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Bituminous macadam, also known as penetration macadam because of its type of construction, is probably done an injustice more frequently than most any other type of pavement through inferior construction, attempts to construct too cheaply, and the salvaging of old gravel and stone surfaces that are not worthy of the consideration given them.

The quantity and quality of material that combines to make this pavement is of the utmost importance, yet no less important is the skill and judgment of workmen who assemble, rake, spread, penetrate, roll and mould these ingredients into the final compact surface. Weather conditions are a factor and must always be taken into account, low temperatures and dampness being especially objectionable. Unlike some types of pavement wherein costly mechanical appliances have been provided, which, if operated by honest hands, will do uniformly good work, the degree of refinement and perfection of a bituminous macadam job depends to a large extent upon the skill of workmen and the knowledge and alertness of the inspector in charge.

It is well to surface-treat a bituminous macadam pavement the first and probably second year after construction, and thereafter as surface conditions require. Original construction and surface treatment may be of either tar or asphalt. The lighter tar being more pliable, has been found to be quite practical for the first treatment after construction. It may be gone over with the ordinary drag such as is used in stone and gravel road maintenance. The drag carries surplus material (tar and stone chips) to the low places, also helping to eliminate the mechanical defects if any exist. The asphalt treatment will ordinarily wear longer and not need to be repeated so often. Those roads of which I have had personal observation, have had treatments ranging from a third of a gallon of bituminous material per square yard of surface, when first taken over by the state in bad condition, to as low as one sixth of a gallon per square yard of surface when found in good condition, treatments coming about every other year.

Before applying bituminous material, the surface to be treated must be thoroughly cleaned and dry. Traffic should be
kept off, both for its own protection and the good of the work, until after covering material has been added. If possible the road should be closed for one or two days, though in actual practice, I suspect there are more cases where traffic is merely warned of fresh bituminous materials than there are where the road being treated is really closed. The bituminous material should be uniformly applied at proper temperature from an approved pressure distributor.

It is essential and imperative that covering material be applied without delay after a surface has been treated, said covering to consist of stone, slag or gravel, thoroughly clean and graded closely between one-quarter and three-quarter inch in size. An excess of the larger size is preferable when treating an open, comparatively rough surface, while the smaller size is desirable when you have a surface that is well closed and smooth. The quantity of covering material to be used per square yard of surface depends upon the condition of the surface, the grade of tar or asphalt being applied, and the amount of same that is applied per square yard of surface. For estimate purposes, where tar is used, it might be said that fifty-four pounds of stone to the gallon or one cubic yard to forty-six gallons and where asphalt is used eighty-eight pounds of stone to the gallon or one cubic yard to twenty-eight gallons of the bituminous material is about right. The same gallonage would prevail per cubic yard for slag or gravel. The covering material should always be spread direct from dump trucks as they will spread it more uniformly and cheaper than can possibly be done by hand from piles or conveyance not equipped with dump. A bituminous macadam pavement properly constructed will improve under traffic and maintenance, riding smoother year after year.

**Lincoln Highway**

It has been my lot to have charge of the Lincoln Highway through Porter and LaPorte Counties where the State Highway Commission through its Maintenance Department has reconstructed the entire section of twenty-one miles between the cities of Valparaiso and LaPorte. Within this distance there were many vexing, if not contemptible things to handle, not the least of which was the matter of securing sufficient right-of-way on which to construct and operate a creditable pavement. There were drainage pipes and small concrete culverts to extend, new alignments requiring fills of half or entire width of roadbed, narrow grades to be widened, and worst of all a satisfactory base course to be prepared on which to place the bituminous top. Parts of the original road
had been well constructed as a waterbound macadam pavement (though with excess crown) to the width of ten and twelve feet and later surface treated, then parts were allowed to lapse into an ordinary stone road through failure to follow up with subsequent treatments. Other parts of this road consisted of a conglomeration of stone, slag, gravel, and cinders varying in width, depth, and quality of material until it was difficult to know just what additional new material should be added in preparing suitable base without being extravagant. The outer three feet on either side of an eighteen foot strip had to be built up throughout and a light waterbound course was necessary over the entire top, in most cases, to reduce the crown of the old surface when not required to give additional strength of base. At a few points it was found necessary to alter grade because of abrupt changes, but in the main every bit of the old road was salvaged and stands today as a part of the new construction, the taxpayer still realizing from the original investment in roadbed, stone, and drainage structures. This is the feature that should appeal to the taxpayer in this type of construction—nothing is wasted or destroyed that already exists.

