Longevity of Diamond-Ground Concrete Pavements

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Longevity of Diamond-Ground Concrete Pavements

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ABSTRACT

Diamond grinding restores a smooth riding surface with the desirable friction characteristics on concrete pavements. This technique was first used in 1965 on a 19-year-old section of I-10 in southern California to eliminate excessive faulting *(1)*. Since then, diamond grinding has become a major element of concrete pavement restoration (CPR) projects. Despite this long history, very little valid documentation of the performance of diamond-ground pavements exists. In recognition of the critical need for such information, the Portland Cement Association (PCA), in association with American Concrete Pavement Association (ACPA) and International Grooving and Grinding Association (IGGA), sponsored a study of performance of diamond-ground pavements.

The study involved conducting a comprehensive review of existing information on diamond grinding, data collection, data analysis, and documentation of the study findings. Extensive field surveys were conducted to obtain the performance data needed for the analysis. In all, 60 pavement sections in 18 States were surveyed. In addition, performance data for 133 sections were obtained from an earlier study of the performance of diamond-ground pavements *(2)*. The LTPP database was also used because the SPS-6 sections (concrete pavement rehabilitation) provide opportunity for the direct, side-by-side comparison of the performance of diamond-ground pavement sections and other rehabilitation alternatives. Various analyses were conducted to document the performance of diamond-ground pavements, including an evaluation of faulting performance, longevity of diamond-ground texture, and the effects of diamond grinding on service life. This paper presents a brief description of the work conducted and a summary of the findings.

Key Words: diamond grinding, concrete pavement rehabilitation, pavement performance, faulting, surface texture

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INTRODUCTION

Diamond grinding is a concrete pavement restoration (CPR) technique that provides a smooth riding surface with the desirable friction characteristics on concrete pavements. Diamond grinding can offer numerous advantages over other rehabilitation alternatives. Diamond grinding costs substantially less than an overlay *(3)*, and for many rehabilitation projects, other characteristics of diamond grinding can also offer significant benefit. For example, diamond grinding can be accomplished during off peak hours with short lane closures, and without having to close the adjacent lanes. Also, grinding of one traffic lane does not require grinding of the adjacent lane, which may have perfectly acceptable surface characteristics. For concrete pavements in good structural condition, diamond grinding can be a highly effective and economical rehabilitation alternative.

The history of continuous diamond grinding for pavement restoration dates back to 1965, when the technique was first used on a 19-year-old section of the San Bernardino Freeway (I-10) in southern California to eliminate excessive faulting *(1)*. Diamond grinding was used as the final step in the CPR program to provide a smooth riding surface. Diamond grinding has since become a major element of PCC restoration projects; however, very little valid documentation of the performance of diamond-ground pavements exists.

Recognizing the need for such documentation, PCA, in association with ACPA and IGGA, sponsored a study to evaluate the performance of diamond-ground pavements. The objective of this study was to provide the answers to frequently asked questions about diamond grinding, including the following:

- What is the immediate impact of diamond grinding on pavement performance?
- How long can diamond-ground surfaces provide acceptable ride quality?
- How long can diamond ground surfaces provide acceptable surface texture?
- When is diamond grinding feasible and effective?
- Can diamond grinding be used more than once on a pavement?
- Are there any adverse effects of diamond grinding?

These objectives were accomplished by conducting a comprehensive review of existing information on diamond grinding, gathering performance data, analyzing the collected data, and documenting the findings.

The performance data needed for the evaluation were obtained from existing databases and by conducting field surveys. The main source of existing data was the database created by Snyder et al. *(2)* for the 1989 FHWA-sponsored study of concrete pavement rehabilitation. That database contains 133 diamond-ground pavement sections at 76 sites. The number of sections is greater than the number of sites because replicate sections were taken at many of the sites.

The field survey for the current study revisited surviving sites from the 1989 FHWA study. At the time of field survey in fall 1997, 38 of the 76 sites were surviving. The field survey sites also included additional sites located in several States. In all, 60 sections at 54 sites were surveyed, bringing the total number of pavement sections available for data analysis to 193. Figure 1 shows the geographical distribution of the pavement sections included in this study.

Another important source of existing data for diamond-ground pavements is the Long-Term Pavement Performance (LTPP) database. The LTPP SPS-6 sections (concrete pavement rehabilitation) provide the opportunity for direct, side-by-side comparison of the performance of diamond-ground pavement sections and other rehabilitation alternatives, including asphalt concrete (AC) overlays.

The field survey consisted of a visual distress survey and taking faulting measurements. The macrotexture depth of diamond-ground surfaces was also measured at selected sites using the sand-patch method (ASTM E 965) for the evaluation of the surface texture. Various analyses were conducted on the collected data to accomplish the study objectives, including evaluation of service life, faulting performance, longevity of diamond-ground texture, and the effects of diamond grinding on slab cracking. This paper presents a summary of the findings from these analyses.

EFFECTS OF DIAMOND GRINDING

The immediate effect of diamond grinding is significant improvement in smoothness. Figure 2 shows a comparison of International Roughness Index (IRI) values before and shortly after rehabilitation of SPS-6 sections. The *Min Prep* and *Max Prep* refer to the different levels of CPR. The Indiana sections were not diamond ground, and the CPR activities actually caused a slight increase in roughness. Other sections show a significant drop in IRI after diamond grinding.

Figure 3 shows that the level of smoothness that can be achieved through diamond grinding is comparable to that of a new pavement or an AC overlay. However, it is important to recognize that diamond grinding only addresses serviceability problems. Diamond grinding should not be used on pavement sections with a material problem such as D-cracking or reactive aggregate. If the existing pavement is structurally deficient, an overlay or reconstruction may be more appropriate. Application of diamond grinding on a structurally deficient pavement can result in rapid redevelopment of roughness. Even in such cases, however, it may be appropriate to consider diamond grinding as an economical short-term (less than 5 years) solution to a roughness problem until the pavement section can be overlaid or reconstructed.

Another very important effect of diamond grinding is the significant increase in surface texture and consequent improvements in skid resistance and safety. Drakopoulos et al. *(4)* studied the effects of diamond grinding on accident rates on concrete pavements in Wisconsin. The study included 30 diamond-ground pavement sections totaling 290 km (180 mi) and 21 tined pavement sections totaling 115 km (71 mi). This study showed that diamond-ground pavements have 58 percent the accident rate of tined pavements (a 42-percent reduction) under both dry and wet conditions *(4)*. The difference is less pronounced under snow and ice conditions, but the accident rate was 16 percent less on diamond-ground pavements.

PERFORMANCE OF DIAMOND-GROUND PAVEMENTS

Service Life

The 76 projects included in the 1989 FHWA study were used to evaluate the effects of diamond grinding on pavement service life. Because replicate sections are subjected to the same rehabilitation treatments, they could not be considered independently for this analysis. The age distributions of both failed (overlaid or reconstructed) and surviving sections in figure 4 show an excellent performance of diamond-ground pavements. Only 10 of the 76 sections (13 percent) failed at an age less than 25 years. The figure also shows that 44 sections (58 percent) lasted 30 years or more, and 27 (36 percent) are still surviving. The average age at failure (of the failed sections) was 29.3 years. For surviving sections, the average age was 34.9 years (average age for all 76 sections was 32.2 years). Therefore, the average age of failure for all 76 sections is greater than 32.2 years because of the additional life of the 38 sections surviving in 1997. This is about 10 years more than typical design life. The distribution of traffic placed on these sections is shown in figure 5. Again, excellent performance is observed.

