3. STUDY APPROACH

3.1 Introduction

The components of vehicle-pavement interaction were investigated in Chapter 2, with the focus on five themes, to establish current practice and knowledge. In terms of the problem statement, study objectives and scope of this thesis, further development work is performed for two of these themes (vehicle-pavement interaction framework and pavement response). In this chapter the study approach followed for the necessary development and improvements identified is presented.

3.2 Problem Statement and Study Objectives

The problem statement for this thesis states that current pavement design and analysis methods are based on simplifying assumptions regarding traffic loading and material characteristics. Implicit analysis errors that affect the reliability of the pavement analysis, and subsequently affect the cost of a pavement, are caused by these assumptions. These implicit errors must be accommodated for in the final product.

The two primary objectives of this thesis are to develop a practical systems framework to evaluate the various components in vehicle-pavement interaction and to develop and verify a practical approach for the analysis of the transient response of pavement structures to dynamic input loads where appropriate.

A schematic indication of the components of this thesis is shown in Figure 3.1. This figure is used in the remainder of this chapter to indicate the various processes planned and relationships between processes.

3.3 Vehicle-Pavement Interaction Framework

3.3.1 Overview

A thorough framework or system is needed for any problem to understand its holistic nature. In such a framework all the relevant components and factors, and the logical procedure for solving the stated problem should be identified. Once this framework is developed, the components that need focus and attention can be identified.

The main features and limitations of three viewpoints toward vehicle-pavement interaction systems were identified in Section 2.2. It was indicated that a simple unbiased framework for evaluation of vehicle-pavement interaction does not exist in the pavement analysis field. This leads to the main objective of Chapter 4, which is to develop a practical systems framework to evaluate the various components in vehicle-pavement interaction with.

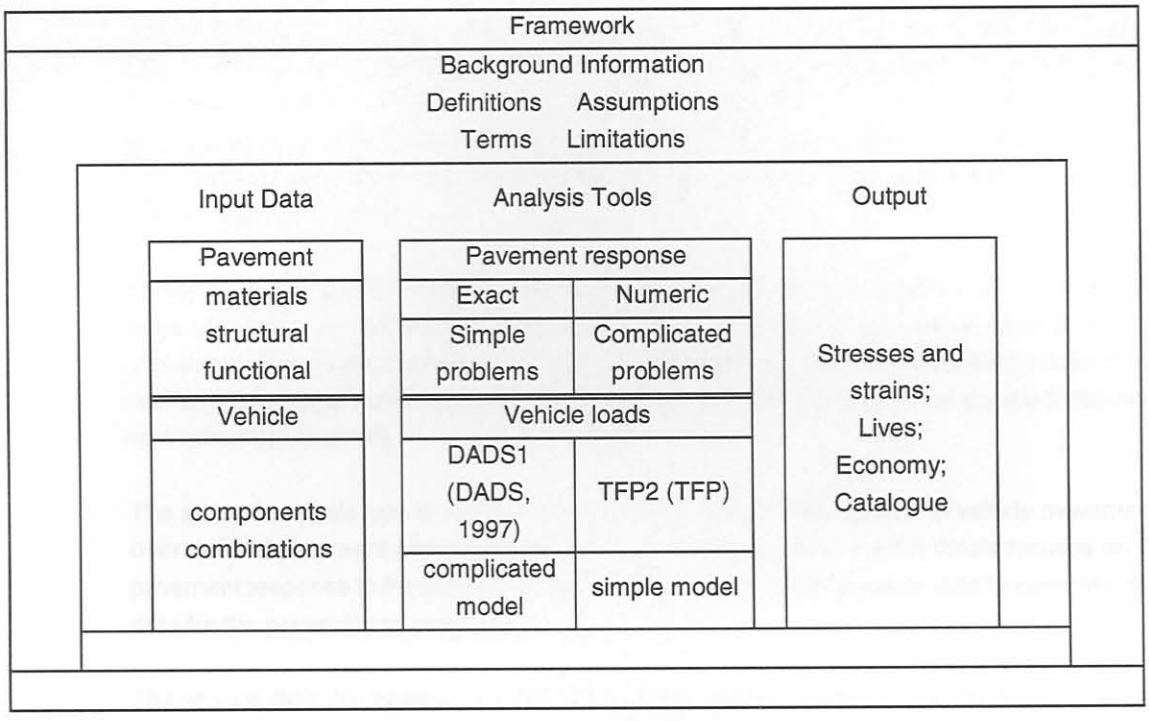

Figure 3.1: Indication of nominal framework for thesis contents for Chapters 4 to 6.

In Figure 3.1 it is shown that a nominal framework may consist of 4 main components (based on the references in Section 2.2). These are the Background Information, Input Data, Analysis Tools and Output. The development of the framework forms part of Chapter 4. This includes definitions of terms and other required background information. The input data required for the analyses are also part of this chapter, as the collection and/or development of such data do not form the major part of this thesis.

3.3.2 Process

The process identified for development of the systems framework for vehicle-pavement interaction components consists of the following steps:

a. Development of definitions of relevant concepts and terms for tyre loading and pavement response analysis: Concepts and terms for which confusion exist on their actual definitions are clearly defined. New concepts and terms are defined where necessary. The basic assumptions and limitations of the proposed framework are identified and discussed.

b. Incorporation of the vital components of the various viewpoints into a the framework: The components identified to play a vital role in vehicle-pavement analysis are combined into the framework to be used for the analysis of static and non-static loading and pavement response analyses.

