CHAPTER 8

PREDICTION OF TRACK DETERIORATION

In this chapter two applications of the Dynamic Track Deterioration Prediction Model and the Static Track Deterioration Prediction Model are given. The first application is the prediction of void forming and the second one is the prediction of tamping cycles. Before doing these analysis, the track design and maintenance criteria as used by Spoornet are defined. The criteria are given to illustrate the value of predicting the dynamic loading and differential settlement of the track.

8.1 EVALUATION CRITERIA

In this section a list of track design and maintenance criteria as presently used by Spoornet is given. The limits as used by Spoornet are largely based on a dynamic wheel load as proposed by Eisenmann (1972) and are described in more detail in a paper by Lombard (1978).

- *Track roughness:* Track roughness is a direct indication of track quality and can be described in terms of the standard deviation as well as the Power Spectral Density (PSD) of the vertical track profile. Both criteria have not yet been finalized within Spoornet, but research work done up to now gives a good indication of possible limits. The track roughness, which is the standard deviation of the vertical track profile over 200m, is presently limited to 1.6mm on the coal export line. As can be seen from Figure B39 in Appendix B, the measured track roughness after 2.84 MGT is still well below the proposed limit. With respect to PSD value limits, an international envelop of PSD values as a function of track geometry wave lengths is recommended (Fröhling, 1995). The advantage of PSD values is that they can be used to analyse the dynamic behaviour of the rail vehicle in the frequency domain.

- *Track geometry standards:* Track geometry standards are clearly defined in the Permanent Way Instructions (1984) of Spoornet. These standards are used to ensure that the track is maintained above a certain specified serviceability level and that the dynamic loading of the track due to passing traffic does not cause track design stresses in excess to those assumed in the design of the track. Predicted track settlement values can directly be related to these standards.
- *Stresses in rails:* The permissible stress in rails with an ultimate tensile strength of 700 to 800 MPa is given as 235 MPa. This allows sufficient reserve for the influence of temperature. Indications are that a 17% increase in the permissible stress (235 MPa to 275 Mpa) could reduce rail life by a factor of ten.
- *Wheel/Rail contact stresses:* The maximum contact stress between a wheel and a rail is proportional to the dynamic wheel load. The exact relationship depends on whether conical or profiled wheel profiles are used. A qualitative indication of the performance which could be expected from the rail is given in terms of the ratio of the dynamic contact stress to the yield strength. In general satisfactory performance can be expected with a ratio less than 2.8.
- *Rail seat load and sleeper bending strength:* Limits of the rail seat load are set at 153 kN or 172 kN depending on the type of track structure. Spoornet requires that the tensile stress in prestressed concrete sleepers is kept below 2.75 MPa.
- *Stresses below the sleeper:* The stresses in the ballast and the formation of the track are not evaluated in terms of limiting values but rather in terms of an expected change in track quality relative to a known condition. This approach makes the absolute stress values of secondary importance.

8.2 VOID FORMING

The influence of spatial track stiffness variations on differential track settlement is now investigated in terms of void forming. Using both the dynamic as well as the static prediction models, void forming is simulated. Only one set of vehicle parameters, as close as possible to the test vehicle, is used to place the focus on track stiffness variations. To be able to determine and analyse the properties of the ballast and sub-ballast, a trench was excavated 2.84MGT after tamping. After taking the required samples the ballast was replaced without any form of tamping, thus creating a low track stiffness at Sleeper 77. Measurements of the vertical space curve and the spatial variation of the track stiffness were taken at this stage and used as input to the Track Deterioration Prediction Model to simulate void forming. For this analysis it is assumed that the void was created at the same time when the track was tamped. The analysis is thus done as if 13 MGT has passed over the entire test section. Simulated and measured results are shown in Figure 8.1 and Figure 8.2.

