PERFORMANCE OF CONCRETE PAVEMENTS ON COUNTY ROADS IN IOWA

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This paper reports on a performance evaluation of 2,044 miles of pavement on the secondary road system in Iowa. The survey was made during the past 2 construction seasons and used the PCA road meter, a device installed in a passenger car to measure PSI of pavements while traveling at a speed of 50 mph. BPR roughometer measurements of all newly constructed projects since 1955 are charted, as are current PSI readings. The information has been of particular interest to Iowa contractors, who have shown marked improvement in attaining smooth concrete pavements over the study period. The survey shows a weighted average PSI of 3.91 for the total 2,044 miles under study. The system furnishes a continuing opportunity to observe the performance of these thinner concrete pavements constructed on a variety of subgrades and carrying mixed traffic whose present counts vary from about 200 to 2,000 vehicles per day.

During 1968 and 1969 a performance evaluation was made on over 2,000 miles of concrete paving on the secondary road system in Iowa. The performance survey was made using the Portland Cement Association road meter (1).

The secondary system in Iowa consists of roads constructed and maintained by the counties. Concrete paving on this system got under way in 1955 with the advent of the slip-form paver. Prior to that year, only 3½ miles had been built, 1½ miles in 1949 and 2 miles in 1954. These were constructed on an experimental basis to determine the feasibility of the method. At the end of the 1969 construction season there were 2,156 miles of portland cement concrete paving on this system in Iowa.

This survey includes 2,044 miles, or 95 percent of the total mileage constructed to date.

PAVEMENT DESIGNS

Ninety percent of the roads surveyed are of 6 in. thickness. The remaining 10 percent in the survey is made up of about 1.5 percent built of 8 in. thickness and approximately 8.5 percent of 7 in. thickness. The projects vary in width from 20 to 24 ft. Until 1966, a 20-ft width was the minimum approved by the Iowa State Highway Commission, which must approve the design before construction. Since 1966, the minimum width has been 22 ft.

The standard design for these pavements calls for a uniform thickness. Tie bars ½-in. round are used across the sawed longitudinal centerline joint at 4-ft centers. Transverse joints are sawed at 40-ft intervals. (Because Iowa aggregates have a normal crack interval of a little less than 20 ft, it might be advantageous to use a 20-ft transverse joint interval in the interest of eliminating the intermediate crack that

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usually forms during the first 5 to 10 years of service.) No mechanical load transfer device or distributed steel reinforcing is used.

No special subbase or base course is used in this design. However, because these are roads carrying the major traffic in the county, they have been previously surfaced with either gravel or crushed limestone. It is the usual practice to establish a grade line that will permit utilizing as much as possible of the existing granular surface in the subgrade. The existing roadbed is usually scarified to a 6-in. depth and recompacted to the proper cross section just prior to paving.

SURVEY PROCEDURE

This survey was made by running a passenger car equipped with a PCA road meter device over each project. The road meter is a relatively inexpensive, simple device (1). It measures the magnitude and number of deviations between the car and the road while traveling at a constant 50 mph. The results can be directly correlated with the slope variance measured by the CHLOE profilometer (2).

During the AASHO Road Test, the performance level of the various test sections was determined by the present serviceability index (PSI). This is a simple numerical scale (Fig. 1) ranging from 0 to 5 as follows: 4 to 5, very good; 3 to 4, good; 2 to 3, fair; 1 to 2, poor; and 0 to 1, very poor.

When the PSI of a test section reached 1.5 on the scale at the road test, it was taken out of test and considered to have failed. Later studies and general practice generally have established PSI's of 2.0 for secondary roads and 2.5 for Interstate and primary highways as the minimum value of acceptable serviceability. When pavements reach these PSI levels, they should be resurfaced or reconstructed.

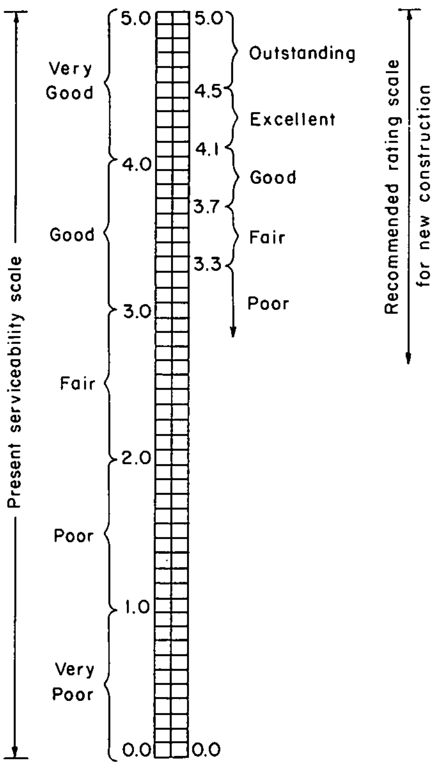

Figure 1. Pavement rating scales.

