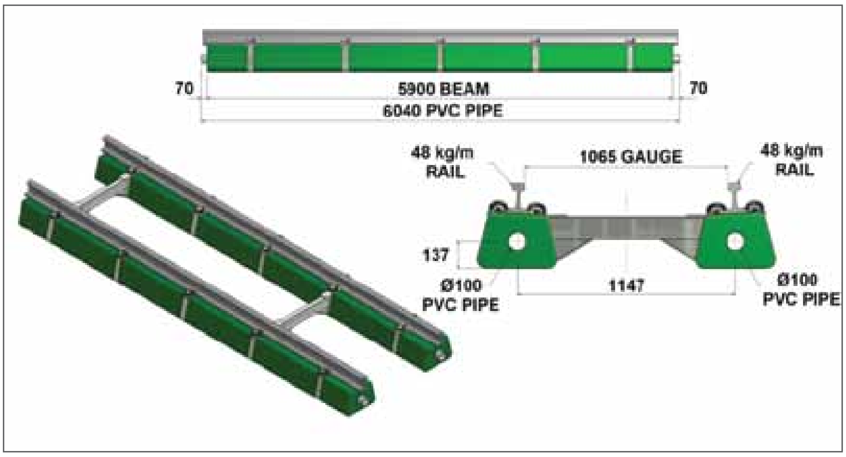
# An inside look at the stresses due to lateral forces in Tubular Modular Track

Brendan van Schoor and Prof Hannes Gräbe

**The Tubular Modular Track (TMT) system is a relatively new innovation in railway technology. It is a non-ballasted track structure that provides a more stable and reliable track system. It also requires less maintenance. Improvements in railway track structures in South Africa, such as the TMT system, will succeed in satisfying the need for higher capacity, and faster, safer and more economic public transport systems.**

The TMT system was developed in South Africa and has been implemented since 1989. It was originally used in the mining industry, but also has applications in the passenger and freight transport sectors, as it provides a stable and low-maintenance track. A TMT module is commonly 5.9 m in length and consists of two parallel steel rails held in place by Pandrol fastening clips on parallel, reinforced concrete beams. To maintain the gauge (the spacing between the rails), gauge bars connect the concrete beams at approximately every 3 m, depending on the specific application, axle load and whether it is on a curved or straight section of track.



→ *Figure 1: Tubular Modular Track module*

A research project implemented by the University of Pretoria focused on the strains and stresses experienced by the gauge bar in three different sections along the track structure: a transitional curve, a circular curve and a tangent section of track.

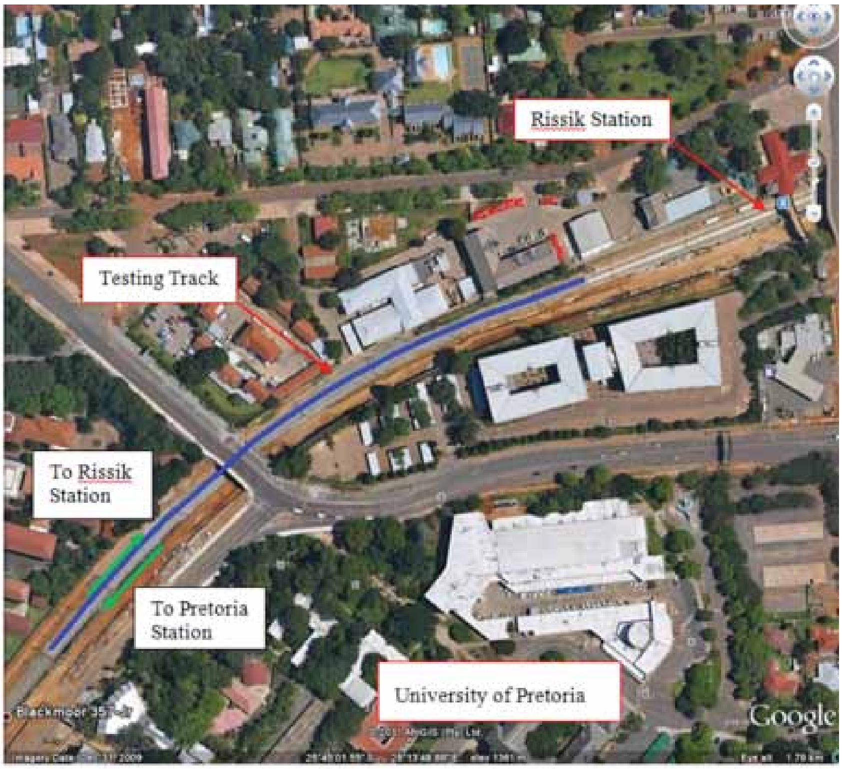
The testing was done by installing strain gauges at different positions on the gauge bars on an active line of the Passenger Rail Agency of South Africa (PRASA) in Hatfield, Pretoria, to the west of the Rissik Street station.

