SOLUTIONS

RESEARCH PROGRAMS

Winter 2018

IN THIS ISSUE

PROJECT HIGHLIGHTS

MDT Rockfall Hazard Process Assessment

http://www.mdt.mt.gov/research/projects/geotech/rockfall.shtml

Between the 1940's and the 1970's highway construction involved nominal excavation. This sped up construction of the highway system we know and use today, but left today's drivers to pass along thousands of rock slopes throughout our mountainous region. When rocks fall in these areas, they can become an instantaneously dangerous hazard. In 2005, MDT addressed the danger of falling rocks by completing the Rockfall Hazard Rating System (RHRS). The RHRS was a valuable tool and naturally became a regular part of the department's decision-making process.

Time marches on and with it, technology continues to advance. MDT's geotechnical personnel found that an update to the RHRS database had the potential to increase usability of the information within. The resulting tool is the new Rock Slope Asset Management Program (RAMP).

The RAMP program provides decision-supporting data for geotechnical elements of highway projects or for stand-alone rock slope mitigation. With a strong foundation in the data from the previous RHRS program, RAMP packages rock slope data and decision-making models used by a variety of executives, planners, maintenance, and engineering professionals into one accessible tool. One of the forecasting tools in the RAMP is a rating system known as Condition States. This terminology was initially pulled from the RHRS. Condition States help to calculate risk factors for areas subject to rockfall. The Condition State is generally presented as a number (1, 2, 3, etc.) or as a category (Good, Fair, or Poor).

The RAMP also includes a rockfall event tracking tool. The form has been tailored to encourage busy maintenance supervisors and district geotechnical personnel to provide data to help the department understand where priority maintenance must occur, track costs, and update risk forecasting tools. Rock slopes should be re-rated after any significant mitigation project or rockfall event. Correspondingly, it was recommended MDT conduct another large-scale assessment in 5 to 10 years. This assessment will capture changes in statewide conditions, and provide the Department with feedback to improve the rate of deterioration and life cycle models used in budget forecasting.

CONTINUED ON PAGE 2

The research team recommends:

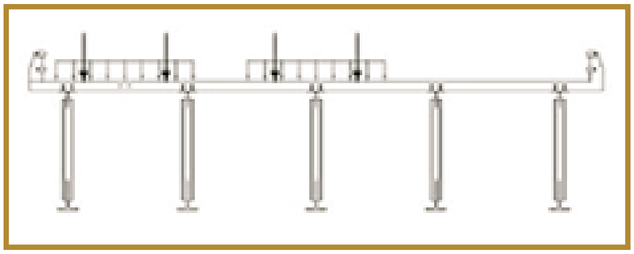
- The Department integrate the RAMP tool into its regular planning workflow. This ensures improvements to existing Fair and Poor condition rock slopes are addressed early in the project selection and development process.
- Utilization of the Condition State approach in conjunction with percent retention for developing rock slope design goals.
- Initiating annual maintenance of the RAMP program and a periodic inventory and re-assessment program. These efforts reduce corridor risks, improve user safety, and help slow overall asset deterioration, as measured at the statewide level.

While the MDT Rockfall Hazard Rating System has served a useful purpose over the last 10 years, the newly updated RAMP has the potential to improve the MDT transportation system by improving rock slope condition over time through life cycle cost-based project decisions, safety by risk reduction through selective project development, and reductions in the life cycle cost of maintaining safe Montana slopes.

View the full report and related material. For more information on this project, please contact Sue Sillick (ssillick@mt.gov, 406.444.7693).

