CHAPTER 1

INTRODUCTION

In the quest to survive in a competitive transport market railway organisations have to, amongst others, minimise maintenance expenditure while still maintaining the track and the vehicle in a functionally acceptable condition. To become more efficient in maintaining track, the maintenance approach has changed with time. Initially subjective track inspections were used to assess the condition of the track. This approach was replaced by more objective measurements, evolving into the philosophy of "what gets measured gets managed". By correlating the deterioration of track geometry with accumulating traffic, researchers have produced empirical models for predicting the need for track maintenance so that planning can be done well in advance. But to support these empirical models, further insights are required into the physical processes by which vehicle/track interaction can cause track geometry to deteriorate. For this reason a lot of research is presently being conducted to develop experimentally verified mathematical models that can predict track deterioration under changing circumstances such as axle load, vehicle speed and track structure variations and degradation.

Although there was an early interest to model the dynamic loading and the subsequent deterioration of the track in order to solve practical problems, only a few papers in this respect were published before 1980. Since then the situation has changed largely due to the availability of modern computers. Some of the relevant research on problems due to vehicle/track interaction, modelling of the vehicle/track system, and track settlement in general is given in Appendix A.

Following recent research (Ebersöhn and Selig, 1994), indications are that track maintenance is amongst others a function of the track support characteristics. It was found that due to the varying condition of the track support, track settlement is not uniform and the resultant differential settlement causes a loss of track geometry requiring costly regular maintenance to return the track to the required smoothness. Hence certain maintenance operations are required to minimise or at least contain induced dynamic load variations on the track. These findings have raised the question as to what is the influence of the nonlinear and spatially varying track stiffness on the dynamic loading between the wheel and the track and the subsequent differential track settlement.

1.1 OBJECTIVE

The objective of this thesis is to develop a validated mathematical model to predict track deterioration due to dynamic vehicle loading and nonlinear spatially varying track stiffness, and to contribute to a better understanding of the relationship between spatially varying track stiffness and track deterioration.

In this thesis the influence of the vertical surface profile of the track, the nonlinear and spatially varying vertical track stiffness, vehicle speed and axle load on the vertical dynamic response of the vehicle/track system and subsequent deterioration of the vertical space curve of the track due to differential track settlement, is investigated. Both on-track measurements and mathematical simulations are used to analyse the current and to predict the future performance of the vehicle/track system.

1.2 SCOPE

The scope of this thesis is given in the following brief outline of the contents of the remaining chapters. The main part of the document describes the development, validation and application of the Track Deterioration Prediction Model (TDPM),

while a number of appendixes give additional information relevant to the research that was conducted.

In Chapter 2, a review is given with respect to literature closely related to the present work. The literature review thus deals with the topic of modelling the influence of spatial track stiffness variations on track deterioration. A further literature review covering problems related to vehicle/track interaction, vehicle/track interaction models, and research with respect to track settlement is given in Appendix A.

The experimental work that was done to support the development of the validated Track Deterioration Prediction Model is summarised in Chapter 3. A comprehensive description of the rolling stock used, the infrastructure at the test site, the instrumentation, and a representative part of the results is, given in Appendix B. Attention is also given to the measured influence of axle load, vehicle speed, and accumulating traffic on the performance of the vehicle/track system.

Chapters 4, 5 and 6 deal with the development of the Dynamic and the Static Track Deterioration Prediction Model. In Chapter 4, the basic methodology of predicting track settlement and the development of a modified track settlement equation is described. Chapter 5 presents the development of the mathematical model of the vehicle/track system. In this chapter a chronological overview of the development of the model is given together with a discussion of relevant assumptions. In Chapter 6 the Dynamic Track Deterioration Prediction Model (DTDPM) and the Static Track Deterioration Prediction Model (STDPM) are presented. The Dynamic Track Deterioration Prediction Model makes use of the vertical space curve of the track, the spatial variation of the track stiffness, and engineering parameters of the rail vehicle to be used. The Static Track Deterioration Prediction Model on the other hand only requires information about the spatial variation of the track stiffness and the nominal wheel load.

In Chapter 7, the developed models are verified against experimental results and a discussion about the assumptions and simplifications that were made in the development of the models is given. Chapter 8 deals with the prediction and evaluation of track deterioration. After listing track evaluation criteria as used by Spoornet, two applications of the developed models are given. In the first application void forming is simulated and in the second application a tamping cycle is predicted. Finally a conclusion, together with references to further recommended research and development work, is given in Chapter 9.