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Energy harvesting from electrospun piezoelectric nanowires for structural health monitoring of a cable-stayed bridge

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Wireless monitoring could greatly impact the fields of structural health assessment and infrastructure asset management, but some technological challenges pose unsolved issues toward its reliable use in continuous large-scale applications. Among the others, it is worth highlighting that power supply by means of batteries is usually implemented within wireless sensor networks, even though it causes practical concerns that heavily prevent the development of efficient monitoring systems for large structures and infrastructures. Conversely, scavenging ambient energy can alleviate or eventually eliminate the problem of electrical supply by batteries, a strategy that has emerged in recent years as a promising technological solution for bridges [1,2]. Within this framework, the present work proposes to harvest ambient-induced vibrations of bridge structures using a new class of piezoelectric textiles. The considered case study is an existing cable-stayed bridge located in Italy along the high-speed road that connects Rome and Naples, for which a recent monitoring campaign has allowed to record the dynamic responses of deck and cables. In order to enhance the electric energy that can be converted from wind- and traffic-induced bridge vibrations, the energy harvester exploits a piezoelectric nanogenerator built using arrays of piezoelectric electrospun nanofibers. Particularly, several fiber arrangements are studied at the nano/micro-scale leading to different macro constitutive laws and different electric energy output. A computational study is performed to demonstrate that such nanogenerator is able to provide higher energy levels from recorded dynamic loading time histories than a standard piezoelectric energy harvester. The feasibility of this piezoelectric nanogenerator for bridge monitoring applications is finally discussed.

Keywords: Cable-stayed bridge, electrospun nanofibers, energy harvesting, piezoelectric textiles, structural health monitoring.

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