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: 4/1/12 through 6/30/12
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

06/30/12 It was learned that the transportation reauthorization bill "Moving Ahead for Progress in the 21st Century," also known as MAP-21 is anticipated to be signed by the President sometime in July 2012. The bill will authorize the funding for the implementation of SHRP 2 products using SP&R money.

01/22-26/12 The LTPP State Coordinators' meeting and the LTPP Technical Session were held as part of the annual TRB meeting. Several presentations were made pertaining to LTPP program.

12/31/11 No reported activity during this quarter.

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.

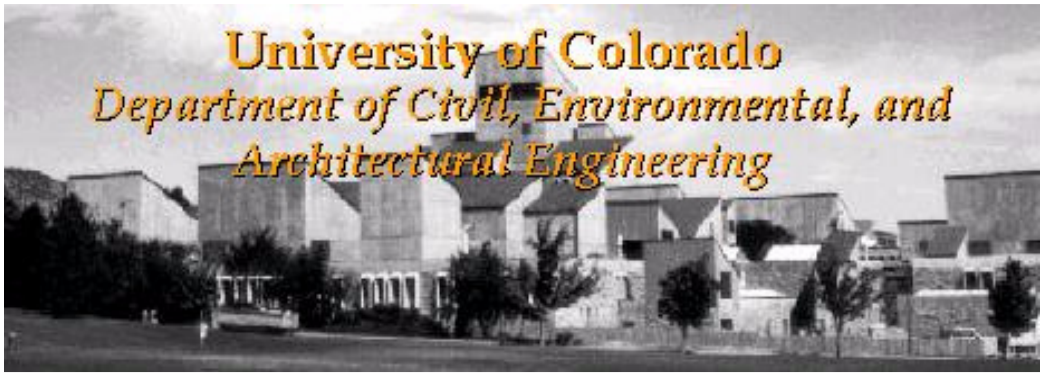
01/11	FHWA held LTPP Coordinators' meeting and had LTPP sessions on leveraging the LTPP experience to collect quality weigh-in-motion (WIM) data.
12/01/10	FHWA and Nichols Consulting Engineers (NCE) conducted the Long-Term Pavement Performance (LTPP) seminar at the Turnpike Conference Room in Materials 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 4/1/12 through 6/30/12 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

See next page for the quarterly report from the University of Colorado



COLORADO LTAP

LTAP Quarterly Report

Report Period
April 1, 2012 – June 30, 2012

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

Submitted by:
Colorado LTAP
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UCB 561
Boulder, CO 80309-0561
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Table of Contents

Colorado LTAP

4th Quarter

April 1 – June 30, 2012

Program Dashboard*:

Total number of training sessions:	24
Total number of participants:	415
Total of participant training hours:	2857
Total newsletter circulation:	1530 mailed; 154 electronic
Total class brochure circulation:	1071 mailed; 135 electronic
Total number of LTAP FTEs:	2.25

*Only statistics for activities completed April 1 – June 30, 2012.

Four Strategic Focus Areas

In 2008, FHWA issued guidance indicating that LTAP Centers transition from the traditional six tasks to a work plan that addresses the LTAP focus areas outlined in the national plan. The four focus areas are further divided into two general groups - the first three designed around external outcomes and processes, and the last a function of both internal and external LTAP center organization.

1. Safety – worker and roadway safety;
2. Infrastructure Management;
3. Workforce Development; and
4. Organizational Excellence

Colorado LTAP's FY2011-2012 work plan reflects this outline and completed activities emphasize these four focus areas.

A. Program Administration

- April 1-June 30, 2012, Colorado LTAP had two full-time staff persons working for the center – Program Director and Training Coordinator. The University PI was paid this quarter for his annual time served.
- Colorado LTAP got a new graduate student working for the center this quarter – Wang Xingang.
- The center hired a new webmaster at the end of last quarter and extensive website updates were completed in April.
- Due to University policy on temporary aid workers, Office Assistant-Marty Butcher, had to stop working in April and cannot return to LTAP for 6 months (October).

B. Training

- Colorado LTAP finished up spring courses in its three training programs – *Roads Scholar I*, Roads Scholar II, and *Supervisory Skills and Development Program.* This quarter, there were 24 days of training events offered - 12 of the classes qualified for Roads Scholar I credit, 5 Roads Scholar II credit, and 2 classes qualified for the Supervisory Skills and Development program. In addition, there were 4 Flagger Certification & Temporary Traffic Control workshops and 1 roadshow on Equipment Maintenance & Inspection offered. Class evaluations received an average of 94.68% this quarter.
- There were 9 Roadway Safety, 7 Worker Safety, 4 Infrastructure Management, and 2 Workforce Development courses offered this quarter. A full list of the courses offered in each focus area is shown in the table below. The list also shows the distribution of attendance between local (City/County), Tribal, State, Federal, and Other (Contractors, etc.).
- There were 16 Roads Scholar I graduates that received their plaques; and no Supervisory Skills graduates this quarter.
- 62 attendees passed CDOT's flagger certification exam with a score of 80% or higher and were issued certification cards good for two years. 1 attendee failed the exam with a score lower than 80%. There were 6 participants that received a score of 100% on the exam.
- *Roads Scholar II: Road Master* is the second and highest achievement level in Colorado LTAP's Roads Scholar training program. The *Road Master* program is an advanced training program geared towards the experienced maintenance worker, equipment operator, and manager. It is an opportunity for training at a more complex level than Roads Scholar I provides. Courses in this program are offered in 4 focus areas: Safety, Technical Skills, Environment, and Transportation Management. This new program, started in January 2012, is slowly gaining in popularity. Participation was limited this spring due to the RS II Program's prerequisite requirement of having to take the RS I's four Core classes to participate. Because there was so much interest in the RS II classes by those that didn't meet this requirement and therefore ineligible to take the courses, it was decided that for the first year only people that don't meet the pre-requisite would be allowed to sign up on the wait-list initially. If at one week before the training there is still space available, they would be allowed to attend. This will allow those participants one year to complete the required four Core classes in the meantime. This allowance is being promoted in classes and in the newsletter. The RS II program offered a good variety of topics this spring, with most of the classes never having been offered before. Several agencies that had attendees at the *Designing Pedestrian Facilities for Accessibility* and *Road Safety 365* classes spoke very highly of the courses and the instructor, and said they had learned a lot.
- Attendance was down a bit for the *Heavy Equipment Operation: Motor Grader* training class. This was surprising because usually this class is at capacity with a waiting list. It may have been scheduled during a busy week or perhaps it was because the class was on the western slope where attendance is always lower.
- The LTAP Training Coordinator, Lindsay also helped coordinate out-of-cycle training requests for local agencies including heavy equipment and concrete topics.
- Colorado LTAP usually prints all class brochures in-house. However, we recently started printing the Roads Scholar II program brochures through an online printing company and saved a considerable amount of money. They also have a more professional quality.

- Details on any training course are available upon request; additional detail is also provided in the annual Work Plan.
- A complete list of training classes offered between April 1 – June 30, 2012 and evaluation scores is provided in Appendix A.

Class Name by Focus Area	Hrs. per Class	# Sessions	# Contact Hours						# Paritcpants	Total Participant Hours
				Local	State	Federal	Tribal	Other		Hrs/class x #Part.
Roadway Safety										
RS CORE: Signing, Pavement Markings & MUTCD	7	2	14	57	2	0	0	6	65	455
RS CORE: Roadway Safety & Work Zone Traffic Control	7	4	28	108	1	0	0	4	113	791
RS ELECTIVE: Work Zone Development	7	1	7	10	0	0	0	0	10	70
RS II: Road Safety 365	7	2	14	34	0	0	0	1	35	245
TOTAL Roadway Safety:	**28**	**9**	**63**	**209**	**3**	**0**	**0**	**11**	**223**	**1561**
Worker Safety										
RS ELECTIVE: Heavy Equipment Operation - Classroom	7	1	7	21	0	0	0	0	21	147
Heavy Equipment Operation - Motorgrader - In-field	14	2	28	21	0	0	0	0	21	294
Flagger Certification & Temporary Traffic Control	4	4	16	63	0	0	0	2	65	260
TOTAL Worker Safety:	**25**	**7**	**51**	**105**	**0**	**0**	**0**	**2**	**107**	**701**
Infrastructure Management										
RS II: Invasive Weeds Management	7	1	7	21	0	0	0	0	21	147
RS II: Designing Pedestrian Facilities for Accessibility	7	2	14	19	0	0	0	1	20	140
RS ELECTIVE: Equipment Maintenance and Inspection	7	1	7	30	0	0	0	0	30	210
TOTAL Infrastructure Management:	**21**	**4**	**28**	**70**	**0**	**0**	**0**	**1**	**71**	**497**
Workforce Development										
SSDP: Ethics for New Supervisors	7	1	7	7	0	0	0	0	7	49
SSDP: Written Communications	7	1	7	7	0	0	0	0	7	49
TOTAL Workforce Development:	**14**	**2**	**14**	**14**	**0**	**0**	**0**	**0**	**14**	**98**
TOTALS:	**88**	**22**	**156**	**398**	**3**	**0**	**0**	**14**	**415**	**2857**
				Local	State	Federal	Tribal	Other		

C. General Program Support

Some tasks serve to advance all four focus areas. These are addressed in the *General Program Support* section of the report. Two tools utilized for technology transfer and information exchange include our quarterly newsletter publication and free lending library.

C0.1 Newsletter & Information Exchange

One of the main tools used for technology transfer and information exchange was a quarterly Newsletter publication. Newsletter articles were designed to educate transportation personnel to produce enhanced maintenance, workforce and safety outcomes.

- The Summer issue was designed at the end of the quarter. There were 1530 recipients on the hard copy mailing list, and 154 people on the electronic mail list.
- Topics covered in the Summer issue of the newsletter included new library videos, Spring training program graduates, upcoming fall classes, and articles on the Regional Local Road Safety Peer Exchange in Denver, recent MUTCD Final Rule clarification, annual You Show Us Contest, recently updated CDOT manuals, developing local safety plans, Roads Scholar II program, and upcoming fall classes.
- A newsletter article written by the LTAP Director, Renée, on MUTCD Compliance Dates was recently reprinted in several other LTAP newsletters across the country.

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 April 1 – June 30, 42 items were loaned free to local transportation agencies. The loaned materials covered all 4 focus areas – 6 in Highway Safety, 3 in Infrastructure Management, 29 in Worker/Workplace Safety, and 3 in Workforce Development. Separate from the lending library, we also distributed 416 free publications, guidebooks, handouts and videos. Loaned materials focused on heat stress, CDL, accident prevention, and workplace safety.
- 34 new titles were added or updated in the library, some with multiple copies for free distribution – 12 Books, 3 CDs, 2 DVDs, and 17 Free Publications. Some of the recently added/updated materials include: *Basic Spanish : For Safety & Emergencies; Erosion Control and Stormwater Quality Field Guide; Fall Factors: Understanding & Preventing Slips, Trips & Falls; Flagging Fundamentals: 6 Steps To Safety; Sustainable Concrete Pavements: A Manual of Practice*; and various work zone guidelines booklets.
- This quarter, $371.87 was spent to mail requested materials to local agencies, and $366.40 was spent on purchasing new videos and publications for the library loan program.
- Work on the library included updating the online library database's list of free materials available for distribution with what was actually in stock. New materials were ordered or printed and bound if necessary. Work was also done to transfer VHS tape videos onto CD.
- The table below illustrates the number of materials *loaned or distributed* April 1 – June 30, by type and focus area.

Distributed Materials	Highway Safety	Infrastructure Management	Worker/Workplace Safety	Workforce Development
Book			1	
CD				
DVD	4	2	17	3
Video	3	1	11	
Free Publications	203	138	75	

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. Local agencies also value the opportunity to *show* you their challenges on-site.

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.

These opportunities also help to advance staff knowledge base on the latest transportation technologies, processes, and resources.

- Colorado LTAP handles pre-registration, agenda & speaker coordination for the annual APWA/CARMA Spring Street Conference and is reimbursed for time and direct costs by APWA. The LTAP Director, Renée, is on the conference planning committee and has significant influence on the chosen topics for the conference. Suggestions are made based on recent local agency needs. Renée also presented a session at the conference on MUTCD Misconceptions. The session was very well received and several local agencies requested to have the session repeated back at their agency for the rest of their employees. Colorado LTAP has a vendor booth at this conference. This year, the conference was held during *National Work Zone Awareness Week* and booth materials highlighted this awareness program. Colorado LTAP also designed and distributed 50 folders of work zone resources. Refer to the *Roadway Safety Programs* section of this report for more details on folder contents and the *Work Zone Resources* guidebook that was designed.
- Colorado LTAP was provided a free vendor booth at this year's ACPA Concrete Conference. This year it was held in Loveland and there were about 250 attendees. It was a good opportunity to give out related resources and free publications. This concrete conference attracts a different audience than some of the other conferences we attend and is a good opportunity to promote the LTAP programs resources to a new audience.

Marketing

- Colorado LTAP staff attended a free seminar provided by our promotional items distributer to get new ideas for safety products that could provide LTAP contact information.

Technical Assistance

- LTAP center staff spent about 25% time providing technical assistance to local agencies.
- Examples of technical assistance provided this quarter included coordinating out of cycle heavy equipment and concrete workshops for local agencies, sign management software options, Temporary Traffic Control checklists for AM/PM inspections, flexible delineators, and extensive questions on interpreting recent MUTCD Final Rules and retroreflectivity requirements.

C0.4 Out-of-State Travel

FHWA DC 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.

- The Program Director, Renée, served on the Executive Committee as the NLTAPA Vice President, and chairperson of the National Partnerships Committee. Renée participated in monthly NLTAPA EC conference calls. There was one out-of-state EC meeting scheduled in April, however, Renée had to cancel due to health reasons.

- Another "out-of-state" meeting usually scheduled this quarter is the Region 7 LTAP meeting. Colorado hosted the meeting this year, and the region meeting was held in Denver on May 30th. Renée is no longer the Region 7 rep, and therefore did not have to organize the agenda; but Colorado LTAP handled location logistics. 21 people attended the Region 7 meeting from 9 states and Washington DC. Each state's LTAP Center presented on challenges and best practices, FHWA managers presented on national center successes and development of a national Safety Toolkit, the LTAP Clearinghouse presented on the development of a national library loan system, and members of the Executive Committee presented updates from the national association executive committee activities. At the end of the meeting, the Region split to discuss coordination of its two successful regional local roads conferences – MINK and Local Road Advisors' Conference.
- A Regional Local Road Safety Peer Exchange was also coordinated in conjunction with the Region 7 meeting, and will be discussed under *Safety Programs*.