The PSI equation derived at AASHO is as follows

$$PSI = 5.41 - 1.80 \log (1 + \overline{SV}) - 0.09 \sqrt{C + P}$$

where

$\overline{SV}$ = average slope variance in both wheelpaths as measured by the CHLOE profilometer;

C = major cracking in linear ft per 1,000 sq ft of pavement area (major cracks are sealed cracks and those that are spalled to a width of ¼ in. for at least half of their length); and

P = bituminous patching in sq ft per 1,000 sq ft of pavement area.

In the survey reported here, no reduction in PSI was made for cracks and patches. Consequently, except in the cases of relatively new construction, it is possible that the true PSI would be slightly less than the result shown. For the purpose of this study as originally conceived, the smoothness or rideability, which obviously is the major part of the PSI, was felt to give sufficient evidence of the performance. Because of the slab length used in Iowa, it is not felt that one intermediate crack really reflects a change in pavement serviceability, and there were very few bituminous patches in the 2,044 miles. Those engineers who have the manpower required and sufficient interest in obtaining the exact PSI are urged to make a crack survey and to modify the reported result where indicated.

It is also important to note that, for projects constructed earlier than 1968, the original "as constructed" PSI was not available and the PSI reported here is the current PSI. In order to establish the performance trend, it is necessary to correlate current PSI values with BPR roughometer results that were obtained as soon after construction as possible. It is a common practice in Iowa to measure pavement smoothness of all new pavement with the BPR roughometer.

Examination of the results reported by the Iowa State Highway Commission for BPR roughometer measurements shows that the surface riding qualities of slip-formed concrete have indeed improved. In 1955, for example, road roughness averaged 98 in./mile for all projects. In 1969, the average of all projects had been reduced to 73 in./mile. A plot of average values for each year on semilogarithmic paper results in a curve shown in Figure 2.

SURVEY RESULTS

The weighted average of current PSI values for each year's construction shows a range from 3.26 in 1955 to 4.15 in 1969 (Fig. 3). Comparison of this plot with the pavement roughness plot shows that the lower PSI of earlier projects is only partially accounted for by loss of PSI due to age. Much of the difference is due to improvements made during the period in both equipment and construction techniques.

There is a difference in the rideability or serviceability rating of new pavements built by different contractors. Such variations are shown by plotting the PSI's of the work done by each during each year as shown in Figure 4.

An earlier research report (3) lists a change in supervision as one important factor in quality control. It is interesting to note that 2 of the Iowa contractors showing the most consistent performance (contractors F and G) have maintained essentially the same organization throughout the period studied. Looking at their records, we find that projects built by contractor F have maintained an average of 3.8 or better since 1960; and contractor G pavements have maintained an average 4.0 or better since 1961.

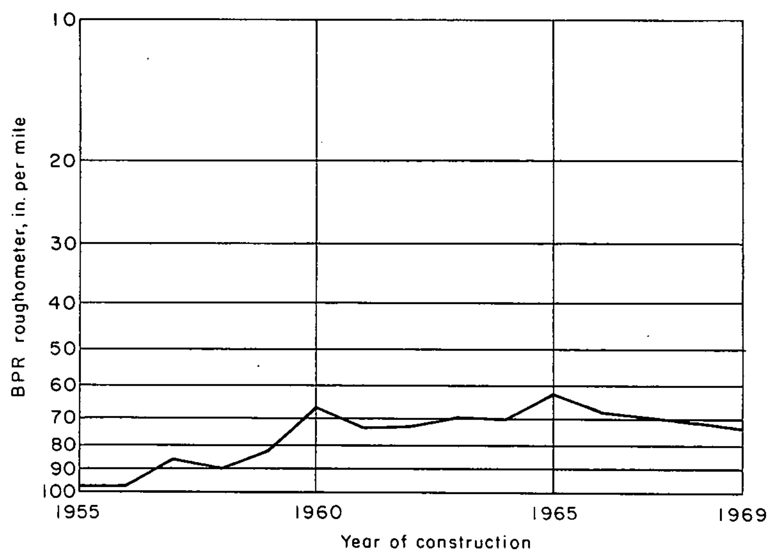

Figure 2. Average pavement roughness measured by BPR roughometer at time of construction.

