

Singapore's used water underground infrastructure to be monitored with Distributed Fiber Optic Sensing (DFOS) technology by fibrisTerre

#fiberoptics #sensing #DFOS #SHM #bofda #bofdr #dtss #fibristerre #ftB5020 #DTSS

Singapore's Deep Tunnel Sewerage System

The Deep Tunnel Sewerage System (DTSS) is a key part of the long-term Singapore's used water system, which comprises a network of link sewers leading to two major tunnels (Phase 1 & 2) criss-crossing Singapore with three large water reclamation plants (WRP), as well as outfall pipes.

DTSS uses deep tunnels to convey used water entirely by gravity to the treatment plants strategically located at coastal areas. The treated used water is then reclaimed and further purified into NEWater water treatment facilities (www.pub.gov.sg/dtss), with excess effluent discharged to the sea in an environmentally responsible manner.

On track to be completed in 2025, the underground labyrinth of pipes will comprise 40 km of deep tunnels and 60 km of link sewers, traversing 100 km across the western half of Singapore.

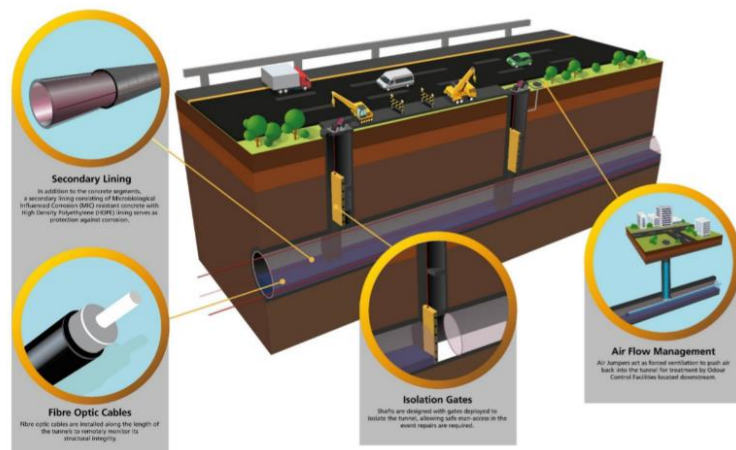


Constructing DTSS - Phase 2

19 Tunnel Boring Machines will be used to dig at depths of between 35 metres to 55 metres below ground through a variety of ground conditions, as well as tunnel beneath existing underground infrastructures and even under the sea, to create 40 km of deep tunnels and 10 km of link sewers.

Advanced maintenance features of the deep tunnels include the use of embedded fiber optics for remote sensing and monitoring of structural integrity, and tunnel shafts innovatively designed with gates to isolate tunnel sections for used water flow diversion, enabling safe maintenance access with no disruption to used water conveyance.

Advanced features of new DTSS superhighway



Tunnel Integrity Monitoring System (TIMS) based on embedded fiber optic sensors

The B&V+AECOM Joint Venture team has been working with PUB, Singapore's national water agency, to shape one of the most significant and anticipated water projects in Asia. The Deep Tunnel Sewerage System - Phase 2 (DTSS-2) shall be implemented with Tunnel Integrity Monitoring System (TIMS) for the purpose of monitoring the structural health of the tunnels, particularly critical when other

construction works will be underway in the vicinity, or by the occurrence of events such as seismic activity. The system relies on fibre optic sensing cables as a medium to obtain data for the structural assessment of the tunnels. A total of about 50 km of tunnels and link sewers with internal diameters ranging from 3 m to 6 m is going to be longitudinally monitored, with hybrid (strain and temperature) fiber optic sensing cables, specifically designed to respond to the demanding project requirements. In order to obtain the 3D information about the deformation of the structure, multiple sensing cables are going to be installed at different positions along the wall linings. Additionally, critical tunnel sections are going to be also transversally instrumented.

fibrisTerre's Brillouin Optical Frequency Domain Analyser (BOFDA) FTB 5020

The Brillouin optical frequency domain reflectometry technology produced by fibrisTerre Systems GmbH has met the specifications required to interrogate the fiber optic sensing network, which will be embedded in the tunnel walls, and to provide reliable spatially distributed strain and temperature measurements along the DTSS-2 infrastructure. Several FTB 5020 Brillouin read-out units shall be installed at strategic positions and remotely accessed by the Singapore Public Utility Company (PUB), to provide Structural Health Monitoring (SHM) information of the DTSS-2 in real time for the decades to come.



Strong consortium for the realization of the Tunnel Integrity Monitoring System

The ongoing validation, the upcoming installation, commissioning, and long-term operation of the fiber optic Tunnel Integrity Monitoring System (TIMS) require the efficient and precise joint activities of a team of experienced project stakeholders. The local integrator company, **Ryobi Geotechnique International Pte Ltd** – Singapore (www.ryobi-g.com), a highly qualified provider of a wide range of solutions in geotechnical engineering in Southeast Asia, is going to manage the whole TIMS project during the realisation and operation phases. The **Institute of Engineering Geodesy and Measurement Systems (IGMS) of the Technical University of Graz** - Austria (www.tugraz.at/institutes/igms/home/) is an internationally acclaimed technology pioneer for solutions based on geodetic and fiber optic sensors enabling the early detection of deterioration of large structures. **fibrisTerre Systems** – Germany (www.fibristerre.de) is a manufacturer of state-of-the-art distributed fiber optic sensing systems for uninterrupted and long-range structural health monitoring. fibrisTerre's unique BOFDA and BOFDR (Brillouin Optical Frequency Domain Analyser and Reflectometer) instrumentation shall be implemented for the SHM of the DTSS-2.

References:

1. www.pub.gov.sg/dtss , PUB – Singapore's National Water Agency
2. BV-AECOM, "FACTSHEET About the Deep Tunnel Sewerage System (DTSS)"
3. *The Straits Times* on April 05, 2019, 'Work begins on Phase 2 of used water superhighway'
4. www.fibristerre.de