

OTC Student of the Year

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The OTC congratulates Stephen Busam for his selection as the 2010 Student of the Year. Mr. Busam is a graduate student at Ohio University under the advisement of Dr. Deb McAvoy. As an undergraduate and graduate student in transportation engineering courses at Ohio University, Mr. Busam consistently ranked at the top of his class and his scholastic accomplishments have been outstanding with high standards of excellence.

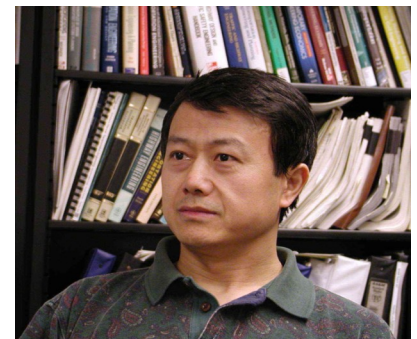
As a reflection of his scholastic achievements and personality, Mr. Busam was invited to join Tau Beta Pi, the National Honor Society for Engineers and Chi Epsilon, the National Honor Society for Civil Engineers, where he served as

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A Message from the Director

Today's slow economic recovery offers little help in tackling the prolonged financial problems. Budgetary constraints by the government are expected to impose an even greater impact than last year on transportation funding, while the state and local transportation agencies are striving to keep our infrastructure in a state of good repair.

At the UTC level, those challenges require visionary planning and management of the limited transportation funding to achieve greater efficiency and effectiveness in support of the research innovations and competitive workforce training. In the context of system sustainability and green transportation energy, we are proudly sharing this issue of our newsletter, which features several collaborative projects on cutting edge research and student activities.



Ping Yi

An Efficient and Accurate Genetic Algorithm for Backcalculation of Flexible Pavement Layer Moduli

Dr. Ernian Pan

Overlay Design Procedure is used to calculate the Asphalt overlay thickness based on the measured deflections. The current procedure used in ODOT is based on deflections collected with dynaflect. Recent research found instability with the current procedure because the deflections measured with dynaflect were approaching the magnitude of the sensor measurement error and the recommended use of falling weight deflectometer (FWD) is being considered.

According to Dr. Irwin from Cornell University, “the procedure to determine Young’s modulus of elasticity for pavement materials using measured surface deflections by working elastic layer theory backwards is generally called backcalculation”. In pavement engineering, backcalculation is based on the experimental records of material profiles and the results from FWD evaluations. Backcalculation is popular today and numerous approaches have been proposed for backcalculation of layer moduli and thickness in recent years. The backcalculation process is an iterative method and frequently is carried out with computer software. The advent of high-speed computers made it possible to accomplish the backcalculation in a reasonable amount of time.

Under the joint sponsorship of ODOT and OTC, the Computer Modeling and Simulation group (CMS) in the Civil Engineering department at The University of Akron has already accomplished an efficient genetic algorithm for backcalculation of layer moduli in flexible pavements for the backcalculation (Fig. 1). A graphical user interface (GUI) has been

designed for the corresponding software to make it more user-friendly. The alpha version of the software has been validated by ODOT staff, and the final version is expected to be finished by summer 2011.

