

Consideration of the elastic strain recovery rates of the formation layers of a railway track

BACKGROUND

Maintenance makes up a significant portion of the total life cycle costs of a railway track. The condition of the formation layers of a railway track dictates these maintenance costs to a large extent. The purpose of this study (a final-year BEng research project) was to aid the progression towards more cost-effective railway infrastructure by understanding the strain recovery process of the formation layers.

OBJECTIVE

It was surmised that the elastic strain recovery rate of the formation layers would change as ageing of the formation occurred in relation to cumulative loading over its lifetime. Thus, deformation data from different time periods had to be analysed to compare the formation recovery characteristics. For the purpose of this study, the strain recovery after the last wagon/locomotive had moved over the site was considered.

PROJECT DESCRIPTION

In order to analyse recovery of the formation, Multi-Depth Deflectometers (MDDs) were used. The MDDs were installed in 2004 by Transnet Freight Rail (TFR) at the Amandelbult test site near Northam in Limpopo Province. The test site is located at a Tubular Modular Track (TMT) section, as shown in Figure 1.

TFR conducted MDD tests at this site in 2004 after installation. In 2014 further tests were conducted as part of the study described here.

Rick Vandoorne
Postgraduate Student
University of Pretoria
Department of Civil Engineering
rick.vandoorne@up.ac.za



Prof Hannes Gräbe
Department of Civil Engineering
University of Pretoria
Transnet Freight Rail Chair in
Railway Engineering
hannes.grabe@up.ac.za



The railway line at the Amandelbult test site was built on a layer of black turf/clay. During the analysis of the elastic strain recovery this layer proved to be of particular interest, as it displayed the slowest recovery in both the 2004 and 2014 deformation measurements.

The layer works at the Amandelbult test site are shown in Figure 2 at each installation of MDDs. Stations 1, 2 and 3 are located on the TMT and are where the tests were conducted. Figure 3 shows the MDD connectors connected to the logging equipment on site.

PROBLEMS ENCOUNTERED

The biggest problem was the lack of continual data between 2004 and 2014. A trend could therefore not be established relating



Figure 1: The test site was located at a Tubular Modular Track section of the railway line at the Amandelbult test site near Northam in Limpopo



Figure 3: Multi-Depth Deflectometer connectors coupled to the logging equipment on site

The magnitude of the peak deformation for a respective formation layer was larger in 2004 than in 2014 for all the layers under consideration (crusher run, rockfill and clay), despite similar loading. This could be due to strain hardening of the formation. Furthermore, the percentage of elastic strain recovered after 18 seconds had on average reduced from 2004 to 2014 in the clay layer. This phenomenon could be ascribed to the change in elasticity of the clay, possibly due to fatigue and long-term changes in the stiffness and elasticity of the material.

