Feasibility of Using More Highly Polishable Aggregates in Asphalt Surface Mixture: A Case Study for West Virginia Division of Highways

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Abstract

For regions that have a large amount of highly polishable aggregates, optimizing the use of these aggregates in asphalt surface mixtures becomes critical for both economic and roadway safety considerations. This study aimed to evaluate the feasibility of using more highly polishable aggregates (e.g., dolomite) in asphalt surface mixtures that are typically used by West Virginia Division of Highways (WVDOH). Asphalt slabs containing different percentages of dolomite coarse aggregates were fabricated in the laboratory and abraded by the three-wheel polishing device (TWPD). The dynamic friction tester (DFT) was used to measure the friction deterioration of these asphalt slabs. The laboratory DFT test results indicated that increasing dolomite content in asphalt surface mixtures resulted in a faster deterioration rate at the early polishing stage (i.e., 5,000 – 20,000 polishing cycles). In addition, asphalt surface mixtures containing more than 50% dolomite coarse aggregates had a terminal friction coefficient less than 0.30, which would significantly reduce roadway safety when using for asphalt pavements. At the National Center for Asphalt Technology (NCAT) Test Track, two sections were built in 2018 that used 70% and 90% dolomite coarse aggregates in the asphalt surface course. DFT and locked-wheel skid trailer (LWST) tests were conducted to determine the friction performance of these two sections and confirmed that replacing sandstone coarse aggregates by 70% and 90% dolomite aggregates resulted in asphalt surface mixtures with fairly low long-term skid resistance. These results justified why the WVDOH requires that dolomite shall not exceed 50% of coarse aggregate in asphalt surface mixture if the projected traffic volume is greater than three million equivalent single axle loads (ESALs). Due to the roadway safety concern, a shotblasting treatment was applied to enhance both the microtexture and macrotexture of the test sections. After 2.3 million ESALs of traffic, both sections exhibited adequate friction performance, indicating that the shotblasting treatment was effective in improving the long-term friction performance of asphalt pavements. Through the pavement performance evaluation, the shotblasting treatment was found to have no detrimental impact on cracking, rutting, and surface roughness of asphalt pavements.

Introduction

Pavement friction is defined as the resistance to motion between a vehicle tire and a pavement surface (Hall et al., 2009). It is generally characterized by the coefficient of friction, which is the ratio of the tangential force at the contact interface to the longitudinal force on the wheel (Mayora and Pina, 2009; Flintsch et al., 2012). In the laboratory, the British Pendulum Tester and Dynamic Friction Tester (DFT) are typically used to measure the surface friction of asphalt and concrete slabs (Vollor and Hanson, 2006; Georgiou and Loizos, 2014; Fowler and Rached, 2012). In the field, a variety of highway-speed pavement friction test systems have been developed, including but not limited to the locked-wheel skid trailer (LWST), Sideway-force Coefficient Routine Investigation Machine (SCRIM), GripTester, and British Mu-Meter (Hall et al., 2009). In the United States, the majority of state highway agencies have adopted the LWST method with either smooth or ribbed test tire running at a certain speed (40 mph or 64 km/h) and quantify pavement friction in terms of skid number, denoted as SN40S for smooth tire and SN40R for ribbed tire, which is equal to the friction coefficient multiplied by 100.

Existing studies have demonstrated that pavement friction is a critical factor in improving roadway safety, especially in wet weather. Wallman and Astrom (2001) found that if the pavement friction coefficient is improved from less than 0.15 to the range of 0.35 to 0.44, the car accident rate will be reduced by 75%. Xiao et al. (2000) developed a fuzzy-logic model for predicting the risk of car accidents occurring on wet pavements. They estimated that roadway safety, measured by the percent reduction in wet pavement crashes, could be improved by nearly 60% if the pavement skid number increased from 33 to 48. Najafi et al. (2019) developed an artificial neural network model to predict the rate of wet and dry accident rates at different levels of surface friction. They concluded that increasing the average skid number of urban principle arterial roads from 32 to 45 would result in a 40% reduction in wet accident rate and 15% reduction in dry accident rate. Thus, to maintain roadway safety, state highway agencies are encouraged to establish minimum friction thresholds based on engineering judgement, historic friction deterioration trends, and car accident records (Hall et al., 2009; Fwa, 2017). For instance, Idaho Department of Transportation (DOT), Texas DOT, and Maryland DOT adopt a minimum skid number threshold of 30 for heavy traffic highways (Henry et al., 2000).

For asphalt pavements, surface friction (also called skid resistance) is affected primarily by the amount of traffic polishing at the tire-pavement interface, pavement surface macrotexture and microtexture, and the properties of coarse aggregates in the surface mixture (Li et al., 2017; Rezaei et al., 2009). Kowalski et al. (2009) analyzed the influence of traffic volume on changes in friction properties of different asphalt pavements. They pointed out that when new asphalt pavement is exposed to traffic, the friction value initially increases due to wearing off asphalt binder coated onto surface aggregates, and gradually decreases to a stable level. After that, traffic volume has no significant impact on pavement friction (Skerritt, 1993). Flintsch et al. (2003) illustrated how surface texture affects the skid resistance of asphalt pavement. They pointed out that surface macrotexture contributes to the hysteresis component of friction and influences the adhesion component of friction. Generally, increasing the surface texture improves the skid resistance of asphalt pavements. Kogbara et al. (2016) identified a number of aggregate properties that influence pavement friction, which included aggregate mineralogy, hardness, shape, texture, angularity, and soundness. Among them, aggregate mineralogy is possibly the most important factor (O'Brien and Haddock, 2009). O'Brien and Haddock (2009) reported that dolomite and limestone are highly polishable aggregates due to their fairly uniform texture and low hardness. West et al. (2001) investigated the polish resistance of four types of aggregates using the British Pendulum Tester. They showed that slag had the greatest polish resistance, followed by sandstone, dolomite, and limestone. Other aggregates such as granite, basalt, crushed gravel, and calcined bauxite were also found to have a high resistance to polishing (Ongel, et al., 2009).

Many studies have investigated the feasibility of using alternative frictional aggregates in asphalt mixtures to improve asphalt pavement friction. Li et al. (2007) found that using crushed gravel in dense-graded asphalt mixtures achieved a much higher friction coefficient than using dolomite or crushed stone. Greer and Heitzman (2017) reported that the terminal friction coefficient of granite-based stone-matrix asphalt (SMA) was over double than that of limestone-based SMA. Turner and Heitzman (2013) evaluated the benefits of using slag and granite in a typical gravel-limestone hot mix asphalt surface mixture and found that replacing two-thirds of coarse aggregates by slag substantially improved the terminal friction coefficient. Chen and Wei (2016) confirmed that incorporating slag in an asphalt mixture provided better long-term skid resistance. Although frictional aggregates are effective in enhancing pavement friction, material cost must also be considered in the selection of aggregates. From the economic perspective, locally available aggregates are preferred for producing asphalt mixtures. However, for regions that have a large amount of highly polishable aggregates but a limited amount of frictional aggregates, balancing friction performance and material cost is crucial. To maintain adequate friction and acceptable construction costs, state highway agencies in the United States typically limit the amount of highly polishable aggregates (e.g., dolomite) in asphalt surface mixtures. For example, West Virginia Division of Highways (WVDOH) requires that dolomite shall not exceed 50% of coarse aggregate in an asphalt surface mixture if the projected traffic is greater than three million equivalent single axle loads (ESALs). To reduce material costs, asphalt contractors always explore the feasibility of using more highly polishable aggregates in asphalt surface mixtures. Meanwhile, there is also a critical need for highway agencies to determine an appropriate threshold for the amount of highly polishable aggregates.

