Performance of resilient rail pads used in Tubular Modular Track under South African service conditions

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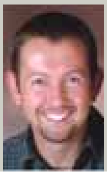

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BACKGROUND

Of the many requirements modern railways must meet, those of safety, speed, efficiency and cost-effectiveness are paramount. These requirements have been the driving force for railway engineers to develop new and innovative track structures. Conventional track structures consisting of a superstructure resting on a ballast bed have over time given way to ballastless track structures. These innovative structures, though often costly to construct, remain feasible due to the decreased maintenance requirements. Lower maintenance requirements lead to fewer interruptions to traffic, and considerable cost savings over the design life of the structure.

Ballastless track structures, however, lack the resiliency provided by the ballast bed in conventional track structures. Resiliency requirements in ballastless track are met by incorporating resilient elements such as rail pads, placed discreetly or continuously between the rail and the supporting structure, into the design. Resilient rail pads play an important role in ballastless track structures. One such role is the damping of dynamic forces caused by the movement of rolling stock. Without this damping, the resulting vibrations could cause accelerated deterioration of structural components, rolling stock and unwanted ground-borne vibrations which could negatively impact the environment adjacent to the structure.

Rail pads are manufactured from a variety of materials, selected on the basis of properties which will impact the performance of the final product. A desirable property is that of durability. A durable pad will perform well under service conditions without the need for regular replacement. Railway engineers must therefore select rail pads carefully, as a pad whose properties are suited to the conditions to which it will be subjected will most likely meet performance requirements.

AIMS AND OBJECTIVES

The objective of the study was the comparison of four different rail pads on the basis of performance. Performance data obtained was used to recommend a suitable rail pad for use on Tubular Modular Track which could result in a durable and cost-effective system for application in the South African rail transport network. Rail pads were assessed on the basis of in-service deflection and vibration attenuation.

PROJECT DESCRIPTION

Experimental work for the study was carried out on a section of Tubular Modular Track (TMT) which forms part of the Pretoria Metrorail system. TMT is a ballastless track structure developed in South Africa. The track structure consists of longitudinal reinforced concrete beams which are supported on an engineered foundation and held in position by galvanised steel gauge bars. Fastening systems that are fixed to steel gussets and stirrups which encircle the concrete beam hold the rail in place. The track modules are precast off site in lengths of 5.9 m and then assembled on site. Figure 1 shows the TMT structure at the test site. The test section was a 384 m long curve. The location of the test sites along the curve are indicated in Figure 2.

Three of the four rail pads assessed in the study were an Amorium rubber-bonded cork pad which will be referred to as the Portuguese pad, a Tiflex FC 55 rubber-bonded cork pad and a studded

Figure 1: Typical Tubular Modular Track structure

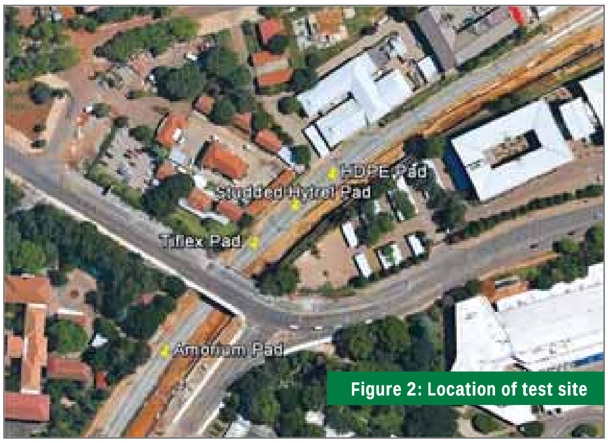

Figure 2: Location of test site

Hytrel pad supplied by Pandrol. The fourth pad tested was an HDPE pad. Results obtained for the HDPE pad served as a basis of comparison for the other pads assessed. Rail pads were supplied and installed in continuous lengths of 6 m. Figure 3 shows a length of studded Hytrel pad.

Deflection measurements were taken using a technique relatively new in the field of in-service railway deflection monitoring. The technique is known as Remote Video Monitoring (RVM). The RVM technique is based on that of Particle Image Velocimetry (PIV). PIV is an optical deflection measurement device which can be applied in both field and laboratory investigations of track deflection. The RVM system makes use of a high-definition video camera which captures images of the movement of a target applied to the track component under study. The video is then analysed using software which calculates the vertical and horizontal displacement of the target. RVM measurements are sensitive to sudden changes in lighting, such as shadows caused by the passing of trains. To ensure the quality of data collected using the RVM technique, a shading technique was developed at the University of Pretoria. The technique took the form of a simple PVC cover as shown in Figure 4.

