RESEARCH INFORMER

— FALL 2020 —

A Newsletter by the Arkansas Department of Transportation Research Section

Pavement Smoothness, Part 1: PI and IRI Explained

BY JD BORGESON, P.E.

What if the Department had a time machine? One that allowed you to travel 20, 30, even 40 years into the future from the point just after a certain new pavement is laid? When you returned, you'd be better able to point out deficiencies in the new pavement. You could see where the pavement failed over time and for what reasons; this would help you determine if there was anything you could do to the new road today to save on rehab in the future. Conversely, if the job was bid based on a design with a certain design life, and the trip in the time machine revealed that the pavement was greatly exceeding this design life, then the contractor might logically expect some additional compensation. After all, if there is no incentive to do the best job possible, why would the contractor care what happens to the pavement after they get paid?

A time machine is really the only way to know for sure; however, as you know, no such machine exists. We must rely on other indicators, ones that we can measure today. One, and arguably the best, indicator for long-term pavement performance, as well as ride quality, is pavement smoothness. Devices that measure pavement smoothness can tell you where there are certain deficiencies on a new pavement that will accelerate deterioration over time. These devices can also tell you when a pavement is exceptionally smooth, something the Department is willing to pay incentives for. And why not? The increase in pavement longevity means that the contractor exceeded their end of the bargain; and the incentives, though significant to the contractors, are still cheaper than pavement preservation or rehabilitation. So while smoothness data is not quite as definitive as a time machine would be, it is one of our best options for predicting future pavement performance as well as user experience.

So how is smoothness measured? The concept of the profilometer began surfacing in the early 20th century, culminating in the invention of the California Profilograph in 1940. This device was quite revolutionary at the time and is the backbone to most of the profilographs we still see today. With this device, the operator must push what is essentially a long, moving straightedge down the roadway. In the center, a free wheel

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Spotlight On T²

TRAINING UPDATE DURING SOCIAL DISTANCING

BY LAURA D. CARTER

The Arkansas Technology Transfer (T2) Program hosted two 4-hour webinars while practicing social distancing in our state. An Asphalt Pavement Maintenance webinar for local agencies was held on May 19th and 20th with 124 class participants. A Basic Pavement Maintenance webinar was held on June 9th and 10th with 100 class

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Request for Problem Statements

BY BETHANY STOVALL

The Department's Transportation Research Committee (TRC) is currently accepting Problem Statements, the first step in determining what new TRC research projects will be funded for the 2022 Fiscal Year. Problem Statements provide a description and outline of an observed research need. The one-page document also briefly lists what the objectives, implementation, and return on investment for such a project would be. After the Problem Statements are received, they will be assigned to one of the seven Standing Subcommittees, each consisting of Department personnel with expertise in that specific area. Problem Statements are reviewed and ranked by the Standing Subcommittees, followed by the TRC Advisory Council, and finally the Transportation Research Committee. They will make the final decision regarding which new TRC projects will be conducted in the upcoming Fiscal Year based on the needs of the Department and availability of funding. Project Subcommittees comprised of Department personnel are then formed for each selected project. Requests for Proposals are mailed out in the Spring and are then reviewed by the Project Subcommittees. Proposals are voted on at the TRC Spring Business Meeting in May.

Anyone is welcome to submit a Problem Statement for consideration. The Problem Statement form can be found on the Research Section's page of the ArDOT website and the Research Section SharePoint site. The due date for Problem Statements this year is September 11, 2020.

ArDOT TRC TRANSPORTATION RESEARCH COMMITTEE

TRC1902

Capillary Pressure Sensor Testing to Identify Curing Regimen in Freshly Placed Bridge Decks Update

Plastic shrinkage cracking while mostly aesthetically unpleasing can allow the ingress of chemicals/elements into the concrete structure creating weak points and problems down the line. TRC1902 is providing us with insights into the curing process of concrete decks, as well as steps to take to mitigate these problems going forward. This project is using various curing regimens, including surface sheeting and curing compounds, to determine which is most effective in mitigating plastic shrinkage cracking. A correlation has been shown between capillary pressure and the potential for plastic shrinkage cracking, so a Capillary Pressure Sensor System was employed to determine the capillary pressure of the water in the pores of the curing concrete. With these tools, the researchers have been able to determine which regimens were most effective in the curing process of the concrete. While the information provided by this project has proven valuable and exciting so far, research is ongoing, so it will be some time before we have the full picture of the results.

