Construction of a Half-scale Bridge to Examine Load Transfer and Shear Behavior of Composite Bridge-slab System

C. D. Murray[1], R. W. Floyd[2], and J. S. Pei[3]

[1] University of Oklahoma, cdmurray@ou.edu
[2] University of Oklahoma, rfloyd@ou.edu
[3] University of Oklahoma, jspei@ou.edu

Abstract

This poster details the construction of a scale bridge in Fears Laboratory at the University of Oklahoma as part of an ongoing project involving the shear behavior of prestressed concrete. In the last two years, two full-scale AASHTO Type-II bridge girders were tested in Fears lab. The purpose of this testing was to evaluate the residual shear capacity of the girders after roughly 50 years in service. Another goal was to investigate the effects of composite action of the slab and girder system on shear capacity. In order to observe this effect more closely, a scale bridge was built. This bridge was constructed using the same methods as would be used in the field. Loads will be placed near the supports to cause increased shear demand and the response of the bridge system will be observed and compared to the AASHTO Bridge Design Specifications.

Effect of PPA Modification on Performance of Oklahoma Asphalt Binder

S. Rani[1], S. A. Ali[1], R. Ghabchi[2], and M. Zaman[3]

[1]Graduate Research Assistant, School of Civil Engineering and Environmental Science, The University of Oklahoma, 202 West Boyd Street, Room 334, Norman, OK 73019, E-mail: shivani.rani@ou.edu; syed.a.ali@ou.edu

[2] Assistant Professor, Department of Civil and Environmental Engineering, 134 Crothers Engineering Hall, South Dakota State University, Brookings, SD 57007, E-mail: rouzbeh.ghabchi@sdstate.edu

[3]David Ross Boyd Professor and Aaron Alexander Professor of Civil Engineering, Alumni Chair Professor of Petroleum and Geological Engineering, Director, Southern Plains Transportation Center, The University of Oklahoma, 202 West Boyd Street, Room 334, Norman, OK 73019, E- mail: zaman@ou.edu

Abstract

Polyphosphoric acid (PPA) is used by state DOTs to improve the high-temperature performance of asphalt binders and to increase the rutting resistance of asphalt pavements. Such improvements, however, have been found to depend on asphalt binder type and source, and aggregate type. In this study, the effects of PPA modification were investigated on the performance of asphalt binders commonly used in Oklahoma. For this purpose, two PG 58-28 asphalt binders were collected from Oklahoma refineries. The asphalt binders were blended with five different amounts of PPA (0%, 0.5%, 1.0%, 1.5% and 2.0%) using a high shear mixer. Superpave® performance grading (PG) and rotational viscosity of the blends were determined following the Superpave® guidelines. It was found that adding PPA increased the high-temperature PG grade and consequently enhanced the rutting resistance of the asphalt binder. No significant effect of PPA was observed on the low-temperature PG grade of the asphalt binder. PPA was found to increase the rotational viscosity of the binder significantly. This study also focused on the effect of using a warm-mix asphalt (WMA) additive, i.e. Evotherm® and an anti-stripping agent (ASA), i.e. AD-Here HP Plus®, on the PPA-modification of asphalt binder. It was observed that adding WMA or ASA or both decreased the high-temperature PG grade of the PPA-modified asphalt binder. A significant reduction in the rotational viscosity of PPA-modified asphalt binder was observed due to WMA and ASA.

Evaluation of High Temperature Characteristics of Polymer and RAP Modified Asphalt Binders Using Multiple Stress Creep and Recovery Method

S. A. Ali[1], S. Rani[1], R. Ghabchi[2] and M. Zaman[3]

[1] Graduate Research Assistant, School of Civil Engineering and Environmental Science, The University of Oklahoma, 202 West Boyd Street, Room 334, Norman, OK 73019, E-mail: syed.a.ali@ou.edu

[2] Assistant Professor, Department of Civil and Environmental Engineering, 134 Crothers Engineering Hall, South Dakota State University, Brookings, SD 57007, E-mail: rouzbeh.ghabchi@sdstate.edu

[3] David Ross Boyd Professor and Aaron Alexander Professor of Civil Engineering, Alumni Chair Professor of Petroleum and Geological Engineering, Director, Southern Plains Transportation Center, The University of Oklahoma, 202 West Boyd Street, Room 334, Norman, OK 73019, E-mail: zaman@ou.edu

Abstract

Accurate rheological characterization of polymer-modified and asphalt binders blended with Reclaimed Asphalt Pavement (RAP) binders is important to addressing the rutting susceptibility of asphalt pavements. The Multiple Stress Creep Recovery (MSCR) method is reported to be capable of accurately characterizing the high temperature properties of asphalt binders while taking the traffic level into account. In this study, polymer-modified and RAP-blended binders collected from different sources in Region 6 were evaluated based on the Superpave® and MSCR grading systems. The rutting parameter ($G^*/\sin\delta$) obtained from the Dynamic Shear Rheometer (DSR) test and non-recoverable creep compliance (Jnr) and % Recovery obtained from the MSCR test were used to examine performance of binders under high temperatures. It was found that the MSCR test is capable of differentiating between the polymer-modified and non-polymer-modified asphalt binders. Also, high %Recovery and low Jnr values were observed for polymer-modified binders, indicating a high rutting resistance. Furthermore, all the polymer-modified binders were found to sustain extreme level of traffic at 64°C. RAP blended binders were found to exhibit a decrease in Jnr values with an increasing RAP content. The stress and temperature sensitivity of the binders were found to increase with an increase in stress level and temperature. The Superpave® and MSCR test methods were found to rank the rutting resistance of polymer-modified binders differently. A MSCR database is being prepared. which can be used as a pre-screening process for selection of asphalt binders in Region 6.

