Fiscal Year 2014/15
Annual Research Program Highlights

Caltrans

DRISI

Caltrans Division of Research, Innovation and System Information

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Caltrans Research Program

Fiscal Year 2014/15

Annual Research Program Highlights

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DRISI

For more information:

California Department of Transportation
www.dot.ca.gov

Division of Research, Innovation and System Information
www.dot.ca.gov/research

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DRISI

Caltrans Division of Research,
Innovation and System Information

Division Chief's Message

I am pleased to present on behalf of our staff, the Caltrans Division of Research, Innovation and System Information's (DRISI) Annual Research Program Highlights for the fiscal year ending on June 30, 2015. In one of my first acts as division chief, I want to thank my predecessor, Coco Briseno, for her dedicated leadership of the division from 2013 to 2015. Through her guidance, the division purpose was redefined as **providing solutions and knowledge that improve California's transportation system**. It reflects the vital function that DRISI performs in support of the Caltrans mission to **provide a safe, sustainable, integrated, and efficient transportation system to enhance California's economy and livability**. In the past few years, Caltrans has redoubled its commitment to innovative and sustainable transportation solutions. Research is the key to success in these areas, and DRISI continues to find ways to turn innovative ideas into sustainable solutions that address a wide range of transportation challenges.

Meeting California's Transportation Challenges Through Innovation

Research and innovation go hand-in-hand. Research expands knowledge and understanding and finds solutions to problems. It reduces the chance of making unsatisfactory or unsafe decisions and safeguards us from uncertainty by ensuring that all approaches are considered and investigated. We make progress and streamline processes through research. This past fiscal year, DRISI managed a robust research program that innovatively addresses California's transportation challenges.

Fostering Sustainable Transportation

Sustainability is a key focus for Caltrans, and our team at DRISI is committed to finding solutions to current transportation needs that improve the quality of life for Californians without compromising future generations. Our research takes these areas into account:

- People—Fostering livability, health, safety, quality of life, mobility, and accessibility for all
- Planet—Preserving and restoring environmental and ecological health and resiliency
- Prosperity—Promoting statewide economic goals and local community vitality

As part of our goal of promoting alternative energy sources, Caltrans is one of the sponsors of the Sustainable Transportation Energy Pathways (STEPS) program at the University of California, Davis. STEPS is working toward transitioning to a sustainable transportation energy future, disseminating research and knowledge to decision-makers in the private and public sectors so that they can make informed technology, investment, and policy choices.

Developing Innovative and Sustainable Solutions Through Research

Through our research efforts, we continue to develop innovative and sustainable solutions vital to enhancing California's economy and livability. This past fiscal year we touched on many aspects of California's vast transportation network. Following are a few of the highlights.

Encouraging multimodal transportation solutions—Expanding bus rapid transit to some of the state's busiest corridors can reduce congestion and greenhouse gas emissions, but new methodologies were needed to assess the tradeoffs of having dedicated bus lanes. Incorporating state-of-the-art vehicle assist and automation technology on buses is one approach to reduce right-of-way costs when buses can travel safely on narrower lanes.

Making pavements sustainable—Reducing the environmental impact and effects of pavement is in the forefront of Caltrans research, from using reclaimed materials, such as recycled asphalt shingles and rubber tires, which conserves natural resources and limits dumping, to researching materials and designs for decreasing noise pollution, and studying ways to diminish urban heat islands.

Extending innovative technologies to rural communities—Developing affordable intelligent transportation systems and other innovative technologies for rural areas improves safety and addresses the specific traffic management challenges of more sparsely populated regions.

Constructing seismically-sound bridges faster—Accelerated bridge construction (ABC) innovations offer cost and time saving benefits but have not been tested for seismic regions and modifications designed to facilitate the adoption of ABC methodologies.

Improving safety through innovation—Many projects focus on improving safety through innovation, such as updating ShakeCast software to improve post-earthquake response by providing projections about the status of infrastructure minutes after an earthquake, using sensors to reduce uncontrolled avalanches, and improving collision formulas to put dollars where needed.

This document highlights a variety of the research projects that contributed to changes and improvements that will meet our future needs. Read on to learn more about our research efforts to improve safety, enhance mobility and sustainability, encourage the management of public facilities and services, and protect public investment in transportation infrastructure.

Jim Appleton, Chief
Division of Research, Innovation and System Information

Accomplishments and Innovations

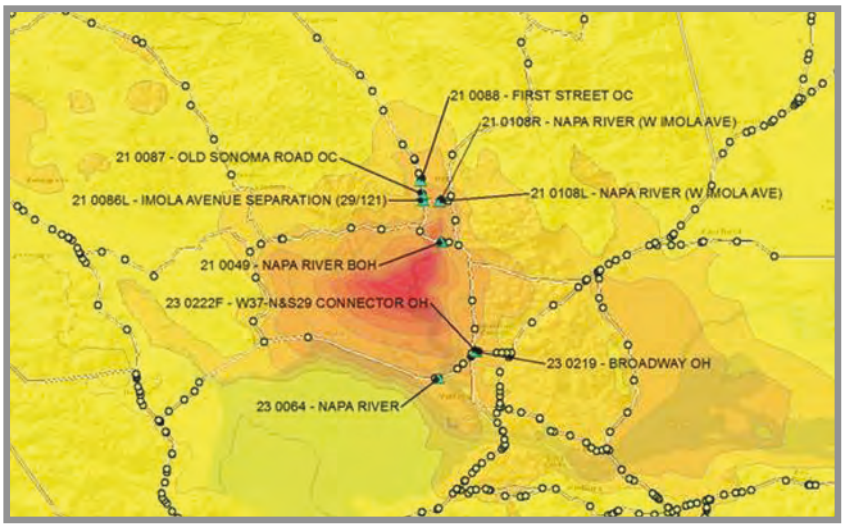
Caltrans continues to find groundbreaking approaches to deliver a safe, sustainable, and integrated transportation system for all Californians. Guided by Caltrans' mission and vision, DRISI is focused on developing innovative transportation solutions and disseminating transportation-related knowledge across all Caltrans.

Best New Innovative Practice for Research, Design and Innovation Award

DRISI's efforts were rewarded on September 9, 2014 at the World Congress on Intelligent Transportation Systems when the Intelligent Transportation Society of America awarded Caltrans its top honors for the Best New Innovative Practice for Research, Design and Innovation for the One-Stop-Shop (OSS) for Rural Traveler Information web application. The development of OSS, a collaborative effort by DRISI, Caltrans District 2, Western Transportation Institute, and Western States Rural Transportation Consortium member states, came about after extensive research. OSS improves traveler safety by offering real-time travel data on weather conditions and traffic in California, Oregon, Washington, and Nevada and provides information about highways, rest stops, and points of interest. Portions of the OSS technology have been integrated into Caltrans' QuickMap. To learn more, visit *http://oss.weathershare.org.*

Shakecast: A Valuable Tool in Caltrans' Response to the Napa Earthquake

ShakeCast is a post-earthquake response tool that DRISI and scientists at the United States Geological Survey developed. Following the Napa Valley 6.0 earthquake on August 24, 2014, ShakeCast identified bridges and buildings that experienced shaking and helped Caltrans and first responders focus efforts on inspecting them. The system delivered key information on the potential impacts to the state bridge inventory within 11 minutes of the event. Applying the latest advancements in seismic science is a process that will never end.



Locations where minor damage was observed on state bridges

SHRP2 Implementation Assistance Awards

The mission of the Strategic Highway Research Program 2 (SHRP2), administered by the Federal Highway Administration (FHWA) in cooperation with the American Association of State Highway and Transportation Officials (AASHTO) and Transportation Research Board (TRB), is to find solutions to three national transportation challenges: improving highway safety, reducing congestion, and improving methods for renewing roads and bridges. The program has carried out 145 research projects, developed 130 products, and published 132 research reports.

The Implementation Assistance Program helps state departments of transportation deploy SHRP2 Solutions. A range of opportunities is available to raise awareness of SHRP2 Solutions and to encourage early adoption of these products.

In FY 2014/15, Caltrans received five implementation assistance awards for the following SHRP2 Solution products.

3D utility location data repository—Enhancing storage and easy retrieval of underground utility location data. Caltrans modified a model utility management process so that each district can adapt the program for its specific needs.

Utility investigation technologies—Advancing technologies to help agencies detect subsurface utilities. Caltrans applied the transient electromagnetics unit in conjunction with multichannel ground-penetrating radar and time-domain electromagnetic induction on a pilot basis to selected projects in California.

Identifying and managing utility conflicts—Improving cooperation among highway agencies and utilities for faster project delivery. Caltrans adopted a utility conflict matrix and implemented a database approach to managing utility conflicts.

PlanWorks: Better planning, better projects—Deploying PlanWorks to improve collaboration with the various regional agencies and partners in corridor planning. PlanWorks is a systematic web-based resource that supports collaborative decision-making to deliver projects that meet environmental, community, and mobility needs.

Composite pavement systems—Fostering guidance for designing and constructing long-life composite pavement systems that provide durable, sustainable aggregate surfaces at a potentially lower cost than conventional pavement. Caltrans piloted a two-lift composite concrete pavement technology (wet-on-wet) with the goal of including recycled concrete material in the new pavement.

Research Program Administration

DRISI manages a comprehensive portfolio of projects to address the research and operational needs across Caltrans. The division seeks to take full advantage of strategic opportunities by identifying public, academic, and private partnering solutions. These partnerships leverage the dollars invested in present and future public infrastructure.

The research program's two main funding sources are the State Planning and Research (SP&R) Part II and the State Highway Account (SHA). These funds support researching new knowledge areas, developing technologies that turn findings into practical applications, and transferring these technologies and innovations through dissemination, demonstration, training, and adoption. In FY 2014/15, DRISI managed a $23.3 million research program to deliver research results and products that addressed transportation challenges across California.

SP&R Part II provided $12.8 million (55%) of DRISI's FY 2014/15 research program budget. DRISI allocated these monies to:

- Fund state-specific transportation research tasks identified as Caltrans functional research
- Support the national research program, which includes the National Cooperative Highway Research Program (NCHRP) and the Transportation Research Board (TRB)

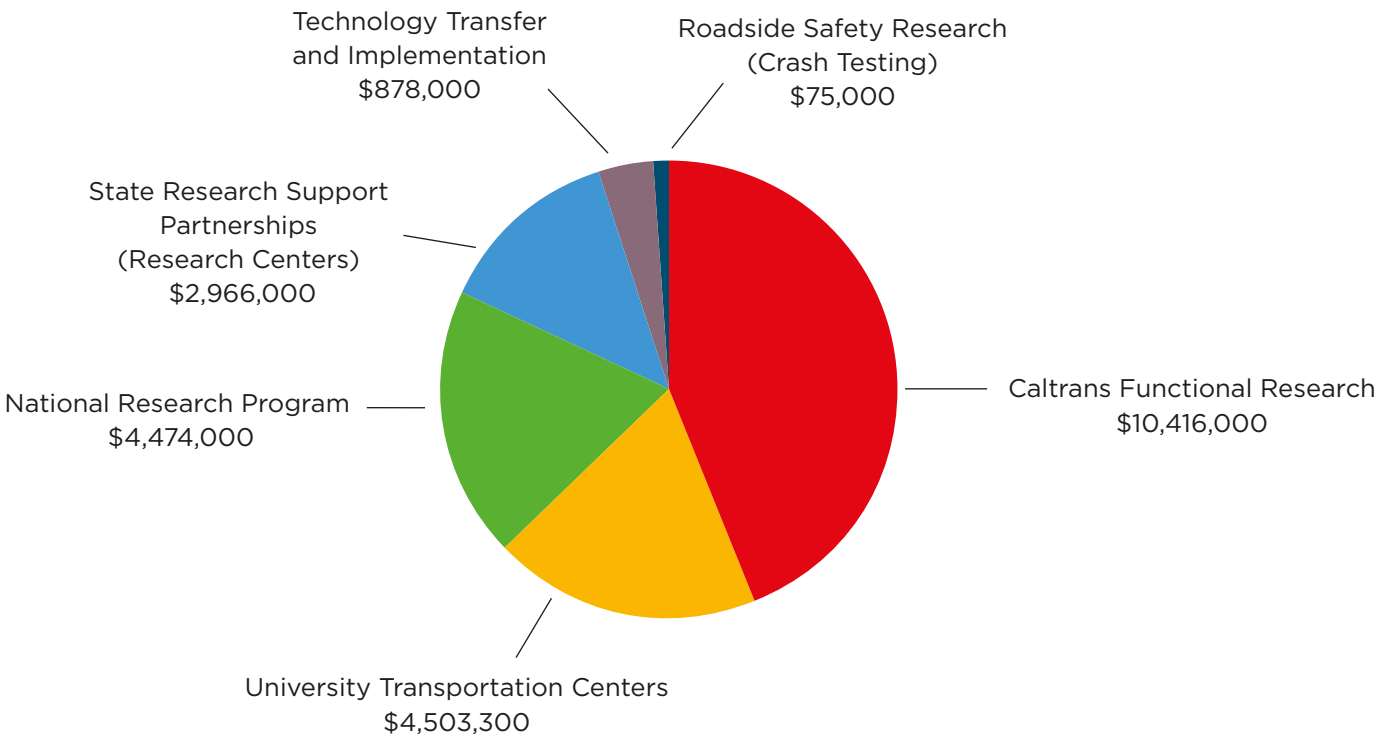
SHA is generated from the state excise tax on gasoline and diesel fuels and provided $10.5 million (45%) of the research program budget. DRISI used SHA monies to:

- Provide match funding for federally funded research tasks
- Fund university transportation centers
- Support technology transfer and implementation of research results and products
- Assist state research support partnerships (research centers)
- Fund roadside safety research (crash testing)

DRISI funds a balanced, comprehensive research program to efficiently administer research tasks from idea to product for customers in Caltrans' programs and districts. DRISI allocates research funds in the following six categories:

- Caltrans functional research
- University transportation centers
- National research program
- State research support partnerships (research centers)
- Technology transfer and implementation
- Roadside safety research (crash testing)

Allocation of FY 2014/15 Research Funds

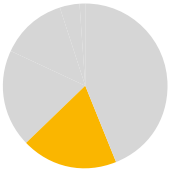


Total FY 2014/15 funding: $23.3 million

FUNDING CATEGORIES

Caltrans Functional Research | $10,416,000

The Caltrans functional research portfolio includes state functional transportation research that addresses the areas of construction, design, environmental, maintenance, modal, geotechnical structures, safety, mobility, pavement, planning, and policy. Tasks are selected through the process described on page 12 and grouped by functional areas to align with Caltrans' core programs. In FY 2014/15, DRISI managed 246 research tasks covering various functional areas, of which 57 reached completion. For a summary of all research tasks underway in FY 2014/15, see pages 20–29.



