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Performance-Based Specifications for Unbound Pavements: A New Era with Advanced Rutting Models

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Extended Abstract

The design approaches to the construction of roads have a huge history. As the failure of the roads is accompanied by several factors such as rutting characteristics of materials, water-retention characteristics of materials, applied load, drainage conditions, environmental factors, etc., several researchers and road research industries came up with empirical design charts. The origin of the concept of thickness design charts can be traced back to the early 1940s Porter's experiments [1]. These charts have evolved from Porter's initial methods to the guidelines set forth by the US Corps of Engineers [1], and subsequently to the Country Road Boards in Australia [2], UK Road Notes [3], and the modern-day specifications of several countries [4]. Potter et al. found out with a limited number of surveys that pavements designed in accordance with the design charts had about a 90% probability of exceeding the design traffic; thus, the pavements are over-designed [1], [5]. Consequently, these methods carry over their limitations into mechanistic designs, as the mechanistic design approach was developed based on these empirical charts. On the other hand, traditional laboratory tests, such as Repeated Load Triaxial (RLT) tests, do not replicate the stress rotation experienced by road materials under traffic loads [6], [7]. As a result, these methods fall short of predicting pavement performance accurately.

To address these issues, the Constant Radial Stiffness Test (CRST) with the precision Unbound Material Analyser (PUMA) [8] was used to investigate the rutting behaviour of the unbound materials, as the confining stresses are not fixed as in tri-axial or RLT tests; rather, the mould is deformable in the radial direction, when the vertical loads are applied, the soil sample deforms vertically and radially. The radial stresses are exerted by the rubber band according to the amount of radial deformation. Here, the rubber band replicates the radial stiffness of the surrounding material in a specific pavement layer/material. Therefore, this advanced testing device replicates a 90° stress rotation and a similar stress path experienced by unbound materials under traffic loads [8], [9]. The resulting data on the base, subbase, and subgrade materials, were used to develop a robust rutting model that incorporates repetitive load effects and climatic conditions, providing a more accurate prediction of rutting over time. The developed rutting model was validated through the analysis of long-term pavement performance data [10]. Further validations are being undertaken through extensive field investigations, ensuring its reliability. By integrating traffic characteristics and climate data, the model can predict rutting at any given time, for the pavement, given that the rutting characteristics of the pavement materials are known using the CRST PUMA device.

The innovative approach of using the CRST PUMA device and the development of an advanced rutting model represents a significant advancement in pavement engineering. The model not only accounts for the stress paths experienced by unbound materials but also incorporates the effects of climate, which are crucial for long-term performance predictions. The ultimate goal is to develop performance-based specifications for the construction of unbound pavements and to apply this model to a software plugin compatible with existing mechanistic design software.

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