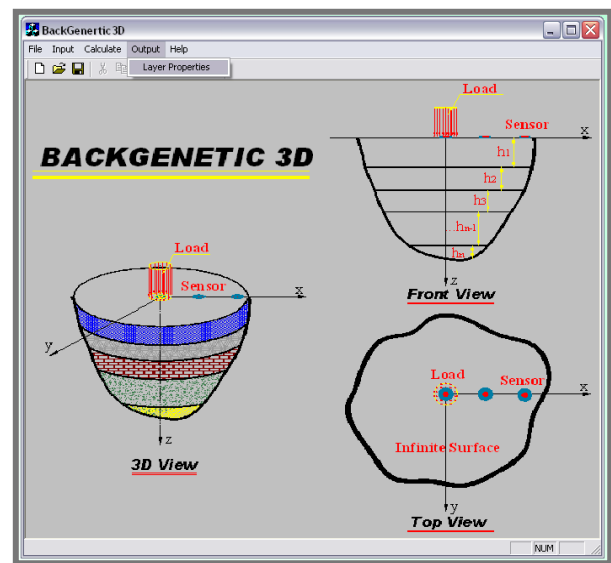


Fig. 1. BackGenetic3D Graphical User Interface (GUI) under ODOT/OTC

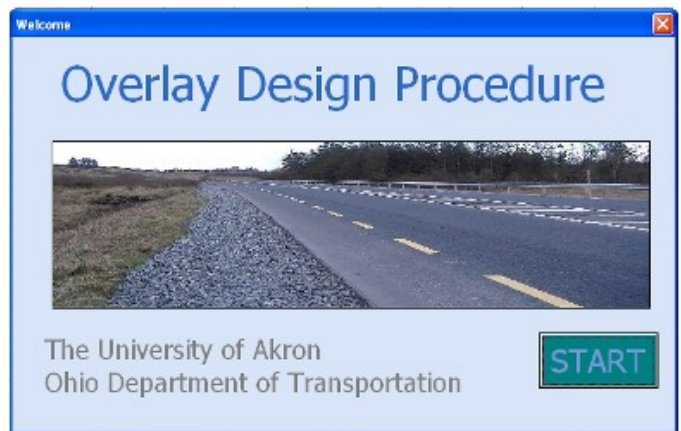


Fig. 2. The Overlay design software developed for ODOT, under the sponsorship of ODOT and OTC

An Innovative Non-contact Sensing Platform to Prevent Traffic Accident due to Driver Drowsiness

Dr. Bill Yu



A non-contact ECG system monitors driver physiological signals at no interference to drivers.

Dr. Xiong (Bill) Yu and his team (graduate student Ye Sun, technician Jim Berilla) are developing an innovative non-contact ECG sensor for fatigued driver assistance. Electronics design was implemented to detect the weak signal under high noise environments. The current sensor can detect ECG signals at a

distance of up to 30cm. The signals, after applying the signal processing algorithm, can determine important physiological information such as the Heart Rate, Heart Rate Variability, and breathing frequency. The team is continuing refine the device for real time monitoring of driver behaviors.



Amrikabir University of Technology and Sharif University of Technology in the field of Materials

The Computer Modeling and Simulation group (CMS) at The University of Akron has recruited a new student this semester from Iran. Mr. Ali Sanghaleh graduated from

Science and Engineering. He is interested in structural mechanics and mechanical behavior of materials, and he has already published a couple of journal papers prior to joining the group. Ali has done research on the mechanical behavior of ceramic-matrix and metal-matrix composites during his bachelor and master studies and now he is very keen to work on multilayered structures in the CMS Group. The CMS Group is currently working on the OTC-funded project “An Efficient and Accurate Genetic Algorithm for Backcalculation of Flexible Pavement Layer Moduli”.

PEV Readiness

A collaborative project led by The University of Akron

To position the United States to compete in the 21st century global economy, the US Department of Commerce has identified twelve US regions as Innovation Clusters based on core competencies. The Pittsburgh, Akron and Cleveland cluster is distinct within the nation for its focus on Clean Energy Technology. Akron and Columbus have stepped forward to create Ohio's first workable schemes for PEV (Plug-in Electric Vehicle) - readiness under the leadership of ODOT.

Both Akron and Columbus were approved by the Rocky Mountain Institute (RMI)'s Project Get Ready (PGR) initiative in Colorado as Ohio's cities for leadership and best practices, and for inclusion in the national conversation and roll-out of PEV-readiness strategies. PGR is a collaboration between the RMI think tank and an array of partners and technical advisers (including General Motors, Ford and Nissan).

It proposes to create a Web-based template for cities to link up with local utilities, politicians and other power brokers.

