Case Study — Structural Monitoring in Foundation Piles

Sensornet Strain Sensor (DTSS) Provides Long-term Structural Monitoring for Major London Development

Introduction

In conjunction with Skanska – Sensornet installed a fibre optic strain sensor into the foundation piles during the construction phase of Bankside 123, a major new London development (see photo below). The installation was carried out as part of the RUFUS program (**R**e-**U**se of **F**oundations for **U**rban **S**ites). And the aim of the testing was twofold. Firstly to analyse the loading effects on the piles once the building is constructed and secondly to investigate the long term strain and stress effects in foundation piles and whether the foundations can be re-used.

Why Monitor Structures with Fibre Optic Sensors?

At the moment modern office buildings in London typically have a 30 year lifetime before being replaced. The cost of the foundations is a major part of the overall project and so if the foundations can be re-used, this can present a major saving.

Currently, vibrating wire sensors are used to provide structural measurements in the industry. However, the fibre optic **D**istributed **T**emperature and **S**train **S**ensor (DTSS) by Sensornet provides two major advantages of traditional sensors. Firstly, the sensors are designed with 30 year+ lifetimes and so remain stable over the lifetime of the structure. Secondly, due to the distributed nature of the sensor you have the ability to measure strain every 1 metre along the length of the sensing cable – as opposed to at only a few discrete points with conventional sensors.

The DTSS utilizes standard telecoms fibre and the key factor is that **the fibre itself is the sensor**, which makes it a very cost effective method of monitoring strain. In comparison with competing fibre optic sensors, the Sensornet DTSS equipment has a unique ability to measure strain and temperature simultaneously and independently without the cross-sensitivity experienced by other instruments.

Case Study

Installing the Sensing Cable

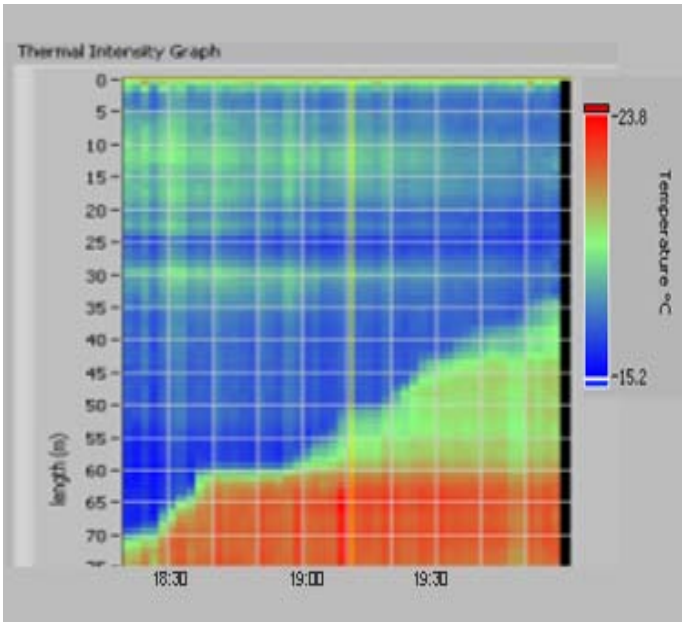
The fibre optic sensing cable was attached to the re-enforcement bars of the pile cage and was run longitudinally along the length of 3 cages. The total length of the sensing cable profile along the cages was 35m – and the DTSS provided a full strain profile along the length of the pile with a total of 35 independent measuring points.

The sensing cable used is a variation on the cable developed by Sensornet & HydroResearch, which has been developed for structural monitoring in dams. This cable has been designed with 2 key factors in mind. Firstly the cable must be robust enough to withstand the extreme forces experienced during compaction or cement curing processes. Secondly, any strain experienced by the outer layers of the cable must be mechanically transmitted to the optical fibre, so that the fibre is able to accurately measure the strain. The initial strain measurements were in September 2004 and once the building is finished further analysis will be carried out.

Thermal Profile of Concrete Curing

Although the primary purpose for the installation is for long-term structural monitoring of the foundations. There are a number of shorter term effects which can be useful to monitor One such application of this technology is the ability to measure the temperature profile of the concrete as it cures. Depending on the heat distribution during curing and the absolute maxiumum temperature you are able to analyse the quality of the curing.

Below, is an example of the Sensornet thermal mapping visualisation software throughout a 180 minute period. The screenshot shows how the temperature profile in the pile changes as the concrete is poured in.



The vertical axis represents the length along the pile cage, the horizontal axis the progression in time and the colour of the data points is proportional to the temperature – with red representing the hottest temperature and blue the coldest. What you can see in the diagram above is 2 separate pouring session of concrete, with the first filling starting at 18:20 (from 75 to 60m) and the second filling starting at 19:10 (from 60 to 40m). As you can see, from the colour coding the first batch of concrete was warmer with a temperature of 23°C and the second batch at 19°C.

For more information on Sensornet's range of distributed sensing solutions and associated hardware and software accessories - please contact a Sensornet representative.

Diagrams

Front Left :	Bankside development
Front Right::	Sensornet DTSS & engineers on site
Back Left:	Sensor attached to pile cage
Back Right:	Sensornet visualization software
Back Bottom:	Installation of Sensor Cable