GROUP H

OTHER PERMANENT DEFORMATION

Chairman, Roger V. LeClerc; recorder, Stuart Williams; members, Richard D. Barksdale, Arthur T. Bergan, J. E. Fitzgerald, C. R. Hanes, Chester McDowell, James M. Rice, Frank H. Scrivner, James F. Shook, Aleksandar S. Vesic, and Harvey E. Wahls

Other permanent deformation, for the purpose of this workshop and this report, was defined as those permanent deformations in the roadway that are not induced by traffic and that do not include cracking, although the distortion might be a precursor to or cause of cracking. The primary cause or source of these deformation manifestations was considered to be hydrothermal volume changes in elements of the pavement structural section and the foundation thereof. Other sources of ancillary concern to the pavement designer, but nevertheless to be recognized, are problems associated with distortion due to differential settlement within embankments or displacement (creep) within embankment foundations.

PROBLEMS AND THEIR PRIORITIES

Discussions relative to definitions and delineation of specific deformation problems soon led to the realization that their import to the pavement designer could not be correctly and properly assessed until means were available for expressing the effects of distortion in terms of pavement serviceability, or lack of it. This then became the ranking problem—the one considered to have first priority in this area: the need to establish a means for measuring the effects of permanent deformation on the roadway in units of serviceability. Without this, the designer has no basis for decision criteria in selection of different designs to accommodate the anticipated volume change. With this, the designer will have a relevance yardstick.

Obviously, the major manifestations of permanent deformation turned out to be those associated with volume change that is nonuniform or differential in nature and is related to expansive soils and effects of freezing temperatures. Some means are now available for identifying and controlling expansive soils, and studies are currently in progress in the United States, Australia, South Africa, Morocco, and Israel. However, more answers are needed for design. Studies on freezing temperature volume changes are also under way, but there is much yet to be learned.

Whereas discussions were thorough on both aspects of volume change, the second most important problem area recommended for study combined these as follows: a need to improve our ability to predict, quantify, and control or design for movements, both total and differential, caused by hydrothermal volume changes in the pavement structure and the underlying foundation.

In the realm of overlay, second-stage, or maintenance design a badly distorted or warped roadway surface may be encountered. This may be the result of volume change activity either fully or partially complete. Such design situations represent the problem area considered next most important: a need to develop economical and effective means for at least semipermanent correction of serious pavement distortion resulting from hydrothermal volume change activity. Current measures are frequently of fleeting effectiveness if the volume change is of a continuing or cyclic nature. Means for permanent correction of the problem are many times quite gross and costly.

Not strictly within the province of the pavement designer, but still something leading to pavement deformation, is the distortion that results from uneven consolidation within

an embankment and its foundation and from displacement associated with the latter. Although the pavement designer can do little to control the consequences of this movement by design techniques, he can at least recognize this possibility (or probability) as an element in his decision criteria. Means for predicting and quantifying total settlement are available; no such methods are at hand for differential movement. This then becomes the problem area of fourth ranking: a need for means to predict embankment settlement, both total and differential, due to nonuniform consolidation and creep (flow) of soft foundation soil.

Two other aspects of permanent deformation considered of lesser import or possibly not strictly within the aegis of this group were discussed and are identified here. Additional details on all items are given in the discussion section. Permanent deformation in asphalt concrete from cyclic thermal effects has been noted in Utah Department of Highways laboratory studies but it has not been confirmed by field measurements except possibly deformation manifested by cracking. This information is, therefore, referred to the group concerned with this problem. Possibilities of permanent deformation from subsurface discontinuities (conduits) were noted and deemed inappropriate to our discussion of pavement design. Designers, however, should recognize it and encourage implementation of proper backfill techniques.

DISCUSSION OF PROBLEMS

Group H discussed a number of types of problems considered by various individual members to be pertinent and within the scope of the subject for this group. A brief summarization of the discussion on each item follows.

Volume Change Due to Moisture Variations in Expansive Soils

Although fractures of the pavement surface may result as a secondary manifestation of distress in this category, the group considered this within its subject scope because nonuniform permanent deformation is the principal and most significant result. After considerable discussion, it was the consensus of the group that this is a major problem in a large portion of the country.