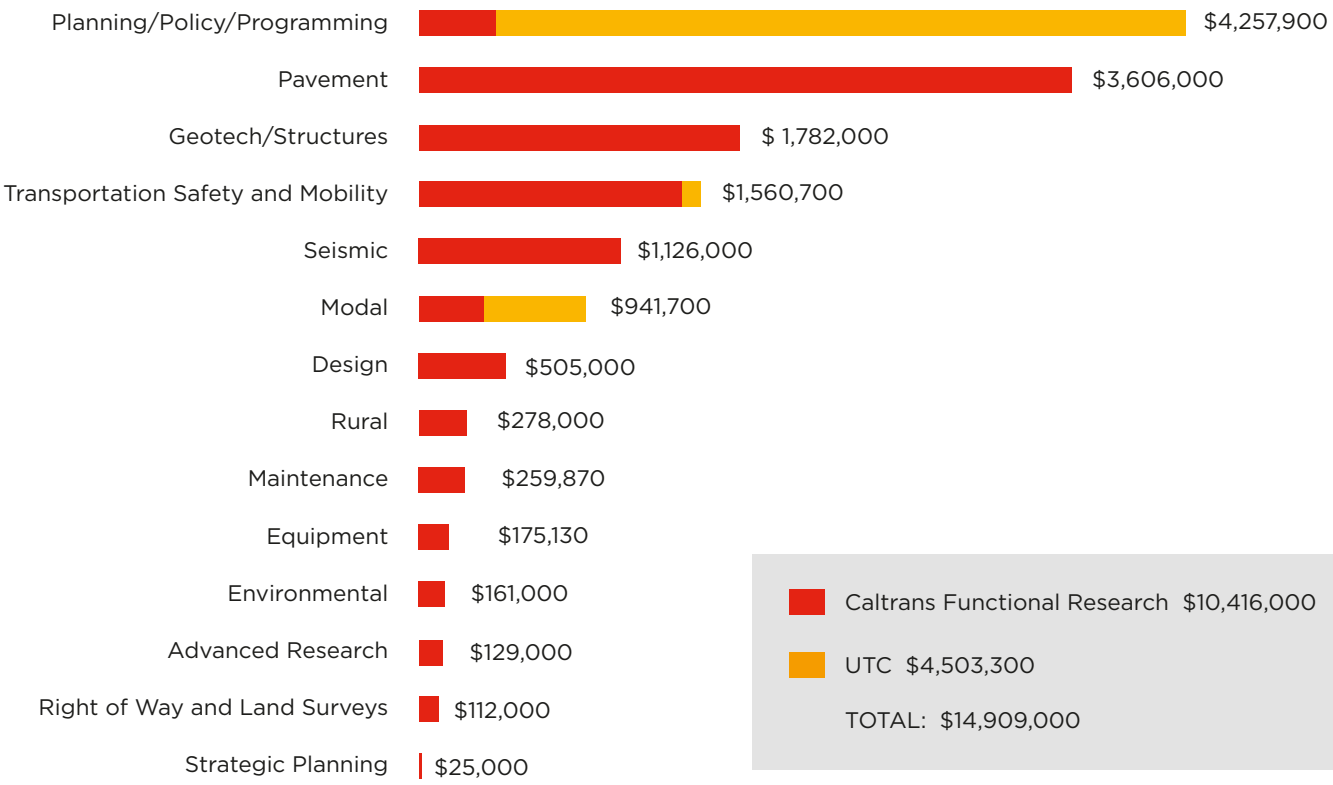
University Transportation Centers | $4,503,300

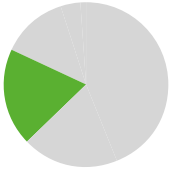
UTCs are internationally recognized centers of excellence that are fully integrated within institutions of higher learning. The UTC program is administered by the U.S. Department of Transportation (U.S. DOT). The UTC program's purpose is to advance transportation technology and expertise through research, education, and technology transfer; provide a critical transportation knowledge base outside of the U.S. DOT; and address the vital workforce needs for the next generation of transportation leaders.

DRISI works in partnership with UTCs to identify, research, and develop solutions for California's transportation challenges. In FY 2014/15, DRISI provided match funding for five UTCs. More information about these five UTCs is on pages 18–19:

- METRANS Transportation Center
- Mineta National Transit Research Consortium
- National Center for Sustainable Transportation
- University of California Center on Economic Competitiveness in Transportation
- University of California Transportation Center

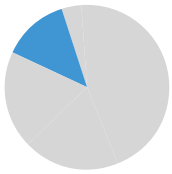
Distribution of Caltrans Functional Research and UTC Funds by Research Area





National Research Program | $4,474,000

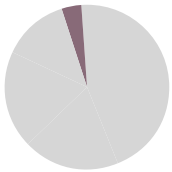
Caltrans partners with national transportation organizations, including the TRB and the National Cooperative Research Program (NCRP). Caltrans benefits from national research efforts through leveraging research conducted at the national level and by serving on committees and panels that identify critical transportation issues, recommend project selection, and guide implementation. More information about these national programs is on pages 13–14. In FY 2014/15, Caltrans staff actively participated on 109 highway, 11 freight, 3 airport, and 1 transit cooperative research project panels (see Appendices 2-5).



State Research Support Partnerships (Research Centers) | $2,966,000

DRISI partners with university-based research centers to deliver research results and products. Each research center offers specialized technical expertise and state-of-the-art facilities, equipment, and materials. More information about the following research centers is on pages 15–17:

- Advanced Highway Maintenance and Construction Technology Research Center (AHMCT)
- Pacific Earthquake Engineering Research Center Lifelines Program (PEER)
- Partners for Advanced Transportation Technology (PATH)
- Sustainable Transportation Energy Pathways (STEPS)
- University of California Pavement Research Center (UCPRC)



Technology Transfer and Implementation | $878,000

Promoting the implementation of research results into Caltrans routine practice requires multichannel, sustained technology transfer. DRISI uses various tools and methods to encourage the adoption of research results and products. These efforts include communication and engagement with DRISI customers and stakeholders.

Research products are the mechanism by which Caltrans is encouraged to make changes to business practices, with the goal of improving organizational effectiveness and efficiency. The research products are categorized by one or more of the following:

- New or improved technical standard, plan, or specification
- New or improved manual, handbook, guidelines, or training
- New or improved policy, rule, or regulation
- New or improved business practice, procedure, or process
- New or improved tool or equipment
- New or improved decision support tool, simulation, model, or algorithm (software)
- Processed data/database
- Evaluation of new commercial products to determine if they meet Caltrans' needs

DRISI uses various methods to communicate research results and products. Informational and outreach activities include:

- Conferences and forums
- Demonstrations and training
- Meetings, presentations, and webinars
- Research events and workshops

Print and web-based publications and materials include:

- **Annual Research Program Highlights reports** showcase DRISI's activities and completed research over the past fiscal year.
  www.dot.ca.gov/research/researchreports/index.htm
- **Final reports** document the executed methodology, detailed findings, and technical analysis of the research tasks.
  www.dot.ca.gov/research/researchreports/dri_reports.htm
- **Preliminary Investigation reports** provide a comprehensive overview of historical and existing national and international research and best practices for defined research needs.
  www.dot.ca.gov/research/researchreports/preliminary_investigations/index.htm
- **Research Notes** give an overview of research in progress to a general audience. Released at the beginning of a research task, the notes describe the need, methodology, goal, benefits, milestones, and next steps.
  www.dot.ca.gov/research/researchreports/current_research/index.htm
- **Research Results** communicate to a general audience what was accomplished with the research. They summarize the need, goal, methodology, outcome, and benefits.
  www.dot.ca.gov/research/researchreports/technical_summaries.htm

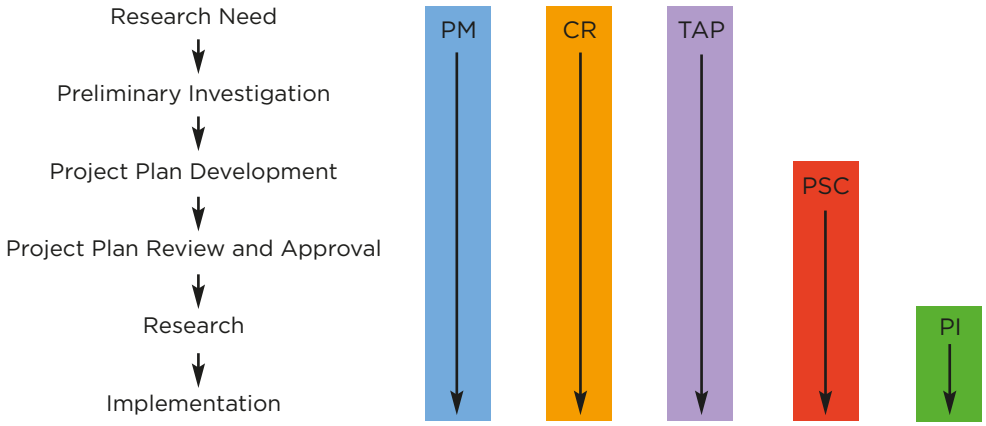
Roadside Safety Research (Crash Testing) | $75,000

The roadside safety research group evaluates the crash worthiness of safety technology, such as barriers, guardrails, crash cushions, bridge rails, sign supports, and other hardware. They conduct full-scale crash tests on roadside safety hardware designs developed by Caltrans to ensure that these designs comply with applicable crash performance criteria. The group also evaluates the crash worthiness of proprietary hardware developed by others to ensure that it is acceptable for use on state highways. The group provides support to Caltrans Legal Division in tort liability cases by conducting crash tests and delivering technical assessments and expert witness testimony.

RESEARCH PROGRAM DEVELOPMENT

DRISI engages three levels of committees to aid in developing research needs, selecting research projects, and deploying and implementing research products. The Research and Deployment Advisory Committee (RDAC) recommends research priorities and funding allocations among the functional areas and actively sponsors the deployment and implementation of the resulting research products. The RDAC includes deputy district directors and the division chiefs, who might also lead one of the program steering committees (PSC). The PSCs adopt an agenda for a multiyear integrated research program. Each PSC has at least one technical advisory panel (TAP), which includes experts from the various divisions and districts. The TAPs act in an advisory role to the PSC.

In coordination with PSC leads, DRISI project managers propose new research projects. The PSCs and DRISI management review the proposals in February. PSC leads prioritize their respective proposals in March, and the RDAC recommends the portfolio in April.



Project Manager (PM)
Caltrans staff member with full authority and responsibility, delegated by the appropriate division chief, to manage projects and produce the intended results on schedule and within budget. The PM keeps the project sponsors, customers, stakeholders, and end users satisfied by managing all aspects of the approved project, from the initial problem statement to a deployed product.

Customer Representative (CR)
A representative from one of Caltrans' program areas who participates as a liaison between DRISI and the PSC and takes ownership of the final research product.

Technical Advisory Panel (TAP)
Each TAP has a vital role in evaluating research needs, providing recommendations for continuing and new projects, developing and ranking project plans and requests for preliminary investigations, and identifying opportunities for deployment and implementation of research products.

Program Steering Committee (PSC)
Each PSC has an essential role in generating new research projects, developing program-level research priorities, and supporting the deployment and implementation of research products.

Principal Investigator (PI)
Contractor or researcher responsible for project development and the completion of the contract obligations.

National Research Programs

Caltrans partners with national transportation organizations and benefits from leveraging research conducted at the national level.

Transportation Research Board

The Transportation Research Board (TRB), the major national multimodal transportation research organization, brings practitioners and researchers together to solve critical transportation problems. With more than 200 standing committees, almost every transportation mode and topic is represented. Each committee proposes research, shares research findings, sponsors special activities, and provides a forum for transportation professionals to discuss current and future transportation issues.

State departments of transportation funded approximately 44% of TRB's 2014 core program budget. The remainder came from federal agencies, other transportation organizations, and TRB self-generated revenue. With a contribution of $475,427 in 2014, Caltrans was able to leverage $32 in research-related activity for every $1 invested.

This beneficial investment in TRB enables Caltrans to:

- Have a voice in setting national research priorities and agendas
- Access user-oriented research
- Avoid duplication of research efforts
- Support the uniform, practical, and common-sense application of transportation research results
- Develop a more informed and forward-thinking workforce
- Improve customers' experiences by accelerating the development and implementation of solutions to problems that affect transportation planning, design, construction, operation, and maintenance
- Retain employees by offering stimulating and professionally rewarding opportunities to participate in efforts that help improve the nation as a whole

National Cooperative Research Programs

The National Cooperative Research Programs address research on safety, planning, design, construction, operations, and maintenance at the national level. This research includes developing and evaluating new technologies and techniques. The programs also foster sharing best practices among states.

Caltrans leaders work with the following national research programs:

- National Cooperative Highway Research Program (NCHRP)
- Transit Cooperative Research Program (TCRP)
- National Cooperative Freight Research Program (NCFRP)
- Airport Cooperative Research Program (ACRP)
- Second Strategic Highway Research Program (SHRP2)

In 2015, the National Cooperative Highway Research Program selected 61 projects for funding, of which 26 were important to Caltrans, 15 were of significant interest, and 7 have Caltrans staff currently serving on the project panel. As project panel members and a member of the Standing Committee on Research and Research Advisory Council, Caltrans is able to influence national projects to directly benefit California.

Transportation Pooled Fund Program

When significant or widespread interest is shown in solving transportation-related problems, several federal, state, regional, and local transportation agencies, academic institutions, foundations or private firms might jointly fund research, planning, and technology transfer activities. The Transportation Pooled Fund (TPF) program combines resources to support transportation research studies.

State Research Support Partnerships

DRISI partners with university-based research centers to deliver research results and products. Each research center offers specialized technical expertise and state-of-the-art facilities, equipment, and materials.

Advanced Highway Maintenance and Construction Technology Research Center

The AHMCT Research Center, located at UC Davis, performs research leading to the development of innovative technologies, data, and methods for highway and civil infrastructure. It uses advanced robotics, automation, sensing, networking, and information technologies in developing methods for highway and civil infrastructure construction, maintenance, and operations. AHMCT's mission is to improve the safety, mobility, and reliability of California highways, achieve lean operations, and minimize the environmental impacts, while considering life-cycle assessments, sustainability, and cost-benefit analysis.

Highway maintenance and construction operations are labor intensive and can expose workers and travelers to the risk of injury. While these operations have become more efficient over the past several decades, they can still benefit from advanced mechanization and enhancements in communication, networking, and digitization technologies. AHMCT evaluates and deploys new and advanced technologies for existing Caltrans operations, with a focus of promoting safety and efficiency by developing human-assist machinery and tools that allow staff to perform operations without being on foot on highways.

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http://ahmct.ucdavis.edu

Pacific Earthquake Engineering Research Center Lifelines Program

The PEER-Lifelines Program, located at UC Berkeley, is a partnership between lifeline providers that share a common interest in improving the response to seismic hazards. The multi-institutional research and education center focuses on developing performance-based earthquake engineering methods and design tools to better characterize potential threats due to severe ground shaking, fault rupture, soil liquefaction, and tsunami inundation.

