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Editorial

Advanced Railway Infrastructures Engineering

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1. Introduction

The European Commission is developing a Single European Transport Area and has promoted a modal shift from road to rail to achieve a more competitive and resource-efficient transport system. The European Commission has outlined several targets: one of them is to shift 30% of road transport to other modes, such as rail transport, by 2030, and more than 50% by 2050. Many actions are required to provide appropriate the infrastructure to meet this goal. Past research has emphasized the application of technology in solving problems in the railway industry. Although practical knowledge has been developed alongside corporate knowledge, science and technology are still deficient in innovating and revolutionizing the railway industry from a fundamental principle viewpoint. This Special Issue gathers together the latest research studies, findings, and achievements regarding the advanced planning, design, construction, monitoring, maintenance, and management of railway infrastructures.

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2. Scientific Topics

This Special Issue has selected various novel and original research topics related to advanced analytical and numerical simulation approaches, as well as experimental contributions applied to railway infrastructures. The scientific topics addressed in this issue are summarized as follows:

- Stability and dynamics;
- Safety, risks, and uncertainty;
- Infrastructure engineering;
- Structural engineering and materials;
- Transportation geotechnics and train-induced ground vibrations;
- Rail transportation;
- Mechanics, prognostics, and diagnostics;
- Health monitoring, inspection, NDT&E (non-destructive testing and evaluation), and signal processing;
- Big data analytics and railway operations;
- Multi hazards and climate change adaptation;
- Train–track interactions, vehicle–infrastructure interactions, and wheel–rail interface;
- Safety, reliability, and runnability of railway infrastructure in strong winds and/or earthquake-prone areas;
- Drainage, surveying, photogrammetry, remote sensing, and drone technology;
- Intelligent railway and transportation technologies;
- Structural integrity, fatigue, and residual lifetime;

- Weigh-in-motion and wheel defect detection of the railway, and damage detection of rolling stock.

3. Overview of the Themed Issue

This section briefly addresses the scientific papers published in this special issue related to advanced analytical and numerical simulation approaches as well as experimental contributions applied to railway infrastructures.

Rakoczy et al. [1] presented analytical and measured effects of freight railcars on a two-span truss bridge, with spans of 61 m and 33.5 m, and a 35-m riveted steel deck plate girder (DPG) bridge. Their investigation confirmed that short railcars cause higher load effects on the main bridge components: the 35-m riveted steel DPG had 28% higher stresses at mid-span, while in the truss the difference in stresses depended on the location of the member, and ranged from 15 to 35%.

Kim and Kim [2] from the Korea Railroad Research Institute constructed a full-scale reinforced subgrade for railways (RSR). Furthermore, repetitive and static load tests were conducted for railway subgrade-reinforced rigid walls with short reinforcements to analyze their deformation characteristics. Their test results confirmed the reduction of the settlement and horizontal displacement of the wall, owing to the restraining effect of the short reinforcement and the rigid wall.

Mosleh et al. [3] from the University of Porto focused on identifying the type of sensors that can be adopted in a wayside monitoring system for wheel flat detection, as well as their optimal position. The study relied on a 3D numerical simulation of the train-track dynamic response to the presence of wheel flats. The shear and acceleration measurement points were defined in order to examine the sensitivity of the layout schemes, not only to the type of sensors (strain gauge and accelerometer), but also to the position where they were installed. By considering the shear and accelerations evaluated in 19 positions of the track as inputs, the wheel flat was identified by the envelope spectrum approach using spectral kurtosis analysis.

In the research proposed by Zeng et al. [4], the long-span steel truss slab track was used to analyze a new type of sleeper slab track structure with an experimental method. A full-scale model was established in the laboratory, and a fatigue test was performed on the track structure. Moreover, the cyclic load was set up and the performance of the track structure under the cyclic train load was studied. After every 10^6 loading cycles, the vertical static loading test and horizontal resistance test of the track structure were carried out to obtain the strain and displacement under different loading cycles. After 3×10^6 cycles of sine wave, a horizontal ultimate resistance test of the track structure was carried out to study its horizontal failure mode. In order to study the mechanical properties and long-term performance of the new type of sleeper slab track structure, this paper carried out a full-scale indoor modal loading test of the concrete sleeper slab track structure to provide a reference for the engineering application.

In the study proposed by Lee et al. [5], the lateral resistance requirements of a girder-sleeper fastener were investigated through a series of finite element (FE) analyses and parametric studies. The effects of peak lateral resistance of the fastener, curve radius, girder length, and lateral displacement of the girder were examined. From the analysis results, the girder-sleeper fastener's peak lateral resistance criterion was proposed to design a new fastener for continuous welded rail (CWR) tracks on an open-deck steel plate girder bridge.

