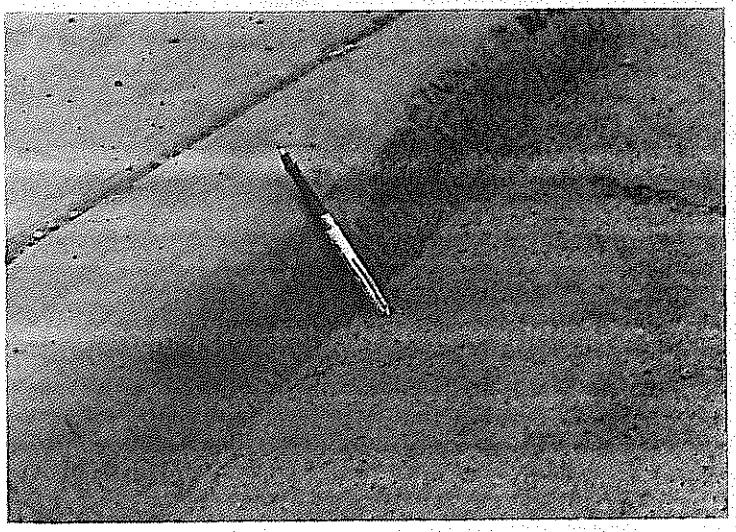
PLACED in 1969, asphalt-rubber shows no sign of reflective cracking, although the adjacent surface is badly cracked. Asphalt-rubber seal coats will reduce loss of curb depth, an inevitable effect of repeated overlaying.

HOT RUBBER-ASPHALT SEAL COATS TO CURE CRACKING STREETS



This article is a sequel to an article by Mr. McDonald which appeared in PUBLIC WORKS *for July, 1966, entitled "New Patching Material Corrects Pavement Failures." The 1966 article presented an innovative approach to the problem of fatigue or "alligator" type cracking. An asphalt-rubber composition was used to provide the cementing agent for chip seal coats or resurfacing of asphalt pavements over elastic subgrades or bases. The new concept employed ground tread rubber from old tires to obtain a reaction product between hot asphalt and rubber. It also called for much higher percentages of rubber that were previously used. In numerous small scale applications the concept produced a highly elastic membrane tolerating high pavement deflections without cracking. The current article tells about the practical application of the process on a large scale.*

