Condition Surveys Used in Oklahoma to Evaluate Flexible Pavement Design

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THIS PAPER outlines the procedure of making flexible pavement condition surveys and its use in evaluating the flexible pavement design of the Oklahoma Highway Department.

In cooperation with the Bureau of Public Roads the Oklahoma Highway Department initiated a comprehensive research study in 1955 to evaluate the flexible pavement design adopted in 1947. The thickness design adopted in 1947 uses the California Bearing Ratio curves as given in HRB Proceedings, Vol. 22.

The pavement studied was selected from a list of projects consisting of 2,388 mi of flexible pavement constructed after the rational method of design had been adopted in 1947. Analysis of the projects indicated that five principal types of construction had been used. The mileage of each type of construction in the sample selected was in proportion to the total miles of each type of construction. The selected sample consisted of 321 mi of two-lane pavement which had been constructed under 42 separate contracts.

There are twelve soil problem areas in Oklahoma—so designated because the agricultural problems are similar throughout each area. Of these twelve areas, there are five major areas which encompass approximately 80 percent of the state. This was the second consideration in the selection of a test sample. The 42 projects selected for study were located within the five major problem areas. No other consideration was given to the selection of projects than those previously mentioned.

The study consisted of completing a testing program to evaluate the performance of the pavement and the compilation of historical and environmental data to be analyzed in connection with the testing program. Procedures were written for assembling the data, for analyzing it, and for making all tests. Some 40 items were included which may be summarized into five general classes.

1. Construction Data.—The items in this group included information taken from the construction plans; such as, typical pavement section, type of construction, and quality tests of materials made during construction.
2. Other Existing Data.—This group included geology, weather, original soil surveys, traffic data, and maintenance costs.
3. Field Data.—This group included condition surveys of the pavement structure, roughometer surveys, field checks of the original soil surveys, and pedological soil surveys.
4. Field Tests.—Included plate bearing tests, Benkelman beam deflection tests, field California Bearing Ratio tests, density tests, moisture tests, and the taking of samples for laboratory testing.
5. Laboratory Tests.—Included routine laboratory testing to determine whether field samples conformed to specifications for the subbase, base, and surface courses.

Many factors determine the performance of the pavement structure. It was intended to include in this study all the principal factors that could possibly be evaluated. It was deemed necessary to obtain a factor for evaluation purposes which could represent the depreciation of the pavement structure. Expended maintenance funds for the pavement structure were considered as partial payment for depreciation. The present condition of the pavement structure was considered as the other part of depreciation.

To begin the study of depreciation, maintenance costs of each of the 42 construction projects, as indicated by statistical records, were tabulated and reduced to 1950 costs. All maintenance costs were then converted to a factor which represented the average cost per mile per year for each project. The average cost per mile for the contract construction of the pavement structure was obtained and converted to the 1950 cost. The average maintenance cost per mile per year was divided by the average cost per mile for contract construction, 1950 cost, to obtain a percentage factor which represented repaired depreciation. As previously mentioned, the present condition of the pavement structure was considered as the other part of depreciation. Unrepaired depreciation can be estimated by a condition survey and can be expressed as a percentag of the cost of the pavement structure. Condition surveys require an estimation founde on the judgment of the individual, and the personal factor is a major consideration.

For an observer to pass over an extent of pavement and mentally total up and reduc to an exact figure a number of areas of several kinds of defects, is an ability that will differ greatly among individuals. For long extents and many items, this ability probably varies greatly in the same individual at different times. To minimize the person al factor it is advisable to divide a project into a number of small parts and to evaluat each part separately. The final condition rating of the project can be made by averag ing the evaluation of the parts.

To begin the condition surveys, reference points were painted on the surface of the pavement at each 0.2-mi longitudinal interval throughout the length of the project and numbered in consecutive order from the beginning. The exact stations from the construction plans were determined for each of the reference points. The reference poi were used as ties for the condition survey, soil and geological surveys, Benkelman beam deflection sites, and plate bearing sites.

