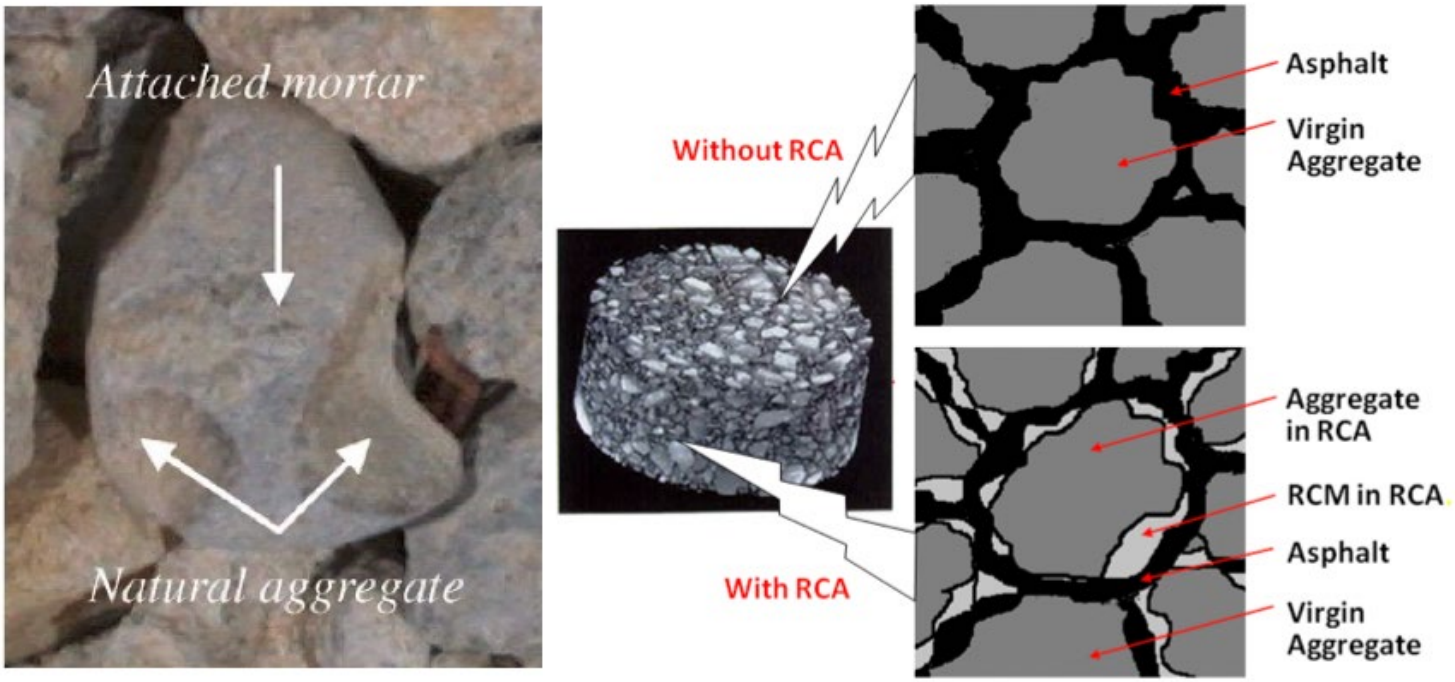
SJSU SAN JOSÉ STATE UNIVERSITY

FRESNO STATE
Discovery. Diversity. Distinction.

Development of a Quality Control Method and Guidelines for Hot Mix Asphalt Using Recycled Concrete Aggregate

Project 1854
March 2020

Xiaojun Li, PhD, Dingxin Cheng, PhD, Kun Zhang, PhD, Kanwar M.S. Jakhar, and Uday V. Pericherla



RCA and Schematic of HMA with and without RCA

Each year, asphaltic mixtures in pavement construction use about 122 million tons of aggregates. At the same time, aging U.S. infrastructure produces around 200 million tons of demolition waste each year, half of which is concrete debris. Introducing recycled concrete aggregate (RCA) as hot mix asphalt (HMA) aggregate, therefore, can not only relieve the disposal pressure, but also result in considerable reductions of cost and environmental footprint of the asphalt-paving industry.