California, located at the boundary of the Pacific and North America tectonic plates, has the greatest seismic risk exposure of any state in the country. About 13,000 Caltrans–owned bridges and a roughly equal number of local agency–owned bridges face seismic risk. Caltrans' priority is to ensure that the roadways and bridges are safe and can support emergency response and regional recovery efforts. To achieve these goals economically, accurate characterization of potential threats is necessary. Some locations are more vulnerable than others because of their proximity to active faults or poor soil conditions. PEER-Lifelines develops statistical models that characterize various earthquake-related hazards to improve the understanding of where these high-risk locations are and how large the seismic demands might be. These models are then incorporated into Caltrans design procedures to advance cost-effective mitigation strategies.

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http://peer.berkeley.edu

Partners for Advanced Transportation Technology

PATH, a research and development center at UC Berkeley, is a leader in Intelligent Transportation Systems (ITS) research. The center works in conjunction with experts in the fields of information technology, electrical engineering, electronics engineering, mechanical engineering, economics, transportation policy, and behavioral studies. In close collaboration with Caltrans, PATH executes a diverse portfolio of multidisciplinary transportation research projects with its staff, UC Berkeley faculty, and students.

PATH provides Caltrans the tools needed to help meet its safety and mobility goals by conducting leading-edge research on transportation; evaluating and conducting controlled experiments and field operational tests; and developing public, private, and academic partnerships.

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www.path.berkeley.edu

Sustainable Transportation Energy Pathways

Focused on the future roles of alternative fuels and vehicles, the UC Davis STEPS program is a four-year (through 2018) multidisciplinary research consortium. Sponsored through a private-public collaboration, STEPS promotes the transition to a sustainable transportation energy future by generating the theory, tools, and methods to compare promising alternative energy sources. The program addresses the uncertainty that governments and companies face in choosing new fuel-vehicle pathways, highlighting the necessity of a comprehensive approach to reducing oil use and greenhouse gas emissions. It disseminates knowledge and tools to industry, government, the environmental NGO community, and the general public to enhance societal, investment, and policy decision-making. STEPS researchers host webinars and workshops for consortium members on energy policy and technology.

In 2004, California put forth the Hydrogen Highway Initiative, resulting in a partnership between Caltrans, as the owner-operator of California's highway system, and University of California, Davis to research using hydrogen for transportation applications. However, since then, other alternative fuel types show promise and perhaps are more practical. The STEPS comparative analysis provides Caltrans a full research portfolio of the major alternative fuel types and the potential impacts and challenges to public-sector entities and policy makers.

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http://steps.ucdavis.edu

University of California Pavement Research Center

UCPRC is a major component in the statewide pavement program, focusing on improving the durability and management of pavements. UCPRC is multidisciplinary, addressing the areas of pavements, structures, materials, mechanical, environmental, transportation, geotechnical, and chemistry, with research programs at both UC Davis and UC Berkeley. Its goals include implementing mechanistic-empirical design, incorporating recycling and sustainability, developing quieter pavements, enhancing construction practices and project delivery, and implementing smoothness.

California's economy depends on the ability to move goods rapidly and without damage. California's traveling public expects a safe and efficient transportation network. As resources become limited, Caltrans must find ways to maintain and improve its extensive pavement infrastructure. UCPRC provides expertise in areas that Caltrans requires to maintain this critical transportation infrastructure.

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www.ucprc.ucdavis.edu

University Transportation Centers

In FY 2014/15, Caltrans provided state match funding for five California UTCs. Two of them, the Mineta National Transit Research Consortium (MNTRC) and the University of California Transportation Center (UCTC), received funding under the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The Moving Ahead for Progress in the 21st Century Act (MAP-21) provided federal funding for the other three UTCs: the METRANS Transportation Center; the National Center for Sustainable Transportation (NCST); and the University of California Center on Economic Competitiveness in Transportation (UCCONNECT).

The UTCs are fully integrated within institutions of higher learning and provide a vital source of leaders prepared to meet the nation's need for safe, efficient, and environmentally sound movement of people and goods. The centers work in partnership with DRISI to support the research needs of Caltrans and the state of California, primarily in the areas of mass transportation, rail, traffic operations, and transportation planning.

MNTRC, led by the Mineta Transportation Institute at San José State University, provides expertise on alternative fuels, safety and security, public policy, finance, workforce development, livable communities, environmental sustainability, economic competitiveness, new modes, and other critical factors essential to sustainable mobility. MNTRC primarily supports the research needs of Caltrans' divisions of Rail and Mass Transportation and Transportation Planning. Consortium members include:

- Bowling Green State University
- Grand Valley State University
- Howard University
- Penn State University
- Rutgers, The State University of New Jersey
- University of Detroit Mercy
- University of Nevada, Las Vegas
- University of Toledo

UCTC, led by the University of California, Berkeley, focuses on environmental sustainability, economic competitiveness, and livability and the connections between them. UCTC primarily supports the research needs of Caltrans' divisions of Rail and Mass Transportation and Transportation Planning. Consortium members include:

- University of California, Davis
- University of California, Irvine
- University of California, Los Angeles
- University of California, Riverside
- University of California, Santa Barbara

Affiliate members include:

- California Polytechnic State University, San Luis Obispo
- California State Polytechnic University, Pomona
- California State University, Sacramento
- California State University, San Bernardino

METRANS, led by the University of Southern California, is a two-member consortium that includes California State University, Long Beach. METRANS conducts an integrated, multidisciplinary program of research aimed at increasing the economic competitiveness of large metropolitan areas through improved transportation system performance, addressing passenger and freight across all surface transportation modes. METRANS primarily supports the research needs of Caltrans' divisions of Rail and Mass Transportation, Transportation Planning, and Traffic Operations.

NCST, led by the University of California, Davis, addresses the U.S. DOT's strategic goal to advance environmentally sustainable policies and investments by asserting national leadership in reducing carbon emissions from transportation systems while supporting climate adaptation activities and continued mitigation of air pollution and other environmental impacts. NCST primarily supports the research needs of Caltrans' Division of Transportation Planning. Consortium members include:

- California State University, Long Beach
- Georgia Institute of Technology
- University of California, Riverside
- University of Southern California
- University of Vermont

UCCONNECT, led by the University of California, Berkeley, promotes economic competitiveness, pursuing projects to reduce congestion, improve highway operations, and enhance freight movement. UCCONNECT primarily supports the activities of Caltrans' divisions of Rail and Mass Transportation, Transportation Planning, and Traffic Operations. Consortium members include:

- University of California, Irvine
- University of California, Los Angeles
- University of California, Riverside
- University of California, Santa Barbara

Affiliate member includes:

- California State Polytechnic University, Pomona

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www.dot.ca.gov/newtech/utc

Research Task Summary

The Research Task Summary lists selected research tasks completed in FY 2014/15 and scheduled to be completed in FY 2015/16 or 2016/17 that highlight the breadth of the research program. Tasks are arranged by functional program areas, with transportation pooled funds (TPF) listed separately, in ascending order by task end date. For tasks appearing in bold, a Research Results summary document is included in this report on the page number indicated.

Research tasks completed in FY 2014/15

Research tasks scheduled to be completed in FY 2015/16 or 2016/17

Advanced Research

Task ID	Task Title	DRISI Manager	End Date	Page #
2234	Dedicated Short Range Communications (DSRC) for Work Zones and Major Incident Management	Gwynne, Gloria	9/15/15	-
2819	Vehicle-to-Vehicle Communications in Mixed Passenger-Freight Convoys	Siddiqui, Asfand	12/31/15	-
2536	Clean, Green and Smart Corridor Development: MCOM Advance Adoption of Alternative Fuel Commercial Vehicles	Hanson, Matt	8/31/16	-

Construction

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2524	Validating the Effects of Collaborative Partnering on Major Capital Projects	Chung, Haniel	8/1/16	-

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2820	Smart Truck Driver Assistant: A Cost-Effective Container Delivery for Trucks	Hanson, Matt	12/31/15	-
2831	Spatial Dynamics of the Logistics Industry and Implications for Freight Flows	Hanson, Matt	2/15/16	-

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0918	Development of Aesthetic, Low-Maintenance Guardrail System Alternatives	Caldwell, Christopher	11/10/15	-
2530	Environmental Effects of Cured-in-Place Pipe (CIPP) Repairs	Benouar, Azzeddine	12/31/16	-
2553	Development of an Aesthetic/Low-Maintenance Guardrail System, Phase 2	Caldwell, Christopher	12/31/16	-

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2455	Watershed Modeling System License Renewal Agreement, TPF-5(265)	Chung, Haniel	7/1/15	-

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2824	Do California Highways Act as Barriers to Gene Flow for Ground-Dwelling Mammals?	Hunt, Harold	3/30/16	-
2528	Culvert Project Planning Cost Estimate Tool	Hunt, Harold	6/30/16	-
2978	Using Non-invasive Genetics to Compare How a California Freeway Affects Gene Flow in a Disturbance-adverse versus a Disturbance-tolerant Species	Hunt, Harold	6/30/17	-

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1010	**Structural Acoustic Analysis of Piles, TPF-5(140)**	**Hunt, Harold**	**12/31/14**	**34**
1579	Tire/Pavement Noise Research Consortium, TPF-5(135)	Hunt, Harold	12/31/15	-

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2738	Analysis of Fleet In-house Assembly to Purchasing Completed Equipment from Vendors	Nagra, Sukhdeep	8/31/16	-
2737	Investigation of DOE Fleet Equipment Repair Costs and Replacement Criteria	Nagra, Sukhdeep	3/31/17	-

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2181	**Compliance Crash Testing of the Caltrans Type 26 Bridge Rail (732SW)**	**Whitesel, David**	**4/30/15**	**36**
2107	Nondestructive Damage Evaluation of Viscous Dampers, Lead Rubber Bearings and Friction Pendulum Bearings	Sikorsky, Charles	5/31/15	-
2316	**Shear Resistance of End Panels in Steel and Steel-Concrete Composite Plate Girders**	**Sikorsky, Charles**	**5/31/15**	**38**
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1946	Time Dependent Deflection of In-span Hinges of Prestressed Concrete Structures During Construction	Ikram, Hamid	8/31/15	-
2111	Geophysical Methods for Determining the Geotechnical Engineering Properties of Earth Materials	Owen, Bill	3/31/16	-
2343 2605	Reusable Instrumented Test Pile, Phase 2	Shantz, Tom	3/31/16	-
1805	Corridor-Scale Landslide Hazard Mapping: Conversion of CGS Hazard Maps	Roblee, Cliff	6/30/16	-
2346	Controlling Temperature and Shrinkage Cracks in Bridge Decks and Slabs	Lee, Peter	6/30/16	-
2934	Development of an Economic Framework to Evaluate Resilience in Recovering from Major Port Disruptions	Provost, Leanne	9/1/16	-
2747	Bridge Strong Motion Instrumentation System Data Recovery	Hipley, Pat	9/30/16	-
2557	Compliance Crash Testing of a MASH 2009 Test Level 4 Side Mounted Bridge Rail	Her, Vue	12/31/16	-
1780	Generation-2 Bridge Fragility Relationships: Production Analytical Components	Roblee, Cliff	6/30/17	-

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2444	Peer Exchange and Review of Deep Foundation Testing Methodologies at Caltrans, TPF-5(263)	Hunt, Harold	6/30/16	-
1097	Structural Health Monitoring System, TPF-5(219)	Sikorsky, Charles	9/30/16	-
1648	Application of Three-dimensional Laser Scanning for the Identification, Evaluation, and Management of Unstable Highway Slopes, TPF-5(166)	Meline, Bob	12/11/16	-

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2944	Traction Control Devices Durability Study	Mizuno, Bradley	9/18/15	-
2299	Mobile Real-time Information System for Snow Fighter Supervisors: System Design & Test	Baumeister, Larry	9/30/15	-
2335	Improved Deicing Methods for Snow and Ice Removal: Epoke Evaluation	Baumeister, Larry	9/30/15	-
2336	Evaluation of the TowPlow Trailer System	Baumeister, Larry	9/30/15	-
2337	Evaluation of GPS-based Mountain Pass Opening for Tioga Pass	Baumeister, Larry	9/30/15	-
2771	Support for Avalanche Sensing and Communications	Baumeister, Larry	9/30/15	-
2543	Validation of Polyester Concrete Rehabilitation Strategy to Extend the Service Life of Concrete Bridge Decks	Sahs, Steve	6/30/16	-
2887	Solar Lighting Evaluation for Highway Applications	Ziaullah, Fouad	10/31/16	-

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2508	**Field Operational Tests of Vehicle-Assist and Automation (VAA) System for Public Transit Buses**	**Mizuno, Bradley**	**2/28/15**	**46**
2627	**Integrating Highway and Transit Data into Benefit-Cost Analysis**	**Ziaullah, Fouad**	**5/1/15**	**48**
2892	**Passenger Flows in Underground Railway Stations and Platforms**	**Tyner, Patrick**	**6/30/15**	**50**
2461	Smart Travel Choices: Field Operational Tests	Ziaullah, Fouad	9/30/15	-
2627	Integrating Highway and Transit Data into Benefit-Cost Analysis	Ziaullah, Fouad	9/30/15	-
2631	Promoting Intermodal Connectivity at California's High Speed Rail Stations	Tyner, Patrick	11/30/15	-
2629	Comparing Modes of On-Board Transit Passenger Surveys: Assessing Trade-Offs between Data Quality and Cost	Ziaullah, Fouad	12/31/15	-

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2634	Bicycling and Access to Transit by Low-Income Immigrants	Chursenoff, David	12/31/15	-
2806	Promoting Peer-to-Peer Ridesharing Services as Transit System Feeders	Chursenoff, David	12/31/15	-
2642	An Activity-based Toolbox for Planning Applications with Special Relevance to Transit	Chursenoff, David	1/30/16	-
2628	A Tool to Evaluate and Optimize Multi-Modal Transit Access	Saetern, Lai	1/31/16	-
2664	Bus Rapid Transit (BRT) Toolbox: Assessing Person Throughput to Measure Transportation Impacts for BRT Projects	Ziaullah, Fouad	1/31/16	-
1768	Integration of AWOS with RWIS, Phase 2: Prepare system for deployment	Clark, Melissa	3/31/16	-
2499	Pricing Your Way To Operational Efficiency: One-Way Electric Vehicle Carsharing In San Diego	Chursenoff, David	3/31/16	-
2860	Rail and the California Economy	Azevedo, Christine	4/1/16	-
2873	Coordinating Transit Transfers in Real Time	Saetern, Lai	4/1/16	-
2875	Analyzing Spread of Influence in Social Networks for Transportation Applications	Araya, Juan	4/1/16	-
2758	Investigating Relationships Between Highway System Performance and Transit System Management	Mizuno, Bradley	4/30/16	-
2637	International Lessons for Promoting Transit Connections to High-Speed Rail Systems	Tyner, Patrick	05/01/2016	-
2521	Dynamic Transit Trip Planner (DTTP)/Interactive Transit Station Information System (ITSIS)	Mizuno, Bradley	5/30/16	-
2802	Heightening Walking Above its Pedestrian Status: Walking and Travel Behavior in California	Gwynne, Gloria	5/31/16	-
2866	Bringing a Community Health Lens to Highway-to-Main Street Conversions	Gwynne, Gloria	8/31/16	-
2969	A Comparative Analysis of High Speed Rail Station Development into Destination and/or Multi-use Facilities	Iacobucci, Lauren	12/30/16	-

