

LOW COST IMPROVED ROADS—MAINTENANCE METHODS AND EQUIPMENT

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THE NECESSITY FOR A WELL ORGANIZED MAINTENANCE DEPARTMENT

A well organized maintenance division is a prerequisite of efficient and economical maintenance such as is essential for the proper service to the constantly increasing volume of highway traffic and for the judicious control of the increasing highway maintenance costs

• With the lower cost roads the effect of repairs on the serviceability and on the annual cost of the road is of greater import than with the higher first cost durable types. The increasing volume and weight of highway traffic is each year throwing a greater burden and responsibility on all of the roads. The high type construction is able to sustain the increasing volume and the greater loads without appreciably augmented deterioration, but the lighter types of improvement under more constant and heavier traffic suffer and require more frequent extensive repairs.

The frequency and extent of repairs causes inconvenience and interruption to travel as well as drainage of highway funds so that it is each year of greater importance that maintenance methods be standardized to the maximum of efficiency. This is the principal function of a maintenance division. Organization should be centralized for efficient planning and control of work and decentralized for effective and economical performance.

Headquarters should administer the maintenance funds so that each road is financed as closely as possible in accordance with its requirements. The central office should also program the work for the benefit of traffic and for the avoidance of interference between districts, purchase and furnish labor and equipment, provide transfer of funds, materials, equipment and labor at need; furnish the necessary auditing and accounting of expenditures and apply the improvements worked out in individual localities to the standards for the entire organization.

Field supervision keeps constant information as to condition of roads and work requirements, plans the work so as to use a minimum of labor and equipment and directs the operations to secure thoroughness and economy. Working forces should be supplied with the best

of tools and materials. As far as possible work should be planned to furnish steady employment to the necessary key men for maintenance work.

CONTINUOUS MAINTENANCE

The essential highway maintenance is of the traveled roadway or surface. Any inequality of surface is obstructive to traffic and detrimental to the surface itself. Any break in the surface exposes the subgrade to moisture with consequent weakening and any inequality of surface causes impact under wheel loads, at least annoying to traffic and in cumulative effect destructive to the road surface.

The first principle of surface maintenance, therefore, is continuous repair, patching holes when they first appear and before they become sufficiently large to be an annoyance to traffic or a serious damage in the road surface.

An ideal organization and method of continuous repair is, probably, the patrol or caretaker system, whereby a maintenance man is resident on and responsible for the care of a section of road of such length that he is able to patrol its entire length in one or two days.

Under some conditions, however, the patrol system is not practicable. In some sections, resident labor of this kind is not available, for instance, in mountainous sections, mining or industrial districts, or in the suburban areas adjacent to the large centers of population. Under these conditions close daily patrol being impracticable, recourse must be had to gang maintenance, which to be effective should be organized to provide repair service with sufficient frequency to approach continuous maintenance.

Whether the surface repair is provided by patrol or gang maintenance, there are periodic operations such as blading for earth and gravel roads and surface treatment (either chemical or bituminous) for stone and, in some cases, gravel roads. These operations require more equipment than is supplied to the patrolman or caretaker and are characteristically gang maintenance operations.

The field organization, generally, will require a judicious use of gang as well as patrol or caretaker methods.

Continuous maintenance is necessary to provide continuous road service as well as to avoid excessive costs.

Winter maintenance, in the northern parts of the United States, is largely snow removal. When snow is plowed from the wheelway, it should be moved back far enough to provide room for handling successive accumulations; that is, at least two feet back of the line.

of demarkation between surface and berm. Ample openings in the snow bank should be provided for draining off the water resulting from the melting snow so that the same operations that keep the road open for travel will be effective toward lowering spring maintenance costs

On roads where there is a width of surface sufficient to carry the travel, berm maintenance is very much simplified by sodding shoulder and slope. This practically eliminates erosion and necessitates only occasional mowing to keep shoulder and slope in good condition. This type of berm is also very pleasing to the eye.

ADEQUATE EQUIPMENT

Providing adequate equipment is important. Time as well as money must be considered. Method and performance of maintenance is dictated by expediency with a view to traffic service as well as efficiency with reference to maintenance costs. Frequently there are operations which could be more economically performed if spread throughout a period of months but which for the service of the traveling public must be performed within a space of weeks or even days. In other cases the work that is to be done, again in consideration of the traveling public, must be planned so as to avoid unnecessarily obstructing the roadway. The requirements are to keep the road open as well as to keep the cost down. Equipment demands are seasonal and peaked and the peak demand must be fulfilled even though the result is a certain amount of equipment idle for a large part of the year. About 25 per cent of the total highway maintenance expenditures are equipment charges. Selection is a principal factor in reducing the time requirement for maintenance operations.