To minimize and standardize the personal factor for rating purposes in making the condition survey, the following terms, classifications, and ratings were adopted. De inition of the terms used in describing the different characteristics of the classes is as follows:

Terms	Percent of Area
Few - slight	Less than 5
Some	5 to 15
Considerable	15 to 30
Extensive	More than 30

The percentages are given as part of the total area of the extent rated. The class ratings, and definition of the characteristics of the classes are as follows:

Excellent (98-100 percent)

1. No major or minor defects are apparent.
2. No maintenance has been performed.

Superior (90-97 percent)

1. There are no base failures or other major defects.
2. No structural maintenance has yet been necessary.
3. Any one or all of the following characteristics may be present within a 0.2 mi extent: (a) slight surface roughness; (b) slight cracking; and (c) the riding quali is impaired but very slightly.

Good (80-89 percent)

1. No base failures.
2. Any one or all of the following characteristics may be present within a 0.2 mi extent: (a) some surface roughness; (b) some cracking; (c) slight raveling; and (d) slight distortion.

Any one or all of the characteristics listed in the following classes may be prese within a 0.2-mi extent:

Average (65-79 percent)

1. Few localized base failures.

2. Considerable surface roughness.
3. Considerable cracking.
4. Some raveling, especially in the outer wheel lanes and along the edges.
5. Some distortion.

Poor (50-64 percent)

1. Considerable base failures.
2. Extensive surface roughness.
3. Cracking is extensive.
4. The surface has raveled extensively throughout its width.
5. Considerable distortion.

Failure (Less than 50 percent)

1. Base failures are numerous and extensive.
2. Distortion is extensive.
3. Traffic hazards are extensive due to failures and distortion.
4. Routine and special maintenance repairs have not been effective.

If maintenance had been performed, the maintained area was rated in one of the pre-eding classifications as to its effectiveness. A note was made in the remarks column f the condition survey form regarding the type of maintenance that had been performed. ther remarks included the general condition of the pavement structure. The final con-ition rating of a project was obtained by averaging the ratings of each 0.2 miles. Fig-re 1 shows the condition survey form.

A glossary of terms used in the condition survey follows:

Pavement Structure: The traveled portion of the road consisting of the subbase, base, and surface.

Surface Roughness: Inequalities in the pavement surface which adversely affect the riding quality.

Cracks: Approximately vertical cleavage due to natural causes or traffic action.

A. Transverse cracks—a crack which follows an approximate course at right angles to the centerline.

B. Longitudinal cracks—a crack which follows an approximate course parallel to the centerline.

CONDITION SURVEY DATA

ta taken by ________________ Date ________ Control Section ____________

oject # ________________ Research Group # ______ Research Project # ______

unty ________________ H'way US SH ______ Length ____________ Miles

oject Description & Location ______________________________

______________________________ Date Started ________

Date Completed ________

hicle # __________ Mileage Conversion Factor __________ Final Rating ______

eter ading	Acc'l. Mileage	Corrected Mileage	Defl. No.	Defl. Type	Cond. Rating	Remarks

Figure 1.

C. Shrinkage cracks—interconnected cracks forming a series of large polygons usually with sharp corners or angles.
D. Slippage cracks—frequently crescent-shaped cracks which usually point in the direction of the thrust of traffic.

Stripping: The separation of bituminous films from aggregate particles.

Raveling: The progressive disintegration of the surface by the dislodgement of aggregate particles.

Distortion: Any type of irregularity tending to distort the pavement surface from its original shape.

A. Corrugations—transverse undulations at regular intervals in the surface of the pavement consisting of alternate valleys and crests not more than 2 ft apart.
B. Waves—transverse undulations at regular intervals in the surface of the pavement consisting of alternate valleys and crests 2 ft or more apart.
C. Rutting—the formation of longitudinal depressions under traffic in the wheel lanes.

