COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

SHRP2 Support
Study No: 3.20

Background

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

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

Reporting Period: 7/1/09 through 9/30/09
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 Members:
Tim Aschenbrener, CDOT 303. 757-9449
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 will attend the LTPP Coordinators sessions at the TRB annual meeting.
6/30/09			Nichols Consulting will conduct the final round of LTPP data collection for CDOT

SIGNIFICANT EVENTS

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. The estimated cost of coring is $34k (estimate from Nichols Consulting Engineers).

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background

The Colorado LTAP program 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.

The Colorado LTAP program is comprised of seven basic tasks. Providing training for rural and urban transportation communities is the number one priority of Colorado LTAP.

A. Maintain a Mailing List
B. Publish a Quarterly Newsletter
C. Provide Technology Transfer Materials
D. Provide an Information Service
E. Conduct or Arrange Seminars and Training Sessions
F. Evaluate the Effectiveness of the Program
G. Special Projects

The Colorado LTAP program 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%).

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

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

Study Manager:
Beth Moore, Tech Transfer (303) 757-9220

Study Panel Members:
Beth Moore, CDOT (303) 757-9220
Rick Santos, FHWA

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
Ongoing			LTAP contract oversight
8/1/07		8/1/07	Issue new IA for 5-year LTAP contract – write new Scope of Work
11/30/07		12/17/07	Award new 5-Year LTAP Contract
12/07/07		12/17/07	New 5-year LTAP contract starts
1/1/08		4/18/08	2008 LTAP Task Order
5/15/08		5/15/08	Advisory Committee Meeting
7/20/08		7/17/08	National LTAP Conference
9/10/08		9/10/08	Advisory Committee Meeting
10/1/08		12/10/08	2009 half-year program work program/begin work
12/10/08		12/10/08	Advisory Committee Meeting
12/31/08		1/1/09	Begin 6 month extension of program to June 30,2009
2/18/08		2/14/09	Advisory Committee Meeting
3/31/09		5/3/09	2010 work program submitted
6/15/09		5/20/09	Advisory Committee Meeting
7/1/09		6/30/09	Fiscal Year ’10 task order begins
8/20/09		8/20/09	Advisory Committee Meeting
12/1/09			Advisory Committee Meeting

SIGNIFICANT EVENTS

See Attached Progress Report from UCB

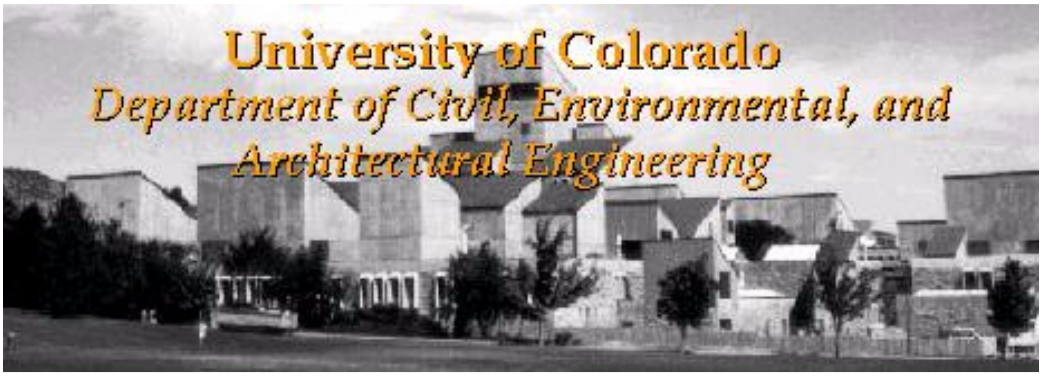
Colorado was awarded the 2008 National LTAP Conference. Conference completed.

CU was selected to continue as contractor for the Colorado LTAP program 2008-2012.

Craig Larson retires from FHWA\LTAP program duties - October 2008.

Rick Santos becomes the new FHWA\LTAP liaison - October 2008.

LTAP Program changes to Fiscal Year from Calendar Year starting with Fiscal Year ‘10



COLORADO LTAP

Quarterly Report

July 1 – September 30, 2009

Submitted to:
Federal Highway Administration
Colorado Department of Transportation

Submitted by:
Colorado LTAP
3100 Marine St A-211
Campus Box 561
Boulder, CO 80309-0561

A. Table of Contents

COLORADO LTAP
1st QUARTER REPORT

B. Colorado LTAP at CU-Boulder

B1. Staffing Plan

The core staff of the Colorado LTAP consists of a university administrator (part time), a Program Director (full time), a training coordinator (full time), and program assistants (full time or part time). The program assistants will be hired from graduate students and undergraduate students at CU-Boulder. Other persons such as instructors for training classes and webmasters for the website will be hired as the need arises. In addition, there is an advisory board for the Colorado LTAP.

B1.1 Advisory Board

The Colorado Advisory Board for LTAP is composed of transportation specialists throughout the state. There is currently seven board members representing cities and counties across the state. The members are not paid for their participation. The board met once this quarter in September. During the September meeting, the board received an update on the success of the National LTAP meeting held in Pittsburgh in July and Federal updates. The group discussed changes needed in the annual needs assessment survey results for 2009, new fiscal year work plan & projects, upcoming fall training programs, new electronic mail lists, new resources available for local agencies. The advisory committee reviewed, discussed, and voted on the 2009 state winner of the You Show Us contest, and discussed topics for the winter newsletter.

B1.2 Colorado LTAP Staff

University Administrator

The University Administrator is Professor Yunping Xi. The administrator oversees program activities throughout the year. The administrator is responsible for allocating office space, library space and other office facilities as needed. The internal position of the administrator in the University's system is the principal investigator (PI) of the project. Professor Yunping Xi is a full professor in the Department of Civil, Environmental and Architectural Engineering at CU-Boulder. He conducts regular teaching, research and service work for the University. The administrator is also responsible for additional tasks outlined in the 2009-2010 Work Plan.

Program Director (Director)

The Colorado LTAP Program Director is Renée Koller. She is fully responsible for daily operation of the LTAP program. She manages and executes the work plan within budget constraints. The Program Director is hired by the university administrator and works full time

for Colorado LTAP. The internal position of the Colorado LTAP Program Director in the University's system is a professional research assistant (PRA). The Program Director is also responsible for additional tasks outlined in the 2009-2010 Work Plan.

Training Coordinator

Colorado LTAP Training Coordinator is Lindsay Nathaniel. She is responsible for a broad array of office duties with a focus on the training program of Colorado LTAP. The training coordinator is hired by the university administrator and works full time for Colorado LTAP. The internal position of the Colorado LTAP Program Director in the University's system is a professional research assistant (PRA). In general, appointment of PRA depends on funding availability and performance. The Program Director reports to the university administrator and the Program Director. The Training Coordinator is also responsible for additional tasks outlined in the 2009-2010 Work Plan.

Program Assistants

Program assistants assist the Program Director and the Training Coordinator in office duties. A detailed list of tasks is included in the 2009-2010 Work Plan. The program assistants are hired by the university administrator and work full time or part time for Colorado LTAP. The internal position of program assistants in the University's system is graduate research assistant (GRA) or undergraduate students. It should be clarified that a full time GRA does not mean the GRA works full time for Colorado LTAP. Under the university's system, all full time GRA must take courses for required credit hours and fulfill requirement on their thesis or dissertations in order to graduate. The program assistants report to the Program Director. Program assistances working this quarter included: Marty Butcher and Moad Istieta.

C. Work Plan

C1. Training Programs

C1.1 Training Classes

Colorado LTAP offers technical training through workshops, road shows, the Roads Scholar Program, and the Supervisory Skills and Development Program. Training events are scheduled at varying locations throughout Colorado. Colorado LTAP courses are open to all public works employees with an interest in transportation related topics. In the 1st Quarter of 2009, Colorado LTAP provided 3 training events throughout Colorado; 0 full-day Roads Scholar classes, 0 Supervisory Skills courses, 3 Special Training Programs, and 0 Workshops. There were no graduates in the Roads Scholar program that received their plaques this quarter, and no graduates of the Supervisory Skills program.

Included in Appendix A of this report is a detailed list of training classes, dates, locations of training classes, types of training, hours of training and number of people attending the classes.

Type of Training	Number of classes held 1st Quarter
Roads Scholar	0
Supervisory Skills	0
Special Training Programs	3
Workshops: 402 Flagger Training, ½ day ea.	0
Un-reimbursed Road Shows	0
TOTAL	**3**

C1.1a ROADS SCHOLAR PROGRAM

There were no Roads Scholar Core or Elective classes held this quarter. The first two parts of the Heavy Equipment Training Program were the only classes offered between July and September. Between July and September 2009, there were no plaques distributed to graduates of the Roads Scholar program.

C1.1b SUPERVISORY SKILLS AND DEVELOPMENT PROGRAM

All nine courses of the Supervisory Skills program are offered each year between July and June; half on the Front Range and half on the Western Slope. There were no Supervisory Skills courses offered this quarter.

C1.1c SPECIAL TRAINING PROGRAMS

The Colorado LTAP program works with other transportation associations, local agencies, and surrounding LTAP centers to provide, and in some cases co-sponsor, special training programs that meet particular transportation training needs. In support of our national LTAP partnerships, Colorado LTAP also considers training opportunities that offer comprehensive training and certification programs to improve and promote the safety of roadway workers, pedestrians, and motorists in the transportation industry. This quarter, Colorado LTAP offered the following Special Training Program.

RS ELECTIVE: Heavy Equipment Training - Motorgrader

The first series of Heavy Equipment training courses for 2009-2010 was completed this quarter. This is the sixth year Colorado LTAP has continued with this partnership program. Colorado LTAP partners with a City or County agency to provide the equipment and gravel roadway section necessary for the training. Colorado LTAP alternates the training location by quadrant. The course is designed to offer participants an 8-hour classroom session plus 2-days in-field on the equipment. Participants are required to attend the classroom session in order to attend the in-field session, and are not informed of the in-field location until the first day of the classroom session.

This quarter, the training was a partnership with LaPlata County. Advisory Committee member Doyle Villers, with LaPlata County was the contact person for this training. Roger Johnson an instructor for the Heavy Equipment Training Solutions taught this course. The program covered equipment preventive maintenance, daily walk-around inspections, equipment safety, OSHA and industry standards, road maintenance practices, followed by

hands-on motor grader operations. The classroom portion of the training was held at the LaPlata County training room in Durango, CO. There were 28 participants attending the classroom session on Monday. Due to the large number of participants, attendance was broken up into two groups for the in-field session. Group 1, consisting of 13 participants, attended the in-field session on Tuesday & Wednesday. The 2nd In-field session, consisting of 13 participants was held on Thursday, October 1 & Friday, October 2. These two classes will be counted in the October - December Quarter report.

Participants felt Roger was very knowledgeable and had all the answers whenever anyone had a question. Participants would have liked the training to be a couple days longer, more pictures of different kinds of slope cuts, and to include more time on blue topping. Many wanted the training to be longer, and one suggested 3 days on blade and 1 day just for hydraulics. There were no Roads Scholar graduates presented with their plaques in the motor grader classes.

RS ELECTIVE: Heavy Equipment Training - Motorgrader				
Evaluation	**Location**	**Date**	**Attendees**	**Comments**
98.72%	Durango - Classroom	9/28/09	28	
100%	Durango – 1st In-field	9/29-9/30	13	
100%	Durango – 2nd In-field	10/1-10/2	13	
		TOTAL	**54**	

C1.1d WORKSHOPS

There were no workshops offered this quarter.

C2. Support Program

C2.1 Newsletter

Colorado LTAP publishes a quarterly newsletter designed to help promote the program throughout Colorado. The Fall newsletter was published in August this quarter. Each newsletter contains articles directed at local agencies in regards to problems or situations they encounter. Newsletter articles are solicited by the LTAP center or written by program staff. The Fall issue highlighted the 3 local Colorado agencies that received national recognition for taking 1st, 2nd, and 3rd place in the National LTAP Build a Better Mousetrap competition. This issue also included articles on an update from the Strategic Highway Safety Plan Peer Exchange in Chicago, results from the Colorado Roundabout Survey, grant funding available from the AAA Roadway Safety Foundation, and the new texting while driving law. A new Ideas that Work project, new library materials, upcoming events and conferences, *Put the Brakes on Fatalities Day*, and Free Materials were also listed.

This issue was printed by the University of Colorado's Imaging Services and was printed in full-color. It was also posted on the Colorado LTAP website.

C2.2 Maintenance of the Colorado LTAP Mailing List

The mailing list is continually updated and revised. Persons are added to the mailing list by requests made at classes, conferences, and calls placed to the LTAP office. Name changes and mailing list removals are conducted upon request and by return of mailed items. A mailing list update form was included in the summer issue of the Newsletter. Participants are encouraged to make mailing list changes and additions through the Colorado LTAP website. This quarter, there were fifteen (15) *additions* to the Colorado LTAP mailing list. A complete list of this quarter's mailing list additions for July through September 2009 is included in Appendix B.

C2.3 Provide Technology Transfer

Colorado LTAP provides a toll free number for its customers: 1-888-848-5827. Our performance goal is to return phone calls within a 24-hour period. The Colorado LTAP has established hours for the technical information service of 8am - 4pm Monday through Friday. Requests may also be received through email and the Colorado LTAP website and personal interaction. When away from the office on Colorado LTAP related business, the Program Director will be available for staff questions and requests through email and personal cell phone. The Program Director will respond in a timely manner and instruct office staff in the steps for appropriate action or response.

C2.4 Library Services

Reference Library

Colorado LTAP has a small, but comprehensive, in-house library of reference materials, including videos and reports. There are over 1500 books, reference materials, reports and research documents in the library. These items are categorized on a library system developed by Colorado Department of Transportation (CDOT). The cataloging system is on a database for easy access. All media in the LTAP library is available to agencies for checkout free-of-charge for a two-week period. A free video/publication catalogue is also available on disk upon request or can be accessed through the Colorado LTAP website.

Library Services

Colorado LTAP provides a free-of-charge technology transfer reference material and library service. The library loan collection includes over 1500 reports, books, pamphlets, pocket guides, videos, CDs, DVDs, floppy disks, and slides. There are also over 150 varieties of free materials available.

There were 49 library materials checked out and 474 free materials distributed July through September 2009. Requests were made for 4 publications; 0 bulk materials; 7 CDs; 0 disks; 14 DVDs; 0 slides; 0 software; and 24 videos. There were 6 library requests called into the Colorado LTAP office, 0 requests made in person, 0 submitted by fax, and 43 library requests made online through the Colorado LTAP website. The most loaned items this quarter addressed topics on Contracting, CDL license, Trenching & Shoring Safety, Snow Removal, and How to Deal with Difficult People.

There were 109 new materials added to the library this quarter - 40 new publications, 0 bulk materials, 35 new CDs, 11 new DVDs, 1 new videos, and 22 free materials added to our library this year. Some of the new materials added include: *21 Ways to Defuse Anger and Calm People Down; Maintenance Manual for Roadways & Bridges; All Weather Pavement Marking Systems for Work Zones; Back Safety Update; Backing, Parking & Intersections; Business Writing; Crafting a Written Snow & Ice Plan; Emergency Traffic Control for First Responders; Excavator Handbook.*

Based on the National LTAP strategic plan, the library includes a report that divides new and loaned materials into the four Strategic Plan focus areas: Safety (Worker/Highway), Workforce Development, Infrastructure Management, and Value Delivery.

Distribution of new and loaned materials into each Focus Area:

1ST QUARTER

Focus Area	New Mat'ls Added	Mat'ls Loaned	Free Mat'ls Sent
Highway Safety	45	4	171
Worker/Workplace Safety	14	28	226
Infrastructure Management	40	6	44
Workforce Development	10	10	5
Operational Excellence	0	1	28
TOTAL	**109**	**49**	**474**

Materials Loaned By AGENCY TYPE

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	**2009-2010 Total**
City	13				**13**
County	13				**13**
Federal	0				**0**
CDOT	2				**2**
Tribal	0				**0**
Out-of-State	11				**11**
Other	10				**10**
TOTAL	**49**	**0**	**0**	**0**	**49**

Materials *Distributed* By Material Type

Material Type	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	2009-2010 Total
Publications	4				**4**
Bulk Material	0				**0**
CD	7				**7**
Disk	0				**0**
DVD	14				**14**
Slides	0				**0**
Software	0				**0**
Video	24				**24**
TOTAL	**49**	**0**	**0**	**0**	**49**
Free Materials	474				**474**

Materials *Added* By Material Type

Material Type	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	2009-2010 Total
Publications	40				**40**
Bulk Material	0				**0**
CD	35				**35**
Disk	0				**0**
DVD	11				**11**
Free Materials	22				**22**
Slides	0				**0**
Video	1				**1**
TOTAL	**109**	**0**	**0**	**0**	**109**

Materials Distributed By REQUEST METHOD

Material Type	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	2009-2010 Total
Email	43				**43**
Fax	0				**0**
In Person	0				**0**
Phone	6				**6**
TOTAL	**49**	**0**	**0**	**0**	**49**

C2.5 Program Marketing and Promotion

Marketing & Promotion

Each year, Colorado LTAP schedules to have a vendor booth at various trade shows around the state. The booth has been a very useful tool in marketing the program and providing technical assistance for local governments. Items on display in the booth include class training schedules and registration forms, recent newsletters, video/publication catalogues, and various free videos and publications available for distribution. The contents displayed in the booth vary on the type of conference and its audience.

In addition to several of the LTAP training courses, Colorado LTAP staff attended the following meetings and conferences in the first quarter of 2009. Colorado LTAP had a booth at the APWA West Slope Snow & Ice Conference in Gunnison, and the Western Regional APWA Snow & Ice Conference in Estes Park this quarter.

- Colorado LTAP hosted three Monthly LTAP Meetings; 2 at the Colorado LTAP offices in Boulder, 1 in Broomfield. The FHWA and CDOT LTAP Managers as well as the University Administrator were in attendance.
- Colorado Program Director Renée Koller attended the National LTAP-TTAP Conference in Pittsburgh, PA in July.
- Training Coordinator Lindsay Nathaniel attended and presented at the West Slope APWA Snow & Ice Conference in Gunnison. Colorado LTAP had a booth at this conference.
- The first quarterly Advisory Committee Meeting was held in Gunnison, CO in September.
- Colorado Program Director Renée Koller attended the Western Regional APWA Snow & Ice Conference in Estes Park. Colorado LTAP had a booth at this conference.

Out-of-State Travel Requirements

The program director Renée Koller attended and presented at the National LTAP Conference in Pittsburgh, PA, July 27 – July 30, 2009. Renée also led the National NLTAPA Safety Work Group Meeting.

C2.6 Web Site Maintenance

Web Site (http://ltap.colorado.edu)

The Colorado LTAP website is maintained and upgraded each month with our current class schedules and newsletters and other pertinent information. Colorado LTAP offers on-line registration for our classes. Our website is linked to other transportation related websites and LTAP centers. Upcoming training classes, newsletters, pictures, and staff bios are also posted. Our website is advertised in every newsletter. A few of the items that appeared on the website this quarter included: updated course schedules and registration, the 2009 Needs Assessment Survey, the application for the 2009 You Show

Us Contest, registration for the Local Road Coordinators' Conference, and Fall Newsletter.

Forty-three (43) of the library requests this quarter were submitted online through our website or by email. Jeremy Goldsmith is Colorado LTAP's current web designer.

C2.7 Office Equipment

From time to time, Colorado LTAP will identify the need to buy new equipment, software, or have maintenance performed on old equipment. A vital part of the program is to keep up with technology that will help Colorado LTAP successfully deliver technology deployment. All equipment is recorded with its model and serial number and reported to CDOT in the annual report.

Equipment Accountability and Control

A replacement Transfer Kit for the HP printer was purchased by Colorado LTAP this quarter. The end of year report will contain a list of all equipment still owned and in use by Colorado LTAP.

C2.8 Office Supplies

Supplies for normal operation of Colorado LTAP are purchased on a regular basis and include but is not limited to: stamps, printer cartridges, paper, folders, binders, pens, dividers, organizers, certificates, etc. In the first quarter, $1,110.05 was spent on various office supplies.

C2.9 Special Projects

Each year, Colorado LTAP participates in special projects as they apply to the program. Special projects may include acquiring funding, demonstrating and participating in conferences, promotion of safety awareness programs, contests, agency outreach efforts, and additional resources. Colorado LTAP has designed nine such "Special Projects" to be completed in 2009. The following section outlines *only* those Special Projects conducted during July - September 2009.

C2.9i Local Roads Coordinators' Conference Promotion

Colorado LTAP is a sponsor of the Region 7 LTAP Local Roads Coordinators' Conference in Rapid City, SD in October. Registration brochures promoting the conference were designed and distributed to local agencies throughout Colorado. Reimbursement for this program includes brochure design, printing, mailing; and sponsorship of a session speaker from Colorado. Colorado LTAP will be sponsoring Monty Sedlak from Arapahoe County to speak on Roadway Management programs. This will be reimbursed after the conference and appear next Quarter. As a member of Region 7, Colorado LTAP may also have to split the cost of purchasing plaques for the

You Show Us contest winners that are distributed at the conference if the regular conference budget cannot cover these expenses.

C2.9i Local Roads Coordinators' Conference Promo		CDOT	CU	ACTUAL
Sept 09	Brochure Printing	$326	$109	$435.29
Sept 09	Brochure Mailing	$369	$123	$491.87
-	Regional Winner Plaques (Split by Region 7 centers)	$0	$0	$0.00
	CO Sponsored Speaker	$0	$0	
	TOTAL Local Roads Coord Conference:	**$695**	**$232**	**$927.16**

C3. Evaluate the Effectiveness of the Programs

Effectiveness of the training program and the support program will be evaluated by the following six methods.

C3.1 Advisory Committee Meetings

On the Advisory Committee, there are currently seven voting members, and four non-voting members. Four quarterly Advisory Committee meetings are scheduled in various parts of the state each year. The first Advisory Committee Meeting of 2009-2010 was held on Friday, September 11, 2009. During the September meeting, The board met once this quarter in September. During the September meeting, the board received an update on the success of the National LTAP meeting held in Pittsburgh in July and Federal updates. The group discussed changes needed in the annual needs assessment survey results for 2009, new fiscal year work plan & projects, upcoming fall training programs, new electronic mail lists, new resources available for local agencies. The advisory committee reviewed, discussed, and voted on the 2009 state winner of the You Show Us contest, and discussed topics for the winter newsletter.

These are a few of the highlights of the Advisory Committee meeting held this quarter. All minutes are kept on file at the Colorado LTAP center and Colorado Department of Transportation office, and available for review.

C3.2 Needs Assessment Survey

Each year, Colorado LTAP conducts a statewide needs assessment survey. This year the survey was designed and distributed in June 2009. The new design of the survey was discussed at the September Advisory Committee meeting. The survey was designed this year to include more fact finding questions for finding out genuine "needs" of local agencies – addressing training restrictions, training preferences, funding, hands on activities, certifications and software training needs. There were also questions included to gather "challenges" and "unique solutions" used by agencies. No Drawing Gift Cards were offered this year for returning the survey. CDOT wanted to see how this impacted responses. There have been 108 responses received so far; compared to 131 in 2008, 202 in 2007, 240 in 2006. There was great discussion

about why responses have been on the decline for the past couple of years. Committee members made a few suggested changes for 2010. Some of the suggestions included: sending out the survey every other year, shortening it to one page, if offering it each year then have a different focus each year – supervisor, operator, fleet, etc. Responses were discussed and results will be compared to the current program, and adjustments will be made accordingly. The results of the annual survey will be used as a foundation to develop the training classes in the work plan for the next year.

In addition to the annual needs assessment survey, other means are continually sought to determine customer needs in the local transportation community. One important way is to screen the survey results obtained by other professional organizations including local committees and nationwide organizations. This provides information on the needs of local customers as well as on upcoming trends in the national level.

C3.3 Training Participant Evaluations

Evaluation forms are administered after each class and reviewed for constructive ideas and suggestions. These evaluations offer an informative review of the instructor's performance and aid in future scheduling. Issues related to class site locations such as; ease of access, classroom size, driving distance, and host requests are collected from these evaluations and incorporated into the organization of the training program. The evaluation forms are designed to provide information, such as what types of agencies and employees are attending, how they are notified of the training classes, and suggestions for future training.

The evaluation forms for the one class topic held between July and September 2009 were compiled and analyzed. The complied result of each class evaluation was offered to the instructor and provided to CDOT with the Claim for Payment. This information is summarized for review at the advisory committee meetings. All evaluations received in the first quarter received a grade of at least 98.72% or greater excellent/good rating. The *average* evaluation score for the class held *this quarter* was 99.57%.

C3.4 Quarterly Reports

Colorado LTAP submitted this first quarter report to CDOT and FHWA in October 2009. Included here is a written report of the program accomplishments and task-by-task evaluation for July through September 2009.

C3.5 Annual Report

There will be an annual evaluation report developed and submitted to CDOT and FHWA by June 30, 2009. In that report, in addition to the task-by-task evaluation, a complete list of the training accomplished during the year, and a complete list of Colorado LTAP owned equipment will be provided. Detailed financial information will be summarized for the review by CDOT Program Director and FHWA representative. The financial information will be itemized by category (such as salary, travel cost, etc…) as well as by task. In addition to the annual report, a

PAR and CAR report will be completed and submitted to the National LTAP Association, National FHWA and CDOT by January 31, 2010.

C3.6 Monthly Meetings

Each month, a meeting is held with the CDOT-LTAP Program Manager, the FHWA-LTAP representative, the university administrator, and the LTAP Program Director. There were three monthly meetings held this quarter on July 21, August 17, and September 11, 2009. The schedule of monthly deliverables was examined and updated to make sure the scheduled work is schedule to be completed. Funding issues and pressing needs for the program were also discussed. Detailed meeting minutes are provided to attending members and available upon request.

Appendix A: July - September Training Classes

Class Name	Location	Date	Hrs/class	# Part.	NS	WL	CAN	Tot. Part. Hours
SPECIAL TRAINING PROGRAMS								
RS ELECTIVE: Heavy Equipment Training - Motor Grader								
98.72%	Durango - Classroom	9/28/09	7	28				196
100.00%	Durango - 1st In-Field	9/29-9/30	14	13				182
100.00%	Durango - 2nd In-Field	10/1-10/2	14	13				182
RS ELECTIVE: Heavy Equipment Training - Motor Grader								
	Classroom		7					0
	1st In-field session		14					0
	2nd In-field session		14					0
99.57%			**Total 08-09 Participants:**	**54**				
Evaluations			Total **RS** Participants:	54				560
			Total **SSDP** Participants:	0				0
			Total **Workshop** Participants:	0				0
				Total Participant Hours:				**560**

Appendix B: July - September Mailing List Additions

	Name	Agency	Address	City	State	Zip
Jul-09	Jeannie Romero	City of Montrose PW	P.O. Box 790	Montrose	CO	81402
	Robert Garcia	CDOT	1420 2nd St	Greeley	CO	80631
	Sterling Rife	Fremont County	1170 Red Canyon Road	Cañon City	CO	81212
	Lynne Eschback	Elbert County	P.O. Box 116	Kiowa	CO	80117
	Benerito Martinez	San Juan Public Lands Center	15 Burnett Ct	Durango	CO	81301
	Mark Gallegos	City of Durango	105 Sawyer Dr	Durango	CO	81303
	Rick Morgan	Town of Kiowa	P.O. Box 237	Kiowa	CO	80117
	Donna Buchwald	Iowa DOT	800 Lincoln Way	Ames	IA	50010
	Thaddeus Gembczynski	TFG Connection	1065 Big Valley Dr	Colorado Springs	CO	80919
	Dean Lebeda	US Forest Service	2468 Jackson St	Laramie	WY	82070
	William Jamieson	Plastic Safety Systems	2444 Baldwin Rd.	Cleveland	OH	44104
Aug-09	M. Ali	Glow Tek	11833 E Cornell Circle	Aurora	CO	80014
Sep-09	Julie Scott	City of Alamosa	P.O. Box 419	Alamosa	CO	81101
	Frank Grant	Crowley County	603 Main St	Ordway	CO	81063
	Darla Hopson	Town of Cheraw	P.O. Box 16	Cheraw	CO	81030

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Technology Transfer
Study No: 5.00

Background	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: Ongoing
Technology Transfer is the process in which existing research and development findings and other new technology are transferred operationally into useful processes, products or programs that fulfill existing or potential public or private needs.	Principal Investigator(s): Beth Moore, CDOT Research (303)-757-9220 Study Manager: Beth Moore, CDOT Research (303)-757-9220 Study Panel Members: Rick Santos, FHWA, (303) 969-6335

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Durable Wearing Surfaces for HMA
Study No: 10.37

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

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
		7/02	Request projects from regions to include in research study.
9/02		9/17/03	Monitoring of OGFC and SMA construction on I-70 near Genesee.
9/02		9/02	Monitoring of Nova Chip Construction in Region 3.
10/03		9/24/03	Construction field notes for OGFC placement on I70 near Genesee.
10/03		9/17/03	Annual evaluation of test sections
3/03		12/1/03	Notes documenting the construction and first year evaluation of the Region 3 NOVA chip project.
11/05		11/05	Annual evaluation of test sections.
11/08		11/08	Annual evaluation of test sections. This was delayed due to malfunction of the skid tester.
12/09			Draft Final Report. (May be adjusted pending decision of panel)
2/10			Publish final report.

