Welcome to the UDOT Research Division September 2010 Edition Newsletter

This is a quarterly publication that provides highlights of the Division's research activities as well as other helpful information.

New Director of Research

The Utah Department of Transportation Division of Research is pleased to announce that Cameron Kergaye, PhD, PE, has joined the research team as its new Director of Research.

Cameron Kergaye has been with UDOT for the past twenty years and has worked in many different disciplines including design, construction and materials. He has also worked on I-15 reconstruction and in engineering services and project management. In 2003 and 2004, Cameron served as AASHTO's Engineering Management Fellow working with technical committees and policy initiatives.

During his career at UDOT, Cameron has gained significant experience in various positions. As the I-15 Reconstruction Project Quality Manager, Cameron was instrumental in providing oversight for acceptance testing, management of independent assurance testing, verification testing and incentive programs.

As the Engineer for Engineering Services, he provided management to the Consultant Services, Access Management, Statewide Permitting, Utilities/Railroads, and Value Engineering Sections. Cameron also implemented special programs such as zero-based budgeting and project delivery. He was responsible for the management of multiple transportation projects and has provided statewide technical support of UDOT's program management activities.

Cameron received his Doctorate in Civil Engineering from the University of Utah. He is the author of publications on Adaptive Traffic Signal Control Studies and Traffic Variability Studies. Cameron is also a member of American Society of Civil Engineers (ASCE) and Institute of Transportation Engineers (ITE).

The Research Division will benefit from his educational background, technical knowledge, and leadership skills. Please join us in welcoming Cameron to UDOT Research.

You may contact Cameron at 801-965-2576 or ckergaye@utah.gov

We would also like to take this opportunity to extend our sincere gratitude to Mr. Michael Fazio who held the position of Deputy Director of Research for the past few years.

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By Pedro Romero, Ph.D, PE
U of U Department of Civil & Environmental Engineering
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Asphalt Engineer, UDOT Central Materials

DEVELOPMENT OF METHODS TO CONTROL LOW TEMPERATURE PROPERTIES OF ASPHALT MIXTURES

Asphalt concrete mixtures are expected to be designed to withstand the temperature variations encountered throughout their service life. This means that the mixtures should be stable during hot weather to withstand traffic loads without any permanent deformation and should be ductile enough during cold temperatures so that they can resist cracking. Unfortunately, current specifications place emphasis on high temperature properties only. Tests such as the Hamburg Wheel Tracking Device (HWTD) are now routinely used on UDOT paving projects to ensure the high temperature stability of asphalt mixes. This practice results in mixtures that that have high resistance to deformation but are likely to be brittle when the temperature drops. Furthermore, the addition of reclaimed asphalt pavement (RAP) might benefit the high temperature properties but, if not properly accounted for, could be detrimental to low temperature performance.

As a result, pavement distresses caused by low and intermediate temperatures are a significant source of problems for UDOT and other highway agencies. As an example, the off ramp from State Route 201 (SR-201) to 3200 West in Salt Lake City was recently surveyed, and the asphalt concrete shows premature and significant cracking that will require expensive maintenance in the coming years (Figure 1).

Figure 1: Off Ramp from SR-201 and 3200 West

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By Pedro Romero, Ph.D, PE
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UDOT and other highway agencies have struggled to adopt a testing method that can capture the low and intermediate temperature properties of asphalt mixtures. Unfortunately, common methods such as the indirect tensile test (IDT), shown in Figure 2 (AASHTO T322), require new equipment and staff training and are too time consuming for day-to-day operations.

Figure 2: Indirect Tensile Test Setup

Work conducted at the University of Minnesota showed that the low temperature modulus or stiffness of asphalt mixtures can be obtained from thin mixture beams tested using a slightly modified Bending Beam Rheometer (BBR) commonly used for asphalt binder testing (Figure 3).

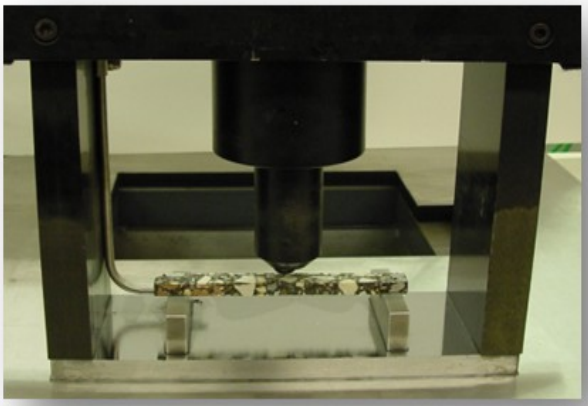

Figure 3: Testing asphalt mixtures using the BBR

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By Pedro Romero, Ph.D, PE
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A research project was started in 2007 between UDOT and the University of Utah to evaluate the applicability of using the BBR to determine the low and intermediate temperature properties of asphalt mixtures in an effort to prevent premature failures such as the ones shown in Figure 1.

Through a rigorous statistical analysis, researchers at the University of Utah determined the number of replicate thin-mixture-beam samples needed for valid conclusions so that the test can be used for quality control/quality assurance (QC/QA) during asphalt pavement construction. Viscoelastic modeling was employed to evaluate the effect of aggregate size and to predict thermal stress within the pavement. Based on the theoretical and experimental analysis, it was concluded that the BBR is a viable tool to determine low temperature properties of asphalt mixtures. This is a significant conclusion since this is commercially available equipment that is already in UDOT's laboratories. Laboratory staff and material engineers are already familiar with this equipment thus eliminating many implementation barriers that have troubled other tests. There is no need for new equipment development or technician training, other than the use of a standard tile saw to prepare specimens from compacted samples.

