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Caltrans Division of Research, Innovation and System Information

Research Results

Evaluation of Rubberized Open Graded Asphalt Concrete (OGAC) for Counteracting Wet Pavement Collisions

To establish the correlation between skid resistance as a function of traffic, environment, roadway attributes, and pavement types.

Transportation Safety and Mobility

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Project Title:
Evaluation of Traffic and Environment Effects on Skid Resistance and Safety Performance of Rubberized Open Graded Asphalt Concrete

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WHAT WAS THE NEED?

According to a U.S. study of collision data, in 2001 more than 22 percent of collisions nationwide were weather-related. More than 16 percent of fatalities and over 20 percent of injuries in passenger vehicles occurred in adverse weather and/or on slick pavements. Research indicates that a major factor in wet pavement accidents may be the lack of adequate friction between the tire and the pavement.

Skid resistance is a measure of the friction that develops when a tire is prevented from rotating and instead skids along the pavement surface. To determine the safety of roadway pavement, state agencies employ a skid number system. In the United States, the most commonly used skid resistance measuring techniques involve measuring the force required to drag a non-rotating tire over wet pavement. In terms of physics or mechanics, the coefficient of friction is commonly used to describe the friction properties of the pavement and the object in contact. For the skid resistance properties of a pavement surface, a skid number (SN) is specified based on a standard test procedure according to American Society for Testing and Materials (ASTM) E 274.

In this test procedure, a locked wheel is towed at 40 mph and from the measured resistance force, the skid number at 40 mph, SN40 is calculated. SN40 is used as a reference value when skid resistance is measured at speeds other than 40 mph. For most Departments of Transportation (DOTs) in the U.S., pavements for which the SN40 is below 30 are deemed unacceptable and

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corrective actions are required. In California, however, there are no specific guidelines for how to control skid resistance, and skid resistance is not regularly measured.

The California Department of Transportation (Caltrans) has recently employed different types of pavement materials experimentally, to improve drainage systems and increase skid resistance. This study investigates three different types of pavement currently in use on California roads:

- Open Graded Asphalt Concrete (OGAC), which contains a high percentage of air voids.
- Groove Pavement (GP), which has longitudinal or transverse cuts on its surface.
- Rubberized Open Graded Asphalt Concrete (R-OGAC) - asphalt modified by the incorporation of rubber, which helps to increase the fatigue resistance of the asphalt.

WHAT WAS OUR GOAL?

The main goals of this study are as follows:

1. Evaluate and analyze skid test results from the test data inventory collected by Pavement Field Testing Branch (PFTB) at the Caltrans Sacramento Laboratory.
2. Identify and analyze before-and-after historical collision data at operational test sites where the three experimental types of pavements have been used.

WHAT DID WE DO?

The first part of the study involved evaluating the effects of traffic and environment on skid resistance. The data set contains more than 50,000 observations along five routes of freeway in seven districts of California from 1988 to 2008. To begin with, the characteristics of skid resistance as a function of traffic, temperature, precipitation, and roadway attributes were established. Two estimations were made: one focusing on large variations in measured skid resistance using a broad range of data excluding the time variable, and the other on the deterioration model with all possible variables, including time, using relatively limited data from asphalt concrete pavement on four routes in California. To evaluate the effects of traffic and environmental factors on skid resistance, the research team attempted to model SN40 as a function of all potential factors affecting skid resistance.

The second part of the study focuses on the safety performance of each of the pavement types. Before-and-after comparisons using collision data from Traffic Accident Surveillance and Analysis System (TASAS) were conducted to assess the safety performance of resurfacing pavement with OGAC, GP and R-OGAC. Because the experimental pavement types are expected to improve drainage, the focus of the before-and-after study was on the reduction in wet pavement-related collisions, specifically.

WHAT WAS THE OUTCOME?

Large variations in measured skid resistance were observed even at the same location. The potential sources of the variations were estimated using SN40. It was found that seasonal conditions and temperature variations are the primary factors causing the variations in measurement. Skid resistance is typically higher in fall and winter when temperatures are lower, and lower in spring and summer, when temperatures are higher.

Other findings were as follows:

- The location of the measured lane also has a significant effect on skid resistance. The shoulder lane tends to have lower skid resistance than the center lane.
- Variation due to testing devices was not observed. However, the estimated results indicate that this factor represents a relatively small proportion of the total variation.

- A skid resistance deterioration model was estimated for evaluating the effects of traffic and environment on skid resistance. The estimated results are as follows:
- SN40 significantly decreases with average daily traffic (ADT).
- SN40 in the shoulder lane is significantly lower than the average SN40 values.
- This is due to heavy traffic.
- Temperature causes significant decreases in SN40 at the 90% confidence interval.
- Months with higher levels of precipitation have a significant negative impact on SN40.
- SN40 decreases with the increased length of dry periods.
- Increased age of pavement causes a decrease in SN40.

Compared with wet-related collision rates before and after the new pavement types were implemented, we observed the following:

- Resurfacing with Open-Graded Asphalt Concrete (OGAC) significantly decreased the number of collision by 10-73 percent.
- Resurfacing with OGAC decreased the number of collisions by a total of 25.86 collisions over a two-year period, although the reduction was not statistically significant.
- Each of the implementation sites for Groove Pavement (GP) and Rubberized
- Open Graded Asphalt Concrete (R-OGAC) was analyzed, but due to the small sample set, no conclusions could be drawn.

The results suggest that there is a significant relationship between SN40 and weather, particularly the temperature at the time of measurement, average monthly precipitation, and the number of dry months prior to the last significant precipitation. The combination of these factors can cause seasonal variations in SN40. Therefore, if highway agencies want to prioritize pavement improvements using SN40, SN40 must be standardized. The model estimated in this study can provide the adjustment factors.

Findings from the analysis of the safety performance of the three new pavement types indicate that resurfacing with OGAC significantly decreased the number of wet-related collisions. Unfortunately, the researchers did not currently have sufficient data to draw any significant conclusions for resurfacing with GP or R-OGAC. This would be a fairly straightforward extension of our study and could be conducted by including additional sites in our analysis.

In general, the study demonstrated that seasonal effects, average daily traffic (ADT), and age of pavement need to be considered to maintain safe levels of skid resistance. SN40 needs to be monitored selectively in high-risk locations where ADT is higher and in the more heavily-used shoulder lanes, rather than across all sections of freeway. In addition, while further research is needed, results suggest that new pavement types such as OGAC can improve the safety performance of roadways.

WHAT IS THE BENEFIT?

This study is a multi-year project that will explore potential improvements in the safety performance of roadways. The scope of this project will cover the tasks identified in the proposal to establish, qualitatively and quantitatively, the correlation between skid resistance as a function of traffic, environment, roadway attributes, and pavement types. Additionally, it will evaluate the safety performance of experimental highway segments where rubberized open-graded asphalt concrete (OGAC) pavement has been tested.