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Instrumentation by distributed optical fiber sensors of a new 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. With its service life of at least 60 years, they require little maintenance and hence they offer 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.

A new ballastless track structure has been designed to be circulated up to 300km/h, with a target life of 100 years. It is an interoperable way on concrete slabs that are cast-in-place and slip formed. This structure has been built and tested at the scale one in our laboratory. Indeed, ten millions cyclic loads were applied at 2.5Hz to evaluate the fatigue behaviour under selected mechanical and thermal conditions.

To monitor the thermo-mechanical behavior of this new structure and to verify the numerical simulations used for its design, a lot of sensors have been embedded. In particularly, we have tested an optical fiber as distributed sensors to measure strain distribution in the railway model. This sensor can also be used to detect, localize and monitor cracks in concrete slabs. The optical fiber sensing technique ("Rayleigh technique") used in this experimentation has a centimetric spatial resolution which allows to measure complex strain profiles unlike electrical strain gauges which only give local information.

Firstly, optical cables used as sensors have been successfully embedded and attached to the reinforcing steel bars in the structure. We have noted that they are resistant enough to resist concrete pouring and working activities. Secondly, strains measured by conventional strain gauges has confirmed the quality of the strain profiles measurements obtained by optical fiber sensors. Moreover, we have found a good agreement between experimental profiles measurements and those obtained by numerical simulations.

Early during the fatigue test, some cracks have been observed. It is a current phenomenon in concrete slab which is due to drying shrinkage, load action, environmental factors and creep of concrete. Cracks can reduce the durability of the tract structure. So, it is important to be able to monitor them during the service of ballastless track line. We have demonstrated that cracks can detect, localized and monitor by a judicious placement of optical fibers. A crack corresponds to the appearance of a narrow peak on the strain profile. This peak can be detected and localized thanks to the very high spatial resolution of the optical Rayleigh sensing technique. Thus, we have noted that the cracks remain localized in slab edge without affecting the mechanical performances of the ballastless track structure.

In conclusion, distributed sensing based on optical fiber sensor is a promising technique to monitor ballastless track structures and more generally, civil engineering structures. Some tests on a portion of a ballastless track line (still under construction) are planned in the next month.