The next step consisted in demonstrating the applicability of this test as a quality control method on a real paving project. During the month of August 2009, a paving project was evaluated using the BBR and the asphalt mixture from the field. As it is typical for UDOT projects, the asphalt mixture was sampled behind the paver and taken to the regional laboratory where it was reheated and compacted into the standard 150-mm (5.9-in) diameter samples using the Superpave gyratory compactor. The compacted samples were then tested for density as a means to ensure all required volumetric properties were met. Based on the laboratory reports, the mixes were satisfactory in meeting the volumetric requirements.

Once the project was completed, the compacted samples were obtained and transported to the Materials Laboratory at the University of Utah. No information was given to the researchers other than that the mixture met all volumetric requirements. For each paving day, one sample was cut. Given the size of the beams tested in the BBR, over 15 valid thin-beam samples were easily obtained from each compacted sample. All samples were tested in the BBR at a temperature of -24 °C (-11 °F), which corresponds to the performance grade of the binder plus 10 degrees C. The BBR software automatically reported stiffness and the m-value (slope of the curve) at 60 seconds. These values were plotted in a control chart without the need for any data manipulation. The results of the tests run at the University of Utah are shown on Figure 4.

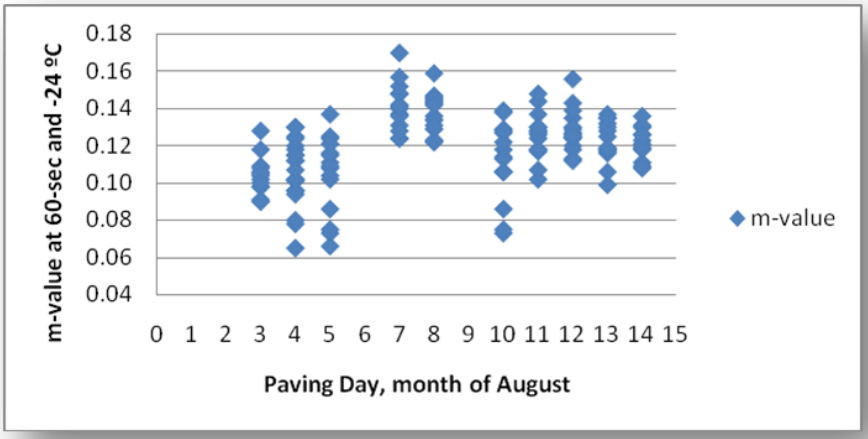

Figure 4: Control chart for the m-value at 60-sec at a temperature of -24 ºC.

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By Pedro Romero, Ph.D, PE
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The figure shows the m-value at 60 seconds. As can be seen in the figure, there seems to be an anomaly on the 7th and 8th of August. The m-value during those two days seems higher than during the rest of the days. Based on these findings, the researchers at the University of Utah went back to the records and talked to the field engineer and the plant operator. Through these discussions, it was learned that during those two days, the mixture arrived at the project at a temperature 50 °F (27 °C) higher than the rest of the days. Apparently, there were some operational problems that were not discovered on time. It is well known that overheating the asphalt material is detrimental to its properties and that it might lead to a decrease in low temperature performance. Such effect was not evident at high temperatures where current tests were run but, as shown on Figure 4, it can be easily detected using the BBR. Had BBR testing of mixtures been in place during this project, it would have raised a flag during August 7 resulting in more detailed inspection of the operation and further testing to determine the decrease in pavement performance as a result of overheating the material.

This research demonstrated that the BBR is a viable test to determine the low temperature properties of asphalt mixtures. It was concluded that the size of the specimen used for testing is not an issue regarding the validity of the test. Finally, it was shown that the BBR can be used for day-to-day QC applications using equipment that already exists at UDOT's laboratories.

Results from this work will allow material engineers to optimize asphalt mixtures so that both high and low temperature properties result in longer lasting pavements. The final report on the completed research by University of Utah researchers will be published by the Research Division this year. Future work will focus on developing acceptable limits, involving BBR testing of asphalt mixes from several UDOT projects, and incorporating these findings into a provisional specification.

David Stevens of the Research Division and Doug Anderson (retired from UDOT) have been the project managers for this research. For further information on this project, contact Kevin VanFrank at kvanfrank@utah.gov, Dr. Pedro Romero at romero@civil.utah.edu, or Mr. Stevens at davidstevens@utah.gov.

By Blaine Leonard
UDOT Research Division

PREPARING FOR EARTHQUAKE

We sometimes talk about 'the big one', the major earthquake that is destined to ultimately shake northern Utah. We know that the Wasatch Fault is capable of producing a 7.5 magnitude earthquake, and based on average recurrence intervals, we are overdue for it. A local seismologist has said that we happened to settle in the SLC Valley in a relatively quiet period, and we may have simply been lucky up to now. But, the event will come, eventually. The real question is, are we ready for it, and what are we doing to make ourselves ready?