PAVEMENT SMOOTHNESS, PART 1: PI AND IRI EXPLAINED

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records all deviations from the straightedge as the device moves along. By correlating the deviations that the center wheel records with the longitudinal distance at which the deviations are experienced, the profilograph can effectively trace the roadway, resulting in a plot that resembles the actual surface of the pavement. As you can imagine, it would be difficult to simply look at a trace of profile and tell if the pavement is smooth or not (especially when these sections can be many miles long!). This is what led to the need for a metric for smoothness, a number that can simply tell you if a section is smooth or not. This is where the Profile Index (PI) number came into play.

The profile index synthesizes all of the data the profilograph collects into "deviations per mile." The data is broken down into 528' sections (typically with some short sections), and a PI number is generated for each section; additionally, the device will detect if there are any significant bumps or dips that need grinding regardless of the PI number. For reference, California's first spec regarding the profile index was written around the year 1960 and stated that new roadways should have a PI number of less than 7" per mile. This standard for new construction is still used by many DOTs today, including Arkansas, whose 2014 Standard Specifications state that any sections with deviations over 7" per mile are required to have corrective work. As you can see, the profile index is a very mechanistic metric; it is physically measuring the deviations in the surface of the roadway and using them to predict or estimate ride quality. This has led to some issues that I will explain later, but perhaps the biggest issue concerning the use of PI is its incredibly time-consuming process to collect.

Profilographs of old, including the California Profilograph, are not motorized and must be physically pushed and steered. That means, depending on the spec requirements, an operator must push this profilograph (sometimes 25 feet long and made of metal) while also steering it and monitoring the measuring device for the required distance for each lane, and sometimes even each wheel path. As you can imagine, using this method to even profile a one-mile section would be very time consuming; so, imagine a 10 or 20 mile section! This is what led to the development of the inertial profiler, the high-speed alternative to the profilograph.

These devices use lasers attached to a vehicle moving at a defined speed; the lasers measure the vertical distance to the ground from the datum established by the vehicle. While inertial profilers can trace the profile of a roadway, the profile produced will look different than what is produced by a profilograph for the same stretch of road. This is because the inertial profiler is not attempting to measure the actual deviations in the road; it is measuring the vehicle's response to the deviations in the road. This type of data, as you can see, is much more empirical than that obtained by the profilograph: it is based more on what the vehicle is experiencing rather than the actual surface deviations. Due to this, the need for a new metric was realized, and in the 1980s the International Roughness Index (IRI) was born.

While IRI is measured in inches per mile like PI, the numbers are very different. IRI is calculated based on a mathematical model called the "quarter-car model." It requires a computer to combine the distance-to-ground and accelerometer data from the lasers, along with the recorded longitudinal speed data, to simulate what the effect would be to the suspension of one wheel of a passenger car (specifically the accumulative deflection that the suspension would experience per mile of roadway analyzed). So IRI is more concerned with what a vehicle's suspension is experiencing due to deflections in the pavement, not the actual deflections in the pavement. This is important to understand because it really illustrates that PI and IRI are not convertible values. There is no equation that you can insert PI into and get IRI out of. They simply achieve the answer the same question, how smooth the roadway is, in completely separate ways. Though many inertial profilers are able to measure PI, the IRI values from the inertial profilers are determined via a much more cumbersome computer calculation. IRI considers many more factors related to actual ride quality than PI, and is thus the better metric for describing smoothness in terms of ride quality.

So now that we have a better understanding of PI, IRI, and smoothness in general, in the next installment of this newsletter, we will discuss how it all relates to us, ArDOT, and other DOTs. While PI has been the standard measure for smoothness around the US for many decades, many DOTs are changing their smoothness specifications from PI requirements to IRI requirements. We will discuss why this is, how they are doing it, and why it is important. So please tune in next time for this continued discussion on pavement smoothness!

Breakeven Cost Analysis of 100,000 lbs. Agricultural Permit

BY GLORIA HAGINS

In March of 2017, House Bill 2211 (Act 1085) sponsored by Representative Michael John Gray and Representative Joe Jett proposed an amendment to the law concerning the transportation of agricultural products. The amendment would allow farmers to transport up to 100,000 pounds, 15,000 pounds over the legal limit, of agronomic or horticultural crops, using a truck tractor and semi-trailer combination. On April 7, 2017, the bill passed, allowing for the overweight permits.

A decision was made in 2018 to authorize an annual permit to be issued for one truck tractor and semi-trailer combination, allowing up to five routes for a fee of $1,000.00, pending a level one inspection performed by the Arkansas Highway Police (AHP). The price of the permit was formulated using Arkansas Code 27-35-202 Penalties for overweight vehicles based on a vehicle weighing 15,000 pounds over the legal weight limit.

