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Green Strategies for Design and Construction of Non-Auto Transportation Infrastructure

Project 1872
July 2019

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Non-auto transportation infrastructure serves as an efficient and environmentally conscious means for public mobility. An initiative towards sustainable design and construction of the concrete slabs that compose these routes promotes both green sources of materials and reduced economic maintenance costs over their life cycle. As a result, this research aims to investigate the application of tire-derived aggregates (TDA) in combination with expanded clay (EC) aggregates in precast concrete slabs in road pavements and bridge decks serving non-auto traffic, such as bicycle routes. Given that TDA is a recycled, durable, and economically-efficient material, this project aims to enhance its usage and its ability to increase the sustainability of such transportation infrastructure, along with attempting to influence future decision-making on the rehabilitation and maintenance of such roads.

Study Methods

Three concrete mix designs are incorporated in this study with 0% (i.e., MIX A or the control mix), 80% (i.e., MIX B), and 100% (i.e., MIX C) TDA replacements by the volume of the light-weight EC coarse aggregates. The experimental program throughout the course of this research study is composed of two phases: materials testing of concrete cylinders (Phase I) and structural components testing (Phase II). The latter consists of two parts: static flexural testing of beam specimens (Phase II- Part 1) and dynamic impact-fatigue testing of slab assemblies (Phase II- Part 2). Furthermore, a life-cycle cost analysis is conducted to investigate the long-term benefits of constructing green and durable infrastructure on future investments in transportation.

This research highlights the sustainable design and construction of non-auto transportation routes with promoting both green sources of materials and reduced economic maintenance costs over their life cycle.

Findings

- *Materials/Compression Testing of Cylinders*: The compressive strength of concrete cylinders was reduced by 70% and 83% by replacing 80% (MIX B) and 100% (MIX C) of EC coarse aggregates with TDA, respectively. However, a ductile type of fracture was observed in the concrete cylinders with added rubber aggregates compared to the control mix, which fractured in a brittle manner with little warning prior to complete failure.
- *Static Flexural Testing of Beams*: The modulus of rupture of the concrete beams was reduced by 50% and 61% in MIX B and MIX C, respectively. On the other hand, the rubberized specimens (i.e., MIX B and C) sustained larger deformations at their mid-spans before their flexural failure. Additionally, the flexural toughness was increased by a factor of 2.78 and 4.42 at rubber replacement ratios of 80% and 100%, respectively. This confirmed the higher energy absorption capacity of rubberized concrete specimens.
- *Dynamic Impact-Fatigue Testing of Slabs*: By replacing 80% and 100% of EC with TDA, the slab assemblies respectively sustained 2.9 and 3.6 times more cycles of impact loading up to their fatigue failure, compared to the control mix.
- *Life-Cycle Cost Analysis*: Allowing for similar placement and maintenance costs for the three slab assemblies and an AADT of 200, it was concluded that their service life (to reach failure) has been increased from 1.6 years for the control slab to 24 and 37 years for the rubberized slabs with MIX B and C, respectively. The results of this section indicated considerable reduction in the life cycle cost due to residual strength of ductile mixtures.

Policy/Practice Recommendations

The application of green strategies for design and construction of non-auto transportation infrastructure can help improve transportation safety and secure long-term economic benefits of transportation investments. By promoting the use of TDA in non-auto roads/bridge, the diversion of waste tires, which is currently about 40 million per year in California, from landfills can be increased.

About the Authors

Dr. Maryam Nazari is an Assistant Professor of Structural Engineering in the Department of Civil and Geomatics Engineering at CSU, Fresno. Her main research interest is the application of sustainable and seismic-resilient precast concrete solutions for design of structures.

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/1872.

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