Talk on Distributed Optical Fibre Strain Sensing in Piles and Retaining Walls

By Ir. Dr Chan Swee Huat

Ir. Dr Chan Swee Huat graduated with a 1st Class Honors Degree in Civil & Structural Engineering from the Universiti Kebangsaan Malaysia in 1997. He obtained his Ph.D degree from the National University of Singapore in 2003. He is currently a lecturer in the University of Nottingham Malaysia Campus, responsible for teaching the geotechnical engineering and critical state soil mechanics. He is also the committee member of Geotechnical Engineering Technical Division.

The evening talk on "Distributed Optical Fibre Strain Sensing in Piles & Retaining Walls" was organized by the Geotechnical Engineering Technical Division on 27 September 2012 at the Tan Sri Prof. Chin Fung Kee Auditorium, Wisma IEM. The talk was delivered by Dr. Hisham Mohamad. A total of 58 registered participants attended the talk.

The speaker started his talk with an introduction to optical fibre, which is defined as a cylindrical structure that transmits light along its axis. Distributed optical fibre sensing technique takes advantage of the natural sensitivity of the optical fibre with respect to ambient parameters like temperature and strain. The strain or temperature, to which the fibre is subjected to, influences the properties of a light signal travelling through the fibre, which can then be analysed for measurement of temperature or strain changes.

Subsequently, comparisons were made among three different common strain sensor technologies, as summarized in Table 1 below.

Table 1. Comparisons of strain sensor technologies

Sensor	Vibrating wire	Fibre Bragg grating (FBG)	Optical fibre
Measurement	Discrete	Discrete	Distributed
Strain resolution	0.5-1me	0.1-10me	2-30me
Limit of spatial resolution	50-250mm	~2-20mm (length of grating)	~1m (centre weighted)
No. of measurements	1 per copper cable	Typically 40 sensors	20,000-100,000 (up to every 50mm for ~10km)
Measurement speed	600Hz-3KHz	Acoustic frequencies	4-25 minutes
Detected physical quantity	Change of resonance in wire	Bragg reflection frequency shift	Brillouin gain spectrum frequency shift
Maximum strain	3,000me	~10,000me	~10,000me
Cost	Analyser ~RM5k-50k Sensor RM400-1000	Analyser RM100k-250k Gratings ~RM250-1500 each	Analyser RM250k-400k Fibre ~RM0.50-50/m
Features	Established technique	High strain accuracy, fast	Distributed measurement

Using a case history in UK, the speaker then illustrated application of distributed optical fibre strain sensing in studying pile response to excavation induced heave and construction loading. For comparison purpose, vibrating wire strain gauges and Bragg grating system were also installed in the pile. The axial strain observations from these three systems were found to be broadly consistent.

In the second case study, the speaker illustrated the application of distributed optical fibre strain sensing in a secant pile wall for measuring lateral deformations and interpretation of shear forces and bending moments. The benefits and limitations of using distributed optical fiber sensing, as opposed to inclinometers, in retaining walls were discussed. The following conclusions were drawn:

1. The results obtained from the strain measurements were in good agreement with the inclinometer data obtained from the adjacent piles.
2. Further analysis in terms of bending moment and shear force showed that distributed optical fiber sensing gave a better measurement than the inclinometer.

At the end of the talk, the speaker fielded a number of questions from the audience. Lastly, a token of appreciation was presented to the speaker. The seminar ended at about 7.00 p.m. with applause from the floor.