BITUMINOUS ROADS.*

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B ITUMINOUS roads constitute a modern development to meet both the actual needs under modern traffic and the desires of modern civilization for greater efficiency, comfort, satisfaction and better sanitary conditions.

The introduction of the motor vehicle has greatly changed the conditions under which a road exists. The suction action of yielding tires is to remove the binder in a macadam surface and thus expose the stone to the action of traffic and the weather. There is then no longer a solid mass to meet conditions and disintegration occurs. Therefore, it is necessary to protect the macadam surface against this action of high-speed vehicles. Of the various materials which have been used in several types of roads, there is none equal to bitumen in its ability to withstand water, abrasion, and temperature changes.

There are three ways in which a road may be treated with bitumen, namely: (1) Penetration method, known as bituminous macadam; (2) mixing method, known as bituminous concrete; (3) bituminous surface, known as carpet coat.

A choice of these methods depends upon conditions, traffic conditions being the chief factor in deciding which of the three methods should be adopted.

Foundation and Drainage.—The necessity for stronger foundations and to this end for the best possible subdrainage, seems to be generally accepted, especially by those whose vision into the future is keen enough to permit them to recognize the probable increase in demands on the foundations, to be brought about by better surfaces and by the consequent growth in both the bulk and weight of traffic as well as in its severity. A firm foundation is an essential factor for permanent bituminous surfaces.

Again, in bituminous macadam the binding action of the bitumen tends to make the top course "spring" after each passing of the roller and in that way the road never can become firm with a yielding bottom course or foundation.

Bituminous Macadam (penetration method of construction).—On the prepared foundation, a layer of clean stone, varying in size from $1\frac{1}{2}$ ins. to 2 ins. or 2 ins. to 3 inc. 3 ins., should be spread to an uniform depth, usually 4 the stones have keyed together. On this surface prepared bitumes have keyed together. bituminous material heated to about 375° F., is applied at the rate of 13⁄4 gallons per square yard. Following this applicat: application stone chips are spread on the surface to fill the void. voids, and in sufficient quantity to cover the surface and permised in sufficient quantity to cover the surface and permit the passing of the roller without adhesion of the bitume bitumen to the wheels. This is then thoroughly rolled until the surface is uniform and hard. The squeegee or seal coat of bituminous material is then applied at the rate of ^{1/3} Sallon per square yard, followed with an application of ^{1/3} Store clean, dry of stone screenings from 1/8 in. to 1/2 in. in size, clean, dry and free from dust, sufficient to take up all excess bituminous material. The whole is then rolled, and by the aid of broom of brooms and the adding of more screenings if necessary, a unit

a uniform hard and smooth surface results. With this method of construction the question of size It is not so much the size as a practical uniformity in size that is essential. That is to say, if the smaller stone run

^{*}Read before the Conference on Road Construction, Department of Highways, Ontario, 1916. about $1\frac{1}{2}$ ins. to $1\frac{1}{2}$ ins., then the larger stone should not be greater than $2\frac{1}{2}$ ins. On the other hand, if the smaller stone is 2 ins. in size, then the larger stone may run 3 ins. The point is that a wide variation in size of the stone causes an irregular delivery; one load may run all fine and the next load all coarse stone. This condition is detrimental to the surface of road. The best results have been obtained by the use of stone passing a $2\frac{1}{2}$ -in. screen and retained by a $1\frac{1}{2}$ -in. screen, with stones breaking cubically with fairly rough surfaces and with sharp angles.

Still another important factor affecting a bituminous road is the sufficiency of the rolling given, as also in the case of a waterbound macadam road. It is fully recognized that with waterbound macadam roads, the utmost possible compaction and interlocking of the stone by rolling is necessary for first-class results. Hence, let us all remember the saying, "Rolling is the life of the road."

The proper selection of the bituminous material for use under this method, or under any method, is a serious one and is influenced by many conditions other than method of use, such as price, soil, weather and traffic conditions, conditions likely to prevail regarding aftermaintenance and cleaning.

The use of unrefined tars has been found unsatisfactory and has been practically abandoned. It is generally agreed that the presence in the tar of more than a minimum of water or ammoniacal liquor renders it undesirable for this method of use; that certain amounts of "light oils" are necessary for giving the desired fluidity in handling; that a good proportion of "heavy oil" is necessary in order that the tar may retain the longest possible life in elasticity after use, and under the effects of weather and traffic as well as for giving the body to the tar asked by this method; and that a limited amount of "free carbon" may be advisable in order to help to give body to the tar and to assist in reducing its susceptibility to changes in temperature. This "free carbon" may be either the natural fraction of the tar or it may be added foreign material, such as Portland cement or finely powdered limestone.

Some surfaces built by this method with a low carbon tar have improved as fine material was supplied by traffic.

It is acknowledged that uniformity of penetration is desirable. To this end, as well as for the sake of economy, efforts have been made to supplant the early system of hand-pouring by some mechanical distribution of the bituminous material. Some very successful machines have been devised for the purpose and it seems generally agreed that the best results under this method are secured by the use of such appliances distributing the tar under pressure.

An excess of bituminous material will give a surface which will become wavy under travel, and a similar effect is produced by material containing dirt, which does not permit enough penetration. In cases of unequal distribution, which is more likely under the hose application than in the method described, lean spots break up and go to pieces, while fat spots bunch up and form bumps. If the lower course is not filled, the hot bituminous material penetrates too far, with consequent loss of material in the surface.

Cost.—The usual variations in cost, resulting from different local conditions, have been present with penetration as with any other method.

However, it may be stated that with labor and material at average prices and work within reasonable distance from railway station, the cost for constructing a bituminous macadam road, in manner described, would be about 35 cents per square yard over and above the cost of building a waterbound macadam road. A decrease in