Of course, we have seismic design codes and criteria that we follow in the design of bridges, embankments and other features. These measures have proven effective in other places, and are based on valid experience and research. But we don't have a full understanding of all the seismic responses and mitigation tools that we would like. For instance, we now build a lot of bridge abutments using Mechanically Stabilized Earth (MSE) walls. There are presently no design methods available to predict the capacity of the piles immediately behind these MSE walls to resist lateral (seismic) loads, or the loads that these piles may impose on the walls. So, research continues here and around the globe.

At UDOT, we have participated in, and funded, research in a variety of seismic topics over the past 20 years. During the I-15 Reconstruction in Salt Lake County, we supported work by Drs. Reaveley and Pantelides from the University of Utah on seismic response of bridge bents. We also experimented with retrofitting concrete beams and columns using carbon fiber to give them additional strength. This composite material research was performed by Dr. Reaveley and Pantelides and by Dr. Fonseca of Brigham Young University. At that same time, we supported research by Dr. Lawton, of the University of Utah, on the response of Geopier foundations during seismic loading.

Additional I-15 testing was performed by Drs. Halling, Womack and Barr from Utah State University on the dynamic characteristics of bridges. They installed permanent seismic monitoring equipment on one of the bridges in the 'spaghetti bowl' area of I-15 near SR-201 and I-80.

UCLA Shaker mounted on a pile cap

This equipment is still operational, as are adjacent downhole instruments installed by Dr. Youd, of Brigham Young University, and will provide incredibly valuable data when the earthquake strikes. Dr. Ryan, also at Utah State, has performed research evaluating and prioritizing our bridges for seismic retrofit.

Drs. Bartlett and Martin of the U of U are looking more broadly at our lifelines along the Wasatch Front, bridges and highways, to assess our vulnerability and try to prioritize retrofits on our critical facilities. Dr. Bartlett and our own Michael Fazio traveled to Italy last year to assess the damage caused on transportation systems by the L'Aquila earthquake, and brought back valuable information on the infrastructure systems and community response.

Dr. Rollins of Brigham Young University has performed a number of full scale tests on pile foundations to learn more about their seismic behavior, and on prefabricated vertical (wick) drains to assess their ability to prevent liquefaction. He often collaborates with other researchers, such as Dr. Ashford at the University of California at San Diego, or with local consultants, contractors and suppliers. Some of these projects are on-going, as we continue to expand our knowledge. For instance, Dr. Rollins has a project on two abutments in Utah County where we are trying to learn more about the loads on those piles behind MSE walls, mentioned above.

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By Blaine Leonard
UDOT Research Division

We also learn from seismic research being performed in other parts of the country. A large oscillating shaker owned by UCLA has been employed in Utah on some of Dr. Rollin's pile tests. As we observed, it can put a whole pile cap into pretty intense motion. A shake table at the University of Buffalo will soon be used to evaluate liquefaction mitigation with wick drains on the study mentioned earlier. In addition to the shake table, they have a special shear box which allows soil failure to be modeled more accurately. This project will be supported by several states through a FHWA Pooled Fund arrangement.

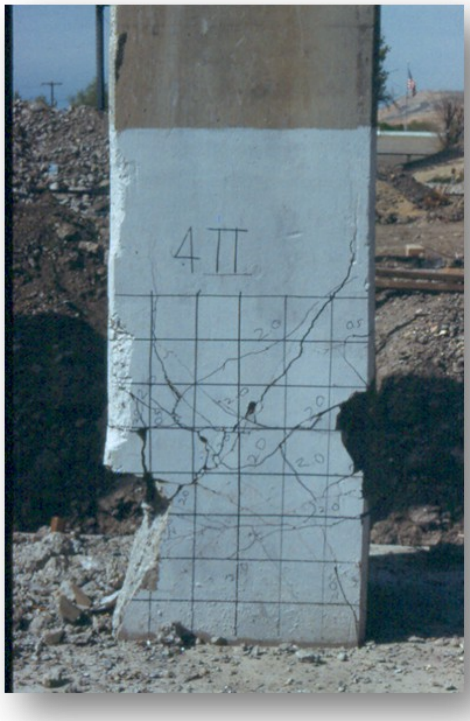
Similar tests on bridges and buildings are often performed on a set of four sophisticated shake tables at the University of Nevada at Reno. Researchers from around the world come to Reno to study earthquake effects. Through conferences, workshops and publications, we learn of innovations realized there and elsewhere. And, we often share information with other states that face the same kinds of challenges we do, like California and South Carolina. A workshop held at Region 2 four years ago brought people from both of those states to discuss seismic bridge design and performance.

Seismic issues are the focus of researchers in many parts of the world. I had the opportunity to visit Tong Ji University in Shanghai, China, recently, and saw the shake table they use to test models of high-rise buildings. There are many tall buildings in Shanghai, and they test models of most of them to understand their behavior. Their 'boneyard' of building models is like a miniature version of downtown Shanghai. The University of Wellington, in New Zealand, also puts a lot of focus on seismic issues, since they have a risk that is a little higher than ours here in Utah. Some of the expertise developed there impacts us directly. A specialized structural consulting firm in Wellington has worked on base isolation designs for two Salt Lake projects.

We don't know when the big earthquake will hit us, but, statistically we are overdue. There are many things we can do on a personal level to be prepared, but researchers at UDOT, our local universities, and around the world are focused on trying to get us ready.