A moving train induces complex loading on a railway track. The resultant force can be divided into three separate components: a vertical, a longitudinal and a lateral force component (see Figure 2).

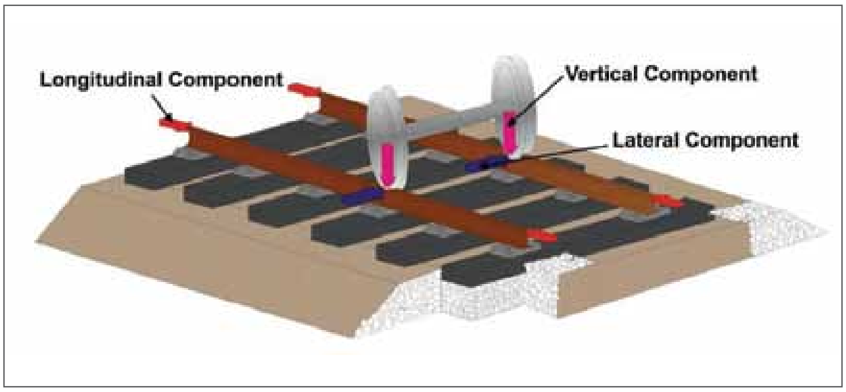
The focus of the study was on the lateral forces induced on the track and on the behaviour of the gauge bar, when subjected to train loading. Four factors contribute to the resulting lateral force on the track: the lateral force of the wheel flange pressing on the outer rail, the lateral force due to centrifugal force, a component for crosswind, and dynamic lateral forces.

By determining the strains and stresses induced by lateral forces in the gauge bar at different sections of the TMT test section, and investigating the strains and stresses throughout the top of the gauge bar of a TMT system, the researchers were able to confirm how the results can be optimised to enhance the performance of the TMT system with regard to the gauge bar.

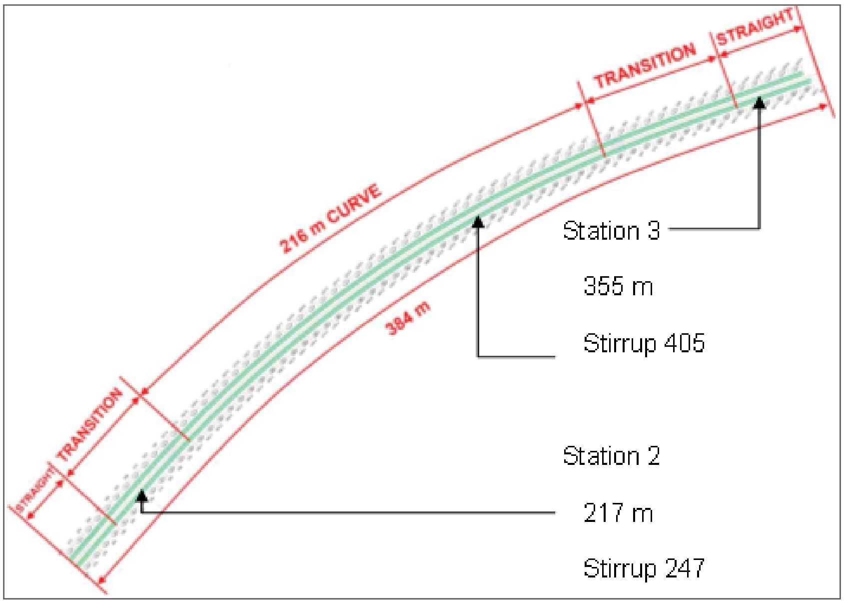
Three gauge bars were used for the testing: one on the tangent portion of the track, one in the transitional curve and one in the circular curve (see Figure 3). Installing them at different



→ *Aerial photograph of the testing site.*



→ *Figure 2: Schematic illustration of forces acting on track structures*



→ *Figure 3: Track layout showing the testing stations*

sections enabled the researchers to identify the portion of the track in which the highest lateral forces were generated.