SIGNIFICANT EVENTS

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 that was 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.

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

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

Principal Investigator(s):
Donald Watson, NCAT

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

Study Panel Members:
Jim Zufall, Materials and Geotechnical Br.
Jay Goldbaum, Materials and Geotech. Br.
Bill Schiebel, Region 1 Materials
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

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.
12/31/07			Submit final report for the assigned research project completed.

SIGNIFICANT EVENTS

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.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of the Performance, Cost-Effectiveness, and Timing of Various Preventive Maintenances
Study No: 10.50

Background Currently, the selection of a maintenance treatment is made based on the maintenance personnel experience. Guidelines are needed to assist the engineer and maintenance personnel in the selection process and to determine the appropriate time of an application of a preventive maintenance treatment. The main objectives of this research are four-fold: 1. To determine the most appropriate time and use of various preventive maintenance treatments. 2. To monitor the performance of preventive maintenance treatments. 3. To evaluate the effectiveness of treatments in prolonging the life of pavements. 4. To track the service life of the pavement in order to make better, more informed decisions on an objective basis The goal of the study is to develop step-by-step guidelines that show when and where to use specific preventive maintenance treatments.	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: 07/01/04 Principal Investigator(s): Dr. Scott Shuler, CSU Study Manager: Roberto DeDios, CDOT Research Study Panel Members: Richard Zamora, Region 2 Materials Jay Goldbaum, Mat/Geotechnical Br. Mark Mueller, Staff Maintenance Donna Harmelink, FHWA Colorado Div. Denis Donnelly, Consultant FHWA Washington Contact:

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
02/28/04	100	02/28/04	Assemble a study panel, hold the first meeting, fine tune the study work plan and develop the scope of work to be advertised.
05/30/04	100	04/15/04	Develop a request for proposal (RFP) and advertise it through selected universities.
07/30/04	100	06/20/04	Collaborate with the study panel reviewing proposals and select a competent research principal investigator (PI) to conduct the study.
08/30/04	100	9/23/04	Notice to proceed
01/31/05	100	3/31/05	Task 1- Literature review of the existing preventive maintenance practices
09/30/05	100	10/19/05	Task 2- Development of a draft manual for best preventive maintenances practice
04/30/06	100	4/30/06	Task 3- Selection of test sections: the panel decided to add more test sections.
03/30/06	100	4/15/06	Task 4- Interim reports documenting Task 1, Task 2, Task 3, and activities that took place in the field, analysis of the acquired data to date and findings.
6/30/06	100	06/30/06	Complete Construction of 2 thin overlays and 2 chip seal test sections Complete Condition surveys of all test sections constructed in 2005 and prior
9/30/06	100	06/30/06	Complete construction of thin overlay test sections on US550, Purgatory
9/30/06	100	09/30/06	Eighteen experimental test sections have been established on US550, Purgatory
3/31/07	100	6/30/07	Conduct condition surveys on low elevation chip seals and US287 concrete sections
6/30/07	100	7/30/07	Conduct condition surveys on high elevation chip seals and some thin overlays
9/30/07	100	8/30/07	Conduct condition surveys on high elevation thin overlays
12/31/07	100	12/31/08	Begin development of work plan for Task 5
10/30/08	100	12/31/08	Complete remaining condition surveys for all test sections
12/30/08			Task 5- Execution of the approved work plan (starting phase II) - the study panel must approve the work plan for the phase II. The work in this task will entail evaluation and comparison of pavement performance for test sections with and without treatment and

			estimation of economic benefit of using different preventive maintenances.
06/30/09	20	09/30/09	Task 6- Preparation of the final report, review by panel and distribution of the approved final report.

SIGNIFICANT EVENTS

All condition surveys have been completed and performance data is being analyzed. Completion of the data analysis will require more time than originally anticipated. However, a draft of the final report will be available for review before 12/30/09.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Longitudinal Joint Density
Study No. 10.155

Background	Reporting Period 7/1/09 through 9/30/09 Type: SP&R Start:7/03 Ver:
The longitudinal joint between asphalt mats is a major area of pavement distress. During the placement of asphalt pavement it is difficult to compact the unconfined edge, which typically results in lower densities than in the remainder of the asphalt mat. The inconsistent quality of the longitudinal joints in hot mix asphalt pavements was a concern with both the asphalt industry and CDOT and eventually was identified by the Chief Engineer to be addressed. A task force effort was identified and the direction of the task force was to develop an end result specification based on density at the longitudinal joint. In 2000, the longitudinal joint construction on 7 projects was monitored to determine the state of the practice for the construction of the longitudinal joints. The construction method and density at the joint and adjacent mat was documented. A minimum of seven projects constructed under the new longitudinal joint density specification will also be monitored for comparison to the joints in the projects from 2000. In 2005 7-12 new sites will be recruited, at least one for each regions. SMAs are also included in the study.	Principal Investigator(s): 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.
6/08			Review and Document any distresses at the site.
6/09			Review and Document any distresses at the site.
6/10			Review and Document any distresses at the site.
12/10			Final report will be written documenting final performance and the impact the new specification on the quality of longitudinal joints.

SIGNIFICANT EVENTS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Investigation of Crack Sealants' Performance and Thin Overlay Bumps Caused by Sealants in Colorado
Study No: 12.69

Background

Various guidelines have been established by CDOT throughout the years to find crack sealants that are cost-effective yet still provide expected performance. The existing requirements require that the sealant meet certain specifications but these specifications do not necessarily correlate to performance and do not eliminate or mitigate the formation of bumps in thin hot mix asphalt (HMA) overlays. Are failures due to poor construction practices, poor materials, or both?

Some research was done in other states to attempt to track performance of various crack sealants to determine future use of those materials. It would be beneficial for CDOT to establish effective guidelines specific to Colorado conditions in the use of crack sealers/fillers that perform well. The current joint and crack sealant specification for CDOT is included at the end of this document.

The Nevada and/or Minnesota DOT evaluation of crack sealant materials, recently completed, may serve as models for CDOT research study.

The objective of this study is to determine the performance of crack sealant materials from a maximum of four producers. Performance of a sealant is defined as its ability to remain in place and maintain a watertight seal over a 3-year period of time. In addition, if the schedule and logistics permit, methods to mitigate bump formation in thin overlays will also be evaluated.

Reporting Period: 7/1/09 through 9/30/09
Type: SP&R Start: 03/30/08

Principal Investigator(s): Dr. Scott Shuler, CSU

Materials Advisory Committee (MAC)
Task Force Chairman:
Mike Coggins CDOT R-5 Materials 970-385-1625
michael.coggins@dot.state.co.us

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

Study Panel Members:
Roy Guevara CDOT Materials 303-398-6526
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carl.valdez@dot.state.co.us

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
3/31/08	100	3/31/08	Notice to proceed
3/31/08	100	3/31/08	Task 1 – Literature Review and Sealant Selection
3/31/08	100	3/31/08	Task 2 – Establish Test Sections and Survey Cracks
3/31/08	100	3/31/08	Task 3 - Test Section Installation
6/30/09	100	9/15/09	Task 4 – Interim Report
3/31/11	60	9/30/09	Task 5 – Condition Inspections
3/31/11	60	9/30/09	Task 6 – Quarterly Progress Reports
3/31/11	50	9/30/09	Task 7 – PowerPoint Presentation
3/31/11	0		Task 8 – Final Report

SIGNIFICANT EVENTS

9/30/09 Condition surveys were conducted at all three sites.

Overlays of SH151 and US285 were constructed in August and September 2009. The overlays of SH 151 and US285 occurred after the spring 2009 condition surveys. In addition, the leveling course on US285 was observed by the Principal Investigator and some evidence regarding the source of bumps in the thin overlay was collected and reported in the Interim Report submitted in September 2009. The locations of cracks 169 to 204 have been retained and re-marked on the shoulder of the southbound lane for possible future evaluation of reflection cracking. The crack sealants on US 350 will be monitored until an overlay can be scheduled.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Investigation of the Benefits from Utilizing Small Aggregates for Seals on Hot Mix Asphalt (HMA) Roadways

Study No: 12.72

Background Many existing highways in Colorado are far from ideal HMA aggregate sources. Often due to the high cost of aggregate transportation to these areas, highway pavements are not timely preserved. An additional maintenance or rehabilitation treatment for HMA pavements is needed to help preserve deteriorating roadway structures until funding is secured for traditional resurfacing projects. Several river basins in Colorado exist that may provide aggregates that with minimal processing may extend the serviceable roadway life in a value-added analysis. The Nebraska Department of Roads (NDOR) has developed specifications for an aggregate application referred to in NDOR context as "**Armor Coat**." The application is a generic term which generally refers to an emulsion-aggregate combination with aggregate derived from river sources such as the North or South Platte River. It is commonly applied by NDOR maintenance personnel utilizing standard "chip seal" equipment. The aggregate size is generally 3/8 inch.	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: 03/30/09 Principal Investigator(s): Dr. Scott Shuler, CSU Study Panel Leader: Gary DeWitt, CDOT Region 4 Materials Study Panel Members: Masoud Ghaeli, CDOT R-6 Materials Rex Goodrich, CDOT R-3 Materials Roy Guevara, CDOT Materials Donna Harmelink, FHWA Colorado Division Gary Strome, CDOT R-4 Materials 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	90	9/30/09	Task 1 – Literature Review
8/31/09	100	6/30/09	Task 2 – Activity Plan and Schedule
3/31/13	100	9/30/09	Task 3 - Execute Activity Plan
3/31/13	0		Task 4 – Final Presentation
3/31/13	6	6/30/09	Task 5 – Quarterly Progress Reports
3/31/11	0		Task 8 – Final Report

SIGNIFICANT EVENTS

9/30/09 Condition surveys of the three pavements to receive the chip seals has been completed. Construction of two of the three sites was completed this quarter and supervised by the PI. Condition surveys of the sites will proceed next quarter.

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 7/1/09 through 9/30/09
Type: SP&R Start:7/03 Ver:

Principal Investigator(s):
Research Branch Personnel

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

Study Panel Members:
Jim Zufall, Materials & Geotech 303.398.6501
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
10/31/09			Draft final report
12/31/09			Publish final report

SIGNIFICANT EVENTS

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

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

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

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

09/30/08 No work was done during this quarter. Schedule of milestones revised as above.

06/30/08 No work was done during this quarter.

03/31/08 No work was performed during this quarter.

12/31/07 Data analysis is still in process.

9/30/07 Data analysis is underway.

6/30/07 The Materials and Geotechnical Branch Lab personnel completed the air voids testing and provided the results to Dave Weld.

3/29/07 Dave Weld took cores to the Materials and Geotechnical Branch Lab and cut them for testing.

12/31/06 Roberto DeDios took over as the Study Manager. Dave Weld has completed coring of the required testing sites.

06/06 The interim PI and Study Manager, Ahmad Ardani, has retired.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of Longitudinal Joint/Tie Bar System
Study No: 20.60

Background

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

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

1. Develop an improved design procedure and model for longitudinal joint tie bar system that consider critical factors and distresses impacting the performance of both tie bar (between travel lanes and between shoulder and travel lane) and concrete pavement such as excessive joint opening, faulting, and lane separation.
2. Determine the need for tie bar and the maximum number of lanes that can be tied together for various base course materials and climatic conditions in Colorado before inducing significant and harmful stresses.
3. Develop construction specifications and best management practices to insure that the required pull-out resistance of tie bar is not compromised.

Reporting Period: 7/1/09 through 9/30/09
Start: 2/22/08 Complete:

Principal Investigator(s):
Applied Research Associates, Inc. (ARA)
Jagannath Mallela, ARA Principal Engineer
(217) 356-4500
Ahmad Ardani, ARA Co-Principal Engineer
(303) 795-8106

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

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

Study Panel Members:
Gary DeWitt, R-4 Materials 970-506-0359
Glenn Frieler, Staff Materials and Geotechnical Branch 303-398 -6541
Bob Mero, R-6 Materials 303-398-6703

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
09/28/07	100	09/28/07	Develop scope of work, evaluation criteria, and request for proposal (RFP).
11/09/07	100	12/31/07	Complete the RFP process.
12/11/07	100	12/31/07	Select the Principal Investigator.
02/14/08	100	02/22/08	Award the contract/Complete Purchase Order.
02/20/08	100	02/28/08	Send Notice to Proceed.
04/13/08	100	04/02/08	Hold kickoff meeting.
05/17/08	75		Perform literature review.
06/20/08	75		Evaluate current tie bar system design procedure.
07/20/08	100	07/15/08	Identify comparable sampling site locations statewide for good and failed tie bar system. Select sites for instrumentation
10/1/08	100	10/1/08	Instrumentation of the selected sites and data acquisition
1/20/09	70		Analysis of the acquired data
02/28/09	100	1/15/09	Submit 6-month interim report.
03/28/09	95		Propose prediction model to design longitudinal joint tie bar system.
04/31/09	40		Verify, calibrate, and validate model with Colorado data.
05/14/09	100		Develop improved design procedure.
10/07/09	45		Compile all data and prepare draft final report.
11/21/09	15		Conduct PowerPoint presentation of the final report.
12/28/09	15		Submit draft final report incorporating panel's comments.
02/28/10			Submit the study panel-approved final report.

SIGNIFICANT EVENTS

9/30/09 No significant events were reported for this quarter.

6/30/09 Field evaluations of the joints examined with MIT scan with and without misalignment did not correlate well with joint opening at some of the sites.

4/1/09 No significant events were reported for this quarter.

1/15/09 Most of the data has been analyzed and we are in the process of finalizing the design approach.

10/31/08 Selected sites were instrumented with snap rings. Acquisition of the data included falling weight deflectometer (FWD) data to examine load transfer efficiency, ambient and pavement temperature at three different depths and slab movement measurement. These data were acquired and recorded on an hourly basis for a period of anywhere from 15 to 18 hours.

05/27/08 Field visits in Regions 1 and 6 were performed by ARA consultant Ahmad Ardani, Region 1 Assistant Materials Engineer Shamshad Hussain, and Pavement/Materials Research Engineer Roberto de Dios to identify suitable candidate test sites for instrumentation and monitoring.

04/02/08 A technical panel meeting with the Principal Investigators was held in Region 4 Materials Lab.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background CDOT, as part of a multi-state, FHWA-sponsored study conducted in 1995, adopted a new texturing specification for its concrete pavements. The new specification, which was adopted in 1977 called for uniformly spaced longitudinal tining at 3/4 of an inch intervals with the depth and width of 1/8 of an inch. The results of this study indicated that longitudinal tining in addition to possessing adequate frictional properties, were easier to install and produced a lower noise level than CDOT's traditional transverse tining (1"uniformly spaced). However, CDOT has been receiving numerous complaints concerning the handling of vehicles on newly constructed Portland cement concrete pavements textured with longitudinal tining. An effort is under way to address the handling problems associated with longitudinal tining through an experimental study (Study 21.81) in region IV of CDOT. Meanwhile, CDOT in an attempt to identify an ideal texturing method is planning on evaluating several surface texturing techniques with the following objective: The goal of this new study is to identify a texturing method that is safe and durable, provides adequate surface friction and lowers the noise levels.	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: 06/30/01 Principal Investigator(s): Skip Outcalt, CDOT Research, 303.757.9984 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 Jay Goldbaum. Mat'l. & Geotech 303-398.6561 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.
06/30/09			Annual data collection
12/31/09			Publish and distribute the final report. Hold a slide presentation to show results to the Materials Engineers.

SIGNIFICANT EVENTS

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

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

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

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

09/30/08 Field data collection is ongoing.

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

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

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

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

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

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

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

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

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Alternate Longitudinal Tining to Address Vehicle Handling
Experimental Feature on US287 - Berthoud
Study No: 21.81

Background	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start:
An effort is under way to address the handling problems associated with longitudinal tining through an experimental study in Region IV of CDOT. As part of this study it is proposed to install several variations of the existing longitudinal tining on the upcoming concrete paving on US 287 near Berthoud Pass. CDOT, as part of a multi-states, 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 inch intervals with the depth and width of 1/8 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 address the causes of vehicle handling problems associated with longitudinal tining.	Principal Investigator(s): Dr. Mike Mooney of Colorado School of Mines Skip Outcalt, CDOT Research, 303-757-9984 Study Manager: Roberto DeDios, CDOT Research Branch, 303.757.9975 Study Panel Members: Gary DeWitt, R4 Mat'ls. 970-350-2131 Jay Goldbaum, Staff Mat'ls. 303-757-9133 Richard Zamora, R2 Eng. 719-546-5778 Donna Harmelink, FHWA 720-963-3021

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
04/08/03	100	04/08/03	Meet with the CDOT/FHWA personnel to discuss the issues related to longitudinal tining and to develop strategies for conducting a study.
04/30/03	100	04/30/03	Assemble a study panel and brainstorm and discuss several alternate longitudinal tining.
09/30/04	100	06/06	Identify and install test sections on upcoming new concrete paving on US 287 near Berthoud By-Pass in Region IV.
7/15/08	100	10/31/08	Task 1: summarize prior research
11/15/08	100	11/3/08	Task 2: refine squirming measurement
11/30/08	100	11/19/08	Task 3: characterize squirming over various sections and tining patterns*
11/30/08	100	6/30/09	Task 4: further quantify severity of squirming (low, medium, high)
12/15/08	NA	NA	Task 5: develop recommendations & guidelines for CDOT construction specs
12/31/08	100	8/30/09	Task 6: provide report to CDOT

*as indicated below, squirming was characterized at the I70-E470 site only

SIGNIFICANT EVENTS

11/19/08 Field testing performed at the I70-E470 location (rescheduled from original planned date of 11/7 due to weather). Based on personal communication with both Skip Outcalt and David Weld, field testing was only performed at this one site.

9/30/08 Schedule revised as shown above. Work to be completed by December 31.

5/5/08 Held kick-off panel meeting at CDOT Headquarters. Schedule was revised as shown above such that a draft final report would be submitted in September 2008.

10/30/07 The Purchase Order No. 211003554 was signed and sent to CSM by Procurement Officer Detrica Wilson.

9/30/07 CSM's proposal was selected. Dr. Mike Mooney of CSM will be the Principal Investigator (PI). The processing of the interagency agreement/Purchase Order is projected to be completed on October 30, 2007. Dr. Mooney will be able to start on this project sometime in January of 2008.

6/13/07 Proposals were received from Colorado School of Mines and University of Colorado-Boulder. The panel is still in the process of selecting the responsive and acceptable proposal.

3/19/07 Developed a new scope of work and distributed to study panel members for review and comment.

11/06: Breakdown of new skid truck has delayed skid testing. The study panel is seeking additional funds for Dr. Mooney of CSM to perform addition measurements of squirming. Schedule has been adjusted for construction delay, skid testing delay, and time to perform more squirming tests.

06/06: The construction problems at the site have been dealt with. The project will open to the public in July 06. Professor Mike Mooney of Colo. School of Mines is developing a system to quantify the lateral forces caused by the longitudinal tining.

06/05: Due to an unexpected problem associated with the subgrade at the study site this study is delayed till Spring of 06.

12/03: Construction of the test sections has been delayed until June 04.

06/03: based on a detailed discussion with the study panel, six different test sections were proposed for this study including:

1. Standard longitudinal tining.
2. Standard longitudinal tining without astroturf (California spec).
3. Longitudinal sawing.
4. Random pattern longitudinal tining. Tines shall be ⅛" x ⅛" placed at the following spacing repeated every 38": 1¼", ⅞", 1¼", ¾", ⅝", 1⅜", 1⅛", ⅝", 1¼", ¾", 1½", 1½", ⅞", ⅝", 1⅜", 1⅛", ⅝", 1⅜", ⅞", 1⅛", ⅝", 1", 1", 1½", ¾", ⅞", ¾", 1", 1⅜", 1¼", 1", 1½", 1⅛".
5. Meandering longitudinal tining. Tines shall be ⅛" x ⅛" placed as a sinusoidal wave with a wavelength of 16" ± 2" and an amplitude of 8" ± 2".
6. Grinding.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Long-Term Performance Monitoring of Asphalt and Concrete Pavements
Study No: 22.75

Background

Are Hot Mix Asphalt (HMA) and Portland Cement Concrete Pavement (PCCP) equally suitable for heavily traveled intersections and roadways? Do HMA intersections and PCCP intersections perform similarly? Do PCCP and HMA provide equal value? What determines the selection of one type over the other? What input variables including traffic, initial cost, user and agency cost, maintenance cost, etc. affect the overall selection? Can a reasonable life cycle cost analysis be established to evaluate and compare both types side by side? How does the cost-effectiveness of HMA intersection design compare with PCCP? What role, if any, does the number of Equivalent Single Axle Loads (ESAL) ultimately play in the selection of a pavement type?

In an attempt to answer these questions, a research study has been initiated to examine and compare the pros and cons of HMA and PCCP using side-by-side test sections for intersections and roadways. The goal is to gain a better understanding of the cost, performance and overall applicability of the two pavement types. It is envisioned that the work for this study will continue through the year 2012.

Reporting Period: 7/1/09 through 9/30/09
Type: SP&R Start: 10/01/02

Principal Investigator(s): Roberto DeDios
CDOT Research 303.757.9975

Field coordinator:
Skip Outcalt, CDOT Research 303.757.9984

Study Manager: Roberto DeDios
CDOT Research 303.757.9975

Study Panel Members:
Gary DeWitt, R4 Mat'ls 970.506.0359
Denis Donnelly, CAPA 303.548.5558
Jay Goldbaum, Staff Mat'l. 303.398.6561
Donna Harmelink, FHWA, 720.963.3021
Ron Youngman, ACPA 303.775-3360
Richard Zamora, R2 Eng 719.546.5778

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
09/30/02	100	09/30/02	Assemble a study panel and discuss issues related PCCP & HMA, develop the preliminary scope of work
11/30/02	100	11/27/02	Meet with the study panel, fine-tune and finalize the scope of work, identify test sections on existing and upcoming HMA and PCCP.
06/30/03		06/30/05	Acquire information on initial cost, design, traffic load, construction practices and maintenance of the existing site. Project in Colorado Springs was completed on 10/3/05 and cost data was not available till then.
08/30/05		9/15/05	Conduct the first round of data collection; this includes distress survey of the entire test site using pavement management data, skid testing acquiring SN40R, photographic documentation, smoothness and the first round of FWD testing.
6/30/08			Analyze all the acquired data, complete and disseminate a field report to study panel and interested parties.
10/31/08			Perform another round of data collection and analysis as in the last two milestones above.
			Complete brief construction reports on upcoming new sites describing construction issues, including initial cost, design and other pertinent matters.
			Complete interim reports every 5th year or as needed (panel consensus is required).
12/31/12			Complete final report.

SIGNIFICANT EVENTS

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

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

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

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

07/27/08 Skip Outcalt, Dave Weld, and Ed Trujillo performed field data collection consisting of distress survey and FWD testing.

05/01/08 Roberto de Dios gave an update on the status of the project using PowerPoint presentation slides. No field work was performed but data collection was firmly scheduled for July 27, 2008 with the required traffic control.

03/31/08 No work performed. Field data collection is scheduled during the last week of April, 2008.

12/31/07 The data collection scheduled for the last quarter of 2007 was postponed for completion in June of Skid truck malfunctioning and inclement weather conditions prevented the completion of this annual round of data collection effort as initially scheduled..

9/30/07 Data collection is still under way.

6/30/07 Data collection is in progress.

3/31/07 Skip Outcalt planned to resume data collection on skid resistance, Falling Weight Deflectometer (FWD), rutting, and cracking distress information for selected test sites. The FWD data collection will be done by Ed Trujillo at night by summer.

1/01/07 Roberto de Dios took over as the Study Manager.

06/30/06 Ahmad Ardani, The PI and Study Manager, has retired.

September 05 – The first round of data was collected.

June 05 - Data acquisition for this study will commence in mid July 2005

September 04 - Acquisition of skid numbers and texture measurement has been delayed until early 05. The research branch will be acquiring a new skid testing machine equipped with texture measuring device sometime toward the end of 04.

December 03 - Due to unavailability of FWD and the skid-testing machine, this study is delayed one season.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Concrete Deck Performance Relative to Air Entrainment
Study No: 22.80

Background

Using the current specifications, when concrete is pumped into forms or onto a bridge deck, it is uncertain if concrete has the required amount of air entrainment to resist freezing and thawing. Currently, CDOT only verifies the air content of fresh concrete delivered from a concrete truck. Other agencies in the state and surrounding state DOTs verify air content at the point of placement. The air content level that can be lost through a pump can be as much as 5%. If concrete is delivered at the CDOT specified air content level of 5-8%, there could be very little or no air in the concrete placed in a structure after it had been pumped. Air entrainment in concrete gives it the flexibility to withstand Colorado's freeze-thaw cycles. Concrete with no or low air entrainment will crack and deteriorate after time. This will cause greater maintenance costs and shorten the life span of the structure.

Currently, we are designing structures with an expected service life of 75 to 100 years. Ensuring that our structures are constructed with the proper amount of air entrainment is an important factor in reaching this life span. With the current specification that tests only at the point of delivery, CDOT has no idea what the air content of the concrete is in their pumped structures. This study has been initiated to identify and evaluate significant factors that affected the performance, durability, and formation of distresses in selected CDOT bridge structures built in Metro-Denver area, to find a solution to mitigate any resultant negative effects observed, and to address the following questions:

1. Was there any statistically significant difference in total air content between the concrete deck of structures that performed successfully and unsuccessfully?
2. How much air is lost due to pumping under different configurations of the pump?
3. Is the air content that is lost the beneficial entrained air, or just entrapped air?
4 Do these concrete structures have the correct amount of entrained air to resist damage caused by freeze-thaw cycling?
5. What is the current condition of these structures in relation to the amount of actual air entrainment in the concrete?
6.Is there a better nondestructive test or equipment to determine entrained air content in concrete such as an air void analyzer?

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

Principal Investigator(s):
ARA, Dr. Chetana B. Rao, 217-239-9575
Ahmad Ardani 303-795-8106

Study Manager:
Roberto DeDios, CDOT Research Branch 303-757-9975
Panel Leader:
Glenn Frieler, Staff Materials and Geotechnical Branch

Study Panel Members:
Gary DeWitt, R-4 Materials 970-506-0359
Matthew A Greer, FHWA, Colorado Division
Ali Harajli, Staff Bridge Branch
Dr. Aziz Khan, Research Branch
Eric Prieve, Staff Materials and Geotechnical Branch
Scott Roalofs, Staff Materials and Geotechnical Branch
Joe Rottman, Colorado Ready Mixed Concrete Association
Brooke A Williams, Holcim

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
11/16/07	100	11/16/07	Develop scope of work, evaluation criteria, and request for proposal (RFP).

02/29/08	100		Complete the RFP process.
03/28/08	100	04/07/08	Select the Principal Investigator.
04/30/08	100	06/19/08	Award the contract/Complete Purchase Order.
05/01/08	100	07/08/08	Send Notice to Proceed.
05/14/08	100	07/25/08	Hold pre-kickoff meeting.
05/28/08	100	04/07/08	Hold kickoff meeting.
06/27/08	100	05/30/09	Perform literature review.
07/28/08	100	07/28/08	Evaluate and recommend test methods.
08/29/08	100	10/31/08	Shortlist structures, acquire cores from selected structures.
09/30/08	100	06/30/09	Determine and evaluate factors that impact deck performance and durability.
11/07/08	100	06/30/09	Analyze data.
05/07/09		06/30/09	Submit interim report. Submit quarterly progress reports.
06/06/09	100	07/20/09	Compile all data and prepare draft final report.
06/25/09	100	08/07/09	Conduct PowerPoint presentation of the final report.
07/02/09	100	09/28/09	Submit draft final report.
08/27/09	100	09/28/09	Submit the study draft final report.

SIGNIFICANT EVENTS

09/28/09 The project team revised the project report and addressed all comments from the panel. The report was submitted to CDOT. The CDOT Study Manager has distributed the report to the panel for further suggestions, if any.

08/07/09 The project team presented the study findings to the project panel and also discussed potential future activities for the department to monitor and ensure appropriate air entrainment in future construction. The Study Manager provided the panel until 8/31/09 to submit further comments on the draft report..

07/20/09 The draft Final report was submitted to CDOT for distribution to the panel. Plans for an interim panel meeting were also discussed with the CDOT Study Manager.

07/15/09 All test data were analyzed and important findings and conclusions for the study were discussed amongst the team members.

