The dissertation about railway track drainage – What was learnt?

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Introduction

In early 2024, the dissertation about railway drainage and its effect to sub-ballast layer was published in Finland. This abstract and presentation deal with the main results that were found from the long series of research projects related to track drainage in Finland. Many things regarding drainage are now better understood and drainage maintenance can be improved by new guidelines.

Analysis and conclusions

The change in climate conditions is going to increase floods and heavy rainfalls. Water content is one the most important factors influencing the performance of earth structures. The dissertation "The effect of drainage on the functionality of railway track sub-ballast" assets the research problem by using multiple research methods like field monitoring, laboratory testing and reviews of maintenance methods and contracts. After the entire dissertation process, it can be stated that:

- The effect of axle load is very important, many old materials can withstand the external load of passenger trains even in almost saturated conditions. The heavy traffic with 225 or 250 kN axle loads starts to utilize the strength properties of sub-ballast layers and leads to a need for deeper drainage depth.
- The thick structural layers due to frost protection in Finland prevents the effects of climate change and excessive water content in structural layers. If the water level is below an intermediate layer (about 800 mm from the top of ballast in Finland), problems regarding loading resistance are unlikely with axle weights used in Finland.
- This dissertation proposes a model, where lowered drainage depth can be used, if the materials are good and the traffic is not very heavy.
- Drainage maintenance needs to be planned by using methods collecting numerical data about the state of the drainage. Visual inspections may lead to problems.

References

Latvala, J. (2024). The Effect of Drainage on the Functionality of Railway Track Sub-ballast. Tampere University Dissertations, 959.

Ballasted Track Simulator – a new tool for simulating dynamic loading behaviour of railway structures

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Introduction

A new type of calculation model has been developed to examine the effects of train speed and axle weight on the dynamic loading behaviour of railway structures. This model combines a multibody dynamics-based vehicle model with a non-linear track model. The rail structure is modelled using finite element method, and a non-linear contact model has been used between sleepers and ballast layer. Substructure and subsoil properties, as well as their changes along the longitudinal direction of the track, can also be considered in the model. To simulate the long-term loading behaviour of different railway structures, separate damage models have been developed to calculate plastic deformations in granular layers using an iterative approach. Finally, the model has been verified using versatile field measurement data and material available in the literature.

Conclusions

In the presentation, the main features of the model are discussed, and the functionality of the model is demonstrated using some case examples. Based on the preliminary results, axle load appears to be the primary factor determining load response of the track structure in most cases. However, as driving speed increases, the role of track geometry becomes increasingly important. The presented model can be used e.g. to model dynamic response of rolling stock and track system or to simulate long-term functionality of different structure solutions. To enable wider use of the tool, a simple graphical user interface has also been built into the software.

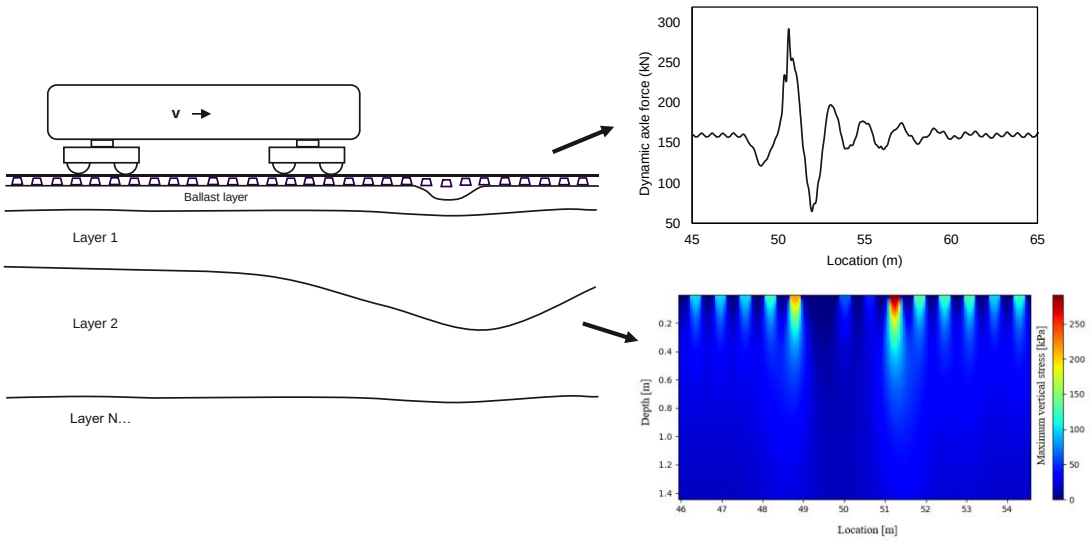

Figure 1. Model overview.