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2374	**Recycling of Rubberized Hot Mix Asphalt in Reclaimed Asphalt Pavement and Full-Depth Reclamation Projects and with Warm Mix Technologies**	**Sadraie, Hamid**	**9/30/14**	**56**
2375 2600	**Monitoring of Selected Quieter Pavement Test Sections**	**Wang, Yue**	**9/30/14**	**58**
2558	**Rubber Binder Testing and Acceptance**	**Sadraie, Hamid**	**9/30/14**	**60**
2565	**Blending Effects of Recycled Asphalt Pavements on Virgin Binders**	**Sadraie, Hamid**	**9/30/14**	**62**
2354	**Complete Quality Assurance on Automated Pavement Condition Survey and Ground Penetrating Radar Contracts**	**Holland, Joe**	**11/30/14**	**64**
2376 2580	**Using Environmental LCA to Develop Tools and Recommend Practices to Reduce Environmental Impact (Sustainable Pavements)**	**Holland, Joe**	**11/30/14**	**66**
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2827	Evaluation of the Combined Effect of Recycled Asphalt Pavement (RAP), Recycled Asphalt Shingles (RAS), and Different Virgin Binder Sources on Performance of the Blended Binder for Mixes with Higher Percentages of RAP and RAS	Sadraie, Hamid	9/30/15	-

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2020	Improving the Foundation Layers for Concrete Pavements, TPF-5(183)	Wang, Yue	6/30/16	-
2258	Technology Transfer Intelligent Compaction Consortium (TTICC), TPF-5(233)	Chung, Haniel	6/30/16	-
2606	Demonstration of Network Level Pavement Structural Evaluation with Traffic Speed Deflectometer, TPF-5(282)	Holland, Joe	7/19/16	-
2611	Development of an SPS-2 Pavement Preservation Experiment, TPF-5(291)	Holland, Joe	8/7/16	-
0570	Improving the Quality of Pavement Profiler Measurement, TPF-5(063)	Rodriguez, Alfredo	12/30/16	-

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2603	**Pilot Study Investigating the Interaction and Effects for State Highway Pavements, Trucks, Freight, and Logistics**	**Nokes, Bill**	**9/30/14**	**72**
2656	**Road Usage Charge Initial Study**	**Williams, Scott**	**12/30/14**	**74**
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2891	The Nexus Between Infrastructure and Accessibility	Chursenoff, David	5/31/15	-
2309	Next STEPs: Scenarios and Transition Strategies	Tyner, Patrick	6/14/15	-
2636	Synergistic Integration of Transportation Demand Management Strategies (Land Use, Transit, and Auto Pricing) with New Technologies and Services (Battery Electric Vehicles and Dynamic Ridesharing) to Enhance Reductions in VMT and GHG	Tyner, Patrick	7/31/15	-
2893	Interregional Transportation Strategic Plan (ITSP)	Tyner, Patrick	7/31/15	-
2888	Park and Ride Linkage to Public Transit Service Productivity	Chursenoff, David	8/30/15	-
2821	Exploring Unintended Environmental and Social-Equity Consequences of Transit Oriented Development Using a Spatial Economic Land Use and Activity-Based Microsimulation Models	Law, Frank	8/31/15	-
2829	The Role of Environmental Concerns, Lifestyles, Mobility-Related Attitudes and Peers' Influence in Affecting Travel Behavior and Aspirations Towards the Purchase of Private Vehicles of Young Adults in California	Chursenoff, David	9/30/15	-
2635	The Impact of Public Bikesharing on Bicycle Safety in North America	Rudulph, Kimberly	10/31/15	-
2742	ITS America-Facilitated Charrette on Environmental Performance Measures	AbouKhadijeh, Hassan	12/15/15	-
2651	The Impact of the Sharing Economy on Latent Individual Modal Preference	Nagra, Sukhdeep	12/31/15	-

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2825	White Paper on Future of Travel Demand in the U.S.	Chursenoff, David	12/31/15	-
2828	Whitepaper on Performance-Based Approaches to Incentivize Local Adoption of Sustainable Land Use Policies	Chursenoff, David	12/31/15	-
2644	Spatial Transferability Using Synthetic Population Generation Methods	Chursenoff, David	1/30/16	-
2648	Accounting for Interregional Travel in Regional Land Use and Transportation Plans: A Comparison of Attribution Methods	Chursenoff, David	1/30/16	-
2643	Towards Inferring Welfare Changes from Changes in Curbside Parking Occupancy Rates: A Theoretical Analysis Motivated by SFpark and LA Express Park	Chursenoff, David	1/31/16	-
2645	Balancing Life-cycle Cost and Life-cycle Impact Considerations in Pavement Management	Holland, Joe	1/31/16	-
2854	Traffic Volume and Aggregate Economic Activity: Implications for Taking the Pulse of the U.S. Economy	Chung, Haniel	1/31/16	-
2848	UCLA ITS Tech Transfer Program	Tyner, Patrick	2/29/16	-
2641	Infill Dynamics in Rail Transit Corridors: Challenges and Prospects for Integrating Transportation and Land Use Planning	Iacobucci, Lauren	3/15/16	-
2793	Demand Forecasting and Activity-based Mobility Modeling from Cell Phone Data	Law, Frank	3/31/16	-
2798	Accessibility and Economic Development: How the Transportation Network Affects the Economic Performance of Regions	Alkadri, Mohamed	3/31/16	-
2850	California Integrated Border Approach Study (CA-IBAS), Phase 2	Azevedo, Christine	3/31/16	-
2794	Crowdsourced Data to Activity Models: Human Mobility Prediction for Real-time Ride-sharing	Law, Frank	4/1/16	-
2832	Urban Spatial Structure and the Potential for VMT Reduction	Tyner, Patrick	4/1/16	-
2799	Strategic Charging Infrastructure Deployment for Electric Vehicles	Iacobucci, Lauren	4/15/16	-
2851	Business Establishment Survival and Transportation System Level of Service	Tyner, Patrick	4/29/16	-
2869	Public Transportation and Industrial Location Patterns in California	Provost, Leanne	4/30/16	-
2987 2988	White Papers on Emission Reducing Efficiency Strategies to Incorporate into the California Sustainable Freight Strategy	Azevedo, Christine	5/1/16	-
2822	Environmentally-friendly Driving Feedback Systems Research and Development for Heavy-Duty Trucks	Iacobucci, Lauren	5/15/16	-
2918	Effectiveness of State and Local Incentives on Household Ownership of Alternative Fuel Vehicles	Iacobucci, Lauren	5/15/16	-
2942	Planning Workshop-Seminar Series	Iacobucci, Lauren	5/15/16	-
2797	Impacts and Future of the California Fuel Tax Swap of 2010	Williams, Scott	5/27/16	-
2919	Toward Accurate and Valid Estimates of Greenhouse Gas Reductions from Bikeway Projects	Hunt, Harold	6/30/16	-
2862	Potential Greenhouse Gas Emissions Reductions from Optimizing Urban Transit Networks	Hunt, Harold	7/30/16	-
2939	Developing Affordable Housing Guidelines Near Rail Transit in Los Angeles	Chursenoff, David	8/14/16	-
2932	Investigations of the Effect of Humid Air on NOX & PM Emissions of a CNG Engine	Saetern, Lai	9/1/16	-
2937	Route Choice Characteristics of Owner-Operated Trucks in Southern California Freeways	Nokes, Bill	9/1/16	-
2968	Transportation Data Trends and Best Practices	Chursenoff, David	9/30/16	-
2941	Decline in Inter- and Intra-urban Mobility and its Impact on Passenger Travel	Iacobucci, Lauren	11/15/16	-
2976	Effect of State and Federal Housing Policies on Vehicle Miles of Travel	Iacobucci, Lauren	11/15/16	-

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2852	Professional Planner Workforce Development Training Program	Law, Frank	1/30/17	-
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2996	Research and Support for MTLS Data Management and Visualization	Lofton, Arvern	9/30/16	-
2729	Expanding Mobile Terrestrial Laser Scanning (MTLS) Capability and Capacity throughout Caltrans	Lofton, Arvern	2/14/17	-

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1747	Professional Capacity Building for Communication Systems, Phase 3: Telco Wireless Communications	Perez, Jose	12/29/15	-
2283	WeatherShare, Phase 3: Visualization Tools	Campbell, Sean	12/31/15	-
1846	Responder Study, Phase 3: Enhancements, Specifications and Deployment	Clark, Melissa	3/31/16	-
1753	California and Oregon Advanced Transportation System (COATS) IV	Campbell, Sean	6/30/16	-

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2424	**Development of a Rational Design Method for Shear Keys at In-Span Hinges in Multi-Frame Highway Bridges**	**Sikorsky, Charles**	**8/31/14**	**84**
2493	**Interaction of GRS Abutments with Bridge Superstructures under Seismic Loading**	**Sikorsky, Charles**	**11/30/14**	**86**
2264	**Development and Verification of Concrete Models for Pier Walls and Hollow Columns: Analytical Phase**	**Sikorsky, Charles**	**12/15/14**	**88**
1793	**ShakeCast V3–An Enhanced Tool for Post-Earthquake Response**	**Turner, Loren**	**12/31/14**	**90**
2417	**Concrete-Filled Tube Pier Connections for Accelerated Bridge Construction**	**Lee, Peter**	**3/15/15**	**92**
2419	Parametric Study of Ordinary Standard Bridges Using OpenSees and CSiBridge	Sikorsky, Charles	4/30/15	-
2265	**Seismic Performance of Connections that Facilitate Accelerated Bridge Construction**	**Sikorsky, Charles**	**5/31/15**	**94**
2171	**Structural Behavior of Column-Bent Cap Beam-Box Girder Systems in Reinforced Concrete Bridges Subjected to Gravity and Seismic Loads**	**Lee, Peter**	**6/15/15**	**96**
2420	Seismic Assessment of Cut-and-cover Tunnels	Sikorsky, Charles	7/31/15	-
2582	Omni-directional Hysteretic p-y Models for Piles Embedded in Cohesive Soils	Sikorsky, Charles	9/30/15	-
2287	Analytical and Experimental Development of Bridges with Foundations Allowed to Uplift during Earthquakes	Lee, Peter	10/31/15	-
2263	Evaluation and Improvement of Design Methods and Details for Shear Keys and Stem Walls in Bridge Abutments	Sikorsky, Charles	11/30/15	-
2423	Performance of the Column-to-shaft Pin Connections in Type-II Shafts	Lee, Peter	11/30/15	-
2560	Evaluation of the Development Length for Headed Steel Reinforcing Bars	Sikorsky, Charles	11/30/15	-
2563	Evaluation of Grade 80 Steel Reinforcement Bars for Seismic Applications	Sikorsky, Charles	12/31/15	-
2173	Impact of Inspection Tube Placement on Structural Performance of CIDH Piles	Sikorsky, Charles	4/30/16	-
2562	Evaluation of Durability and Wear Characteristics of Viscous Fluid Dampers	Sikorsky, Charles	4/30/16	-
2756	Calibration of Probabilistic Damage Control Approach (PDCA) for Seismic Design of Bridges, Phase 2	Lee, Peter	12/31/16	-
2544	Seismic Performance of Bridge Superstructure in Accelerated Bridge Construction	Lee, Peter	1/1/17	-
2755	Efficient Nonlinear Time History Analysis of California Bridges	Sikorsky, Charles	1/31/17	-
2754	Development of Validated Methods for Soil-Structure Interaction Analysis of Buried Structures	Lee, Peter	5/31/17	-
2744	Numerical Assessment of Liquefaction-induced ground deformations and loading mechanisms	Sikorsky, Charles	6/30/17	-

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2317	**Methods for Identifying High Collision Concentrations for Identifying Potential Safety Improvements**	**Kwong, Jerry**	**1/31/15**	**102**
2293	**Enhancement and Technical Support of Intelligent Roadway Information System (IRIS) in Caltrans Districts 1, 2, 5 and 10**	**Clark, Melissa**	**3/31/15**	**104**
2165	**San Diego Integrated Corridor Management (ICM), Phase 3, Demonstration and Evaluation**	**Perez, Jose**	**6/30/15**	**106**
2257	**Work Zone Injury Data Collection and Analysis**	**Ikram, Hamid**	**6/30/15**	**108**
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2529	Advanced Traffic Signal Control Algorithms, Phase 2	Siddiqui, Asfand	8/31/15	-
2839	Travel Time Detector Installation and Integration in District 3	Slonaker, John	10/30/15	-
2841	Testing MS Sedco INTERSECTOR Radar Detectors for Car/Bike Differentiation	Slonaker, John	10/30/15	-
2449	Queue Storage and Acceleration Lane Length Design at Metered On-ramps in California	Perez, Jose	10/31/15	-
2815	Tracking Truck Flows with Programmable Mobile Devices	Mizuno, Bradley	10/31/15	-
2795	Smartphone Information and Transportation Demand Modeling: An Analysis of Transportation Network Companies	Ziaullah, Fouad	12/31/15	-
2811	Developing an Agent-based On-line Adaptive Signal Control (ASC) Framework Using Connected Vehicle (CV) Technology	Siddiqui, Asfand	12/31/15	-
2816	Analysis and Prediction of Spatiotemporal Impact of Traffic Incidents for Better Mobility and Safety in Transportation Systems	Clark, Melissa	12/31/15	-
2818	A Dynamical Framework for Integrated Corridor Management	Perez, Jose	12/31/15	-
2836	Develop a Plan to Collect Bicycle Infrastructure and Volume Data for Future Incorporation into TASAS-TSN	Loebs, Nathan	1/30/16	-
2855	Congestion-responsive On-ramp Metering: Before and After Studies, Phase 1	AbouKhadijeh, Hassan	1/30/16	-
2876	A Unified Framework for Analyzing and Designing Signals for Stationary Arterial Networks	Chung, Haniel	1/30/16	-
2912	Communication Technology Management (CTM)-based Optimal Signal Control Strategies in Urban Networks	Chung, Haniel	1/31/16	-
2809	Modeling and Control of HOT lanes	Siddiqui, Asfand	2/28/16	-
2810	Control Strategies for Corridor Management	Perez, Jose	2/29/16	-
2801	Bicycle Crash Risk: How Does it Vary and Why	Loebs, Nathan	3/31/16	-
2803	Automated Assessment of Safety-critical Dynamics in Multimodal Transportation System	Mizuno, Bradley	3/31/16	-
2874	Combining California Household Travel Survey Data with Harvested Social Media Information to Form a Self-Validating, Statewide, Origin-Destination Travel Prediction Method	AbouKhadijeh, Hassan	3/31/16	-
2915	HOT Lane Calibration and Simulation Algorithms	Saetern, Lai	3/31/16	-
2826	Bicyclist Behavior in San Francisco: A Before-and-after Study of the Impact of Infrastructure Investments	Loebs, Nathan	4/1/16	-

Transportation Safety and Mobility (continued)