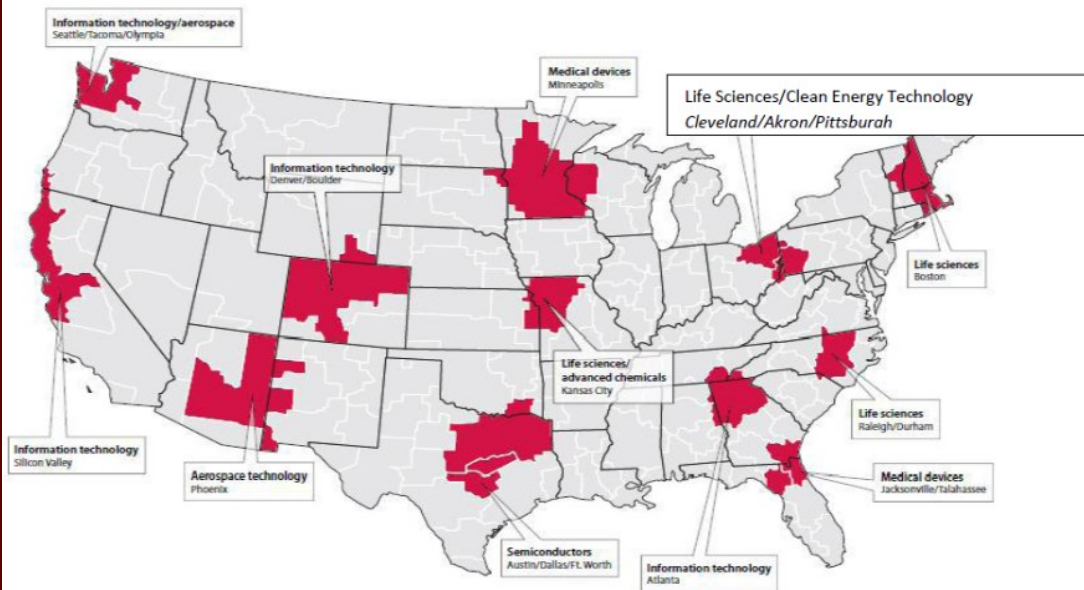
Collaborations

The OTC works closely with the City of Akron and Akron Metropolitan Area Transportation Studies (AMATS) to promote the deployment of PEV-readiness information, initial plug-in locations, and communication strategies with the RMI's PGR initiative, as well as the public. AMATS has made PEV-readiness a priority of its planning strategies. This includes working with The University of Akron (UA) as well as meeting with the mayors and service directors of the surrounding towns and cities to exchange information and gather questions.

The OTC is also working closely with Youngstown State University's UTC in research collaboration on PEV-readiness, energy system

optimization, student training and community outreach. OTC Director Dr. Ping Yi is leading UA's PEV-readiness strategies. In December 2010, his team began preparing a methodology that maps charging station installation using a layered intersection of demographic and transportation data that will, when complete, be

A SNAPSHOT OF U.S. INNOVATION CLUSTERS
A selection of high-tech clusters in different parts of our country



Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School. Copyright © 2005 President and Fellows of Harvard College. All rights reserved.



applicable to all US urban areas.

In 2010, UA, Lorain County Community College and Stark State College entered into an unprecedented alliance that will accelerate educational efficiency by combining the collective resources of a number of community colleges in the region and a research university. This consortium offers an opportunity to share curriculums for electric-automobile safety training which will speed deployment. Safety training, which is currently offered (fire, police) as curriculums of study in community colleges, will play an important role in PEV-readiness needs in the region. Additional regional partners are now being actively solicited.

A long term partner with UA on research related to clean coal power generation, FirstEnergy is working with UA as well as others on the creation of a micro-grid testing facility for new technology in Warren, OH, near Youngstown. FirstEnergy has been involved with various PEV smart charging research initiatives to evaluate the potential grid impacts that large adoption of this technology could pose to its electric infrastructure.

Testing facilities are sparse for emerging technology solutions in smaller companies. They require the kind of 'smart' data results needed to fortify product development and advance commercialization lifecycles. Plans are to build-out a Tech Belt Energy Innovation Center (TBEIC) as a dual "smart" power platform for evaluating grid

compatibility and readiness of commercially focused energy solutions. This will offer testing in a representative distribution circuit and distributed-energy resources connectivity environment. TBEIC will be one of several initiatives across the state to service the emerging geographic clusters of advanced energy activity so critical to the future of Ohio's competitive position in the global market.