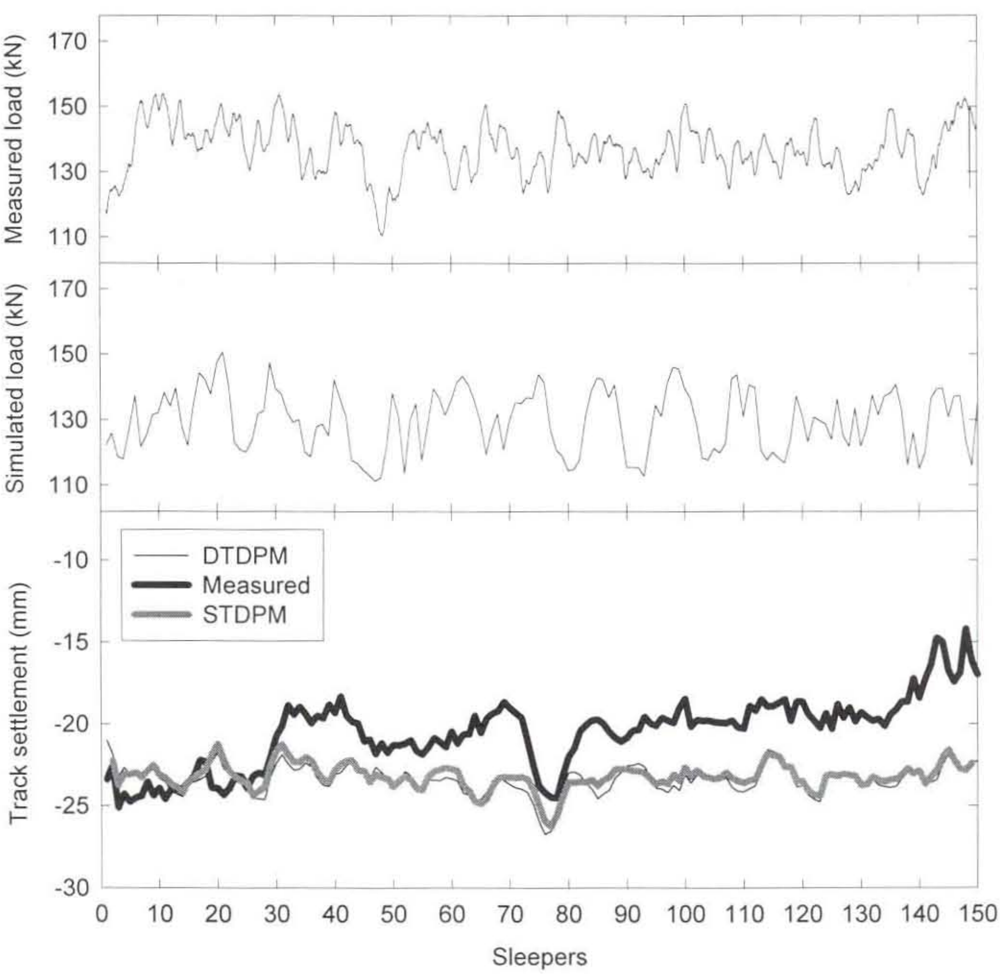

Figure 8.1: Simulated and measured void forming on the left side of the track.

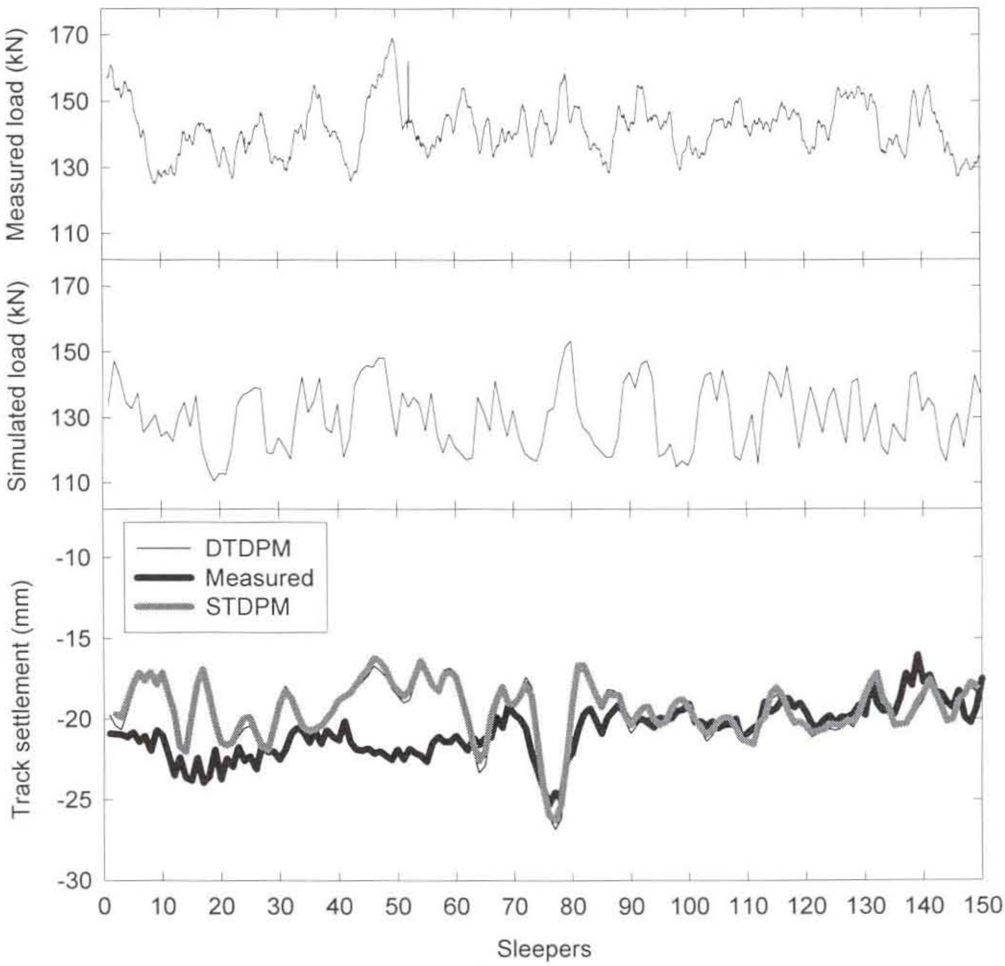

Figure 8.2: Simulated and measured void forming on the right side of the track.

As can be seen from Figure 8.1 and Figure 8.2, the increased settlement in the area around Sleeper 77 where the track was disturbed is predicted successfully. From the traces of both the measured and the simulated dynamic wheel loads it can be noted that the track had not yet deteriorated to such an extend as to significantly influence the dynamic wheel load even after 13 MGT of traffic.

8.3 TAMPING CYCLE

Another item of interest is that of predicted versus actual maintenance cycles. Maintenance history of the test site is given in Table 8.1. At present a standard deviation of the vertical space curve of 1.6 mm over 200 m is used as the track roughness limit on this particular line. To predict the track roughness nine months after tamping (January to October 1996), 60 MGT of 26 ton axle load traffic was assumed. Using the Static Track Deterioration Prediction Model, the differential track settlement after the nine month period was calculated and converted into a roughness value over the length of the test site. The result was a track roughness of 1.57mm which agrees very well with the track roughness limit.

Table 8.1: Maintenance history at Km 7.

Tamping date	**Condition measurement date**	**Standard deviation of top profile**
January 1996		
	June 1996	1.0 mm
	August 1996	1.2 mm
	September 1996	1.4 mm
October 1996		