Failure: Disintegration of the pavement structure.

A. Alligator cracking—interlaced cracking of a bituminous surface course into small irregular blocks caused by inadequate base support.
B. Shoving—lateral displacement of the pavement material due to the action of traffic.
C. Disintegration—deterioration into small fragments or particles due to any cause.
D. Potholes—bowl-shaped holes of varying sizes in the pavement resulting fro localized disintegration.

After the completion of the condition survey, the average condition rating of the project was computed and divided by the age of the project to obtain the average condi tion depreciation per year. This factor was considered as the unrepaired depreciatio percentage and added to the repaired depreciation factor to obtain the total depreciati per mile per year as a percent of the contract construction cost based on 1950 costs.

The depreciation per mile per year of the pavement structure was used as a basic factor in the study to determine the relationship and effect of the following:

1. Load supporting ability of the pavement structure as determined by plate bearing tests and Benkelman beam deflection tests.
2. Thickness of the "as built" pavement structure.
3. Traffic and wheel load densities.
4. Soil and geological extents.
5. Climatic conditions.
6. Quality of subbase, base, and surface courses of the pavement structure.
7. The original construction cost of the pavement structure.
8. The maintenance cost since completion of the pavement structure.

Although this study was started in 1955, the complete analysis has not as yet bee completed. The relationship of items 2, 3, 4, 5, 7, and 8 to depreciation has been determined and is included in Part One of the Final Report of the Oklahoma Flexible Paving Research Project, 1958. Analysis is under way as to the effect of each of th items to total depreciation and will be published in Part Two of the Final Report whe completed.

The procedure described herein for making condition surveys was found to give reasonably good results. It was developed in 1955 prior to the first condition surve of the 42 projects. The procedure has been used for making surveys of the same pr jects in 1957, 1959, and 1960.

The average condition depreciation per mile per year of the 42 research projects is as follows:

Date of Survey	Average Age of Projects, Yr	Condition Depreciation, %	Average Condition Rating
une 1955	4.402	1.43	91.92
une 1957	6.285	2.05	87.12
une 1959	8.154	2.00	83.73
une 1960	9.154	2.47	77.30

Since the original condition survey was made in 1955, maintenance consisting of ingle bituminous surface treatments has been placed on 19 of the 42 projects. The reults of the condition surveys indicate that the pavements are depreciating at a more apid rate than was anticipated and maintenance performed has not been adequate.

The rapid depreciation also indicated that the pavement structure was underdesigned r the poorest soil types and resulted in the development of an interim design method, lopted in 1958, which extended the design curve to give greater thickness of the pavement structure for the poorest soils. The interim design method consisted of the delopment of a subgrade index number ranging from 0 to 40 for soil characteristics pendent on the plasticity index, liquid limit, and percent passing the No. 200 sieve. e relationship between the subgrade index numbers and the California Bearing Ras of the soils was determined, and the appropriate pavement thickness was deterined from standard CBR curves for subgrade index numbers. The subgrade index mber was then used in place of the standard CBR curves.

Preliminary analysis indicates that factors other than strength of the subgrade soils ect the performance of the pavement structure and inadequate design results from lure to provide for the other factors. Climatic environment, traffic, and wheel load nsity are among the chief factors affecting the performance. One project included the study gave almost perfect performance for approximately eight years while preitation was below normal and then depreciated 38 percent in three years when rainl exceeded the normal average.

Another project on a secondary road gave good performance until heavy truck loads asphalt were moved over it.

Another project performed good for a period of time and then the edges started fail-, probably due to a lack of shoulder width.

The condition survey, which resulted in the calculated depreciation, is being used a basis for evaluation of flexible pavements. The relationship of depreciation to the ny factors affecting performance is being determined by machine analysis. The end ult of the study will be a mathematical regression equation, including major factors, designing flexible pavement thickness.