## EFFICIENCY OF THE APPLICATION OF BITU-MINOUS MATERIALS FOR SURFACE TREAT-MENTS ON GRAVEL AND BROKEN STONE ROADS\*

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BOUT ten years ago the dual problem of dust prevention and road preservation-to borrow the commonly used terms-first assumed importance. A large mileage of hard surface roads which were threatened with destruction; and a variety of bituminous products, differing widely in origin, consistency and behaviormany of which have now disappeared entirely from the market-were applied in the effort to preserve them. Prior to that time a good macadam road had been defined as one having a smooth, hard surface, furnishing a watertight roof for the earth subgrade beneath; and acting as a "more or less rigid stratum to distribute the concentrated pressure of wheel loads"-in other words, a foundation and wearing surface in one. Under this description, however, were included many roads which were in no wise suited to carry successfully a bituminous surface treatment.

The present-day macadam road requires at least equal rigidity, and regularity of surface contour has assumed even greater importance; but in addition it must meet the special requirement of presenting a suitable surface for the application of a liquid bituminous material. For the latter purpose there is fairly general agreement as to the necessity for a clean mosaic surface, with a maximum exposed area of tightly locked, coarse road metal and the least possible part of the surface occupied or covered by screenings, dust, or other fine material. If a graded aggregate has been used in the construction or resurfacing of the road it is essential that the distribution of the different sizes shall be uniform, the smaller pieces tending as nearly as possible to assist in locking the larger pieces and to reduce the size of the individual surface voids surrounding them; and that there shall be a complete absence of "pockets" of segregated small sizes. If this result is accomplished successfully the bitumen, after application, will have a direct and approximately uniform anchorage to the surfaces of pieces of solidly embedded road metal, and the gaps between the individual pieces, which must be filled and spanned by the mixture of bituminous material and mineral covering, will be of the least practical size. Stated in other words, it may be said that it is now an established fact that the success of bituminous surface treatments is far more dependent upon the condition of the roadway treated than upon the kind of bituminous material used or any other details in the process of application.

After making reasonable allowance for availability of bituminous materials and for all the differences in the climatic and traffic conditions to which the bituminous surface treated road will be exposed, it appears that a greater and more desirable degree of uniformity of practice in connection with this work will be reached only by more careful inquiry into the real purposes of bituminous surface treatments—leading to a more general agreement among engineers as to the general types of materials and methods to be employed to meet similar sets of conditions. Bituminous surface treatments at first

\*Paper presented before Section "D" of the American Association for the Advancement of Science, December 28th, 1917. appear to serve a number of distinct purposes in the preservation of the road surface but upon analysis these may be placed into two classes: (a) Priming and binding the upper portion of the road crust; (b) sealing and smoothing the road surface.

The screenings or fine material occupying the small voids or pockets surrounding the coarser pieces of aggregate must be saturated by the bituminous material to a degree that the particles will adhere to one another as well as to the contact surfaces of the adjacent road metal. This should further result in the formation of an irregular, but continuous, water-proofing layer below the road surface, serving to intercept water, drawn by capillary attraction from the subgrade. Contrasted with this, the sealing action consists in the formation of a continuous film of bitumen or bitumen-coated particles, coating the exposed surfaces of the upper layer of road metal and filling and bridging the gaps between the individual pieces of the latter with a tough, elastic mixture of mineral covering material and bitumen. This seal coat, so long as it remains intact, serves to waterproof the road surface and tends to produce a generally smooth and slightly resilient surface, lowering tractive resistance, reducing the abrasive and picking action of horse-drawn traffic and offering more effective resistance to the shearing and displacing action of motor-driven traffic.

In the selection of the proper material for application to a stone or gravel road these two functions should be weighted according to the necessities of the case. Roads receiving their first treatment undoubtedly require the priming action above described, as the first essential to successful results. Contrary to the practice of some localities, this would seem to limit first application materials to those which are liquid at normal air temperature. The full range of products which can be applied successfully for this purpose is not yet known, but in a given case the selection of the particular material to be used should undoubtedly be influenced by the question of whether the priming coat will be followed by the seal coat within a period of a day, a month, or whether an entire season would elapse. In the latter case, it is obvious that a heavier bodied material would be required than in the first instance. On the other hand, it cannot safely be assumed that all bituminous materials-regardless of character or origin-are necessarily of the same value as primers simply because they are of approximately the same liquid consistency. Observation and experience have taught that there is a considerable difference in behavior in this respect, and while no specifications as yet attempt to cover definitely this particular point, it has been suggested that a study of the surface tension of different products of about the same consistency be made, since this property bears a direct relation to the height to which a liquid will rise in a capillary tube, which may also be regarded as a measure of its ability to creep down into the irregular capillary tubes formed between the fine particles of mineral matter in a road surface.

In this same connection it should be remembered that just as the usual "hot application" bituminous material is liquid only so long as it retains its heat, similarly, many products which are liquid at normal temperature may remain so only so long as they retain their volatile constituents. If the latter are lost too quickly, the bituminous material will thicken so rapidly as to fail to serve its purpose as a primer. If, as is frequently the case, a bituminous material for first application must serve not only as a primer, but also provide sufficient surface sealing so that the road may safely carry a season's traffic, the most desirable product is that which is so constituted that,