January 2011

RESEARCH
ENGINEERING THE FUTURE

Welcome to the Utah Department of Transportation (UDOT) Research Division Newsletter

A MESSAGE FROM THE DIRECTOR OF RESEARCH

By: Cameron Kergaye, PhD, PMP, PE

As we begin the new year, I'd like to share one of my objectives for 2011: improving the coordination of research with our partners. Since the identification of valuable research requires matching needs with resources, it's important to develop a cooperative relationship between UDOT professionals and our research community.

Valuable research answers UDOT's transportation questions and provides implementable solutions. The challenge is in asking the right questions and working with the right research talent. In an ideal exchange of research topics, UDOT subject experts would be aware of the specific skills and related knowledge within our research community, and those in our research community would be familiar with UDOT's transportation goals and areas for technical improvement.

The UTRAC Workshop has been one of our successful forums for matching needs to resources. And while we prepare to hold the UTRAC Workshop this spring, I encourage UDOT professionals and those in the research community to jointly develop problem statements. Similar to the results of the NCHRP solicitation process, selected UTRAC problem statements usually demonstrate a close cooperation between UDOT and university or consultant subject matter experts.

This year the Research Division will strive to bring our research partners into closer association with UDOT's many knowledgeable subject experts. Whether the motivation is to develop a UTRAC or NCHRP problem statement, an AASHTO or TRB proposal, a Transportation Pooled Fund study, or other endeavor that enhances UDOT's transportation system using local research resources, the first step towards identifying valuable research relies on good communication between interested parties.

I have recently met with professors and graduate students in each of Utah's premier research-oriented universities to discuss this initiative and have begun similar measures within UDOT. My aim is to foster a cooperative dialog between UDOT professionals and our research partners with the expectation that such a collaborative relationship will produce the most valuable research. I welcome your suggestions to make this a successful year.

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By: Blaine D. Leonard, P.E., F.ASCE
UDOT Research Division

THE NEW YEAR BRINGS NEW RESEARCH IDEAS

The UTRAC Workshop is the event where we gather together to discuss the research needs of UDOT, and decide which ones are the highest priority. UTRAC is the acronym for Utah Transportation Research Advisory Committee. This year's workshop is scheduled for Thursday, April 7, and will once again be held at the SLCC Larry Miller Campus near 90th South in Sandy, Utah. Put it on your calendar and begin to make plans!

The one-day UTRAC Workshop will provide an opportunity for people from UDOT, FHWA, the Universities, consulting firms, contractors, and vendors to gather and discuss research ideas and needs. In addition to discussing research efforts, we will also be able to have general discussions about the many initiatives and projects that UDOT is undertaking. As usual, the participants will gather in small discipline-specific groups to assess our progress and map out directions for new research. These groups will include Structures, Geotechnical, Maintenance, Traffic Safety/Management, and Construction/Materials. Other groups will be considered in the future UTRAC workshops.
The highest priority Problem Statements selected by each of these groups will be considered for funding by the Research Division.

Due to funding constraints and the large number of on-going research projects, we didn't hold the UTRAC Workshop in 2010, so there should be plenty of creative ideas and issues to discuss this year. At the 2009 UTRAC Workshop, Dr. Rollin Hotchkiss, of Brigham Young University, emphasized the role of research to save lives, conserve financial resources, and help the environment. He highlighted work on hydraulic characteristics of culverts and the ability of certain fish species to pass upstream through these structures. The presentation emphasized the necessity for cooperation among researchers, agencies and others involved in the design and construction process to improve the work we do. The UTRAC Workshop is exactly such a forum, where ideas can be shared, challenges discussed, solutions envisioned, and relationships built which help move UDOT and other transportation agencies forward.

At the 2009 UTRAC Workshop, 144 individuals evaluated 68 unique research problem statements, and selected 42 of them as priorities. Of these, the Research Division was able to fund 13 projects, with a total contract value of about $600,000. Most of these projects are funded with federal "State Planning and Research (SPR)" dollars allocated to the Department each year, and matched with state dollars.

Problem Statements are prepared and submitted in advance of the UTRAC Workshop, with a deadline of March 21. This is a rigid deadline; no problem statements will be accepted after that date. Statements can be submitted through the leader of the discipline group or directly to the Research Division. Problem Statement forms, a list of the group leaders, and other pertinent information will soon be provided on the Research web site under the UTRAC "2011 Workshop" topic.

