PERFORMANCE OF CONCRETE PAVEMENTS WITH RCA

ACPA

Decades of excellent performance have proven the use of RCA in applications such as subbases and new concrete surface courses.

Recycled concrete aggregates (RCA's) produced from existing concrete pavements have been used in new concrete pavement structures in the U.S. since shortly after World War II, although the practice did not gain widespread use until the mid-1970's. A literature review conducted in 1994 found that nearly 100 RCA concrete paving projects had been built in the United States by that time, including projects that successfully used RCA produced from existing concrete pavements that had succumb to materials-related distresses such as D-cracking and alkali-silica reactivity (ASR). More recently, some surface courses containing 100% coarse and fine RCA have been constructed with excellent results. A few of these projects are briefly discussed here, but more details about these and other projects are available in ACPA's EB043P, "*Recycling Concrete Pavements*."

Using existing concrete pavements as a source of aggregate for new pavement construction is not new. A portion of U.S. 66 was constructed using RCA concrete shortly after World War II, and many European countries utilized building rubble in new concrete pavement construction just after World War II (Yrjanson 1989).

After those early recycling efforts, little recycling was done in the United States until the mid-1970's, when interest and activity in concrete pavement recycling increased. By the early 1980's, many old concrete pavements were being recycled into new concrete pavement systems. A 1994 literature review (Snyder et al 1994) identified almost 100 RCA concrete paving projects in the United States, including several where D-cracked or alkali-silica reactivity (ASR) damaged pavements were recycled. Most of these projects have performed well and are considered successes.

In 1993, the FHWA sponsored a study (Wade et al 1997) that included a comprehensive evaluation of the properties and performances of nine pavement projects that used RCA in new concrete paving. At the time of evaluation, these pavement sections ranged in age from 6 to 15 years and included a broad range of pavement designs, traffic loads, and environmental conditions. The study included pavements that had and had not performed acceptably. Many of the selected sites included "control sections", while others had alternate designs or other features. Data collected included field condition information, falling weight deflectometer test results, results of strength and mechanical property tests on cores, etc.

In 2006, the University of New Hampshire's Recycled Materials Resource Center (RMRC) conducted follow-up visits to all of the sites evaluated in the FHWA 1993 study (these sections were aged 18 to 27 years in 2006), and also evaluated additional RCA concrete pavement sites in Iowa and Illinois. This study included the collection of pavement condition data and tests of cores from the midpanel and joint areas. The full details of this study are available elsewhere (Sturtevant 2007).

Some of the key findings of these studies include the following (Wade et al 1997, Sturtevant 2007):

- The measurement of air content in fresh RCA concrete may be accurately obtained using volumetric techniques rather than pressure techniques (e.g., the because of the air content and more porous nature of reclaimed mortar.
- Measures of the coefficient of thermal expansion (CTE) were generally higher for RCA concrete than for conventional concrete.
- Modulus of elasticity test values for the aged cores were generally 1 to 18% lower for RCA concrete than for conventional concrete. Most literature reports a greater difference (15 to 50%) for younger concrete specimens. The reduced differences were attributed to modified mixture designs for the RCA concrete in this study (e.g., lower water-to-cementitious materials ratio (w/cm)) and the benefits of extended curing.
- Tests of cores showed that the RCA concrete on these projects had compressive strengths similar to or higher than those of their companion control sections. This was again caused by a reduced w/cm ratio and other modifications to the RCA concrete mixture designs.
- Reducing coarse RCA top size may be effective in preventing the recurrence of D-cracking, but it also reduces the texture available for aggregate interlock load transfer at crack and joint faces. The use of dowel load transfer devices and properly designed longitudinal reinforcing often is essential to good performance.
- D-cracked or ASR-damaged pavement can be successfully recycled into coarse and fine RCA for use in new concrete pavement with appropriate adjustments to the concrete mixture design and structural design of the pavement (e.g., panel lengths, load transfer design, etc.).
- RCA should be considered an "engineered material," and concrete mixture designs and pavement structural designs should be adjusted according to the specific properties of the material being used to ensure good performance.

A few details about two projects evaluated under these national studies (I-80 in Wyoming and U.S. 59 in Minnesota) and a more recent project in Texas are presented here.

I-80 near Pine Bluff, Wyoming – Recycling an ASR-Damaged Pavement

During the early 1980's, an ASR afflicted section of I-80 west of Pine Bluffs, Wyoming was recycled into a new undoweled concrete pavement surface. After almost 20 years of service, the Wyoming DOT rehabilitated the section in 2002 through dowel bar retrofit, diamond grinding and resealing the joints (Figure 1). Since that time, the section has performed very well, providing excellent ride quality and developing very little distress.

Figure 1. Wyoming I-80 concrete recycling project near Pine Bluff in 2006, after 20 years of service (Photo credit: University of New Hampshire Recycled Materials Research Center).

U.S. 59 near Worthington, Minnesota – Recycling a D-cracked Pavement

The Minnesota DOT selected a 16-mile (26-km) D-cracked segment of U.S. 59 near Worthington for their first concrete recycling project, completed in 1980. The mixture design featured 100% coarse RCA and 100% natural sand fine aggregate. In 2004, a major rehabilitation project was undertaken, with activities including replacement of some long panels that had cracked, retrofit dowels (outer wheelpaths only), diamond grinding (to remove the accumulated faulting) and joint sealing (Figure 2). Since that time, the pavement has provided a smooth, quiet ride.

Figure 2. U.S. Highway 59 near Worthington, MN in 2006, after 15 years of service and 2004 rehab.

I-10 near Houston, Texas – Using 100% RCA in Concrete

In 1995, the Texas DOT began a project to replace a distressed continuously reinforced concrete pavement (CRCP) portion of I-10 near Houston using RCA produced from the existing CRCP that included siliceous river gravel in the recycled pavement. The concrete for the new CRCP was manufactured using 100% coarse and fine RCA. After 12 years of service, the performance of the RCA CRCP (Figure 3) has been described as excellent, with narrow crack widths, few minor spalls, no punchouts and none of the meandering cracks and spalls that have typically been associated with the use of siliceous river gravel in other CRCP sections in Texas (Won 2007).

Figure 3. Photo of I-10 100% RCA CRCP near Houston, Texas.

References

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