Research Background

The National Center for Asphalt Technology (NCAT) Test Track is a full-scale accelerated performance testing facility. Forty-six sections with a typical length of 61-meters are built around the 2.7-kilometer oval. Five trucks each pulling three heavily loaded trailers run approximately 400 laps per day. In 2018, WVDOH sponsored two test sections (W4 and W5) on the track to investigate how an increase in the amount of dolomite impacts the friction characteristics of an asphalt surface mixture. In West Virginia, sandstone is typically used as frictional coarse aggregate in asphalt surface mixtures. In this study, section W4 used the surface mixture containing 70% dolomite and 30% sandstone as coarse aggregates, and W5 had 90% dolomite and 10% sandstone as coarse aggregates. Both sections had a 50.8 mm-thick surface course. The performance of these sections was closely monitored over two years, which included surface friction, texture, and roughness, as well as cracking and rutting distresses. Based upon the performance results, this study aimed to develop a friction-based framework to evaluate the feasibility of using more highly polishable aggregates in asphalt surface mixtures.

Materials and Methods

Materials

The asphalt surface mixture's job mix formula is shown in Table 1. The design traffic level was 3 to 30 million ESALs. Note that WVDOH defines coarse aggregates as the particles retained on sieve No. 4 (4.75 mm). Both W4 and W5 asphalt surface mixtures had the same amounts of asphalt binder and fine aggregates; the only difference was the coarse aggregate proportion. The W4 mixture had 28% dolomite and 12% sandstone as coarse aggregates, while the W5 mixture contained 36% dolomite and 4% sandstone. After conversion, there was 70% dolomite in coarse aggregates for the W4 mixture and 90% dolomite in coarse aggregates for the W5 mixture. Figure 1 presents the blended aggregate gradations, both of which met the requirements of WVDOH. The nominal maximum aggregate size of these mixtures was 12.5 mm. Table 2 shows the properties of dolomite and sandstone aggregates that were measured by the Aggregate Imaging System (AIMS). Compared to sandstone aggregate, dolomite aggregate has slightly higher angularity but much lower texture.

Table 1. Mixture Composition of Asphalt Surface Mixtures

Mixture Composition		**Mixture Type**	
		W4	W5
Coarse Aggregate Content[1]	Dolomite	28%	36%
	Sandstone	12%	4%
Fine Aggregate Content[2]	Limestone	44%	44%
	RAP	15%	15%
	Baghouse Fines	1%	1%
Binder Type		PG 76-22	PG 76-22
Binder Content[3]		5.6%	5.6%
Liquid Anti-strip Additive Content[4]		0.5%	0.5%

Note: [1] Coarse aggregate content is by weight of aggregates;
[2] Fine aggregate content is by weight of aggregates;
[3] Binder content is by weight of asphalt mixture;
[4] Liquid anti-strip additive content is by weight of asphalt binder.

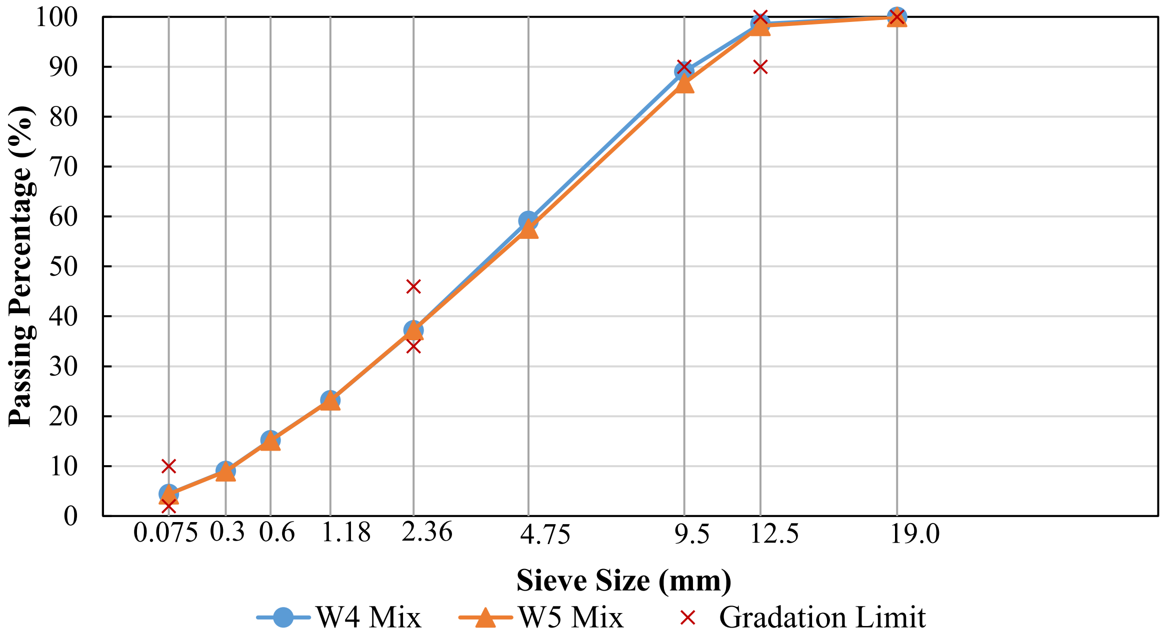


Figure 1. Blended Aggregate Gradations of Asphalt Surface Mixtures

Table 2. Results of Aggregate Imaging System Test for Dolomite and Sandstone Aggregates

Aggregate Properties	**Aggregate Type**		**Specified Range**		
	Dolomite	Sandstone	Low	Medium	High
Angularity	3100.1	2882.9	≤3300	3300-6600	6600-10000
Texture	183.8	349.4	≤260	260-550	550-1000
Sphericity	0.60	0.63	≤0.3	0.3-0.7	0.7-1.0

Methods

The experimental plan of this study is presented in Figure 2, which includes friction evaluation of laboratory-compacted asphalt slabs, field test sections, and one field friction treatment. The laboratory friction evaluation was focused on the quantification of the different friction performance of asphalt surface mixtures containing various percentages of dolomite aggregates. The field friction evaluation was conducted to examine the rationality of the findings from the laboratory tests. Note that this study utilized an accelerated traffic loading platform, the NCAT Test Track, to investigate the field friction performance of asphalt surface mixtures. This platform was not open for public traffic, which minimized the safety risk of the friction study. Due to the poor friction performance, this study also applied one type of friction treatment to the test sections, and the relevant friction tests were performed to evaluate the long-term benefits of this treatment. The experimental methods used in this study included the three-wheel polishing device (TWPD) test, DFT test, circular track meter (CTM) test, and LWST test, which are described as follows.

