# Numerical modelling of road with chip seal surfacing layer

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**Abstract:** Most low-traffic roads are primarily thin chip seal surfacing with an unbound granular base and subgrades layers. This paper describes the development of a 3-D numerical model of a low-traffic road. The numerical model was built using the finite element modelling. A 3-D chip seal surface was constructed using X-ray tomography scans of multiple layer seal samples removed from a road. Stones particles were modelled as rigid body; the bitumen was modelled as deformable using a viscoelastic constitutive model. A stress dependent nonlinear anisotropic material model was used for the granular base and subgrade. The material parameters for the bitumen and granular layers are estimated using inverse modelling technique from experimental measurements. The inverse model is formulated as a non-linear least squares minimization problem coupled with a finite element model. It is done by constructing an iterative procedure using an optimisation routine in MATLAB's and at each iteration, finite element problem is solved.

***Keywords:*** Finite element modelling; Inverse modelling; Parameter estimation; Chip seal surfacing, Pavement deformation;

## 1 Introduction

Chip seals surfacing provide low cost roads particularly in low traffic locations. Chip loss, cracks and permanent deformation of road layers reduces its strength and can result in traffic safety concerns. This problem may become more apparent with increasing axle loading and repetitions. Therefore, the assessment of the optimal cost and serviceability of a road design problem has to be studied carefully. This can be done efficiently by modelling the road response using numerical methods. The accuracy associated with modelling the road response is highly related to the material model used especially its material parameter values. Inaccuracy associated with model parameter values can lead to differences between estimated and actual behaviour.

The numerical model of a road response simulation describes the mechanical response of a material under load. It could be used during the design process to study the effect of factors such as binder type, aggregate geometry and traffic stress on likely seal performance.

The novel concept of this paper is to demonstrate the work undertaken to construct a 3D chip seal surfacing road FEM using data derived from a real road surface and to exhibit methodologies for estimating material constants of bitumen and granular layers. In the present work the demonstration process is categorized into three parts. In the first part the construction of a 3-D finite element road model with a chip seal surfacing is considered. A 3-D chip layer was constructed using X-ray tomography scans of multiple layer seal samples removed from a highway. The preliminary development of this study is already reported in one of our previous paper [2]. In the second part the estimation of unknown parameters of bitumen using experimental data is demonstrated. It is based on dynamically loaded ball bearing assembly with the least square minimization technique and finite element modelling. In the third part the process for estimation of basecourse and subgrade layer parameters from falling weight deflectometer data is demonstrated. The inspiration behind the methodology is based on the work of [3].

## 2 Construction of finite element model of road

The geometry of the cross-section of an exemplary road cross-section can be seen in Figure 1. The geometry contains three layers, chip seal surface, base course, and subgrade. The chip seal layer contains stones and bitumen. Stones are assumed to be rigid body and bitumen was assumed to be viscoelastic. Both basecourse and subgrade are assumed to be deformable