06/30/09 The draft Final report will be submitted to the panel for their review and comments before July 2009. The research team will be presenting the results in late July to early August depending on panel's review time.

04/1/09 The results of the lab testing on the cores are complete, we will start analyzing the results and looking for completing the draft final report and sending it to Mr. Roberto DeDios by the end of April. We are looking at presenting the results to the panel by mid May. We will address the panel's comment and submit the final report by the end of June.

1/15/09 A total of 18 cores (3 cores per sites) were sent to the lab for petrographic analysis- Ahmad will be scheduling a meeting with Steve White of the Bridge Branch to acquire any available QA/QC data on the 6 bridges that were evaluated.

10/31/08 Cores were extracted from 5 of the selected 6 structures (3 cores per structure)

06/19/08 The task order letter no. 2 was approved and signed by the DTD Director and State Controller.

04/07/08 A technical panel meeting with ARA representatives was held to discuss different options to explore to keep the scope of work within the original budget. Three options were proposed and the first option without increase in the cost was selected with revisions in the scope acceptable to the panel.

03/25/08 A panel meeting was scheduled on April 7, 2008 to discuss ARA's proposal which was the only one received out of 3 NPS consultants invited to submit proposals. At this meeting, the ARA Research team was asked to prepare different options on how to accomplish the goal and objectives of the research project.

01/31/08 A request for task order proposal from Non-Project Specific (NPS) consultants was sent out because no proposals were received from local colleges and universities.

11/30/07 Sent out the solicitation for proposals to universities and colleges with the deadline for submittal of proposals by January 4, 2008.

9/28/07 Held the first study panel meeting to discuss and finalize the draft scope of work (SOW).

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background

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

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

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

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

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

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

Study Manager:
Roberto de Dios CDOT-DTD Research Branch

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
10/30/09	80	9/30/09	Perform literature review
10/30/09	50	9/30/09	Develop research plan

12/31/09	10	9/30/09	Collect and analyze data for first year
4/21/10			Prepare first year progress report and perform PowerPoint presentation
10/31/09			Collect and analyze data for final work completion
1/17/11			Prepare draft final report and PowerPoint presentation
3/17/11			Submit final report

SIGNIFICANT EVENTS

9/30/09 No significant events were reported in this quarter.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background

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

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

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

Reporting Period: 7/1/09 through 9/30/09
Start: 9/13/07 Complete: TBD

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

Study Manager:
Vanessa Henderson, CDOT-DTD Research
303-757-9787

Study Panel Leader:
Mike Banovich, CDOT-DTD EPB
303-757-9542

Study Panel Members:
John Bordoni, CDOT R-1 Maintenance
303-512-5765
Cathy Curtis, CDOT-DTD EPB
303-757-9174
Allan Hotchkiss, CDOT Materials and Geotechnical Branch 303-398-6587
Amanullah Mommandi, CDOT Staff Hydraulics
303-757-9044
Ina Zisman, 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	75	spring 09	Analyze Time 0 samples (fresh amendment mixed with Straight Creek substrate) to determine initial nutrient content
			2009
winter 09	50	spring 09	Analyze nutrient release from T0, develop fractionation scheme for organics and nutrients
meltoff 09	50	spring 09	First field sampling of nutrient release experiment (Time 1 treatment).
summer 09	50	fall 09	Soil and vegetation sampling on existing plots (Insert additional nutrient sampling time??)
fall 09			Second field sampling of nutrient release experiment (Time 2 treatment).
11/30/09			Submit draft interim report for review by CDOT study panel.
12/31/09			Respond to study committee review on the timing of nutrient release and field sampling.
			2010
meltoff 10			Nutrient release experiment sampling
sum/fall 10			Nutrient release experiment sampling and soil and veg transect sampling
10/31/10			Prepare and submit draft final report to CDOT study panel for review.
11/30/10			Complete review of draft final report by CDOT study panel with comments to be addressed.
12/31/10			Prepare and submit final project report.

SIGNIFICANT EVENTS

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

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

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

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

Jan - Mar 2008: Soil sample preparation.

April 2008: Finish soil testing and data summary

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.

July 20, 2008: Provide initial project findings to CDOT study panel, arrange for review by

meeting or conf call.

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.

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.

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.

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.

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.

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.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Rockfall Prediction Using LIDAR Technology
Study No: 30.35

Background Rockfall threatens thousands of miles of highway in the United States bordered by rock slopes. In addition to older, increasingly unstable, highway cuts, expansion of transportation networks and populations into areas of rugged mountainous terrain has resulted in many additional rock cuts that expose highway users to rockfall hazards, and transportation agencies to economic and social liabilities. In order to ensure public safety, to make certain that rockfall maintenance is organized and cost efficient, and to address potential rockfall hazards proactively, many state agencies have adopted rock cut management systems. Implementation of these rockfall management and mitigation programs requires comprehensive geologic characterization of individual rock slopes in order to assess their stability and assign hazard ratings. Despite the advantages of rockfall management systems, the identification, evaluation, and categorization of comparatively high risk slopes remains a labor-intensive task that is further complicated by the broad range of geologic conditions that influence rockfall hazards. Laser based, three-dimensional imaging, combined with advanced 3D image processing algorithms, can accelerate field data acquisition, reduce identification difficulties, eliminate safety constraints, and remove human bias and subjectivity. This study will evaluate selected areas on Colorado's highway systems to determine if LIDAR technology can reliably identify areas where increased likelihood of rockfall exists.	Reporting Period: 7/1/09 through 9/30/09 Type: Pooled Fund Start: FY'07 Ver: TPF5(166) Principal Investigator(s): Dr. John Kemeny Univ. of AZ Study Manager: Frank Darmiento, AZDOT FHWA Washington Contact: Carl Ealy

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
	100	12/06	Study proposal to AZDOT Research Council to serve as study manager.
			Solicit participants from among other agencies for a pooled fund study.
	100	12/07	Establish national pooled fund study

SIGNIFICANT EVENTS

9/08 – quarterly report at http://www.pooledfund.org/documents/TPF-5_166/Quarterly_Rpt-2008-04-01.pdf

06/07 – 6 States have committed. Study status is Cleared by FHWA, SP&R Funding is pending approval.

03/07 – Arizona has established pooled fund study, it is unlikely that study will get off the ground in FY 2007 as AZ solicits participants from other states (3 committed so far)

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Greening of State Government
Study No: 32.05

Background

Greening Government Executive Orders have been signed by both Governor Ritter and previous Governor Owens, requiring Colorado state agencies to reduce their environmental footprints through conservation of natural resources. In April, 2007, Governor Ritter's Order required that, among other things, each state agency needs to reduce their energy use by 20%, water consumption by 10%, paper use by 20%, and petroleum fuel use by 25%, between 2005 and 2012. In addition, agencies are required to design and build more efficient buildings, adopt a zero-waste goal, increase purchasing of environmentally preferable products, reduce employee driving, appoint an energy management liaison, and track the progress made in these areas.

To respond to these requirements, research is needed to begin to understand how CDOT operations are affected by these requirements and what needs to be done. The research needs to define the "pre-greening" baseline, including assessing what actions, programs, and features are already being done to be efficient and conservation-oriented. Short-term actions need to be identified to begin to address the Greening Government goals, and long-term goals need to be defined. The research will involve interviews of pertinent staff, research into other agency efforts in Colorado and elsewhere, research into potential measures available, and development of a management system whereby CDOT can improve and develop efforts to meet the Governor's expectations.

Because of the Executive Orders signed in April, 2007, this project was expedited, and Phase 1 was initiated the same month. Phase 2 will be initiated in spring, 2009.

Reporting Period: 7/1/09 through 9/30/09
Start: April '07 Complete: Dec. '07

Principal Investigator(s):
Felsburg Holt & Ullevig for Phase I

Study Manager:
Vanessa Henderson, CDOT-DTD Research
303-757-9787

CDOT Study Panel Members:

Brad Beckham, Environmental 303-757-9360
Walt Black, Fleet Management 303-512-5513
Marcella Broussard, Property Management 303-512-5505
Betsy Jacobsen, Planning 303-757-9982
Joe Mahoney, Facilities Mgmt. 303-757-9152
Tom Mauser, Trans. Develop. 303-757-9768
Cheryl Wright, Procurement 303-757-9660

MILESTONES

Planned	**% Done**	**Achieved**	**Description, Discussion, and Related Issues**
3/31/07	100	4/07	Develop the scope of work (SOW) for Phase 1 and select Principal Investigator (PI)
4/01/07	100	4/07	Initiate task order/purchase order/agreement/contract.
4/05/07	100	4/07	Award the contract. (Task order signed and Notice to Proceed Letter issued)
5/01/07	100	5/07	Conduct the CDOT Study Panel/PI kick-off meeting.
6/15/07	100	6/07	Monitor, gather and analyze data.
6/23/07	100	6/07	Prepare and submit interim and final report to CDOT study panel for review.
6/30/07	100	12/07	Complete review of draft Phase 1 report and presentation materials by CDOT staff with comments to be addressed. Revise draft and submit final report and presentation slides.
3/15/09			Initiate Phase 2. Develop Scope of Work, initiate contracting.
9/15/09			Award contract, begin project work for Phase 2 to monitor, gather and analyze data.
4/30/10			Prepare and submit draft report to CDOT study panel for review.
5/31/10			Complete review of draft report by CDOT study panel with comments to be addressed.

6/30/10			Revise and submit final Phase 2 project report. Present findings to task panel and EMT.

SIGNIFICANT EVENTS

09/30/09 Vanessa Henderson was hired and is now the Study Manager.

Phase II is not being initiated at this time. The Greening Council final report gave recommendations on future steps for sustainability. The Greening Council will meet one last time in October and a sustainability council will be initiated to oversee CDOT's sustainability initiatives and implementing the recommendations from the Greening Council report. The Sustainability Council will consist of DTD, Staff Branches, and Facilities Management. Another recommendation was made to hire a full-time sustainability coordinator, which may be difficult in the current budget conditions. DTD has formed a sustainability working group to focus on DTD activities and a recommendation has been made for the other two divisions to do the same (Staff Branches and Facilities Management).

DTD is going to conduct a pilot project using NYDOT's GreenLITES program on two Region 3 projects. The RFP should be out shortly for the pilot project. EPB has $150,000 budgeted for sustainability and approximately $25,000 of that budget will go for the pilot project. The DTD working group is discussing options for the rest of the budget.

Joe Mahoney is conducting an energy audit of the headquarters facilities.

A sustainability subcommittee to the Transportation Environmental Resource Council was formed to look at what other state, federal, and local agencies are doing for sustainability. Future subcommittee items could include developing a statewide sustainability policy.

06/30/09 No activity was reported for this quarter.

03/13/09 The CDOT Greening Council held a meeting. Research Director, Dr. Kononov attended the meeting.

02/28/09 Pat Martinek retired. Roberto de Dios temporarily took over her responsibilities.

9/25/08 Greening Council met monthly throughout quarter.

8/15/08 Greening Council resurrected and meeting monthly with Skip Spensley contractor. Phase II was put on hold until 2009 and results of Council efforts formalized.

6/30/08 Requested feedback on new study panel members, to get started on Phase II

3/31/08 Discussing partnering on Phase II with Water Quality staff and contractors

12/15/07 Phase I Report completed and published on Research website.

8/13/07 Steering Committee met to discuss Phase I report. Comments due 9/30/07

8/31/07 Draft report comments from task panel due. Phase II scope of work to be drafted.

8/13/07 Task panel meeting held to present Phase I findings and request again draft report comments.

6/30/07 Phase I draft completed and submitted. Review from task panel requested.

4/16/07 Executive Orders signed by Governor Ritter to proceed with Greening initiatives.

4/5/07 Notice to Proceed issued to PI for Phase 1, and staff interviews commenced.

3/31/07 Draft Executive Orders from Governor Ritter prompt CDOT to expedite project, with Phase 1 to be completed by June 30, 2007.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background

CDOT's Strategic Plan for Improving Roadway Safety states that motor vehicle crashes involving wildlife were ranked as the third leading cause for crashes in Colorado during the past 3 years. CDOT is motivated to improve the safety of the traveling public where Animal-Vehicle Collisions (AVCs) are frequent and increasing in frequency. CDOT has prioritized 11 countermeasures to test in reducing AVCs, and is testing several of these systems.

For the AVC research project, CDOT installed an electromagnetic animal detection/driver warning system in LaPlata County on Highway 160 in a major wildlife migration location. Traffic speeds, animal crossings activities and rates, weather conditions, and AVCs will be monitored and analyzed to investigate system reliability and effectiveness.

The researchers hired for this project will test whether the system is reliable in detecting ungulates at or about to cross the highway, and whether the driver warning signs result in lower vehicle speed and fewer collisions with large wild ungulates (i.e. deer, elk).

Reporting Period: 7/1/09 through 9/30/09
Start: 11/25/08 Complete: TBD

Principal Investigator(s):
Dr. Marcel Huijser, Montana State University

Study Manager:
Through 27 Feb 2009:
Patricia Martinek, CDOT Research 303-757-9787

After 27 Feb 2009:
Roberto DeDios 303-757-9975
Roberto.DeDios@dot.state.co.us

After 31 August 2009:
Vanessa Henderson (303) 757-9794
Vanessa.Henderson@dot.state.co.us

CDOT Study Panel Members:
Jeff Peterson, EPB 303-512-4959
Bryan Roeder, EPB 303-512-4420
Alison Deans-Michael, USFWS 303-236-4758
Tony Cady, R5 Environmental 303-385-9371
Bryan Allery, HQ Safety/Traffic Engineering 303-757-9967
Mike McVaugh, R5 Traffic 970-385-1449

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
9/01/07	100	9/01/07	Develop the scope of work (SOW).
2/13/08	100	12/1/07	Complete the task order or request for proposal (RFP) process.
4/08/08	100	05/15/08	Select the Principal Investigator (PI). Initiate task order/purchase order/agreement/contract.
11/15/08	100	11/25/08	Award the contract. (Task order signed and Notice to Proceed Letter issued)
1/12/09	100	1/14/09	Conduct the kick-off meeting in Durango
11/30/09	25%		Final report year 1 (draft 30 Sep, comments 31 Oct)
11/30/10			Final report year 2 (draft 30 Sep, comments 31 Oct)
11/30/11			Final report year 3 (draft 30 Sep, comments 31 Oct)
3/31/11			Prepare and submit draft final report to CDOT study panel for review.
4/30/11			Complete review of draft final report by CDOT study panel.
5/31/11			Revise and submit the final report.

SIGNIFICANT EVENTS

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

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

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

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

06/29/09 Public talk at Durango Arts Center on 30 June (organized by Living With Wildlife Advisory Committee (LWAB) (see attachment for newspaper article). In person meetings between CDOT, SWCA and WTI personnel at the study site.

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

DETAILED UPDATE

System Troubleshooting: There have been numerous system malfunctions due to faulty sensor modules, signs remaining active beyond the programmed turn-off time, signs not activating when tripped, and sensors recording events when nothing was present. In addition, several problems with the speed data (communications, inability to record per/vehicle data) have confounded the ability to relate changes in vehicle speed to system detections. To troubleshoot these system malfunctions, CDOT, WTI, and SWCA conducted several days of system troubleshooting in early July to identify possible causes of system malfunctions and collect per vehicle data at radar detectors. The following paragraphs summarize these efforts and follow-up actions by CDOT:

- We are still in need of determining how to force all the signs off and on, as this is a critical component in relating changes in traffic speed to periods of signs being active or inactive. Senstar did visit the site and the configuration did not work (driveways interrupted 'all on' command). CDOT has informed us that they will let us know when they are successfully able to initiate the 'all on' command but we have not heard of this item being addressed. The speed study cannot be conducted successfully as described in the work scope without being able to manipulate the signs. We are waiting to obtain the instructions from CDOT who in turn depends on Magal Senstar for these instructions.
- One shortfall of the radar detectors that were installed is their inability to collect per vehicle data (the data are averaged over e.g. 10 minute periods, averaging vehicle speed, regardless of vehicle type). Although per vehicle data can be collected at each unit, we are unable to simultaneously collect this information for all units at the same time. Therefore, we cannot investigate potential changes in vehicle speed as vehicles approach, travel through, and leave the road section with the system. CDOT installed three traffic counters in late July to collect per vehicle data. The data were to be sent to WTI, communication took place about the required file format, but the files have not arrived yet (please correct me if I am wrong and if I overlooked an incoming e-mail). However, during the period that the counters were active, we were unable to force all the signs on due to the situation described above (i.e. instructions to force all warning signs on were unavailable, and still are unavailable). Conducting the speed study in winter is limited, as road tubes cannot be used.
- As of September 2009, there are sensors broken in Zones 5 and 10. CDOT has indicated that an engineer will be repairing the sensors but we have not received confirmation that those were indeed repaired.

Reliability Testing: We conducted a round of reliability testing in late June/early July to determine system response under dry conditions. Due to the variety of problems encountered with the sensors, we have not additional conducted reliability testing during wet (rainfall) periods.

Camera Surveys: Camera surveys concluded in June.

Event Data: We continued to downloaded event data during the camera monitoring sessions, in addition to the period when the traffic counters were installed. We have also set up several plots to ensure that crossing events, as depicted by the cameras, are being accurately recorded.

Speed Data: The only speed data that has been collected has been by the traffic counters installed by CDOT in late July. However, due to our inability to turn all the signs on/off, we are unable to relate vehicle speed data to signs being active/inactive. The problems were communicated with CDOT personnel both on site (29 June – 1 July 2009), a strategy and a list of tasks and responsibilities was agreed upon, and additional communication between WTI, SWCA and CDOT took place in the weeks and months thereafter. Scheduled road reconstruction just west of the road section with the system in 2010 may be problematic to a speed study in 2010, jeopardizing our ability to conduct the speed study under summer conditions.

Off Site Reliability tests in Lewistown, MT: A 50 m section of the detection technology was successfully installed at the test-bed on 11 and 12 August 2009. The first test with livestock (as models for large wild ungulates) is scheduled for October 2009.

Anecdotal Information: We recorded roadkill (deer; GPS points) during camera surveys and continue to collect some anecdotal information regarding sign activation when deer are present near the system.

Conclusion: Some progress has been made on-site as well as off-site. *However, no further progress can be made on-site until the problems with the faulty sensors are solved and until instructions are available on how to manipulate the warning signs. These problems are a serious threat to the success of the project,* and the problems were brought to the attention of the contract manager of CDOT (Roberto DeDios) and other CDOT personnel on 24 July 2009 (see attachment A). Unfortunately, as far as WTI and SWCA know no progress has been made with regard to the two main issues since then. *Progress needs to be made quickly though as the season with the highest ungulate-vehicle collision numbers is in the fall, and that is when the system needs to be investigated for its effectiveness most.* WTI and SWCA are ready and have been ready for many months to initiate more intensive reliability testing on-site and to conduct the speed study. However, we have had to stop the activities on-site until the two problems mentioned above have been addressed to avoid making expenses that do not result in the desired data. The research at the off-site location appears to have no serious problems and a first test period is expected in October 2009.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Colorado Historic Bridge Inventory
Multiple Property Documentation Form
Study No: 34.11

Background

For all of its construction projects, CDOT is responsible for ensuring compliance with Section 106 of the National Historic Preservation Act of 1966 (Section 106) and Section 4(f) of the Department of Transportation Act of 1966. Section 106 requires that federal agencies evaluate the effect of their undertakings on historic properties. CDOT carries out the Section 106 compliance process on behalf of the Federal Highway Administration (FHWA). The Section 106 process involves identifying historic properties, evaluating effects to properties, and mitigating adverse effects to historic properties. In order to determine if a property is significant, historians evaluate it against the National Register of Historic Places (NRHP) criteria. To qualify for eligibility to the NRHP, properties must be significant for association with events, significant people, or must be an example of architecture or engineering. Typically, properties that are 50 years or older are evaluated for eligibility. Once CDOT historians have identified properties and assessed effects, they are required by Section 106 to consult with the State Historic Preservation Officer (SHPO) and other interested or consulting parties, about those findings. Concurrence on eligibility and effects is sought from SHPO and consulting parties in order to move forward with the Section 106 process and ultimately, to clear the project for construction. CDOT is also responsible for compliance with Section 4(f), a substantive law that applies to properties listed in or eligible to the NRHP. Because the process of going through Section 4(f) is rigorous, it is important for CDOT to know which properties are eligible and will be impacted by projects.

Among the many resources that CDOT historians evaluate in the field are vehicular bridges. Highway projects can involve a variety of effects to bridges, including everything from minor maintenance and rehabilitation, to replacement. Like other resources along project corridors, bridges that are 50 years or older must be evaluated to determine if they are eligible to the NRHP. Since 1984, CDOT has conducted three statewide bridge surveys to aid in streamlining the Section 106 process. Each survey resulted in the evaluation of hundreds of on and off-system bridges statewide. The most recent survey—completed in 2000—documented bridges constructed up to 1958. In the next few years, bridges that were not covered in the 2000 survey will reach the 50-year age requirement and will need to be evaluated as part of the Section 106 project clearance process. A revised survey of bridges constructed between 1959 and 1968 is necessary to save time and streamline the clearance process.

The purpose of this study is to update the three previous bridge surveys and document bridges built between 1959 and 1968. The project includes an update of the previous bridge studies, eligibility determinations and site forms for bridges in the inventory, and the development of a searchable electronic database of the bridge data. In addition, the work will involve the

Reporting Period: 7/1/09 through 9/30/09
Start: 2/23/09 Complete:

Principal Investigator(s):
Clayton Fraser, Fraserdesign

Study Manager:
Lisa Schoch, CDOT EPB—Headquarters

Study Panel Members:
Dianna Litvak, CDOT Region 6
Robert Autobee, CDOT Region 4
Jennifer Wahlers, CDOT EPB HQ
Amy Pallante, OAHP/SHPO
Joseph Saldibar, OAHP/SHPO
Vanessa Henderson, CDOT DTD Research

development of a Multiple Property Documentation Form (MPDF), which facilitates the nomination of groups of related significant properties. It is comprised of historic context information that covers the themes, trends, and patterns of history shared by those properties, property types related to the historic properties, and registration requirements that aid historians in determining if a property meets the National Register Criteria. One of the main benefits of the bridge survey will be to streamline the Section 106 clearance process for CDOT projects. CDOT historians will be able to use the results of the survey to quickly clear bridge projects involving bridges determined not eligible in the survey, and will know when to budget more time for the clearance process for replacement projects involving bridges determined eligible. The survey will also result in heightened awareness of historic bridges and preservation issues associated with those structures.	

MILESTONES

Planned	**% Done**	**Achieved**	**Description, Discussion, and Related Issues**
	100	2/15/2008	Develop scope of work, evaluation criteria, and publish Invitation for Bid (IFB)
	100	2/22/2008	Hold Pre-Bid Meeting
	100	9/2008	Complete the IFB process.
	100	9/2008	Select the Principal Investigator
	100	2/17/2009	Award the contract.
	100	2/23/2009	Send Notice to Proceed
	100	3/12/2009	Develop draft project schedule
	100	3/16/2009	Hold project kickoff meeting
3/31/2009	100	3/31/2009	Submit 1st Quarterly Report to CDOT (2009) Monthly update to CDOT
4/30/2009	100	4/30/2009	Finalize bridge site form for use in survey Monthly update to CDOT
May 2009			Update meeting with Task Panel
May 29, 2009	100	6/2/2009	Monthly update to CDOT
6/30/2009	100	7/7/2009	Submit 2nd Quarterly Report to CDOT (2009) Monthly update to CDOT
July 31, 2009	100	8/6/2009	Monthly update to CDOT
8/14/2009	100	9/22/2009	Submit draft database structure to CDOT
8/28/2009	100	8/12/2009	Submit detailed draft outline of MPDF to CDOT for review Monthly update to CDOT
August 2009	100	8/17/2009	Update meeting with Task Panel
9/30/2009	100	10/2/2009	Submit 3rd Quarterly Report to CDOT (2009) Monthly update to CDOT
10/1/2009			Submit revised database structure to CDOT for review
10/30/2009			Submit draft sample of site forms for 1959-1968 bridges to CDOT Monthly update to CDOT
Nov 2009			Update meeting with Task Panel
11/30/09			Submit draft site forms for bridges in previous surveys to CDOT Monthly update to CDOT
12/30/2009			Submit 1st set of draft site forms for 1959-1968 bridges to CDOT Submit 4th Quarterly Report to CDOT (2009) Monthly update to CDOT

1/4/2010			Submit sample draft database to CDOT
1/29/2010			Monthly update to CDOT
2/26/2010			Submit draft report and final site forms for previous surveys to CDOT Submit draft MPDF to CDOT for review Submit 2nd set of draft site forms for 1959-1968 bridges to CDOT Monthly update to CDOT
Feb 2010			Update meeting with Task Panel
3/1/2010			Submit final database sample to CDOT
3/30/2010			Submit 1st Quarterly Report (2010) Monthly update to CDOT
4/30/2010			Submit final revisions of report for previous bridge surveys to CDOT Submit revised final draft MPDF to CDOT for final review Submit final revisions to site forms for 1959-1968 bridges to CDOT Submit draft DTD report to CDOT Submit draft PowerPoint of Bridge Inventory to CDOT Monthly update to CDOT
April 2010			Final update meeting with Task Panel
5/31/2010			Complete database training and submit written guidelines Monthly update to CDOT
6/15/2010			Submit revised draft DTD report to CDOT for final review
6/30/2010			**Submit final deliverables to CDOT**: Final report and site forms for update of previous bridge surveys Final site forms for 1959-1968 Multiple Property Documentation Form (MPDF) Final Electronic Database DTD Research Report PowerPoint Presentation of Bridge Inventory All research materials, photos, negatives, notes, maps, and any other materials used in preparation and completion of the survey project

SIGNIFICANT EVENTS

The Historic Bridge Inventory was initiated on March 16 with a kick-off meeting among the principal participants in the project from CDOT, OAHP and Fraserdesign. Prior to the meeting, Clayton Fraser produced a draft schedule for the project, and as a follow-up, he produced the meeting notes. Additionally, he reviewed data and inventory forms for the project and organized research materials, preparatory to the research and data entry.

During the April-June 2009 Quarter, Fraserdesign Principal Clayton Fraser worked on tasks that would establish the basic formats for the project. Fraser met with Steve White in the CDOT Staff Bridge Branch to establish the roster of data fields using a combined query of several of CDOT's Structure Inventory and Appraisal and other databases. This query, which will form the basis for the project's database, was able to address approximately half of the questions asked in the SHPO historic inventory form; the remainder will need to be generated in data fields created by Fraser over the course of the project. The format for the historic inventory form was finalized, and Fraser completed forms for six structures in Region 6 that were needed for FASTER, while at the same time establishing the extent of information needed for each form. These forms were produced manually, because the database had not been completed to the point that the forms could be generated automatically. Fraser began selecting and editing photographs among the tens of thousands supplied by CDOT for the individual bridges that comprise the field

survey sample for this project. As there are about 2,000 photos ultimately needed, this is a sizable task that will continue over the course of the project. Finally, Fraser began research on the draft MPDF form, concentrating primarily on the relative significance of the associated property types.

The July-September 2009 Quarter was spent further laying the foundation for the project in terms of the bridge database, OAHP inventory forms, and National Register Multiple Property Documentation Form [MPDF]. In mid-August Principal Investigator Clayton Fraser submitted a draft outline for the MPDF, which he presented before the Task Panel on August 17, 2009. Comments on the draft were due September 30 and were received from the project manager on August 14, 2009. Fraser also submitted a draft inventory form based on the electronic database, with improvements made to the original OAHP inventory form. He then voluntarily submitted a second revision of the form a month later, further refining the original form. CDOT informed Fraser that the original form agreed upon by SHPO and the panel in April 2009 would be used for the bridge survey. During the quarter Fraser has been otherwise engaged researching AASHO and CHD bridge design standards, editing photographs, mapping bridges and populating the electronic database.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Best Practical Noise Wall Utilizing Waste Tires Along CDOT Highways (Noise Walls Using Waste Tires)
Study No: 34.23

Background

The Colorado Department of Transportation (CDOT) builds noise walls along new construction projects, where highway noise is expected to exceed acceptable levels in nearby residences. These walls are very expensive and cost roughly $1-2 million per lane mile. In 2006 Colorado House Bill 06-1257 was passed which made available funding for public projects which use waste tires. This bill included a requirement that the projects include building of noise mitigation walls.

CDOT applied for funding through this funding source to study the feasibility of building noise mitigation walls which utilize waste tire rubber. The application proposed a four-part project: 1) Research the state-of-the-art in noise mitigation walls designs and technologies, both built and not built, and define a short list of 1-5 best technologies; 2) Design a prototype wall with 1 or more of the best technologies and prepare a bid package for construction; 3) Contract and oversee the construction of the prototype wall; and, 4) Monitor the wall during and for one year or more afterwards for feasibility, constructability, cost, performance, and durability.

