

Survival Analysis of Highway Pavements in Illinois

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Introduction

A survival analysis was conducted on the interstate highway pavement network in Illinois.

The points for developing survival curves were determined by using the LIFETEST procedure in SAS*. The LIFETEST procedure estimates survival against time or other variables. Pavements were considered to have "failed" when a major pavement rehabilitation was performed.

Survival curves were generated based on age or accumulated traffic loadings, for many pavement design categories. These curves have proven useful in presentations and decision-making activities of the Illinois Department of Transportation (IDOT).

Background

The interstate highway network in Illinois encompasses approximately 1,900 miles and is the third largest in the country. The network is primarily composed of varying thicknesses of concrete pavement encompassing two types, Jointed Reinforced Concrete Pavement (JRCP) and Continuously Reinforced Concrete Pavement (CRCP). Figure 1 shows the composition of the interstate by pavement type.

The pavements were constructed during the years 1952 through 1990 with the bulk of the construction during the period 1960 through 1977. In addition, approximately half of the pavements have undergone major rehabilitation primarily by means of various thicknesses of an asphalt overlay of the concrete pavement.

Description of Survival Curves

IDOT engineers were interested in determining the relative performance of these original and rehabilitation pavement designs in order to assist policy and programming activities. The LIFETEST procedure in SAS was used to perform this analysis.

In order for the LIFETEST procedure to be used, a failure criteria had to be identified. Original concrete pavements were considered to have failed when complete rehabilitation was performed such as an asphalt overlay or complete concrete pavement restoration. Routine patching was not considered failure.

For asphalt overlaid pavements, failure occurred when a second asphalt overlay was placed, or in a few cases, when the first overlay was cold milled off due to severe rutting.

The useful life of a pavement can be characterized both in terms of years that a pavement provides service and the amount of traffic it carries. Survival distributions were analyzed against two criteria, pavement age and accumulated traffic loadings reduced to 18,000 pounds Equivalent Single Axle Loads (ESAL's).

Survival Analysis

A survival analysis was then performed for different pavement characteristics such as design thicknesses and material properties. A point was generated on a survival curve for each age or ESAL corresponding to at least one failed section. Ages or ESAL's which did not correspond to at least one failed section were not used in the analysis. The percent failure for a given age or ESAL is the probability that a given section will fail when it reaches that age or ESAL. The greater the number of surviving sections at a given age, the lower the percent failures is for that age.

Figure 2 portrays the survival curves by ESAL's for 7, 8, 9, and 10-inch CRCP and 10-inch JRCF pavements. As expected, thicker pavements provided longer life in terms of traffic loadings. Figure 3 shows the survival curves by age of thin (less than 4") asphalt overlays over JRCF pavements as split by "D" cracked and non-"D" cracked concrete pavement types. Detailed description of the survival analysis procedures can be found in Reference 1 and 2.

All pavements in the analysis have not yet failed, especially for the asphalt overlaid concrete pavement category. Shapes of the survival distribution of asphalt overlaid categories will change with time as the "failure" database becomes more complete.

Summary

The survival analysis has proved useful in the decision making activities of IDOT in terms of evaluating the performance of different pavement designs and the anticipated effectiveness of different rehabilitation techniques based on existing conditions. Survival analysis will continue to be conducted on the network as a whole as more information becomes available.

References

1. Dwiggins, M. E., M. I. Darter, J. P. Hall, C. F. Flowers, and J. B. DuBose, "Pavement Performance Analysis of the Illinois Interstate Highway System," University of Illinois and Illinois Department of Transportation, Report No. FHWA-IL-VI-220, 1989
2. Vespa, J. W., K. T. Hall, M. I. Darter, and J. P. Hall., "Performance of Resurfacing of JRCF and CRCP on the Illinois Interstate Highway System," University of Illinois and Illinois Department of Transportation, Report No. FHWA-IL-VI-229, 1990.

Trademark Notice

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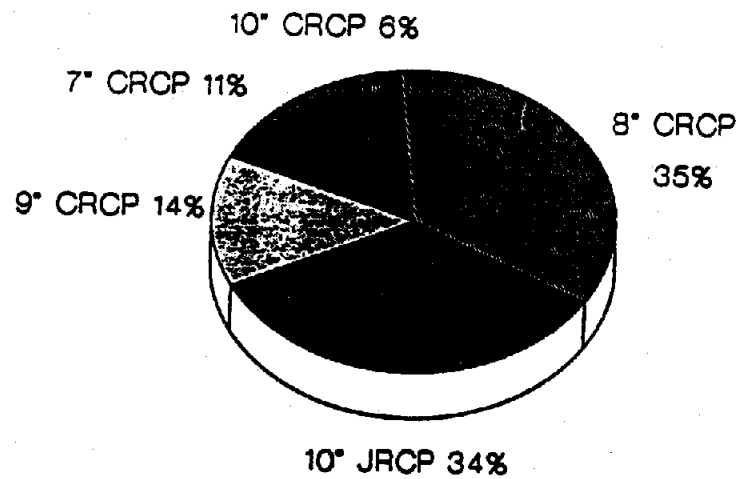


Figure 1. Illinois Interstate Pavement Types.