Predicting Deficiency Status for Steel Bridges using Statistical Analysis of Oklahoma National Bridge Inventory Data

M. Alabdullah[1], P. Lewis[2]

[1]Department of Civil & Environmental Engineering, Oklahoma State University, Stillwater, Ok, 74075; Phone (405) 334-7559; email: mfabdul@okstate.edu

[2]Department of Civil & Environmental Engineering, Oklahoma State University, Stillwater, Ok, 74075; Phone (405) 744-5207; email: phil.lewis@okstate.edu

Abstract

The needs of an accurate reliability model to predict the end service life of bridges is an important issue for any bridge owner to ensure an adequate rehabilitation or when maintenance is required. The main objectives behind this research are to create a simple, rational statistical model that characterize bridges condition in Oklahoma National Bridge Inventory database. Thus, this research focuses on addressing the influence of aging on bridge components such as the deck, superstructure, and substructure. This will be done by tracking a historical data for steel bridges condition rating that were built in since 1992 to 2015. In this study, condition rating of 2,145 steel bridges were analyzed to determine the first time to reach deficiency status (FTRDS). Four well-known statistical distributions such as gamma, Weibull, lognormal, and log-logistic were investigated to predict the bridge components service life. The goal will be achieved by identifying the best distribution that fits Oklahoma NBI steel bridges to obtain the probability for the FTRDS. Based on Anderson-Darling test for the goodness of test process, the Weibull distribution was determined as the most appropriate distribution that characterizes the effect of aging on bridge components. The Weibull parameters, scale and shape factors were estimated to calculate the survival probabilities based on the bridge ages from the year built to any point that bridge reach deficiency status (4 to 0). Results show that only NBI data for superstructure and substructure elements are useful to calculate FTRDS while deck element was excluded due to insufficient data for the variable age. Finally, these models will be helpful to assist agenesis such as Oklahoma Department of Transportation (ODOT) to monitor the behavior of their bridges to create more public safety.

Validation of the Super Air Meter with Lab and Field Mixtures

H. Hall[1], M. T. Ley[2], D. Welchel[3], J. Peery[4], and J. LeFlore[5]

Oklahoma State University: [1]hhall@okstate.edu, [2]tyler.ley@okstate.edu, [3]david@weainc.com, [4]jpeery@okstate.edu, [5]kleflor@okstate.edu

Abstract

Surfactants are added while mixing concrete to stabilize billions of small bubbles in the concrete. These bubbles help with the freeze thaw durability by creating pressure relief when water freezes. Oklahoma State University has spent the last eight years developing a new tool to help the concrete industry evaluate the freeze thaw performance of concrete before it has been poured. The device is names the Super Air Meter or SAM. Testing to investigate the freeze thaw durability of concrete (ASTM C666) takes approximately 3.5 months and the SAM (AASHTO TP 118) can give similar results in 5 to 10 minutes before the concrete had hardened. This allows the mixture to be adjusted if needed. This research compares the SAM measurements to freeze thaw testing and hardened air void analysis (ASTM C 457). Independent testing completed by ten different state DOTs and FHWA is also presented. The SAM results show good agreement to freeze thaw testing and to hardened air void analysis by all investigators. Results are also given about the variability of the test and uses of the method to rapidly investigate bubble size and distribution. The SAM can more than doubles the lifespan of structures exposed to freezing environments (i.e. roads and bridges), and can save the traveling public billions of dollars each year in maintenance and repairs.

Vehicular Networks for Driver Safety during Adverse Weather Conditions

M. Atiquzzaman[1], R. Barnes[2], J. Havlicek[2], C. Nguyen[2], Z. Sadri[1], W. Guo[1] ,Y. Xu[1] , J. Williams[2]

[1]School of Computer Science, atiq@ou.edu
[2]School of Electrical and Computer Engineering, ron@ou.edu
[2]School of Electrical and Computer Engineering, jebob@ou.edu
[2]School of Electrical and Computer Engineering, chuong@ou.edu
[1]School of Computer Science, Zahra.sadri@ou.edu
[1]School of Computer Science, wguo@ou.edu
[1]School of Computer Science, yimming.xu@ou.edu
[2]School of Electrical and Computer Engineering, jwilliams77@ou.edu
University of Oklahoma, Norman, OK 73019.

Abstract

The objective of this project is to inform drivers of dangerous road situations caused by severe weather and reduce the number of fatalities and crashes. Our aim is to provide information about the road conditions and events that may result in hazardous situations on the road such as black ice or vehicle losing traction due to ice on road that can cause accidents. Informing drivers of road conditions that could cause an accident can help avoid fatalities by giving drivers more time to react to the event. Therefore, they can make decisions more wisely and avoid dangerous conditions. Eventually, this could lead to reduced number of crashes and fatalities. The project's objectives are as follows:

- Establish communication between vehicles using wireless networks.
- Collect vehicle operating conditions from the engine and analyze information to detect an event on the road.
- When an event is detected in a vehicle, related information like its location will be broadcast to other vehicles and Roadside Unit (RSU).
- RSU can send proper message to traffic display signs to warn drivers of road conditions.

