Innovative Teaching Methods In Flexible Pavement Systems

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Abstract

Flexible pavement systems consist of materials exhibiting complex mechanical behavior, like asphalt concrete, granular or clayey base conditions and various inset conditions. The interaction of these materials within a pavement system is still not understood very well. Solving complex pavement systems has always been very challenging for researchers and practitioners and even more challenging for faculty. The instructors make unrealistic simplifications to explain the concepts without explaining its implications. The authors present a detailed outline and recommend a flow of topics so that the students can understand the pavement system better. Before the instructor can begin explaining a pavement system it should spend some classes on reviewing the different materials involved in a pavement system. Then explain the how the individual layers in the pavement system serve its purpose and then explain the various interactions between materials. Begin with assuming all materials as elastic material, but clearly explain why it is unrealistic focusing on the interaction between layers. The concept of interaction does not change if the mechanical behaviors of the individual layers are modified. Then change the properties of individual layers to realistic values, briefly explaining the test methods and illustrating with actual laboratory data. Then solve a single problem in class step by step with realistic values and then use pavement analysis programs to solve complex problems, making sure they understand the output of the program. The authors recommend using backcalculation analysis and a field visit to observe the falling weight deflectometer tests to explain the behavior of the pavement system. The authors present the illustrations, typical example problems and tools to be used in the course, which will be extremely useful to effectively teach this complex system.

Background

A flexible pavement system consist of various components, the materials include subgrade or natural soil at the bottom, then unbound granular base or subbase, followed by bound granular material and then the asphalt concrete layer at the top. The mechanical behavior is considerably

different for all these materials. For example, asphalt concrete layer exhibit more temperature dependency than the unbound granular material, on the other hand, unbound material are more susceptible to moisture changes than bound material. For all these materials, it is possible to explain theoretically the mechanical behavior and properties, but it is still very difficult to visualize its behavior. To visualize the behavior of the materials it is necessary to explain the response of the material under a given input history in the laboratory. Subsequently, the mechanical property that may be appropriate for the application under consideration should be calculated. The purpose of this paper is to present a course outline that presents this complex information in a very organized manner that is easy to understand and visualize. An example is also presented to illustrate this concept.

Pavement Distresses

Understanding the distresses in the pavements and discussing the cause of failures is good starting point to get the students thinking about pavement materials and interaction between layers within a pavement system. For example: rutting in pavements can be caused due to surface course or subgrade being soft.

Flexible Pavement System

A flexible pavement system consists of various miniature systems of complex materials. Understanding the behavior of these materials within a pavement system is extremely challenging. The true mechanical behavior is very difficult to characterize and model. To explain the interaction between the components it is necessary to make simple assumptions to begin with and then proceed towards the actual material behavior.

Elastic Analysis

The elastic analysis is the simplest mechanical behavior of a material and it is the easiest to explain the interaction of pavement layers with this theory. Even though none of the pavement layers are elastic, the concepts of interaction and compatibility are the same irrespective of the material behavior. The elastic analysis allows the computations to be simple and can be demonstrated without intensive calculations. It also serves as a good introduction to computer softwares.

Computer Softwares

Several analysis programs have been developed to analyze a pavement system; the analysis should be conducted using more than one, to demonstrate the concepts. The analysis should begin with a simple elastic layered analysis program to demonstrate concepts of interaction between layers within a pavement system. For example: effect of various thicknesses' or stiffness' of different pavement layers on mechanical response. In addition, the effect of mechanical response on the pavement distress should also be presented. This will help the students identify the contribution of each of these layers to pavement performance.

Backcalculation

Once the concept of interaction between layers is explained within a pavement system, the backcalculation should be introduced to the students. Backcalculation is a process of calculating the properties of pavement layers from a series of surface deflections using equipment called Falling Weight Deflectometer. It is a method widely used by the Departments of Transportations for overlay design. These processes exposes the students to a brute force method of analyzing a pavement system and understand the response of the pavement system as a whole. The available computer software programs should be used for analysis. This analysis also reinforces the concepts of the response of the pavement system. After the Backcalculation analysis is conducted, the students should be introduced to actual mechanical properties and behavior of pavement materials

Field Visit

A field visit should be conducted to demonstrate the process of falling weight deflectometer and the factors on which the surface deflections will vary. This is important to emphasize the factors that influence pavement response and hence pavement performance.

Material Properties

To understand pavement materials it is important to explain the purpose of each of the material within the pavement system, and it always makes sense to start from the bottom. For example, subgrade is the natural soil and most probably cannot be altered. The purpose of other materials in the pavement system is to provide a most cost effective protection to the subgrade under the given loading and environmental conditions. The rock and aggregates is the most cost-effective load bearing materials available on earth and would provide the best support structure for the traffic. Since all aggregates are not the same, the selection of aggregates is significantly influenced by the availability and its mechanical properties. The aggregates materials closer to the pavement surface are expected to withstand higher stresses and should perform better than the aggregates closer to the subgrade. The aggregates closer to the surface alone cannot withstand traffic loads without a binding material. Hence, the aggregates closer to the surface need binding material to interlock and sustain stresses due to loads and environmental conditions. Hence, asphalt concrete is used closer to the surface. When this concept is explained different types of locally available materials should be showed to the students so that they get the feel of the material and where they could be used within the pavement system.

After the pavement materials are introduced, the mechanical behavior of the materials should be explained. These include elastic versus viscoelastic versus plastic behavior, stress and temperature dependency. These should be theoretically explained with illustrations of mechanical responses to simple input histories. The change in the responses with environmental conditions should also be demonstrated to clearly indicate the effect of the pavement response to these environmental changes.

Non-Linear Elastic and Viscoelastic Analysis

After a brief overview of pavement materials is done, the elastic analysis should be modified to account for the non-linear behavior of pavement materials. The non-linear layered analysis is computationally intensive, but computer programs have been widely used to conduct such analysis. The students should do case studies using both elastic and non-linear elastic and compare the results. The data input and the analysis should be conceptually explained before the softwares are used. The interpretation of the output and the implication of the difference in assuming an elastic material to a non-linear material should be emphasized.

Assessment of Course

The students understood the concepts based on the outline presented, especially, incorporating laboratory data and reiterating the importance of each material and its mechanical properties within the pavement system. The students have provided positive feedback to this learning process and have shown to have more retention of the information when they were required to apply the concepts in senior and graduate level classes.

Conclusions

The authors believe that the flexible pavement material is an extremely challenging topic to be understood. In fact several experienced people in the industry have serious misunderstanding about the topic. This outline has proven very useful in making this topic interesting and practical. This follows the cognitive learning style. This was extremely important considering the complexity of the topic. The outline presented has provided positive feedback from the students; they have enjoyed and retained the information longer.

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