If successful, the wall design(s) would be placed on CDOT's Approved Products List, used by CDOT where applicable, and easily approved by CDOT staff where adjacent citizens wish to build their own noise walls adjacent to CDOT's highways.

Reporting Period: 7/1/09 through 9/30/09
Start: 12/20/07 Complete: TBD

Principal Investigator(s):
Felsburg Holt & Ullevig

Study Manager:
Vanessa Henderson, CDOT Research
303-757-9787

CDOT Study Panel Members:
Katie Dawson, R6Design 720-497-6960
Bob Mero, R6 Materials 303-398-6703
Jordan Rudel, R6 Environmental 303-757-9881
Roy Smith, R6 Maintenance 303-757-9888
Sarah Czajka, R6 Environmental 303-757-9935
Melissa Nelson, Gov't Relations 303-757-9703

MILESTONES

Planned	**% Done**	**Achieved**	**Description, Discussion, and Related Issues**
2/19/08	100	3/08	Assemble task panel. Develop the scope of work (SOW).
4/30/07	100	4/08	Complete the task order or request for proposal (RFP) process.
4/30/08	100	4/08	Select the Principal Investigator (PI). Initiate task order/purchase order/agreement/contract.
9/15/08	100	9/08	Award the contract. (Task order signed and Notice to Proceed Letter issued)
9/25/08	100	9/08	Conduct the kick-off meeting.
12/15/08	100	12/08	Perform the literature search.
12/17/08	100	12/08	Recommend designs and possible applications for construction and monitoring.
1/31/09	100	8/14/09	Complete prototype design and planning documents
6/30/09	70	9/31/09	Build prototype wall at location on west 6th Avenue, begin monitoring
6/30/10			Complete monitoring by PI, complete final project report
8/30/10			Prepare and submit draft final report to CDOT study panel for review.
9/30/10			Complete review of draft final report by CDOT study panel with comments to be addressed.
10/31/10			Revise and submit the final report.

SIGNIFICANT EVENTS

9/31/09 Traffic barriers are constructed. Vanessa Henderson has taken over the project from Roberto.

8/31/09 Wall is under construction with foundation started.

03/31/09 The tire-tie noise wall was scheduled for advertisement on April 30, 2009.

02/28/09 Pat Martinek retired. Roberto DeDios took over her job.

12/17/08 Task panel meeting held to discuss research phase results and initiate design. Project was turned over to R6 design to complete design phase

9/15/08 Notice to Proceed issued to Felsburg, Holt & Ullevig

2/04/08 Grant awarded by CDPHE to CDOT

11/15/07 Application made by CDOT to CDPHE for funding

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Metropolitan Denver Post World War II Residential Suburbs
Multiple Property Documentation Form
CDOT Study No: 34.72

Background

The Colorado Department of Transportation (CDOT) always strives to ensure the safety, maintenance, and effectiveness of public roads while upholding an environmental responsibility and following state and federal regulations to protect historic resources from transportation projects. The Environmental Programs Branch (EPB), located at CDOT-Headquarters, interprets regulations and policy for environmental issues, conducts scientific investigations, and develops mitigation strategies for environmental staff members within each Transportation Region. CDOT historians at Headquarters and in Regions 4 and 6 work with other CDOT staff in planning, design, construction and maintenance to ensure that all projects with the potential to affect historic resources are carefully planned and executed.

The purpose of this research is to evaluate the history of residential suburban growth in the Denver metro area between 1940 and 1965. By starting at 1940, historians will be able to describe and evaluate what the metro area looked like before the explosive phases of growth occurred. The study ends in 1965, a concise period to analyze post-war trends. The study is limited to 25 years because of the sheer numbers of buildings and structures—homes and their non-residential components such as shopping malls, schools, and other community institutions—built during this time period. As the project commences, these dates may change, but the focus will remain upon the decades of the mid-20th century. To provide a better idea of the broad scope of the study, it should be noted that in Arapahoe County there are currently over 6,000 subdivisions; in Broomfield, over 500; and in Denver, over 2,200. Winnowing these numbers down to structures built between 1940 and 1965 will result in a more manageable study. The project will not provide eligibility determinations for all of the property types covered in the study.

The completed document will provide a framework to evaluate the historical and architectural significance of these properties and property types, and to be used by historians who undertake additional work and research to make eligibility determinations for post-World War II residential property types throughout the metro area. Such determinations are used for Section 106 compliance, nominating historic districts to the State and/or National Registers, surveying specific neighborhoods and suburbs throughout the metro area, as well as a number historic preservation planning goals. The completed document will focus not only on suburbs adjacent to major transportation corridors, but also will take a broader view across the entire metropolitan Denver area and, therefore, be useful to a wider audience.

Reporting Period: 7/1/09 through 9/30/09
Start: 02/2009 Complete: 06/2011

Principal Investigator(s):
Dawn Bunyak, Bunyak Research Associates

Study Manager:
Dianna Litvak, CDOT Region 6

Study Panel Members:
Lisa Schoch
Bob Autobee
Jennifer Wahlers
Vanessa Henderson
Matt Tomaszewski
Mary Therese Anstey, Colorado Historical Society
Elizabeth Blackwell, Colorado Historical Society

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
	100		Develop scope of work, evaluation criteria, and request for proposal (RFP)
	100		Complete the RFP process.
	100		Select the Principal Investigator
	100		Award the contract.
	100		Send Notice to Proceed
	100		Hold pre-kickoff meeting
4/2009-9/2009	85		Conduct literature review and field work Field work and GIS process still under work and have been brought to the attention of CDOT project manager
9/30/2009	100		Submit draft outline to CDOT and State Historical Fund (SHF)
11/2009-4/2010			Synthesize and prepare draft report
5/2010-			Perform peer and internal review of draft report and revise draft as needed
6/2010			Review of draft of Multiple Property Documentation Form (MPDF) by CDOT and SHF
			Hold study panel and consultant meeting
9/2010			Submit MPDF to State Review Board
11/2010			Approve MPDF by State Review Board
3/2011			Revise and submit final report for production

SIGNIFICANT EVENTS

Planning. Consultants met on June 25, 2009, to discuss direction of project with particular emphasis on approaches for producing the draft MPDF outline. Consultants prepared Draft outline for the MPDF to submit to CDOT by Sept. 30, 2009. Conference Call with CDOT project manager Dianna Litvak, Wilson & Co. project consultant Douglas Eberhart, and consultants Front Range Research Associates and Bunyak Research Associates on Sept. 24, 2009, to discuss Draft Outline and schedule of interim deliverable products. On-going telephone coordination between the consultants.

Literature Review. Continued research related to the history of suburbanization and suburban development in the United States, Colorado, and the Denver metropolitan area through the examination of National Register documents, planning histories, architectural guides and analysis of styles, local histories, newspaper articles, journals, magazines, and other materials. Conducted interviews with City Planners, City Council members, City Clerks, Community Development representatives for assigned municipalities, and individuals in various suburban developments representative of the period 1940-1965. Reviewed DPL builder files and card file indexes for corresponding newspaper articles at the Western History Library. Examination of books covering Denver planning and the early years of ICRPC and general suburban history. Researched and analyzed the growth of transportation networks in the Denver metropolitan area and prepared a written draft for MPDF. Digital capture and scans of selected photographs, oblique aerial views, news advertisements, and architectural drawings.

GIS Component. Tom Simmons attended meetings related to the final steps to complete integration of the DRCOG Regional Dataset. Meetings were held on June 4 and July 8, 2009. He discussed deficiencies in the DRCOG corrected regional database and how to address the raw county assessor data. Throughout the summer, he addressed email and telephone inquiries

between GIS consultants and kept project leaders informed of on-going matters as necessary. In addition, he examined raw assessor data collected by DRCOG and the corrected DRCOG parcel database and provided suggestions to CDOT on useful and appropriate data fields; used a raw assessor file from DRCOG for Arapahoe County to produce a subdivision layer with platting year and produced a thematic map.

As the date for receipt of the database lengthened, the team began to have concerns regarding the interim dates for scheduled task completion. At the kickoff meeting, Tom Simmons reported to the assembled participants that analysis of the final, corrected database would take approximately two months. The database would guide the field work to determine property types, integrity, and significance. However, due to the delay in receiving the database, field work has not yet been completed. The consultant team expected the database at the end of July after meeting with GIS participants on July 8th. However, the corrected DRCOG parcel database with Jefferson County parcel data was received by Tom Simmons on Sept. 12, 2009. An initial review of the database revealed that there continue to be some issues making field values consistent among the counties and translating important fields in the Denver files. Tom has agreed to expedite the process by making these corrections. Once the database is finalized, the various analytical reports and maps will be undertaken. The corrected DRCOG parcel database guides not only the field work, but the course of the work necessary to complete the MPDF. This additional delay and concern for meeting interim deadlines has been discussed with CDOT, Wilson & Co, and the consultants. This may or may not adjust interim deadline schedule, but will not adjust the final deadline for the project's completion. It was agreed that a potential slippage on the date to deliver the MPDF draft to the peer reviewer is acceptable if it is only a month or two. Otherwise, the CDOT project manager Dianna Litvak will be notified immediately.

General Metropolitan Population Growth. Produced a table of population trends by county, municipality, and region for 1940 through 1970 by Census year. Acquired scan of the oversize 1957 USGS map of the Denver region for use in project.

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.

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

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

- Determine the noise generation/reduction characteristics of pavements as functions of pavement type, pavement texture (where applicable), age, time, traffic loading, and distance away from the pavement;
- Determine a correlation between close-proximity (CPX) noise trailer testing, statistical pass-by index (SPBI) testing, and environmental noise measurements at various distances from the highway; and
- Accumulate information that can be used for validation and verification of the accuracy of TNM to use on future Colorado highway projects.

Reporting Period: 7/1/09 through 9/30/09
Start: 2/2006 Complete: 12/2011

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

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

Study Panel Members:
Judy DeHaven, R-2 Environmental 719-546-5409
Gary DeWitt, R-4 Materials 970-506-0359
Jay Goldbaum, Materials and Geotechnical 303-757-9449
Donna Harmelink, FHWA 720-963-3021
Bob Mero, R-6 Materials
Bill Schiebel, R-1 Materials 303-757-9134
Tammie Smith, R-3 Environmental 970-248-7226
Corey Stewart, Materials and Geotechnical 303-757-9299
Jordan Rudel, R-6 Environmental 303-757-9881

Richard Zamora, R-2 Materials 719-546-5778
Jill Schlaefer, CDOT Environmental

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)
10/15/09	85		End testing (Year 4)
12/31/09	0		Submit draft Year 4 Report for CDOT panel review

SIGNIFICANT EVENTS

9/30/09 No significant event noted for this quarter.

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

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

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

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

2/4/08 A fifth panel meeting was held in concert with a presentation on the QPR made to the Colorado/Wyoming Chapter ACPA. During the meeting, the preliminary findings of the Year 2 testing was presented. There was further discussion of the final report from Year 1, and it was

decided that an additional review cycle for CDOT would be initiated. Submission of the final report from Year 1 was therefore postponed until all comments are received and addressed. The Year 2 report will use the Year 1 report as a template.

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

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

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

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

9/14/06 After a thorough evaluation of the equipment and procedures, testing of the sites kicked off with measurement of CPX and OBSI on two sites north of Colorado Springs. An evaluation of the data was immediately done in order to ensure reasonableness and repeatability. Having passed these checks, testing will continue through November 2006.

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

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

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

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Tire/Pavement Noise Research Consortium
Study No: 35.05

Background	Reporting Period: 7/1/09 through 9/30/09 Start: 5/1/02 Complete: TBD Principal Investigator: Washington DOT Study Manager: Vanessa Henderson, CDOT Research 303-757-9787 Study Panel Members: Bob Mero, CDOT-R6 303-598-6703 Jill Schlaefer, CDOT EPB 303-757-9016 TPF-5(135)
Minimizing the impact of traffic noise on the public is a priority for state highway agencies and the FHWA. As tire-pavement noise is the single largest contributor to traffic noise on many highways, increased utilization of low-noise pavement surfaces may reduce overall traffic noise or reduce the need for expensive traditional noise mitigation measures. Developing low-noise pavement surfaces that are both durable and safe is of high interest. Utilization of low-noise surfaces may also provide a noise reduction alternative where traditional noise mitigation measures such as walls and berms are not a viable solution. Research into low-noise pavement treatments and materials is the focus of this consortium. The consortium provides a forum for states to discuss tire-pavement noise issues and develop a research plan. The consortium provides pooled resources and efforts of a multi-state group in a unified, efficient and shared process. A technical advisory group will be developed consisting of a pavement expert and noise expert from each contributing agency plus other invited participants	

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
6/18/07	100	8/07	Funding request to Business Office completed for transfer of $10,000 to Lead Agency
4/08/08	100	4/08	Annual meeting scheduled for consortium members. CDOT staff planning to attend
7/27/09	100	7/27/09	Annual meeting for consortium members.
On-going			Submit the final report and the final Users Guide documents.

SIGNIFICANT EVENTS

09/30/09 Bob Mero attended the Tire/Pavement Noise Consortium in Dayton, OH, in July 2009. See below for his summary report.

Vanessa Henderson was hired and is now the CDOT Study Manager.

06/30/09 Jill Schlaefer was hired to replace Zac Graves as Noise and Air Pollution Specialist. Jill will serve as a panel member for this study.

02/28/09 Pat Martinek retired from CDOT. Roberto DeDios took over her responsibilities.

02/09 The Research Implementation Council approved the $10,000 pooled-fund

	contribution for this Tire-Pavement Noise Consortium effort.
04/08	CDOT staff, Zac Graves and Bob Mero, attended annual meeting in Minneapolis, Minnesota. This two-day meeting was held to discuss detailed noise data gathering techniques, future research topics, and in general, to jump-start the effort.
12/31/07	PI is setting up meeting for the spring with CDOT and other participants.
07/07	CDOT sent money to pooled-fund study for participation.

Tire/Pavement Noise Research Consortium (Pooled Fund Study)
2009 Meeting
Trip Report
Bob Mero, R6 Materials

I recently had the opportunity to attend the recent Tire/Pavement Noise Research Consortium meeting in Dayton, OH. This interagency collaboration effort was implemented as a result of discussions that occurred during the April 2006 FHWA Tire-Pavement Noise Strategic Planning Workshop. The objectives of this research project are to provide a forum for states to discuss tire/pavement noise issues, develop a proposed research plan, to pool resources and efforts of multiple state agencies and industry to perform tire/pavement noise research in a similar manner (avoiding duplication), and sharing of data. Continued CDOT participation in this study has been approved by the CDOT Research Implementation Council (RIC) through FY10.

The tire/pavement noise issue has generated a great deal of conversation and rhetoric over the past few years. In response, CDOT has conducted numerous studies in regards to tire/pavement noise and is currently in the middle of a six-year, $500,000 project to evaluate the noise levels along Colorado highways.

Attending the meeting were representatives from the CA, CO, KS, MT, NC, OH, TX, and WA DOTs, as well as from FHWA and private consulting firms. This was the third meeting of the Consortium—the first was in Austin, TX in 2007 and the second was in Minneapolis, MN in 2008. This meeting followed the TRB Subcommittee ADC40 (Committee on Transportation-Related Noise and Vibration) annual meeting, which also included a few presentations discussing tire-pavement noise.

http://www.pooledfund.org/projectdetails.asp?id=364&status=4
http://www.adc40.org/

Highlights of the Consortium meeting are as follows:

OBSI Discussions: A substantial portion of the meeting was dedicated discussions regarding the On Board Sound Intensity (OBSI) measurement method. The OBSI method is very likely going to be the standard procedure for measuring tire-pavement noise at the source. In fact, the method is part of AASHTO TP-76, released in 2008 and updated in 2009. While Close Proximity testing (CPX) is still being performed, its use is diminishing (CDOT's research project eliminated the collection of CPX data after 2006 and is now using OBSI only).

OBSI Apparatus (portable, can be used with any vehicle)

State DOT Updates:

I gave a brief presentation detailing CDOT's Tire-Pavement Noise Research project and a summary of the results for the 2006 and 2007 measurement efforts. Also discussed was the CDOT crumb rubber asphalt paving project in R4, which although not being a noise-driven project, was a big step to take for CDOT and that we were going to attempt to add the site to our noise research project for the 2009 and 2011 measurement seasons. Additionally, I informed the group of CDOT HQ's new Noise Specialist, Jill Schlaefer.

California continues to be one of the leading states as far as research and application of quiet pavement is concerned. They have developed an approved list of "Approved Quiet Pavement Surface Treatments" and criteria for their implementation. In addition, they are currently investigating a roadway noise specification. The idea is that it will be an incentive-based specification, similar to specifications used for smoothness. This is still a ways off, as it will require that they arrive at a standard OBSI test method. They are also doing additional research, much of it being very technical in nature.

North Carolina has secured funding for their research project to do noise testing on their network and will also purchase the equipment for use after the initial project is complete.

Montana would like to schedule an ambassador tour and will be selecting sites. They are also asking for assistance developing a PCCP texturing specification.

Kansas is taking noise measurements on a few isolated areas which are notorious for noise complaints adjacent to some of their more heavily traveled PCCP sections.

Texas is partnering with the Texas Transportation Institute (TTI) in a 5-year project to test and evaluate a permeable friction course section.

Ohio would also appreciate help from the Consortium to assist in gathering noise data.

Washington State is continuing their major study to characterize the acoustic performance of new pavements over time. This is being referred to as a "Quieter Pavement Evaluation". This project is finding that rapid deterioration has occurred within the 2-3 years of the study. They are placing one more test section in conjunction with a major widening effort, which may be the last test section performed unless the results are better.

http://www.wsdot.wa.gov/Projects/QuieterPavement

FHWA Update: While FHWA has not changed their overall policy regarding the use of pavement as a substitute for permanent noise mitigation, they do remain committed to working with states regarding quiet pavement research and quiet pavement pilot programs. There is a national research project underway that is investigating all methods of noise mitigation, of which pavement is a part. A lingering issue continues to be the treatment of pavements in the FHWA Traffic Noise Model (TNM), which is the required model for environmental noise analyses. While it will still be quite some time before any changes will be realized in the model, the OBSI data that is currently being collected nationwide (including the data from Colorado) will be used in the development of the model. Prior to that, FHWA is hoping to finish development of the next version of TNM (Version 3.0) in the near future.

http://www.fhwa.dot.gov/environment/noise/tp_noise.htm

Research Efforts: One of the major items emphasized at this meeting was the desire to finalize plans to

implement Consortium-funded research projects. These include many of the refinements to the OBSI technique as mentioned above, additional noise education materials, and support of the ongoing development of TNM.

National Tire-Pavement Noise related research also includes the following NCHRP studies:

NCHRP 1-44 (Measuring Tire-Pavement Noise at the Source) has been completed and is available as NCHRP Report 630. This research identified OBSI as the preferred method for source measurement of tire-pavement noise.

http://www.trb.org/trbnet/projectdisplay.asp?projectid=230

NCHRP 10-76 (Methodologies for Evaluating Pavement Strategies and Barriers for Noise Mitigation) is currently ongoing. This two-phased study will attempt to analyze the available technologies for noise mitigation

http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=1628

NCHRP 08-56 (Truck Noise Source Mapping) is currently completed with publication pending. The purpose of the study is to better characterize the noise generated by heavy vehicles by more accurately identify, locate, and quantify those sources.

http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=932

OBSI Rodeos and Standardization: Many states, as mentioned above, have undertaken their own quiet pavement research projects and noise measurement efforts. However, other states who would like to do so are not able to for many reasons. As such, a service that may be able to be provided by the Consortium is to travel to those states and perform these measurements, which is much easier to do with the very portable and repeatable OBSI system than before when this effort had to utilize the CPX trailer. These efforts for those states that are interested may be able to take place in the near future.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Used Traction Sand Reuse in Highway Applications: CDOT Standard Specifications for Construction and Standard Operating Guidelines for Maintenance
Study No: 40.11

Background

The Colorado Department of Transportation (CDOT) uses an immense amount of traction sand each winter to keep roadways safe and open. Such use has created problems with sedimentation and aggradation of receiving streams particularly in the mountain areas. As a result, the Colorado Department of Public Health and Environment (CDPHE) has classified some streams as "impaired" because of high sediment loadings. Over the past 10 or more years, Region 1 has spent millions of dollars on sedimentation controls in these watersheds. As part of sediment control in these watersheds and other locations, Region 1 alone picked up more than 100,000 tons of used sand for the 2004-2005 winter seasons. The cost of disposing of this traction sand is high and expected to increase dramatically statewide.

Few local uses for the large quantities of traction sand collected in the mountain areas have been identified and successfully employed including placement in berms and caps for mill tailings. However, these types of applications are limited in size and availability. Maintenance staff is running out of local and free places to pile the used sand. Permitted gravel pits and landfills located close to highway projects are becoming scarce. Since the cost of using these traditional resources is rising, reuse of materials is becoming a more attractive option for CDOT highway applications. Reuse of traction sand in traditional way and other highway applications is an untried concept to many CDOT employees. Current, accurate, and accessible information is needed to help personnel evaluate practical and cost-effective uses of these spent materials. CDOT material specifications are perceived to imply not only a preference but a requirement for virgin materials. Reused traction sand does have some restrictions. For example, if it is used to backfill behind mechanically stabilized earth (MSE) walls, presence of grease precludes using plastic ties in the walls. New CDOT specifications need to be developed to address issues like this in order to make reuse of these materials successful in the long term.

Reporting Period: 7/1/09 through 9/30/09
Start: 12/20/07 Complete: TBD

Principal Investigator(s):
Alex Pulley, Felsburg Holt & Ullevig

Study Manager:
Vanessa Henderson, CDOT Research
303-757-9787

Study Panel Members:
Kevin Ashoury, CDOT Staff Services Maintenance 303-512-5503
Del French, CDOT R-4 Maintenance 970-350-2158
Holly Huyck, CDOT R-1 Planning and Environmental 303-757-9790
Fred Schulz, CDOT R-1 Maintenance 303-757-9649
Roy Smith, CDOT R-6 Maintenance 303-757-9888

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
2/19/07	100	3/07	Assemble task panel. Develop the scope of work (SOW).
4/30/07	100	6/07	Complete the task order or request for proposal (RFP) process.
6/30/07	100	7/07	Select the Principal Investigator (PI). Initiate task order/purchase order/agreement/contract.
12/20/07	100	12/07	Award the contract. (Task order signed and Notice to Proceed Letter issued)
1/31/07	100	1/31/08	Conduct the kick-off meeting.

3/15/08	100	6/30/08	Perform the literature search.
8/31/08	95		Finalize reclaimed sand characterization
8/01/09	100	9/30/09	Monitor field test of contaminant reduction processes. Gather and analyze data.
8/31/08	25		Recommend possible applications for construction and monitoring.
9/30/09			Develop pilot special specifications and operating guidelines for successful applications.
10/2/09			Submit pilot special specifications and standard operation/maintenance recommendations to the CDOT study panel for review and comment.
10/15/09			Complete review of specifications and guide by the CDOT study panel.
11/20/09	60		Prepare and submit draft final report to CDOT study panel for review.
12/7/09			Complete review of draft final report by CDOT study panel with comments to be addressed.
12/31/09			Revise and submit the final report.

SIGNIFICANT EVENTS

9/09 PI received final data regarding the TRPH sampling results of split fractions (>0.85 mm and <0.85 mm). Contamination exists in both the fractions.

9/09 PI conducted and received final sampling information regarding bench scale remediation techniques. Based on preliminary findings, the average TRPH concentration is decreased by approximately one-third for the control and tilling. Adding compost material and tilling reduces TRPH concentrations by two-thirds.

6/09 PI analyzed and obtained results from retained traction sand samples (2) for physical characteristics. PI analyzed retained samples for TRPH concentrations in sand particles greater than 0.85 mm and less than 0.85 mm.

5/09 PI analyzed TRPH results of 3-month sampling effort for bench scale test.

3/09 PI incorporated new data into chemical and physical analysis.

2/09 PI received multiple results from bench testing of contaminant removal showing a decrease in total recoverable petroleum hydrocarbons.

1/09 PI continued on-going bench-scale test to reduce total recoverable petroleum hydrocarbons.

12/08 PI initiated bench-scale test to determine what simple composting actions sufficiently reduce total recoverable petroleum hydrocarbons. Study samples were collected from Vail Pass.

12/08 PI received CDOT report on sand characterization, including chemical and physical analyses. Conclusions of report suggested splitting material into two grain sizes.

8/15/08 PI received engineering results of sampled sand from Berthoud Pass and Vail Pass. Preliminary analysis concluded material did not meet all CDOT specifications for aggregates.

7/24/08 PI submitted characterization report and bench-scale study protocol.

6/15/08 PI continued work on characterization of traction sand and compared CDOT sand data to California sand characterization, Colorado background values, and risk-based soil screening levels.

6/1/08 PI initiated work on bench-scale study analysis and potential protocol.

5/15/08 PI initiated Market/Options Analysis investigation, initially focusing on the work that has been completed in the recycled aggregate industry.

5/1/08 PI continued work on Literature Search. Contacted numerous DOTs and municipalities and determined few were considering reuse of traction sand. Montana DOT and City of Edmonton had the most expansive programs.

2/1/08 PI initiated work on Literature Search of municipalities and DOTs to determine their practices regarding reuse or recycling of traction sand. PI initiated review of collected traction sand characterization data.

1/31/08 First task panel meeting conducted. General project plan presented, discussed and agreed upon.

12/20/07 Notice to Proceed issued. First task panel meeting with PI scheduled for January 31. 2008.

12/5/07 PI submitted revised costs and scope for tasks achievable by June 30, 2008 for final approval and issuance of Notice To Proceed.

9/30/07 PI modifying contract to include subcontractor.

6/30/07 Documented quote solicitation advertised twice. PI selected on 6/28.

3/31/07 Task panel reviewed Statement of Work. Comments being compiled.

2/27/07 Revised task panel met and revised Statement of Work. Comments due 3/12.

1/31/07 The SOW and RFP are being finalized by Patricia Martinek. The RFP is anticipated to be completed in April.

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

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Improving the Performance of Roadside Vegetation
Study No: 41.71

Background

Previous research has determined that chloride-based deicers that become airborne and coat the needles of evergreens can have much more impact on tree health than the same materials when they get into the soil. But chloride-based liquid deicers have been found to be the most cost-effective materials available, and forgoing their use could have a huge impact on safety and mobility. If sand is used instead, air pollution, stream sediment, and cleanup problems would result. Maintenance staff continuously considers alternate deicers and methods to minimize the use of deicers.

CDOT does not plant trees very often on the roadway slope and embankment areas, but the Department does seed. It is very important that seed germinates to reduce erosion and resulting sedimentation into streams. Any further study that CDOT can conduct on the effects of chlorides on seed germination would be beneficial (additional species studied, for example). Recent study did show that some species germination was inhibited by the chlorides, but when rinsed off, some seed recovered. The problem reduces to how we can mitigate for inhibited germination. In order for CDOT to obtain NPDES permits, a pre-existing vegetation cover of seventy percent (70%) should be present on our projects. The result of this research effort should help achieve this goal.

Reporting Period: 7/1/09 through 9/30/09
Start: 08/12/2008 Complete: 09/30/2010

Principal Investigator(s):
Jacobi, Brown, Koski, Shonle
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Study Manager:
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Study Panel Members:
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Cathy Curtis, CDOT EPB
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Celia Greenman, Colorado Geological Survey
303-866-2811

Holly Huyck, CDOT R-1 Environmental
303-757-9790
Susie Smith, R-6 Planning and Environmental
303-757-9932

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
9/01/07	100	9/01/07	Develop the scope of work (SOW).
10/15/07	100	12/1/07	Complete the task order or request for proposal (RFP) process.
12/31/07	100	05/15/08	Select the Principal Investigator (PI). Initiate task order/purchase order/agreement/contract.
1/31/08	100	07/07/08	Award the contract. (Task order signed and Notice to Proceed Letter issued)
5/01/08	100	07/15/08	Conduct the kick-off meeting.
7/31/08	50%	7/31/08	Perform the literature search and maintenance staff interviews.
7/31/08	100	7/31/08	Recommend possible vegetative species for lab and field planting, and field locations.
9/1/08	100	9/1/08	Planters constructed at two field locations
11/1/08	100	11/15/08	All treatments applied and fall seed planted at two field sites
3/15/09	100	3/15/09	Seed quality and purity assessed
5/30/09			Mid-term progress report
6/30/09	80	7/15/2009	Spring monitoring of field sites-performance of vegetation. Gather and analyze data.
9/1/09	80	8/21/2009	Fall monitoring of field sites-vegetation performance- Gather and analyze data
8/31/09	25	9/30/2009	Lab testing of seed germination for one temperature

10/30/09			Data all entered and first draft data analysis completed
1/30/10			Progress report
2/28/10			CDOT study panel review of progress report
3/31/10			First draft of final report
4/30/10			Develop standard construction specifications and operating guidelines for maintenance of successful planting and seeding programs.
5/30/10			Submit standard specifications and standard operation/maintenance guide for successful planting and seeding programs to the CDOT study panel for review and comment.
6/28/10			Complete review of specifications and guide by the CDOT study panel.
7/15/10			Prepare and submit draft final report to CDOT study panel for review.
8/15/10			Complete review of draft final report by CDOT study panel with comments to be addressed.
9/30/10			Revise and submit the final report.