Vehicles are equipped with OBUs, and RSUs are installed along the road. Car operating conditions, like speed, traction control, etc. are read through the On Board Diagnostics (OBD) port. The OBU receives car operating conditions from OBD-2 via Bluetooth and broadcasts the information to other vehicles and RSUs using the Dedicated Short Range Communications wireless protocol. An RSU sends messages to display sign via a cell phone operator network. To sum up, vehicular communication helps to warn drivers of road events and reduce probable accidents on the road.

Thermal and Live Load Deflections in Steel Bridges Made Composite with Concrete Deck Slabs

H. Jayaseelan[1], B.W. Russell[2]

[1]Oklahoma State University, hema.jayaseelan@okstate.edu
[2]Oklahoma State University, bruce.russell@okstate.edu

Abstract

Concrete bridge decks are subjected to temperature gradient throughout the depth of the slab. This causes internal thermal stresses resulting in bridge deformations. The sustained thermal loads cause the concrete to creep in tension which may lead to cracking of concrete decks. Creep strain in concrete is better understood in compression but not in tension. Analytical models were developed to calculate the theoretical stresses due to ASHTO temperature gradient. W 8x15 prototype beam was subjected to thermal load and live load testing. The beam was instrumented with thermocouples, bonded foil strain gages and displacement transducer to measure the concrete temperatures, strains in concrete and steel and beam deflection. The thermal load testing was conducted to quantify the nonlinear thermal stress gradients in concrete bridge decks. The results showed that the concrete temperatures, strain and the beam deflection at the mid-span steadily increased with the increase in thermal loads. The data and analysis indicated that the deflections were caused by a combination of temperature change and expansion in concrete. In the live load testing the prototype beam was loaded to yield for four load cycles before it was loaded to failure. The load vs. deflection graph showcased the beam hysterics cycle and the failure mechanism of concrete deck and the steel girder.

Nanomechanistic Investigation of RAP-Modified Asphalt Binders by Using an Atomic Force Microscope

F. Rashid[1] and Z. Hossain[2]

[1]M.Sc. Candidate, Arkansas State University, PO Box 1740, State University, AR 72467, USA, Phone: (870) 680 4299; E-mail: amferoze.rashid@smail.astate.edu
[2]Assistant Professor of Civil Engineering, Arkansas State University, PO Box 1740, State University, AR 72467, Phone: (870) 680 4299; E-mail: mhossain@astate.edu

Abstract

In recent years the use of reclaimed asphalt pavement (RAP) in pavement construction has become a common practice in the U.S. Use of RAP with virgin asphalts alters the properties of base binders, resulting in different in-service performance properties. Superpave tests are routinely used to characterize modified asphalt binders even though they are applicable for unmodified binders and cannot capture properties of modified binders. Recently, several researchers used Atomic Force Microscopy (AFM) techniques to characterize asphalt binders at their molecular level. In this study, binders from two field RAP samples, collected from I-40 and I-30 in Arkansas, were recovered by using a Rotavapor (AASHTO T 319-08). Different amounts (25%, 40%, and 60%) of RAP binders were blended with a selected Performance Grade (PG 64-22) binder. Selected microscale (stiffness) and nanoscale (morphology, hardness and elastic modulus) properties of the blended binders were evaluated in the laboratory through selected Superpave and AFM tests, respectively. In the AFM technique, the PeakForce Quantitative Nanomechanical Mapping™ (PFQNM™) mode was followed. As expected, the addition of RAP binder with the base binder increased the stiffness, thereby increasing the high PG temperature up to 85°C for a 60% RAP. The micro-structures as well as the nanomechanistic properties of the blended binders were found significantly different from those of the base binder; the elastic modulus of the 60% RAP-modified binder was over 70% higher than that of the base binder. The modulus was found to be correlated with the morphology. The AFM-based nanoscale properties of the tested binders were also found to be in agreement with their Superpave-based microscale properties. The findings of this study are expected to be beneficial for pavement professionals to have a better understanding of atomic level performance properties of asphalt binders modified with RAP.

Blowing Dust on Highway Safety: Characterizing and Modeling of Dust Emission Hot Spots in the Southern Plains

J. Blackwell[1], J. Li[1], R. Kandakji[2], J. Collins[3], J. Lee[2], T. Gill[3]

[1]Department of Geosciences, University of Tulsa, OK, 74104
[2]Department of Geosciences, Texas Tech University, Lubbock, TX, 79409
[3]Department of Geological Sciences, University of Texas, El Paso, TX, 79968

Abstract

Blowing dust and highway safety have become increasingly prevalent problems concerning human safety and welfare. Two factors precipitate wind-blown dust accidents: sudden loss of visibility, and loss of traction due to soil particles on the road surface. The project, using remote sensing and in situ measurements of surface and subsurface characteristics, will identify the location of dust emission "hotspots" and associated geomorphic features within the southwest region and panhandle (New Mexico, Texas, and Oklahoma), measure the threshold shear velocity and vegetative cover and model the results. These results will provide land managers, policy makers, and highway personnel critical information when making timely and informed potentially life-saving decisions and modifications. Decisions relevant in the southwest region and panhandle, may be applied to elsewhere in the world where blowing dust is a hazard to highway safety.

