Oregon Department of Transportation

Research Leader

Fall 2008

In This Issue:

Innovations in Public Work Zones

Workers on the US 101 - Youngs Bay bridge project

Highway construction projects, undertaken by the Oregon Department of Transportation (ODOT), commonly involve the control of traffic through work zones. To ensure safe travel through construction work zones, Traffic Control Plans (TCPs) are developed to communicate required traffic control measures to the construction team. The quality of the design and implementation of TCPs impacts the safety hazards experienced by motorists and workers in the work zone. Research is needed to identify how to effectively design, review, implement, and inspect TCPs in order to minimize work zone safety hazards, help prevent worker and motorist injuries and fatalities, and optimize mobility throughout the state's highway transportation system.

ODOT entered into a contract with the School of Civil and Construction Engineering at Oregon State University (OSU) to study the development and implementation of TCPs and develop guidelines for their optimal implementation in practice. The first interim report for the study, dated April 2008, provided a summary of initial study activities undertaken to document and review previous research, regulatory requirements, current industry practice, and available resources. The report provided recommendations and proposed research methods to be undertaken for the subsequent research activities.

This study will include a survey of ODOT personnel and consultants regarding TCPs, and investigation of individual case studies for in-depth analysis. Technical oversight for the project is provided by the ODOT Technical Advisory Committee (TAC), who provides feedback and project guidance. The data collection phase of this study is due to be finished in December 2008, with the data analysis and final report due in the first and second quarter of 2009, respectively. With the cooperation of ODOT Maintenance teams around the state, informal site reviews have started.

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Principal Investigator:

John Gambatese

Project Schedule:

Currently a survey and data gathering effort is being performed. Thirty-nine projects have been identified to be included as individual case studies across Oregon. The study is expected to have a majority of that information collected by December 2008. Analysis, results and guidelines for implementation of the results is scheduled to end in June 2009. The final report will be generated from June to September 2009.

Newest Appointment

Recently ODOT Research gained a new full-time member: Lyn Cornell. Lyn replaces Vincent Van Der Hyde as the office's newest Research Coordinator. She will coordinate multimodal transportation projects.

Lyn Cornell

Lyn is a California native and moved to Oregon several years ago. Before coming to Research, Lyn worked with ODOT Region 2 as a Local Program Coordinator for federally funded projects. Lyn also has over 20 years of engineering experience through California DOT, where she was an Engineering Technician. Something you may not know, is that she loves green technology. Lyn lives in a solar powered house that she helped build with mostly sustainable and recyclable materials, and is one of more than 20 homes she has helped design and construct over the years. She is looking forward to working on a number of other green technology projects in the future.

Lyn's duties while with the Research Unit will include:

-Coordinating the development of contracts and agreements with outside organizations to conduct research projects focused on multimodal and intermodal transportation.

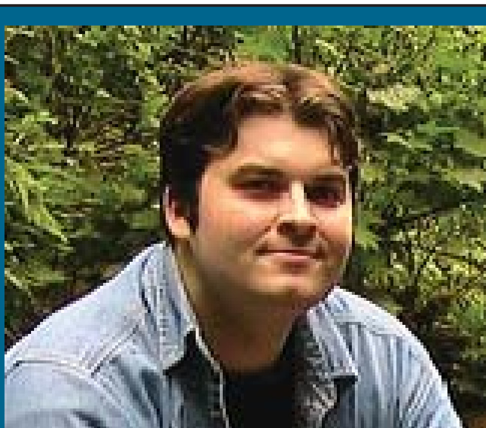
-Leading the Expert Task Group (ETG) on multimodal transportation.

-Monitoring the progress and reviewing the ongoing research being performed with contracted agencies specifically working on multimodal projects.

-Independently working to develop and carry to completion a variety of research projects.

You can reach Lyn at 503-986-2853 or via email: Linda.S.Cornell@odot.state.or.us

Resignations



In November, 2008, Christopher Thomas resigned from the Research Unit. Chris was the office's General Research Specialist. He will be greatly missed.

