

Automated manufacturing of smart tunnel segments

Industrial PhD Project with the University of Strathclyde, COWI UK and Highways England

Driven by demands of increasing urbanisation and high expectations of the travelling public for efficient and reliable travel, owners and operators of transport infrastructure are increasing their focus on performance and availability of critical structures on the network, such as tunnels and bridges. The traditional method of managing these structures is to undertake periodic inspections which can be disruptive and therefore infrequent. This approach means that emerging defects often progress significantly before being identified, thus necessitating more acute remedial measures and, hence, disruption. To improve reliability, sensors can be installed to measure real-time changes, giving early warning of problems and allowing planned, pro-active maintenance which minimises disruption to the travelling public. Currently sensors and construction are poorly integrated, and monitoring is often neglected or included as an afterthought. Good asset management, pro-active maintenance and intelligent re-design all demand data throughout an asset's life by integrating sensor technology in the construction process.

This PhD project will focus on major tunnels and we will solve this integration challenge by automating the deployment of wireless monitoring during precast concrete tunnel segment manufacture to produce *smart tunnel segments*. Automation will deliver truly integrated monitoring without additional human effort and will increase sensor reliability and performance. Like their parent segments, the sensors will be modular, setting up ad-hoc wireless networks to self-identify, report location and continuously monitor environments and loads throughout the entire asset lifecycle. The project will develop lab-scale implementation of robotic sensor installation; performance testing of sensors and development of wireless networking. This will lead to definition of monitoring requirements and development of specifications which can then be implemented on real projects.

COWI are collaborating with Highways England and the University of Strathclyde to deliver this project. Highways England manages the strategic road network in England and is COWI's Client on the Lower Thames Crossing project, which will be one of the largest diameter road tunnels in the world on completion. Highways England has a strong interest in the opportunities for integrated intelligent monitoring of their structures and will provide the owner's perspective. They are matching COWI's funding for the project. The Centre for Intelligent Infrastructure at the University of Strathclyde brings expertise in smart cement sensor technology and automation in construction to the project while COWI brings expertise in the design and manufacture of segmental tunnel lining, as well as understanding of appropriate parameters for monitoring.

The PhD project will run from October 2019 until March 2023. The academic supervisor will be Dr Marcus Perry of the University of Strathclyde and industrial supervisors will be Dr Efi Tzoura of Highways England and Dr Chris Hoy of COWI.