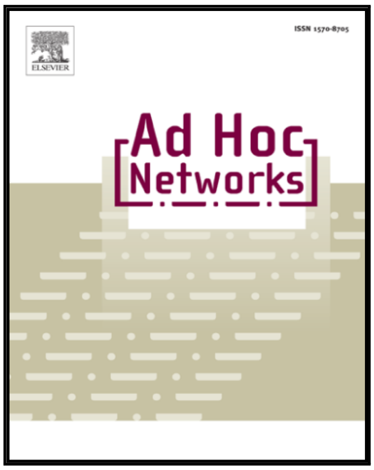

Structure Health Monitoring Using Wireless Sensor Networks on Structural Elements

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***Abstract*— This paper presents a system that monitors the health of structural elements in Reinforced Concrete (RC), concrete elements and/or masonry buildings and warn the authorities in case of physical damage formation. Such rapid and reliable detection of impairments enables the development of better risk management strategies to prevent casualties in case of earthquake and floods. Piezoelectric (PZT) sensors with lead zirconate titanate material are the preferred sensor type for fracture detection. The developed sensor mote hardware triggers the PZT sensors and collects the responses they gather from the structural elements. It also sends the collected data to a data center for further processing and analysis in an energy-efficient manner utilizing low-power wireless communication technologies. The access and the analysis of the collected data can be remotely performed via a web interface. Performance results show that the fractures serious enough to cause structural problems can be successfully detected with the developed system.**

***Index Terms* — wireless sensor networks, structural health monitoring.**

I. Introduction

DETECTION of structural deficiencies poses a great importance on the prevention of casualties caused by unforeseen structure collapse. Structural deficiencies causing collapses may occur because of earthquakes, dead loads, live loads, floods or ageing. These factors exert external forces on structural elements causing fracture generation. Two of the most influential external effects are bending moments and shear forces that provoke bending cracks and shear cracks, respectively [1]. In a concrete building, bending cracks signal an ongoing deficiency progression within the element. Therefore, monitoring the visible crack over time enables taking precautions. However, such process cannot be applied on shear cracks since they are formed abruptly [2]. Shear cracks are capable of causing building collapse solely although they are usually formed besides bending cracks. To prevent casualties resulting from abrupt building collapse, utilization of systems that enable forecasting bending and shear cracks are vital [3]. Recently, Structural Health Monitoring (SHM) systems have been designed to detect and classify these impacts. In general, SHM systems are used to monitor the physical status of critical structural elements, structure integrity and usually consist of multiple sensors placed on these locations, and microcontroller(s) responsible for environmental parameter measurement and data processing tasks. Statistical analysis of the measurement data gathered from sensors enables the assessment of current physical status of the structure. This way, structural problems can be detected earlier and thus, this provides better risk assessment. In addition, after a catastrophe, health evaluation of the structures in the catastrophe area takes a long time using traditional Non-Destructive Evaluation (NDE) methods [4]. Considering the absolute necessity of performing such analysis in a short time due to the need of shelter of the people affected, the SHM systems support timely actions in crisis management thanks to their capability of providing rapid results. For monitoring tasks, the SHM systems may use various types of sensors depending on the parameters desired to be monitored. Moreover, the same kind of data may be measured using various types of sensors to increase reliability or availability. The performance within the target environment and the price of the sensor are the main criteria for sensor type evaluation.

In addition to regular hardware components, radio hardware to relay the gathered information may also be preferred. Integration of Wireless Sensor Network (WSN) technology into SHM applications provides many benefits in terms of cost, scalability, ease of deployment, and reliability [3]. Besides these benefits, the migration from tethered to wireless systems require detailed consideration of battery lifetime [5]. Therefore, the microcontroller to which sensor(s) attached are desired to have low power consumption. Moreover, the lifetime of the system also depends on the way measurements are handled. While some applications require measurements with predefined intervals, others may desire data measurements to be performed based on external trigger. For example, earthquake focused SHM applications may remotely initiate measurements only after an earthquake occurs. Similar to remote command reception, the data gathered via measurements can be processed and the extracted useful

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