SIGNIFICANT EVENTS

9/30/2009 ARDEC field site dismantled.

9/18/2009 Gilpin field site dismantled.

9/18/2009 Biomass samples collected at Gilpin high elevation site. No biomass collected at ARDEC

8/24/09 Colorado Seed lab has completed germination assessments of four of the fifteen plant species.

8/20/09 Second assessment of field sites at Gilpin (8/20) and ARDEC (8/21). Soil samples collected at ARDEC (8/21) and Gilpin (8/29).

7/15/09 First assessment of plant totals and heights at ARDEC (7/15) and Gilpin County (7/16) field study sites.

6/15/09 Germination was assessed at both field sites but no readings taken since many species had not germinated. Evaluations will take place in July.

5/01/09 Spring treatments applied at Gilpin site and seeds planted.

4/02/09 Spring treatments applied at Fort Collins site and seeds planted.

4/01/09 Initial germination test completed, utilizing slender wheatgrass (*Elymus trachycaulus*)

4/27/09 Drs, Jacobi, Brown, Koski and Shonle and Graduate Student Meg Dudley review project.

3/15/09 Seed purity and quality analysis completed on all 15 seeds

12/20/08 Sodium and Magnesium based deicing products obtained from Loveland CDOT facility and samples sent for chemical analysis. Seed germination tests will be using these commercial products and pure NaCl and MgCl2 compounds.

11/15/08 All seeds planted and covered by coco mat by this date at both research planter sites (Fort Collins and Gilpin County)

11/1/08 All seven treatments of salt applied to soils in planters at both locations.

10/2/08 PI and graduate student consulting with seed germination lab director at CSU on laboratory seed germination tests.

9/26/08 All three soil types added to planters at both low and high elevation sites.

9/15/08 Seeds and purchased for field and lab experiments. Solution holding tanks purchased.

9/1/08 Planters constructed at ARDEC, Fort Collins, low elevation site and Gilpin County high elevation site.

8/22/08 PI consultation with soil scientists about soil types to represent sandy plains soils, clay based, and mountain soils.

8/15/08 Sampling of surface (4 inches) soils along I-70 chemical analysis complete.

8/12/08 Funding account established at CSU

7/7/08 Purchase Order forwarded to PI

5/15/08 Negotiations completed with revised Scope of Work submitted. Award made to Colorado State University

3/31/08 Negotiations continuing with PI over Scope of Work

12/31/07 PI selected. Scope of Work needs further revision. Contract expected in January or February.

9/30/07 Scope of Work revised, advertised to universities. One proposal received and being reviewed.

6/30/07 Documented quotes solicited. One submittal received. Meeting with potential PI scheduled in July. Panel agreed that proposal was not responsive and to rewrite and re-advertise scope.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Bird Nesting and Droppings Control on Highway Structures
Study No: 41.76

Background

With the avian flu a public health concern on the radar screen this year, bird droppings of all kinds are suspected potential sources of diseases. Additionally, pigeon droppings specifically can get piled high and deep, hiding the status of structural members of the bridges. And finally, pigeons also present a public interest of concern regarding pedestrian passage under bridges due to the presence of a slip/trip hazard, possible disease conveyance, and the unappealing visual aspect of pigeon droppings.

Currently, maintenance is being asked to clean up the pigeon droppings prior to Colorado Department of Transportation (CDOT) Staff Bridge personnel inspecting the structural integrity of bridges. This is becoming a costly, time consuming, cyclical, and never ending task. Alternatives to reduce long-term costs and to improve worker and public health and safety are needed.

A final report and a maintenance guide on various detailed alternatives/ techniques to control pigeon droppings shall be prepared. The technical report will include topics such as comparing available bird roosting discouraging methods, their effectiveness for pigeons or other birds, their public acceptability, their initial costs per typical bridge in CDOT R6, and long-term maintenance time and cost expected over time. These methods need to be compared with what maintenance is currently doing (i.e., cleaning up bird droppings each time Staff Bridge wants to inspect a structure.) These methods must also be evaluated for how they perform under the requirements for bridge inspection and sidewalk protection needs. A combination of these methods can be considered to finally make a recommendation of the most practical, reasonable, and feasible method to install or employ.

Additionally, other methods will be considered and evaluated that could also achieve Staff Bridge's objectives such as the use of scopes instead of sending people physically down under the bridges, and developing new bridge designs to eliminate the bird roosting problems.

Reporting Period: 7/1/09 through 9/30/09
Start: 7/24/07 Complete: TBD

Principal Investigator(s):
D. Jean Tate, Ph.D., Enviro-Support, Inc.
303-403-4748

Study Manager:
Vanessa Henderson, CDOT Research
303-757-9787

Study Panel Members:
Jeff Anderson, HQ Engineering and Bridge Design
303-757-9188
Debra Angulski, R-1 Planning and Environmental
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Jim Eussen, R-4 Planning
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Rob Haines, R-6 Maintenance
303-757-9514
Jane Hann, R-6 Planning and Environmental
303-757-9397
Jeff Peterson, HQ EPB
303-512-4959

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
7/31/06	100	11/28/06	Assemble the research study panel. Develop the scope of work (SOW).
11/28/06	100	11/28/06	EROT approved combining this proposal with swallow nesting problem statement.
1/29/07	100	1/29/07	New Problem Statement with larger scope approved for funding by RIC.
4/23/07	100	4/23/07	First meeting with new research study panel, and finalize revised SOW.

3/31/07	100	6/30/07	Complete the request for proposal (RFP) process.
6/30/07	100	6/30/07	Select the Principal Investigator (PI). Initiate task order/purchase order/agreement/contract.
7/15/07	100	7/24/07	Award the contract. (Task order signed and Notice to Proceed Letter issued).
8/15/07	100	10/2/07	Conduct the study panel/PI kick-off meeting.
8/31/07	100	10/2/07	Perform the literature search.
12/31/07	100	12/31/07	Interim report.
4/30/08	100	6/12/08	Perform field investigation and inspection. Gather and analyze data.
1/31/09*	100	2/2/2009	Prepare the draft final report and the guidelines to address the pigeon droppings problem. Submit the draft final report and guidelines documents to CDOT study panel for review. Preliminary draft final report and guideline documents were submitted to the CDOT study panel for review on September 24. Feedback on the above preliminary draft copies was sought via email on October 23, November 18, and December 4. On December 4, completion of the draft copies with the feedback received to date was authorized.
2/28/09*	100	No Study Panel Comments Received	Complete review of the draft final report and guide by the CDOT study panel.
2/28/09-4/30/10	30	Ongoing	Periodically check nesting deterrents from Spring 2009 through Spring 2010 to see how they have held up to the weather and to see if any swallows occupy the test CBCs.
12/31/09			Revise and submit the final versions of the Report. Safe Operating Guide_PPE, the Information Sheet to Guide Workers in Cleaning Up Pigeon Droppings, and the Safe Operating Procedure.
6/30/2010			Submit Update to be appended to final version of Report

*If possible, submissions will be before these dates.

SIGNIFICANT EVENTS

9/30/2009 Phone conversation with Vanessa Henderson on September 15, 2009. Discussed project status. As a result of that phone discussion and subsequent follow up (documented in a September 22, 2009 email) it was decided that the documents submitted on January 28, 2009 (Report. Safe Operating Guide_PPE, the Information Sheet to Guide Workers in Cleaning Up Pigeon Droppings, and the Safe Operating Procedure.) would be finalized before the end of the year. Any subsequent information obtained from observation of the field site would be prepared as a Report Update.

Site Visited on August 18, 2009. More (12) of the Bird Slide have fallen down from the N side of the northernmost CBC so that there are only 5 panels plus both end caps left. Swallows have moved into this side in many of the spaces between the remaining panels. There were 45 completed nests in all plus more that were incomplete/collapsed. Also, one of the remaining Bird Slide panels had a nest on the flat space provided by the top of the attachment triangle—likely the nest of the Say's Phoebes observed there in May.

On the S side of northernmost CBC one-half to two-thirds of the white paneling is still up, with one paneling strip dangling but not blown out of the grooves because

of two screws that had been added. There were 3 complete nests on this S side in the spaces between the panels.

There were no swallows observed in the vicinity of the test CBCs during my visit and no nests in any of the other three test CBCs. The plastic strips were still intact. Photos taken of corner slope panels, and nests. All 4 test CBCs were walked through, end to end.

6/30/09 Site visited on May 15 in the afternoon to determine whether swallows had returned and how various deterrents were holding up. Cliff swallows were present in the vicinity and using the CBC occupied in the summer of 2008. Perhaps 50-60 swallows were flying high in loosely coordinated subgroups, and occasionally flying into the CBC, then again flying high and often out of sight. No sign of swallow use of test CBCs, though a pair of Say's Phoebes appeared to be starting to nest in the northernmost test CBC. Little change in the deterrent materials.

On May 15, 2009, the period of performance for this project was extended to June 30, 2010 so that the deterrent materials can be monitored through another winter if this is approved by the City of Broomfield. The Total Item Cost was not modified.

Site visited on April 9, 2009. No swallows observed in the area.

3/31/09 Site visited on January 2, 2009 to determine how various deterrents were holding up to winter weather. Strong winds had hit the area on the evening and night of 29 December and into 30 December, with gusts recorded up to 77 mph in south Boulder and 74 mph at Rocky Mountain Metropolitan Airport on the morning of 30 December. Arvada, to the south of the site, recorded all time average high wind gusts of 39.1 mph on 30 December 2008. Damage was sustained primarily by the corner slope methods. The Bird Slide product had been attached with GE Silicone II because the intent was to remove (and potentially reuse) this product.

Approval to leave the deterrents in place until the fall of 2009 was obtained on January 16, 2009 from Ron Jones of the City of Broomfield. Depending on their condition at the end of summer, 2009, it may be desirable to leave the deterrents in place through another winter. If CDOT wishes, permission to do so can be requested from Ron Jones, who said he would consider a further extension at that time.

Draft Final versions of the Safe Operating Guide_PPE, the Information Sheet to Guide Workers in Cleaning Up Pigeon Droppings, and the Safe Operating Procedure submitted on January 28, 2009. These were modified based on a late September markup by CDOT of previously submitted versions. They follow the agreed upon format, but cross-reference other documents for specific details rather than repeating the information. The Draft Final Report, although ready for

submission on January 28, was not submitted until February 2, 2009 after it was decided to reduce the size of the included photographs so it could be emailed.

12/31/08 In follow up to decisions made at the August 25, 2008 Study Panel meeting, Jeff Peterson picked up unused materials on September 12, 2008. These materials will be used or stored by CDOT. Also on September 24, 2008, preliminary draft copies of the Final Report, the Safety Information Sheet, and Project Special Specification Sheet were submitted to CDOT for review of their format and proposed content. These items were accomplished during the last quarter, but not mentioned below.

Feedback on the above preliminary draft copies was sought via email on October 23, November 18, and December 4. On December 4, completion of the draft copies with the feedback received to date was authorized. Subsequent work on integrating Study Panel comments on the preliminary draft copies of the Final Report, the Safety Information Sheet, and Project Special Specification Sheet was initiated. In addition, the addition of results and discussion of the field study to the Draft Final Report was initiated and a list of all participants in the field study sought and obtained from CDOT on December 16.

Finally, on December 4, Dr. Sivakumar emailed a query regarding our testing of the Analytical Services & Materials, Inc. aerokret coating. He was advised that swallows do not leave enough droppings near their nests to be useful as a test. Therefore, our intent is to put the panels up on areas intensively used by pigeons during some regular maintenance activity in those areas next spring.

9/24/08 The Study Panel met to discuss the results of the temporary swallow nesting deterrent tests and to discuss next steps in this study. Since there was no nesting in any of our test CBCs (including the controls) and all area nesting occurred in an undisturbed fifth CBC that was nearby and contained existing nests, it was decided that no final conclusions could be drawn regarding the effectiveness of the deterrents tested in our study because a number of untested factors could have contributed to these unexpected results. While there is insufficient money left in the budget to add additional studies to test these factors systematically, some further checking of the current approach could yield additional information. Thus, after completion of the Draft Final and Final Reports, Draft and Final Sample Project Special Specification Sheets, and Draft and Final Safety Information Sheets, it was decided that any remaining consultant time would best be spent rechecking the site over the winter (to see how the deterrents hold up to weather) and spring (to see whether any and which of the CBCs are used by swallows). Consultant time will also be used to remove the deterrents once they begin to deteriorate. Approval to leave the deterrents in place until that time is being sought from the City of Broomfield.

6/12/08 Observation of four test CBCs began on April 16, when swallows were reported in the Denver Metro Area. Cliff Swallows first seen in vicinity of test CBCs on

April 24th (site checked three times in the interim but no swallows observed). Swallows absent on April 25th (a cold and windy day), but seen on April 28th when site next visited and thereafter whenever site was visited (April 29 & 30; May 6, 13, 16, & 21; June 4 & 6). However, with one minor exception, swallows have never been seen in or near any of the four test culverts including the control where nothing was installed, but any nests were removed. The minor exception occurred on May 16 when a single Cliff Swallow flew just inside the entrance of CBC #4 (which is furthest north) and appear to be catching insects. It showed no interest in the walls of the CBC. Instead of visiting any of the test CBCs, all of the Cliff Swallows in the area are using a CBC beneath Midway Boulevard that is just south of the walkway that goes from Midway Boulevard to CBC #4. This CBC has hundreds of nests in it, and the Cliff Swallows were seen entering this CBC on April 24th, the first day they were observed at the site. They have continued to fly in and out of this CBC, sometimes individually and sometimes in large numbers (if they are disturbed). This appears to be the only place Cliff Swallows are nesting in the immediate vicinity. The full length of CBC#1 was walked on May 6 and the other test CBCs were inspected with binoculars from their entrances. The entire length of all four test CBCs was walked on June 4 and photographs were taken.

3/31/08 Comments on Interim Report received and incorporated as revisions for Draft Final Report. Study Panel meeting held on February12, 2008 and decision made to test two curtain methods, and two corner slope methods as the primary swallow deterrents, plus a blue painted ceiling. Work Plan (distributed February 25, 2008), Work Plan Addendum 1 (distributed March 9, 2008), Table of Needed Equipment (distributed March 7, 2008), and Special Use Access Permit (submitted February 15, 2008) completed. Meeting held with Ron Jones, Streets Foreman, City and County of Broomfield and decision made to use four City and County of Broomfield CBCs because they were easier to access than any CDOT CBCs identified to have significant swallow activity. Installation work days held on March 18 and March 28 when installation was completed. Excellent support provided both times by CDOT Headquarters Research and Environmental staffs plus Region 4 Environmental and Maintenance staffs. No other CDOT regions contributed to the installation effort. Monitoring of swallow behavior in the four City of Broomfield CBCs will begin as soon as it is known that swallows have migrated into the region.

12/31/07 Completion of literature survey and Interim Report. Interim Report contains draft recommendations on best methods to use for permanent pigeon roosting/nesting deterrence and draft recommendations on best methods to use and field test for temporary swallow nesting deterrence. Significant progress made on development of information source spreadsheet and contact spreadsheet for Final Report. Subsequent emphasis will be on finalizing recommendations for best methods to field test for temporary swallow nesting deterrence and on finalizing field test locations, permissions, and protocols. Study Panel meeting must be scheduled in late January.

9/30/07 Significant progress on literature survey. Initial emphasis on general deterrent

	measures employed for multiple species, on potential for human health hazards, and on issues associated with pigeon nesting and droppings in the literature. Subsequent emphasis will be on temporary swallow deterrents in the literature, and on ongoing research.
7/24/07	Contract awarded to Dr. D. Jean Tate.
6/30/07	Documented quote solicitation completed. PI selected and contract initiated.
3/31/07	New task panel developed, draft Statement of Work written. First panel meeting scheduled for April 23, to finalize SOW.
1/29/07	RIC approved combined problem statement.
1/12/07	New combined Problem Statement written for RIC consideration
11/28/06	EROT approved combining this Problem Statement with a new similar one about swallow Nesting. RIC will consider approval of the combined statement on 01/29/07

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Deicer Corrosion Inhibitor Performance Pooled-Fund Study
Study No: 41.90

Background	Reporting Period: 7/1/09 through 9/30/09 Start: 11/30/01 Complete: 12/31/10 Principal Investigator(s): Western Transportation Institute Study Manager: Vanessa Henderson, CDOT Research 303-757-9787
Public agencies throughout the Northwest buy and use inhibited deicing chemicals in an attempt to reduce the corrosive effects of the deicer they use. These organic inhibitors are effective but expensive, and their "shelf-life," effective life after application, and overall field performance are uncertain. This pooled-fund study, TPF-5(035) will be overseen by DOTs in 8 states and two companies, in addition to CDOT. Phase 1 of this study would help to determine the longevity and cost effectiveness of corrosion inhibitors added to liquid and solid deicing chemicals. This work would involve field observations of stored materials over time under various conditions (solid deicers which are either uncovered or partially covered, and liquid stored in tanks) and mixtures. Phase 2 would evaluate the field performance (longevity and effectiveness) of various deicers with varying mixtures of corrosion inhibitors and additives. Each product will be applied at varying rates, road conditions, temperatures, and humidity, and their performance measured. Deicers to be studied include magnesium chloride, calcium chloride, and solid sodium chloride. Final results should provide CDOT with an updated list of effective deicer mixtures for use during winter operation and maintenance.	

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
8/20/07	100		Completed fund transfer to Pooled-Fund Study lead agency.
12/31/10			Submit the final report.

SIGNIFICANT EVENTS

9/30/09 Vanessa Henderson was hired and is now the CDOT Study Manager.

The research project "Determine the Longevity and Cost-Effectiveness of Corrosion Inhibitors added to Liquid and Solid Deicing Chemicals" continues. The research team at WTI has been working very hard to set up the field testing (with corresponding lab tests) that will result in the best data possible. A fifth progress report has been issued along with specific data from some of the lab testing.

The Qualified Products List (QPL) and deicer specifications can be viewed at:

http://www.wsdot.wa.gov/partners/pns/resources.htm.

Summary of Activities Expected to be Performed Next Quarter:
Research project will continue.

06/30/09 No progress report received.

02/28/09 Pat Martinek retired from CDOT. Roberto DeDios took over her responsibilities.

11/30/07 Project planning moving forward, participants notified of upcoming events.

8/20/07 Request completed transfer funds to Pacific Northwest Snowfighters.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

CDOT Revenue Model
Study No: 61.11

Background The Revenue Planning process involves the forecasting, management, and reporting of the Colorado Department of Transportation's expected monetary resources. The data from this process are linked to the Resource Allocation, and the Administrative and Commission Budget process. The current revenue estimating, management, and reporting are performed with the Excel application. It does not integrate with any other application for reporting purposes. However, CDOT is in the process of implementing a SAP system where revenue estimates will be entered, extracted, planned, and reported in and from their business planning system (BPS).	Reporting Period: 7/1/09 through 9/30/09 Start: 26/01/09 Budget Amount: $ 300,000 Principal Investigator: Dye Management Group Bill Dye Study Manager: Rich Sarchet, DTD-Research 303-757-9518 Study Panel Members: Will Ware, CDOT Office of Financial Management and Budget (OFMB) Pat Baskin, CDOT OFMB Ben Stein, CDOT OFMB Steve Rudy, Denver Regional COG Heather Copp, CDOT OFMB Jake Kononov, DTD-Research, 303-757-9973

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
	100	12/3/07	Establish Study panel and hold first meeting.
	100	3/18/08	Finalize scope of work and determine domain for RFP.
4/15/08	100		Issue RFP
5/15/08	100		Select Principal Investigator
5/30/08	100	12/29/08	Notice to Proceed
3/31/09	100	4/30/09	Task 1 Project Initiation:
4/30/09	100	07/09	Task 2 Dependent Variable Data Collection and Business Process Documentation
5/31/09	100	07/09	Task 3 Define and Collect Data for Independent Variables
5/31/09	100	07/09	Task 4 Specify Model Sketch Plans
7/31/09	75		Task 5 Design and Construct Model Components
9/30/09	75		Task 6 Design and Construct Integrated Model
10/31/09	45		Task 7 Document Model Specifications and Results
10/31/09	10		Task 8 Knowledge Transfer
12/31/09	0		Final Report (Published by CDOT)

SIGNIFICANT EVENTS

Scope finalized 3/18/08 Domain determined to be all consultants and research entities 3/11/08

RPO package to DTD Business office 3/19/08

06/08 RFP advertised 6/30/08. NTP now expected by 9/1/08.

09/08 Contractor Selected, negotiations in progress. Indefinite delay to NTP due to freeze effecting new professional services contracts. An exception has been requested.

12/08 Exemption granted and NTP issued.

Project Initiation: Project kick-off meeting was held on 26 January 2009. Project work plan submitted by principal investigator on 22 February 2009. Project initiation concluded with a presentation to the Colorado State Transportation Advisory Committee on 10 April 2009.

Dependent Variables: Data collection initiated on 6 March 2009. Initial upload of data from the Colorado Department of Revenue completed on 23 March 2009.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Optimization of Stabilization of Highway Embankment Slopes Using Driven Piles (Phase I - Literature Review and Preliminary Assessments of Highway Slopes)
Study No: 74.90

Background Failure of fill slopes on Colorado's mountain highways is a common problem. Horizontal and vertical movements of slopes often cause settlement of the highway surface, resulting in pavement distress and dangerous conditions for highway users. Maintenance resources are commonly used to deal with stability problems. Maintenance forces have attempted to stabilize slopes by driving piles along the downhill side of the road. Pile materials include H-piles, guard rail, and light posts. These stabilization efforts are carried out with little or no geotechnical engineering input. There are several design methods for slope stabilization using piles in the current engineering literature. However, these methods vary widely in the engineering methods used and the results obtained. Furthermore, few if any of these design methods have been verified with field monitoring. To help maintenance and engineering staff determine if use of driven piles is the best method to correct a slope stability problem, a coherent design method based on actual installations is needed. Phase I of this project will consist of a literature review of current practice and sites identification on CDOT highways, and Phase II will include an instrumented field installation to verify current design methods.	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: 01/09 Ver: Contract: 2100235 (P.O. # 211006524) Principal Investigator(s): Panos Kiousis, Colorado School of Mines 303-384-2205 Study Manager: Aziz Khan, Research Branch 303-757-9522 Study Panel Members: Steve Laudeman, CDOT Materials and Geotechnical Branch Craig Wieden, CDOT Region-2 Materials Del French, CDOT Region-3 Maintenance Rex Goodrich, R-3 Material Engineer John Hart, Coggins and Sons, Denver Alan Lisowy, H-P Geotech, Denver Matt Greer, FHWA-Colorado

RESEARCH TASKS

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
7/31/09	100%	10/1/2009	Task 1 Perform a literature review stabilization.
7/31/09	80%		Task 2: Conduct a national survey of state DOTs to determine if other states have had similar problems
7/31/09	70%		Task 3: Detailed review of CDOT/Consultants inspection and slope stabilization mitigation reports for Colorado, and other states
11/30/09	100%	8/31/2009	Task 4: Perform targeted field inspections of approximately 20 sites in Colorado in consultation with CDOT maintenance and engineering staff.
11/30/09	20%		Task 5: Provide a cost comparison of driven piles to other deep foundation stabilization methods.
11/30/09	20%		Task 6: Analysis of data collected in above tasks
12/15/09			Task 7: Submit draft report and final report addressing the comments of the study panel

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
09/01/08	100	Y	Study Advertised (Proposals Solicitation)
01/14/09	100	Y	Notice to Proceed (NTP) to CSM
02/06/09	100	Y	Kick-Off Meeting with CSM

SIGNIFICANT EVENTS

Note 1: A survey on slope stabilization has been sent to DOTs around the United States, where the DOTs are asked to provide information regarding slope stabilization issues that they may have had to deal with. Eighteen DOTs have responded. You can see the results of the survey as they are updated at https://www.surveymonkey.com. Login as cdot01 with a password of cdot.

Note 2: A site has been visited on SH 72, where short piles (7 foot long, possibly HP8x36-could not verify, although they looked smaller) were used to correct stability issues along this highway.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background

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

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

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

Reporting Period: 7/1/09 through 9/30/09
Type: SP&R Start: 03/30/08

Principal Investigator(s):
Dr. J. Antonio H. Carraro, CSU

Study Manager:
Robert de Dios, DTD Research

Study Panel Members:
James Chang, Region 6 Materials
Gary DeWitt, Region 4 Materials
Rex Goodrich, Region 3 Materials
Donna Harmelink, FHWA
Alan Hotchkiss, HQ Materials and Geotechnical
Shamshad Hussain, Region 1 Materials
Aziz Khan, DTD Research Branch
Cheng 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	05/18/09	Pre-Kickoff Meeting-1, a meeting planned for end of July
07/01/09	80		Task 1 – Literature Review

05/18/09	100	09/11/09	Task 2 - Material selection
08/01/09	25		Task 3 - Laboratory Experimental Program – Phase I
05/01/10			Task 4 - Laboratory Experimental Program – Phase II
07/01/10			Task 5 - Development of the MEPDG Database
09/1/10			Task 6 - Development of the ESR Stabilization Design Protocol
06/1/10			Task 7– Construction of Small-Scale Test and Control Sections
05/1/10			Task 8 - Development of Construction, Monitoring and Documentation Procedures
06/1/10			Task 9– Field Section Monitoring
Every 3 months		07/15/09(QR1) 10/07/09(QR2)	Task 10 - Quarterly and Final Report Writing
06/2010 & 06/2011			Task 11– Research Results Presentation

SIGNIFICANT EVENTS

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.

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

09/07/2009: Documentation on pavement cross section for the Berthoud By-Pass project 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.

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

10/01/2009: Task 3 Update (% progress for all subtasks provided below):

Basic material characterization: 25%

Compaction and time domain reflectometry: 10%

Resilient modulus testing: 0%

Poisson's ratio evaluation: 0%

Swell consolidation testing: 0%

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Strategic Evaluation of Different Topical Protection Systems for Bridge Decks and the Associated Life-Cycle Cost Analysis
Study No: 80.09

Background

Providing an effective system for the protection of concrete bridge decks is the only long-term low maintenance solution to prevent concrete deterioration on bridge deck systems. The current systems used like asphalt membrane (AM) and silane sealers (SS) require routine maintenance activities to insure proper performance. Even though CDOT has had good success using the AM system, it still requires milling a portion of the existing asphalt overlay every 5 to 7 years and replacing it with new asphalt. The milling process often damages the underneath membrane allowing the chloride ions to attack the concrete. In a similar manner, the SS system when used for bare decks without an asphalt overlay, require multiple applications every one to two years in order to provide the protection desired. Traffic wears off the silane sealer especially in the areas of the wheel lines.

Cold weather and freezing temperatures in Colorado require the use of anti-icing chemicals in order to maintain ice-free roads and bridges. Several applications of 28% Magnesium Chlorides ($MgCl_2$) solutions are currently being used as deicing agents on our bridge structures. The chlorides penetrate the concrete porous structure and when the concentration levels get high enough, the rebar will start to corrode. The corrosion causes an increase in the volume of the rebar and applies pressures high enough to cause cracks in the concrete deck. This cracking causes additional chloride intrusion that damages the concrete completely if not repaired timely to mitigate this process.

The objective of this study is to perform a literature review to evaluate topical protection systems and their 75-year service life with an emphasis on the life-cycle cost analysis and to compare it with the service life and cost of the more traditional methods such as waterproofing, AM and SS currently used.