Quantification of Reduction in Hydraulic Conductivity and Skid Resistance due to Fog Seal in Low Volume Roads

M. R. Islam[1], S. Arafat[2], N. M. Wasiuddin[3]

[1]Post Doctoral Researcher, Civil Engineering, Louisiana Tech University, mri007@latech.edu
[2]Graduate Research Assistant, Civil Engineering, Louisiana Tech University, mar059@latech.edu
[3]Robert Howson Associate Professor of Civil Engineering, Louisiana Tech University, wasi@latech.edu

Abstract

Fog seal increases pavement life and postpones major rehabilitation. The reduction of permeability due to fog sealing will reduce moisture induced damage, but this benefit comes with temporary loss of surface friction. However, quantifying the effectiveness of fog seal by measuring the permeability is a difficult task. Four low volume parish roads in Caddo parish, LA have been selected for this study. Two emulsions, namely CSS-1H and E-fog with three different application rates were used to evaluate the reduction of hydraulic conductivity and to assess the characteristics of friction over time. Results show that fog seal is expected to be fully cured within 2.5 to 3.5 hours for 0.2-0.4 gal/yd^2 application rate. The same field-cores were tested before and after fog sealing to exactly quantify the reduction of hydraulic conductivity. It was observed that fog seal has significant potential to reduce the hydraulic conductivity. Considering all four pavements and application rates of 0.1-0.22 gal/yd^2, the average reduction of hydraulic conductivity was 38.5%. Reduction of hydraulic conductivity shows very slight sensitivity to the application rate. Irrespective of road type, emulsion and application rate, fog seal causes a sudden drop in the International Friction Index parameter F_{60} by 20 to 40%. Fog sealed surface does not return to the original level of friction after three months, however the rate of recovery is higher for high traffic road.

The Use of Acoustic Emission for Monitoring the Extreme Load and Climate Impact on Infrastructure

H. Zeng[1] and J. A. Hartell[2]

[1]Oklahoma State University, hang.zeng@okstate.edu
[2]Oklahoma State University, julie.hartell@okstate.edu

Abstract

Climate impact in terms of temperature and humidity cycling during the service phase of the structure's life cycle can induce the initiation of cracks and thus accelerate the deterioration process. Meanwhile, repeat traffic loading at different stress level on the infrastructure, especially on bridge and pavement, may also initiate cracks and further result in disintegration of surface concrete and thus altering the mechanical and physical properties of concrete. The combination of the two damaging mechanisms only amplifies the rate at which the material deteriorates. Therefore, to address the problem of climate impact on concrete infrastructure, two exposure mechanisms (phase I), high-temperature cycling and wet-dry cycling are carried out based on climatological data from 2004 to 2013 in Oklahoma City. After that, mechanical tests (phase II) will be conducted on these samples after 120 cycles of the two exposure conditions. Acoustic emission (AE) and other non-destructive testing (NDT) methods such as resonant frequency and ultrasonic pulse velocity (UPV) are introduced during the two phases for assessing the change in mechanical property and developing evaluation and monitoring guidelines which are capable of qualifying and quantifying damage and locating zones in distress induced by different exposure condition as well as various level of loading conditions.

Reliability-Based Slope Stability Analysis on a Slurry Wall Trench

O.A.M. Moudabel[1], X. Yang[2], G.H. Gregory[3]

[1]Graduate Research Assistant, School of Civil and Environmental Engineering, Oklahoma State University,
[2]Assistant Professor, School of Civil and Environmental Engineering, Oklahoma State University, xmyang@okstate.edu
[3]Adjunct Professor School of Civil and Environmental Engineering, Oklahoma State University ggregory@gregeo.com

Abstract

Stability analysis of slopes susceptible to different types of failures can be performed with different techniques to determine factor of safety (FS) from the mean values of each parameter of the media. In the recent two decades, factor of safety values are determined regard to the degree of uncertainty involved in its calculation which called the probabilistic analysis. Probabilistic analysis is probabilistic approach to find probability of failure and reliability index to assess the slope stability. Slurry walls are popularly used for excavation support especially when excavating on high groundwater sites. The required design factor of safety usually ranges from 1.2 to 1.3 based on a simplified two dimensional analysis. This research aims to assess the 3D effect of the slurry wall in a slope stability analysis. A reliability-based slope stability analysis was performed on an earth slope stabilized with a slurry wall. Factors of safety (FS) of the slope were determined using a two dimensional (2D) and a three-dimensional (3D) finite difference method programs. The probability of failure (Pf) of the slope was also accessed based on the Taylor series method. The result demonstrated that the 2D slope stability analysis is more conservative for slurry wall design which yields much lower factor of safety and higher probability of failure.

