STATE OF FLORIDA

LONG TERM PERFORMANCE EVALUATION OF ASPHALT-RUBBER SURFACE MIXES

Research Report
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EXECUTIVE SUMMARY

In 1988, the Florida legislature passed a bill (Senate Bill 1192) directing the Florida Department of Transportation (FDOT) to conduct an investigation on the feasibility and potential use of ground tire rubber in asphalt concrete mixtures. To address this legislative mandate, the FDOT planned and constructed three test projects to define performance that would allow for rational decisions about the use of ground tire rubber (GTR) in Florida.

A major finding of the long term performance evaluation of these test sites is that the wet process addition of rubber improved the crack resistance of surface mixtures. State Road16 test sections with wet process rubberized mixes showed approximately 1 to 6 percent cracked areas, depending on the amount of rubber, while those with virgin asphalt or dry-mixed asphalt rubber showed about 30 percent cracked areas. In addition, the cracking data collected during this evaluation seems to suggest that an effective optimum rubber content be within the 10 to 15 percent range.

The present report describes the long term performance evaluation program of the three test projects and discusses its findings.

INTRODUCTION

The early work on the use of rubber in asphalt pavement was not intended to dispose of tires, but rather, to improve the pavement performance. Such a use was first reported in the early 1960s in Arizona. The results of that experience indicated that the addition of rubber lowered the temperature susceptibility and increased the ductility, cone penetration, resiliency and softening point of asphalt cements *(1)*. Arizona's experience also showed that asphalt-rubber mixtures resisted reflective cracking and improved skid resistance over conventional mixtures by about 30 percent *(2)*. Improved pavement performance with the addition of rubber was also reported in California *(3)*. According to the California Department of Transportation, for an equal overlay thickness, rubberized overlays resulted in 5 to 10 percent cracked areas while those with virgin asphalt showed 70 to 80 percent cracked areas. Other benefits attributed to the addition of rubber including increased skid resistance and decreased traffic noise levels were also reported *(4, 5)*.

BACKGROUND

As previously mentioned, the rubber from scrap tires was originally intended to enhance the rheological properties of conventional asphalts. From the late 1980s, however, the emphasis for its use has been on the potential as a solution to the scrap tire disposal problems. In 1988, the Florida legislature passed a bill (Senate Bill 1192) directing the Florida Department of Transportation (FDOT) to conduct an investigation on the feasibility and potential use of ground tire rubber in asphalt concrete mixtures. It has to be acknowledged though that, during the late 1970s, nearly 10 years before the passage of this bill, FDOT had initiated the use of asphalt-rubber as a stress absorbing membrane interlayer and as a moisture barrier. A test project constructed on State Road 60, Hillsborough County, was used to evaluate the effectiveness of such specific applications *(6)*.

Based on the encouraging results obtained from this test project, FDOT has then permitted the use of GTR in selected surface treatment and interlayer construction.

To address the legislative mandate, the FDOT considered its different mixture types that would potentially benefit from the addition of rubber. Approximately 85 percent of all Florida HMA structural mixtures contain on the average 30 percent reclaimed asphalt pavement (RAP). These recycled mixtures have had good performance history and cost generally 25 percent less per ton of mix as compared to conventional mixtures with virgin aggregates. Furthermore, it was felt that these structural mixtures would not be suited for the addition of rubber since the latter would interfere with the rejuvenation of the older binder that occurs during the recycling process. It was also felt that a more promising use of rubber would be in friction course mixes which require the use of virgin materials. The addition of GTR would increase the overall strength or rutting resistance of the dense-graded friction courses and would also improve the durability of the open-graded friction courses. The primary difference between the two mixes is the aggregate gradation. Though the open-graded friction mix air void content is higher, its binder film thickness is typically greater than that of the dense-graded mix. The total asphalt content for an open-graded friction mix is slightly higher than that for a dense-graded mix with the same maximum size of aggregate. Therefore, the addition of GTR in the production of an open-graded friction course mix would improve the ability of the binder to hold the aggregate in place as well as its durability. Consequently, building on experiences and practices of other states, and information acquired on the properties and production requirements of asphalt rubber mixtures, three test projects were constructed to evaluate the ease of construction and field performance of asphalt-rubber surface mixtures for the Florida conditions.

OBJECTIVE

A number of studies were performed on the construction and short-term field performance of rubberized asphalt mixtures. However, few of these studies had long term performance data and/or a direct comparison with conventional mixtures. Therefore, there was a need for long term, field test sections to define performance that would allow for rational decisions about materials selection. Thus, the three test projects were planned with a primary objective of monitoring the long term field performance of the rubberized asphalt surface mixtures for the Florida conditions. The results of such a long term performance evaluation are documented in this report.

PROJECT DESCRIPTIONS

In 1989 and through 1990, a total of three test projects, two using open-graded and one using dense-graded friction course mixtures, were constructed. Each test project consisted of a series of test sections. Each test section was designated for a different level of GTR content. A summary of key information related to each of these projects is presented in Table 1. A brief description of each one of these three projects is given below. Further details may also be found in other technical reports *(7, 8, 9)*.

State Road 120

In March of 1989, the first asphalt-rubber test project was constructed on a section of State Road 120, within the city of Gainesville. A dense-graded friction mix containing 0 to 10 percent GTR by total weight of binder was used . The total project consisted of four test sections. Respective mixtures containing 3 and 5 percent 80 mesh size GTR were placed on the first two 1070-m long (3500 feet) test sections. Another mixture containing 10 percent 40 mesh size GTR was placed on a 760 m long (2500 feet) section. This mixture also included a 5 percent extender oil. The remaining segment of the project was paved using the conventional dense-graded friction mix (zero percent rubber). The latter was used as a control section. Although all of the asphalt-rubber mixtures exhibited some degree of adherence to the paver's screed, it was only considered excessive during the paving of Test Section 3 (10 percent GTR). Otherwise, no major problems were encountered during construction of these asphalt-rubber friction courses.

State Road 16

The second asphalt-rubber test project is located on State Road 16 starting about 1.5 miles northwest of its intersection with State Road 200 (US - 301) in Starke, and ending at State Road 225. The project, constructed in June 1989, is a two-3.6 m (12 feet) wide roadway lanes with 1.2 m (4 feet) wide paved shoulders. An open-graded friction course mix with an AC-30 asphalt cement and various amounts of GTR was used throughout the project. Five test sections were constructed with each section, again, designated for a different rubber content. The first four test sections were constructed using rubberized asphalt with respective GTR contents of 5, 10, 15, and 17 percent by total weight of binder. The fifth one was a control section with conventional asphalt cement. Whenever rubberized asphalt was used, preblending of asphalt and rubber was required. Number 80 mesh size GRT from Rouse Rubber Industries, Inc., Vicksburg, Mississippi, was used in the first three test sections without any extender oil. A binder consisting of an AC-20 with 17 percent of the number 24 mesh size GTR was used in the construction of the Section 4. Furthermore, a short test section (Section 6) was added to the project to evaluate the pugmill mixed asphalt-rubber mixture without pre-blending asphalt cement (AC-30) and GTR. This mixture was produced at the plant using 10 percent GTR dry mixed with aggregate for 20 seconds in the pugmill, then followed by wet mixing with AC-30 for 32 seconds.

Placement of the asphalt-rubber mixtures was accomplished with little difficulty. The results obtained from the construction phase of this test project seemed to indicate that 10 to 15 percent GTR can effectively be added to an open-graded friction course mix *(8)*.