A survival analysis was conducted to quantify the effectiveness of diamond grinding in extending the service life of concrete pavements. Figure 6 shows two different survival curves based on different criteria for failure, and both show an excellent survival trend. The *Pavement age to overlaying or reconstruction* curve shows that there is less than a 15 percent probability that a diamond-ground pavement will have to be overlaid or reconstructed at age 30 years or less. The probability that the pavement will fail after age 40 years is 60 percent. This relatively low probability of failure for older pavements is reflected in the high average age (34.9 years) of the 38 surviving sections.

The *Time to regrind or rehabilitation* curve in figure 6 presents more practical information. This curve shows that the probability that a diamond-ground pavement will require resurfacing before providing at least 10 years of service is about 12 percent. In other words, the probability that a diamond-ground surface will last at least 10 years is almost 90 percent. The probability that it will last fewer than 8 years is less than 2 percent. The survival analysis results show that we may expect (with a high degree of reliability) 8- to 10-year life for diamond-ground surfaces. A diamond-ground pavement may be reground to further extend its service life.

Faulting

Excessive faulting is perhaps the most common reason for grinding jointed concrete pavements. Faulting is noticeable when the average faulting in the pavement section reaches about 2.5 mm (0.1 in). When the average faulting reaches 4 mm (0.15 in), diamond grinding or other rehabilitation measures should be considered.

A significant scatter is observed in faulting performance of diamond-ground pavements, particularly nondoweled pavements. Diamond-ground pavements are typically pavement sections that had developed significant faulting prior to grinding, with accompanying void and support problems at slab corners. Hence, the high degree of variability in faulting performance for these sections is not surprising. Concurrent rehabilitation is another source of variability. The amount, type, and performance of rehabilitation performed concurrent with diamond grinding can all affect the faulting performance. Full-depth repairs are typically doweled and reduce average faulting by replacing existing original faulted joints. Slab stabilization and retrofit edgedrains also affect average faulting by reducing pumping. However, the performance of stabilized slabs and retrofitted edgedrains is highly variable, resulting in high variability in faulting performance after diamond grinding.

A mechanistic-empirical faulting model for nondoweled pavements was developed using the energy of deformation in the subgrade at the slab corner as the main component of faulting. The effect of precipitation on faulting performance of nondoweled diamond-ground pavement is shown in figure 7. Immediately after grinding, all nondoweled jointed concrete pavements show a rapid increase in faulting and reach 1.3 to 2.0 mm (0.05 to 0.08 in) of faulting within 1 million equivalent single axle loads (ESALs). The rate of faulting decreases after 2 million ESALs. Faulting performance after diamond grinding varies significantly, depending on the amount of precipitation. For the specific pavement design and subgrade support value shown in figure 7, pavements in dry regions (precipitation < 380 mm [15 in]) fault to 3.8 mm (0.15 in) after 20 million ESALs. Pavements in wet regions (precipitation > 1270 mm [50 in]) reach this level of faulting after about 7 million ESALs.

Figure 8 includes the best-fit linear regression line for doweled diamond-ground pavements and predicted faulting for new pavements determined using the model developed under a recent NCHRP project *(5)*. The faulting performance of doweled diamond-ground sections is significantly worse than that of new pavements, although the amount of faulting did not reach the significant level in any of the sections. The reason for the relatively poor faulting performance might be that the doweled section that had been diamond-ground had other problems with load transfer, such as looseness around the dowels, excessive joint opening, or dowel misalignment. Nevertheless, the faulting performance of the doweled sections is significantly better than that of the nondoweled sections, and the doweled sections do not reach the level of faulting that requires a corrective action.

Surface Texture

Diamond grinding results in a significant increase in surface macrotexture and corresponding improvement in skid resistance. The surface macrotexture is defined as the amplitude of deviations of a pavement surface with wavelengths from 0.5 to 50 mm (0.02 to 2.0 in) *(6)*. Skid resistance is an important safety variable. Texture life, therefore, is important for safety considerations.

The improvement in skid resistance of a pavement immediately after diamond grinding is dramatic. One study showed that the average friction number on five projects across the U.S. increased from 42 to 80 after grinding (a 90 percent increase), as measured with a smooth (ASTM E524) tire *(7)*. Some studies have indicated that the improvement in skid numbers may be temporary, particularly if the pavement contains aggregate that is susceptible to polishing. Tyner *(8)* observed that while the skid numbers will decrease over the first few years, an adequate macrotexture will normally be maintained for many years.

To evaluate the longevity of surface texture, macrotexture depths were measured at in-service diamond-ground sections in 15 States, using the sand-patch method (ASTM E 965). Figure 9 shows the macrotexture depths determined from the field measurements by climatic region. The analysis results showed that the longevity of diamond-ground texture is most strongly correlated to the age since grinding. The climatic region (freeze vs. nonfreeze) was also a significant factor (the texture lasts longer in nonfreeze climate). Other factors that might significantly affect longevity of surface texture include traffic and aggregate hardness, but neither was found significant. It is possible that the significance of the effects of traffic is confounded with age, which is a surrogate for many parameters. The effects of aggregate hardness may have been lost because closer blade spacing is used on harder aggregates, resulting in smaller land area that would wear down faster. The regression equation for the mean texture depth is given by:

$$MTD = -0.152\ (1 + 0.233\ FREEZE)\ \ln(AGE) + 0.887 \quad (1)$$

R^2 = 0.83

SEE= 0.098 mm (0.0038 in)

N = 35

where:

MTD = Mean texture depth, mm.

AGE = Age since grinding, years (0.5 to 16 years).

FREEZE = Dummy variable for freeze climatic region.

(0 = wet nonfreeze or dry nonfreeze, 1 = wet freeze or dry freeze)

Figure 9 is shown with a dashed reference line at 0.5 mm (0.02 in) to represent a nontextured concrete surface. The trend lines show that the reference level of texture is reached at age 8 years in the freeze region and at age 12 years in the nonfreeze region. Macrotexture depths can be correlated to skid number. The correlation results obtained using the model developed by Henry and Wambold *(9)* are shown in figure 10.

Cracking

Diamond grinding reduces slab thickness. Since slab thickness is one of the most sensitive factors affecting cracking performance of concrete pavements, any reduction in slab thickness can be a concern. The effects of diamond grinding on cracking performance of concrete pavements were evaluated based on both analytical results and field observations.

For the analytical evaluation, a fatigue analysis was conducted to examine the sensitivity of fatigue life to slab thickness and concrete strength. The results are shown in figure 11. The predicted fatigue life was determined using the jointed plain concrete pavement (JPCP) cracking model developed by Yu et al. *(10)*. Fatigue life of a pavement slab is extremely sensitive to slab thickness. A 5-mm reduction in slab thickness results in about 30 percent reduction in fatigue life, if the concrete strength remains constant. However, long-term strength of concrete is significantly higher than the design strength, which is typically the 28-day strength. The strength of conventional concrete (non-fast-track) after 1 year can be up to 20 percent higher than the 28-day strength *(11)*. If the increase in concrete strength is considered, the small reduction in slab thickness can be shown to have a negligible effect on service life.

