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This paper on the maintenance phases of grass or turf shoulders adjoining road pavements is compiled from information received from a Nation-wide survey of the experiences of highway engineers in performing the necessary maintenance operations on shoulders for the convenience and safety of the highway users. The views and opinions expressed in this report are a summary of those given by maintenance engineers of practically all State highway departments and field engineers of the Public Roads Administration.

The substance of the information requested of highway engineers in the survey is briefly outlined as follows:

A low maintenance rating of shoulders during inspection disclosed a shoulder maintenance problem; hence a report was requested from the field for information on:

1. Grass shoulders
   a. Advantages
   b. Limitations
2. Effect of grass shoulders on various types of road surfaces.
3. Data regarding costs of grass shoulders relative to:
   a. Treated shoulders
   b. Untreated shoulders

The information received from highway maintenance engineers discloses that engineers ascribe variable functions to road shoulders. An example of this variance is found in the statement concerning the primary purposes for establishing a shoulder along roadway pavements. One State engineer holds that "shoulders are an integral part of the roadway," (traveled way) while another holds that the principal function or purpose of a shoulder is to provide "lateral support to the pavement, base and subgrade." A road shoulder should serve both of the above purposes as well as possess sufficient stability to support without harmful deformation any load which it may be called upon to sustain.

It is apparent from an examination of the shoulder maintenance reports that the problems of shoulder upkeep and repairs vary in some details in each section of the country. Likewise the emphasis given different types of shoulders varies in accordance with the amount of traffic, types of terrain, climatic condition, and other variables. There are, however, certain salient features of shoulder performance under maintenance that are generally experienced by all maintenance engineers. Those experiences that are found to be in common are summarized below. Special comment is made on features that appear to be conspicuous in the various States.

ADVANTAGES AND LIMITATIONS OF TURF SHOULDERS. Advantages commonly recognized among highway engineers are:

1. Economy of construction.
2. Maintenance economy where the road surface is at least 22 ft. in width, the volume of traffic is low, roughly not over 1000 vehicles per day, and the percent of heavy truck traffic is small.
3. Pleasing appearance of grass shoulders which normally blends with the roadside area and adds to the aesthetic aspects of the highway.
4. A good turf when once firmly established is quite effective in preventing erosion by wind or water.

5. Such a shoulder presents a distinct line of demarcation from the road pavement which tends to keep traffic off the shoulder area.
6. Maintenance and repairs can be accomplished with materials and equipment on hand or readily available.

Limitations commonly recognized by maintenance engineers are:

1. Grass shoulders have a tendency to rut badly when weakened by rains, during spring thaws or before the sod has developed.
2. As a corollary to item 2 above, the volume and character of traffic may limit the use of grass shoulders. This would be particularly true on heavily traveled high speed primary routes where there is considerable heavy weight traffic, and on narrow pavements. Excessive maintenance is required as well as a source of danger created by the shoulder conditions.
3. Grass shoulders have a tendency to "build up" or rise above the pavement edge which is caused by the accumulation of foreign matter such as sand, dust, debris, and yearly accretion of vegetation. This condition requires a "scalping" or "paring down" process periodically which may result in loss of all grass and root systems of the turf. Replacement of the shoulder may require reseeding or resodding.
4. Because of the "build-up" tendency described in subparagraph 3 above, surface water may be held on the road pavement causing - (a) Interference with snow removal operation; (b) Hazardous condition during freezing weather by the formation of ice; and (c) Damage to road pavement.
5. Grass shoulders as such are usually not of sufficient stability, especially when wet, to support vehicles for changing tires or other necessary off-pavement parking.
6. Maintenance and repair work are usually dependent upon the season of the year and weather condition for satisfactory results.
7. Grassed areas will not provide adequate stability for mail box turn-outs, farm or private road approaches or parking areas.
8. Vegetation on the shoulders may be destroyed by chemicals used in snow removal operations.
9. Turf shoulders are slippery when wet.

FURTHER PERTINENT ASPECTS.

1. In certain areas of the southwest and far west there is insufficient precipitation to provide year around vegetation. Several States in that area are currently in the process of removing the existing vegetation from the road shoulders and replacing the turf with granular materials having good binding qualities. Texas is leading in this process.
2. In several States the stability of the existing grass shoulders is being progressively enhanced by the addition of granular materials, while retaining within the shoulder material, sufficient fertile soil to support vegetation. This process is carried on at considerable maintenance expenditure. Illinois, Michigan, and Ohio are among other States following the above procedure.
3. In Ohio turf shoulders are presently in most general use and are usually included in the design of the new highways. Grass shoulders are considered desirable here because of the fertility of the soil and the abundance of precipitation which promotes quick and luxuriant growth.
4. In Michigan recent shoulder design generally calls for stabilized earth shoulders. Where a good stand of grass develops, an excellent shoulder results, but if grass does not grow, the shoulder is maintained as a stabilized earth surface. Michigan engineers assert that the shoulder efficiency "does not depend upon the establishment of sod for stability; however, if a sod does develop, the shoulder presents a better appearance and is easier to maintain."
5. Indiana engineers report "that a shoulder built of a mixture of stone and earth, capable of growing a sod surface may be a solution for the shoulder problem in Indiana."

6. The use of lip curbs or raised edge of pavement is an aid in protecting grass shoulders. This type of pavement construction was quite common in many States and is found on the older types of cement concrete surfaces. Kentucky appears to be a strong advocate of the lip curb although this State has recently modified its use to grades of 3 percent or over.

7. The present design of shoulder crown or "drop per foot" for grass shoulders is generally three-fourths of an inch per foot. Illinois engineers suggest that this be increased to one inch per foot to provide more rapid drainage. Virginia engineers have suggested as much as a 2-inch drop per foot. It is general practice to construct the grass shoulder at least one-half inch below the edge of pavement in order to mitigate the build-up tendency.