Strain gauges were installed at different positions along a gauge bar in each of the abovementioned sections of the track (see Figure 4). As the trains passed the test section, the strains could be measured and recorded.

Typical results obtained from the strain gauge readings are illustrated in Figure 5, which shows the strains of all seven strain gauges of one gauge bar as a single train passes. Positive values indicate compression and negative values indicate tension. The highest peak values coincide with the wheels of the motorised coaches (weighing 60 metric tons) and the lower peaks represent the carriages (weighing 30 metric tons).

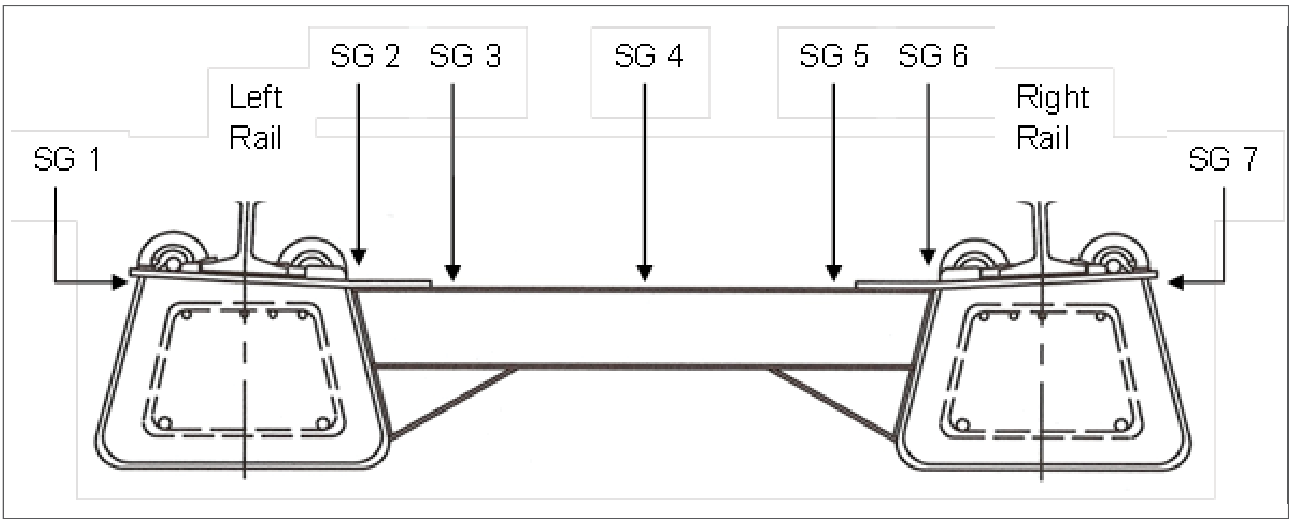
The strains measured were used to calculate the stresses throughout the top of the gauge bar and are indicated as maximum calculated stresses in Figure 6.