Interstate 95

The third test project was constructed on a section of Interstate 95 in St. Johns County during September of 1990. An open-graded friction course mix containing 10 percent of 80 mesh size GTR (by weight of asphalt cement) was used throughout the test section. An additional objective on this project was to evaluate the feasibility of a prototype field asphalt rubber blending unit on a conventional construction project. There were no major problems reported during the construction of this project. However, the blending time required to provide adequate reaction of GTR with the asphalt cement had to be increased to 45 minutes. Lower than anticipated temperatures (135 instead of 155°C) were encountered with this prototype blending equipment. This indicated the need to either increase the blending unit capacity or provide additional heating for the unit to assure adequate blending to maintain the desired hot-mix production rate of 90 metric tons per hour.

PERFORMANCE EVALUATION

Scope

The objective of this work was to evaluate the test projects such that an analysis could be made regarding the effect of rubber on the performance of each pavement section considered. Test sections on all three projects were evaluated, at the time of construction and periodically thereafter, to determine if service performance was enhanced when adding rubber. Each test section within a project was evaluated for relative performance to an appropriate control section at the same location under equal service conditions. The performance was judged based on varying levels and amounts of specific distresses, namely, (1) rideability, (2) rutting, (3) cracking and patching, and (4) skid resistance.

Findings

The trends in the performance data collected during this study are illustrated in Figures 1 through 16. The skid resistance data, obtained using a rib tire and summarized in Figures 1 to 4, seem to indicate that both asphalt-rubber and control pavement sections provided similar friction performance. Generally, it is expected that the friction numbers obtained immediately after construction be lower that those obtained at later times. As shown in Figure 1, the friction number for SR-120 with the dense-graded friction course mixes decreased slightly during the first year after construction, as expected, but then remained relatively constant thereafter. The open-graded friction course mixes on SR-16 in general exhibited a slight increase in friction number after approximately 50 months of traffic, then remained somewhat constant afterwards as indicated in Figure 2. The Interstate 95 data in Figures 3 and 4 indicated that, after a slight decrease within 18 months after construction, the friction number remained relatively steady, on both lanes and in both directions of traffic.

A more definite and conclusive performance trend on the addition of rubber is better observed from the performance data obtained from the test sections on State Road 16. The SR-16 cracking and patching data, in combination with visual inspections, indicated that all wet process asphalt-rubber sections performed significantly better than the control and dry-mixed asphalt-rubber test sections. As illustrated in Figure 10, test sections with wet process rubberized mixtures showed approximately 1 to 6 percent cracked areas, depending on the amount of rubber, while those with virgin asphalt or dry-mixed asphalt rubber showed about 30 percent cracked areas. Furthermore, the amount of cracking was relatively insignificant in test sections with 10 and 15 percent rubber. This observation seems to suggest that an optimum rubber content be within the 10 to 15 percent range. The ride rating data of Figure 14, as determined using Mays ride meter, shows a higher ride quality was achieved with a wet process addition of rubber of up to 15 percent. Of all the test sections on this project, sections with conventional and dry-processed asphalt-rubber mixtures had the lowest ride ratings. The latter mix also had the highest rut depth measurements while the lowest rut depth was measured on test section with 17 percent asphalt-rubber as seen in Figure 6.

The rut depth measurements as recorded on State Road 120 and plotted in Figure 5 indicated that less rutting occurred in dense graded mixtures when 10 percent of ground tire rubber was added. However, it was not determined if such ruts were directly associated with these surface mix layers.

Implementation

Based on the initial findings of these test projects, the Florida Department of Transportation initiated the implementation of specifications requiring the use of ground tire rubber in all asphalt surface mixes. These specifications define the ground tire rubber, the blending process, and the amount of rubber.

Since the implementation of these specifications in 1994, over 2,700,000 metric tons of rubberized asphalt surface mixtures have been placed throughout the state. Moreover, approximately 12 million tires are discarded annually in Florida. It is expected that about one-fifth of this quantity will be used annually in hot mix applications.

CONCLUSIONS

The present investigation was performed to evaluate the long term effect of ground tire rubber on the performance of surface mixes of three test projects. The performance was judged based on varying levels and amounts of specific distresses, namely, (1) rideability, (2) rutting, (3) cracking and patching, and (4) skid resistance. The long term performance data obtained from these test projects provided the Florida Department of Transportation with the necessary information to outline the use of ground tire rubber in all asphalt surface mixtures. Based on the findings of this investigation, the following conclusions can be drawn:

! To the present date, the addition of rubber has not had any observable beneficial or detrimental effects on field performance as related to skid resistance.

! The wet process addition of rubber of up to 15 percent resulted in higher ride ratings on open-graded surface mixes as determined using Mays ride meter.

! The wet process addition of rubber significantly improved the cracking resistance of the open-graded friction course mixes on SR-16 project. Test sections with wet process rubberized mixtures resulted in approximately 1 to 6 percent cracked areas, depending on the amount of rubber, while those with virgin asphalt or dry-mixed asphalt rubber showed about 30 percent cracked areas.

! The amount of cracking was relatively insignificant on SR-16 test sections with 10 and 15 percent rubber. This observations seems to suggest that an optimum rubber content be within the 10 to 15 percent range.

! Less rutting was measured in dense-graded mixtures when rubber was added.

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8. Ruth, B.E. *Evaluation of Experimental Asphalt-Rubber, Open-Graded Friction Course Mixtures: Materials and Construction of Test Pavements on State Road 16*. Technical Report, Project No. 4910450426912, Department of Civil Engineering, University of Florida, November 1989.

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Table 1 Test Projects Information Summary

Project	SR-120	SR-16	I-95
Location	Gainesville	Starke	St. Johns County
Mix Type	Dense-grade friction mix	Open-grade friction mix	Open-grade friction mix
Length of Test Sections, m	Section 1: 1070 Section 2: 1070 Section 3: 760 Section 4: 1067	Section 1: 640 Section 2: 770 Section 3: 550 Section 4: 880 Section 5: 540 Section 6: 80	Section 1: 1600 Section 2: 1720 Section 3: 1680 Section 4: 1810
Total Binder Content, %	Section 1: 7.1 Section 2: 7.3 Section 3: 8.1 Section 4: 7.0	Section 1: 8.0 Section 2: 8.4 Section 3: 11.5 Section 4: 10.3 Section 5: 6.3 Section 6: 6.9	Average of 7.17% for all sections
GTR Content, by weight of total binder	Section 1: 3% of 80 mesh size Section 2: 5% of 80 mesh size Section 3: 10% of 40 mesh size Section 4: Control	Section 1: 5% of 80 mesh size Section 2: 10% of 80 mesh size Section 3: 15% of 80 mesh size Section 4: 17% of 24 mesh size Section 5: Control Section 6: 10% of 80 mesh size (dry process)	Section 1: 10% of 80 mesh size Section 2: 10% of 80 mesh size Section 3: 10% of 80 mesh size Section 4: 10% of 80 mesh size