For further information on these projects, contact Blaine Leonard at bleonard@utah.gov

Shake Table at University of Nevada Reno



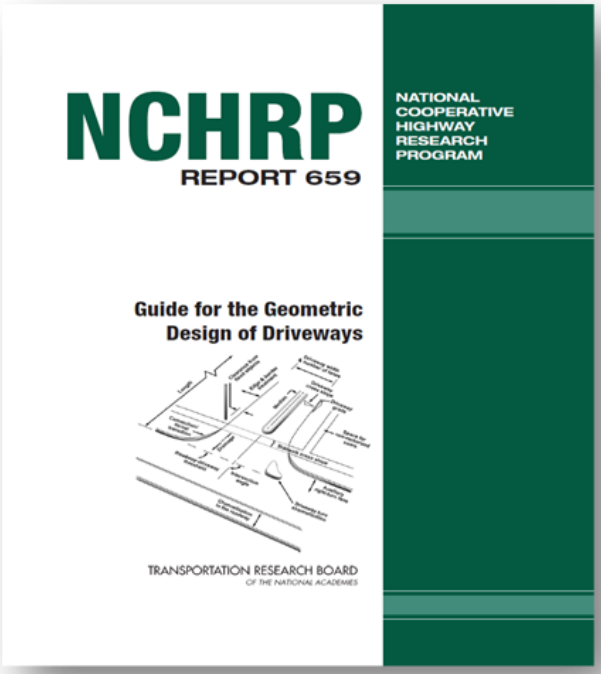
I-15 bridge column after testing to failure

By Nick Jones
Utah LTAP Director

DRIVEWAY DESIGN, PRESERVING CAPACITY ON OUR STREETS AND HIGHWAYS

Most of us are marginally aware that driveways, and how they intersect with our streets, are important to preserving capacity and safety. Large commercial driveways on our higher classified streets interrupt flow and increase congestion if not properly designed and constructed. Small driveways on our residential streets affect the safety of our local streets.

Access management which is being actively employed on state roads, and some local roads is certainly part of the solution, but proper design of the driveway such as slopes, grade breaks, angle of entry, sight distance, pedestrian safety, and lining up of opposing drives on each side of the street are also important to consider.



A new publication entitled "Guide for the Geometric Design of Driveways", which is NCHRP Report 659, has been recently published and is an excellent resource from which to establish review standards for driveway connections to our streets.

The report can be purchased or downloaded as a PDF at this link. http://www.trb.org/Publications/Blurbs/Guide_for_the_Geometric_Design_of_Driveways_163868.aspx

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By Nick Jones
Utah LTAP Director

Some excerpts from the report are shown which illustrate some of the useful guidance incorporated into the report. Insufficient driveway length is an issue that seems to come up in the more dense housing developments. Recommendations on reasonable length standards are discussed in detail in the publication.

Exhibit 5-50. Insufficient driveway length leads to vehicles blocking the sidewalk.

Another issue that can be seen in many locations are driveways with sidewalk cross slopes exceeding the 2% maximum. Sidewalk accessibility for many is seriously hindered.

Exhibit 5-62. Example of driveway grade creating unacceptable sidewalk cross slope.

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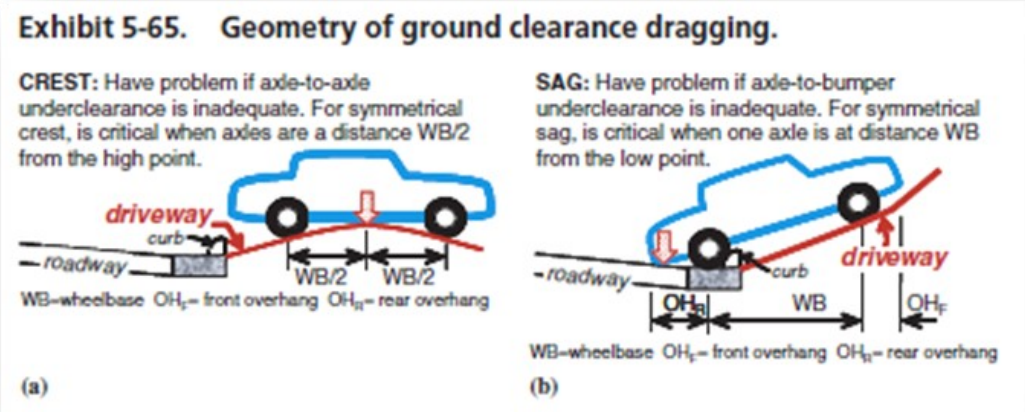
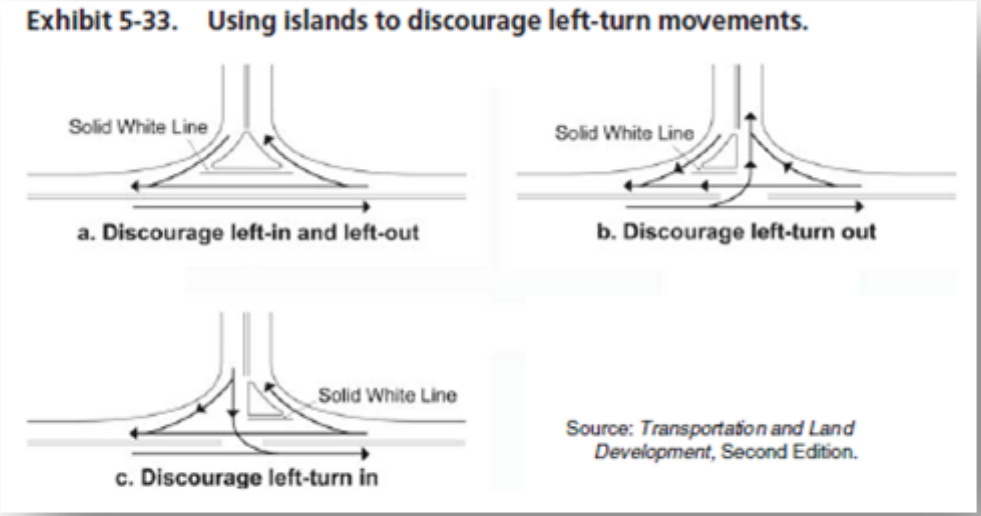
By Nick Jones
Utah LTAP Director

