COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

SHRP2 Support
Study No: 3.20

Background

Strategic Highway Research Program (SHRP)/Long-Term Pavement Performance (LTPP) program entered into its second decade beginning in 1998. A portion of the discussions at the national level is now centered on SHRP product implementations. CDOT has also shifted gear and is focusing on product implementation, especially those products that are applicable to CDOT. Over the last few years we have moved some of the LTPP products from concept to full implementation. Among them are the narrower concrete joint design (1/8" wide), the Wider slabs (14-ft. wide) and other innovative technologies such as spray injection patcher for potholes, Georgia-fault-meter for measuring faults at concrete joints, Iowa-vacuum tester to identify leaks and a new distress identification manual (DIM).

As part of the SHRP product implementation, AASHTO enacted the Lead States Program in 1996. The centerpiece of the program is seven Lead State teams responsible for the implementation of a specific SHRP technology at the national level. The teams include states, FHWA, academia, industry representatives, as well as one AASHTO member. The primary objective of the AASHTO lead state program is to provide an avenue for timely implementation of proven SHRP technologies by those states that are in the forefront of a specific technology. CDOT has selected two lead-state teams: Innovative Pavement Maintenance Technologies and Anti-Icing, and Road Weather Information System (RWIS).

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 1/1/89

Principal Investigator(s):
Nichols Consulting Engineers, Inc.-Kevin Senn
775.329.4955

Study Manager:
Roberto DeDios, Research Branch, 303.757.9975

Study Panel Member:

Skip Outcalt, CDOT 303.757-9984

FHWA Washington Contact:
P. Teng, HNR-40

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
02/28/01	100	02/28/01	Coordinate the acquisition of weather data from the SPS-2 and SPS-8 sites near Barr Lake with the SHRP Western Region. SPS-2 and SPS-8 experiments were designed to investigate the effects of various structural and environmental factors on the long-term performance of rigid pavements.
09/30/01	100	09/31/01	Secure funding for participating in a FHWA pooled fund study to examine the practicability of using new equipment for acquiring WIM data at the SPS sites including the SPS-2 site in Colorado.
04//03/03	100	04/04/03	Attend the SHRP/LTPP regional meeting in Reno. Present the status of the LTPP sites and give a presentation on LTPP Product Implementation Activities
07/30/03	100	09/30/03	Investigation of the permeability/drainability of the permeable asphalt treated base (PATB) test sections at the SPS-2 sites at Barr Lake. The investigation will be a coordinated effort between FHWA and CDOT Research.
03//25/03	100	03/25/03	Establish an FWD Calibration Center in Region 6

08/30/03	100	08/30/03	Meet with the representatives of FHWA, CDOT's Chief Engineer, to discuss the status of the LTPP Studies in Colorado
09/15/03	100	10/23/03	Investigation of the LTPP sites on US 40 West of Lay, I70 at Rifle, SH 24 at Manitou Spring, and SH 50 at Delta acquiring 4 and 6 inch cores
09/28/04	100	02/15/05	Conduct lab testing on the acquired 6-inch cores for the sites at Lay, Rifle, Manitou Spring, and Delta.
01/31/04	100	04/15/04	Submit Rehabilitation data sheet for the LTPP sites at Rifle and Lay.
06/30/05			Annual field review of all the SHRP sites in Colorado. Marking and replacing missing signs.
04/30/04	100	03/25/04	Provide estimated traffic (sheet 10) and if available monitored traffic data for all the in-service sites to the SHRP/LTTP Western contractor.
12/30/04	100	06/30/05	Coordinate with FHWA to evaluate the condition of the WIM equipment for the SPS-2 site at Barr Lake and decide on a course of action to install a bending plate or just use the existing WIM (piezo- electric cables).
5/15/06		5/15/06	Bending plate WIM equipment was installed by IRD on I-76 at MP 39.7 near Keensburg for monitoring the traffic and truck weights for the SPS-2 site.
3/15/07	100		Coordinate with SHRP Western Region in acquiring core samples and bulk sample of subgrade, and base for some of the SPS-2 test sections on I-76 near Barr Lake. Decisions need to be made as who pays for this field investigation.
3/31/07	100	3/12/07	PI to submit sampling of materials at SPS-2 Site (I76 and Barr Lake). Nichols Consulting has been chosen by FHWA to conduct the sampling. Roberto de Dios is working with Nichols Consulting regarding traffic control for the coring and sampling activity. The revised Material Sampling and Testing Plans for LTPP SPS-2 and LTPP SPS-8 Projects were e-mailed to Skip and Roberto on 03/12/07.
7/25/07	100	N/A	Participate in the TRB Expert Task Group (ETG) committee for the LTPP Materials data collection and analysis in October 2005. The ETG is charged with setting priorities and work plan for data collection and analysis, technical assessment of ongoing work and recommendation to enhance the success of the LTPP products. With the retirement of Ahmad Ardani, CDOT will no longer have a representative on this ETG.
8/31/07	100	9/21/07	Perform another round of LTPP data collection. Nichols Consulting was hired by FHWA for this job.
01/13/08	100	01/13/08	Roberto de Dios attended the LTPP Coordinators sessions at the TRB annual meeting.
12/31/10	100	12/01/10	Conducted FHWA LTPP Visit

SIGNIFICANT EVENTS

09/19-30/11 LTPP data collection activities for Specific Pavement Studies (SPS) sites were performed by the consultant personnel (Nichols Consulting Engineers, Inc.) during this quarter.

05/24/11 CDOT Field Test Engineer Skip Outcalt provided the requested information that was available at that time.

04/17/11 The Principal Investigator Kevin Senn of Nichols Consulting Engineers, Inc. solicited input on rehabilitation and maintenance activities on active LTPP test sections for the next two years.

01/11 FHWA held LTPP Coordinators' meeting and had LTPP sessions on leveraging the LTPP experience to collect quality weigh-in-motion (WIM) data.

12/01/10 FHWA and Nichols Consulting Engineers (NCE) conducted the Long-Term Pavement Performance (LTPP) seminar at the Turnpike Conference Room in Materials Lab building.

09/30/10 Nichols Consulting Engineers (NCE) in coordination with FHWA and CDOT sent a draft of the agenda for the FHWA LTPP seminar/meeting between CDOT and FHWA/Consultant scheduled on December 1, 2010.

06/30/10 Nichols Consulting Engineers initiated coordination of FHWA visit to promote LTPP program

03/31/10 No activity this quarter.

12/31/09 No activity this quarter.

9/30/09 The budgeted amount for this project under the WBS 90050 needs to be rolled forward to a new WBS number. The 90050 account needs to be closed. The new WBS account will be used for SHRP2 project activities. No significant activity was reported by the consultant for this quarter.

6/30/09 No activity by the consultant was reported for this year.

03/31/08 The assessment, calibration and performance evaluation of LTPP SPS Weigh-In-Motion (WIM) Site ID 080200 is scheduled on April 29, 2008. Barbara K. Ostrom, Principal Investigator of MACTEC Engineering and Consulting, Inc., 12104 Indian Creek Court, Suite A, Beltsville, Maryland 20705, Phone:301-210-5105 scheduled the site visit and evaluation meeting.

12/31/07 Samples cored from the SHRP test location (SH 40) were brought to the Staff Materials and Geotechnical Branch Lab for testing and analysis. CDOT Lab personnel are testing these samples.

9/21/07 Nichols Consulting Engineers performed the required coring and data collection for the Long-Term Pavement Performance (LTPP program). CDOT sent check to FHWA in the approximate amount of $32k to cover the cost of coring job.

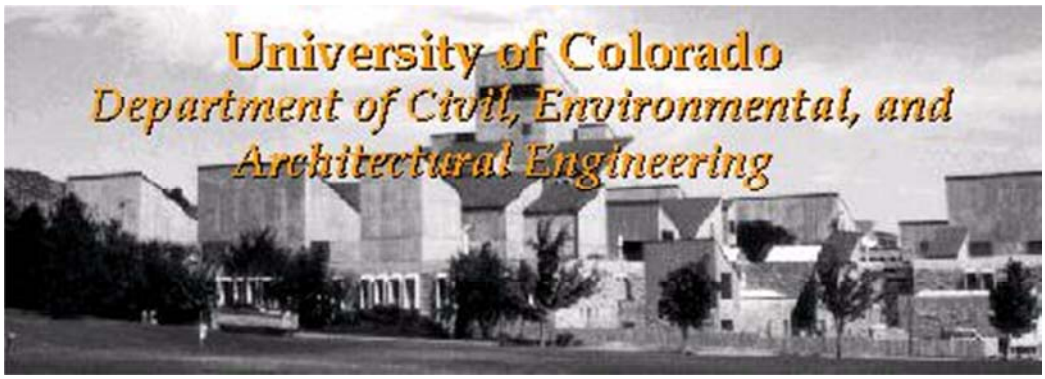
6/30/07 It was confirmed that approximately $75k is left unspent in FY07. This money has to be rolled forward and must be approved by the Transportation Commission before it becomes available again to be spent. Kevin Senn of Nichols Consulting Engineers indicated that his company cannot do the coring as this is not part of the scope of work that is stipulated in their contract with FHWA. CDOT has no manpower/equipment to do the coring in-house specially the 12-inch cores. CDOT needs to contract out this work using the unspent SHRP program money. CDOT requested Nichols Consulting Engineers to submit an estimate of the coring work. The estimated cost of coring is $34k.

3/12/07 Kevin Senn of Nichols Consulting Engineers estimated that 16 days of traffic control will be required for 11 locations in 2007 and 7 days of traffic control will be needed in 2008. Latest information from the Division of Transportation Development (DTD) indicates that approximately $75k appears to be remaining in the budget. Roberto de Dios has to double check the actual amount left. In the revised Materials Action Plans for both SPS-2 and SPS-8 projects, a total of sixty one (61) 4-inch cores and eighteen (18) 12-inch cores will be required to complete this round of testing.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Colorado Local Technical Assistance Program (LTAP)
Study No: 4.50

Background	Reporting Period 7/1/11 through 9/30/11 Type: SP&R Start: Ver:
The Colorado LTAP Center is part of the nationwide FHWA LTAP program aimed at providing technology transfer and exchange of transportation information to local communities. In all, there are over 57 LTAP programs in the United States, with at least one LTAP Center in each state. Providing training for rural and urban transportation communities is the number one priority of Colorado LTAP. Colorado LTAP is administrated in partnership with the FHWA by the Colorado Department of Transportation (CDOT). Funding for the program is as follows: FHWA (50%), CDOT (25%), and the University of Colorado at Boulder (25%).	Principal Investigator(s): Yunping Xi, University of Colorado/Boulder (303)-492-8991 Study Manager: Joan Pinamont (303) 757-9972 Study Panel Members: Joan Pinamont, CDOT (303) 757-9972 Rick Santos, FHWA



COLORADO LTAP

LTAP Program Assessment Report

Report Period
July 1, 2011 – September 30, 2011

Submitted to:
Federal Highway Administration
Colorado Department of Transportation
University of Colorado at Boulder

Submitted by:
Colorado LTAP
3100 Marine St A-211
UCB 561
Boulder, CO 80309-0561
303-735-3530

Table of Contents

Colorado LTAP

1st Quarter

July 1 – September 30, 2011

Program Dashboard:

Total number of training sessions*: 3
Total number of participants*: 72
Total number of participant hours*: 504
Total newsletter circulation: 1,609 (hard-copy), 155 (electronic)
Total number of LTAP FTEs: 2.25
(Only for classes held between July and September 30.)

A. Program Administration

- Colorado LTAP still remained without a web master this quarter. However, we have been working with the ND LTAP web designers to take over the service. A new grad student started working part-time this semester – Yu-Chang Liang. Due to University policy on temporary aid workers, Office Assistant-Marty Butcher will not be able to return until October.
- Program Director, Renée Railsback, was out of the office for 3-weeks in September for her wedding and honeymoon.
- The University of Colorado voted to provide all faculty and classified staff with a 3% raise, the first in several years. The increase will not appear until October 31, 2011.

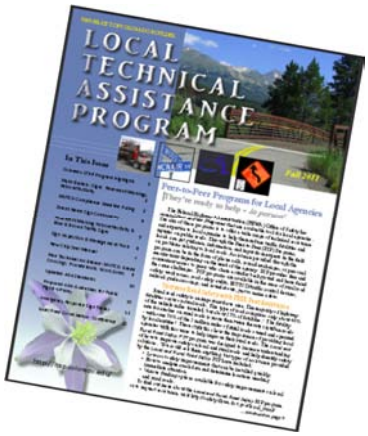
B. Training

- Colorado LTAP began fall courses in its two training programs – *Roads Scholar I* and *Supervisory Skills and Development Program.* In the 3 classes held, there were 3 Roads Scholar graduates that received their plaques this quarter - Chance Harmon - Teller County, John Hardy - City of Golden, and Tim Cose - Garfield County. There was one Supervisory Skills course (Legal and Liability Issues) that was schedule for September in Grand Junction, but had to be canceled due to lack of registrations. This class may be rescheduled to a more convenient date. The following are the classes held in the first quarter, July 1 – September 30, 2011.

Worker/Workplace Safety

Session Name	Session Length [hours]	Total # of Sessions	Total # of Participants					Total # of Participants	Total Participant Hours
			Local	Tribal	State	Federal	Other		
Chainsaw Safety	7.00	3	71	0	0	0	1	72	504
Total	7.00	3	71	0	0	0	1	72	504

C0.1 Newsletter & Information Exchange



Two tools utilized for technology transfer and information exchange include our quarterly newsletter publication and free lending library.

- We strive to develop newsletter content to educate transportation personnel, and produce enhanced maintenance, workforce and safety outcomes. Topics covered in the Fall issue of the newsletter included articles on *Peer-to-Peer Safety Programs Free for Local Agencies; Colorado LTAP 2010-2011 Program Highlights; Myth Busters: Signs, Pavement Markings Retroreflectivity; MUTCD Compliance Deadline Ruling; Street Name Sign Controversy; Blue & Brown Traffic Signs; Sign Inspection & Management Tools; New Chip Seal Manual; Free Technical Assistance: MUTCD, Grade Crossings, Roundabouts, Work Zones; Updated ADA Standards; Proposed ADA Guidelines for Public Rights-of-Way; Emergency Response Sign Trailer;* and *Local Road Coordinators' Conference*.

Circulation

Name of Newsletter	Circulation				
	Local	Tribal	State	Federal	Other
Colorado LTAP - Fall	1,117	10	147	64	426

Number of Articles per Focus Area

Newsletter Issue	Safety			Workforce Development	Infrastructure Management
	Highway	Worker	Work Zone		
Fall 2011	5	0	1	2	2

C0.2 Library Materials Distribution

- Continued to manage our in-house lending library consisting of over 2400 items - instructional videos, publications, and resources focusing on transportation design, maintenance, safety, and workforce related topics. Between July 1 – September 30, 42 items were loaned free to local transportation agencies. The table below shows the distribution by type and focus area. Separate from the lending library, we also distributed 45 free publications, guidebooks and videos.
- The most frequently loaned titles included: *Road Crew Safety: Safe Practices; Road Construction/Paving Crews; Snow Removal Techniques: Plowing Tips from the Pros; Working Safely with Snow Plows and Other Snow Removal Vehicles;* and *21 Ways To Defuse Anger And Calm People Down; and Trenching & Shoring Safety*.
- 52 different titles of new or additional materials were added to the library in the 1st quarter including – *2011 Traffic Sign Retroreflective Sheeting ID Guides; Industrial & Agricultural Mower Safety Practices; Customer Driven Service in Transit-Instructor's Guide; 2011 Guidelines for Temporary Traffic Control; and Hollow Bar Soil Nails* to name a few.
- About $400 was spent on Free Publications printing, and about $160 was spent on postage for mailing loaned materials.

Pub Type	Highway Safety	Infrastructure Management	Worker/Workplace Safety	Workforce Development
Book	1	2	0	0
Bulk Material	0	0	0	0
CD	0	1	0	1
DVD	5	3	7	6
Free Publication	18	21	3	3
Software	0	0	0	0
Video	2	4	9	1

C0.3 Program Marketing, Outreach & Research

The Program Marketing, Outreach and Research portion of our work plan covers a spectrum of daily tasks related to technical assistance, local agency outreach, program marketing and promotion, and field research. We find making personal contact is an invaluable opportunity to assess local agency needs and challenges.

Program Marketing & Outreach

- Colorado LTAP provided a booth of educational, promotional and free library materials at a select few transportation meetings and conferences that benefit the scope of the program – including the APWA Snow & Ice Conference in Estes Park this quarter. These opportunities also help to advance staff knowledge base on the latest transportation technologies, processes, and resources.
- Stock photos were purchased for LTAP designed print materials and Newsletter graphics.
- 10 dozen LTAP logo safety construction gloves were purchased for distribution to training program graduates and at conferences.

Technical Assistance

LTAP center staff spent about 25% time providing technical assistance to local agencies. Examples of technical assistance provided this quarter included requests for help in reviewing field services guides, and answers to recent changes in MUTCD rulings.

C0.4 Out-of-State Travel

FHWA encourages centers to participate in the activities of state, regional, and national organizations such as the National LTAP Association (NLTAPA), and to participate on NLTAPA work groups and committees when appropriate. NLTAPA helps expand the capacity of each Center to best meet customer needs by developing local agency resources for Center use, building awareness about LTAP amongst the transportation community, providing Centers a voice in Washington, and assisting FHWA in developing future strategies for the Program.

- In July, Renée and Lindsay attended the National LTAP-TTAP Conference in Boston. This conference offers many peer learning opportunities, and has sessions geared specifically to different levels of LTAP staff. Renée and Lindsay both submitted entries into the Poster

Session; and Renée presented in several sessions on: HSM Update, SHSP Peer Exchange, Sign and Pavement Marking Retroreflectivity, and EDC Safety Edge Implementation.

- At the National LTAP conference, Renée was voted in as the new NLTAPA Vice-President. As the VP, she will transition from being the Safety Chairperson to the External Communications Chairperson on the NLTAPA Executive Committee. In this role, she will handle issues relating to reauthorization, and providing resources for centers to educate legislatures on the benefits of the LTAP-TTAP programs.

C.1 Safety Programs

Center staff worked on several initiatives to bring national and local attention to the importance of improving safety on our local and rural road system.

- Renée presented in several safety sessions at the National LTAP Conference in Boston; and organized a full-day Safety workshop for FHWA.
- Renée was invited to present a 2-hour safety session at the Mesa County Safety Fair in August. It was very well received.
- Three Chainsaw Safety courses were provided around the state. This class always receives rave reviews – including compliments from the US Forest Service chainsaw instructors in attendance.

C.2 Infrastructure Management

- Between July 1 – September 30, most of the work in this focus area occurred under training development.
- Center staff responded to several technical assistance requests in regards to transportation infrastructure topics.

C.3 Workforce Development

- Several articles to promote Workforce Development were provided in the newsletter this quarter.
- Registration brochures were designed, printed and distributed for the LTAP Region 7 *Local Road Coordinators Conference* in Rapid City, SD in October.
- Colorado "You Show Us" contest entries were collected from local agencies. The two submissions received this year were provided to the LTAP Advisory Board for selection of the state winner. The *Sign Repair Stand* submitted by the City of Cherry Hills Village was selected as the winner and their project was submitted to compete in the Regional "You Show Us" contest. The regional winner and state awards will be announced at the Local Roads Conference in October.
- Save-the-Date postcards were designed, printed and distributed for promotion of the upcoming 2012 Street Conference in Grand Junction.

C.4 Operational Excellence

- The Colorado LTAP Advisory Board did not meet in person this quarter. However, the committee was convened via email to review and select the state winner of the "You Show Us" contest.
- Colorado LTAP staff held one monthly meeting this quarter with FHWA, CDOT and CU managers in August. The group discussed the fiscal year financial wrap up, the National LTAP conference, results of the AASHTO SHSP Peer Exchange, Summer Newsletter, You Show Us contest, fall training, local project administration, safety presentations, and center staffing.
- We did not have a website designer this quarter, however, we have been working with the webmaster from the ND LTAP to try and work out an agreement for contracted services.
- The only equipment expenses this quarter were related to lease and meter readings of the office copier/printer.
- Additional expenses in this category were for office supplies and campus parking.

Financial Report

- Total program expenses for July 1, 2011 – September 30, 2011 are included in Appendix A. The attached itemized categories list shows a positive balance of $2,702.76, however, not all training and operational expenses (telephone, etc) have been posted.

Appendix A: Total Program Expenses July 1, 2011 – September 30, 2011

Itemized Categories

7/1/2011 through 9/30/2011

Date	Memo	Tag	Amount
INCOME			**60,625.55**
1. SPONSOR REIMBURSEMENTS			**60,625.55**
a. CDOT Reimbursement			**59,625.00**
7/31/2011	July'11		19,875.00
8/31/2011	August'11		19,875.00
9/30/2011	September11		19,875.00
c. Class Registration Fees			**1,000.55**
c1. Deposits			**1,025.00**
c2. Credit Card Charges			**-24.45**
EXPENSES			**-57,922.79**
A. PROGRAM ADMINISTRATION			**-38,771.44**
A1. Administration Costs			**-30,060.30**
A2. Program Administration Fee			**-8,711.14**
B. TRAINING PROGRAM			**-9,526.40**
B1.1 Training			**-9,526.40**
a. Roads Scholar			**-9,007.87**
b. Supervisory Skills			**-518.53**
C.0 GENERAL			**-6,761.36**
C0.1 Newsletter & Information Exchange			**-2,374.83**
9/15/2011	Fall Mailing, M42058 (1545887)	Mailing	-497.30
9/13/2011	Fall Printing, P42082	Printing	-1,877.53
C0.2 Library Services			**-574.80**
C0.3 Prog Marketing Outreach Research			**-1,007.11**
C0.4 Out-of-State Travel			**-2,804.62**
3.National LTAP Meeting			**-2,804.62**
C.1 SAFETY PROGRAMS			**-286.75**
C1.1 Public Safety Awareness			**-286.75**
8/25/2011	Present at Mesa County Safety Fair (15...	Travel Reimburs.	-286.75
C.3 WORKFORCE DEVELOPMENT			**-1,258.64**
C3.2 Local Roads Conference			**-1,133.24**
9/8/2011	Local Roads Conference Brochure, M4...	Mailing	-461.57
9/8/2011	Local Roads Conference Brochures, P...	Printing	-671.67
C3.3 APWA Conf Admin & Library Matls			**-125.40**
C.4 OPERATIONAL EXCELLENCE			**-1,318.20**
C4.1 Information Technology Services			**-292.17**
C4.2 Equipment			**-455.27**
C4.3 Office Supplies			**-520.76**
C4.8 Program Parking			**-50.00**
Balance Forward			**0.00**
		OVERALL TOTAL	**2,702.76**

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Durable Wearing Surfaces for HMA
Study No: 10.37

Background	Reporting Period: 7/1/11 through 9/30/11 Type: SP&R Start: 09/01/02 Ver: 12/31/02
The Colorado Department of Transportation spends a large sum of money each year on the design and placement of new asphalt pavements. Inevitably, these pavements will need rehabilitation. Wearing surfaces provide an alternative to CDOT's current rehabilitation strategies. A pavement design system incorporating wearing surfaces will both protect the existing pavement structure and provide a quality overlay system for all pavements. A durable wearing surface is essential for preserving CDOT's investment in its paving program. The wearing surfaces will be evaluated on an annual basis at eleven sites: Five SMA sites, three Nova chip sites and three SHRP SuperPave SX sites. The test sites will have their ruts measured, cracks mapped, general condition visually evaluated and the skid number and texture depth measured using the CDOT Pavement Friction Test System (skid truck and trailer).	Principal Investigator(s): Skip Outcalt, Research 303-757-9984 Dave Weld, Research 303.512.4052 Study Manager: Skip Outcalt (303)-757-9984 Study Panel Members: Bill Schiebel, Region 1 Materials Dave Eller, Region 3 Materials Jay Goldbaum, Materials and Geotechnical Branch

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
		7/02	Request projects from regions to include in research study.
9/02		9/17/03	Monitoring of OGFC and SMA construction on I-70 near Genesee.
9/02		9/02	Monitoring of Nova Chip Construction in Region 3.
10/03		9/24/03	Construction field notes for OGFC placement on I70 near Genesee.
10/03		9/17/03	Annual evaluation of test sections
3/03		12/1/03	Notes documenting the construction and first year evaluation of the Region 3 NOVA chip project.
11/05		11/05	Annual evaluation of test sections.
11/08		11/08	Annual evaluation of test sections. This was delayed due to malfunction of the skid tester.
12/09			Draft Final Report. (May be adjusted pending decision of panel)
12/11			Publish final report.