Task ID	Task Title	DRISI Manager	End Date	Page #
2867	Mobile Apps and Transportation: Exploring Data Metric Potential and User Response to Multimodal Traveler Information	Ziaullah, Fouad	4/1/16	-
2846	One California Proposal for FHWA's CV Pilot Deployments	Sah, Prakash	4/17/16	-
2872	SB-743: From LOS to VMT, VHT and Beyond Through Data Fusion: Application to Integrated Corridor Management	Wang, Yue	4/30/16	-
2844	Performance Measures for Bicycle Suitability on the State Highway System	Loebs, Nathan	5/30/16	-
2871	What Can a Bike Lane Do? Performance Metrics for Proposed Bicycle Infrastructure	Kwong, Jerry	5/31/16	-
2446	Development of Safety Performance Functions for California-Type 2, Advanced	Kwong, Jerry	6/29/16	-
1546	C1 Loop Detector Reader/Analyzer	Kwong, Jerry	6/30/16	-
1559	Onsite Evaluation of Roadside Devices and Operational Strategies	Palen, Joe	6/30/16	-
2445	Field Experiment of Coordinated Ramp Metering (CRM), Phase 2	AbouKhadijeh, Hassan	6/30/16	-
2535	Coordination of Freeway Ramp Meters and Arterial Traffic Signals, Phase 2A: Site Selection & Simulation Development	AbouKhadijeh, Hassan	6/30/16	-
2646	An Evaluation of Signalized Intersection Safety Using Centracs System	Ziaullah, Fouad	6/30/16	-
2804	Experimental Studies for Traffic Incident Management	Clark, Melissa	6/30/16	-
2926	Evaluating the Performance of Traffic Detection Devices	Ziaullah, Fouad	6/30/16	-
2935	Integration of Passenger and Freight Rail Scheduling	Loebs, Nathan	6/30/16	-
2652	Adaptive Coordination Algorithm for Arterial Traffic Signals	Slonaker, John	9/30/16	-
2837	Assist in the Development and Testing of the Connected Corridors I-210 Pilot Project	Slonaker, John	10/10/16	-
2911	Evaluating Deployability of Cooperative Adaptive Cruise Control (CACC) to Form High-Performance Vehicle Streams	Siddiqui, Asfand	10/31/16	-
2304	Evaluating Alternative Design of Geometric Configuration for High-Occupancy Vehicle (HOV) Facilities in California	Perez, Jose	12/30/16	-
2564	Assist in the Development and Support of an Enterprise-Wide Traveler Information System	Campbell, Sean	12/31/16	-
2531	Automated Video Incident Detection (AVID) System	Slonaker, John	1/11/17	-
2450	Strategies for Reducing Pedestrian and Bicyclist Injury at the Corridor Level (SMART), Phase 2	Kwong, Jerry	1/31/17	-
2975	Warehousing and Distribution Center Facilities in Southern California: The Use of the Commodity Flow Survey Microdata to Identify Logistics Sprawl and Freight Generation Patterns	Tyner, Patrick	3/31/17	-

Transportation Safety and Mobility TPF

Task ID	Task Title	DRISI Manager	End Date	Page #
0373	High Occupancy Vehicle (HOV) Systems, TPF-5(322)	Loebs, Nathan	12/31/15	-
2306	Traffic Signal Systems Operations and Management, TPF-5(258)	Clark, Melissa	3/31/16	-
2061	Support for Research and Deployment of System Ops Applications of VII, TPF-5(206)	Siddiqui, Asfand	12/31/16	-
2318	Highway Safety Manual Implementation, TPF-5(255)	Kwong, Jerry	12/31/16	-
0788	Traffic Control Devices Pooled Fund Study, TPF-5(316)	Perez, Jose	5/1/17	-


Caltrans

Fiscal Year 2014/15

Research Results

For this report, DRISI selected a variety of research tasks that highlight elements of the research program. The research results are organized by topic area and provide a high-level summary of the research need, goal, methodology, outcome, and benefit. These documents were produced with the collaboration of the participants of the tasks.

You can access and download the summaries from *www.dot.ca.gov/research/researchreports/technical_summaries.htm.* For more information about a specific task, contact the task manager listed.

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Research Results

Reducing Tire-Pavement Noise

Better practices for constructing and texturing quieter concrete pavement surfaces

Environmental

JANUARY 2016

Project Title:
PCC Surface Characteristics: Tire-Pavement Noise Part 3, TPF-5(139)

Task Number: 1029

Start Date: January 1, 2007

Completion Date: November 3, 2014

Product Category: New or improved guidelines; new or improved business practice, procedure, process

Task Manager:
Harold Hunt
Senior Environmental Planner
harold.hunt@dot.ca.gov

WHAT WAS THE NEED?

The noise generated by tires on pavement can adversely affect those residing or working near roadways. Although portland cement concrete (PCC) pavements can produce a considerable amount of traffic-generated noise, they can be designed and constructed using standard textures to be as quiet as other conventional pavement types. One reason why all PCC pavements are not quiet is a lack of a collective understanding of the texturing characteristics that yield quieter pavements while not compromising other pavement requirements, such as safety and durability. This study identified the means for producing PCC pavements that are safe and durable but produce less traffic-related noise.

WHAT WAS OUR GOAL?

The goal was to be able to specify the appropriate surface characteristics of individual PCC pavement projects prior to construction to meet site-specific requirements for noise, skid, texture, and smoothness.

Measuring tire pavement noise

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WHAT DID WE DO?

Led by the Iowa Department of Transportation (DOT), Caltrans and the other participating DOTs of this pooled fund study—Minnesota, New York, Texas, Washington, and Wisconsin—evaluated over 1,500 test sections in North America and Europe and developed an understanding of the fundamental surface properties that affect noise. This third phase of the project had the following objectives:

- Continue comprehensive data collection on new and existing pavements for measurements over time
- Analyze the data to identify the relationships between texture, noise, friction, and other characteristics
- Create and assess construction specifications of conventional texture techniques, including grinding
- Develop and evaluate innovative construction techniques that have the potential to significantly reduce noise

WHAT WAS THE OUTCOME?

The project amassed the largest database to date of PCC pavement surface characteristics, including noise, texture, and friction measurements, helping to formulate an understanding of the fundamental surface properties that affect noise. Both the best and the worst of almost every concrete pavement texture in use today has been catalogued. Pavements are categorized by texture type and overall noise levels measured using the on-board sound intensity method. The variability within distributions is due to differences in design, construction, age, climate, traffic, and other factors.

Variability of drag texture surface and its effect on overall OBSI level

The researchers identified better practices that enhance surface properties to produce quieter PCC pavements. These practices address:

- Constructing and texturing quieter concrete pavements
- Reducing tire-pavement noise
- Solutions that do not compromise other pavement elements that are of equal or greater importance, including safety, cost, and durability

WHAT IS THE BENEFIT?

By using these better practices, quieter PCC pavements that are safe, durable, and cost effective can be built. The practices address the challenges faced in producing a high-quality product in a low-bid environment. The collected data has shown that quieter concrete pavements do not sacrifice safety because there is no direct relationship between friction and noise.

LEARN MORE

To view the final pooled fund study report:
www.pooledfund.org/Details/Study/368

Longitudinal tining of a newly placed concrete surface

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Research Results

Mitigating Acoustic Impact of Driving Underwater Piles

A double-walled steel tube can reduce the underwater sound level up to 10 decibels and the effect on aquatic life

Environmental

NOVEMBER 2015

Project Title:
Structural Acoustic Analysis of Piles, TPF-5(140)

Task Number: 1010

Start Date: September 14, 2005

Completion Date: December 31, 2014

Product Category: New or improved guidelines

Task Manager:
Harold Hunt
Senior Environmental Planner
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WHAT WAS THE NEED?

Bridges, ferry terminals, and other structures constructed over water typically have driven pile foundations. Pile driving in water produces high sound levels in both the surrounding air and underwater environment. Underwater it can produce intense sound, adversely affecting aquatic life and other sensitive receptors. For this reason, pile driving is a highly regulated construction process. To mitigate the noise impact while ensuring proper structural integrity, state departments of transportation, harbor districts, and other agencies must be able to forecast the acoustical properties of the sound that a project will generate. However, relatively little is known about the process of underwater sound generation and propagation from pile driving. Understanding the acoustical properties and the noise potential of pile driving helps government agencies and private entities select the appropriate materials and methods for pile driving to minimize the adverse impacts of underwater sound.

Surrounding a 30-inch-diameter pile with a temporary double-walled steel tube to suppress noise

WHAT WAS OUR GOAL?

The goal was to develop a scientific understanding of how the variables associated with pile driving, such as pile material and hammering characteristics, influence the generation of underwater sound and investigate ways to reduce aquatic noise.

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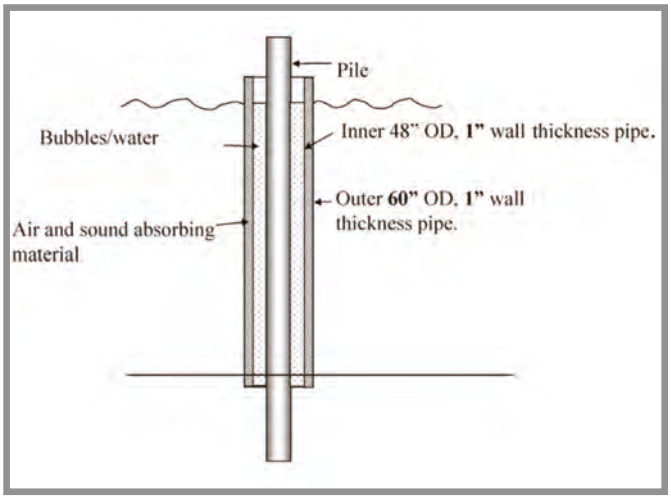
WHAT DID WE DO?

Caltrans, as part of this pooled fund study with the Port of Oakland and the Alaska, Virginia, and Washington departments of transportation, investigated the origin and propagation of sound waves from underwater pile driving. The researchers examined how the characteristics of sound produced during pile driving are influenced by modifications in pile materials, pile shape, hammering, and other variables. The team studied ways to reduce underwater sound close to the piles during pile driving with attenuation systems, synthesizing the information with previous efforts.

WHAT WAS THE OUTCOME?

The dominant underwater noise caused by impact driving is from the Mach wave associated with the radial expansion of the pile. The wave propagates down the pile after impact at supersonic speed. Surrounding the pile underwater with a double-walled steel tube, also called a temporary noise attenuation pile (TNAP), reduces the sound level by approximately 10 decibels. The reduction is limited due to the unconstrained propagation of Mach waves directly from the sediment into the water.



Schematic of the TNAP

WHAT IS THE BENEFIT?

We now have basic scientific and engineering information that can be used to develop better methods to mitigate the propagation of sound waves and reduce the impact on aquatic life. This knowledge promotes environmental sustainability, addresses environmental regulations, and helps move transportation projects forward. The ability to cost-effectively attenuate underwater noise from pile driving enables construction and repair of transportation facilities in sensitive aquatic habitats.

LEARN MORE

To view the complete report:
www.wsdot.wa.gov/research/reports/fullreports/781.1.pdf

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Research Results

Crash Testing the Revised Type 26 Bridge Rail

A taller version of the Type 26 pedestrian barrier rail meets crash testing guidelines

Geotech/ Structures

JANUARY 2016

Project Title:
Compliance Crash Testing of the Caltrans Type 26 Bridge Rail (732SW)

Task Number: 2181

Start Date: February 3, 2012

Completion Date: April 30, 2015

Product Category: New or improved technical standard, plan, or specification

Task Manager:
David Whitesel
Transportation Engineer
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WHAT WAS THE NEED?

Since 1973, Caltrans has used the Type 26 bridge rail throughout California along routes with pedestrian walkways and posted speed limits of 45 mph or less. The bridge rail is a vertical, reinforced concrete wall on a sidewalk with a steel-tubular pedestrian handrail or chain link fence on top. Over the decades, the Type 26 has functioned well, however it has never been crash tested. A project to assess its crashworthiness was initiated in the early 2000s but redirected to test a higher priority structure. When testing was ready to be restarted, the Federal Highway Administration (FHWA) had released new guidelines, the *Manual for Assessing Safety Hardware* or MASH 09. Because the Type 26 would likely not meet the more stringent MASH criteria, Caltrans developed a taller and stronger version, called the Type 732SW. The sidewalk is also wider to comply with Americans with Disabilities Act (ADA) requirements. Caltrans then needed to determine whether the Type 732SW met the crash-testing guidelines.

WHAT WAS OUR GOAL?

The goal was to verify the crashworthiness of the Type 732SW bridge rail for use on California highways and local roads.

Type 732SW bridge rail

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Crash Testing the Type 26 Bridge Rail

WHAT DID WE DO?

To test whether the 732SW bridge rail met MASH 09 Test Level 2 for longitudinal barriers, Caltrans built a test section at the Caltrans Dynamic Test Facility in West Sacramento. MASH 09 Test Level 2 consists of two crash tests: an 1,100-kilogram (kg) car at 70 kilometers per hour (km/h) and a 25-degree impact angle, and a 2,270-kg pickup truck at 70 km/h and a 25-degree impact angle. All vehicles had standard equipment and front-mounted engines. To ensure that the barrier is strong enough to withstand higher speed impacts, the pickup truck test was conducted at Test Level 3 (100 km/h and a 25-degree impact angle). MASH 09 recommends that crash test performance be assessed according to three factors: structural adequacy, occupant risk, and vehicle trajectory. The researchers video-recorded each crash test and analyzed the data.

WHAT WAS THE OUTCOME?

The results of the Test Level 3 pickup crash test and the Test Level 2 car crash test were within the limits of the MASH 09 guidelines. Occupant risk was acceptable. Damage to the bridge rail was mostly cosmetic, with no structural damage to warrant immediate repair, if any. For all tests, the vehicles were in good condition, free of major body damage and not missing structural parts. The researchers submitted the videos and report to the FHWA for federal-aid eligibility to use the Type 732SW on California highways requiring Test Level 2 bridge rails with pedestrian traffic. FHWA approved the Type 732SW by providing a federal-aid eligibility letter on May 6, 2016.

Pickup test impact

WHAT IS THE BENEFIT?

The upgraded Type 732SW bridge rail is safer and more crashworthy than its predecessor and is ADA compliant. It meets federal guidelines, making it eligible for federal aid.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA15-2181_FinalReport.pdf

Close-up of the 732SW barrier after a test

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Research Results

Evaluating the Shear Strength of End Panels in Steel Bridge Girders

Proposed shear design equations eliminate the need to retrofit steel bridges or restrict loading

Geotech/ Structures

FEBRUARY 2016

Project Title:
Shear Resistance of End Panels in Steel and Steel-Concrete Composite Plate Girders

Task Number: 2316

Start Date: December 1, 2011

Completion Date: May 31, 2015

Product Category: New or improved technical standard, plan, or specification

Task Manager:
Charles Sikorsky
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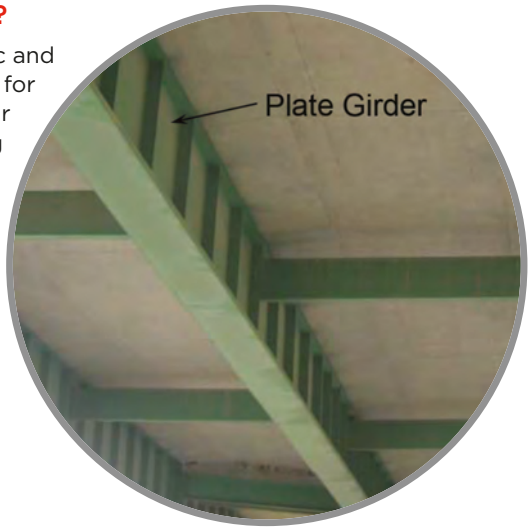
WHAT WAS THE NEED?