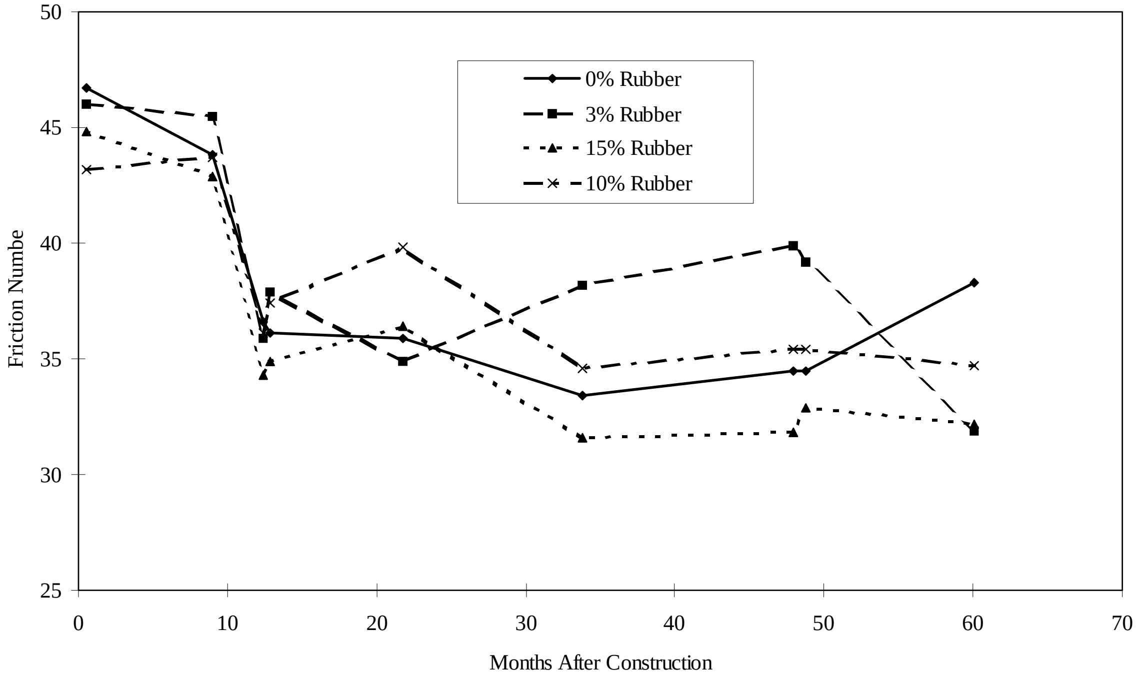


Figure 1 Friction numbers versus time as recorded on SR-120 demonstration project (1996 AADT = 13,500)

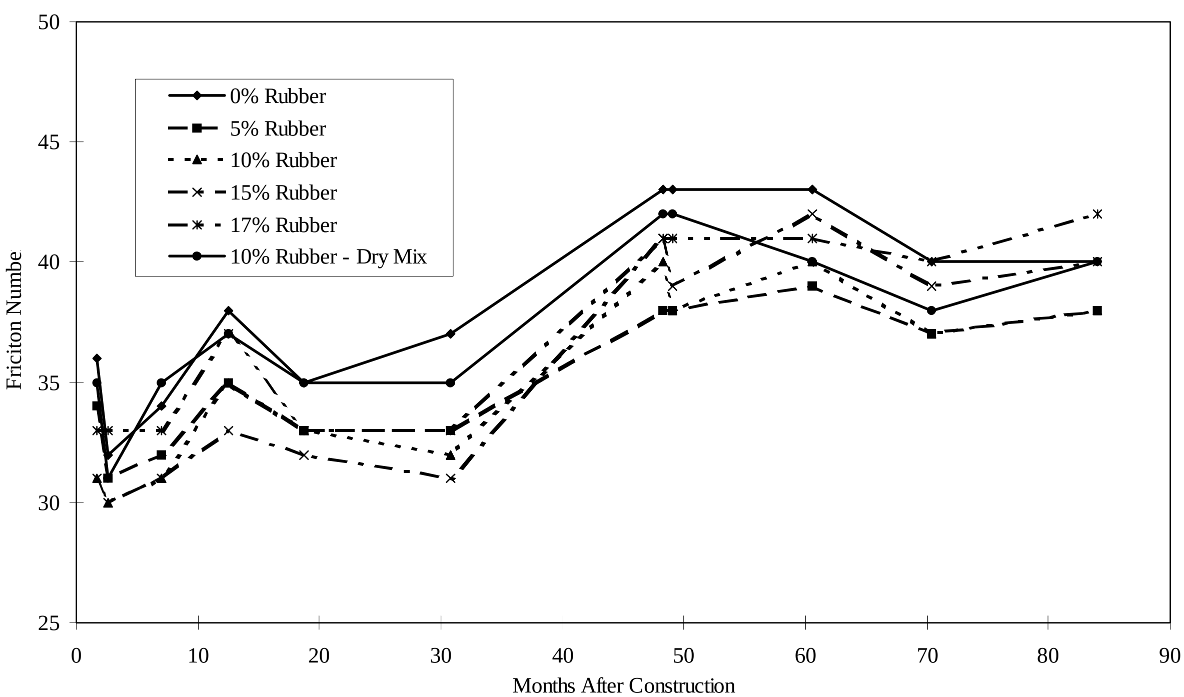


Figure 2 Friction numbers versus time as recorded on SR-16 demonstration (1996 AADT = 4,200)

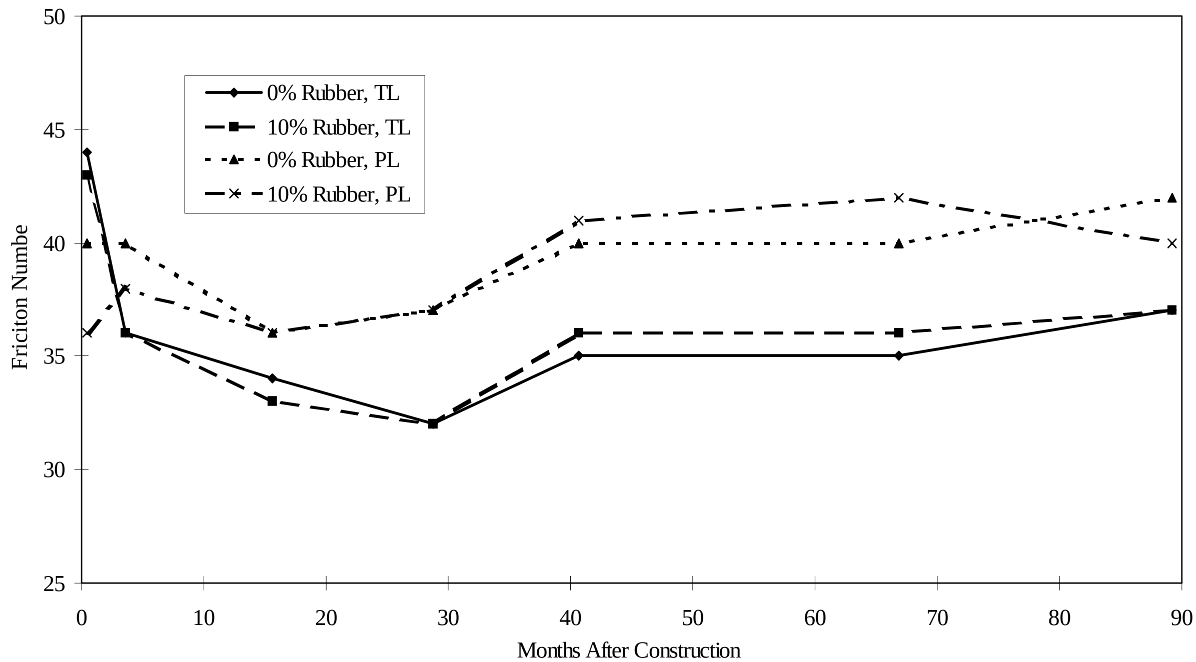


Figure 3 Friction numbers versus time as recorded on I-95, Northbound, demonstration project (1996 AADT = 37,000)