SIGNIFICANT EVENTS

09/11: Site evaluations for 2011 in progress

09/10: Site evaluations for 2010 continue

06/10: Site evaluations for 2010 in progress

12/09: Site evaluations completed for 2009

10/09: Site evaluations are in progress.

12/08: Site evaluations have been completed.

08/07: Skid equipment is functional and site evaluations have begun.

11/06: Problems with the Skid testing equipment and weather made it impossible to evaluate the test sections during the fall of 2006. The testing will be done in July and August of 2007.

11/05: This study is now being handled by Skip and Dave. Eleven test sites were established and evaluated. The evaluations found no significant developments at any of the sites.

03/05: The study panel members for this study met and as a result expanded the scope of the study to cover more sites. There are now 10 sites for this study which covers: SMAs, Nova chips, SHRP SuperPave SX mixes.

12/1/04: Region 1 decided to cover up the OGFC test section due to problems with icing.

7/31/04: The principal investigator, Donna Harmelink, has retired.

9/17/2003: An open graded friction course (OGFC) section and a stone matrix asphalt (SMA) section were constructed in Region 1 on I-70 near Genesee and are being evaluated under this project.

10/2002: A Nova Chip project was constructed in Region 3 on SH82 north of Aspen and is being evaluated under this project.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Participation in Southeastern Superpave Center
Study No: 10.40

Background

In 1992, following 5 years of research and testing, the Strategic Highway Research Program (SHRP) introduced the Superpave system. The Superpave system included new specifications, test procedures and testing equipment for building more durable asphalt pavements. Five Superpave Regional Centers were established to provide technical leadership, assistance and training to highway agencies during the implementation of the Superpave system.

One of the Superpave centers established is the Southeast Superpave Center. This center is located at National Center for Asphalt Technology (NCAT), Auburn University in Auburn, Alabama. This Center has a well-qualified and educated staff. The Center has been responsible for a number of research studies. Some of the studies include: permeability characteristics of coarse-graded Superpave mixes, development of mix design criteria for 4.75 mm mixes, case studies of the tender zone in coarse-graded Superpave mixes, development of critical field permeability and pavement density values for coarse-graded Superpave pavements, evaluation of OGFC mixtures containing cellulose fibers, evaluation of the effect of flat and elongated particles on the performance of HMA mixtures and permeability of Superpave mixtures; evaluation of field permeameters. Currently, NCAT is performing the monitoring for the warm mix asphalt (WMA) experimental feature on I-70, west of Eisenhower Tunnel in Region 1. Three WMA additives are being evaluated in this research project.

The products of this research may include the development of specifications, practices, and equipment to help build and extend the service life of a hot mix asphalt pavement.

Reporting Period 7/1/11 through 9/30/11
Type: SP&R Start:7/03 Ver:

Principal Investigator(s):
Dr. Randy West/Donald Watson, NCAT

Technical Panel Leader:
Bill Schiebel, Region 1 Materials
(303) 398-6801

Study Panel Members:
Jim Zufall, Materials and Geotechnical Br.
Stephen Henry, Materials and Geotechnical Br.
Jay Goldbaum, Materials and Geotech. Br.
Richard Zamora, Region 2 Materials
Rex Goodrich, Region 3 Materials
Gary Dewitt, Region 4 Materials
Michael Coggins, Region 5 Materials
Masoud Ghaeli, Region 6 Materials
Donna Harmelink, FHWA

Research Study Manager:
Roberto DeDios, CDOT Research
(303) 757-9975

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
06/12/04	100	07/30/04	Tim Aschenbrener, Jay Goldbaum, Bob Laforce, Bob Mero and Donna Harmelink met to discuss the possibility of developing a study to conduct noise evaluation on pavements in Colorado. It was decided that the evaluation this fall would be conducted by NCAT with their Close-Proximity Noise Trailer. Each year a summary of the data would be provided to CDOT. After the final evaluation a final report will be written that documents the performance of each of the evaluation sections.
10/18/04	100	10/18/04	NCAT will measure noise levels using the close proximity method on 21 sites.
12/31/04	100	4/08/05	NCAT will provide a report regarding noise levels measured and compare measurement from the 17 sites the previous year.
06/30/05	100	07/05	Draft final report was accepted and loaded into CDOT Research Branch website.
10/12/05	100	10/18/05	NCAT performed (Close Proximity Testing) CPX noise measurements in same locations as last year.

06/30/06	100	11/06	NCAT completed the final report for 2005 noise measurements. The report was accepted and loaded into Research Branch website.
10/31/07	100	9/30/07	NCAT plans to complete another round of noise measurements and may perform other types of research services or projects for CDOT.
9/30/08	100	9/30/08	Perform warm mix asphalt pavement distress survey.
11/17/09	100	11/17/09	Perform warm mix asphalt pavement distress survey.
9/30/10	100	10/15/10	Perform warm mix asphalt pavement distress survey.
12/31/11	100	11/01/11	Submit final report for the assigned research project (WMA report) completed.

SIGNIFICANT EVENTS

09/30/11 Comments to the draft report were provided by Region 1 Materials Engineer, Bill Schiebel.

06/30/11 No activity was reported during this quarter.

03/02/11 Dr. Randy West of NCAT gave an electronic copy of the draft report on WMA research to Roberto DeDios. Region 1 Materials Engineer, Bill Schiebel will review and provide comments.

10/15/10 The National Center for Asphalt Technology (NCAT) and CDOT performed the final distress survey of the warm mix asphalt (WMA) test sections in I-70 from Mileposts 208 to 211.

09/30/10 Region 1 Materials Engineer Bill Schiebel scheduled a pavement distress survey of WMA test sections on I-70, west of Eisenhower Tunnel on October 15, 2010.

06/30/10 No work was reported for this quarter.

03/31/10 No work was reported for this quarter.

11/17/09 Performed pavement distress survey on WMA test sites on I-70.

09/30/09 No work was performed for this quarter. A new pooled-fund study for this effort is being set up for the next three years with the Alabama DOT as the lead agency. The pooled-fund transfer process is currently being done by the Office of Financial Management and Budget (OFMB). NCAT is currently involved in evaluating Region 1 warm mix asphalt (WMA) experimental project built on I-70 west of Eisenhower Tunnel.

06/30/09 No work was performed this quarter.

12/31/08 No work was performed this quarter.

09/30/08 The draft report is still being reviewed by the Study Manager for final editing by the CDOT Librarian before uploading into the branch web site.

06/30/08 The draft report is still being reviewed by the appropriate Research Branch staff before uploading into the branch website.

02/11/08 The Research Implementation Council (RIC) approved the continued annual funding in the amount of $20k for Southeast Superpave Center/NCAT research activities.

10/02/07 NCAT submitted the draft final report for the CPX noise measurements project involving 30 test sites. The review of the draft report by the technical panel is still under process.

9/30/07 NCAT completed the CPX noise measurements for 30 sites that Transtec Group is also doing.

7/07 to 8/07 NCAT personnel participated in monitoring the Warm Mix Asphalt (WMAs) installations carried out by Region 1 on I-70 west of the Eisenhower Tunnel.

6/30/07 NCAT is in the process of conducting the noise study using the close-proximity trailer test that was planned for calendar year 2006. Also, NCAT is currently doing the Warm Mix Asphalt (WMA) experimental research project on I-70 in Region 1. NCAT will have the responsibility of monitoring, collecting data, documenting the placement of WMA additives consisting of Aspha-min, Sasobit, and Evotherm.

3/20/07 Communication with Don Watson of Auburn University indicated that the $20k approved by the RIC for participation in Southeastern Superpave Center should be contributed to the pooled-fund no. TPF 5-037. As soon as the contribution is made to this fund, NCAT should be able to proceed with the noise testing as well as other asphalt/pavement-related research needed by CDOT.

3/02/07 The DTD Director and Chief Engineer approved the entire Research Branch Program which included the $20k pooled-fund money for participation in Southeastern Superpave Center.

1/29/07 The Research Implementation Council (RIC) approved $20k funding for participation of CDOT in the pooled-fund research effort of the Southeastern Superpave Center/National Center for Asphalt Technology.

11/06 The final report for the tire-pavement noise data collected by NCAT for the year 2005 was completed and loaded into CDOT Research Branch website.

6/06 NCAT was reminded to submit the final report that incorporates the recommended changes from the research study panel but NCAT never responded.

5/06 NCAT submitted the draft final report for review and comment. The draft report was reviewed by the research panel members and comments were transmitted back to NCAT for incorporation into the final report. The revised final report has not been received until the end of this quarter's reporting period.

2/06 NCAT promised to deliver the draft final report. The draft final report has not been received by the end of the first quarter of 2006.

12/15/05 NCAT indicated that it will send the preliminary noise data in 01/06. The analysis is almost complete. CDOT requested NCAT to deliver one updated report that included all the data collected in the past and the year 2005.

10/03/05 Research Coordination Engineer Rich Griffin notified NCAT to go ahead with another round of noise measurements for Colorado Noise Study this year.

6/16/05 The revised draft final report was submitted by NCAT. The draft final report is being reviewed and processed for final publication, distribution, and uploading into the CDOT Research Branch website.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Longitudinal Joint Density
Study No: 10.155

Background

The longitudinal joint between asphalt mats is a major area of pavement distress. During the placement of asphalt pavement it is difficult to compact the unconfined edge, which typically results in lower densities than in the remainder of the asphalt mat.

The inconsistent quality of the longitudinal joints in hot mix asphalt pavements was a concern with both the asphalt industry and CDOT and eventually was identified by the Chief Engineer to be addressed. A task force effort was identified and the direction of the task force was to develop an end result specification based on density at the longitudinal joint.

In 2000, the longitudinal joint construction on 7 projects was monitored to determine the state of the practice for the construction of the longitudinal joints. The construction method and density at the joint and adjacent mat was documented. A minimum of seven projects constructed under the new longitudinal joint density specification will also be monitored for comparison to the joints in the projects from 2000. In 2005 7-12 new sites will be recruited, at least one for each regions. SMAs are also included in the study.

Reporting Period 7/1/11 through 9/30/11
Type: SP&R Start:7/03 Ver:

Principal Investigator(s):
DTD Research Branch
Dave Weld, Research 303.517.4052

Study Manager:
Roberto DeDios, Research 303.757.9975

Study Panel Members:
Bill Schiebel, R1 Materials 303.398.6801
Donna Harmelink, FHWA 720.963.3021

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
6/05		9/15/05	Approximately, two sites from each region will be identified for incorporation into this study, one of which may be an SMA.
9/05		10/15/05	Establish 10 test sections. Acquire 10 cores at 5 locations in a 1000 foot test section, one on the center of the joint and one on the hot side. Deliver the cores to staff materials for density. Review and document any distresses at the site. Only 8 test sections established.
06/06	100	12/31/06	Materials Lab testing of cores
9/06	100	6/30/07	Review and document any distresses at the site.
9/11			Review and document any distresses at the site.
12/11			Final report will be written documenting final performance and the impact the new specification on the quality of longitudinal joints.

SIGNIFICANT EVENTS

9/30/11 No activity during this quarter.
6/30/11 No activity during this quarter.
3/31/11 No activity during this quarter.

12/31/10 No activity during this quarter.
09/30/10 Dave Weld conducted a field inspection and took photos of the various test sites during this quarter to document any observed distresses in the pavements.
06/30/10 No activity during this quarter.
03/31/10 No activity during this quarter.
12/31/09 No activity during this quarter.
09/30/09 No work was performed during this quarter.
06/30/09 No work was performed during this quarter.
03/31/09 No work was performed during this quarter.
12/31/08 No work was performed during this quarter.

09/30/08 The monitoring and documentation of the test sections are in process.

06/30/08 The monitoring and documentation of the test sections are in process.

03/31/08 The monitoring and documentation of the test sections are in process.

12/31/07 The documentation of the test sections is ongoing.

9/30/07 The documentation of the test sections is still in progress.

6/30/07 The visual survey of the remaining sites to be evaluated is underway.

3/31/07 Powers Blvd. was dropped from the 8 test sections being monitored because it was milled. Four sites had been visually inspected and no distresses related to longitudinal joint failure were observed. No cracking and rutting were noted. Photos for these four sites are shared in Dave Weld's PC. The visual survey or evaluation of the other three sites is planned to be completed sometime in June of this year.

1/01/07: Roberto de Dios took over as Study Manager for this project.

06/30/06: The principal investigator, Ahmad Ardani, retired June 1, 2006.

03/31/05: The scope of work was revised and Research is now soliciting two sites from each region to incorporate into this study. These sites may include SMAs.

7/31/04: The principal investigator, Donna Harmelink, has retired.

12/31/04: The Materials Engineer and the Materials Advisory Committee discussed the lack of projects available for evaluation in 2004 and set a target of seven projects in 2005.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Investigation of the Benefits from Utilizing Small Aggregates for Seals on Hot Mix Asphalt (HMA) Roadways
Study No: 12.72

Background

Many existing highways in Colorado are far from ideal HMA aggregate sources. Often due to the high cost of aggregate transportation to these areas, highway pavements are not timely preserved. An additional maintenance or rehabilitation treatment for HMA pavements is needed to help preserve deteriorating roadway structures until funding is secured for traditional resurfacing projects. Several river basins in Colorado exist that may provide aggregates that with minimal processing may extend the serviceable roadway life in a value-added analysis.

The Nebraska Department of Roads (NDOR) has developed specifications for an aggregate application referred to in NDOR context as "Armor Coat." The application is a generic term which generally refers to an emulsion-aggregate combination with aggregate derived from river sources such as the North or South Platte River. It is commonly applied by NDOR maintenance personnel utilizing standard "chip seal" equipment. The aggregate size is generally 3/8 inch.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 03/30/09

Principal Investigator(s): Dr. Scott Shuler, CSU
970-491-2447

Technical Panel Leader:
Gary DeWitt, CDOT R-4 Materials
970-350-2379

Study Panel Members:
Masoud Ghaeli, CDOT R-6 Materials
Rex Goodrich, CDOT R-3 Materials
Donna Harmelink, FHWA Colorado Division
Stephen Henry, CDOT Materials and Geotechnical Branch
Gary Strome, CDOT R-4 Materials

Research Study Manager:
Robert de Dios CDOT-DTD Research
303-757 9975 roberto.dedios@dot.state.co.us

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
3/31/09	100	3/31/09	Notice to proceed
7/31/09	100	3/31/10	Task 1 – Literature Review
8/31/09	100	6/30/09	Task 2 – Activity Plan and Schedule
3/31/13	100	6/30/10	Task 3 - Execute Activity Plan
3/31/13	0	9/30/11	Task 4 – Final Presentation
3/31/13	70	9/30/11	Task 5 – Quarterly Progress Reports
3/31/13	0		Task 8 – Final Report

SIGNIFICANT EVENTS

9/30/11 No work was planned or conducted in the third quarter. Field condition surveys will continue in the second and fourth quarters. The next condition survey is scheduled for the fourth quarter of 2011.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Longitudinal Joint Tie Bar System
Study No: 20.60

Background

Adequate longitudinal joint tie bar system is essential in the overall performance of concrete pavement. Tie bars if installed properly prevent the joints from opening and improve load transfer efficiency (LTE) between slabs and between slabs and shoulders, resulting in increased load carrying capacity. Many transportation agencies have been experiencing excessive longitudinal joint openings and faulting, which are believed to be attributed to improper tie bar installation or inadequate tie bar diameter. Whatever the reasons, excessive joint opening in addition to being a detriment to longevity of the pavement, could impose hazardous driving conditions for vehicles, motor cycles and bicycles.

Recommended diameter sizes and spacings for tie bars vary from one state to another. The predominant diameter of deformed tie bar used today is 0.625 inch or #5 bars with Grade 40 steel or higher. Currently, only six (6) states use No. 4 bars and ten (10) states use No. 6 bars. The spacing of the bars is predominantly 30 inches, with a few Departments of Transportation (DOTs) using shorter (18 to 24 inches) and longer (36 to 48 inches) spacings. In addition, tied multi-lane highways have become more prevalent in urban setting, increasing the width of the concrete pavement to over 60 ft. Because these wide concrete pavements are not monolithically laid, they could contract and expand at a different rate inducing stresses that may be detrimental to longevity and overall performance of concrete pavements. There is no specific guidance on the optimum diameter size or spacing required for tie bars and on the maximum number of lanes that can be tied together before extreme stresses could develop. It should be noted that what has been successful in the past is not necessarily optimal or reliable in a variety of future situations. Thus, there is a need for reevaluating the longitudinal joint tie bar system currently used by CDOT, examining the criteria for proper use of tie bars, and determining the maximum number of lanes that can be tied together without negatively impacting the concrete pavement structure.

Reporting Period: 7/1/11 through 9/30/11
Start: 2/22/2008 Complete: 6/30/11

Principal Investigator(s):
Applied Research Associates, Inc. (ARA)
Jagannath Mallela, ARA Principal Engineer
217- 356-4500

Study Manager:
Roberto DeDios, CDOT Research
303-757-9975

Panel Leader:
Shamshad Hussain, R-1 Materials
303-398-6782

Study Panel Members:
Gary DeWitt, R-4 Materials
970-506-0359
Mike Stanford, Staff Materials and Geotechnical Branch 303-398 -6544
Bob Mero, R-6 Materials
303-398-6703

SIGNIFICANT EVENTS

9/30/11 Published the final report. This report can be accessed at:
http://www.coloradodot.info/programs/research/pdfs/2011/tiebars.pdf/view
This will be the last quarterly progress report for this project.

7/13/11 Presented results of completed research at the Materials Advisory Committee (MAC) meeting.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Assessment of Alternate PCCP Texturing Methodologies in Colorado
Study No: 21.80

Background

CDOT, as part of a multi-state, FHWA-sponsored study conducted in 1995, adopted a new texturing specification for its concrete pavements. The new specification, which was adopted in 1977 called for uniformly spaced longitudinal tining at 3/4 of an inch intervals with the depth and width of 1/8 of an inch. The results of this study indicated that longitudinal tining in addition to possessing adequate frictional properties, were easier to install and produced a lower noise level than CDOT's traditional transverse tining (1"uniformly spaced). However, CDOT has been receiving numerous complaints concerning the handling of vehicles on newly constructed Portland cement concrete pavements textured with longitudinal tining. An effort is underway to address the handling problems associated with longitudinal tining through an experimental study (Study 21.81) in region IV of CDOT. Meanwhile, CDOT is planning on evaluating several surface texturing techniques. The goal of this study is to identify a texturing method that is safe and durable, provides adequate surface friction and lowers the noise levels.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 06/30/01

Principal Investigator(s):
TBD

Technical Field Support:
Skip Outcalt, CDOT Research, 303.757.9984

Technical Panel Leader:
Jay Goldbaum. Mat'l. & Geotech 303-398.6561

Study Manager:
Roberto DeDios, CDOT Research, 303.757.9975

Study Panel Members:
Jim Zufall , Materials & Geotech 303-757-9249
Eric Prieve, Materials & Geotech 303-398.6541
Donna Harmelink, FHWA, CO Div. 720-963-3021
Richard Zamora, R-2 Materials 719-546-5778

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
07/30/01	100	07/30/01	Meet with the ACPA/CDOT task force members to discuss the issues related to longitudinal tining and to develop strategies for conducting a study.
09/31/01	100	03/30/01	Assemble a study panel and identify locations with vehicle handling problems. Conduct preliminary investigations and report the results
09/31/01	100	10/30/01	Identify test sections on upcoming new concrete paving projects and examine the use of astro-turf as a method to texture concrete.
07/30/02	100	08/30/02	Conduct noise and skid tests on the existing nine experimental test sections on I-70 near Deer Trail and SH 40 near Wild horse.
11/30/02	100	0915/02	Analyze all the acquired data from the Deer Trail test sections, new astro-turf test sections, and document the results. Work with region IV, Gary DeWitt in establishing the second site for this study.
9/30/04	100	9/30/04	Establish new sites: 1- Proposed PCCP on US 287 at Berthoud Bypass in Region IV scheduled for construction in 2003. 2- Proposed PCCP on Powers Blvd in Colorado Springs in Region II in 2004. 3-Recently built PCCP on SH 83 near the Town of Parker and the control sections near Arapahoe Rd. 4-PCC Pavement on SH 85 south of c-470. Acquire skid, sand patch test, on all the new test sections on a yearly basis. Conduct other methods of texture measurement using FHWA's ROSAN van (if available).

06/30/08			Acquire skid and texture depth on several older sites including: US 160 at South Fork, I-76 at Nebraska state-line, I-70 at Rifle, I-76 at Brush-Atwood, I-225 at Iliff, SH 287 at Campo, and SH 270 at Vasquez Blvd to I-70. Acquire skid texture depth on the new sites. The Skid trailer is up and running and Skip Outcalt will complete the first round of data by the end of June, 2008. Problem with delivery of new skid truck and licensing of the trailer has delayed data collection till Spring of 06. Breakdown of new Skid truck further delayed data collection.
09/30/11			Annual data collection
6/30/12			Publish and distribute the final report. Hold a slide presentation to show results to the Materials Engineers.

SIGNIFICANT EVENTS

09/30/11 Plan to hire a private consultant to complete this project.

06/30/11 No activity during this quarter. The skid truck broke down and was under repair.

03/31/11 No activity during this quarter.

12/31/10 No activity during this quarter.

09/30/10 Skid data collected are being compiled.

06/30/10 Skip Outcalt collected skid data during this quarter for some of the test sites.

03/31/10 No activity during this quarter.

12/31/09 No activity during this quarter.

09/30/09 No work was performed during this quarter.

06/30/09 No work was performed during this quarter.

03/31/09 No work was performed during this quarter.

12/31/08 No work was performed during this quarter.

09/30/08 Field data collection is ongoing.

