Kansas Department of Transportation

TECHNICAL SUMMARY

Field Monitoring of a Mechanically Stabilized Earth Wall Backfilled with Lightweight Cellular Concrete

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Introduction

When used as an alternative to aggregates as backfill material, lightweight cellular concrete (LCC) can decrease the self-weight of mechanically stabilized earth (MSE) walls by 75% or more compared to aggregate backfill, leading to a corresponding reduction in ground settlements. In addition, after curing, LCC typically exerts little to no lateral earth pressure on the back of the wall facing. Therefore, LCC is an excellent substitute for MSE backfill aggregate for walls on soft ground. However, research on the performance of LCC-MSE walls and the interaction between reinforcement and LCC is limited. This report provides the results from a study of an LCC-MSE wall test section, including vertical earth pressures and settlement, lateral earth pressures, temperatures throughout the fill, and pullout resistance of reinforcement at various points in the curing process for approximately one year.

Project Description

As an alternative to aggregate as backfill material in mechanically stabilized earth (MSE) walls, lightweight cellular concrete (LCC) significantly reduces the weight of MSE wall mass, corresponding settlement of the foundation soil, and lateral earth pressures behind wall facing. Steel strips, geogrids, or steel rods are commonly used to reinforce the LCC in an LCC-MSE wall. This research used LCC to replace a test section with aggregate backfill in a new MSE wall on I-35 in Kansas to investigate LCC performance. Seven steel reinforcement strips of various lengths were pulled out of the backfill at different times in the curing process to study the effects of curing time and length on pull-out capacities. In addition, the LCC-MSE wall was instrumented with earth pressure cells, shape arrays, thermistors, strain gauges, and survey targets to explore LCC-MSE wall performance.

Settlements were very low under the weight of the LCC, with maximum settlement less than 0.3 inches partly due to apparent rotation of the fill mass because of horizontal pressures behind the mass. Lateral earth pressures were a function of the fluid density of the LCC during placement but dropped to near zero for most of the facing during curing. Lateral earth pressures for the top panel experienced significant fluctuations with ambient air temperatures. High temperatures exceeding 190 °F within the mass early in the curing process may complicate future designs. Reinforcement pullout strengths were much higher than reinforcement strengths in aggregate with similar normal stress. A modest reduction in pullout resistance was observed over the first 14 days, possibly due to decreased normal stress due to cooling. Overall, cement hydration increased interface strength between LCC and steel strips, thereby increasing pullout capacities of steel strips.

Project Results

Research results showed that settlement of the ground soil under the weight of the LCC-MSE wall and traffic loading was less than 0.3 inches, which was less than the adjacent MSE wall with aggregate backfill. Although little to no lateral creep of the wall was observed after the wall had set, there was some lateral movement of the panels during LCC placement. This movement could likely be avoided with more rigid bracing of the panels. Test strip pullout resistances were very consistent among the tests and were much higher than the expected resistance from aggregate backfill with an equivalent overburden pressure. Test strips demonstrated substantial residual pullout resistance even at high deformations.

Observations made from this study resulted in several recommendations. First, because LCC was shown to effectively decrease the weight on foundation soils, it should be considered as an alternative to conventional fills where settlement is a concern. Second, high fluid pressures during fill placement require rigid bracing to prevent shifting or tilting of panels during placement of fill. Third, lateral earth pressures at the wall facing in an LCC-MSE wall changed with air temperatures, and high air temperatures may result in higher lateral earth pressures in the upper portion of backfill in LCC-MSE walls compared to AG-MSE walls. A thin layer of expanded polystyrene is recommended for the back of the panels prior to LCC placement to relieve potential thermal stresses, although additional research is recommended to increase understanding of the issue of earth pressure changes due to air temperature changes. Finally, heat emitted from cement hydration in LCC caused high temperatures in the LCC, which likely damaged installed sensors such as strain gauges. Therefore, the temperature resistance of sensors, or other inclusions such as plastic pipe, should be considered during the design of LCC-MSE walls.

Project Information

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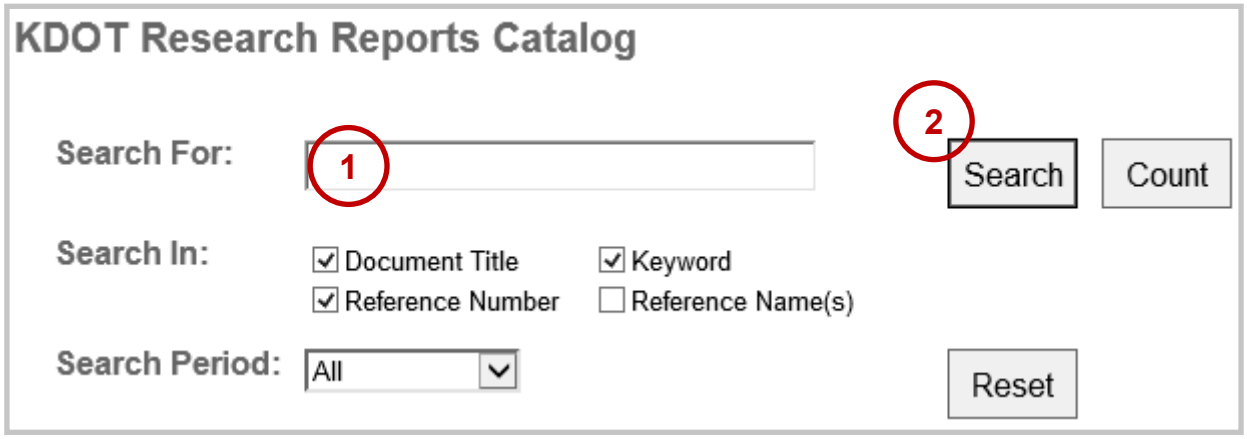

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