Dynamic Life Cycle Modeling of Pavement Overlay System: capturing the impacts of users, construction, and roadway deterioration

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While pavements are central elements of transportation systems, pavements in the United States are significantly deficient. An estimated 58% of America's urban and rural roadways are in poor, mediocre, or fair condition. Concrete and asphalt are the most common materials used in the construction of pavement system. Both concrete and asphalt pose significant environmental challenges. Production of cement, a key constituent in concrete, accounts for more than 1.6 billion tons of CO_2 over 8% of total CO_2 emissions from all human activities and significant levels of other pollutants, such as particulate matter and sulfur oxides. Asphalt, a petroleum byproduct, is energy intensive and emits high levels of volatile organic compounds (VOC) during construction. Additionally, concrete and asphalt have some physical limitations that contribute to limited durability, which increase pavement failure and maintenance frequency.

To improve the sustainability in pavement rehabilitation design a promising alternative material, engineered cementitious composites (ECC), is explored. This study conducts a comparative life cycle assessment (LCA) of an unbonded concrete overlay, a hot mix asphalt (HMA) overlay and an ECC overlay over a 40 year life cycle. A dynamic life cycle model is developed to capture the environmental impacts on material production and distribution, overlay construction and maintenance, construction-related traffic congestion, overlay usage, and end of life management. Because of the physical properties improvement of ECC, results show that the ECC overlay system saves at least 14% of the total life cycle energy consumption and 34% of the greenhouse gas (GHG) emission. The processes contributing the greatest environmental impact are highlighted in life cycle study.