Recycled aggregates

green SOLUTIONS

Q: I have more and more projects pursuing LEED ratings. How can I increase the recycled content of concrete? I already allow fly ash in my concrete; should I start specifying recycled aggregate?

A: With the rapid increase in the number of projects pursuing a LEED rating from the U.S. Green Building Council, structural engineers have become more aware of the environmental impacts of the materials we specify. The negative impacts of structural materials range from resource depletion to water pollution to the emission of greenhouse gasses. While LEED currently evaluates materials primarily by their recycled content, the goal of LEED is to minimize environmental impact and specifically greenhouse gas emissions. Examination of recycled content in concrete is an excellent example of where a focus on recycled content may not tell the whole story and could actually be counterproductive.

To understand the relationship between recycled content and greenhouse gas emissions from concrete, we must consider how each of the constituents contributes to the environmental footprint of a concrete mix. Cement is usually only 10 to 15 percent (by weight) of concrete, but it accounts for the majority of the embodied energy and embodied CO_2 of concrete. A recent Portland Cement Association publication *Life Cycle Inventory of Portland Cement Concrete* showed that cement is responsible for roughly 86 percent of the fuel consumption and 96 percent of the embodied CO_2 in a common concrete mix. Understanding that cement dominates these embodied impacts is essential when considering the impact of specifying recycled concrete aggregates (RCA).

Using RCA in concrete that is economical and has reduced embodied impacts presents technical mix design challenges and significant logistical considerations. The logistical considerations are straightforward but can pose significant barriers to using RCA. First you must find a local ready mix supplier who maintains a stockpile of RCA and can easily integrate this material into your mix. Once you find a ready mix plant able to accommodate the material, you must verify the quality of the stockpile or find a reliable source of consistently suitable RCA. This can be challenging because the variability of the crushed concrete is dependent on the materials the crushing yard accepts. Many crushing yards accept only clean concrete. Clay masonry, asphalt, wood, and dirt have been found in samples of RCA. When testing RCA it is important to remember that ASTM C33 Standard Specification for Concrete Aggregates contains not only grading requirements but also abrasion and sulfate soundness criteria. Finally in some instances concrete has been demolished because it exhibited problems such as Alkali Silica Reaction (ASR).If your source contains such materials they must be mitigated.

Once you find a reliable source for RCA, perhaps from a structure being demolished to make way for your new building, you face new challenges in proportioning your mix design. RCA is normally more angular and has a higher absorption than conventional virgin aggregates. The increased absorption is due to the residual mortar content, the cement paste from the source concrete that remains adhered to the aggregates. Conventional mix proportioning methods indicate that increased water content is required for RCA mixes to maintain the required slump. This can then lead to increased cement content to maintain the required water to cement ratio. This chain of events results in a mix that makes use of RCA, but also uses more cement and has a higher embodied energy and CO_2. This can be avoided by using a blend of virgin and RCA and by using fly ash to replace cement. Studies have shown that a blended coarse aggregate has little impact on the water demand of a mix, and the use of fly ash in RCA mixes not only reduces the cement content but can help counter the harshness of the RCA and the resulting water demand.

There is an even easier way. RCA has successfully been used for many site work applications such as select fill, granular base under slab-on-grade, and coarse drainage backfill. When used in a drainage application, it is important that a grading similar to #57 (ASTM C-33) be used to prevent the finer particles, which can contain unhydrated cement, from clogging drainage fabrics. These applications allow the immediate reuse of this material without the complications discussed above. The use of a mobile crusher to produce the RCA on-site can further reduce both the financial and environmental costs.

For now, if you want to reduce the footprint of your concrete mix, first aggressively use complementary cementitious materials to use less cement, and then incorporate the RCA. However, don't forget to also add RCA into your other specifications. ▼

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