

Competition Webinar – Questions and Answers

The questions submitted during the webinar follow with answers that our speakers have provided.

Key resources available include:

https://intrans.iastate.edu/app/uploads/2018/09/RCA_practioner_guide_w_cvr.pdf

Are recycled concrete aggregates reactive in concrete? New York

Tara Cavalline: The susceptibility of RCA concrete to AAR depends on the remaining reactivity of the aggregates contained in the source concrete as well as the reactivity of new aggregates introduced into the mixture. If the source concrete used to produce the RCA was affected by AAR, the reaction may continue when the RCA is used in new concrete. The potential future expansion partially depends on the extent of the alkali-aggregate reaction completed while the original concrete was in service.

Producing RCA from agency-sourced concrete containing aggregates that have been previously evaluated for AAR is one strategy to mitigate the risk of ASR. Testing of the RCA in accordance with AASHTO R 80 is another strategy. Conventional approaches to mitigate AAR, such as SCMs and lithium compounds have also been successfully used with RCA. RCA can also be blended with conventional aggregates to reduce the potential for AAR.

Is the cement mortar on the aggregate reactive? New York

Tara Cavalline: Reactive fine aggregates could be present in the mortar contained in RCA. Testing in accordance with R 80 could be performed to help assess the potential for the mortar fraction of RCA to be reactive.

If the coarse aggregate contained in the RCA is reactive, but the fine aggregate contained in the adhered mortar is not reactive, the mortar could also play a role in supporting progression of the AAR, if it allows sufficient alkalis and moisture to contact the reactive coarse aggregate.

1. ASR in the concrete used to make RCA, can manifest in the new concrete. SCMs and low-alkali PC may not control it, because of the cement in the original paste fraction. See papers by M. Shehata et al. Ontario

Tara Cavalline: This is good cautionary advice, and use of ASR-susceptible RCA should follow the guidance provided in AASHTO R 80 to evaluate the potential reactivity of the RCA materials and potentially identify approaches (such as inclusion of SCMs) to control the expansion. This paper (and others by the research team led by University of Toronto) are excellent papers for the readers to review:

Shehata, M.H., Christidis, C., Mikhael, W., Rogers, C., Lachemi, M. (2010). “Reactivity of reclaimed concrete aggregate produced from concrete affected by alkali-silica reaction.” *Cement and Concrete Research*, 40(4), 575-582.

Matt Fonte: We replaced 600,000 SY of concrete pavement in eastern Colorado with a severe ASR problem. When the recycled concrete was tested it fail the C1206 Reactive test, and then we ran the 1567 and it showed that the type F Fly Ash was able to mitigate the ASR, much as it would in a natural aggregate.

2. Can RCA be used in roller compacted concrete? Washington

AND

Are the Recycled Concrete Aggregates RCA with similar aeromechanical properties to be used on Concrete Mixing Wearing Course for Roadways? If not, what kind of further research should the RCA go through to be used on other structural layers like Rolled Compacted Concrete RCC? Pennsylvania

It appears that RCA has successfully been used in RCC in some international studies (Fardin and dos Santos 2020, Lopez-Uceda et al. 2018). I am not aware of RCA used in RCC in the United States, but there could be some instances that ACPA is aware of.

Fardin, H.E., and dos Santos, A.G. (2020). “Roller Compacted Concrete with Recycled Concrete Aggregate for Paving Bases.” *Sustainability*, 12, 3154. doi:10.3390/su12083154

Lopez-Uceda, A., Agrela, F., Cabrera, M., Ayuso, J., and Lopez, M. “Mechanical performance of roller compacted concrete with recycled aggregates.” *Road Materials and Pavement Design*. 19(1), 36-55. <https://doi.org/10.1080/14680629.2016.1232659>

3. What do you think it will take to get to 100% Replacement of the coarse and fine agg with RCA? Colorado

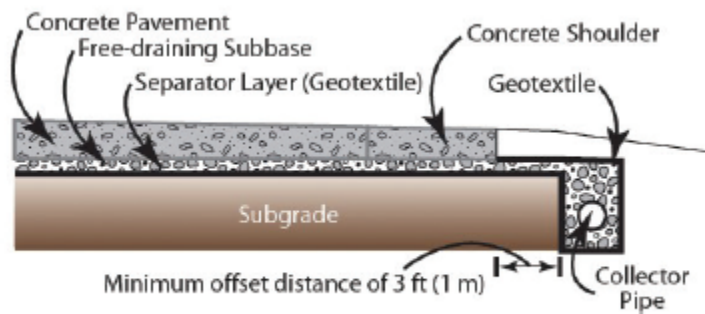
Matt Fonte: Fine aggregates are readily available throughout much of Colorado and the price is relatively low. I don't see a large demand for recycled fine aggregates in Colorado at this time.