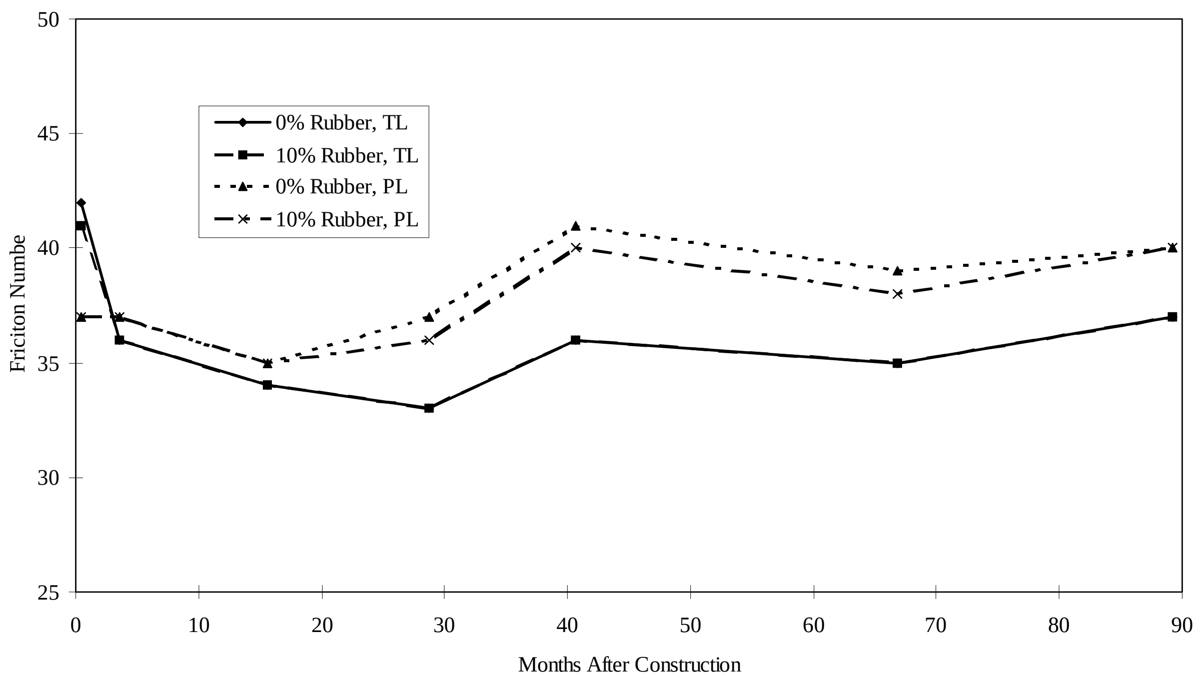


Figure 4 Friction numbers versus time as recorded on I-95, Southbound, demonstration project (1996 AADT = 37,000)

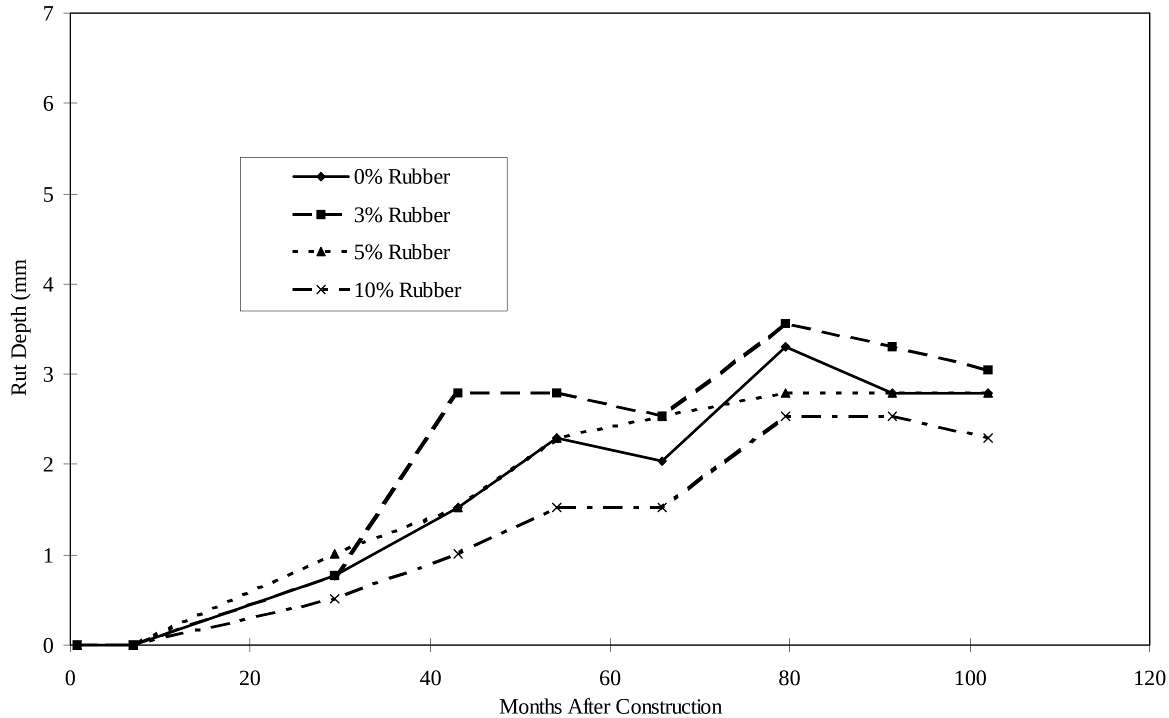


Figure 5 Rut depth measurements versus time as recorded on SR-120 demonstration project

