REPORT OF COMMITTEE ON MAINTENANCE

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The work of the Committee on Maintenance during 1926 has been concentrated on five major topics Each of these studies was given particular attention by one or two committee members, as follows

I Maintenance of Concrete Pavements—W A McLean and W E Hawkins

II Snow Removal and Snow Removal Equipment—H K Bishop and G C Dillman

III Coverings for Poorly Constructed and Disintegrating Concrete Roads—J T Donaghey

IV Annual Reduction in Thickness of Gravel Roads under Different Traffic and Effect of Dust Palliatives—A H Hinkle

V Maintenance Costs as Affected by the Type of Pavement and Amount of Traffic—W A Van Duzer

I MAINTENANCE OF CONCRETE PAVEMENTS

The repair and maintenance of concrete pavements is a matter in which experience is developing more effective methods and a better understanding of materials employed, and is therefore a field in which research may be expected to provide useful results

Maintenance work in concrete pavements will generally consist of—

Maintenance of contraction or other construction joints, treatment of cracks, treatment of small holes and spalled surfaces, treatment of scaling, replacement of cuts made for trenches, and restoration of sections of pavement broken under traffic, removal of inequalities in concrete surfaces, and treatment of subgrade settlement

Broadly, principles recognized in respect to maintenance are

1 So far as practicable, repairs should be made with the same material as that of which the pavement is constructed That is, cement concrete pavements should, when expedient, be repaired with cement concrete.

2 When it is impracticable to repair concrete pavements with the construction material, the materials now used are of a bituminous type, variously employed as conditions render expedient

3 The cause of cracking and breaking of the concrete slab should be removed as far as possible, and this may require the strengthening of the subgrade before the repair is made

4 Inequalities should be corrected after construction when necessary to provide an easy riding surface

1 REPAIRING WITH CONCRETE

The use of concrete in the repair of concrete pavements is indicated in cases where the pavement is cut for trenching purposes, or where a slab or section of a slab is so far broken that its replacement is desirable The following "Instructions for Replacing Cuts in Concrete Pavements" have been issued tentatively during the past year by the Portland Cement Association, and are representative of the best practice in this respect

"The most important thing about replacing pavement in cuts made for trenches is that the replacement be durable and its surface so uniform with the surrounding pavement that the repaired spot will be neither unsightly nor uneven It is of particular importance that the surface of the patch be even with that of the surrounding pavement If the following simple directions are carried out, the results will be satisfactory to all concerned

"*Preparation of the Cut for Replacement*—Trim the edges of the old pavement around the cut so they will be vertical with clean-cut, square corners at the pavement surface Remove all loose concrete and clean the edges of the old pavement by vigorous brushing with a stiff brush and clean water The earth in the bottom of the cut should be well tamped and should be damp when ready to place the concrete in the excavation The patch will always look better if it can be made of some regular shape, say round, or square, or rectangular A patch of irregular outline is always more or less unsightly in any type of pavement

"*Proportions for Concrete for Patching*—In most cases it is necessary to permit traffic over the replacement within a couple of days after placing This can be done with entire success, if the concrete for the replacement is proportioned and mixed so that it will develop high strength soon after placing The important details to be followed are to use rich mixtures, just as little mixing water as possible, together with plenty of tamping while the concrete is being placed in the excavation Use clean, coarse sand and clean pebbles or crushed stone The pebbles or crushed stone should have a maximum size of 1½ or 2 inches In general, stone or pebbles over 2 inches in size should not be used, as they offer some difficulty in placing and finishing with the stiff, dry mixture that is recommended

"It is also essential, when necessary to turn traffic over the replacement in a couple of days, that all the work be done in warm weather Concrete hardens much more rapidly in warm weather than in cold weather When the general temperatures are above 60 degrees Fahrenheit, most of the concrete materials, including the water, will be fairly warm The warmer the materials are and the warmer the air temperature, the faster the concrete will harden