Anticipated Research Outcomes

A hybrid-electric 12-seat handicap-accessible bus is being purchased through the assistance of the Electric Power Research Initiative (EPRI) as a 'Roo Express' university shuttle bus in collaboration with The City of Akron and FirstEnergy, each of which will use it for various shuttle purposes. Plans are to download the data on energy usage and savings for curriculum use in the Akron Public Schools middle schools. These students will be driving age when electric vehicles are being sold and they will learn about electric power generation in terms of sustainability. The curriculum, which will be developed for this purpose, will be distributed to cities around the nation.

Ironically, few tools exist to analyze the best initial locations for public charging stations. Developing this methodology is the core expertise of the OTC and is being developed for facility location analysis of Level 2 and Level 3 charging stations. The results are being back-tested by electric vehicle pre-orders, and will further be tested by orders once automotive companies begin delivering vehicles to Ohio.

Transportation Infrastructure Applications of Titanium and its Alloys - A Feasibility Study

Dr. Anil Patnaik, Dr. Craig Menzemer and T.S. Srivatsan

Annual national highway bridge inventories revealed time and again that over 20% of bridges in the United States are structurally deficient or functionally obsolete. Researchers and engineers continue to study the causes of bridge deterioration in order to develop probable solutions to slow down the degradation of bridges and to extend their life spans. Corrosion of steel has a major role in the degradation of transportation infrastructure. Metal loss due to corrosion of structural steel members and connections is a well known phenomenon and is well documented (e.g., see Fig. 1).

Titanium has grown in stature to be recognized as a modern metal that is much stronger and lighter than many of the widely chosen and used steels in the industry for high performance applications. One of the most attractive properties of titanium and its alloys is non-corrosiveness. However, a major drawback of titanium and its alloys for applications in transportation infrastructure is the exorbitant initial cost. Therefore, the use of titanium and its alloys has been confined to performance critical structures in the aerospace and defense industries.

In order to fully derive the benefits of titanium and

its alloys, part weight, cost and lead time need to be reduced, while concurrently facilitating enhanced performance of structural parts made from titanium. Thus, there is an immediate need to (i) develop structural design methodologies and specifications, and (ii) put forth innovative manufacturing and fabricating techniques with the primary purpose of producing and promoting the use of cost-effective titanium structures in both the defense sector and civil transportation sector.

In an ongoing research project at the University of Akron, titanium and its alloy counterparts are being studied to develop an insight into the structural performance and to assist potentially viable implementation in cost-critical structures. The project comprises two major phases. In Phase I, studies were conducted on built-up welded beams made from titanium and its alloy counterparts, while in Phase II, structural performance of titanium gusset plates is being studied along with possible isolation techniques.

Built-up welded beams can be an alternative to machining structural components from thick plates or billets. There can be a noticeable reduction in both lead time and cost primarily because of the reduced cost of



Fig. 1 Corrosion Affected Elements of a Bridge (Source: www.flickr.com [Tag: ascerportcard])

using thin sheets and plates of titanium to make large structural components without adequately compromising on structural performance. Furthermore, the US Army's division at Picatinny Arsenal (NJ, USA) has recently developed a Pulsed Gas Metal Arc Welding (GMAW-P) process for use on titanium and its alloys.

The primary objective of Phase I of the project was to investigate structural performance of built-up welded beams fabricated from Commercially Pure (CP Grade 2) titanium and a common titanium alloy (Ti-6Al-4V) under both static loading, and fatigue loading. Welded built-up titanium beams were fabricated and tested to experimentally and theoretically evaluate their structural performance. Comprehensive material characterization was also done to investigate the influence of composition and microstructure on hardness and tensile properties, cyclic fatigue and fracture behavior, and their influence on the structural performance of welded built-up titanium beams.

The project demonstrated that it is feasible to fabricate large built-up titanium beams by welding parts together using the GMAW-P welding process so as to achieve structural performance that is comparable with an identical beam made from a monolithic counterpart. The welds produced by this process were found to be sound and without any visible cracks. The study also revealed that there is no deleterious influence of welding on static structural performance of the built-up welded beams of commercially pure titanium (Grade 2) and Ti-6Al-4V titanium alloy.