06/30/08 Data collection was resumed and gathered information is being analyzed for inclusion into the final report in the future.

03/31/08 No data collection was performed during this quarter.

12/31/07 The projected data collection to be performed was not successfully achieved during this reporting period because of weather-related conditions and malfunctioning of skid truck. This task is re-scheduled to be completed by June 2008.

9/30/07 The data collection is under way.

6/30/07 The data collection is still in progress. The malfunctioning of the skid truck hampered the data collection process.

3/20/07: Skip Outcalt planned to complete the data collection within the next four (months).

11/06: Ahmad Ardani, the original PI has retired. Roberto DeDios will take over. Breakdown of new skid truck delayed skid testing.

09/04: Acquisition of skid numbers and texture measurement has been delayed until early 05. The Research Branch will be acquiring a brand new skid testing machine equipped with a texture measuring device toward the end of 04.

12/03: Due to problems associated with the Research Branch skid testing machine, this project is now on hold until a new skid testing machine is purchased.

09/03: Skid testing machine was calibrated during this quarter. The study was delayed somewhat due to unavailability of ROSAN equipment. Nevertheless, field work will commence on this study in the first week of October 03.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Developing Criteria for Performance-Based Concrete Specifications
Study No: 22.50

Background

Many of CDOT's mix design requirements are based on results of studies in the 1940's and 1950's on durability. For more than 50 years now, concrete technology has advanced, but CDOT specifications for durability have remained mostly unchanged. The minimum cement content for a given strength is derived from mix design guidelines that were developed before water reducing admixtures were widely used and accepted. These minimum cement contents generally control the mix design process with many mix designs exceeding the minimum strength requirements by 500 to 1,000 psi. Ready-mix suppliers that supply to non-CDOT projects have developed mix designs that use less cement and more fly-ash than CDOT mix designs and exceeded their strengths. They are able to accomplish this improvement through gradation optimization and admixture combinations.

The proposed study will test current CDOT standard mix designs to determine minimum required performance criteria that will be used to develop performance-based concrete mix design criteria.

After performance criteria are defined, the ready mixed concrete producers will be asked to submit mix designs they would like to use on CDOT projects. These mix designs will be tested and evaluated based on the performance criteria established. CDOT will use the developed performance criteria to prepare a project special provision to allow the use of performance-based criteria for mix design approval on pilot projects. The ultimate goal is to develop and adopt a performance-based concrete standard special provision for use in applicable projects.

The product of this research will provide CDOT Materials and Geotechnical Branch with criteria that can be used in the development of a performance-based concrete mix design specification. The use of performance-based specifications would allow ready mixed concrete suppliers to optimize the materials used in creating mix designs. This materials optimization can lower cement contents and increase fly-ash content that would lead to reduction of costs and concrete carbon footprint in CDOT construction projects.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 09/23/10

Principal Investigator(s): Dr. Stephan Durham, University of Colorado-Denver 303-352-3894
Research Study Manager:
Robert de Dios CDOT-DTD Research 303-757 9975
Technical Panel Leader:
Eric Prieve, CDOT Materials and Geotechnical Branch 303-398-6542

Study Panel Members:
Gary DeWitt, CDOT R-4 Materials
Todd Gonser, CDOT R-4 Materials
Donna Harmelink, FHWA Colorado Division
Aziz Khan, CDOT-DTD Research Branch
Patrick Kropp, CDOT Materials and Geotechnical Branch
Michael Stanford, CDOT Materials and Geotechnical Branch
Scott Rees, CDOT Project Development Branch

FHWA Washington Contact:
Ahmad Ardani, Turner-Fairbank Highway Research Center 202-493-3422

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
9/23/10	100	9/23/10	Issue Notice-to-Proceed letter
10/13/10	100	10/13/10	CDOT Panel/Principal Investigator (PI) kick-off meeting
12/31/10	100	7/14/11	Comprehensive literature review
12/31/10	100	9/01/11	Obtain needed materials for testing
12/31/10	100	12/31/10	First progress report
1/31/11	100	5/10/11	Complete selection of concrete mixture designs
3/31/11	100	4/31/11	Second progress report
6/30/11	100	7/14/11	Summarize past research activities/Third progress report
8/31/11	25		Create concrete mix in lab, test, and develop performance criteria
9/30/11			Summarize past research activities/Fourth progress report

9/30/11			Solicit and batch non-standard mixture designs
12/31/11			Test supplier-provided concrete
12/31/11			Summarize past research activities/Fifth progress report
12/31/11			Analyze and summarize test results
1/31/12			Draft project report
1/31/12			Conduct PowerPoint presentation to CDOT Panel
2/28/12			CDOT Panel review of draft report/Return report with comments to PI
3/30/12			Submit final project report to CDOT
TBD			Conduct PowerPoint presentation to the Materials Advisory Committee (MAC)

SIGNIFICANT EVENTS

10/10/11	Submitted fourth progress report.
7/14/11	Completed literature review. Submitted third progress report.
6/30/11	Principal Investigator informed Study Manager that he would complete literature review/submit third progress report with attachment on 7/14/11
05/09/11	Submitted second progress report with attachment
04/02/11	Attended two-day presentation sessions on Performance-Based Specifications at the American Concrete Institute Spring Conference
12/31/10	Literature review progress report
12/20/10	UCD Laboratory Inspection
10/13/10	Project “Kick-off” meeting
9/23/10	Project officially begins

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Application of Roller Compacted Concrete in Colorado's Roadways
Study No: 25.00

Background

Roller compacted concrete (RCC) is relatively less expensive than the traditional Portland cement concrete that is used in high volume roads. Currently, RCC is used in a few industrial lots and roads in Colorado and has been found to be performing successfully for these low volume road applications. RCC can be placed and used as a wearing surface, although its pavement smoothness is not as good as conventional concrete. To harness the potential of RCC and identify its appropriate applications in Colorado's roadways, the following issues and information must be researched using highway pavement pilot test sections:

- Minimum strength needed for durability;
- Minimum thickness needed to hold different volumes of traffic;
- Minimum cement contents needed;
- New design procedure for designers to use;
- Minimum equipment requirements for placing RCC; and
- Other factors that may impact its performance.

Roller-compacted concrete (RCC) takes its name from the construction method used to build it. It is placed with conventional or high-density asphalt paving equipment and then is compacted with rollers. RCC has the same basic ingredients as conventional concrete which include cement, water, and aggregates. However, unlike conventional concrete, RCC is a drier mix, meaning it is stiff enough to be compacted by vibratory rollers. Typically, RCC is constructed without joints. It needs neither forms nor finishing, nor does it contain dowels or reinforcing steel. RCC has been historically used for dam construction and heavy duty industrial pavements such as rail yards (Denver Burlington Northern Yard, 22 years old), paper mills, and port facilities. State highway agencies (SHAs) like Georgia have also used RCC for shoulders along interstate highways.

RCC, as claimed by the cement industry, has the strength and performance of conventional concrete with the economy and simplicity of asphalt. Because of these qualities and low initial cost, it would be beneficial for CDOT to investigate and determine its various applications to highway construction projects. The goal of the research work is to develop guidelines, procedure, and specifications for the design, placement and maintenance of RCC in Colorado's roadways.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 06/2009

Principal Investigator(s): Dr. Yunping Xi
University of Colorado - Boulder
303-492-8991

Study Manager:
Roberto de Dios, CDOT-DTD Research Branch
303-757-9975

Study Panel Members:
Gary DeWitt, Region 4 Materials
Jay Goldbaum, Materials & Geotechnical Br.
Rex Goodrich, Region 4 Materials
Matt Greer, FHWA-Colorado Division
Shamshad Hussain, Region 1 Materials
Jamie Johnson, PCA RMCC
Steve Olson, Materials & Geotechnical Branch
Eric Prieve, Materials & Geotechnical Branch
Scott Rees, Project Development
Bill Schiebel, Region 1 Materials

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
4/21/09	100	2/21/2009	Issue Notice-to-Proceed Letter
6/09/09	100	6/09/09	Conduct kick-off meeting
9/30/09	100	9/30/09	Perform literature review
9/30/09	100	9/30/09	Develop research plan
9/30/09	100	9/30/09	Collect and analyze data for first year
2/23/10	100	3/31/10	Prepare first year progress report and perform PowerPoint presentation
12/31/10	100	12/31/10	Collect and analyze data for final work completion

10/31/11	100	11/09/11	Submit draft final report and conduct PowerPoint presentation
12/31/11			Submit final version of final report

SIGNIFICANT EVENTS

6/30/11 The Principal Investigator stated that he was in the process of completing the draft final report.

10/29/10 The research team of CU and the study panel of CDOT conducted the second field trip to the two construction sites (SH 66 and Weld County Road 28). Concrete cores were taken for testing.

7/16/10 The no-cost extension of the project was approved. The ending date will be 6/30/2011.

3/31/10 All durability tests for the first year were completed. A project meeting was held on 03/18/2010. A PowerPoint presentation was made at the meeting and the work plan for the second year was discussed with the study panel.

2/02/10 All durability tests were completed, except the freeze-thaw test which will be completed by the end of Feb., 2010. A project meeting was scheduled in March for progress report of the durability tests.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Soil Resources for Sustained Vegetative Cover of Cut and Fill Slopes along I-70 near Straight Creek
Study No: 30.02

Background

Severe weather and erosion on steep slopes can destroy revegetation plots testing tackifiers, fertilizers and mulches along any highways. Several reapplications of seed and fertilizer may be needed before vegetation is reestablished using standard CDOT methods and materials. The longevity of these amendments and the sustainability of the vegetative cover are not known. Adequate plant cover is critical for erosion control on these steep and sandy sites.

The objectives of this research initiative are: to evaluate the moisture and nutrient characteristics of revegetated soils along wall embankments, fill slopes and cut slopes along I-70 near Straight Creek; and to compare these values with those of native, undisturbed sites (topsoil retained) and barren slopes with inadequate plant growth. This data will verify the current ability of the sites to support vegetation and it will help evaluate the ability of the soils to continue to support adequate vegetative cover in the long term.

The anticipated product will include construction and maintenance specifications that promote long-term sustainability of the vegetative cover and provide guidelines to modify specifications as needed to encourage growth of sustainable vegetative cover for steep and sandy sites. The developed specifications should be applicable to control erosion on steep and sandy sites anywhere in the nation.

Reporting Period: 7/1/11 through 9/30/11
Start: 9/13/07 Complete: 12/31/11

Principal Investigator(s):
Vic Claassen, University of California Davis

Study Manager:
Bryan Roeder, CDOT-DTD Research
303-512-4420
Study Panel Leader:
Mike Banovich, CDOT-DTD EPB
303-757-9542

Study Panel Members:
John Bordoni, CDOT R-1 Maintenance
303-512-5765
Allan Hotchkiss, CDOT Materials and Geotechnical Branch 303-398-6587
Amanullah Mommandi, CDOT Staff Hydraulics
303-757-9044
Vacant, CDOT R-1 Resident Engineer
303-512-5751

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
			2007
3/31/06	100	4/07	Assemble the CDOT Study Panel. Develop the scope of work (SOW).
4/30/07	100	6/07	Complete the SOW and request for proposal (RFP) process (if applicable).
6/30/07	100	9/07	Select the Principal Investigator (PI). Initiate task order/purchase order/agreement/contract.
9/13/07	100	9/07	Award the contract. (Purchase Order signed)
11/15/07	100	09/07	Conduct the CDOT Study Panel/PI kick-off meeting. (field meeting with CDOT group, now need to present preliminary work to committee)
12/31/07	100	09/07	Establish control and experimental sites.
9/15/07	100	09/07	Prepare experimental set-up.
10/15/07	100	09/07	Monitor, gather and analyze plant cover data.
			2008
	100	due 05/08	Gather, prepare and analyze soil data
11/30/07	100	July 20 08	Prepare and submit interim report to CDOT study panel for review.
08/20/08	100		Research oversight committee Aug 26, 2008
09/30/08	100	10/02/08	Design and install nutrient release experiment using common soil amendment materials

10/01/08	100	spring 09	Analyze Time 0 samples (fresh amendment mixed with Straight Creek substrate) to determine initial nutrient content
			2009
winter 09	75	spring 09	Analyze nutrient release from T0, develop fractionation scheme for organics and nutrients
meltoff 09	100	spring 09	First field sampling of nutrient release experiment (Time 1 treatment).
summer 09	100	fall 09	Soil and vegetation sampling on existing plots (Insert additional nutrient sampling time??)
fall 09	100	spring 09	Second field sampling of nutrient release experiment (Time 2 treatment).
11/30/09	100	fall 09	Submit draft interim report for review by CDOT study panel.
12/31/09	100	fall 09	Respond to study committee review on the timing of nutrient release and field sampling.
			2010
meltoff 10	100	June 2010	Nutrient release experiment sampling
sum/fall 10	100	September 2010	Nutrient release experiment sampling
winter 2011	85	Dec 2010	Sample prep, N extraction
spring 2011	30		N release report
melt 2011			Field sampling
Fall 2011			Final field sampling
10/31/11			Prepare and submit draft final report to CDOT study panel for review.
11/30/11			Complete review of draft final report by CDOT study panel with comments to be addressed.
12/31/11			Prepare and submit final project report.

SIGNIFICANT EVENTS

September 2011: No activity reported this quarter.

May, June 2011: Found problems with limits of detection on N analysis, start re-work on sensitivity and look for alternate forms of N in remaining samples. Completed improved method to evaluate soil water retention in soils using tension infiltrometer for general evaluation of field growth conditions.

May 2011: Study Manager Vanessa Henderson was promoted to a position in the Division of Transportation Development Environmental and Planning Branch and was temporarily replaced by Roberto De Dios.

March 2011: Extractable nitrogen evaluation mostly completed, including ammonium and nitrate by amended horizon and leached horizon. Samples prepared to run total nitrogen and carbon. Preliminary data set up for modeling leaching losses from amendments in sandy granite substrates during snowmelt or summer rain events.

December 2010: Project extended to fourth and final year. Sample fractionation by horizons and nitrogen extraction starting.

July - Sept 2010: Sampled fall fertilizer release trial tubes September 30 (T4). Preparation in progress for bulk analysis of all samples. Three sample points remaining in the field tube sets, so the next sampling will be scheduled based on data results this winter.

Apr - Jun 2010: Worked up incubation equipment (no charge, but necessary for project) and sampled Spring 2010 samples from field sites. Start work with drying, fractionating samples. Nutrient analysis ongoing through summer.

Jan - Mar 2010: Soil sample analysis continued on the fertilizer incubation chambers collected from the I-70

Straight Creek field site. Several instruments were evaluated to determine if the fertilizer materials could be "read" instrumentally rather than relying on chemical extracts or lengthy incubations. Spring 2010 samples are to be taken when the snow pack comes off and precipitation predominantly switches to rainfall. Data are to be compiled for a research committee interim report.

Oct - Dec 2009: The samples were collected before snow cover in Fall 2009. No other activity occurred on this project, but analysis is starting Jan 1, 2010.

July - Sept 2009: The field incubation chambers survived the first winter, so now are experiencing the first summer growing season. The next time point will be collected in Fall 2009. The lab work involves learning the hydrological modeling software and preparing instruments for analysis of the Time 0, 1 and 2 samples in late Fall 2009 and Winter 2010.

March - June 2009: First winter nutrient release soil columns were collected right at snow melt and prepared for analysis. Lab methods were prepared (non-dispersed particle size analysis, water release curves from organics and substrates, respiration curves) and will be run uniformly on a set of the first year's samples (T0, T1, T2) in Fall of 2009.

January - March, 2009: Field work for the project was inactive during this winter period due to snow cover at the I-70 Straight Creek site. Weather is being monitored (MM209 I-70 truck ramp; I-70 Eisenhower web cams) and the winter 2009 soil amendment leaching columns will be harvested and monitored at final snow melt. Meanwhile, in the lab, work is being done to more effectively evaluate field soils for soluble nitrogen release, either from soil organic matter or soil amendments. This involves fractionation of soil N-containing compounds for N analysis and interpretation of soil respiration.

September 27 - Oct 2, 2008: Return to site and install groups of leaching tubes in time for measuring first season nutrient release. Time 0 samples were returned to the lab Fall 2008. Time 1 samples will be collected at melt off in Spring 2009 before growth begins. Time 2 samples will be collected just before snow fall in Fall 2009. This spring and fall sampling (twice per season) is incorporated into the experimental construction for three additional sampling times, but can be accelerated if initial nutrient release rates turn out to occur quickly, or the sampling times can be delayed if release appears to be slow.

September, 2008: Plan and design and construct nutrient release experiment to test release from soil amendments. The rate and chemistry of the release will be measured from PVC leaching tubes installed at the Straight Creek site. Replicate tubes of fungal biomass amendment, humate, a blend of these two, and a nitrified organic amendment were loaded into experimental columns.

August 26, 2008: Field site meeting with CDOT study panel. Gather second year of field survey data. Study panel recommends modifying work plan to include nutrient release tests from common soil amendments used along the Straight Creek Corridor.

July 20, 2008: Provide initial project findings to CDOT study panel, arrange for review by meeting or conf call.

May, June 2008: Statistically analyze non-N nutrient content and vegetation cover for plot comparisons.
A general tentative finding is that as slope conditions become more harsh, grasses tend to decline relative to forbs, which maintain their cover area. This suggests that grasses are more directly affected by declining soil conditions than forbs. This helps focus the search for growth limiting conditions to differences between these vegetation types. Alternatively, the change in forb species may indicate differences in survival ability as stress conditions increase. A field monitoring approach to surface horizon hydrology and availability of selected

nutrients is being developed for presentation to the CDOT study panel.

April 2008: Finish soil testing and data summary

Jan - Mar 2008: Soil sample preparation.

12/20/07: Summarize initial plot locations, cover and soil information.

9/21/07: Meet with CDOT field crews, review site selection, select plot locations, collect soils and evaluate late season plant cover using point intercept transects.

9/15/07: PI met with CDOT staff at site to set up test plot locations and inventories

9/13/07: Purchase Order issued to PI.

6/30/07: Documented Quotes received and reviewed. PI selected.

3/31/07: Statement of Work completed. Contract process to begin this month.

2/26/07: Task panel met and revised Statement of Work. Comments due back March 16, then Pat will finalize and begin contracting process.

9/30/06: The SOW and RFP is still being finalized by Mike Banovich and Roberto de Dios. The RFP is anticipated to be completed sometime in November 2006.

8/15/06: A major change in the time of completion of the Scope of Work (SOW) was proposed by the champion of the research project. The two-year time for completion is being planned to be changed to four years to gather more information without increase in cost.

6/27/06: The study panel kick-off meeting was held to refine the problem statement and start developing the Scope of Work (SOW) and Request for Proposal (RFP) document.

6/5/06: The research study panel was assembled and established.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Mileage Based User Fee Study
Study No: 30.51

Background

The Colorado Transportation Finance and Infrastructure Panel (CTFIP) identified a gap between infrastructure investment and use of the system compounded by the funding gap between revenue and needs over the long term. In short, Colorado's current system and extent of transportation finance is insufficient to maintain the state's highway and transit network, let alone grow the system to adequately address anticipated population, employment, and visitor growth. There are many options available to the state for resolving this finance gap. One strategy proposed by the CTFIP, and the subject of this study, is Mileage Based User Fees (MBUF). MBUF involves the collection of a user fee that is directly scalar with the use of designated roadways. At its simplest, an MBUF implementation may involve simply a per-mile fee; however, the specific rate of pay may include various deviations from a flat fee, in order to provide for incentives and mitigation (be it traffic, environmental, or geographic equity purposes). In order to properly assess the efficacy of MBUF towards these objectives, this study has been designed to:

1. evaluate the policy parameters surrounding a potential pilot program,
2. create a preliminary concept of operations for the conduct of MBUF, and
3. develop a framework for testing this program in Colorado.

Project Goal

In 2008, the CTFIP recommended that the Colorado Department of Transportation (CDOT) conduct a MBUF pilot project. Through the current effort, CDOT intends to develop a scope of work for the pilot program and produce a competitive proposal for Federal grant funding.

Project Scope

To achieve the objectives identified above, the study scope of work provides not only the technical parameters for the pilot program, but also sufficient research into the policy parameters that inform the technical procedures.
Whereas the objectives of the study are directly responsive to the goal of developing a successful proposed demonstration program of MBUF, these objectives are informed by the overall goals of a potential MBUF pilot program. The goals of the MBUF pilot program are to:

1. demonstrate the potential effectiveness of MBUF as a strategy for resolving the financial gap identified by the Panel, and
2. engage public, stakeholders, and institutions towards a potential full-scale MBUF implementation in Colorado.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 04/26/11

Principal Investigator(s):
David Ungemah; Parsons Brinckerhoff, 720-837-1522

Study Manager:
David Reeves, CDOT Division of Transportation Development, 303-757-9518

Study Panel Members:
Jake Kononov, CDOT DTD Research
Sandy Kohrs, CDOT DTD Intermodal Planning
Charles Meyer, CDOT Chief Engineer's Office
Ben Stein, CDOT CFO
Michael Cheroutes, HPTE Director
Herman Stockinger, CDOT Office of Policy & Govt Relations

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
10/19/10	100	10/19/10	Advertise RFP
11/22/10	100	11/22/10	Receive Proposals
1/24/11	100	1/24/11	Selection

4/26/11	100	4/26/11	Notice to Proceed
8/15/11	25		State of the Practice Assessment
9/15/11	5		Policy Outreach
9/15/11	0		Performance Measures
10/21/11	0		Preliminary Concept of Operations
11/18/11	0		Pilot Scope of Work / Final Report

SIGNIFICANT EVENTS

- 4/26/11 – Project commencement
- 6/24/11 – Meeting with CDOT policy guidance team

ANTICIPATED EVENTS FOR Q4 2011

- Delivery of draft State of the Practice Technical Memorandum
- Development of draft Goals and Objectives
- Conduct of stakeholder interviews
- Development of focus group protocol
- Development of draft performance measures spreadsheet

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Helicopter Avalanche Control
Study No: 30.70

Background

Avalanche danger presents many hazards to the transportation infrastructure in Colorado. In hazardous areas, near roads too arterial to close, these hazards must be mitigated by forcing slides during temporary road closures. Often the avalanches are triggered via high explosive charges dropped from helicopters. Many factors such as weather, explosive duds, or charges rolling away from trigger zones can prolong or even scrap a mission. When traffic is stopped, loaders are staged for snow removal, ground control is in operation, and the helicopter crew is working, costs drastically increase with mission time. Also, increasing the amount of time in flight increases the probability of an in-flight accident.

This research project is designed in two phases. The first is focused on a global survey designed to identify current methods in avalanche control. The goal of phase one is to determine what differences, if any, exist in the methods of helicopter avalanche control performed by CDOT in comparison to other agencies.

The second phase is designed to field test any differences found in phase one, as well as test any promising technology not identified in phase one. One potential avenue of investigation in phase two is the DaisyBell system. The DaisyBell generates a compressed gas explosion, while tethered to a helicopter, and can therefore be fired many times. This increase in firings can potentially increase the number of avalanches triggered per flight. The DaisyBell apparatus itself, however, may cause more mission scraps due to wind and the increased aircraft cross-section. Phase two intends to field test such cost to benefit ratios with real world technologies.