JAMES A. STOKELY
Director of Street Maintenance,
and
CHARLES H. McDONALD
Engineering Supervisor,
Materials Testing Section,
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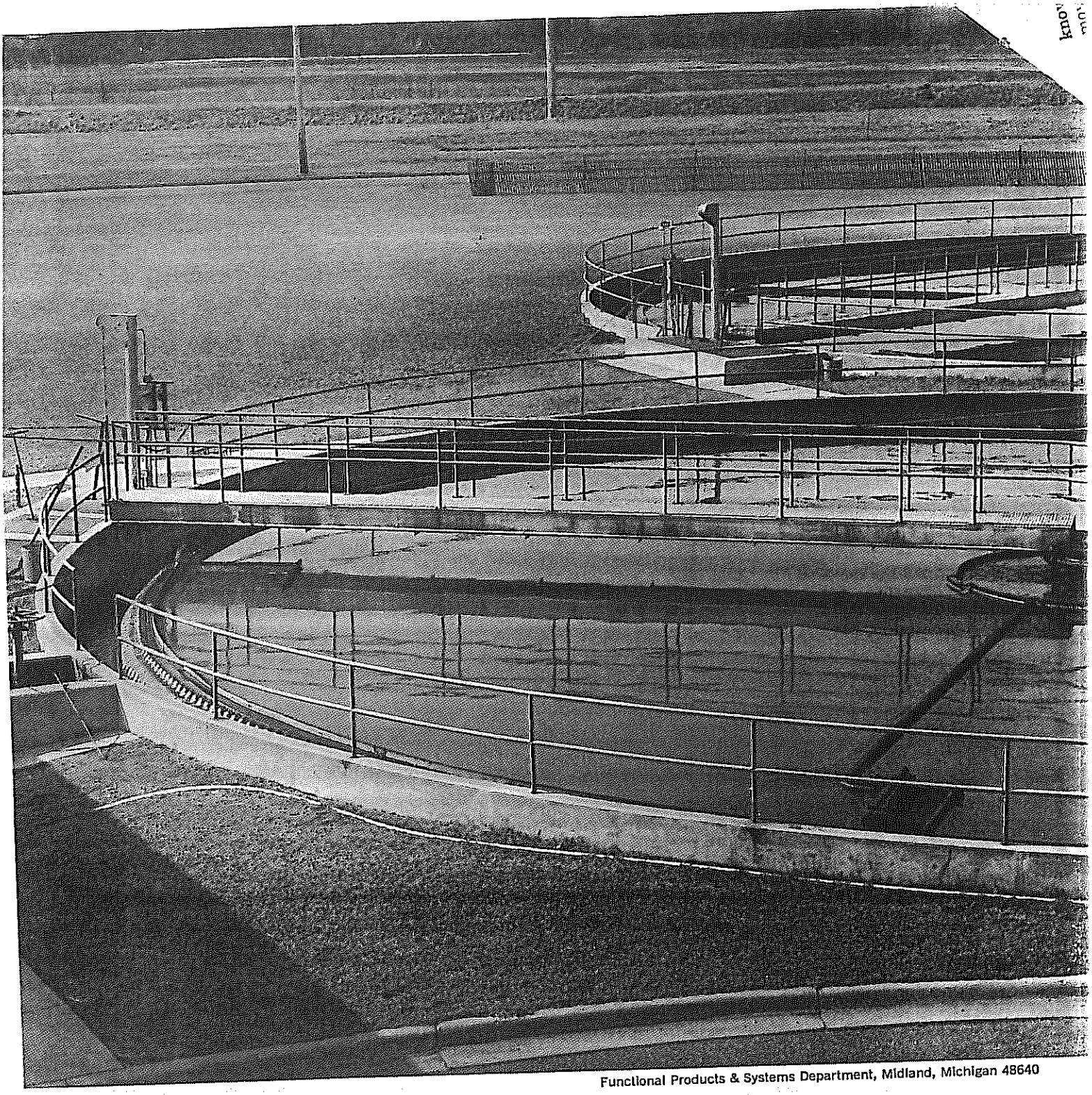
THE City of Phoenix, like other cities experiencing rapid growth, has many miles of older streets which were not designed and built to handle today's traffic loads and volume. While our forward-looking program of full improvement of major streets is making progress with limited funds, our Street Maintenance Department faces the task of holding some of these old streets together for many years.

In too many cases we are seeing surface distress in the form of fatigue or "alligator" cracking and we



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in the manufacture of plastics for a number of years in reducing their tendency to shatter.

Precoated Chips Used

The 1971 City of Phoenix contract called for the Street Maintenance Department to clean the street and apply a light tack coat of diluted asphalt emulsion SS-1h prior to the application of the asphalt-rubber. This work usually preceded the contractor's operation by one or two days. The contractor then applied the hot, kerosene diluted, asphalt-rubber. This was followed with an application of approximately 38 pounds per square yard of hot ⅜ inch nominal sized chips, precoated with 0.3 to 0.5 percent of asphalt, and rolled with a minimum of three coverages by three pneumatic rollers carrying 5,000 pounds on each wheel and 100 pounds per square inch in the tires in order to insure optimum initial embedment of the cover aggregate.

We have found that the precoating of the cover aggregate in any chip seal work is of great importance to eliminate the dust problem. Creation of dust pollution would be serious in the city from an ecological standpoint and could not be tolerated from a public relations standpoint.

After the rolling has been completed, traffic follows right behind the operation with very little interference. We averaged approximately 70,000 square yards of production placed per seven-hour day (work time restricted because of traffic control).

Excess chips are swept up the following night after application by the Street Maintenance Department, and as soon as the streets are cleaned the Traffic Engineering Department moves in to restore the traffic delineation stripes.

Here, we will take up some of the more specific recommendations for placing this material that have not been previously touched on. For the airport apron area we used the following grading with the idea in mind that the nominal chip size should be small to minimize any possible damage to jet engines from loose chips.

However, provision should be made for a flush coat of .05 to 0.1 gallon per square yard of emulsified asphalt (SS-1h) to be used wherever chip embedment is 50 percent or less or to tie down any chips that may otherwise come loose. The grading for the ¼ inch nominal sized chip was as follows:

Sieve Size	Percent Passing
⅜"	100
¼"	80-100
#8	0-5
#200	0-2

The grading for the ⅜ inch nominal chip used on the street work was as follows:

Sieve Size	Percent Passing
½"	100
⅜"	70-100
¼"	0-10
#8	0-5
#200	0-2

The chips are heated to a temperature between 250°F and 325°F and precoated at the time of heating in the hot plant with a small amount of asphalt to control dust, as previously stated.