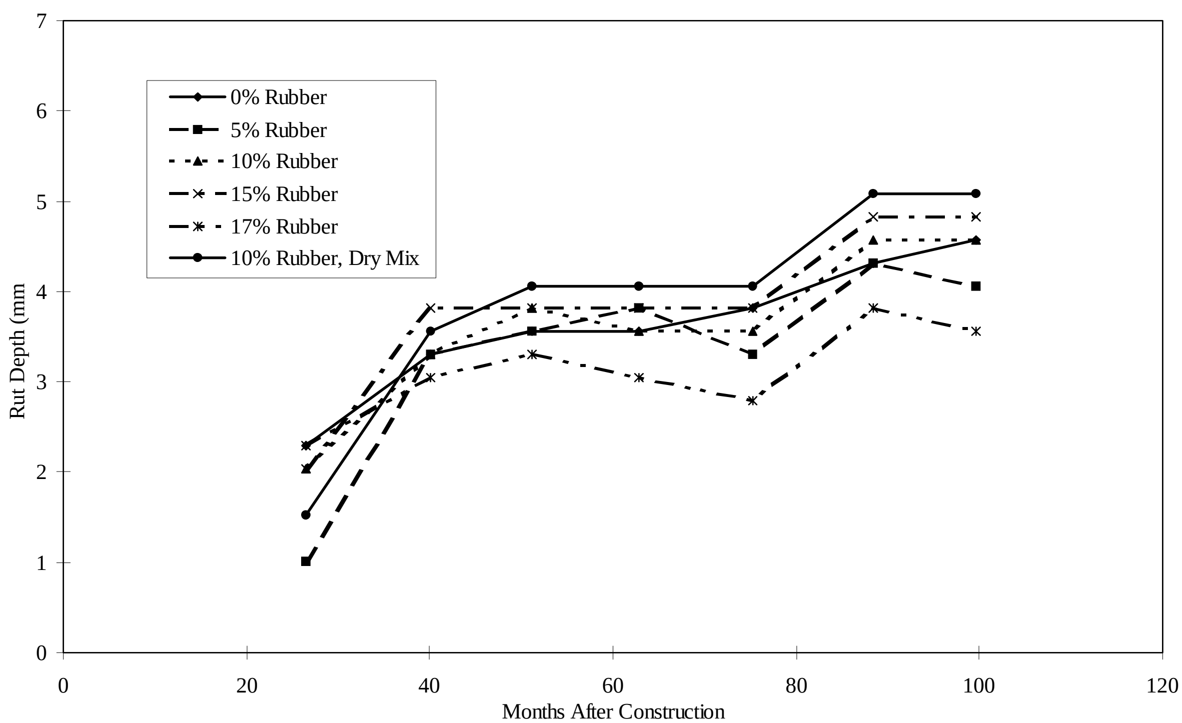


Figure 6 Rut depth measurements versus time as recorded on SR-16 demonstration project

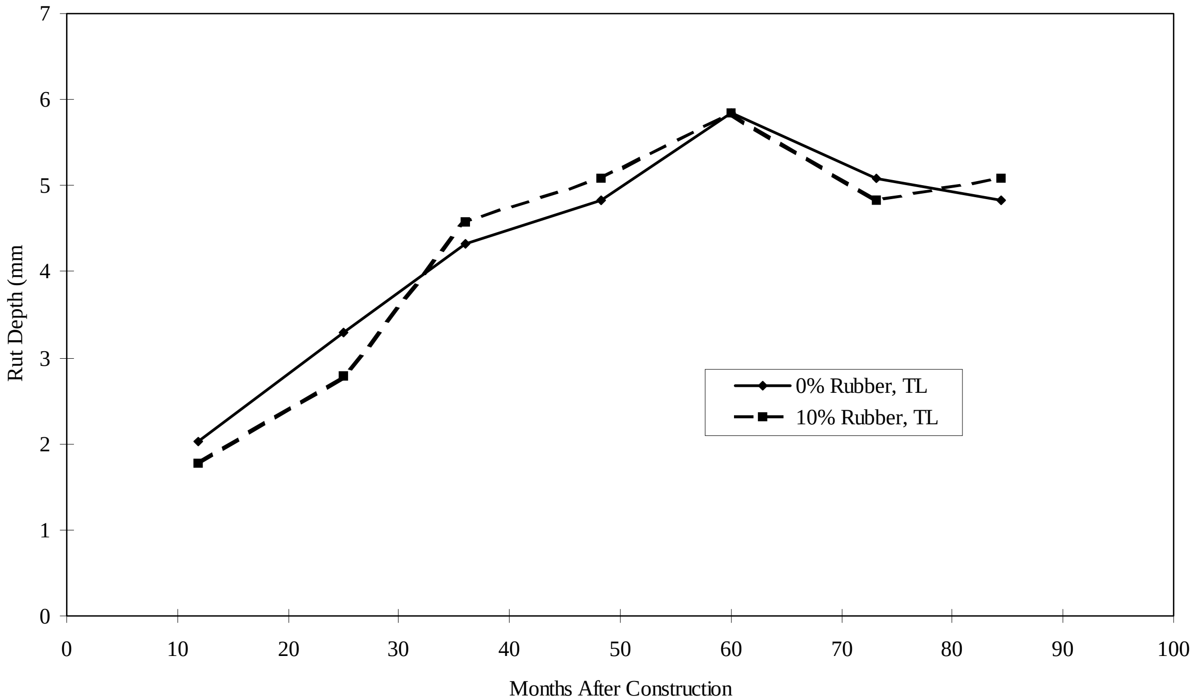


Figure 7 Rut depth measurements versus time as recorded on I-95, Northbound, demonstration project

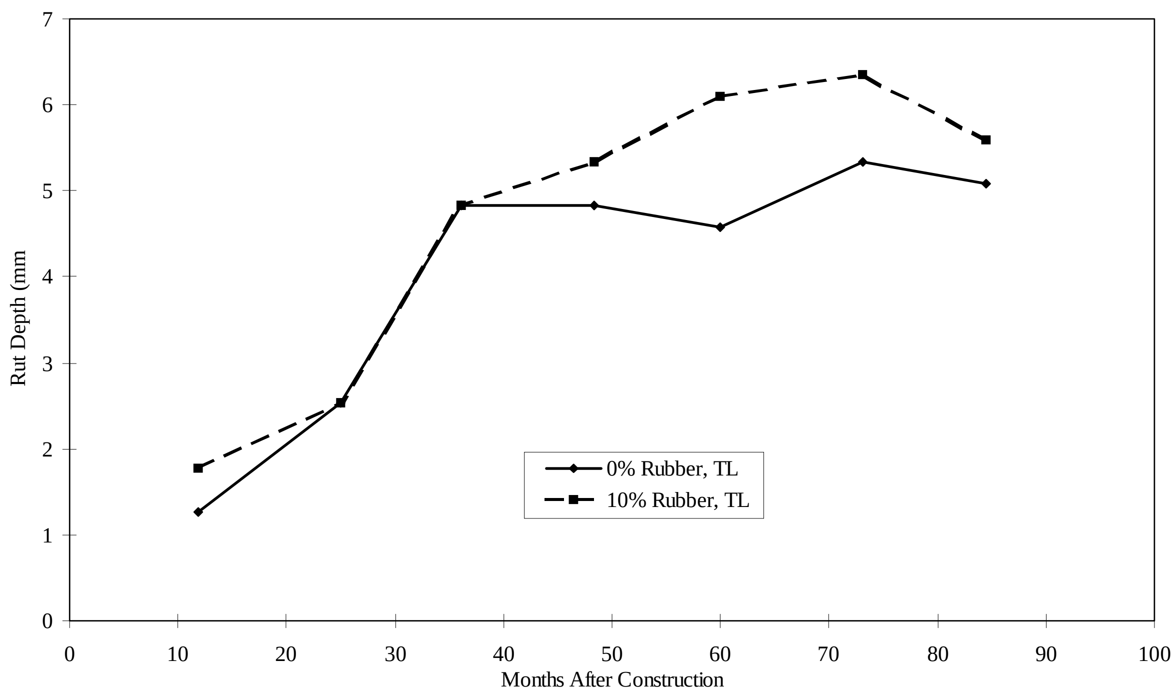


Figure 8 Rut depth measurements versus time as recorded on I-95, Southbound, demonstration project