1 Dynamic Analysis and Design System
2 Tire Force Prediction programme

c. Incorporation of existing input data: The input data required for the tyre loading analyses and pavement response analyses are sourced, shown and discussed. Methods for obtaining the data (i.e. laboratory tests) are also discussed where applicable.

d. Identification of the components of the framework that need further attention in this thesis, and those outside the scope of this thesis: Specific components that receive attention are identified and the possible effects of excluding the other components evaluated.

3.3.3 Output

Steps a to d are addressed in Chapter 4 with a framework populated with current data and techniques as output.

3.4 Pavement Response Analysis Tools

3.4.1 Overview

Various tools are needed to perform the necessary analyses identified in the vehicle-pavement interaction framework. These tools consist of mathematical equations, solvers for the equations and software for performing some of the analyses.

It was shown in Section 2.5 that it is possible to analyse the response of a pavement structure to tyre loading using a static, quasi-transient or full transient pavement response model. Typical pavement structure models and pavement material models for South African pavement materials were presented. Parameters that influence primary pavement response were identified. A need exists for a standardised, user-friendly and accurate method for analysing non-static pavement response to tyre loading.

In Figure 3.1 analysis is shown to be at the centre of the proposed framework. This represents the tools needed to convert the data to user-friendly outputs that may be used in decision-making processes. Two types of analyses are identified for this thesis. The first (and primary) is pavement response analyses. Pavement response analyses methods can broadly be grouped into exact and numerical methods.

The second analysis type is vehicle load analyses. These are simulations of vehicle movements over defined pavement profiles that provide tyre loads as output. As this thesis focuses on the pavement response to these types of loads, the various methods are only used to generate input data for the pavement response analyses.

The various tools are needed to assist in fulfilling the second objective of developing a practical approach to pavement design incorporating vehicle-pavement interaction issues.

3.4.2 Process

The process for developing the pavement response analysis tools involves the following steps:

a. Definition of a multi-layered mathematical method for analysing static pavement response to static and non-static tyre loading: A study is conducted of available multi-

layered methods to obtain a procedure by which the static response of a layered pavement to input functions can be determined.

b. Generation of realistic tyre load functions for different pavement and vehicle conditions: The DADS and TFP software are used with the vehicle and pavement fingerprinting information in Sections 2.3 and 2.6 to obtain detailed tyre load functions for specified conditions. These simulations are compared (Chapter 5). The load functions are used in the pavement response analyses in Chapter 6.

c. Definition of the ranges of and methods for determining vital parameters influencing pavement response: The parameters defined in the framework are investigated to determine the parameters most likely to affect the response analyses. Typical ranges for these parameters are defined and the effect of these ranges on the pavement response analyses determined.

d. Definition and verification of analytical methods for analysing non-static pavement response to static and non-static tyre loading for complex load cases: Software is sourced for the analytical analysis of the vehicle-pavement interaction problem. The problem is defined analytically and optimised for analysis. Similar problems are analysed using the multi-layered and analytical methods and the results compared.

3.4.3 Output

The output from the described process includes the standardised multi-layered and numerical analysis methods, a set of tyre loading functions and an understanding of the likely effect of various parameters on the outcome of an analysis. These outputs are presented in Chapter 6.

3.5 Evaluation

3.5.1 Overview

A tool is only worth its cost if the ultimate effect of its application justifies its use. It thus needs to be shown that the tools developed in this thesis will cause a cost-effective justification for their implementation in relation to the current tools being used.

The last objective of this thesis is to evaluate the effect of transient pavement response analysis on pavement design. This involves a comparison of the results of traditional pavement analyses with that using the proposed framework and tools.

In Figure 3.1 the final part of the proposed framework consists of the output. This contains all of the results from the various analyses. The output can take on various forms depending on the level of analysis and user requirements. In Chapter 7 the focus is on providing the output in a format familiar to general pavement engineers in South Africa, and showing examples of using the proposed analysis procedures. The final output of the thesis is a guideline for effective use of the proposed analysis methods for non-static pavement response to various load conditions.

3.5.2 Process

The process for performing the evaluation of the effectiveness of the proposed framework consists of the following steps:

a. Development of guidelines for indicating the process of including non-static tyre loading effects in a pavement analysis: Static and non-static pavement response analyses of various load functions are performed and the results compared.

b. Comparison of the results of static and non-static response analyses: A pavement structure is analysed using the various tyre loading and pavement response analysis procedures developed and the s results compared to evaluate the effect of the proposed non-static methods.

3.5.3 Output

The outputs of these analyses are the proposed guidelines. These are provided in Chapter 7 in a format compatible with the TRH4 (1996) manual.

3.6 Conclusions

A study approach for dealing with the problem statement identified for this thesis is discussed. The study approach consists of development of a framework for vehicle-pavement interaction analyses, population of the framework with existing data, development of tools for performing static and non-static pavement response analyses to varying tyre loading conditions, and verification of the effect of incorporating non-static pavement response analyses in pavement design.

3.7 References

DADS. 1997. **Dynamic analysis and design system.** User's guide. Revision 8.5.

Structural design of flexible pavements for interurban and rural roads. 1996. Pretoria: Committee of Land Transport Officials (COLTO), Department of Transport. (Technical Recommendations for Highways; TRH4).

TFP see The University of Texas at Austin.

The University of Texas at Austin. **Tire force prediction program users guide.**

TRH 4 see Structural design of flexible pavements for interurban and rural roads.