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The Use of Foamed Glass Aggregate (FGA) as a Lightweight Fill Above Culverts

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Introduction

Many culverts and drains in California are in need of repair. California Senate Bill 1, the Road Repair and Accountability Act of 2017, provides additional funding for the State of California to address the deferred maintenance needs of the transportation system's assets and designates an annual allocation of $400 million, specifically, for culverts and bridges. This law requires Caltrans to meet the preliminary performance outcomes and indicates that "not less than 90 percent of culverts [should be] in good or fair condition" by the end of 2027. Transportation infrastructure—including culverts, buried utilities, and drainage systems—must routinely withstand considerable external stresses from existing site conditions or new construction. Added stresses from new construction are particularly common in urban areas where aging buried infrastructure often exists alongside ongoing development. Lightweight fills offer a promising alternative to conventional backfill materials by reducing the loads imposed on buried structures. This research project investigates the use of lightweight fills as a sustainable strategy to "Fix Culvert" in support of California Senate Bill 1 (SB1) efforts and for new construction. The study focuses on Foamed Glass Aggregate (FGA) as an emerging, innovative, and sustainable lightweight fill.

Study Methods

In simple terms, the study tested whether using lighter backfill materials could reduce pressure on culverts and improve their performance over time. To do so, the research team conducted a numerical investigation to evaluate the benefits of using FGA lightweight fills in place of conventional fills above culverts, either to alleviate stresses on existing culverts or to optimize the design of new culverts,

leading to cost-effective solutions. Numerical models were developed for reinforced concrete (RC) box culverts and corrugated steel pipe (CSP) culverts to compare their mechanical behavior under conventional and lightweight fills. The models were validated using experimental data from physical models. Parametric evaluations were then conducted using the developed numerical models to assess the extent of these benefits across a range of culvert configurations. FGA lightweight fills were found to result in significant reductions in culvert straining actions, soil stresses on culverts, culvert deformation, and culvert settlement.

Foamed Glass Aggregate (FGA) significantly reduces loads on culverts, offering a sustainable and effective solution for extending the service life of existing and new buried drainage structures.

Findings

The results showed that FGA lightweight fills considerably reduce culvert straining actions, soil stresses on culverts, shape deformation, and settlement. Across all culvert configurations studied herein, the maximum bending moment in the culvert's envelope could be reduced by 25% to 70% when using FGA lightweight fill in place of conventional fill. This percentage is most sensitive to fill height. In practical terms, reducing these stresses can help buried culverts better withstand heavy loads and ongoing development, potentially extending infrastructure service life and reducing future maintenance needs. Given the often-prohibitive initial costs of synthetic fill materials, the benefits of using FGA fills were quantified across varied culvert configurations to provide insight into which culverts would benefit most from such alternative fills. The findings can assist agencies in identifying, based on culvert attributes, which culverts could benefit from lightweight fills.

Policy/Practice Recommendations

Caltrans should consider incorporating lightweight fills, including FGA, as a standard design option for projects involving buried drainage structures where excessive loads, settlement, or deformation are concerns. Current design practices and tabulated cover limits are based on conventional fills and may not reflect the load-reduction benefits of lightweight materials. Accordingly, future guidance should explicitly support project-specific design approaches that account for material-specific properties such as unit weight, strength, compressibility, and drainage characteristics. It is recommended that the Geotechnical Manual and Highway Design Manual be updated to include design procedures, construction considerations, and specification guidance for FGA and similar materials. In practice, lightweight fills should be prioritized for culvert rehabilitation under SB1 programs and for new construction in soft ground or high embankment conditions to improve performance and reduce lifecycle costs. Pilot projects, monitoring, and performance-based evaluation should support broader implementation and refinement of design criteria.

About the Author

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Dr. Morsy is an Assistant Professor in the Department of Civil Engineering and Construction Engineering Management at California State University, Long Beach. His research focuses on the deterioration of geotechnical infrastructure and asset management.

To Learn More

For more details about the study, download the full report at https://transweb.sjsu.edu/research/2549

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