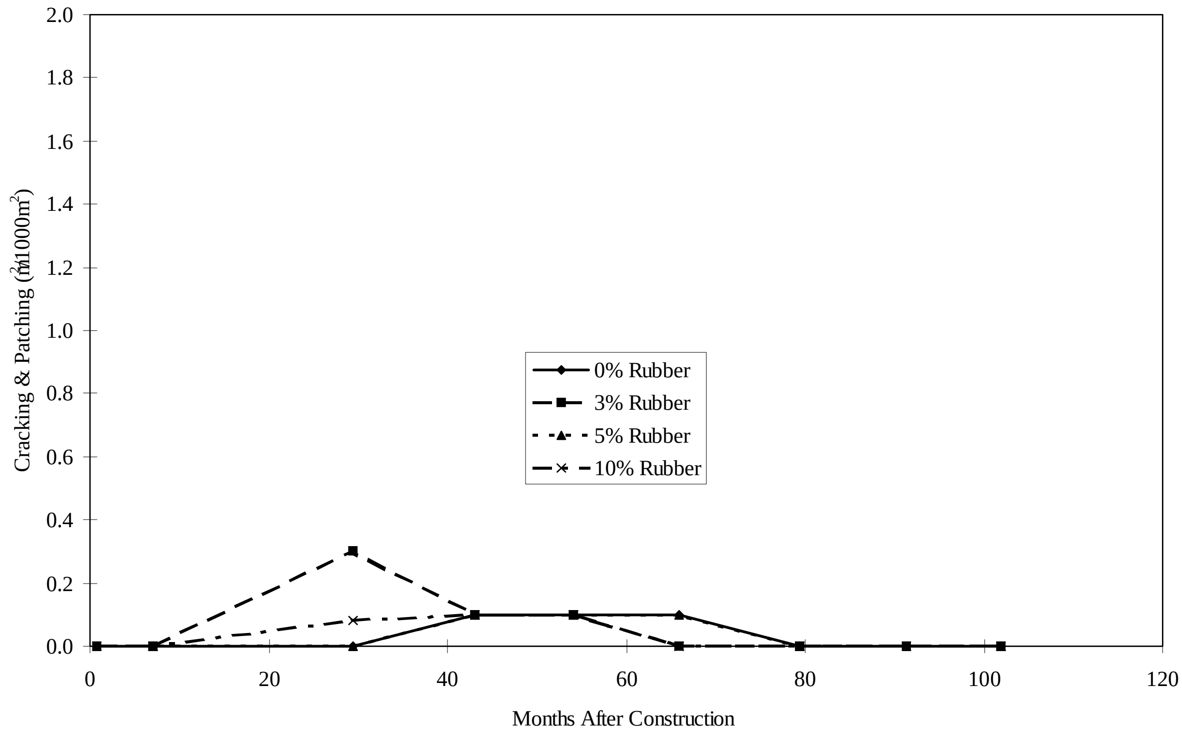


Figure 9 Amount of cracking and patching versus time as recorded on SR-120 demonstration project

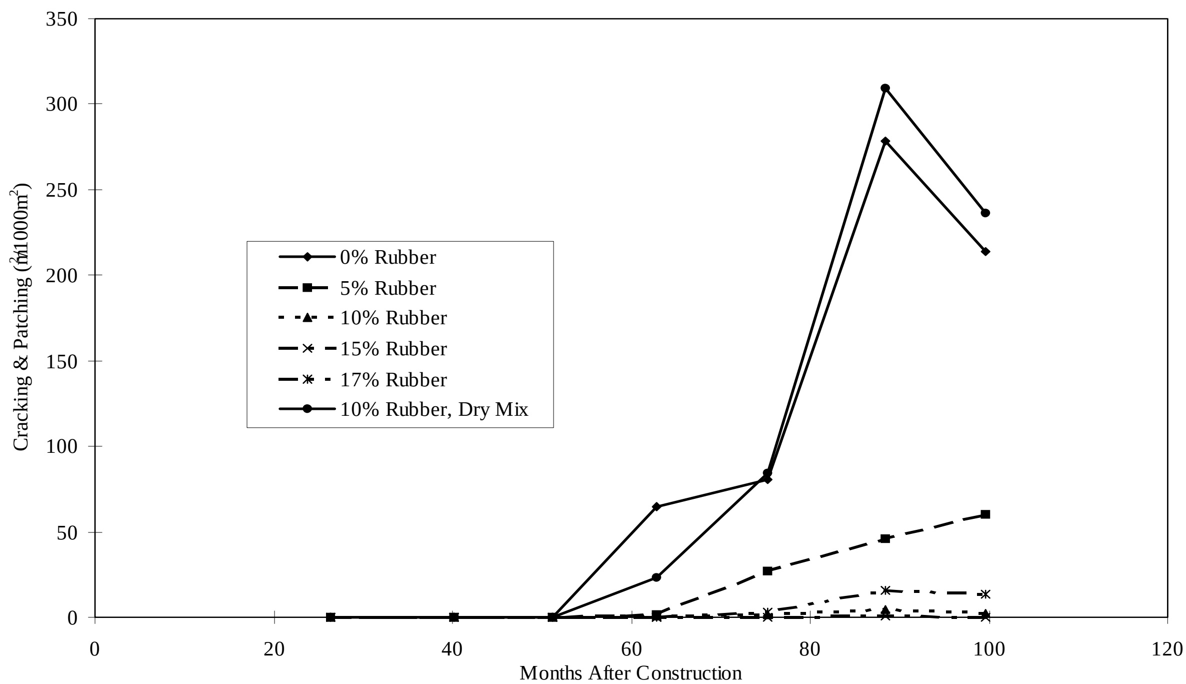


Figure 10 Amount of cracking and patching versus time as recorded on SR-16 demonstration project