C.1 Safety Programs

Roadway safety and worker safety are the core of Colorado LTAP's program and are included in most of our efforts. Specific safety related classes and workshops were completed this quarter and effort was made to emphasize safety in all outreach activities. LTAP also serves as a safety advocate and stakeholder to further other FHWA and CDOT safety efforts such as support and implementation of the Colorado Strategic Plan for Improving Roadway Safety (SPIRS). Colorado LTAP consults with its Advisory Board and local customers to deliver appropriate Safety training programs and also responds to requests for safety related technical assistance. The Colorado LTAP Director, Renée worked on several initiatives to bring state and national attention to the importance of improving safety on our local and rural road system.

- From April 1–June 30, 16 safety related training courses were provided – 9 on roadway safety and 7 on worker safety topics. These courses are listed in the *Training* section of this report.

C1.1 Public Safety Awareness Programs

Safety Awareness Programs are used to promote worker safety focused on increasing the awareness of the travelling public as opposed to the transportation workers. These efforts often coincide with National outreach efforts such as National Work Zone Awareness Week in April, Click-It or Ticket campaigns in May, or Put the Brakes on Fatalities Day in October.

- *National Work Zone Awareness Week* (NWZAW) was April 23-27, 2012. To promote this event and work zone safety best practices, Colorado LTAP designed and printed 250 "Work Zone Safety Resources" folders. In addition, a 20-page "Resources" booklet was designed and printed. Topics covered in the booklet include: Background on National Work Zone Awareness Week, National Work Zone Statistics, Top 10 *Worker* Safety Tips, Top 10 *Driver* Safety Tips, CDOT's Slow for the Cone Zone Program, National Work Zone Safety Information Clearinghouse, Work Zone Safety Websites, Online Flagger Training, Work Zone Safety Online Publications, Work Zone Safety Recent Reports, High Visibility Safety Apparel, Nighttime

Work Zone Operations, Work Zone Safety in the LTAP Lending Library, Spanish Work Zone Materials in the LTAP Library, and Spanish Work Zone Materials Online. The booklet is also now available for download on Colorado LTAP's website. A "Work Zone Quiz" and "Know Your Flagging" handouts were printed and distributed. Several other work zone safety brochures, posters, guidebooks, etc. were ordered free from the Work Zone Safety Clearinghouse. Fifty of the folders will be assembled and distributed during Work Zone Awareness Week at the Spring Street Conference in Grand Junction. Colorado LTAP also purchased 2 of the official work zone awareness t-shirts to promote the event at our conference booth; and ultimately provided them to two local agency winners in the conference drawing.

- Multiple copies of the following Work Zone Safety Guidelines were added to the library for free distribution: *Strategies on Improving Worker Safety in Work Zones; Ensuring Positive Guidance in Work Zones; Payment for Temporary Traffic Control; Use of Law Enforcement in Work Zones; Managing Speeds in Work Zones; Motorcycle and Bicycle Work Zone Safety; Work Zone Access and Egress; Improving Work Zone Safety Through Public Information and Traveler Information;* and *Use of Exposure Control Measures*.
- Safety related newsletter articles provided this quarter were related to the Regional Local Road Safety Peer Exchange in Denver, recent MUTCD Final Rule clarification, CDOT's Guide Signing Policies, and developing local agency safety plans.
- The "Website in Focus" aspect of our website homepage highlighted links to the MUTCD's May release of the Final Rule on Compliance Dates.

C1.2 Retroreflectivity Program

FHWA released new regulations regarding minimum sign retroreflectivity standards. For the first time, agencies are responsible for maintaining the nighttime visibility of their signs to a minimum level of service. Colorado LTAP Director, Renée has become a local and National expert in this area. Retroreflectivity training sessions and technical assistance are frequently provided throughout the year.

- Based on the success of LTAP's Street Conference presentation on *MUTCD Misconceptions & Retroreflectivity*, Colorado LTAP Director, Renée received two local agency requests to provide the training locally. One of these trainings was provided for Ft Morgan and Morgan County road and bridge employees; the other was provided at the Town of Erie Street Dept with City of Lafayette and Louisville employees also in attendance.
- Colorado LTAP owns 2 sign sheeting DELTA RetroSign® GR3 Retroreflectometers, and manages a local agency equipment loan program. Retroreflectometer loan and training were provided to the Town of Buena Vista, City of Federal Heights, City of Ft Morgan, Morgan County, and Colorado Springs Airport.
- LTAP staff participated in and promoted the TRB webinar on *NCHRP Synthesis 431: Practices To Manage Traffic Sign Retroreflectivity*. Copies of the new report were also added to the library loan program.

C1.3 Safety Training Support

- Colorado LTAP staff worked with the FHWA Office of Safety to host a *Local Road Safety Peer Exchange* in Colorado for Region 7 states. The Safety Peer Exchange was held May 31 and June 1, following the LTAP Region 7 meeting in Denver. Colorado LTAP staff participated on 6 planning meetings, organized the meeting location logistics, and helped coordinate agenda topics and LTAP center regional participation. The peer exchange convened regional representatives from Region 7 FHWA, state DOTs, local and tribal technical assistance programs (LTAP/TTAP), and local government agencies to discuss local road safety issues. The peer exchange was designed to facilitate the exchange of information and exploration of opportunities between state safety stakeholders on local road safety including:
  - Improving local road safety data collection and analysis;
  - Local involvement in Strategic Highway Safety Plan (SHSP) development and implementation; and
  - Local involvement in the Highway Safety Improvement Program (HSIP).

  A primary goal of the event was to improve the coordination between FHWA, state DOTs, LTAPs, and local officials within each state to better address local road safety issues. Forty-one representatives from Colorado, Iowa, Kansas, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wyoming, and FHWA participated in the event. Five local agency reps also traveled to Denver to participate, including Local Road Engineers, Public Works Directors, and County Highway Superintendents. The peer exchange provided a key opportunity to get Colorado's local safety stakeholders together – including Major Kris Meredith, Colorado State Patrol; Martina Wilkinson, Larimer County Traffic Engineer; Charles Meyer, CDOT Safety and Traffic Engineering Manager; Bryan Allery, CDOT HQ Traffic Engineer; Shane Chevalier, CDOT Local Roads/Traffic Engineer; Renée Railsback, CO LTAP Director; Lindsay Marshall, CO LTAP Training Coordinator; Ron Hall, CSU TTAP Director; John Cater, FHWA CO Division Administrator; Dahir Egal, FHWA CO Division Safety /Traffic and Operations; Rick Santos, FHWA CO Division LTAP Manager; and Hillary Isebrands, FHWA Resource Center Safety Specialist. Colorado LTAP staff looks forward to maintaining the connections and looks forward to working with State safety stakeholders to improve safety on our local and rural roads. A Peer Exchange report, best practices, and State action plans are available upon request.
- LTAP serves as a safety advocate to further FHWA and CDOT safety efforts such as support and implementation of Every Day Counts (EDC) initiatives. This quarter's EDC Exchange webinars addressed transportation management topics are is detailed in that section below.
- The training program for *Safe and Effective Use of Law Enforcement Personnel in Work Zones* was requested once again. Colorado LTAP does not have any current plans to offer this class, however, the course materials are available for loan from LTAP's library and include - an Instructors Manual, Participants Guide, Pocket Guide, and PowerPoint Training Modules. These materials were distributed to the requesting agency.
- Colorado LTAP owns several Work Zone Traffic Control training kits that were used in the Work Zone Development courses this spring. These toolkits allow for hands-on classroom instruction on traffic control and work zone planning, incident and emergency response training, problem solving, and determining device needs and quantities. Toolkits include flexible road design material, a multitude of regulatory and warning signs, barrels, cones, and a carrying case. FHWA staff also borrowed our kits for use in some of their training as well.

- 36 Safety related items were loaned and 278 free Safety items distributed from the LTAP library this quarter. 30 new items on Safety were added or updated to the library this quarter.
- Colorado LTAP promotes online training opportunities, webinars and conferences to its Advisory Board and local transportation agencies. Safety events promoted through our electronic mail list this Spring included:
    - FHWA Office of Safety's *Systemic Approaches to Roadway Safety* Webinar
    - FHWA's Work Zone Fatality Reduction Strategies Webinar
    - Best Practices in Work Zone Safety 2012: Local Transportation Asset Management Virtual Conference & Innovation Showcase

C.2 Infrastructure Management

- From April 1 – June 30, there were 4 Infrastructure Management training courses provided; three of them were offered in the Roads Scholar II program.
- LTAP serves as a safety advocate to further FHWA and CDOT safety efforts such as support and implementation of Every Day Counts (EDC) initiatives. Colorado LTAP helped FHWA promote and coordinate presentation of their EDC Exchange webinars in 5 locations around the state. Colorado LTAP designed, printed and mailed promotional brochures for the EDC Exchange workshops. There were two EDC Exchanges held this quarter on Flexibility in Right-of-Way and In Lieu Fees/Mitigation Banking. The Colorado LTAP Training Coordinator attended the exchange at CDOT in Pueblo, and FHWA managed the site at their headquarters in Lakewood. In the Right-of-Way exchange, there was good discussion about the different ways that CDOT handles obtaining right-of-ways versus how it has to be handled in smaller cities like Canon City. There was also discussion on how to come up with a fair value to offer landowners, and how the offer has to be the same for everyone involved in the same project. The local discussion also addressed the benefit of offering people bonuses if the land was made available sooner than the standard time required. The In Lieu Fees/Mitigation Banking exchange was a different sort of topic for local agencies. We had to cancel the Grand Junction, Durango, and Greeley locations because there was no interest from surrounding agencies. However, we added a location in Colorado Springs and Montrose for interested agencies there. The Colorado LTAP Training Coordinator attended the exchange at CDOT in Pueblo again due to the amount of repeated interest at this location. Exchange participants felt like the prices people were paying in other states were a lot less than the prices they were paying in Colorado. There was discussion about who oversees the mitigation banks once they are established to make sure they are being run correctly and that the owners are holding up their end of the bargain. There were a lot of questions posed at the National level, which was interesting for local attendees to see the responses and learn more than was presented in the scripted presentations. The next EDC Exchange is on Adaptive Signal Control Technology, scheduled in August.
- Colorado LTAP staff attended CDOT's Traffic Data Collection meeting in May.
- Infrastructure Management related newsletter articles provided this quarter were related to CDOT's 2013 Pavement Design Manual, 2011 Construction Specifications, and 2012 Laboratory Manual of Test Procedures.
- Colorado LTAP Director, Renée participated as Secretary on the Colorado Association for Roadway Maintenance (CARMA) Board of Directors at two meetings this quarter, and

designed and distributed the CARMA spring newsletter. Colorado LTAP is fully reimbursed for costs related to printing and mailing this publication.

- 3 Infrastructure Management related items were loaned and 138 free Infrastructure Management items distributed from the LTAP library this quarter. 2 new items on Infrastructure Management were added/updated to the library this quarter.
- Colorado LTAP promotes online training opportunities, webinars and conferences to its Advisory Board and local transportation agencies. Infrastructure Management events promoted through our electronic mail list this Spring included:
  - CDOT Consultant Services Requirements and Updated Q&A Guidance Webinars
  - NHI Bridge Preservation Online Training
  - TRB's Webinar on Erosion and Sediment Control for Native and Aggregate Surfaced Roads
  - LoTrans Local Transportation Asset Management Virtual Conference

C.3 Workforce Development

- The training classes, workshops and other educational offerings described above can all be considered part of LTAP's workforce development program. From April 1 – June 30, there were 2 training courses specifically related to Workforce Development provided in the Supervisory Skills and Development Program.
- Colorado LTAP handled the pre-registration and speaker coordination for APWA's Street Conference in Grand Junction. APWA reimburses LTAP for all direct costs and overhead, an additional $1500 is provided for LTAP administration, and $500 is provided to purchase additional materials for the LTAP lending library.
- Colorado LTAP administers the "You Show Us" Contest each summer. In its 16th year, the concept for the "You Show Us" Contest began in 1994 with FHWA's "Show Us How". LTAP encourages local agencies to enter as a profitable way to share their innovative ideas with others that may benefit from their cost saving concepts. It is a good way for road crews to get some well earned recognition for solving problems requiring efficient use of existing funds and materials, along with the application of cost-reducing and innovative techniques. Brochures promoting the contest were designed and distributed to government agencies in Colorado. Entries will be presented to the Advisory Board in September for selection of a State winner. Colorado's winning entry will then be submitted to compete in the regional contest. To encourage local agencies to share their successful programs and ideas, LTAP offers to sponsor two participants from the state winning agency to represent their project at the Local Road Coordinators' Conference in Rapid City in October to receive their awards.
- Workforce Development related newsletter articles provided this quarter addressed the Spring training program graduates and upcoming fall classes.
- 3 Workforce Development related items were loaned from the LTAP library this quarter; and 2 new items on Workforce Development were added/updated to the library.
- Colorado LTAP promotes online training opportunities, webinars and conferences to its Advisory Board and local transportation agencies. Workforce Development events promoted through our electronic mail list this Spring included:
  - USDOT OIG/FHWA Fraud Prevention & Awareness Training
  - USDOT FHWA Civil Rights Training for Title VI

C.4 Operational Excellence

Colorado LTAP seeks to provide high quality services to meet the needs of its customers. Several specific activities are conducted to help ensure that LTAP is meeting this goal including obtaining feedback on emerging needs of Colorado's customers as well as their perception of the program. Operational Excellence is a continuous service management improvement program – both internal and external to the program.

C4.1 Information Technology Services

- Colorado LTAP managed its Information Technology Services (ITS) to provide communication services to agencies across the state. Internal networking and database issues were addressed. Phone service, toll-free 1-800 number, and email continue to be available for LTAP customers to reach us for direct technical assistance. Excluding costs for website maintenance, expenses for ITS including phone service, toll-free number, and network connection services totaled $10.75 from April 1-June 30. LTAP was not charged by the University for the network connectivity fee.
- Colorado recently hired a new webmaster, Becky Miller, after 15 months without one and extensive updates to the Colorado LTAP website were completed this quarter. We are excited to say that the new website designer has been very easy to work with and she completes our update requests quickly. Web design services averaged $100/month this quarter.
- Colorado LTAP regularly updates the contact information of local transportation agency contacts for the efficient dissemination of training announcements, newsletter publications, library resources, outreach efforts, and technology transfer. LTAP staff work with transportation industry associations to identify potential customers, meet needs, and disseminate technology. The electronic mail lists for course brochures and quarterly newsletter have increased to 135 and 154 recipients respectively. This service expedites facilitates communication, and provides more efficient service and improved coordination and delivery of technical assistance and technology services. It is extremely helpful to regularly update locals on upcoming free online or webinar based training opportunities. The mailed brochure and newsletter lists are still maintained until the recipient chooses to switch to electronic mailings. These lists currently have 1071 and 1530 recipients respectively.

