Distributed Deflection Measurement of Reinforced Concrete Elements Using Fibre Optic Sensors

Andre Brault, Sara Nurmi, and Neil A Hoult

Department of Civil Engineering, Queen's University, Kingston, ON, Canada

Contact: andre.brault@queensu.ca

Abstract

The construction of new infrastructure required to meet the demands of a growing global population has substantial negative impacts on the environment. Structural engineers can help reduce these negative impacts through efficient material use in reinforced concrete (RC) design, as steel and concrete production accounts for a significant portion of global greenhouse gas emissions. In RC design, stiffness and support condition assumptions often lead to large discrepancies between design models and true behaviour. Critical insight would be captured if the deflected shape of RC beams could be practically measured. A method of measuring the deflected shape of RC beams using distributed fibre optic sensors (FOS) is presented. Six RC beams were tested in three-point bending. The FOS results were evaluated against displacement transducers and were found to capture deflected shapes accurately until loading exceeded 50% of the beams' ultimate capacities.

Keywords: Reinforced concrete; fibre optic sensors; displacement; deflected shape; distributed sensors; concrete cracking; strain.

1 Introduction

Recent projections estimate that 50% of the infrastructure required by the year 2050 has yet to be built [1]. The need to build new infrastructure and repair existing infrastructure places a burden on not only the global economy but the environment as well. Furthermore, it is estimated that material use in structural design could be reduced by as much as 30% if structural elements were truly designed for their purpose [2]. Structural engineers are often limited during the design and analysis of RC elements due to a lack of detailed information regarding the true behaviour of these elements when interacting with surrounding structural elements. In lieu of having this information, engineers can be required to make several conservative assumptions regarding the behaviour of RC elements within a structure, as there is an inherent need to err on the side of caution in structural design.

Deflections of RC elements often govern the design of RC structures as deflections are a critical serviceability limit state. However, RC deflections are difficult to predict as cracking behaviour, shrinkage, creep, loading history, support conditions, and variable beam stiffness all impact the way in which RC elements deform [3]. If the full deflected shape of RC elements, both in the laboratory and *in situ*, could be monitored in a feasible manner, critical insight regarding RC deflections would be captured and the conservativism of assumptions required in RC design and analysis could be reduced. This paper will investigate the use of strain measurements from distributed fibre optic sensors to accurately estimate the full deflected shape of RC beams.

Currently, the common deflection monitoring techniques used on RC elements capture discrete measurements [4], however, discrete measurement techniques often miss critical localized behaviour that can be captured by

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