For more information about attending or participating in the workshop, review the information on our web site, or contact David Stevens (801-965-4377, davidstevens@utah.gov). We look forward to sharing innovative ideas and developing creative solutions with you in April at the UTRAC Workshop. See you there.

By: Travis Gerber, Ph.D., P.E.,
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David Stevens, P.E.,
UDOT Research Division

ASSESSING CORROSION OF MSE WALL REINFORCEMENT

Mechanically stabilized earth (MSE) walls are now widespread in UDOT's retaining wall inventory. MSE walls like the one shown in Figure 1 rely on internal reinforcement buried inside the retained soil mass to provide stability. Many of UDOT's MSE walls were constructed during the I-15 Corridor Reconstruction Project through Salt Lake County prior to the 2002 Winter Olympics. Motivated by the convergence of several potential issues regarding MSE walls, UDOT has sponsored several MSE wall-related research projects in recent years. As part of these efforts, UDOT's MSE wall inventory was defined, most of the walls were visited and visually inspected, and a GIS-based database was created. This work together with analytical modeling, field observations, and input from a panel of experts has increased UDOT's understanding of potentially adverse performance and its causal mechanisms, and is leading to improved design and construction of UDOT MSE walls.

Figure 1. An MSE wall along US-89 in Davis County

The recent inspection work documented current MSE wall conditions. Unfortunately, one parameter that could not readily be assessed at that time was the condition of the metallic reinforcement buried inside many of the MSE walls. Since corrosion can significantly affect the long-term serviceability of MSE walls, it is important to quantify the extent to which detrimental corrosion may be occurring in the reinforcement. This aspect of MSE wall performance was the subject of a research project recently completed by Brigham Young University (BYU) for UDOT. The primary objective of this project was to extract buried metallic reinforcement coupons from select MSE walls and document the extent of corrosion. These coupons had been installed for this purpose along with the regular horizontal reinforcement elements in the wall backfill during construction. A secondary objective of this project was to develop and assess techniques for removal of coupons on two-stage MSE walls.

To realize the objectives of this project, existing information was collected regarding the coupon installations and included reviews of UDOT and engineering consultant project files. Next, a procedure for coupon extraction was developed and a manually operable jacking device was designed and fabricated. After some preliminary testing of the device, the project then entered a production phase and twenty-two wire coupons were extracted from the walls. Afterward, the conditions of the coupons were quantified through laboratory testing and analysis. A one-stage MSE wall, the coupon jacking device, and an extracted coupon are shown in Figure 2.

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The twenty-two wire coupons that were extracted had been buried for approximately 11 to 12 years. Based on field observations, the galvanization on the coupons generally appeared to be intact but exhibited a variable amount of white oxidation product. In some places the galvanization appeared to have flaked or spalled from the underlying steel. A minor amount of localized steel corrosion was observed on several specimens. There was no readily observable evidence of excessive corrosion of the vertical welded wire mesh facing of the two-stage MSE walls, as observed through the small coupon access holes in the wall panels. An example of the more severe corrosion that was observed on the extracted coupons is shown in Figure 3.

Figure 2. An extracted coupon at a one-stage MSE wall

Based on laboratory acid-stripping tests, the average thickness of the galvanization on all of the extracted coupons currently exceeds the minimum value specified for the time of installation. There was also no readily discernable trend in corrosion conditions along the length of the coupons. Unfortunately, because the initial conditions of the coupons could not be determined, a reliable corrosion rate could not be determined using the direct measurement methods employed in this study. However, the data collected regarding current conditions can be used as baseline information going forward to compute corrosion rates when additional coupons are extracted in the future. This data will help UDOT in the assessment of the risk of adverse MSE wall performance. One additional finding from the project was that during the extraction process, there was a significant difference in the coupon pullout resistance between one-stage and two-stage MSE walls (with the former being about 4 to 5 times the latter). Current MSE wall design procedures do not suggest that there should be such a difference, and it was recommended by the research team that this behavior and its implications for design and performance should be investigated further.

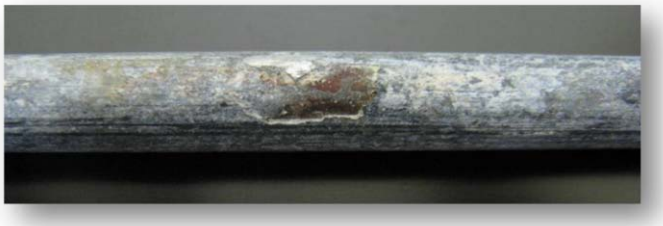

Figure 3. Close-up of an extracted coupon

The final report for this project is available for download at the Research Division website. For more information on this study, contact Dr. Travis Gerber (tgerber@byu.edu) of BYU, Grant Gummow (ggummow@utah.gov) of the UDOT Geotechnical Section, or David Stevens (davidstevens@utah.gov) of the Research Division.