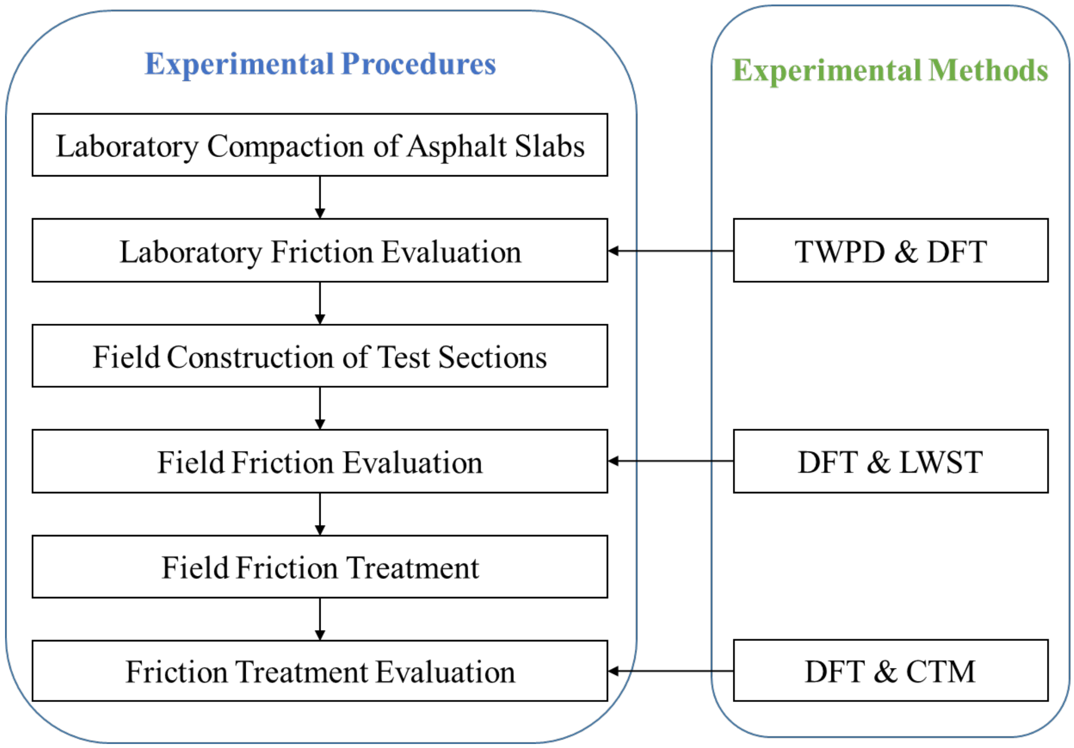


Figure 2. Experimental Plan of This Study

Three-Wheel Polishing Device Test

The TWPD was developed by NCAT to simulate the field traffic polishing of asphalt pavement in the laboratory. As shown in Figure 3a, the TWPD was operated at a rational speed of 56-60 rpm using three pneumatic tires with inflation pressure of 241 kPa (35 psi). The carriage weight on top of the tires was 66.2 kg (146 lbs). The diameter of the polishing path was 284 mm (11.2 inches), which is identical to that of the DFT measuring path. Asphalt slabs fabricated by a kneading compactor had dimensions of 508mm×508mm×51mm (20”×20”×2”). During the polishing process, a water spray system was used to wash away abraded particles and simulate wet conditions. The DFT was periodically used to measure the friction coefficient of asphalt slabs. Heitzman et al. (2019) suggested that polishing asphalt slabs for 100,000 cycles was adequate to achieve the terminal friction coefficient. Thus, the TWPD test was terminated at 100,000 cycles in this study.

Dynamic Friction Tester Test

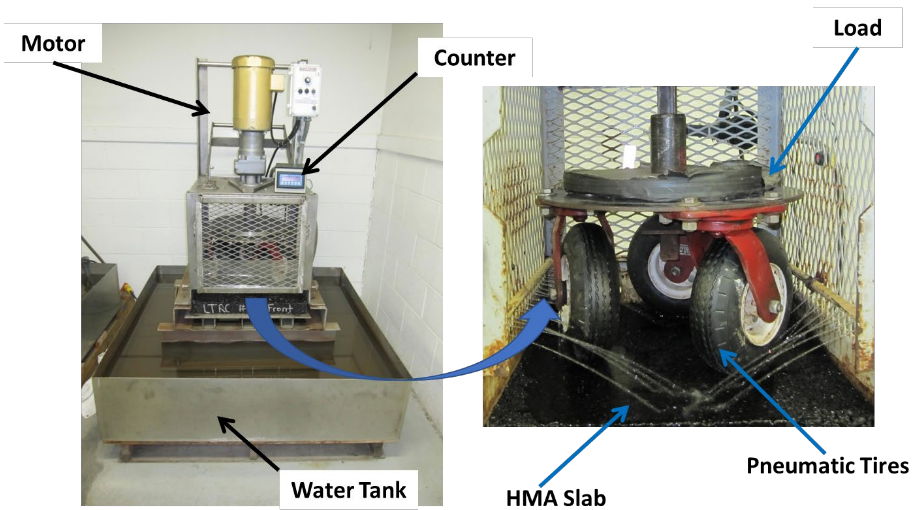
As shown in Figure 3b, the DFT consists of a horizontal spinning disk fixed with three spring-loaded rubber sliders that contact the pavement surface. A water spray system was used to simulate wet conditions. When the disk started rotating, the DFT measured the torque generated by the sliders’ resistive force to calculate the friction coefficient of the asphalt mixture. The friction coefficients measured at 20km/h, 40km/h, and 60km/h were reported for data analysis. The detailed test procedures are described in ASTM E1911. In this study, the DFT was used in both laboratory and field evaluations.

Circular Track Meter Test

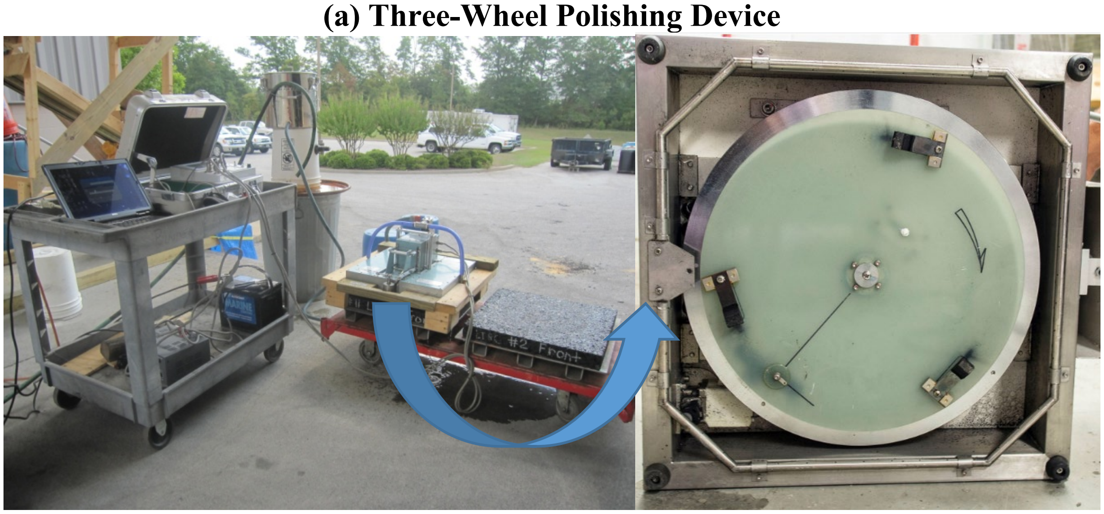
As shown in Figure 3c, the CTM utilized a laser-based displacement sensor to measure the profile of a circle 284 mm (11.2 inches) in diameter. The profile was divided into eight segments to determine the average mean profile depth (MPD) of the circle. The detailed test procedures are described in ASTM E2157. In this study, CTM was used in the field experiment.