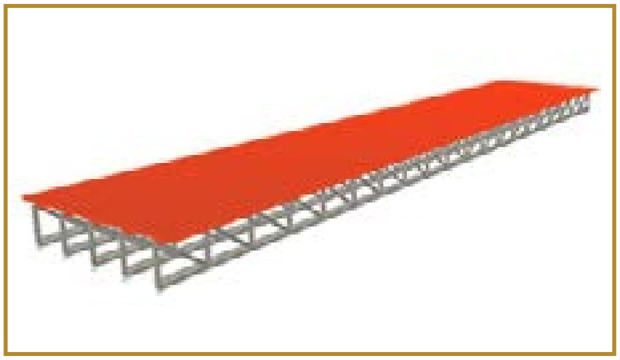
Investigation of Prefabricated Steel Truss/Bridge Deck Systems

Steel truss bridges are not only charming to see, they can be the most efficient option for highway crossings. Their light weight in comparison with plate girder systems makes them a desirable alternative for both material savings and constructability. A prototype prefabricated steel truss bridge system has been proposed as a potential alternative for accelerated bridge construction (ABC) projects in Montana. The proposed system consists of a prefabricated welded steel truss topped with a composite concrete deck cast-in-place at the fabrication facility. These elements are transported to the site and placed on a prepared foundation to create the bridge.



There is little published information available on this specific bridge deck and truss configuration, making it important to identify potential bridge spans and traffic volumes where this system is an efficient alternative. At the request of MDT, researchers at Montana State University performed such an investigation, with a focus on the fatigue of welded member-to-member connections in the trusses. This work also included cost analyses with the proposed system and exploration of plate girder alternatives. Specifically, researchers focused on identifying member sizes and connection details with the greatest potential for material and construction efficiencies for a 205-ft. span. This span was selected to compare materials and fabrication costs with the Swan River plate girder project recently designed by MDT.

A preliminary design of a 205 ft. steel truss bridge with bolted connections between diagonal members and chords satisfied AASHTO fatigue requirements for an infinite life design. This finding led to a refined analysis to further investigate the potential material and fabrication cost savings for a lighter weight truss system. A three-dimensional finite element model was used to more accurately estimate the distribution of multiple lane and axle loads to the trusses in the system. The attendant forces in individual truss members were lower in magnitude than determined by the simple analysis, resulting in a reduction of member sizes and material costs.



CONTINUED ON PAGE 3

Both conventional and accelerated construction scenarios were considered. The conventional construction alternative utilized a concrete deck cast after truss erection at the site and assumed a single splice at mid-span. The accelerated construction alternative utilized a concrete deck cast prior to shipping the prefabricated system to the bridge site. For the accelerated construction scenario, the truss elements with integral concrete deck were assumed to bridge the span in three segments (resulting in two splices).

The final designs were compared with the equivalent 205-ft. Swan River plate girder design. Input from fabrication and construction professionals was used to assess the efficiencies and constructability of the 205-ft. bolted/welded steel truss bridge constructed using both conventional and accelerated methods. To accommodate the construction loads involved in casting the deck after erection, a larger top chord member was needed for the conventional construction method.

Even with this increase, the weight of the bolted and welded steel trusses assuming conventional and accelerated construction, respectively, were 15% and 28% less than the weight of the Swan River plate girders. This indicates a cost reduction of up to 10% and 26% for the conventional and accelerated construction alternatives, respectively. Based on this investigation, both steel truss configurations, are attractive options for bridges in Montana. The study suggested that potential materials, fabrication, and construction savings from these systems could be more specifically identified by performing a full design for a specific construction site. Other study recommendations included a) having further discussions with steel fabricators and local contractors to gain additional insights on the constructability/feasibility of these systems, b) considering alternative contracting methods for early projects contemplating use of these systems, and c) planning to closely monitor and evaluate the behavior and performance of any such systems when they are built and placed in-service.

To date, the results of this study were presented and discussed at a meeting with MDT staff, steel fabricators, consultant designers, researchers, and construction contractors. The most likely next step is to identify a bridge crossing and contracting method where a prefabricated steel truss bridge could be constructed. Once built, such a structure would then be evaluated through MDT's experimental feature program. Additionally, this structure could be instrumented to more closely study its behavior and performance.

View the full report and related material. For more information on this project please contact Sue Sillick (ssillick@mt.gov, 406.444.7693).