By: Elizabeth Giraud
Architectural Historian
UDOT Environmental Division

POST-WAR HISTORIC BRIDGE SURVEY COMPLETED!

Avid readers of the UDOT Research newsletter might remember that last year at this time I wrote an article announcing the beginning of UDOT's historic bridge survey. UDOT hired the national consulting firm of Mead & Hunt, based in Madison, Wisconsin, at the end of 2009. The bridge survey is necessary to guide UDOT's environmental staff and consultants in determining whether a bridge is eligible for listing on the National Register of Historic Places, a required step in the agency's efforts to comply with state and federal environmental laws.

People often wonder what makes a bridge, or any historic building or site, eligible for the National Register. First, a "property," as a bridge or building is known, must generally be 50 years old, although UDOT uses 45 years as a cut-off date in order to accommodate the length of time between the completion of environmental documents and the beginning of construction. Second, a property must have historical integrity, meaning that the features that render it historically significant are still intact and visible. "Historical" integrity should not be confused with "functional" or "structural" integrity. And third, a property must be significant for its association with historic trends, important events or people, or noteworthy for its construction or design.

Significance is established by preparing a context that isolates trends or events that directly impacted the construction of a particular property, in this case Utah's bridges. Briefly stated, a historic context provides the "big picture." Owing to funding constraints, Mead & Hunt prepared a context and provided a list of alterations that would render a bridge ineligible only for post-war bridges constructed between 1947 and 1965. For pre-war bridges, the consultants relied upon a previous survey prepared in 1990, and did not prepare a list of alterations that might affect eligibility, relying instead only on the age of the bridge and the existing historic integrity.

Figure 1 shows Cart Creek Bridge (OC 372) which was built along SR-191 in 1962 as part of a federal-aid program of highway work intended to create better access to Flaming Gorge dam. The bridge is eligible for its monumental size and outstanding aesthetic treatment, and because it was a type rarely used in the state. It is Utah's longest single-span bridge in the study period (1947-1965).

The difference between the numbers of post-war bridges determined eligible when evaluated within a context and the pre-war bridges is startling.

Figure 1. Cart Creek Bridge (OC 372)

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Out of 409 post-war bridges, the consultants determined that only 32 are eligible for the National Register. Compare this number to the pre-war bridges, of which 164 out of 221 are considered eligible. For this reason, the Environmental staff is pursuing additional funding to hire Mead & Hunt to prepare a context and criteria evaluations for the pre-war bridges. We anticipate that once these documents are completed, far fewer will be eligible for the National Register. Ultimately, the UDOT Central Environmental staff intends to prepare a Programmatic Agreement with the Utah State Historic Preservation Office that will streamline the environmental process for bridges.

Figure 2 shows a bridge (C 371 2) which was constructed in 1964 over the Kennecott Railroad spur. This steel stringer bridge is eligible for the National Register for its association with the transport and processing of ore, and because its exceptional skew (more than 54 degrees) demonstrates an engineering solution to accommodate a particular site challenge.

Figure 2. Bridge "C 371 2" over the Kennecott Railroad spur

Within a few weeks, the bridge survey will be posted on the UDOT Environmental web site. Take a minute to review the survey and learn more about the history of bridge construction in Utah. We may not have as many bridges as other states because of our dry climate, but our bridges present a unique perspective through which to understand Utah's history, and we have our share of spectacular examples.

For more information regarding this project, please contact Elizabeth Giraud at egiraud@utah.gov.

By: Grant G. Schultz, Ph.D., P.E., PTOE, FITE
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Jeremy E. Searle, E.I.T.
Brigham Young University
John Thomas, P.E.
UDOT Systems Planning and Programming

ECONOMICS OF TRANSPORTATION PROJECTS IN UTAH

Understanding how transportation can affect the economy is a challenging but useful tool. The United States has experienced several economically challenging years recently. To better comprehend this relationship, UDOT partnered with BYU to research this topic. Their study produced several interesting results.

Transportation projects influence the economy in a variety of ways. Understanding the economic impacts of transportation projects in Utah is essential for decision makers, officials, and stakeholders as they determine what the best course of action is for Utah. Economic impacts can guide decisions of future projects and help explain past economic fluctuations. It is important to have a process that can be used to identify the economic impacts of transportation projects, and further refine that process to increase the understanding of economic impacts of transportation projects in Utah.

