LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

IBER project: Impact of Runoff on Railroad Ballast (2010-2013)

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Introduction

A severe thunderstorm occurred in Sarry, on the High Speed Line (LGV) Paris South East in 2000. This incident has highlighted the flood risk on the platform, with ballast entrainment. The damage to the platform and to the ballast generates a destabilization of the railroad that could cause a derailment.

Objective of the Research

It was found that the runoff on the platform, usually caused by the overflowing of the drainage system, is the main cause of ballast entrainment. When obstacles, such as drainage manholes, catenary poles or bridge pier, are present along the railroad, the ballast entrainment risk increases drastically (Fig. 1).

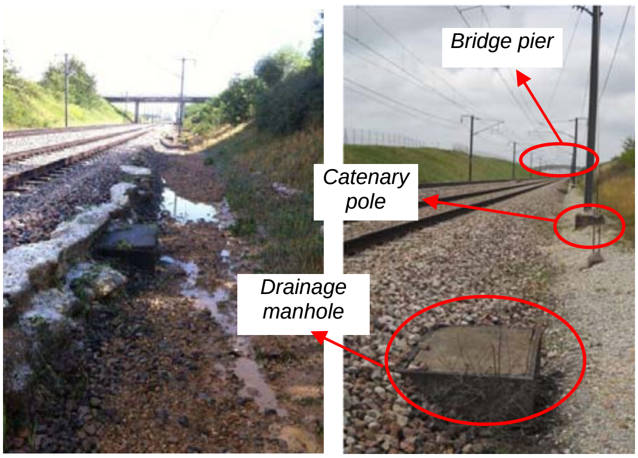

Figure 1 : Left, effect of thunderstorm. Right, common obstacles along the railroad

The Laboratory of Hydraulic Constructions (LCH) of the Ecole Polytechnique Fédérale de Lausanne (EPFL) has conducted systematic tests for ballast entrainment on a physical scale model and has provided an optimized configuration for the drainage system on the platform by means of numerical simulations.

Physical Model

The model, built on a geometric scale of 1:3, is 10 m long and 1.5 m wide. It is operated on Froude similarity, which means respecting the conservation of the inertial to gravity forces ratio. The sediment transport similarity is guaranteed by the respect of the Shields criteria for ballast entrainment.

The tests were divided in phases. During the first series (IBER1), the tested longitudinal slope of the platform lied between 0.5 and 3.5%. The influence of one obstacle per time was evaluated. The tests were carried out on both rough and smooth platform. According to these results, the second phase (IBER2) studied the combined impact of two obstacles (Fig. 2). Tests with two obstacles were carried out for two platform slopes (0.65% and 3%). Two distances between obstacles have been used (3 m and 4.5 m on prototype) and were decided according to the zone of maximum erosion caused by the upstream obstacle alone.

Figure 2: Left, test with 2 obstacles: catenary pole downstream of bridge pier; distance between obstacles 4.5 m, slope 3%. Right, test with vibrator, slope 0.65%, discharge 0.05 m^2/s.

In the third phase, the effect of a train transit was tested by means of a vibrator machine installed on the model. Finally, to avoid the overflowing of the drainage system, a part of the water must be drained into the manholes by means of grid gutters transversal to the platform. The position and dimensions of the grid gutters was optimized. The performance of several configurations deriving water into the manhole was studied by means of a numerical simulation with the Solver CFD of FLOW-3D.

Results

Through IBER1, it can be said that on a rough platform: the bridge pier has a great impact, independent of the slope, while the effect of the catenary pole decreases with slope. In both cases, the erosion remains local.
The drainage manhole has a negative impact for low slopes, but it stabilizes the upstream ballast in case of steep slopes. On the smooth platform, the effect of the slope is almost negligible in the absence of obstacles.

IBER2 has highlighted that different obstacle combinations have different impacts on the platform, either stabilizing or destabilizing. The outcome, as the erosion regions around the obstacles, changes substantially as a function of distance, slope and discharge. The behaviour of the manhole have been confirmed in presence of a second obstacle upstream, regardless the obstacle type.
The vibrator machine has shown a stabilising effect on the platform, inducing no additional negative effect for the ballast entrainment.
Through the numerical simulations, it was established that the hydraulic behaviour of the drainage configurations varies as a function of the platform slope. The higher drainage efficiency was provided by a grid gutter combined with a downstream transversal weir. The presence of the weir slows down the flow and increases the water depth at the location of the grid gutter. The flow on steep slopes (3.5%) creates a skimming flow above the gutter, not allowing the water to fall in and, thus, recommending a minimum length of 0.2 m in flow direction.

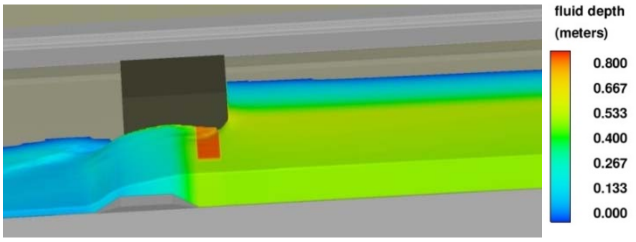

Figure 3: Optimised configuration, discharge 0.05 m^2/s. *Numerical simulation result.*