3D DEM-based ballasted track and rail vehicle interaction: model construction, verification and analysis

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Introduction

Ballasted track systems are used in railway networks worldwide, with the benefits of rapid installation, cost-effectiveness and ease of maintenance. However, the granular nature of ballast beds leads to particle displacement, abrasion and crushing under vehicle loads. This increases the dynamic wheel-rail interaction and may lead to higher maintenance of ballast track and potentially even compromise the running safety. In this work, an advanced numerical model is proposed and then used to further understand this interaction and the meso-mechanical behaviour of ballasted track.

Modelling and Analysis

Firstly, the ballasted track is modelled by the discrete element method (DEM) where the actual geometric morphologies of ballast samples are used to simulate the complex clamping action among ballast particles. The railway vehicle is modelled as a multi-rigid-body dynamics system (MDS) with 35 degrees of freedom (DOF). The two sub-systems are coupled through a wheel-rail spatial interaction constructed in the DEM simulation environment. Figure 1 shows a 3D DEM-based ballasted track and vehicle interaction model of the rail vehicle and ballasted track system. Then, simulation results based on the hybrid MDS-DEM model and the classical vehicle-track coupled dynamics model are compared to validate the validity of the former. Finally, using the hybrid MDS-DEM model, macro-meso mechanical behaviours of the ballasted track are analysed comprehensively.

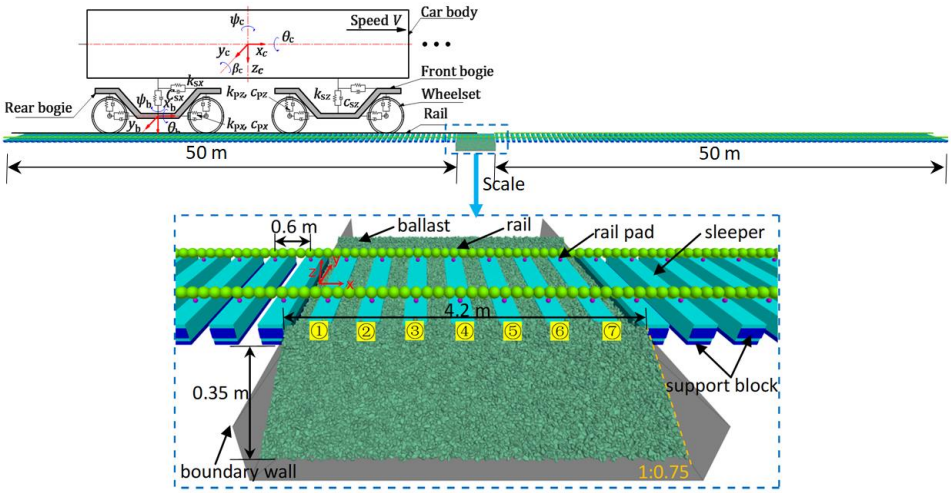

Figure 1. Hybrid MDS-DEM model of the rail vehicle and ballasted track system.

Conclusions

The proposed 3D DEM-based ballasted track and vehicle interaction model provides a useful numerical solution for studying the macro-meso dynamic interaction between the vehicle and ballasted tracks. It also provides an efficient way to systematically optimize and improve the design of the ballast bed under different train operation conditions.

Economies of scale and scope in LCC for Switches & Crossings

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Introduction

Infrastructure managers (IMs) need a decision tool for minimizing the life cycle cost (LCC) of its railway assets. However, the LCC for each of these assets cannot be evaluated in isolation. An IM needs to consider several adjacent assets due to economies of scale and scope in carrying out maintenance and renewal activities. For example, closing a line during a weekend creates significant costs for traffic disturbances, and it can therefore be more efficient to carry out several activities during that weekend rather than closing the line one extra time at a later stage. This implies that renewing a specific asset, e.g. a Switch & Crossing (S&C), earlier or later than the optimum renewal point for the individual asset can give a lower LCC on a network level.

The purpose of this paper is to analyse actual S&C renewals carried out in combination with other activities and provide a framework for calculating the impact on the total LCC of a set of adjacent assets.

Analysis

The analysis uses information on a set of asset renewals comprising a varying number of asset types per renewal project, where at least one is an S&C. This is combined with information on infrastructure characteristics, traffic intensity, maintenance, train delay minutes caused by infrastructure failures (see e.g., Ait-Ali, et al. 2023).

The paper estimates the impact of traffic intensity on the number of assets that are renewed within each renewal project, providing an indication if and to what extent economies of scale and scope matters for S&C renewals. In addition, a framework is proposed that provides the LCC impact of changing the S&C renewal time given various levels of economies of scale and scope.

Conclusions

Carrying out an S&C renewal earlier or later than what is prescribed by the LCC analysis for that specific asset can be motivated by economies of scale and scope. This paper shows if and to what extent this can be explained by traffic intensity. LCC-calculations for a set of adjacent assets show how large the economies of scale and scope effects need to be to motivate earlier or later S&C renewals.

References

Ait-Ali, A., Odolinski, K., Pålsson, B., Torstensson, P., Evaluating the mix of maintenance activities on railway crossings with respect to life-cycle costs. VTI Working Paper 2023:6.