The study examined many of the projects that occurred over the last 10 years. For each project, sales tax, employment, and vehicle miles travelled (VMT) data around the project location were collected. The data covered the four years previous to construction and two to four years after construction was completed.

The results of data analysis were widely variable, and the following discussion and graphs represent one example that represents what the research team might have expected from the data. However, specific conclusions should not be made from this information since data sources need to be improved before UDOT can provide decision makers with this type of information.

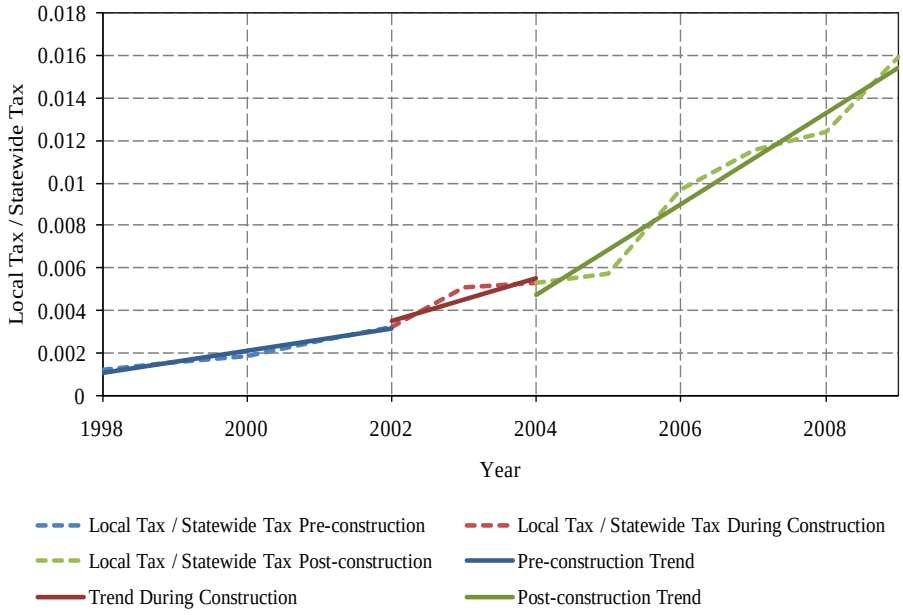

Figure 1: Sales tax / statewide tax around reconstruction project on Redwood Road.

To account for variability in the economy it was necessary to use a comparison location, in this case the state. All of the local data were normalized (divided by) the total state data to obtain a ratio of the local to the state. This was used to look at trends over time. If the trend was positive, then the local area was growing faster than the state overall (or declining slower than the state). If the trend was flat, the local area and the state were growing at the same rate. If the trend was negative, the local area was growing more slowly than the state overall. An example of this analysis is shown in Figure 1.

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Note that the trend in Figure 1 is positive before construction – so the area was growing faster than the state, but after the project was completed, the area was growing much faster than the state as a whole.

A similar analysis was completed for employment and VMT around each of the projects. Figure 2 shows the employment analysis around the same reconstruction project on Redwood Road. The figure shows that before construction, the local area was growing slower than the state in terms of employment. However, after the construction was completed, employment growth was approximately the same as the state. This represents an increase in the post-construction trend. Results for VMT were similar.