An Integrated Framework for Probabilistic Risk Assessment of Bridges Susceptible to Failure due to Flood and Scour

M. Shah[1], M. Soliman[2], O. Khandel[3]

[1]Graduate Research Assistant, School of Civil and Environmental Engineering, Oklahoma State University, malav@okstate.edu
[2]Assistant Professor, School of Civil and Environmental Engineering, Oklahoma State University, mohamed.soliman@okstate.edu
[3]Graduate Research Assistant, School of Civil and Environmental Engineering, Oklahoma State University, omidk@okstate.edu

Abstract

Bridges represent a very important component of the Nation's transportation system. These structures are exposed to several mechanical and environmental stressors during their life-cycle. Extreme events such as earthquakes and floods can significantly increase the risk of bridge failure. With more than 600,000 bridges across the Nation, management of the stock of ageing bridges, aiming at improving their condition state and serviceability levels, imposes a substantial challenge to bridge owners. Maintenance planning for bridges requires proper methodologies to determine the risk of failure associated with structural deterioration due to ageing and extreme events. Streamflow in rivers causes erosion of the river bed soil over time. An occurrence of flood increases this process significantly, causing scour holes around the bridge piers which may expose the foundation of the bridge. Removal of soil support potentially affects the stability and load carrying capacity of the substructure, which may damage the bridge or eventually lead to structural collapse. Climate change is expected to increase the intensity or frequency of floods which may lead to an increase in the failure risk of scour vulnerable bridges. In this study, an integrated probabilistic approach for risk assessment of bridges vulnerable to flood and scour is proposed. The approach uses Monte Carlo simulation and Latin Hypercube sampling to run finite element simulations capable of quantifying the time-dependent risk due to flood and scour considering climate change. This approach is illustrated on an existing bridge on the Red River in Oklahoma.

The Use of Resistivity Testing on Concrete Mixture

D. Zeng[1], W. Gurlez[2], and J. A. Hartell[3]

[1]Oklahoma State University, dali.zeng@okstate.edu
[2]Oklahoma State University, wassay@okstate.edu
[3]Oklahoma State University, julie.hartell@mail.okstate.edu

Abstract

Resistivity testing is one of the prevailing non-destructive testing method to determine the properties of the concrete mixture. The two resistivity methods are popular now days, which are four-probe surface resistivity and bulk resistivity method. The resistivity of concrete can be directly correlated to the likelihood of corrosion and the corrosion rate. Additionally, resistivity can be linked to the chloride diffusion rate. The wide usage of resistivity testing makes it possible and popular to perform easy and less time consuming test with accurate outcome. The Giatec SURF equipment and the Proceq Resipod equipment are used in the surface resistivity testing, which are designed based on the four-probe (Wenner-Array) technique. The Giatec RCON equipment is used to determine the bulk resistivity using uniaxial method. This poster presentation also shows multiple curves for concrete resistivity with different water/cement ratio, and with different amount of fly ash content from day 1 to day 56. Since electrical resistivity is one of the most sensitive indicators of changes in the concrete, resistivity testing can capture this important parameter regardless of concrete ages or stages of hydrations. Resistivity testing can be easily conducted to study durability performance of concrete. The electrical resistivity has been correlated well with important durability parameters such as permeability and diffusivity.

Hydro-Mechanical Study of Shrinkage Settlement and Cracking

H. Al-Dakheeli and R. Bulut

School of Civil and Environmental Engineering, Oklahoma State University, Stillwater, OK 74078, USA

Abstract

The desiccation from dry climate induces effective stress in the soil due to the increase of pore pressure, soil suction. The effective stress causes a shrinkage in clay soils. The vertical shrinkage develops vertical settlement in the soil while the lateral shrinkage can happen and initiate cracks when the lateral tensile stress exceeds the soil tensile strength. Therefore, the shrinkage settlement and cracking take place simultaneously. In spite of the notable researches studying both phenomena, shrinkage settlement and cracking are still not well understood. This research first investigates the stress-strain regime of the soil subject to desiccation induced shrinkage settlement and cracking by establishing the relation among effective stress-suction- shrinkage for the saturated and unsaturated states of soils. Second, building the characteristic curves of the hydro-mechanical behavior changing with the reduction of water content in the desiccation process (i.e. soil water characteristic curve, soil shrinkage characteristic curve, tensile strength characteristic curve, fracture toughness characteristic curve, and suction stress characteristic curve). Further, in the second task the hydro-mechanical behavior for the above curves is interpreted in a unified framework. Third, based on the second task this research extensively examines the critical stage of crack initiation. Finally, a simple and rational approach is proposed to modelling both the one and three dimensional shrinkage in addition to the crack depth and space as a response to the change in soil suction profile. All tasks are achieved by conducting a comprehensive literature review and laboratory tests. The experimental tests involve subjecting soils collected from Oklahoma to air drying and measuring the internal stresses developed using strain gauges and the volume change using digital image processing technique.

Parametric Study of the Adhesive Failure Mechanism of Asphalt Sealant

D. Stagg[1], S. Arafat[2], N. Wasiuddin[3]

[1]Author, dts018@latech.edu
[2]Co-Author, mar059@latech.edu
[3]Co-Author, wasi@latech.edu

Abstract

Although adhesive failure is the predominant distress responsible for early sealant failure in asphalt pavement, there are hardly any studies available on the variation of adhesive strength of sealant-asphalt concrete with temperature change. This study was performed to investigate the adhesive strength of sealant by utilizing a new test setup with a modification of the Texas overlay test. This test method applies direct tension to a sealant-substrate assembly, uses reasonable large scale asphalt concrete substrates, performs tests on easily prepared specimens, and does not require any specialized sealant testing machine. In this study, type I and type IV sealants were tested at four temperatures on two different thicknesses to evaluate the adhesive strength. A general conclusion obtained from this study is that sealant recommended for low temperature use (type IV) fails in adhesion irrespective of temperature or thickness. In addition, it follows a good correlation (R^2 value of 0.93) with the elongation at failure. A correlation between shear modulus and adhesive strength for both the sealants at each thickness were also established in this paper having R^2 values over 0.90 for every cases. A general trend on the effect of thickness was observed and was explained by proposing a hypothesis that there exists a certain modulus for each sealant type at which the bond strength remains same irrespective of its thickness. Also, in this study, it was clearly demonstrated that water conditioning of sealant joints reduces adhesive strength significantly by changing failure pattern from cohesive or mix mode to fully adhesive.