Evaluation of Effectiveness of Woolen Roadside Reclamation Products

The temperature is dropping, toes and fingers are getting cold, and most of us have already rediscovered our winter gear. This is the time of year to get reacquainted with wool. Winter socks, cozy coats, and mittens all come to mind. Perhaps the most common use of this fluffy textile is blankets. Those interested in land reclamation certainly think so. Erosion control blankets can aid soil conservation efforts and wool might be a helpful ingredient for these blankets, used in compost, or even specialty fencing.

Wool can be a helpful substance in the science of soil conservation and erosion control.

- In Poland, waste wool added to horticultural crops resulted in higher yields (Gorecki and Gorecki 2010).
- Scoured weed-seed free wool can store up to 400% of its weight in water (Upton 2003).
- Wool becomes saturated at 33% of its weight of moisture-free fibers (D'Arcy 1990).
- Sheep wool contains 16% to 17% nitrogen (Simpson and Crawshaw 2002).
- Wool can act as a slow release fertilizer for plant growth (Herfort 2010).
- Research from European testing of the use of woolen fabrics for establishing vegetation on green roofs resulted in over three times more plant canopy cover when wool was used in mats compared to traditional coconut fibers (Herfort 2010).

CONTINUED ON PAGE 4

- Waste wool pellets are marketed as fertilizer in both the U.S. and Germany (Bohme et al. 2010).
- In addition to providing soil fertility, wool pellets hold 20 times their weight in water (Wild Valley Farms 2016).

The project was supported by the Montana Department of Transportation (MDT) and the Center for Environmentally Sustainable Transportation in Cold Climates through which researchers evaluated 16 different wool-based soil conservation and revegetation products for roadside applications. Five were selected for further development, testing, and review. It was determined that three of the most promising applications: erosion control blankets (ECBs), wool as an additive to compost, and for use in 100% biodegradable silt fencing should be pursued further.

Wool as a component of erosion control blankets (ECBs) was tested along the same Montana highway. Eleven replicates of six types of ECBs as well as control plots were tested in an area selected for its arid, nutrient poor characteristics. Site preparation, seed mix, and seed rate were identical for the various treatments and controls. Performance was measured by each plot's plant canopy cover, which is an estimate of the relative amount of vegetation.

The ECBs included 2 weights of carded wool blankets, 2 types of needle punched wool blankets, and 2 different rolled ECBs of varying wool-straw ratios. The ECBs have variables such as density, thickness, strength, and amount of wool. Some resulted in greater desirable plant establishment than others. In general, the control plots had lower seeded grass canopy cover than all wool treatments except for the four-pass needle punch ECB. This suggests wool material, regardless of type, may be providing a benefit to seeded grass establishment.

The two best performing treatments were the plots covered with rolled wool/straw ECBs. The 100% wool ECB and 50% wool/50% straw ECB had the greatest grass canopy cover after two years. These two ECBs were developed specifically for this project and were produced by geotextile manufacturing machinery that creates ECB rolls. The grass cover was four to five times higher for these two wool ECBs than the standard 70% straw/coconut ECB currently used by MDT.

Soil tests revealed an increase of total nitrogen with use of the wool ECBs. Plant measurements indicate a positive response to the improved soil. The results provide strong evidence that those woolen ECBs commercially produced and developed for this project provide a benefit to the revegetation of slopes. When there is wool in the filler, its decomposition, provides nitrogen to emerging plants. Although not quantified in the field, some of wool was still visibly present two years after the ECBs were deployed, as was jute netting. Less so was the straw, which either was decomposed or lost to wind and rain. Thus, the woolen ECBs were still functioning at some level as a shield for the slopes, giving at least some minimal protection to the soil from rain and wind years after the initial installation.

Given the results, woolen ECBs are well suited for arid areas or windy locations in Montana where water stress challenges vegetation establishment and growth. Areas with poor soil are other potential sites for this material.

