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Measured Dynamic Loading of Railway Underground

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ABSTRACT: Some in-situ measurements related to dynamic stress, velocity and acceleration in the substructure and subsoil from railway traffic are reported. The dependency of these parameters on train speed and superstructure is revealed. The measured maximum dynamic stress increases linearly with train speed between 150 and 300 km/h. Based on these, a stress amplification factor k_{dyn} is introduced. In addition, a correlation of the measured maximum dynamic stress with vibrating acceleration is illustrated.

KEYWORDS: railway foundation, dynamic stress, vibrating velocity, vibrating acceleration

1 INTRODUCTION

Generally speaking, the dynamic loading of railway foundation is affected by many factors, such as wheel set loads, super- and substructure, train speed, depth and the type of subsoils. The dynamic loads can be calculated based on a theoretical analysis of stress wave propagation in soils. Such analyses have been made possible by using numerical methods, e.g. Hanazato et al (1991), and Müller & Huber (1991). These analytical models are based on elastic half-space theory. Some of them even consider different soil layers and can simulate the stress waves produced by a passing train. However, they have for the most part not been calibrated using in-situ measurements.

An altenative for determining the dynamic loading in subsoil is the direct measurement of dynamic stress, vibrating velocity, and other parameters induced by passing trains. This method is certainly very expensive, it may provide a more realistic picture of the dynamic loading in the substructure and subsoil. Furthermore, the measured results can be used to calibrate the existing analytical models.

In this paper, the data of seven measuring projects conducted in Germany related to the dynamic stress, vibrating velocity and acceleration are reported. The influence of different boundary conditions on the loading behaviour in the substructure and subsoil are revealed. The results can be used for the design of railway foundation.

2 DYNAMIC STRESS

In Table 1, a survey of seven measuring projects is given. The measurements were made under very different boundary conditions, such as different superstructures, different subsoils and different train speeds. This provides a broad spectrum for the analysis.

The measurements of dynamic stress in the substructure and subsoil on the Hannover-Würzburg/Germany railway line were carried out in 1987/1988, see Schwarz (1989). The superstructure was exclusively conventional ballasted track. The subsoil has different compositions and varies from gravelly sand, silty sand to clayey sand. The measurements were made with train speeds up to 400 km/h. To measure the dynamic stress induced by passing trains, numerous pressure gauges were installed at three different levels in the substructure and subsoil.

To illustrate some of the results, the measured dependency of the maximum dynamic vertical stress on train speed for the pressure gauges 102 and 202 (measuring cross section 1 and 2) is presented in Fig. 1. A clear increase of the resulting dynamic stress in the substructure and subsoil can be observed within the range of the train speed between 150 and 300 kph.

The measured distribution of the maximum dynamic vertical stresses with depth is illustrated in Fig. 2. They are given in the form of a band-width for all measurements with train speeds of 10 and 280 km/h, respectively.