Many localities deal with maintaining drainage through driveways, especially in hillside areas, and providing reasonable slopes and transitions into garages.



Discouraging left turn movements in dangerous situations is often desirable especially for some shopping area accesses. Most localities deal with these issues frequently.



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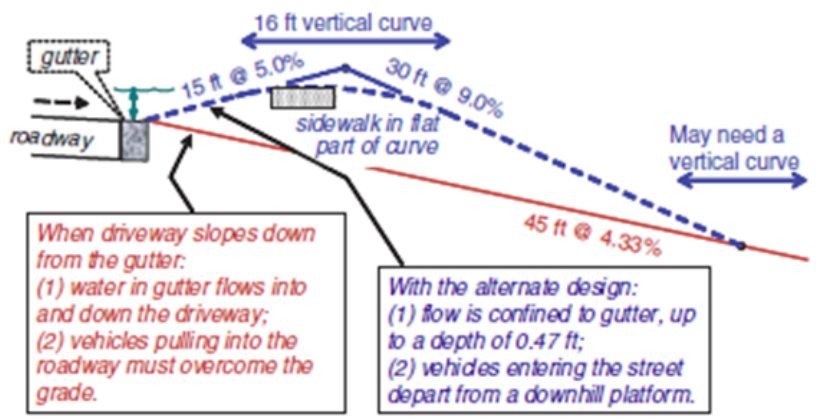
By Nick Jones
Utah LTAP Director

Protecting houses from flooding on the downhill side of the street is often a problem. Most cities and towns have dealt with flood damaged houses built by a developer that is now gone.

Exhibit 5-76. Example design for a downhill situation.



Site distance problems where driveways intersect the street should always be checked, to avoid drivers entering the street blind, which results in dangerous side impact collisions.

Exhibit 5-4. Placement of planter and utility pole limit the sight distance for a driveway exit.

Use this valuable Guide to increase safety, maintain capacity on streets, and protect the drivers and pedestrians in your jurisdictions. A significant amount of research and recommendations are incorporated into the guide and will be a very useful tool for local and state governments to preserve the functionality and safety of their transportation systems. For further information, please contact Nick Jones at nick.jones@usu.edu. For information regarding Utah LTAP Center, please click on this link: http://utahltap.org/

By Denis Stuhff
UDOT Hydraulics Section

NEW HYDROLOGY TOOL FOR MID-SIZED DRAINAGE BASINS AVAILABLE

The Hydraulics Section is pleased to announce the availability of yet another Research Report; Report No. UT-10.11 "Methods for Estimating the Magnitude and Frequency of Peak Flows for Small Watersheds in Utah". This useful new UTRAC study is the result of the efforts of the graduate student Aaron J. Timpson and his advisor Dr. Christine A. Pomeroy of the University of Utah.

Developing design flows for a highway project is one of the first hurdles that every highway Engineer or designer must tackle before they can size hydraulic structures such as bridges, culverts or open channels. Traveling throughout the State of Utah one is at once struck by the great diversity in physical and climatic characteristics. Just a few miles drive and one can move from an arid desert to a forested mountain valley. This very same diversity and complex mix of climatic types that makes living here so enjoyable as one travels our wonderful State presents a real challenge to designers and Engineers as they strive to develop appropriate design flow estimates for the many hydraulic structures needed to keep the roads and highways connecting Utah's communities, industries, ranches, farms and grazing areas and recreational venues fully functioning during storm events.

Report No. UT-10.11 provides the designer with a straightforward, and importantly a less data-intense way of estimating flow events for mid-sized drainage basins of less than 30 square miles. Data requirements are similar to those needed for the familiar "Rational Method" commonly used to estimate recurrence flood year discharges for drainage areas up to 300 acres or so. Larger catchment areas can be investigated with current USGS Regression equations and often have stream gagging records to aid the Engineer in developing design flows.

This research project helps close the gap between the small area and large area approaches. Based upon dominate hydrologic and climatic properties, the State was delineated along hydrologic unit code or "H.U.C." boundaries into seven differing Geo-Hydrologic regions.