Wool as an additive to compost was also tested along the same Montana highway as the ECBs. The wool compost

CONTINUED ON PAGE 5

blended product was compared to a wood- based compost control treatment developed from typical compost prescriptions used regularly by MDT on its post-construction roadside reclamation projects. Site preparation, seed mix, and seed rate were identical for both the traditional compost and the compost with wool pieces added. This project tested only one wool-compost ratio and only one commercially available compost; it found that desirable plant cover was better in areas with compost incorporating wool pieces versus compost alone. Future testing should incorporate different wool to compost ratios, as well as experiments with different types of composts and mulches used by transportation agencies.

The fencing was the most developmental of the three. The standard silt fence is made of synthetic woven plastic material and must be removed before a highway project can be concluded. The hope behind using wool instead of conventional materials is the fence would be biodegradable and left in place, to fertilize the soil after a roadside reclamation project concludes.

There are no known silt fence products available for testing, and researchers had to learn how such a product would be manufactured. Working with product manufacturers, prototypes were manufactured for testing. Variations of wool silt fences had differing results. Some were not weather resistant enough to withstand strong winds. One wool felted fence with stitching for strength and durability lasted for a year in field conditions. This fence had a plastic lining that would need to be replaced with a biodegradable fiber netting to meet the desired outcome in biodegradability.

View the full report and related material. For more information on this project please contact Sue Sillick (ssillick@mt.gov, 406.444.7693).

References

Bohme, M., I. Pinker, H. Gruneberg, and S. Herfort. 2010. Sheep Wool as Fertilizer for 7 Vegetables and Flower in Organic Farming. XXVIII International Horticultural Congress on 8 Science and Horticulture for People. Acta Hortic. 933: 195-202. 9

D'arcy, J.B. 1990. Sheep management and wool technology, 3rd edition. New South Wales 14 University Press, Kensington, NSW, Australia. 15

Gorecki, R.S. and M.T. Gorecki. 2010. Utilization of waste wool as substrate amendment in pot 25 cultivation of tomato, sweet pepper and eggplant. Polish J. of Environ. Stud. 19 (5), 1083-1087. 26

Herfort, S. 2010. Use of sheep wool vegetation mats for roof greening and development of a sheep 27 wool fertilizer. Presentation at World Green Roof Congress, Mexico City, August 10, 2010, 28 Mexico City, Mexico 29

Simpson, W.S. and Crawshaw, G.H. 2002. Wool: Science and technology. Woodhead Publishing 5 Limited, Cambridge, England, UK. 6

Upton, C. 2003. The Sheep Production Handbook. Prepared by the American Sheep Industry 26 Association, Inc., Englewood, CO, USA. 27

Wild Valley Farms. 2016. Wild Farms UT, https://www.wildvalleyfarms.com/wool-pellets.html, 2018

Feasibility of Non-Proprietary Ultra-High Performance Concrete for Use in Highway Bridges in Montana

What do body armor, electronics, and building materials all have in common? Everyone wants them to be thinner, lighter, stronger, and less expensive to manufacture. That is a tall order especially as it applies to building materials. One material likely to do the job is ultra-high-performance concrete (UHPC). However, using UHPC in conventional concrete applications is extremely expensive, with commercially available/proprietary mixes exceeding $2,000 per cubic yard, which is approximately 20 times the cost of conventional concrete.

The Montana Department of Transportation Bridge Bureau is understandably interested in using UHPC as a field-cast jointing material between precast concrete deck panels and girders in bridge construction. Using this material would decrease the cost of maintenance and lengthen the life of a bridge. At the high cost of proprietary products, it seems reasonable to research and test non-proprietary UHPC mixes, utilizing more affordable materials right here in Montana. The local materials identified for use in the creation of this generic brand include Type I/II Portland cement, class F fly ash, fine masonry sand, silica fume, and high range water reducer (HRWR).

Batch size and mixing performance are factors in the outcome of these blends and were analyzed to determine recommended procedures for the most robust mix design. Recent test mixes developed at Montana State University demonstrated compressive strengths of approximately 20 ksi with flows of 8-11 inches. The mixes were also tested for tensile strength, elastic modulus, and shrinkage.

