



## **Monitoring and analysis of large landslides: a case study of Teso Tunnel (N Spain)**

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This study focused on the big landslide case at a section of the high-speed railway line linking Madrid and Gijón (Spain), currently under construction. The movement terrain characterization is a particularly complex one. It partially reaches the “Teso Tunnel” (230 m) (where concrete milimetric fissures were observed) and a stretch of the platform (250 m). They are located in the “Sotiello-Camponames” section (Asturias, N Spain), which is 4,3 km long and had a budget of 79,8 million euros. In this area the bedrock is formed by carboniferous formations: sequences of shales and siltstones with sandstones and coal bed interlayered. The bedrock shows a significant superficial alteration.

In a preliminary investigation, 25 inclinometers were installed on the slope and were monitored for 3 years (2007-2010) to study the depth and speed of the slide. These showed slips > 90 mm at depths between 10 and 40 m. Furthermore, a global geological model of the slope was developed based on data provided by 25 boreholes. This large amount of information was integrated in to a GIS database, together with digital elevation models and remote sensing images at different times that helped to analyze the slip. Several geological profiles were modelled to compare the observed movements.

The results obtained revealed a deep slide which involving the bedrock. The total area and volume of the primary sliding mass were estimated at 250.000 m<sup>2</sup> and 5,5 million m<sup>3</sup>, respectively. The main vector displacement of the landslide and the railway line form approximately an angle of 70°. The tunnel excavation and the creation of slopes in the landslide toe, as well as the building of two dumps in the head seems to be acting as triggering factors.

The chosen technical solution, which is currently under construction, consists of two 165 m lengths parallels pile walls. Moreover, a 6 m diameter and 330 m length drainage gallery has been drilled parallel to the section to lower the ground water level. This solution brings in 14 million euros more than the initial budget for this railway section, which it was brought to a standstill during three years.