Texas Department of Transportation
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Recycled Concrete Aggregate in Portland Cement Concrete Pavement

Problem Statement

Recycling of old concrete pavement has become an important issue as more concrete pavement reaches the end of its functional and structural life. Currently, economic considerations are the primary thrust for the use of recycled concrete aggregates (RCA) in Portland cement concrete (PCC) pavement. However, as landfill spaces become more scarce and expensive, environmental considerations will play an important role as well.

The section of IH 10 in the Houston District between Loop 610 and IH 45 is under reconstruction. The contractor decided to use 100% RCA in the new pavement concrete. This project is the first one in the nation where all the aggregates used for pavement concrete, both coarse and fine, are recycled with no virgin aggregates used. As such, there is not much information available regarding the performance of PCC pavement with 100% RCA.

Objectives

Objectives of this study were to (1) evaluate the engineering properties of recycled concrete aggregate (RCA) and Portland cement concrete (PCC) made with that aggregate, (2) investigate the effect of RCA and PCC properties on continuous reinforced concrete pavement (CRCP) performance, and (3) develop guidelines for the effective use of RCA for CRCP.

There are a number of factors affecting CRCP performance. They include adequacy of the pavement structure, material properties, and environmental conditions during concrete placement, and construction practices. The scope of this study was limited to laboratory evaluation of RCA and PCC material properties, performance evaluation of CRCP sections in the Houston District, and analysis of information to develop guidelines for the use of RCA in CRCP.

Findings — Performance

The following conclusions are made based on the investigation of the effect of RCA and PCC properties on CRCP performance. Specific findings include:

- The CRCP sections utilizing 100% recycled coarse and fine aggregates have performed well. No distresses, including spalling, wide cracks, punchouts, or meandering cracks, have taken place. The transverse crack spacing distributions are comparable to those in concrete with natural siliceous river gravel.
- The large amount of old mortar in recycled coarse aggregate does not appear to have an adverse effect on CRCP performance.
- Moisture control of recycled aggregate is critical in producing consistent and workable concrete.
- No significant adjustment in paving operations is necessary due to the use of 100% recycled coarse and fine aggregate in concrete.

Findings regarding the engineering properties of recycled concrete aggregates and PCC made with them include:

- The properties of recycled aggregates measured in this study are consistent with those reported elsewhere — lower specific gravity, higher water absorption, and higher sulfate soundness loss and LA abrasion loss — compared with those of virgin aggregates.
- Recycled aggregates do not have a pronounced effect on compressive strength.
- Recycled fine aggregates have an adverse effect on flexural strength.
- The use of both recycled coarse and fine aggregates reduces modulus of elasticity significantly.

- For the same water/cement ratio, replacing virgin sand with recycled sand does not result in changes in tensile strength.
- Thermal coefficient of concrete containing 100% recycled aggregate is much higher than that of virgin aggregate concrete.
- Recycled coarse aggregate has a much higher thermal coefficient than virgin aggregate due to the attached old mortar.
- Sodium sulfate causes more damage to recycled coarse aggregate than magnesium sulfate, which is opposite to virgin aggregate.
- The effect of recycled aggregate on the abrasion resistance of concrete is inconclusive.
- The validity of sulfate soundness and LA abrasion tests as tools for evaluating the quality of recycled aggregate needs to be investigated.

The use of RCA in concrete has positive (larger creep, low modulus) and negative (low strength, higher thermal coefficient) effects on CRCP performance. The combined effects can only be evaluated by actual long-term performance of CRCP in the field.

Findings — Constructability

In the beginning of the project, there was a problem producing concrete with consistent workability that met the minimum strength requirement. The primary reason for inconsistent workability was due to the lack of moisture control of recycled aggregate. A better sprinkler system was installed later for aggregate stockpiles, and moisture of the recycled aggregate was better controlled. This system mitigated the inconsistent workability problem. Paving operations were closely monitored to identify any variations that might result from using the recycled aggregate. Not much difference was observed.

Construction crews were interviewed for their opinion and experience with handling PCC containing RCA. One of the most often heard comments was that the concrete was not consistent. The next most frequent comment was that concrete sometimes set too quickly. This quick-setting problem is believed to be caused by recycled fine aggregate not being saturated during the mixing. Construction crews stated that when the concrete was of good workability, the finishing operation was not much different from normal concrete paving.

Implementation

Even though it is too early to make any firm conclusions concerning the long-term effects of 100% RCA on pavement performance, the good performance so far indicates RCA might be used for pavement concrete without compromising pavement performance.

Guidelines for the effective use of RCA for CRCP are under development. Once complete, the document will provide information on how to recycle crushed concrete for pavement concrete and what needs to be done to maximize its potential benefits.

The contents of this summary are reported in detail in TxDOT Research Report, 1753-1F, *Use of Crushed Concrete as Aggregate for Pavement Concrete*, by Moon C. Won, 1998. This summary does not reflect the official views of TxDOT nor FHWA.