C4.2 Equipment

This budget category covers purchasing office equipment and supplies necessary for production of training materials, office tasks, and to keep up with technology that will help the program efficiently deliver technology deployment.

- The majority of the expense in the Equipment category is related to the monthly lease and meter readings of the office Konica Minolta copy machine. Monthly lease of the machine was $101.98/month, and expenses for copies made averaged $132/month this quarter. Meter readings are higher during training periods for printing of course registration brochures and class handout materials.
- Additional equipment purchased this quarter included a fax machine cartridge. Because LTAP sends and receives credit card information for class payments, a separate fax machine has to be maintained that is not connected to the network, as the other office print machines are.

C4.3 Office Supplies

- A majority of previous office supply costs are now included in the copier lease program. However, additional expenses in this category include paper for any printed products – brochures, certificates, name badges, flyers, etc – large envelopes, batteries, and CDs/DVDs for data storage or replication, etc. There was $325 spent on office supplies this quarter.

C4.5 Monthly and Quarterly Advisory Meetings

Quarterly Advisory Board and Monthly Sponsor meetings are organized to solicit input for program content, provide feedback on needed services, and evaluate the effectiveness of the program. Advisory Board members are not paid for their participation, but are reimbursed for direct expenses incurred due to attending LTAP meetings.

- There are currently 9 voting members on the Colorado LTAP Advisory Board representing cities and counties across the state (2 City/Town and 7 County representatives). There are also four non-voting members representing the program and sponsoring agencies.
- The Advisory Board met once this quarter at the Summit County building in Frisco, CO. Colorado LTAP staff presented on best practices gleamed from the regional Local Road Safety Peer Exchange held in Denver the week before; highlights from the LTAP Region 7 Meeting; and Proposed training classes for 2012-2013. There were 8 attendees from local agencies, CDOT and FHWA for the meeting.
- Colorado LTAP staff held one monthly meeting this quarter via conference call with FHWA, CDOT and CU managers.
- As NLTAPA Vice-President, LTAP Director, Renée participated in monthly board meeting conference calls with Center representatives from across the country.

C4.8 Program Parking

- One parking meter card was purchased for parking access for meeting participants and local agencies meeting at the LTAP offices.

Financial Report

- As this quarter closes the fiscal year, total program expenses for July 1, 2011 – June 30, 2012 are included in Appendix B. The attached itemized categories list shows a positive balance of $3,848.90. This balance combined with the FY2010-2011 balance should total the necessary $21,000 that was set-aside to purchase the pavement marking retroreflectometer. Currently, the total balance amongst both accounts is $11,958.27 as shown in the table below. However, the University CEAE Grad School has not yet paid its $27,500 matching for 2012. Once the meter is purchased and the matching paid, this will result in a final $17,000 surplus. Part of the reason for this positive balance is that the overhead on the LTAP revenue account was budgeted at 7.5% when in fact it is now only 5.5%. Another reason is that due to the drastic budget cuts in the 2011-2012 budget, many measures were used to drastically cut costs in program activities such as Training - which ended up being $10,600 under budget. A balance will be instituted in the coming year's program management, as to relax some of this past year's cost cutting measures in order to relieve some of the time and stress it added to staff. The balance will also be useful to cover cuts in the FY2012-2013 budget.

2010-2012 Income/Expenses

7/1/2010 through 6/30/2012

Category Description	7/1/2010-12/31/2010	1/1/2011-6/30/2011	7/1/2011-12/31/2011	1/1/2012-6/30/2012	OVERALL TOTAL
INCOME					
1. SPONSOR REIMBURSEMENTS	192,816.96	216,139.98	172,448.14	157,061.19	738,466.27
TOTAL INCOME	**192,816.96**	**216,139.98**	**172,448.14**	**157,061.19**	**738,466.27**
EXPENSES					
A. PROGRAM ADMINISTRATION	107,197.21	121,134.23	92,573.28	99,547.94	420,452.66
B. TRAINING PROGRAM	53,091.23	64,450.64	38,623.91	60,769.90	216,935.68
C.0 GENERAL	10,934.87	18,909.76	11,860.60	10,014.13	51,719.36
C.1 SAFETY PROGRAMS	1,367.56	2,293.44	296.74	2,948.64	6,906.38
C.2 INFRASTRUCTURE MANAGEME...	112.41	0.00	0.00	23.50	135.91
C.3 WORKFORCE DEVELOPMENT	2,314.67	7.61	3,960.16	-1,600.00	4,682.44
C.4 OPERATIONAL EXCELLENCE	5,645.49	13,388.45	2,862.66	3,778.97	25,675.57
TOTAL EXPENSES	**180,663.44**	**220,184.13**	**150,177.35**	**175,483.08**	**726,508.00**
OVERALL TOTAL	**12,153.52**	**-4,044.15**	**22,270.79**	**-18,421.89**	**11,958.27**

Appendix A: Training Classes Provided April 1 – June 30, 2012

Class Name	Location	Date	Hrs/class	# Part.	NS	WL	CAN	Tot. Part. Hours
ROADS SCHOLAR I CORE COURSES								
RS CORE: Signing, Pavement Markings & MUTCD								
90.35%	Denver	4/10/12	7	46	3	37	3	322
93.16%	Durango	5/1/12	7	19	2		4	133
RS CORE: Roadway Safety & Work Zone Traffic Control								
89.76%	Pueblo	4/30/12	7	29	3		2	203
76.08%	Northglenn	5/1/12	7	48	6		2	336
91.23%	Frisco	5/2/12	7	20			2	140
91.11%	Montrose	5/4/12	7	16				112
ROADS SCHOLAR I ELECTIVE COURSES								
RS ELECTIVE: Work Zone Development								
98.33%	Durango	5/2/12	7	10			3	70
RS ELECTIVE: Heavy Equipment Training - Motor Grader								
99.19%	Rifle - Classroom	4/2/12	7	21	3			147
-	Rifle - 1st In-Field	4/3-4/12	14	10	3			140
-	Rifle - 2nd In-Field	4/5-6/12	14	11				154
ROADS SCHOLAR II COURSES								
RS II: Technical Skills Focus Area								
Designing Pedestrian Facilities for Accessibility								
98.81%	Lakewood	4/16/12	7	14	2			98
100.00%	Grand Junction	4/19/12	7	6				42
RS II: Environment Focus Area								
Invasive Weed Management								
91.38%	Loveland	4/5/12	7	21	1		2	147
RS II: Safety Focus Area								
Road Safety 365								
98.52%	Lakewood	4/17/12	7	26				182
100.00%	Grand Junction	4/20/12	7	9				63
WORKSHOPS & ROADSHOWS								
Flagger Certification & Temporary Traffic Control								
100.00%	Gypsum	4/12/12	4	14				56
100.00%	Pueblo	4/23/12	4	15	3			60
98.08%	La Junta	4/24/12	4	26	4			104
	Durango - *Cancelled*	5/7/12						0
100.00%	Montrose	5/8/12	4	10			1	40
Equipment Maintenance & Inspection								
-	Granby	4/19/12	7	30				210
SUPERVISORY SKILLS & DEVELOPMENT PROGRAM								
SSDP: Ethics for Supervisors								
82.93%	Montrose	4/2/12	7	7				49
SSDP: Written Communications								
100.00%	Montrose	4/3/12	7	7				49
94.68%		**Total 4th Quarter Participants:**		**415**				
Eval AVG		Total **RS I** Participants:		230				1757
		Total **RS II** Participants		76				532
		Total **SSDP** Participants:		14				98
		Total **Workshop** Participants:		95				470
				Total Participant Hours:				**2857**

Appendix B: Total Program Expenses July 1, 2011 – June 30, 2012

Itemized Categories:4
7/1/2011 through 6/30/2012

Categories		Amount
INCOME		**329,509.33**
1. SPONSOR REIMBURSEMENTS		**329,509.33**
a. CDOT Reimbursement		**238,500.00**
b. CU Matching		**27,499.50**
c. Class Registration Fees		**62,509.83**
c1. Deposits	63,170.00	
c2. Credit Card Charges	-660.17	
d. Partner Reimbursement		**1,000.00**
EXPENSES		**-325,660.43**
A. PROGRAM ADMINISTRATION		**-192,121.22**
A1. Administration Costs		**-153,512.12**
A2. Program Administration Fee		**-38,609.10**
B. TRAINING PROGRAM		**-99,393.81**
B1.1 Training		**-99,393.81**
a. Roads Scholar	-68,453.31	
b. Supervisory Skills	-15,537.37	
d. Special Training Programs	-12,014.88	
d2. Heavy Equipment Training, Spring	-8,640.54	
d3. Flagger Certification	-3,374.34	
Other B. TRAINING PROGRAM:B1.1 Training	-3,388.25	
C.0 GENERAL		**-21,874.73**
C0.1 Newsletter & Information Exchange		**-8,699.78**
C0.2 Library Services		**-3,693.04**
C0.3 Prog Marketing Outreach Research		**-3,780.45**
C0.4 Out-of-State Travel		**-5,701.46**
1.TRB	-1,238.36	
2.Region 7 LTAP Meeting	-67.08	
3.National LTAP Meeting	-3,504.62	
4.Local Roads Conference	-891.40	
C.1 SAFETY PROGRAMS		**-3,245.38**
C1.1 Public Safety Awareness		**-1,009.04**
C1.2 Retroreflectivity Prog		**-189.99**
C1.3 Safety Training Support		**-1,966.35**
C1.4 Miscelaneous		**-80.00**
C.2 INFRASTRUCTURE MANAGEMENT		**-23.50**
C2.1 Agency Traffic Counts		**-23.50**
C.3 WORKFORCE DEVELOPMENT		**-2,360.16**
C3.1 You Show Us Contest		**-2,133.00**
C3.2 Local Roads Conference		**-1,884.61**
C3.3 APWA Conf Admin & Library Matls		**1,657.45**
C.4 OPERATIONAL EXCELLENCE		**-6,641.63**
C4.1 Information Technology Services		**-349.70**
C4.2 Equipment		**-2,516.67**
C4.3 Office Supplies		**-1,379.04**
C4.5 Advisory Meetings		**-1,746.22**
a. Quarterly Meetings	-1,746.22	
C4.7 NLTAPA Dues		**-500.00**
C4.8 Program Parking		**-150.00**
	OVERALL TOTAL	**3,848.90**

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Development of Estimation Methodology for Bicycle and Pedestrian Volumes Based on Existing Counts
Study No: 8.41

Background

In 2009, the Colorado Department of Transportation adopted the Bicycle and Pedestrian Policy directive stating that "...the needs of bicyclists and pedestrians shall be included in the planning, design, and operation of transportation facilities, as a matter of routine..." (CDOT 2009). However, without sufficiently accurate estimates of bicycle and pedestrian volume on CDOT facilities, whether or not these road users are being adequately accommodated remains unknown. Consequently, this research project will help establish methods that will facilitate improved use of existing bicycle and pedestrian data through the development of Colorado-specific methodologies for estimating bicycle and pedestrian volumes using a limited sample of existing counts. More specifically, the research proposed herein will:

- Survey the state-of-the-practice literature for bicycle and pedestrian volume estimation;
- Contact local, state, and national agencies working with bicycle and pedestrian count data;
- Collect and evaluate existing bicycle and pedestrian count data from around the state of Colorado;
- Overlay and compare variations in bicycle and pedestrian volumes to variations for motorized traffic volumes;
- Develop and validate bicycle and pedestrian volume models based upon direction of travel, hourly peaking, seasonality, weather, and special events;
- Document standard bicycle and pedestrian statistical estimation methods in a procedures report for CDOT facilities; and
- Nationally disseminate findings in peer-reviewed journal papers and presentations at key conferences.

This work will enable CDOT to better understand the needs of bicyclists and pedestrians and best allocate limited resources in order to properly meet those needs. Local and regional agencies will also benefit from this research via data usage as well as access to the procedures and methodologies. An ancillary benefit from the dissemination of this research is national recognition and highlighting CDOT as a leader in managing and estimating annual bicycle and pedestrian work using statistically-based methods. The primary deliverables from this research to CDOT will be a final report and presentations that cover all study findings and recommendations.

Reporting Period: 4/1/12 through 6/30/12
Type: SP&R Start: 11/16/11

Principal Investigator(s):
Wesley E. Marshall; University of Colorado Denver, 303-352-3741

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

Study Panel Members:
Jake Kononov, CDOT DTD Research
Betsy Jacobsen, Bicycle Pedestrian Unit
Mehdi Baziar, Mobility Analysis Manager
Steven Abeyta, Traffic Analysis Unit
Leo Livecchi, Traffic Analysis Unit

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
10/19/10	100	10/19/10	Advertise RFP
9/9/11	100	9/9/11	Receive Proposals
9/20/11	100	9/20/11	Selection

11/16/11	100	11/16/11	Notice to Proceed
1/17/12	100	1/17/12	Kick-Off Meeting
2/1/12	100	2/1/12	Literature Review
3/1/12	100	3/1/12	State of the Practice
3/1/12	100	3/1/12	Data Collection and Evaluation
6/1/12	90		Data Analysis
9/1/12	50		Bike/Pedestrian Models and Estimation Factors
11/15/12	10		Final Report

SIGNIFICANT EVENTS

- Data analysis near completion
- Testing methods for developing the bike/pedestrian models and estimating factors in order to determine what method will be used for the subsequent work
- Report underway

ANTICIPATED EVENTS FOR Q3 2012

- Completion of data analysis
- Statistically selecting best method for factor creation
- Continue documenting work in final report

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Optimum Use of CDOT French and Hamburg Data
Study No: 10.15

Background

The Euro Lab has been used by CDOT for asphalt performance testing on asphalt projects for over ten years now. The Materials Lab produces reliable and valuable test results that are indicative of the expected pavement performance over the life of the pavement. A number of Transportation Departments and organizations are using results from the Hamburg and French Pavement Performance Testing Machines for project acceptance testing, as well as for incentive/disincentive payments. The CDOT European Test Lab is a robust lab, with experienced testers, and valuable equipment. The potential inclusion of the European test results into the acceptance criteria for projects could provide CDOT with improved pavement performance prediction capabilities, increased pavement performance, and improved system quality/reliability.