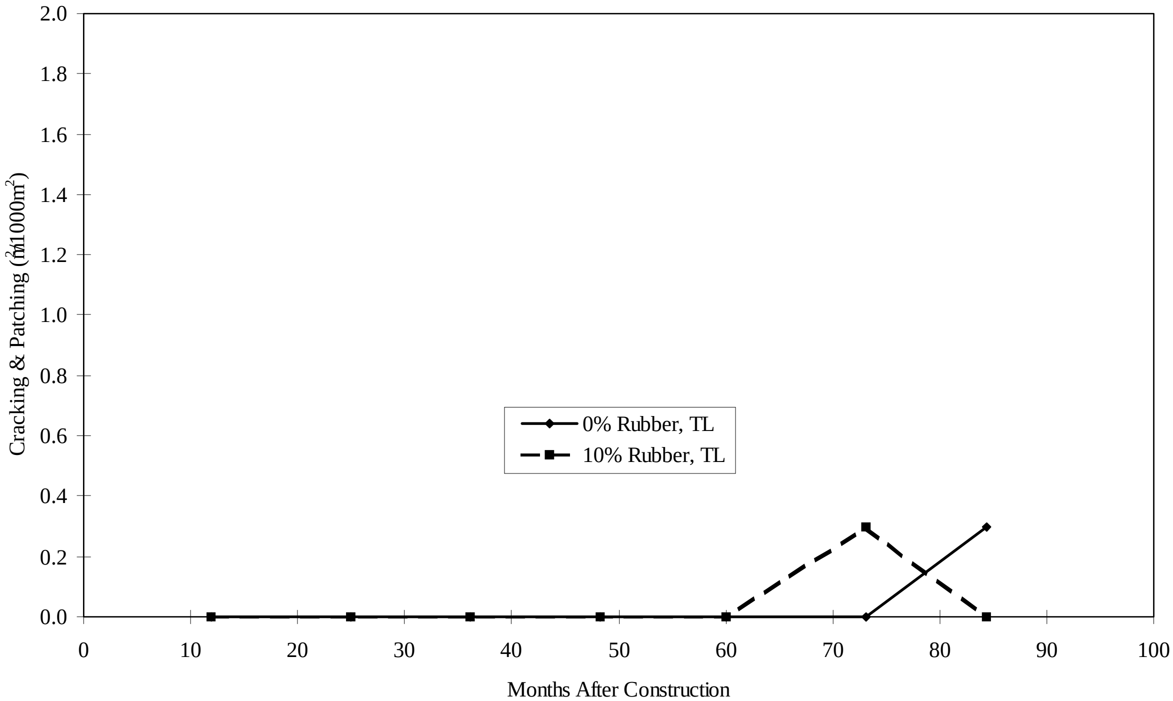
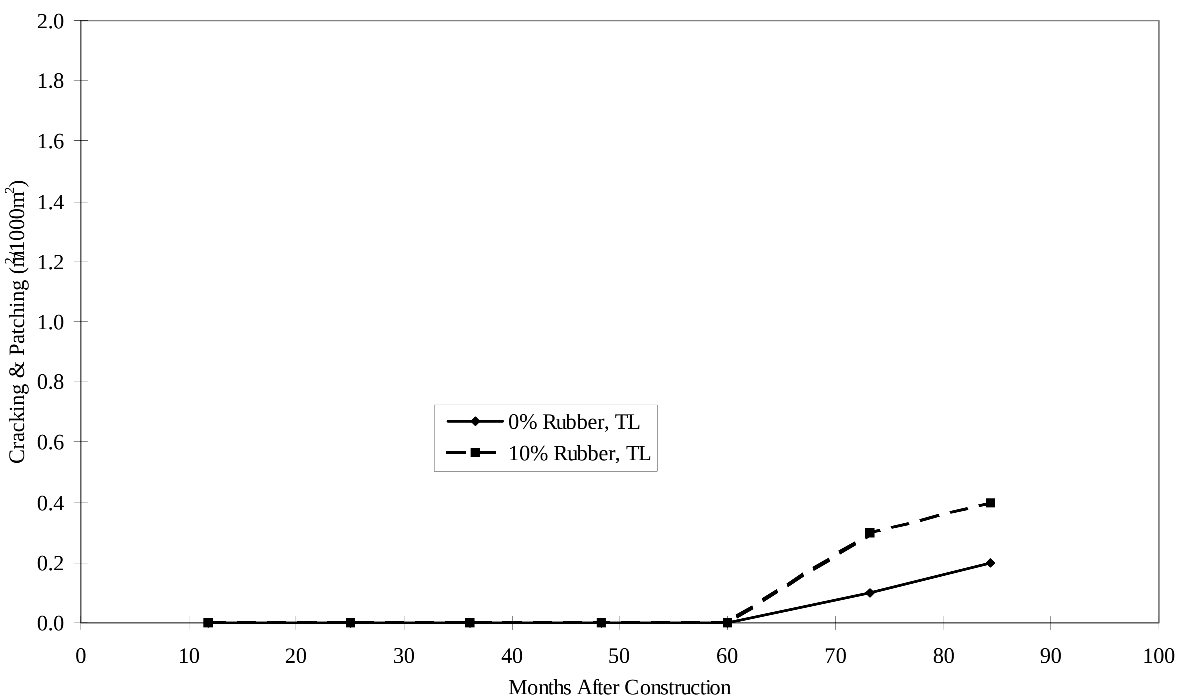


Figure 11 Amount of cracking and patching versus time as recorded on I-95, Northbound, demonstration project



FIigure 12 Amount of cracking and patching versus time as recorded on I-95, Southband, demonstration project

