RESEARCH INFORMER

— SUMMER 2021 —

A Newsletter by the Arkansas Department of Transportation Research Section

The New Madrid Seismic Zone and Why Arkansas Must Consider Seismic Hazards

BY KIM ROMANO, P.E.

Since 2008, consultants for ARDOT have conducted three research studies to identify methods that will better estimate the effects of seismic forces on bridges. Why, you may ask, does Arkansas need to be concerned with earthquakes? Only a handful of residents have experienced a minor earthquake in their Arkansas homes. Seismic events in Arkansas are typically small, rarely more than magnitude 3.0 to 4.0, and barely perceptible except in the immediate area.

However, in the recent past – in terms of geological time – northeast Arkansas and parts of Missouri, Tennessee, and Kentucky experienced what may have been the most remarkable series of earthquakes known to hit the conterminous United States. Indeed, they were the greatest documented in the central United States east of the Rocky Mountains.

Guesstimates of the strongest magnitude earthquakes ranged between 7.2 and 8.2; the United States Geological Survey (USGS) settled on magnitude 7.5. Instruments to measure seismic forces did not exist then. On December 16, 1811, at about 2:15 AM, the first in the series of earthquakes (magnitude 7.5) struck northeast Arkansas. Several smaller but intense quakes continued until about 7:15 AM when a 7.0 magnitude quake struck. Figure 1 is a graphic comparison of earthquake magnitudes. Go to www.britannica.com/place/New-Madrid to view a map of the location, intensity, and timeline of the 1811-1812 New Madrid events.

The New Madrid Seismic Zone (NMSZ) is 125 miles long and contains several faults between Marked Tree, Arkansas, and Cairo, Illinois. The faults are buried below thick layers of floodplain sediments. Because they are not visible at the surface, they are challenging to study. The exact nature of the NMSZ is not well understood. New Madrid, Missouri, the namesake of the NMSZ, was the closest inhabited town when the first quakes struck. Although the first quake struck northeast Arkansas, subsequent earthquakes in

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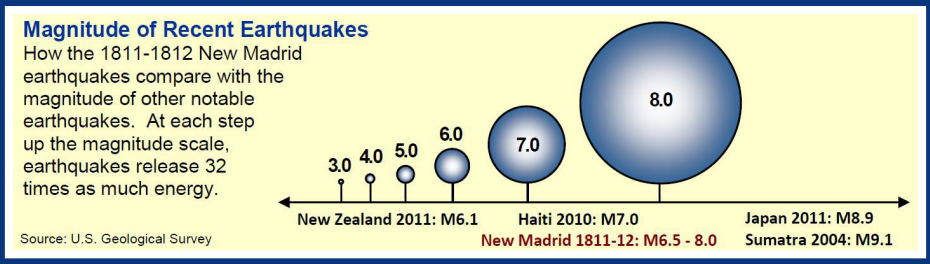
Figure 1 – Earthquake Magnitude



Spotlight On LTAP

TRAINING UPDATE DURING SOCIAL DISTANCING

BY LAURA D. CARTER

Stormwater Management webinars were held in two 2-hour sessions on May 5, 2021, and June 2, 2021, with class participants from various parts of Arkansas, as well as from numerous regions in

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Research is More Than TRC

BY ROBIN RUSSELL

The Transportation Research Committee (TRC) is a major part of ARDOT's Research Program, but the Section includes much more. Various services are provided to the Department to assist in many different areas. From audio/video (AV) support to finding potential applications for unmanned aircraft systems, the Research Section has a lot to offer. Here's a brief description of just a few of the services Research can provide:

Product Evaluation – This includes the evaluation of products or processes for highway construction and maintenance that the Department is interested in using for future projects.

Subsurface Drainage Research – This includes evaluating the performance of subsurface drainage under various conditions and making determinations regarding their effectiveness. This also includes inspecting culverts that are inaccessible to humans for issues using a remotely controlled rover.

Local Research Initiative (LRI) – The purpose of LRI is to conduct research that focuses on issues facing local transportation agencies, such as cities or counties.

Library Services – This includes locating relevant information to meet the needs of Department staff.

Unmanned Aircraft Systems (UAS) – The purpose of the UAS program is to determine potential applications for which drones can be used by the Department.

AV Equipment and Services – This includes setup and use of projectors and screens, microphones, cameras,

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SPOTLIGHT ON LTAP

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the United States. The first session covered guidance for documenting construction and maintenance activities, as well as permit requirements and regulation guidelines. The second session covered the importance of best maintenance practices to prevent pollution in waterways that could lead to unnecessary fines, as well as best management practices for preventing erosion and controlling sediment. Dr. Stacy Williams, Director of the Center for Training Transportation Professionals (CTTP) at the University of Arkansas, was the instructor for these webinars.