A further performance aspect which was assessed as part of the study was the vibration attenuation of the rail pads. The attenuation was determined by placing accelerometers on the concrete beam of the TMT module and on the rail, as can be seen in Figure 5. The difference in the acceleration of the concrete beam and that of the rail is the vibration attenuation capability of the rail pad. Figure 6 shows the complete instrumentation setup on site.

RESULTS

Rail pad deflection was determined by subtracting the relative deflection of the concrete module from that of the rail. Figure 7 shows a plot of deflection (mm) against time (s) for the TMT rail and beam, while Figure 8 shows the deflection of the Portuguese pad. Similarly, acceleration data was used to determine the vibration attenuation capabilities of each pad. Figure 9 shows a plot of acceleration data obtained from testing. Results for each of the pads tested are summarised in Table 1 (see page 22).

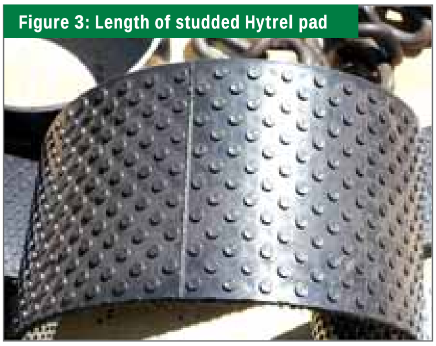
Figure 3: Length of studded Hytrel pad

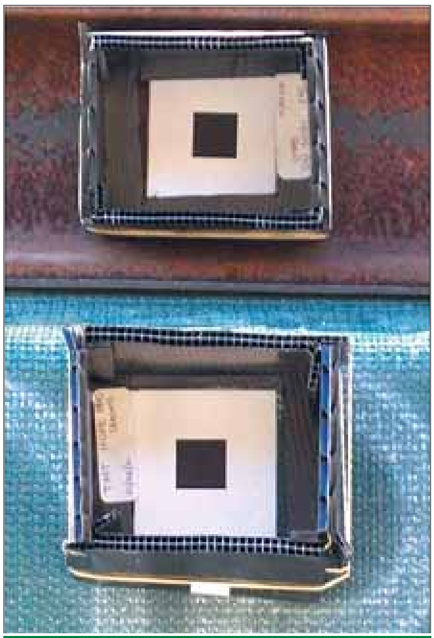
Figure 4: Shading technique for RVM targets


Figure 5: Accelerometers mounted on TMT structure

Figure 6: Instrumentation setup on site

CONCLUSIONS

From the assessment of the data collected during the field experimentation, the following conclusions were drawn:

- Of the pads investigated, the Portuguese pad and the Tiflex pad had similar vibration attenuation and deflection characteristics. The mean deflection of these two pads falls between that of HDPE and the studded Hytrel pad. When compared to HDPE, these results could be expected, as the Portuguese and Tiflex pads are less stiff than the HDPE pad.
- The increased deflection value of the studded Hytrel pad, in comparison to the rubber-bonded cork pads, could be contributed to the surface profile of the pad. The studded profile is such that a stud on one side of the pad does not line