Upon analyzing the results of phases one and two, suggestions can be made, and training implemented, to help reduce the cost and safety hazards associated with CDOT's helicopter avalanche operations.

Reporting Period: 7/1/11 through 9/30/11
Type: Start: 5/1/11

Principal Investigator(s):
Dr. Vilem Petr, Colorado School of Mines 303.273.3222
Dr. Ethan Greene, Colorado Avalanche Information Center 303.499.9650

Study Manager:
David Reeves, CDOT Division of Transportation Development, 303-757-9518

Study Panel Members:
Jake Kononov, CDOT Research Manager (HQ-DTD)
Mark Mueller, Staff Maintenance Engineer (HQ)
James Walker, Maintenance & Operations (HQ)
Aziz Khan, CDOT Research Engineer (HQ-DTD)

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
5/11	50	5/11	Task 1.1: Review of current practices in helicopter avalanche control at CDOT and by other agencies performing the same kind of work.
5/11	100	5/11	Task 1.2.0 thru 1.2.2: Perform national and international survey of current helicopter safety and use in avalanche control. Survey will include types of explosives used, their delivery methods, and respective initiation systems. Special focus on delivery methods of "turkey bombs" will be reviewed.
5/11	100	5/11	Task 1.2.3: Industry survey of available initiation systems for explosives used in helicopter avalanche control.
5/11	100	5/11	Task 1.3: Perform national and international survey for alternative methods to explosives within avalanche control such as DaisyBell and Gas-Ex avalanche control systems.
5/11	25	6/11	Task 1.4: Contingent on availability of equipment and coordination with CDOT maintenance operation, the research team will conduct a preliminary field experiment to help guide phase 2. The experiment will collect data and compare effectiveness of two

			types of ANFO charges, emulsions/heavy ANFO and the DaisyBell. The field data would include, but not be limited to, measuring crater dimensions, atmospheric overpressure, high-speed images, and initial and final snow structure. The data would be used to evaluate the different explosive methods and help to validate and benchmark the new numerical simulation of other blasting scenarios.
9/11	0		Task 1.5: Submit written report summarizing findings from tasks 1 through 3 as per CDOT research report format within six months from start of project. This report will compare effectiveness of current CDOT helicopter avalanche control efforts to other agencies in terms of number of successful efforts per mission, how often the efforts fail, and by what mechanism (snow failed to slide despite apparently good charge placement and initiation, dud, charge rolled/bounced down slope, weather caused scrub after takeoff, etc.) failure occurred.

SIGNIFICANT EVENTS

- **5/11** The project was funded and phase one began.
- **5/5/11** The survey was launched around the world to ski areas and transportation departments. As of this writing, 32 legitimate responders have been recorded. The analysis of this survey is to come in the next quarter but it has been noted that none of the survey participants thus far use the DaisyBell system.
- **7/20/11** The project kickoff meeting was held at the Colorado School of Mines. Overall project goals, as described in the project background, were discussed. It was determined that the primary goal of this study is to improve (and/or verify) CDOT efficiency in helicopter avalanche control. It was stressed that CDOT would like to see phase one completed as thoroughly as possible before moving on to phase two. Potential locations for phase two testing was also discussed, and determined to be Loveland ski area. Emphasis on the DaisyBell system was suggested. Also, interest in developing an easy means of ANFO quality control measurement was expressed.
- **7/20/11** The survey was launched again to all emails that have not yet responded. At the time of this writing ten more participants have been recorded due to this launch.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Innovative Methods to Reduce Animal-Vehicle Collisions (AVC Reduction)
Study No: 32.42

Background CDOT's Strategic Plan for Improving Roadway Safety states that motor vehicle crashes involving wildlife were ranked as the third leading cause for crashes in Colorado during the past 3 years. CDOT is motivated to improve the safety of the traveling public where Animal-Vehicle Collisions (AVCs) are frequent and increasing in frequency. CDOT has prioritized 11 countermeasures to test in reducing AVCs, and is testing several of these systems. For the AVC research project, CDOT installed an electromagnetic animal detection/driver warning system in LaPlata County on Highway 160 in a major wildlife migration location. Traffic speeds, animal crossings activities and rates, weather conditions, and AVCs will be monitored and analyzed to investigate system reliability and effectiveness. The researchers hired for this project will test whether the system is reliable in detecting ungulates at or about to cross the highway, and whether the driver warning signs result in lower vehicle speed and fewer collisions with large wild ungulates (i.e. deer, elk).	Reporting Period: 7/1/11 through 9/30/11 Start: 11/25/08 Complete: TBD Principal Investigator(s): Dr. Marcel Huijser, Montana State University Bryan Roeder (303) 512-4420 Bryan.Roeder@dot.state.co.us CDOT Study Panel Members: Jeff Peterson, EPB 303-512-4959 Bryan Roeder, EPB 303-512-4420 Alison Deans-Michael, USFWS 303-236-4758 Tony Cady, R5 Environmental 303-385-9371 Bryan Allery, HQ Safety/Traffic Engineering 303-757-9967 Mike McVaugh, R5 Traffic 970-385-1449

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
9/01/07	100	9/01/07	Develop the scope of work (SOW).
2/13/08	100	12/1/07	Complete the task order or request for proposal (RFP) process.
4/08/08	100	05/15/08	Select the Principal Investigator (PI). Initiate task order/purchase order/agreement/contract.
11/15/08	100	11/25/08	Award the contract. (Task order signed and Notice to Proceed Letter issued)
1/12/09	100	1/14/09	Conduct the kick-off meeting in Durango
11/30/09	100	10/14/10	Draft report was not received, not noticed until early 1 July 2010, then it was submitted and receipt was confirmed.
11/30/10	100	7/1/10	Final report year 2 (draft 30 Sep, comments 31 Oct) Comments 7/22/10
11/30/11	100	2/19/11	Final report year 3 (draft 30 Sep, comments 31 Oct) Comments 3/10/11
9/26/11	100	6/22/11	Prepare and submit draft final report to CDOT study panel for review.
10/28/11			Complete review of draft final report by CDOT study panel with comments to be addressed.
11/18/11			Revise and submit the final report.

SIGNIFICANT EVENTS

06/22/11 Draft final annual report submitted for review and comment of the study panel members.

05/31/11 Study Manager Vanessa Henderson was promoted to a position in the DTD Environmental and Planning Branch and was temporarily replaced by Roberto DeDios.

03/10/11 Comments on draft annual report (through 2010) were received

02/19/11 Draft annual report (through 2010) submitted

10/14/10 Final annual report (through 2009) submitted.

03/18/10 Subcontract (2nd fiscal year) completed for contract WTI/MSU – SWCA

01/12/10 Amendment (2nd fiscal year) completed for contract CDOT – WTI/MSU

12/23/09 Subcontract SWCA to WTI-MSU signed by SWCA

12/16/09 – 11/26/09: Second reliability test conducted at Lewistown site

11/18/09 – 11/28/09: First reliability test conducted at Lewistown site

08/11/09 – 08/12/09: A 50 m long section of the system was installed in the test bed to investigate the reliability of the system in detail.

01/12-14/09 Project kickoff meeting in Durango

Around
01/07/09 Subcontract SWCA to WTI-MSU signed by WTI-MSU

11/25/08 Contract signed, Notice to Proceed issued to Montana State University

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Environmental Commitment Tracking Programs for Use at CDOT
Study No: 33.10

Background The Federal Highway Administration (FHWA) and Colorado Department of Transportation (CDOT) recently completed a Quality Assurance Review (QAR) of CDOT's Local Agency program. The QAR recommended development of a standardized environmental commitment tracking process. Such a process was deemed necessary after review of several local agency projects failed to be able to demonstrate whether environmental commitments had been completed. While the local agency projects identified the initial problem, the need to be able to track environmental commitments for all CDOT projects, not just local agency projects, has emerged as a serious concern. A Scan Tour was conducted by CDOT and FHWA staff of four state DOTs. The Scan Tour recognized how a process for tracking environmental commitments can improve environmental compliance and made recommendations for implementation of an environmental commitment tracking system. CDOT's Environmental Advisory Committee (EAC) is currently looking at identifying and implementing a long-term statewide environmental commitment tracking system for CDOT. The EAC has been able to identify the basic components and needs for the commitment tracking system and is pursuing an interim solution using basic spreadsheets. However, the recognition is that there are other systems that may provide more effective and efficient means of commitment tracking. To further refine what should be pursued by CDOT, an investigation of existing tracking mechanisms used in other states as well as within CDOT is needed. This research will focus on the various tracking formats, ranging from simple spreadsheets to integrated web-based systems, to determine what type of system would be most beneficial to implement at CDOT. The objectives of this study will include a review of existing commitment tracking mechanisms including technology and process and a recommendation as to which system should be pursued for long-term implementation at CDOT. This research project will provide direction for CDOT in developing its own environmental tracking system based upon the lessons learned in other states and with existing CDOT methodologies/systems. This will minimize development and redevelopment costs. Implementation of an environmental tracking system will reduce time and money spent in responding to questions about environmental commitment completion progress, will more clearly communicate environmental commitment responsibilities, and will reduce the likelihood of future liability resulting from compliance failures. Being able to more effectively track costs will also help future projects during cost estimating.	Reporting Period: 7/1/11 through 9/30/11 Start: 9/22/10 Complete: 9/30/11 Principal Investigator(s): Caroline Clevenger, CSU Ft. Collins Mehmet Ozbek, CSU Ft. Collins Study Manager: Roberto DeDios, CDOT Research 303-757-9975 Study Panel Members: Chuck Attardo, R1 Janet Gerak, R1 Stephanie Gibson, FHWA Mark Gosselin, R4 Yates Oppermann, HQ Environmental David Singer, R6

SIGNIFICANT EVENTS

The panel-approved final report was submitted to CDOT. The research was completed. This will be the last quarterly progress report for this project.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Recycled Materials Resource Center, TPF-5(199)
Study No: 33.20

Background

Over the past 10 years, State DOTs have made significant progress incorporating recycled materials and industrial byproducts in transportation applications. As a whole, recycled materials can add value to DOT projects, yet many of these materials still remain under-utilized due to technical and institutional barriers. The Recycled Materials Resource Center (RMRC) was created to assist State DOTs and FHWA in breaking down these barriers by providing the research and outreach activities needed to further the appropriate use of recycled materials.

The Center was started in 1998 at the University of New Hampshire (UNH) through an agreement with FHWA based on language in TEA-21. Under the original agreement, the RMRC sponsored 39 research projects in 14 states, resulting in seven regular or provisional AASHTO standards, with three additional draft standards submitted to the AASHTO Subcommittee on Materials. This research also produced new guidance documents for characterizing the environmental performance of recycled materials, and for conducting life-cycle cost analysis for transportation projects using recycled materials. In addition to the standards and other guidance documents, the RMRC organized and hosted four Regional Recycled Materials Workshops that covered the Northeast, Southeast, Midwest, and Western regions of the United States. The workshops brought together State DOT Materials Engineers, State DOT Environmental Specialists, State EPA Beneficial Use Specialists, FHWA Division Office personnel and U.S. EPA personnel to learn about appropriate recycled materials use for each region of the country. Each workshop was the same in that attendees were given a "tool box" of information to allow them to develop their own recycling expertise within their State. The RMRC also hosted an international conference on the use of recycled materials in transportation projects to learn about technology and practices be used in other countries.

The RMRC was renewed in 2007 by FHWA for an additional 4 years. The University of Wisconsin at Madison has joined the RMRC as a major partner to provide additional expertise as well as providing a more national perspective to the Center. As part of the new agreement, FHWA mandated that the RMRC seek funds through a pooled fund study to provide support for research and outreach activities.

Reporting Period: 7/1/11 through 9/30/11
Start: 8/15/09 Complete: 6/1/13

Principal Investigator:
Federal Highway Administration
Jason Harrington
Steve Mueller

Study Manager:
Bryan Roeder, CDOT Research

Study Panel Members:
David Wieder, Operations & Maintenance
Jim Zufall, Materials & Geotechnical

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
7/30/10	100	7/30/10	Funding request to Business Office for transfer of $30,000 to Lead Agency
10/12/10	100	10/12/10	Business Office signs transfer request and sends to Lead Agency.
10/26/10	100	10/26/11	Lead Agency processes transfer.

SIGNIFICANT EVENTS

September 2011: No activity was reported during this quarter.

May 2011: Study Manager Vanessa Henderson was promoted to a position in the Division of Transportation Development Environmental and Planning Branch and was temporarily replaced by Roberto DeDios.

April 2011: A pooled fund study member update meeting was held. The meeting update can be accessed at: http://www.pooledfund.org/documents/TPF-5_199/RMRC_Pooled_Fund_Update_April_2010.pdf

March 2011: No updates available. A pooled fund study member update meeting will be scheduled for April.

October 2010: CDOT officially part of RMRC Pooled Fund Study.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

FHWA Traffic Noise Model: Version 3.0 Software Development, TPF-5(158)
Study No: 34.22

Background The FHWA Traffic Noise Model (FHWA TNM) was originally released in 1998 and has undergone several upgrades. On May 2, 2005 the FHWA TNM, Version 2.5 became the required traffic noise prediction model to be used on Federal-aid highway projects. FHWA TNM Version 3.0 Software Development: FHWA is currently funding the development of the FHWA TNM Version 3.0. The main objective of Version 3.0 is to contemporize the software, making sure that the FHWA TNM does not become obsolete as computers/operating systems advance. Contemporizing FHWA TNM will allow for more efficient upgrades and future maintenance. The FHWA is also funding a limited number of enhancements which will be included in Version 3.0. Objectives for the FHWA TNM Version 3.0 Software Development include: 1) Enhance the graphical user interface (GUI). 2) Correct known software bugs. 3) Enhance functionality.	Reporting Period: 7/1/11 through 9/30/11 Start: 6/16/10 Complete: 12/26/12 Principal Investigator: Federal Highway Administration Mark Ferroni Study Manager: Bryan Roeder, CDOT Research Study Panel Members: Jill Schlaefer, CDOT Environmental Programs Branch Bob Mero, CDOT Region 6

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
11/24/09	100	11/24/09	Funding request to Business Office for transfer of $30,000 to Lead Agency
1/4/10	100	6/8/10	Business Office signs transfer request and sends to Lead Agency.
2/1/10	100	6/16/10	Transfer completed to Lead Agency for first year of participation.
7/22/10	100	7/22/10	Annual TRB Transportation Related Noise committee meeting.
7/26/11	100	7/26/11	Annual TRB Transportation Related Noise committee meeting.
12/26/12			Project completion.

SIGNIFICANT EVENTS

Through 9/30/11	Pooled fund study is in progress. See link below for the quarterly progress report. http://www.pooledfund.org/documents/TPF-5_158/Quarterly_Report_20110630.pdf
Through 6/30/11	Study Manager Vanessa Henderson was promoted to a position in the Division of Transportation Development Environmental and Planning Branch and was temporarily replaced by Roberto DeDios.
Through 12/31/10	Transfer request for second year of participation sent to CDOT Business Office on 11/30/10.
Through 9/30/10	Coding and development in progress.

7/22/10	CDOT study panel members attended the TRB ADC40: Transportation Related Noise committee meeting in Denver. During this summer meeting the contractor presented and had demonstrations of the progress of TNM 3.0.
6/16/10	CDOT officially joined the Pooled Fund Study.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Use of Waste Tires (Crumb Rubber) on Colorado Highways
Study No: 34.24

Background

The Colorado Department of Transportation (CDOT) has used rubber in hot mix asphalt (HMA) for over 25 years. Since the early 80's, CDOT used AC-20R which was an AC -20 base grade of asphalt cement with a styrene-butadiene-rubber polymer blended at a terminal plant and shipped to the various locations throughout Colorado. Since CDOT's AC-20R was performing well, CDOT retained the ductility value along with the toughness and tenacity requirements for the newly initiated PG 64-28 grade of binder when the Department switched to the SuperPave performance graded HMA specifications in 1995. In 1994, CDOT built three trial sections in Colorado where crumb rubber was blended into the dense graded HMA using the dry method (crumb rubber is added as a component of the aggregates). Based on the information from Research Report Number CDOT-DTD-R-99-9, these trial sections proved to be a feasible asphalt pavement alternative and were performing well. The research noted that this process increased the cost per ton by 21 percent when the crumb rubber was added at a rate of 20 pounds per ton. It was recommended that CDOT not pursue any use of crumb rubber until it became cost effective. Other state DOTs have tried the dry method with their dense graded HMA but opted not to continue using the process because of similar concerns and other problems. Therefore, CDOT will not pursue investigating this method at this time.

The use of crumb rubber in chip seal using the wet method was also investigated in the late 80's with the results and findings documented in the Research Report Number CDOH-DTP-R-86-3. The finished product performed comparably well with the conventional chipseal materials used for pavement rehabilitation but was found to be more expensive. With the influx of improved crumb rubber technologies, it is thought that the asphalt pavement life could be longer and the use of crumb rubber employing the wet and terminal blend method might prove cost-effective. For this reason, CDOT is revisiting the use of crumb rubber in HMA utilizing pilot test sections to gather the required information for developing specifications for wet and terminal blend method.

It is proposed to evaluate the feasibility of using waste tires (crumb rubber) in the construction of asphalt pavements. As part of the evaluation, two pilot test sections and one control section using the Superpave Performance Grade, PG 64-28 asphalt binder in dense graded HMA will be built. The two pilot test sections will be built with crumb rubber modified (CRM) asphalt mix using the wet method (crumb rubber is first reacted with asphalt binder in an open system plant before mixing with the aggregates) and the terminal blend method (a special form of the wet process in which reaction takes place in a closed system plant). Each test section will consist of approximately 1,000 tons of 2-inch asphalt overlay placed in the same single lane of the roadway. The control section will be constructed with the conventional polymer modified binder, PG 64-28 without the crumb rubber modifier.

The goal of this research project is to evaluate the performance of crumb rubber test sections and as appropriate, develop Colorado-specific materials and construction specifications for rubberized asphalt pavement. Also, the research project aims to develop guidelines and best management practices for the

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 12/1/09

Principal Investigator: Dr. Scott Shuler, CSU
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Research Study Manager:
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Technical Panel Leader:
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Study Panel Members:
Rick Chapman, CDOT R-4 Materials
John Cheever, Aggregate Industries
Gary DeWitt, CDOT R-4 Materials
Denis Donnelly, CAPA
Eric West, Westest
Masoud Ghaeli, CDOT R-6 Materials
Roy Guevara, CDOT Materials Asphalt Program
Rex Goodrich, CDOT R-3 Materials
Donna Harmelink, FHWA
Vanessa Henderson, CDOT-DTD Research
Stephen Henry, CDOT Materials Asphalt Program
Bob Mero, CDOT R-6 Materials
Bill Schiebel, CDOT R-1Materials
Niki Upright, CDOT R-4 Construction
Richard Zamora, CDOT R-2 Materials
Jim Zufall, CDOT Materials Branch

construction of rubberized asphalt pavements. The Colorado Department of Public Health and Environment (CDPHE) provided the grant money to construct the two pilot test sections in this research project.	

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
12/1/09	100	12/1/09	Notice to proceed
3/31/10	100	3/31/10	Task 1 – Literature Review
3/31/10	100	3/31/10	Task 2 – Planning
6/30/14	30	9/30/11	Task 3 - Data Collection
12/31/14	50	9/30/11	Task 4 – Project Status Reporting
6/30/14	0	9/30/11	Task 5 – Draft and Final Report Presentation and Submittal

SIGNIFICANT EVENTS

No work was planned or done in the third quarter.

Condition surveys are scheduled for the second and fourth quarters. The next survey is scheduled for the fourth quarter of 2011.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Tire/Pavement and Environmental Traffic Noise in Colorado
Study No: 35.00

Background

FHWA noise regulations are published in 23 CFR 772, and specify the rules and requirements for consideration of highway traffic noise in the development of highway projects that add capacity or substantially alter the existing highway. Noise mitigation must be considered in accordance with these regulations if it is determined that any noise-sensitive receptors (i.e. residences, businesses, etc.) are found to be impacted by noise, either by future noise levels approaching or exceeding the noise abatement criteria, or noise levels that are substantially greater than existing noise levels. The regulations further state that the highway plans and specifications will not be approved by FHWA unless feasible and reasonable noise abatement measures are incorporated into the plans to reduce or eliminate the noise impact. Of the mitigation measures to be considered, the use of quiet pavement is not one of them. FHWA's position regarding use of quiet type of pavement as a noise mitigation measure is very clear.

It is very difficult to forecast pavement surface condition into the future. Unless definite knowledge is available on the pavement type and condition and its noise generating characteristics, no adjustments should be made for pavement type in the prediction of highway traffic noise levels. Studies have shown that open-graded asphalt pavement can initially produce a benefit of 2-4 dBA reduction in noise levels. However, within a short time period (approximately 6-12 months), any noise reduction benefit is lost when the voids fill up and the aggregate becomes polished. The use of specific pavement textures must not be considered as a noise abatement measure.

In response to state transportation agencies' interest in traffic noise mitigation using quiet pavements, FHWA has provided guidance to State DOT(s) in developing a Quiet Pavement Pilot Program (QPPP) or in conducting tire/pavement noise research. The QPPP evaluates the highway traffic noise reduction benefits gained from the use of various pavement types and/or textures and defines the protocols for conducting proper analysis of highway traffic pavement noise. At this time, CDOT opted to postpone developing a QPPP and instead elected to conduct tire/pavement noise research. For this approach, a Data Acquisition Plan (DAP) will be developed to collect data not only related to highway traffic noise characteristics but also to the safety and durability aspects of the associated pavements. CDOT's DAP will follow closely the data collection requirements set forth by FHWA.

The goal of this research project is to develop and execute a comprehensive, long-term study to determine if a particular pavement surface type and/or texture can be successfully used in Colorado to help satisfy FHWA noise mitigation requirements. The study is needed to:

- Determine the noise generation/reduction characteristics of pavements as functions of pavement type, pavement texture (where applicable), age, time, traffic loading, and distance away from the pavement;
- Determine a correlation between close-proximity (CPX) noise trailer

Reporting Period: 7/1/11 through 9/30/11
Start: 2/2006 Complete: 12/2011

Principal Investigator(s):
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Study Manager:
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testing, statistical pass-by index (SPBI) testing, and environmental noise measurements at various distances from the highway; and • Accumulate information that can be used for validation and verification of the accuracy of TNM to use on future Colorado highway projects.	