The development of a proposed roadmap for inclusion of the French and Hamburg Test results in QA/QC for pay on asphalt projects would assist the CDOT Staff Materials and Geotechnical Branch Asphalt Program in facilitating the discussion with CDOT Regions and industry on the potential options, costs, and other opportunities for associated inclusion. CDOT currently performs testing on asphalt project materials in the Euro Lab for information only. The Euro Lab has a considerable investment in equipment (~$600,000) and personnel (2-FTEs). The operating costs are considerable and the continued use of information only testing may be of limited value. Other DOTs (i.e. Utah, Texas, Illinois Tollway Authority) have advanced the use of their European labs to be included in acceptance and possibly for incentive/disincentive payments for quality. The CDOT Materials and Geotechnical Branch Asphalt Program anticipates that industry and possibly CDOT Regions would be resistant to incorporating the results from the Euro Lab, as it would require substantial capital expenditure to set up a statewide program. There may be opportunities to eliminate some existing testing requirements with the inclusion of Euro Lab results in the QA/QC acceptance items, and the test results from the European test results may be better indicators of the expected performance of in-place asphalt pavements.

Reporting Period: 4/1/12 through 6/30/12
Type: SP&R Start: End:

Principal Investigators:
TBD

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

Study Panel Leader:
Mike Stanford, Materials and Geotechnical Br.
303-398-6544

Study Panel Members:

Stephen Henry, Materials and Geotechnical Br.
Shamshad Hussain, Region 1 Materials
Donna Harmelink, FHWA-Colorado Division
720-963-3021

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
8/20/12			Hold initial study panel meeting
9/19/12			Develop scope of work
9/26/12			Select researcher
10/01/12			Start project
07/26/13			Submit draft final report

09/12/13			Conduct presentation of completed work to CDOT
10/17/13			Submit final report

SIGNIFICANT EVENTS

6/29/12 Funds are now available for this project

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Durable Wearing Surfaces for HMA
Study No: 10.37

Background	Reporting Period: 4/1/12 through 6/30/12 Type: SP&R Start: 09/01/02 Ver: 12/31/02 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 Eng Jay Goldbaum, Materials and Geotechnical
CDOT 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).	

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.
12/11			Draft Final Report. (May be adjusted pending decision of panel)
12/12			Publish final report.

SIGNIFICANT EVENTS

6/12: Data collection and analysis in progress

3/12: Data collection and analysis in progress

1/12: Data collection and analysis in progress

06/11: 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 4/1/12 through 6/30/12
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.
Steve Olson, 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-Colorado Division

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

06/30/12 No activity was reported during this quarter.

12/31/11The final report is kept in our experimental features published materials.

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.

3/22/05 The draft final report was submitted by NCAT for review and comment.

10/22/04 A meeting was held with both members of the Pavement and Environmental Oversight Teams to hear presentations from Doug Hanson of NCAT and Mike Hankard of Hankard Environmental, Inc. on the status of pavement and environmental noise studies in Colorado. Also, the meeting was held to evaluate the needs for future noise research studies.

7/31/04 The study manager, Donna Harmelink, has retired. Robert DeDios is serving as manager for now.

7/30/04 Based on two meetings in July, the study panel decided to request NCAT to conduct CPX noise testing on 21 sites in Colorado. Seventeen of these sites were tested in the fall of 2003, while four additional sites were added. This will help establish a trend in noise emissions as pavements age.

7/30/04 The panel also decided to submit a problem statement for the Research and Implementation Council to consider for funding July 1, 2005. The problem statement will outline a long-term study on pavement noise to determine how pavement/tire noise varies as the pavement ages. SBPI roadside noise testing will also be incorporated into this proposed study to determine how pavement/tire noise affect neighborhood noise levels.

3/31/04 With the FY 04 money from the Southeast Superpave Center, NCAT brought their specially developed noise trailer to Colorado to evaluate 17 projects with various surface treatments. The seventeen projects included different textured concrete, including the evaluation of the Minnesota drag, carpet drag, longitudinal tining, transverse tining, and ground surface. In addition several different asphalt mixtures were included. The asphalt surface treatments evaluated were SMA, OGFC, Nova Chip and Superpave S and SX. The data was collected in fall 2003 and NCAT analyzed the data and provided the department with a written report. The conclusion of their evaluation indicated that the OGFC surface was the quietest and that the age of an HMA pavement can have a major effect on the noise level of the pavement. This was a limited study and further research was recommended. The report no. is CDOT-DTD-R-2004-5.

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 added, at least one for each regions. SMAs are also included in the study.

Reporting Period 4/1/12 through 6/30/12
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.
12/12			Final report will be written documenting the final performance and impact of the new specification on the quality of longitudinal joints.

SIGNIFICANT EVENTS

05/31/12 Research staff met with FHWA personnel to discuss the final disposition for this project which had been inactive for a while. Construction specifications have already been developed and implemented in the field. FHWA suggested soliciting the opinion of the Materials Advisory Committee (MAC) on what direction to take since construction specifications are already in place and working well, which was the ultimate

goal of the study in the first place. It was decided that this project will be closed out and a letter will be drafted to inform FHWA of this decision.

5/07/12 Dave Weld conducted field inspections and noted that the longitudinal joints are performing very well.

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.

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

CDOT Pavement Crack Seal and Fill Best Management Practices
Study No: 11.40

Background Crack sealing and filling are cost effective pavement preservation techniques that can provide significant return on investment, improve pavement performance and increase remaining service life, and provide potential contracting opportunities for disadvantage business enterprise (DBE) and other small companies bidding CDOT work. However, CDOT does not have an effective or current crack sealing and filling policy, contracting process, installation and inspection manual, and quality assurance protocols. The policy and manual used was developed in 1994, and is not readily available, understood or applicable to the current state of practice. This research will: 1) recommend a policy for application and use of crack sealing and filling, 2)develop a Best Practices Guidelines for the design, construction, and maintenance of crack sealing and filling treatments. 3) develop Design Guidelines that identifies the process and data requirements to develop a plan, specifications and estimates (PS&E) level project, and identify appropriate QA/QC procedures for crack sealing projects.	Reporting Period: 4/1/12 through 6/30/12 Type: SP&R Start: End: Principal Investigators: TBD Study Manager: Roberto de Dios, Research Branch, 303-757-9975 Study Panel Members: (Tentative) Mark Mueller, Staff M&O, 303-512-5503 Bob Mero, R-6 Materials, 303-398-6703 Mike Stanford, Mat. and Geotech Branch, 303-398-6576 Donna Harmelink, FHWA-Colorado Division 720-963-3021

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
8/31/12			Hold initial study panel meeting.
9/15/12			Develop scope of work
9/30/12			Issue RFP
10/31/12			Select researcher
11/31/12			Notice to Proceed
9/15/13			Draft Final Report
11/31/13			Final Report

SIGNIFICANT EVENTS

6/29/12 Funds are now available for this project

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Preventing Transverse Bumps and Cracks in New Asphalt Overlays Over Crack Sealants
Study No: 11.60

Background	Reporting Period: 4/1/12 through 6/30/12 Type: SP&R Start: End:
Crack sealants are often placed in transverse cracks to extend pavement life. However, when a hot mix asphalt overlay is placed on top, a pavement bump and additional transverse cracks often occurs in the new overlay asphalt above the sealant. Previous research and observations indicate that much of the problem may result from the overlay slipping on the sealant during rolling. Suggestion to mitigate this age-old problem include: 1) overlay mixtures with high frictional properties 2) variations of the compaction equipment and rolling scheme, and 3) the use of stiffer tack coats and sealant materials. This research will seek to identify the primary reasons for these bumps and determine the best approach to mitigation.	Principal Investigators: TBD Study Manager: Roberto de Dios, Research Branch, 303-757-9975 Study Panel Leader: Bill Schiebel, Region 1 Materials, 303-398-6801 Study Panel Members: Donna Harmelink, FHWA-Colorado Division 720-963-3021

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
8/31/12			Hold initial study panel meeting.
9/15/12			Develop scope of work
9/30/12			Issue RFP
10/31/12			Select researcher
11/31/12			Notice to Proceed
9/15/13			Draft Final Report
11/31/13			Final Report

SIGNIFICANT EVENTS

6/29/12 Funds are now available for this project

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Alternative Materials Investigation for Selective Use of Permeable Pavements Outside of State Highway Travel Lanes and Shoulders
Study No: 12.00

Background The term permeable pavement is used to describe any one of several storm water quality best management practice (BMP) pavements that allow movement of water into the layers below the pavement surface. These pavements are typically intended for light vehicle parking areas, and not for roadway installations, high speed, or heavy traffic. Depending on the design, permeable pavements can be used to promote runoff volume reduction, provide treatment and slow release of the water quality capture volume (WQCV), and reduce effective imperviousness. Use of permeable pavements is a common Low Impact Development (LID) practice and can be used in combination with other BMPs to provide full treatment and slow release of the WQCV. Installations can also be designed with an increased depth of aggregate material in order to provide flood control storage for large storm events. The three most common permeable pavement wearing courses are pervious concrete, porous asphalt, and permeable interlocking concrete pavers. The research will 1) evaluate the wearing course with regard to surface infiltration rate decay over time, clogging propensity, ease of maintenance; and also with regard to surface durability and serviceability of the wearing course over time; and 2) provide a side-by-side comparison of two slotted concrete pavement installations, featuring two different water quality treatment methods below the pavement. The key difference between the two pavements will be that one incorporates a sand layer to clean the runoff via filtering while the other will rely solely on settling and subsequent aerobic digestion by a biological film of microorganisms that will develop naturally on the surface of the aggregate.	Reporting Period: 4/1/12 through 6/30/12 Start: TBD Contract Amount: $ 70,000 Principal Investigator: Ken A. MacKenzie, P.E., CFM Master Planning Program Manager Urban Drainage and Flood Control District Study Manager: Bryan Roeder, CDOT, 303-512-4420 Study Panel Leader: Mommandi, Amanullah, CDOT Hydraulics Program Manager Study Panel Members: Rik Gay, CDOT EPB

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
7/15/12			Select study panel
7/31/12	70		Finalize scope of work that will be attached to the IGA. PI submitted draft SOW for review by study manager and study panel.
9/1/12			Execute an intergovernmental agreement (IGA) with the Urban Drainage and Flood Control District.
9/1/12			Begin Study
6/1/14			Draft report
9/15/14			Final Report publication

SIGNIFICANT EVENTS

6/29/12 $70,000 now available from the FY13 SP&R Work Program

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: 4/1/12 through 6/30/12
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
Roy Guevara, CDOT Materials and Geotechnical Branch
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		Task 4 – Final Presentation
3/31/13	90	6/30/12	Task 5 – Quarterly Progress Reports
3/31/13	0		Task 8 – Final Report

SIGNIFICANT EVENTS

6/29/12 Coordination with Region 4 began to establish traffic control at the site so condition surveys can be conducted.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Asphalt Emulsion Full Depth Reclamation Best Practices
Study No: 12.75

Background Asphalt Emulsion Full Depth Reclamation (AEFDR) is a cost effective, green technology process that recycles and rejuvenates the existing pavement surface and subgrade, providing an improved structure for the final surface pavement. To increase the use of the AEFDR process, CDOT pavement designers, roadway design and construction staff need design guidance, standardized plans and specifications, construction inspection best practices and quality assurance and quality control protocols. The research will develop AEFDR design criteria, standard specifications, plan sheets or other design aides, construction inspection requirements, materials testing procedures and frequencies, and a performance evaluation process guide.	Reporting Period: 4/1/12 through 6/30/12 Type: SP&R Start: End: Principal Investigators: TBD Study Manager: Roberto de Dios, Research Branch, 303-757-9975 Study Panel Members: (Tentative) Gary DeWitt, R-4 Materials, 970-350-2379 Shamshad Hussain, R1Materials, 303-398-6802 Steven Henry, Mat. and Geotech Branch, 303-398-6579 Mike Stanford, Mat. and Geotech Branch, 303-398-6576 Donna Harmelink, FHWA-Colorado Division 720-963-3021

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
8/31/12			Hold initial study panel meeting.
9/15/12			Develop scope of work
9/30/12			Issue RFP
10/31/12			Select researcher
11/31/12			Notice to Proceed
9/15/13			Draft Final Report
11/31/13			Final Report

SIGNIFICANT EVENTS

6/29/12 Funds are now available for this project

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

In-Place Void Follow-Up
Study No. 12.92

Background

With a perfect mix design methodology, the in-place voids should match the design voids after a certain length of time. Data from a recently completed study indicated that pavements in Colorado achieve final densification under traffic within the first three years. However, the in-place voids at three years average 1.2% higher than one would expect based on the design voids. This indicates that these projects were designed at too high of compactive effort and resulted in stiffer mixes.

This study recommended two options for adjusting mix designs for Colorado. The first option was to lower the compactive effort during the mix design process. The second was to adjust the target mix design air void content. The first option was undesirable as the required change in compaction effort to achieve the difference in voids would be quite large.

Implementation of the second option has already begun, and will change constructed air voids while maintaining historic design void requirements and ensure that additional asphalt cement is used to fill mix voids. Recommendations to change the air voids target on the Job Mix Formula (Form 43) at 0.6% lower voids will decrease field voids by 0.6%, half the difference shown by the study. The change will result in more asphalt in the field-produced hot-mix asphalt.

Even though this change is felt to be a step in the right direction additional research is needed to track these changes to ensure the desired outcome is achieved.

