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Instrumentation by accelerometers and distributed optical fiber sensors of a real ballastless track structure

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While relatively expensive to build, ballastless track structures are presently seen as an attractive alternative to conventional ballast. Firstly, they are built quickly since the slabs can be cast in place in an automated fashion by a slipform paver. Secondly, with its service life of at least 60 years, they requires little maintenance and hence they offers great availability. Other reasons for using ballastless tracks instead of ballasted tracks are the lack of suitable ballast material and the need of less noise and vibration for high-speed, in particularly.

In the framework of a FUI project (n° 072906053), a new ballastless track structure based on concrete slabs was designed and its thermal-mechanical behavior in fatigue under selected mechanical and thermal conditions was tested on a real scale mockup in our laboratory [1,2]. By applying to the slabs both together mechanical stresses and thermal gradients, finite elements simulation and experimental results show that the weather conditions influence significantly the concrete slabs curvatures and by the way, the contact conditions with the underlaying layers. So it is absolutely necessary to take into account this effect in the design of the ballastless track structures in order to guarantee a long target life of at least of 50 years.

After design and experimental tests in laboratory, a real ballastless track structure of 1km was built in France at the beginning of year 2013. This structure has 2 tracks on which several trains circulate every day since the beginning of year 2014. Before the construction, it was decided to monitor this structure to verify that the mechanical behavior is conform to the simulations. One part of the instrumentation is dedicated to monitor quasi-continuously the evolution of the curvature of a concrete slab. For this, 2 accelerometers were fixed on the slab under the track. One was placed on the edge and the other in the middle of the slab. The acquisition of the signals by a nano computer (called Pegase and developed at Ifsttar for data acquisition [3]) were performed automatically every time that a threshold is exceeded due to the passage of a train. These data are then send to a web server via a 3G Wireless Network. Many data was thus stored daily for several months. Moreover, several thermocouples were embedded at different depths in order to measure thermal gradients into the track slab.

From the accelerometers signals, the deflection of the track slab are then obtained and compared to the measurements of thermal gradients. This comparison show clearly the daily evolution of the curvature with the thermal gradient changes as estimated by the simulation. This result was confirmed indirectly by strain profile measurements obtained by the Rayleigh fiber optic sensing technique. Two fiber optics embedded in the upper and lower part of the foundation slab show that contact conditions between the foundation slab and the track slab change with thermal gradient.

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3 – V. Le Cam, L. Lemarchand, L-M. Cottineau and F. Bourquin. Design of a generic smart and wireless sensors network – benefits of emerging technologies. Structural Health Monitoring 2008, 1(1), pp. 598-605.