Locked-Wheel Skid Trailer Test

As shown in Figure 3d, the LWST with a ribbed tire was used to measure the tractive force on a locked wheel as it was dragged at a constant speed (64 km/h) over a wet pavement surface. In this study, the locked wheel was mounted on the left wheel path of the vehicle. The detailed test procedures are shown in ASTM E274. The skid number is a ratio of the tractive force to the normal force multiplied by 100, which is used to characterize the friction of a pavement surface.



(a) Three-Wheel Polishing Device



(b) Dynamic Friction Tester

(c) Circular Track Meter

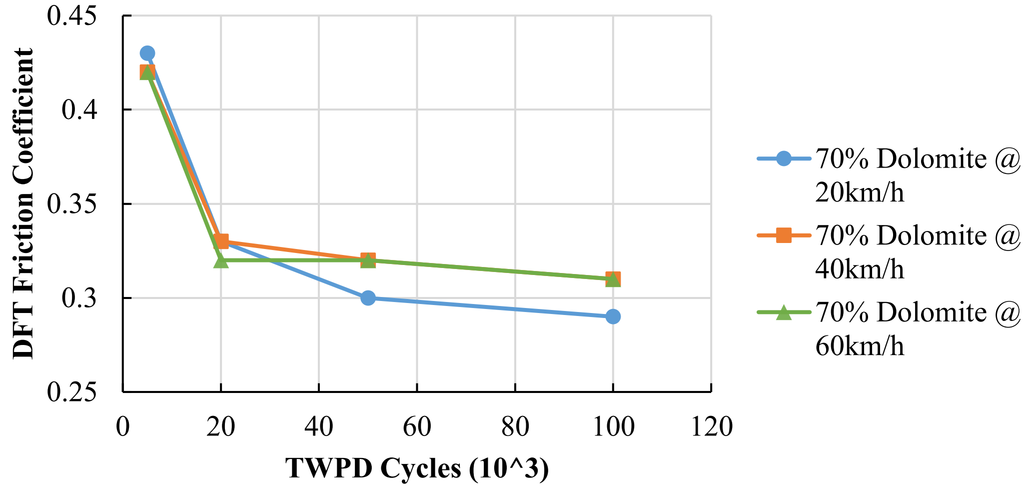
(d) Locked-Wheel Skid Trailer

Figure 3. Friction and Texture Test Devices Used in This Study

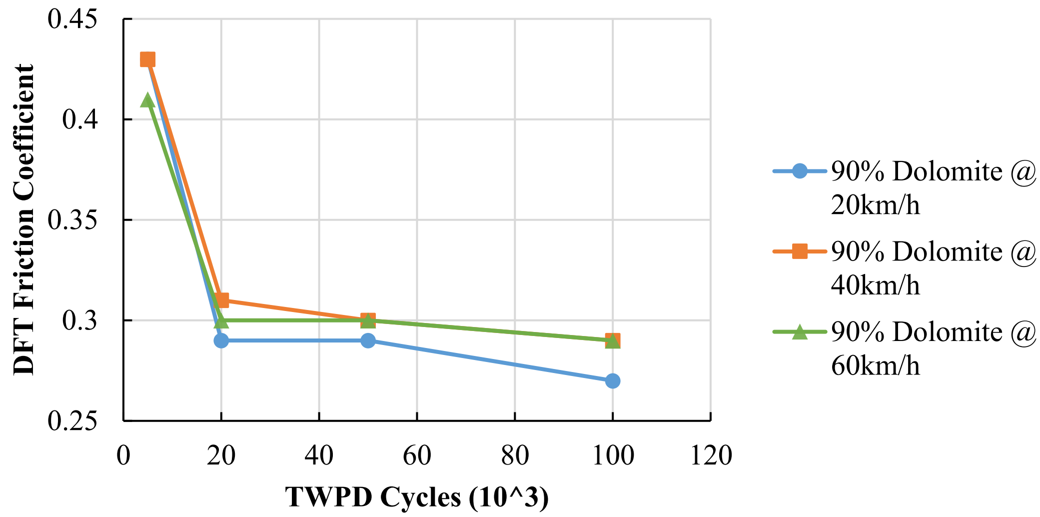
Results and Discussion

Laboratory Friction Performance of Asphalt Mixtures

In the laboratory, dolomite and sandstone aggregates were blended in different proportions to fabricate asphalt slabs. The TWPD was used to simulate the polishing of field traffic to the surface of asphalt mixtures. The DFT test was conducted at the 5,000th, 20,000th, 50,000th, and 100,000th cycles to characterize the deterioration trend of asphalt surface friction. Figure 4 illustrates the influences of polishing cycle and test speed on the friction coefficient of asphalt mixtures. It is shown that the DFT friction coefficient was sensitive to the number of polishing cycles. The friction coefficient decreased rapidly from 5,000 to 20,000 polishing cycles, indicating poor resistance to traffic polishing. After 20,000 cycles, the deterioration rate of friction coefficient became much slower. Typically, the pavement friction coefficient decreases with an increase in driving speed (Kogbara et al., 2016). However, the DFT test results shown in Figure 4 did not demonstrate any clear trend between test speed and friction coefficient. This might be attributed to the different modes of rubber-pavement interaction between DFT sliding and vehicle braking. Accordingly, the DFT test might not be appropriate to evaluate the influence of test speed on pavement friction coefficient. This study employed the DFT friction coefficient measured at 20km/h to quantify the friction performance of asphalt mixtures.



(a) 70% Dolomite



(b) 90% Dolomite

Figure 4. Influences of Polishing Cycles and Test Speed on DFT Friction Coefficient of Asphalt Mixtures

Figure 5 shows the effect of dolomite content on the DFT friction coefficient of asphalt mixtures. It is not surprising to see that the asphalt mixture containing dolomite had a slightly higher friction coefficient than the mixture containing only sandstone. This is because dolomite has relatively greater angularity and less sphericity than sandstone, which is important to initial friction of asphalt mixtures. From 5,000 to 20,000 polishing cycles, asphalt mixtures containing dolomite aggregate all experienced much more rapid reductions in friction coefficient than those without, which is because sandstone typically has better polishing resistance. From 20,000 to 50,000 polishing cycles, the friction coefficients continued decreasing but the deterioration rates were slow. After 50,000 cycles, the friction curves tended to be flat, indicating that traffic polishing no longer had a significant impact on asphalt friction. To compare the friction performance of asphalt mixtures, the deterioration rates of friction coefficient from 5,000 to 20,000 polishing cycles were calculated using Equation 1.

$$Friction\ Deterioration\ Rate = \frac{Reduction\ of\ Friction\ Coefficient}{Number\ of\ Polishing\ Cycles} \quad (1)$$