DO YOU HAVE RESEARCH PROJECT IDEAS?

Tell us about them and let us help you

We are located at:

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Listening to Bridges

Reinforced concrete (RC) bridges generally operate at service-level loads except during discrete overload events that can reduce the integrity of the structure by initiating concrete cracks, widening or extending existing cracks, as well as reinforcing steel slip or yielding. Identification of previous damage and predicting the possible impact on future performance has increasingly become of interest to load rating engineers. In September 2008, a report was finalized which determined if the Acoustic Emission (AE) Technique can assist in: assessing and identifying previous damage; monitoring existing bridges for real-time detection of occurring damage; and predicting critical conditions or failure of bridge members.

Four conventionally reinforced concrete (CRC) girders were designed to fail in shear-compression mode and constructed with different reinforcement details. This was to investigate the AE response due to increasing loads up to capacity, cyclic loading representing ambient service-level trucks, and simulated test trucks also at the service level were used.

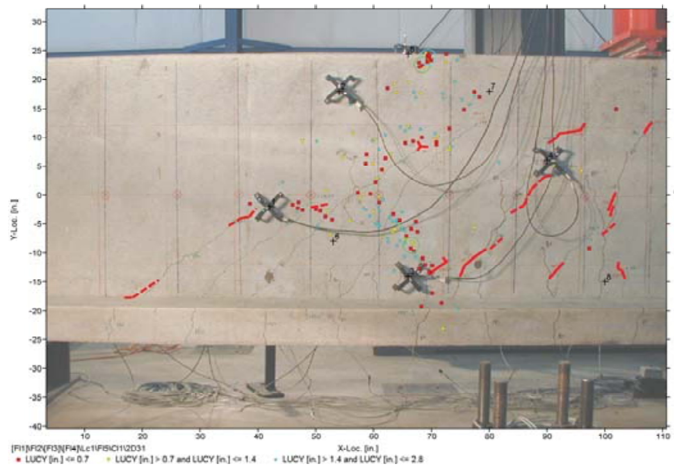
The Federal Highway Administration (FHWA) requires owners of structurally deficient bridges to repair, replace, restrict truck loads, or conduct analysis and testing on bridges in order to maintain a safe highway system. Past experiments on reinforced concrete beams showed acoustic emission (AE) testing, which “hears” the “sound” given off by the material when it is damaged, to be a highly sensitive method for detecting damage.

The research effort produced guidelines for practitioners without AE expertise on how to employ AE monitoring for reinforced concrete bridges. The guidelines cover sensor placement, data collection, and data interpretation and can be used to implement a short-term structural performance test or develop a long-term structural health monitoring system.

The following conclusions and recommendations were drawn from the study:

• The main source of AE for reinforced concrete (RC) comes from the mechanics of crack formation and propagation. Friction between crack surfaces and interaction of reinforcing bars and concrete, as well as plastic deformation and shrinkage of concrete are other potential sources.

• AE parameters such as signal energy, amplitude, counts, etc. depend on boundary conditions, specimen size, load rate, choice of sensor, material inhomogeneities, etc.



Locating AE sources on a laboratory beam

• Estimation of 3-D AE source locations from crack formation and propagation works well and located AE sources correspond with observed cracks and crack surfaces. However, it is important that the sensor network is established so that potential sources or zones of interest are not shaded by existing cracks. Also, not using all eight sensors in the network enabled maximization of detection and minimization of location errors. This is because the signals with the largest arrival time errors could be omitted from location estimations.

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Principal Investigator(s):

Steven Lovejoy, Dr. Christopher Higgins, Richard Nordstrom and Dr. Timothy Kennedy.

