girder due to the tearing of the burlap over the hump at the cross girder joint. This seemed to be caused by a slight expansion and contraction of the slabs and tendency of the waterproofing to travel down the slope of the hump due to the load of an engine above it. The crack which opened up was sometimes as wide as ¼ in. Some method of allowing for this had to be used so a 1-in. pipe was laid over the joint, the burlap put on in the regular way, the pipe withdrawn, and the mastic applied. This scheme was used on all work during the year 1909 and thereafter. Another precaution was taken by putting a flatter slope on the hump, the concrete being run out with about 3 ft. 6 in., so that the tendency of the waterproofing to slide down was diminished. The bridges waterproofed during 1909 are almost devoid of leaks.

The bridges which were waterproofed by filling the joints in 1906 and 1907 have since been waterproofed by the latter method. Those which were waterproofed during 1908 developed leaks where the waterproofing cracked and repair work was started during the fall of 1911. In this repair work the mastic was chipped off for a distance of 8 in. each side of the crack. The burlap was cut away from the crack to the edge of the mastic on the street slab. A 1-in. pipe was then laid over the joint and the mastic and the burlap was cut away from the crack to the edge of the mastic on the street slab. A 1-in. pipe was then laid over the joint and the mastic and the burlap on the street slab lifted up so that a new strip of burlap could be inserted under it. It was lapped under about 9 in. and then laid over the old burlap on the slope. Five-ply were laid, each painted with asphalt, the pipe withdrawn (thus allowing for expansion), and new mastic put on.

Records have been kept of the dates when different portions of the bridges were waterproofed. This repair work has shown that during the cold weather the asphalt that is applied to the cold concrete becomes chilled and does not penetrate the burlap which is laid on it. If the weather was very cold even the coat which was mopped on this first layer of burlap did not penetrate it, due to the fact that the cold concrete had chilled it. The second layer of burlap seemed to have been pretty well saturated in all cases, while the third layer was thoroughly saturated. In waterproofing which was laid during warm weather all of the burlap was in a good state of preservation, having been well saturated with the asphalt. The mastic seemed to protect the burlap very well, although in some cases track tools had penetrated it, causing leaks. The smaller sizes of crushed stone of about ½ in. did not penetrate the mastic as much as the larger sizes on account of the more uniform bearing.

The average force used on this work consisted of:

1 foreman	.....at	$.33	per hour.
3 finishers	.....at	.25	per hour.
1 kettleman	.....at	.27½	per hour.
8 laborers	.....at	.20	per hour.

These men waterproofed a bridge 14 ft. wide and 75 ft. long, or 1,050 sq. ft. per ten-hour day. The average cost of the latter waterproofing was a little less than 14 cents per sq. ft. for the burlap and the mastic, not counting the concreting over the hump and bridge seat and the filling of the joints with mortar. This work was done by another gang the day previous to the waterproofing. It added about three cents per sq. ft. to the cost, making a total of 17 cents.

This work was done under the direction of C. H. Cartlidge, bridge engineer, and L. J. Hotchkiss, assistant bridge engineer, and was directly in charge of F. H. Cramer, by whom much of the material in this article was furnished.

SOME METHODS OF PREVENTING DUST ON MACADAM ROADS.*

By John F. Icke, City Engineer, Madison.

A macadam road, as we all know, is made of crushed stone of varying sizes, held in place by filling the interstices with smaller stone, stone dust, or other suitable material as a binder. In the ordinary water bound macadam a cementing action takes place between the crushed stone and the dust used as a binder, the degree of this cementing action depending upon the material used as crushed stone and the material used as a binder.

The harder the rock, the less able it is to absorb moisture, and the more difficult it is to bind. For this reason the granites are more difficult to bind than the limestones when used as a road material.

In order to keep macadam street in good condition it must receive sufficient traffic to furnish more or less dust, and moisture must be provided to aid in keeping the stone cemented. If a sufficient amount of moisture is not present then the road will ravel and will be rapidly destroyed, especially if very much automobile traffic passes over the road:

In order to supply the necessary moisture the method known to all of us of applying water with a sprinkling wagon has been used almost exclusively in the past. The water so applied furnishes the moisture which is absolutely necessary to keep the macadam well bound, and also acts as a dust layer, or dust preventative.

Many objections to the use of water as a dust preventative may, however, be urged. If the water is applied in just the right quantity to lay the dust, but not in quantities enough to make the road surface unnecessarily muddy, then the service may be considered fairly satisfactory. The difficulty lies, however, in the almost impossible task of having the water applied often enough, and in quantities sufficient only to keep the surface moist.

Another objection to the use of water is on account of the injurious effect upon the road material that the frequent application of water has. Any slight depression in the surface of the road will collect and hold water, which will soften up the road surface and hasten the formation of still greater depressions. Still another objection exists in case the supply of water is inadequate. The demand upon the waterworks system is usually already great at that season of the year when the sprinkling of the streets is most urgent and in many cases the heavy demand of the sprinklers seriously interferes with the pressure throughout the system.

For some years past engineers and others interestel in road work have been experimenting with various materials and methods of application, designed as a substitute for water as a dust layer. The use of tar or asphaltic oil applied to the surface of the road, or of tar or asphalt as a binder for the upper two or three inches of th eroad surface is now good practice in many localities.

The application of tar or asphaltic oil on the surface of the road is generally spoken of as surface treatment. The writer's experience with the use of tar in the surface treatment of macadam streets dates back to the year 1908, when the first trial was made. The material used was a prepared tar, known as Tarvia A, made by the Barrett Manufacturing Company.

The street in question was one built of crushed limestone in 1897. The surface was in ideal condition, with very

* Extract paper read at 1912 meeting Engineering Society of Wisconsin.