When eggshells are crushed and heated at high temperatures, they transform into a soil additive that increases the stability of pavement foundations and gravel roads.

RESEARCH SOLUTIONS

Using eggshells as a soil stabilizer in Iowa road construction

Iowa's soil is renowned for its agricultural richness. But when it's used in road construction, the soil needs stabilizing additives. This study explored the viability of eggshell powder (ESP) as a potential stabilizer for Iowa's soil when used in pavement foundations and gravel road systems. Researchers examined three techniques for processing eggshells into usable powder form. Laboratory tests then evaluated the properties of silt and clay mixed with ESP, confirming the potential dual benefits of eliminating eggshell waste and providing environmentally friendly road construction material.

THE NEED

Iowa's soil tends to retain moisture, which enhances its ability to grow crops for Iowa's farmers. However, this property also makes it less stable as a foundation for pavements and roads. For this application, materials such as lime and cement are added to the soil during road construction to create more durable, cement-like layers.

Iowa is also notable as the country's largest producer of eggs. In 2024, egg production estimates ranged from 13.5 billion to 15 billion. To compete with other egg-producing states like Pennsylvania and California, Iowa delivers eggs to both coasts in liquid or dry form, processing them in Iowa and generating eggshell waste that is transported to landfills. Calcium carbonate makes up to 96 percent of eggshells, and other studies have demonstrated that pulverized eggshells can create cement-like mixtures. Iowa DOT saw an opportunity to study whether ESP from Iowa's egg producers could address the stabilization needs of Iowa's soil in road construction.

(continued)

"Most eggshell waste currently goes to the landfill, but the study results show its potential as a soil stabilizing material. If we can process the eggshells on a larger scale, Iowa counties and Iowa DOT will be able to use them in road construction."

— LEE BJERKE,
Secondary Roads Research Engineer

RESEARCH APPROACH

Laboratory testing assessed the performance of ESP as a stabilizer when mixed with two soil types commonly found in Iowa: silt and clay. Three treatments of ESP were evaluated. The first treatment ground and air-dried the eggshells. The second treatment dried the eggshells in an oven at 220°C for 12 hours. The third treatment—calcination—required that the eggshells be heated to 1000°C for five hours, followed by six hours of cooling.

Both laboratory and field studies were conducted to evaluate engineering characteristics of the soils mixed with the three ESP types. Of interest were the consistency and compaction of the soil, which indicate a soil's load-bearing capacity, resistance to water infiltration, and stability over time. By varying the ESP percentages, moisture levels, and curing conditions of samples, researchers were able to measure changes in the performance of the different resulting soils.

WHAT IOWA LEARNED

Study results from air-dried and oven-dried ESP indicated that eggshells do not possess the engineering properties required for application in road construction. In contrast, calcinated ESP performed optimally as a stabilizer when mixed with the two Iowa soils.

After the intense heat of calcination's eggshell-drying process, nearly all of the calcium carbonate from the eggshells decomposed to calcium oxide and carbon dioxide, reducing the material weight and significantly enhancing its stabilizing properties, making it function similar to lime.

Testing revealed that moisture content and curing temperature significantly influenced the engineering properties of the calcinated ESP, yet these factors did not affect the performance of the other two ESP types. Adding 3 percent more moisture and curing for 28 days at room temperature increased the strength of calcinated ESP by five to eight times.

PUTTING IT TO WORK

Study results confirm the potential use of eggshell waste as an additive in stabilizing soil for pavement foundations and gravel roads without the environmental concerns of lime and cement. The eggshells are abundantly available in Iowa, and using this waste would save egg producers the costs of hauling the waste to landfills. The next step in evaluating ESP's viability as a construction material is to explore how to scale up processing of the eggshells into ESP to make the material widely available.

ABOUT THIS PROJECT

PROJECT NAME: Use of Iowa Eggshell Waste as Bio-Cement Materials in Pavement and Gravel Road Geo-Material Stabilization

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