Figure 11 shows that with 10 percent increase in concrete strength, up to 13 mm (0.5 in) of thickness can be removed and still achieve the design life predicted based on design strength. If the long-term strength is 15 percent higher than the design strength, up to 18 mm (0.7 in) may be removed without compromising the projected performance. These results suggest that a typical concrete pavement may be ground up to three times without compromising its fatigue life. The fact that several concrete pavements have been ground 3 times and are still performing well supports this result.

The analytical results are consistent with the field observations. None of the pavement sections evaluated exhibited unusual levels of cracking. Figure 12 show the cracking data for the sections in wet freeze and wet nonfreeze climatic regions, along with the predicted performance for typical sections in each climatic region. This figure exhibits significant scatter because the plot includes pavement sections with significantly different design features. For the wet freeze region, the model predictions represent the average case, which means the unusually high levels of cracking are not observed in the field data. For the wet nonfreeze region, the predicted performance represents the upper bound of the cracking data, meaning that actual performance was better than predicted.

The results of the cracking evaluation clearly show that diamond grinding is not expected to cause increased slab cracking, and field observations confirm the analytical findings. These findings are consistent with the findings from a California study, which reported similar conclusions (*12).*

Durability

Field observations conducted for this study do not suggest diamond grinding may cause any increased potential for durability problems. To date, there are no reported problems of deleterious microcracking associated with diamond grinding, and in theory, diamond grinding does not introduce any unusual conditions that would lead to poorer surface durability. The fact that the ground surface is nearly always dry (except during storms) reduces any freeze-thaw problems. Also, removal of a thin layer at the pavement surface is more likely to result in improved durability because the concrete at the pavement surface is usually prone to weakening by bleed water during construction.

The excellent survival trends exhibited by diamond-ground pavements strongly suggest that any concern for increased risk of durability problems may be unfounded. Durability problems on fresh cut surfaces of concrete containing susceptible aggregate can develop in about 5 years *(13)*. The survival analysis results show that the probability that a diamond-ground surface will last at least 10 years is almost 90 percent. At about 10 years of age, both the level of faulting and surface texture on diamond-ground sections reach a point where another cycle of rehabilitation is needed. Thus, the survival trend is consistent with the performance life based on faulting or surface texture, and no other cause of failure is indicated.

CASE STUDIES

Interstate 10, EB, San Bernardino County, CA1

CA1 is a diamond-ground JPCP section in San Bernardino County, near Fontana, California. This is the historic project where continuous diamond grinding was used for the first time on a concrete pavement in 1965. The pavement structure consists of 203-mm (8-in) slabs on a 76-mm (3-in) asphalt-treated base with a 4.6-m (15-ft) constant joint spacing. This pavement was constructed in 1946 and ground in 1965. Two lanes in each direction were added on the inside to widen the 4-lane freeway to 8 lanes. The original truck lane was diamond ground.

By 1984, the 2-way average daily traffic (ADT) on this pavement was 84,000, and the truck lane had carried more than 19 million ESALs since construction. Retrofitted edgedrains were installed, and the pavement was diamond-ground for a second time in 1984. In 1997, 51 years after construction, this pavement was ground for the third time. The current ADT on this freeway is 158,000, which corresponds to more than 2.25 million ESALs per year on the truck lane. The truck lane has carried more than 24 million ESALs since rehabilitation in 1984 and more than 43 million ESALs since construction.

The part of the pavement surveyed in 1997 for this study was last ground in 1984. Faulting at this section ranged from 0.0 to 5.3 mm (0.000 to 0.21 in) and averaged 2.5 mm (0.10 in). This section had low-severity spalling at many of the joints, and most of the slabs exhibited low-severity transverse cracking.

This 51-year-old pavement is an excellent showcase of the endurance and durability of concrete pavements and effectiveness of CPR with diamond grinding. In 1997, this section had low-severity cracks on almost every slab and spalling at many joints. However, 14 years after the second grinding, this nondoweled 203-mm (8-in) JPCP had average faulting of only 2.5 mm (0.10 in). Further extension of the service life is expected due to the grinding in 1997. Ride quality on the newly ground pavement was very good.

Interstate 85, NB, Anderson, SC1

SC1 is a project that was included in the 1989 FHWA study. This portion of I-85 is a 229-mm (9-in) nondoweled JPCP placed on a 102-mm (4-in) permeable asphalt-treated base over a 203-mm (4-in) soil cement subbase with joints spaced evenly at 7.6 m (25 ft). The pavement was constructed in 1963 and rehabilitated 1977. The rehabilitation consisted of full-depth repair, joint undersealing, diamond grinding, and joint resealing. This section was rehabilitated again in 1991 with similar treatments. The 1991 CPR activities for this section included full-depth repair, diamond grinding, and joint resealing.

At the time of rehabilitation in 1977, the truck lane had carried 12 million ESALs since construction. When this section was surveyed in 1985, it had carried 11 million ESALs since rehabilitation. This pavement was severely distressed in 1985. The average faulting was 4.6 mm (0.18 in) and 8.4 mm (0.33 in), respectively, for the two replicate sections. About 29 percent of the slabs exhibited transverse cracking.

This project was rehabilitated and ground again in 1991. The ADT in 1997 was roughly 26,000, with 48 percent heavy trucks. This represents more than 2 million ESALs per year in the truck lane and more than 12 million ESALs since rehabilitation in 1991. By 1997, the truck lane had carried more than 43 million ESALs since construction. The faulting in 1997 ranged from 0.0 to 11.9 mm (0.00 to 0.47 in), with an average value of 4.3 mm (0.17 in), 6 years after the second grinding. Although none of the joints was spalled, there was visible seal damage at roughly 20 percent of the transverse joints. Many of the original transverse cracks had been repaired when the pavement was rehabilitated in 1991. About 20 percent of the slabs had transverse cracks. The southbound portion of this project had less faulting, fewer repairs, and distressed less than the northbound portion, which contained the survey section.

This project is a good example of a section that was diamond ground for a second time to extend service life. This pavement is scheduled for reconstruction in 1998, at which point the pavement would have carried 30 million ESALs since the first grind, 12 million ESALs since the second grind, and more than 43 million ESALs since initial construction.

Trunk Highway 10, EB and WB, Elk River, MN1 and MN2

MN1 and MN2 are also projects included in the 1989 FHWA study. This portion of TH10 is a 203-mm (8-in) nondoweled JPCP on a 76-mm (3-in) aggregate base with 4.6-m (15-ft) joint spacing. It was constructed in 1946 and rehabilitated in 1982. The rehabilitation consisted of diamond grinding and joint sealing in the eastbound (EB) truck lane and grinding, joint sealing, and edge support installation in the westbound (WB) truck lane.