Project Status:

This project has been completed. A copy of the final report can be found on the Research Unit website:

http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/2008/Acoustic_Emission.pdf

Capacity of Aging Bent Caps

Many of Oregon's conventionally reinforced concrete (CRC) bridges that were built in the 1950's were designed to permit higher shear stress in the concrete than permitted by current AASHTO standards. Compounding this problem are increased traffic volumes and truck load magnitudes. These bridges are nearing the end of their originally intended design lives and they have been exposed to millions of load cycles from traffic. As a result, Oregon highways have nearly 500 bridges exhibiting diagonal cracks due to overload, environmental conditions, or some combination of these factors. Diagonal cracks have been identified in both the main girders and the bent caps. Consequently, ODOT contracted with Oregon State University to investigate methods for estimating the capacity of cracked bent caps.

A research project was undertaken at Oregon State University to assess the remaining capacity and life of conventionally reinforced concrete girders in 2004. The research focused on typical main girder proportions (4 ft deep and 14 in. wide) and rebar details for reinforced concrete deck girder (RCDG) bridges in Oregon. The research program included field and laboratory tests as well as analytical components to develop a methodology for assessment of diagonally-cracked girders.

To investigate bent caps as a system, six full-size bent caps were fabricated with integral column sections and protruding stubs at the interior girder positions. Vintage details from the 1950s were replicated as much as possible, including the overall geometry, reinforcement configuration, and material properties. Load was applied to the girder stubs incrementally up to the point of failure, while internal and external strains were measured and crack progression documented. To simulate the effect of 50 years of ambient traffic loading, 1,000,000 cycles of repetitive loading, based on in-situ measured stress ranges from three in-service bridges, was applied to one of the specimens prior to failure testing.

The research evaluated several methods for predicting the capacity of bent caps by comparing the calculated values with measured capacities of the test bent caps. Though computer modeling provided the most accurate prediction, a simpler method, which does not require specialized modeling skills, was recommended. A spreadsheet application was developed to perform the calculations, and an example load rating was conducted.

Conclusions reached from this project include:

Bent cap with crack highlighted.

- Failure mode was generally brittle; however, a ductile failure mode was observed in one specimen due to substantial yielding of the flexural anchorages.

- None of the current North American design codes takes into account the beneficial effects of active confinement on bond, resulting in overly conservative development lengths.

- At intermediate steel cut-offs, vertical flexural cracks were observed to turn into diagonal cracks near the bar cut-off locations due to the stress concentration at those locations. However, these did not control the strength of the specimens.

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Principal Investigator(s):

Dr. Christopher Higgins

Project Status:

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Oregon Opening Up Work Zones to Automated Enforcement

According to the Oregon Department of Transportation, Transportation Safety Division (OTSD), the state has experienced a steady increase in both work zone crashes (4,634 between 1998 and 2007) and fatalities (74 between 1998 and 2007). The charts to the right show the year-by-year totals.

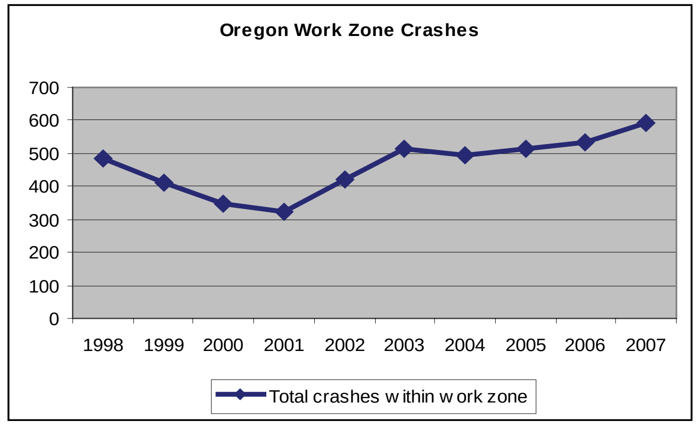
For more than two decades, automated enforcement has been in use throughout the United States, serving two primary purposes: abating red light running and countering speeding. Crashes resulting from either red light running or speeding can be expensive or can often result in a fatality.

