Evaluation of Performance of an Existing Concrete Pavement Under Accelerated Load Application

A. TARAGIN, Bureau of Public Roads, Member of the Symposium on the Evaluation of Pavement Performance

● THIS discussion is based exclusively on the experience gained from the load testing, through an accelerated program, of an existing concrete pavement on a section of road which 7 years ago attained national prominence. It is, of course, the research project known as Road Test One-MD. The results of this research were published in 1952 by the Highway Research Board as Special Report 4. It is not intended to present all the results of the test, but to discuss briefly the several methods used to evaluate the performance of the pavement under applied load. The project was conducted under the direction of the Highway Research Board according to a plan of accelerated loading and testing unanimously agreed upon by all the participating states, the Bureau of Public Roads, the Automobile Manufacturers Association, the petroleum industry, the American trucking associations, and the Department of Defense.

The principal purpose of the test was to determine the relative effects on a particular concrete pavement of four different axle loadings—two single axles and two tandem axles. The word "relative" in the objective is stressed because the methods of rating the performance were identical in all test sections under as nearly as possible identical conditions. The only variable was the axle loading. Therefore, any difference in the pavement performance of two parallel test sections was due primarily to the relative effects of the two different axle loadings.

In its operation the test consisted primarily of comparing the relative effects of 18,000- and 22,400-lb single rear axles and 32,000- and 44,800-lb tandem rear axles. The test sections were subjected to the designated load applications at a frequency of one a minute by the single-axle loads and at a frequency of one for each 45 sec by the tandem-axle loads.

The test pavement consisted of two 12-ft lanes each having a 9-7-9 in. cross-section, both reinforced with wire mesh. Expansion joints were spaced at 120-ft intervals with two intermediate contraction joints at 40-ft spacings. All transverse joints had dowel bars ¾ in. in diameter at 15-in. spacing and the adjacent lanes were tied together with ⅝ in. tie bars 4 ft long spaced at 4-ft intervals.

The following methods were used to determine the performance of the existing concrete pavement before, during, and after running of the test traffic: soil survey; physical properties of the concrete; load strains and deflections; temperature warping stresses; surface roughness; and slab settlement—precise leveling. Observations were made daily of the following during the period of test traffic: edge and joint pumping; pavement cracking; and edge and corner spalling.

The principal objectives of the soil survey were the investigation, analysis, and correlation of subgrade information with pavement performance—pumping, cracking, and settlement. Over 1,400 soil samples were analyzed from beneath the 1-mi test section. The results showed (a) that there was a significant difference in the pavement performance on granular and fine-grained subgrade soils for the magnitude and frequency of axle loads used in the test, and (b) that the physical test data could be used to distinguish between satisfactory and unsatisfactory subgrade soils for concrete pavements.

Over 150 cores and 80 beams, obtained from the test pavement, were subjected to various laboratory tests for the determination of the physical properties of the concrete. The results showed that the pavement was of the designed thickness, had an average compressive strength of about 7,000 psi and an average modulus of rupture of over 800 psi. In other words the concrete in the test road was of average quality and its fatigue properties were normal.

During the load-strain and load-deflection tests, 9,000 strain readings, 3,000 deflection readings, and 2,500 readings for the development of the influence line data were ob-

tained. The load strain studies were divided into five cases of loading: interior, free-edge, corner, transverse joint edge, and special. The special case of loading was included primarily to determine the cause of longitudinal cracking. This research developed information of (a) load-stress and load-deflection relations for slabs on granular soil where no pumping existed and for slabs on fine-grained soil prior to and after the development of pumping, (b) comparison of the effects of single- and tandem-axle vehicles, (c) effect of speeds and transverse placement of vehicles, load transfer, faulting, and warping of the slab on the magnitude of stress and deflections caused by loads, and (d) stresses resulting from restrained warping of the slab.

The most important warping stresses in concrete pavements are those caused by the daytime and nighttime temperature differentials. Restrained daytime temperature warping causes tensile stresses in the bottom of the slab, whereas restrained nighttime warping causes tensile stresses in the top of the slab.

Road-surface roughness measurements were obtained at four different periods using the Bureau of Public Roads roughness indicator. Measurements were made in both directions of travel along each normal wheel path at 20 mph. The degree of roughness increased in greater amounts in the sections subjected to the heavier axle loads of each vehicle type.

Slab settlement was determined by using precise levels. The U.S. Coast and Geodetic Survey placed 15 permanent bench marks at 400-ft spacings along the project and determined their elevations. Using these elevations precise level observations were made at four different periods to determine the elevations of 10 spots painted on each slab under test as follows: two at the transverse joint, two 5 ft from the transverse joint, and one at midslab, both at the free edge and at the longitudinal joint. The greatest settlement was found at the free-edge corners of the slabs and the least settlement was noted at the midpoint of the slab along the longitudinal joint.

A pumping survey was made each day during the course of the test. The survey consisted of recording the number of places together with the lineal feet along the free edge, and the number of the transverse joints where pumping was occurring. This method proved very satisfactory for this test. The extent of pumping varied with the magnitude and character of the load applied. For similar types of soil, pumping developed earlier at expansion joints than at contraction joints.

A detailed survey was made of the cracks in each slab prior to the beginning of test traffic. During the test traffic, each slab was checked daily for cracks. The exact position of each crack as it developed was recorded on a card with the date and number of load applications when the crack was first noticed. The structural cracks recorded were those that appeared during the test-load applications for which there could not definitely be assigned a cause other than the probable effects of loads, and which upon examination showed a definite and continuous cleavage plane in the concrete. As new cracks or extensions of old cracks developed, they were painted with lines of contrasting color 1½ in. in width. Early in the study and again after test traffic was terminated, the U.S. Air Force flew a jet plane over the project and obtained a Sonne-strip photograph in color showing the cracks as variously painted in each slab.

In conjunction with the crack survey, observations were made of the number of spalled places and of the number of small corner cracks. Although these areas were greater in number for the heavier axle loads than for the lighter loads, this method of determining pavement performance was not as effective as the other methods used. The number of such such spalled areas and small corner cracks were too few to be significant.

In conclusion it may be stated that for the condition of the Road Test One-MD, the methods used to determine the performance of the concrete pavement were quite satisfactory. The objectives of this particular study were accomplished.