4

CONCRETE SOLUTIONS GUIDE

Embrace Circularity

Concrete Recycling

The simplest way to reduce concrete emissions is to produce less of it—that’s where recycling comes in. The rate of change of the built environment often outpaces the longevity of concrete. Although normally treated as a waste material, concrete from decommissioned buildings should be viewed as a resource. When used on-site for nonstructural application (e.g., as base material), recycled concrete offers significant cost savings and obvious emissions reductions.

Key Takeaways

For nonstructural applications, recycled concrete sourced on-site offers approximately 50% cost savings compared with natural aggregate and reduces the volume of new material required.

Among the most promising applications for this material are uses as a base layer for roads, parking lots, and driveways; as backfill material or shoulder stone; and as aggregate in nonstructural concrete.

Current technology for incorporating recycled concrete aggregate in new structural concrete mixes does not achieve significant reductions in embodied carbon.

Opportunity

The Construction Materials Recycling Association estimates that 140 million tons of concrete are recycled annually in the United States,[1] which is approximately 13% of the total natural aggregate produced for construction. Increasing this circularity is a vital step toward a low-carbon future. When approaching a new building project, it is important to recognize old concrete as a new resource.

The application of recycled concrete aggregate (RCA) is best suited to use cases where high strength is not required, such as for base layers in gravel and in pavement concrete. Several studies have demonstrated that the use of recycled concrete aggregate can reduce costs, particularly when the aggregate is processed on-site, eliminating further transport requirements. A direct cost savings for RCA of 60%–80% can be readily achieved when the RCA is used on the same site where it is produced,[2] while reducing life-cycle environmental impacts in emissions and water consumption.[3]

Considerations

Processing RCA is cost-effective compared to using natural aggregate. But when used to replace natural aggregate in concrete for structural applications, the benefits are limited. Unlike natural aggregate, RCA contains adhered mortar, which can result in reduced performance when it is recycled to produce new concrete.[4] Studies also indicate increased contraction as the RCA fraction is increased.[5] As a result, it would be necessary to increase the amount of cement or admixtures used in a mix to offset the strength impacts, cutting into the emissions benefit from the use of RCA.

In order to reduce the variable performance in RCA, further treatment can either remove or fortify the adhered mortar. Several techniques are likely cost-competitive, including mechanical abrasion, heat treatment, and ultrasonic water cleaning for removal, as well as carbonation for fortification.[6] Of these methods, carbonation is particularly promising given its potential to both enhance the RCA properties and reduce carbon emissions by acting as a permanent mineral store of carbon dioxide (see **Solution 5**).

Thus far, these challenges have stymied efforts to achieve significant carbon savings by using RCA in structural applications.[7] Although the carbon emissions reductions for RCA compared with natural aggregate on a mass basis are significant (approximately 66%), the overall impact on embodied carbon becomes nearly negligible due to the increased use of cement, which usually accounts for over 90% of the total associated emissions in concrete.[8] Put simply, the gains are nearly canceled out by losses when RCA is used in mixes with structural applications.

Related Solutions

1. Know Your Numbers: Performance-oriented specifications

2. Mix It Up: Supplementary cementitious materials (SCMs)

5. Carbon as a Service: Sequestering CO_2 in concrete

6. Use Green Heat: Decarbonize kiln technology

Future breakthroughs, such as those discussed in Solution 5, have the potential to change the unfavorable math on using RCA in mixes with structural applications. But until that point comes, RCA remains a highly cost- and carbon-effective material for on-site, nonstructural applications.

State of the Market

In most markets across the United States, companies provide on-site concrete recycling services as well as centralized facilities for processing and upgrading RCA. Several ready-mix companies also offer on-site concrete recycling services.

Promising regulatory changes are also under way. The American Concrete Institute (ACI) committee on concrete with recycled materials is currently updating its guide on removal and reuse of concrete. This guide will provide updated research on RCA use as well as best practices and recommendations for RCA deployment. Meanwhile, public entities are gravitating toward increased uptake of RCA. The City of San Francisco has specified a minimum of 15% RCA in all concrete pavement applications.[9]

Endnotes

1. “Recycled Concrete,” Portland Cement Association, 2010, **https://www.cement.org/docs/default-source/th-paving-pdfs/sustainability/recycled-concrete-pca-logo.pdf.**

2. M. Eckert and M. Oliveira, “Mitigation of the Negative Effects of Recycled Aggregate Water Absorption in Concrete Technology,” *Construction and Building Materials*, vol. 133 (2017): 416–424.

3. E. A. Ohemeng and S. O. Ekolu, “Comparative Analysis on Costs and Benefits of Producing Natural and Recycled Concrete Aggregates: A South African Case Study,” *Case Studies in Construction Materials*, vol. 13 (2020): e00450; and V. W. Tam, “Economic Comparison of Concrete Recycling: A Case Study Approach,” *Resources, Conservation and Recycling*, vol. 52, no. 5 (2008): 821–828.

4. J. M. Khatib, “Properties of Concrete Incorporating Fine Recycled Aggregate,” *Cement and Concrete Research*, vol. 35, no. 4 (2005): 763–769.

5. A. Domingo-Cabo et al., “Creep and Shrinkage of Recycled Aggregate Concrete,” *Construction and Building Materials*, vol. 23, no. 7 (2009): 2545–2553, **https://doi.org/10.1016/j.conbuildmat.2009.02.018.**

6. E. A. Ohemeng and S. O. Ekolu, “A Review on the Reactivation of Hardened Cement Paste and Treatment of Recycled Aggregates,” *Magazine of Concrete Research*, vol. 72, no. 10 (2020): 526–539.

7. P. Visintin, T. Xie, and B. Bennett, “A Large-Scale Life-Cycle Assessment of Recycled Aggregate Concrete: The Influence of Functional Unit, Emissions Allocation and Carbon Dioxide Uptake,” *Journal of Cleaner Production*, vol. 248 (March 2020): 119243, **https://doi.org/10.1016/j.jclepro.2019.119243.**

8. Johanna Lehne and Felix Preston, *Making Concrete Change: Innovation in Low-Carbon Cement and Concrete*, Chatham House, June 2018, **https://www.chathamhouse.org/sites/default/files/publications/2018-06-13-making-concrete-change-cement-lehne-preston-final.pdf.**

9. “Section 02520: Portland Cement Concrete Paving,” San Francisco, **https://sfport.com/ftp/uploadedfiles/about_us/divisions/real_estate/City%20Concrete%20Paving%20Specification%20with%20Recycled%20Content.pdf.**

Charles Cannon, Valentina Guido, and Lachlan Wright, *Concrete Solutions Guide: Six Actions to Lower the Embodied Carbon of Concrete,* RMI, 2021, http://www.rmi.org/concrete-solutions-guide/.

All images used are from iStock.com unless otherwise noted.

RMI Innovation Center
22830 Two Rivers Road
Basalt, CO 81621

www.rmi.org