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Structural Behavior of a Ballasted Small Railway Track Under Static and Dynamic Loadings

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Abstract – *The aim of this work is to see the structural behavior of ballasted small rail track system under static moving and dynamic loads. The ballasted rail track system is firstly modeled by solid hexahedral and tetrahedral elements representing the rails, sleepers and the ballast. Three simulations are then conducted in LISA; moving static loading, modal vibration and dynamic loading. Four locations are selected to simulate the moving static loading. The longitudinal displacement of the rails and the ballast can be captured on these four locations. The simulation results show that the ballast displaces more at locations where the sleepers are attached. The fluctuations depend on the moving wheels. The first two vibration modes are the cross swaying of the rails followed by two vertical motions and the fifth mode is the longitudinal motion. The velocity and acceleration responses show similar pattern with that static displacement response. In future research, the results can be used for the optimization of the ballast foundation to improve the stability of the small rail.*

***Keywords**: Rail Track, Finite Element Analysis, Ballasted Rail Track*

I. Introduction

Railroad vehicle systems consist of a large number of bodies that include wheel sets, bogie frames, car bodies, suspension elements, and other components. These components are connected by force elements such as springs and dampers as well as joints that impose restrictions on the motion of the system [1].

Rails are defined as the longitudinal steel members that directly guide the train wheels evenly and continuously [2].

The rails serves as a beams to transfer the concentrated wheel load to the spaced sleepers support without excessive deflection between support, also as an electrical conductors for the signal circuit, and as the ground line for the electric locomotive circuit [3], [4].

The primary requirement of train transportation is to ensure safety, reliable, and punctual movement of passengers and goods to various destinations. Many example cases related to derailments are well documented and exposed to public for the improvement of safety awareness has been documented by [5]. Among the large number of derailments, many were caused by mechanical failures of either tracks or vehicles [6]. Some of these failures might be caused by poor designs and others were possibly the accumulative results of undesired performance or poor maintenance. The problems on railway track must be detected and maintenance should be making constantly.

Basically the track components can be divided into superstructure and substructure. The superstructure consists of the rails, fasteners and sleepers.

It is the foundation to support the substructure and reaches its optimum performance while substructure consists of ballast, sub ballast and sub grade [2]. An additional system in a ballasted rail track is the drainage system [1], [7], [8], [9].

The track structure is the most important part in the railway track system. It supports the rolling change of the train transmitted through the contact wheelrail [10]. The foundation of the track where the ties or sleepers of the continuum beam rails are put on to it consists of ballast, subballast and subgrade [11]. In recent publication [12] analyzed the rail vehicle axle on dynamics behaviors, and a modelling of Tunisian railways has also been published [13].

The longitudinal track force is usually due to acceleration and braking of trains and thermal expansion or contraction of the rails. The lateral track force usually comes from the lateral wheel force due to the friction between the rail and wheel. It also comes from the buckling reaction force of the rail which is usually caused by a high longitudinal force in the rail [14], [15].

The static component is the weight of the train while the dynamic component is a function of track conditions, train characteristics, operating conditions, train speed, and environmental conditions. The axle load of the locomotive is approximately 20 tones [16]. It is the dynamic component that usually causes an adverse effect to the track as it can be much larger than the static load [17], [18].

This present work provides a computational model and analysis of a typical small railway track found in Malaysia.

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