In the summer of 2018, Representative Dan Douglas wrote a letter to the Director of ArDOT, Scott Bennett, asking that emergency rules be adopted for the upcoming harvest season. A decision was made by ArDOT to prorate the fee and allow a permit to be issued for $333.00, as the emergency rules can only be in place for 120 days. The Commission adopted Minute Order 2018-065 on July 11, 2018, approving the emergency rules for issuance of the permits, which were approved by the Arkansas Legislative Council, and were valid for up to four months, August to November, 2018.

During the same Commission meeting, Minute Order 2018-064 was approved, adopting the permanent rules. The permanent rules had to go through publication, public comment, review and consideration of the comments, and subsequent approval by The Arkansas Legislative Council (ALC). The ALC approved the rules on October 19, 2018, and the new rules took effect.

At the 92nd General Assembly, Regular Session in 2019, Representative David Hillman sponsored House Bill 1855 (Act 859) to amend the law concerning permits for the hauling of agronomic or horticultural crops to include truck tractor and semi-trailer-trailer combination. On April 10, 2019, House Bill 1855 (Act 859) passed.

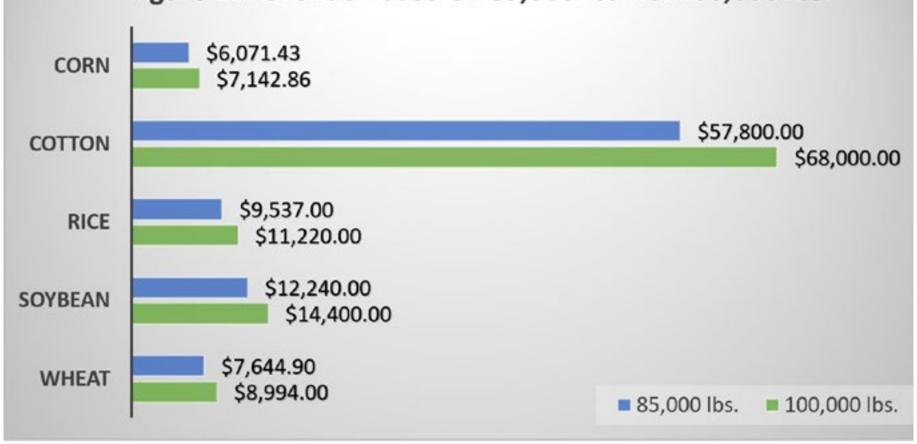
Beginning in August 2018, 12 companies utilized the prorated permit issued under the emergency rules and permitted a combined total of 44 trucks traveling 191 routes. The revenue from the prorated permits totaled $14,652.00. In 2019, the total number of companies who chose to utilize the permit fell to six. The six companies permitted a total of 14 trucks traveling 36 routes. While the number of trucks permitted fell by 68 percent, the revenue received through the permits only fell by 4.45 percent. The number of permitted routes fell 81 percent.

Of the twelve companies issued permits in 2018, only two returned in 2019 for the permit. Six of the remaining ten companies cited cost as the primary reason they did not purchase again, three companies were not available for comment, and one company was no longer hauling.

While the Harvest permit fee in Arkansas is most costly in comparison to surrounding states, Arkansas allows for one of the highest allowable weight limits. Although the cost of the permit is considerably higher, Arkansas farmers could recoup the cost of the permit with their first 100,000 lb. load of corn, cotton, rice, soybean, or wheat (Figure 1).

The companies who chose to utilize the Harvest Permit for 2019 provided an estimation of the total number of loads for each crop they hauled using the 2019 permit. Each company had an estimated 15 percent fewer trips than if they had stayed at the legal maximum weight of 85,000 lbs. By using the permits, the companies traveled an estimated 33,330 fewer miles, saving on fuel and potentially offsetting the cost of the permit.

Figure 1: Revenue Based on 85,000 lbs. vs. 100,000 lbs.



SPOTLIGHT ON T²

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participants. Class participants included local and state attendees from the United States and Puerto Rico.

During these challenging times, scheduling, priorities, and budgeting are concerns for our roadway departments. Proper asphalt pavement maintenance techniques are important for keeping our roadways in good condition. The Asphalt Pavement Maintenance webinar covered best practices for various pothole patching methods, applications for crack sealing/crack filling, chip seals, slurry seals, fog seals, microsurfacing, and pavement overlays.

Class participants learned the most efficient methods for preserving the integrity of their asphalt roadways so they can prioritize projects and maximize maintenance dollars.

