

Concrete Q&A

Does Crushed Concrete Aggregate Meet Building Code and Specification Requirements?

Q. *We're considering having the concrete supplier use crushed concrete as coarse aggregate, and perhaps fine aggregate, in the 3000 psi (21 MPa) concrete specified for a project we're building. Does aggregate produced by crushing returned concrete meet the requirements for aggregates in building codes and commonly used specifications?*

A. Section 3.3.1 of ACI 318-08, "Building Code Requirements for Structural Concrete," and Section 4.2.1.2 of ACI 301-05, "Specifications for Structural Concrete," both require that concrete aggregates conform to ASTM C33, "Standard Specification for Concrete Aggregate." ASTM C33 is also referenced in ASTM C94, "Standard Specification for Ready-Mixed Concrete," and in the AIA MasterSpec, which is the basis of specifications in many design firms. ASTM C33 permits the use of crushed concrete aggregate (CCA).

Section 9.1 of ASTM C33-08 states: "Coarse aggregate shall consist of gravel, crushed gravel, crushed stone, air-cooled slag, or crushed hydraulic-cement concrete or a combination thereof, conforming to the requirements of this specification." In a study prepared for the RMC Research & Education Foundation,¹ aggregate test results

indicated that the coarse aggregate produced by crushing 1000, 3000, and 5000 psi (7, 21, and 35 MPa) concrete met ASTM C33 coarse aggregate specification requirements with one exception. Soundness test results for the aggregate made with the weakest (1000 psi [7 MPa]) concrete did not meet the requirements. Aggregate soundness test conditions are attempts to simulate the weathering action in concrete; soundness requirements are therefore specified for concrete exposed to moderate or severe freezing-and-thawing conditions. Section 11.3 of ASTM C33-08, however, includes a provision permitting the use of an aggregate that does not meet one or more of its criteria if there is a satisfactory service record for concrete made with the aggregate, or the aggregate produces concrete having satisfactory relevant properties for the intended application.

Section 5.1 of ASTM C33-08 states: "Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof." ASTM C125-09a, "Standard Terminology Relating to Concrete and Concrete Aggregates," defines manufactured sand as "fine aggregate produced by crushing rock, gravel, iron-blast furnace slag, or hydraulic-cement concrete." In the RMC Foundation study, aggregate test results indicated that fine aggregate produced by crushing 1000, 3000, and 5000 psi (7, 21, and 35 MPa) concrete meets ASTM C33 specifications with two exceptions:

- Material finer than the No. 200 sieve is slightly higher than the 5 to 7% limit allowed; and
- Soundness test limits are exceeded.

Section 6.3 of ASTM C33 permits the use of an aggregate that does not comply with the grading limits with the documentation of service record or performance tests.

Questions in this column were asked by users of ACI documents and have been answered by ACI staff or by a member or members of ACI technical committees. The answers do not represent the official position of an ACI committee. Only a published committee document represents the formal consensus of the committee and the Institute.

We invite comment on any of the questions and answers published in this column. Write to the Editor, *Concrete International*, 38800 Country Club Drive, Farmington Hills, MI 48331; contact us by fax at (248) 848-3701; or e-mail Rex.Donahey@concrete.org.

Concrete Q&A

Sections 8.2 and 8.3 state that even if the soundness test results are not met, the fine aggregate shall be regarded as meeting the requirements if the supplier supplies a satisfactory service record or demonstrates that it gives satisfactory results in concrete subjected to freezing-and-thawing tests (ASTM C666).

ASTM C33 requires the testing of aggregates for clay lumps and friable particles, coal/lignite, and chert. These tests were not conducted in the RMC Foundation study. The study recommended that before using CCA, the producer should consider conducting all of the tests that document compliance with ASTM C33 or other requirements of the project specification.

Note 6 in ASTM C33-08 lists some precautions that may be needed when CCA is used in concrete:

- Mixing water requirements may be increased because of the harshness of the aggregate;
- Partially deteriorated concrete, used as aggregate, may reduce freeze-thaw resistance; affect air void properties; or degrade during handling, mixing, or placing; and

- Crushed concrete may have constituents that would be susceptible to alkali-aggregate reactivity or sulfate attack in the new concrete or may bring sulfates, chlorides, or organic material to the new concrete in its pore structure.

The notes in ASTM C33, however, are for information only and are not considered requirements of the specification.

Reference

1. Obla, K.; Kim, H.; and Lobo, C., *Crushed Returned Concrete as Aggregates for New Concrete*, National Ready Mixed Concrete Association, Silver Spring, MD, 2007, 51 pp.

Additional information on the ASTM standards discussed in this Q&A can be found at www.astm.org. Information on AIA MasterSpec can be found at www.arcomnet.com.

Thanks to Ward Malisch, Northville, MI, and Karthik Obla, NRMCA, Silver Spring, MD, for reviewing the answer to this question.

Using Air Entrainment in the Caribbean

Q. *We do most of our work in Canada, and we've become accustomed to using entrained air in our concrete to help protect it from freezing-and-thawing cycles. Because air entrainment also provides improved workability and decreased bleeding, we use it in most concrete—not just concrete exposed to freezing and thawing. Recently, one of our larger clients has asked us to work on a project in the Caribbean. The project includes a swimming pool near the ocean, and we're considering using air entrainment for the pool and surrounding slabs.*

We know that air entrainment isn't commonly used where the project is located. Even so, shouldn't air entrainment be used in concrete that will be in constant or intermittent contact with dissolved chlorides or sulfates?

A. Before prescribing air entrainment for use in a location where it's not commonly used, you should make sure that the local concrete suppliers can consistently and economically produce concrete of the desired air content and that the local testing labs can test for it.

A few phone calls to the local concrete producers and testing labs should tell you what you need to know. If the local producers and labs don't have experience with air-entrained concrete, it would be best not to request it.

Another concern would be the finish requirements for the slab surfaces. While hard-trowelled surfaces aren't normally used around swimming pools, there may be nearby slabs that require such finishes. If air-entrained concrete is used in those slabs, there could be an increased risk of delamination.

If you do elect to use air entrainment, its primary benefit will be to enhance workability and allow a reduction in water-cement ratio. Note that other ways to achieve the desired workability—for example, optimized grading of the aggregate—may be easier for the local suppliers to produce consistently. Also keep in mind that slag cement can improve workability while also reducing the permeability of the concrete and enhancing its ability to protect reinforcement from corrosion.