

## Measurement of wheel-rail contact forces

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### 1 INTRODUCTION

Short wave rail defects, such as squats and welds, can result in large wheel-rail interaction forces. The vibrations resulting from these forces will cause both rolling stock and track to deteriorate at increased speed. To assess welds, and limit the force and vibration levels caused by welds, geometrical limit values have been developed by ProRail in corporation with TU Delft [1]. In order to validate these limit values, Lloyd's Register Rail was asked to provide a measuring system that is able to determine the wheel-rail interaction force caused by rail defects.

### 2 MEASURING SYSTEM

For the measurements a mobile version of an in-house developed measuring system will be used: Gotcha [2]. It's normal function is Weighing In Motion (WIM) and Wheel Defect Detection (WDD) and needs to be adapted for this specific application. The system consists of fibre optic sensors which are mounted to the rail foot (Figure 1). The sensors measure the strain of the rail foot when a wheel is passing the sensor (WIM) or when a wheel defect has an impact on the rail in the vicinity of the sensor (WDD). Based on the transfer  $H(x, \omega)$ , the force  $Q$  can be determined from the sensor output  $Y$  (Figure 2).



Figure 1: Gotcha sensor in operation

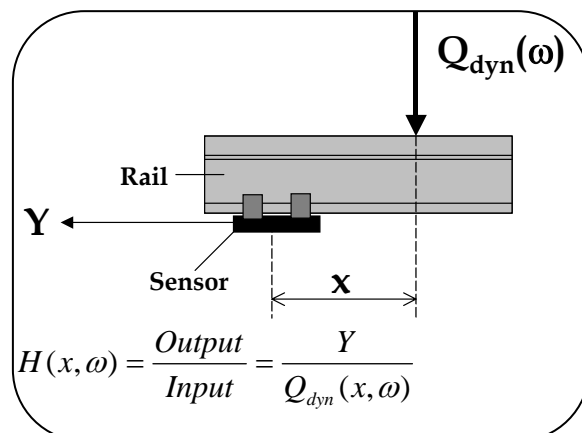


Figure 2: Transfer of measuring system

### 3 WORK DONE

Most of the work done in making the system suitable for measurements at welds is determining accurate transfer functions. These transfer functions are constructed by making use of an extensive set of experiments which were carried out specifically for this project. The experiments were designed to determine the transfer from sensor signal to force while taking into account the following parameters:

- Frequency content of the force  $Q$ ;
- Distance between the force  $Q$  and the centre of the sensor;
- Effect of unsprung mass of the wheelset on the measurements.

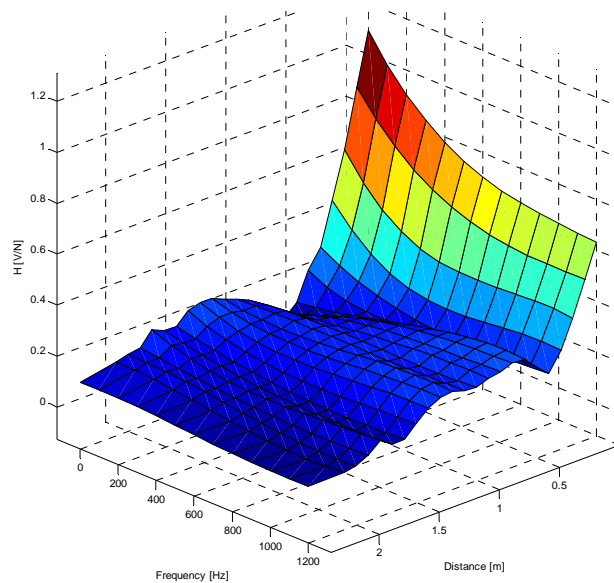
In the experiments, various forces with known amplitude, frequency and location were applied to a track that was fitted with the measuring system. Determining the transfer of one specific combination provides a single point in the frequency- and distance-dependant transfer. Experiments were carried out up to frequencies of 1000 Hz and 1.2 meter distance from the sensor.

### 4 RESULTS

The main result from the set of experiments are two dimensional transfers of the system. During the investigation of the experiments the following was observed.

- Response of the sensing system on an unloaded track shows significant non linear behaviour.
- The response of the sensor system on a loaded track shows a response that is linear in nature. This enables the construction of a reliable transfer function.
- The difference between loaded and unloaded track mainly determines the transfer in the low frequency range.

In the next and final stage of the project, the system transfer will be implemented in the software of the measuring system and measurements will be carried out in the field.



**Figure 3: Response surface of system transfer**

### 5 REFERENCES

- [1] M.J.M.M. Steenberg; *Wheel rail interaction at short wave regularities*. PhD Thesis, TU Delft, April 2008.
- [2] <http://www.gotchamonitoringsystems.com>