

## Tunnel Convergence Monitoring by Distributed Fiber Optics Embedded into Concrete

**Authors :** R. Farhoud, G. Hermand, S. Delepine-lesoille

**Abstract :** Future underground facility of French radioactive waste disposal, named Cigeo, is designed to store intermediate and high level - long-lived French radioactive waste. Intermediate level waste cells are tunnel-like, about 400m length and 65 m<sup>2</sup> section, equipped with several concrete layers, which can be grouted in situ or composed of tunnel elements pre-grouted. The operating space into cells, to allow putting or removing waste containers, should be monitored for several decades without any maintenance. To provide the required information, design was performed and tested in situ in Andra's underground laboratory (URL) at 500m under the surface. Based on distributed optic fiber sensors (OFS) and backscattered Brillouin for strain and Raman for temperature interrogation technics, the design consists of 2 loops of OFS, at 2 different radiuses, around the monitored section (Orthoradiale strains) and longitudinally. Strains measured by distributed OFS cables were compared to classical vibrating wire extensometers (VWE) and platinum probes (Pt). The OFS cables were composed of 2 cables sensitive to strains and temperatures and one only for temperatures. All cables were connected, between sensitive part and instruments, to hybrid cables to reduce cost. The connection has been made according to 2 technics: splicing fibers in situ after installation or preparing each fiber with a connector and only plugging them together in situ. Another challenge was installing OFS cables along a tunnel mad in several parts, without interruption along several parts. First success consists of the survival rate of sensors after installation and quality of measurements. Indeed, 100% of OFS cables, intended for long-term monitoring, survived installation. Few new configurations were tested with relative success. Measurements obtained were very promising. Indeed, after 3 years of data, no difference was observed between cables and connection methods of OFS and strains fit well with VWE and Pt placed at the same location. Data, from Brillouin instrument sensitive to strains and temperatures, were compensated with data provided by Raman instrument only sensitive to temperature and into a separated fiber. These results provide confidence in the next steps of the qualification processes which consists of testing several data treatment approach for direct analyses.

**Keywords :** monitoring, fiber optic, sensor, data treatment

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