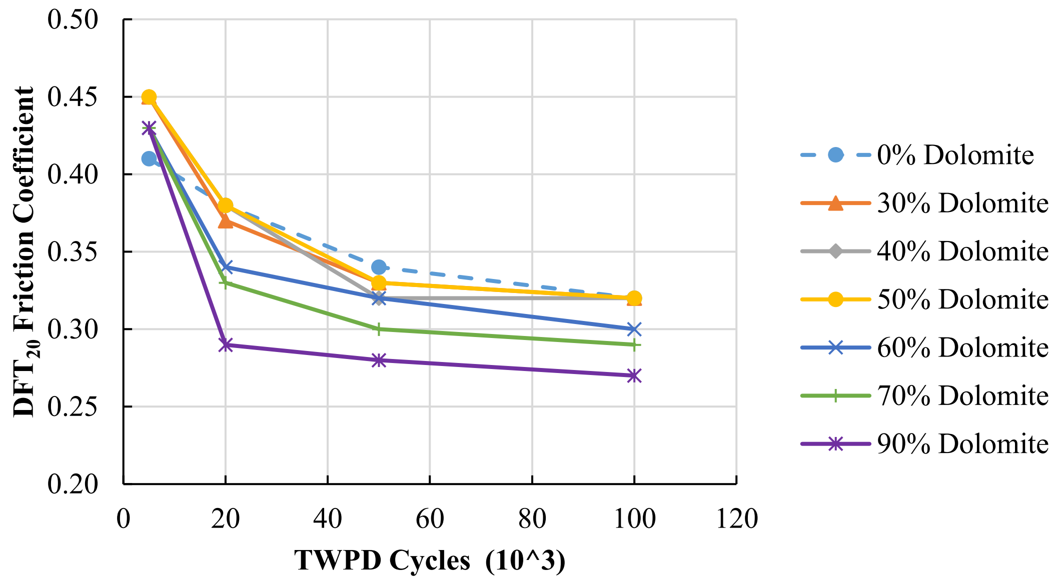


Figure 5. Effect of Dolomite Content on DFT Friction Coefficient of Asphalt Mixtures

Figure 6 shows that the friction deterioration rate from 5,000 to 20,000 polishing cycles had a good linear correlation with dolomite content. Increasing dolomite content resulted in a faster deterioration rate of friction at the early polishing stage (5,000 to 20,000 cycles). This implies that asphalt surface mixtures containing more dolomite aggregates would enter into the terminal friction stage much faster. Figure 7 illustrates how dolomite content affected the terminal friction coefficient. It is shown that the terminal friction remained constant when dolomite content increased from 0% to 50%, but decreased linearly as dolomite content increased from 50% to 90%. The terminal friction coefficients of asphalt mixtures containing 70% and 90% dolomite aggregates reduced to 0.29 and 0.27, respectively, which were less than the minimum threshold of DFT friction coefficient (i.e., friction coefficient = 0.30) recommended by NCAT. Therefore, limiting dolomite content to no greater than 50% ensures an adequate terminal friction coefficient for asphalt mixtures, which justifies why WVDOH requires that dolomite shall not exceed 50% of coarse aggregate in asphalt surface mixtures for high traffic volume applications. According to the historic experience, the terminal friction coefficient typically ranges from 0.35 to 0.45 for dense-graded asphalt surface mixtures, which is higher than the terminal friction coefficients of West Virginia asphalt mixtures measured in this study. This could be explained by the AIMS test results that both dolomite and sandstone aggregates had relatively low angularity and texture, and high sphericity.

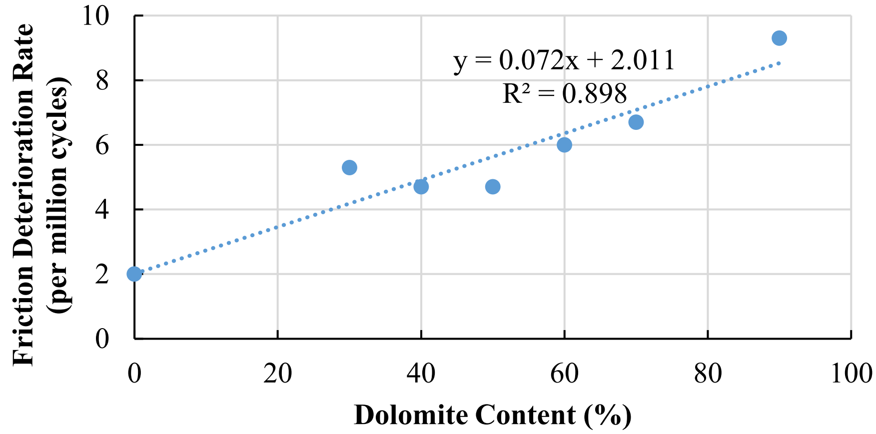


Figure 6. Correlation between Friction Deterioration Rate and Dolomite Content

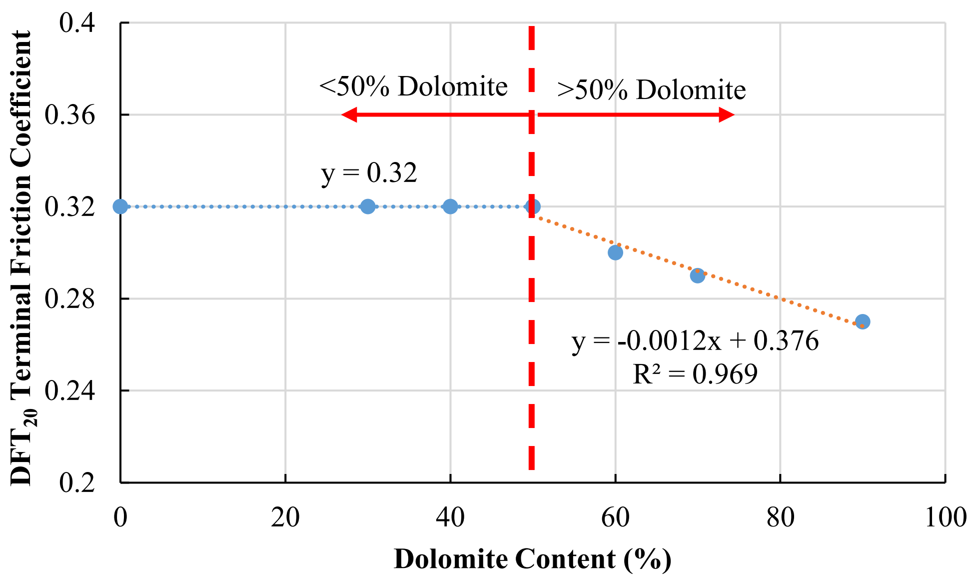


Figure 7. Relationship between Terminal Friction Coefficient and Dolomite Content

Field Friction Performance of Asphalt Mixtures

As mentioned previously, two sections were built at the NCAT Test Track to investigate the friction performance of asphalt surface mixtures containing highly polishable aggregates. Section W4 used an asphalt mixture containing 70% dolomite and 30% sandstone as coarse aggregates, and section W5 had an asphalt mixture with 90% dolomite and 10% sandstone as coarse aggregates. These sections were trafficked by five heavy trucks each pulling three loaded trailers. The LWST was used to monitor the skid resistance of these two sections on a monthly basis. Figure 8 presents the LWST test results of sections W4 and W5. It is shown that the skid resistance of both sections dropped rapidly after being trafficked for one million ESALs and continued degrading from one to three million ESALs of traffic. When the accumulated traffic reached three million ESALs, the skid resistance of W4 and W5 sections reduced to 26.4 and 22.8, respectively, which were much lower than the minimum roadway safety threshold (i.e., skid number = 30) recommended by NCAT. This is consistent with the finding from laboratory friction evaluation and confirms that the asphalt surface mixtures in West Virginia should not contain 70% or 90% dolomite if the projected traffic is greater than three million ESALs. After three million ESALs of accumulated traffic, the traffic polishing had a negligible influence on pavement friction. Compared to section W4, section W5 generally had a lower skid resistance due to the higher dolomite content. It is also noted that the skid number of both sections slightly increased when the accumulated traffic was beyond 4.3 million ESALs. Considering that these sections could not regain skid resistance without any treatment, the increase in skid number must be attributed to the influence of test temperature on the LWST measurement. For the same pavement surface, the skid number measured in winter is typically greater than that measured in summer due to the lower test temperature (Anupam et al., 2013).