4. How do you get around the calcium/lime leaching out when using it in filter layers? British Columbia

Tara Cavalline: Several tactics to address potential issues with calcareous tufa include:

- limit the fines content or avoid use of fine RCA
- wash the RCA
- blend the RCA with virgin aggregate
- use high-permittivity filter fabrics
- use effective drainage design features

Geotextile fabric wrapped around the RCA base and drain trench (per ACPA detail, below) is also a strategy to help prevent clogging. Alternatively, daylighted base designs or stabilized bases (encapsulating the RCA particles in binder) can be used to mitigate precipitate-related drainage problems. Additional guidance is presented in Snyder et al. (2018).



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ACPA. 2009. *Recycling Concrete Pavements*. Engineering Bulletin EB043P. American Concrete Pavement Association, Skokie, IL.

Snyder, M. B., Cavalline, T. L., Fick, G., Taylor, G., and Gross, J. 2018. *Recycling Concrete Pavement Materials: A Practitioner's Reference Guide*. National Concrete Pavement Technology Center, Iowa State University. Ames, IA.

How much asphalt millings / chunks can you tolerate in the RCA? British Columbia Tara Cavalline: The allowable level of contaminant material in RCA is dependent on the use of the RCA (Unbound base or fill? Stabilized base? New concrete?). For unbound bases, AASHTO M 319 provides limits on various types of contaminant material. Per AASHTO M 319, RCA should not contain more than 5% bituminous concrete materials by mass if it is to be used in unbound base.

In general, for bound uses, the contaminant levels should be minimized to the extent possible, and the material produced (concrete or stabilized base) should be tested during mixture development to ensure adequate mechanical and durability performance. Excessive contaminant material will likely also increase variability in test results. Additional guidance is contained in Snyder et al. (2018).

Snyder, M. B., Cavalline, T. L., Fick, G., Taylor, G., and Gross, J. 2018. *Recycling Concrete Pavement Materials: A Practitioner's Reference Guide*. National Concrete Pavement Technology Center, Iowa State University. Ames, IA.

5. When used as road base what structural drainage layer coefficients are typically used in design? British Columbia

Tara Cavalline: For RCA used as base materials, I have not heard of designers changing the drainage coefficient for RCA from that used for conventional aggregates.

6. Do the references that are cited in this presentation contain any information on CBR values of RCA vs virgin materials for base and subbase applications? Maryland

Tara Cavalline: CBR values for RCA in base/subbase applications were not provided in this presentation. However, it appears there is some data compiled in this ASTM publication:

A. Arulrajah, J. Piratheepan, M. Ali, and M. Bo, "Geotechnical Properties of Recycled Concrete Aggregate in Pavement Sub-Base Applications," *Geotechnical Testing Journal* 35, no. 5 (2012): 743-751. <https://doi.org/10.1520/GTJ103402>

7. A large issue we had was the small fines from the crushing. We used for fill on Capital projects and on trails. Do you have any other suggestions? Iowa
AND

What could be the ways to enhance use of recycled fine aggregate? France

Tara Cavalline: Recommended applications for use of RCA fines include unbound bases, embankment or fill material, and (if free from soil contamination) treated bases. Guidance is provided in Snyder et al. (2018), with additional information published in an upcoming publication, "Use of Construction Byproducts in Concrete Paving Products.

Snyder, M. B., Cavalline, T. L., Fick, G., Taylor, G., and Gross, J. 2018. *Recycling Concrete Pavement Materials: A Practitioner's Reference Guide*. National Concrete Pavement Technology Center, Iowa State University. Ames, IA.

Matt Fonte: The quarries in Colorado have the same problem they have large amount of crusher fines that they have a hard time selling. That is one of the reasons we choose to only take the 3/4" plus material for RCA. Leaving the 3/4" minus material as a class 6 road base which is a lot easier to find uses for. In some cases you could use the fine as a structural back fill. As a 1/4' minus material.

