Analysis and Use of Condition Data in the Design of Pavements

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•PAVEMENT condition surveys have formed an integral part of the activity of the Virginia Council of Highway Investigation and Research every since its establishment in 1949. The methods used have undergone considerable evolution until the present scheme, in which condition survey data are used to compute a serviceability index, was initiated in 1961. The data are derived from measurements of cracking, patching, and rutting, as defined at the AASHO Road Test, and of riding quality as determined with Virginia's BPR type road roughness trailer. The expressions for PSI were developed by the Road Test staff after the Virginia trailer had been correlated with the AASHO profilometer on 26 sections of pavement, both on and off the AASHO Road Test site. These expressions are

Rigid pavements:

$$PSI = 14.30 - 5.15 \log \overline{VR}_{20} - 0.09\sqrt{C + P}$$

Flexible pavements:

$$PSI = 12.54 - 4.49 \log \overline{VR}_{20} - 0.01\sqrt{C + P} - 1.38\,\overline{RD}^2$$

or

$$PSI = 12.98 - 4.70 \log \overline{VR}_{20} - 0.01\sqrt{C + P}$$

in which

PSI = present serviceability index (from 0 to 5.0),
C = pronounced cracking in sq ft per 1,000 sq ft (flexible) or lineal feet per 1,000 sq ft (rigid),
P = bituminous patching in sq ft per 1,000 sq ft, and
$\overline{RD}$ = mean rut depth in both wheel paths (depth of depression under a 4-ft straightedge) in in.

A trial has been given to the use of continuous strip-film photography to facilitate measurement of cracking and patching. On flexible pavements the contrast between cracked or patched pavement and completely undistressed pavement was considered inadequate, and at present the C and P factors are estimated from visual examinations made at the same time roughness measurements are made. On rigid pavements, where the effect of cracking and patching on PSI is nine times as great, the contrast fortunately is more obvious, and it has been decided that the strip-film photography will continue to be used as a part of the pavement condition survey. A contract for this service on about 75 lane miles of concrete pavement in Virginia is being negotiated.

To insure against error creeping into the PSI values from changes in the behavior of the road roughness indicator, this machine is checked at frequent intervals over various sections of road which seem unlikely to undergo significant changes in roughness. The machine also is checked often against a similar machine built and maintained to high standards of accuracy by the Bureau of Public Roads' Physical Research Laboratory at Langley, Virginia.

Most of the pavement condition surveys made in Virginia have as their purpose the furnishing of information to help evaluate the success of certain typical pavement designs. Condition surveys may take various forms, but generally they are made with a view to one or more of the following considerations:

1. Smoothness, or riding comfort.
2. Structural adequacy, or ability to carry and continue to carry the loads.
3. Safety.

These three aspects might be termed the three S's of pavement condition.

To the designer, whose job it is to decide the type and thickness of pavement and select the component materials to be used in each given situation, the first two S's are of chief concern. The contribution of the pavement itself to safety is limited largely to its skid resistance, which is governed by the type and proportioning of materials used in the surface course rather than by structural adequacy as a whole. To the designer, then, pavement condition surveys should result in a rating (or ratings) to indicate both smoothness and structural adequacy; such ratings should not consider skid resistance because that factor, important as it is, normally is not the concern of the man charged with designing the pavement from the structural standpoint.

The present serviceability index (PSI) has been touted widely as being one of the most significant developments to have come out of the AASHO Road Test. The HRB Pavement Condition Evaluation Committee has taken note of this fact and has made plans to conduct a correlation study to compare a number of different methods of measuring pavement roughness. Such a study would attempt to evaluate the effectiveness of the various systems of obtaining objective measurements which might be used to compute "present serviceability."

But the designer's interest goes well beyond the present. He is also interested in future serviceability, and in this respect the "present serviceability index" concept falls short. The fully useful pavement condition survey, to the designer as well as to the maintenance engineer, must include a measure of the second "S," structural adequacy.

The presence of cracks and patches in the pavement would seem to offer evidence of deficiencies in the pavement's ability to carry its traffic load. The expressions for the computation of the present serviceability index, given earlier, do take into account to some extent the presence of cracking and patching, but in the case of flexible pavements the total possible impact on the PSI value due to these manifestations is only 0.3 in the scale from 0.0 to 5.0. Cases have been noted in Virginia in which rather severely cracked asphaltic concrete pavements have higher PSI values than certain brand new pavements with other types of bituminous surfacing which happen to have a poorer riding quality. One pavement in particular, though its PSI value was still in the "good" range, was so badly cracked that maintenance funds were obtained to apply a seal treatment, after the accomplishment of which the PSI value was found not to have risen but to have dropped appreciably. It is doubtful that the maintenance division could ever be convinced that this pavement was less serviceable after the seal was applied than before.

Foremost in the mind of the designer, as well as of the maintenance engineer, is a question not so much of how serviceable a pavement is now but how long it will retain adequate serviceability under the anticipated traffic loads. The function of a complete pavement evaluation has been quite aptly described in a Corps of Engineers manual, EM 1110-45-751, entitled "Airfield Pavement Evaluation Concepts." This manual states:

> The design of a pavement contemplates the use of materials with certain strengths, placed at certain thicknesses, and with the capability of carrying a given load. Because of variations ... strengths and thicknesses obtained in construction may be greater or less than those contemplated in the design. The purpose of an evaluation is to determine the physical properties of an airfield as actually built, or in its current condition, and to establish its load carrying capacity for various aircraft types.

Such a determination obviously requires a more complete condition survey than would be required merely to obtain a present serviceability index.

Questions before this forum are, then, how best can a complete evaluation be accomplished? Should not a pavement condition survey provide measurements of present strength as well as present serviceability? How can plate bearing tests or pavement deflection measurements, made both on the surface and perhaps at the interfaces of the various layers, be used to evaluate structural adequacy? And, finally, can the joint contributions of riding quality, visible defects, and measurable strength be integrated into a single index of pavement adequacy?