This project had been subjected to relatively low levels of traffic. In 1997, the truck lanes had approximately 2.5 million ESALs since grinding and 5 million ESALs since construction. Some sections in the EB direction have been overlaid. The faulting in the EB truck lane in 1997 ranged from 0.5 to 3.3 mm (0.02 to 0.13 in), with an average value of 1.8 mm (0.07 in). The average faulting in 1986 was 1.0 mm (0.04 in). The EB section had a high number of transverse and longitudinal cracks. Fifty-six percent of the slabs in this section had low-severity longitudinal cracking and low- to medium-severity transverse cracking. The WB section had fewer transverse cracks and no longitudinal cracks, but the average faulting was the same as that in the EB section (1.8 mm [0.07 in]).

This is an example of a low-volume rural highway that has lasted more than 50 years since construction and more than 15 years since rehabilitation. Rehabilitation with diamond grinding is as effective and useful on low-volume roadways as on high-volume highways. Other examples of 40+-year-old diamond-ground pavements in Minnesota include TH10 near Wadena and TH23 in St. Cloud. TH10 near Wadena was constructed in 1948 and diamond ground in 1985. TH23 in St. Cloud was constructed in 1958 and diamond ground in 1982.

CONCLUSIONS

The results of this study show that CPR with diamond grinding is an effective means of extending service life of concrete pavements. The immediate effect of diamond grinding is a smooth pavement surface with the desirable surface texture. The level of smoothness that can be achieved through diamond grinding is comparable to that of a new pavement or an AC overlay. Another important benefit of diamond grinding is significant increase in surface texture and corresponding improvements in skid resistance. Studies have shown that diamond-ground surface texture can lead to significant improvement in safety, in terms of reduced accident rates *(4)*.

Long-term effectiveness of diamond-ground pavement depends on numerous factors, but the most significant factors are the condition of the existing pavement structure and level of CPR applied. If the existing pavement is structurally sound, the pavement section may be reground numerous times to greatly extend its service life. However, it is important to recognize that diamond grinding addresses serviceability problem only. Structurally deficient pavements or pavements with material problems (e.g., D-cracking and ASR) are not good candidates for diamond grinding.

The field performance of diamond-ground sections is excellent. CPR with diamond grinding was effective in providing significant extension in service life at numerous projects. The average age at failure of diamond-ground sections is greater than 32 years, with many sections surviving 40 or more years. The results of service life, faulting, and surface texture analyses showed that a diamond-ground surface may be expected to provide about 10 years of service, at which time the pavement may be reground to provide further extension to service life. Cracking analysis showed that a pavement slab could be reground up to 3 or 4 times without compromising fatigue life. No evidence of any deleterious effects of diamond grinding was observed at any of the field sites.

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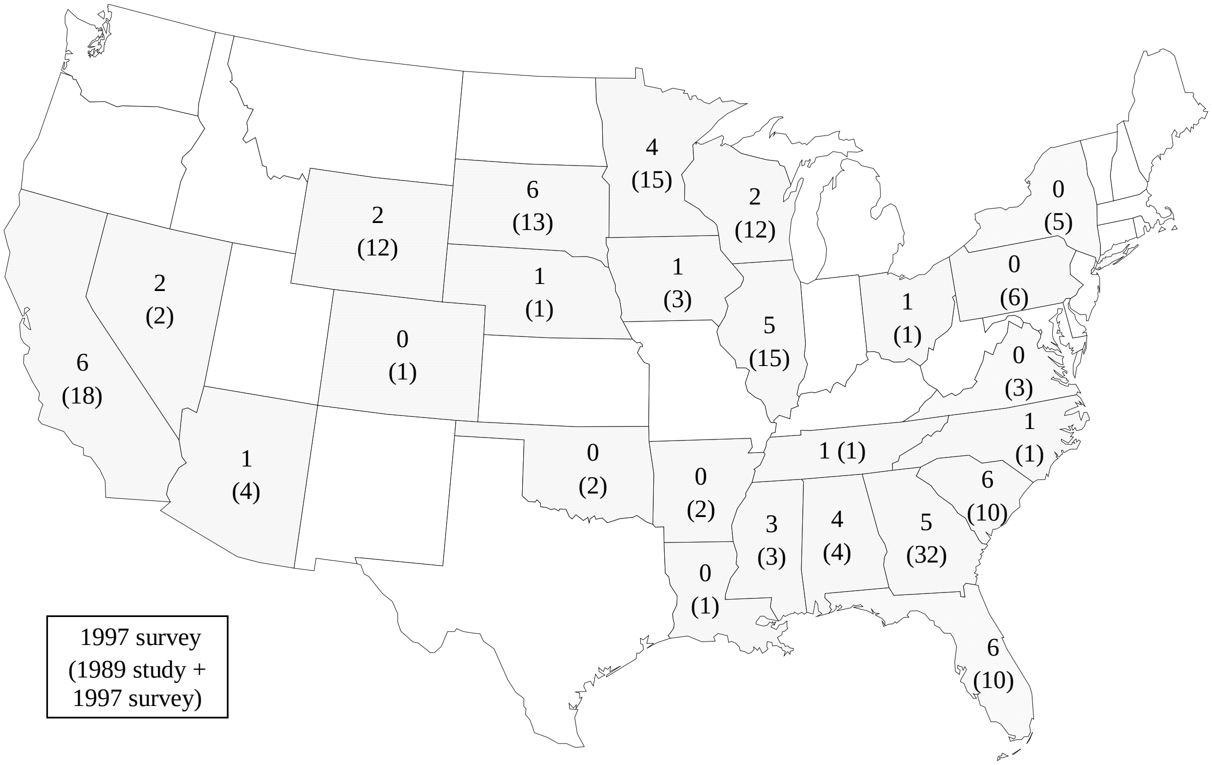

Figure 1. Geographical distribution of the pavement sections included in the study.

