The Quality of the Substructure as the key to Success

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Introduction

The quality of the substructure has a significant impact on the durability of railway tracks. Enhancing the substructure results in fewer track settlements, which reduces the need for track geometry corrections. Improving the quality of the subballast layer can significantly extend the life cycle of railway tracks, as it supports the ballast and reduces differential deformations beneath it. Achieving better compaction quality during rehabilitation is a key method to enhance the overall performance of the subballast layer (Auer et al., 2008).

Track-bound substructure rehabilitation machines are widely used for renewing railway tracks because they allow for a fast substructure rehabilitation. During the rehabilitation process, plate compactors are used to compact the newly installed layer of subballast material, applying concentrated force in confined areas (see Figure 1). However, the effectiveness of plate compactors in achieving optimal density and sufficient compaction of the subballast layer has been underexplored.

This research aims to address this issue by examining various parameters, including the contact force between plate compactor and subballast, the excitation frequency of the compactor, and the thickness of the subballast layer, to comprehensively evaluate the performance and effectiveness of plate compactors.

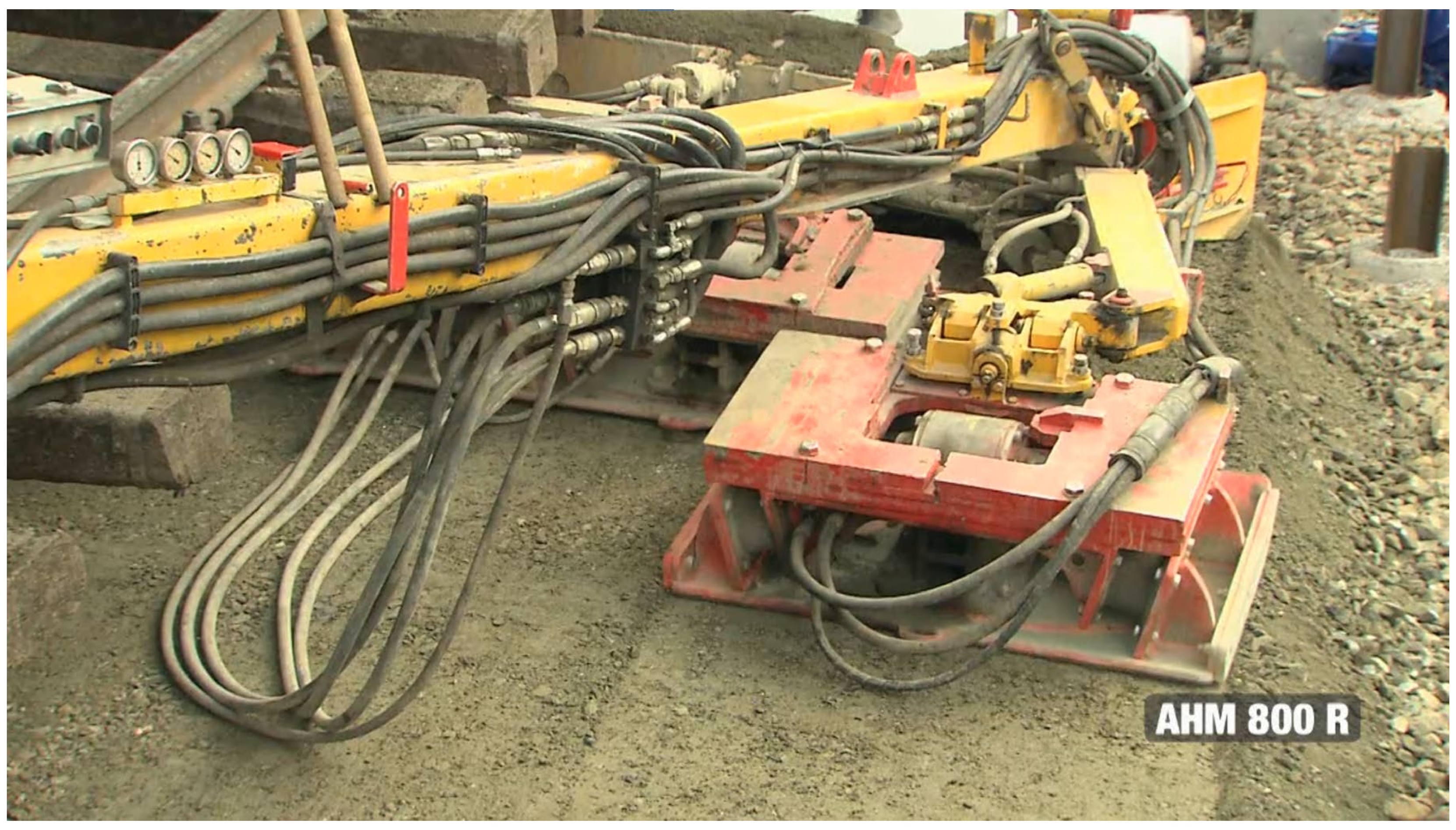

