Use of Asphalt-Rubber on Low-Cost, Low-Volume Streets: A Review After 13 Years

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Asphalt-rubber, a new product developed in 1963, was introduced in the pavement maintenance program of the City of Phoenix in the late 1960s. In this paper its performance on the city streets after 13 years is reviewed. A qualitative and economic analysis concludes that asphalt-rubber, by eliminating maintenance and doubling pavement life, provides a reasonably good road surface at a reduced overall cost. The developments in the use of asphalt-rubber are reviewed briefly.

After the development of asphalt-rubber by McDonald (1) in 1963, the City of Phoenix started its use on an experimental basis; initial developments were directed toward improved application procedures. In 1971, it was decided to use asphalt-rubber as a binder in the annual preventive maintenance chip seal program in Phoenix (2). About the same time, Arizona Department of Transportation (ADOT) also started using asphalt-rubber on their projects (3). In 1972, the City of Phoenix set up a standard specification, which in the course of time has been modified to allow competitions, product improvements, procedure modifications, and cost reductions (2). The developments in Arizona initiated the involvement of the Federal Highway Administration (FHWA) in this field. FHWA encouraged the widespread use of the asphalt-rubber product by initiating almost 50 demonstration projects all over the nation (4). These projects not only caught national attention but also initiated research in Canada, Australia, Great Britain, France, and Sweden; these studies, too many to include here, are referenced elsewhere (5,6). This research made considerable improvement in material quality (7), application procedures, design concepts, and general overall knowledge of this useful product (6). The object of this paper is to evaluate qualitatively and economically the use of asphalt-rubber on the low-cost, low-volume streets of Phoenix after 13 years.

QUALITATIVE EVALUATION

Since 1970, asphalt-rubber has been used by the City of Phoenix in various projects as pavement seal coats, subgrade seals, joint fillers, and runway surface courses. In 1975, there were approximately 300 lane miles of asphalt-rubber seals (8), whereas in 1982, more than 400 lane miles altogether have been placed, all of which might not exist due to reconstruction. Initially, until 1975, asphalt-rubber was used in three major design concepts:

1. Stress-absorbent membrane (SAM), a design developed by the City of Phoenix in 1971;
2. Treatment of existing deteriorated surfaces with asphalt-rubber followed by an application of aggregate chip; and
3. Application of asphalt-rubber as the only surface material by using the existing soil as a base.

As the experience with this material increased, more design methods were involved, one of which was the stress-absorbent membrane interlayer (SAMI). SAMI, developed by ADOT in 1975, which later gave rise to mini-SAMI, was used extensively, not only in the City of Phoenix, but throughout the nation.

The on-going conditions and performances of these projects were reported in 1975 (8) and in 1980 (9). Recently, these projects were again inspected and it was found that asphalt-rubber chip seals had performed, and are still performing, quite satisfactorily in Phoenix. The placement of asphalt-rubber on the native soil on 55th Avenue as reported in 1975 (8) is still in working condition after 14 years, with practically no maintenance. This is well illustrated by a comparison of Figures 1 and 2 with Figures 3 and 4. Detailed inspections of these streets, after such a long period, has revealed quite a few beneficial facts about this material.

By now, it has been well accepted that asphalt-rubber

1. Seals and waterproofs the pavements;
2. Provides cost-effective, all-weather, skid-resistant surfaces;
3. Revitalizes the dry and weathered surface;
4. Reinforces the pavement strength; and
5. Improves the visibility.

In addition, from recent observations, the advantages of asphalt-rubber can be summarized as follows:

1. It prevents reflection cracking and spalling at pothole edges.
2. Unlike conventional chip seal, it improves with time; and by molding itself to the pavement subgrade conditions, it prevents cracks in spite of the movement in the pavement.
3. It provides a truly flexible surface.
4. It eliminates the need for maintenance for at least eight years, and hence, by increasing the pavement life, it delays the need for reconstruction.
5. It renovates and retains the characteristics of the existing asphaltic concrete, which would have normally been lost by oxidation, exposure, and use.

Nonetheless, asphalt-rubber cannot be considered a trouble-free product. One needs to be especially careful in its application. In order to prevent chip loss, at least half of the aggregate chip needs to be embedded in asphalt-rubber. To accomplish this, the construction unit needs to be very close to the application unit with little or no gap between the spreader truck, the chip spreader, and the rollers. At the time of application, asphalt-rubber needs to be well mixed and kept at proper temperature to avoid roping and spreading problems and to obtain required embedment. It is also noted that asphalt-rubber requires some time to cure. Asphalt-rubber has the poorest appearance in the first year but improves with age, whereas asphalt, which has its best appearance in the first year, deteriorates in its quality with time.

ECONOMIC EVALUATION

An economic evaluation was prepared for asphalt-rubber from data collected since 1971. The cost-variation data were collected for asphalt-rubber chip seal, conventional chip seal, asphalt cement, and asphalt concrete. From Figure 5, it can be seen that the cost of asphalt-rubber has increased from

Figure 1. Grade preparation in alfalfa field soils on 55th Avenue, Phoenix, March 1971.

Figure 2. Completed surface immediately after construction with asphalt-rubber, March 1971.

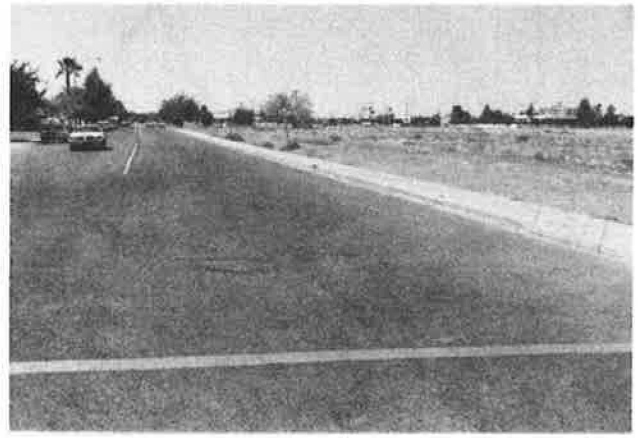


Figure 3. Pavement in 1982 after single chip-seal application and sidewalk addition.