8. What is an established way of separating the hydrated cement paste from aggregate during recycling? France

Tara Cavalline: From a practical construction standpoint, it is not economical to separate the hydrated cement paste from the aggregate during the RCA production process. Instead, users should develop their production process in a manner that produces RCA with consistent properties and minimal contamination.

Characterization tests can be performed on the RCA in order to understand and account for the differences in properties due to the adhered mortar.

From a laboratory testing standpoint, the residual mortar content has been determined by using chemical solutions to dissolve the adhered mortar, using thermal treatment methods, or combinations of both methods. A summary of these methods is presented in the literature review of this report:

Hu, J., Cavalline, T., Mamirov, M., and Dey, A., “Effective Characterization of Recycled Concrete Aggregate (RCA) for Concrete Applications. American Concrete Institute.

9. Has RCA for internal curing of concrete (ICC) or modified ICC been used (since there's higher absorption of aggregate)? Virginia

Tara Cavalline: There has been some research performed on use of prewetted RCA for internal curing, with reduced autogenous shrinkage being observed as one of the measurable benefits. Publication of interest:

Kim, H., and Bentz, D. (2008). “Internal Curing with Crushed Returned Concrete Aggregates for High Performance Concrete.” NRMCA Concrete Technology Forum: Focus on Sustainable Development. Available at:
https://www.researchgate.net/publication/242283414_Internal_Curing_with_Crushed_Returned_Concrete_Aggregates_for_High_Performance_Concrete

10. How are absorptions accurately determined to control water in a concrete mix design? Virginia

Tara Cavalline: The absorption of RCA can be measured using the same testing methods use for fine and coarse natural aggregates. For RCA fines, which may have a relatively high absorption, the Centrifuge Method by Miller et al. (2014) could be an alternative method to the paper towel method.

Miller, A.E., Barrett, T.J., Zander, A.R., and Weiss, W.J. (2014), “Using a Centrifuge to Determine Moisture Properties of Lightweight Fine Aggregate for Use in Internal Curing,” *Advances in Civil Engineering Materials*, 3(1),142–157.
doi:10.1520/ACEM20130111. ISSN 2165-3984

11. Should the RCA mortar be testing for pH and chlorides? Does RCA reduce the pH of concrete when RCA is used? Virginia

Tara Cavalline: Typical qualification testing requirements for RCA used in different applications (unbound base/fills, bound base, new concrete) is presented in Snyder et al. (2018). RCA is not typically tested to determine its pH. For use in concrete mixture designs, ACPA (2009) recommends that the chloride content of RCA be limited to 0.06 lb/yd³.

Snyder, M. B., Cavalline, T. L., Fick, G., Taylor, G., and Gross, J. 2018. *Recycling Concrete Pavement Materials: A Practitioner's Reference Guide*. National Concrete Pavement Technology Center, Iowa State University. Ames, IA.

ACPA. 2009. *Recycling Concrete Pavements*. Engineering Bulletin EB043P. American Concrete Pavement Association, Skokie, IL.

12. I would like to learn of any reference using the recycled concrete aggregate in geopolymer concrete? Virginia

Tara Cavalline: Some recent work in this area that I've identified include:

Koushkbaghi, M., Alipour, P., Tahmouresi, B., Mohseni, E., Saradar, A., and Sarker, P.K. (2019). "Influence of different monomer ratios and recycled concrete aggregate on mechanical properties and durability of geopolymer concretes." *Construction and Building Materials*, 205, 519-528. <https://doi.org/10.1016/j.conbuildmat.2019.01.174>

Nuaklong, P., Sata, V., and Chindaprasirt, P. (2016). "Influence of recycled aggregate on fly ash geopolymer concrete properties." *Journal of Cleaner Production*, 112(4), 2300-2307. <https://doi.org/10.1016/j.jclepro.2015.10.109>

13. Once it's crushed on site is the testing done in site also? California

Tara Cavalline: It seems that the location of RCA characterization testing would be project-specific, depending on the contractor's QC laboratory capabilities and whether an outside testing firm may be hired to assist with QC testing. Field tests would be performed in the same manner as those performed on conventional aggregates.