Some Restraints

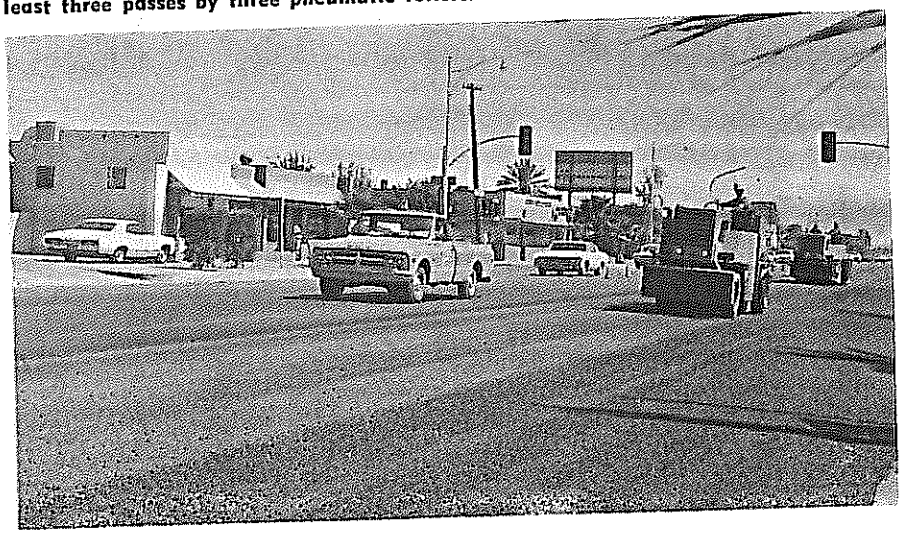
Hot asphalt-rubber should not be applied when the ambient temperature is below 70°F or when the pavement temperature is below 85°F. The distributor bar widths should not exceed 10 feet or maldistribution is apt to occur.

The application rate of the hot asphalt-rubber should be approximately 0.5 gallon per square yard for most conditions. This can be increased up to 1.0 gallon per square yard for severely cracked situations, although it is usually more economical to place a less costly crack-sealing or leveling material, such as slurry seal or a thin overlay prior to placing a lighter application of asphalt-rubber. At the application rate of 0.5 gallon per square yard we have found that it is desirable to use the ⅜ inch nominal sized chip at an application rate of 35 to 40 pounds per square yard in order to prevent excessive embedment. A smaller chip will be completely embedded under heavy traffic but will serve under light traffic. It should be noted that the grading is intended to provide a "one sized chip" for more uniform embedment and less chip loss due to either under-embedment, or "drowning" of chips.

PUBLIC WORKS magazine reported on the ecological and recycling aspects of the use of rubber in asphalt in an article in their November, 1971 issue entitled "Wasted Solids (Solid Waste) and Pavement Design", by Douglas Bynum, Jr. He states that over 100 million tires a year are thrown away and that this constitutes approximately one million tons of solid waste of an originally expensive product that should be recycled as a valuable resource, particularly when it is considered that new rubber costs approximately 50 cents a pound. Dr. Bynum goes on to state, "Asphalt binder costs about $0.015 per pound and increased binder costs are usually avoided. However, an economic analysis shows that a 20 percent costs saving could be realized with a $0.29 per pound binder, if the pavement life were increased by a factor of 4." The solution to both the pavement deterioration problem and the old tire disposal problem is the recycling of these old used rubber tires and thereby "kill two birds with one stone."

In conclusion, our previous experience indicates that we may expect many years (possibly ten) of essentially maintenance free service from this application. Whenever it becomes apparent that additional maintenance is required, another application of hot asphalt-rubber will satisfy requirements without concern for reducing curb height or disturbing the drainage. □□□

AFTER chips are spread on hot asphalt-rubber mix, they are set in place by at least three passes by three pneumatic rollers. Precoated chips prevent dust problem.



know it is caused by elastic, vertical movement under traffic of some member of the street's substructure. Heavy overlays, adequate to control the cracking (three to four inches in thickness), are costly and tend to impair drainage and other benefits of the original design and construction of the curb and gutter. Thus, it becomes a matter of constant and expensive patching or complete reconstruction of large sections of pavement and base.