Analytical Chemistry-based Analyses of PPA-modified Asphalt

S. Alam[1] and Z. Hossain[2]

[1]Graduate Research Assistant, Arkansas State University, USA, mdshahri.alam@smail.astate.edu
[2]Assistant Professor of Civil Engineering, Arkansas State University, USA, mhossain@astate.edu

Abstract

Asphalt binders are often modified chemically to obtain desired rheological and physical superiority over the unmodified (neat) binder. Obviously, the chemical compositions of the base binder change upon this modification, which eventually leads to the rheological changes. The changes in chemical compositions due to the modifications of two Performance Grade (PG) binders (PG 64-22) of crude sources (Canadian-a basic binder; and Arabian-an acidic binder) with a commercial grade (105%) Polyphosphoric Acid (PPA) were observed in this study. The Asphaltenes content was found to increase linearly with the addition of PPA, and so did their viscosity values. Unlike the acidic (Arabian) asphalt binder, the basic (Canadian) asphalt binder demonstrated a distinctive decline in terms of pH with PPA modification. The Aromatics and Resins contents made a sharp change in slope at certain level of PPA addition that could be entitled as the optimum PPA content, beyond which further addition of PPA would result in no desirable benefits. The demarcation points were different for two different (crude origin) binders. Further, addition of PPA results in an abundance of solid phase (Resins and Asphaltenes), which makes the binder excessively hard and highly susceptible to low temperature pavement distresses.

Feasibility Study of the Use of Rice Husk Ash as a Supplementary Construction Material in Concrete

B. Ahsan[1], and Z. Hossain[2]

[1]Graduate Research Assistant, Arkansas State University, USA, mohammad.ahsan@smail.astate.edu

[2]Assistant Professor of Civil Engineering, Arkansas State University, USA, mhossain@astate.edu

Abstract

In recent years, concrete industries investigated the use of supplementary construction materials such as rice hush ash (RHA) to promote a greener world. High silica content in RHA is expected to make pozzolanic actions with water and can possibly replace some of the Portland cement used in producing concrete. Riceland Foods, Inc., situated in Arkansas, produces about 2.5 million metric tons of rice on annual basis. A significant amount of RHA is produced during the rice milling process. RHA contains about 75% amorphous silica, which can potentially be used as a cementitious material. But, its properties as a cementitious material in concrete production have not been investigated yet. The current study aimed at investigating the feasibility of the use of RHA produced by Riceland through selected laboratory-based physical and mechanical test procedures. The nominal maximum size of the RHA samples was found to be 600 μm. This RHA sample in the amounts of 0%, 10% and 20% (by weight) of a selected Type I Ordinary Portland Cement (OPC) were used in preparing concrete and mortar samples. It was found that 10% OPC replaced by RHA was optimum based on mechanistic properties of concrete. This bulk RHA-modified concrete can be used in backfill and structural fill as controlled low strength material (CLSM).

Liquefaction-induced Dragload and Downdrag on Deep Foundations in the New Madrid Seismic Zone

E. Ishimwe[1], R. A. Coffman[2], K. M. Rollins[3]

[1]Graduate Research Assistant, University of Arkansas, Fayetteville, AR 72701. eishimwe@uark.edu
[2]Associate Professor, University of Arkansas, Fayetteville, AR 72701. rick@uark.edu
[3]Professor, Brigham Young University, Provo, Utah, USA, rollinsk@byu.edu

Abstract

The New Madrid Seismic Zone (NMSZ) has been the source of several earthquake events. Several earthquake events, which occurred in the past, had sufficient ground motions that induced soil liquefaction due to the presence of deep, loose, sandy soil deposits within this region, Because of 1) the past earthquake events and 2) the soil classification within this region, engineers and researchers have been focusing on this seismic zone to evaluate the potential of soil liquefaction. Despite a large factor of safety employed during the design of the foundations for bridges or heavy structures, the dragload and downdrag induced by soil liquefaction may add additional load to the foundation that can lead to structure to collapse during or after an earthquake event. This research project is being conducted to evaluate and obtain a better understanding on the development of dragload and downdrag on shafts and piles installed into the liquefiable sand deposits at the Turrell Arkansas Testing Site located in Northeast Arkansas, within NMSZ. Eight deep foundations including: two four-foot diameter drilled shafts (90.5ft long) and one six-foot diameter drilled shaft (72ft long), a HP 14x117 steel H-pile (92ft long), two 18-inch diameter 0.5-inch wall thickness closed-ended steel pipe piles (78ft long), and two 18-inch by 18-inch precast prestressed concrete pile (74ft long) were instrumented and installed within the soil, and blast-induced liquefaction tests were performed around each installed pile and shaft. The results obtained from installed instruments are being evaluated.