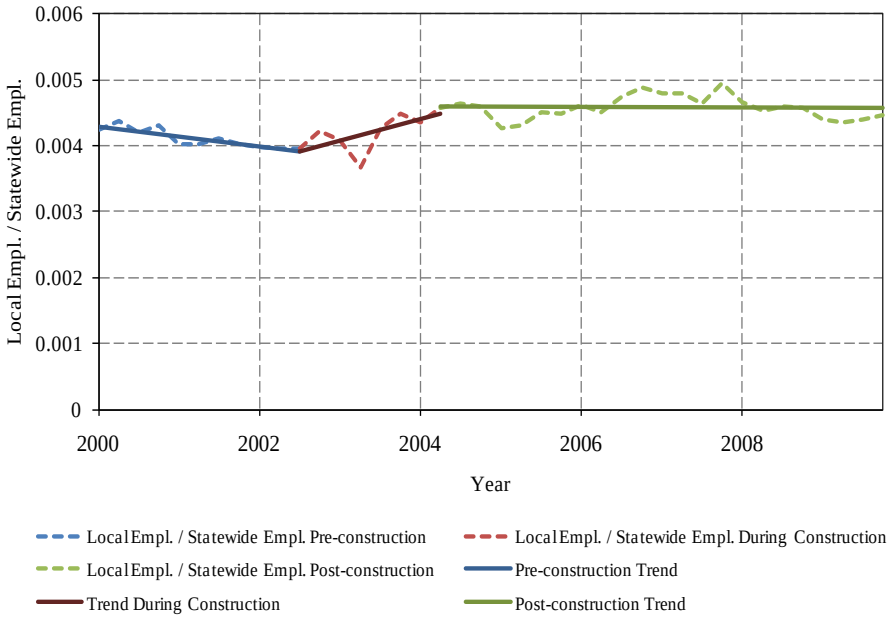

Figure 2: Employment / statewide employment around reconstruction project on Redwood Road.

A statistical analysis of the results for each of these analyses was completed to determine if the post-construction trend was greater than the pre-construction trend. A paired *t*-test was used to complete the statistical analysis. The statistical analysis showed that for both sales tax and employment there was a difference between the pre- and post-construction trends.

The results of this study indicate that there is a positive relationship between transportation improvement projects and sales tax revenues when comparing the trends before and after construction. Employment also showed a positive relationship with transportation improvement projects. The VMT analysis showed that VMT around transportation improvement projects is also positive, wherein the VMT grows at approximately the same rate as the state. The results of the analysis are limited by the availability of complete data and include a wide range of variability. As such, it is recommended that a more complete data set be developed, and that further analysis be completed to better quantify these relationships. Useful data sets that could be better developed for possible use in further analysis might include sales tax revenues at individual businesses, employment figures disaggregated to the business, VMT or related measures such as average daily traffic, and UDOT project locations and descriptions in a geospatial format. As further analysis with more complete data is done, the exact nature of these relationships can be refined and quantified.

For further information regarding this research project, please contact Grant Schultz of BYU at: gschultz@byu.edu or John Thomas of the UDOT Planning Division at: johnthomas@utah.gov.

By: Ryan Richins, P.E.,
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CONSTRUCTION MACHINE CONTROL GUIDANCE IMPLEMENTATION

Machine Controlled Guidance (MCG) technology generally utilizes a Global Positioning System (GPS) and a three-dimensional computer model of the road design to guide equipment used to place, level, and compact materials for road construction. MCG technology has been developed to improve construction efficiencies, resulting in reduced cost and accelerated schedule. This new technology is enabling contractors to reduce the amount of construction surveying (and associated errors), as well as to improve construction quality and reduce design errors to provide smoother, more consistent finished surfaces. Use of GPS to guide earth moving equipment such as dozers, graders, scrapers, and excavators is quickly becoming common place in private sector and DOT construction because of its ability to speed project delivery and cut costs. Horrocks Engineers recently completed a research study on this topic for UDOT.

MCG technology offers significant benefits, but it does require some additional costs, special provisions and a 3-D model. For this reason, it is important to determine during the scoping and design phase whether time and money are available. In addition to budget and schedule constraints, the following characteristics should be considered in determining whether MCG would be beneficial and practical:

- New roadway construction
- Total roadway reconstruction
- Significant changes to the terrain surface
- Large cut/fill slopes

Careful consideration should be given when evaluating the potential use of MCG on widening, extremely flat grades, and flat pipe installations, due to the vertical limitations of GPS technology. A robotic total station may be used instead of GPS when tighter vertical tolerances are required; however, there are also limitations with the use of robotic total stations, such as horizontal distances and sight distances.

There are some risks and issues that should be evaluated when implementing MCG on a project. The risks include vertical accuracy requirements (GPS has the potential to introduce errors in vertical accuracy), liability issues (potential discrepancies between 3-D model and project plans), and construction inspection and documentation requirements. UDOT will need to develop policies and procedures identifying areas of responsibility between the contractor and owner.