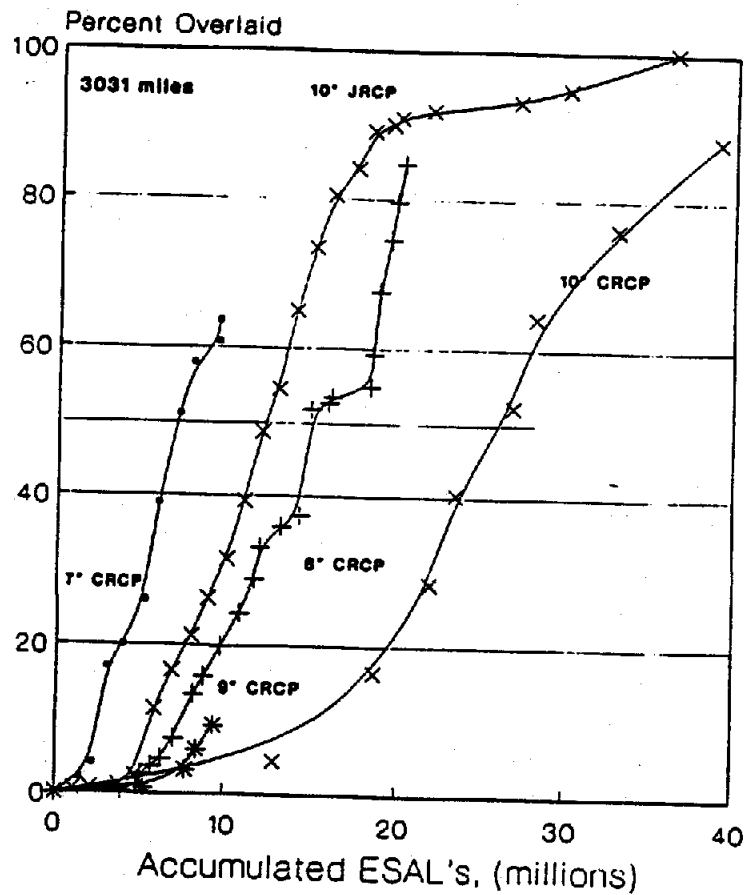


Figure 2. Survival Curves by ESAL for 7, 8, 9, and 10-inch CRCP, and 10-inch JRCP.

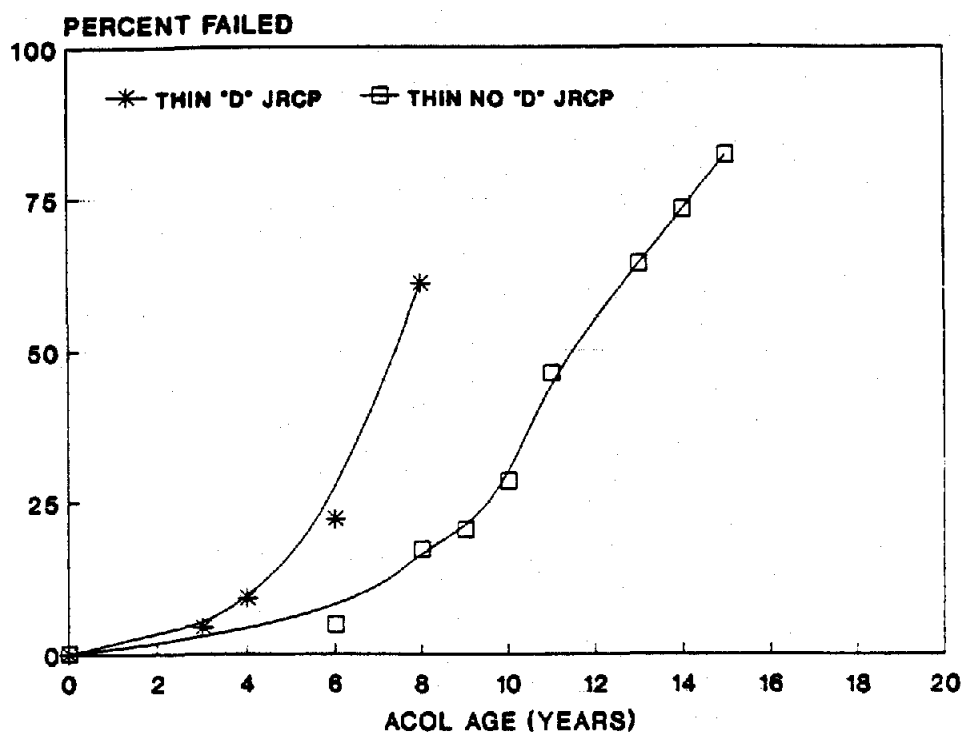


Figure 3. Age Survival Curve for thin Asphalt Overlays of "D" Cracked and Non-"D" Cracked JRCP.