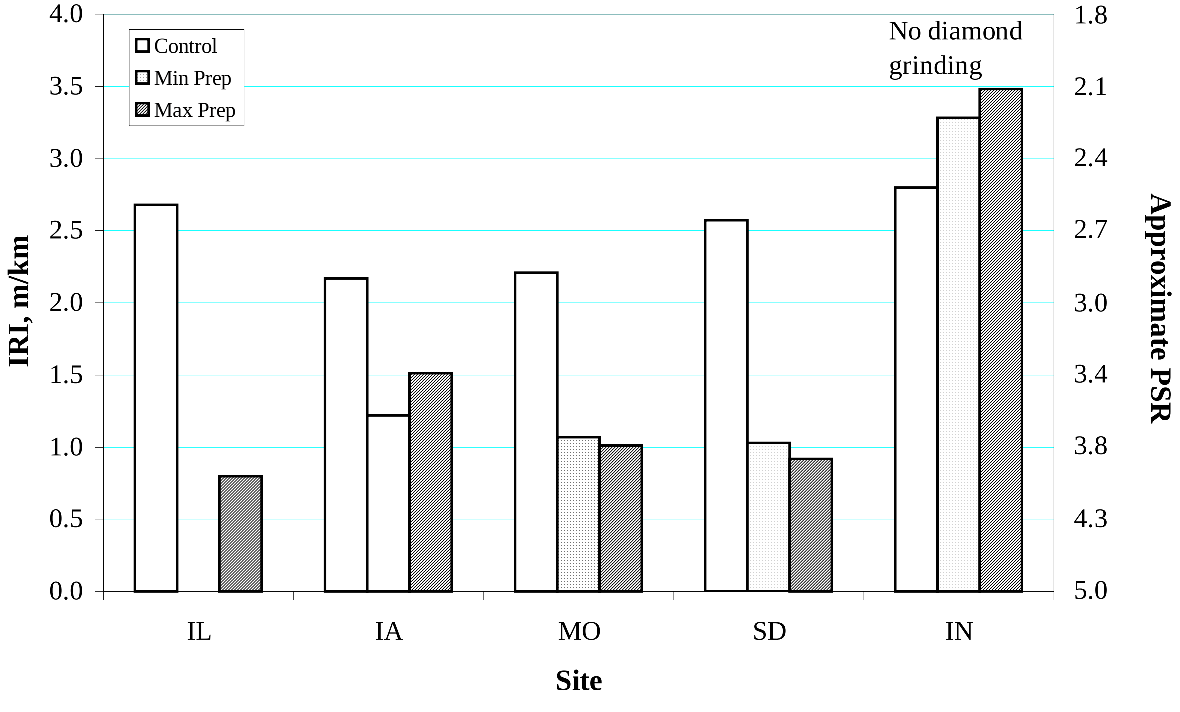

Figure 2. Immediate effects of diamond grinding on pavement roughness.

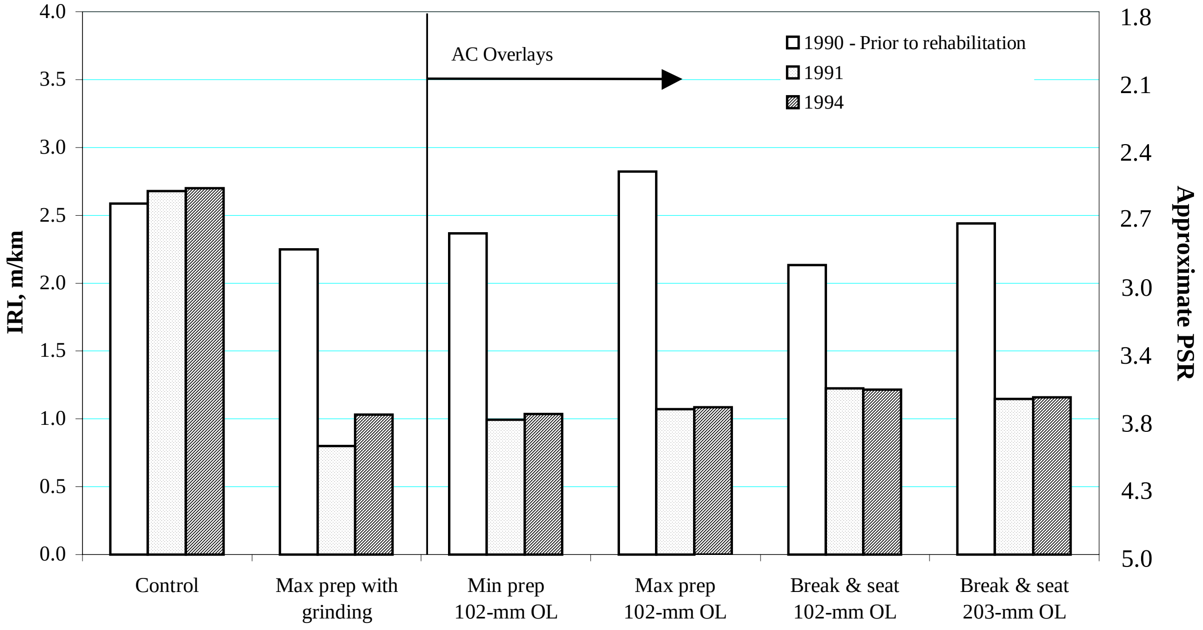

Figure 3. Roughness performance of diamond-ground and AC overlay sections at the Illinois SPS-6 site.

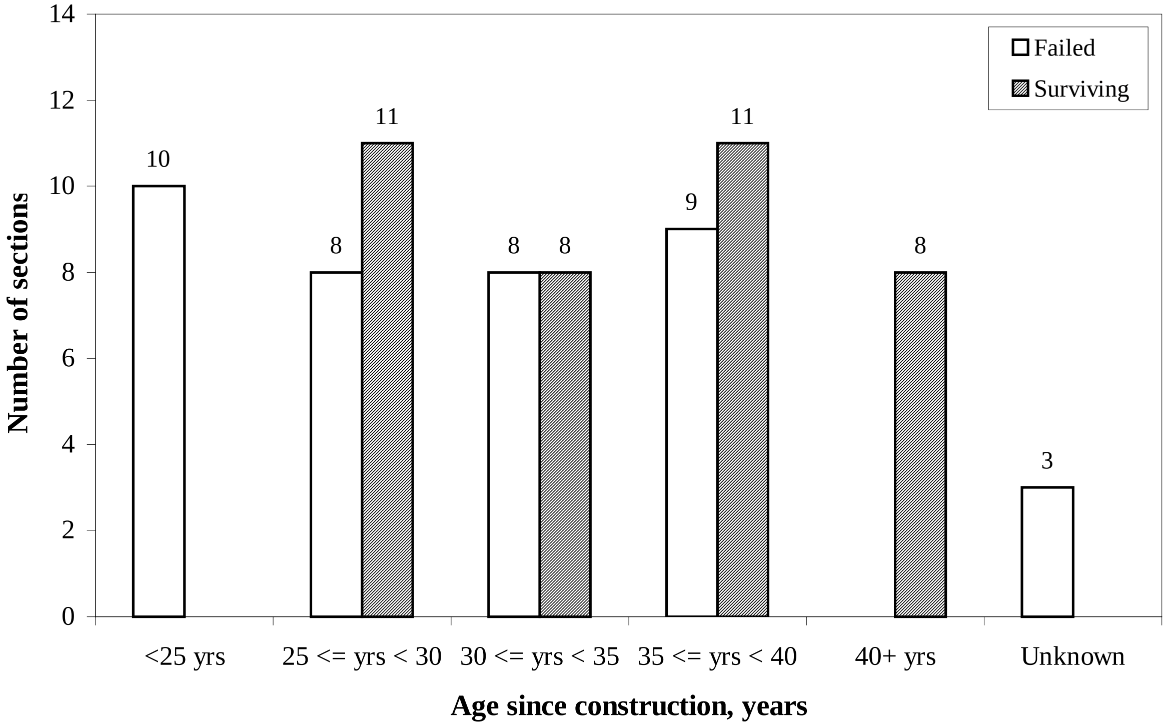

Figure 4. Age distribution of diamond-ground pavement sections for service life evaluation.