The Basic Pavement Maintenance webinar helped class participants to determine how to get the most from their maintenance budget and increase the long-term quality of their roadway network. Class topics included deterioration curves, inventory and condition of pavement, distresses and causes of pavement failure, treatment options, pavement service life and its relationship with planning their budgets and case studies.

Dr. Stacy Williams, the Director for the Center for Training Transportation Professionals (CTTP) at the University of Arkansas is an expert in this field and was the instructor for these webinars, as well as the instructor for the instructor-led training for these classes. She is also the instructor for some of our additional infrastructure and safety classes.

Attendees received four hours of ROADS Scholar credit in the infrastructure and maintenance category for each webinar, and PDH hours were available for professional engineers. Although the T2 Program is practicing social distancing, we're receiving requests for instructor-led training. To view the list of available training, class descriptions, or to request a class for your local agency, visit www.cttp.org/ardot/t2. Training through this program remains free to class participants.

For additional information regarding the Arkansas Technology Transfer Program, contact Laura D. Carter, T2 Program Manager at Laura.Carter@ardot.gov.

The ArDOT State Planning and Research (SPR) Work Program

BY BETHANY STOVALL

Every year, as our New Year resolutions start faltering, the Work Program starts knocking. The System Information & Research and Transportation Planning & Policy Divisions come together annually to co-author our Work Program, and almost every employee in the two divisions has a part to play in this process. For most of us in Research, that means updating the descriptions and activities for the job numbers assigned to us. The FY 2021 Work Program was submitted in June to FHWA thanks to everyone's hard work.

In case you have ever wondered what exactly the Work Program is, and why we almost always seem to be working on it, here is a brief overview. Each state is required to submit a Work Program to FHWA that outlines how their SPR funds will be allocated for the upcoming Fiscal Year. At a minimum, it must include a description of research, development, and technology (RD&T) activities to be accomplished during the program period, estimated costs, and participation in pooled fund studies. All research studies must be included in the Work Program until the final report has been completed. Financial summaries that show funding levels and share (Federal, State, other) for all RD&T activities must also be included. It should also contain major items to be purchased, including a cost estimate. Work Programs have to be approved by FHWA for funding to be received, but State DOT's are also required to have a management process in place (outlined in our Research Manual) that results in the implementation of the RD&T activities described in the Work Program. Failure to comply with any of these requirements can result in the withdrawal of SPR funds from the state DOT until full compliance is again achieved.

Hopefully this brief overview helped explain why the Work Program is so vital to what we do in Research. A special thanks to the great staff in the Planning Division for all the work they do every year to complete the Work Program.

Access Management for Arkansas Highways

BY KIM ROMANO, P.E.

TRB's Access Management Manual, 2nd Edition defines access management as "the coordinated planning, regulation, and design of access between roadways and land development. It encompasses a range of methods that promote the efficient and safe movement of people and goods by reducing conflicts over the roadway system and at its interface with other modes of travel." This definition was revised from an older description that specifically referenced driveway access and geometric design strategies that limit turning movements.

The final report addressing Access Management Implementation (TRC1805) is being completed. The research recommends additional steps ArDOT and local public agencies can take to standardize a more comprehensive access management policy. Implementation will not be quick and easy; it will take some buy-in from both public agencies and property owners. Implementation of access management is challenging because it cuts across organizational lines and involves several interrelated practices.

Access management techniques can include requiring dedicated turn bays, limiting left turn access by median barriers, restricting highway access to only public streets, and restricting driveway spacing or numbers. Access management techniques help reduce the number of vehicles turning on and off a highway and especially reduce left-turn conflicts. Its ultimate goal is to improve traffic safety and traffic flow.

Shared driveways and connections between parking lots help reduce the number of turning movements at major streets. These techniques are a different way of thinking for competitive business owners, and usually require a local champion to facilitate discussions with property owners. This strategy, though not formal, was used when the Highway 67 and I-30 frontage roads were converted to one-way traffic operations.

Access Management Plan agreements are another tool in ArDOT's toolbox. These have been used in conjunction with MPOs to designate design guidelines for corridors and allow regional design standards to be implemented. There are only a handful of access agreements currently in place, including for Highway 60 in Conway, Highway 100 in North Little Rock and Maumelle, and Highway 265 in Fayetteville.

ArDOT's current guidance is the Rules for Access Driveways to State Highways, 2017, which is used by District Permit Officers to permit new or modified driveway requests. These rules reflect Arkansas land use codes and are mainly limited to specific and usually single driveway permits on State Highways. TRC1805 investigated possible changes to that document that would facilitate a complete access management program.

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