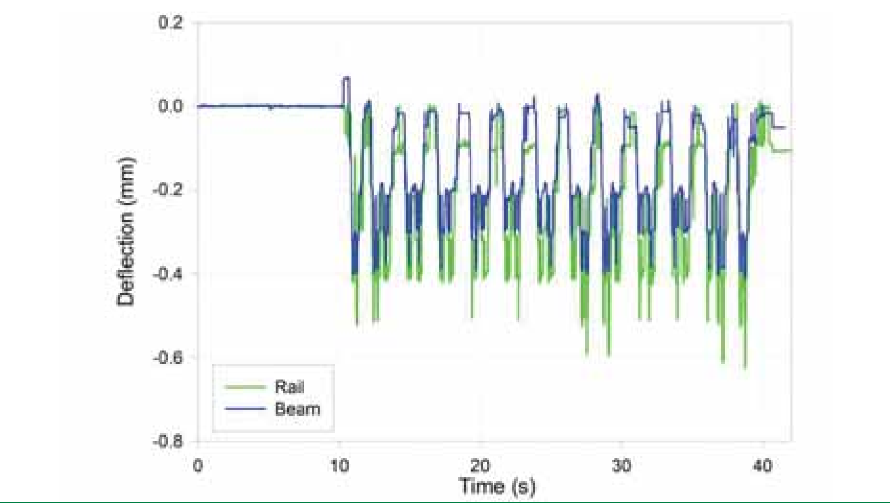

Figure 7: TMT rail and beam deflection

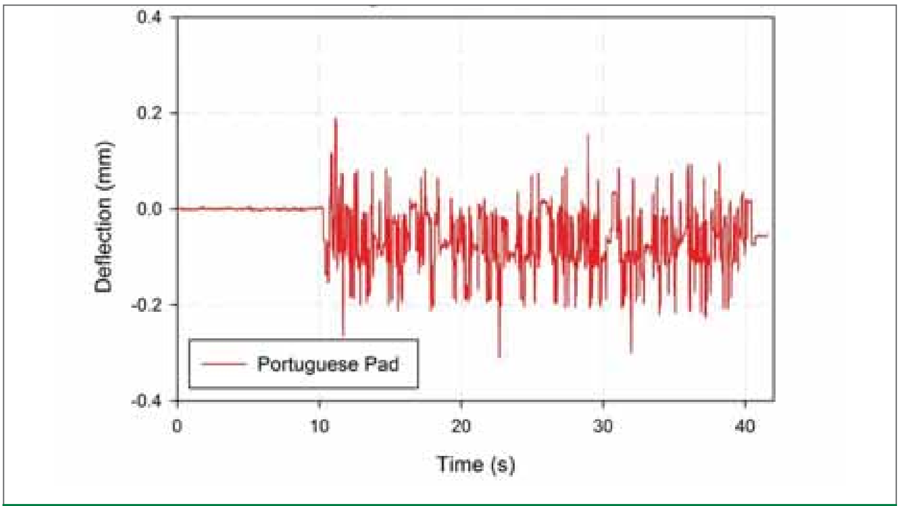

Figure 8: Portuguese pad deflection

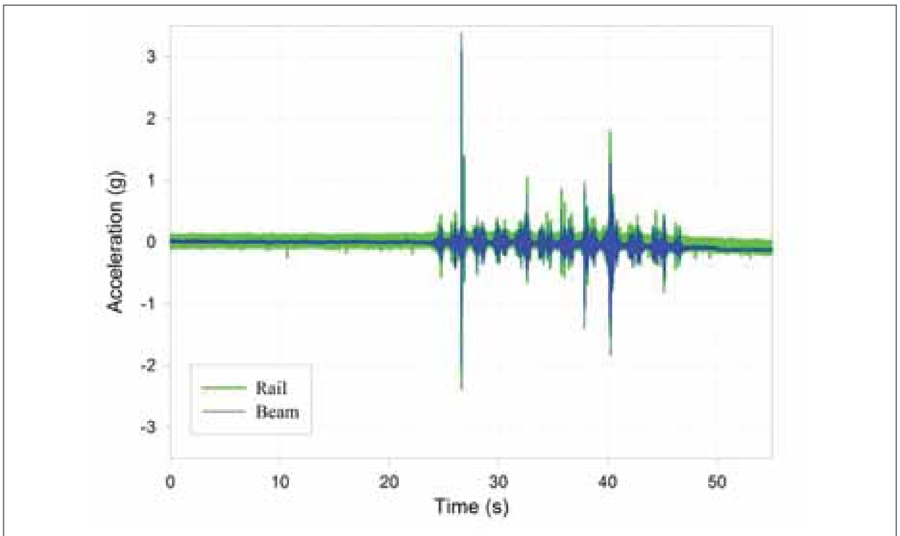

Figure 9: TMT rail and beam vibration

up with a stud on the opposite side of the pad, allowing for increased deflection.

- Vibration attenuation capabilities of the Hytrel pad are the highest of all the pads tested.
- The improved performance of the Hytrel pad is partly due to its surface profile, but also to the inherent stiffness and damping properties of the Hytrel material.

RECOMMENDATIONS

Recommendations from the study are as follows:

- Whilst both the Tiflex and Portuguese pads provided relatively low vibration attenuation, their continued use needs to be investigated to determine their effect on track deterioration. Their continued use on Tubular Modular Track cannot be endorsed or discouraged.
- The studded Hytrel pad appears to give improved performance when compared to the other pads tested and its use in Tubular Modular Track is recommended.
- Further research into the durability of all the pads investigated is recommended. The most cost-effective pad can only be selected when deterioration rates of the pads are known. Continuous replacement of a more cost-effective pad cannot be justified when an increased investment can result in a pad that not only has improved performance, but also extended service life. A detailed cost analysis is recommended.

ACKNOWLEDGEMENTS

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- Jaco Vorster (UP) for the instrumentation and field work. ☐

Table 1 Summary of experimental results

Pad	Average deflection (mm)			Average vibration (g)		Vibration attenuation (%)
	Rail	Beam	Pad	Rail	Beam	
Portuguese pad	0.506	0.391	0.114	0.392	0.287	26.8
Tiflex pad	0.733	0.625	0.108	0.860	0.617	28.4
Hytrel pad	0.641	0.476	0.165	0.524	0.296	43.5
HDPE pad	0.567	0.657	0.090	0.411	0.383	6.8

Source:
http://www.saice.org.za/downloads/monthly_publications/2012/2012-Civil-Engineering-May/#/0