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
6/30/05	100	6/24/05	Develop scope of work, evaluation criteria, and request for proposal (RFP)
8/31/05	100	7/20/05	Complete the RFP process.
9/30/05	100	8/24/05	Select the Principal Investigator
10/31/05	100	10/04/05	Award the contract.
12/15/05	100	2/01/06	Send Notice to Proceed
2/09/06	100	2/09/06	Hold pre-kickoff meeting (#1)
4/03/06	100	4/04/06	Hold kickoff meeting (#2)
4/06/06	100	4/06/06	Visit testing sites
8/01/06	100	9/14/06	Prepare for and begin testing (Year 1)
10/31/06	100	11/10/06	End testing (Year 1)
1/31/07	100	1/31/07	Presentation at CDOT Environmental Winter Conference
1/31/07	100	1/31/07	Hold panel meeting #3
1/31/07	100	2/28/07	Analyze data (Year 1)
3/31/07	100	3/30/07	Submit draft Year 1 Report for CDOT panel review
6/22/07	100	6/22/07	Hold panel meeting #4
7/15/07	100	6/23/07	Prepare for and begin testing (Year 2)
9/30/07	100	9/01/07	End testing (Year 2)
2/04/08	100	2/04/08	Hold panel meeting #5
4/30/08	100	7/08/08	Submit final Year 1 Report
9/30/08	100	9/30/08	Analyze data (Year 2)
10/31/08	100	12/10/08	Submit draft Year 2 Report for CDOT panel review
2/28/09	100	1/29/09	Submit final Year 2 Report
3/02/09	100	3/02/09	Hold panel meeting #6
5/31/09	100	5/06/09	Prepare for and begin testing (Year 4)
10/31/09	100	10/31/09	End testing (Year 4)
7/16/10	100	7/09/10	Submit draft Year 4 Report for CDOT panel review
7/23/10	100	7/23/10	Hold panel meeting #7
9/30/10	100	11/4/10	Submit final Year 4 Report
3/16/11	100	3/16/11	Hold panel meeting #8
5/06/11	100	5/23/11	Prepare and begin testing (Year 5/last)
8/31/11	100	7/05/11	End Testing (Year 5/last)
9/30/11	80		Analyze data (Year 5/last and all years combined)
10/31/11	40		Submit draft (Year 5/last and all years combined) report for CDOT panel review
12/15/11			Hold last meeting and final presentation to the study panel
12/31/11			Submit final (Year 5/last and all years combined) report

SIGNIFICANT EVENTS

7/05/11 Field testing for 2011 was completed.

3/16/11 A meeting was held between the project panel and the team to discuss the plan for 2011 testing and the final report.

11/4/10 Following confirmation that all comments have been received and addressed, the final report from

Year 4 was submitted to CDOT for publication on their website.

7/23/10 Following submittal of the draft 2009 test report, a meeting was held between the project panel and the team to discuss the most relevant findings and recommendations for the final round of testing to be conducted in 2011.

10/31/09 Field-testing for 2009 was completed.

3/2/09 A meeting was held between the project panel and the team to discuss the most relevant findings from the testing to date. Details of the Year 4 testing were also discussed.

1/29/09 Following confirmation that all comments have been received and addressed, the final report from Year 2 was submitted to CDOT, and will be published on their website.

7/8/08 Following confirmation that all comments have been received and addressed, the final report from Year 1 was submitted to CDOT, and subsequently published on their website.

4/8/08 At the request of CDOT, a presentation on the progress of the CDOT QPR was made during the Tire-Pavement Noise pooled fund meeting.

2/4/08 A fifth panel meeting was held in concert with a presentation on the QPR made to the Colorado/Wyoming Chapter ACPA. During the meeting, the preliminary findings of the Year 2 testing was presented. There was further discussion of the final report from Year 1, and it was decided that an additional review cycle for CDOT would be initiated. Submission of the final report from Year 1 was therefore postponed until all comments are received and addressed. The Year 2 report will use the Year 1 report as a template.

9/1/07 Field-testing for 2007 was completed. Thirty of the 31 sites visited during the first year of testing have been revisited (one site was dropped due to active construction). SPBI+ testing was conducted on the US 287 project. Center-lane testing with OBSI was also conducted which will allow the project team to present the potential effects of wear in the wheelpaths.

6/22/07 A fourth panel meeting was conducted to discuss the key findings from Year 1 of testing. The final report was discussed, and a punch list of outstanding items noted. There was also discussion of the plan for upcoming testing.

1/31/07 The project team attended the CDOT Winter Environmental meeting in Denver. After the meeting, the team met with several members of the project panel to discuss the current status of the project including preliminary results of the 2006 testing. Based on the work conducted thus far, it is recommended that OBSI using the SRTT tire be used to characterize the tire-pavement source for future testing.

11/10/06 Field testing for 2006 was completed. A total of 31 sites were visited. This included 15 sites with both near field (OBSI/CPX) and SPB/Time Averaged measurements, and 16 sites with near field testing only. Throughout the testing, preliminary analysis of the data were conducted as part of quality control. Subsequent data analysis will be conducted for validation and verification, and to prepare for the data presentation as part of the Year 1 report.

9/14/06 After a thorough evaluation of the equipment and procedures, testing of the sites kicked off with

measurement of CPX and OBSI on two sites north of Colorado Springs. An evaluation of the data was immediately done in order to ensure reasonableness and repeatability. Having passed these checks, testing will continue through November 2006.

4/6/06 Immediately following the kickoff meeting on 4/4, CDOT and Transtec team members along with Dr. Judy Rochat of the Volpe Center traveled together to nearly all of the SPB and SPB+ sites identified in the original CDOT plan. As part of each site visit, the participants identified candidate locations for SPB microphone locations. The information gathered during these site visits serves as a key component of the site-specific testing plans.

4/4/06 A formal kickoff meeting was held at the CDOT Research offices in Denver. It was held in conjunction with a FHWA Tire-Pavement Noise 101 workshop conducted the day prior. The project team and other stakeholders met to discuss the refined plan for the project, including the identification of requisite data.

2/9/06 A pre-kickoff meeting was held in Greeley with several panel members. During this meeting, a presentation was made of the initial thoughts on the testing program that will be executed under this effort. Discussion followed. In addition, preparations were made for the official kickoff meeting to be conducted in April, which will coincide with a "van trip" of the state to visit most of the proposed "SPBI/SPBI+" sites.

2/1/06 The Transtec Group was provided with a Notice to Proceed.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Clear Roads Winter Highway Operations Pooled Fund, TPF-5(218)
Study No: 40.03

Background

The Clear Roads pooled fund project began in 2004 with four members and a focus on real world testing of winter maintenance materials, methods and equipment. During its five years of funding and overseeing research projects, the pooled fund grew to include fourteen member states funding two or three research projects annually. As the group grew, however, there was much interest in expanding the project scope to include more technology transfer and direct support for staff in the field. The group proposes to close the original pooled fund project---TPF-5(092) and request funding and support for a new Clear Roads project with this solicitation. See the Clear Roads Web site at www.clearroads.org for both the history and latest information on this project. It is now TPF-5(218).

This new Clear Roads pooled fund project will maintain its focus on advancing winter highway operations nationally but will include a more pronounced emphasis on state agency needs, technology transfer and implementation. State departments of transportation are aggressively pursuing new technologies, practices, tools and programs to improve winter highway operations and safety while maintaining fiscal responsibility. This pooled fund is needed to evaluate these new tools and practices in both lab and field settings, to develop industry standards and performance measures, to provide technology transfer and cost benefit analysis and to support winter highway safety. This project responds to research and technology transfer needs not currently met by other pooled fund projects. Existing partners make every effort to coordinate with other agencies to avoid duplication of efforts and to encourage implementation of results.

State and local winter maintenance organizations will be able to make informed operational and purchasing decisions based on objective evaluations of promising materials and equipment. By pooling resources, agencies will be able to conduct more extensive studies across a greater range of conditions than could be done by a single agency with only its own funds. By collaborating and sharing information, agencies will benefit from each other's experiences and avoid the duplication of research efforts. The outcomes of these projects will help agencies get the maximum financial benefit out of their investments in materials, equipment and technologies.

Reporting Period: 7/1/11 through 9/30/11
Start: 1/22/10 Complete: TBD

Principal Investigator(s):
Minnesota Department of Transportation

Study Manager:
Bryan Roeder, CDOT Research
303-512-4420

Study Panel Members:
Paul DeJulio, R5 – retired, Dave Wieder new study panel member
Dave Wieder, Operations & Maintenance

FHWA Washington Contact: TBD

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
12/31/09	100	1/22/10	Complete initial funds transfer to Pooled-Fund Study lead agency.
12/31/10	100	1/20/11	Complete second fiscal year funds transfer. *Initiated 11/30/10.
12/31/11			Complete third fiscal year funds transfer.

SIGNIFICANT EVENTS

Please connect to the following link for the latest quarterly progress report:
http://www.clearroads.org/downloads/CTC-Clear-Roads-Quarterly-Progress-Report-1Q11.pdf

May 2011:	Study Manager Vanessa Henderson was promoted to a position in the DTD Environmental and Planning Branch and was temporarily replaced by Roberto DeDios.
March 2011:	Website updates, contract extension, and scoping of projects for next year.
November 2010:	Funds transfer initiated. Paul DeJulio retired and Dave Wieder is now the maintenance contact (and main pooled fund study contact). Ongoing data and research available.
January 2010:	Funds transfer completed to Minnesota DOT.
December 2009:	Funds transfer initiated.
November 2009:	Vanessa Henderson spoke with Paul DeJulio in Region 5. The maintenance sections had been participating in the Clear Roads pooled fund study for a few years and the sections had started splitting the payment. It was agreed that the Research Branch would pay the dues for the next three years as long as funding is available.
February 2009:	Participation in pooled fund study approved by RIC.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Deicer Corrosion Inhibitor Performance Pooled-Fund Study, TPF-5(035)
Study No: 41.90

Background Public agencies throughout the Northwest buy and use inhibited deicing chemicals in an attempt to reduce the corrosive effects of the deicer they use. These organic inhibitors are effective but expensive, and their "shelf-life," effective life after application, and overall field performance are uncertain. This pooled-fund study, TPF-5(035) will be overseen by DOTs in 8 states and two companies, in addition to CDOT. Phase 1 of this study would help to determine the longevity and cost effectiveness of corrosion inhibitors added to liquid and solid deicing chemicals. This work would involve field observations of stored materials over time under various conditions (solid deicers which are either uncovered or partially covered, and liquid stored in tanks) and mixtures. Phase 2 would evaluate the field performance (longevity and effectiveness) of various deicers with varying mixtures of corrosion inhibitors and additives. Each product will be applied at varying rates, road conditions, temperatures, and humidity, and their performance measured. Deicers to be studied include magnesium chloride, calcium chloride, and solid sodium chloride. Final results should provide CDOT with an updated list of effective deicer mixtures for use during winter operation and maintenance.	Reporting Period: 7/1/11 through 9/30/11 Start: 11/30/01 Complete: 12/31/10 Principal Investigator(s): Western Transportation Institute Study Manager: Bryan Roeder, CDOT Research 303-512-4420 Study Panel Members: Kandy Lukow, R3 – retired and Dave took over on study panel Dave Wieder, Operations & Maintenance

SIGNIFICANT EVENTS

June 2011: Project's final report was completed. Please see attached link to view the final report: http://www.wsdot.wa.gov/research/reports/fullreports/759.1.pdf.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Optimization of Stabilization of Highway Embankment Slopes Using Driven Piles (Phase II – Development and Verification)
Study No: 74.91

Background

Slope stability problems are of special importance to CDOT because of the number of mountain highway embankments which are vulnerable to progressive lateral slope failure, causing pavement distress and settlement which can be hazardous to highway users. This is often triggered by increased soil saturation during spring snow melt periods. While maintenance crews can often repave an affected area to mitigate the highway settlement, the original failure often creates a slip surface which sets up subsequent failure of the remolded soil in future years. Driven piles have been used with some success to solve the local slope stability problem, however, geotechnical research and input can improve these efforts both in regards to performance and economy.

This phase of the study follows a preliminary investigation in Phase I, where it was found that the stabilization of laterally failing slopes using driven piles could be effective and economical. To develop these findings, a literature review, surveys of state DOTs, cost comparisons analyses and targeted field inspections were performed.

Using extensions of traditional two-dimensional methods of analysis together with modern finite element computational techniques, this study aims to better understand the effectiveness of driven piles in reinforcing at-risk highway embankment slopes. Additionally, the research will lead to practical guidelines by which lateral piles can be prescribed and implemented at optimal locations. Specifically, the guidelines will address the most economical pile size, spacing and driven depth based on observed site characteristics and geotechnical investigation.

Reporting Period: 7/11/11 through 9/30/11
Type: SP&R Start: Ver:
Contract: (P.O. #)

Principal Investigator(s):
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D.V. Griffiths, Colorado School of Mines
303-273-3669

Study Manager:
Aziz Khan, Research Branch
303-757-9522

Study Panel Members:
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Craig Wieden, CDOT Region-2 Materials
Del French, CDOT Region-3 Maintenance
Russel Cox, CDOT Region-1
Rex Goodrich, R-3 Material Engineer
John Hart, Coggins and Sons, Denver
Alan Lisowy, H-P Geotech, Denver
Matt Greer, FHWA-Colorado

RESEARCH TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
7/1/11	100%	Y	Task 1: Analysis of test site
6/1/11	95%		Task 2a: Spreadsheet-based model
12/31/11	75%		Task 2b: Finite Elements-based model
2/1/12	0%		Task 2c: Develop test site mitigation plan from results of above models
2/15/12	0%		Task 3: Develop pile instrumentation plan for test site
7/1/12	0%		Task 4: Test site implementation with instruments
5/1/13	0%		Task 5: Analysis of test site performance over one snow-thaw period
8/1/13	0%		Task 6a: Compare and calibrate results to develop design methodology
12/31/13	0%		Task 6b: Draft and Final Report

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
1/17/11	100%	Y	Unofficial project start
3/22/11	100%	Y	Kick-Off Meeting with CSM
5/1/11	100%	Y	Official project start
5/17/11	100%	Y	Update Meeting w/ Laudeman, Kiousis, Ebersole
7/7/11	100%	Y	Site Visit

SIGNIFICANT EVENTS

Note 1: The site visit has been completed (July 2011), where visual data was collected to improve modeling accuracy.

Note 2: The spreadsheet-based model uses an extension of Bishop's Method of Slices to account for three-dimensional slope failure with end effects. Some common assumptions are made in this model, including a spherical failure surface and assumptions regarding interslice forces – it will be seen how reasonable these assumptions are in light of the results garnered from the finite elements model and test site implementation. These assumptions aside, the flexibility and options of this model are fairly robust, and results have been verified against two-dimensional problems with satisfactory accuracy. This model is substantially complete, with a possible extension based on Lu & Likos' work to improve vadose zone modeling.

The finite-elements model is currently under development, using the LS-Dyna software package. While progress here has been slowed by the lack of documentation for geotechnical applications, the model is nearing completion, with good benchmarking results along the way.

Note 3: While several pile implementation plans have been considered, a finalized plan is on-hold until further theoretical analysis (the two models from task 2) are completed. This comes from the realization that the best pile instrumentation data will come from a situation where the piles develop plastic hinges, but with small enough total deflection to still remain effectively in place (rather than being entirely swept away). This will reveal the precise point where the ability of the pile to contribute to slope stability is exceeded by the capacity of the soil to be supported by lateral piles. In this manner, both geotechnical modeling of the soil and structural modeling of pile fixation can be verified.

Note 4: Unfortunately, in light of the delay in model development, it was not possible to drive instrumented piles before weather made operations difficult for the winter. An instrumentation and pile location plan will be developed for implementation over the summer of 2012.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Assessment of MSE Wall Attachment Details Meeting New AASHTO Seismic Connection Requirement and Implementation of End-of-Wall (EOW) Treatment for Bridge Worksheet
Study No: 74.75

Background

This study aims to provide displacement-based seismic design recommendations for Mechanically Stabilized Earth (MSE) walls for the state of Colorado. The AASHTO LRFD Bridge Design Specifications, 2008 Interim, now mandate a more stringent 1000 year seismic return period as opposed to the previous 500 year return period. This change results in an increased in predicted maximum USGS peak ground acceleration (PGA) for Western Colorado from 0.025g to 0.14g. Given the importance of CDOT retaining walls on the operations of transportation corridors, the impact of the PGA contour upgrades on CDOT design practices should be examined.

The AASHTO LRFD Specifications provide guidelines for seismic design of MSE Walls in section 11.10.7. While the overall external stability requirements for MSE walls may be addressed through limit equilibrium analyses and their associated design methodologies, the behavior of the individual components of an MSE wall (e.g., the facing panels, modular blocks, coping, and the connections to the soil reinforcement) are not fully understood or codified. Such detailing issues cannot always be adequately addressed through typical limit equilibrium analyses of overall system behavior and may require a more explicit deformation-based approach.

This study therefore aims to provide displacement-based seismic design recommendations for MSE walls. Specifically, we will address the design of: (1) reinforcement of the cap element (coping), (2) the connection of the coping to the tops of MSE or soil nail facing, (3) the connections of the upper blocks in modular block MSE walls, (4) the design and detailing of the ends-of-the-walls, and (5) the connections between MSE facings and the soil reinforcement. This will be done a) by reviewing existing studies, b) by examining related practices of other state DOTs, and c) by performing a series of dynamic finite element analyses on typical MSE and soil nail walls, explicitly modeling all of the individual components and their interaction when subjected to a series of dynamic ground motions representing the extreme seismic events predicted by the Western Colorado PGA contours. General behavior tendencies will be determined from these analyses and will be used to inform the detail work for MSE walls.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 03/03/10 Ver:
Contract: 10HAA11438 (P.O. # 271001132)

Principal Investigator(s):
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Judith Wang, Colorado School of Mines
303-273-3836

Study Manager:
Aziz Khan, Research Branch 303-757-9522

Study Panel Members:
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Russel Cox
Lynn Crosswell
Hsing-Cheng Liu
Cheng Su
Trever Wang
Steve Yip

FHWA Washington Contact:
Daniel Alzamora

RESEARCH TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
3/03/10	100%		Task 1: Literature Review
3/03/10	100%		Task 2: National DOT Survey
6/03/10	90%		Task 3: Displacement-Based Analysis
12/03/10	100%		Task 4: Interim Report
7/03/11	75%		Task 5: Draft and Final Report

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
11/15/09	100	Y	Study Advertised (Proposals Solicitation)
03/03/10	100	Y	Notice to Proceed (NTP) to CSM
03/31/10	100	Y	Kick-Off Meeting with CSM

SIGNIFICANT EVENTS

Note 1: We have completed a literature review of material in academic journals and texts, from state DOT websites, and national reports which was included in the interim report submitted to CDOT on February 22, 2011.

Note 2: We have sent out a national survey in which we have received 40/50 responses. Of the state DOTs that have responded, 39/40 maintain existing MSE walls, 29/40 use the AASHTO LRFD Bridge Design Specifications, 18/40 mention seismic design in their current state standards, and 2/40 are currently performing research on seismic loading on MSE walls. This report was submitted to CDOT on October 12, 2010.

Note 3: It has been determined that ground motions in the range of desired accelerations for a 1000 year return period earthquake have not been recorded in Colorado. We have performed a deaggregation analysis for a site class D soil. Using spectrum matching of existing records, a maximum design acceleration was determined in accordance with ASCE 07. In order to produce a time history of a likely Colorado ground motion, this acceleration will be used as the peak value in the combination of a parabolic and an oscillating function which use the natural frequency of the wall structures to obtain a worst case ground motion. A more in-depth knowledge of the program LS-Dyna has been obtained. A modal analysis has been performed on a 15 foot high panel wall, a 15 foot high modular block wall, and a 30 foot high modular block wall. We have applied the created ground motions to the 15 foot walls and are completing the process of applying them on the 30 foot walls. A final report is being prepared on our findings for the CDOT Study Panel.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Real-time In-situ Monitoring of Infiltration-Induced Instability of I-70 Embankment West of the Eisenhower Tunnel
Study No: 74.92

Background

The objective if this study is to develop a new methodology for in-situ, near real-time forecasting of the stability of highway embankments. Snow-melt and rainfall induced landslides occur every year along the highways of Colorado. These failures of natural and engineered slopes potentially threaten human lives and private property and severely disrupt transportation. An active landslide on I-70 west of the Eisenhower Tunnel (Mileposts 212.0 to 212.1) was identified. In the past forty years, the hillslope in this area has episodically moved causing settlement of the pavement. Based on the current asphalt thickness, the settlement on this area is in the order of 2 feet in two decades. Currently, CDOT utilizes survey and geotechnical staff to record periodic measurements of monuments and below grade instruments, which provides for two to three data sets per year. However, at present there is not an installed system that can provide year round and continuous data on the slide movement. The improved monitoring and forecasting processes can reduce the uncertainty associated with planning improvements to the slide as well as providing an action level or early warning for the period of greater than expected movement.

As water infiltrates into the soil and rock hillslopes, soil suction and the water table vary dynamically, causing changes in effective stress and , in turn, changes in the stability of the slope. Recent advances in unsaturated hydrology and soil mechanics provide new opportunities to quantitatively measure soil suction and effective stress changes in highway embankments. In-situ measurements of the variations in soil-suction and moisture content in the upper 20 m of the embankment permit directly monitor stress changes, and thus, the occurrence of landslides can be forecast.

The development of the new methodology will be accomplished by: a) performing a thorough literature review that includes information from other state DOTs and CDOT current methodologies, b) testing the new methodology, and c) analyzing all data collected. Testing of the new methodology consists of four steps: 1) characterization of the site geomorphology and groundwater, 2) material sampling and lab characterization, 3) instrumentation of the field and site monitoring, and 4) modeling synthesis, validation, and landslide prediction. The technology can then be deployed at any similar geomorphologic environment around the country and the world.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 12/07/10 Ver:
Contract: 11HAA25597

Completion/End Date: 12/07/2012

CDOT SAP # 27100300

Principal Investigator(s):
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303-273-3654

Co-Principal Investigator(s):
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303-273-3961

Study Manager:
Aziz Khan, Research & Innovation Branch
303-757-9522

Study Panel Members:
H-C., Liu, Materials & Geotechnical Branch (Panel Leader)
Bill Scheuerman, R-1 Resident Engineer
Mark Vessely, Shannon and Wilson, Inc.
Trever Wang, Bridge Design and Management Branch
Russel Cox, R-1 Resident Engineer
David Thomas, Materials and Geotechnical Branch
Tonya Hart, CTL Thomson, Inc
Mathew Greer, FHWA-Colorado

RESEARCH TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
4/30/11	100%	Y	Task 1: Literature Review
7/30/11	100%	Y	Task 2: National DOT Survey

4/30/11	100%	Y	Task 3: Detailed review of CDOT/Consultants methodologies
11/07/12	35%		Task 4: Testing of new proposed methodology
11/07/12	15%		Task 5: Analysis of data
12/07/12	0%		Task 6: Draft and final report

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
08/11/10	100	Y	Proposal presented
09/01/10	100	Y	Kick-Off Meeting with CSM and USGS Landslide Hazard Team
12/07/10	100	Y	Notice to Proceed (NTP) to CSM

Project completion

Project completion/end date is 12/07/2012. PI/CSM would request an extension beyond the completion date (if needed) at least six months prior to the end date.

SIGNIFICANT EVENTS

Note 1: We have completed a national survey to all DOTs. Currently, we have received 38/50 responses. Of the state DOTs that have responded, 6/38 reported more than 100 landslide events along highways within the last 5 years, 18/38 reported 16 – 100 events, and 15/38 reported 15 or less landslide events. Information on the number of infiltration-induced landslides and shallow landslides was also obtained. The failure frequency of most landslides are either moderate (15/38 responses) or annual (13/38 responses). The instrumentation used by most DOTs include: slope inclinometers, rain gauges, piezometers, open air standpipes, observation wells, etc. Most DOTs recommend improving the drainage system and replacing the failed mass with rock. Other remediation methods include Reinforce soil slope, French drains, soil replacement with geogrid, berms, rock buttresses, rock shear keys, construct pile walls with the pile tips embedded 10 ft into bedrock, soil nails, and soil anchors.