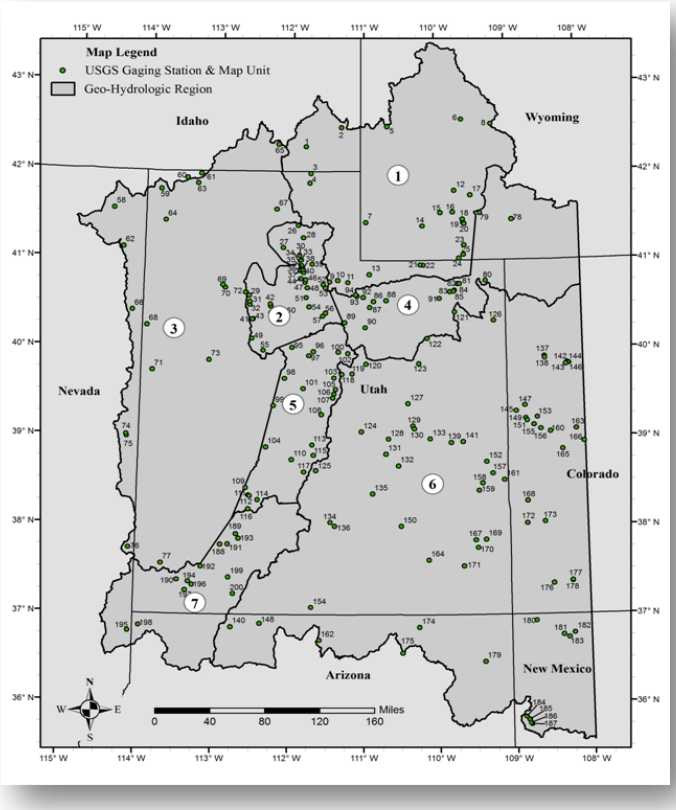


Figure.1: Geo-Hydrologic regions, as defined by Kenney et al, (2008), and USGS gaging stations for study region.

The East boundaries end at the 108th longitudinal line, where a change in soil and precipitation data was observed.

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By Denis Stuhff
UDOT Hydraulics Section

The runoff coefficient was regressed in each of these seven climatic regions of the State against drainage basin area, maximum flow distance, sinuosity, composite curve number, saturated hydraulic conductivity, and various catchment characteristics such as the basin centroid, the 2-year 24-hour precipitation, and basin centroid mean annual precipitation. Catchment areas used in the study ranged in size from 600 acres to 30 square miles with a selection caveat of having a minimum of 10 years of annual peak discharge data. Regression equations were then developed in the format of the familiar "Rational Method". The resulting equations permit the designer to estimate different recurrence flood year flows (i.e.10-, 25-, 50-, 100-, 500-year flow events). The Report nicely summarizes the protocol the user should follow to use these equations in practice. With the publication of "Methods for Estimating the Magnitude and Frequency of Peak Flows for Small Watersheds in Utah" a significant new tool is now available to the designer to allow a more rapid design of mid-sized drainage crossings.

For further information on this project, please contact Denis Stuhff at dstuhff@utah.gov

To see the full report, please click here and to see other useful hydraulics related information, please go to the hydraulics website at this link:http://www.udot.utah.gov/main//f?p=100:pg:0:::1:T,V:285,

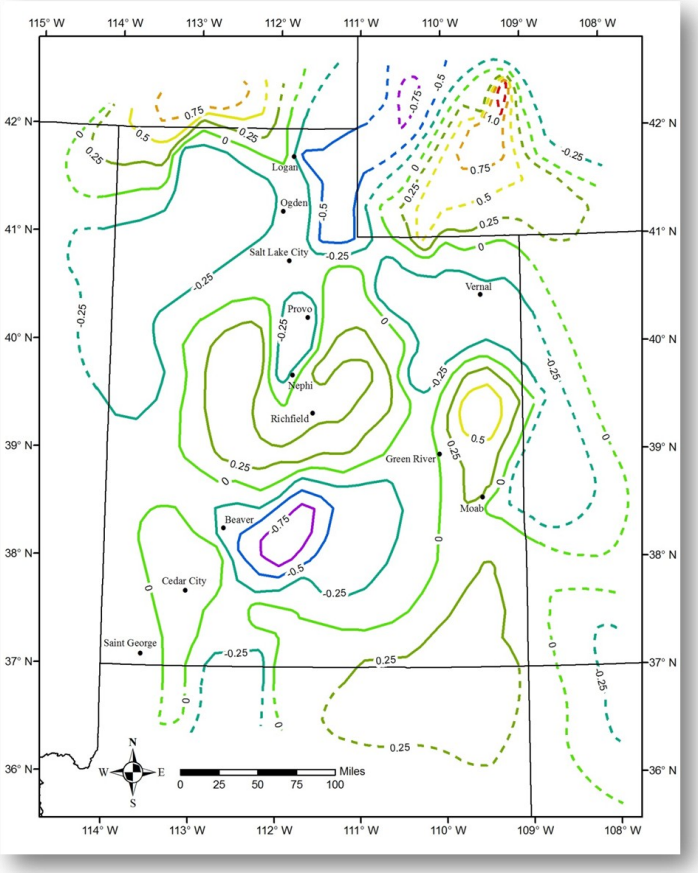

Figure 2: Generalized skew map for Utah showing contour lines of constant skew value for flood frequency analysis (modified from Perica and Stayner (2004) using a preliminary skew map detailing skew contour lines as shown above). Dashed lines show the approximated skew lines after modification.

Figure 3: Watershed delineation and for example problem located 25-miles north-east of Moab, UT.