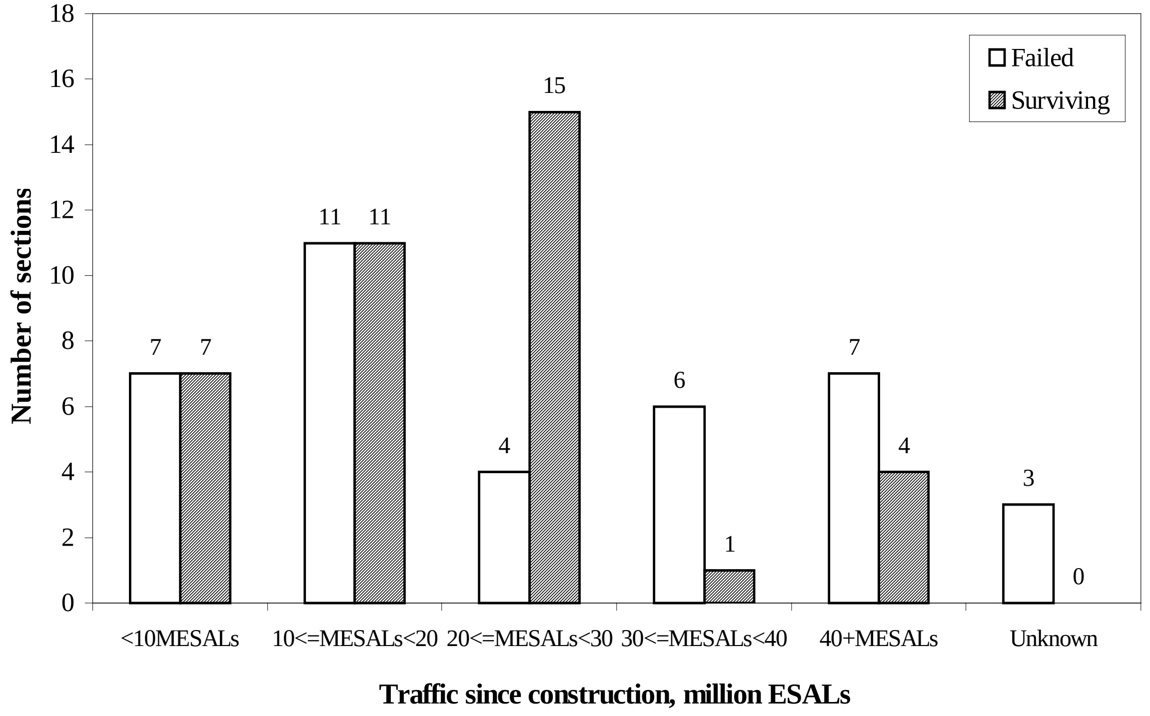

Figure 5. Distribution of traffic levels in the pavement sections for service life evaluation.

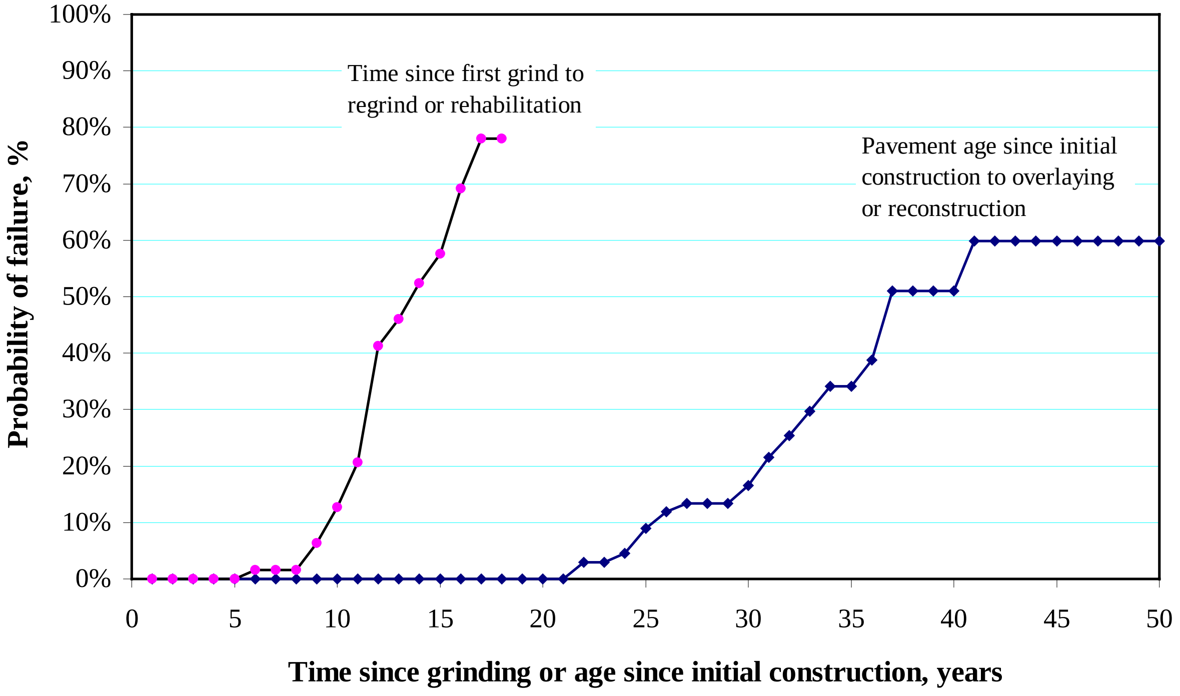

Figure 6. Survival curves for diamond-ground pavements.

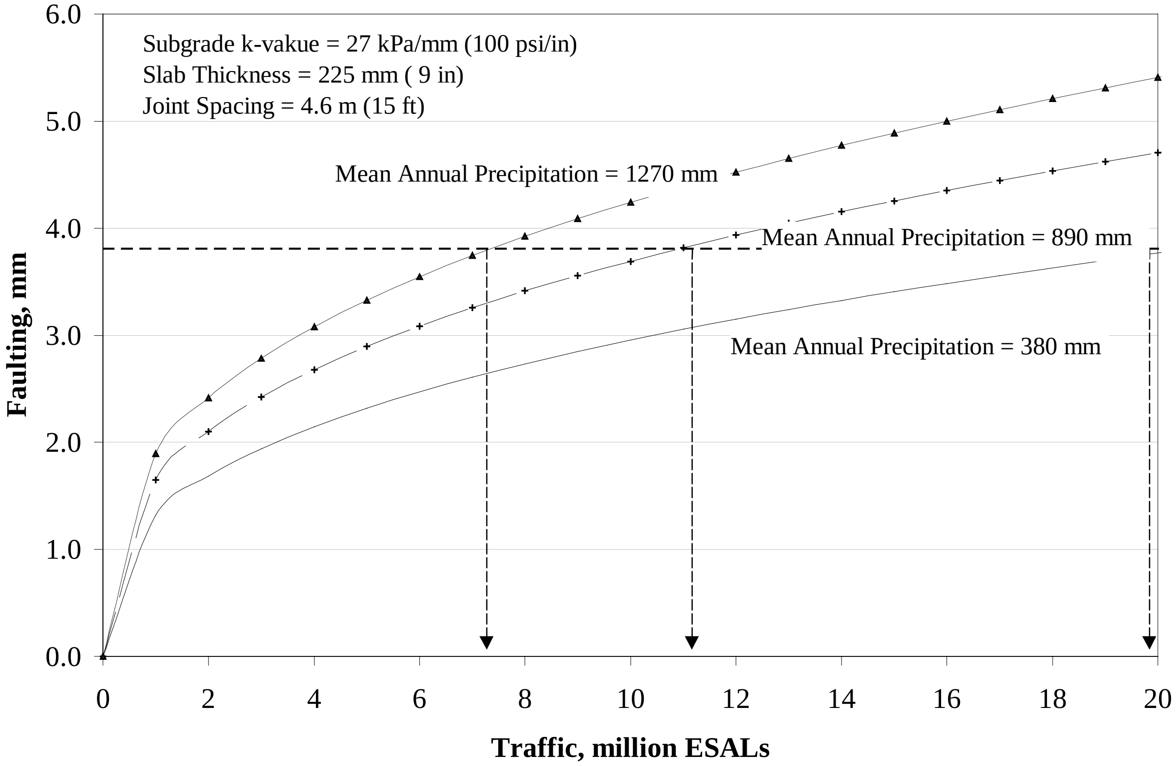

Figure 7. Effects of precipitation on nondoweled JCP faulting after diamond grinding.

