \Rightarrow \quad ER_{asphalt\text{-}asphalt} > ER_{quarze} > ER_{calcite}$$



The moisture sensitivity of the asphalt-solution-asphalt model under any filler binder ratio is lower than that of the asphalt-solution-aggregate model under the same conditions. This is a new perspective to consider why the strength of the aggregate always decreases sharply at the adhesion place after immersion in water.

Solution invaded ASPHALTS



DSR asphalt samples with three filler/binder ratios show the "water aging" behavior, that is, the increased G * master curves. Moreover, alkali solution has the most significant influence on the aging behavior of asphalt. On the one hand, it is due to the esterification reaction between the solution and the carboxyl functional group of asphalt, and on the other hand, through MD simulation, this study found that alkali solution and asphalt mastic have the largest binding energy.

Conclusions

The mastic model with salt solution possessed the most hydrogen bond adsorption sites between silica and water molecules. Interestingly, In the actual solution erosion experiment, it is found that the alkali solution has the greatest deterioration on the G* master curve of asphalt. This might be related to the chemical esterification reaction on the binder surface in alkaline solution.

In the two interface models of asphalt-solution-aggregate and asphalt-solution-asphalt, it is found that the ER values of the latter are greater than the former no matter what the fillere/binder ratio is. This also explains why the degree of adhesion damage is always greater than that of adhesion damage after water intrusion into asphalt mixture from the molecular level.