With suitable modifications, the current AISC Steel Design Specifications can be used for the design of welded built-up beams made from titanium and its alloys. The failure modes, failure loads, deflections, and strains of welded built-up titanium beams are predictable to a reasonable and acceptable level of accuracy. Furthermore, the test beams demonstrated significant reserve

strength and ductility following initial yielding. The deflection curves and the load versus strain relationships obtained from tests demonstrate a reasonably close match between the theoretical predictions and experimental test results up until the elastic limit of the material. The study reiterated that an elastic stress analysis based on a classical beam bending theory or finite element analysis is adequate to predict the stresses, deflections, and strains that are developed under static loading up until the initiation of yield in the material.

The fatigue tests conducted in this research study revealed that welded built-up beams made from commercially pure (CP Grade 2) titanium have better fatigue life than those made from Ti-6Al-4V. Additional work is being planned to develop further insight into the fatigue behavior of welded built-up titanium beams. The proposed welded built-up beam approach is anticipated to be a viable and cost-effective alternative to fabricating large structural elements and members by machining of parts from thick plates or billets.

In bridges, the key elements for effective functioning of the structure are the connections between different members. Failure of connections in a bridge truss due to a loss of strength occurring due to corrosion can be very devastating. Experts believe that deterioration of gusset plates due to corrosion or stickiness of roller bearings due to corrosion can potentially trigger gusset plate failures.