EFFECT OF GRASS SHOULDERS ON VARIOUS TYPES OF ROAD SURFACES.

(A) Climatic Changes - 1. Very meager direct comments were made on the effects of climatic changes on road surfaces where grass shoulders were constructed. Mr. E. L. Worthington, Commissioner, State Roads, West Virginia, finds "there is nothing to indicate that grass shoulders have any particularly different effect on the various types of pavement surfaces."

(B) Tendency of Turf Shoulder Build-up - 1. All State engineers mention the gradual building-up of grass shoulders, especially at the edges of the pavement. Mr. Bruce, Division Engineer of Division 1, Albany, New York, reports that "shoulders do not have any different effect on pavements except as the shoulders become high, especially true of grass shoulders. Surface water held on the pavement causes interference with snow removal and ice operations in winter and as the water seeps down into the subgrade a pumping action may occur, causing a breaking up of the surfacing." The report from Division 5,-North, St. Paul, Minnesota, contained nearly the same wording as above except the report stated more specifically of "surface failures as pumping of the joints on concrete pavements and progressive disintegration inwards of bituminous mats." The report from Division 5-South, Kansas City, Missouri, indicates that some maintenance engineers contend that sod shoulders have a tendency to weaken the edge of bituminous mats. It is also conceded that the maintenance of sod shoulders along concrete pavements is more expensive than similar shoulders along a bituminous pavement. There seems to be more of a tendency to drive off a concrete pavement which may cause the formation of ruts. Ruts at the pavement edge increase the cost of maintenance, but of more consequence present a distinct hazard to the traveling public.

DATA RELATIVE TO COSTS OF MAINTENANCE OF TURF SHOULDERS. The majority of State maintenance departments have meager data available on which to compare maintenance costs. Those States that have available cost figures claim that they are not conclusive. A few pertinent observations are made as follows:

1. Mr. Worthington, West Virginia, makes these comparisons: (a) Grass shoulders are cheapest to maintain; (b) Stabilized shoulders of selected material next cheapest; and (c) Earth shoulders are most expensive to maintain.

2. Maintenance engineers of Virginia have made a comparison between the cost of maintaining grass shoulders adjacent to narrow pavements and adjacent to wider pavements, each carrying a varying volume of traffic. It appears from this comparison that it is more expensive to maintain a grass shoulder along a 20-foot roadway than the same type shoulder along a 30-foot roadway, even though the latter carries considerably more traffic. In one district of the State it is shown that grass shoulders have been satisfactorily maintained where the volume of traffic on a two-lane road was under 1000 v.p.d., on a three-lane road from 1500 to 2000 v.p.d., and on a four-lane highway from 3000 to 4000 v.p.d.

3. Mississippi reports that the average maintenance cost of grass shoulders over several years was $55.70 per mile. These shoulders were not totally grass

covered. Certain sections were partially stabilized or paved. One section, having three-fifths of the width grass covered and the remaining two-fifths treated with gravel, cost on the average of $11.50 per mile over a 5-year period.

4. Indiana maintenance men contend that it is cheaper, where possible, to widen all surfaces of 16 feet, 18 or 20 feet to 22 feet, using grass shoulders adjacent to the wider surface than to maintain narrower surfaces with consequent expensive shoulder maintenance.

5. Minnesota reports little difference in the cost of sod or grass shoulder maintenance and the cost of maintaining gravel shoulders.

CONCLUSIONS.

1. Grass or turf shoulders are not structurally adequate to withstand the wear and tear prevalent along primary highways. These shoulders have a tendency to rut after heavy rains and during the spring thaws, presenting a hazardous condition.

2. The "build-up" tendency of grass shoulders requires frequent maintenance. This work is apt to be neglected by maintenance crews. As a result water may collect on the road surface, causing icy conditions in winter and instability of the shoulder and sub-base at all seasons of the year.

3. Areas - such as mail box turn-outs, farm, or private road approaches and roadside parking places - should have a more stable surface in order to support traffic under all weather conditions. Grass surfaces do not meet this requirement.

4. Several State highway departments, especially those where climatic and soil conditions are conducive of rapid and sustained vegetative growth, continue to favor grass shoulder design. This design is modified where traffic is heavy, both in volume and weight, and where off-pavement driving or parking is frequent, such as near schools, business and urban areas. In such places, some type of stabilized or paved shoulder should be provided.

5. Grass shoulders are more prevalent, especially on rural highways. This is primarily the consequence of earlier shoulder design when the traffic volume, weight, and speed were less than at present.

6. The data relative to the cost of maintenance of grass shoulders compared to treated or untreated shoulders were not sufficient to warrant drawing conclusions. It would seem, however, from a strictly dollars-and-cents value, that grass shoulders are more cheaply maintained under certain conditions. The intangible aspects of public safety and convenience should, however, be considered in a final analysis.

7. Where curbing is installed and to a lesser extent, where lip curbs were built as a part of the pavement, grass shoulders are adequate. The area adjacent to the outside of a curb, is in effect, however, not a shoulder but a portion of the roadside.

Attention should be directed to the basic source of information used in the preparation of this paper. In this respect the views and opinions of engineers responsible for the maintenance of turf shoulders embrace all shoulders under their jurisdiction and thus certain conclusions may not reflect accurately the maintenance viewpoint of the modern highway shoulder. The resemblance of a lawn-topsoil type of turf shoulder in general use along the older roads to the newly designed type of turf on a stabilized base is superficial. Shoulders best suited for the future highway will necessarily be influenced by the width of pavement and the volume and character of traffic.