Recorded webinars and PowerPoint presentations of various training sessions conducted by CTTP and ARDOT for the Arkansas Local Technical Assistance Program (LTAP) are available at www.cttp.org/ardot/t2 in the Hot Topics section. Sessions include Asphalt Paving Basics, Concrete 101, Stormwater Management, and Work Zone Awareness. Additional training information, including upcoming training sessions, are also available on the website.

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that two-month series destroyed New Madrid, Missouri.

Eyewitness accounts and journal entries reported that the earth shook intermittently for days. The last big quake struck on February 7, 1812, in New Madrid, Missouri, or what was left of it. The few people who lived in those parts back then were scattered in small settlements or were working on the Mississippi River. We know details of those great quakes from journal entries and letters collected and maintained by the University of Memphis Center for Earthquake Research and Information. Eyewitness accounts documented that the Mississippi River temporarily ran backward, perhaps due to upheavals in the riverbed. Calving of the banks created risks for riverboats and their crews. Changes to land features included long rifts, sunken lands (like that which created Reelfoot Lake in Tennessee), raised lands that drained lakes, and sand blows that spewed sulfurous gas. Trees were felled or split by rolling waves of earth. Sounds of thunder were heard, sometimes in conjunction with flashing lights. Photo 1 shows a tree where the land sank after the earthquake and a second set of roots formed.

Seismic activity receives much-deserved attention from researchers, academia, engineers, and emergency planners. An abundance of resources is available documenting both old and recent earthquakes, including USGS's Far-Field Reports Map for December 16, 1811, Earthquake. The USGS maintains a website showing historical and current earthquakes in the United States linked below. The AASHTO LRFD Bridge Design Specifications and the AASHTO Guide Specifications for Load and Resistance Factor Design (LRFD) Seismic Bridge Design provide general procedures and specific design requirements considering seismic loads on bridges. ARDOT's completed and ongoing research into site-specific ground motion response to seismic loads will inform methods to clarify where that additional analysis would benefit bridge design in the NMSZ.

Photo 1: Tree with a double set of roots, formed in the aftermath of the New Madrid earthquakes (1811–12). The ground sank by several feet, creating low areas that were flooded by the Mississippi River.

Links:
Causes: tinyurl.com/j9k5nxam
Map: tinyurl.com/z5wvfwmf
Eyewitness Accounts: tinyurl.com/u6aea3js
Far Field Reports MMI Map for Dec 16, 1811 Earthquake: tinyurl.com/xn67w5sc
USGS : tinyurl.com/3c33354t

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and other AV equipment. Research Staff is available to facilitate the use of this equipment.

Other Equipment – Rebar locators, retroreflectometers, sound meters, field permeameters, generators, and a pole-mounted PTZ camera.

If you have a need for any services provided, contact the Research Section at 501-569-4922 or research@ardot.gov.

TRC1901 – Spatial Analysis of Benefits of Site-Specific Ground Motion Response Analysis

BY KIM ROMANO, P.E.

TRC1901 concluded in spring 2021. Dr. Ashraf Elsayed, with Arkansas State University, was the Principal Investigator (PI). Dr. Shahram Pezeshk, with the University of Memphis, was the subcontractor performing the field investigations and technical documentation, along with graduate students.

Bridges in areas of the United States with a history of strong earthquakes can be expensive to construct, including those in northeast Arkansas. The American Association of State Highway and Transportation Officials (AASHTO) specifies general procedures to estimate seismic forces for bridges designed in the United States. The AASHTO LRFD Bridge Design Specifications, 9th Edition, and AASHTO Guide Specifications for Load and Resistance Factor Design (LRFD) Seismic Bridge Design provide guidance on the general procedure and specific design requirements. The general procedure replaces the need for detailed site-specific hazard studies. However, if site-specific studies are not performed in areas with moderate to high earthquake risk, short period bridges can be over-designed, and long period bridges can be under-designed.

