

all of whom have used the method of periodically taking accurate elevations in order to determine the amount of wear.

Various Methods of Bituminous Treatment. (a) Mixing Methods.—(1) in Factories; (2) on the Spot.—

Type A.: In 1910 practically all of the bituminous pavements of this type were constructed by hand mixing methods. In very few cases was the broken stone heated. During 1911 and 1912 there has been a general abandonment of hand mixing methods and a substitution thereof of various machines especially designed for the heating of the mineral aggregate and the mixing of it with bituminous materials. The introduction of these machines has made possible the use of the most suitable types of bituminous materials. Generally this type of mineral aggregate is mixed in portable mixing plants at the roadside.

Types B and C.: The mineral aggregate of these types of pavement has during 1911 and 1912 been universally mixed in a special machine designed to heat the mineral aggregate and mix with it the bituminous material. The location of the machine depends upon local conditions. In some cases the mixing plant is located at a railroad siding at which both the broken stone and the bituminous material are available and in other cases, near the road to be constructed. In some instances large mixing plants have been installed in municipal yards. Type C is also manufactured in the form of asphalt blocks at factories. The following reference to heated aggregates in the "Am. Soc. C.E. 1912 Report" is pertinent:

Your committee recommends that in the use of a heated aggregate for the construction of a bituminous pavement, non-uniformity or excess in the heating of stone, such as usually occurs with the use of flat plates or similar crude appliances for this purpose, should be avoided.

All of the above types have been constructed with and without a seal coat of bituminous material. The best practice, however, favors the use of a seal coat.

(c) Carpeting Methods: In the case of macadam roads, the mode of procedure is to thoroughly clean the surface by sweeping with hand bass brooms or horse sweepers or a combination of these methods. The bituminous material, which is generally heated, is applied to the surface with the aid of pouring cans, hose attached to gravity tanks, hand-drawn gravity distributors, horse-drawn or power-driven gravity distributors and pressure distributors. After a varying interval, some kind of mineral coating is generally applied to cover the bituminous material. The construction of bituminous surfaces on bituminous concrete pavements during the construction of the latter is usually accomplished by the use of brooms, squeegees or hand-drawn gravity distributors. For a periodic application of bituminous materials all the above methods are used.

Relative Advantages and Use of Tar, Tarry Compounds, Asphalt, Bitumen, and Other Materials. Tests and Chemical Analysis of Tarry, Bituminous and Asphaltic Compounds.—Bituminous surfaces: Since 1910 there has been slowly crystallizing an objection to the use of bituminous materials on macadam roads which require from one to three weeks to "set up" to such an extent that tracking will not occur. Refined coal tars and water gas tars, combinations of asphalts and tars, and certain asphalts have given satisfaction in this respect as they have "set up" satisfactorily within 6 to 48 hours. Usually about $\frac{1}{2}$ gal. per square yard has been used which

has been applied either in one or two applications. In the construction of bituminous surfaces at the time of the building of macadam roads, it has been found possible to employ the same grades of asphalt as are employed in the construction of bituminous pavements by penetration methods provided large stone is used in the surface and the latter is dry and thoroughly broomed.

Bituminous Concrete Pavements: In the construction of both the mix and the seal coat of Types A, B and C, asphalts, possessing the proper physical and chemical properties, have given excellent results. Coal gas and water gas tars have been used in the construction of Type A and to a very limited extent in the construction of Types B and C. In the construction of Type A, coal tar has been used in the mix and an asphalt for a seal coat with satisfactory results. The use of high carbon tar of a certain consistency does not appear to give satisfaction as a seal coat when the traffic includes many horse-drawn vehicles. Compounds of asphalt and tar have been used in the construction of Type A and to a limited extent in the construction of Types B and C.

The amount of bituminous material used is expressed as either so many gallons per square yard of wearing surface or as a given per cent. by weight of the mix. In the various types mentioned, the amount of bituminous material used varies from 5 to 10 per cent. by weight.

Climatic Effects Causing Slipperiness of the Roadway—Remedies.—In some cases bituminous concrete pavements with seal coats of tar and certain grades of asphalt have been slippery, especially in cold weather. Many types of bituminous pavements are rendered non-slippery by the application of an additional covering of stone chips or pea gravel.

Effect on Public Health, Fish Life, or Vegetation.—The effect of using bituminous surfaces and bituminous pavements has been beneficial from the above standpoints except that the odors characteristic of certain asphaltic oils are obnoxious.

Specification of the Methods of Construction.—Detailed specifications have been drawn up covering the construction of bituminous surfaces and the various types of bituminous concrete pavements referred to above. These specifications generally cover the quality and size of the various components of the mineral aggregate, the physical and chemical properties of the bituminous material and detailed descriptions of the methods to be used in mixing and in the laying of the wearing surface. Typical detail descriptions of methods are covered by the following references:

Bituminous surfaces: Trans. Am. Soc. C.E., 1911, Vol. LXXIII., pages 44-73, and 1912, Vol. LXV., pages 548-571. Bituminous concrete pavements. Types A, B and C: Trans. Am. Soc. C.E., 1911, Vol. LXXIII., pages 99-135, and 1912, Vol. LXXV., pages 572-648. Type A: Borough of Queens, N.Y., Special Report, 1912. Type B: 1911-1912 Specifications, Washington, D.C.; 1912 Specifications, Lincoln Park, Chicago, "Good Roads," April 6, 1912. Type C: 1911 Specifications, Borough of Richmond, N.Y.; 1912 Specifications, Borough of Queens, N.Y.; 1912 Specifications, New York State Highway Commission, 1912 Specifications, City of Philadelphia.

Cost Data.—Bituminous surfaces: The average cost of constructing a bituminous surface, using 0.5 gal. per square yard with either an asphaltic or a tar product or a combination of the two, is 7 cents per square yard.

Bituminous Concrete Pavements: Besides variations dependent upon local conditions, the cost varies with the