Reporting Period: 7/1/09 through 9/30/09
Type: SP&R Start: 11/07 Ver:
Contract:

Principal Investigator:
Dr. Yunping Xi, Professor at CU-Boulder
303-492-8991

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

Study Panel Members:

Ali Harajli, Bridge Design & Management Branch (Panel Leader), 303-512-4078

Glenn Frieler, R-4 North Program
(970)622-1268

Mark Nord, Bridge Design & Management Branch
(303)512-4073

Golda Davydov, Bridge Design & Management Branch,
(303)512-4200

Gary DeWitt, Material Engineer, R-4
970-350-2379

Mathew Greer, FHWA-Colorado
720-963-3008

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
09/05/07	100	09/05/07	PI Selected
11/02/07	100	12/02/07	Notice to Proceed Issued
01/31/08	100	02/02/08	Completed Task 1 Literature review, and started Task 2 Detailed review

04/30/08	100	05/01/08	Completed Task 2 Detailed review, and started Task 3 for selection of bridges for inspection
06/30/08	100	07/01/08	Selected five bridges for inspection, and get ready for inspection
09/30/08	100	10/09/08	Inspected five bridges, and performed tests on the concrete cores
10/09/08	100	3/30/09	Prediction of corrosion initiation times of the inspected bridges, and life cycle cost analysis of the inspected bridges, development of the final report

RESEARCH TASKS

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
01/31/08	100	02/02/08	Task 1: Literature review
02/02/08	100	02/02/08	Task 2: Detailed review of the bridge inspection reports
09/30/08	100	09/30/08	Task 3: Perform targeted field inspections
10/30/08	100	10/30/08	Task 4: Analysis of data collected in above tasks
01/30/09	100	05/31/09	Task 5: Perform detailed life-cycle cost analysis of each treatment system
02/15/09	90	07/09/09	Task 6: Final report

SIGNIFICANT EVENTS

11/07 Project officially begins

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background	Reporting Period: 7/1/09 through 09/30/09
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 (05/20/08-11/19/09) 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.

	80%	07//09/09	Task 2: Field evaluation of monitoring system
	80%	07/09/09	Task 3: Interim report and testing plan
			Task 4: Field evaluation of sealers
			Task 5: Analysis of field evaluation results
			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.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Field Evaluation and Comparison of Standard and New Methods for Construction of Bridge Approaches in the 120th Construction Project
Study No: 80.16

Background

Currently, MSE (mechanically stabilized earth) embankments are used behind most of the abutment walls in Colorado. Significant settlement problem at the sleeper slab is still observed, leading to abrupt change in elevation grade at the sleeper slab. To alleviate this problem, it is recommended to provide more direct support for the sleeper slab where the settlement problem develops, something currently lacking in CDOT construction details for MSE embankments. After careful review, the study panel decided to investigate the use of driven piles and extended MSE embankment systems for the additional support of the sleeper slab and compare the performance of these two new systems with the performance of the current MSE embankment system. The best way to evaluate the performance of the two new systems is to construct side-by-side approaches, side constructed with the new system and the other constructed with regular MSE embankment system. The new and current side-by-side approaches will have similar foundation systems and bridge superstructures and will be subjected to the same traffic load and environmental conditions. The opportunity to conduct such evaluation and comparison came out in the 120th project where two structures were selected for evaluation: The South Platte structures with two separate bridges (eastbound or EB and westbound or WB) and the Riverdale structure with two separate bridges (EB and WB bridges).

The study objectives are to evaluate and compare the performance of bridge approaches constructed with new and current systems for support of bridge approaches and sleeper slab. The instrumentation work will determine the magnitude, location (edge or center of the highway or all over), sources (foundation, embankment, or fill), and timing (season, 1st year) of the developed settlements. Based on the results, CDOT may make changes to the construction procedure for its future bridge approaches.

Reporting Period: 7/1/09 through 09/30/09
Type: SP&R Start: 05/2005

Principal Investigators:

Study Managers:
Aziz Khan
Research Branch, 303-757-9522
Rene Valdez
R-6, 303-358-0028 and 303-398-6739
William (Skip) Outcalt
Research Branch, 303-757-9984

Study Panel Members:
C.K. Su
Material & Geotechnical Branch, 303-757-9750
Trever Wang
Bridge Design & Management, 303-757-9486
Matthew Greer
FHWA, 303-969-6730

FHWA Washington Contact:

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
5/18/05	100	5/18/05	Develop Instrumentation Plan for the South Platte Bridge
11/15/05		5/31/06	Collect 1st of performance data for the South Platte Bridge and information on the materials and construction of the test sections. Instrumentation was delayed because

			of construction project schedule and is now expected to be complete in October of 2005.
12/1/05		12/1/05	Develop instrumentation plan for the Riverdale bridges.
12/31/05		5/31/06	Collect 1st of performance data for the Riverdale bridge and information on the materials and construction of the test sections.
5/31/06	50		Collect second round of performance data. The collection was delay due to the resignation of the principal investigator. When data collection was attempted in November 2006, it was discovered that the access boxes were buried during the final construction steps. Arrangements are being made to dig out to secure access to the boxes.
4/1/07		10/15/07	Collect the data and complete the second round of performance data.
12/31/09	80		Set of performance data will be collected every six months on the two structures for four years until December 2009.

SIGNIFICANT EVENTS

06/08	Data collected from horizontal and vertical inclinometers, settlement gages both east and westbound. The Surpro 2000 was used to profile across the roadway at the west end of both structures, along the expansion joint.
10/07	Data collected from horizontal and vertical inclinometers, settlement gages both east and westbound. The Surpro 2000 was used to profile across the roadway at the west end of both structures, along the expansion joint.
3/07	Site visit, budget inquiry and meeting with Project Engineer
12/31/05	Problem with construction caused the delay in the construction and thus the research.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Investigation of CDOT Specifications for Flowfill
Study No: 80.23

Background Since 1990, flowfill as an alternate to compacted soil backfill has been used by CDOT to backfill bridge abutments, culvert and pipes, utility cuts, and minor inlet structures because: 1) Its self-leveling ability: it can flow, so no compaction is needed, and it can fill voids and hard-to-reach- zones (curved and cornered zones); 2) Experience negligible settlements after curing; 3) Utilization of fly ash and other waste by-products in the mix; and 4) It is also a low-strength and excavatable material, a feature needed for repair of pipes and bridge approaches. But CDOT has several problems with the use of flowfill: 1) The flowfill is expensive (2004 at a cost of $88.55/CY); and 2) Field performance problems, as seen in the Trinidad Project, due to lack of adequate and tight materials and construction specifications and construction guidelines for the flowfill. To address these problems, CDOT Study Panel concluded that a performance-based specification for the flowfill is needed with the following materials and construction requirements: 1) Flowability with minimum segregation; 2) Strength consistent with easy removal; and 3) Rapid but limited strength gain. Mr. Greg Lowery suggested a performance-based specification for the flowfill. Objectives of this study are to address all CDOT problems with flowfill by critical review and improvement of the following: 1) Draft Revisions of Sections 206 and 703 of CDOT Standard Specifications as proposed by Mr. Lowery. 2) Quality Assurance Procedure for Materials and Construction of Structure Backfill listed in CDOT Field Materials Manual.	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: 12/19/2005 Principal Investigator(s): Task 1 and 2 - David Gonser, (719) 661-4550 Task 3 and 4 - Dr. Vilm Petr, (720) 273-8550 Study Manager: Aziz Khan, Research Branch 303-757-9522 Study Panel Members: Glenn Frieler, R-4 North Program (970) 622-1628 Amanullah Mommandi, Project Development (303) 757-9044 Steve Yip, Staff Bridge (303) 512-4171 Rich Zamora, R2 Materials (719) 546-5778 Joe Garcia, R-2 South Program Engineering, (719) 546-5727 Roberto de Dios, Research Branch 303-757-9975

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
10/1/05		9/30/05	Arrange for a meeting for the research study panel to finalize the scope of this study.
10/31/05		9/30/05	Finalize study scope. Scope of work will advertised on procurement bid system.
12/31/05		12/19/05	Hire a local consultant to perform Tasks 1 and 2 of the study scope that address Colorado's issues. Dave Gonser was hired.
4/1/06		5/31/06	Contact CDOT materials, construction, and design offices to obtain information relevant to this study.
4/1/06		5/31/06	Contact CDOT typical construction contractors to obtain information relevant to this study.
		7/11/06	Draft report for task 1 and 2 submitted
3/1/07	80	3/30/07	After completion of the NCHRP study on the flowfill, hire a national expert to

			address Tasks 3 and 4 of the study. The NCHRP report is still in final review and correction.
5/10/07	100	10/10/07	Select a Consultant/Principal Investigator (PI) for Task 3 and 4.
10/10/07	100	11/05/07	Notice to Proceed

RESEARCH TASKS

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
11/01/07	100	02/05/08	Task 1 (72 days) and Report - 1
01/01/08	100	03/25/08	Task 2 (72 days) and Report - 2
03/01/08	100	04/10/08	Task 3 (72 days) and Report - 3
05/01/08	100	04/25/08	Task 4 (72 days) and Report - 4
07/01/08	85		Task 5 (72 days) and Report - 6
06/30/09	50		Draft and Final Report
			Task 6 (Optional)

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Determination of Strength and Modulus for the Design of Lime Stabilized Soils (Lime Stabilization)
Study No: 80.26

Background

The unconfined compressive strength test been used for decades to characterize lime stabilized subgrade soil behavior when cured under various conditions. The design parameters of interest – flexural strength, deformation potential, stiffness (resilient modulus) can be approximated from the unconfined compressive strength. ASTM D 5102-96 proposes a curing period of 7 days at room temperature or an accelerated curing condition. The MGPEC (Metropolitan Government Pavement Engineers Council) Pavement Design Standards use an accelerated process of 5-day curing at 100°F (38°C). This has become the standard practice of local engineers. The strength difference for both curing conditions needs to be evaluated.

The research should produce the following: (a) correlation of unconfined compressive strength to resilient modulus for lime concentration, curing time and soil types selected; (b) relationship defining unconfined compressive strength gain from 5 to 7 to 28 day curing for each soil type and lime concentration selected.

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

Principal Investigator(s):
Colorado School of Mines, Dr. Mike Mooney, (303) 384-2498

Study Manager(s):
Alan Hotchkiss, Mat. & Geotech Branch (303) 398-6587
Roberto de Dios, Research Branch (303) 757-9975

Study Panel Members:
C.K. Su, Mat. & Geotech Branch (303) 398-6586
Gary Dewitt, Region 4 Materials (970) 506-0359
Aziz Khan, Research Branch (303) 757-9522
Bob Locander, Mat. & Geotech Branch (303) 398-6562
Shamshad Hussain, Region 1 Materials (303) 398-6582
Paul Smith, Mat. & Geotech Branch (303) 398-6549
Mathew McMechen, Region 6 Materials (303) 398-6706
Jim Noll, Kumar and Associates, (303)882-1954

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
10/1/06	100	11/2/06	Hold first panel meeting to discuss scope of work and domain of RFP. This meeting is scheduled for November 2, 2006
10/31/06	100	11/9/06	Finalize scope of work
12/1/06	100	02/27/07	Issued RFP – It was decided that the RFP would be issued to state universities
04/30/07	100	6/11/07	Select PI
01/31/08	100	2/29/08	Task 1: summarize Colorado practice
2/29/08	100	2/29/08	Task 2: perform literature review
3/31/08	100	3/13/08	Task 3: document task 1 and 2 findings and phase II recommendations
4/21/08	100	4/21/08	Panel meeting
4/30/08	100	8/31/08	Task 4: determine optimal lime & moisture-density for 3 soils
6/30/08	100	9/30/08	Task 5: conduct unconfined compressive strength testing

10/21/08	100	10/21/08	Task 6: analyze and present report findings
5/30/09	100	5/31/09	Task 7: resilient modulus and UC testing (& repeat of task 5 testing with high PI soils)
5/30/09	100	6/30/09	Task 8: prepare and submit draft final report
6/15/09	100	7/28/09	Panel meeting
6/30/09	100	9/28/09	Edits to draft final report
6/30/09	100	9/28/09	Submit draft final report/

SIGNIFICANT EVENTS

3/1/09 Task 7 schedule revised to accommodate locating and Task 5 re-testing of high PI soil (we secured a PI=37 soil) and to accommodate the Dec-February renovation of CSM soils lab.

10/21/08 Phase II Report submitted and panel meeting held. Principal Investigator and panel agreed to re-test (task 5) soils particularly a high PI (30-40) soil through 28 day curing, and to carry out Phase III (task 7) as originally proposed.

4/21/08 Phase I Panel meeting held.

3/13/08 Report of Phase I findings and recommended Phase II work submitted by PI to CDOT.

10/18/2007 Held the first study panel meeting with the Principal Investigator (PI). The consultant has started the literature search for correlating the unconfined compressive strength to resilient modulus, the preparation of the summary of Colorado practices, and the development of recommendations for the next phase of work by the end of March, 2008.

9/27/07 The Purchase Order/Interagency Agreement was completed and signed with the Colorado School of Mines with Dr. Mooney as the Principal Investigator (PI). A kick-off meeting between the study panel and the PI was scheduled for October 18, 2007 to discuss the scope and details of the research project.

6/30/07 Research Director Dr. Jake Kononov requested FY07 funding for roll-forward action to FY08. The DTD Business Office is initiating the procurement process.

3/16/07 Two proposals were received one each from Colorado School of Mines and Colorado State University.

3/2/07 Research Branch Manager Jake Kononov sent out solicitation for proposals to state universities and colleges.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Strategic Plan for Data Collection and Evaluation of Grade 50 Piles into Bedrock
Study No: 80.50

Background

Resistance factors vary with the design methodology. In the past, CDOT largely used the blow-count based design methods for determining geotechnical capacity of driven piles. Alternative methods are available and needed to be explored for application in the Rocky Mountain region. Additionally once design methods are chosen, the immediate subsequent task is the evaluation of Colorado-specific resistance factors. To evaluate the Colorado-specific resistance factors, it requires the support of a large database of pile capacity; soils and bedrocks design parameters, and subsurface exploration data. Formulation of a specific plan is needed for the collection of the above-mentioned data and the associated tasks.

To achieve more cost effective foundations by becoming LRFD design compliant while taking advantage of higher pile material strength and larger hammers, and in doing so;
1) Establish a database for driven pile foundations on sedimentary bedrock and friction piles using existing PDA data and data from new projects completed during the study period,
2) Evaluate the potential for Colorado-specific resistance factors for friction piles relative to those provided by AASHTO in order to achieve more economical friction pile solutions
3) Recommend the LRFD design procedures for end bearing driven piles on sedimentary bedrock in order to achieve more economical end bearing pile solutions; and,
4) Recommend future research studies needed for changes in pile design and construction specifications.

Reporting Period: 7/1/09 through 09/30/09
Type: SP&R Start: 07/07 Ver:
Contract:

Principal Investigator:
Dr. N.Y. Chang, Professor (UCD)

Study Manager:
Aziz Khan, Research Branch

Study Panel Members:
H-C Liu, Material & Geotechnical Branch (MGB) – Panel Leader
CK Su, (MGB)
Alan Hotchkiss, (MGB)
Mark Vessely, (MGB)
Richard Osmun, Bridge Design and Management Branch (BDMB)
Trever Wang, (BDMB)
Nurul Alam, (BDMB)
Russell Cox, Region -1 Construction
Frank Rausche, GRL Engineers, Inc.
Matthew Greer, FHWA

1st quarterly progress report

1. Four research assistants attended the workshop on the use of GRLWEAP and CAPWAP programs by Dr. Frank Rausche at CDOT conference in the Materials Lab. on February 7 and 8, 2008.
2. Collected the pile database for 69 piles (10 pipe piles and 59 H piles.
3. All research assistants are capable of using GRLWEAP and CAPWAP programs.
4. Begin to perform DRIVEN analyses and GRLWEAP analyses. The tasks are expected to complete in 1st week of May.
5. UCD research group has been ready to begin the CAPWAP effort. However, some PDA equipment problems cause the delay. Mr. Alan Hotchkiss sent PDA system back to PDI to install a CD drive to facilitate the downloading of PDA files. Mr. Spencer from PDI promised to send the PDA system back to CDOT in one week on April 12, 2008. So the machine should be back to CDOT shortly and we should then have the PDA database. Once available, CAPWAP effort will begin immediately.
6. The UCD research group aims at delivering the product in a timely fashion. So far the progress indicates that projected time frame for the delivery can be achieved.

2nd quarterly progress report (April to June, 2008)

1. Discussion of the coordinated use of DRIVEN, WEAP, and CAPWAP in the design of driven piles.
2. Driven analyses were completed on all 60-plus boring holes and results summarized. The results indicate the variation of drilled shaft capacity in both shaft and end bearing resistances.
3. WEAP analyses were partially completed and effort will continue into the next quarter (July, August, and September) and results summarized.
4. CAPWAP analyses were completed on all data with the PDA records for H piles of Grade 50 steel. The records showed that the PDA monitors were all conducted after 2001. This could be due to the timing for the switch from Grade 36 to Grade 50.
5. Some WEAP analyses were also performed on some peculiar geological conditions occurring in Colorado, such as thin layers of sandstone, claystone, and clay shale, etc.
6. Effort has also been devoted in zoning the Colorado based on geological distinction.
7. The CAPWAP analysis results show that the CASE capacities provided by CDOT are, in general, higher than the corresponding CAPWAP capacities through PDA signal matching. The latter are considered more precise than the former.
8. The above higher CASE capacities show the critical nature of the choice of J_c. The CDOT chosen values for J_c were, in general, lower than the values depicted in the CAPWAP analyses.
9. The UC Denver research group visited the Plum Creek site for the temporary bridge widening project, where a steel pile was driven with PDA monitoring. The first on-site exposure for the students. Some good information was observed and learned.

3rd quarterly progress report (July 1 to September 30, 2008)

1. Completed all DRIVEN, WEAP, and CAPWAP analyses for all the data made available to the study group.
2. The above analyses were performed for both Grade-50 Steel H-piles and Pipe Piles.
3. Began to analyze, discuss, and summarize the results of the above-mentioned analyses.
4. The above mentioned types of analyses are still continuing for the new PDA data from the Plum Creek project and Greely project.
5. Began to organize the analysis results for the final report. Some preliminary observations are provided as:
    a. For the Steel H-Piles in sand, using the full box surface area of an H-pile will result in the gross over-estimation of the pile capacity. The half box area provides much better result.
    b. GRLWEAP shows that the pile capacity is very sensitive to both damping and quake and the use of default values is not advised.

4th quarterly progress report (October 1 to December 31, 2008)

1. Continual discussions and interpretation of all analyses results for drawing the conclusions of this study.
2. The study group has contacted and obtained Dr. Frank Rausche's comments to the interpretation of some analysis results pertaining to some special geological conditions.
3. All analyses were completed and the results are being interpreted for special geological conditions.
4. Final research report is being drafted and the final draft will be submitted for review by the end of February.

5th quarterly progress report (January 1 to March 31, 2009)

1. The Phase I final report is completed and will be submitted by April 30, 2009.
2. The work plan for Phase II study will be submitted for review by the Study Panel.

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
11/05/07	100	11/05/07	PI Selected
12/17/07	100	12/17/07	Notice to Proceed Issued
02/04-08	100	01/31/07	Meeting Alan Hotchkiss three times about the database, PDA system, and copying some documents pertinent to the proposed research. Marked on a Colorado geology map the locations of all PDA monitored piles. Next step is to perform DRIVEN and WEAP. The PDA database is not available yet and upon its availability, we will begin to perform CAPWAP analyses.

2/7-8/08		2/8/08	Finish training for GRLWEAP and CAPWAP
2/29/08		2/20/08	Collected the pile database for 69 piles (10 pipe piles and 59 H piles
3/1/08		3/30/08	All research assistants are capable of using GRLWEAP and CAPWAP programs.
5/1/08	100	5/1/08	Begin to perform DRIVEN analyses and GRLWEAP analyses. The tasks are expected to complete in 1st week of May.
5/31/08	100	5/31/08	CAPWAP effort to assess the pile capacity
6/30/08	100	6/30/08	Delivery of the 2nd quarterly report including the design and construction procedures
9/30/08	100	10/17/08	Delivery of the 3rd quarterly report including the design and construction procedures

TASKS

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
7/30/08	100%	9/30/08	Task 1: Review the current status of LRFD procedures
9/30/08	100%	9/30/08	Task 2: Establish the driven pile capacity database
11/30/08	100%		Task 3: Recommend design and construction procedures
12/31/08	80%		Task 4: Using reliability theory and CDOT PDA database and/or data from others; recommend if specified AASHTO PDA test frequency can be reduced per prior CDOT experience.
12/31/08	25%		Task 5: Update the resistance factors for friction piles based upon driven pile capacity data in CDOT PDA database
01/31/09	95%		Draft Final Report for review
03/31/09	95%		Final Report

SIGNIFICANT EVENTS

4/1-6/30/08	Numerous communications with Alan Hotchkiss to obtain PDA data and also many technical discussions.
6/15/08	Completed CAPWAP analyses for all available PDA data.
6/25/08	Visited the construction site at the Plum Creek Bridge site to witness the PDA monitoring during the driving of an H pile at the temporary bridge widening project.
6/30/08	Completed all Driven analyses
9/30/08	Completed 100% of all GRLWEAP and CAPWAP analyses where PDA data are available.
9/30/08	Begin to perform the sensitivity analyses of the effect of damping and quake on the pile capacity assessment.
9/30/08	Begin to study the effectiveness of N-based capacity assessment with the intent of establishing a new formula for the capacity evaluation at a given blow counts, N.
9/30/08	Extend the study into the pipe pile capacity in a thick sandy silt and silty sand deposit in the Eastern Plain of Colorado.
10/17/08	The project progress is on schedule.
12/31/08	All project related tasks and analyses for Phase 1 of the study have been completed. The final report to CDOT is being drafted. The draft is expected to be ready for review by the end of February 2009.
3/31/09	The final Phase I report is complete besides putting it in the final format. Phase II work plan will be submitted for review.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Documentation of Cantilever Signal Support Structures' Wind Response and Analysis of Existing Response Models (Mast Arm Galloping)
Study No: 82.02

Background Signal support structures are approximately cylindrical in shape with a highly tapered diameter. The addition of traffic signals and other components results in dynamic properties, e.g. frequency, that causes cantilevered signals to be susceptible to wind induced vertical motion which is most likely a combination of vortex shedding and galloping. This vertical motion has a significant effect on fatigue life at/near the connections for these long slender steel structures. To date, this problem has been addressed by increasing the resistance, or strength and stiffness, of the structure, e.g. the addition of stiffeners. Numerical modeling of wind/structure interaction has progressed enough in the last 15 years that it is now possible to accurately model the interaction behavior, opening the door to explore better, more economical solutions. As mentioned above, transverse motion (vertical for the cantilevered signal support arm) can be observed routinely depending on the dynamics of the structure and wind velocity. Researchers at Colorado State University recently completed a CDOT project for the Safety and Traffic Branch that developed a method for reliability-based design of high-mast lighting structural supports. During that project, the researchers developed a 3-D wind-structure interaction model which was used during the study.	Reporting Period: 7/1/09 through 9/30/09 Start: Budget Amount: $ 80,000 Principal Investigator: Dr. John van de Lindt, CSU 970-491-6605 Study Manager: Rich Sarchet, DTD-Research 303-757-9518 Study Panel Members: Lynn Croswell, HQ-Bridge Ken DePinto, ITS Branch Jake Kononov, DTD-Research Jeffry Lancaster, R6 Signal Foreman Richard Osmun, HQ-Bridge

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
9/07	100%	11/09/06	Solicitation for Task Proposals circulated to NPS Consulting Contractors
	100%	12/07	Proposal from CSU selected.
	100%	1/08	Contract completed, NTP issued
5/08	50%		Literature Review
4/08	100%	3/09	Develop a method to instrument
5/08	100%	6/09	Install instrumentation
5/09	20%		Data Collection
6/09			Exploratory Data Analysis
7/09			Final Report

SIGNIFICANT EVENTS

3/08 The instrumentation was tested using a "loaner" from the manufacturer and after several accelerometer changes is working.

4/08 A sole source justification was prepared and submitted for purchase of the instrumentation.

6/08 Instrumentation ordered for July delivery.

9/08 Instrumentation package will be tested in controlled conditions on campus during October. Field installation expected in November.

12/08 Selected anemometer did not perform adequately in on campus test. Replacement selected. On campus testing planned for January – Site installation now planned for February, weather permitting.

3/09 Replacement Anemometers are in hand and have performed well in on campus testing (which didn't take place until March). Field installation tentatively planned for late April, again weather permitting.

6/09 Field installation occurred in June after several aborted (due to weather) attempts.

9/09 First field location functioning well – installations at 2 additional sites planned for October.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Research Study Evaluating the Specifications for Class H and HT Crack Resistant Concrete
Study No: 84.14

Background Cracking of reinforced concrete is a problem that has baffled maintenance and bridge engineers since it was first developed. Cracking allows water and contaminates to enter the structure and corrode the reinforcing steel. A concrete structure that is constructed with a concrete that is less susceptible to cracking will last longer and be more maintenance free than one that is susceptible to cracking. CDOT has developed a Class H and HT concrete that is meant to fill the requirement of a crack resistant concrete. Though the current specification is an improvement over the Class D concrete that is commonly used, there are still some problems with cracking. In addition, the current specification allows the concrete to achieve full strength at 56 days of age. All mix designs submitted thus far meet the full strength requirement in less than 7 days. Since all Class H and HT mix designs submitted thus far meet the strength requirement in less than 7 days, why does our spec allow 56 days? Additional questions need to be answered include: • Are the bridge decks that were built with Class H concrete cracking due to thermal expansion or evaporation? • Would a specification that limited the amount of strength growth in the first 7 to 10 days decrease the cracking potential of the finished product? • Is there a better test than AASHTO PP 34 to predict the cracking potential of a mix design? • Does the current specification require 56 days to reach full strength? Can the specification be revised to require full strength in the standard 28 days?	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: 07/07 Ver: Contract: Principal Investigator Dr. Stephan Durham, Professor at UCD Study Manager: Aziz Khan, Research Branch Study Panel Members: Glenn Frieler, Material and Geotechnical Branch (Panel Leader) Ali Harajli, Bridge Design and Management Branch Gary DeWitt, Material Engineer, R-4 Eric Prieve, Materials and Geotechnical Branch Brooke Williams, Holcim (US) Inc. Mathew Greer, FHWA-Colorado6 :

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
11/05/07	100	11/05/07	PI Selected
12/17/07	100	12/17/07	Notice to Proceed Issued
01/25/08	100	01/25/08	Project “Kick-Off” Meeting
03/24/08	100	03/24/08	DOT Survey Findings Report Submitted to the CDOT
03/24/08	100	05/30/08	Literature Review Completed

RESEARCH TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
03/31/08	100%	05/30/08	Task 1: Literature review
03/31/08	100%	03/24/08	Task 2: Conduct a national survey of state DOTs
3/31/08	100%	08/01/08	Task 3: Review current physical property tests and research other test procedures
07/01/08	100%	08/31/08*	Task 4: Design various concrete mixture using local cement and aggregates
07/01/08	80%		Task 5: Acquire needed materials and batch mixes for physical properties testing
07/01/08	75%		Task 6: Run material properties testing on these mixture designs to determine whether they meet or exceed the current specifications
08/01/08	75%		Task 7: Compile all data and compose reports as per CDOT's research guidelines

*It is expected that the research team may design and batch additional mixtures beyond the ten mixtures included in this report.

SIGNIFICANT EVENTS

12/07	Project officially begins
01/08	Project "Kick-off" meeting
03/08	DOT Survey Findings Report Submitted
03/08	Progress Report Submitted
03/08	UCD Concrete Materials Laboratory Inspection Scheduled
06/08	Progress Report Submitted
10/08	Progress Report Submitted
12/08	Batching and Testing of Concrete Mixture Designs Started
01/09	Progress Report Submitted
03/09	Progress Report Submitted
03/09	No-Cost Extension Submitted to the CDOT for Period 04/01/09 – 09/30/09
04/09	No-Cost Extension Accepted
07/09	Progress Report Submitted

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Comprehensive Risk Analysis for Structure Type Selection
Study No: 86.00

Background

Historically, little "soft" data (such as traffic operations, user cost for detours and delays, and safety during construction) are typically included in this evaluation and selection process, and if included, no model or consistent procedure is available to include / evaluate these issues.

Recent investigations through NCHRP, TRB, etc. have begun to quantify direct and indirect "construction" costs related to accident risk (both rate and severity) during construction, user delay time to the traveling public during construction (both on the route under construction and on detour routes), and safety of workers during various construction operations. This project will consider a comprehensive approach to total cost optimization, utilizing a risk-based decision model. Tradeoffs among structural design "optimization", direct construction costs, and indirect construction cost to various stakeholders will be included and quantified.

Optimization of bridge selection and design is generally sought in terms of the finished structure. A comprehensive risk-based analysis that includes all issues during the construction phase will lead to more effective and efficient designs for the State of Colorado. The appropriate balance of tradeoffs between the structural design and the construction issues can be made explicit. Facility construction cost and risk-based issues of erection costs and public user costs can be demonstrated..