A report on the findings of the survey has been submitted to CDOT together with this report.

Note 2: Drilling effort, sample recovery, and installation of piezometers and inclinometer casings was coordinated and accomplished between CDOT, CSM, and USGS. This effort is a significant milestone that will allow us to obtain detailed information on the slope profile and water table changes in the North-South and East-West directions. After the undisturbed samples are tested in the laboratory and the data analysis is completed, we will be able to design the placement and procedure of suction and moisture content sensors as well as continue monitoring the data. The tasks accomplished include:

- Drill, log, and obtain undisturbed samples to 57ft depth on I70, West bound (BH1).
- Install piezometer and set up automatic data acquisition for BH1
- Drill, log, and obtain undisturbed samples to 30ft depth near the toe of the slide (BH2).
- Install piezometer and set up automatic data acquisition for BH2

Note 3: We are in the process of coordinating drilling of 2 more boreoles near the toe of the slope (BH3 and BH4), piezometer and data acquisition installation for BH3, and open well installation for BH4.

Note 4: Two research progress update meetings with CDOT personnel took place on September 19th and September 28th.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Sustainable Stabilization of Sulfate-Bearing Soils with Expansive Soil-Rubber (ESR) Technology
Study No: 74.95

Background

Pavement construction and maintenance problems due to the presence of sulfates in lime-stabilized subgrades have been reported in many transportation projects. In Colorado, problems associated with sulfate-induced distresses have been observed at the Denver International Airport and, more recently, at the U. S. Highway 287 Berthoud By-pass project. Although problems caused by conventional calcium-based stabilization of sulfate-bearing subgrade soils may be mitigated by carrying out preliminary tests to determine sulfate concentrations, it would be desirable if CDOT engineers could count on alternative soil stabilization techniques that are not affected by the potential presence of sulfates. A sustainable stabilization technique has been developed at Colorado State University (CSU) to mitigate the swell potential of expansive soils with rubber from scrap tires. The main objectives of this new stabilization technique are two-fold: (1) reduce the swell potential of expansive soil (including soils containing sulfates), and (2) maximize recycling of scrap tires in the state (Colorado has one of the largest inventories of stockpiled scrap tires in the country and one of the lowest recycling rates in civil engineering applications (CDPHE 2007).

Previous ESR research carried out at CSU with soils collected from the U. S. Highway 287 Berthoud By-Pass project suggest that both the swell percent and the swell pressure of ESR mixtures prepared with this new technology are significantly lower than the swell percent and swell pressure of the untreated natural soil (Seda et al. 2007). Thus, the proposed ESR technology may be used to reduce the swell potential of expansive soil layers in a variety of geotechnical and highway projects including (but not limited to) stabilization of subgrade soils and bridge abutment embankments. Since ESR technology does not rely upon conventional calcium-based stabilization mechanisms, it may be particularly suitable for projects where local soil deposits are rich in sulfates and traditional chemical stabilization techniques are either unsuitable or require additional mitigation efforts for implementation.

This study's goal is to help develop a new stabilization protocol that will allow CDOT and other state and federal transportation agencies to rely upon an alternative stabilization method that is not subject to the typical problems associated with calcium-based stabilization of sulfate-rich soils (the proposed technology is also appropriate to stabilize sulfate-free subgrade soils).

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 03/30/08

Principal Investigator(s):
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Study Manager:
Robert de Dios, DTD Research (303)757-9975

Study Panel Members:
James Chang, Region 6 Materials
Gary DeWitt, Region 4 Materials
Rex Goodrich, Region 3 Materials
Donna Harmelink, FHWA-CO Division
Alan Hotchkiss, HQ Materials and Geotechnical
Shamshad Hussain, Region 1 Materials
Aziz Khan, DTD Research Branch
C.K. Su, HQ Materials and Geotechnical

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
4/10/09	100	4/10/09	Notice to Proceed
05/18/09	100	5/18/09	Task 1 – Pre-Kickoff Meeting-1, a meeting planned for end of July
07/01/09	80		Task 2 – Literature Review
05/18/09	100	9/11/09	Task 3 – Material selection

08/01/09	-		Task 4 – Laboratory Experimental Program – Phase I
	100	5/25/11	Sub-Task 4.1 – Characterization
	100	2/15/11	Sub-Task 4.2 – Compaction
	100	9/30/11	Sub-Task 4.3 – Resilient Modulus Testing I
	95		Sub-Task 4.4 – Resilient Modulus Testing II
	100	9/30/11	Sub-Task 4.5 – Poisson's Ratio Evaluation
	90		Sub-Task 4.6 – Swell Consolidation
05/01/10	-		Task 5 – Laboratory Experimental Program – Phase II
	100	9/30/11	Sub-Task 5.1 – Triaxial Testing
	100	9/30/11	Sub-Task 5.2 – Bender Element Testing
07/01/10			Task 6 – Development of the MEPDG Database
09/1/10			Task 7 – Development of the ESR Stabilization Design Protocol
06/1/10			Task 8 – Construction of Small-Scale Test and Control Sections
05/1/10			Task 9 – Development of Construction, Monitoring and Documentation Procedures
06/1/10			Task 10 – Field Section Monitoring
Every 3 months		7/15/09(QR1) 10/7/09(QR2) 3/12/10(QR3) 2/15/11(QR4) 5/25/11(QR5) 7/14/11 (QR6) 10/5/11 (QR7)	Task 11 – Quarterly and Final Report Writing
06/2010 & 06/2011			Task 12 – Research Results Presentation

SIGNIFICANT EVENTS

9/30/2011 - Majority of the tests required for Tasks 4 and 5 (Laboratory Experimental Program – Phases I and II) have been completed. A couple tests for Sub-Tasks 4.5 and 4.6 are still ongoing but should be completed in the near future. Activities related to Tasks 6 and 7 have started.

7/12/2011 - Resilient modulus testing resumed.

7/11/2011 - Resilient modulus equipment repaired and re-calibrated (vertical steel shaft and bronze bushing were damaged and had to be completely rebuilt at the CSU machine shop).

5/25/2011 - Resilient modulus equipment undergoing repair and re-calibration.

2/15/2011 - Research update provided to Roberto DeDios.

9/23/2010 - New research assistant started working on the project.

9/23/2010 - A summary of preliminary results was submitted on September 23, 2010.

6/30/2010 - No activity was reported in this quarter.

3/12/2010 - Verbal offer made to new research assistant.

2/25/2010 - New research assistant candidates shortlisted.

12/11/2010 - Preliminary search for new research assistant started.

12/10/2009 - PI notified of research assistant's health issues.

10/01/2009 - Task 4 Update (% progress for all subtasks provided below):

4.1 Basic material characterization: 30%

4.2 Compaction and time domain reflectometry: 25%

4.3 Resilient modulus testing: 10%

4.4 Resilient modulus testing: 0%

4.5 Poisson's ratio evaluation: 0%

4.6 Swell consolidation testing: 10%

09/17/2009 - Copy of the CDOT Field Materials Manual provided by Mr. Gray Currier.

09/11/2009 - Mr. Gray Currier visited the CSU geotechnical research laboratory to inspect the samples from the Berthoud site delivered by CDOT personnel. After inspecting the samples, Mr. Gray Currier pronounced them to be the correct samples for testing.

09/07/2009 - Documentation on pavement cross section for the Berthoud By-Pass project provided by Mr. Gray Currier.

08/18/2009 - Copy of the sulfate content analysis procedure (followed at CDOT laboratories) provided by CDOT.

07/28/2009 - Sampling at the Lafayette site conducted by Mr. Robert Gonser and Mr. Louie Lopez. Both intact samples and bulk samples from this site were delivered by CDOT to the CSU's geotechnical research laboratory.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Development of CDOT Materials and Construction Specifications for Bridge Deck Sealers (Deck Sealer Products)
Study No: 80.11

Background

Chemical sealers, applied on the top concrete surface, are employed by CDOT for waterproofing bare new and existing bridge decks that do not have asphalt overlay. The type of sealers includes silane, siloxane, epoxy, and methacrylate. These and other commercially available sealers products have been developed to reduce the penetration of chloride ions from deicing salts and thereby preventing the corrosion of the reinforcing steel. Unfortunately CDOT material specifications allows for only limited types of sealers, silane for the "penetration sealers" and methacrylate for the "crack sealers."

This research should develop generic type of performance-based material and construction specification for penetration and crack sealers that would allow for acceptance of other type of sealers materials based on the results of performance tests. The study should present all the details for the types of these tests (laboratory and field) and for interpretation of the test results. Some of the tests that should be considered for the penetration sealers include the chloride ponding test, elongation test, skid test, UV stability test, freeze-thaw tests, and tests for quality assurance of the placed sealers during construction. Some of the tests that should be considered for crack sealers include skid test, UV stability test, freeze-thaw tests, depth of penetration into the typical size of cracks developed in bridge decks, and tests for quality assurance of the placed sealers during construction. The crack sizes for application of the crack sealers should be established. The construction requirements should include information on the surface preparation before application of the sealers.

Reporting Period: 7/1/11 through 9/30/11

Type: SP&R (05/20/08-11/19/09)

Principal Investigator(s):
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Study Manager:
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Panel Leader:
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MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
10/1/06	100	10/26/06	Hold first panel meeting to discuss scope of work and domain of PI. This meeting is scheduled for October 26, 2006
11/1/06	100	12/29/06	Finalize scope of work (SOW) and RFP
3/5/07	**100**	**3/5/07**	**SOW sent to purchase office for finalizing RFP**
7/30/07	100	10/15/07	Finalize the selection of the Principal Investigator (PI)
2/15/08	100	5/20/08	Notice to Proceed

RESEARCH TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
7/31/08	100%	09/30/08	Task 1 Literature review on sealers and sensors Literature review completed.
	100%	07//09/09	Task 2: Field evaluation of monitoring system

	100%	04/01/10	Task 3: Interim report and testing plan
	100%	06/02/10	Task 4: Field evaluation of sealers
	80%	06/31/11	Task 5: Analysis of field evaluation results
	70%	09/31/11	Task 6: Draft report and final report

SIGNIFICANT EVENTS

1/07: RIC Approved additional funding

12/06: It was determined that additional funds were needed to for traffic control. The study has been put on hold until the additional funds could be secured through the Research and Implementation Council (RIC).

11/06/08: The CU research team and CDOT program managers had a field trip to bridge structure F-17-KJ, which was selected as the bridge to install the sealers and sensors for performance monitoring. During the field trip, it was found that de-icing salts will not be applied on the bridge decks of F-17-KJ in the winter of 2008. As a result, another bridge will be selected by CDOT study panel.

04/03/2009: Four bridges were recommended by CDOT study panel for the application of selected sealers. They are E-17-NX, E-17-QM, E-16-PJ, and E-17-PD. One of the four bridges will be selected for actual application. Field trips will be arranged.

05/27/09: Two field trips for bridge selection on May 21 and May 27, 2009. Bridge structure E-17-QM is the final candidate bridge for the project. A meeting to coordinate the effort for setting up power supply on E-17-QM is scheduled on 07/13/09.

10/15/09: CU Boulder research team completed confined space training needed for the box girder instrumentation installation and data collection.

10/15/09: CU Boulder research team filed a no-cost extension for the project. The ending date will be Nov. 30, 2010.

05/26/10: 18 moisture/temperature sensors were installed and concrete cores from four testing sections were taken.

06/02/10: Four types of sealers were applied on the bridge.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Seismic Testing for Quality Assurance of Lime-Stabilized Soil
Study No: 80.30

Background

In AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) procedure, the critical design parameter required for subgrade, subbase, base and stabilized layers is modulus. In CDOT design practice, the resilient modulus (M_R) of the material is estimated via correlation to unconfined compressive strength (UCS). During quality assurance (QA) process, the M_R is also estimated from correlation to UCS. For stabilized soils, the correlation to M_R is based upon UCS of samples that have undergone accelerated curing (100 ^oF) for 5 to7 days. There are a number of limitations to this QA approach:

- This lab-based assessment is not a true evaluation of the field-constructed product. While the soil does come from the construction site, specimens are prepared in the lab using standard Proctor energy (and not actual field compaction energy). This creates a structure that is different from the field-compacted soil. It has been demonstrated that field compaction and lab compaction can be significantly different.

- The estimation of field-constructed M_R comes from a correlation to UCS that may not be representative for all soils. The test does not directly measure M_R.

- The M_R - UCS correlation equation is based on 28-day normally cured samples; however, the M_R is determined via correlation by using UCS results from accelerated cure (e.g., 5 days at 105 ^oF) samples to expedite construction. This introduces additional uncertainty because 5-day accelerated curing is only an approximation of 28-day normal temperature curing. As documented in the Department research study Report No. CDOT-2010-1, there is no unique 105 ^oF curing duration that mimics 28-day normal curing for all soils. Therefore, 5-day 105 ^oF curing will overestimate or underestimate strength and stiffness, depending on soil type.

Ideally, a QA approach should directly measure the design parameter (i.e., modulus) of the field-constructed material. The technique should allow for testing after 3, 4 or 5 days to expedite construction.

The seismic technique enables the direct measurement of modulus in the lab and in the field. Seismic waves propagate through the soil at a speed that is proportional to Young's modulus E and shear modulus G. The design modulus may be determined in the laboratory for the given stabilized soil using a free-free resonant (FFR) test, and can be verified directly in the field with a seismic method.

The main objective is to determine the technical and economic feasibility of using seismic techniques to measure the laboratory and field modulus of lime-stabilized soils (LSS) used in a CDOT construction project.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 06/29/10

Principal Investigators:
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MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
9/17/10	100	9/17/10	Hold study panel kick-off meeting.
10/31/10	100	6/30/11	Perform comprehensive literature review
12/31/10	100	6/30/11	Develop a detailed plan and schedule of activities to complete the research project
12/31/10	100	6/30/11	Identify candidate projects
12/31/10	100	6/30/11	Select a project
12/31/10	100	1/10/11	Submit quarterly progress report
3/31/11	100	4/20/11	Submit quarterly progress report
4/30/11	50		Perform laboratory testing of lime-stabilized soil (LSS) design mix
6/30/11	100	7/15/11	Submit quarterly progress report
7/31/11	10		Perform field testing of LSS
7/31/11	30		Perform additional laboratory testing of field LSS
7/31/11	10		Conduct cost-benefit/usability analysis
8/31/11	20		Perform data analysis
9/30/11	0		Develop Quality Assurance (QA) specification
9/30/11	100	10/10/11	Submit quarterly progress report
12/31/11			Submit quarterly progress report
5/01/12			Submit draft final report.
5/09/12			Present results of research work to the Materials and Advisory Committee (MAC)
6/15/12			Submit panel-approved final report

SIGNIFICANT EVENTS

10/10/11 Testing at Truth Christian Academy project site was completed with success. We still plan to conduct further testing in Fall of 2011 and Spring of 2012.

7/15/11 The Truth Christian Academy project has been delayed until late July/early August. A second project – Candelas in Arvada, CO has been identified and is expected to be conducted in Fall of 2011 and Spring of 2012.

4/20/11 Through conversation with ARS, our first candidate project is at the Truth Christian Academy (Bellevue/Quincy streets). This project is scheduled to begin in May.

1/10/11 Through conversation with the major lime-stabilization contractor ARS, we learned that we must wait until end of February (or thereabouts) to have a good idea for candidate project sites and project site selection. This is why we have not selected a project.

6/29/10 CDOT Procurement Office issued Purchase Order No. 211010111 to have the Colorado School of Mines perform the research to evaluate the feasibility of using seismic testing for quality assurance of lime-stabilized soil.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Thin-Bonded Overlays on Asphalt and Concrete Surfaces
Study No: 84.14

Background

The CDOT and other state DOTs are faced with a continuous problem of maintaining and replacing the wearing surfaces on bridge decks. Wearing surfaces are utilized on many bridge decks in an effort to maximize the life of the bridge deck, prevent the infiltration of water and aggressive chemicals such as chlorides from deteriorating the concrete surface and corroding the steel reinforcement.

There are a number of wearing surface materials available; however, the service life of many of these materials is less than ten years and requires extensive time and equipment to remove and replace such surfaces. In addition, care is need when removing these types of surfaces as to no damage the impermeable membrane placed atop the concrete bridge deck surface.

Recently, advancements in thin-bonded overlays have produced materials that promote an improved wearing surface and anti-icing properties. These innovative materials can replace more traditional overlays such as asphalt, portland cement concrete, non-reinforced polymer cement concrete.

If the products examined in this study prove successful in providing a durable skid resistant wearing surface that prevents the formation of bonded snow or ice to the bridge surface, the CDOT will be able to recommend these products for future bridge construction and rehabilitation projects. Ultimately this could be a cost savings, as it would potentially reduce maintenance costs on bridge structures. In addition, the anti-icing component of these materials may improve driver safety during winter conditions thereby reducing weather related accidents.

Reporting Period: 7/1/11through 9/30/11
Type: SP&R Start: 05/09 Ver:
Contract:

Principal Investigator
Dr. Stephan Durham, Professor at UCD

Study Manager:
Aziz Khan, Research Branch

Study Panel Members:
Glenn Frieler
Ali Harajli
Eric Prieve
Roberto de Dios
Ryan Sorensen
Mark Mueller
Skip Outcalt
Patrick Kropp
Mickey Madeliro
Matt Becker
Telecia McCline

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
5/20/09	100	5/20/09	PI Selected
7/22/09	100	7/22/09	**Notice to Proceed Issued**
8/24/09	100	8/24/09	Project “Kick-Off” Meeting
10/05/09	100	5/01/10	Traffic Control, Instrumentation, Testing, and Const. Plans
10/15/09	100	6/09/10	Field Implementation of SafeLane Overlay
10/22/09	100	10/31/09	Literature Review Completed
10/22/09	100	10/31/09	DOT Survey Findings Report Completed

RESEARCH TASKS

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
10/22/09	100%	10/31/09	Task 1a: Literature review

10/22/09	100%	10/31/09	Task 1b: Conduct a national survey of state DOTs
10/05/09	100%	5/01/10	Task 2: Develop a traffic, instrumentation, and data collection plan
10/05/09	100%	6/09/10	Task 3: Install the approved products on I-76 and Weld County Road 53 east bound bridge at MP 36.54. Document installation process.
08/22/10	100%	6/24/10	Task 4: Collect and analyze data to determine the effectiveness of the anti-wearing/anti-icing products. The examination will included, but not limited to: anti-icing, skid resistance, chloride penetration, permeability and snow melting.
10/22/10	75%		Task 5: Prepare and submit a Draft and Final Report to the CDOT.

SIGNIFICANT EVENTS

07/09 Project officially begins
08/09 Project "Kick-off" meeting
08/09 Preliminary Literature Review Submitted
09/09 DOT Survey Findings Report Completed
09/09 Progress Report Submitted
09/09 DOT Survey Findings Report Submitted (to be submitted by 09/30/09)
10/09 Field Cores Taken from Bridge Deck (to be used for chloride and permeability testing.
12/09 Chloride Testing of Bridge Cores Performed
12/09 RCIP Permeability Testing Performed on Bridge Cores
01/10 Progress Report Submitted
04/10 Testing Plan Complete (meeting between CDOT and UCD on April 8, 2010)
04/10 Instrumentation Plan Complete (meeting between CDOT and UCD on April 8, 2010)
04/10 Traffic Control and Construction Plans Meeting Scheduled (April 21, 2010)
06/10 Construction of SafeLane Product on I-76 and WCR 53 by Region 4 Personnel
09/10 Meeting to Discuss Maintenance, Testing, and Data Collection for Winter
01/11 Project Update at CDOT Materials Laboratory (Holly Branch)
03/11 Additional Physical Testing of Overlays on I-76/Parker Rd./I-25
06/11 Permeability and Chloride Results Complete

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Innovative and Economical Steel Bridge Design Alternatives for Colorado: Hybrid Girders, Double-Composites, Epoxy FRP Cover Plates, and External Post
Study No: 85.10

Background

Hybrid weld plate SMC girders are a valid competitor not only to continuous hybrid steel girders but also to the dominant precast post-tension prestressed spliced girders. However to move along from steel wide flange rolled beams to welded plate girders, more rigorous theory and validation regarding continuity, fatigue, buckling and plasticity at the negative moment region needs to be investigated. Specifically, during the Phase-I study, several key detail issues arose which have not been addressed adequately throughout the U.S. or in Colorado. These include:

(1) Concrete slab steel distribution that is required to ensure shear capacity near an interior support where two beams come together. It is anticipated that there is significant shear lag as the lateral distance between the steel and beam joint increases, as depicted in Figure 1;
(2) Rotation at the interior support that is not accounted for when the assumption of a continuous beam design is made has not been addressed. This is a critical issue when going from preliminary design, i.e. beam size selection, to design detailing; and
(3) Possibility of beam web crippling at the interior support due to the rotation described in 2. Figure 1 depicts this rotation which is currently not accounted for in SMC design.

This phase II study addresses these three issues above and then focuses on other potential approaches that include:

(1) External post tensioning using either steel or FRP rods;
(2) Use of hybrid steel girders to enable the use of high performance steel in key regions of the girders;
(3) Use of double composite steel-concrete bridges as depicted in Figure 2 (this can also be a beam with two webs angled to form a tub and a bottom concrete flange poured; and
(4) Application of an FRP cover plate to the bottom flange using epoxy to optimize the cross section.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 06/09 Ver:
Completion/End Date: 10/22/11

Principal Investigator:
Rebecca Atadero & Suren Chen, CSU

Study Manager:
Aziz Khan, Research Branch, 303-757-9522

Study Panel Members:
Trever Wang, (Panel Leader)
Staff Bridge, 303-512-4072

Tawedrose (Teddy) Meshesha
Staff Bridge, 303-757-9046

Mahmood Hasan
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Staff Bridge, (303) 757-9337

Dan Groeneman
Staff Bridge, 303-512-4079

Matt Greer
FHWA, 720-963-3008

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
2/09	100	2/09	Project approved
12/1/09	100	12/1/09	Project begins
3/30/10			Hold first panel meeting to discuss literature review and remaining scope of work
5/1/10	100	5/1/10	MPC proposal submitted to perform experimental portion of project
6/15/10	100	6/15/10	FEA modeling approach refined
6/15/10	100	6/15/10	MPC proposal funded
9/21/10	100	9/23/10	Survey sent out for first time

10/22/10	100	10/22/10	Follow up survey sent out
Jan 2011	100	2-1-11	Survey Finished

TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
3/15/10	100		Task 1: Literature review
6/1/10	100		Task 2: National survey
6/30/12	40		Task 3: FEA Investigation
12/31/11	60		Task 4: Investigate innovative approaches
12/31/12	20		Task 5: Laboratory test program
3/1/13	20		Task 6: Quarterly reports & Final report

SIGNIFICANT EVENTS

12/1/09 Project officially begins. Project completion/end date is 10/22/11. PI/CSU would request an extension beyond the completion date (if needed) with a brief justification at least six months ahead of the end date.
3/10 Kickoff Meeting
5/1/10 MPC proposal on experimental task submitted
6/1/10 New PI transition meeting in Denver
12/1/10 PhD student Nathan Miller identified to pick up the project in the spring.
3/17/11 Project Meeting with CDOT with new PIs and PhD student

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Long Term Monitoring of Mechanical Properties of FRP Repair Materials
Study No: 85.11

Background

Fiber reinforced polymer composites (FRPs) are currently being used by state departments of transportation to repair deteriorating concrete structures. FRPs are attractive as a repair option because they can be applied quickly, they can conform to a variety of existing geometries, they are lightweight, and they do not significantly alter the dimensions of a structure. They are also attractive because they do not corrode in the presence of chlorides as steel reinforcement does. However, other environmental exposures such as moisture, UV light and freeze-thaw cycles do have the potential to degrade the material. Although extensive research has demonstrated their effectiveness as a structural material, concerns remain about their long term performance. These concerns are primarily due to the fact that FRP is still a relatively new technology and as such there are few FRP projects with extended time in service. The vast majority of existing durability studies on FRP materials has occurred in laboratory settings using accelerated testing conditions and degradation models to predict FRP performance in the field. What is needed is degradation data on FRP
materials that have been in service environments. Furthermore, their relative novelty means that designers may not be familiar with the materials, and design guidance is needed.

