SOUTHERN PLAINS TRANSPORTATION CENTER

SPTC Brief

Highlighting Developments at Southern Plains Transportation Center – October 2015

# EVALUATION OF PAVEMENT SURFACE CHARACTERISTICS WITH IMAGING FOR ENHANCING SAFETY

**OVERVIEW:** Hydroplaning on pavement occurs when water pressure builds up in front of a moving tire resulting in an uplift force sufficient to separate the tire from the pavement. Occurrence of hydroplaning is highly associated with several factors, including pavement texture, cross slope, longitudinal grade, pavement width, pavement type, pavement condition, tire characteristics, and rainfall intensity. The loss of steering and traction force produced during hydroplaning may cause a vehicle to lose control.

Historically, effects of pavement slope on vertical wheel load and relevant hydroplaning speed prediction have not been investigated, nor the related safety issues. Therefore, the present study uses an innovative technology, called *PaveVision3D* (Figure 1) available at Oklahoma State University (OSU) to: (1) properly predict hydroplaning speeds on pavement with large slopes using hydroplaning prediction model; (2) calibrate the *Inertial Measurement Unit* (IMU) used to measure cross slope by eliminating the effects of vibration of the survey vehicle; and (3) identify the potential hydroplaning segments in network level survey to enhance safety.

**Figure 1 PaveVision 3D technology (OSU)**

Previous studies indicate that the risk of hydroplaning increases with the exaltation of the Water Film Depth (WFD), which is dependent on surface texture properties, flow path slope, flow path length, rainfall intensity, and pavement surface type.

It is evident from the literature search that very few studies have been conducted to investigate surface drainage of pavements at network levels. This is due to existing data acquisition systems being incapable of continuously measuring related data sets at high speeds. Using the 1mm 3D PaveVision3D Ultra technology (illustrated in Figure 2), texture data are continuously collected at high speeds, while the cross slope and longitudinal grade data are acquired with an Inertial Measurement Unit (IMU).

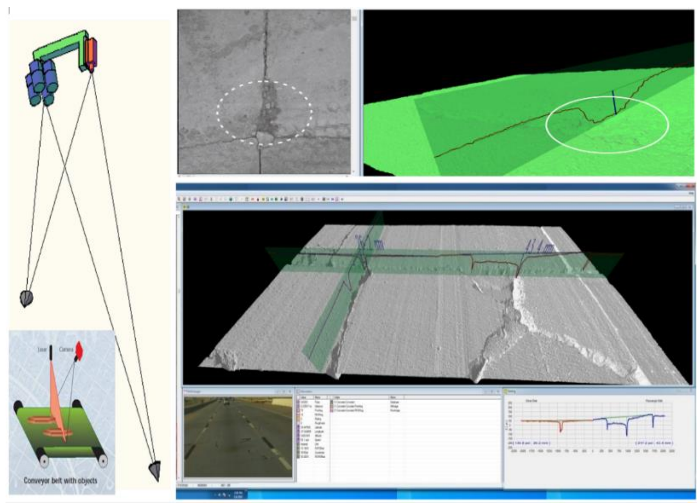


**Figure 2 Prototyping 3D Sensors and Software Interfaces with 3D Data**

Data collected at highway speed are fed into the widely used PAVDRN model to calculate hydroplaning speed, and the potential hydroplaning performance of the pavement.

Figures 3 and 4 show the predicted hydroplaning speeds based on the PAVDRN model at two test sites. At test site 1 (Figure 3), the speed limit is 35 mph (represented by the solid line). The predicted hydroplaning speeds across the entire section (represented by symbols) are much greater than the speed limit, which indicates that there is no potential hydroplaning at this site if drivers abide by the speed limit.