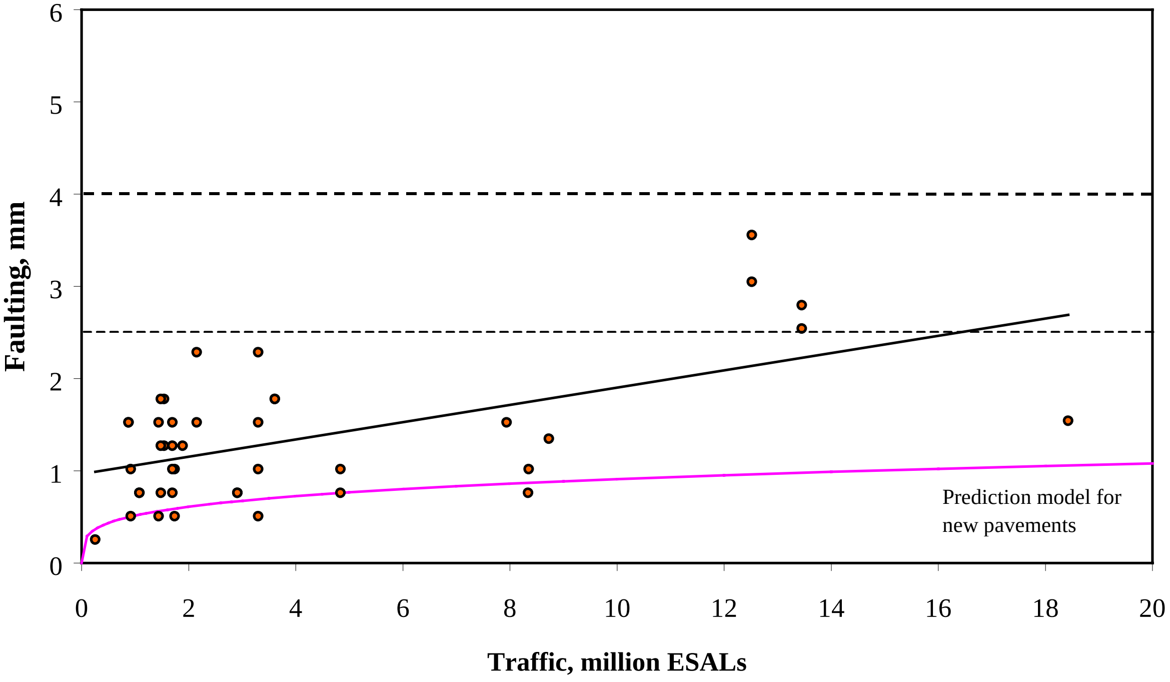

Figure 8. Faulting performance of doweled diamond-ground pavements.

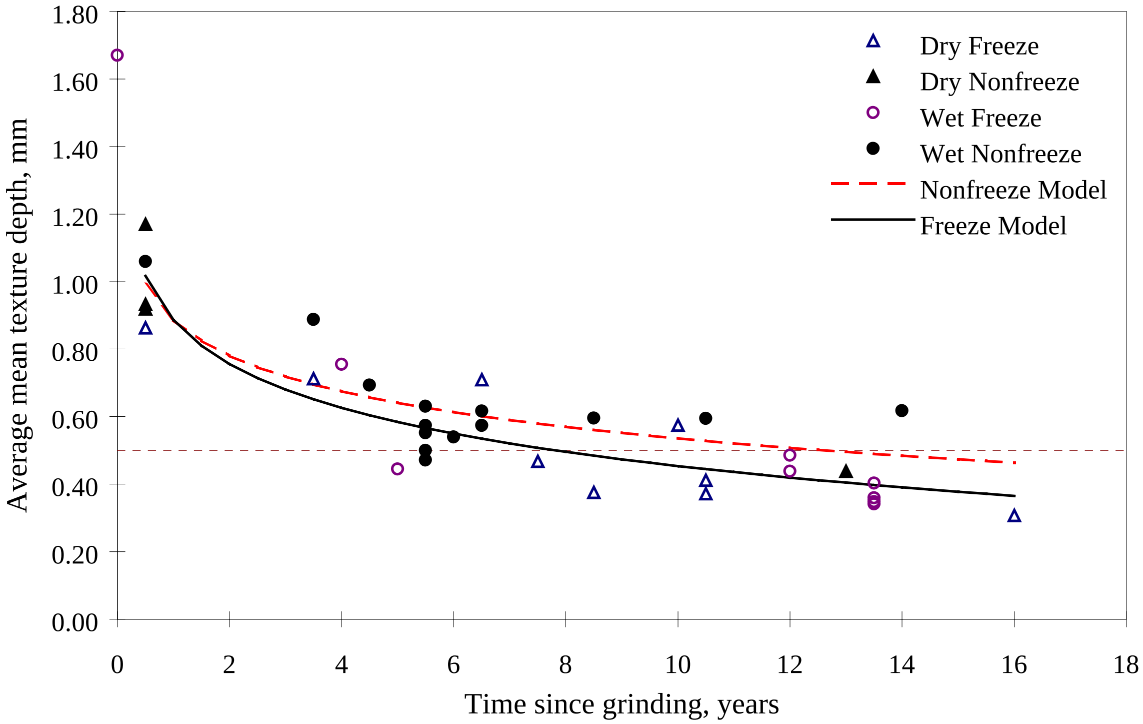

Figure 9. Variation in mean texture depth with age since grinding.