“TITANIUM” continued on page 9

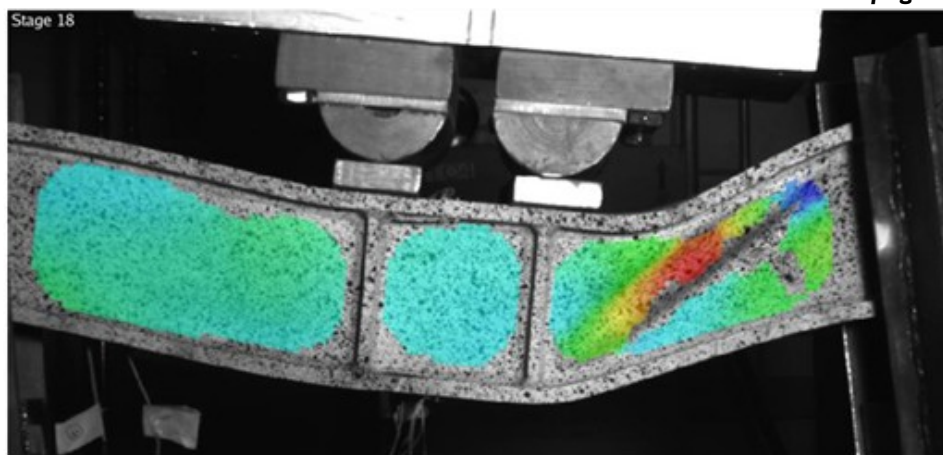


Fig. 2 Failure of a Built-Up Welded Titanium Beam by Web Shear Buckling

Developing Furan-Based Materials for High Performance Anti-Corrosion

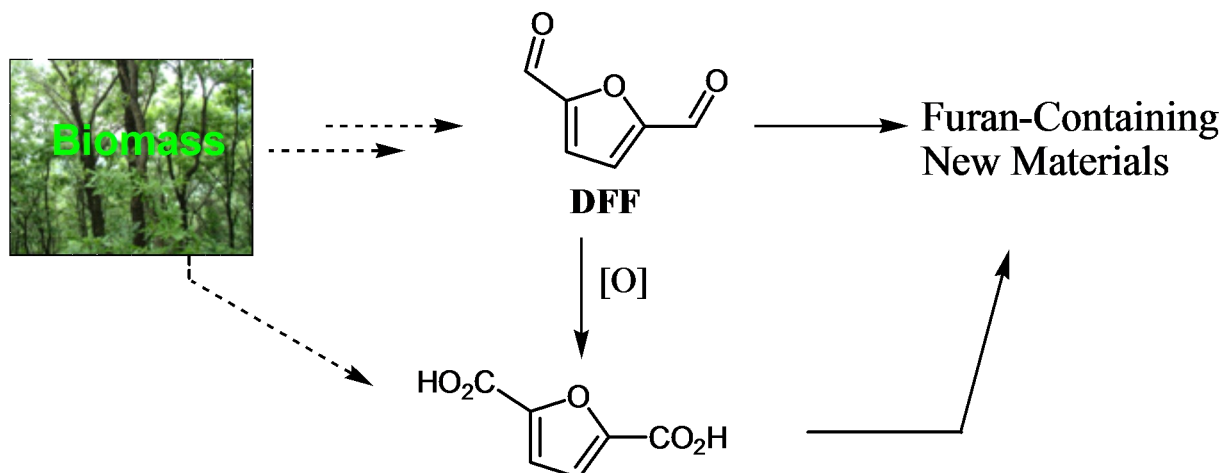
Dr. Yi Pang

Due to its excellent mechanical properties and low cost, mild steel is widely used as construction materials. The steel, however, tends to undergo certain chemical reactions with its surroundings (such as moisture and oxygen), causing corrosion that disintegrates an engineered material into its constituent atoms. Recent studies estimate the direct cost of corrosion in the United States to be \$275-500 billion dollars per year. About 21.5% of the annual corrosion cost occurs in the transportation sector.³ For example, rust of steel is one of the most common causes of bridge accidents. As rust has a much higher volume than the original mass of iron,⁴ its build-up can also cause failure by forcing apart adjacent parts. It was the cause of the collapse of the Mianus river bridge in 1983, when the bearings rusted internally and pushed one corner of the road slab off its support.

The corrosion study of carbon steel and iron is of both theoretical and practical concern. In industrial acid cleaning, acid descaling, and acid pickling, corrosion inhibitors are widely used in order to restrain the corrosive attack on metallic materials.

Common structural features for organic inhibitors are (1) containing oxygen, sulfur or nitrogen atoms; (2) having p-orbitals. The most efficient organic inhibitors are organic compounds having p-bonds in their structures.

Furan derivatives are an interesting class of compound for anti-corrosion applications, as the furan ring has a unique electron-rich p-conjugated system with oxygen. For this reason, furan derivatives are known to exhibit useful inhibitor function for steel corrosion, and furan-based materials are excellent candidate for corrosion protection. Encouraged by our recent success to access furan-based starting material such as diformylfuran (DFF), we are currently developing new polymeric materials for corrosion control. The approach has several advantages: *first*, it is green, as the starting materials can be obtained from readily available biomass; *second*, the rust inhibitor function of furan will be coupled with rich chemistry of carbonyl groups to lead to a broad range of new materials. With the graduate student support from the OTC, Tengfei Xiang, one of the materials has shown promising anti-corrosion properties.



“TITANIUM” continued from page 8

Gusset plate failures and the related collapses of bridges can be minimized if the gusset plates are made from non-corrosive and high strength titanium or its alloys. The use of the metal for the entire bridge structure is cost prohibitive, but it is feasible to provide titanium gusset plates in a bridge structure primarily because of the small tonnage of gusset plates relative to the entire structure. This will mean that the main members are still made from the routinely used structural steel, but the connections are made from titanium or its alloys. The proposed solution will require a dual use of structural steel and titanium in close proximity to each other. The mixed mode use could lead to galvanic corrosion of steel. Such a problem can be overcome by isolating the parts from each other with the use of coatings or a physical barrier (e.g., transition piece).

The primary objective of Phase II of the study is to develop a design methodology for bolted titanium gusset plates and to study viable alternatives for isolating titanium and steel parts to prevent accelerated galvanic corrosion of steel. Several tests were conducted to determine the tensile, shear and block shear strength of bolted gusset plates. Extensive finite element analyses (FEM) were done for the selected connection

configurations using ANSYS. Theoretical stresses and stress concentrations, strains, and failure modes were predicted at key points in the test specimens for comparison with the test results. The design guidelines are being developed and will be illustrated with simple step-by-step explanations and examples. Corrosion tests were conducted to determine the corrosion potential and to develop methodologies to isolate titanium from surrounding steel components. The research is currently in progress.

This project demonstrated that the potential use of titanium and its alloys in cost-critical structures is feasible. However, cost reduction technologies, such as built-up welded beams, mixed mode use of titanium in critical elements of structures, need to be further developed so as to eventually facilitate the design, fabrication, and implementation of large structural elements using titanium and its alloys for potential use in defense and transportation infrastructure applications.

