Consideration of Appropriate Elements For Rating a Pavement

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● THE APPROACH to the rating of a pavement is a negative thing. By this is meant that no thought was given to a pavement structure in terms of the original condition which existed in any pavement which was being rated, but always in connection with the amount of destruction which has occurred or the amount of failure which had taken place from the time that the pavement had been constructed. Thinking then about the rating of a pavement in terms of failure, the following is presented.

In approaching the rating of a pavement in a rational manner, it appears to be sound that the pavement, as a structure, can act no differently than would be indicated by the behavior of its constituent parts. Any one of its several parts, for example, wearing course, base or subbase, might behave in a satisfactory manner alone, but might, in combination with other elements of a pavement, behave in a faulty manner.

An excellent wearing course of appropriate design and dimensional characteristics placed on a completely unstable foundation is taken as an example. Certainly, the expectation is that the pavement will fail because of the lack of stability in the foundation. That same wearing course on top of a good foundation would, on the other hand, behave in the desired manner.

ELEMENTS WHICH WILL CONTRIBUTE TO FAILURE

Any one of the elements of a road, starting with the wearing course and proceeding through the base course, subbase course and into the basement soil or foundation, can and does perform in a manner which will cause a pavement failure.

BASIC CAUSES OF A PAVEMENT FAILURE

The knowledge of engineers regarding the design of a wearing course has advanced to the point that pavement technicians can provide formulas of the combinations of aggregates, fillers and binder materials that provide both good stability and good durability. Occasionally, an attempt is made to utilize local materials which are not consistent enough to fall within the limits of good design practice. In these instances, failures in a number of wearing courses have occurred. To the greatest extent, however, the design of wearing courses has been good and their performance has been consistent with our design.

Assuming a wearing course properly designed, with good durability and with resistance to the natural forces of nature such as oxidation, freezing, thawing and moisture changes, then analysis of other basic causes which may result in a pavement failure and which are disassociated from the design of the mixture of the wearing course may proceed.

If a properly designed mixture in the wearing course remains in the exact position of the presumption of its design, there is no evidence of failure. Movement or distortion of the pavement structure can be caused by either the application of loads or by the natural forces of nature which are not associated with loading. The distortions which occur through the application of loads are well known to persons associated with highway construction and maintenance. To summarize briefly, rutting occurs through additional consolidation or displacement; shearing occurs through the application of loads beyond the capabilities of the structure. Not as commonly thought, but just as destructive of the integrity of a pavement, are movements caused by frost or by the change of volume associated with the swelling of some soils that behave badly when in the presence of water.

A project in Colorado was built to a modified AASHO standard of compaction and then covered with a rigid pavement. Within a period of 18 months, there was a differential heaving of the surface that varied from negligible amounts to as much as 12 in. Simply

stated, the pavement at certain points was 12 in. higher than when poured. There was no free water source to a depth of 30 ft. This type of differential movement of the basement soil causes disruptive forces which are readily apparent on the surface.

VISIBLE EVIDENCES OF FAILURE

In a wearing course, failures or incipient failures have the visible evidence of distortion from the design cross-section. For instance, where oxidation is present in bituminous materials, a pattern of cracking and surface abrading are common characteristics. In rigid pavements, there is the usual joint faulting, spalling and shearing cracks.

Movement or failure in the foundationing base and subbase courses is often visible in a surface distortion if it is of a magnitude which would not be possible in the wearing course alone. Some of the subsurface indications are rather hard to detect because they are of a type which is not readily detectable at the surface. There is, for instance, the loss in volume due to additional densification of the materials under the vibratory effect of traffic. There are cases where plastic materials have intruded upwards into the granular course and have, with the addition of a proper amount of moisture, caused a plastic flow.

The basement soils can be affected by a number of things, all of which cause them to act in a manner which occasions movement of a magnitude which induces failure of the pavement structure. Most common is a change in volume occasioned by a change in moisture. This increase or decrease in volume can be of an order which will be readily apparent at the surface. An increased volume usually is associated with a decreased bearing value, and this decreased bearing value might be of a magnitude which would put it in an area where the soil no longer would be able to resist the shearing stress.