Figure 1. Plate compactors during substructure rehabilitation

Field tests and semi-analytical model

In the initial phase of the project, field tests were carried out to analyze the motion behavior of the current plate compactor design (see Figure 2a). During the field tests a plate compactor was attached to an excavator and then pulled along the test lanes to ensure a constant travel speed (Sigmund, 2021).

Furthermore, a semi-analytical model of the plate compactor and the subballast was developed (Pistrol et al., 2022) and verified using data from the field tests. The mechanical model consists of two subsystems, the plate compactor and the soil, which are connected through contact conditions (see Figure 2b). The plate compactor subsystem is further divided into the base plate and the frame which are connected by rubber buffers modeled as a Kelvin-Voigt element.

Results

The results of the motion analysis from the field tests indicated a sub-optimal performance of the plate compactor under specific boundary conditions. For certain sets of process parameters, the plate compactor shows distinctive, periodic movement while other sets of parameters lead to highly indistinctive motion behavior.

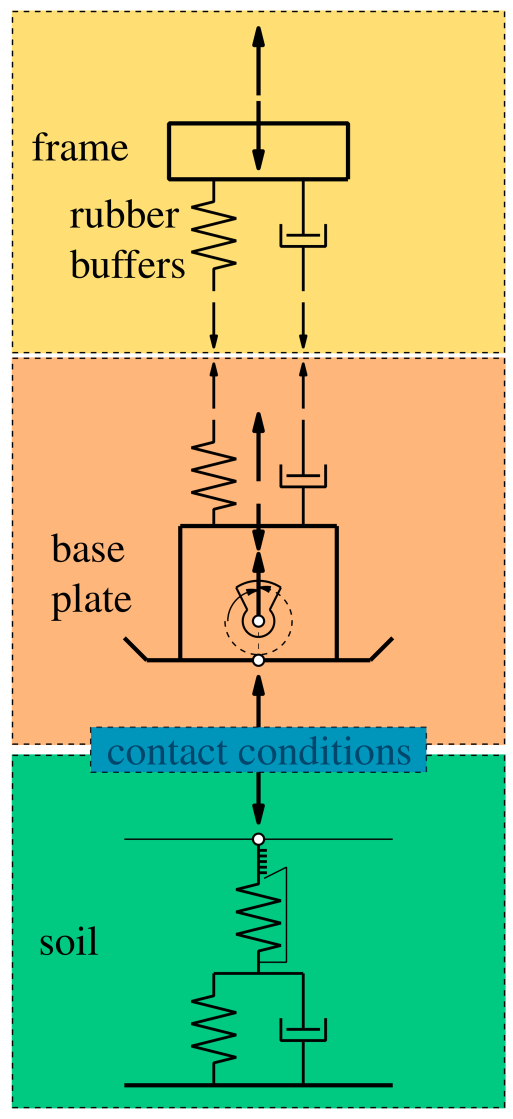

Figure 2a. Plate compactor during field tests Figure 2b. Mechanical model

While comparing field data and simulation, the model adequately reproduces the data for certain sets of parameters, it needs further improvement to accurately reproduce certain patterns of the measured motion behavior.

