SUBGRADE BEARING TESTS USED IN KENTUCKY’S FLEXIBLE PAVEMENT DESIGN

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In Kentucky we have a rather wide variety of soil conditions that produce a dominate influence on pavement design. These soils run the scale from very fat clays to some dense sands. Most of the soils are residual but there are some wind deposited silts in the western regions and many alluvial deposits.

The Basis for flexible pavement design by the Kentucky Department of Highways had been for several years a modified Laboratory C.B.R. test and the 1942 curves developed by the California Department of Highways. Some modifications for pavement thickness were applied for local conditions and observed performance. However, road performance had become so unpredictable that direct application of the empirical curves has been seriously questioned by the design engineers.

Accordingly, in the fall of 1947, the Highway Materials Research Laboratory was asked to evaluate for Kentucky conditions the Laboratory C.B.R., as well as other methods currently advanced for flexible pavement design. This study was completed in 1948 and a brief discussion of what was undertaken will be given.

Twenty-five roads were selected throughout the state representing variations in design, soils and traffic. On these roads 185 locations were picked for testing, approximately one half of these being from good performing sections and the remainder from bad performing sections, along the same road if possible. Figure 1 shows the distribution of the road selected.

The pavement and base were removed at each site and three subgrade bearing tests were performed. A field C.B.R. test on the freshly exposed subgrade was run using a loaded truck for reaction. Then three sizes of bearing plates were used. Figure 2 is a photograph of a field bearing test in progress. A cone penetrometer test, which consists of loading a standard cone and measuring the penetration, was also accomplished for each location. The density and moisture content of the base and subgrade were determined. The existing pavement thickness and base course thickness were measured. A sample of disturbed soil was taken to the Laboratory along with an undisturbed sample, which was taken for as many locations as possible.

Laboratory testing included mechanical analysis, plasticity tests, specific gravity, moisture density, and the C.B.R.
Fig. 1 — Map showing sample distribution on the roads studied.

Fig. 2 — Field Bearing test in progress. The upper extensionmeter dial in the proving ring measures the applied load. The lower dial on the plate measures penetration of the plate. A mechanical jack is used to apply the load.
The most important factors influencing flexible pavement design are load, subgrade support and total thickness. These three factors were given primary consideration in the analysis. The load or the traffic that each of these 25 roads had been subjected to since final surfacing was studied. The available traffic data included loadometer measurements from ten routine stations operated from 1942 and seventeen special stations operated in 1947. The traffic count was available for all roads.

These data were expended and converted into an equivalent number of 5000 lb. wheel loads by load factors, recommended by California. This system made it possible to classify each road into a certain traffic grouping according to both volume of traffic and weight of traffic carried. The roads were divided into 5 traffic groups, according to the number of equivalent 5000 lb. wheel loads.

The data now available included subgrade bearing values, traffic values, total thickness above subgrade, and performance (good or bad).

This data was represented on a plot of thickness of pavement versus bearing value. Each location was located and plotted with a number from 1 to 5 which was a traffic group designation. The number was underlined if the location represented a failed section. Thus a 2 (underlined) represented a sample that was from traffic group 2 and was from a failed location (See fig. 3). The curves numbered I to V were drawn to best separate the failed locations from the good sections. These plots were made for each method of test, using Field C.B.R., bearing plates, cone penetrometer and Laboratory C.B.R.

The best correlation was obtained from the modified laboratory C.B.R. test and is shown in Fig. 4. This set of curves was prepared for obtaining design thickness.

The procedure is to sample the soil along a proposed road or relocation and to obtain the average C.B.R. for the section being designed. The C.B.R. values are furnished the Design Division by the Division of Materials and Tests. The Division of Planning then calculates the expected traffic. With this information and the curves shown it is then possible to arrive at a total thickness of base and pavement for that condition. The thickness obtained by this design method does not take into account frost action which we know can affect many of our soils under severe weather conditions. The different types of bases are not differentiated.

Practically every State Highway Department, as well as the Federal Bureaus, have a different design method for flexible pavements.
Fig. 3 — Plot of C.B.R. values versus pavement thickness. Numerals represent traffic group of road from which sample was taken. The numbered curves were drawn to best separate the good from failed locations of each traffic group.

Fig. 4 — Set of curves that were recommended for obtaining design thickness using the modified laboratory C.B.R. test minimum value. The curves are numbered for traffic designations.
Several of these methods take into account the action of frost. Others for the more arid states have designs adapted to those regions.

The Highway Research Board through its flexible pavement design committee set up a "Correlation of Thickness Design Methods" study. This activity was undertaken to determine the magnitude of the range in design thickness for a given type of pavement, for a given soil and the same amount of traffic, when computed or arrived at by several different agencies using their respective methods of design. The plan for carrying on this activity included:

(a) Sending out to a number of testing laboratories samples of a typical subgrade soil and base course material.
(b) The strength evaluation of these materials, and
(c) The development of a design pavement to carry a specified amount of traffic.

Three volumes of traffic were given.

Kentucky submitted designs based on the Laboratory C.B.R. Sixteen other organizations cooperated by giving designs. The thickness required for a given condition varied considerably. Some states require the use of a sub-base material for frost protection and many had local restrictions on design thickness. An average of these thicknesses showed that the Laboratory C.B.R. method produced thicknesses within 2 inches of the average for all three cases. This may not indicate which design method is best but does give a picture of the problems that do exist. The Highway Research Board is expending a great amount of effort to rationalize flexible pavement design. It is planned to send out other identical soil samples in different bearing value ranges to compare the methods of design still further.

These design curves as were shown in the Fig. 4 have been used along with the modified C.B.R. test since 1948 to govern flexible pavement and base thickness. This includes only new designs from the subgrade up. Time and traffic changes will be the proof of this evaluation method.