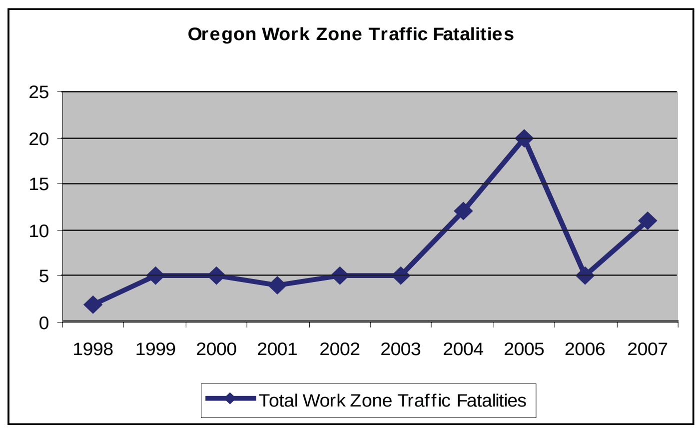
Although overall traffic-related fatalities and crashes are trending downward in Oregon, in recent years, there continues to be problem areas in need of improvement. One of these is Oregon work zones. In Oregon, work zone area crashes have increased over the last ten years and fatalities and major injuries in those areas are showing drastic increases with no sign of decreasing unless more is done.

Though raising the level of enforcement or revising engineering practices are countermeasures to these problems, another, and consequentially cheaper solution, is automated enforcement. In order to reduce resource intensive traditional enforcement, and to decrease high-risk enforcement methods associated with high-speed pursuits, automated solutions have become reasonable and viable alternatives. Utilization of this technology has expanded far beyond intersections and speed traps, and is now used in school zones, residential areas and work zones.

The good news is that the primary causes of these incidents (tailgating and speeding) can be easily preventable with automated enforcement cameras. As is being proven in Illinois, automated enforcement can be effective, if followed up with stiff penalties and a statewide education program. Already; some larger states, with similar problems, are signing onto this technology to address their own work zone crash dilemmas.

In June 2007, the State of Oregon amended the Oregon Revised Statutes (ORS) 810.438 and 810.439, authorizing the use of photo radar on Oregon freeways. Since that time, the OTSD and the Oregon Department of Transportation have taken the initiative to discover how best to implement this directive. A study was commissioned by OTSD to explore the effectiveness of automated enforcement devices in Oregon work zones. This study is expected to take place during FY 2009.





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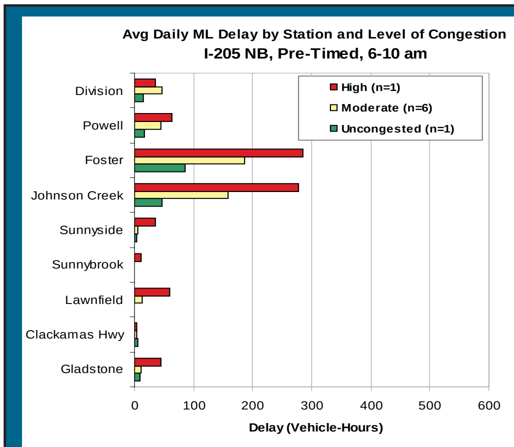
Project Status:
The project started January 15, 2008. Completion of the project is dependent on the schedule for the test site, which has yet to begin. Anticipated completion is late summer, 2009.

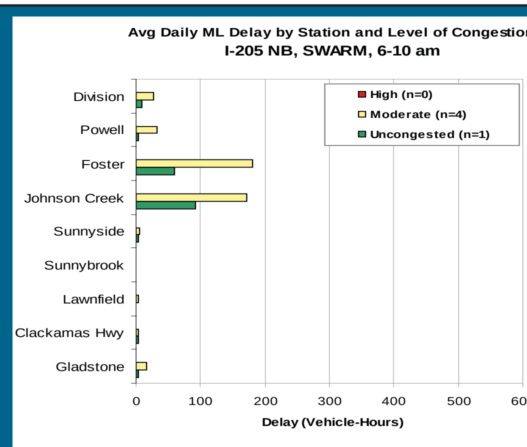
SWARM Improves Freeway Operations

By the end of the year, the Oregon Department of Transportation (ODOT) Research Unit expects to publish a report on the results of a "before" and "after" evaluation of the performance of a new ramp metering algorithm known as SWARM (System-Wide Adaptive Ramp Metering).

