

year except in a few places. This same road also has an average of 55 motor trucks a day.

Near two traffic taking stations, where the teaming was heavy, for one-quarter of a mile in each place (out of four miles), the blanket oil failed. It crumbled, went into mud, developed holes and was disappearing. We have replaced the top 3 in. with an asphaltic bituminous macadam.

**Heavy Horse-Drawn Wagons Cause Failure.**—The traffic study shows that it is not the number of wagons, but heavy wagons—two or more horses and heavy loads on narrow tires—that cause the failure. The failure of roads treated with heavy oil has occurred on a few miles of road at certain places where it was clear that heavy horse-drawn wagons were responsible.

In two instances it was 50 to 75 ice-wagons a day, together with other wagons, carrying 3 tons or more each on 2½ to 3-in. tires which did the damage. In a month the oil surface began to crumble and break up on the side of the road on which the loaded teams travelled. The surface lasted three months on the other side of the road where these wagons came back empty. The same road, treated with the same oil, is still in good condition beyond the ice-houses. In one case for 3 miles, in the other for 15 or 16 miles, the oil surface is three years old and still needs only patching. Light cold oil has been substituted as a dust-layer and has proved reasonably satisfactory, though the stone of course is wearing out, and a bituminous macadam would probably prove economical.

In 1909 another important road, which had been covered with a hot oil blanket, was rutting and wearing out rapidly. A coal team was passing to some hotels three or four times a day during the summer (carrying 6 or 7 tons of coal on narrow tires). When a motor truck was substituted for the coal team the surface of the road, which had been oiled, was again in good condition. It has worn three years and now needs only patching.

**Hot Oil Blanket Surface.**—A hot oil blanket surface, made of a good asphaltic oil, will be economical and will carry large numbers of automobiles at high speeds (over 1,000 a day in summer) for several years, will carry large numbers of light wagons (500 a day), and quite a number of motor trucks (50 or so a day), but will be destroyed by a large number of heavy wagons, especially those with narrow tires. Fifty or more such vehicles daily, farm wagons, wood wagons, etc., will rapidly destroy the road surface. A surface coat of a good quality of tar will last satisfactorily under a large amount of automobile travel, but usually it has to be renewed more often than a good quality of oil.

In all cases it is assumed that holes and depressions will be filled before tar or oil is used, that the bituminous material is evenly distributed and is sufficiently covered and kept so that it will not be picked up on tires, and that all holes that develop are patched at once as soon as they appear.

Constant repairs, at a cost of 1 to 2c. a sq. yd. a year will save an expenditure of from 40c. to \$1 a sq. yd. for the resurfacing of these bituminous surfaces if they are allowed to go to pieces; and they will do it in a year or two at the most, if not cared for properly.

When these surface treatments fail, as they will where the traffic is extremely heavy (heavy in weight of vehicles, not numbers of vehicles), then some more permanent form of construction must be selected and the road reconstructed as soon as possible. It will prove to be true economy in the end, and the end is not far off.

Light cold oils, water-gas tar, etc., used as dust-layers help to prevent the ravelling of roads. These materials may be economical and work satisfactorily for small wagon traffic (30 to 50 a day) and medium automobile traffic (50 to 100 a day), provided the road is not one where high speeds are usual.

They may also help to preserve the road from the effect of automobile traffic where the team traffic is too heavy, or the loads are carried on such narrow tires that a hot oil blanket surface will not wear satisfactorily, until money becomes available to resurface the top 3 in. with some form of bituminous macadam.

**Conclusions Summarized.**—The accompanying table shows as nearly as possible the results observed after four years of experience with bituminous materials, comparing these results with the traffic going over the road in 1909 and again in 1912.

It is fully realized that more experience will undoubtedly change or modifications in some of the present opinions.

**Table Showing Kinds of Road Surfacing Best Adapted to Different Classes of Traffic for a Standard Road 15 Ft. in Width, With a 3-Ft. Gravel Shoulder on Each Side.**

	Light wagons	Average Daily Traffic Heavy wagons one horse	Heavy wagons 2 or more horses	Automobiles a day
A GOOD GRAVEL ROAD will wear reasonably well and be economical with.....	50 to 75	25 to 30	10 to 12	100 to 150
Needs to be oiled with.....				over 150
OILED GRAVEL fairly good either hot or heavy cold oil ½ gal. coating (cold oil must be used yearly) ....	75 to 100	30 to 50	20	500 to 700
WATER - BOUND MACADAM will stand with.....	100 to 150	175 to 200	60 to 80	Not over 75 at high speed
Dust-layer will prove serviceable on such macadam with.....			perhaps more	50 to 100
Macadam will then stand (but the stone wears, of course), with.....				300 to 500
WATER - BOUND MACADAM WITH HOT OIL BLANKET COAT will be economical with.....	250 to 300	75 to 100	25 to 30	Up to 1400 and more with fewer teams
Will stand at least.....	50 motor trucks		probably more	
But will crumble and perhaps fail with over.....	100 on narrow tires (loaded farm wagons)	50 ice and wood wagons, etc.)		
WATER - BOUND MACADAM WITH A GOOD SURFACE COATING OF TAR will stand with.....	30 to 50	25 to 30	10 to 15	1800

The quality of gravel or other material and the speed of motor vehicles in particular localities are important factors and account for the above minimum and maximum variations.

It has not yet been satisfactorily determined when the weight of traffic makes it more economical to use a bituminous macadam, either tar or asphaltic products by penetration with a sealing coat of tar or asphalt, or by the mixing method, but it is believed that some such method would be economical and desirable where the team traffic is so heavy (75 to 100 heavy wagons on narrow tires with two or more horses), that a heavy, hot oil blanket surface will not carry the traffic but fails within the year.

We have several such bituminous macadam roads which have stood for three or four years very well indeed, but time alone will determine the ultimate economy. In surfacing with a 3-in. bituminous macadam top the extra cost for such top has varied from 30 to 60c. a sq. yd., depending on material and methods used.