14. The process uses a lot of water. How much on average? Is environmental impact taken into account? California is facing another draught year. Can you use grey water? California

Matt Fonte: If you are talking about the washing process, we use very little water. For the two options I showed, we either use a series of ponds and recycle the water as the sediment settles in the ponds. Or we use a water clarifier system which uses even less water as it only recirculates between the clarifier and the washer.

15. I am concerned about the soundness results. West Virginia

Tara Cavalline: Since the paste component of RCA is susceptible to sulfate attack, results in the magnesium and sodium sulfate soundness tests are unreliable for RCA. Therefore, alternative soundness tests can be used, as described in AASHTO M 319. These approaches include AASHTO T 103, which is a freeze-thaw procedure conducted in water with 25 cycles of freezing and thawing and a maximum allowable loss of 20%. Other listed alternates are the NYSDOT Test Method NY 703-08 and

Ontario Ministry of Transportation Test Method LS-614, both of which involve freeze-thaw cycles in a sodium chloride brine solution with a maximum allowable mass loss of 20%.

16. Are the sediments suitable to be used as a liner for landfills? Florida

Tara Cavalline: I have not seen publications regarding the suitability of RCA fines to be included as material lining a landfill. It would seem to me that RCA fines could potentially be used in landfill applications if the material meets the specification requirements of other aggregates. One characteristic that may be explored is the potential for high pH runoff, and its implications, if the material is used in a drained application.

17. Can you talk about the suitability of RCA from vertical construction? Florida

Tara Cavalline: I will assume that this question is asking about RCA in concrete mixtures, as opposed to RCA used in unbound applications (fill/base) to support vertical construction.

Much research has been performed on RCA concrete mixtures, with the aim at understanding the potential for this material to be used in vertical construction. Many studies have indicated that the undesirable changes to concrete mixture performance resulting from use of RCA can be accommodated using readily implementable mixture design and proportioning techniques. However, widespread use of RCA in vertical construction has not become accepted in the United States.

Recent changes to the building code ACI 318-19 allow crushed concrete or recycled aggregate. However, the code does not include specifications for design criteria, and instead indicates that any alternative materials just be approved by the licensed design professional and the building official. Therefore, suppliers and producers will be required to perform testing, providing data regarding the anticipated product performance. Some additional information, including testing considerations, is presented in Mohle (2019).

Mohle, J.P. (2019). "ACI 318-19 brings new provisions for alternative cements and aggregates." Concrete Products, September 10, 2019 edition. Available at: <http://concreteproducts.com/index.php/2019/09/10/aci-318-19-brings-new-provisions-for-alternative-cements-and-aggregates/>

18. Does the log washer have magnets to remove any metal pieces? Florida

Matt Fonte: No, the magnets are on the crushers. The metal is removed during the crushing process usually in large pieces.

19. Do you only use the product with a portable batch plant or have you had success in stationary batch plants? California

Matt Fonte: Castle Rock Construction only owns portable plants, but the process would be the same for stationary plants. You can use RCA in any concrete plant.

20. Does it matter what the original mix design was of the RCA and how it's applied to a new concrete mix design? Iowa

Tara Cavalline: The quality of the source concrete used to produce the RCA will influence both the mechanical properties and the durability performance of the new concrete produced using that RCA. The performance history of the source material should be assessed prior to use as RCA in new concrete. Often RCA concrete has reduced strength compared to concrete produced with natural aggregates. However, the stronger the source concrete mixture, the smaller the reduction in strength (Snyder et al. 2018). The permeability of the new concrete (and its ability to resist penetration of fluids and aggressive agents) will be dependent on the w/cm ratio used in the new mixture, as well as the permeability of the adhered paste contained on the RCA. The air content of the source concrete must also be considered when aiming to use RCA to produce new, freeze-thaw resistant concrete mixtures. The potential for alkali-aggregate reactivity and D-cracking distress being introduced to the new concrete through use of susceptible RCA must also be considered. Additional guidance is presented in Snyder et al. (2018).

Snyder, M. B., Cavalline, T. L., Fick, G., Taylor, G., and Gross, J. 2018. *Recycling Concrete Pavement Materials: A Practitioner's Reference Guide*. National Concrete Pavement Technology Center, Iowa State University. Ames, IA.