By Chris P. Pantelides, Ph.D., S.E.
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UDOT Structures

HEALTH MONITORING OF PRECAST GFRP-REINFORCED BRIDGE DECK PANELS

UDOT has been researching methods and products to extend the lives of bridge decks in Utah to match the service life of the entire bridge. Currently Utah bridges are designed to a 75 year design life, but the decks are requiring replacement after 30 to 40 years. Deck replacement projects increase the life cycle cost of the structure as well as adding to user delays. UDOT decided to evaluate Glass Fiber Reinforced Polymer (GFRP) reinforcing bars as an alternative to steel rebar in bridge decks. However, there is no significant amount of research regarding precast concrete panels for bridge decks totally reinforced with GFRP bars.

GFRP reinforcing bars were used in place of traditional epoxy coated steel rebar in both mats of reinforcing in the deck of the Beaver Creek Bridge on US-6 in rural Utah. The bridge is a single span creek crossing with access for wildlife passage. The overall span length is 88 feet-2 inches. The girders are AASHTO Type IV prestressed beams. The deck was designed in accordance with the American Concrete Institute's ACI 440 Committee recommendations. The deck was constructed using precast deck panels mildly post-tensioned in the longitudinal direction. The bridge was constructed in two phases; this required a closure pour between the Eastbound and Westbound lanes. The authors believe that this may be the largest bridge utilizing GFRP bars in precast deck panels.

The research project has three major phases: pre-construction, a truck load test, and post-construction long-term monitoring. Two GFRP reinforced precast concrete panels were monitored during construction, lifting, and placement using electrical strain gauges. In addition, the two panels are being monitored during post-tensioning, truck load testing, and long-term using vibrating wire strain gauges. The bridge deck deflections relative to the two diaphragms connecting the prestressed concrete girders were monitored using linear variable differential transformers. Finally, the absolute deflection of the girders at midspan during a static truck load test and the dynamic performance of the girders during a dynamic truck load test were monitored using surveys and accelerometers.

The design of the deck panels was controlled by crack width and deflection. The low modulus of elasticity of GFRP bars leads to wider crack widths than with traditional steel reinforcing. The acceptable crack width tolerances can be relaxed some with GFRP bars due to their non-corrosive nature, but this does not completely counteract the wider crack widths, which can lead to loss of aggregate interlock and reduction in shear friction capacity. GFRP reinforcement also exhibits higher deflections than steel. Due to these design limitations, several adjustments had to be made to the structural design. The first adjustment was to the bar spacing. In the transverse direction the spacing was reduced from 8in. down to 4in. It was not practical to reduce the spacing any further, so alternative methods for decreasing crack width and deflection had to be used. A balance between thickening the deck and decreasing girder spacing was used. The deck was increased from the standard 8½ in. thickness, up to 9¼ in. The girder spacing was decreased from 9ft-4in. down to 7ft-7in., increasing the number of girders by three. In order to reduce construction time and user impacts, this bridge was constructed using 24 precast deck panels with mild longitudinal post-tensioning.

During the summer of 2009, construction began on the Beaver Creek Bridge, located on US-6. The pre-construction phase focused on instrumentation and monitoring of two precast concrete deck panels; two panels were chosen for instrumentation. Monitoring included the initial lift from the formwork, a lift from the precast yard to the back of the truck, transit of the panel, a second lift placing the panel on the bridge, as shown in Figure 1, and post tensioning.

(Continued on page 15)

By Chris P. Pantelides, Ph.D., S.E.
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Rebecca Nix, S.E.
UDOT Structures

Figure 1. Lifting points of GFRP reinforced precast concrete panels at bridge site.

Each panel was instrumented with 28 electrical strain gauges, to be used during the lifting and transport of the panel. These gauges were attached to both the top and bottom GFRP mats. Of the 28 electrical strain gauges 20 were placed in the transverse direction of the bridge (longitudinal direction of the panel) to record strains in the long direction of the panel during lifting. The remaining 8 gauges were placed in the longitudinal direction to record strains in the short direction.

The two panels were each instrumented with four vibrating wire strain gauges (VWSG) placed in the longitudinal direction of the bridge. These gauges were used to record strains induced by post tensioning as well as the change in strain due to creep and shrinkage and for long-term monitoring. In addition to the 4 longitudinal VWSGs, one panel was equipped with an additional 16 VWSGs placed in the transverse direction of the bridge. These gauges were primarily used during the truck load test and for long-term monitoring. Figure 2 shows both the electrical and VWSGs.

Figure 2. Electrical and vibrating wire strain gauge installation in one of the GFRP reinforced panels.

(Continued on page 16)

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The relative deflection from the bottom of the bridge deck to the top of the steel diaphragms that join the prestressed girders was measured using Linear Variable Differential Transducers (LVDTs). The bridge was instrumented with six LVDTs that were placed above the east and west diaphragm between girders 1 and 6; LVDT 6 was placed between girder 2 and 3 above the east diaphragm, at approximately ⅓ of the bridge span. Six single-axis accelerometers were attached at the midspan of each girder to measure vertical acceleration of the girders.

All instrumentation data was collected by an electronic data acquisition system at an appropriate sampling rate appropriate for each instrument and test. The monitoring of the lifting of the precast panels was achieved wirelessly using a modem. During the truck load test the data was also recorded using a modem. For the long-term monitoring the modem is connected with a cell phone and is continuously sending data through a secure cell phone connection to the University of Utah.