"For quick hardening mixtures, use the following proportions for mixing the concrete One bag of standard Portland cement, one cubic foot of clean, coarse sand, two cubic feet of clean screened pebbles or crushed stone

"The mixing water should not exceed four gallons per sack of cement Use a small batch mixer if possible The batch can be mixed by shoveling,

but it is much better to use a mechanical mixer All of the materials, including the water, should be accurately measured and not guessed at To this mixture there should be added, for each sack of cement in the batch, two quarts of concentrated calcium chloride solution Directions for preparing this solution are given elsewhere In figuring the amount of mixing water, the calcium chloride solution should be included, that is, if a one-bag batch is used requiring two quarts of solution, then the amount of mixing water should not be over three and one-half gallons Addition of the calcium chloride solution has a tendency to make the concrete work more easily and makes it set up much more quickly

"The materials should be mixed in the drum for at least two minutes In general, the longer the material is mixed, the stronger will be the concrete and the more easily will it be handled

"*Placing and Finishing*—As the stiff mixture of concrete with the addition of calcium chloride will harden quite rapidly, it is necessary to work fast After mixing thoroughly, the concrete may be shoveled into the cut, and as it is placed it should be tamped hard against the sides and bottom of the cut It is especially important to tamp it vigorously against the sides and lower corners This can be done with a short piece of timber about 2 by 4 or 2 by 6 inches and 3 or 4 feet in length As the hole becomes filled up with concrete, tamp its surface vigorously both with the timber mentioned, and also with a paving tamper having a square metal face 12 inches each way and a long vertical handle The concrete should be filled in to slightly overfill the cut and the tamping should be kept up until the concrete is so hard that the tamper does not mark it and it can be walked upon without leaving footprints

"The surface should be checked with a straight-edge which will span the entire patch and any surplus worked down by means of a wooden hand float If necessary, sprinkle water on the surface occasionally so that this floating can be continued until the entire surface is smooth and even, and level in every direction with the surrounding pavement As soon as it is neatly finished, cover it with burlap sacks or canvas and keep it wet continuously for at least 10 hours If necessary, earth or sand can be placed on top of the burlap to a depth of 5 or 6 inches and saturated with water to keep the patch damp If necessary, provide a watchman or barricades to keep traffic off the patched area until it is at least 24 hours old In hot weather—that is, when the temperature day or night does not fall below 75 degrees Fahrenheit—such a patch will be hard enough to carry almost any traffic in 24 hours When the temperature falls to 60 degrees, especially within a short time after the patch is finished, then traffic should be kept off for 48 hours In colder weather much longer periods are necessary and it is best to keep the patch closed to traffic from 5 to 10 days at least before removing barricades

"*Caution*—The secret of success in good patching is to use a stiff and rich mixture with plenty of tamping Such mixtures shrink very little during the hardening period, and if there is plenty of tamping while the concrete is being placed, there will be almost no shrinkage at all Wet and sloppy mixtures shrink considerably and are almost sure to crack away from the edges of the pavement around the cut Never use wet or sloppy mixtures for patching

"*To Prepare the Concentrated Solution of Calcium Chloride*—Calcium chloride is a commercial salt which is now quite extensively used in pave-

ment construction It is sold in 100-pound, moisture-proof burlap bags or in light metal drums containing 350 pounds It is a very simple matter to prepare a concentrated solution of this salt

'Where only small patches are being made and only a batch or two of concrete required at a time, an ordinary 10 or 12 quart metal pail is large enough to mix the solution Have the pail about two-thirds full of clean water Pour into this water all of the calcium chloride that it will dissolve This material comes in flat white flakes, each about the size of a grain of corn It dissolves quite rapidly in water, and also has the property of attracting moisture out of the air, so if the sack of calcium chloride is left open, it will soon become very damp and lumpy Always keep it dry until you are ready to use it Keep pouring salt into the pail of water and stirring it vigorously until the water will dissolve no more salt You can make sure of this by pouring in enough calcium chloride so that there will be some remaining undissolved in the bottom of the pail Have a two-quart measuring pail and dip out two quarts of this saturated solution to add to the batch in the mixer for each sack of cement that it contains As the solution in the pail is used up, add more water and more of the calcium chloride, remembering to stir it frequently and always keep some undissolved chloride in the bottom of the pail

