Design and Performance Evaluation of Porous Pavement Integrated with Piezoelectric Energy Harvesting System

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Abstract

Porous pavements are gaining increasing attention due to their ability to enhance stormwater management while supporting sustainable urban infrastructure. This study presents the design and performance evaluation of a porous pavement system integrated with a piezoelectric energy harvesting mechanism. The primary objective is to assess the mechanical performance of porous concrete with varying percentages of fine aggregate replacement and to examine its suitability for energy harvesting applications under traffic-induced loading. Experimental investigations were carried out on porous concrete cube specimens incorporating 0%, 5%, and 10% fine aggregate (8 mm size). Compressive load and stress values were recorded at curing periods of 7, 14, and 28 days. The results indicate a consistent increase in both load-bearing capacity and compressive stress with higher fine aggregate content and longer curing duration. At 28 days, specimens with 10% fine aggregate exhibited the highest performance, achieving a maximum load of 38.9 kN and compressive stress of 1.728 MPa, compared to 30.4 kN and 1.351 MPa for the control mix. Similar trends were observed at 7 and 14 days, confirming improved strength development with fine aggregate inclusion. The enhanced mechanical performance of the porous pavement ensures sufficient structural integrity to support embedded piezoelectric elements for energy harvesting without compromising permeability. The study demonstrates that an optimized porous pavement mix can effectively balance load resistance and functional performance, making it a viable solution for sustainable pavements capable of generating renewable energy from vehicular loads.