When calculating shear strength, many of California's steel bridges, designed based on previous editions of the American Association of State Highway and Transportation Officials (AASHTO) specifications, consider the contribution of the post-buckling tension-field action for the girders' end web panel. Because the maximum shear occurs at the support, the end web panel becomes the controlling component for steel girder design, evaluation, and load rating. The current AASHTO load and resistance factor design (LRFD) and load and resistance factor rating (LRFR) specifications limit the shear strength of a web end panel to either the shear yielding or shear buckling without considering the tension-field action. Based on the specification change, numerous steel girder bridges with end shear controls have a rating factor below 1.0, requiring Caltrans to strengthen the bridge or restrict vehicular loading. However, AASHTO specification commentaries recognize that the current shear design strength for end panels is overly conservative, for example, the contribution of the concrete deck is ignored when evaluating the shear strength. To avoid unnecessary and costly retrofitting or load restrictions, more accurate and practical shear capacity equations that include the potential contributions from both tension-field action and the concrete slab are needed.

WHAT WAS OUR GOAL?

The goal was to develop realistic and practical shear rating provisions for the end web panel of steel girder bridges to use in Caltrans' rating program and recommend for adoption in the California amendments to the AASHTO LRFD and LRFR specifications.



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WHAT DID WE DO?

Caltrans, in partnership with the University of California, San Diego Department of Structural Engineering, tested two steel and two steel-concrete composite girder specimens to investigate the shear resistance of the end panels. The researchers then conducted nonlinear finite-element analyses to simulate the test results and performed a parametric study to identify factors affecting the shear strength of end panels. Based on the observed failure mode from both testing and finite-element simulation, the team developed an analytical model to simulate the collapse mechanism. The researchers used plastic analysis to derive a predictive shear strength equation for the end panels. In a second phase, the team tested four more specimens with different panel width-to-depth ratios and depth-to-thickness ratios, using the results to verify the adequacy of the proposed shear strength equation.

WHAT WAS THE OUTCOME?

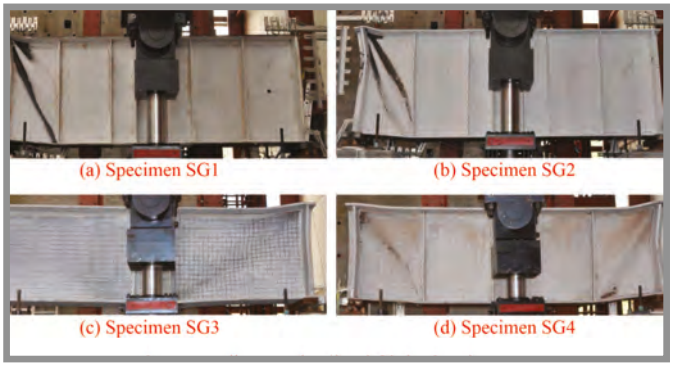
All specimens showed much higher shear capacity than as predicted by the current AASHTO specifications. The shear over-strength varied from 1.60 to 2.56 in the first phase, and from 1.15 to 2.57 in the second phase. These results indicate that a large amount of post-buckling strength exists in the end panels and should be considered in determining their shear capacity. The proposed shear strength equation is similar to the one used in the AASHTO specifications, but it includes a coefficient to account for the partial tension-field action in the end panels. The proposed equation was applied to 17 test specimens—4 large-size specimens from the research and 13 small-scale specimens from literature—and 99 finite-element models with different parameters and provided an accurate prediction of the shear strengths. Additional testing is required to more accurately estimate the shear contribution of the concrete slab.

WHAT IS THE BENEFIT?

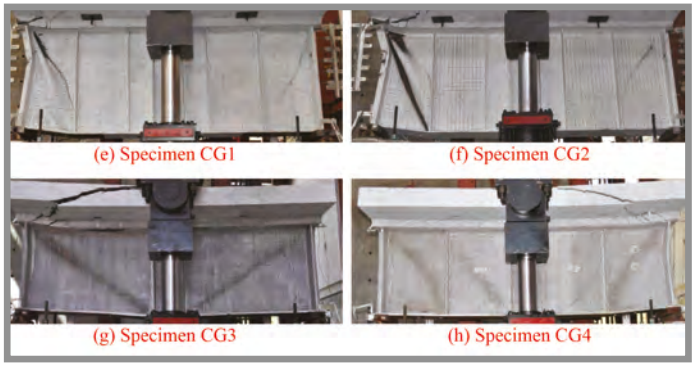
The current AASHTO specifications for the shear design and rating of plate girder end panels are overly conservative and require unnecessary rehabilitation of existing steel girder bridges that have provided satisfactory service for several decades. The proposed shear design equation can reduce the need to either retrofit bridges or restrict vehicular loads. Both options are costly and affect the traveling public in terms of congestion and the trucking industry by restricting load capacity.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2015/CA15-2316_FinalReport.pdf



Failure modes of the steel girder specimens



Failure modes of the composite girder specimens

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Research Results

Managing Avalanches Along Roadways

Sensors can gather the needed data to initiate controlled avalanches and improve safety

Maintenance

DECEMBER 2015

Project Title:
Field Operations for GPS-assisted Winter Maintenance Vehicles (Avalanche Sensing)

Task Number: 1810

Start Date: June 29, 2009

Completion Date: September 30, 2014

Product Category: New or improved tool or equipment

Task Manager:
Larry Baumeister
Transportation Engineer (Electrical)
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WHAT WAS THE NEED?

Avalanches pose a challenging problem for roadways traversing mountainous areas of California. An unexpected avalanche can shut down roads and endanger motorists. Conducting controlled avalanches reduces the number of naturally occurring snow slides, resulting in improved safety and lower maintenance costs. To safely trigger an avalanche requires accurate information to determine the best time and conditions. Sensors can provide the needed data, such as snow depth, temperature, wind speed, and wind direction, as well as camera imaging.

WHAT WAS OUR GOAL?

The goal was to investigate commercially available components to build an avalanche sensing and detection system and test it for one snow season.

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Advanced Highway Maintenance and Construction Technology Research Center, designed a prototype avalanche sensing and detection system using commercially available parts. The system was placed in the avalanche zone on State Route 88, known as chute 4 of the Carson Spur.

The project involved several steps. To determine the best location to place the prototype, Caltrans Surveys measured the entire face of the Carson Spur using a stationary laser scanner. The researchers then installed a 5-foot tower to hold the instrumentation equipment on the rock face. The system included an outdoor network video camera to allow remote monitoring and visual corroboration of the sensor measurements. The wind speed sensor can detect wind speeds up to 224 mph, with an accuracy of 2.2 mph. The temperature sensor can detect temperatures down to –58°F, with an accuracy of 0.54°F. The equipment was powered by a wind generator that can supply up to 350 watts.

The sensors transmit measurement data regularly through wireless communications to the Caples Lake maintenance staff. Many features have been developed to ensure that the system functions in all scenarios so that no on-site visits are required throughout the winter season.

Tower installed on Carson Spur to hold the instrumentation equipment

WHAT WAS THE OUTCOME?

The instruments were successfully bench-tested, but installing the equipment was more challenging than anticipated. In particular, it was difficult to find a location for the tower that provided the right field of view for imaging and distance measurements as well as secure mounting and system survivability. For this reason, the system was not installed by the end of the project. Final system installation, field testing, and analysis are occurring in follow-up research.

WHAT IS THE BENEFIT?

Inducing controlled avalanches reduces the number of spontaneous avalanches. As a result, motorist and worker safety increases, avalanche control costs decrease, and delays to the travelling public are minimized. To ensure that controlled avalanches are executed at the right time and under the right conditions requires data that the sensing and detection system developed under this research provides.

LEARN MORE

To view the complete report:
http://ahmct.ucdavis.edu/pdf/UCD-ARR-14-09-30-01.pdf

Prototype system in lab

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Research Results

Incorporating Bay Area Airports in Disaster Recovery Plans

Airports can aid response and recovery, such as after an earthquake

Modal

JANUARY 2016

Project Title:
Bay Area Airport Disaster Recovery Plan

Task Number: 1912

Start Date: June 1, 2012

Completion Date: September 30, 2014

Product Category: New or improved manual, handbook, guidelines, or training

Task Manager:
Patrick Tyner
Associate Transportation Planner
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WHAT WAS THE NEED?

Transportation is essential for quick and effective response and recovery during and after a catastrophic event. After a large earthquake, the San Francisco Bay Area's roadways could experience major damage. Therefore, the transportation system must have enough redundancy and interoperability between modes to not hinder recovery efforts. The region's aviation facilities could play a critical role during a disrupting event, yet the Bay Area does not have a comprehensive, coordinated airport emergency response plan. To better utilize airports, it is important to identify their strengths and vulnerabilities and how the various lifeline systems, such as ground transportation, fuel, and electricity, interact and impact each other.

WHAT WAS OUR GOAL?

The goal was to review the resiliency of the nine-county Bay Area's airports and determine how to integrate them into existing disaster recovery plans and activities.

The region's aviation facilities could play a critical role during a disrupting event.

Caltrans

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WHAT DID WE DO?

Caltrans worked with the Association of Bay Area Governments to analyze the interdependency of the region's major lifeline systems and their strengths and vulnerabilities. The researchers surveyed the commercial and general aviation airports to understand their place in the community and explore how they could support recovery activities. The project collected information from the region's commercial fuel provider about fuel supply chains and interviewed pilots regarding how their volunteer services could be used to support relief efforts. The researchers also evaluated how susceptible the three commercial airports, Oakland, San Francisco, and San Jose, are to liquefaction.

WHAT WAS THE OUTCOME?

Incorporating airports more fully in recovery plans strengthens community resiliency and can speed disaster recovery efforts. Of the 24 airports that completed the emergency plan survey, 21 have some sort of plan, and 16 of them address earthquake events. Although general aviation airports are not required to have airport emergency plans, it would be beneficial to develop a plan scaled to the airport's ability to aid in disaster response and recovery.

The three commercial airports could develop more collaborative working relationships with the regional and local emergency departments and adjacent transit districts. Airports might have to house and feed thousands of travelers as they wait for flights out or even serve as shelter for displaced residents. The liquefaction analysis identified areas at each commercial airport that are especially vulnerable to damage.

This study provided insights to the relationship between lifelines and the cascading and unpredictable nature of failures that can ripple through multiple systems in a disaster. The greatest threat to an airport's ability to function might come from other than the airport. The region's two greatest concerns post disaster are fuel delivery, which depends on functioning surface transportation, and lack of power. These vulnerabilities affect the airports' ability, as well as other essential services, to respond rapidly.

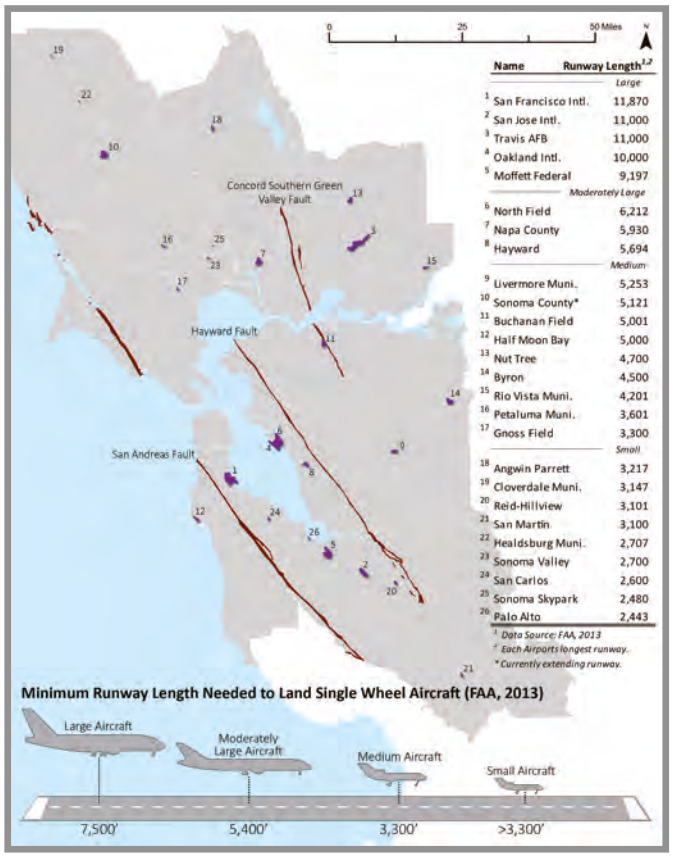
WHAT IS THE BENEFIT?

Airports are part of the mix of interconnected lifeline systems. Having airports remain in operation provides valuable functions during disaster response, including temporary shelter, moving medical supplies and personnel, and airborne search and rescue. The study produced recommendations of actions that airports could take to ensure that they can more quickly recover from an incident, increase their value to regional response actions during a disaster, add mechanisms to speed repair of damaged airport facilities or the infrastructure serving those facilities, and opportunities for improved coordination with and within the regional airport system.

LEARN MORE

For more information, visit:
http://resilience.abag.ca.gov/wp-content/documents/Cascading_Failures/Role-of-Airports-in-Disasters_2015.pdf

http://resilience.abag.ca.gov/wp-content/documents/Cascading_Failures/InfrastructureReport_2014.pdf



Location of Bay Area airports in relation to the three major faults

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Research Results

Can Bus Rapid Transit Reduce Congestion?

Measuring person throughput provides a more complete picture of BRT benefits and impacts

Modal

JANUARY 2016

Project Title:
BRT Person Throughput-Vehicle Congestion Tradeoffs

Task Number: 2333

Start Date: June 25, 2012

Completion Date: November 24, 2014

Product Category: New or improved business practice, procedure, or practice

Task Manager:
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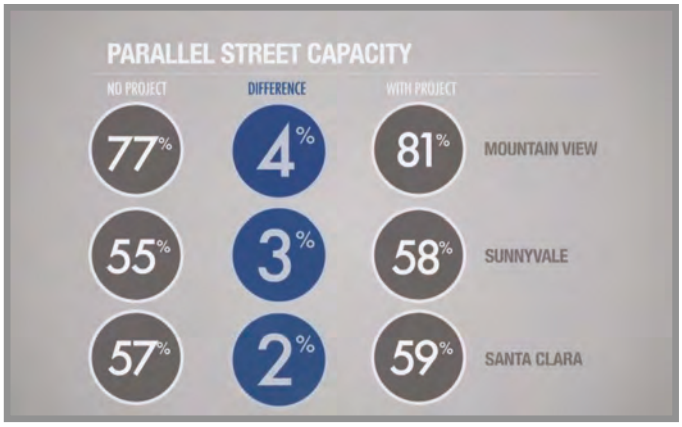
WHAT WAS THE NEED?