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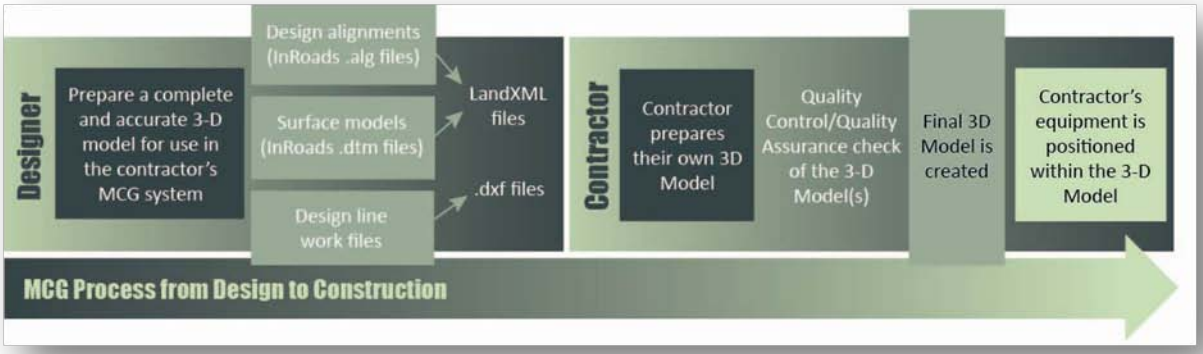
When utilizing MCG technology the designer(s) should prepare a complete and accurate 3-D model for use in the contractor's MCG system. These 3-D models are then provided to the contractor to be used for information and comparison as they prepare their own 3-D model. The design alignments (InRoads .alg files) and surface models (InRoads .dtm files) are provided as LandXML files, while the design line work files are provided as .dxf files. The models may be checked against each other to ensure accuracy. Ultimately the contractor is responsible for the 3-D model(s) used for MCG on the project. A full quality control and quality assurance check of the 3-D model(s) must be performed by the contractor.

The contractor's equipment, utilizing an on-board computer, can then be positioned within the 3-D model by registering its X, Y, and Z coordinates for the machine to the local coordinates of the model.



Several recommendations regarding implementation of the MCG process were given by Horrocks Engineers. Before this technology can be fully implemented, UDOT will need to complete the rewrite of the 01721 specification, develop the documentation requirements, and train project inspectors in MCG. The specification rewrite should also address tolerance requirements for construction survey control and construction staking. The tolerances should be realistic, achievable, and enforceable. The contracting community will need to continue to be highly involved in these activities.

Standards and criteria also need to be created and adhered to for establishing survey control during the pre-construction phase. The survey control established during this phase should meet the same tolerance requirements as those required during the construction phase. Creating these standards will help to resolve the current survey control issues that are present on many projects to date.

The following individuals helped with this research project along with the authors of this article: Michael Fazio (UDOT Research Division), Kris Peterson (UDOT Construction and Materials), Craig Hancock (UDOT ETS), Scott Thayn (Geneva Rock), Greg Olson (Horrocks Engineers), Lonnie Olson (Horrocks Engineers), and Scott Bishop (Horrocks Engineers).

For further information on this research, please contact Ryan Richins at: RyanR@horrocks.com or Michael Fazio at: mfazio@utah.gov.

By: Abdul Wakil, P.E.
UDOT Research Division

TECHNOLOGY TRANSFER CORNER

Timely Distribution of Research

There is a range of reasons why UDOT practitioners choose to conduct research projects. They may wish to use research to solve problems, or advance and evaluate current practice for individuals or services. However, despite the opportunities presented by research, there are key challenges associated with marketing, or the sharing and dissemination, of research findings within and between organizations.

UDOT research staff work together with research end users/champions in UDOT, universities, and consultants to address these challenges. All parties should encourage article publication, newsletters, final presentations on the findings of the research and implementation of recommendations. A pro-active research approach is key to boosting the likelihood of findings being implemented, and such steps would also enable others at UDOT to become more research aware.

Dissemination of research information needs to be considered timely at the earliest stage of research project planning, with strong links between departments or organizations to support implementation. Academics working on UDOT research projects can provide support for end users to interpret findings and consider how to implement any changes to practice.

Pro-active research stands a greater chance of being implemented because it is being carried out in line with local needs and issues, encourages full involvement of staff and permits change throughout the process of project work.

Effective dissemination can support staff to share information about developments in research practice, and help services adopt and implement innovation. In addition, dissemination is a key process in evidence-based practice, enabling research staff to make decisions based on quality information regarding the effectiveness, and cost-effectiveness.

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:

www.udot.utah.gov/go/research

If you would like to obtain an electronic copy or a printed copy of our completed research reports, please contact awakil@utah.gov.

Need a Literature Search?

The UDOT Research Division and Lester Wire Library provide an important service through literature searches. These searches help identify published information about a topic of interest. To request a literature search, provide a brief description and some key words and submit it to awakil@utah.gov.

This is a quarterly publication that provides highlights of the Research Division's activities. We hope you find our newsletter informative and we look forward to your input.
Wishing all of you a peaceful and prosperous 2011.

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