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Ballast bed cleaning and recycling – influence on stability of continuously welded rail track

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Abstract

The ballast bed main functions are to bind the sleepers to the substructure, to distribute the dynamic loads from the vehicle to the embankment and to ensure the track stability. Fouling may increase in time due to various reasons, under normal dynamic loads. If the ballast bed functions are no longer fulfilled, the welded track can lose its stability with highly damaging results. The purpose of the paper is to investigate the ballast bed fouling degree on welded tracks, with potential loss of stability. Once the ballast bed elasticity decreases and the geometry of the track cross section is modified, the track is subjected to longitudinal axial compression due to thermal loads that can result in stability lost: buckling of the rail. The ballast bed is required to ensure lateral and longitudinal resistance to the track. The lateral resistance force depends on the ballast depth, material properties, maintenance and tamping. The study uses the Energy Method to determine the critical stability force on fouled ballast bed conditions, with irregular settlements due to insufficient track maintenance. Continuously welded track stability was studied for three different fouling cases, both on curved track and on straight line, with various types of horizontal geometrical imperfections, using the maximal thermal effort as a reference. The results of the critical stability force determined using the Energy Method were compared to a real study case situation from a rail sector were ballast bed cleaning was performed. The paper aims to correlate the fouling degree of the ballast bed to continuously welded track stability problems due to thermal effect in connection with insufficient track maintenance. The critical stability force in three various situations were compared to the maximum temperature effort due to thermal load taking into consideration the geometrical aspect of the line, fouling degrees and existing geometrical imperfections.

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1. Introduction

Railway tracks represent a wide transport system that is able to carry important loads: both goods and passengers. The rail track system has a geotechnical component that plays a significant role in its stability: the ballast bed. Defects and lack of maintenance can cause settlements and deformations of ballast bed section that can lead in time to misalignment or stability loss in case of continuously welded track (CWR). Ballast bed layer consists in a coarse granular medium, placed above the sub ballast layer and below the rail sleepers, with different roles, such as loads distribution, providing energy absorption from the track, drainage, resisting to lateral, longitudinal and vertical forces applied to the sleepers and keeping the gauge between sleepers and there the alignment of the track [1]. Researchers are trying to optimize the railway ballast gradation in order to meet future requirements for freight and passenger traffic loads.

Due to improper maintenance and lack of tamping, the efficiency of the ballast bed material gradually loses its characteristics and properties, the result being a significant decrease of lateral resistance, ballast fouling, and ballast shoulder width reduction.

2. Track geotechnology

2.1. Ballast bed fouling

Ballast bed contamination or filling of voids between particles due to infiltration of other materials from surface, stone particles crushing (breakage of angular projections) or sub grade pumping under excessive cyclic loads, can result in ballast fouling. Fouling decreases the ballast bed drainage capacity and its shear strength [2].

The major problems of the railway track stability, settlement and drainage represent the ballast breakdown that is depended on ballast properties, gradation etc. In case of ballast breakdown due to repeated cyclic dynamic loads, over loads, sleeper moving etc., the stress carrying capacity of the ballast bed decreases that leads to a higher pressure on the sub grade layer resulting in sub layer failure [3].

Ballast behaviour can be elastic when the particles are clean and the compaction is adequate, but it can also be plastic in cases of fouling due to breakdown of ballast particles. Ballast settlement developing uniformly along the length of the track is not as dangerous as the differential track settlement [4].

Fouling materials can be dust, coal, fine particles from ballast degradation, clay as the result of pumping of the sub grade, having both beneficial and adverse effect on fouled ballast, the result depends on the types of fouling material present, the degree of fouling and the water content. Before the ballast particles lose their contact, the ballast bed still preserves his stiffness, the result being an increase of the normalized shear force modulus. In cases of highly fouled ballast, with large amount of impurities, the particles will lose their contact with one another, as a result of ballast particles reorientation upon the cyclic loading and sliding effect due to impurities [5, 6].

Fig. 1. Fouled ballast.