"If you are making large patches or replacements and are using a considerable quantity of concrete, it might be advisable to use a keg or even a large barrel for mixing this solution The solution will keep indefinitely without deteriorating, but always remember to keep your unused calcium chloride tied up in its moisture-proof bag so that the air does not get to it"

To the foregoing the Committee would add the recommendation that the effect of calcium chloride be tested for each brand of cement used, as reaction varies with different brands, also, that the patch should be extended under the adjacent pavement, so as to cover a larger area and reduce the load per square foot The spreading of the patch in this way will also support the adjoining pavement, so that it will not continue to fail

In making repairs and replacements with concrete, it is evident that a leading necessity is the use of a quick hardening concrete in order that interference with traffic may be minimized

In repairing corner breaks, it is particularly advantageous to open the repaired pavement at the very earliest time possible, as the concentration of traffic on the other side of the road tends to produce additional corner breaks on that side

When ordinary Portland cement is used, this involves (*a*) a mixture rich in cement, (*b*) the use of a minimum quantity of water, (*c*) thorough mixing, (*d*) the use of calcium chloride, and (*e*) the making of repairs during summer temperature In cases where these conditions are not obtainable, the use of a quick-hardening cement should be considered

Surface scaling is ordinarily caused by improper curing, over-manipulation, or light freezing Deep scaling results from heavy

freezing or from use of improper aggregate We do not consider a light surface scaling to be a serious matter and would not recommend any treatment If the scaling exceeds one-half inch in depth, or if excessive cracking develops, a bituminous covering is recommended

2 REPLACING WITH BITUMINOUS MATERIAL

The use of various grades of tar and asphalt for the maintenance of joints and cracks is common practice and has been the subject of a previous report by this Committee It is particularly recommended that when filling joints and cracks, the bituminous material should be merely brought flush with the adjoining pavement To permit it to spread two or three inches on each side of the crack is unsightly and causes a rough and poor riding surface Attention should therefore be given to the spout of the distributing can, to see that the opening is sufficiently small In case an ordinary watering can is used, it is sufficient to make an extension to the spout with small opening, and long enough that the man can fill the cracks without leaning

Protection of the men engaged in crack-filling work should not be overlooked On extremely heavy traveled roads this can be accomplished by working one side of the road at a time, keeping the equipment between the men and the oncoming traffic Filling cracks at night has also been resorted to, both to speed up the work and to protect the men

For the repair of holes, spalled depressions and wider cracks, a bituminous mastic is satisfactory The use of hot mix material implies, however, a large yardage of repairs, and ingredients of the cold-patch variety are therefore more commonly used

The Committee is of the opinion, however, that the maintenance of cracks, such as those in which bitumen is commonly used, is less difficult and expensive in pavements which have a reasonable number of temperature joints placed at the time of construction The Committee is further impressed with the possible value of "dummy joints" in this regard These joints are made by cutting a groove with a T-iron in the fresh concrete immediately after final floating, and inserting a strip of one-quarter-inch bituminous joint filler two inches in depth into this groove, the T-iron being such as to make a groove 2½ or 3 inches in depth The "dummy joint" is of special application in the case of longitudinal joints and in the case of joints where contraction rather than expansion is to be anticipated

3 STRENGTHENING THE SUBGRADE

Instructions for strengthening the subgrade and for more effectively supporting the concrete slab are very adequately given in a series of instructions to district engineers by the State Highway Engineer of Washington, in part as follows