Reporting Period: 7/1/09 through 9/30/09
Start: Budget Amount: $ 80,000

Principal Investigator:
Dr. Ross Corotis, CU 303-735-0539

Study Manager:
Rich Sarchet, DTD-Research 303-757-9518

Study Panel Members:
Bryan Allery, CDOT HQ Safety and Traffic
Aziz Khan, CDOT DTD Research Branch
Jake Kononov, CDOT DTD Research Branch
Scott McDaniel, CDOT R1 East Program
Richard Osmun, CDOT HQ Bridge Dsgn/Mgmt
Zane Znamenacek, CDOT R3 Traffic and Safety

FHWA Washington Contact:

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
3/07	100%	6/07	Notice to Proceed
8/07	100%	9/07	Kick off Meeting – task 1
11/07	100%	12/07	Gather Project Data – task 2
12/07	100%	6/09	Assemble Duration Data for Construction Phases for Various Structure Types – task 3
2/08	100%	6/09	Assemble Accident Data as a Function of Roadway Characteristics and Volume – task 4
3/08	60%		Analyze data on Traffic Delays Due to Different Construction Operations – task 5
5/08	50%		Analyze Accident and Construction Process Data – task 6
8/08	20%		Develop Decision Flow Diagram – task 7
10/08			Final Report – task 8

SIGNIFICANT EVENTS

6/09 Data collection is complete. Progress is being made on remaining tasks.
9/09 Still some difficulty in getting project specific information from those familiar with the projects.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Innovative Bridge Research & Construction (IBRC)
Self-Consolidating Concrete Demonstration
Study No: 87.40

Background

As part of a national experiment sponsored by FHWA under the Innovative Bridge Research and Construction (IBRC) program, CDOT will be putting to work an innovative material called self-consolidating concrete (SCC) in the abutment, piers and retaining walls of several structures in the town of Trinidad and Mead, Colorado. SCC is a very fluid and stable concrete mixture, which is known for its excellent deformability, high resistance to segregation and its use without applying vibration. SCC can be produced by adjusting mixture proportions and using special admixtures such as viscosity-modifying admixtures (VMA) and high-range water-reducing agents.

The use of conventional concrete for bridge components can lead to inadequate consolidation of concrete mix in the congested and hard to reach reinforced area, causing entrapped air that can compromise the concrete's strength and durability. Due to its fluidity, SCC can be placed in forms with congested reinforcement eliminating the need for vibration. In general, SCC mixes must meet three key properties:

1. Ability to flow into and completely fill spaces under its own weight.
2. Ability to pass through and bond to congested reinforcement without vibration.
3. High resistance to aggregate segregation

The ultimate goal of this study is: 1- to examine the feasibility of the use of SCC mixes in Colorado. 2- Develop step-by-step guidelines that can be used for future projects.

Reporting Period: 7/1/09 through 9/30/09
Type: IBRC Start: 06/05 Ver:
Contract: HAA 05 HTD 00108

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

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

Study Panel Members:
Dick Osmun, Staff Bridge 303.512.4202
Joe Garcia, CDOT R2 Const. 719.546.5727
Glen Frieler, R-4 North Program 970-622-1268
Matt Greer, FHWA 720.963.3008

FHWA Washington Contact:

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
04/30/05	100%	6/27/05	Research Branch will secure a task order with Colorado School of Mine (CSM) to initiate the work for this research study
09/30/05	100%	09/30/05	Development of background, collecting and reviewing literature related to SCC
const. sch. dep.	100%		Evaluation of SCC for the construction of the abutments, piers, and retaining wall examining lateral pressures on the forms, drop height, aggregate blocking, stability, and evaluate segregation at Trinidad site.
1/06	100%	10/1/06	Determination of the vibration characteristics (frequency & amplitude) for selected girders with and without traffic at the Mead site. The Mead bridge was instrumented and data has been collected for vibrations under many traffic combinations including the following: 1. Small vehicles on left lane only. 2. Small vehicles on right lane only. 3. Small vehicles on both lanes. 4. Big trucks on left lane only. 5. Big trucks on right lane only. 6. Big trucks on both lanes. 7. General traffic.

5/06	100%		Required lab testing, which includes casting specimen with embedded bar for rotational and axial testing while concrete being cured with the intent of identifying the shortest curing time that allows the application of the load. Dynamic tests are currently conducted at the School of Mines structural laboratory. Concrete blocks with model beam inserts are created. Some cure while being vibrated for 24 hours with the recorded vibrations of the Mead bridge, while others cure perfectly still. Pull-out tests are performed to evaluate the effects of beam vibrations during curing.
8/06	100%		Draft report that discusses the findings, conclusions of the task 5 and 6 at the Mead site
4/07	60%		Evaluate and observe the contractor's SCC mix at the Mead site. Based on an earlier meeting that the PI had with the CDOT staff it was decided that the SCC mix developed at the Colorado School of Mines will be used in this project. Unless this plan changes in the future, this SCC mix has been evaluated for static and dynamic stability, for strength, and fluidity. Pumping, ring-test for shrinkage, and vibration tolerance testing is currently under way.
9/07	90%		A report summarizing the SCC activities for the Mead site
1/08	100%		Placement of SCC at the Trinidad site has seen both successful and moderately acceptable results. A retaining wall was completed with acceptable placement techniques and consolidation. The placement of SCC at the Northern abutment at the Main Street Bridge incurred insufficient flow characteristics out of the pump, resulting in visual stratification of the concrete, as well as poor aesthetic results in the artificial rock face incorporated in the forms. Upon mix design refinements, the Southern abutment achieved acceptable results. Three main span piers were cast successfully with SCC, whereas one pier designated to be cast with SCC was replaced with Class D concrete due to multiple problems with air content in the delivered SCC. The concrete batching company complained about inconsistencies with the air content due to variable ambient and concrete temperatures.
3/08	95%		Reviewing results of contractor placement of SCC at the Trinidad site and reporting the quality of the finished product at the Main St. abutments, retaining wall and 8 pier locations. Compiling a survey for the contractor and CDOT personnel to determine their opinions about the use of SCC at the Trinidad site.
10/08	100%		Panos Kiousis (PI) and Brent Whitcomb of CSM met with CDOT representatives to present current status of the project. Discussed construction practices and finished results at the Trinidad Bridge. Also discussed the difficulties of the concrete producer to meet entrained air requirements and maintain sufficient flowability throughout the placement timeline, the failure of which has resulted in concrete surface imperfections at some locations on the Trinidad bridge abutments using form liners. Lessons learned during placement in Trinidad shall be incorporated at the Mead site.

SIGNIFICANT EVENTS

09/09 The final report for the Trinidad site is almost complete.

07/09 The final report for the Trinidad site is now under preparation.

12/08 The project has been extended for a year to allow for the unavoidable delays in the repair of the Mead Bridge, which is now tentatively scheduled for the summer of 2009.

10/08 The bulk of the project has been completed. The most significant tasks that remain are as follows: 1) Visit the Trinidad site for a final inspection of the SCC elements. 2) Complete the final report associated with the Trinidad Bridge. 3) Execution of the Mead project (expected

during summer of 2009, depending on availability of funds). 4) Final report on the Mead Bridge.

12/06: Aziz Khan was hired as the Structures and Geotech Research Manager and is now the manager for this project. Sharon Wilson has retired and will no longer be a panel member.

06/06: Ahmad Ardani, the study manager, retired. The Trinidad project (IM 0251-166, PCN 14551) is scheduled to go to Ad on July 27 with bid opening planned on September 21, 2006.

September 05- Due to high bid (15 percent over the engineer's estimate) this project is being re-advertised in early 2006.

June 05- Contract for this study was finalized and fund was appropriated.

March 05- The low bid for the Trinidad project came in over the engineer's estimate by more than 10 percent. As a result, the project will be re-advertised in June with notice to proceed in early August. This will delay the project by about 4 months.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Deterioration and Cost Information for Bridge Management
Study No: 87.60

Background PONTIS is a comprehensive bridge software management program developed as a tool to assist in the challenging task of managing bridge inventories (http://aashtoware.org/). PONTIS stores bridge inventory and inspection data; formulates network-wide preservation and improvement policies for use in evaluating the needs of each bridge in a network; and makes recommendations for what projects to include in an agency's capital plan for deriving the maximum benefit from limited funds. CDOT's bridge inspection unit is directly responsible for the inspection of the bridges on the State Highway System, the administration of consultant contracts for a bridge inspection program for the city and county bridges, and maintaining inspection standards using PONTIS. CDOT's bridge management unit is responsible for bridge database maintenance, development, and all reports derived from the bridge inspections and the resulting databases. The primary product of this research will be an effective and functioning use of the preservation module in PONTIS that is appropriately calibrated for Colorado's bridges. The module will be able to include realistic deterioration rates for various bridge elements used in the State.	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: 11/08 Ver: Contract: Principal Investigator: Dr. George Hearn, Associate Professor of Civil Engineering, University of Colorado, Boulder 303-492-6381 Study Manager: Aziz Khan, Applied Research and Innovation Branch, 303-757-9522 Study Panel Members: Jeff Anderson, Bridge Design and Management Branch (Panel Leader), 303-757-9188 Mark Nord, Bridge Design and Management Branch, 303-512-4073 David Ellison, Bridge Design and Management Branch, 303-757-9068 Jake Kononov, Applied Research and Innovation Branch, 303-757-9973 FHWA Washington Contact: Mathew Greer, FHWA-Colorado 720-963-3008

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
06/15/08	100	06/30/08	PI Selected
9/30/08	100	11/03/08	Notice to Proceed Issued
12/04/08	100	12/04/08	Kick-Off Meeting
12 /08	100	12/22/08	Meet with CDOT Maintenance about maintenance management system
5/1/08			Interim report & meeting with study panel
1/1/09			Draft final report
2/28/09			Final report

RESEARCH TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
2/1/08	80		1. Literature Review
3/1/08	60		2. CDOT databases
3/1/08	80		3. Other DOTs
4/1/08	20		4. Deterioration data
7/1/08			5. Calibrate deterioration
9/1/08			6. Reliability Analysis
9/1/08			7. Inspection reliability
10/1/08	50		8. CDOT cost data
10/1/08			9. Cost data by region
11/1/08			10. Input to PONTIS
11/1/08			11. Transition probabilities
1/1/09			12. PONTIS scenarios
1/1/09			13. Automated data process
2/28/09			14. Final report

SIGNIFICANT EVENTS

2008 – Fourth Quarter

The kick-off meeting was held on Dec. 4, 2008 at CDOT offices in Denver. Minutes of the meeting were submitted by CU on Dec. 9, 2008.

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

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

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

2009 – First Quarter

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

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

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

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

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

2009 – Third Quarter
Work in the third quarter included:

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

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Safety Performance Functions for Intersections
Study No: 90.72

Background	Reporting Period: 7/1/09 through 9/30/09 Start: Budget Amount: $ 250,000 Principal Investigator: David Hattan, Felsburg Holt and Ullevig 303-721-1440 Study Manager: Rich Sarchet, DTD-Research 303-757-9518 Study Panel Members: Bryan Allery, HQ Safety and Traffic Branch Jake Kononov, DTD-Research, 303-757-9973 Scott Thomas, Apex Engineering Zane Znamenacek, R3 Traffic
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 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 intersections using data from Colorado highways.	

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
	100	10/1/07	Establish Study panel and hold first meeting.
	100	10/3/07	Finalize scope of work and determine domain for RFP. (Domain is NPS Consultants)
	100	10/4/07	Issue RFTP
10/31/07	100	10/29/07	Select Principle Investigator
11/15/07	100	1/31/08	Notice to Proceed
8/31/08	100	6/09	Task 1, Data Collection
9/30/08	100	08/09	Task 2, Develop Intersection SPFs
11/30/08			Task 3, Draft Final Report
1/31/09			Final Report

SIGNIFICANT EVENTS

NTP Issued 1/31/08 after unexpected difficulty in developing Task Order agreement

Feb and Mar 08, Initiated work to review CORIS database to identify study intersections. GIS work including spatial analyses for data organization and evaluation of identified intersections also underway.

June 08, Preliminary needs for additional field data collection identified.

Sept 08, Additional funds have been identified to allow increased data collection – this will

require an exemption under CDOT hiring freeze – exemption has been applied for.
12/08 Still waiting on exemption to allow expansion of the project. Original scope nearly complete except for final report.

3/09 Scope expansion approved and data collection in progress. Interim report (more or less the draft final report for the original project scope) expected in May.

6/09 Interim report received. Data collection for increased scope complete. SPF Development underway for additional intersection types.

9/09 Draft Version of Final report is in progress. Expect CDOT to receive draft report in early November

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: 7/1/09 through 9/30/09
Type: Experimental Feature

Principal Investigator:
Skip Outcalt, CDOT Research, 303.757.9984

Study Manager:
Skip Outcalt CDOT Research 303.757.9984

Study Panel Members:
John Crowder, R1 Eng. 303.716.9925
Tony DeVito R1 Eng. 303.716.9925
Larry Haas, R4 Traf. 970.350.2143
Rick Jensen, Sec 1 Maint 970.535.4757
Steve Johnson, Stds & Design 303.757.9083
Al Roys, Sec 1 Maint 303.910.8574

FHWA Contact:
Marcee Allen, FHWA CO Div. 720.963.3007

MILESTONES

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

SIGNIFICANT EVENTS

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

LED Lighting to Replace Overhead Lighting
Study No: 92.20

Background State law requires lighting methods to minimize light pollution caused by overhead lighting at highway interchanges. Light pollution or trespass can be a significant problem, especially when overhead lighting is employed on elevated structures. During reconstruction of a pair of structures on I-25 in Trinidad, the overhead luminaire lighting will be replaced by Light Emitting Diode (LED) lights mounted on the barriers adjacent to the highway rather than on poles above the structures. The LED lighting will be evaluated for effectiveness in delineating the highway and interchanges associated with the structures, and for costs and ease of installation and maintenance, and durability of the LED lighting components The study will continue for 5 years to provide time for evaluating the durability and life of lighting components. Accident data will be gathered during the study and compared with a like time period before construction. Implementation This study will be an assessment of the durability and cost effectiveness of barrier mounted LED lighting in lieu of overhead lighting.	Reporting Period: 7/1/09 through 9/30/09 Type: Experimental Feature Principal Investigator(s): Nancy Clanton, Clanton & Assoc 303.530.7229 Study Manager: Skip Outcalt, CDOT, 303.757.9984 Study Panel Members: Gregg Adams, Clanton & Assoc 303.530.7229 Joe Garcia, Reg 2 Design 719.546.5727 Darrell Dingus, Stds & Design 303.757.9083 Doug Lollar, R 2 Eng 719.546.5439 Dwayne Wilkinson, Safety 303.512.5134 FHWA: Marcee Allen, FHWA CO Div 720.963.3007

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
04/04		04/04	Establish study panel
05/04		04/15/04	First study panel meeting to determine the methods of research and evaluation.
07/04		07/04	Initial evaluation of the light levels associated with the overhead luminaire lighting on the two structures on I-25 in Trinidad. Levels on the deck and on the ground below the structure will be measured to compare with levels after the LED installation.
7/08	100		Begin construction of the structures including the installation of the LED lights to replace overhead luminaires.
9/09			Light levels of the of the LED lights at Trinidad initial post construction evaluation.
01/10			Evaluation of the measured post-construction light levels by Clanton & Assoc.
			Other projects may be added to the study as they become available.

SIGNIFICANT EVENTS

9/09 – Construction complete. Light levels were taken on the deck with only the LED lights on. Clanton & Associates will evaluate the light levels and prepare an interim report. Due to time

constraints and construction scheduling, the evaluation of the light levels was done before the lane stripes were painted on the deck. Start of construction of the southbound lanes requires two way traffic on the northbound structure which will be in effect until the completion of the new southbound structure. Further evaluations will be made when the southbound structure is complete and ready for traffic.

12/08 – About 25 % of the bridge rail is done; 90% is expected to be done by March. LED installation will begin late April or May, 2009

07/08 – Girders are being set. Deck and barrier work should begin around January, 09.

07/07 – Demolition of the structures has begun. The power to the northbound bridges was cut so some of the light standards could be removed, so it was not possible to gather pre-construction light data in the northbound lanes. The data previously collected on the southbound bridge will be used.

12/06 – Demolition of the existing structures is scheduled for April of 2007, construction of the new structures is scheduled to begin July 2008 and completion is planned for June of 2009.

09/30/06 – The project has yet to be awarded.

06/19/06 – The scheduled Ad date is July 20, bid openings on Aug 31 for the new project. Since the plan now is to construct northbound first, the baseline readings will have to be re-taken. Dates for the Milestones will be established after the project has been awarded and the schedule established.

01/06 – Region to re-advertise the NB project on June 15, 2006

11/05 – Region is waiting for decision if additional money will be given to the project to AD as whole project or half a project. AD date postponed until sometime in 06.

11/05 – Referendum C passed, D failed.

5/05 – The project will be re-advertised in January 06. Depending on the passing of Referendums C and D it may be done as either a single project or two separate projects.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

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

Background Wild animal vehicle (WAV) collisions are a serious problem in Colorado. The current practice of establishing deer and elk fencing to keep animals off of the highway in major roadway corridors can disrupt existing migration patterns of deer and elk herds that reside in the area. It may also result in the inability to co-mingle herd populations, resulting in increased in-breading. This study will look at two methods of reducing wild animal vehicle (WAV) accidents without limiting herd migration routes. For comparing the two methods, an ITS Branch report, titled *US-160: Study on Analysis of Accidents Involving Wildlife*, was used to identify two areas with similar accident histories, terrain topographies, and roadside foliage. On average 30 to 40 percent of the accidents recorded on these segments are wild animal vehicle collisions – one of the highest WAV accident rates in the state. The Vegetation Clearing Treatment Area, on US-160 from M.P. 97.5 to 98.5, will analyze improving driver visibility of the roadway shoulders through controlled and managed clearing of roadside foliage. This will be evaluated by comparing historic WAV accident statistics within the area with WAV accident statistics after the foliage clearing has been made. A control area will be selected in order to eliminate potential confounding variables. The Animal Detection/Driver Warning Treatment Area, on US-160 from M.P. 95.5 to 96.5, will include the same controlled and managed clearing of the roadway shoulders as in the Vegetation Clearing Treatment Area. In addition, electromagnetic detection equipment will be used to determine when wildlife is within the shoulder area of the roadway. When animals are detected, drivers entering the area will be warned by a series of blank out signs that alert drivers to the fact that animals are actually entering the roadway.	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: As soon as SOW is finalized Ver: Principal Investigator(s): Chris Beller, CDOT Region 5, 970.385.3622 Study Manager: Mike McVaugh, CDOT Region 5 Traffic Engineer 970-385-8360 Study Panel Members: Chris Beller, CDOT Region 5 970-385-3622 Jon Holst, CDOT Region 5 970-385-1473 Paul DeJulio, CDOT Region 5 970-382-9095 John Nelson, CDOT ITS 303-512-5820 Bruce Coltharp, CDOT ITS 303-512-5807 KC Matthews, CDOT Staff Traffic 303-757-9543 Patt Dorsey, CDOW Rick Santos, FHWA 720-963-3009

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
10/7/05	99%		Final Scope of Work to be completed. Draft scope of work reviewed by study and discussed with PI.
10/15/05	50%		The Region and the ITS Branch have been investigating and evaluating various technological detection applications such as; infrared sensors and cameras, motion sensors, geophones, triggers, DVR recorders (and environmentally controlled cabinets) etc. in order to determine the most effective technology and all necessary interface requirements. Also, we have been evaluating power and communications requirements.
11/21/05			Began a lighting simulation analysis to determine lighting spacing and angulations based on lighting capabilities in conjunction with terrain, and optimum lighting color.
11/21/05	100%		Region cleared brush in the study segment and in a control segment.

1/19/06	100%		Completed lighting analysis to determine spacing and lamp requirements
1/30/06	100%		Completed preliminary cost estimate, which indicated that budget is inadequate to implement the entire one-mile section.
2/15/06	100%		Performed field evaluation on infrared sensors to determine if they could identify animals and be tuned to their profiles.
3/8/06	50%		Investigated buried cable sensor system and scheduled call with vendor for 4/7/06.
4/7/06	50%		Met w/ vendor. Scoped system feasibility, parameters, cost.
5/30/06	100%		Received Enhancement grant request from Southern Rockies Ecosystem Project.
7/21/06	100%		The Region obtained revised quotes from the vendor for a 0.2-mile test section and an additional 0.8 mile test section (if additional funding becomes available).
8/16//06	100%		The Region submitted a grant application for $143,920 to the Mule Deer Foundation requesting that the foundation pay for the sensor control modules and sensor cable.
8/21/06	100%		The Region submitted an application for CDOT Hazard Elimination Funds in the amount of $702,624 to supplement the project budget.
9/25/06	100%		The Region completed sole source justification and procurement requests for $77,334 to purchase the equipment and vendor support for the 0.2 mile test section.
	100%	10/06	Secured HES funding of $600,000
	100%	12/06	Design “Elk Farm” Test Section
	100%	2/07	Construct and Test “Elk Farm” Test Section
8/07	100%	11/07	Advertise US 160 Test Section
	100%	12/07	Project Awarded – Construction Schedule TBD (2 feet of snow on ground at site).
	100%	9/08	Test section construction

SIGNIFICANT EVENTS

11/05 – The brush was cleared in the control and study sections on US-160

3/06 – Reviewed available technologies for sensing.
Refined cost estimate. Unable to complete project with fiscal ’07 funds.
Preliminary decision to phase system multi-year, starting with detection system first year.

4/06 Met with vendor. Scoped system and cost estimate. No response from other vendors.

5/06 Enhancement request from SREP (Southern Rockies Ecosystem Project) for separate source of additional
funding for project.

6/06 Unable to find additional buried cable sensing vendors meeting requirements. Identified sole-source
vendor and out-of-state travel issues for implementing detection system.

7/06 Revised vendor estimate obtained for 0.2 mile test section (within budget).

8/06 Additional funding requests submitted to the Mule Deer Foundation and CDOT Traffic and Safety.

9/06 Sole source justification and procurement requests submitted for 0.2 mile test section.

10/06 Team secures $ 600,000 in HES funding for detection system.

11/06 Team designs limited test section at local elk farm to test detection and size threshold.

12/06 Team schedules delivery of elk farm test section components and installation/installation training.

02/07 Team successfully tests detection system at elk farm. Installation training by Vendor.

03/07 Team starts preparing design for US 160 test section, CDOT project for advertisement.

06/07 Preparation of plans for full scale test section bid package continues. Late August advertisement is expected.

11/07 After Delays due to funding issues the project is advertised

12/07 Project Awarded – The advertising delay has resulted in the arrival of winter before construction could begin.

3/08 Still waiting for snow to melt

6/08 Construction in progress!

9/08 Test section is complete. Data collection in progress.

12/08 Still collecting data

6/09 Data collection continues

9/09 Should have a year of data at this point.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Worker Safety
Study No: 93.00

Background The aim of the study is to identify organizations performing work of types similar to CDOT which have exemplary worker safety records, determine what characteristics differentiate these organizations from their peers and identify ways in which CDOT can emulate the best practices identified to become an exceptionally safe organization.	Reporting Period: 7/1/09 through 9/30/09 Type: SP&R Start: FY'07 Ver: Principal Investigator(s): Paul Chinowsky and Hyman Brown, University of Colorado 303.735.1063 Study Manager: Rich Sarchet, 303-757-9518 Study Panel Members: Jake Kononov, CDOT Research Rich Sarchet, CDOT Research TBD

MILESTONES

Planned	**% done**	**Achieved**	**Description, Discussion, and Related Issues**
08/07	100	Conducted preliminary Interviews – we are now expanding to more industry companies – that is the reason for partial completion	Focus Group
12/07	100	Currently comparing data from multiple states, CII organizations, the military and private companies – on schedule	Safety Comparisons
01/08	100	After research meeting with CDOT, focus placed on completing a simplified safety "manual" for CDOT employees. Draft is complete and ready for review.	CDOT Analysis
02/08			SNA Analysis
04/08			Recommendations
05/08			Focus Groups 2
05/08			Draft Final Report
06/08			Final Report
07/08			Final Presentations

SIGNIFICANT EVENTS

07/07 Task Order and Notice to Proceed Issued.

10/01 Have received safety data from a number of states including Oregon, Washington and Texas, safety data from OSHA and the US Army, and are in discussions with several private companies including Kiewit. This data is providing the team with a comparable to CDOT and providing the basis for specific comparison points between CDOT and industry safety leaders.

4/1 Based on a meeting with Rich and Jake, the research team altered its focus near-term to consolidate the findings from the states and private companies into a short safety program for CDOT employees. The idea is that a safety process should be put in the field as quickly as possible. In response, the team has modeled a safety practice short manual after successful programs. The manual is nearing completion and will be ready for an initial feedback review within 10 days.

6/08 Plans underway for presentation to CDOT Safety Committee of the draft manual, for input into direction of remainder of study.

9/08 Waiting for approval to continue work after task order was inadvertently allowed to expire 8/3108.

12/08 Work resumed with focus on determining how well present Job Hazard forms are working for maintenance staff, and possible improvements.

3/09 Pilot interviews collected in R4, proceeding to full survey (all Superintendents) in April.

6/09 Survey complete, findings presented to CDOT Executive Safety Committee. Draft report in progress.

9/09 Additional survey requested by ESC completed. Draft report in progress

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Evaluation of the Safety Edge (Pooled Fund Study)
Study No: 95.10

Background	Reporting Period: 7/1/09 through 9/30/09 Type: Transportation Pooled Fund study number TPF-5(097) Start: 2005 Ver:
When an errant vehicle leaves the edge of the traveled path and encounters a pavement edge drop-off, it may be difficult for the driver to negotiate the drop-off and safely return to the traveled way. There is potential for the tire to scrape along the drop-off instead of being able to negotiate safely back into the traveled way. This unexpected tire engagement and corresponding resistance often leads to driver over-correction, directing the vehicle to return to the roadway at a sharper angle than necessary, resulting in a head-on or sideswipe collision with the opposing lane traffic, a run-off-road crash on the opposite side of the road, or a roll-over either on or off the roadway. One pavement edge solution being used by some states, particularly when a pavement overlay is applied, is the termination of the pavement edge at a sloped angle, creating a fillet rather than a vertical edge. Prior research tends to indicate that the edge fillet, currently termed the "safety edge" or "edge wedge," presents less resistance to vehicle tires and can lead to a smoother, more controlled reentry back into the traveled way. Further evaluation is needed on the safety edge to determine its effectiveness. Transportation Pooled Fund study number TPF-5(097) sponsored by the FHWA has been approved and is under way to address the problem.	Principal Investigator(s):Kerry Perrillo Childress, P.E., FHWA 202.493.3318 Jerry Graham, 816.753.7600x1437 Study Manager: Bryan Allery 303.757.9967 Study Panel Members:

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
01/06		02/06	CDOT commits to participation in the pooled fund study.
03/06		03/06	Jerry Graham of Midwest Research Institute came to Colorado to evaluate two test sections and two control sections. He gathered traffic and accident data for the sites and did an initial evaluation at the sites.
			Data Collection and evaluation
04/08		04/08	Interim Report

SIGNIFICANT EVENTS

09/09 – A Safety Edge Fact Sheet describing the problem, what a Safety Edge is, and its benefits, was sent to CDOT engineers. The fact sheet also included the following links.
A standard detail for the Safety Edge:
http://www.dot.state.co.us/DesignSupport/MStandards/2006%20M%20Standards/2006%20Index/2006%20Project%20Details%20Index.htm
Videos showing actual construction of Safety Edge:

\\Public\trafcom\Traffic_Engineering_Resource_Library\Safety_Edge\Video\Paving.wmv
\\Public\trafcom\Traffic_Engineering_Resource_Library\Safety_Edge\Video\Rolling.wmv

11/08 – Evaluation of the Safety Edge, Year 1 - Interim Report was posted on the TPF Web site. http://www.pooledfund.org/documents/TPF-5_097/110495-01R_Interim_Report.pdf

04/08 – An interim report has been written.

01/08 – MRI is getting close to putting out an interim report on the research so far. Once received, it will be available for review.

08/07 – MRI took pre-construction measurements at a site on US-385 near Burlington. CDOT Safety and Traffic has a list of projects recommended for the use of the Safety Edge and is waiting on confirmation that it will be used and that the sites are suitable for the study.

06/06 – MRI has visited Colorado, obtained the field and design information, and CDOT has provided the historical accident data for the before conditions of both the test sites and the control sites.

03/06 – Jerry Graham will come to Colorado to visit test sites and begin accident report evaluation.

02/06 - CDOT commits to participation in the pooled fund study using uncommitted FY'06 funds. Bryan Allery will be the Colorado Technical Contact for the study.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Encouraging Innovation by Colorado DOT Employees
Study No: 98.20

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

MILESTONES

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

SIGNIFICANT EVENTS

09/30/10 Contract and Notice to Proceed Issued.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Development of an Internet-Based Tool for Estimating Flood Magnitudes for Eastern Colorado
Study No: 105.08

Background

Information about streamflow characteristics of Colorado rivers and streams is needed by the Colorado Department of Transportation for the correct sizing of culverts and bridges. Estimates are commonly needed at ungaged sites where no observed flow data are available. Manual methods to determine streamflow statistics are slow and resource intensive. These methods may produce results that are not reproducible, and are difficult to independently verify because they require training, multiple data sources, and expensive computer software and resources. Estimates of the magnitude and frequency of flood-peak discharges and flood hydrographs are used for a variety of purposes, such as the design of bridges, culverts, and flood-control structures, and for the management and regulation of flood plains.

