Engineering Brief # 47

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Subject: INFORMATION: ENGINEERING BRIEF NO. 47
DESIGN OF AIRPORT PAVEMENTS USING
LAYERED ELASTIC ANALYSIS

From: Acting Manager, Engineering and Specifications Division, AAS-200
To: All Regions

Attn: Managers, Airports Division

Engineering Brief No. 47, DESIGN OF AIRPORT PAVEMENTS USING LAYERED ELASTIC ANALYSIS, provides information and guidance on the use of draft computer programs for an advanced method of design for airport pavements.

About 3 years ago the FAA contracted the U.S. Army, Corps of Engineers, Vicksburg, MS, to develop an advanced method of airport pavement design based on layered elastic theory. The programs are contained on three diskettes, copies of which are enclosed. The fourth diskette contains an example problem of the design of a rigid overlay of an existing rigid pavement.

We would appreciate your comments at your convenience.

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ENGINEERING BRIEF NO. 47

DESIGN OF AIRPORT PAVEMENTS USING
LAYERED ELASTIC ANALYSIS

Background:
The FAA funded the development of an advanced airport pavement design method over a three year period. The development effort was performed by the U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg MS. Enclosed are four diskettes which contain computer programs for the new design method. The programs are named as follows:

LED.191 - Layered Elastic Design, New Pavement, Rigid or Flexible, released in January 1991.

LEDFRO.191 - Layered Elastic Design, Flexible overlay of a Rigid Pavement, released January 1991.

LEDRRO.191 - Layered Elastic Design, Rigid Overlay of a Rigid Pavement, released January 1991.

LEDOV.191 - Layered Elastic Design Overlay, Example Problem of a Rigid Overlay of a Rigid Pavement, released in January 1991

General Information:
All programs have the same theoretical basis, layered elastic theory. The pavement structure is assumed to be composed of layers of material that are linearly elastic, homogeneous, isotropic, and infinite in horizontal extent. Loads are statically applied through circular footprints of uniform pressure. Solution of the layered elastic problem was developed by Dr. Jacob Uzan, Technion, Haifa, Israel.

Each pavement layer is defined by a modulus of elasticity value, E, a thickness, and a value for Poissons ratio. Seasonal variations can be considered by assigning different E values to the layers. For example, in an area subject to seasonal frost, E can be varied to represent summer, fall, winter (frozen) and spring (thaw) conditions. The program treats these as four different structures and sums the damage done by loadings during each of these different seasons.

The LED program applies to both rigid and flexible pavements. Mixed traffic is analyzed by calculating the damage done to the pavement by each aircraft and summing the cumulative damage. The cumulative damage is expressed by the term Cumulative Damage Factor (CDF). A CDF of 1.0 is the means the pavement will serve out its intended design life. It is not necessary to select a design aircraft as the programs sum the damage done by each aircraft. The program considers aircraft wander, lateral deviation from the pavement centerline, as well as differences in tread widths of different aircraft.

Two design criteria apply to flexible pavements, horizontal strain at the bottom of the asphalt layer and vertical strain at the top of the subgrade. One design criterion is used for rigid pavement design, horizontal strain at the bottom of the concrete slab.

The design of asphalt overlays of rigid pavement is considerably different than previous overlay design methods. Various overlay thicknesses are input and the overlay design is based on time required to reach failure. Failure criteria are based on limiting the amount of cracking in the base slab and an estimate of the amount of reflection cracking. Cracking in the base slab is controlled by limiting the horizontal strain at the bottom of the base slab. Reflection cracking is assumed to develop after one year/ inch of overlay thickness. For example a 3 inch thick overlay would develop reflection cracking after 3 years of use.

The design of rigid overlays of rigid pavements is approached similarily, i.e., trial thicknesses are input and the time to reach various failure levels is calculated. Failure criteria are based on cracking in both the base slab and overlay slab. The time required for cracks to develop in these slabs is estimated by the magnitude of the horizontal strain at the bottom of both slabs. An assessment of the condition of the existing pavement to be overlayed is required. The program computes the time required to reach varying degrees of failure for each trial overlay thickness input.

Hardware:
The programs are designed to operate on IBM compatible personal computers. A math co-processor is necessary to provide reasonable solution times (6-7 minutes depending on complexity). Solution time without a math co-processor will be on the order of 4 times longer. Since the program analyzes each load and each structure individually, it is not unusual to encounter long running times for a complex traffic mix and complex structure of many layers. Note, the OATS computers (AT&T) normally do not come equipped with math co-processors.

Execution:
Trial thicknesses of each layer are necessary to initiate the program. The program analyzes each trial thickness and computes the CDF. Several trial thicknesses should be selected. The program offers a graphic display of the CDF for each structure. The goal is to select thicknesses which will yield a CDF of 1.0. Excellent trial thicknesses can be selected by using values from the present design curves.

Implementation:
The programs are not presently in an implementable form. There are a number of design parameters which can be varied within the programs. Certain design parameters will have to be fixed before the programs can be used as a standard. For example, the interface friction between the layers can varied from full friction (100% shear transfer across the interface), to no friction (0% shear transfer across the interface), or any value in between.

We plan to conduct a sensitivity study of these programs to assist us in setting design parameters and establishing default values which must be fixed before a standard could be adopted. We also plan to release the programs to members of the American Society of Civil Engineers, Airfield Pavement Committee, who volunteered to exercise and comment on the programs.

John L. Rice
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