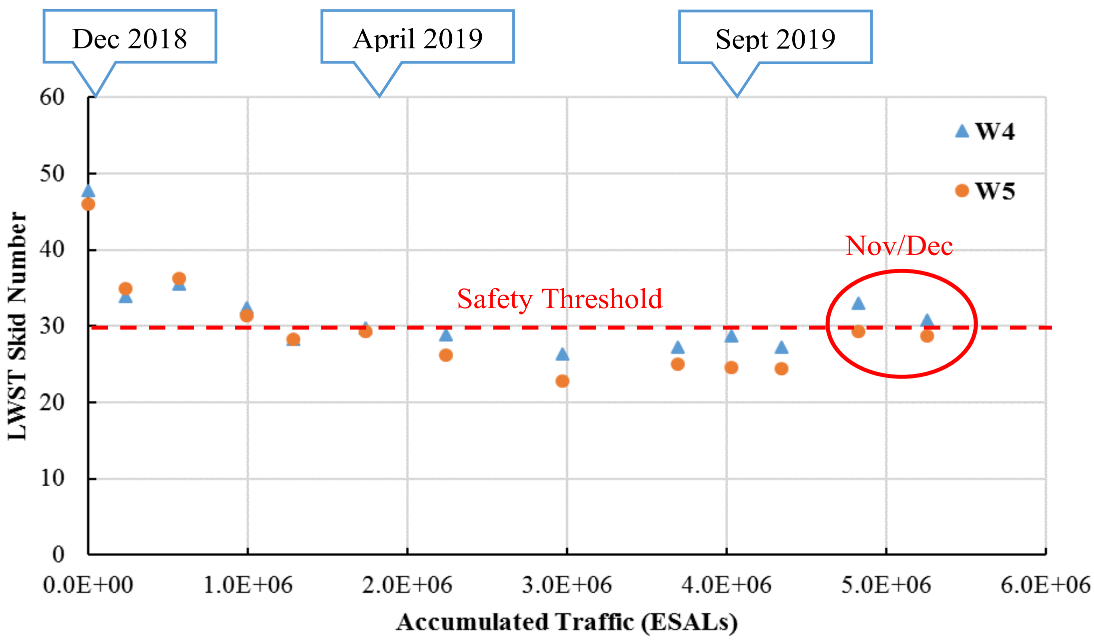


Figure 8. LWST Test Results for NCAT Test Track Sections W4 and W5

In addition, DFT was used to measure the friction coefficient of sections W4 and W5. Figure 9 shows the DFT test results of these two sections. Similar to the LWST test results, both sections showed poor friction performance after 1.5 million ESALs of traffic. This confirms that the asphalt surface mixtures containing 70% and 90% dolomite aggregates could not provide adequate friction coefficient if the projected traffic volume is greater than three million ESALs. It is also shown that section W5 had a lower friction coefficient than section W4 in general, which is consistent with the finding from the LSWT test.

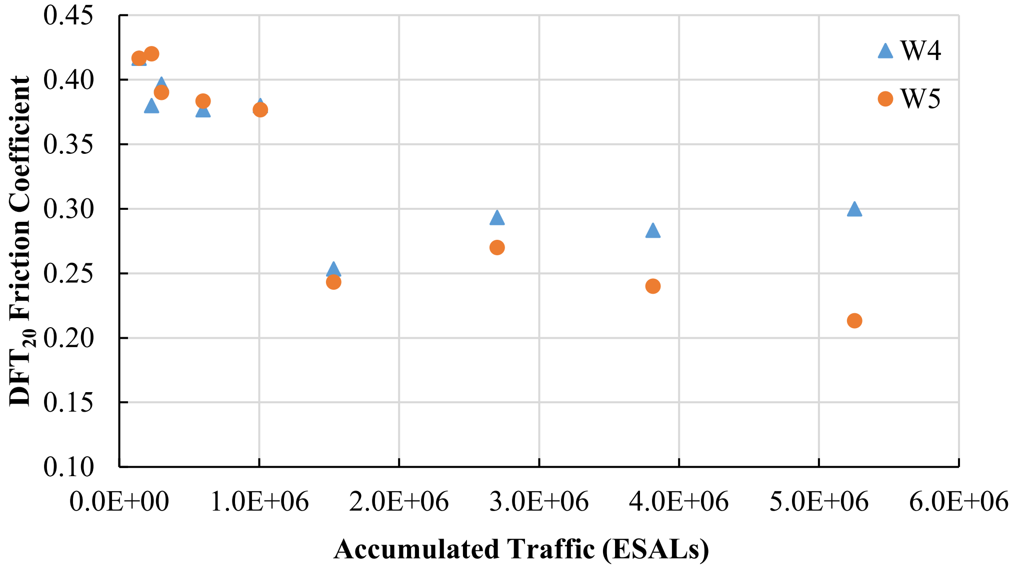


Figure 9. DFT Test Results for NCAT Test Track Sections W4 and W5

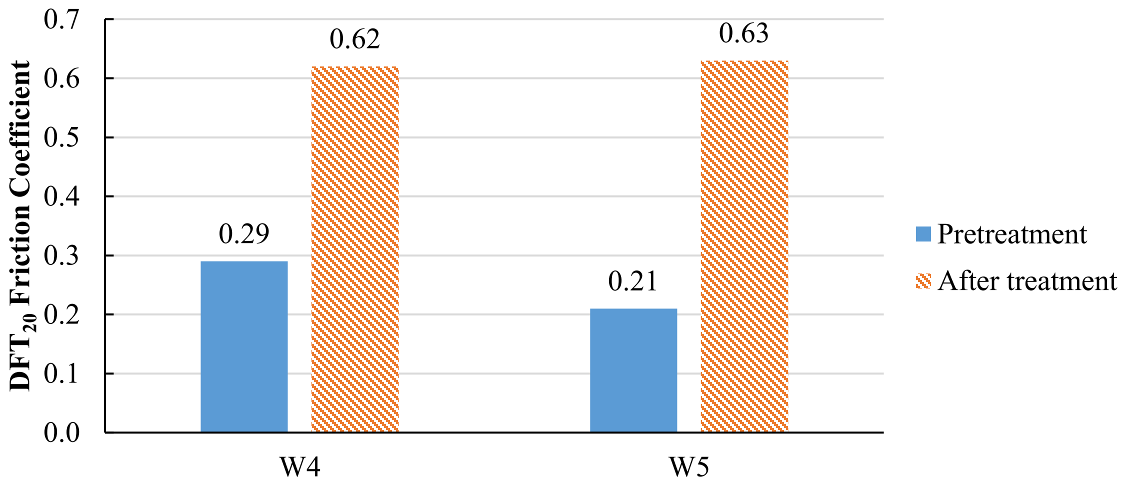
Influence of Shotblasting Treatment on Surface Friction

When sections W4 and W5 kept showing friction coefficients lower than 0.3, there was an urgent need to apply friction treatment to address roadway safety concerns. In this study, due to the ease of application and low cost, the shotblasting treatment was adopted after 5.3 million ESALs of accumulated traffic (Gransbert, 2009). Figure 10a illustrates a typical shotblasting system, including an operating room, a shotblasting apparatus, a shot recycler, and a dust collector. The shotblasting apparatus is an essential unit that consists of shot propeller, vacuum system, magnetic separator, brush, and broom. Figure 10b shows the shotblasting treatment at the NCAT Test Track. The shotblasting train ran at a speed of 28.3 m/min with a treatment width of 1.8 m.