AASHTO procedures may require site-specific

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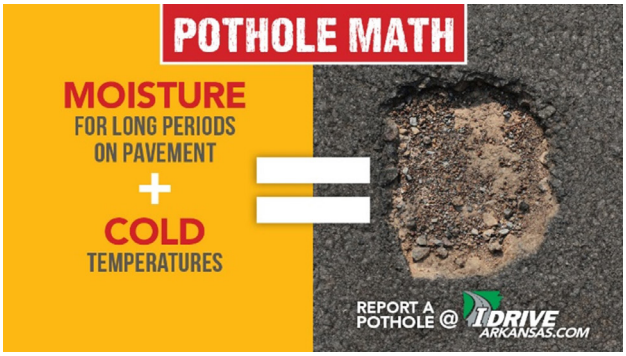
Potholes: What Causes Them and How to Prevent Them

BY SANGHYUN CHUN, PH.D., E.I.

Potholes are bowl-shaped holes with variable sizes observed on the surface of asphalt pavements that penetrate the entire surface asphalt concrete hot mix (ACHM) layer through to the underlying base course. Potholes induce significant roughness problems for the pavement surface that can cause accidents and serious damage to vehicles, especially when driving over potholes at higher speeds. Also, potholes accelerate the moisture intrusion to underlying unbound layers that will further deteriorate the overall pavement structural capability. Therefore, when the roads get potholes, it is essential to repair them correctly and as soon as possible.

In general, the primary causes of potholes include the combined effects of (1) moisture-induced damage with repeated traffic load, (2) localized disintegration induced by the connection of severe cracks, and (3) freeze and thaw cycles. The permeation of the water into the micro-cracks of the pavement with repeated traffic load will lead to the localized disintegrations of the pavement materials and facilitate the stripping process that will eventually develop potholes. A pothole is the latter stage of fatigue cracking initiated from a small portion of pavement layer by the interconnection of cracks. In particular, this type of distress can be further exacerbated by extreme winter weather conditions with freeze and thaw cycles since the infiltrated water underneath can expand and contract due to the temperature changes that expedite the formation of potholes with repeated traffic load applications.

As mentioned earlier, cracks will become potholes. Therefore, it is imperative to have appropriate crack sealing as a pavement preservation treatment in the earlier stage before severe cracks are formed to prevent potholes. The primary purpose of crack sealing is to keep water out of the pavement system. Also, crack sealing prevents any extraneous materials in addition to water from infiltrating into the crack and causing further deterioration as the pavement expands and contracts due to freeze and thaw cycles. In practice, crack sealing is probably the most important preventive maintenance activity to mitigate potholes. From a materials standpoint, moisture-induced damage can be mitigated by using anti-stripping additives, less moisture-susceptible mixtures with compatible aggregate-binder systems, and robust stripping/moisture-damage tests for quality control during the mixture production.



"Flowers aren't the only thing spring brings! Pothole repair crews can also be seen roadside these days. Please both help by reporting the locations of potholes and driving carefully around our crews. Thanks!" - @myArDOT on Twitter

A Look at the Staff of ArDOT's Research Section

BY ROBIN RUSSELL

When Research employees at the Arkansas Department of Transportation are asked about their favorite part of being in Research, answers range from the variability of the work, the many opportunities to learn something new, sharing new knowledge with others, to having relationships with the Sections and Divisions across the Department. The Section would be unable to function without these relationships across the Department. Staff meets with personnel from each Division during a Round Table meeting held at the Central Office each summer. Staff also travels yearly to each District to meet with personnel. The purpose of these meetings is to ask, "What problems are you having, and how can we help?" Information from the Round Table and District meetings is used to create problem statements. Input from each Division and District is requested for guidance throughout the project lifecycle. This makes teamwork an important skill.

There are so many great aspects to being part of the Research staff, but there are also challenges. Many challenges, which diminish over time, come from being new to the Section. The life cycle of a project can take more than three years, from the idea before the problem statement is written to the final report and implementation. There are many steps to complete before a project becomes a project. The Research Manual explains each step, but until you spend time in the process and see how it all comes together, the first year in Research can seem overwhelming.

A challenge for some that come from a specialized background is the broad nature of the Department's research needs and the need to learn or relearn broader aspects of other areas. Many Divisions focus on one part of the overall process of creating and maintaining highway infrastructure. Research encompasses all the parts, from planning and designing to constructing and maintaining. The various backgrounds and interests of the Research staff mean there is always someone ready to take on any topic presented to the Section. Pavements, materials, construction, innovative technologies, active transportation modes, human behavior, and data analysis are a few of the favorite topics among Research staff.

There is no specific set of skills that one must have to be successful in Research. Useful skills besides teamwork include self-motivation, flexibility, effective time management, organization, communication, and adaptability. It is important to understand the significance of your work and to recognize and utilize all the tools at your disposal. The most important part of RESEARCH is SEARCH. You don't always have to know all the answers; you just have to be willing and able to search for the answers.