Reporting Period: 4/1/12 through 6/30/12
Type: SP&R Start:7/03 Ver:

Principal Investigator(s):
Research Branch Personnel

Dave Weld, Field Coordinator/Support
CDOT Research Branch
303-512-4052

Study Manager:
Roberto DeDios, CDOT Research Branch,
303.757-9975

Study Panel Members:
Bill Schiebel, R1 Materials 303.398.6801
Donna Harmelink, FHWA Colorado Division
720-963-3021

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
5/03	100	7/03	Identify the projects for evaluation. 17 sites were selected for evaluation in 2003. The remaining sites to complete the environmental and temperature matrix will be established next year during construction.
9/03	100	10/03	Monitor 2003 construction
5/04	100	7/04	Additional sites to complete the environmental and temperature matrix were identified: SH385 near Holyoke and SH135 at Almont.
9/04	100	8/31/04	Monitor 2004 construction projects: Holyoke done in June and Almont done in August.
9/04	100	3/31/05	Collect cores for first year evaluation.
11/04	100	11/24/05	Laboratory testing of Cores
9/05	100	10/1/05	Collect cores for second year evaluation, complete void testing in laboratory
11/05	100	05/06	Laboratory testing of Cores
9/06	100	11/06	Collect cores for final evaluation, 15 of 19 sites have been cored and evaluated

7/31/07	100	6/30/07	Complete testing of Cores
11/14/12			Draft final report
12/31/12			Publish final report

SIGNIFICANT EVENTS

5/31/12 Research staff met with FHWA to decide what to do with this inactive project. FHWA personnel suggested bringing this issue to the Materials Advisory Committee for final disposition. Some test results are missing and need to be recovered or reconstructed. It was decided that a final report will be prepared for this research project. A consultant will be hired to analyze data and prepare the final report.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Investigation of the Need for a HMA Layer Bond Strength Test
Study No: 12.94

Background	Reporting Period: 4/1/12 through 6/30/12 Type: SP&R Start: End:
Poor bonding with underlying HMA layers can greatly influence the long term performance of HMA in the form of premature cracking and fatigue. The primary method to achieve bonding between layers is through the use of an emulsified tack coat, which is typically diluted at 50/50 with water before application. The tack coat is often tracked by HMA delivery vehicles during the paving process. Additionally, field staff is charged with determining whether an existing pavement, especially a milled surface, is clean enough prior to tack coat placement, to ensure an adequate bond. Because CDOT is prescriptive in its tack coat application specifications, we assume responsibility for any pavement failures related to poor bonding. CDOT should consider adopting a bond strength test method, and associated specification limits based on performance information. CDOT could then transfer responsibility to the Contractor for determining appropriate cleaning and tack coat application rates and practices. This research will first determine if bond failure is a significant problem and then if it is, the research will develop a bond strength test and test it on several overlay projects with varying tack coats to determine an acceptable range for the specification.	Principal Investigators: TBD Study Manager: Roberto de Dios, Research Branch, 303-757-9975 Study Panel Members: Richard Zamora, Program Development 303-757-9040 Gary Dewitt, R-4 Materials , (970) 506-0359 Shamshad Hussain, R-1 Materials, 303- 398-6582 Michael Stanford, Mat. & Geotech Branch, 303-398-6544 Craig Wieden, R-2 Materials, (719)546-5438 Donna Harmelink, FHWA-Colorado Division 720-963-7021

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
7/25/12		7/25/12	Hold initial study panel meeting.
8/15/12	85		Develop scope of work
8/30/12			Issue RFP
9/30/12			Select researcher
10/31/12			Start Project
10/31/15			Draft Final Report
12/31/15			Final Report

SIGNIFICANT EVENTS

6/29/12 Funds are now available for this project

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Design and Analysis Procedures for Asphalt Mixtures Containing High-RAP Contents and/or RAS (Pooled-Fund Study)
Study No: 13.10

Background	Reporting Period: 4/1/12 through 6/30/12 Type: SP&R Start: End:
Despite recent advancements in the design of asphalt mixtures containing Reclaimed Asphalt Pavement (RAP), many states are still cautious in their regulations to avoid durability problems related to the recycling process. In many states, RAP is currently not allowed in highest-class asphalt mixtures and in polymer-modified asphalt products. In addition, high percentages of RAP exceeding 25% are not commonly used in practice. On the other hand, many state agencies are taking a more aggressive approach by considering increasing the allowable percentages of RAP in hot-mix asphalt (HMA) to take full advantage of this promising technology. For instance, up to 50% RAP has been used in some asphalt mixtures, which produced an acceptable level of performance. However, to ensure successful use of RAP, confidences in the mixture design procedure require addressing many concerns related to the interaction between virgin and recycled materials and durability of the produced mixture. Current AASHTO recommendations make it difficult to design asphalt mixtures with high-RAP contents. Modifications to the current specifications are needed to assure agencies that satisfactory performance will result from the use of high-RAP content HMA mixes.	Principal Investigators: TBD Study Manager: Roberto de Dios, Research Branch, 303-757-9975 Study Panel Members: Masoud Ghaeli, Region 6 Materials, 303-398-6701 Bill Schiebel, Region 1 Materials, 303-398-6801 Mike Stanford, Materials and Geotechnical Br.

MILESTONES

Click on the link to access the Transportation Pooled-Fund website to view the solicitation details for this research project: http://www.pooledfund.org/Details/Solicitation/1318

SIGNIFICANT EVENTS

6/29/12 Funds are now available for this project.

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. 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: 4/1/12 through 6/30/12
Type: SP&R Start: 06/30/01

Principal Investigator(s):
The Transtec Group, Inc.
Robert Otto Rasmussen, Ph.D., INCE, P.E.(TX)
512-451-6233

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.
04/30/12			Perform sand patch testing.
9/30/12			Publish and distribute the final report. Hold a slide presentation to show results to the Materials Engineers.

SIGNIFICANT EVENTS

06/19/12 A teleconference meeting between the study panel and Transtec Inc. was held to discuss test results and details of draft report/presentation. It was agreed that a final presentation will be made in September for CDOT and the industry.

03/31/12 Skip and Dave performed more sand patch testing this quarter. They planned to complete the testing by the end of 4/12.

12/31/11 Sand patch testing was carried out by Skip Outcalt and Dave Weld of Research Branch to gather surface texture data for selected state highway Portland cement concrete pavements.

11/02/11 A purchase order to procure professional service to complete the research was issued by the CDOT Purchasing Agent to Transtec Group Inc.

09/30/11 Planned 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.

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.

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.

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: 4/1/12 through 6/30/12
Type: SP&R Start: 09/23/10

Principal Investigator(s): Dr. Rui Liu/
(Dr. Stephan Durham) University of Colorado-Denver, 303-556-5270
Research Study Manager:
Roberto 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
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

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	100	2/15/12	Create concrete mix in lab, test, and develop performance criteria
9/30/11	100	1/16/12	Summarize past research activities/Fifth progress report
9/30/11	100	2/15/12	Solicit and batch non-standard mixture designs

12/31/11	100	4/16/12	Test supplier-provided concrete
12/31/11	100	4/16/12	Summarize past research activities/Sixth progress report
12/31/11	100	2/15/12	Analyze and summarize test results
1/31/12	100	6/29/12	Draft project report
1/31/12	100		Conduct PowerPoint presentation to CDOT Panel
2/28/12			CDOT Panel review of draft report/Return report with comments to PI
7/11/12	100	7/11/12	Conduct PowerPoint presentation to the Materials Advisory Committee (MAC)
9/21/12			Submit final project report to CDOT

SIGNIFICANT EVENTS

2/15/12	Completed laboratory batching of non-standard concrete mixtures.
1/16/12	Fifth progress report
12/31/11	Principal Investigator Stephen Durham left the University of Colorado-Denver for another university. Completed laboratory batching of concrete mixtures.
10/10/11	Fourth progress report
9/01/11	Obtained all of needed materials from around the state for batching mixtures
7/14/11	Complete literature review/third progress report
4/31/11	Second progress report
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

Evaluation of Internal Curing of HPC Using Lightweight Aggregates and Other Techniques
Study No: 22.60

Background	Reporting Period: 4/1/12 through 6/30/12 Type: SP&R Start: End:
Traditional curing methods are mostly external and are divided into two categories: a) water curing by supplying additional moisture, such as wet burlap and ponding, and b) sealed curing by preventing loss of moisture. External curing does not work very well for high performance concretes (HPC) due to their low water content (autogenous shrinkage and internal desiccation) and their low permeability that prevents external water sources to reach the interior of the concrete element in need of curing. To resolve the problems listed above, curing water can be supplied from an internal source. In this case, the process is called internal curing (IC). IC can introduce a curing agent into the concrete mixture, such as an admixture, or a special aggregate. Most commonly this is a water-saturated lightweight aggregate, but strength and durability concerns still prevail. Therefore, alternative approaches to IC are sought in this study, which can produce HPC with improved strength (compressive and tensile), durability, permeability, and overall performance.	Principal Investigators: TBD Study Manager: Roberto de Dios, Research Branch, 303-757-9975 Study Panel Members: Gary Dewitt, Region 4 Materials ,(970) 506-0359 Eric Prieve, Mat. And Geotech Branch, 303-398-6542 Mike Mohseni, Bridge Design and Management 303-512-4300 Matt Greer, CO div. of FHWA, 720-963-3008

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
7/31/12	100	7/31/12	Hold initial study panel meeting.
8/15/12			Develop scope of work
8/30/12			Issue RFP
9/30/12			Select researcher
10/31/12			Start Project
10/31/14			Draft Final Report
12/31/14			Final Report

SIGNIFICANT EVENTS

6/29/12 Funds are now available for this project

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Recycled Tires as Coarse Aggregate in Concrete Pavement Mixtures
Study No: 22.65

Background

The State of Colorado has an estimated inventory of more than 70 million used tires, the highest number of scrap tires stockpiled in any state. It generates about 4.83 million waste tires annually while recycling about 4.49 million tires mostly as a source of tire derived fuel, leaving a balance of about 340,000 tires that are destined for "mono-fills" which are landfills exclusively for waste tires. The Colorado Senate Bill 09-289 requires elimination of all Colorado waste tire mono-fills by year 2019.

A recent research study conducted by the University of Colorado at Denver for the Colorado Department of Public Health and Environment indicated the feasibility of using commercially processed crumb rubber as a partial replacement for the fine aggregate in CDOT Class P paving concrete mixes. Up to 50% by volume of fine aggregates was replaced. Although, the stated cost of $300-$400 per ton seemed to be high for a well-processed crumb rubber to replace fine virgin aggregates that are readily available in eastern Colorado, the processed crumb rubber materials would be much less expensive than using scarce virgin coarse aggregates suggesting that a more economical alternative exists if tire chips are used to supplement the coarse aggregate.

Costs associated with crushing, shredding and screening materials, including tires, to ever smaller sizes progressively increase. The less effort required to create a product, the less its associated costs will be. In this case, it is suggested that rather than investing in higher expenditure to create finer crumb rubber particles, create a coarse fraction that facilitates an end product that meets the intent of the design performance needs, and costs less than finer crumb rubber materials. The proposed use of recycled tires would replace the more expensive virgin coarse aggregate, and not the fine aggregates found abundantly on the eastern plains of Colorado. Research is needed to determine if recycled tires can be used as a coarse aggregate in concrete pavements and to determine if it creates the overall anticipated value.

Reporting Period: 4/1/12 through 6/30/12
Type: SP&R Start: End:

Principal Investigators:
TBD

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

Study Panel Leader:
Eric Prieve, Materials and Geotechnical Branch, 303-398-6542

Study Panel Members:

Patrick Kropp, Materials and Geotechnical Branch 303-398-6541
Bob Mero, Region 6 Materials, 303-398-6703

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
7/31/12			Hold initial study panel meeting.
9/19/12			Develop scope of work
9/26/12			Select researcher
10/01/12			Start project
03/29/13			Draft final report
05/31/13			Submit final report

SIGNIFICANT EVENTS

6/29/12 Funds are now available for this project

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 is to develop guidelines, procedure, and specifications for the design, placement and maintenance of RCC in Colorado's roadways.

Reporting Period: 4/1/12 through 6/30/12
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

06/30/12	The Principal Investigator promised to submit the revised final report by first week of 8/12.
03/31/12	The Principal Investigator is still in the process of revising the final report. RCC mix designs needed to be incorporated into the final report.
12/31/11	The Principal Investigator has submitted the draft final report and in the process of revising the final report to incorporate comments made by the study panel.
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: 4/1/12 through 6/30/12
Start: 9/13/07 Complete: 6/30/12

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
			2011
winter 2011	85	Dec 2010	Sample prep, N extraction
spring 2011	30		N release report
melt 2011	100		Field sampling
			2012
Fall 2011	100	Feb 2012	Final field sampling
Aug 2012			Field survey for surviving plant species and growth
Sept 01 '12			Prepare and submit draft final report to CDOT study panel for review.
Nov 01 '12			Complete review of draft final report by CDOT study panel with comments to be addressed.
Dec 01 '12			Prepare and submit final project report.

SIGNIFICANT EVENTS

June 21, 2012: Project extended through 12/31/2012

March 2012: Final field sampling was made, soils were dried and nitrogen loading and nitrogen leaching horizons were separated. Final data analysis was started and materials gathered for final report.

December 2011: A request for extension was submitted and received , setting the current end-of-project deadline to June 30, 2012. Since most of the nitrogen fertility being released from the soil amendments will be in the nitrate form, and since this is a very water soluble form, supplemental work was done to be able to estimate the flow of nitrate through the porous sand during snow melt and summer rains. This additional information will be integrated with the main purpose of the project, which was nutrient loading and release from soil amendments added to the cut slopes along Straight Creek section of I-70.

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.

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: 4/1/12 through 6/30/12
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	100	1/10/12	State of the Practice Assessment
9/15/11	40		Policy Outreach
9/15/11	50		Performance Measures
10/21/11	30		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
- 12/5/11 – Restart project
- 12/8/11 – Submission of MBUF Options Technical Memorandum (serves towards defining program goals and objectives)
- 12/8/11 – Submission of MBUF Focus Group protocol
- 12/8/11 – Submission of MBUF Stakeholder Interview protocol
- 1/10/12 – Submission of State of the Practice Technical Memorandum
- 2/13/12 – Presentation to CDOT DTD.
    - Outcome from presentation and technical memoranda: rescope project to incorporate an expanded array of public opinion assessment prior to development of MBUF policy, concept of operations, and pilot program design.
- 5/1/12 – Presentation to MBUF Symposium
- 5/18/12 – Reallocation of scope and budget to emphasize more public opinion data collection
- 6/25/12 – Initiation of Stakeholder Interviews and data collection

ANTICIPATED EVENTS FOR Q2 2012

- Completion of stakeholder interviews
- Conduct first MBUF workshop at CDOT HQ
- Conduct first public opinion data assessment (via survey to longitudinal panel)
- Complete analysis of first public opinion data assessment
- Develop revised MBUF alternatives for public opinion testing

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Helicopter Avalanche Control
Study No: 30.70

Background	Reporting Period: 4/1/12 through 6/31/12 Type: SP&R 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, DTD Research, 303-757-9518 Study Panel Members: Mark Mueller, Staff Maintenance Engineer (HQ) James Walker, Maintenance & Operations (HQ) Aziz Khan, CDOT Research Engineer (HQ-DTD) Amanullah Mommandi, Hydraulic Engineer (HQ) Dr. Aziz Khan, DTD Research (HQ)
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.	