Starting in 2005, SWARM was implemented on six major freeway corridors in the Portland, Oregon metropolitan area, replacing the previous pre-timed ramp-metering system that had been in operation since 1981. Three corridors and four peak traffic periods (OR-217 southbound morning, OR-217 northbound afternoon, and I-205 northbound morning and afternoon) were studied as part of this research project, which was funded by the Oregon Department of Transportation (ODOT) and the Oregon Transportation Research and Education Consortium (OTREC).



Pre-Timed



SWARM

The study used data from the existing freeway, surveillance infrastructure, which were captured as part of the regional data archive system known as the Portland Oregon Transportation Archive Listing (PORTAL). The evaluation revealed that the operation of the SWARM system produced mixed results when comparing selected performance metrics to pre-timed operation. For the I-205 corridor, the results were generally positive. In the morning peak period, SWARM operation resulted in an 18% decrease in mainline delay and decreased variability. For the afternoon peak period, an 8% decrease in mainline delay occurred overall; however, on moderately congested days there was a slight increase in delay.

The figures above show the change in delay (vehicle hours) as measured at each station for each congestion level on I-205 during the AM Peak.

On the OR-217, however, significant increases were found in overall average delay. In the morning peak period, delay increased 34.9% while in the afternoon period delay increased 55.0%. These conclusions, however, must be tempered because of incomplete ramp demand data and significant communication failures, which caused the system to operate inefficiently. The researchers speculate that if the ramp demand data were available it would indicate reduced delay for those on the ramp. Incorporating additional logging capabilities into the SWARM system would make it easier to evaluate system operations on an on-going automated basis. These, as well as a number of measures to improve communication, are being addressed by ODOT's Region 1 staff.

When published, the report will include, as an appendix, a PORTAL User's Manual for Ramp Metering Evaluation. This will provide guidance to ODOT staff responsible for day-to-day monitoring and troubleshooting of problem areas. Additionally, it will help them to assess ramp meter operation as changes are made to upgrade the detection and communications. For more information visit the ODOT Research Unit website at:

http://www.oregon.gov/ODOT/TD/TP_RES/index.shtml

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Project Status:
The project started in December 2005 and the final report will be published in December 2008.

T2 Customer Satisfaction Survey

Oregon Technology Transfer Center

T2 Staff

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Bill Kolzow, Circuit Rider

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The T2 Center offers programs and services in an effort to support its mission of fostering a safe and efficient transportation system through training, technical assistance and technology transfer. The T2 Center is a source for transportation related information, which can be obtained through the T2 website, a publication and video lending library or by person-to-person contact over the telephone.

Training opportunities are provided by the *Roads Scholar* program, through Circuit Rider training, and by co-sponsored events and classes with the American Public Works Association (APWA). In addition, Circuit Riders often conduct on-site visits to agencies and organizations.

Recently, the T2 center completed an online Customer Satisfaction Survey from mid-June through the end of July. A total of 130 people responded to the survey, with an average response time of 10 minutes. The majority of those responding were city employees (63%), followed by county (25%), state (8%), federal (3%), and self employed (1%). A majority of respondents (72%) were either a manager (44%) or supervisor (28%).

On average, one in four people were unaware of at least one of the services or programs offered by the T2 Center. Several respondents commented that the T2 Center needs to do a better job at marketing itself and at outreach. Creating informational cards that reference T2 services and programs was suggested, as was following up with local agencies and organizations, particularly in more rural areas.

The results from the survey have been, and will continue to be, beneficial in helping to shape the future of the T2 program. The Center will meet with its stakeholders later this year to discuss the outcome of the survey and next steps.

The T2 Center extends a special thanks to those of you who participated in the survey.