INVESTIGATION OF GROUND VIBRATIONS DUE TO MOVING TRAINS

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Degree of Master of Science

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Thesis submitted in partial fulfilment of the requirements for the degree Master of Science in Civil Engineering

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DECLARATION OF THE CANDIDATE & SUPERVISOR

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Signature of the supervisor: Date: 10/07/2023

Name of the supervisor: Prof. C. S. Lewangamage

Signature of the supervisor: Date: 10/07/2023

ABSTRACT

This research focuses on the assessment of train-induced ground vibrations through experimental analysis and the development of a Finite Element (FE) prediction model. The study aims to evaluate the intensity of vibrations caused by trains and understand their effects on different soil types and train speeds.

A vibration sensing device named "VIBSEN" was developed for the measurement of ground vibrations. Experimental data were collected at 3m intervals from the centreline of the railway track and processed using MATLAB software. The accuracy of the device was confirmed through gravity calibration and comparison with a vibrometer. Based on the experimental study conducted at a specific site, it was determined that the minimum safe distance from the centreline of the track is approximately 10m when two trains cross simultaneously and approximately 6m when considering the passage of a single train. It should be noted that these recommendations are specific to the soil profile at the experimental site and may vary depending on subgrade soil type and parameters.

The FE prediction model, developed using MIDAS GTS NX FE software, was validated using experimental results from the study and further compared with literature data. The model successfully predicted train-induced ground vibrations, demonstrating its applicability. Parametric analysis was conducted to investigate the effects of soil type and train speed on vibration intensity, including the identification of resonance frequencies and critical velocities. The findings of the study indicate that vibration intensity varies significantly depending on the soil type, with lower intensities observed for soils with higher elastic moduli. Additionally, the study highlighted that vibration intensity increases with train speed, and certain speed levels may lead to a sudden increase in intensity due to resonance effects. The resonance frequency was found to be influenced by the elastic modulus of the subgrade soil.

Overall, this study provides valuable insights into train-induced ground vibrations and offers recommendations for safe distances from the track centreline. The developed VIBSEN device and FE prediction model offers reliable tools for future investigations and allow for parametric studies considering different soil properties, train loads, and speeds. These findings contribute to mitigating risks, minimizing structural failures, and reducing hazards associated with prolonged exposure to vibrations.

Keywords: Train-induced ground vibration; VIBSEN device; Peak Particle Velocity (PPV); Finite Element (FE) prediction model.

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LIST OF ABBREVIATIONS

FE – Finite Element

FEM – Finite Element Model

SHM – Structural Health Monitoring

HST – High-speed train

LRT – Light rail transit

PPV – Peak Particle Velocity

TGV – Train à Grande Vitesse

LIST OF APPENDICES