Engineers at the Colorado Department of Transportation are interested in the material, but have questions about the long term performance and application techniques for FRP (particularly with respect to environmental conditions in Colorado), which currently
prevent its frequent use. In this project we will work with CDOT to begin to address these concerns. The project will assess the condition of a structure that was repaired using FRP in the summer of 2003. Samples of the FRP material will be collected from the bridge to verify residual mechanical properties of the composite. The project will include a literature review to determine which of CDOT's concerns have been addressed by previous research, and which merit further experimental study. We will also initiate a laboratory testing program to begin to understand the effect of Magnesium
Chloride deicing agent on the mechanical properties of the FRP and the bond between FRP and concrete.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 06/09 Ver:

Completion/End Date: 05/31/2012

Principal Investigator:
Rebecca Atadero, CSU

Study Manager:
Aziz Khan, Research Branch, 303-757-9522

Panel Leader:
Mike Mohseni, Bridge Design and Management (Panel Leader)

Study Panel Members:
Trever Wang, Bridge Design and Management
Dick Osmun, Bridge Design and Management
Mac Hassan, Bridge Design and Management
Patrick Kropp, Materials and Geotechnical
Reichard Wenzel, Materials and Geotechnical
James Chang, R-6 Materials
Skip Outcalt, DTD-Research
Steve Nunn, FRP Consultant (HJ3)
Mathew Greer, FHWA-Colorado

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
Jan 2011	100	2-17-11	Kick-off Meeting
April 2011	100	6-8-11	Start laboratory durability study Control specimens have been tested. All durability specimens are now in conditioning environments.
July 2011	100	7-14-11	On site bridge inspection

December 2011			6 month durability tests
June 2012			1 year durability tests

TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
2/1/2011	100	5/31/2011	Task 1: Testing and Data Collection Plans
5/1/2011	100	7/14/2011	Task 2: Site-Visit On-site Testing
8/1/2011	100	8/30/2011	Task 3: Laboratory Testing /Data Analysis
9/1/2011	35		Task 4: Literature Review
Ongoing	35		Task 5: Long Term Testing
4/1/2012			Task 6: Reporting

SIGNIFICANT EVENTS

7/1/10 MPC project with matching funds is awarded

12/15/10 Project officially begins. Project completion/end date is 05/31/2012. CSU would request an extension beyond the completion date (if needed) with brief justification at least six months ahead of the end date.

2/17/11 Kickoff meeting at CDOT

5/31/11 Progress report Meeting at CDOT to discuss site visit

7/14/11 Finish Site Visit

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Deterioration and Cost Information for Bridge Management
Study No: 87.60

Background

PONTIS is a comprehensive bridge software management program developed as a tool to assist in the challenging task of managing bridge inventories (http://aashtoware.org/). PONTIS stores bridge inventory and inspection data; formulates network-wide preservation and improvement policies for use in evaluating the needs of each bridge in a network; and makes recommendations for what projects to include in an agency's capital plan for deriving the maximum benefit from limited funds.

CDOT's bridge inspection unit is directly responsible for the inspection of the bridges on the State Highway System, the administration of consultant contracts for a bridge inspection program for the city and county bridges, and maintaining inspection standards using PONTIS.

CDOT's bridge management unit is responsible for bridge database maintenance, development, and all reports derived from the bridge inspections and the resulting databases.

The primary product of this research will be an effective and functioning use of the preservation module in PONTIS that is appropriately calibrated for Colorado's bridges. The module will be able to include realistic deterioration rates for various bridge elements used in the State.

Reporting Period: 7/1/11 through 09/30/11
Type: SP&R Start: 11/08 Ver:
Contract:

Principal Investigator:
Dr. George Hearn, Associate Professor of Civil Engineering, University of Colorado, Boulder 303-492-6381

Study Manager:
Aziz Khan, Applied Research and Innovation Branch, 303-757-9522

Study Panel Members:

Jeff Anderson, Bridge Design and Management Branch (Panel Leader), 303-757-9188
Mark Nord, Bridge Design and Management Branch, 303-512-4073
David Ellison, Bridge Design and Management Branch, 303-757-9068
Jake Kononov, Applied Research and Innovation Branch, 303-757-9973

FHWA Washington Contact:
Mathew Greer, FHWA-Colorado
720-963-3008

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
06/15/08	100	06/30/08	PI Selected
9/30/08	100	11/03/08	Notice to Proceed Issued
12/04/08	100	12/04/08	Kick-Off Meeting
12 /08	100	12/22/08	Meet with CDOT Maintenance about maintenance management system
11/15/10	-		Interim report & meeting with study panel
12/15/10	100	3/31/11	Draft final report
12/31/10	-		Final report

RESEARCH TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
2/1/08	100	3/31/10	1. Literature Review
3/1/08	100	3/31/10	2. CDOT databases

11/1/10	100	3/31/10	3. Other DOTs
4/1/08	100	3/31/10	4. Deterioration data
11/1/10	100	3/31/10	5. Calibrate deterioration
11/15/10	100	3/31/10	6. Reliability Analysis
11/15/10	100	3/31/10	7. Inspection reliability
11/15/10	100	3/31/10	8. CDOT cost data
11/1/10	100	3/31/10	9. Cost data by region
11/15/10	100	3/31/10	10. Input to Pontis
11/1/10	100	3/31/10	11. Transition probabilities
12/1/10	100	3/31/10	12. Pontis scenarios
12/1/10	100	3/31/10	13. Automated data process
12/31/10	100	3/31/10	14. Final report under review

SIGNIFICANT EVENTS

2008 – Fourth Quarter

The kick-off meeting was held on Dec. 4, 2008 at CDOT offices in Denver.

CDOT's listing of bridge projects was obtained by email on Dec. 12, 2008.

A meeting with CDOT Maintenance branch was held on Dec. 22, 2008 in Golden, Colorado. Data available in the MMS were discussed, and the collection of data on actions and unit costs was started. B.J. McElroy provided maintenance cost data by email on Dec. 30.

CDOT's PONTIS BMS software and bridge database were obtained as CDs on Dec. 26, 2008.

2009 – First Quarter

Costs used in CDOT maintenance management system for bridge maintenance actions were obtained in January 2009 from B.J. McElroy. Ms McElroy also kindly provided a copy of the user's Level-of-Service (LOC) rating manual for CDOT's maintenance management system.

Literature reviewed began in January 2009 and continued through the first quarter. We are reviewing maintenance manuals and maintenance guides collected from US DOT websites. We are identifying the maintenance activities that are preservation actions. We will seek cost data for these activities.

We obtained costs for Pontis actions from Mr. Arthur D'Andrea, the assistant bridge engineer for Louisiana DOT.

2009 – Second Quarter.
Work in the second quarter included:

- Collection of complete Pontis unit costs from Delaware DOT.
- Collection of bid tabulations for CDOT bridge-related projects for the years 1998 and 2000 through 2008.
- Creation of a software application to parse CDOT bid tabulations and create Excel-ready files for import and computational work.
- Analysis of bid tabulations for projects in 2001 and 2002. Computation of the first set of CDOT unit costs for use in Pontis.
- Continuing collection of literature sources.

2009 – Third Quarter
Work in the third quarter included:

- Continuing collection of literature sources.
- Computation of element-level maintenance costs from crew and contract maintenance data obtained from DOTs in California, Michigan, Oregon and Tennessee.

2009 – Fourth Quarter
Work in the fourth quarter included:

- Software applications and data processing for Pontis element inspection data.
- Adjusting quantities and units in element reports.
- Applications and processing for project data from CDOT Staff Bridge Branch.
- Development of basis, in bridge components, to link construction projects to records from element-level inspections.

2010 – First Quarter
Work in the first quarter included:

- Software applications and data processing for Pontis element inspection data.
- Software applications and data processing for bid tabulations collected from CDOT Contracts Unit.
- Completion of literature search.

2010 – Second Quarter
Work in the second quarter included:

- Collection and verification of selected element-level condition data.
- Collection of CDOT bid tabulations for bridge-related contract work.
- Processing of bid tabulation to form data tables.
- Identification of bridges affected by contracts.
- Identification of bridge-related bid items and costs.
- Identification of events, such as deterioration or repairs, in service life of bridge elements.
- Correlation of service life events with specific contracts.
- Computation of deterioration probabilities.

2010 – Third Quarter
Work in the third quarter included:

- Creation and use of software to calibrate deterioration models to element-level condition data.
- Creation of software to generate element-level repair costs from CDOT bid tabulations.

2010 – Fourth Quarter
Work in the third quarter included:

- Completion of work on costs, deterioration rates, transition probabilities, reliability and inspection intervals.
- Drafting of final report in progress.

2011 – First Quarter
Work in the first quarter completed all tasks in Study 87-60. A draft final report was sent to CDOT on Mar. 21, 2011. A final revised reported will be submitted after input by the study panel.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Tension Cable Guardrail
Study No: 91.06

Background

Tensioned cable guardrail (TCGR) systems have been used all over the world for several years. In windy areas, guardrails can act like a snow fence causing drifts across the highway. Cable guardrail systems could be very useful in Colorado in areas with snow-drifting problems. Cable guardrail is bi-directional making it a useful option in narrow medians in addition to shoulder applications. It provides a relatively "soft" barrier that, in most situations, is somewhat gentler on vehicle occupants than steel rail or concrete barriers. In addition, after an accident, maintenance is simple, fast and inexpensive, and the system retains its functionality even before repairs are made. Cable guardrail is also visually less obtrusive than other designs.
This study will monitor the performance of tensioned cable guardrail systems installed in Colorado. Important factors include: Severity of injuries and damage to vehicles; cost for repairs including time and materials; availability of materials and product support; ease of repair and maintenance.
Accident, maintenance and repair data will be evaluated to establish criteria to help in selection of the best system and best configuration for a particular situation.

Implementation

Accident data together with maintenance and repair data will provide insight into the suitability of tensioned cable guardrail used under varying conditions. The data will also provide information regarding situations where cable guardrail is not the best alternative and the reasons why. Recommendations will be made for use of various criteria in selecting the appropriate system.

Reporting Period: 7/1/11 through 9/30/11
Type: Experimental Feature

Principal Investigator:
Skip Outcalt, CDOT Research, 303.757.9984

Study Manager:
Skip Outcalt CDOT Research 303.757.9984

Study Panel Members:
R1 Eng. 303.716.9925
Tony DeVito R1 303.716.9925
Larry Haas, R4 Traf. 970.350.2143
Darrell Dinges, Standards 303.757.9083
Al Roys, Sec 1 Maint 303.910.8574

FHWA Contact:
FHWA CO Div. 720.963.3007

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
06/02		09/02	Monitor and document the installation of Brifen guardrail on US 285 at MP 141 – Windy Point.
04/03		04/03	A study panel meeting will be held to discuss the work plan for the study, what information will be kept in the databases, and to establish the length of the study and the number of sites that will be accepted for evaluation under this study.
08/03		08/03	Monitor construction of the site on I-25 near MP 250
12/03	90		Evaluate the systems based on repair costs and time needed to repair hits and the effectiveness of the system in reducing the severity of accidents.
05/04		06/04	Write and distribute interim report with recommendations for suitable situations and specific items that should be addressed on each project
12/04		05/05	Construction of median WRSF systems has begun on I-25 mp 229 – 269. CASS is being installed along the frontage road at mp 252. Very little accident data has been received in Research for inclusion in the accident database.
04/05		04/05	Study panel meeting to evaluate the progress of the study and discuss accident reports.
10/05		12/05	Installation of Trinity CASS systems in the median on I-25 ≈mp 174 – 181 and on SH-86

			near Castle Rock.
07/07		07/07	Install approximately 1 mile of each of the 5 certified manufacturers' systems in the median of C-470 from mp 14 to 19
06/11	90		Evaluate post construction crash data. Write and distribute the final report.

SIGNIFICANT EVENTS

9/1/11: Precise locations of terminals and barrier sections are being added to the data base to improve evaluation of crash data. There are cross-over crash reports in areas where TCB is installed that do not mention cable barrier. These crashes may have occurred at emergency turn-around locations, or between two barrier anchors.

1/1/11: Crash data through 2008 is available for most TCB locations. Post-construction crashes can now be compared to pre-construction crashes so the TCB can be evaluated for cost and crash prevention effectiveness.

12/09: Crash Data and maintenance costs are being summarized and analyzed for the final report.

6/09: A spec has been drafted for TL-3 and TL-4 Tensioned Cable Barriers.

12/08: A database with site locations, construction specifications and costs, and traffic data is completed for projects completed through summer of 2008.

09/08: Data from the C-470 project which includes all five of the NCHRP 350 approved TCGR systems is being included in the study.

12/07: An Excel spreadsheet database with extensive information about each of the high tension cable barrier (HTCB) sites constructed through 12/07 is available. Also available is a "Things to Watch" list that explains many of the problems encountered by CDOT and their solutions.

A five-mile long site has been constructed using about one mile from each of the five manufacturers who currently have HTCB that has received NCHRP 350 certification – Trinity, IA Safence, GSI Nucor, Gibraltar and Brifen. The systems will be evaluated for performance and "maintainability".

08/07: The Research Branch (Skip Outcalt & Rich Sarchet) will set up and maintain a database with information concerning tensioned cable barrier systems installed by CDOT.

07/07: Rich Sarchet attended a seminar sponsored by TRB to discuss TCGR with manufacturers and representatives of several DOTs.

09/06: Several anchor blocks have been seen to be pulled out of the ground and the tension is low in some of the systems installed on I-25 north of Denver. Brifen has recommended a fix for the anchors and sent representatives to Colorado to conduct training system maintenance methods seminars for personnel who have cable guardrails.

06/06: Accident data for all sites before the TCGR installation is being reviewed and tabulated. Maintenance data for the sites built before mid-2005 is being reviewed and tabulated. The first draft of the report will be sent to the panel for review by the end of July 06.

01/06 No new sites will be added to this study. The accident and maintenance data will be evaluated and the final report written by the end of the fiscal year.

12/05: The FHWA will approve no more project specific FIPIs to justify the use of proprietary TCGRs As of December 2005 there are five TCGR systems that have FHWA approval at NCHRP TL-3. Of the five, CDOT has installed and is evaluating two for this study: Brifen's WRSF and Trinity's CASS. Because there are five systems with similar capabilities (according to the NCHRP 350 testing), and only two of them have been installed up to this time, this study will be concluded. The accumulated data will be evaluated and a report written based on the WRSF and CASS systems.
A five-mile project, STU 4701-107, will be constructed on C-470 in 2006 to include about one mile of each of the Trinity, Nucor, Blue Systems and Gibraltar systems. The new site is contiguous to an existing Brifen WRSF median site; however, a section of the newly approved three-cable Brifen system may be built as part of the new study.

7/05: New systems installed: Brifen – on I-70 and SH-9 near Frisco, US-287 near Ted's Place.
Proposed systems: Trinity on I-25 and SH-86 near Castle Rock, and the newly approved Brifen TL-4 system on I-70 east of the Eisenhower Tunnel.

8/05: End anchor blocks in Brifen systems on I-25 ≈mp 243 and on US-287 near Ted's Place, were pulled out of the ground by hits near the end of the guardrail systems. Initial evaluations indicate that the blocks may be tapered from top to bottom forming a cone shape rather than the designed 4' diameter cylinder.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Active Traffic Management for I-70
Study No: 92.11

Background

Colorado DOT is in the process of developing an Active Traffic Management (ATM) system along several of their freeways. Region 1 is implementing ATM along the I-70 Mountain Corridor from Eisenhower Tunnel to Bakerville initially. The CDOT ATM system along this mountainous corridor is expected to incorporate Variable Speed Limits (VSL) based on advanced algorithms to improve traffic turbulence in real-time and therefore reduce crash risk and improve flow.

Historically, crashes along this section of road are attributed to drivers driving too fast for the road condition and geometry as there is a potential for severe weather conditions. The approach of this project is to develop real-time crash risk assessment models by analyzing historical crashes to traffic surveillance data corresponding to these crashes in order to detect patterns that are observed before crash occurrence. If these patterns are then repeated in the future on a freeway section, then ATM can then appropriately adjust ramp-metering and speed limits in order to avoid a potential crash in real-time.

The goal of the first phase of this project is to develop a database with crashes, ITS archived data, geometry, and archived weather data and then conduct a preliminary analytical safety study. Based on the outcome of the first phase of this project and available funding CDOT will then determine if they will pursue the other tasks as outlined in UCF's proposal.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 03/21/2011 Ver:

Principal Investigator:
Mohamed Abdel-Aty
University of Central Florida
(407) 823-5657

Study Manager:
David Reeves,
Traffic & Safety Research Engineer
(303) 757-9518

Study Panel Members:
Jake Kononov, Research Director
Bryan Allery, Traffic Engineer (HQ)
Ken DePinto, Traffic Engineer (ITS)
Ali Imansepahi, Traffic Engineer (ITS)
Bernardo Guevara, Traffic Engineer (Region 1)
Clark Roberts, Traffic Engineer (Region 1)
Saeed Sobhi, Traffic Engineer (Region 1)

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
10/01/10	100	3/24/11	Notice to Proceed
04/15/11	100	04/26/11	Get all appropriate VPN Access to CDOT network and ITS Databases
12/15/11	70	8/31/11	**Task 1** – Develop database with crashes, ITS-archived data, geometry, detailed weather archived data
12/15/11	40	6/20/11	**Task 2** – Conduct a preliminary analytical safety study
	30	8/1/11	
01/15/11	0		**Task 3** – Submit draft system design report
03/20/12	0		**Task 3** – Submit final system design document and final report
03/20/12	30		Phase 1 of project complete

SIGNIFICANT EVENTS

- 03/27/11 – Notice-to-Proceed was issued. Project must be completed by 3/20/2012.
- 04/26/11 – PI has access to CDOT ITS databases and has begun extracting ITS data into their database
- 8/1/11 – Completion of good part of the preliminary analysis, and reaching important findings
- 8/31/11 – Downloaded significant amount of RTMS data

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Traffic Adaptive Signals
Study No: 92.12

Background

The Federal Highway Administration recently began a program called the Every Day Counts (EDC) Initiative. The goal of EDC is to identify and deploy innovation aimed at shortening project delivery, enhancing the safety of roadways, and protecting the environment. One part of the program focuses on accelerating the implementation of technology and innovation aimed at leveraging 21st Century technologies and solutions to improve safety, reduce congestion, and keep America moving. The Colorado Department of Transportation (CDOT) identified Adaptive Signal Control as one such technology that could be easily deployed along State Highways in an effort to maximize the existing capacity of the roadways and prolong the need to reconstruct or add additional capacity.

Poor traffic signal timing is a significant cause of delay, increased fuel consumption, higher levels of vehicle emissions, and an increase in congestion.

Project Goal

To evaluate different adaptive traffic signal control systems along two different State Highways to identify the benefits of the systems compared to traditional time based coordination plans currently installed along the corridors. The evaluation will also compare the different systems to each other in a effort to identify an overall cost benefit for the adaptive traffic signal control and assist CDOT in making decisions regarding the future implementation of additional systems on other State Highways.

Project Scope

The project will collect data and complete an evaluation of the adaptive traffic signal systems current being installed within Region 2 and Region 4. Region 2 is implementing the ACS Lite system along the stretch of US 24 that passes through Woodland Park, while Region 4 is installing the InSync system along a stretch of US 34 Business (10th Street) in Greeley.

To evaluate the systems, identical data will be collected before and after the adaptive traffic signal control systems are installed and made operational along the study corridors. Data to be collected includes pre-implementation travel times for six (6) different time periods on a typical weekday and a single (1) time period on a typical weekend. In addition, four (4) intersections on each corridor were identified by regional staff to have all approaches videotaped for a weekday and weekend day to collect pre-implementation data regarding the vehicle volumes, queue lengths, and delays during the same periods when the travel time data was collected. The videotaped data will allow for the analysis of average queue lengths, average vehicle delay, approach level-of-service, and intersection level-of-service.

After the systems are implemented and operating to the satisfaction of the regional staff, similar travel time and intersection approach data will be collected and used to complete a before and after implementation analysis. Performance of the systems will then be identified to determine overall benefits to the traveling public.

Reporting Period: 7/1/11 through 9/30/11
Type: SP&R Start: 04/26/11

Principal Investigator(s):
David Sprague; Atkins, 303-221-7275

Study Manager:
Larry Haas, CDOT Region 4, 970-350-2143

Study Panel Members:
Jake Kononov, Research Director (HQ)
David Reeves, Research Manager (HQ)
Terri Shippy, CDOT Region 2
Eric Lundberg, CDOT Region 2
Sarah Logan, CDOT Region 4
Eric Bracke, City of Greeley
Richard Santos, FHWA
Jamie Archambeau, Atkins

Results of the analysis will be used to assist Region 2 staff in making an immediate decision regarding the retention or removal of the ACS Lite system from the US 24 corridor. Region 2 staff has a limited time, as provided by the system vendor, to make a decision to retain the system and pay for it or have it removed at the vendor's expense. A similar analysis will be completed for the InSync system being installed in Region 4. The InSync system is being installed by CDOT, but will be turned over to be maintained and operated by City of Greeley staff upon completion of construction and implementation of the system. Decision to maintain the operations of the system will then be a City responsibility. In addition, the Region 2 and Region 4 systems will be compared to each other, to the maximum extent possible, to develop a cost-benefit evaluation aimed at assisting CDOT in making future decisions regarding the implementation of additional adaptive traffic signal systems. Cost data to design, construct, and implement the systems will be gathered and future maintenance costs will be estimated. A user benefit value will be calculated based on travel time saving, reduced delay, lower fuel consumption, and lower vehicle emissions. Together the data will then be used to compute an overall cost-benefit for each system. CDOT Research staff will be involved in a long term safety evaluation of the system(s) that remain in operation for more than three (3) years from final implementation. A minimum of three (3) years is required to adequately collect accident data and do a comparison to conditions before the adaptive traffic signal systems were put into operations.	