The COVID-19 pandemic has had a large impact on Research Staff, research projects, and activities. From canceling the annual TRC Conference in 2020 to changing to a virtual conference in 2021, the TRC Conference is just one impacted activity. Many entities the Section relies on to complete research projects, such as universities and maintenance

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A LOOK AT THE STAFF OF ARDOT'S RESEARCH SECTION...

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crews, were affected by the pandemic as well. Fieldwork was halted, and progress on many projects was stalled. This led to many revisions and extensions being processed.

Not all the effects of the pandemic were negative. The lack of progress on projects gave many the opportunity to focus on other aspects of the job that often are postponed for a more convenient time, such as writing and analysis. Adaptability was a very useful skill during this time. For plans that relied on conventional methods, everyone had to adapt to different approaches for completing tasks.

TRC1901 – SPATIAL ANALYSIS OF BENEFITS OF....

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hazard analyses at locations with increased probabilities for long-duration earthquakes, near known faults, where specific soil conditions warrant, or for critical bridges. The intent of conducting a site-specific hazard study is to develop ground motion and response spectra that are more accurate for local seismic and site conditions than can be determined from the United States Geological Survey (USGS) hazard maps.

TRC1901 focused on developing a method to determine when site-specific ground motion response analysis (SSGMRA) would be warranted and, if so, how to select a consultant and what to specify. The research produced maps for assessing where an SSGMRA would benefit bridge designs in northeast Arkansas. An SSGMRA evaluates a hazard and its effects on bridges by:

1) Characterizing the subsurface soils,
2) Determining probabilistic seismic hazard analysis at the rock level,
3) Determining the site effects, and
4) Obtaining ground motions of a design response spectrum.

The research is built upon work completed in TRC1603 – Deep Shear Wave Velocity Profiling in North-Eastern Arkansas and TRC0803 – Shear Wave Velocity Profiling and Liquefaction Hazard Analysis. TRC1901 performed SSGMRA for 20 bridge sites using non-invasive testing methods. Data was added for 15 sites surveyed in TRC1603 and 16 sites surveyed in TRC0803.

TRC1901 and TRC1603 suggest that an SSGMRA could allow for reduced seismic design forces by up to 33 percent when compared to the AASHTO general procedure. This reduction in the seismic design force could result in construction cost savings of 15 to 30 percent in northeast Arkansas.

Additionally, the PI reviewed the information provided by several State Departments of Transportation with areas of high seismic hazard potential to learn of their practices. Based on that review, contracting language and methods were suggested for ARDOT to consider when SSGMRA is determined to be beneficial. General cost estimates to perform various invasive and non-invasive geotechnical studies were provided to assess where SSGMRA may be economical.

Rice Hull Benefits

BY ANAZARIA ORTEGA

Arkansas is the leading rice producer in America. According to the U.S. Department of Agriculture (USDA), Arkansas produced 108,107,000 CWT of rice in 2020. Repurposing the waste generated in the rice production industry not only contributes to the generation of renewable energy but also can provide a more sustainable alternative to concrete materials. Researchers are constantly studying new alternatives to produce renewable energy and satisfy the increasing energy demand. The use of biomass fuel, such as rice hull, has expanded in the last years. This is due to a collective effort to move away from fossil-fuel and its negative environmental implications[1]. Different processes can be used to transform biomass into energy, with combustion being one of the oldest methods used. The incineration of biomass also generates other byproducts such as rice hull ash (RHA). This residual material has been classified as a Class N pozzolan because it is a natural material with a high silica content. The cementitious properties of RHA allow this material to be used as a cement replacement. Mixing RHA, Portland cement, and water leads to the formation of additional calcium silicate hydrate (C-S-H) gel when the pozzolanic reaction occurs[2]. Calcium silicate hydrate is principally responsible for the strength gain in cement-based materials, but how much of this chemical is produced varies as the RHA percent replacement is changed. The Research Section is currently studying the application of this material in the transportation field. Properties such as strength and durability are key elements in determining the effectiveness of using RHA in highway construction.

1. Hossain, Z. (2019). Use of Rice Husk Ash (RHA) as a Supplementary Cementitious Material in Producing Normal Concrete. In MATEC Web of Conferences (Vol. 271, p. 07007). EDP Sciences.

2. Quispe, I., Navia, R., & Kahhat, R. (2017). Energy potential from rice husk through direct combustion and fast pyrolysis: a review. Waste management, 59, 200-210.

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