SELECTION OF EQUIPMENT

The greater part of the equipment used for maintaining state roads is owned and operated by the state rather than rented from outside parties. The reasons are: First, that the work to be done in a given locality in a certain time frequently demands such a concentration of equipment that it could not be obtained locally, second, that if the state could not handle at least a large part of the work with its own equipment the rentals charged by outside parties might become excessive; third, the highway industry has developed a great deal of special type machinery applicable solely or principally to highway work and the use of such machinery is generally only available through purchase.

The use of light power graders expedites maintenance of unsodded berms and earth and earthbound surfaces. Mechanical spreaders and tank distributors speed up the application of surface treatments. Mechanical loading equipment, mechanical mixers and improved heaters enable the repair organization to patch bituminous surface with a minimum of time on the road.

In purchasing any equipment, first consideration must be given to the serviceability of the machinery for the purpose for which it is being provided, that is, its known ability to stand up and deliver service under road conditions. If the department is buying a type of machinery with which it has had no previous experience, it is necessary to secure reliable information from some other organization that has had the experience. Consideration also must be given to the price, to the adaptability of the machinery for other kinds of work, and to the manufacturer's reliability. It is important that all equipment, so far as possible, be of standardized type, that is, such equipment as has been on the market for several years and in which there is little likelihood of radical change in design. Rollers, traction engines, crushers, concrete mixers, air drills, compressors, and most of the other equipment that a State Highway Department requires, can be purchased in well-known types from reliable manufacturers.

With any class of equipment, standardization is desirable for two reasons. First, to avoid the necessity of carrying multiple stocks of repair parts, and second, to avoid the necessity for training repair men and operators to work on various makes.

In some cases, particularly when prices are uniform or equivalent, it may not be practicable to standardize upon one particular type or make, but it may be desirable to make the limitation two or three different types or makes.

In purchasing road tools, such as shovels, picks, etc., the specifications may be written closer than those for the larger equipment. Frequently the department can supplement its specifications to advantage by making laboratory tests of the fitness of the tool for its intended use. The Pennsylvania Department of Highways, for example, requires that specimen shovels be presented for test when such purchases are made.

The shovel test consists of a mechanical thrusting of the shovel into a standardized mass of loose aggregate. It is very easy, after a test of this kind has been completed, to make a selection with confidence that the purchased tool will give the best service under actual conditions.

The fitness of picks, bars, etc., can be determined easily by tests. It is as important to have reliable methods of testing road equipment and tools as it is to have definite specifications under which purchases can be made.

PARTICULAR REFERENCE TO THE TYPE OF EQUIPMENT FOR
DIFFERENT CLASSES OF MAINTENANCE

In maintenance of earth roads and earthbound surfaces the improved type of equipment is illustrated by the one-man power grader which has the advantage over horse-drawn equipment in being always available for service, able to work continuously through the hottest of days without time out for relief, and incurring practically no expense when idle.

For maintenance of the unbound stone roads and to some extent for use in maintaining gravel roads, there is equipment, either of the trailer or tailgate type for spreading an entire course of material or distributing patch resurfacing.

For the maintenance of bituminous types of pavement there are improved heaters and tank distributors for asphalt or tar. For use in patching there is the oil fuel heater, generally of fifty-gallon capacity, that eliminates the loss of time in gathering miscellaneous fuel and waiting for the somewhat slow heating of the bituminous material from time to time. The tank pressure distributor mounted on motor truck chassis has superseded the old hand-pouring pot in application and similarly the mechanical chip distributor, with mechanical loading device, is superseding the old hand methods for applying cover.

For applying paint to the road surface, for roadside maintenance and for snow removal, machines such as mechanical markers, power mowers on pneumatic tires, and truck and tractor snow plows, are economical and serviceable for the low cost as well as for the higher cost pavements.

A. *Earth Roads and Earthbound Surfaces Under Light Traffic* Maintenance of these roads, as far as possible, should be confined to dragging and blading with such handwork as may be required from time to time to care for drainage. Sections of road which do not properly respond to this class of maintenance should generally be improved by grading, drainage, or some strengthening or stabilization of natural material by application of stone, slag, etc., to surface.