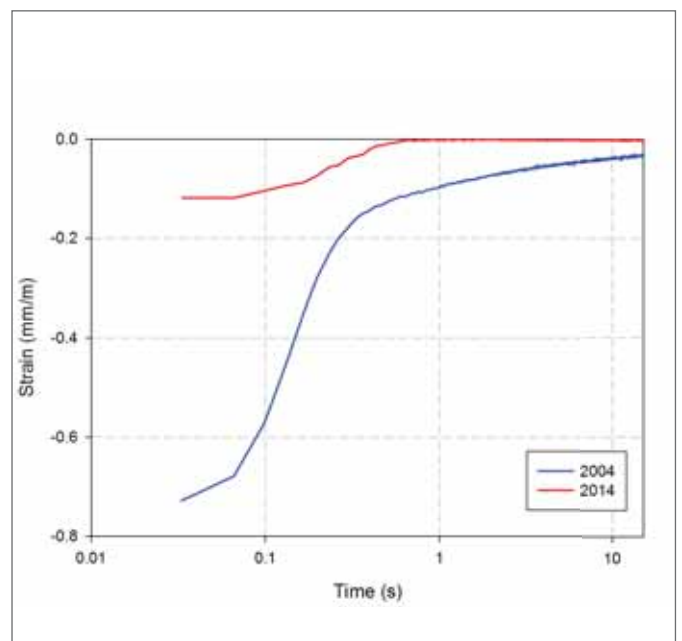


Figure 4: A typical strain recovery comparison graph

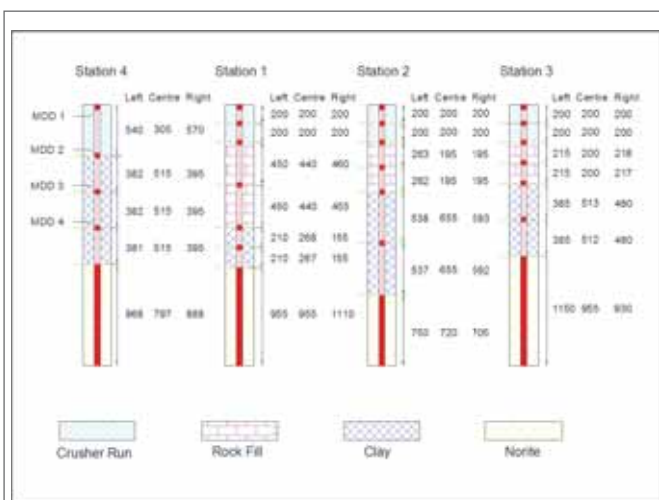


Figure 2: Layer works at the Amandelbult test site at each installation of Multi-Depth Deflectometers; Stations 1, 2 and 3 are located on the Tubular Modular Track and are where the tests were conducted

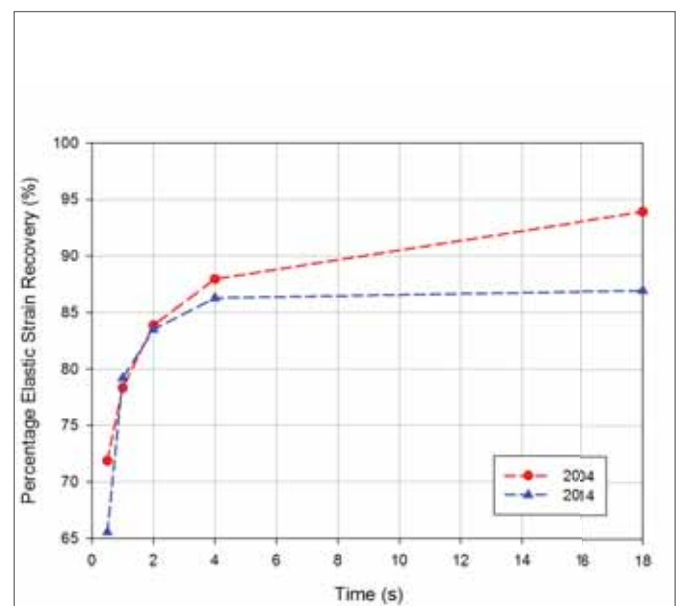


Figure 5: The percentage of elastic strain recovered after 18 seconds had on average reduced from 2004 to 2014 in the clay layer

to total cumulative loading and elastic strain recovery. With the data from only 2004 and 2014 available, the validity of the conclusions would have to be assessed by performing tests at other sites as well, or by establishing a long-term formation-deformation measurement project. Furthermore, in 2014 some of the MDDs were no longer working. Thus, certain layers at certain stations could not be analysed.

The TFR 2004 recorded data represented only the first 18 seconds after the last axle load had moved over the site. For realistic comparison, the 2014 analysis was therefore limited to data captured between $t = 0$ s and $t = 18$ s after the last axle load application.

CONCLUSIONS

The conclusions reached with regard to the elastic strain recovery of the formation are summarised as follows:

- The magnitude of the peak deformation for a respective formation layer was larger in 2004 than in 2014 for all the layers under consideration (crusher run, rockfill and clay), despite similar loading. This could be due to strain hardening of the formation. A typical strain recovery comparison graph is shown in Figure 4.
- The percentage of elastic strain recovered after 18 seconds had on average reduced from 2004 to 2014 in the clay layer (see Figure 5). This phenomenon could be ascribed to the change in elasticity of the clay, possibly due to fatigue and long-term changes in the stiffness and elasticity of the material.

RECOMMENDATIONS

Future research of a similar nature is encouraged. The following recommendations with regard to future research may prove beneficial:

- The formation layers at other railway test sites should be examined to determine if the trends displayed at the Amandelbult test site are displayed elsewhere, too.
- Data should be recorded on a regular basis at approximately 1–6 month intervals, such that a trend in the ageing of the formation layers may be identified.
- Data should be recorded for an extended period of time once the train has passed the test station in order to determine the elastic strain recovery characteristics for an extended period longer than 18 seconds. This data may serve to limit the time spacing between successive trains to allow proper recovery of the formation layers, such that the formation layers have a longer lifespan before maintenance is required.
- The differences between the elastic strain recovery rates of the formation layers of conventional track versus Tubular Modular Track may be investigated for the same formation design. This may provide a basis for selection criteria of one track system over another.
- The strain recovery rate may be analysed to determine if a relationship exists between the change in elastic strain recovery rate over time and the permanent deformation of the specific formation layer.

ACKNOWLEDGEMENT

Transnet Freight Rail (which kindly sponsors the Chair in Railway Engineering at the University of Pretoria) is gratefully acknowledged for giving access to the Amandelbult site, and for providing the necessary safety and security on site. ■