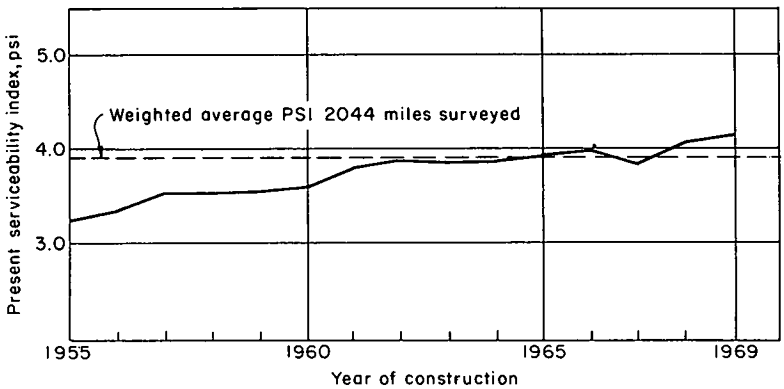

Figure 3. Average PSI of pavement constructed from 1955 through 1969.

Incidentally, 1961 was the first year of slip-form work by contractor G under the supervision of the individual who has headed this operation ever since.

There has been a marked improvement in serviceability results obtained by the contractors in 1968 and 1969 (Fig. 4), which probably is tied directly to the acquisition of electronically controlled subgrading equipment and central mixing plants in the case of all but one contractor. His work has maintained a high level of rideability because of good organization and good personnel.

One of the benefits from the current study has been the interest of the contractors. They are concerned about the ratings as shown on the chart. They understand that the

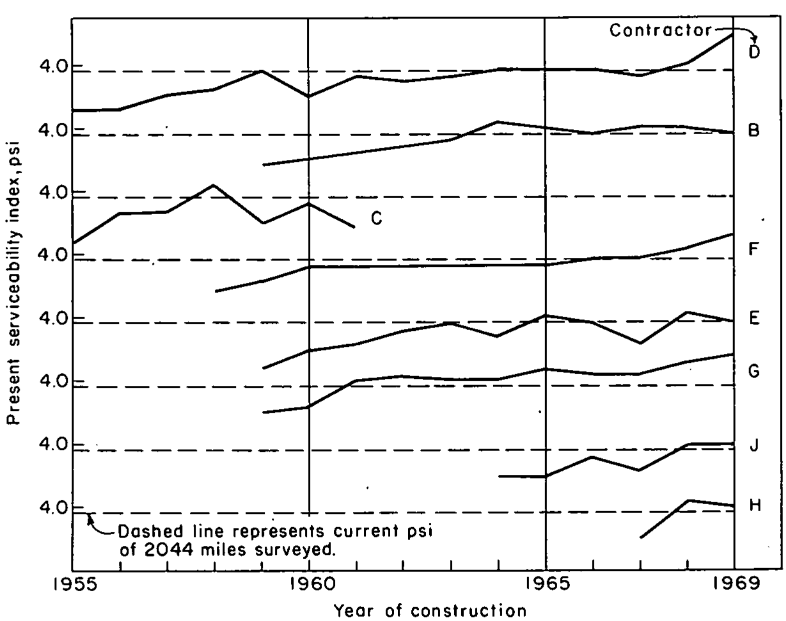

Figure 4. Current average PSI of pavement constructed during the year by each contractor.

purpose of rating these projects by contractor is not to determine which is the best, but rather to allow them to see if they have any deficiencies in their operation and help them to spot the troublesome area. By an analysis of their individual records and their own knowledge of the equipment they used and the personnel involved in each season's work, they can improve their records in the future.

SUMMARY

The roadmeter survey shows the average PSI for the 2,044 miles is 3.91, which is high in the "good" category. It is felt that the differences in construction techniques as the contractors gained knowledge and proficiency account for the slope of the performance trend curve to a larger extent than do age and traffic. It will be some time in the future before a more conclusive evaluation can be determined.

Reporting the findings of the survey as we have here in terms of average does not give the proper performance trend for individual projects. We are, therefore, giving each county engineer the current evaluation of each project in his county. By comparing this with subsequent evaluations he will be able to establish the trend for himself.

We have in Iowa the rare opportunity to observe the performance of thin concrete pavements under actual mixed traffic conditions with varying subgrade and with traffic counts from 200 to 2,000 vehicles per day. It is gratifying that, of the 2,044 miles surveyed, yearly average PSI values are 3.26 or better. This offers evidence that the decision to use 6- and 7-in. pavements for these county roads was valid. By making use of the existing secondary system that has been built at a cost of about $70 million (or an average of $33,000/mile), we can conduct our own road test on which to base future designs for this category of paving.

It is our hope that a continuing program of evaluating each project's initial rating and reevaluating at intervals can be maintained. Only by such a program can the engineers draw realistic conclusions as to the service that can be expected from their designs under differing conditions.

CONCLUSIONS

The PCA road meter was used effectively in evaluating 2,044 miles of concrete pavement on secondary roads in Iowa. These pavements, with up to 15 years of service, on the average rated good (3.26) to very good (4.15) on the PSI scale. The present survey provides basic data for continuing reevaluation of these pavements.

REFERENCES

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