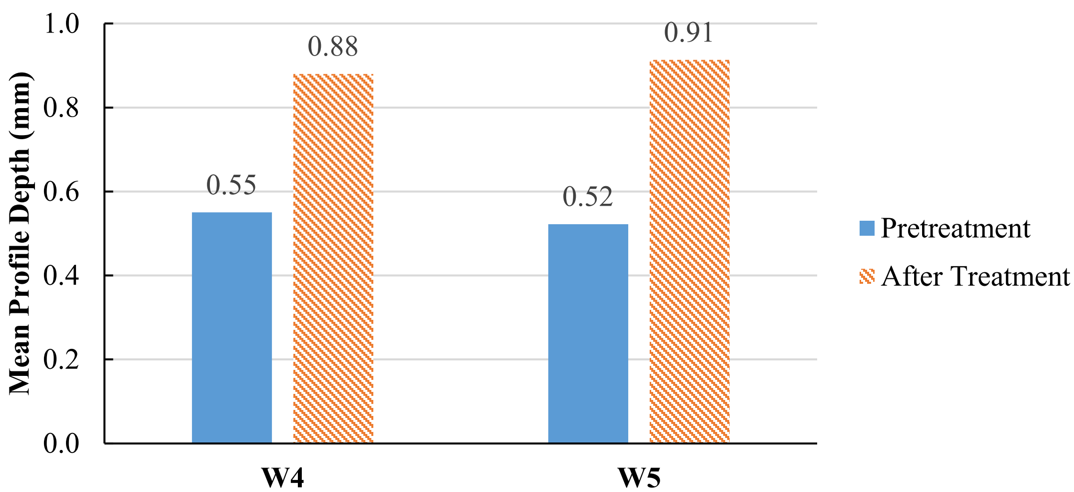
(a) Shotblasting System **(b) Treatment at Test Track**

Figure 10. Shotblasting Treatment at NCAT Test Track

Figure 11 compares the DFT friction coefficient and surface texture of sections W4 and W5 before and after shotblasting treatment. As shown in Figure 11a, the shotblasting treatment remarkably improved the friction coefficient of both sections. This is primarily because shotblasting abraded asphalt pavement surface that caused more angular aggregate faces exposed to traffic, thereby increasing the microtexture of pavement surface. Figure 11b shows that pavement sections had much higher MPD values after shotblasting. This demonstrates that shotblasting treatment substantially enhanced the macrotexture of asphalt pavement surface, which also contributed to the friction gain.



(a) Friction Coefficient



(b) Surface Texture

Figure 11. Comparison of Friction Coefficient and Surface Texture of Pavement Sections before and after Shotblasting Treatment

Figure 12 shows the influence of traffic polishing on the friction performance of shotblasted pavement sections. As presented, the friction coefficient of sections W4 and W5 significantly increased during the first 0.1 million ESALs of traffic, which was attributed to the wearing of coated asphalt binder on the exposed aggregate surface. However, the friction coefficient of both sections sharply reduced from 0.1 to 0.2 million ESALs of traffic, indicating that the exposed angular aggregate faces were worn off during this period. After that, the friction deterioration rate tended to be extremely low. Both sections held friction coefficients above 0.30 after being trafficked for more than two million ESALs due to the increased surface macrotexture, which implies that the benefit of the increased microtexture might not be as sustainable as that provided by the increased macrotexture. Note that the persistence of the microtexture enhancement might be dependent on the aggregate type. Overall, the shotblasting treatment was effective in improving long-term friction performance. Figure 13 presents the influence of traffic polishing on macrotexture of shotblasted pavement sections. It is confirmed that the enhanced surface macrotexture by shotblasting treatment was negligibly affected by traffic polishing, which explains why the shotblasting treatment provided the long-term friction gain.

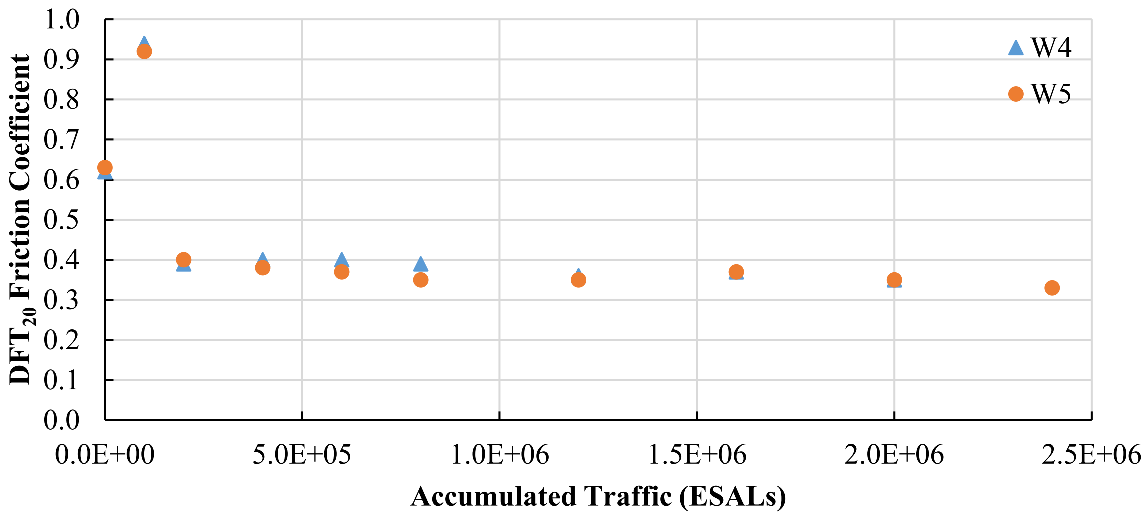


Figure 12. Influence of Traffic Polishing on Friction Performance of Shotblasted Pavement Sections