The generalizations made above regarding wearing courses, supporting courses and the basement soils are certainly not intended to be all inclusive. They have been cited as examples of the types of things which are commonly associated with pavement failures.

OBSERVATIONS AND TOOLS TO MEASURE THE EVIDENCES OF FAILURE

Wearing courses are usually rated by the amount of measurable surface distortion or roughness, the number of linear feet of cracks, the amount of spalling or area of faulting which has occurred. The invisible is, in this case, probably more pertinent than the surface indications.

In recent years, some sonic equipment has been developed which gives a tool for measuring the structure integrity of rigid pavements. In flexible pavements, there are means to extract the binder and determine the amount of hardening of the residual asphalt which has occurred. There are tools to measure increases in density. The pioneering work of Benkleman let to a deflection tool which was associated in the WASHO Test with critical deflections by temperature ranges.

There are no means of evaluating from the surface, the base and subbase courses of the average highway unless the movement has been so severe that the wearing course has been disrupted. Drill tests can determine the thickness of the various layers, their moisture and density and, to some degree, any displacement which has occurred.

The evaluation of basement soils follows the methods that have been discussed for the base and subbase courses.

GROUPING OF ELEMENTS FOR RATING PURPOSES

Having reviewed the elements of the road structure which can have a part in the failure of a pavement, the tools to work with and the extent of the measurements which can be made, those elements which should be given consideration for inclusion in the rating of a pavement should be decided upon.

Table 1 shows the elements, the apparent adequacy of tools of measurement and the interrelationship between the elements which must be rated in order to arrive at a final rating of a pavement.

The assignment of values to any of these elements and their relationships has been omitted because the application of the rating should be known before this is decided. If

TABLE 1
ELEMENTS TO BE RATED, THEIR INTERDEPENDENCY BY RATING ITEMS AND ESTIMATE OF THE AVAILABILITY OF EVALUATION TESTS OR INSTRUMENTS

Elements of Pavement Structure	Items which Contribute to Failure	Dependency on Other Elements of Pavement when Rating	Availability of Tests or Evaluation Instruments for Rating
Wearing course	Design of mixture	No	Yes
	Thickness	Yes	No
	Adequacy of support	Yes	No
	Loading	Yes	Yes
	Environment	Yes	No
Base and subbase course	Basic stability	No	Yes
	Thickness	Yes	No
	Adequacy of support	Yes	No
	Loading	Yes	Yes
	Intrusion of plastic material	No	No
	Change in volume	No	No
Basement soil	Moisture and volume changes	No	Yes
	Overstressing due to inadequate strength in pavement structure	Yes	No

the purpose of the rating is to decide the effectiveness of a design, then the rating is wholly confined to determining the effect of loads of known magnitude on a structure of known characteristic. Opposed to this would be a pavement rating on a highway under normal usage and where the highway geometrics and the placement of the vehicle loads are just as important as the structural elements. The weight that would be given to the various elements in the two cases would have to be substantially different.

CONCLUSION

The preparation of this brief summary has brought to mind the frustration of many years of experience in the rating of highways. Most rating is done at a time when the highway structure has been destroyed as a usable facility, rather than at a time when the rating would provide information of a type which would permit of preventive maintenance. It is hoped that in the not too distant future, tools will become available which will permit prediction of failure in sufficient time to take the necessary steps to stop the destruction that is occurring from either loads or natural forces.

Discussion

W.H. CAMPEN, Manager, Omaha Testing Laboratories, Omaha, Nebraska — The ability to carry loads constitutes the most important function of an existing pavement. This characteristic can be evaluated by making deflection determinations by loaded steel plates or tires.

By either method the maximum load can be determined which will produce practically no permanent deformation and only a limited amount of elastic deformation. As to the latter, there seems to be a difference of opinion in regard to the allowable deflection. However, sufficient information is available to indicate that an elastic deflection of about 0.05 in. will be satisfactory.

R.E. LIVINGSTON, Closure, — The author agrees with Mr. Campen's statement that testing plates do develop good information regarding the load carrying capabilities of existing pavements. The information must be correlated with service behavior. In addition, there is not currently any agreement as to the allowable deflection before a pavement is determined to be distressed.