## Research findings

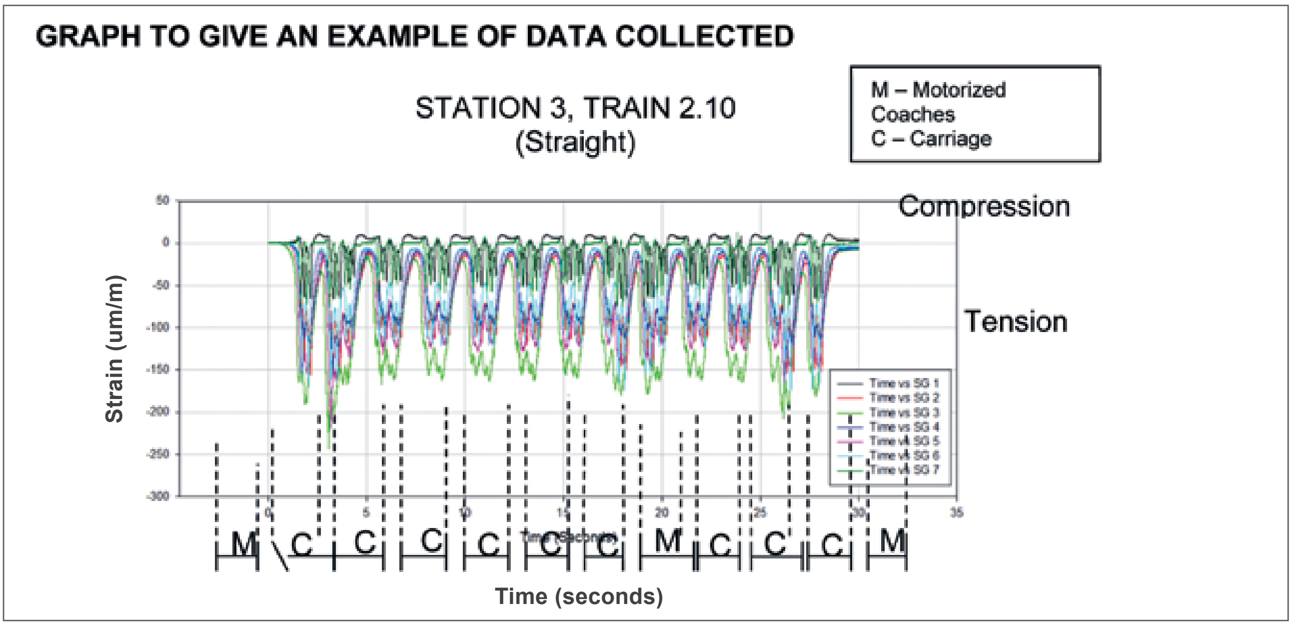
The largest stresses were found to be generated in the transitional curve, but some exceptions were measured where the maximum was located in the circular curve as a result of the relative lateral movement of the train as it travelled through the curve.

Different strain measurements were obtained along the top of the gauge bar, but the highest stresses were measured next to the weld that connected the gauge beam and the shoulder plate. The high peak stresses were believed to be a result of the welding, as well as the change in stiffness between the combined action of the gauge beam and the shoulder plate in comparison with the gauge beam only.

As illustrated, gauge bars can be subjected to tension, as well as compression forces. The top of the gauge bar, between the two rails, experienced tension, regardless of its position on the track. In the transition



→ *Figure 4: Placement of the strain gauges on the gauge bar*



→ *Figure 5: An example of the data collected*

zone, the outside of the gauge bar was in pure tension and in the circular curve in pure compression. However, on the straight portion of the track, the outside of the gauge bar experienced compression first as the train wheel neared the gauge bar, then tension as the wheel reached the gauge bar, and finally compression as the wheel of the train moved away.

The two main factors to influence the stresses in the gauge bar were identified as the weight and the speed of the train. As the researchers expected, the heavier the train, the higher the stresses that were measured. On the other hand, it was observed that higher speeds resulted in lower gauge bar stresses. This can be explained in terms of the balancing speed of this specific curve. Due to the close proximity of the site to the station, most trains travelled at lower speeds than that for which the curve was designed. This excess in superelevation at low speed is responsible for the unbalance in lateral forces and the resultant higher gauge bar stresses.

The researchers concluded that when designing gauge bars for Tubular Modular Track, designers should consider that the gauge bar can experience tension and compression forces, as well as compression stresses, depending on the position of the gauge bar on the track section.