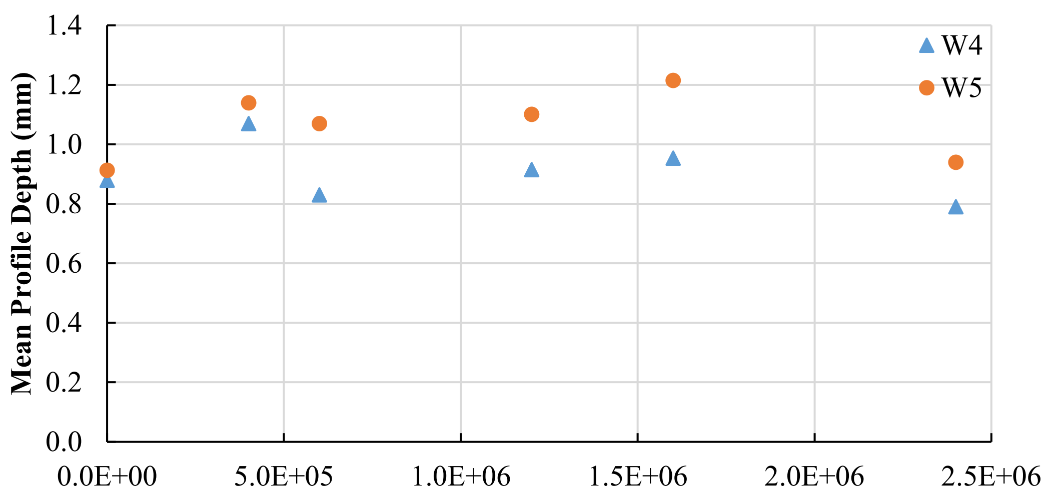
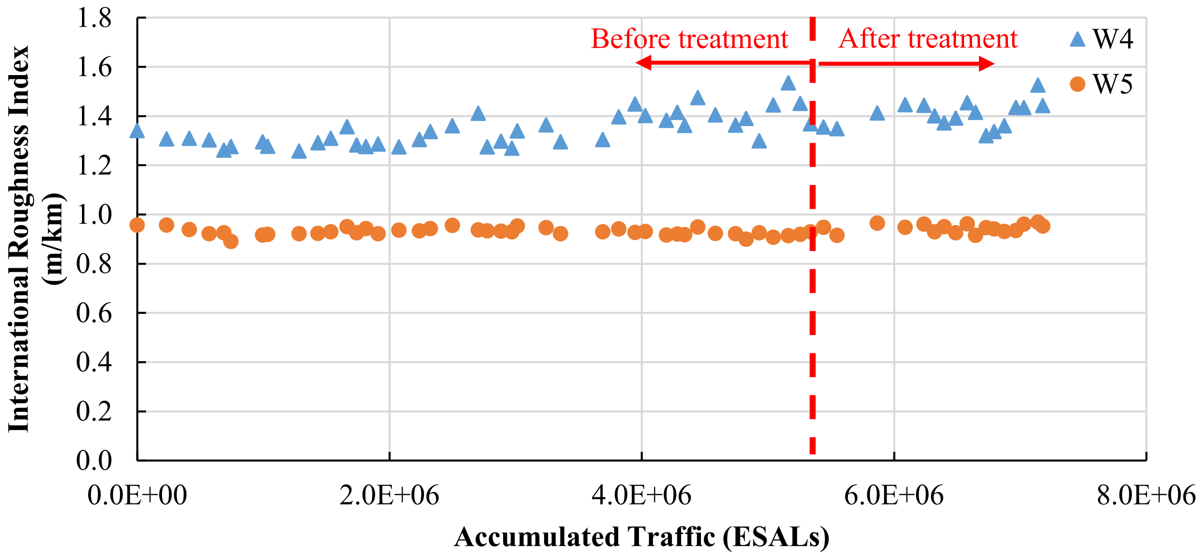


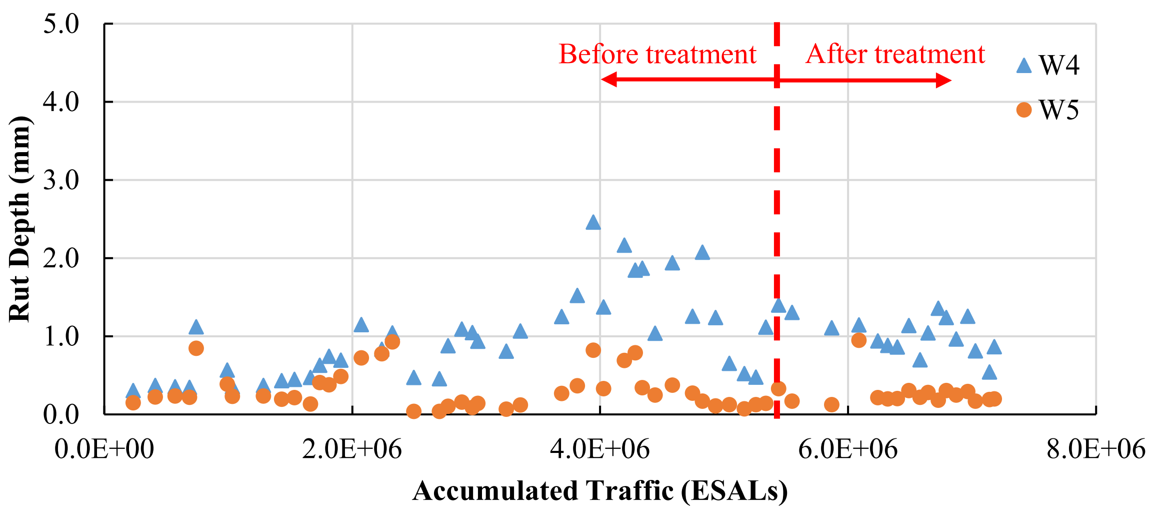
Figure 13. Influence of Traffic Polishing on Macrotexture of Shotblasted Pavement Sections

Since the friction benefit provided by the shotblasting treatment was promising, one question remaining was whether this treatment brought any detrimental impact on pavement performance.

This study investigated the performance of sections W4 and W5 before and after shotblasting treatment in terms of international roughness index, rut depth, and cracking percent. After being trafficked for more than seven million ESALs, both sections did not exhibit any cracking distress. Figure 14 shows the results of international roughness index and rut depth of sections W4 and W5. As presented, both sections remained stable international roughness index and rut depth values before and after shotblasting treatment. This indicates that the friction treatment had no adverse effect on pavement performance. In addition, both sections showed great smoothness and extremely low rut depth, which implies that the friction results obtained from this study were not interfered by pavement distresses.



(a) International Roughness Index



(b) Rut Depth

Figure 14. Influence of Shotblasting Treatment on International Roughness Index and Rut Depth of Pavement Sections

Summary and Conclusions

This study developed a framework to evaluate the feasibility of using more highly polishable aggregates in asphalt surface mixtures, which involved both laboratory and field friction experiments. The dynamic friction tester (DFT) was employed to determine the friction coefficient of the laboratory-compacted asphalt slabs that were abraded by the three-wheel polishing device (TWPD). The locked-wheel skid trailer (LWST) and DFT tests were performed to measure the skid resistance of two test sections at the NCAT Test Track that were polished by heavy trucks. This framework was applied to a case study for asphalt surface mixtures containing sandstone and dolomite aggregates that are typically used by the West Virginia Division of Highways (WVDOH). The major findings of this study are summarized as follows.

- Increasing dolomite content in asphalt surface mixtures led to a faster deterioration rate of friction at the early polishing stage.
- Both laboratory and field test results indicated that the asphalt surface mixtures containing 70% and 90% dolomite coarse aggregates provided poor long-term friction performance.
- Asphalt surface mixture containing no more than 50% dolomite had an adequate terminal friction coefficient. This justified why WVDOH requires that dolomite shall not exceed 50% of coarse aggregate in an asphalt surface mixture if the projected traffic volume is greater than three million equivalent single axle loads (ESALs).
- The comparison of laboratory and field friction results indicated that the TWPD was capable of simulating traffic polishing in the field.
- Due to the increased surface macrotexture, shotblasting treatment was effective in improving the long-term friction performance of asphalt pavements and had no detrimental impact on pavement performance in terms of cracking, rutting, and surface roughness.

Acknowledgements

The authors acknowledge the financial support provided by the West Virginia Division of Highways and Skidabrader Company. Special thanks are extended to the friction team from Alabama Department of Transportation for conducting the locked-wheel skid trailer test, Jason Nelson from NCAT for coordinating the field construction and testing, Jason Moore and Nathan Moore from NCAT for conducting laboratory experiments, and Travis Walbeck from NCAT for providing technical guidance.

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