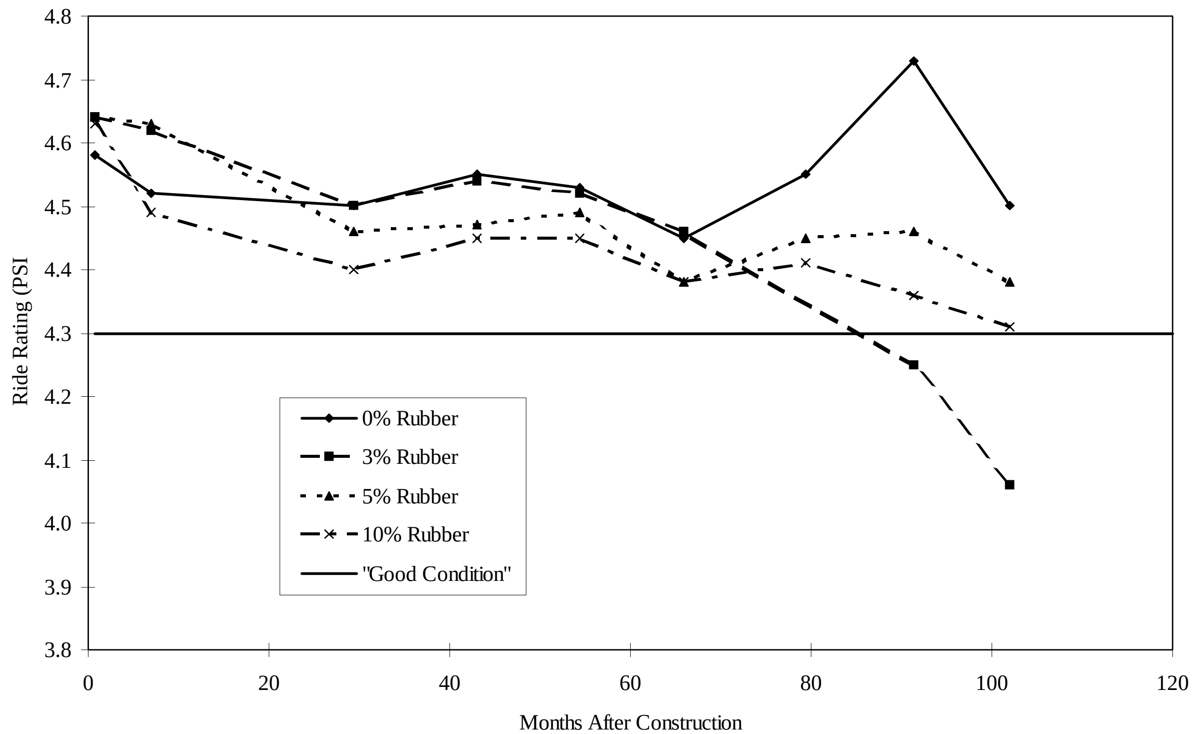


Figure 13 Ride ratings versus time as recorded on SR-120 demonstration project

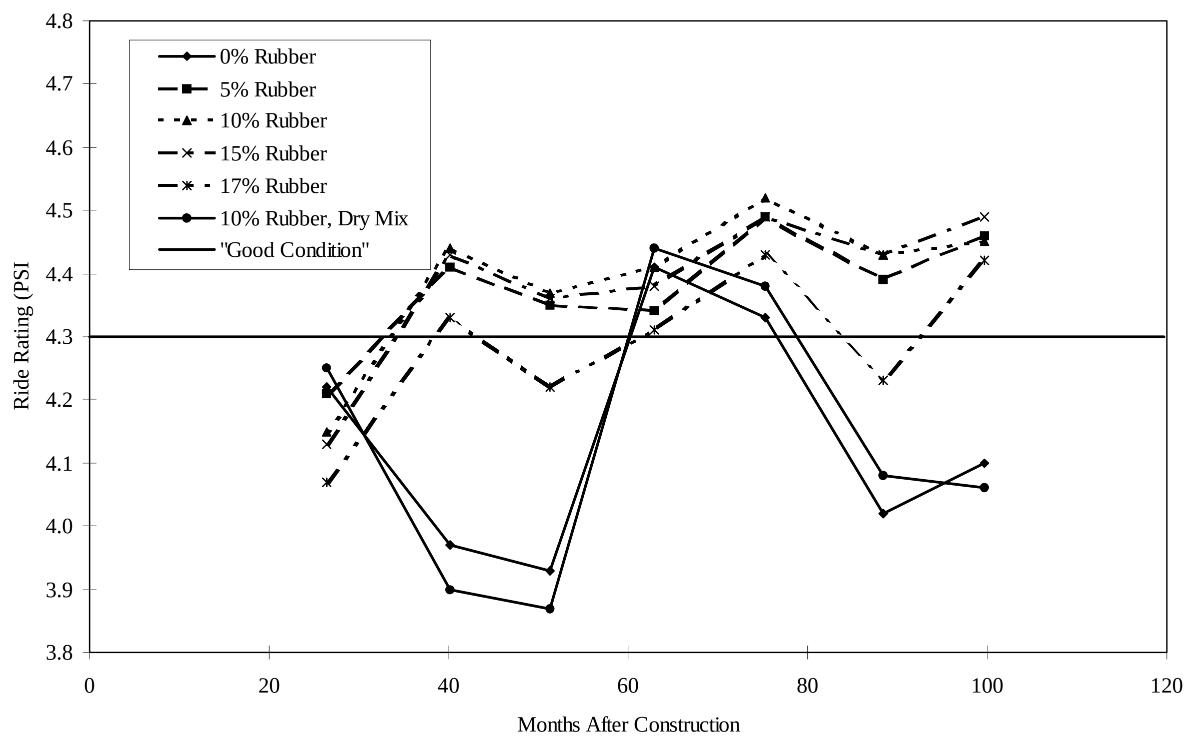


Figure 14 Ride ratings versus time as recorded on SR-16 demonstration project

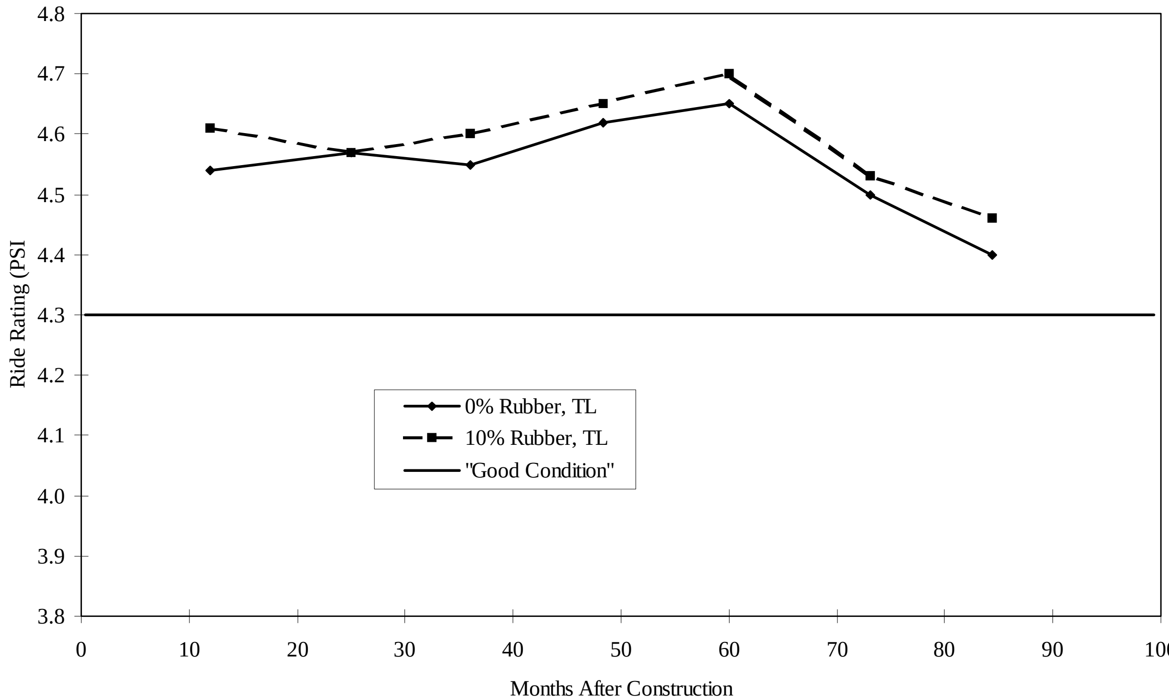


Figure 15 Ride ratings versus time as recorded on I-95, Northbound, demonstration project

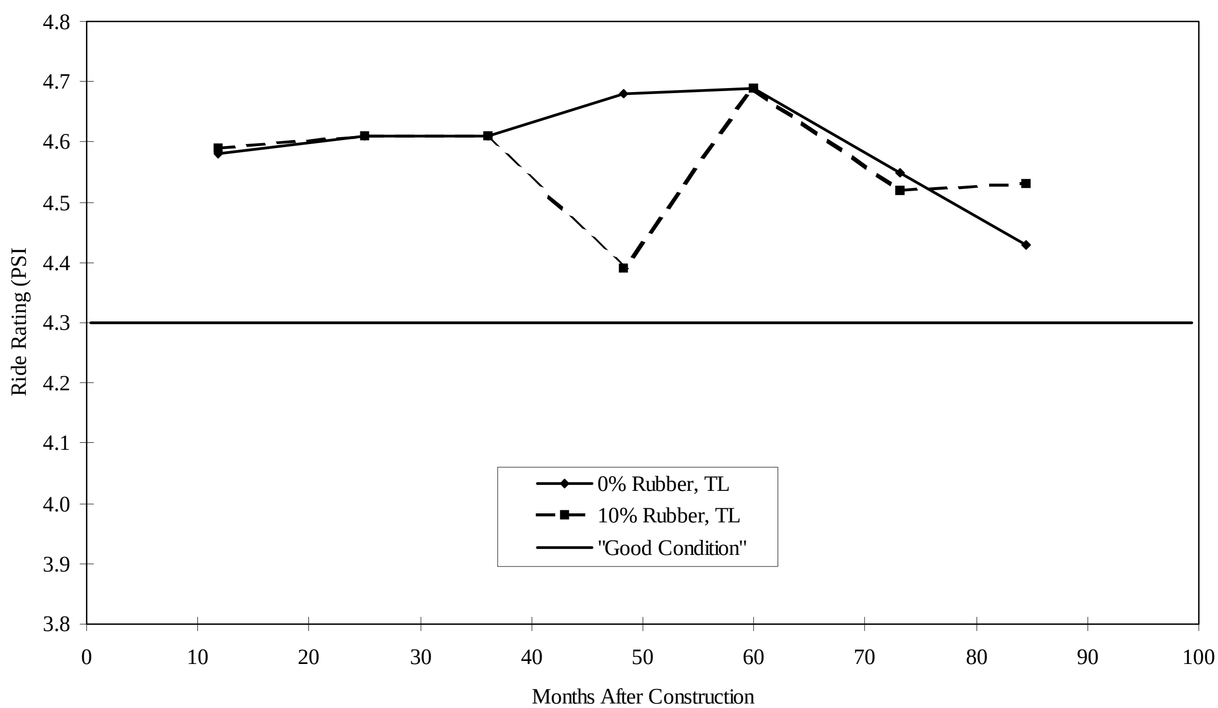


Figure 16 Ride ratings versus time as recorded on I-95, Southbound, demonstration project