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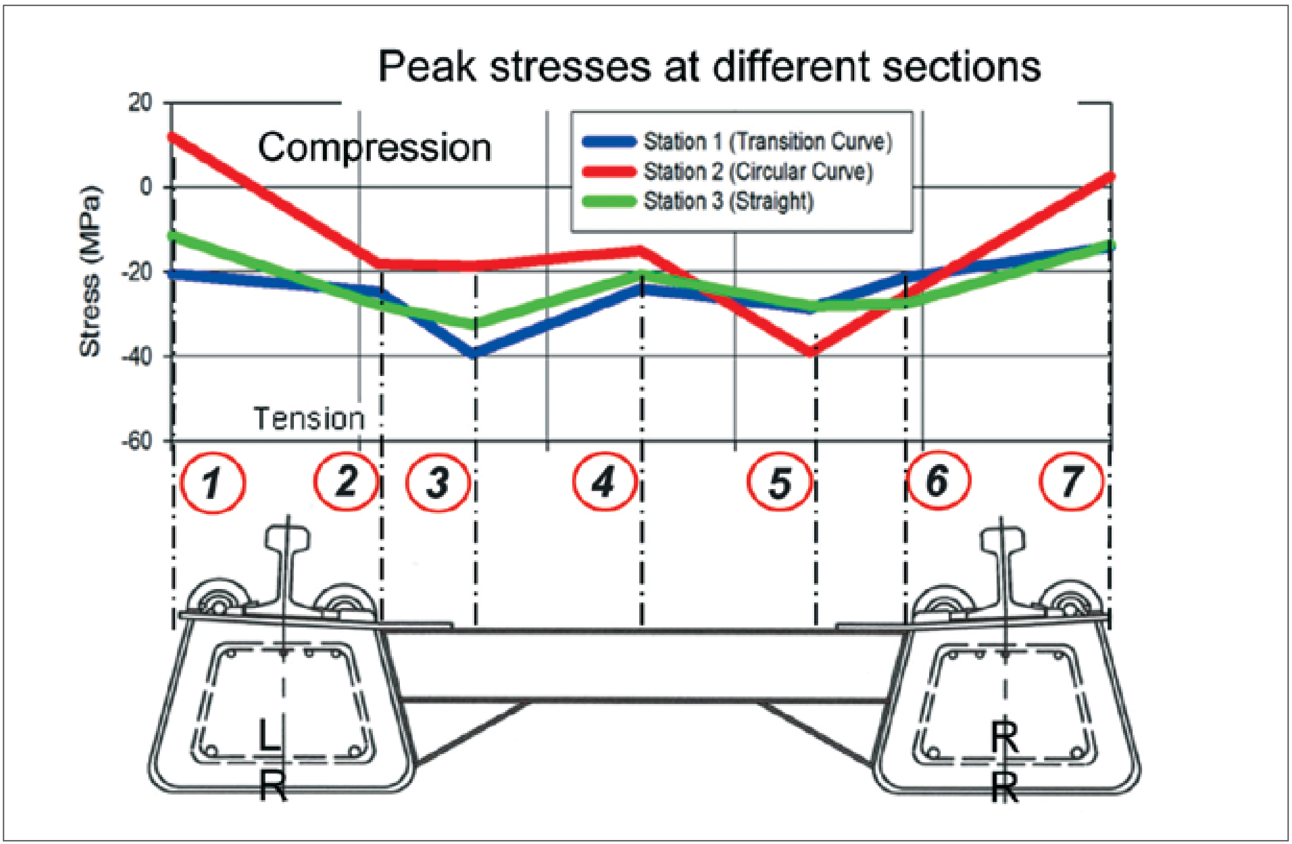

→ *Figure 6: Stresses along the top of the gauge bar*

## About the authors

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## The Chair in Railway Engineering at the University of Pretoria

The Chair in Railway Engineering in the Department of Civil Engineering at the University of Pretoria was established in 1992 when Spoornet (now Transnet Freight Rail) initiated a partnership between industry and the University. This partnership revolves around three major aspects: graduate training, continuing education courses for industry, and railway research. The chairholder is Prof Hannes Gräbe, a civil engineer with 16 years' experience in track technology, track geotechnology, advanced laboratory testing, field investigations, maintenance models and numerical analysis of track structures. He lectures undergraduate and postgraduate courses in railway engineering, and is responsible for railway research, as well as continued professional education in the form of short courses presented to industry.

After completing his undergraduate studies at the University of Pretoria in 1994, Prof Gräbe joined Transnet Freight Rail's Track Technology Centre, Johannesburg. He studied abroad from 1999 to 2002 and obtained a PhD in Geotechnical Engineering from the University of Southampton (UK). This research was focused on the design life prediction of railway foundations under heavy axle loading.

He is a registered professional engineer, Fellow of the South African Institution of Civil Engineering (SAICE) and chairperson of the SAICE Railway and Harbour Division.