Deterioration Models for Cement Bound Materials in Structural Design and Evaluation of Heavy Duty Pavements - DTU Orbit (10/01/2019)


Ports and industries require special types of pavements to resist the heavy static load from containers and continuous loads from operation vehicles. To reduce the risk of rutting and settlements over time concrete or composite pavement systems are typically applied. The structural design of such pavements are today based on Mechanistic-Empirical (M-E) methods. The M-E method is appropriate for many situations, in other situations it may lead to overdesign, or maybe worse, underdesign. The method has limited capabilities and cannot account for significant factors affecting the pavement response, such as geometry, realistic material behavior and arbitrary loading conditions in a unified manner.

In recent years we have seen significant growth in the capabilities of computer hardware and software that has allowed numerical modeling and analysis of structural problems for an increasing variety of applications. Such models allow use of constitutive models that have the potential to replicate a wide range of material behavior under arbitrary loading conditions. However, successful application of numerical models in engineering design is often prevented by complex implementation, unstable simulations and a large number of model parameters.

In order to move a step towards more generalised structural design methods for analysis of heavy duty pavements, this study aims at developing a mechanistic approach based on constitutive models. A simple framework for engineering application is sought; creating a rational link between laboratory tests, design and field applications.

First, a realistic 3-D cohesive finite element model for structural analysis of composite block pavement systems is developed. This model is used for verification and compared to experimental results. Secondly, a simplified two-dimensional engineering model is developed incorporating a cohesive hinge and a two-parameter foundation model into a beam element. This model includes the most significant parameters that influence the structural response, i.e. soil-structure interaction and cyclic damage of the cemented material.

It is found that both the conventional cohesive zone model and the cohesive hinge model is suitable for the description of the fracture behavior of cemented materials in concrete and composite pavement systems. The engineering model is efficient, resulting in computationally fast and stable simulations, and a simple calibration method for estimating foundation model parameters is developed. The consistent format applied enables straightforward implementation of different unloading and reloading schemes. The presented damage model accounts for the material behavior in all the cracked phases, linking the development of the fracture process zone and damage of the existing fracture process zone to the monotonic material characteristics in a unified manner.

The obtained results show that the methodology is attractive and well-suited for further developments and practical use. The real-scale model can be used directly in design, whereas the engineering model can be used in special design cases, for sensitivity analysis and simple studies. The engineering model, can when extended to three-dimensional applications, replace many of the more complex real-scale cohesive zone models. The engineering model can then be used for structural analysis enabling a full mechanistic analysis of concrete and composite pavement structures, something which is not possible today.

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