Acknowledgments

This project was primarily funded by the Defense Metals Technology Center (DMTC), North Canton, Ohio since February 2008 with graduate student support provided by the OTC.

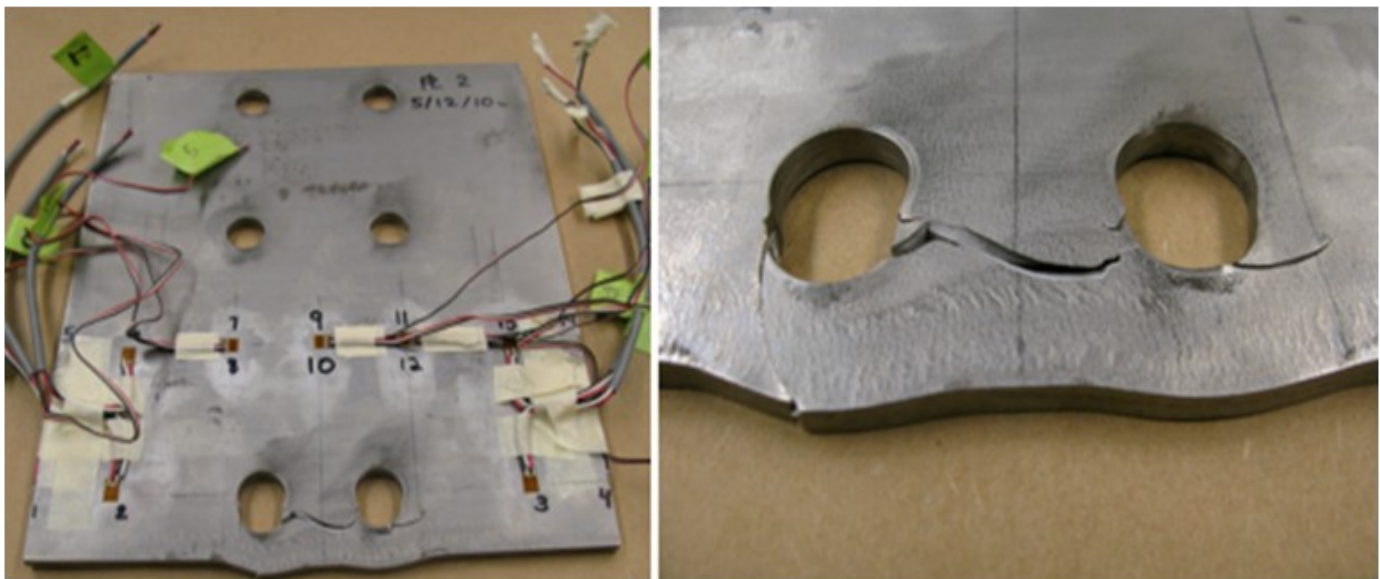


Fig. 3 Typical Failure Mode of a Gusset Plate Test Specimen

LIDAR Based Vehicle Classification

Dr. Benjamin Coifman

Our research into LIDAR based vehicle classification included a field deployment at a vehicle classification station along I-270 in the Columbus area. With the help of ODOT, we collected several hours of concurrent LIDAR, video and axle based

classification data. Fig. 1 shows a picture of the data collection configuration. We continue to refine our shape based vehicle classification system with good results, Fig. 2 and Fig. 3 show sample vehicles, with concurrent video images and LIDAR data.



Figure 1, Site 153 on I-270 to collect LIDAR data

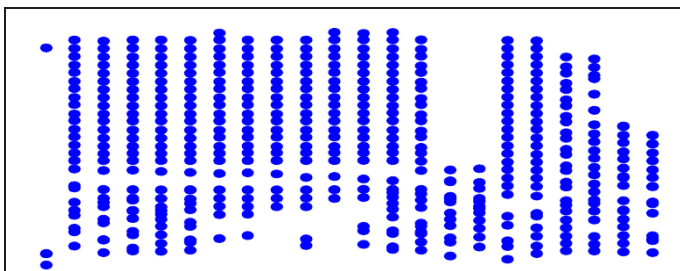


Figure 2, (a) Semi-trailer truck from video image and (b) the corresponding LIDAR image