Remote Sensing of Soils for Evaluating Hazard Following Wildfires

S.E. Salazar[1], R.A. Coffman [2]

[1]Graduate Research Assistant, Department of Civil Engineering, University of Arkansas, Fayetteville, AR 72701. Email: ssalazar@uark.edu

[2]Associate Professor, Department of Civil Engineering, University of Arkansas, Fayetteville, AR 72701. Email: rick@uark.edu

Abstract

Post-wildfire debris flows directly impact transportation infrastructure (highways, bridges, waterways etc.) in mountainous regions of the country every year. Efforts to mitigate risk from unexpected debris flows require advanced probabilistic modeling, which require high quality input data. It has been shown that there is a significant lack of data related to the properties of the soil in wildfire-affected areas, such as soil water potential, soil plasticity, and clay content, which are important parameters in the hydro-mechanical behavior of unsaturated soils. However, existing methods of obtaining these measurements have demonstrable disadvantages. Traditional methods of obtaining unsaturated soil properties, including laboratory-based methods (chilled mirror hygrometer, Tempe cell, and pressure plate extractor) and in situ methods (tensiometer, heat dissipation sensor, electrical resistance sensor), provide only point-wise measurements and consequently suffer from low temporal and spatial resolution and limited soil water potential measurement range. Therefore, a remote sensing technique was developed to measure the soil properties of interest using ultra-violet to near-infrared (UV-NIR) diffuse reflectance spectroscopy at the soil surface without contacting the soil. A partial least squares (PLS) statistical technique was utilized to correlate soil suction to the diffuse reflectance spectrum in the UV-NIR range (350-2500 nm). Measured and predicted values of soil water potential showed good correlation. The PLS regression conducted on 60 calibration specimens explained 98 percent of the variance expressed in the specimen reflectance spectra. The remote sensing technique presented has the potential to provide soil property and soil state measurements at the field scale that may be utilized in probabilistic debris flow modeling.

Creep and Recovery Behavior of Polymeric and Chemically Treated Asphalt Binders

M. Z. Rahaman[1] and Z. Hossain[2]

[1]Graduate Research Assistant, Arkansas State University, Email: mohammed.rahaman@smail.astate.edu

[2]Assistant Professor of Civil Engineering, Arkansas State University, Email: mhossain@astate.edu

Abstract

For quality assurance and quality control purposes, suppliers and users of asphalt binders follow the widely used dynamic shear rheometer (DSR) test method (AASHTO T 315) to capture viscoelastic properties of polymer-modified binders (PMBs), warm mix asphalt (WMA)- and reclaimed asphalt pavement (RAP)- modified binders even though it is designed for unmodified asphalt binders. AASHTO T 315 is inadequate to characterize the aforementioned binders because of the relatively small impact of the phase angle and strain levels on the rutting and fatigue factors, respectively. The recently balloted multiple stress creep recovery (MSCR) test (AASHTO T 350) results can better relate the laboratory-based and field rutting of PMBs and additive-modified binders. In the current study, Superpave, MSCR, frequency and linear amplitude sweep (LAS) tests were performed to evaluate viscoelastic properties of selected asphalt binders approved in Arkansas and Texas. A total of 65 binder samples were tested in the laboratory. Of these, 8 were unmodified binders, 24 were PMBs, 27 were WMA-additive modified, and 6 were RAP modified binders. The non-recoverable compliance and MSCR percent recovery data of the tested binders were analyzed for grading and establishing the MSCR percent recovery criteria for local service temperature and traffic conditions. The developed guidelines are expected to be helpful for transportation agencies in Arkansas and Texas to adopt the MSCR test method in their quality control process.

Geosynthetic Reinforced Soil Integrated Bridge Systems (GRS-IBS) in the U.S. and Oklahoma Experience

L.A. Pena[1] and K. Hatami[2]

[1] Graduate Student, luispenac@ou.edu
[2]Associate Professor, kianoosh@ou.edu
School of Civil Engineering and Environmental Science, The University of Oklahoma, Norman, Oklahoma

Abstract

In 2013, more than 150,000 bridges nationwide had a bump-at-the-end-of-the-bridge problem. Fixing this issue implied spending more than $100 million annually. In 2014, the University of Oklahoma, together with the Oklahoma Department of Transportation (ODOT) and the Oklahoma Bureau of Internal Affairs (BIA) started a feasibility study of GRS-IBS, which was promoted by FHWA as a cost-effective solution to fix and/or rebuild bridges with spans that were primarily shorter than 80 ft. In this study, an extensive literature survey has been carried out on all reported GRS-IBS in the U.S. in addition to performance (i.e. settlement) monitoring of six bridges (i.e. four GRS-IBS and two conventional) that were built in Kay County, OK within a one-mile segment of 44th St. Additionally, laboratory testing was carried out on the construction materials of these bridges, and a numerical model was developed for the analysis of GRS-IBS systems. Finally, an interactive online database of all reported GRS-IBS has been developed (which is currently in its final stage of development), which together with the numerical simulation tool can help ODOT and other departments of transportation examine the costs and benefits of GRS-IBS as a potential solution for bridge construction projects in Oklahoma and other states. At this point, GRS-IBS can constitute a cost-effective solution for bridge spans less than 80 ft. on county and local roads. However, continued development of the GRS-IBS technology, together with increasing reports of successful performance in different states hold promise for their more widespread use across the U.S.