In the study by Matsuoka et al. [6], the accuracy of measuring non-marker image displacement and the effect of illuminance were examined using a model bridge. In addition, field tests on investigated bridges, considering low-speed and high-speed railways, confirmed the accuracy and practical application of non-marker image measurement in a real environment.

Paudel et al. [7] examined the vibrational characteristics of the third rail of the Singapore Mass Rapid Transit system with damaged and missing structural components. A good agreement was observed between the analytical and numerical solutions. The study was further extended to study the sagging of the third rail due to structural failure and its impact on collector shoes. It was found that the structural defects could produce resonance modes below 5 Hz.

Another study related to the applicability of low-vibration track (LVT) in heavy-haul railways was introduced by Zeng et al. [8]. In this study, through a full-scale model test and finite element simulation, the static mechanical properties of Improved LVT (ILVT) and Traditional LVT (TLVT) were compared. The results showed that ILVT had smaller vertical displacement of the rail and the supporting block, and improved the driving safety of the LVT. At the same time, ILVT improved the anti-overturning ability of the rail, supported the block under lateral load, reduced the expansion of the gauge and the lateral spacing of the support block, and improved the stability of the track structure.

A Portuguese–Brazilian team [9] presented an efficient methodology for calibrating a numerical model of a freight train locomotive EURO 4000 with a Sgnss-type wagon based on experimental modal parameters, namely natural frequencies and mode shapes. Dynamic tests were performed for two distinct static-loading configurations, tare weight and current operational overload, under demanding test conditions, particularly during an unloading operation of the train and without disturbing its tight operational schedule. The results demonstrated that the primary suspensions presented an elastic/almost elastic behavior. A comparison of experimental and numerical responses before and after calibration revealed significant improvements in the numerical models and an excellent correlation between the experimental and numerical responses after calibration.

Zeng et al. [10] suggested a study regarding the applicability of LVT in heavy-haul railway tunnels. This paper carried out research on the dynamic effects of LVT heavy-haul railway wheels and rails and provided a technical reference for the structural design of heavy-haul railway track structures. Based on vehicle-track coupling dynamics, the stability of the upper heavy-haul train, the track deformation tendency, and the dynamic response sensitivity of the vehicle-track system were analyzed.

Avsievich et al. [11] proposed a new approach for railway path diagnostics on the basis of track line stress–strain analysis using the data provided by high-precision accelerometers. The research results were conducted at the testing ground of the Kuibyshev branch of Russian Railways, the Samara track. The proposed approach makes it possible to determine the load of the track, and knowing the movement of the rail, to calculate the structural stress in the elements of the railway track, to constantly monitor the parameters of the slope and rail subsidence.

Brighenti et al. [12] from the University of Trento (Italy) proposed an expeditious procedure to conservatively assess the load rating factor of masonry arch railway bridges based on a minimal set of information: the span, rise-to-span ratio, and design code. The results were reported in easy-to-use charts, and summarized in simple, practical rules, which can help railway operators to rank their bridges based on the capacity deficit.

Alternative railroad route variants using the optimization method of multi-criteria analysis were investigated by Vilke et al. [13]. A model was implemented with defined criteria and sub-criteria considering their weighting coefficients to achieve the research goal. To perform the analysis, the authors applied the defined model to evaluate and select the railway route between Rijeka and Zagreb using the PROMETHEE II method for the multi-criteria ranking of options and Visual PROMETHEE computer software. The value of the defined model was expressed by the proposed multi-criteria optimization method that was used in railway planning and design.

In the study of Auersch [14], from the Federal Institute of Material Research and Testing (Germany), besides geometric irregularities at the wheel–rail contact, other types of irregularities, such as stiffness irregularities, irregularities from different track positions, and irregularities in the wave propagation were analysed. The ground vibrations calculated from rail irregularities and corresponding dynamic loads, however, clearly underestimated the measured ground vibration amplitudes. Only the static load that was moving over a varying track supporting stiffness could produce the important mid-frequency ground vibration component by the scatter of axle pulses.

Finally, Hu and Chan [15] presented a review of overhead wiring structures in Australia. Their study provided insights into structural design, construction and the maintenance of similar structures in Australia and abroad.

4. Final Remarks

The guest editors for this Special Issue are pleased with the final result of the published papers, and hope that these scientific works can be useful to researchers, engineers, designers, and other colleagues involved in different thematic aspects of the advanced analytical and numerical simulation approaches applied to railway infrastructures.

Additionally, the guest editors are grateful for the contributions of all authors and reviewers, which are fundamental for the dissemination of scientific findings.

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