RowanUniversity
CENTER FOR RESEARCH & EDUCATION IN
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Technical Brief

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Long-Term Performance of Sustainable Pavements Using Ternary Blended Concrete with Recycled Aggregates

Background

Concrete production requires large amounts of portland cement and natural aggregate, which can be costly and harmful to the environment. Recycled concrete aggregate (RCA) offers an alternative by crushing demolished concrete and reusing it in new mixtures. Although old mortar can make RCA more porous and less durable, properly processed material can still reduce landfill waste, material demand, and transportation costs. Supplementary cementitious materials such as fly ash, slag, and silica fume can also replace part of the portland cement. Combining two of these materials with cement creates a ternary blended binder. These materials also make use of industrial byproducts that might otherwise be discarded. This type of binder may improve concrete performance and help reduce the weaknesses associated with RCA, making the combined approach more practical for sustainable pavement construction.

Research Objectives and Approach

This research investigates the use of ternary blended binders and recycled concrete aggregate (RCA) in portland cement concrete. The goal is to increase the use of RCA use while maintaining acceptable strength and durability. The first task identifies an optimal ternary binder containing portland cement and two supplementary cementitious materials selected from slag, Class C fly ash, Class F fly ash, and silica fume. Mortar strength, isothermal calorimetry, statistical analysis, and larger concrete testing are used to evaluate the best performing blend. The second task assesses concrete mixtures containing RCA from multiple sources at replacement rates up to 100%. Fresh and hardened properties are compared between control mixtures and ternary blended mixtures to determine the effects of RCA source, replacement level, and binder composition on concrete performance.

Direct Benefit to Military Engineering

Ternary blended concrete with recycled concrete aggregate provides a practical material option for military pavement construction and repair. Demolished concrete from roads, runways, and structures can be crushed and reused instead of sent to landfills. This reduces the need for virgin aggregate and lowers material transportation requirements, especially at remote installations where approved materials may be limited. Ternary blended binders can help

maintain concrete strength and durability while reducing portland cement use. The method also supports use of locally available materials and industrial byproducts. For military agencies, this can improve construction efficiency, reduce project costs, and support faster repair of critical infrastructure.

Conclusions and Recommendations

Experimental results show that ternary binders can improve the strength and durability of concrete containing recycled aggregate (RCA). The optimal binder consisted of 77.5% portland cement, 12.5% Class C fly ash, and 10% slag, which improved surface resistivity and reduced drying shrinkage and alkali-silica reaction. Properly screened and graded RCA replaced up to 50% of the coarse aggregate without significantly reducing concrete strength, elastic modulus, or durability, while higher replacement rates caused greater performance losses. Because RCA is highly porous, presoaking and workability improving admixtures may be required, while air contents between 5% and 8% provided acceptable freeze-thaw durability despite an increase in setting time of about 80 minutes. Future research should evaluate additional materials and RCA sources and develop guidelines relating RCA quality to replacement limits and long term performance.

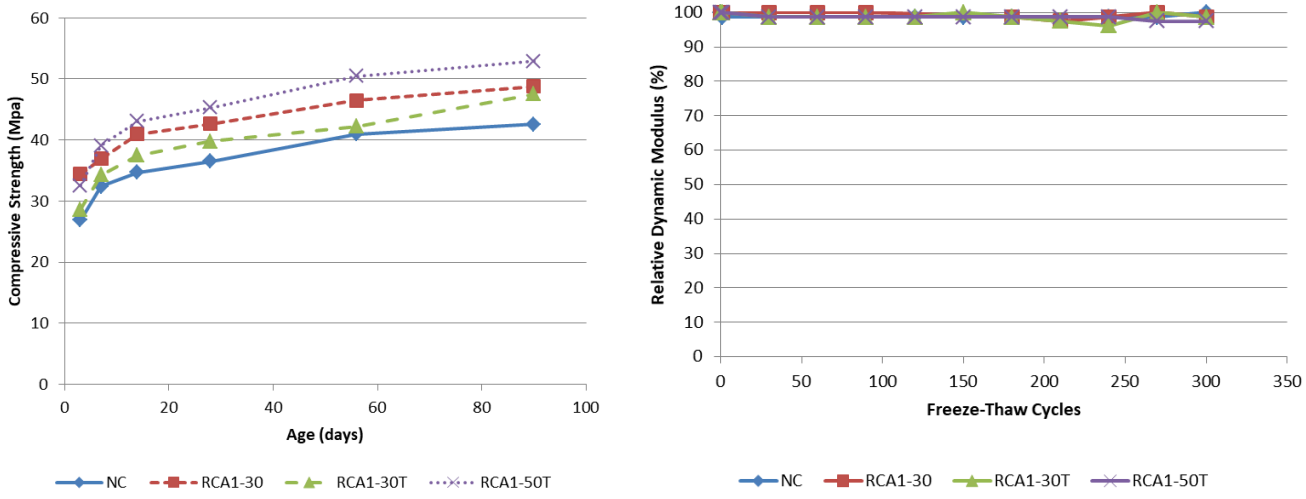

Figure 1. Performance of concrete containing recycled concrete aggregate: (left) compressive strength of normal concrete and RCA1 mixtures; (right) freeze-thaw durability at varying RCA replacement levels and binder types.

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