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RISK ASSESSMENT ASSOCIATED WITH THE DESIGN OF FLEXIBLE PAVEMENTS

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EXTENDED ABSTRACT

The traditional design and structural verification of a flexible pavement, is carried out assuming certain characteristics for the materials and thicknesses of the layers that are used. In this process, all values are assumed to be deterministic variables, although it is known that both the thickness of the layers and the characteristics of the materials used vary over the length of the pavement.

As part of pavement engineering, actions and characteristics of the materials are far from easily determined. On the one hand, knowledge of the actions requires a set of forecasts / projections for traffic growth and climatic conditions; the other hand, the determination of mechanical properties of materials, especially bituminous layers, implies knowledge of a set of parameters, some of which depend for their own actions.

In the process of designing a pavement and during its construction, inherent in every choice made by the designer and each change compared to the baseline, there is a risk of increase or decrease the durability of the final solution. The existence of such risks and the certainty that the vast majority of these cannot be controlled does not mean that all efforts to assess and quantify them should not be made. Against this scenario of uncertainty, the attempt to provide a probabilistic assessment of the pavement design is the aim of the work being developed.

Defined in terms of quality standards previously established (Pais, 1999), the design of a pavement is the definition of a structure which functions structurally and functionally. The structural function is linked to the ability that all layers have to withstand the loads applied by vehicles and by the climate action without suffering degradations that may put the functionality of the pavement at risk. The functional role is related to the safety features and comfort of the users, provided by the surface layer of pavement.

In the early 60's, in parallel with developments at the level of automatic calculation, the rational methods, also called analytical-empirical for having structure analysis of the pavement and empirical observations to validate models and criteria used, appeared.

The determination of the thickness of the layers is made according to two criteria. On the one hand, the limitation of the horizontal strain at the base of the bituminous layers, and on the other hand, restricting the vertical compressive strain of the top of foundation. The two design criteria used were presented by Shell International Petroleum (Claessen et al, 1977) and The Asphalt Institute (Shook et al, 1982) in their empirical - mechanical methods for pavement design.

The multilayer elastic model developed by Burmister (1945) is often used as an analytical structural analysis. Based on continuum mechanics, this model admits the pavement comprises a superposition of isotropic and homogeneous layers characterized by a modulus and a Poisson's ratio. Neglecting the mass forces and admitting the problem as static (zero velocity and acceleration), we are in the presence of elasto-static fundamental problem whose solution is obtained by finding, for each layer, the stress function (ϕ) whose double Laplacian (∇^4) is null: $\nabla^4\phi = 0$.

The variability of the thickness and elastic modulus was studied by Van Cauwelaert (1995) which allowed to develop the analytical resolution of the state of stress/strain of a pavement using the probabilistic analysis for inclusion in the NOAH software (Eckmann, 1998) developed to design pavements.

The consideration of the variability of the materials was performed using the Rosenblueth (1975) theory, which allows replacement of a continuous variable by a discrete variable assigning each point its probability of occurrence.

The Rosenblueth method for calculating the state of stress/strain of a pavement is performed by replacing the function defining the determined parameters by a discontinuous variable, obtaining the stress as a discontinuous variable that can be associated with a continuous real variable that the pavement is subjected.

The model developed by Eckmann (1998) allows the inclusion of the thickness of the layers as a probabilistic variable and the same goes with the modulus of elasticity of the pavement layers. Although the layer thickness, modulus of elasticity and Poisson's ratio, are the only variables to be used to check the pavement structure, there are a number of other factors influencing the choice of the solution to be implemented.

As important as defining the variability of the modulus of a layer is the assessment of the factors that influence them and how they vary. This knowledge allows assigning the variability of design parameters to these factors and not only presenting them as a final result.

In order to achieve this goal, it is necessary to promote two separate tasks: Identification, collecting and processing of different factors that influence the design of a pavement; Incorporation of the information thus obtained in a calculation model.

Data collection was based on nine projects conducted in the district of Bragança. The information available allowed collecting data on bituminous layers covering the following aspects: thickness; percentage of binder; porosity and particle size.

From the analysis of samples collected, probability distributions are defined for subsequent incorporation into the calculation model.

Different methods were studied to incorporate the probability distributions in the structural model verification, pointing out to the Rosenblueth method, the most probable point (MPP) and the Monte Carlo simulation (MC).

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