B. *Earthbound Surfaces Under Moderate Traffic* These surfaces, in addition to drag and blade maintenance, may be preserved, par-

ticularly through the hot dry seasons, by the application of calcium chloride in the amount of one pound to the square yard, or a light oil at the rate of two-tenths of a gallon to the square yard, one application in the late spring, followed, perhaps, by a second application in the middle of the summer.

C. Bituminous Treated Surfaces The characteristic maintenance of bituminous treated surfaces is patching and surface treatment. The patching should be done thoroughly in spring and fall, in the spring to repair damages suffered through the winter during the time when patching was not practicable and in the fall to put the surface into water-tight condition to enter winter service; and the patching should be carried on through the summer to maintain an unbroken surface both for the satisfaction of traffic and to avoid destructive impact on the surface.

The patching method most favored is the application of oil and stone mixed before placing in the proportion of ten gallons of oil to a ton of stone. In repairing holes or breaks, it is customary to cut the surface to square edges, fill to a little above the surface of the road, and tamp level. In special cases where there are shallow depressions to be filled, the so-called "skin patch" can be used to advantage. In this method the surface of the road is cleaned, a light paint coat of about one-tenth of a gallon per square yard is applied, dry chips are added, painted with bituminous material and dry cover added, or after the surface has been cleaned and painted, chips and bituminous material mixed by hand at the side of the road are placed, tamped, and covered with dry chips. The surface treatment essentially consists of cleaning the surface, applying about $\frac{1}{4}$ of a gallon per square yard of bituminous material and covering with 20 to 30 pounds per square yard of clean dry chips. In Pennsylvania the chips used for covering surface treatment are graded $\frac{5}{8}$ to $1\frac{1}{4}$ inches.

The present day practise is to put the distributor over one-half width of the road, following immediately with cover, and allow this to dry from two to four days before treating the other side so that uninterrupted use of one-half width of road can be had without scattering chips and splashing cars. Where grades are heavy it is sometimes found of advantage to put a light scattering of chips on the road before oiling in order to check the tendency of the bituminous material to run along the road before the application of the cover, and also as a safety measure to traffic. This is sometimes called skid chipping.

THE BEST METHOD FOR MAINTAINING DIFFERENT TYPES OF ROAD-
WAY WHETHER OR NOT A LARGE NUMBER OF TYPES ARE A
DISADVANTAGE OR A NON-ECONOMIC INVESTMENT IN CARRYING
ON MAINTENANCE OF ROADS AND IN THE PURCHASE OF
EQUIPMENT

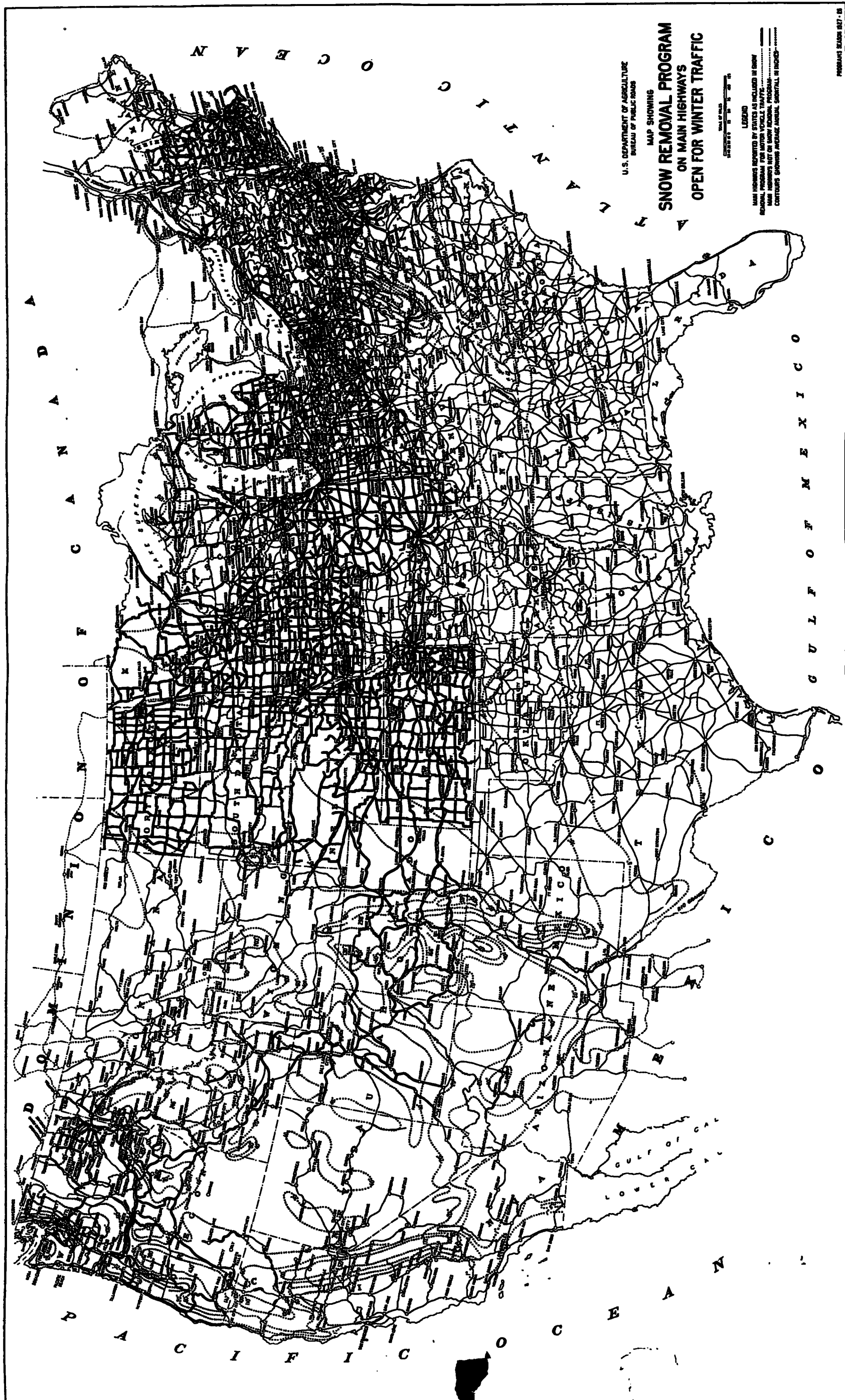
The question as to use of any particular type of improvement should be decided with reference to two points. First, suitability as to traffic requirements, second, economy, that is, annual carrying charges including interest, depreciation and maintenance costs.