Constant patching of major streets is becoming more and more impractical and, in some cases, almost impossible during the daylight hours. As traffic becomes heavier over the years, the problem will worsen. In some areas it has even been necessary to schedule all maintenance as night work, which always means more cost, less efficiency and poor workmanship.

As for the other alternative of reconstruction, the money is simply not there in most cases. Such reconstruction of a major street in our city will often cost $24,000 per city block. With the asphalt-rubber treatment we believe that we have the solution to both of the above dilemmas at a cost of approximately $2,400 per city block and with far less disruption of traffic.

The treatment described here is by no means a "cure all." Sound judgment is needed in using it where it will do the most good. For example, it is not intended or recommended for areas where plastic flow of materials has occurred or will occur.

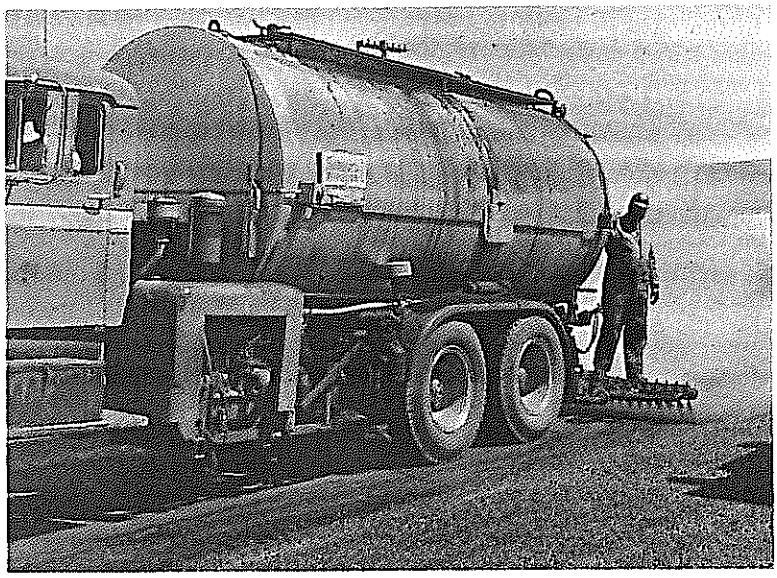
After extensive experimenting since the winter of 1963-64, and some moderate sized full scale projects to check the research, the City let to bid a large contract in the summer of 1971 which included some 208,000 square yards of major streets and airport apron work. This work was accomplished at a contract cost of approximately 51 to 52 cents per square yard. Additional construction costs were assumed by the Street Maintenance Department in the form of preparatory work and cleanup work.

Some Problems

As in all new processes, it took a long time to get the "bugs" out of the process for practical application. The greatest problem was the difficulty or unreliability of getting a uniform spread of the membrane out of an asphalt distributor because of the high viscosity of its composition. This prevented what we call "good workmanship." It was finally solved by first obtaining the reaction between the hot asphalt and the rubber and then diluting the material with kerosene to the point where it could be applied with an asphalt distributor. This is not as easy as it sounds. It was necessary for the contractor to install mixing devices into his distributors to properly blend the asphalt, rubber, and kerosene. Without this good workmanship factor all previous experiments were considered failures due to lack of uniformity.

The process is begun by heating the asphalt to a temperature of between 350°F and 400°F. Ground tire tread rubber, #16 to #25 mesh, produced by Atlos Rubber Company of Los Angeles, is the second ingredient. This is added to hot asphalt in the proportion of 75 percent asphalt (120-150 penetration grade) and 25 percent rubber. A reaction between the hot asphalt and the rubber results causing a gelling effect to occur within 30 minutes to one hour after the first introduction of the rubber. The addition of the rubber cools the mixture below the boiling point of kerosene, and from 5½ percent to 7½ percent kerosene is added to reduce the viscosity sufficiently for spraying.

We might note here that the rubber only partially dissolves in the composition so that the particles themselves serve as units of elastic interference to propagation of cracking from below. Should a crack begin to propagate through the membrane, it encounters an elastic rubber particle and is stopped, whereupon it would start at another location and be stopped, and so on. This principle of introduction of ground rubber has been employed



■ **HOT kerosene-diluted asphalt-rubber mix is applied under pressure to existing surface. Then, precoated ⅜ inch stone chips are spread at rate of 38 pounds/square yard. Daily production averaged 70,000 square yards.**