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
12/30/11	50		Evaluate Region 2 System
3/30/12	50		Evaluate Region 4 System
5/30/12	15		Compare and Contrast Two Systems
6/30/12	33		Complete Evaluation of Two Systems

SIGNIFICANT EVENTS

- 9/21/11 – Project kickoff
- 10/14/11 – All existing conditions data collection completed
- 11/11/11 – Anticipated turn on date for Region 2 system

ANTICIPATED EVENTS FOR Q4 2011

- Complete standalone evaluation of the Region 2 (ACS Lite) system performance
- Provide documentation to CDOT staff regarding the evaluation of Region 2 system
- Provide analysis data and guidance to Region 2 to support decision regarding retention or removal of system

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Use of LED Lighting Bollards to Reduce Vehicle/Wildlife Collisions
Study No: 92.21

Background Wild animal vehicle (WAV) collisions are a serious problem in Colorado. The current practice of establishing deer and elk fencing to keep animals off of the highway in major roadway corridors can disrupt existing migration patterns of deer and elk herds that reside in the area. It may also result in the inability to co-mingle herd populations, resulting in increased in-breeding. This study will look at two methods of reducing wild animal vehicle (WAV) accidents without limiting herd migration routes. For comparing the two methods, an ITS Branch report, titled *US-160: Study on Analysis of Accidents Involving Wildlife*, was used to identify two areas with similar accident histories, terrain topographies, and roadside foliage. On average 30 to 40 percent of the accidents recorded on these segments are wild animal vehicle collisions – one of the highest WAV accident rates in the state. The Vegetation Clearing Treatment Area, on US-160 from M.P. 97.5 to 98.5, will analyze improving driver visibility of the roadway shoulders through controlled and managed clearing of roadside foliage. This will be evaluated by comparing historic WAV accident statistics within the area with WAV accident statistics after the foliage clearing has been made. A control area will be selected in order to eliminate potential confounding variables. The Animal Detection/Driver Warning Treatment Area, on US-160 from M.P. 95.5 to 96.5, will include the same controlled and managed clearing of the roadway shoulders as in the Vegetation Clearing Treatment Area. In addition, electromagnetic detection equipment will be used to determine when wildlife is within the shoulder area of the roadway. When animals are detected, drivers entering the area will be warned by a series of blank out signs that alert drivers to the fact that animals are actually entering the roadway.	Reporting Period: 7/1/11 through 9/30/11 Type: SP&R Start: As soon as SOW is finalized Ver: Principal Investigator(s): Chris Beller, CDOT Region 5, 970.385.3622 Study Manager: Mike McVaugh, CDOT Region 5 Traffic Engineer 970-385-8360 Study Panel Members: Chris Beller, CDOT Region 5 970-385-3622 Jon Holst, CDOT Region 5 970-385-1473 Paul DeJulio, CDOT Region 5 970-382-9095 John Nelson, CDOT ITS 303-512-5820 Bruce Coltharp, CDOT ITS 303-512-5807 KC Matthews, CDOT Staff Traffic 303-757-9543 Patt Dorsey, CDOW Rick Santos, FHWA 720-963-3009

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
10/7/05	100%		Final Scope of Work to be completed. Draft scope of work reviewed by study and discussed with PI.
10/15/05	100%		The Region and the ITS Branch have been investigating and evaluating various technological detection applications such as; infrared sensors and cameras, motion sensors, geophones, triggers, DVR recorders (and environmentally controlled cabinets) etc. in order to determine the most effective technology and all necessary interface requirements. Also, we have been evaluating power and communications requirements.
11/21/05			Began a lighting simulation analysis to determine lighting spacing and angulations based on lighting capabilities in conjunction with terrain, and optimum lighting color.
11/21/05	100%		Region cleared brush in the study segment and in a control segment.
1/19/06	100%		Completed lighting analysis to determine spacing and lamp requirements
1/30/06	100%		Completed preliminary cost estimate, which indicated that budget is inadequate to implement the entire one-mile section.
2/15/06	100%		Performed field evaluation on infrared sensors to determine if they could identify animals and be tuned to their profiles.

3/8/06	100%		Investigated buried cable sensor system and scheduled call with vendor for 4/7/06.
4/7/06	100%		Met w/ vendor. Scoped system feasibility, parameters, cost.
5/30/06	100%		Received Enhancement grant request from Southern Rockies Ecosystem Project.
7/21/06	100%		The Region obtained revised quotes from the vendor for a 0.2-mile test section and an additional 0.8 mile test section (if additional funding becomes available).
8/16//06	100%		The Region submitted a grant application for $143,920 to the Mule Deer Foundation requesting that the foundation pay for the sensor control modules and sensor cable.
8/21/06	100%		The Region submitted an application for CDOT Hazard Elimination Funds in the amount of $702,624 to supplement the project budget.
9/25/06	100%		The Region completed sole source justification and procurement requests for $77,334 to purchase the equipment and vendor support for the 0.2 mile test section.
	100%	10/06	Secured HES funding of $600,000
	100%	12/06	Design “Elk Farm” Test Section
	100%	2/07	Construct and Test “Elk Farm” Test Section
8/07	100%	11/07	Advertise US 160 Test Section
	100%	12/07	Project Awarded – Construction Schedule TBD (2 feet of snow on ground at site).
	100%	9/08	Test section construction

SIGNIFICANT EVENTS

- 11/05 – The brush was cleared in the control and study sections on US-160
- 3/06 – Reviewed available technologies for sensing.
- Refined cost estimate. Unable to complete project with fiscal ’07 funds.
- Preliminary decision to phase system multi-year, starting with detection system first year.
- 4/06 Met with vendor. Scoped system and cost estimate. No response from other vendors.
- 5/06 Enhancement request from SREP (Southern Rockies Ecosystem Project) for separate source of additional
- funding for project.
- 6/06 Unable to find additional buried cable sensing vendors meeting requirements. Identified sole-source
- vendor and out-of-state travel issues for implementing detection system.
- 7/06 Revised vendor estimate obtained for 0.2 mile test section (within budget).
- 8/06 Additional funding requests submitted to the Mule Deer Foundation and CDOT Traffic and Safety.
- 9/06 Sole source justification and procurement requests submitted for 0.2 mile test section.
    - R-5 Wildlife (cont)
- 10/06 Team secures $ 600,000 in HES funding for detection system.
- 11/06 Team designs limited test section at local elk farm to test detection and size threshold.
- 12/06 Team schedules delivery of elk farm test section components and installation/installation training.
- 02/07 Team successfully tests detection system at elk farm. Installation training by Vendor.
- 03/07 Team starts preparing design for US 160 test section, CDOT project for advertisement.
- 06/07 Preparation of plans for full scale test section bid package continues. Late August advertisement is expected.
- 11/07 After Delays due to funding issues the project is advertised
- 12/07 Project Awarded – The advertising delay has resulted in the arrival of winter before construction could begin.
- 3/08 Still waiting for snow to melt
- 6/08 Construction in progress!
- 9/08 Test section is complete. Data collection in progress.

- 12/08 Still collecting data
- 6/09 Data collection continues
- 9/09 Should have a year of data at this point.
- 7/10 David Reeves has replaced Rich Sarchet as the Research Study Manager. Mike McVaugh is still the overall project manager.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Encouraging Innovation by Colorado DOT Employees
Study No: 98.20

Background Historically CDOT Maintenance and Traffic Operations forces have demonstrated their ingenuity and ability to design and manufacture innovative devices and equipment. These innovations have improved productivity and employee safety. CDOT has not taken full advantage of these initiatives. CDOT maintenance workers and traffic operations workers have designed and produced innovative tools such as, an innovative guardrail aligning tool a snow plow blade dolly, and a tool to make loading of glass beads into a striping truck faster and safer. These are not isolated incidents but a reflection of a potential for innovation in our work force. These devices, though used individually, have not been well documented or described, and have not been implemented systematically statewide.	Reporting Period: 7/1/11 through 9/30/11 Type: SP&R Start: 9/30/09 Ver: Principal Investigator(s): Mike Mooney; Colorado School of Mines 303.384.2498 Study Manager: David Reeves, 303-757-9518 Study Panel Members: Jake Kononov, CDOT Research Rich Sarchet, CDOT Research Bryan Allery, CDOT Safety and Traffic Randy Jensen, CDOT Region 6 Skip Outcalt, CDOT Research David Wieder, CDOT Maintenance

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
07/30/09	100	07/16/09	Advertise RFP
8/31/09	100	8/07/09	Receive Proposals
9/15/09	100	8/12/09	Selection
1/1/10	100	9/30/09	Notice to Proceed
3/31/10	100	4/1/10	Identify known innovations
8/31/10	100	6/30/10	Produce mechanical drawings
8/31/10	100	6/30/10	Develop descriptions of use
6/30/10	100	6/30/10	Perform cost-benefit analysis
8/31/10	100	6/30/10	Perform preliminary patentability assessment
8/31/10	100	6/30/10	Evaluate widespread application potential
8/31/10	100	6/30/10	Document all conversations about devices
7/31/10	100	6/30/10	Examine CDOT liability concerns
8/31/10	100	6/30/10	Define process for future documentation
8/31/10	100	9/13/11	Submit Draft Final Report
12/31/10	0		Submit Final Report

SIGNIFICANT EVENTS

- 12/09 – Study will begin in January 2010
- 09/10 – Contract and Notice to Proceed Issued.
- 07/11 – David Reeves has replaced Rich Sarchet as the study manager
- 09/11 – Draft report complete. Most likely this draft will be accepted as-is.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Development of New Corrosion/Abrasion Guidelines for Selection of Culvert Pipe Materials
Study No: 106.00

Background

The existing CDOT corrosion guidelines for pipe material type selection do not specify the service life for any pipes used for drainage. A 50-year service life is assumed for any pipe that satisfies the corrosion level criteria in the existing guidelines. New design and retrofit procedures are needed to incorporate corrosion and abrasion factors to select the proper type of pipes for specific drainage applications with realistic estimates of the service life. Soil and water resistivity and/or abrasion factors will be investigated in addition to pH, chloride, and sulfate level concentrations in areas where drainage pipes failed due to corrosion and/or abrasion. Some of these locations where pipe failures occurred had been or are still being identified in a comprehensive culvert pipe inspection effort conducted by the Bridge Branch across the State of Colorado.

The current guidelines (Corrosion Resistance, CR Table) developed in 1983 use pH, chloride, and sulfate concentrations to determine the corrosion resistance levels that any pipe material should be capable of handling. Since the development of the CR table, various pipe sizes with different types of materials (CMP, RCP, HDPE, etc.) were installed under CDOT roadways using the CR table criteria. However, no concerted effort was made to evaluate these culvert pipes to assess their performance. It was assumed that any pipe material that satisfied the requirements of the CR table would have a service life of 50 years or more. This may be true for pipe materials that are inherently resistant to corrosion/abrasion by virtue of their physical, chemical and biochemical properties. However, this may not be true for other pipes that may fail due to corrosion/abrasion if not properly treated, protected, or coated. New guidelines with information on reliable estimate of service life for each type of pipe material should be developed.

Neighboring states have general guidelines incorporating pH, chloride, sulfate, total dissolved solids, resistivity, water velocity, and slope to assess the impact of corrosion and abrasion on various types of pipes. Some of these factors are associated with estimated service life of the pipe structures. However, this information is site specific and may not be totally applicable to Colorado's unique site conditions. This information from other states will help in the development of Colorado's procedure to determine reasonable service life using various parameters including resistivity and/or abrasion.

The new procedure for selecting pipe material depending on the results of the investigation may include resistivity level and/or abrasion factors in addition to pH, chloride and sulfate concentrations in soil and water. The flexible pipe industry is requesting CDOT to include resistivity and abrasion in developing new pipe materials selection guidelines. The collected data including the findings and recommendations resulting from the inspection effort conducted by the Staff Bridge Branch across the State of Colorado will be used accordingly in the development of the new guidelines for culvert pipe materials selection procedure.

Reporting Period: 7/1/11 through 9/30/11
Start: 5/01/09 Complete: TBD

Principal Investigator(s):
CSU/Dr. Christopher Thornton, 970-491-8394
Dr. Albert Molinas, Mobile: 970-222-2393

Study Manager:
Aziz Khan, CDOT Research
303-757-9975

Panel Leader:
Amanullah Mommandi, CDOT Staff Hydraulics
303-757-9044

Study Panel Members:
Jeffrey Anderson, CDOT Staff Bridge
303-757-9188
Mike Banovich, CDOT Environmental
303-757-9542
Matt Greer, FHWA 720-963-3008
Al Gross, CDOT R-1 Hydraulics
303-757-9342
Keith Powers, R-3 Residency, 970-328-6385
Mohan Sagar, CDOT Specifications
303-757-9649
Fred Schultz, CDOT Maintenance
303-757-9103
C.K. Su, Materials and Geotechnical
303-757-9750
Dave Wieder, CDOT-TREX 303-357-8973

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
	100		Develop scope of work and RFP
	100		Complete the RFP process. The RFP will be issued on 10/22/04.
	100		Select the Principal Investigator: Chris Thornton, CSU
	100		Award the contract.
2/27/09	100	2/27/09	Send Notice to Proceed
3/18/09	100	3/18/09	Attend CDOT's First Culvert Committee Meeting of 2009 to meet panel members
12/31/09	100	12/31/09	Task 1- Literature review
12/31/09	100	12/31/09	Task 2- Applicability of CDOT's CR table
12/31/09	97	12/31/09	Task 3 – Field Testing (97 sites out of 100 tested)
12/31/09	97	12/31/09	Task 4 – Data Analysis (97 sites out of 100 analyzed)
12/31/09	97	12/31/09	Task 5 – Develop service life procedure
04/01/10		04/01/10	Start Phase 2 B – Data collection from Western Colorado
12/31/10	34	06/19/10	Collected data along HW 160 and connecting highways at 34 sites. Data included approximately 10 sites from the critical culvert list.
12/31/10	64	07/16/10	Collected data along I-70 and connecting highways at 30 sites. Data included sites from the critical culvert list.
12/31/10	75	09/17/10	Collected data along HW 40 and 14 and connecting highways at 11 sites. Data included sites from the critical culvert list.
12/31/10	100	10/1/10	Collected data along HW 50 and connecting highways at 29 sites. Data included sites from the critical culvert list.

SIGNIFICANT EVENTS

3/18/09 PI attended CDOT's First Culvert Committee Meeting of 2009 to meet majority of panel members and outline preliminary project goals.

5/5/09 PI met with Research Panel Leader to select initial culvert test sites. The PI scheduled to do field testing starting 6/01/09.

6/03/09 Culvert testing along HW 34 between Loveland and Estes Park

6/05/09 PI met with Research Panel Leader to select additional culvert test sites.

6/09/09 Culvert Testing along I 70 between MP280 and MP370 with CDOT participation

6/15/09 Culvert testing along I-70 between MP370 and MP 425 and along HW40

6/19/09 Culvert testing along I-76 with CDOT participation

6/24/09 Meeting with CSU Soils Testing laboratory to analyze the water and soil samples from the first batch of 40 sites.

7/28/09 Met with Research Panel to update them on the status of the project and to get their approval on the sites that will be included in the study. Phase 2A will include the Eastern half of Colorado.

12/31/09 Completed Phase 2A

04/01/10 Started Phase 2B of the study to compile data from the Western Colorado

06/19/10 Conducted a 4-day trip along State Highway 160 covering the area between I-25 and Cortez, Colorado. Collected water and soils data and soil resistivity data from 34 sites along HW 160 and connecting highways.

07/16/10 Conducted a 3-day trip along Interstate State Highway 70 from Denver to Utah border. Included sites along HW 13, HW 131, and HW 139. Collected water and soils data and soil resistivity data from 30 sites along I-70 and connecting highways.

09/17/10 Conducted a 3-day trip along HW 40 from Walden to Craig. Included sites along HW 13, HW 14, and HW 131. Collected water and soils data and soil resistivity data from 15 sites along HW 40 and connecting highways.

10/1/10 Conducted a 3-day trip along I-70 and HW 50 and collected data from Grand Junction to Gunnison. Inspected culvert sites along HW 6, HW 340, and HW 141. Collected water and soils data and soil resistivity data from 29 sites along HW 50 and connecting highways.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Web-Based Historic Flood Information Database for Colorado
Study No: 107.10

Background	Reporting Period: 7/1/11through 9/30/11
The accuracy of flood-frequency estimates can be greatly improved when historical flood information is used with systematic flood data. At the present, much of the historical flood information for Colorado is stored in numerous published and unpublished reports, files, and photographs in local, state, and federal agency offices as well as consulting engineering offices. Having an easy-to-use Web-based database of historical flood and paleoflood information with links to sources of systematic flood data will allow engineers and water-resource managers to fully use this data to provide accurate flood recurrence estimates of the largest floods in Colorado. Engineers and scientists then will be able to incorporate these estimates for proper floodplain regulation, dam-safety design, and other uses. The objective of this study is to develop a Web-based geodatabase accessible using an ARCGIS map or similar interface for historical flood information that will facilitate easier access to this information for the compilation of flood data and result in improved flood frequency estimates in Colorado. The data sources of historical flood information include: high outliers at gages used in the latest Colorado flood frequency report published by the USGS; unpublished USGS indirect and paleoflood measurements; and the peak flood of record at all USGS gages. A Web-based interface that contains links or data on systematic and historic flood information will be the ultimate product of this project. In addition, a short fact sheet will be published to describe the contents of the database and how to use it.	Start: 10/1/10 Complete: 9/30/12 Contract: Principal Investigator(s): Kenneth Odom, USGS, 303-236-6897 Michael Kohn, USGS, 303-236-6924 Study Manager: Aziz Khan, Research Branch, 303-757-9255 Study Panel Leader: Amanullah Mommandi, Project Development Branch 303-757-9044 Study Panel Members: Alfred Gross, R-1 Hydraulics Jeffry Anderson, Bridge Design and Management Branch Mark S Mueller, Maintenance and Operation Carl Valdez, R-2 Maintenance Hani Lavassani, R-6 RE South Program Veronica Ghelardi, Hydraulics Engineer, FHWA - Resource Center

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
10/1/10	100	X	Agreement between CDOT and USGS finalized and signed.
4/1/11	100	X	Review sources of flood information
7/1/11	100	X	Compile USGS flood data
5/15/11	100	X	Meeting with CDOT and other agencies
12/31/11	75	X	Develop database structure and select web interface
4/1/12	25		Build web interface, populate database, and test
5/1/12	0		Go LIVE to Web
8/30/12	0		Complete USGS publication

SIGNIFICANT EVENTS

All USGS data that compose the database has been compiled. This includes USGS indirect discharge measurements and flood events chronicled in USGS publications, published paleoflood studies, and the peakflow record from all USGS gaging stations in Colorado. The database structure is mostly complete and the web-

interface of database is currently being built. Also, the database is almost completely populated.

DETAILED UPDATE

General

On 14 February 2011 WTI-MSU suggested the following strategy to CDOT:

Hello Vanessa, Mike, Samir,

Chris Haas and I just spoke over the phone about our approach to the animal detection system project in Durango and the test site in Lewistown. I feel that it is important to let you know what we think the situation is and how we propose to carry out the remainder of the project.

The good news is that the "old" system we have in Lewistown appears very reliable now that we have tested it in summer and winter with horses, llamas and sheep as a model for wild ungulates. This seems to confirm our original hypothesis from last year that the problems with the "old" system in Durango are not with the fundamentals of the detection technology but rather with system integration (putting all the parts together, especially where 2 cables connect).

Now that the system in Durango has been "upgraded" to a new and supposedly even better system, and presumably better connectors have been installed for the cables, our hope is that the new system will prove reliable as well, but on a much larger scale than the old system we have in Lewistown. Chris Haas and I discussed the best strategy and options for the remainder of the project, and this is what we propose we do:

1. Measure reliability of new system Durango: Reliability is essential for an animal detection system. Measuring effectiveness (e.g. speed, animals hit) is does not make sense if the system is not detecting animals reliably to begin with. So, we are doing as much snow tracking as we can, supported by wildlife cameras in spot locations to measure the reliability of the system. Hopefully we will have a reasonable sample size within a few weeks.
2. Compare reliability results Durango to suggested norms for reliability: We have suggested norms for reliability based on surveys of 3 stakeholder groups. If the system in Durango meets those norms (the old system in Lewistown does), then we will suggest to CDOT to go ahead and do what is necessary to have us conduct a meaningful study into system effectiveness. If the Durango system does not meet those recommended norms then we suggest either making additional modifications to the system or cancelling the project.
3. Assuming the system will meet the suggested norms for reliability, we move on to measure effectiveness. There are 2 components here: vehicle speed and collisions/carcasses.
    a. For vehicle speed it is very important that we are able to collect speed data with warning signs on vs warning signs off (or normal operation). If we rely on actual animal movements to trigger the system, the system will only take 40 seconds to turn off again. With the drift in the clock from the system and the speed measurement equipment together with the margin (time margin) we must apply to make sure that the vehicle we measure the speed from was actually exposed to the activated warning sign it makes collection of data, tedious, messy, cost-ineffective, and we will likely not get the sample size we need. So, if there is a way to activate all warning signs (e.g. an hour or a few hours at a time) it is very worthwhile investigating if

this can be done. A speed study is likely not worthwhile or cost-effective without it. For periods with all signs off we would look at the detection data with a system that functions normally (warning signs come on after a detection) and then select time periods (e.g. at least 30 minute long bouts) where there happened to be no detection. This way the public is not confronted with "all warning signs forced off" which could lead to dangerous situations. After having been exposed to an unreliable system for a while we may have to wait a few months to conduct the speed study to allow drivers rebuild trust in the warning signs.

   b. Collision/carcass counts may take much longer to reach sufficient sample size, but this could be made into a separate relatively project at some later point in time if necessary.

4. We will produce a report for the project, as we are under contract to do, making a judgment call on how much we continue to spend on reliability research at the Durango site right now vs. producing the actual report. Should CDOT want to change the deliverables and have us direct all of the remaining funds to collecting reliability data, and potentially also vehicle speed data, then please let us know so that the paper work can be changed and we can redirect our activities.
5. There is a difference now in the detection technology between the Lewistown and Durango site. This means that the reliability data from Lewistown no longer relate to the system in Durango also. We have completed the 4 reliability tests on the old system in Lewistown, consistent with our plans. Should there be a wish from CDOT or Magal Senstar to conduct similar reliability studies in Lewistown for the new system, then additional funds have to found, and the time schedule of the project will have to be adjusted. These additional funds may perhaps come from CDOT or Magal Senstar, and they would be needed for a system upgrade in Lewistown and at least 4 more tests in different seasons. So, unless something changes, there will be no detailed reliability data on the new system from the Lewistown location.

Please let me know if you want us to deviate from the proposed strategy.

Durango site:

SWCA has resumed the field work to measure system reliability.
WTI has not received the results yet from the reliability tests conducted by SWCA.

Off Site Reliability tests in Lewistown, MT:

The data from last summer (2010) have been analyzed. WTI has submitted a draft report on 19 February 2011. Comments from CDOT were received and WTI will incorporate them and then submit the final annual report.