"New pavements, particularly those on side hill sections, should be watched for subgrade settlement Side hill embankments and old embankments widened to permit of pavement construction sometimes settle along the edges and afford no support to the pavement If it is found that the subgrade has settled slightly, or considerably, the subgrade should be excavated as far back as the settlement goes and to a depth of 4 to 6 inches or as much as is necessary to permit of backfilling and ramming with a material that will compact, such as a gravelly clay It is impossible to satisfactorily backfill a one-half inch settlement without excavating under the pavement as far as the settlement goes to make room to work The backfill should be placed in small amounts and thoroughly rammed

"Where a panel or a portion of a panel has dropped below its normal elevation, due to a settlement of the subgrade, it should be jacked up and the subgrade built up to support the pavement in its original position This should be done in such a manner as not to break the slab Where possible, the slab should be raised far enough above the subgrade to allow the subgrade to be built up, tamped, and finished to, or slightly above, its original elevation Where the slab cannot be raised clear of the roadway, it should be raised to, or slightly above, its original elevation and the subgrade restored to its original condition, as described in the foregoing paragraph

"It is necessary to remove all expansion joint material surrounding a slab before attempting to raise it and to fill all cracks and joints with bituminous materials after the slab is replaced

"In all cases care should be taken to insure a well-compacted uniform base for the pavement slab, as soft spots in the subgrade will cause the pavement to break up

"Depressed sections of the pavement, such as occur at bridge ends and over culverts, can often be handled very effectively by means of a beam supported on jacks resting on the solid pavement at either side of the section and attached to the block to be raised by chains and cross pins The pin is placed across and on the under side of a hole drilled through the slab, the chain attached to pin and beam and the ends of the beam raised by means of jacks"

4 REMOVAL OF INEQUALITIES

A smooth and easy riding surface is one of the most important objects of present-day paving construction

The correction of inequalities in pavements recently laid is occasionally necessary, but this is particularly the case with older ones laid before the present methods were perfected to permit finishing and checking to insure trueness of surface

Means are now available for the repair of inequalities, comprising portable compressed air equipment and suitable chisels and hammers

CONCLUSION

One of the most valuable contributions of the year to the literature on methods of repairing concrete roads is an article by A H Hinkle, Superintendent of Maintenance, Indiana State Highway Commission, in a paper presented at the annual conference of the Mississippi Valley Association of State Highway Departments, and in which the experience of the State of Indiana is fully outlined We understand that in the State of Iowa, research is in progress with respect to the spalling of concrete

II SNOW REMOVAL AND SNOW REMOVAL EQUIPMENT

"Open roads for winter traffic" have grown considerably in popularity and activity since the last report on snow removal from rural highways and snow removal equipment was presented by this subcommittee Enthusiasm for winter maintenance has augmented to the stage, as judged from extended observations, where the taxpayers demand open roads the year round regardless of the cost, and will have snow removed from their main highways even if the funds required for that purpose curtail their summer road construction program Highway officials of the thirty-six snow States have reported to the Bureau of Public Roads that 62,165 miles of highways were kept clear of snow during the winter 1924-25 by their maintenance departments, with $1,826,800 expended for the work, and also that for the winter 1925-26 the roads cleared were increased to 93,000 miles with $3,757,660 expended This shows a tangible increase in terms of miles cleared of approximately 50 per cent The same officials report a program of open roads for the winter of 1926-27 aggregating 92,765 miles, with data for county programs omitted in some instances

At the close of the calendar year 1925, or during the winter under discussion, approximately 376,575 miles of paved rural roads were in place, both on and off the State systems, extending over the thirty-six snow States, and 16,139,859 motor vehicles were under registration in the same territory This motor vehicle registration for the snow States represents 66 per cent of all motor vehicles registered over the surface of the globe The cost of the improved road mileage is not available, but it is known that over the snow States during the past five years—1921 to 1925, inclusive—three and one-quarter billion dollars were expended on highway improvement and maintenance, and it has been estimated that on January 1, 1926, there were nearly three-quarters of a billion dollars available for construction and maintenance of rural roads over the snow territory for the