Figure 4. Surface condition in 1982 with only 0.5 in asphalt on native soil.

$0.97/yd² in 1971 to $1.25/yd² in 1982, with an average annual increase of 6 percent. It nevertheless remained stable at $0.97/yd² until 1978 and then increased rapidly with the cost increase of asphalt. On the other hand, the cost of the conventional chip seal has increased from $0.15/yd² to $0.82/yd² in the same duration, which represents an average increase of 41 percent annually (Figure 6). Such a large increase is due to the cost increase of its primary ingredient, asphalt cement, which rose from $49/ton to $220/ton--a 32 percent annual increase--in the same duration observed (Figure 7). As a comparison, in the past 12 years the cost of in-place asphaltic concrete has risen from $9.25/ton to $25/ton, an increase of 15 percent annually (Figure 8).

Interpreting this in other words, in 1971 3 miles of conventional chip seal was equivalent costwise to 1 mile of asphalt-rubber, whereas today less than 2 miles of conventional chip seal could be replaced by 1 mile of asphalt-rubber. This reduction in the initial cost difference between these two materials has weakened the arguments against the use of asphalt-rubber.

Although asphalt-rubber is initially more expensive than the conventional chip seal, in the long run this material has turned out to be economical; this is mainly due to a reduced maintenance and an increased life. The recent observations indicate that the average life expectancy of asphalt-rubber seal is 10-12 years, whereas the conventional chip seal lasts 6-8 years. It was also noted that asphalt-rubber, except for utility problems, requires almost no maintenance for at least 10-12 years, whereas conventional chip seal requires some maintenance such as crack filling and pothole repairs by the third year.

This initial cost analysis was carried out in the Phoenix area and it might not be valid for other areas in the nation. Nonetheless, economic evaluations of asphalt-rubber performed in the rest of Arizona (10), in Nevada (11), and in Texas (12) all come to the same conclusions.

CONCLUSIONS

As it was originally viewed, the greatest advantage of asphalt-rubber was to save the roadway until reconstruction funds were available. However, the last 13 years of performance of asphalt-rubber on low-cost, low-volume roads clearly indicate that asphalt-rubber, by eliminating maintenance and doubling pavement life, provides the traveling public with a reasonably good road surface at a reduced overall cost.

Figure 5. Cost-variation data for 0.375-in asphalt-rubber chip seal.

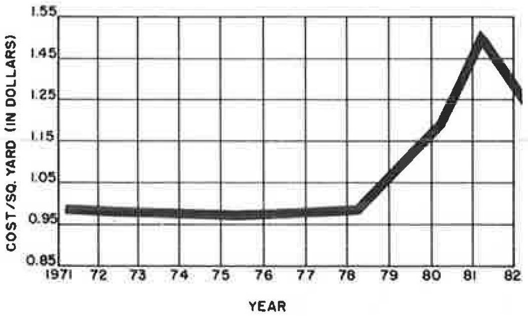


Figure 6. Cost-variation data for 0.375-in conventional chip seal.

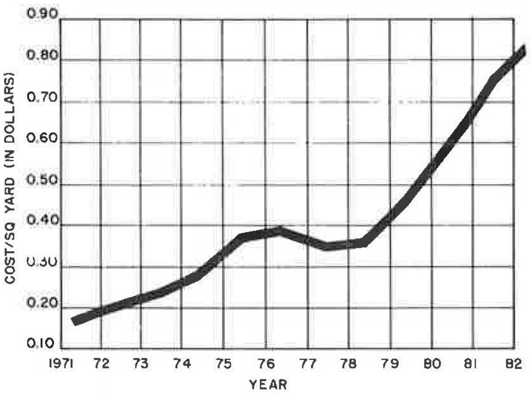


Figure 7. Cost-variation data for asphalt cement.

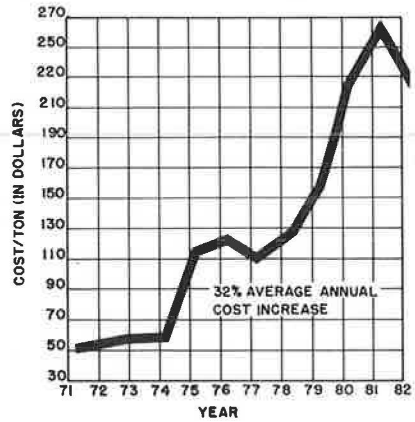
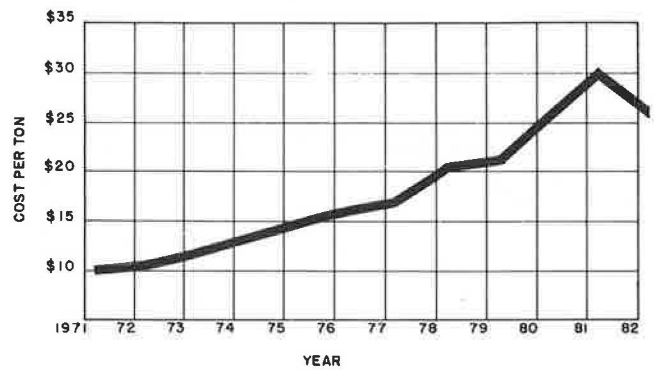


Figure 8. Cost-variation data for asphalt concrete.



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