UNIVERSITI TEKNOLOGI MARA

EVALUATING THE NON-LINEAR STATIC AND DYNAMIC STIFFNESS OF RAIL PAD USING FINITE ELEMENT METHOD

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ABSTRACT

In the realm of railway infrastructure, the significance of rail pads cannot be overstated, particularly in their role in mitigating noise and vibration generated by trains. This study employs the finite element method (FEM) to conduct a thorough analysis of the nonlinear static and dynamic stiffness of rail pads, considering various loading conditions such as temperature, toe-load, and frequency. The investigation reveals a crucial dependency of dynamic stiffness on loading frequency, with higher frequencies resulting in a reduction of stiffness. The nonlinear static stiffness is significantly influenced by temperature and toe-load variations. These findings contribute valuable insights into the behaviour of rail pads under diverse conditions, offering a foundation for optimizing their design to enhance performance in railway applications. Addressing existing research gaps, this study sheds light on the limited exploration of temperature's impact on rail pads' static and dynamic behaviour, emphasizing aspects of deformation and stiffness. Furthermore, the investigation delves into the less-explored territory of varying toe loads, examining their effects on rail pads' static and dynamic responses, particularly in the context of wear and fatigue. Additionally, the influence of frequency on dynamic responses, particularly concerning train speeds and track irregularities, is a focus of this study. To achieve these objectives, a 3D FE model based on hyperelastic formulation for non-linear rail pad materials is developed. The research aims to estimate static and dynamic stiffness under diverse loading conditions and investigate the effects of parametric changes on rail pad stiffness. In conclusion, the findings of this study provide a comprehensive understanding of rail pad behaviour under different conditions, emphasizing the critical factors of temperature, toe load, and frequency. The outcomes contribute to informed decision-making in the design and maintenance of railway infrastructure, ultimately optimizing rail systems for enhanced performance and durability.

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CHAPTER ONE
INTRODUCTION

1.1. Background of the study

Railway transport networks in Malaysia have been growing over the centuries due to continuous increment of demand on transportation for residents and goods volumes. Thus, there has been an increased deployment of new railway projects across the country in recent years. The rail operator in Malaysia comprises heavy rail, including commuter rail, which links interstate controlled by Kereta Api Tanah Melayu Berhad (KTMB). While intercity train in Malaysia was owned by PRASARANA Malaysia Berhad, which covers light rapid transit (LRT), rapid mass transit (MRT), and monorail [1].

A growing number of train lines are being developed near heavily populated districts worldwide, resulting in significant noise and vibration concerns [2]. Railways are considered environmentally friendly, offering safe and effective mass transportation but inevitably generating vibration and noise pollution. The research findings indicate that the vibrations and noise generated by the operational train were assessed within a frequency range of approximately 20 to 250 Hertz (Hz) [3]. This condition may contribute to the rattling of walls, doors or furnishings. At a particular frequency of vibration, shaking can occur, which causes structural or aesthetic damage to structures [3]. It is reported that the vibration strengths induced by trains are much higher than pile driving, leading to minor cosmetic damage to buildings [3]. People can feel vibration at more significant vibration strengths, either with the whole body when standing, sitting or lying, or with their hands. When vibration is noticed, especially when the source is unknown, this may cause concern or anxiety to the human body.

The disturbances caused by railway transportation, such as noise and vibration, can be categorized as either airborne which refers to the transmission of noise and vibration through the air or ground-borne which refers through the ground or track structure. The vehicle suspension, wheel roughness and flat spots at the wheel train were the significant causes of noise and vibration [4]. Figure 1.1 shows the friction produced at the rail interface wheel. The steady axle loads and the dynamic forces caused by wheel/rail unevenness trigger the vibration of the track and the underlying soil as the rail wheel travels along the railway. This pulse propagates waves from the surface and