How transportation projects are evaluated in California is changing. Senate Bill (SB) 743, signed into law in 2013, requires planners to consider throughput of people in addition to the traditional method of level of service—that is, vehicle travel time. SB 743 mandates using broader methods of evaluation when planning projects. As California's population continues to grow, local, regional, and state agencies must consider all available transportation options to address future mobility needs. As a result, transit systems across the state are submitting project proposals to Caltrans for approval. With the focus shifting toward moving people through corridors and less on just moving vehicles, communities are looking at less costly bus rapid transit (BRT) services, which require a fully dedicated right of way for a significant part of the journey to provide some of the advantages of light rail. However, converting an existing traffic lane to a dedicated bus lane can negatively impact overall traffic flow, although the increased person throughput that BRT offers can offset this impact. When reviewing a BRT project, it is important to evaluate the trade-off between person throughput and vehicle throughput. Methods of comparing the benefits and costs have been developed, but districts need thresholds to be able to quantify the level of vehicle congestion that is acceptable.

WHAT WAS OUR GOAL?

The goal was to develop methodologies to measure transportation performance and the trade-off between increased person throughput and traffic congestion to support the decision-making process when evaluating new BRT projects.



Study done by the Santa Clara Valley Transportation Authority on how the proposed El Camino Real Corridor BRT could affect traffic when redistributing traffic to parallel routes.

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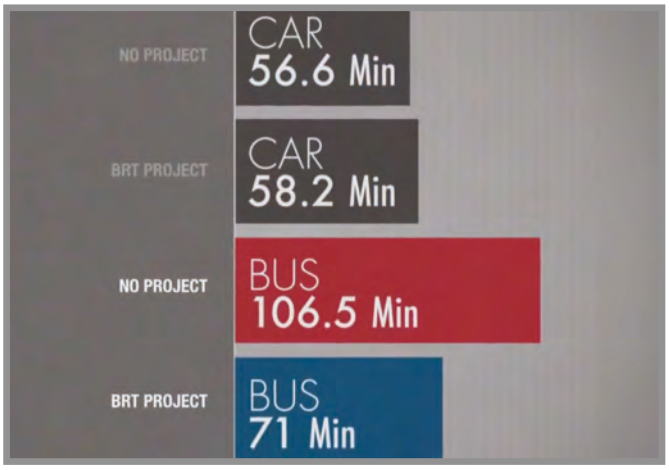
Can Bus Rapid Transit Reduce Congestion?

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology program, interviewed Caltrans districts and transit agencies to understand the approval decision-making process for BRT projects and the measures of effectiveness (MOE) used to evaluate transit and non-transit system performance. The researchers combined the evaluation methods of the various districts and AC transit to develop best practices for BRT planning. The combined methods showed that there are gaps between the various districts' and transit systems' BRT evaluation methods.

WHAT WAS THE OUTCOME?

The study revealed that although Caltrans and transit agencies use a similar set of MOEs to evaluate BRT projects, the emphasis and parametric assumptions can be different, such as focusing more on vehicle level of service rather than the number of people being moved along a corridor. These differences influence the results of the evaluation. A systematic approach of evaluating person throughput needs to be developed and applied during the BRT planning process.



Expected travel times along the corridor by 2035 with and without BRT

WHAT IS THE BENEFIT?

BRT can increase person throughput, decrease congestion for all highway users, mitigate pollution, reduce greenhouse gas emissions, and improve goods movement. Many transportation agencies have resisted supporting projects that increase vehicle congestion even though they could increase person throughput and ultimately improve the overall performance of the transportation system. Having information on person throughput along a corridor provides a more complete picture of system performance and improves the decision-making process. Establishing thresholds provides guidance on what level of congestion increase is acceptable for transit projects that increase person throughput. The findings from this project established the foundation for improving the current BRT planning practice and developing tools and guidelines to assist Caltrans in the evaluation and approval process of future BRT projects.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2014/CA15-2333_FinalReport.pdf

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Testing Vehicle-Assist and Automation Technology in Public Transit Buses

VAA helps bus drivers maintain lateral and longitudinal control, facilitating the expansion of bus rapid transit systems

Modal

FEBRUARY 2016

Project Title:
Field Operational Tests of Vehicle-Assist and Automation (VAA) System for Public Transit Buses

Task Number: 2508

Start Date: June 1, 2012

Completion Date: February 28, 2015

Product Category: New or improved technical standard, plan, or specification; new or improved tool or equipment

Task Manager:
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WHAT WAS THE NEED?

Bus rapid transit (BRT) offers a cost-effective alternative to fixed-rail systems, which are expensive to construct and operate. To run at a high level of reliability, a BRT system requires dedicated bus lanes. Adding lanes is costly, and many metropolitan areas have limited land to expand roadways. Narrowing bus lanes by two feet reduces the right-of-way cost, but causes the buses to go slower for safety concerns. A vehicle assist and automation (VAA) system with guidance and docking functions could enable buses to operate accurately and safely along narrow paths and precisely stop at bus stations, enhancing BRT's efficiency and quality of service.

The VAA technologies developed in the past years show promise in providing transit agencies more efficient operations and cost savings. However, their full technical feasibility and merits have not been quantified. The U.S. Department of Transportation initiated a pilot program to demonstrate the benefits of VAA applications for full-size public transit buses in revenue service and awarded conducting the program to Caltrans.

WHAT WAS OUR GOAL?

The goal was to demonstrate the technical merits and feasibility of VAA technologies in a real-world BRT application and to assess the benefits and costs.

Lane Transit District's Emerald Express BRT dedicated bus-only lane in Eugene, Oregon

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Testing Vehicle-Assist and Automation Technology in Public Transit Buses

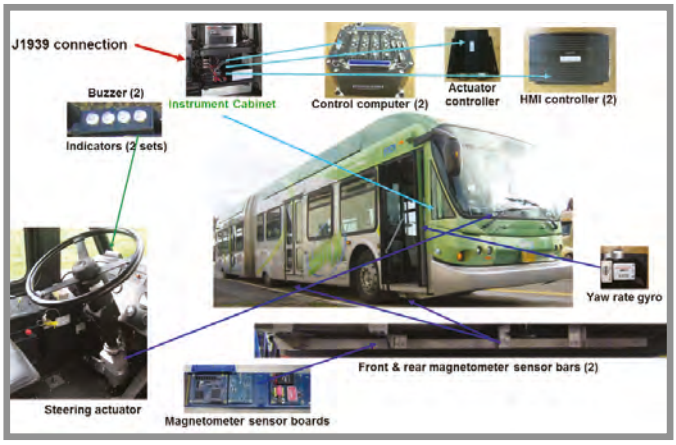
Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology program and the Eugene, Oregon, Lane Transit District (LTD), designed, developed, integrated, and field-tested the magnetic-sensing VAA technology. The pilot used a portion of LTD's Emerald Express BRT system, a four-mile route connecting Eugene and Springfield, Oregon with eight intermediate stations and two terminal stations, to test bus lane guidance and precision docking at stations. The researchers equipped an articulated bus with the VAA system and installed a magnetized section along 1.5 miles and three stations. LTD drivers were trained to use the VAA system and operated it during regular revenue service hours, carrying passengers for a total of six months. Working closely with the transit agency and drivers, the research team gathered feedback for system improvements.

WHAT WAS THE OUTCOME?

The pilot, the first real-world deployment of a VAA system in BRT revenue service in the United States, was successful and has the potential of leading to a commercially viable product. Hardware and software that better integrate with different transit buses was developed. The project produced off-the-shelf-like components and subsystem prototypes designed for easy maintenance, improved the detection and handling of VAA system faults to help ensure operational consistency and public safety, and laid the groundwork for designing and installing systems for future wide-spread national deployment.



VAA system on the LTD bus

WHAT IS THE BENEFIT?

VAA technologies enable buses to operate accurately along narrowly defined paths and precisely dock at bus stops, providing rail-like features at a fraction of the cost. VAA-equipped BRT systems streamline travel time, reduce traffic incidents, allow quicker and easier boarding for passengers, provide a smoother ride, and put less strain on bus drivers. The reduced right-of-way requirements of a BRT system offers a cost-effective public transportation solution to improve mobility and decrease congestion.

LEARN MORE

For more information about this research:
www.dot.ca.gov/research/modal/bus_transit/vaa/index.htm

Precision-docking performance

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Research Results

Integrating Multimodal Data for a Broader View of Transportation Planning

Combining travel demand data with cost-benefit analysis leads to a better understanding of how different modes of transportation impact the network

Modal

FEBRUARY 2016

Project Title:
Integrating Highway and Transit Data into Benefit-Cost Analysis

Task Number: 2627

Start Date: July 9, 2014

Completion Date: May 1, 2015

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
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WHAT WAS THE NEED?

The nation's departments of transportation are shifting from being primarily highway-building organizations to developing multimodal transport systems, as exemplified by the Caltrans mission statement adopted in 2014: Provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability. Major investments in transportation infrastructure and services require careful evaluation to assess the benefits and costs. Benefit-cost analysis (BCA) is a common framework for determining which projects maximize social welfare and bring the greatest good. Ideally, BCA weighs all aspects of a project, but BCA tools can only measure the effects for which data is provided. The Caltrans BCA transportation models do not fully account for multimodal network impacts because of insufficient data regarding public transit, walking, and other modes of transportation and their effect on local streets and the larger transportation network, causing Caltrans BCA decision-making models to be less multimodal than optimal.

WHAT WAS THE GOAL?

The goal was to explore ways of incorporating data about multimodal network impacts to develop more integrated BCA models for transportation planning and shaping public policy.

Caltrans

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WHAT DID WE DO?

Caltrans worked with the Mineta National Transit Research Consortium to explore methods of integrating multimodal data to improve BCA. The project evaluated past policy decisions and current planning and programming for future transportation investments. The researchers reviewed the activities of various Caltrans divisions that influence the planning, monitoring, and managing of the transportation system to identify opportunities for increasing the integration of public transit. The primary BCA model that Caltrans uses—the Cal B/C spreadsheet—is unimodal when evaluating highway and road investments, and important effects from induced demand are ignored in the analysis. BCA is an informative performance measure, but to gain a broader perspective, it is important to consider other models, especially travel demand models (TDM) that combine traffic data with other known data, such as population, employment, trip rates and destinations, and travel costs. To tackle these shortcomings, the researchers modified the Cal B/C model by adding a function that estimates induced demand and suggested changing the method of use to better account for multimodal systems and network effects.

WHAT WAS THE OUTCOME?

To address the lack of available data and integration problems, the research recommended the following.

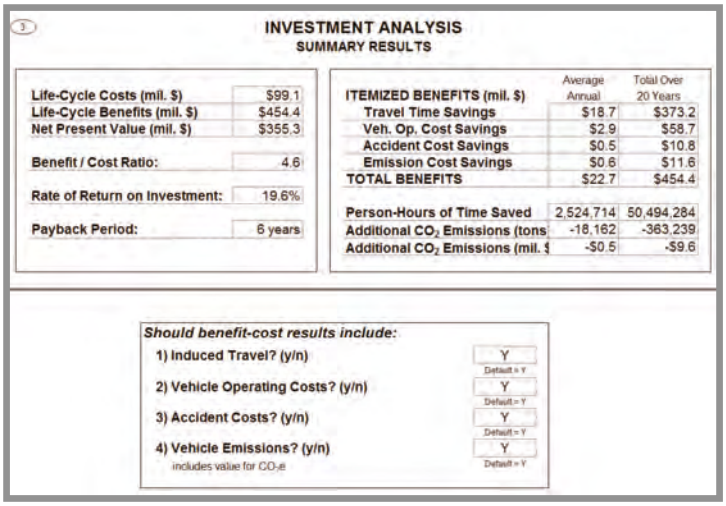
- Improve Cal B/C—Add an induced demand function to the model syntax. Improve multimodal documentation and outreach to encourage Caltrans usage.
- Integrate Cal B/C and TDM models—Encourage Cal B/C users to incorporate TDM data, and use a BCA post-processor for TDM data.
- Address management and contracting practices at Caltrans—Promote closer collaboration between economic analysts and traffic forecasters. Take advantage of external expertise while ensuring that in-house knowledge is adequate to implement state-of-the-art models and methods.

WHAT IS THE BENEFIT?

When investing in transportation, effective decision-making begins with sound estimates of the current and future demand for facilities and services, which includes data about trip destinations and volumes, population and land use, environmental and safety concerns, and travel costs. Today, transportation planning requires more integrated and comprehensive models to capture multimodal data. This research has proposed ways to integrate the data into existing processes and activities to better account for multimodal network effects and foster awareness when forming transportation policy and analyzing projects.

LEARN MORE

To view the complete report:
www.sjsu.edu/people/matthew.holian/docs/integrating_3_9_2015.pdf



INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$99.1
Life-Cycle Benefits (mil. $)	$454.4
Net Present Value (mil. $)	$355.3
Benefit / Cost Ratio:	4.6
Rate of Return on Investment:	19.6%
Payback Period:	6 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$18.7	$373.2
Veh. Op. Cost Savings	$2.9	$58.7
Accident Cost Savings	$0.5	$10.8
Emission Cost Savings	$0.6	$11.6
TOTAL BENEFITS	$22.7	$454.4
Person-Hours of Time Saved	2,524,714	50,494,284
Additional CO_2 Emissions (tons	-18,162	-363,239
Additional CO_2 Emissions (mil. $	-$0.5	-$9.6

Should benefit-cost results include:

1) Induced Travel? (y/n)	Y (Default = Y)
2) Vehicle Operating Costs? (y/n)	Y (Default = Y)
3) Accident Costs? (y/n)	Y (Default = Y)
4) Vehicle Emissions? (y/n) includes value for CO-e	Y (Default = Y)

View from a Cal B/C results worksheet for a lane addition project

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Research Results

Moving People Through Transit Stations Efficiently and Safely

Recommendations for optimizing passenger flows in rail transit stations

Modal

JANUARY 2016

Project Title:
Passenger Flows in Underground Railway Stations and Platforms

Task Number: 2892

Start Date: July 7, 2014

Completion Date: June 30, 2015

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

Rail transit is the highest capacity urban transit mode, typically operating underground in subways or above ground on elevated lines. Unlike buses and light rail transit, passengers move to and from track platforms, ticketing areas, and adjacent streets. Transit stations experience high levels of pedestrian congestion during rush hour and special events but also during extreme events, such as disasters that require evacuation procedures. Crowding can occur on platforms, vertical circulation elements (stairways, escalators, elevators), ticketing machines, fare gates, and station entrances and exits. Excessive congestion can cause passenger inconvenience, delays, and at times endangerment. Because many subway and elevated transit stations have been in service for decades, they often accommodate more passengers than they originally were designed to handle. Transit system managers, planners, and designers need strategies to provide safe and comfortable movement of passengers and implement these strategies within an environment of physical and financial constraints.

WHAT WAS OUR GOAL?

The goal was to understand the infrastructural, operational, behavioral, and spatial factors that affect passenger flow in underground railway stations and identify best practices and recommendations.