Plate compactor redesign

The findings from the experimental field tests and the mechanical modeling led to a better understanding of the motion behavior of the plate compactor. Furthermore, a research project has been started to develop a prototype of a new plate compactor. Figure 3 shows the prototype of the new design without (left) and with (right) additional ballast. For research purposes the size and weight of the prototype has been increased as the size of the base plate as well as the vibrating mass of the plate compactor have a decisive impact on the compaction quality. Additionally, the new prototype is equipped with a new exciter unit consisting of six imbalances (respectively three directional oscillators) to increase the compaction energy. This enables different configurations for amplitude and frequency during field tests.

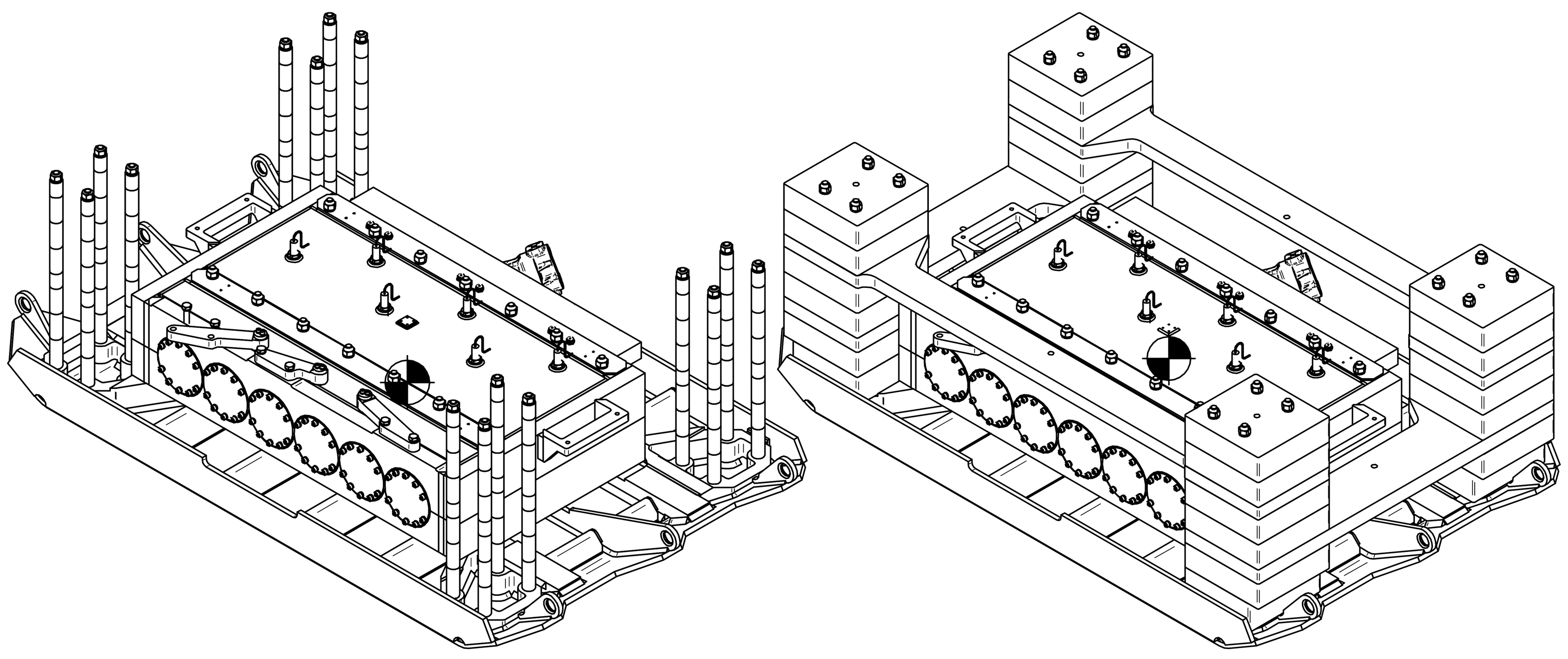

Figure 3. Prototype of the new plate compactor with and without additional ballast

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