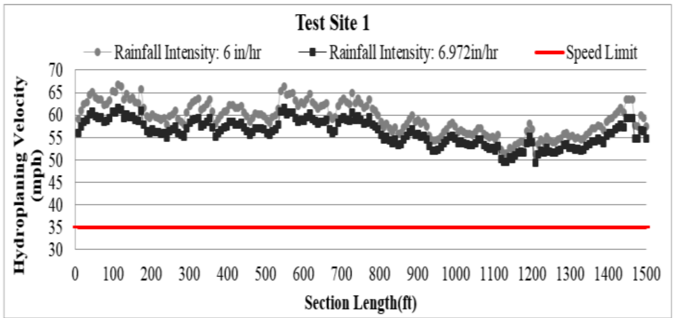


**Figure 3 Hydroplaning speeds for safety evaluation (Site 1)**

At test section 2, the speed limit is 45 mph. Hydroplaning might occur within the segment ranging from 1080-ft to 1185-ft (indicated by the data shown by the solid line), where the predicted hydroplaning speed is lower than 45 MPH (Figure 4).

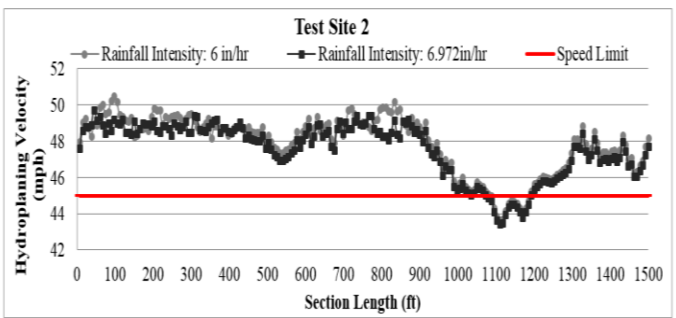


**Figure 4 Hydroplaning speeds for safety evaluation (Site 2)**

Findings show that pavement segments with potential hydroplaning risk can be identified by comparing predicted hydroplaning speeds with a given posted speed limit. Hydroplaning speeds at pavement segments with large slopes are lower than that at pavement segments with no grades. Moreover, by considering effects of cross slope and longitudinal grade on wheel load and flow path length, hydroplaning speed decreases with an increase in the longitudinal grade, but increases with an increase in the cross slope.

**APPLICATION**: The application of the results provide a way to integrate the real-time 1mm 3D pavement texture data and IMU data into the improved models for potential hydroplaning prediction of sloping pavement through a network level survey. This will allow pavement engineers to identify potential hydroplaning risk of a pavement's segment, based on the predicted hydroplaning speed and posted speed limit, so that corrective measures can be taken (e.g., constructing superior texture, posting proper speed traffic signs). Additional related work is currently underway, including collecting 3D pavement surface data for High Friction Surface Treatment (HFST) sites in several states to monitor long-term performance of the safety enhancing technology being implemented by FHWA.

**BENEFITS**: Application of results is expected to reduce potential traffic accidents caused by hydroplaning and enhance driver safety.

## About the Researcher

Dr. Kelvin C.P. Wang, Ph.D., P.E. (Oklahoma State University) is the Principal Investigator on this project. He has been developing the PaveVision3D technology since 2000 with funding from USDOT's UTC program, FHWA, FAA, Arkansas DOT and Oklahoma DOT. Please send inquiries to Dr. Wang (kelvin.wang@okstate.edu).

**The *Southern Plains Transportation Center* is a consortium of eight universities in U.S. Department of Transportation Region VI: the University of Oklahoma, Oklahoma State University, Langston University, University of Arkansas, University of New Mexico, Louisiana Tech University, University of Texas at El Paso and Texas Tech University.**

**The SPTC provides a unique opportunity through multi-institutional initiatives to develop comprehensive, cost-effective, and implementable solutions to critical infrastructure issues facing the transportation systems of the region and the nation, and to prepare transportation professionals for leadership roles through *Research, Leadership, Collaboration, Education, Outreach, Tech Transfer* and *Workforce Development* activities.**