**Maintenance**

Having misjudged strength of base or through other causes having secured faulty pavement, the matter of maintenance or repair becomes a more difficult problem. If the pavement breaks near the edges it indicates a weak base, poorly compacted fill in widening the roadbed, or lack of rolling or perhaps insufficient drainage. There may be a spot that shows signs of raveling or rutting due to insufficient bituminous material or failure to penetrate because of dirty surface closed too tightly or saturated with water. Whatever the cause may be it is well that those who have in charge the matter of making repairs should at first attempt to diagnose the case and then proceed to remedy both defect and cause in an intelligent manner, using one of the several grades of tar or asphalt best adapted to the character of repairs to be made.

Bituminous macadam surfaces can always be patched without seriously interfering with traffic. Patches are made of premixed cold or heated materials, or by penetration method if of sufficient size to warrant same and may be either hand tamped or rolled into place. More frequently the cold mix materials are used (tar T.C.M. or emulsified asphalt) and the patches being small and far apart, are compacted with hand tamp. The refinement to be attained in patching or eliminating construction defects, is entirely within the hands of those
performing the task. A skilled man with mechanical eye will feather-edge his work until you cannot tell where the patch is except by color and not at all after the next surface treatment has been applied.

The size of aggregate to be used should vary with the depth of patch or repairs that are being made. A deep patch might be made with all fine aggregate, but it would be more practical if the coarser sizes of stone were used, and with the thin layer to be feather-edged it is obvious that the smaller aggregate will have to be used. There is a small amount of settlement due to the mixed material compacting under tamp, and under later traffic, varying with the depth. That feature is readily mastered by the observing workman who can make proper allowance.

Where it becomes necessary to make repairs because of raveling or desire to eliminate a low spot due to faulty construction, the hole or surface is thoroughly swept and cleaned of all loose or foreign matter and painted lightly with the bituminous material of which the patch is being made. This insures bonding and helps to seal against moisture getting under the patch. Likewise the top should be sealed and made more dense by brushing a thin coat of the bituminous material over it and applying some fine stone or coarse sand. It is very necessary to have a dry surface and dry aggregate when using any of the bituminous repair materials except emulsified asphalt. This material may be used on a damp surface with damp aggregate, the only difference being that you mix less water with the emulsified asphalt under those conditions.

**Surface Treatment**

Surface treatment road work consists of two distinct types, that following the construction of a bituminous macadam pavement and that wherein the first bituminous material used consists of a treatment direct to the surface of a waterbound macadam, stone or gravel road. A well constructed waterbound macadam road that is not burdened with excessive traffic can be treated, made dustless, less costly in maintenance and frequently pass as a bituminous macadam job at a very low cost. If, when constructing the waterbound macadam road, it is known that a bituminous treatment is to be given, it is well to reduce the quantity of the screenings so as to leave the top stone exposed, making it possible for the bituminous material to adhere to more of the surface of this coarse aggregate. A waterbound surface must be thoroughly swept and cleaned of all foreign matter before treatment. The sur-
face must be dry and the temperature of the atmosphere above 45 degrees Fahrenheit. The temperature of the bituminous material to be as specified for the grade used and to be uniformly applied from an approved type of pressure distributor. Ordinarily on this type of surface treatment work, the gallon- age per square yard of surface is much greater than used on bituminous macadam maintenance, necessitating two or more applications. It should never be applied at such rate as will permit of bituminous material running off the edges of the metal and wasting.

The same principles involved in treating bituminous macadam and waterbound macadam also prevail in the treatment of stone and gravel surfaces. Under proper conditions, the first application of say three-tenths of a gallon per square yard will penetrate until it entirely disappears from the surface. After this treatment has been given sufficient time (perhaps twenty-four hours) in which to penetrate and get set, additional treatment or treatments follow until the required amount of bituminous material has been applied. Then the surface is covered with fine stone, slag, or gravel, the quantity depending upon condition of surface and amount of excess bituminous material that remains to be absorbed. It may be necessary to give a very light application of covering material after each application of bituminous material, to prevent flowing to the edges in case of smooth surface and excess crown, also to prevent picking up on distributor wheels when making the next application. After the last application and all covering material is in place, the surface should be dragged repeatedly until every chip or pebble is thoroughly coated and the surface becomes tacky. Traffic should be kept from the surface throughout the process of treatment and for about two days after dragging operations have ceased, during which time a curing effect takes place leaving a dry dustless surface that will stand up under quite heavy traffic. This is very cheap and practical maintenance when properly carried out under favorable conditions, though I fear it is too often tried as an experiment under adverse conditions, thereby resulting in the abominable pot holes and abrupt breaks in the surface such as we frequently find on heavy traveled streets through the smaller towns where an attempt has been made to eliminate the dust, regardless of the kind of surface to be treated, the grade of material to be used or the correct manner of applying.