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
			Phase 1
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	100	1/12	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.
Phase 2			
12/11	0		Task 2.1: Dependent upon evaluation of data obtained in phase 1, the research team will propose improved strategies in terms of new explosive types, delivery methods, and/or initiation methods which are intended to improve crew safety, mission effectiveness and cost effectiveness. The strategy should consider not only explosive characteristics but also avalanche/snow mechanics and how the process could be optimized for different conditions.
4/12	0		Task 2.2: Design and build a test matrix for comparison of actual explosives, and their alternative systems, studied in phase 1. The research team will perform and analyze these comparisons with different initiation systems, delivery methods, and explosive types in relation to snow mechanics, environmental effects using high speed imaging and other technologies. Numerical modeling will also be performed using results from these comparison tests. Test locations will be pre-selected be CDOT personnel, such as Independence Pass in early spring, to afford realistic snow conditions.
4/12	0		Task 2.3: The research team will design and implement training courses and materials in the proposed strategy based on the test results of Task 2.2 in order to minimize cost and help improve the effectiveness of CDOT's helicopter avalanche control program.
4/12	0		Task 2.4: Continue annual CDOT training while documenting the effectiveness of the newly implemented strategies described in tasks 2.2 and 2.3.
5/12	0		Task 2.5: The research team will submit a final written report on the new helicopter avalanche control strategies, implemented training, and effectiveness of new strategies in the field. This report will also highlight the comparison between current explosive methods to alternative methods such as the Daisy Bell avalanche control systems and will comply with CDOT Research Branch requirements.

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.
- **12/11** 32 responses to the survey have been received. Survey responses have been analyzed with the following results
- **1/5/12** Final survey report was sent to CDOT and other necessary personnel for revision.
- **2/12** Working on setting up testing with Loveland Ski area and finalizing test matrix with CDOT for 1 or 2 days of testing, according to availability of Loveland Ski Area, CDOT personnel, and CAIC personnel.
- **2nd Quarter 2012** – No significant events reported.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Potential Impacts of Solar Arrays on Highway Safety and Operations
Study No: 32.08

Background	Reporting Period: 4/1/12 through 6/30/12
The highway right-of-way provides the opportunity for the development of solar power systems across the state. However, this is only feasible if it can be done in a manner that does not interfere with the operation and maintenance of the highway system and does not create an unacceptable risk to transportation system users. Two reports will be produced, addressing general (not necessarily site specific), potential impacts from solar array installation and operation. The first report should identify visual and other potential impacts to highway user safety, evaluate the probability for these impacts to occur and recommended criteria for minimization or control of any impacts that have a high probability of occurring, or carry very high risk even if probability appears low. The second report will focus on the potential for solar arrays to affect on-going maintenance and operation activities.	Study Manager: Bryan Roeder, CDOT, 303-512-4420 Study Panel Leader: Yates Oppermann, CDOT Environmental Programs Branch Study Panel Members: Sasan Delshad, CDOT Region 2 Traffic and Safety Mike Delong, CDOT Region 1 Maintenance and Operations Jim Eussen, CDOT Region 1 Environmental Sarah Mitchell, CDOT Environmental Programs Branch Dave Ruble, CDOT Region 1 Utility Engineer Rick Santos, Colorado Div. of FHWA

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
6/1/12		6/1/12	Establish Study Panel and hold meeting
07/01/12	90		Prepare scope of work: Panel leader prepared document and awaits comments from panel
07/15/12			Issue request for proposals
8/15/12			Select researcher
9/15/12			Conduct study
7/15/14			Draft report (2 months prior to report publication)
9/15/14			Final Report publication

SIGNIFICANT EVENTS

06/29/12 $75,000 now available from the 2013 SP&R Work Program

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Mule Deer and Elk Right-of-Way Escape Ramp Design Monitoring
Study No: 32.47

Background	Reporting Period: 4/1/12 through 6/30/12 Start: 05/09/12 Contract Amount: $ 71,994 Principal Investigator: Kenneth Wilson, Ph.D. (dept. head) & Jeremy Siemers, M.S. (research associate) Department of Fish, Wildlife, and Conservation Biology at Colorado State University (CSU) Study Manager: Bryan Roeder, CDOT, 303-512-4420 Study Panel Leader: Tony Cady, Region 5 Environmental Study Panel Members: Jeff Peterson, CDOT Environmental Programs Branch Alison Michael, US Fish & Wildlife Service Jim Eussen, CDOT Region 1 Environmental Rob Frei, CDOT Region 2 Environmental David Valentinelli, CDOT Region 5 Engineering
Escape ramps are increasingly being used across the western United States as an escape mechanism in areas where wildlife fencing has been constructed. However, the design and effectiveness of such ramps have been poorly studied and most of the ramps are built with little research informing their design and placement. Much of the current knowledge base is derived from anecdotal experience and we know of no studies that have compared the effectiveness of different ramp designs for deer and elk. The research will provide systematic and focused documentation of ramp usage, and an analysis of attribute features (design or setting) which may influence usage of the ramps by the target species (mule deer and elk). Statistically analyzing pre- and post- construction accident data will serve as a baseline for determining effectiveness, but other aspects of ramp design that influence the benefit of the mitigation will also be documented. Documented effective ramp designs can be incorporated into engineering design standards for deer and elk escape ramps across the state and will contribute to the nationwide knowledgebase regarding the effective siting and design of escape ramps to reduce AVCs. The study aims to develop pilot construction specifications and/or guidance documentation on best practices to effectively locate, design, construct, and maintain mule deer and elk escape ramps.	

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
05/09/12		05/09/12	Notice to Proceed
05/31/12		5/31/12	Kickoff Meeting
06/20/12		06/20/12	Field Meeting with CSU, CDOT, and CPW personnel
07/31/12	50%		Camera testing and deployment evaluation
07/31/12			Cameras deployed at all escape ramps
11/09/12			Collect ramp, road, landscape, and other covariates
07/31/14			Monitoring
01/14/15			Cost-benefit analysis
01/14/15			Ramp use and design analysis
01/14/15			Draft report (75 days prior to report publication)
03/30/15			Final Report publication
03/30/15			End of contract

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: 4/1/12 through 6/30/12
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

March 2012: No activity was reported this quarter. Pooled fund information is available here: http://www.pooledfund.org/Details/Study/425

Sept 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.

December 2011: No activity reported this quarter.

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: 4/1/12 through 6/30/12 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.
1/20/12	100	1/20/12	Transferred $10,000 for FY12 commitment
12/26/12			Project completion.
1/20/13			Tentatively plans to transfer $10,000 for FY13

SIGNIFICANT EVENTS

Through 03/31/12	Pooled fund study is in progress. See link below for the quarterly progress report. http://www.pooledfund.org/Details/Study/384
Through 12/31/11	Pooled fund study is in progress. See link below for the quarterly progress report. http://www.pooledfund.org/Document/Download/3176
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	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

	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 3/31/11	No significant information to report for this quarter. Pooled Fund Study is still progressing.
Through 12/31/10	No significant information to report for this quarter. Pooled Fund Study is still progressing. 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

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 project is to evaluate the performance of crumb rubber test sections and as appropriate, develop Colorado-specific materials, construction specifications, guidelines, and best management practices for rubberized asphalt pavement. The Colorado Department of Public Health and Environment (CDPHE) provided the grant money to construct the two pilot test sections.

Reporting Period: 4/1/12 through 6/30/12
Type: SP&R Start: 12/1/09

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

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

Technical Panel Leader:
Jay Goldbaum, CDOT Materials Pavement Design Program, 303-398-6561

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
Mike Stanford CDOT Materials Asphalt Program
Rex Goodrich, CDOT R-3 Materials
Donna Harmelink, FHWA
Bryan Roeder, 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

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	60	6/30/12	Task 3 - Data Collection
12/31/14	65	6/30/12	Task 4 – Project Status Reporting
6/30/14	0	6/30/12	Task 5 – Draft and Final Report Presentation and Submittal

SIGNIFICANT EVENTS

6/30/12 Coordination with Region 4 began to establish traffic control at the site so condition surveys can be conducted.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Innovative Noise Mitigation Design Solutions for Mountain Corridors
Study No: 34.28

Background	Reporting Period: 4/1/12 through 06/30/12 Start: TBD Contract Amount: TBD Principal Investigator: TBD Study Manager: Bryan Roeder, CDOT, 303-512-4420 Study Panel Leader: Jill Schlaefer, CDOT Environmental Programs Branch (303) 757-9016 Study Panel Members: Jordan Rudel, CDOT Region 6 Environmental Robert Mero, CDOT Region 6 Materials Unit Paula Durkin, CDOT Region 3 Environmental Stephanie Gibson, FHWA Colorado Roberto DeDios, CDOT Research Branch Chuck Attardo, CDOT Region 1 Environmental
Noise impacts from high-volume roads in mountain corridors have increased significantly as truck and car volumes and residential development increase. Compounding the problem because of the terrain, mitigation of noise impacts is particularly challenging. . The I-70 Mountain Corridor Programmatic Environmental Impact Statement (PEIS) (Final published March 2011) has identified highway segments in need of safety and capacity improvements and has delineated general areas of traffic noise concern. Traffic noise has alienated local communities and has resulted in significant project delays and associated costs for CDOT. This study will research and identify noise mitigation technologies from high-volume traffic areas of difficult terrain within sensitive noise environments. The researchers will develop recommended abatement measures and identify innovative materials, acoustical designs or retrofits. The final report will include theoretical noise abatement designs and modeling documentation for required mitigation solutions that reduce community noise levels measurably over conventional barriers. The recommended designs and construction materials shall include a discussion of context sensitive abatement measure installation where terrain is difficult and social costs are high.	

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
11/1/11		11/22/11	Select Study panel and hold meeting
2/1/12		4/25/12	Prepare scope of work
6/15/12		6/22/12	Issue RFP: bids due 7/18/12
8/1/12			Select Research
9/1/12			Contract and notice to proceed
6/15/13			Draft report (75 days prior to report publication)
09/1/13			Final Report publication

SIGNIFICANT EVENTS

06/29/2012 $65,000 is now available from the FY13 SP&R Work Program

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 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 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 testing, statistical pass-by index (SPBI) testing, and environmental

Reporting Period: 4/1/12 through 6/30/12
Start: 2/2006 Complete: 4/2012

Principal Investigator(s):
The Transtec Group, Inc.
Robert Otto Rasmussen, Ph.D., INCE, P.E.(TX)
512-451-6233
Study Manager:
Roberto DeDios, CDOT-DTD Research
303-757-9975
Study Panel Members:
Gary DeWitt, R-4 Materials 970-506-0359
Jay Goldbaum, Materials and Geotechnical
303-757-9449
Donna Harmelink, FHWA 720-963-3021
Vanessa Henderson, CDOT-DTD Research
303-757-9787
Bob Mero, R-6 Materials 303-398-6703
Bill Schiebel, R-1 Materials 303-757-9134
Tammie Smith, R-3 Environmental
970-248-7226
Steve Olson, Materials and Geotechnical
303-757-9299
Jordan Rudel, R-6 Environmental
303-757-9881
Jill Schlaefer, CDOT-DTD Environmental
303-757-9016
Richard Zamora, R-2 Materials 719-546-5778

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	100	10/15/11	Analyze data (Year 5/last and all years combined)
10/31/11	100	12/15/11	Submit draft (Year 5/last and all years combined) report for CDOT panel review
3/14/12	5		Final presentations to the study panel and MAC
6/30/12	100	6/30/12	Submit final (Year 5/last and all years combined) report

SIGNIFICANT EVENTS

06/30/12 The Principal Investigator submitted the revised final report and it was already published in the CDOT Research website. However, the final presentation to CDOT will be made sometime in September ’12.

03/31/12 The Principal Investigator is in the process of revising the report to address all the comments from the panel members.

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: 4/1/12 through 6/30/12 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	100	1/20/12	Transferred $25,000 for FY12 commitment
12/31/12			Transfer $25,000 for FY13 commitment

SIGNIFICANT EVENTS

Jul 2012: Latest update report: http://www.clearroads.org/downloads/Clear-Roads-Update-June-2012.pdf

Jan 2011: Link to latest quarterly progress report:
http://www.clearroads.org/downloads/CTC_Quarterly_Progress_Report_4Q11.pdf

Nov 2011: Bryan Roeder hired as Environmental Research Manager and takes over as Study Manager for the Clear Roads pooled-fund study.

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.

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

Innovative Vegetation Practices for Construction Site Plant Establishment
Study No: 42.00

Background	Reporting Period: 04/01/12 through 06/30/12 Start: TBD Contract Amount: $ TBD Principal Investigator: TBD Study Manager: Bryan Roeder, CDOT, 303-512-4420 Study Panel Leader: Mike Banovich, CDOT Environmental Programs Branch (303) 757-9542 Study Panel Members: (Tentative) Jennifer Klaetsch, CDOT EPB Landscape Brian Laschanzky, CDOT EPB Water Quality Tripp Minges, CDOT EPB Water Quality Susie Smith, CDOT R6 Landscape FHWA Washington Contact:
Proper final stabilization of disturbed soils in the form of plant establishment requires adequate soil preparation, grading techniques, amendments of proper soil fertilizers, plant selection, proper installation, and mulching during the ideal seeding conditions. Once a CDOT construction project is completed, the CDPHE Stormwater Construction Permit holder must wait until the 70% ground cover (from baseline conditions) has been established in order to de-activate the permit. In the meantime, the project site must be monitored and BMPs must be maintained by CDOT or the contractor. This study will provide a fresh and scientifically based review of the effectiveness or shortcomings of proposed and current CDOT specifications, guidelines, processes, and contractor compliance for construction site revegetation. The research project will review revegetation strategies used in other arid states and agencies. The research will survey CDOT contractors on techniques and equipment use; and survey CDOT engineers on successful and unsuccessful measures attempted or implemented. This study will provide species surveys conducted on existing highway areas and adjacent areas for use in ecologically relevant planting suggestions and seed mixes. The emphasis will be to identify ways in which site stabilization can be accelerated, improved and/or optimized using innovative techniques that take into account site specific habitat conditions and the difficulties present in transportation construction and planning.	

