

frozen soil and permit of drainage. It is difficult to see how either of these two methods would be practical in a heavy soil which would not permit of the free movement of water away from the affected area. In some cases the steam jet is forced through the shoulder, so that the water can drain out through the holes left on the withdrawal of the jet. This method of use of the steam jet is certainly more logical in heavy soils. In a number of cases sand is used to replace the material removed from the center of the road, and this is effective for the time being and can be permanently effective if it is arranged to drain the sand after it is once placed. In order to take care of traffic, plank mats have been constructed and placed on one side of the road over the frost boil. Repairs to the other side of the road are then made, and traffic is then shifted to the repaired side. In order to be sure of traffic getting through, it is highly desirable that some means be used to insure this.

To sum up the entire situation, these frost boils are caused by the transfer of water by some means to a location in which the soil is already frozen, and at which this water then freezes. This builds up the amount of water in a given place to a very excessive amount. On thawing, this water practically reduces the soil to a liquid. If drainage is perfectly free at these points, this transfer of water will be to the drainage system and not to the soil itself. A good thick porous layer, preferably with tile drainage, will cure the situation. Stone drains are satisfactory in some of the lighter soil, but in heavy soils, after a few years, their effectiveness is greatly decreased. The points at which these frost boils will occur cannot, at the present time, be predicted, but with a more thorough knowledge of soils and the drainage of water through them, it may at some time be possible

BERM MAINTENANCE

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Maintenance of berms is engendered by two causes. First, with respect to the function of the berm as an earth retaining wall, and second, with respect to the berm, occasionally, as an extension of the effective roadway. The occasional use of berm space for parking does not entail any considerable depreciation.

Two general conditions, then, exist. First, the width of pavement is adequate for carrying traffic, and the use of the berm is only in holding the foundation for the pavement; and second, the width of pavement is inadequate and traffic overruns the edges.

These two conditions determine the use of grassed berms or ungrassed berms, and the analyses of these two conditions, maintenance methods, maintenance costs and special features, are the principal items of interest in this report.

I GRASS BERMS

Under the first condition, the general opinion is that sodding the berm and slopes gives the road a more pleasing appearance and reduces the maintenance to a minimum. The sod prevents erosion and confines maintenance to occasional mowing and raking.

II UNGRASSSED BERMS

Under the second condition, it is necessary to consider sub-topics

A. *Slight Use of Berm for Carrying Wheel Loads.* The light traffic roads are frequently of feathered edge construction and the surfacing material, sand, clay, gravel, slag or stone, is permitted to spread over the berm a sufficient width to protect the surface. The outer edge of the berm and slope can then be sodded to minimize erosion, as in the case of grassed berms.

Similarly, the surface treatments of macadams are permitted to spread a light protective cover beyond the width of the trench section of metal.

B. *Heavy Use of Berm for Carrying Wheel Loads.* In cases where the berm carries considerable traffic, economy of maintenance and protection of edge of the pavement frequently require trenching in a regular section of material, sand, gravel or stone, with soil, chips or bituminous binder, or in some cases, the addition of a concrete edge.

This is really widening, perhaps use of dual type widening. Its placing constitutes improvement and its upkeep constitutes surface maintenance rather than berm maintenance.

As to the width of such trenched shoulder protection, the general opinion is that ten feet is the proper width of traffic lane for effective width of roadway, and twenty, thirty, forty, fifty or sixty feet according to the number of traffic lanes. Practical considerations, however, do not always permit ten-foot width to the traffic lane and nine feet is now considered a serviceable width.

III. MAINTENANCE METHODS

The object of berm maintenance is to keep a smooth substantial berm of good appearance and an effective sealing of the edge of the pavement. The type of berm determines the maintenance upkeep. On grassed berms, operations are filling against the pavement edge, if necessary, mowing and raking, and the only refinement of method practicable is the use of the power mower, which has recently been developed into a practical road machine, to reduce costs. The ungrassed berms, in addition to the special filling along the edge of the pavement, require occasional surface maintenance as is usual with their corresponding type in the roadway, and the improved methods that apply to surface maintenance, such as use of power graders, or power distributors, apply also in these cases of berm maintenance.

IV. MAINTENANCE COSTS

Cost of berm maintenance ranges from about \$20 a mile to \$100 a mile, according to the nature of the berm and the extent of its use by traffic. Exceptional cases are reported of maintenance costs running up to \$300 a mile. The extent of use of the berm by traffic accounts for the higher maintenance charges, and a satisfactory analysis of these maintenance costs is not possible at present as there is not sufficient information available as to volume of traffic by width of road and type of berm.

Records of maintenance costs in Pennsylvania, however, indicate that under equivalent conditions of type and width of pavement and volume of traffic, grassed berms are more economical in maintenance than ungrassed berms. The range of maintenance costs of grassed berms is between from \$10 to \$15 a mile a year for macadams, for light and moderate traffic roads, and from \$20 to \$30 a mile a year for the concrete types, the heavy traffic roads, while the similar range of costs for the ungrassed berms is between from \$30 to \$40 for the light traffic roads and from \$50 to \$60 for the heavy traffic roads. It is true that in some cases there are ungrassed berms with heavy maintenance costs in places where it would not be practicable to maintain a grassed berm, but this condition is not sufficiently general to destroy the indication that there is economy as well as improvement of appearance in the use of sodded berms. (Costs quoted are road mile costs, the road mile constituting, generally, two berm miles)

V SPECIAL FEATURES

In two states the erosion of the berms, and in one of these states the excessive wear of berms, is reduced by use of elevated shoulders, and in the one state by a raised curb integral with the pavement, on heavy grades

The general practice, however, is to accept erosion and wear of berm as incidental to the usual slope of berm and as necessarily incidental to the principle of shedding water from the pavement to provide a dry wheel way and to facilitate maintenance operations, especially snow removal (Pennsylvania's practice is to use paved gutter or riprap where excessive erosion would, otherwise, be anticipated.)

DISCUSSION

REPORT OF COMMITTEE ON MAINTENANCE

C P OWENS

Missouri State Highway Commission

The short notice of my assignment allowed me only a very brief time in which to study the committee's report and to prepare a discussion worthy of this meeting. Having not had the opportunity for careful study, nor the benefits of prior association with the Highway Research Board, it will be necessary to state that my remarks are from my personal observation and experience, rather than from any extensive or intensive investigation and research.

I find very little in the report that might be criticized, rather, the report contains several points which should be emphasized. Other portions of the report might be expanded.

GENERAL

Mr Root's statement that of the one hundred seventy-two questionnaires sent out, only 40 were returned, is discouraging. It appears as if some drastic steps should be taken to awaken the various states, Highway Departments and other organizations to the importance of this work. More interest should be aroused and the various individuals who should be interested, be made to see the importance of the work and to cooperate more fully with the members of the committee.

The committee has divided its report into 5 topics as a matter of convenience. I will follow the same outline in my discussion.