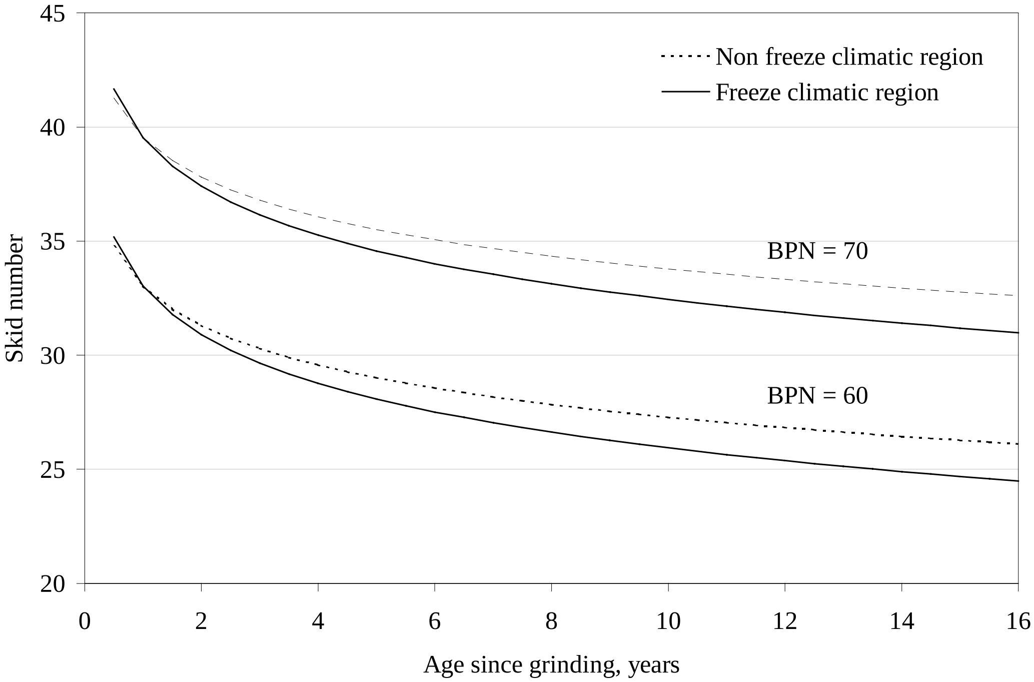

Figure 10. Predicted Structural Number (64 km/hr [40 mph]) after grinding for two values of British Pendulum Number, a measure of pavement microtexture.

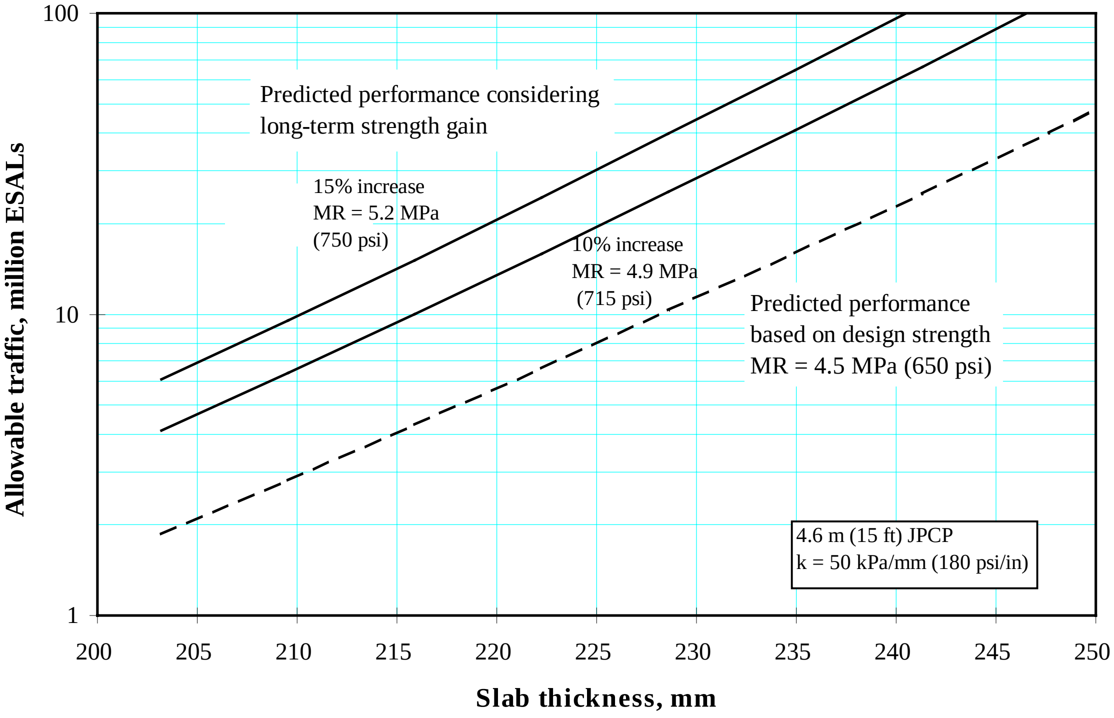

Figure 11. Effects of slab thickness and concrete strength on fatigue life of JPCP.

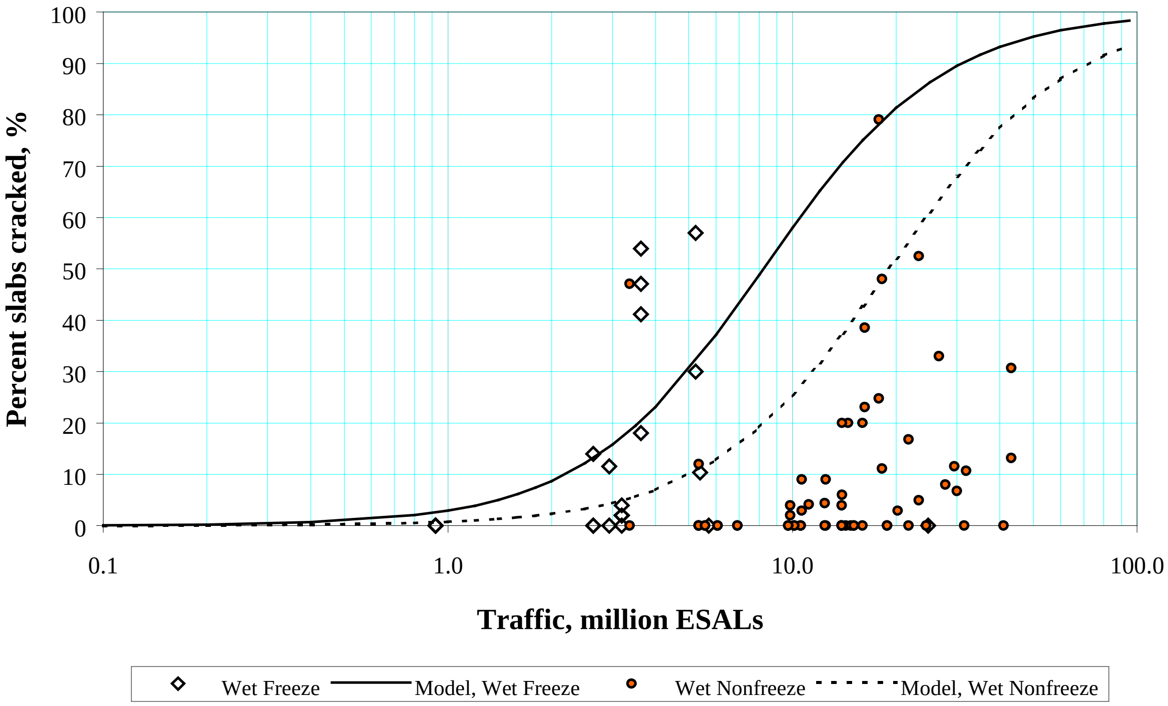

Figure 12. Comparison of predicted and observed cracking for JPCP sections in wet freeze and wet nonfreeze climatic regions.

LIST OF FIGURES