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
7/15/12	90		Establish Study Panel and hold meeting: Invitations to be panel members have been sent out to the above staff.
08/01/12	60		Draft SOW prepared based on problem statement
09/01/12			Issue request for proposals
10/01/12			Select researcher
11/01/12			Conduct study
9/01/14			Draft report (2 months prior to report publication)
10/30114			Final Report publication

SIGNIFICANT EVENTS

6/29/12 $120,000 now available from the 2013 SP&R Work Program

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Assessment and Placement of Living Snow Fences to Reduce Highway Maintenance Costs and Improve Safety
Study No: 47.10

Background Living snow fences are designed plantings of trees and/or shrubs and native grasses along highways, roads and ditches that create a vegetative buffer that traps and controls blowing and drifting snow. These strategically placed fences have been shown to be cost effective in reducing highway maintenance associated with blowing and drifting snow conditions. A Geographic Information System (GIS) will be used to acquire and analyze local environmental condition, topography, weather data and roadside snow condition to identify priority and secondary areas for snow fencing placement. This research project will provide recommendations on how to establish and maintain a living snow fencing program including location selection, partnerships with adjacent landowners, species selection, planting and maintenance guides, and fence design. A test case study living snow fence will be installed.	Reporting Period: 4/1/12 through 6/30/12 Start: TBD Contract Amount: $ TBD Principal Investigator: TBD Study Manager: Bryan Roeder, CDOT, 303-512-4420 Study Panel Leader: Mike Banovich, CDOT Environmental Programs Branch (303) 757-9542 Study Panel Members: TBD

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
08/01/12			Establish Study panel and hold panel meeting
08/20/12	60		Prepare SOW: Draft prepared based on problem statement, will be finalized based on panel input.
09/01/12			Issue request for proposals
10/01/12			Select researcher
11/01/12			Issue contract and NTP
08/15/14			Draft report (75 days prior to report publication)
11/01/14			Final Report publication

SIGNIFICANT EVENTS

06/29/12 $70,000 now available from the 2013 SP&R Work Program

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: 4/1/12 through 6/30/12
Type: SP&R Start: Ver:
Contract: (P.O. #)

Principal Investigator(s):
Panos Kiousis, Colorado School of Mines
303-384-2205
D.V. Griffiths, Colorado School of Mines
303-273-3669

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

Study Panel Members:
Steve Laudeman, CDPHE
Craig Wieden, Region-2 Material
Laura Conroy, HQ-Geotech
Russel Cox, Region-1 Engineering
Rex Goodrich, R-3 Material
Toby Brown, R-3Mainatance
John Hart, Coggins and Sons, Denver
Alan Lisowy, HP 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	95%		Task 2b: Finite Elements-based model
2/1/12	20%		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, Aziz, Kiousis, Ebersole
7/7/11	100%	Y	Site Visit
2/8/12	0%		Update Meeting w/ Laudeman, Aziz, Kiousis, Ebersole

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 essentially complete, using the LS-Dyna software package. While it can be expected that small improvements will be made during the remainder of the project, we are currently able to model any number of slope reinforcement scenarios given enough computational time. Each model run currently approaches 24 hours of computational time.

Note 3: Pile implementation plans will be considered as a part of the update meeting scheduled for February 2012. At this point, it is believed that enough evidence is presented by which an optimized pile implementation plan can be reasonably developed. 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

<u>Background</u>

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: 4/1/12 through 6/30/12
Type: SP&R Start: 03/03/10 Ver:
Contract: 10HAA11438 (P.O. # 271001132)

Principal Investigator(s):
Panos Kiousis, Colorado School of Mines
303-384-2205
Judith Wang, Colorado School of Mines
303-273-3836

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

Study Panel Members:
Nurul Alam
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	85%		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: 4/1/12 through 6/30/12 Type: SP&R Start: 12/07/10 Ver: Contract: 11HAA25597 Completion/End Date: 12/07/2012 CDOT SAP # 27100300 Principal Investigator(s): Ning Lu, Colorado School of Mines 303-273-3654 Co-Principal Investigator(s): Alexandra Wayllace, Colorado School of Mines 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	80%		Task 4: Testing of new proposed methodology
11/07/12	50%		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
12/22/11	100	Y	Interim Progress report presented

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 had a meeting with all the panel members to discuss the progress of the project as well as future actions for a second phase. Minutes of the meeting were distributed to all panel members

Note 2: Laboratory testing of the samples finished.

Note 3: Drill rates from horizontal drilling near the toe of the landslide were obtained. Three distinct speeds were observed probably corresponding to the three main materials: colluvium, fractured gneiss, and bedrock. Water outflow was observed from one drain hole and flow rates were measured.

Note 4: Two topographical surveys of 40 control points were carried out in July. The data was analyzed and will be included in a progress report. In addition, points were surveyed to try to map out more accurately the borders of the landslide.

Note 5: A piezometer is being installed in the East bound of I-70 at a depth of 110ft. Data was logged during drilling and undisturbed soil samples were obtained.

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: 4/1/12 through 6/30/12
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	100		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
	100		Sub-Task 4.4 – Resilient Modulus Testing II
	100	9/30/11	Sub-Task 4.5 – Poisson's Ratio Evaluation
	100		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	100		Task 12 – Research Results Presentation
06/30/12			Submit final report.

SIGNIFICANT EVENTS

6/30/2012 The final report has not been delivered yet. The Study Manager ceased payment of the invoice and will communicate with CSU's Sponsored Program regarding the required submission of the final report for this study.

1/27/2012 A Powerpoint presentation was given to the study panel on 1/27/12 as scheduled. The Principal Investigator moved to Australia but promised to complete the final report. He is still connected with CSU and has committed to provide the final report in due time.

12/31/2011 Principal Investigator indicated he was in the process of completing the remaining work. He planned to make a PowerPoint presentation to the study panel on 1/27/12.

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
Study No: 80.11

Background	Reporting Period: 4/1/12 through 6/30/12
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.	Type: SP&R Principal Investigator(s): Yunping Xi, 303-492-8991 Study Manager: Aziz Khan, Research Branch 303-757-9522 Panel Leader: Ali Harajli, Bridge Design & Management, 303-512-4078 Study Panel Members: Gary DeWitt, Region 4 Materials 970-350-2379 Eric Prieve, Staff Materials 303-398-6542 Scott Roalofs, Staff Materials 303-398-6509 Mathew Greer, CO Div. of FHWA 720-963-3008

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.
07//09/09	100%	07//09/09	Task 2: Field evaluation of monitoring system
04/01/11	100%	04/01/11	Task 3: Interim report and testing plan
06/02/11	100%	06/02/11	Task 4: Field evaluation of sealers
09/31/12	95%		Task 5: Analysis of field evaluation results
10/31/12	95%		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: 4/1/12 through 6/30/12
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
4/30/12	100	4/30/12	Perform laboratory testing of lime-stabilized soil (LSS) design mix
7/31/12	60		Perform field testing of LSS
8/31/12	0		Perform additional laboratory testing of field LSS
8/31/12	10		Conduct cost-benefit/usability analysis
8/31/12	60		Perform data analysis
9/30/12	10		Develop Quality Assurance (QA) specification
9/30/12			Submit draft final report
11/30/12			Submit panel-approved final report
12/31/12			Present results of research work to the Materials and Advisory Committee (MAC)

SIGNIFICANT EVENTS

7/1/12 Identified final field test site to be Candelas Development in Arvada, CO. ARS will be doing the lime stabilization.

2/02/12 Revised project task dates to accommodate additional field testing in 2012.

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

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

Background

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 is 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 to the CDOT 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: 4/1/12 through 6/30/12
Type: SP&R Start: 05/09 Ver:
Contract:

Principal Investigator
Dr. Rui Liu
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 (Thin-Bonded Overlays on Asphalt Surfaces)
I-76/Weld County Road 53

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%	6/24/11	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.
02/28/12	90%		Task 5: Prepare and submit a Draft and Final Report to the CDOT.

*UCD is still planning to continue gather overlay performance data on this bridge structure as the Phase II contract continues through 12/31/13.

RESEARCH TASKS (Thin-Bonded Overlays on Concrete Surfaces)
Parker Road/I-225, and I-25/I-225 Structures

Planned	% done	Achieved	Description, Discussion, and Related Issues
6/14/2011	100%	6/30/2011	Task 1: Literature review
12/15/2011	100%	12/31/2011	Task 2: Conduct a detailed investigation of bridge deck overlay construction and performance
10/14/2013	40%		Task 3: Data collection and analysis of thin-bonded overlays on structures F-17KK and F-17-OD
10/14/2013	45%		Task 4: Laboratory/field testing
12/31/2013	40%		Task 5: Prepare and submit a draft and final report to 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
07/11	Progress Report Submitted
10/11	Progress Report Submitted
12/11	Project Update at UCD
01/12	PI Transition
02/12	Progress Report Submitted
03/12	Meeting held at CDOT to discuss next phase of testing and rad sensor installation on I-225/Parker Rd.
05/12	Field inspection of the I-76/WCR 53 structure (076-035 D-18-BK)
06/12	Progress Report Submitted

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 Tensioning
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: 4/1/12 through 6/30/12
Type: SP&R Start: 06/09 Ver:
Completion/End Date: 10/22/2013

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
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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
	100	Dec 2011	Spreadsheet program to investigate innovative approaches is completed.
Jun 2012			Completion of preliminary FE Analysis
Oct 2012			Interim report with all preliminary analysis to CDOT
Dec 2012			Physical Testing in the Lab

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	80		Task 3: FEA Investigation
12/31/11	100		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: 4/1/12 through 6/30/12
Type: SP&R Start: 06/09 Ver:

Completion/End Date: 11/30/2012

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
Richard 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	100	12-15-12	6 month durability tests
June 2012	100	6-18-12	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	75		Task 4: Literature Review
Ongoing	90		Task 5: Long Term Testing
4/1/2012	25		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
10/26/11	Submit Interim Report with results from site visit
12/14/11	6 month durability tests
6/18/12	1 year durability tests

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Hybrid A-Frame Micro-pile/MSE Wall with Impact Barrier, Unique Design and Construction Approach
Study No: 80.25

Background To protect the public travelling on Colorado mountain roadways from accidents, a well-designed and constructed impact road barrier and shoulder area is a critical component. Many roadways in the mountains were built on very steep terrain by cutting existing rock material and filling at very steep slopes to accommodate a two lane configuration with no or very limited shoulder room. While MSE walls have been commonly used in Colorado, their effectiveness is not clear if they are placed on a narrow steep cut due to the limited development length of reinforcements near the toe of the wall. Furthermore, roads across steep terrains require CDOT Type 7 or Type 10 steel bridge rails that can absorb significantly higher dynamic vehicle impact loads (e.g., 54 kips peak) to redirect a vehicle back onto the road without serious damage to any part of the reinforced soil region underneath. Under such stringent simultaneous design demands, the installation of micropiles in the form of an A-frame into a MSE walls to provide the lateral impact resistance of the barrier-wall system has the potential of being a capable and unique engineering solution for our state's transportation system. Using both vertical and inclined piles (in the same plane or staggered) that are connected to a continuous carrier/grade beam, such a system can provide the head stiffness necessary to support a strong impact barrier on a widened roadway or expanded shoulder in difficult terrains. This novel approach has however not been deployed previously due to a lack of research and development on the foundation engineering mechanics problem. This study aims to develop an improved knowledge base on the possibility of using a A-frame micropile-MSE wall system as an effective alternative for mountainous roadway constructions. The objective of this proposed study is (i) to assess the merit and limitations of the A-frame micropile-MSE wall-foundation design with a top barrier under design impact loads, (ii) to understand the basic load transfer mechanisms involved and their sensitivity to different site and structural conditions, (iii) to develop the design methodology and specification worksheets for approval and usage by CDOT's engineering division. The ultimate goal is to furnish CDOT sound technical information to use the design as a new option, with a sound engineering mechanics basis and confidence for difficult mountain locations.	Reporting Period: 4/30/12 through 6/30/12 Type: SP&R Start: 1/30/12 Principal Investigator: Ronald Pak 303-492-8613 John McCartney 303-492-0470 Study Manager: Aziz Khan, Research Branch 303-757-9522 Panel Leader: Trever Wang, Bridge Design Branch 303-398-6541 Study Panel Members: Ilyess Ksouri Russ Cox Rex Goodrich Gregory, John Richard Wenzel Wieden, Craig FHWA: Daniel Alzamora

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
3/22/12	100%		Held first panel meeting to discuss, update and revise scope of work and research direction
4/24/12	100%		Field visit to Hwy 119 Blackhawk construction site of MSE with metal reinforcement, discuss issues of drilling through reinforcement
5/10/12	100%		Choice of targets of analysis
7/16/12	50%		Calibration and study of basic benchmark cases for FEM simulation of MSE system with and without A-frame micropiles

UPDATED RESEARCH TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
1/31/12	80%		Task 1 Literature review and national survey of state DOTs
7/30/12	80%		Task 2: Review of CDOT methodologies and experience relevant to design of hybrid Micro-pile/MSE walls with impact barriers.
12/1/12	50%		Task 3: Construct computer models and perform parametric study using finite element code LS DYNA for a MSE wall subject to gravity load with a A-frame micropile system to resist lateral loads with corroboration with benchmark numerical and experimental results.
3/1/13			Task 4: Develop design methodology, and construction worksheets for hybrid micropile-MSE walls for CDOT consideration.
5/1/13			Task 5: Draft and submit final report

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Investigation of Optimal Seismic Design of Typical Bridges in Colorado
Study No: 87.00

Background

Significant effort has been expended to develop comprehensive guidelines for the seismic design of bridges after the 1971 San Fernando earthquake near Los Angeles, CA, which led to the development and adoption of ATC-6 as the seismic provision of the AASHTO LRFD Bridge Design Specification. In the current LRFD design specification (called "Current Specification" hereafter), R-factor (also known as "ductility factor") is used to conduct seismic design of bridges, which is a force-based approach whereby elastic forces are reduced by a certain factor to allow for controlled large inelastic deformation and energy dissipation under seismic events. In 2009, the new "AASHTO Guide Specifications for LRFD Seismic Bridge Design" (called "Guide Specification" hereafter) was introduced by incorporating all the previous changes and guidelines for seismic design of bridges, which is based on displacement rather than force. In this approach, a target displacement is designed for to achieve certain performance level.

The new "Guide Specification" was approved as an alternative to the seismic provisions in the "Current Specification". As a result, either the new "Guide Specification" or the "Current Specification" can be used in the seismic design of bridges in Colorado with a possible transition to the Guide Specification in the future. In addition to the western and southwest Colorado area with much higher acceleration requirements, some metro areas may also deserve extensive study because of its high population, busy traffic and potential hazardous consequence to the whole transportation in the area if any bridge is damaged or even fails. Therefore, all bridges are equally important in Colorado and the possible cost-effective design improvements in Colorado by considering the new return period as well as possible consequences for switching from designing with the "Current Specifications" to the "Guide Specifications" in the future is needed. Historically, Colorado has put little consideration on the seismic design of bridges due to the less significant seismic issue compared to those seismic-prone states. The goal of this study is to increase the awareness of seismic risk of bridges in Colorado and give CDOT a preview of the possible outcome to identify the best seismic design methodology to follow in future bridge designs.

