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Hysteresis and breakthrough of dynamic water flow in asphalt mixture

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Dynamic water pressure caused by tire loads accelerates the deterioration of asphalt pavements, leading to water damages and material failure. Understanding water flow dynamics within the voids of asphalt mixtures during cyclic loading is essential for improving pavement performance in rainy regions.
This study developed an in-situ dynamic water flow testing setup within a Fast CT scanning environment. The X-ray projection processing method is utilized to analyze water breakthrough with a temporal resolution of 40 ms. The water flow dynamics in asphalt mixtures were successfully visualized, highlighting the water saturation hysteresis loop under cyclic pressure and capturing rapid water breakthroughs in micro-voids.
The results show that the increasing water pressure drives water to pump into open voids and compress the trapped air. Conversely, as water pressure decreases, the compressed air expels the water. This process illustrates water transportation within asphalt mixtures under cyclic tire loading and unloading. The water saturation hysteresis loop, linked to dynamic water pressure, exhibits a clockwise rotation, reflecting differences in water flow during pressure increases and decreases. Water breakthrough frequently occurs during pressure escalation, requiring a starting pressure of 0.5 MPa and occurring within 520 ms. During pressure drops, reverse breakthrough occurs as compressed air expels water, requiring a starting pressure of 0.3 MPa.
This study introduces a method to quantify water flow dynamics in porous media with high temporal resolution, offering valuable insights for studying water flow dynamics and transient water flow analysis.

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References

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