At gaged sites, statistics can be obtained from existing publications (Richter and others, 1984; Vaill, 2000). However, estimates are more-commonly needed at ungaged sites where no observed flow data are available. A variety of techniques may be used to make these estimates, including methods outlined in CDOT Tech Manual 1 and SCS TR55, the rational method, and regionalized regression equations. The manual methodologies for determining streamflow statistics suffer from several shortcomings. The manual methods are slow and resource-intensive. The results may not be reproducible because varying subjective methods often are used to determine the basin characteristics. Lastly, the methods often are not feasible for the public and non-hydrologists, because they require training, multiple data sources, and expensive computer software and resources; without adequate GIS datasets and a sufficient understanding of GIS techniques, basin characteristics may be inaccurate; and without an adequate grounding in statistical techniques, streamflow statistics may be generated incorrectly and without including information about statistical confidence intervals.

The anticipated product of this study is an internet-based interactive tool for determining streamflow statistics at stream locations within eastern Colorado where applicable streamflow regression equations have been developed. An additional product will be vertically-integrated 1:24,000 scale GIS datasets for the study area (elevation, hydrography, watershed boundaries, base maps, and site locations). These datasets will exist within the ArcHydro framework (Maidment, 2002), which will allow for integration and use in a multitude of water-resources projects where watershed characteristics as predictive variables need to be linked to a hydrologic flow-network for modeling watershed and stream-network processes. The product will provide a time-efficient, reproducible, and documented method for estimating peak flows for eastern Colorado basins. This method could be utilized very efficiently in CDOT regions when the USGS Topo Maps are not available. This technology can get us at tip of a finger the peak flow for an ungaged basin.

Reporting Period: 7/1/09 through 09/30/09

Start: 09/30/06
Complete: 12/15/07
Contract: 07 HAA 00001

Principal Investigator(s):
David Litke, USGS, 303-236-4882x242
Mike Stevens, USGS, 303-236-4882x318

Study Manager(s):
Amanullah Mommandi,
Project Development Branch, 303-757-9044

Study Panel Members:
Aziz Khan,
Research Branch, 303-757-9255
Roberto de Dios,
Research Branch, 303-757-9975

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
9/30/06	100	Y	Agreement between CDOT and USGS finalized and signed.
10/31/06	100	Y	Conduct the kick-off meeting.
1/15/07	100	Y	Perform the literature search.
6/30/07	100	Y	Develop the GIS database for central Colorado
9/30/07	100	Y	Develop watershed boundaries and basin characteristics for streamflow sites in eastern Colorado
12/31/07	100	Y	Develop the GIS database for eastern Colorado
3/31/08	100	Y	Develop regression equations and populate NSS database with equations
6/30/08	100	Y	Prepare and deliver GIS archydro database for Colorado to National StreamStats Team for implementation of prototype (eastern Colorado)
6/1/09	90		Deliver website prototype and conduct CDOT training in the use of the application. *

SIGNIFICANT EVENTS

The USGS will provide cost sharing of $27,000 for this project.

* The National Team (Dave Litke) is in the process of implementation of the web site, and beta testing the software for Colorado. All equations have been entered into the data base as well as all of the published variables. Hopefully this will be finalized within the next few weeks.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Development of an Internet-Based Tool for Estimating Flood Magnitudes for Western Colorado
Study No: 105.09

Background

Information about streamflow characteristics of Colorado rivers and streams is needed by the Colorado Department of Transportation for the correct sizing of culverts and bridges. Estimates are commonly needed at ungaged sites where no observed flow data are available. Manual methods to determine streamflow statistics are slow and resource intensive. These methods may produce results that are not reproducible, and are difficult to independently verify because they require training, multiple data sources, and expensive computer software and resources. Estimates of the magnitude and frequency of flood-peak discharges and flood hydrographs are used for a variety of purposes, such as the design of bridges, culverts, and flood-control structures, and for the management and regulation of flood plains.

At gaged sites, statistics can be obtained from existing publications (Richter and others, 1984; Vaill, 2000). However, estimates are more-commonly needed at ungaged sites where no observed flow data are available. A variety of techniques may be used to make these estimates, including methods outlined in CDOT Tech Manual 1 and SCS TR55, the rational method, and regionalized regression equations. The manual methodologies for determining streamflow statistics suffer from several shortcomings. The manual methods are slow and resource-intensive. The results may not be reproducible because varying subjective methods often are used to determine the basin characteristics. Lastly, the methods often are not feasible for the public and non-hydrologists, because they require training, multiple data sources, and expensive computer software and resources; without adequate GIS datasets and a sufficient understanding of GIS techniques, basin characteristics may be inaccurate; and without an adequate grounding in statistical techniques, streamflow statistics may be generated incorrectly and without including information about statistical confidence intervals.

The anticipated product of this study is an internet-based interactive tool for determining streamflow statistics at stream locations within western Colorado where applicable streamflow regression equations have been developed. An additional product will be vertically-integrated 1:24,000 scale GIS datasets for the study area (elevation, hydrography, watershed boundaries, base maps, and site locations). These datasets will exist within the ArcHydro framework (Maidment, 2002), which will allow for integration and use in a multitude of water-resources projects where watershed characteristics as predictive variables need to be linked to a hydrologic flow-network for modeling watershed and stream-network processes. The product will provide a time-efficient, reproducible, and documented method for estimating peak flows for eastern Colorado basins. This method could be utilized very efficiently in CDOT regions when the USGS Topo Maps are not available, while the computer and the internet are available. This technology can get us at tip of a finger the peak flow for an ungaged basin.

Reporting Period: 7/1/09 through 9/30/09

Start: 07/01/08
Complete: 9/30/2009
Contract: 07 HAA 00001

Principal Investigator(s):
David Litke, USGS, 303-236-4882x242
Mike Stevens, USGS, 303-236-4882x318

Study Manager(s):
Amanullah Mommandi,
Project Development Branch, 303-757-9044

Study Panel Members:
Aziz Khan,
Research Branch, 303-757-9255
Roberto de Dios,
Research Branch, 303-757-9975

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
8/28/08	100	Y	Agreement between CDOT and USGS finalized and signed.
12/30/08	100	Y	Develop the GIS database for western Colorado
12/30/08	100	Y	Develop watershed boundaries and basin characteristics for streamflow sites in western Colorado
3/1/09	100	Y	Prepare and deliver GIS archydro database for Colorado to National StreamStats Team for implementation of prototype (western Colorado).
6/1/09	90		Deliver website prototype and conduct CDOT training in the use of the application. *

SIGNIFICANT EVENTS

The USGS will provide cost sharing of $21,000 for this project.

* The National Team (Dave Litke) is in the process of implementation of the web site, and beta testing the software for Colorado. All equations have been entered into the data base as well as all of the published variables. Hopefully this will be finalized within the next few weeks.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Physical Modeling to Develop Flow Interception Rates for Storm Drain Inlets
Study No: 105.80

Background

CDOT, Colorado municipalities and other public entities, construct hundreds of storm drain inlets each year. The Interception Rate Charts for these inlets have been developed theoretically. Using these charts to design the storm drain system leads to doing one of the following:
1) Underdesigning, resulting in storm drains system that are never maximized, or 2) Overdesigning, thereby wasting construction funding on unnecessarily long inlets.

Physical modeling for this inlet type was not performed. Other DOT has performed physical modeling for their inlets. CDOT cannot use the charts from other states due to that fact that they have different curb opening and configurations. The analysis of street inlets is complex since many different flow conditions and combinations of conditions occur, including: weir, orifice, and sluice gate. Different assumptions and idealizations can be made, but each will provide a different answer and none are any more accurate than the assumptions made. The most accurate way to quantify the interception capacity of various inlets is to build and study physical models. Literature research conducted by the Urban Drainage and Flood Control District (UDFCD) and CDOT has concluded that while physical models of inlets have been studied by others, none of those inlets are similar enough to the types of inlets constructed by CDOT and local municipalities to draw direct quantitative comparison.

In 1977, the FHWA conducted a grated inlet bicycle safety study during which it physically modeled the hydraulic capacity of street sections and studied the capture efficiency of a variety of welded bar steel and riveted bar steel grates on grades (not in sag locations). Some of these grates had bearing bars parallel to the long axis of the grate, others had tilted transverse bearing bars, and one had curved vane transverse bearing bars. The results of this study were incorporated into the FHWA Hydraulic Engineering Circular 22 (HEC-22, 2nd edition), which is the federal standard for urban drainage design today. The Urban Storm Drainage Criteria Manual published by UDFCD in 2001 follows the criteria set forth in HEC-22 for the analysis of street flow and for inlets sizing and design, as do municipal street drainage criteria manuals across the country. No one has adequately modeled the interception capacity of the cast iron grates as they are in use today, nor anyone has actual data on the CDOT Type R curb-opening inlet. No relevant literature was found because the configuration of Colorado R Inlet (opening, length) is different than those used in other states.
This research shall provide a technical tool to size storm drain inlets for different stormdrain inlets such as:

a. Denver No. 13 Combination Inlet (CDOT)
b. Denver No. 16 Combination Inlet
c. CDOT Type R Curb Inlet

Reporting Period: 7/1/09 through 9/30/09
Start: 4/11/06 Complete: TBD

Principal Investigator(s):
Urban Drainage & Flood Control District

Study Manager(s):
Amanullah Mommandi,
Project Development Branch, 303-757-9044
Aziz Khan,
Research Branch, 303-757-9255
Roberto de Dios,
Research Branch, 303-757-9975

UDFCD has developed an Excel™ spreadsheet-based inlet sizing application that will be updated to incorporate information gained from this study. This tool is and will continue to be freely available on the UDFCD website. A report will be published summarizing the results of the testing program and providing design charts for inlet sizing.	

MILESTONES

Planned	% Done	Achieved	Description, Discussion, and Related Issues
4/1/06	100	4/11/06	Award the contract. (Task order or contract signed and Notice to Proceed Letter issued)
1/10/07	100	1/10/07	Conduct the kick-off meeting.
1/15/07	100	1/15/07	Perform the literature search.
1/15/08	75		Construct the inlet for physical modeling in sump condition. Gather and analyze data. Develop design charts. Update the spreadsheet and documentation.
6/1/08	5		Construct the inlet for physical modeling in "on-grade" condition. Gather and analyze data. Develop design charts. Update the spreadsheet and documentation.
8/15/08	0		Submit spreadsheet to the CDOT study panel for review and comment.
9/30/08	0		Prepare and submit draft final report to CDOT study panel for review.
11/15/08	0		Complete review of draft final report by CDOT study panel with comments to be addressed.
12/15/08	0		Revise and submit the final report.

SIGNIFICANT EVENTS

4/11/06 The contract agreement with Urban Drainage & Flood Control District (UDFCD) was signed by the State Controller. The total contract amount is $40,000.

9/30/06 No report has been received yet from UDFCD on the status of the research work.

04/06/07 The physical model construction for the sump condition was completed in mid November 2006.

Testing began on November 21, 2006 and ran until February 18, 2007, with no work completed between December 6 and January 4, when the students were gone for winter break.

A total of 79 tests were conducted in the sump condition. The results of those tests are currently undergoing QA/QC process by the university, after which they will be made available to the principal investigator. Tests were done on:

CDOT Type R inlets

CDOT Type 13 inlet (combination valley grate with open throat)
CDOT Type 13 inlet (valley grate only)
CDOT Type 13 inlet (open throat only)

Denver No. 16 inlet (combination valley grate with open throat)
Denver No. 16 inlet (valley grate only)

Denver No. 16 inlet (open throat only)

The model is currently being reconstructed for the continuous grade testing, which is anticipated to begin in April 2007.

06/27/07 On January 15, 2007, a field trip to the hydraulics laboratory at CSU took place. All of the project sponsors were invited and after a brief presentation on theory and modeling protocols, the sponsors witnessed testing of a 10' CDOT Type R inlet in sump condition.

Testing of the CDOT Type 13 inlet, and the Denver No. 16 inlet both of these inlets in valley grate only and in combination with curb opening box), and the CDOT Type R inlet was conducted in the sump condition until February 18, 2007.

Upon completion of those tests, a thorough Quality assurance / quality control process was undertaken by the university. That effort revealed problems with the testing flow measurement instrumentation, which required the university to reject all test results gathered to date.

As the result of this discovery, the CSU hydraulics laboratory has purchased a state-of-the-art magnetic flow meter, specifically for this project. This flow meter applies Faraday's formula, which states that:

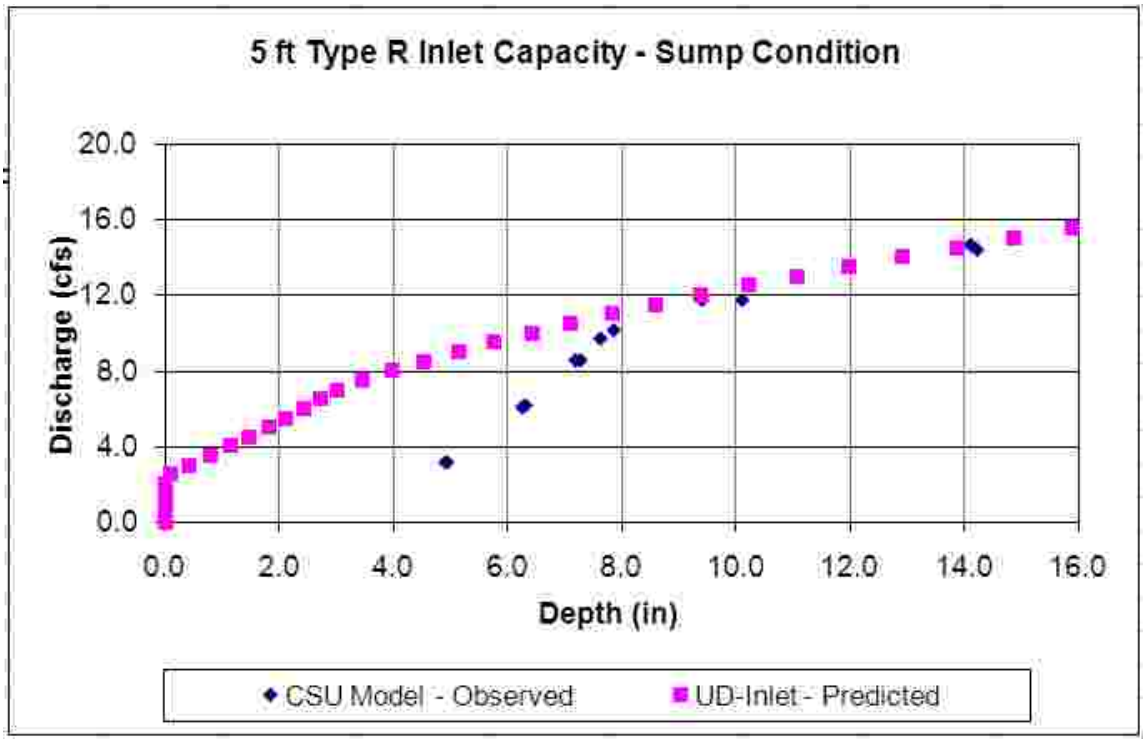
E is proportional to V x B x D where:

E = The voltage generated in a conductor
V = The velocity of the conductor
B = The magnetic field strength
D = The length of the conductor

This new flow meter took the university some time to get, and was installed in late April 2007. Since that time, all of the sump condition tests were redone and the results of those tests are now undergoing the same Quality assurance / quality control process as before.

10/03/07 All of the sump tests have been completed at this time. The data from those tests is undergoing analysis by UDFCD personnel and by Dr. James Guo at the University of Colorado at Denver. Dr. Guo has a graduate student who is using this data to prepare a masters report.

The flood control District is focusing on the comparison of the observed test results to the theoretical calculated capacities predicted by the UD-Inlet computer program. These comparisons will lead to an improved UD-Inlet computer program.



Example of comparisons being made by UDFCD

On August 15 and 16, Dr. Guo and Ken MacKenzie from UDFCD visited the CSU hydraulics laboratory and observed a number of sump tests being conducted. At this time, the inlets were also tested for clogging with a variety of debris types put into the flume and the results photographed for future analysis.

The CSU laboratory staff is currently dismantling the test box in order to reconfigure it for the on-grade tests. At this time, also different flow measuring devises necessary for that configuration are being fabricated and calibrated. It should be noted that on-grade inlet testing portion of this study has not yet begun, and is expected to be more time-consuming than the in-sump portion of the study, which took 10+ months to complete.

12/31/07 The CSU laboratory staff has decided the plywood/lumber building materials used for the sump testing are insufficient to achieve the precise longitudinal and transverse slopes required for the on-grade testing. At this point, they are considering rebuilding the model out of steel sheets and beams but no definitive decision has been made yet. UDFCD continues to work with the University of Colorado at Denver to analyze the sump test data. A new design and sizing procedure is in draft form and has been reviewed by Amanullah Mommandi (CDOT State Senior Hydraulic Engineer).

03/31/08 No significant progress has been made since the last report. In January, the CSU laboratory staff decided to attempt to continue using the plywood/lumber construction previously used in the sump tests. Because the flow depth on a longitudinal slope is sensitive to the roughness of the wetted perimeter,

considerable time was spent calibrating the roughness of the model to a Manning's n value of 0.013, equivalent to 0.016 for the prototype condition. After only a few trials it was determined that the plywood/lumber construction was no longer able to maintain a consistent longitudinal slope and cross slope due to deterioration and sagging of the materials. CSU is currently rebuilding the model with steel material, and testing should resume in May.

06/30/08 The CSU laboratory staff reconstructed the model on a framework of steel beams. This work was finished by June 6, 2008. From June 9th until June 20th calibration of the model to a Manning's n value of 0.013 took place. Two students are now working toward completing all the on-grade testing portion of the study. On June 18, Dr. Christopher Thornton (the Principal Investigator) requested a no-cost extension of the contract between UDFCD and CSU through December 30, 2008. Dr. Thornton is confident that all of the actual testing will be completed by that time, although the analysis of data and interpretation of results may continue beyond the end of 2008.

09/22/08 Of the 243 total "on grade" tests, 162 have been completed with satisfactory QA/QC to this point. This includes the 0.5%/1%, 0.5%/2%, 2%/1%, and 2%/2% configurations. The model and all of its components have performed satisfactorily for these tests. Still remaining are the 4%/2% and the 4%/1% tests. The model is currently being reconfigured for the 4%/2% test. The 4% slope configurations are expected to be the greatest challenge to the design of the model. With this in mind, several simple modifications are being made to the model while it is disassembled for the slope change to prevent possible testing issues. At the testing rate of about 3 weeks per configuration, the remaining tests should be completed around mid November.

12/26/08 All of the tests have been completed with QA/QC showing satisfactory results. Analysis of the data has begun and regression equations will be developed for each inlet type. Possible factors being considered for the equations are (just to name a few): street flow, cross slope, long slope, roughness, kinematic viscosity of water, number of grates, clogging factor, and opening type. Further effort will be made to fit the resulting models developed into the existing context of the UDFCD drainage criteria manual and HEC 22 methods for continuity. It is expected that the analysis will take several months to complete.

04/01/09 All of the test data has undergone satisfactory QA/QC inspection. Regression equations have been developed for all the tests, which predict capture efficiency for any slope configuration and flow within the bounds of the testing. Analysis of the data continues and several trends have become evident. The first of which relates to determination of splash-over velocity from the test data. All of the on-grade tests performed for multiple numbers of inlets were done with a grate and curb opening (combination inlet). Following the guidelines of the UDFCD manual, this type of configuration is typically treated as only a grate for flow capture purposes. While this is a reasonably accurate assumption for lower flows,

it may not be for flows in which the splash-over velocity becomes high and significant flow is captures by the curb opening. When this occurs efficiency is higher than calculated by treating the inlet as a grate only. Theoretically splash-over velocity should increase as a function of increasing grate length, but this trend does not show up in all the data because the curb opening captures flow that splashes over the grate. Current efforts are focusing on determining if it is possible to accurately determine splash-over velocity from the data. Also, determining the point at which a curb opening should be considered (in addition to the grate) for determining efficiency of a combination inlet is being considered.

6/22/09 The CSU report draft presenting the collected data is finished and is working its way through the various levels at CSU for edits. Analysis continues as the test data is compared to currently accepted UDFCD calculation methods for inlet efficiency. When significant differences exist, efforts are being made to determine why. Also, as trends are found in the data (regarding velocity, splashover velocity, roughness, etc.) they are examined to provide additional information on the nature of the hydraulics of street and gutter flow.

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH STUDY PROGRESS REPORT

Street Inlet Design (SID) Using Decay-Based Clogging Factor
Study No: 105.81

Background

The current practice suggests that an inlet be firstly sized without clogging and then its unclogged capacity be reduced by 50% due to clogging. For instance, a 15-ft inlet suggested by the non-clogging design procedure will become a 30-ft inlet. Do we ever ask if the street can sustain so much debris to clog this inlet to a length of 15 feet? Over the years, this procedure has linearly doubled the number of inlets and resulted in street inlets excessively long and wasteful. The major revisions to highway inlet design include: (1) to apply the clogging factor to the length of the inlet, not to its capacity (2) to consider the decay-based clogging factor. For instance, the first inlet is clogged by 50%, the second is clogged by 25%, the third is clogged by 12.5%, so on and so forth. In doing so, the length of street inlets can be SIGNIFICANTLY reduced. This mathematical procedure has been reviewed and published on ASCE journals. At this point, we just need to convert the theory into CDOT's practice. The product of this proposed research will re-write the CDOT design manual at the state level and the HEC 22 manual at the national level.

Study Objectives

The current CDOT's hydraulic design manual only covers the general guidelines for roadway inlet design, and refers the details to FHWA 's HEC22 procedure. In fact, the latest HEC22 does not even include the clogging factor. As a result, the clogging factor has been introduced as a reduction factor on the inlet capacity. This simplified practice results in unnecessarily long inlets and an inconsistent basis among design alternatives. It is imperative that both CDOT and FHWA 's HEC 22 Highway Inlet Design be updated with the latest developments in highway hydraulics. This research project objectives are:

I. Derivation of a new methodology to size street inlet with consideration of the decay nature of clogging effect on inlet hydraulics

2. The new method shall be calibrated using the laboratory data collected by Urban Drainage and Flood Control District in cooperation with CDOT

3. A new Chapter for Street Inlet Design in CDOT Hydraulic Design manual

Reporting Period: 7/1/09 through 9/30/09
Type: SP&R Start: 07/07 Ver:
Contract:

Principal Investigator:
Dr. James Guo, Professor
Department of Civil Engineering, UCD
303-556-2849

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

Study Panel Members:
Amanullah Mommandi (Penal Leader)
Project Development Branch
303-757-9044

Jake Kononov
Research Branch Manager
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Hamid Ghavam
Project Development Branch
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Alfred Gross
Region-1 Hydraulics
720-497-6927

Ken MacKenzie
Urban Drainage & Flood Control District

MILESTONES

Planned	% done	Achieved	Description, Discussion, and Related Issues
6/01/07	100	6/15/07	Proposal Review and Evaluation
6/30/07	100	06/28/07	Issue Notice to Proceed
01/01/08	100	10/25/07	Interim Report and/or Presentation
1/30/09			Draft Final Report and Presentation
3/30/09			Final Report

TASKS

Planned	% done	Achieved	Description, Discussion, and Related Issues
08/01/07	90%		Review of Current Inlet Design Procedure
08/30/07	90%		Derivation of New Method
9/30/08	50%	(a) done (b) just started lab. tests	Calibration of New Method (a) Sump inlet and clogged capacity (b) On-grade inlet and clogged capacity
12/30/08	25%	(a)sump inlet sizing	Development of EXCEL Spreadsheet
			New Chapter for CDOT Hydraulic Manual
			In-House Training
			Final Revision with Feedback from In-house Two-weeks Final report Training

SIGNIFICANT EVENTS

07/01/07 Project officially begins.

07/27/07 Field trip during a server storm event

07/28/07 Field trip to exam the inlet clogging conditions. 200 photos were taken for several street inlets under a severe storm event. Under the clogging condition, the performances of these inlets have been recorded.

08/15-16/07 Work at Hydraulic Laboratory at CSU to investigate Type 16, Type 13, Type R inlets On August 15 and 16, Dr. Guo and Ken MacKenzie from UDFCD visited the CSU hydraulics laboratory and observed a number of sump tests being conducted. At this time the inlets were also tested for clogging with a variety of debris types put into the flume and the results photographed for future analysis.

10/25/07 Presentation of *Flume Study of Sump Inlet Hydraulics* at 2007 CDOT's hydraulic conference. A report in the format of power point was submitted.

10/31/07 Field trip to investigate Type C and Type D inlets (Ken MacKenzie and Mr. Mommandi)

11/31/07 The data from sump inlet tests is undergoing analysis by UDFCD personnel and a graduate student at CU-Denver who is using this data to prepare a master report.

12/15/07 A journal paper entitled "*Sump Inlet Hydraulics*" was completed and submitted to the American Society of Civil Engineers' Journal of Hydraulic Design. The external review will give us more critics on the newly developed methodology and proposed applications.

12/20/07 Development of Excel Spread Sheet for sump inlet design is about 25% completion.

12/31/07 The CSU laboratory staff is currently dismantling the test box in order to reconfigure it for the on-grade tests. At this time also different flow measuring devises necessary for that configuration are being fabricated and calibrated. It

should be noted that on-grade inlet testing portion of this study has not yet begun, and is expected to be more time-consuming than the in-sump portion of the study which took 10+ months to complete.

04/09/08 We are still waiting for CSU to set up a reliable test bed for on-grade inlet studies. I am wrapping up a report on the sump inlet design with consideration of clogging effect. Approximately 50 field photos have been selected and edited for comparison among single, double, and triple-unit inlets. I plan to complete and submit this report to CDOT in May 2008.

06/16/08 A CSU hydraulic laboratory tour was conducted to exam the flume layout for the proposed on-grade inlet
study. The group included Ken MacKenzie, James Guo, Ben Urbonas, and Mommandi. The study of on-grade inlets will commence in early July 2008. The proposed project must work with the laboratory data. The schedule for the CSU hydraulic laboratory has been delayed due to the graduation of student assistants. Although the final report for this project is not even started at this point, the journal article submitted to the ASCE J. of Hydraulics in December 2007 has completed its external review, all comments are positive. The journal editor requests that the paper be revised according to reviewer's suggestions. Dr. Guo will re submit the revised article as the final version for publication.

09/16/08 The CSU flume has been calibrated through the summer break. As soon as the CSU recruits research students to operate this project in the laboratory, we will begin to collect data.

1/20/09 I am waiting for the data for the test inlets flows on a sloping flume. The paper submitted to ASCE journal of Hydraulic Engineering has gone through the 2nd round of review. I have revised the paper for the final acceptance.

4/7/2009 I have received the laboratory data from CSU and waited for their analyses for the inlet capacity on grade. I have worked with UDFCD to submit the second-phase study on Type C and D inlets. This contract is being processed among UDFCD, CDOT, UCD and CSU.

4/12/2009 Up to April 12, 2009, UDFCD confirms that CUS will complete the data analyses in this summer. Dr. Guo turned in a draft report without CSU data analyses and the technical paper accepted by the ASCE Journal of Hydraulic Engineering. This project becomes expired on April 12, 2009.

June/20/2009 Dr. Guo was advised to submit a new Scope of Work (SOW) for an extension of this study. In June 2009, Dr. Guo submitted a new SOW to Dr. Khan. The continuation of this work will begin upon the completion of CSU data analyses.

Sept/21/2009 A journal paper on the sump inlet design has been reviewed and published in the ASCE J. of Hydraulic Engineering. CSU has submitted a letter report on the derivation of splash-over velocity for review and comments.

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 collected data including the findings and recommendations resulting from the inspection effort conducted by the Staff Bridge Branch across the State of Colorado will be used accordingly in the development of the new guidelines for culvert pipe materials selection procedure.

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

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

Study Manager:
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303-757-9975

Panel Leader:
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Study Panel Members:
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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
5/5/09	20	5/5/09	Culvert Test Sites Selection Meeting with Research Panel Leader
6/01/09	60	6/01/09	Literature review
6/01/09	100	6/01/09	Task 2- Applicability of CDOT's CR table
6/31/09	40	6/31/09	Task 3 – Field Testing
6/31/09	20	6/31/09	Task 4 – Data Analysis
7/28/09	100	7/28/09	Research Update to review panel members
9/30/09	90	9/30/09	Task 1- Literature review
9/30/09	100	9/30/09	Task 2- Applicability of CDOT's CR table
9/30/09	74	9/30/09	Task 3 – Field Testing
9/30/09	70	9/30/09	Task 4 – Data Analysis
9/30/09	50	9/30/09	Task 5 – Develop service life procedure

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.