Within the group of types that may be classified as low cost roads, the multiplicity of types is principally made up of various combinations of local surfacing materials and different classes of bituminous oils.

There is little difference in the maintenance methods required for the various types of low cost surfaces, the requirements generally being periodical surface treatments, occasional surface patching and berm maintenance, and the standard oiling distributor, chip spreader and the usual maintenance methods will apply.

The optional use of gravel, slag, or crushed stone, will, of course, require separate specifications and additional advertising and purchasing operations, as will the optional use of various classes of bituminous oils. Particularly, in the case of bituminous oils, there is a certain inconvenience in changing the class of material within a district, and the quantity of each class of material applied within an oiling district should be held to a practicable minimum. Otherwise, the particular characteristics of a type of road surface concern the particular patrolmen or caretakers and, of course, the maintenance superintendent, but do not materially complicate the state highway organization.

Each additional type of pavement may add a number to the maintenance code and may add an item to periodical reports. If there are a number of somewhat similar types, however, they may be grouped into one type and code, if it is essential to consider brevity of accounts. In general, consideration of practical serviceability and economy rather than convenience of administration should govern.



U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

MAP SHOWING

**SNOW REMOVAL PROGRAM
ON MAIN HIGHWAYS
OPEN FOR WINTER TRAFFIC**

SCALE OF MILES
0 10 20 30 40 50

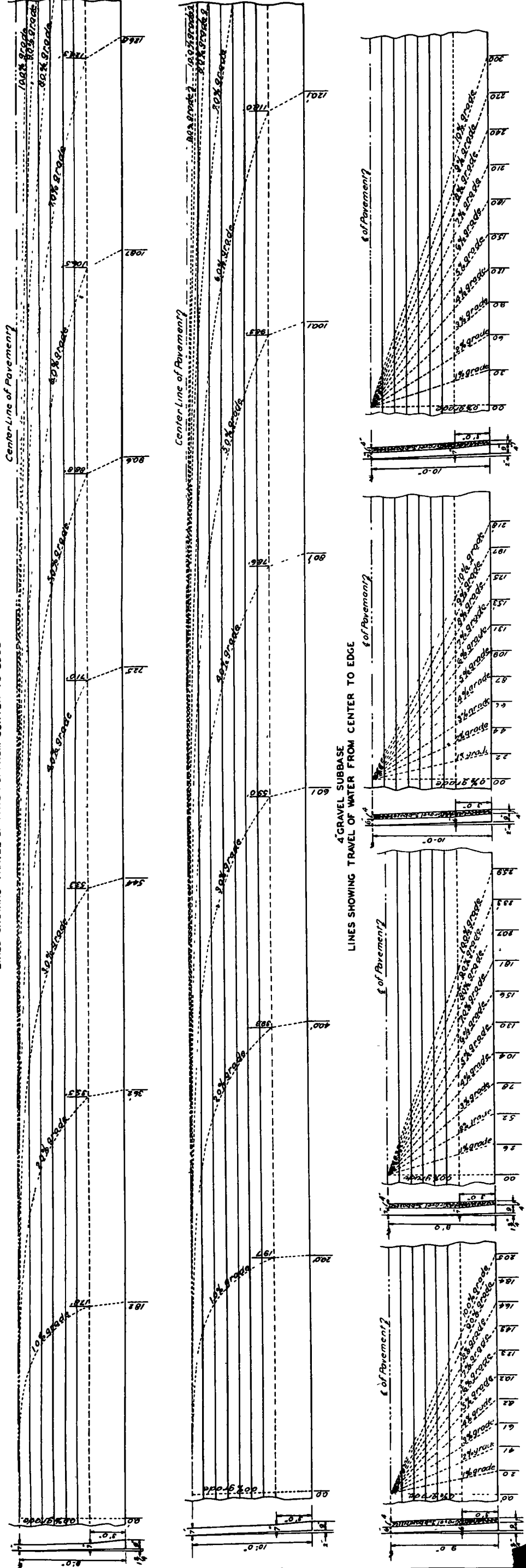
LEGEND

- MAIN HIGHWAYS REPORTED BY STATES AS INCLUDED IN SNOW REMOVAL PROGRAM FOR MOTOR VEHICLE TRAFFIC