The final product must also hold up to Montana's harsh elements. During durability tests, the mixes were evaluated for alkali-silica reactivity, absorption, abrasion, chloride permeability, freeze-thaw resistance, and scaling. The mechanical and durability tests performed on the selected UHPC mix demonstrated exceptional mechanical properties and durability of this material.

This level of performance with a price tag of under $1,000 yd^3 has positive implications for the use of more economical locally sourced materials in the construction and maintenance of Montana infrastructure. A second phase of this project will begin soon.

View the full report and related material. For more information on this project please contact Sue Sillick (ssillick@mt.gov, 406.444.7693).

Notice: Research ideas for federal fiscal year 2019 are due March 31, 2018. They should be submitted on the Stage 1: Research Project Idea form.

LIBRARY CORNER

Research Support

"*To select well among old things is almost equal to inventing new ones*" quote attributed to Nicholas Charles Joseph Trublet.

Information management means addressing both the tried and true and the fresh new research sources being offered to us, but knowing about a source is only a small part of a much bigger task. Efficient utilization and comfort with the tools of the trade help to make us more efficient searchers and, as a result, far more informed about the subject at hand.

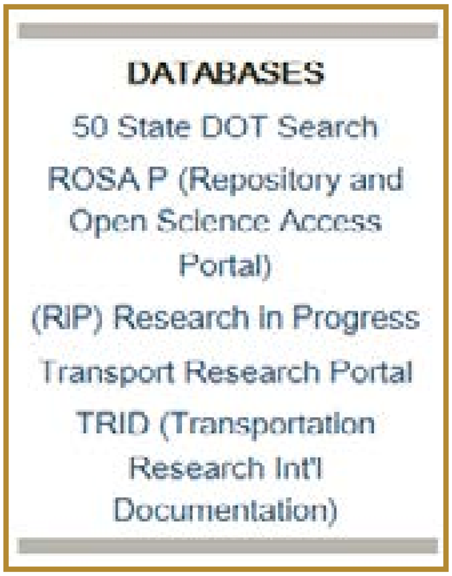
Near the beginning of November, the U.S. Department of Transportation's National Transportation Library (NTL) in the Bureau of Transportation Statistics announced the launch of a new public repository for their collection of over 30,000 items. This resource, the Repository and Open Science Access Portal, or ROSA P is available to both members of the transportation community and the general public. ROSA P is a gateway to open data and publications acquired and managed by the National Transportation Library.

This new point of access is based on an open source platform initially developed by the Centers of Disease Control (CDC). NTL boasts of improved discoverability by employing the use of revised metadata in the search interface. Additionally, each object in the repository has a Digital Object Identifier aiding in the future location of resource material.

The Montana Department of Transportation library catalog contains links to this new resource, ROSA-P, as well as many other databases. One such database is the Research in Progress database (RIP). According to the website, RIP holds information on over 14,000 transportation research projects.

Another database, TRID (Transport Research International Documentation) contains over a million records of transportation research. These originate from state and federal agencies, the Transportation Research Board, University Transportation Centers, and international sources.

These tools are located on the MDT catalog side-bar.



The Montana Department of Transportation library catalog is itself a useful resource, containing FHWA reports, state research reports, and even international publications. The collection includes over 20,500 titles. Over 5,000 of these are electronic resources that provide access from the catalog.

To help combat the overwhelming amount of data sources available to transportation researchers, Rachel Cole of the Northwestern University Libraries developed an electronic guide. Based on the Transportation Research Circular Number E-C194, her guide helps information seekers determine where and how to search. This guide includes examples, tutorials to generate effective literature reviews, annotated bibliography help, tips for data management, and transportation research advice.

Between this guide and many available resources, researchers should be one step ahead in the quest for treasure in the sea of information. Remember, intrepid seekers - if you get stuck along the way, contact the library for assistance as well.

To learn more about library services at the Montana Department of Transportation, please contact Bobbi deMontigny (bodemontigny@mt.gov, 406.444.6338).

DID YOU KNOW?