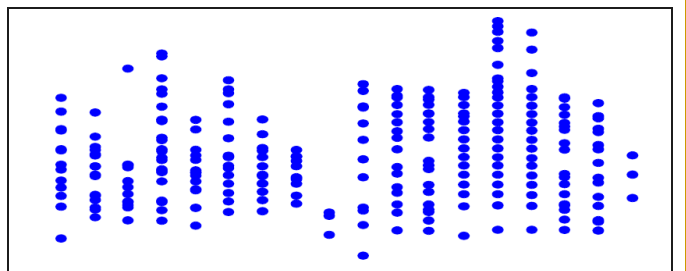


Figure 3, (a) A pickup truck pulling a trailer and (b) the corresponding LIDAR image

SOY Experience at TRB

By: Stephen Busam, OTC Student of the Year

This year marked the 90th annual meeting of the Transportation Research Board in Washington D.C. and thanks to the Ohio Transportation Consortium I was able to attend the conference. This was my third time attending the conference as a graduate student and every year it has amazed me. The conference is three days of meeting and discussing research topics in every facet of transportation with researchers ranging from first year graduate students to topic experts. This year I attained my registration materials and my TRB program Sunday evening and poured through the thousands of presentations and poster sessions in an attempt to plan my next three days. It is nearly impossible to not get lost in the sheer volume of topics and research studies being presented, making the task of creating a daily itinerary quite a challenge. In the end my days were filled from sun up until well after sundown with poster sessions and presentations on topics ranging from roundabout design and implementation, to traffic noise abatement and strategies to create safer work zones. My favorite presentation group was one

about roundabouts. This session was less research based, but rather was presentations by other municipal and state DOT personnel on how they have successfully swayed the opinions of their respective constituents toward accepting roundabouts. While this session did present some results in terms of preliminary safety benefits of roundabouts its main focus was to present successful public opinion campaigns for their implementation. Overall my experience was extremely positive. I only hope I can return to attend the conference as a working professional or even become a member on one of the standing TRB committees in the years to come. I would like to thank the Ohio Transportation Consortium for providing me with the opportunity to attend the conference this year and encourage every student and faculty member to attend this conference at least once. It is a great way to meet fellow researchers in a particular field and get excited about the research which is being performed at universities and in private industry across the country and around the world.



Stephen Busam and advisor Dr. Deb McAvoy, Ohio University



Stephen Busam and OTC Director Dr. Ping Yi

“SOY” continued from front page

treasurer for two academic years. He also has served as the Vice President for the Institute of Transportation Engineers student chapter since 2009.

His leadership skills led to his selection as one of only two students in the senior class for the Robe Leadership Institute Seminar. The institute designs and initiates programs to help selected undergraduate and graduate students reach beyond professional competence and prepare for the challenges of leadership roles. The institute provides opportunities and the means for those with leadership potential to acquire the knowledge and skills that will help them better contribute to their professions and to the betterment of the human condition.

Since the Spring Quarter of 2009, Mr. Busam has been a research graduate student at Ohio University. He has led multiple projects in terms of data collection efforts and analysis. Mr. Busam has co-authored two papers and a report for the OTC entitled “Safety Evaluation of Diamond-Grade vs. High

-Intensity Sheeting for Work Zone Drums” which he also presented at the 2010 Ohio UTC Student Research Conference.

He has assisted in the preparation of various proposals, such as the “Evaluation of Transverse Rumble Strips for Work Zones” funded by Plastic Safety Systems, the “Evaluation of Dynamic Speed Signs” funded by the OTC, and the “Evaluation of the Effectiveness of Alternative Lighting, Paint and Retroreflective Material Schemes on First Responder Vehicle” funded by the U.S. Department of Justice. He has presented his research on the “Safety Evaluation of Diamond-Grade vs. High-Intensity Sheeting for Work Zone Drums” at the Ohio University Student Research and Creativity Expo where he earned first place for presentation. Mr. Busam is an intelligent and self-motivated individual who is destined for success in his professional career as a Transportation Engineer.

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