Reporting Period: 4/1/12 through 6/30/12
Type: SP&R Start: 02/12 Ver:

Completion/End Date: 2/01/2014

Principal Investigator:
Suren Chen & Hussam Mahmoud, CSU

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

Panel Leader:
Richard Osmun, Bridge Design and Management (Panel Leader)

Study Panel Members:
Richard Osmun, Bridge Design and Management Branch
Mac Hasan, Bridge Design and Management Branch
H-C. Liu, Materials and Geotechnical Branch
Trever Wang, Bridge Design and Management Branch
C.K. Su, Materials and Geotechnical Branch
Steve Yip, Bridge Design and Management Branch
Derrell Manceaux, FHWA-Colorado

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
2/21/2012	100	2-21-12	Kick-off Meeting
7/01/2012	100	7-31-2012	Finalized the survey questions and send out the survey invitations on 3-20-12. Prepared the summary report of the survey and was sent to CDOT on May 18th 2012. The literature review report was submitted on July 31 2012.
7/01/2012	100	7-01-2012	Two representative bridges selected. Bridges were modified to be skew and curved. The feedback of the bridge modification has been gathered.
2/01/2013	30		The bridge models are under development. Currently working on detailed modeling of connections and also the abutments.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Safety Performance Functions (SPF) for Freeway Merge Zones
Study No: 90.75

Background	Reporting Period: 4/1/12 through 6/30/12 Type: SP&R Start: 05/14/12 PO: 211015884 PO Expiry: 12/31/2013 Principal Investigator(s): Mr. David Hattan; Felsburg Holt & Ullevig Denver, 303-721-1440 Mr. Craig Lyon; 613-422-2542 Study Manager: David Reeves, CDOT Division of Transportation Development, 303-757-9518 Study Panel Members: Jake Kononov, DTD Research Charles Meyer, Traffic & Safety David Swenka, Traffic & Safety Bryan Allery, Traffic & Safety
Road safety management activities include screening the network for sites with a potential for safety improvement (Network Screening), diagnosing safety problems at specific sites and evaluating the safety effectiveness of implemented countermeasures. The state-of-the-art methodologies for conducting these activities make use of statistical models to predict expected accident frequencies and severity using traffic volumes and other site characteristics as the input to the models. These models are known as Safety Performance Functions (SPFs). Currently, SPFs are not available for all roadway facility types in Colorado. The aim of the proposed research is to fill one of these gaps by developing SPFs for merge lanes using data from Colorado freeways. The mitigation of collisions at on-ramp merge lanes can be accomplished by safety treatments such as ramp metering or design modifications. Thus it is desirable to develop SPFs for these types of facilities.	

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
	100	05/14/12	Notice to Proceed
	100	05/23/12	Kick-Off Meeting
09/30/12	50		Task 1 – Data Colection
10/15/12	0		Task 2 – Develop Merge Zone SPF's
12/15/12	0		Task 3 – Draft Report
02/01/13	0		Task 3 – CDOT Review Draft Report
02/15/13	0		Task 3 – Final Report

SIGNIFICANT EVENTS

- 05/23/12 Kick-off meeting held at CDOT with:
  - CDOT: Jake Kononov, David Reeves, Bryan Allery, David Swenka;
  - Consultant: David Hattan, Ryan Germeroth, Baghwant Persaud & Craig Lyon.
- June 2012 – Task 1 Data Collection
  - Gathering necessary geometric, volume, and crash data. Evaluating accuracy of data and make corrections to the merge area database.
  - Work efforts initiated to create a crash listing and a search file for the safety data. Consultant has begun downloading all the crash data for all study interchanges.
- July 1st – Both Jake Kononov and Bryan Allery retired from CDOT. Added Charles Meyer to the panel but essentially David Swenka and David Reeves will be the primary panel members.

ANTICPATED WORK NEXT PERIOD

- Continue work efforts on gathering data to define merge zones
- Initiate efforts to develop merge zone SPF's

ISSUES

- No issues and project is on track.

TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
7/01/2012	100	7/31/2012	Task 1: Literature review and survey
7/01/2012	100	7/01/2012	Task 2: Identify representative bridges
2/01/2013	30		Task 3: Develop 3-D Sap analytical model
6/01/2013			Task 4: Calibration with nonlinear FEM software
10/01/2013			Task 5: Investigation of design detailing
1/01/2014			Task 6: Illustrative examples
1/31/2014			Task 7: Quarterly reports and final report

SIGNIFICANT EVENTS

1/24/12 Project officially begins. Project completion/end date is 01/31/2012. CSU would request an extension beyond the completion date (if needed) with brief justification at least six months ahead of the end date

2/21/12 Kickoff meeting at CDOT

3/20/12 Send out the national survey questions.

5/18/12 Summary of survey submitted to CDOT

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 more gentle 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: 4/1/12 through 6/30/12
Type: Experimental Feature

Principal Investigator:
Skip Outcalt, CDOT Research, 303.757.9984

Study Manager:
Skip Outcalt CDOT Research 303.757.9984

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

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 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 accident and MMS system data. Write and distribute the final report.

SIGNIFICANT EVENTS

6/12: Median crash data from January 1, 2000 through December 31, 2010 has been entered into the database for 31 project locations. 22 of the locations have some post construction crash data. In the database, a separate sheet for each location calculates the number of crashes per million vehicle miles traveled at that location. It shows severity of crash, type of crash, and the percent change for a given type of crash from before installation of the cable rail to after.

3/12: New TCB sites are being added to the database and will be monitored for performance.

1/12: Data collection and analysis in progress

6/1/11: Crash data through 12/31/2009 has been added to the Tensioned Cable Barriers (TCB) Crashes spreadsheet database. Crash data for 27 projects is in the database and is in the process of being verified. The database analyzes Traffic Accident Reports (TARs) of crashes that were or could have been affected by the presence of TCB. It includes all median and off-left types of crashes in locations where median TCB is installed. On roadway and off-right types of crashes are not included since the presence of median TCB would have no effect on the cost or the outcome of that type of crash. Crash data for sites with right shoulder TCB are also listed, but it is much more difficult to determine the effects of the barrier for these locations because of the way the data is listed in the TARs.

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 FIPI's to justify the use of proprietary TCGR's 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: 4/1/12 through 6/30/12
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
	15	11/30/11	
	15	1/15/12	
12/15/11	40	6/20/11	**Task 2** – Conduct a preliminary analytical safety study
	30	8/1/11	
	20	12/7/11	
	10	2/29/12	
02/15/12	100	6/18/12	**Task 3** – Submit draft system design report
03/20/12	100	6/18/12	**Task 3** – Submit final system design document and final report
06/22/12	75		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
- 11/29/11 - CDOT provide crash data through October 2011
- 12/5/11 – Downloading significant amount of RTMS data
- 12/5/11 – Completion if good part of the preliminary analysis, and reaching important findings
- 1/15/12 – Completion on Analysis
- 2/29/12 – Completion of analysis
- 6/18/12 – Final report submitted and waiting for Study Panel feedback

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 an 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: 4/1/12 through 6/30/12
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. <u>Results</u> The systems were both successful turned on in early 2012 and the evaluation of both systems were completed during May and June of 2012. Both systems were shown to provide significant benefit to the traveling public by reducing the travel times, number of stops, delay, and fuel consumption along the mainline lanes of both 10th Street in Greeley and US 24 in Woodland Park. The systems resulted in a positive benefit-to-cost ratio for the regions, to the point that each system would pay for itself in much less than 1 year after implementation. As the regions leave the system in place both will experience millions of dollars in saved user costs, retiming fees, and maintenance savings over the next 20 years.	

- Project is complete and all deliverables have been delivered to CDOT and stakeholders.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Phase II Study on Safety Performance at the Colorado DOT
Study No: 93.01

<u>Background</u>

In numerous studies sponsored by contractor associations, the Construction Industry Institute (CII), and the Construction Users Roundtable, the consistent outcome has been the need to address safety at all levels of the organization. In the Phase I study of safety practices at the Colorado Department of Transportation (CDOT), the study identified the gap between expected safety practices and the actual implementation of safety policies in the field offices. This finding, along with the industry-wide documentation of the necessity for a strong and mature safety culture, provided the motivation for CDOT to undertake initial efforts toward enhancing organization safety perspectives. The purpose of the current research is to continue the CDOT effort to build upon recent safety successes and by investigating opportunities improve worker safety. The primary intervention strategy to be considered is the strengthening of CDOT's safety culture.

The current research effort will examine how to put in place specific project, policy, and organization actions that will lead to the improvement of the CDOT safety record based on a combination of: 1) understanding existing CDOT safety elements and improvement efforts from an organization perspective, 2) understanding comparable organizations, 3) determining insertion points for safety improvement, and 4) providing specific recommendations for building on existing CDOT efforts to enhance the CDOT safety culture.

The research effort encompasses the following phases:

- Assess and articulate a comprehensive understanding of the existing safety culture within CDOT
- Use case studies to: (1) identify shared characteristics of safety culture within high performing organizations in comparable, high risk industries; (2) document best practices for rapid advancement, measurement, and continuous improvement of safety culture; and (3) identify target areas for CDOT improvement.
- Conduct a focus group session with a minimum of 10 members of leading firms in the construction, manufacturing, and industrial industries to review CDOT's safety program
- Develop recommendations to build on current CDOT safety efforts

Reporting Period: 4/1/12 through 6/30/12
Type: SP&R Start: 03/06/12

Principal Investigator(s):
Paul Chinowsky and Matthew Hallowelll;
University of Colorado Denver, 303-735-1063

Study Manager:
David Reeves, Applied Research Branch (HQ)
303-757-9518

Study Panel Members:
Jake Kononov /Applied Research Branch (HQ)
David Wieder / Maintenance and Operations Branch Manager Office (HQ)
Tracie Smith / DoHRA CHRM RM Risk Mgmt (HQ)

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
3/1/12	100	3/6/12	CU Contract Complete
5/18/12	0		Project kickoff meetings
4/30/12	90		Literature Review
5/31/12	80		Survey and Interview Development
6/30/12	0		Current CDOT Conditions

7/31/12	0		Comparable Organizations
10/31/12	0		Expert Panel Review
1/31/13	0		Recommendation Development
3/31/13	0		Final Report
3/31/13	0		Final Presentations

SIGNIFICANT EVENTS

- 3/6/12 – Project commencement

ANTICIPATED EVENTS FOR Q2 2012

- Completion of kick-off meeting
- Completion of literature review
- Pilot surveys and interviews undertaken
- Collection of initial data on safety and personnel from CDOT

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: 4/1/12 through 6/30/12
Start: 6/30/12 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:
Lynn Croswell, CDOT Staff Bridge 303-757-9188
Mike Banovich, CDOT Environmental 303-757-9542
Al Gross, CDOT R-1 Hydraulics 303-757-9342
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-Maintenance 303-357-8973

FHWA Washington Contact:
Matt Greer, FHWA 720-963-3008

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	50	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	70	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

Alternative Outlet Structure for Water Quality Detention Basins to Reduce Clogging
Study No: 106.20

Background	Reporting Period: 4/1/12 through 06/30/12
Extended detention and full-spectrum detention basins improve the quality of stormwater runoff through settling of sediment. This is achieved by detaining and slowly releasing the stormwater over a prescribed time duration of generally 40-72 hours. An alternative outlet that is less susceptible to clogging and therefore requires less frequent maintenance would be of great benefit to CDOT and others. The primary objective is to study a new type of outlet metering device which is referred to as an elliptical slot weir, its name derived from the elliptical curvature of the weir. Ken MacKenzie with the Denver Metropolitan Area Urban Drainage and Flood Control District will be undertaking a research study in partnership with Colorado State University to investigate an elliptical slot weir for metering water from settling ponds.	Principal Investigator: Ken A. MacKenzie, P.E., CFM Master Planning Program Manager Urban Drainage and Flood Control District Study Manager: Bryan Roeder, CDOT, 303-512-4420 Study Panel Leader: Mommandi, Amanullah, CDOT Hydraulics Program Manager Study Panel Members: Rik Gay, CDOT EPB

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
7/13/12			Establish Study Panel
7/20/12	70		Finalize scope of work that will be attached to the IGA. PI submitted draft SOW for review by study manager and study panel
8/15/12			Execute an intergovernmental agreement (IGA) with the Urban Drainage and Flood Control District
8/15/12			Begin Study
6/1/14			Draft report
8/15/14			Final Report publication

SIGNIFICANT EVENTS

6/29/12 $70,000 now available from the FY13 SP&R Work Program

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background	Reporting Period: 4/1/12 through 6/30/12
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): 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	January 2011	Agreement between CDOT and USGS finalized and signed.
4/1/11	100	April 1, 2011	Review sources of flood information
7/1/11	100	July 1, 2011	Compile USGS flood data
5/15/11	100	June 2011 and Dec. 7, 2011	Meeting with CDOT and other agencies
12/31/11	100	December 31, 2011	Develop database structure and select web interface
4/1/12	70	Expected: July 15, 2012	Build web interface, populate database, and test
5/1/12	100	Expected: June 1, 2012	Go LIVE to Web
8/30/12	75	Expected: September 30, 2012	Complete USGS publication

SIGNIFICANT EVENTS

All USGS data that compose the database has been compiled and is located in a Microsoft Excel database. This includes USGS indirect discharge measurements from USGS offices, historical flood events from indirect discharge measurements chronicled in USGS publications, published paleoflood studies, and the peak streamflow record from all USGS gaging stations in Colorado.

The database structure is complete and the web-interface of database is currently being completed. Currently, the Webpage that displays the database is live on the Web and was displayed at a meeting on 12/7/2011. Work will proceed on the Webpage design which will include finalizing new tools and features to access all of the previously mentioned data. Also, the Microsoft Excel database is completely populated with all USGS data; it is ready to hand over to CDOT. The USGS will wait to see if CDOT would like to include any of their post-flood bridge analysis before sending the Microsoft Excel database to CDOT.

The USGS held an internal meeting May 3, 2012 to demonstrate a preliminary version of the flood database in order to obtain some feedback to improve the database. This feedback will be incorporated into the database prior to demonstrating the database to CDOT at an upcoming meeting. The USGS report has been written and has started down the internal USGS review process, which must be completed prior to publication.

Project completion

Project completion/end date is 09/30/2012. PI/USGS would request a no-cost extension beyond the completion date (if needed) at least six months prior to the end date.