Numerical and Experimental Studies on Thermoelectric Energy Harvesters using Temperature Difference in Concrete Bridges

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Abstract

Thermoelectric energy harvesting was studied using the temperature difference in concrete bridges. A design of the heat sink unit of thermoelectric energy harvesters was parametrically analyzed using FE models. Prototype thermoelectric energy harvesters were fabricated and tested in a simple wind tunnel. The experiment was carried out on a concrete bridge. The concrete bridge accumulated thermal energy from sunlight, and the temperature difference with the air occurred. The thermal energy was harvested especially in daytimes. On the other hand, electric power was less generated at night-times than expected. The harvesting energy would be significantly improved if the problem is solved.

Keywords: Energy harvesting, concrete bridge, temperature difference, thermoelectric element, heat transfer efficiency.

1 Introduction

Nowadays, the deterioration of bridges built in the 1960s during the high economic growth period has become apparent [1]. The demand for structural monitoring to reduce inspection work and life cycle cost increases [2] because of the shrinking workforce and budget. However, the main difficulty in monitoring systems is the power supply.

Solar photovoltaic (PV) power generation is practically used as a power supply to attached structures of bridges such as monitoring systems, display indicators, the ventilation system of box girders. However, these devices face the problem of the limitation on installation location in bridges. The solar radiation does not reach the backside or inside of bridges. Hence, complement methods or counterplan of power supply is required.

Energy harvesting is a concept that converts residual environmental energy into electricity. The energy harvesting would be a solution of power supply to the bridge monitoring systems [2]. Takeya et al. [3] proposed a vibration energy harvester using electromagnetic induction based on tuned mass systems. However, the target structures are mainly steel bridges because of the limitation of tuning and its installation work.

Concrete bridges have the potential of storing thermal energy because of their large heat capacity [4]. Their upper components, including pavement, sidewalk, and balustrade, receive direct sunlight in daytimes. The temperature difference between the bridge and the air occurs for these reasons [5].

Thermoelectric energy harvesting is a concept that