USES OF RCA

Recycled concrete aggregates can be used in any application in which virgin aggregate can be used, and even some it typically is not.

Virgin aggregate costs are increasing because many of the high-quality, conveniently located virgin aggregate resources are being depleted rapidly. Recycled concrete aggregate (RCA) have proven to be a sustainable substitute for virgin aggregates in almost any application that uses conventional virgin aggregates, in some cases proving to be an even better choice than the typically more costly virgin aggregate. This publication details many of the common (and some innovative and uncommon) uses of RCA in lieu of virgin aggregate. More about these topics is available in ACPA's EB043P, "*Recycling Concrete Pavements*."

RCA can be produced as a substitute for almost any conventional virgin aggregate. Because of the chemical and residual cementitious properties of the reclaimed mortar, RCA also is useful in other applications. Some of the most common and interesting applications (and limitations) are discussed in the remainder of this publication.

Unstabilized (Granular) Subbase/Backfill

Unstabilized (granular) subbase applications are common for RCA produced from concrete pavements because of the potential for superior performance, economic savings, conservation of resources and environmental considerations. (See ACPA's EB204P for additional details.) As evidence of this common practice, 38 states use the material for aggregate subbase applications. In fact, some states believe that RCA outperforms virgin aggregate in unstabilized subbase applications (FHWA 2004).

An important benefit to using RCA as unstabilized subbase material is that the presence of contaminants (e.g., asphalt concrete, joint sealant materials, etc.) is of relatively little concern. For example, Minnesota allows up to 3% asphalt binder by weight of aggregate, and California has no limit on the relative proportions of RAP and RCA in their subbase materials. This provides maximum contractor flexibility in production and construction. Figure 1 shows the presence of both RAP and RCA in a Minnesota RCA stockpile (FHWA 2004); through process control and blending, contractors can produce RCA subbase material with almost any gradation.

RCA is an effective and economical material for unstabilized dense-graded subbase applications. When properly graded, the angular nature of the product provides excellent stability. In addition, fine RCA often experiences a degree of secondary cementing, which further strengthens and stiffens the subbase layer.

Figure 1. Photo of RCA aggregate subbase stockpile (containing both concrete and asphalt material) in Minnesota (FHWA 2004).

RCA also can make excellent unstabilized free-draining subbase material when the production yields relatively angular, rough-textured particles that can be graded to applicable specification requirements. The use of RCA in unstabilized free-draining subbase layers, however, has been associated with the deposit of crushed concrete dust and leachate (calcium carbonate precipitate) in drainage pipes and on filter fabric; the potential for these problems can be greatly reduced by washing the RCA and by eliminating fine RCA from the subbase (Bruinsma 1995).

Subbase layer stabilization with cement or asphalt also is effective in practically eliminating dust and leachate concerns. Drainage systems also can be designed to allow residual crusher dust to settle in a granular filter layer while only partially wrapping the longitudinal drain trench with filter fabric.

Cement-Stabilized Subbase

Cement-stabilized subbase layers (e.g., cement-treated subbase (CTB) and lean concrete subbase (LCB)), also can be constructed using RCA. Coating or embedding the RCA in fresh cement paste or mortar prevents the migration of crusher fines and the dissolution and transport of significant amounts of calcium hydroxide, which can otherwise form calcium carbonate precipitate in drain pipes.

The physical and mechanical properties of RCA (particularly the absorption characteristics) must be considered in the design and production of CTB and LCB, similar to their consideration in concrete production using RCA, as described below.

Concrete Mixtures

RCA can be (and has been) incorporated as the primary or sole aggregate source in new concrete pavements. For example, RCA has been used in concrete mixtures in the U.S. since the 1940's for roadway surfaces, shoulders, median barriers, sidewalks, curbs and gutters, building and bridge foundations and even structural concrete (NHI 1998, ECCO 1999). The use of RCA also is common in the lower lift of two-lift concrete pavements in Europe (FHWA 2007).

It should be considered that the physical and mechanical properties of concrete products containing RCA may vary from those containing virgin aggregate. For example, the strength and modulus of elasticity of RCA concrete may be lower and the coefficient of thermal expansion (CTE) higher than for concrete prepared using virgin aggregate when all other factors remain constant. Other concerns when utilizing RCA in concrete mixtures are increased water demand, premature stiffening, and achieving the proper air content and air void distributions; methods and processes exist, however, that can prevent any of these concerns from materializing in a properly design RCA concrete mixture.

There also have been concerns about recycling old concrete with freeze-thaw durability or alkali-silica reactivity (ASR) problems. However, modifications to traditional crushing and mixture design procedures have proven successful in preventing the reoccurrence of durability and reactivity problems in pavements containing RCA.

Other Applications

Asphalt Pavement/Asphalt-Stabilized Subbase

RCA has been used successfully in new asphalt pavement and asphalt-stabilized subbase applications. Typical RCA particle angularity and rough texture provide excellent potential for stability and surface friction, and the use of asphalt to encapsulate RCA particles effectively eliminates the potential for clogging of drainage structures in subbase applications. Unfortunately, the more absorptive nature of typical RCA particles significantly increases asphalt binder demand, which often increases costs prohibitively.

Granular Fill

Crushed concrete is an economical and highly stable material that is well-suited for granular fill applications. This is a particularly good application for fine RCA products, which may be produced in quantities that are excessive for subbase, concrete mixture and other applications.

Erosion Control (Rip-rap)

Most states allow the use of recycled concrete for erosion control ("rip-rap") or slope stabilization (FHWA 2004). In this application, the concrete pavement is broken into pieces that are 6 in. (150 mm) or larger. Maximum size often is dictated by aesthetic consideration and original pavement thickness (to avoid using large flat pieces). Protruding steel usually is removed prior to use.

Innovative Applications

Numerous other applications for RCA products have been implemented, researched or suggested, including some common applications such as soil stabilization, pipe bedding, landscape materials, railroad ballast, and agricultural soil treatments (similar to soil modification using lime), and some more uncommon applications such as treatment of acidic lake waters, trickling filters and effluent treatment, components of SO_2 scrubbers, ingredients in masonry block production, and formation of artificial reefs for establishing oyster beds. Additional details concerning these applications can be found elsewhere (Vandenbossche and Snyder 1993, FHWA 2004 and CMRA 2008).

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