Michigan Department of Transportation
RESEARCH Administration

RESEARCH SPOTLIGHT

Project Information

REPORT NAME: Reduction of pH Levels from Underdrain Outlets

START DATE: May 2018

REPORT DATE: September 2020

RESEARCH REPORT NUMBER: SPR-1696

TOTAL COST: $169,010

COST SHARING: 20% MDOT, 80% FHWA through the SPR, Part II, Program

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Treatments for recycled concrete aggregate reduce pH of roadway drainage

The Michigan Department of Transportation (MDOT) has successfully used recycled crushed concrete as a base layer in highway pavements for several decades. Using recycled aggregate decreases demand for new materials, reduces MDOT's highway costs and promotes sustainability. However, MDOT had observed that some drainage water from roads with a recycled concrete base layer was very alkaline and created mineral deposits at drain outlets. Researchers investigated this issue and recommended treatments that will allow MDOT to continue using recycled materials while easing environmental concerns about roadway drainage.

The impacts of a year's worth of highly alkaline road drainage are apparent on the surrounding vegetation (left), as compared with less alkaline drainage (right).

PROBLEM

Transportation agencies have long used recycled materials as aggregate layers in highway construction. Recycled materials reduce the need for new gravel, decrease construction waste in landfills, and further lower costs when recycled products can be obtained locally. MDOT has used recycled crushed concrete aggregate (RCCA) and slag aggregate reclaimed from iron production as pavement base materials since the 1980s. Whether constructed of gravel or recycled aggregate, a pavement's base layer functions as a stable, permeable foundation, providing support and allowing water to drain away.

Through maintenance inspections, MDOT staff noted that some roadways

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"Recycling crushed concrete is an important part of MDOT's efforts to build a sustainable transportation system. This research project will help MDOT make decisions about the use of crushed concrete that will protect our natural resources."

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constructed with RCCA showed mineral deposits on drainage screens, solid precipitate buildup in underdrains, and signs of highly alkaline discharge at outlets. Informal investigations showed that some drain discharge had pH levels above 10. (The pH scale runs from 0, highly acidic, to 14, highly alkaline or caustic; distilled water is neutral, with a pH of 7.)

Liquids with pH levels at either extreme are corrosive to metals and damaging to plants and aquatic life. In addition, the accumulation of solids can clog the pavement drainage system, shortening pavement life. MDOT needed to ensure that the drainage water from pavements built with recycled materials met environmental standards, including the pH limit of 12.5 set by the U.S. Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System.

RESEARCH

This project's goals were to determine the sources and causes of high pH levels, soluble particles and solid precipitates in the drainage water and check for toxic contaminants. MDOT also wanted recommendations on how to reduce or eliminate problems with RCCA use in highway construction.

Leachate is water that filters through a material and leaves residue behind. Leachate with high pH and soluble particles associated with recycled materials in roadway bases has been an ongoing concern for MDOT and other agencies. Researchers for this project examined previous studies to understand other agencies' investigations and approaches, then designed a laboratory and field research effort that builds on existing MDOT data.

Researchers collected samples at 26 road sites constructed with different types of recycled base materials and at four control sites without recycled materials. Leachate samples were collected at drain outlets and 100 feet downstream from the outlets during rainfall events. The pH and total dissolved solids (TDS) were measured and samples were preserved for chemical analysis. Researchers also conducted laboratory leachate tests, simulating 15 years of rainfall through different base materials: recycled concrete, limestone, slag aggregate and combinations of these materials. They gathered pH and TDS data from the tests.

RESULTS

The laboratory tests confirmed some observations made in earlier MDOT investigations, providing robust quantitative data and additional findings. While the discharge from the RCCA sites was highly alkaline, in no case did it ever reach the EPA's 12.5 pH limit. Tests for heavy metals showed minimal amounts in the leachate, far below EPA limits for wastewater.

Discharge pH levels were lower at the downstream sites, indicating that the leachate quickly becomes diluted by rainfall runoff. Levels also decreased with pavement age for all recycled materials, though initial pH and TDS values were relatively high at the RCCA sites. Researchers determined that starting at around 10.5 to 10.75 pH, mineral formations at the drain outlets increased rapidly. Keeping discharge alkalinity below this level would help decrease solid buildup.

After testing many remedies in the laboratory, researchers made treatment recommendations to MDOT for decreasing leachate pH and soluble particles. These included washing RCCA to reduce fine particulates and mixing RCCA with other types of recycled aggregate. Planting hardy vegetation at the drain outlets and using pH adjustment products at the outlets were also recommended.

VALUE

This project quantified pH data from many sites, and laboratory testing confirmed that the roadway drainage does not exceed pH limits or pose other hazards to the environment. By implementing the project's recommendations, MDOT will be able to continue its sustainable highway construction practices using recycled materials while maintaining good stewardship of the surrounding environment.

Research Administration

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This final report is available online at

www.Michigan.gov/mdot/-/media/Project/Websites/MDOT/Programs/Research-Administration/Final-Reports/SPR-1696-Report.pdf

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