Assessing the Impact of Climate on Bridge Deck Deterioration

C. Contreras-Nieto[1]; Y. Shan[2]; P. Lewis[3]

[1] Graduate student at Oklahoma State University, contrec@okstate.edu

[2] Assistant professor at Oklahoma State University, yongwei.shan@okstate.edu

[3] Associate professor at Oklahoma State University, phil.lewis@okstate.edu

Abstract

Bridge conditions in Oklahoma were rated D^+ according the American Society of Civil Engineers (ASCE) 2013 Report Card for America's Infrastructure, which is lower than the national average of C^+. The condition of decks is fundamental to determine the comprehensive sufficiency rating of bridges. In addition, leaking joints on bridge decks can further induce the corrosion of bridge superstructures. The accurate prediction of bridge deck condition would assist transportation agencies in determining the most appropriate time to schedule maintenance/repairs. Factors, such as the age of the bridge, traffic, materials, design, but climate, are the typical factors considered in predictive models. Therefore, this study aims to assess the deck rating in the state of Oklahoma by analyzing the climate impact. Bridge data from the National Bridge Inventory (NBI) and climate data from the Oklahoma Mesonet system were integrated to create the study dataset. Using SAS Enterprise Miner and SAS Enterprise Guide, correlation, analysis of variance, regression, and neural networks techniques were applied to investigate the relationship between the climate data and the deck rating of bridges. As a result, it was found that the majority climate variables have not changed over the last 19 years. Also, three groups of bridges were classified by the Mesonet station. The group with a highest average deck rating of 6.9 consists of bridges located adjacent to either one of the Mesonet stations including Bessie, Norman, and Beaver stations. It was also identified that the climate variables have a very weak association with the bridge deck rating, and regression models only explain 1.2% of the variation in the bridge deck rating.

Panel Data Analysis of Factors Affecting Surface Skid Resistance for Various Pavement Preventive Maintenance Treatments

You Zhan, Qiang "Joshua" Li *, Guangwei Yang, Kelvin C.P. Wang

School of Civil and Environmental Engineering, Oklahoma State University, Stillwater OK
qiang.li@okstate.edu; 405-744-6328

Abstract

Various preventive maintenance treatments have been employed by highway agencies to restore pavement skid resistance for enhanced safety. Numerous friction deterioration models have been developed over the past decades, while none has incorporated both the cross-sectional and time-series effects. This paper investigates the effectiveness of various preservation treatments on pavement skid resistance using Panel Data Analysis (PDA). PDA not only considers the cross-sectional information reflected in the differences between treatments, but also the time-series changes within treatments over time. Panel data from more than fifty sites in the Long Term Pavement Performance (LTPP) Specific Pavement Study-3 (SPS-3) with multiple years of surface friction data for four maintenance treatments (thin overlay, slurry seal, crack seal, and chip seal) are used in this paper to develop panel friction models under various climate conditions, traffic levels and pavement performance. Both fixed- and random-effects models are developed to evaluate pavement friction performance for the preventive maintenance treatments and to identify the influencing factors that significantly impact pavement skid resistance. Subsequently, comparisons are made between results from traditional ordinary regression models and the PDA models. Fixed-effects panel model is identified to be the most suitable model and the regression friction prediction models are developed. The findings in this study are expected to assist engineers in selecting the most effective preventive maintenance treatments such that the desired level of skid resistance at a given traffic level is achieved to reduce the number of crashes.

Pavement Surface Safety Analysis with Data from Multiple Devices

Guangwei Yang, Qiang "Joshua" Li *, You Zhan, and K.C.P. Wang

School of Civil and Environmental Engineering, Oklahoma State University, Stillwater, OK.
qiang.li@okstate.edu, 405-744-4638

Abstract

Pavement friction and texture characteristics are important aspects of road surface safety. Many different types of equipment have been developed and used to measure these properties. This paper investigates the suitability of using several novel texture indicators for skid resistance analysis. First, discrete wavelet transform is implemented to decompose pavement macrotexture data, which were collected from a high-speed profiler on the six high friction surface treatment (HFST) sites in Oklahoma, into multiple wavelengths. The Total Energy (TE) and Relative Energy (RE) are calculated as indicators to represent macrotexture characteristics at various wavelengths. The macrotexture energy within wavelengths from 0.97 mm to 3.86 mm contributes positively, while the energy within wavelengths from 15.44 mm to 61.77 mm shows negative impacts on pavement friction collected using a Grip Tester. Second, recognizing that Mean profile depth (MPD) is a 2-dimensional (2D) indicator, five categories of 3-dimensional (3D) areal parameters are explored to characterize pavement texture attributes. Pavement texture and friction data are collected in parallel at predefined locations on the Long Term Pavement Performance (LTPP) Specific Pavement Study 10 (SPS-10) in Oklahoma via a portable ultra-high resolution 3D laser scanner and a Dynamic Friction Tester (DFT). Correlation analyses among the twenty-four 3D texture parameters are conducted to exclude those who exhibit strong correlations. The core material volume and the peak density are identified as the most influential macro- and micro-texture parameters which exhibit fairly good correlation with DFT friction data at high- and low-speed. Subsequently, multivariate linear friction prediction models are developed incorporating the novel texture indicators. The results indicate those texture parameters could provide better alternatives to characterize pavement surface texture attributes with respect to the pavement friction performance.