Experimental analysis on the workmanship factors and performance of Fibre Optic Infrastructure Monitoring cables embedded in concrete structures

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Degree of Master of Science

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other university or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Masters under my supervision.

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ABSTRACT

Structural health monitoring helps to protect infrastructure by guiding timely interventions. Distributed Fibre Optic Sensing (DFOS) is one such monitoring technique with significant advantages such as continuous measurement capability, small size and lightweight. This is the first time introducing the Fibre Optic Monitoring technology to Sri Lanka. A recently developed FOS technique, Brillouin Optical Frequency Domain Analysis (BOFDA), provides advantages such as smaller sized analyser unit and faster measurements, however, it lacks experimental evidence on the measurement accuracy. FOS, in general, also has unestablished workmanship practices on pre-straining and placing of fibre optic cables. This study is particularly aimed at BOFDA-based instrument calibration and verification of the accuracy of the BOFDA-based strain and temperature measurements. Firstly, laboratory experiments were performed to investigate the accuracy the measurements provided by the BOFDA-based DFOS system using the strain cable calibration test setup and temperature cable calibration test setup. These calibration tests indicated that actual maximum spatial resolution of the selected BOFDA unit is in the range of 0.4 - 0.6 m. The strain and temperature measurements provided by BOFDA were found to be reliable, since constant strain and temperature coefficients were observed. The workmanship practices were examined using a set of four-point beam bending tests with different configurations of FO cable locations and pre-tensioning levels. The results showcases that the location of the fibre cables, whether on the surface or embedded in concrete either near or away from the reinforcement, had no significant effect on the accuracy of strain measurements. However, contrarily to the practice, clear evidence was found on the need for pre-straining of strain cables to obtain accurate compressive strain measurements. This research therefore showcases the reliability of BOFDA technique and encourage future fibre optic monitoring deployments to ensure pre-straining of fibre optic cables as a good workmanship practice.

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International conferences

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International Journals

1. **A. Gowshikan,** K. Kariyawasam, X. Xu, C. Kechavarzi, de Battista, S. Acikgoz, N. Ferdinando, N.D. Gunawardana and M. Ranasinghe. "Experimental Analysis on the performance of BOFDA-based Distributed Fibre Optic Sensing Technology" – Under Review

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ABBREVIATIONS

DFOS	-	Distributed Fibre Optic Sensing
FO	-	Fibre Optic
BOTDA	-	Brillouin Optical Time Domain Analysis
BOTDR	-	Brillouin Optical Time Domain Reflectometry
BOFDA	-	Brillouin Optical Frequency Domain Analysis
BOFDR	-	Brillouin Optical Frequency Domain Reflectometry
SHM	-	Structural Health Monitoring
RC	-	Reinforced Concrete
FBG	-	Fibre Bragg Grating
BFS	-	Brillouin Frequency Shift
PCC	-	Prestressed Concrete Cylinder