MDT Research Peer Exchange

On September 12-14, 2017, the Research Section held a peer exchange, which is required as per 23CFR, Section 420.207(b). The peer exchange focused on the implementation of research results, research performance measures, and the value of research. Team members were selected based on responses to a survey on the three focus areas.

The team consisted of participants from the Minnesota, New Jersey, Ohio, Texas, and Utah Departments of Transportation, the Vermont Agency of Transportation, Federal Highway Administration (FHWA) – Montana Division, Transportation Research Board (TRB), Applied Research Associates, and CTC & Associates, who also took notes and wrote the final report.

Prior to the peer exchange, participants were asked to submit questions on the three focus areas. The peer exchange began with each participating organization giving a presentation on the three focus areas. Following the presentations, the questions were discussed. An implementation plan was developed in December 2017 and implementation activities will take place in 2018.

View the final report. For more information on this project please contact Sue Sillick (ssillick@mt.gov, 406.444.7693)

CALENDAR OF EVENTS

February
NCHRP Synthesis Topics Due 2/16
MDT RRC Meeting - 2/23

March
NCHRP IDEA Proposals Due 3/1
TCRP Synthesis Topics Due 3/16
MDT RRC Meeting - 3/27
Montana Research Projects Ideas Due 3/31

April
TCRP IDEA Proposals Due 4/1/17
MDT Stage 2 Research Topic Statements Due 4/30/18

May
AASHTO Spring Meeting - 5/21-5/24
MDT RRC Meeting - 5/30

June
MDT RRC Meeting - 6/27
TCRP Problem Statements Due 6/15

July
MDT RRC Meeting - 7/19
AASHTO RAC Meeting - 7/23 - 7/26

For additional information, please see: http://rppm.transportation.org/Lists/Calendar/calendar.aspx.

NEW RESEARCH REPORTS

Evaluation of Effectiveness and Cost-Benefits of Woolen Roadside Reclamation Products

Feasibility of Non-Proprietary Ultra-High-Performance Concrete for Use in Highway Bridges in Montana: Phase 1 Field Application

Investigation of Prefabricated Steel Truss/Bridge Deck Systems

Rockfall Management System

NEW RESEARCH PROJECTS

Alkali-Silica Reactivity in the State of Montana

Concrete-Filled Steel Tube to Concrete Pile Cap Connections – Further Evaluation/Improvement of Analysis/Design Methodologies

Feasibility of Non-Proprietary Ultra-High-Performance Concrete for Use in Highway Bridges in Montana: Phase II Field Application

Guidelines for Stabilizing Problematic Soils using Calcium-based Stabilizers

Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications

A listing of all past and current research projects can be found at

http://www.mdt.mt.gov/research/projects/sub_listing.shtml

NEW EXPERIMENTAL PROJECTS AND REPORTS

210Sprayroq-SprayWall Polyurethane Applied Lining for Culvert Rehabili-

A listing of all past and current experimental projects can be found at

http://www.mdt.mt.gov/research/projects/exp_sub_listing.shtml

REMINDER

Information on research services and products, such as research and experimental project processes and reports and technology transfer services, can be found on the Research web site at www.mdt.mt.gov/research.

MDT's library collection can be searched through the library catalog. The catalog and other information resources are available through the MDT Library web site.

CONTACT US

Sue Sillick – Research Programs Manager
406.444.7693
ssillick@mt.gov

Craig Abernathy – Experimental Projects Manager
406.444.6269
cabernathy@mt.gov

Bobbi deMontigny – Librarian
406.444.0871
bodemontigny@mt.gov

Alternative accessible formats of this document will be provided upon request. Persons who need an alternative format should contact the Civil Rights Bureau, Department of Transportation, 2701 Prospect Avenue, PO Box 201001, Helena, MT, 59620. Telephone (406) 444-9229. Those using a TTY may call 1(800) 335-7592 or through the Montana Relay Service at 711.

0 copies of this public document were published at an estimated cost of $0.00 per copy, for a total cost of $0.00, which includes $0.00 for printing and $0.00 for distribution