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Synergistic Performance of Piezoelectric Transducers and Asphalt Pavement

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Abstract: The deformation of piezoelectric transducer and asphalt pavement differ because of their different stiffness. As the piezoelectric transducer is embedded in asphalt pavement, the differential deformation may cause a non-uniform stress and degrade their performance. In this paper, the synergistic performance of piezoelectric transducer and asphalt pavement is studied through finite element analysis. Results show that the energy conversion efficiency of the transducers decreases with increasing burial depth and modulus of surface course. Under the vehicle loading, the piezoelectric transducer and asphalt pavement are easily separated by shear stress. For the asphalt pavement, the change in the stress of pavement structure and surface deflection is very small, which means that the differential deformation has no effect on fatigue cracking. Furthermore, an energy harvesting system composed by transducers array and asphalt plate is made and evaluated in laboratory. Results show that the transducers within asphalt pavement have acceptable efficiency and high durability.

Keywords: Synergistic Performance; Piezoelectric Transducer; Asphalt pavement; Energy harvesting; Cymbal; Differential deformation

1. INTRODUCTION

Asphalt pavement during its life's cycle is frequented by millions of vehicles that receive strain, stress and kinetic energy from the work of load and gravity of vehicle. Based on piezoelectricity theory, these energies can be converted into electric energy by applying load to the embedding piezoelectric transducer.

Most of typical piezoelectric transducers are used to harvest ambient energy from asphalt pavement, such as the Multilayer [1,2], PZT(Lead zirconate titanate) piles [3], Cymbal [4] and Bridge [5]. As the main piezoelectric material for transducer, the stiffness of PZT is more than 100 GPa. Therefore, the stiffness of most piezoelectric transducers is more than asphalt pavement. As the piezoelectric transducer embedded in asphalt pavement, the differential deformation may degrade their performance and even cause the cracking. Although the Cymbal and Bridge have the moderate stiffness close to asphalt pavement [6], there is little research aiming at the change in performance of piezoelectric transducer and asphalt pavement.