- MAIN HIGHWAYS NOT ON SNOW REMOVAL PROGRAM
- CONTIGUOUS SPANNING AVERAGE ANNUAL SNOWFALL IN INCHES

MICHIGAN STATE HIGHWAY DEPARTMENT
PAVEMENT SURVEY

STUDY OF WATER MOVEMENT BENEATH PAVEMENT
NO SUBBASE
Scale Drawing 1/4" = 1'-0"

LINES SHOWING TRAVEL OF WATER FROM CENTER TO EDGE



WATER TRAVEL UNDER PAVEMENT WITH GRAVEL SUBBASE

Dist. from center line (ft)	Pavement 1% conc		Pavement 2% conc		Pavement 3% conc		Pavement 4% conc		Pavement 5% conc		Pavement 6% conc	
	Water travel	% grade	Water travel	% grade	Water travel	% grade	Water travel	% grade	Water travel	% grade	Water travel	% grade
0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
1.0	0.451	2.04	1.0	0.902	2.0	0.451	2.04	1.0	0.902	2.0	0.451	2.04
2.0	0.902	4.08	2.0	1.804	4.0	0.902	4.08	2.0	1.804	4.0	0.902	4.08
3.0	1.353	6.12	3.0	2.706	6.0	1.353	6.12	3.0	2.706	6.0	1.353	6.12
4.0	1.804	8.16	4.0	3.608	8.0	1.804	8.16	4.0	3.608	8.0	1.804	8.16
5.0	2.255	10.20	5.0	4.510	10.0	2.255	10.20	5.0	4.510	10.0	2.255	10.20
6.0	2.706	12.24	6.0	5.412	12.0	2.706	12.24	6.0	5.412	12.0	2.706	12.24
7.0	3.157	14.28	7.0	6.314	14.0	3.157	14.28	7.0	6.314	14.0	3.157	14.28
8.0	3.608	16.32	8.0	7.216	16.0	3.608	16.32	8.0	7.216	16.0	3.608	16.32
9.0	4.059	18.36	9.0	8.118	18.0	4.059	18.36	9.0	8.118	18.0	4.059	18.36
10.0	4.510	20.40	10.0	9.020	20.0	4.510	20.40	10.0	9.020	20.0	4.510	20.40

WATER TRAVEL UNDER 20 FT PAVEMENT

Dist. from center line (ft)	1% Slope		2% Slope		3% Slope		4% Slope		5% Slope		6% Slope		7% Slope		8% Slope		9% Slope	
	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope
0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

WATER TRAVEL UNDER 18 FT PAVEMENT

Dist. from center line (ft)	1% Slope		2% Slope		3% Slope		4% Slope		5% Slope		6% Slope		7% Slope		8% Slope		9% Slope	
	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope	Dist.	Slope
0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure 18