An approach to the identification and control of potentially "expansive" soils is in use in Texas and is as known as potential vertical rise determination. In addition, several different methods have been developed elsewhere to alleviate or minimize the overall expansive soil problem. However, these methods have not been proved entirely and consequently are not universally used.

Various group members referred to research activities in progress in Texas, Colorado, South Dakota, Australia, Africa, and Israel. These activities include several fairly comprehensive experimental construction projects in which various methods are under operation.

The consensus was that research is needed to (a) predict and quantify potential movements caused by hydrothermal volume changes, both total and differential, that may occur in the pavement system, and (b) provide an adequate methodology for designing new pavements and for rehabilitating older pavements in areas where expansive soils are a problem.

Volume Change Resulting From Moisture Variations Within the Pavement Structure

Although the problem of volume change resulting from moisture variations within the pavement was recognized by the group, it was not considered to be a high-priority item and was, therefore, omitted from the final selection of the most important problems.

Volume Change of Pavement System Materials Resulting From Freezing Temperatures

Pavement deformations may result from positive or negative volume changes caused by temperatures below 32 F in the pavement system materials. Discussion brought out that the heaving effect that results from the formation of ice lenses has been quite

thoroughly studied and that a methodology for solutions to this problem is available. However, it was also brought out that a second type of behavorial phenomenon may occur that results in a decrease in volume with a decrease in temperature below 32 F. This type of deformation is apparently a major problem in Canada and in a number of northern states. The "conventional" expansion of freezing pavement elements or foundations resulting in either uniform or differential displacements was also recognized as a problem.

Adequate solutions to these problems are not available, nor are the problems well understood. Very little related research is in progress. Therefore, recommendations for future research on this item are included as a part of the group's overall recommendation for a study of hydrothermal volume changes.

Creep and Consolidation of Pavement Foundations

A relatively large amount of research on consolidation has been or is being accomplished. However, more work is needed on creep. Also there is a need to obtain information regarding the amount of differential movement that can be tolerated in embankments. Consequently, the group decided to recommend the initiation of the following research studies:

1. Establishment of a means for measuring the effects of permanent deformation on the roadway in units of serviceability; and
2. Development of improved methods for predicting the settlement, particularly differential, of embankments due to creep (flow) of very soft underlying foundations.

As discussions progressed, it became evident that the means for expressing permanent deformation in serviceability terms was a primary need. No means are now available for quantifying the deformation; therefore, evaluation of the extent and severity of the problem is not possible. This item thus became the number one priority.

Other Items

Investigation of volume change (shrinkage) in asphalt concrete due to cyclic thermal changes was reported to be in progress in Utah. Some discussion indicated that this was not confirmed by field measurements but has been possibly tied to transverse cracking. Although the volume change prior to cracking, and the suspected development of internal stresses, was considered within the scope of this group's subject, it was not explored further because the usual manifestation appears to be cracking. Reference of this problem to the appropriate group is made through this report.

A concluding item discussed was that of subsurface discontinuity due to conduit trenches. All agreed that this was a problem but one related only incidentally to pavement design. Consensus of the group was that improper trench backfill techniques would most certainly result in permanent deformation at the pavement surface. However, it was agreed that there was very little the pavement designer could do to rectify poor backfill construction; his efforts would be better spent on endorsing and encouraging proper backfill procedures.

SUMMARY

The deliberations of this group resulted in recommendations for studies or research that, when and if successfully completed, would provide the designer with means for measuring or evaluating consequences of permanent deformation, means for predicting possibility and extent of pavement deformation, means for controlling pavement deformation by design, and means for correcting those situations that have escaped these proper design procedures. However, these research studies will require a considerable length of time because of the complexity of the problem.

Whether the scope and extent of the permanent deformation problems described here will warrant high priority in the overall universe of pavement structural design problems will, of course, have to be evaluated. However, these problems occupy one or two of the "black boxes" in a pavement design system, and the system will not be complete without a solution output.