A truck load test was carried out at the bridge in September of 2009, which included both static and dynamic tests. Based on the measurements carried out during lifting, placement, as well as static and dynamic truck load tests, the following observations are made:

(1) The GFRP bars withstood normal handling at the precast yard and placement without any major problems. In addition, the light weight of the bars made them easy to carry and easier to place. The precast panels were also lighter and easier to transport to the bridge.

(2) The panels were lifted at the precast yard and transported to the bridge using straps, employing a four-point lift using two different lifting configurations, one at the precast yard and one at the bridge. From strain measurements it was found that that the ACI 440 flexural design method is very conservative. In addition, no cracks larger than hairline cracks were observed during lifting.

(3) Extra GFRP bars were used at the shear keyways to reinforce the general area around the post-tensioning anchors. However, the GFRP bars could not provide adequate shear strength for the anchorage and some steel bars were placed on the end panels for anchorage of the post-tensioning.

(4) The relative deflections between the bridge deck and the west diaphragm were measured during the static tests; the magnitude of the relative deflections was found to be very small and shows that the bridge deck and the girders have good composite action.

(5) The live load deflection of the prestressed girders during the static truck load tests was found to be significantly smaller than the allowable deflection specified in the AASHTO Specifications.

(6) Accelerations measured at the midspan of the prestressed girders showed that the maximum vertical acceleration recorded during the tests was acceptable. The results from the other dynamic truck load tests were reasonable both with respect to magnitude and with respect to location of the maximum accelerations observed.

(7) From the tests carried out for the precast concrete bridge deck panels reinforced with GFRP bars it is clear that this is a viable construction method.

The bridge was opened to traffic on October 2, 2009. Long-term monitoring of the bridge is continuing and a second static and dynamic truck load test series is planned for the future.

For further information on this project, please contact Rebecca Nix at rnix@utah.gov or Chris Pantelides at chris@civil.utah.edu.

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LESSONS LEARNED FROM AN I-15 PRECAST CONCRETE PAVEMENT PROJECT IN REGION ONE

In the September 2009 edition of the Research Newsletter, Ken Berg (now in UDOT Central Maintenance) highlighted a concrete pavement rehabilitation project along I-15 near Clearfield and Layton, Utah, that utilized a proprietary Precast Concrete Pavement System for replacement of several damaged slabs. B. Jackson Construction & Engineering, Inc. was the project contractor and used the Fort-Miller Super-Slab® system, supplied by Mountain West Precast. This was the first full-scale precast pavement project for UDOT and was completed in 2009. The Research Division worked with Scott Nussbaum, Region Materials Engineer, and PJ Roubinet, Field Engineer, of Region One to document and report on the construction process and to capture lessons learned from the project that would benefit future projects. These items have been compiled into an experimental feature report by the Research Division that will be posted online on the UDOT Product Evaluation Database.

Lowering a slab into place on the Clearfield/Layton I-15 pavement rehabilitation project in 2009

The following are lessons that UDOT learned from the project that could be applied to future projects with precast slab repair:

(1) For bidding purposes, it is very important to carefully identify all of the locations. Middle lanes require very accurate width verification. Lanes on the edge may require base or shoulder repair.

(2) Whether the precast slabs are placed together or individually have a dramatic effect on installation costs.

(3) There needs to be sufficient time between finalizing the detail and the installation to allow for casting and curing of the slabs.

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(4) To gain the benefits of longevity with the precast concrete, wet curing requirements should be tightened up. The standard at the time of the project required wet cure of 14 days.

(5) UDOT's generic option needs additional design work, drawings, and details to reduce risk in bidding. Included should be casting tolerances, requirements for dowel bar caps, reinforcing steel, joint tolerances, details on how to deal with tie bars and offset transverse joints, bedding grout, and encasement grout.

(6) Asphalt patching requirements should be included in project documents.

(7) Finishing requirements (i.e., a broom finish) should be included in project documents.

(8) Minimum length of slabs to be allowed to remain in place should be clarified.

(9) Additional slab removal instruction should be given (i.e., UDOT Standard Drawing PV 4 for "Concrete Pavement Details for Urban and Interstate").

(10) Vertical placement tolerances should be increased to allow for a little bit of settlement. On the project some slabs ended up below the grinding plane.

(11) The bedding grout is essential to slab stabilization. On the project traffic caused even the shimmed slabs to squirm and settle a little bit if the grout had not been installed.

(12) Acceptance testing should be included and encasement grout strength verified.

(13) Tie bars, No. 5 bars at longitudinal joints, were a construction complication. Drilling increased work exposure to traffic and was a time-consuming part of the process. The need for and benefit from these tie bars should be re-evaluated.

Additional information on the project can be obtained from Scott Nussbaum at snussbaum@utah.gov, Barry Sharp of Central Materials at rsharp@utah.gov, or David Stevens of Research at davidstevens@utah.gov .

Completed UDOT Research

Research publications are valuable resources, documenting the results of important research projects. For a list of recently completed Research Projects, please visit the Research Division website at: http://www2.udot.utah.gov/index.php?m=c&tid=235. If you would like to obtain an electronic copy or a printed copy of our completed research reports, please contact awakil@utah.gov or jdemille@utah.gov.

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- You would like to learn more about how a new product performs on the road.
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- You are introduced to a promising technology and do not have time and funding to test it.
- You require any technology transfer information or any experimental feature tested.
- You have a problem to be researched and solved.
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