Use of Concrete Grinding Residue as a Soil Amendment

tech transfer summary

Amending embankment and pavement shoulder materials with concrete grinding residue can improve the materials' stability, strength, and erosion resistance.

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RESEARCH PROJECT TITLE
Use of Concrete Grinding Residue as a Soil Amendment

SPONSORS
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The Program for Sustainable Pavement Engineering and Research (PROSPER) is part of the Institute for Transportation (InTrans) at Iowa State University. The overall goal of PROSPER is to advance research, education, and technology transfer in the area of sustainable highway and airport pavement infrastructure systems.

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Objective

The objective of this study was to evaluate the potential use of concrete grinding residue (CGR) as a soil amendment for stabilizing roadway shoulders and embankments.

Background

Unpaved gravel shoulders and embankments with little or no vegetation are vulnerable to erosion from wind and rain as well as from wind-whip caused by traffic. Because strength and stiffness are critical design criteria for roadway shoulders and embankments, lime, portland cement, and other additives are commonly used to stabilize soils in these areas.

Problem Statement

While the use of waste byproducts such as CGR can provide an economical and sustainable alternative for stabilizing roadway embankments and shoulder materials, little research and no full-scale field implementation efforts have been undertaken to assess the use of CGR as a soil amendment for mitigating erosivity.

Research Description

Two laboratory tests—a rainfall erosion study and a wind erosion study—and a field evaluation were performed to assess the strength, stiffness, and erosivity of various untreated and CGR-amended soils.

Discharge of CGR during concrete diamond grinding

CGR slurry discharge was collected from five large and small concrete diamond grinding projects across Iowa using direct and indirect collection methods.

The rainfall erosion study evaluated the erosivity of 20% CGR-treated and untreated samples of collapsible Iowa loess soil (a low-plasticity silt) under simulated rainfall conditions of 2 in., 4 in., and 6 in. per hour. Samples were placed in sloped wooden soil forms and compacted, and a ceiling-mounted rainfall simulator produce a fine rainfall over the soil forms.

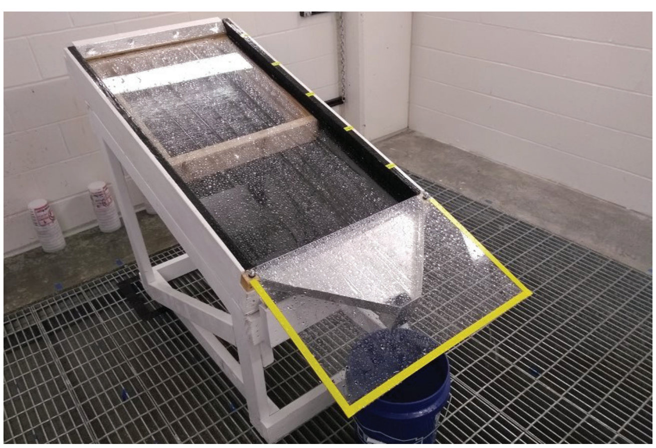
The wind erosion study assessed the erosivity of 20% and 40% CGR-amended and untreated samples of Iowa loess soil and five gravel aggregates (Sites A through E) under simulated wind conditions. Each sample was placed in a wooden soil form with a recessed platform and compacted, and a simulated wind source produced a 35-mph wind across the soil form.

The field evaluation assessed the use of CGR to stabilize shoulder materials at test sites in Washington County and Clinton County, Iowa. Two methods of applying CGR were investigated: application onto the surface of the shoulder materials (CGR Top) and blending with the shoulder materials at a 20% replacement rate (CGR Reclaimed). For comparison, a test section in each county was treated with Base One, a proprietary stabilizer.

Dynamic cone penetrometer (DCP) and lightweight deflectometer (LWD) tests were performed before construction and at three times after construction in both Washington County and Clinton County to compare the strength and stiffness of the field test sections.

Soil form used in wind erosion simulation

Application of CGR to field test section



Courtesy of Nathan Miner

Soil form used in rainfall erosion study

DCP testing

LWD testing

Key Findings

Rainfall Erosion Study

- The CGR-amended soils exhibited higher soil erodibility compared to the untreated control samples.
- The water quality (turbidity) of the CGR-amended loess was much poorer compared to the untreated loess. The water quality was poorest during the 4 in. per hour rainfall for all trials of the CGR-amended loess.
- The amount of total suspended solids (TSS) in the stormwater collected from the CGR-amended loess was higher compared to the untreated loess, in some cases much higher. One CGR-amended loess sample lost 22.11 tons/acre compared to the 4.62 tons/acre lost by an untreated loess sample.

Wind Erosion Study

- The untreated Site A soil exhibited the highest wind erosion rate of -8.07 tons/roadway mile. However, the erosion rates for similar untreated soils (Sites B and C) were substantially lower at -3.72 and -6.52 tons/roadway mile, respectively.
- Amending the Site A shoulder aggregate with 20% and 40% CGR decreased the wind erosivity of the soil by 25% and 58%, respectively. Conversely, amending the Site B and C shoulder aggregates with 20% and 40% CGR increased the wind erosivity of the soil by 25% and 50%, respectively.

Field Evaluation

- In Washington County, the LWD composite elastic modulus values for all sections were lower after construction than before, likely due to higher moisture contents after construction.
- At one and two years after construction, the elastic modulus values of the CGR Reclaimed section in Washington County improved slightly, suggesting that CGR application did not impair the expected performance.
- In Clinton County, the elastic modulus values of the CGR Reclaimed and CGR Top sections increased over time compared to the untreated section. The CGR Reclaimed section showed a 20% to 40% improvement over the untreated section.
- In Washington County, the California bearing ratio (CBR) values for the CGR Reclaimed section were lower seven days after construction than before but were higher one and two years after construction. The CGR Reclaimed section may have gained strength over time due to the hydration of the remaining cementitious compounds in the CGR.
- In Clinton County, the CGR Reclaimed section may similarly have gained strength due to the hydration of cementitious compounds. The CGR Reclaimed section also performed better than the Base One section.
- The CBR values for the CGR Top sections in both counties were lower after construction than before.

Implementation Readiness and Benefits

The results of this research can help the Iowa Department of Transportation and Iowa's cities and counties better manage concrete grinding byproducts by recycling them as stabilizers for roadway materials.

Strengthening and stabilizing exposed roadway shoulders and embankments can decrease erosion due to rain and wind, minimize the hazardous and erosive effects of wind whip, and reduce gravel loss and maintenance requirements.

Generally, adding 20% CGR to shoulder aggregate increases the material's strength and stiffness, but the erosivity of CGR-amended soils depends on soil type. For shoulder aggregate, a 20% CGR dosage is recommended to stabilize the material and improve its stiffness. For loess, a 20% CGR dosage is recommended to provide resistance against wind erosion.

In field applications, blending CGR with the shoulder materials appears to be an effective stabilization technique, while applying CGR on top of the shoulder materials does not.

Additional research is recommended to evaluate the use of CGR in stabilizing the base/subbase layers of paved roads and the gravel layer of unpaved roads. CGR stabilization may improve stiffness, reduce traffic-induced deformation, and ultimately extend roadway service lives.