However, the findings of limited studies in the literature show highly discrepant, sometimes even contradictory results regarding the effects of RCA on HMA (RCA-HMA). The discrepancy and contradiction in the findings of previous research have become a critical problem and an obstacle limiting the use of RCA in HMA.

Why do these studies have such disparate and even contradictory findings? The research team's hypothesis leans on the fundamental difference between RCA and virgin aggregate. RCA differs from virgin aggregate in that RCA particles are at least partially covered by a residual cement mortar (RCM) layer, which has smaller specific gravity, larger porosity and absorption, lower modulus and strength, and different surface texture compared to the natural aggregate. Most importantly, the attached RCM in RCA from different concrete sources can be significantly different in terms of age, composition, modulus, strength, porosity, surface texture, thickness, content, and its distribution on RCA surface, due to the mixture design, loading history, and environmental conditions of the source concrete. Almost all previous studies have used the current

HMA mix design procedure while only considering RCA substitution rates and gradation without considering the variation of RCA from different sources, not to mention variations in the RCM within RCA. In other words, previous research has failed to consider the variations of many specific properties of RCM and RCA due to source variations, which might be the reason for the inconsistencies in the findings regarding the effects of RCA on the properties of HMA.

This study determines the characteristics of RCA and RCM and evaluates their effects on the volumetrics and performance indicators of RCA-HMA. The study's findings can be used in research with the potential impact to considerably reduce both the cost and environmental footprint of the asphalt-paving industry.

Study Methods

This research experimentally evaluates the variation in the properties of RCA and RCM obtained from different sources and their effects on the performance of the RCA-HMA. This study differs from existing literature as the RCM properties, such as RCM addition rate, absorption calculated from RCM, and specific gravity of RCM, are here investigated for their effects on the RCA-HMA performance, instead of solely investigating the properties of RCA, as has been done in previous research.

The RCM addition rate, instead of RCA replacement rate, is a critical parameter for the performance of the RCA-HMA.

Findings

The study found the properties of RCA from different sources are significantly different. The variation of RCA properties is mainly due to the variations of the RCM contents and RCM absorptions. It is insufficient for the prediction of the volumetrics and performance of RCA-HMA to only use information about RCA, such as RCA replacement rate and gradation. The information about RCM properties, such as the RCM content, specific gravity and absorption of the RCM, is critical for the prediction of the RCA-HMA properties, such as optimum binder content (OBC), voids in mineral aggregate (VMA), voids filled with asphalt (VFA), resistance to permanent deformation, and moisture damage susceptibility.

Policy Recommendations

Considering the variance of the RCM contents and its importance for the properties of the RCA-HMA, the findings of this study demonstrate that for the RCA-HMA mix design and process quality control, a criterion setting out the RCM content upper limit ought to be determined and controlled, instead of only controlling the RCA replacement rate. By controlling the properties of the RCM in the RCA, a reliable performance of RCA-HMA can be ensured in practice.

About the Authors

Dr. Xiaojun Li is an Assistant Professor at the Department of Civil & Geomatics Engineering at California State University, Fresno. Dr. DingXin Cheng is a Professor at the Department of Civil Engineering at California State University, Chico. Dr. Kun Zhang is an Assistant Professor at the Department of Civil Engineering at California State University, Chico.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/1854.

MINETA TRANSPORTATION INSTITUTE

CSUTC California State University Transportation Consortium

The California State University Transportation Consortium (CSUTC), led by the Mineta Transportation Institute, fosters synergies across the entire California State University system to conduct impactful transportation research and engage in workforce development initiatives that increase mobility of people and goods and strengthen California's economy.