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WHAT DID WE DO?

Caltrans, in partnership with the Mineta Transportation Institute, identified and compared practices for efficient and safe passenger flows in different station environments and during typical (rush hour) and atypical (evacuations, station maintenance or refurbishment) situations through a literature review and interviews with experts in transit rail station design representing transit agencies across the United States and Canada. The researchers then compiled short-, medium-, and long-term recommendations addressing four key issues: agency planning for passenger flows, data collection and forecasting, analysis, and design.

WHAT WAS THE OUTCOME?

The researchers developed the following recommendations based on their observations and interviews.

- Encourage coordination and knowledge sharing among the various specialists responsible for different aspects of the passenger experience. Planners sometimes fail to adequately account for construction needs, or builders to fully implement planners' strategies, resulting in procedures and routes not fully utilizing the designed station capacity.
- Routinely assess assumptions used to estimate passenger volumes and characteristics, such as walking speed. Ridership forecasts presented to justify new rail transit projects are often inflated. Although forecasts should be as accurate as possible, budget allocation should err on the side of overestimating passenger volumes. It is better to overdesign a station, because adding capacity later is difficult and expensive.
- Select the appropriate analysis tools and methodologies for each question requiring a solution. Deterministic models, established standards, and more-complex micro-simulation models each offer distinct advantages and disadvantages in particular situations.
- Consider the impact that a design strategy implemented in one station area will have on other areas and on the adjacent street environment. To optimize passenger flows, view the station as an entire system rather than individual parts.

WHAT IS THE BENEFIT?

Excessive station crowding prevents passengers from quickly boarding and exiting, making cars linger longer in a station, and also decreasing the attractiveness of transit for potential riders. Inadequate passenger flow can also create unsafe conditions and impede emergency evacuations. This study proposed short-, medium- and long-term strategies and changes in transit operations, messaging and wayfinding, and station design for optimizing passenger flows and queuing, improving the rail transit experience.

LEARN MORE

To view the complete report:
http://transweb.sjsu.edu/project/1230.html

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Research Results

Expanding the Pavement Design Materials Database

Adding the mechanistic-empirical properties of more materials to the CalME library provides engineers with more design options

Pavement

DECEMBER 2015

Project Title:
Updated Standard Materials Library

Task Number: 2356

Start Date: July 1, 2011

Completion Date: September 30, 2014

Product Category: Processed data or database

Task Manager:
Hamid Sadraie
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WHAT WAS THE NEED?

Caltrans is transitioning from using an empirical method to a mechanistic-empirical (ME) approach for flexible pavement design and rehabilitation. As part of the transition, Caltrans developed the CalME software to help designers predict pavement performance. A major benefit of the ME method is the ability to account for regional conditions, such as climate, traffic, and materials. The Standard Materials Library is a vital component of CalME, providing engineers with a number of commonly used materials across California. To better serve pavement designers, more data on regional materials representing various parts of California needs to be collected and added to the library.

WHAT WAS OUR GOAL?

The goal was to populate the CalME materials library with information on a range of regional materials, such as hot mix asphalt (HMA) materials, samples of in-place recycled materials, and cemented bases.

HMA materials being compacted in the laboratory for testing

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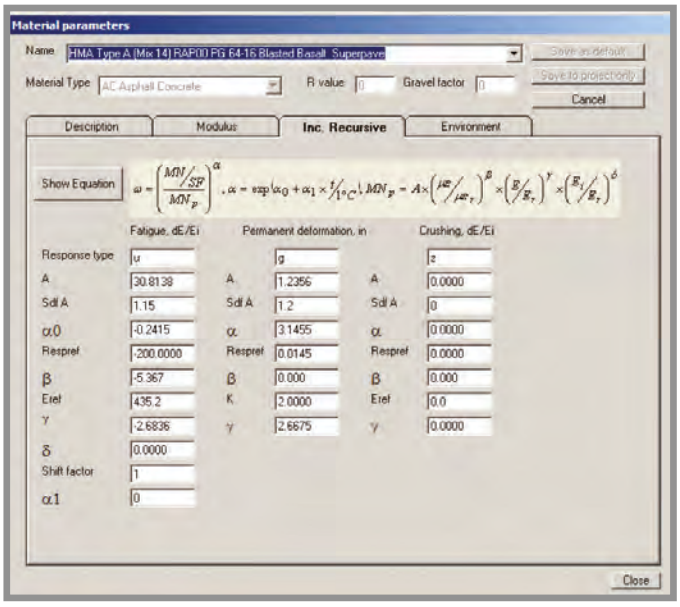
WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center at UC Davis, collected regional materials that needed to be incorporated based on input from designers, engineers, and industry. For this phase, the researchers added HMA materials (including rubberized) from various Caltrans districts and different types of base materials. The properties of these materials were measured in the laboratory or field.

WHAT WAS THE OUTCOME?

The continually expanding Standard Materials Library is a complex, powerful tool that aids designers of HMA pavements in assessing fatigue cracking performance. For HMA materials, mixes are designed with both the older Hveem method and new Superpave method recently adopted by Caltrans for the same binder and aggregates. During Task 2667, the library will be further updated with data focusing on conventional and rubberized HMA mixes with higher recycled asphalt pavement contents, a more extensive sampling of full-depth reclamation materials with different stabilizing agents, and more HMA designed with the Superpave method.



Material parameters for an HMA mix design using the new Superpave method

WHAT IS THE BENEFIT?

For designers to select appropriate materials for the ME process requires a comprehensive materials library that reflects the various materials available in different regions in California. Designers can use the Standard Materials Library database and CalME performance model to run different scenarios to compare the performance and cost of new materials or materials available from nearby sources. The library also provides data for comparing the performance of mixes designed with the Hveem method to the recently adopted Superpave method, helping Caltrans transition from the older mix design to the new Superpave method.

LEARN MORE

To view the complete report:
www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2015-01.pdf

Indirect tensile strength test device and specimen

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Caltrans Division of Research, Innovation and System Information

Research Results

Life-Cycle Cost Analysis for Composite Pavements

Composite pavements can be a cost-efficient alternative to rigid pavements

Pavement

FEBRUARY 2016

Project Title:
Life-Cycle Cost and Environmental Life-Cycle Analysis for Composite Pavements

Task Number: 2371

Start Date: September 30, 2013

Completion Date: September 30, 2014

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

Composite pavement consists of a rigid portland cement concrete structure, either jointed or continuously reinforced, covered with a flexible asphalt concrete layer. By adding an asphalt layer, it is possible to reduce the thickness of the portland cement layer—or extend the life of the typical thickness—because the asphalt surface reduces the differences in temperature between the top and bottom of the concrete that contribute to cracking. Caltrans has a documented design procedure for applying asphalt overlays on aged, cracked concrete pavement for maintenance and rehabilitation, but a comprehensive procedure is not available for designing new composite pavement.

The Caltrans *Highway Design Manual* requires that all major pavement projects use life-cycle cost analysis (LCCA) to determine the most appropriate and cost-effective pavement type for a location. To perform an accurate LCCA requires a variety of information, such as cross-sectional structures, construction schedules in terms of the number of lane closures and duration, traffic volume performance, unit costs, quantities of materials, and knowledge of future maintenance and rehabilitation requirements.

WHAT WAS OUR GOAL?

The goal was to investigate the effect of composite pavement design variables and incorporate the results into Caltrans design procedures and LCCA guidelines.

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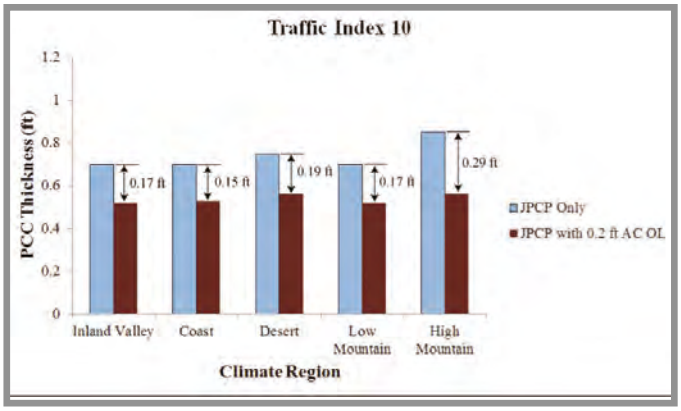
WHAT DID WE DO?

Caltrans worked with the University of California Pavement Research Center to analyze the use of composite pavements for typical highway segments, taking into account the region's climate, volume of truck traffic (measured as a traffic index or TI), soil type, and lateral clearance. The researchers calculated the cracking performance of different thicknesses of the concrete structure with .02-foot asphalt surface for different Tis over the design life of 40 years using mechanistic-empirical (ME) design software and compared the performance to the original thickness of rigid concrete without an asphalt overlay, with respect to their initial construction costs.

WHAT WAS THE OUTCOME?

The ME simulation showed that the rigid layer can be reduced when adding a 0.2-foot asphalt overlay, and the reduction increases for the thicker layers used for higher TIs. The rigid pavement begins slab cracking after it loses full friction, on average after about 136 months, whereas for the composite pavement, cracking begins from the initial age. Although slab cracking for composite pavement appears faster than the rigid pavement between 24 and 34 years, by the end of the 40-year design life, the slab cracking percent of the rigid pavement is higher than the composite pavement for all pavement and climate conditions. Composite pavement construction rates per lane-mile are initially higher than the rigid pavement for higher TIs. The number of closures for construction lane-miles for both pavement types are similar for TI 10, but the number of closures for composite pavement becomes slightly less with increased TIs.



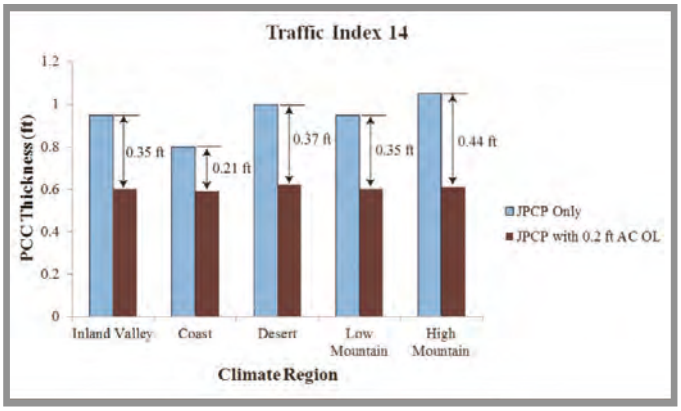
Thickness reductions for the different climate regions for TI 10

WHAT IS THE BENEFIT?

Composite pavements can be a cost-efficient alternative to rigid pavements, but the information needed to compare their durability and performance for different traffic loads and climates was lacking. This research provides Caltrans pavement engineers accurate input values to analyze and compare the life-cycle costs of composite pavements.

LEARN MORE

To view the Caltrans *Highway Design Manual*, visit *www.dot.ca.gov/hq/oppd/hdm/hdmtoc.htm*.



Priority freight regions and corridors in California

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Research Results

Recycling Strategies for Rubberized Hot Mix Asphalt

New guidelines help determine when to use partial- or full-depth reclamation techniques for pavements

Pavement

JANUARY 2016

Project Title:
Recycling of Rubberized Hot Mix Asphalt in Reclaimed Asphalt Pavement and Full-Depth Reclamation Projects and with Warm Mix Technologies

Task Number: 2374

Start Date: May 1, 2012

Completion Date: September 30, 2014

Product Category: New or improved business practice, procedure, or process

Task Manager:
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WHAT WAS THE NEED?

Caltrans has used full-depth reclamation (FDR), which recycles the pavement surfacing and base materials, as a rehabilitation strategy since 2001. Recycling only the upper layers of the surfacing—partial-depth reclamation (PDR) and cold in-place recycling—has been used on a limited scale as of 2009. However, comparative studies between the recycling strategies do not exist. Long-term field performance of FDR-asphalt emulsion and FDR-portland cement or any type of PDR projects have not been documented. Nor have the different types of PDR construction procedures been compared. More information is also needed regarding the influence of recycled rubberized asphalt on FDR or PDR performance. Engineers need comprehensive guidelines to determine which technique to choose for a particular project and the most appropriate stabilizer.

WHAT WAS OUR GOAL?

The goal was to develop project selection and mechanistic-empirical (ME) design guidelines describing the differences between PDR and FDR and when to use each technique.

FDR with foamed asphalt on Highway 20, Colusa County

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WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center at Davis, constructed a test track to compare FDR with no stabilization and with cement, foamed asphalt, and asphalt emulsion stabilization. The researchers performed initial laboratory testing to refine the mix-design procedures and identify suitable criteria for ME design procedures and performance models. The first phase of the study, consisting of dry condition tests, was completed. The second phase of testing under wet conditions is in progress and will be completed in Task 2707.

WHAT WAS THE OUTCOME?

The first phase of testing under dry conditions showed the following:

- FDR can be an appropriate rehabilitation alternative to mill and overlay. All in-place materials are reused. Consequently, no old materials need to be trucked out, and only the new asphalt surfacing is trucked in. No detours are required, and traffic disruption is minimal.
- Using FDR with no stabilizer is appropriate only for low-volume roads.
- FDR with foamed asphalt and FDR with cement provide similar performance, and both are appropriate for high traffic volumes. Projects can be opened to traffic on the same day as construction.
- FDR with an asphalt emulsion has potential, but has limited use in pavements with relatively high in situ moisture contents and on projects that need to be opened to traffic on the same day as construction.
- Preliminary mechanistic analyses indicate that FDR with an appropriate stabilizer is a cost-effective rehabilitation strategy.

FDR with cement on a test track at UC Davis

The results from the two phases will be used to finalize the guidelines and CalME design parameters and revise mix design and construction specifications if considered necessary.

WHAT IS THE BENEFIT?

Having comprehensive guidelines on reclamation techniques supports sustainable pavement rehabilitation and maintenance. FDR can be a cost-effective alternative to traditional mill and overlay or base reconstruction. All in-place materials are reused, and roads can often be reopened to traffic on the same day as construction, minimizing disruption and congestion.

LEARN MORE

To view the complete report:
www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2014-03.pdf

A test section of FDR with foamed asphalt after Heavy Vehicle Simulator testing with 27 million equivalent single-axle loads

Quality control during FDR

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Innovation and System Information

Research Results

Analyzing the Noise Quality of Different Pavement Types

Rubberized open-graded asphalt has the longest noise-reducing performance

Pavement

JANUARY 2016

Project Title:
Monitoring of Selected Quieter avement Test Sections

Task Number: 2375 & 2600

Start Date: November 1, 2011

Completion Date: September 30, 2014

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

Pavement smoothness influences vehicle wear and tear, road user comfort, emissions, and quietness. To determine the most cost-effective approaches for maintaining roadway smoothness and quietness, Caltrans initiated the Quiet Pavement Research program in 2007 to identify the longevity of current materials and potential new alternatives and which strategies to use. For nearly a decade, researchers have been collecting data and conducting extensive field and laboratory studies on the characteristics of pavements surfaced with four typical Caltrans asphalt mixes as well as experimental mixes. The evaluations have included pavements that ranged in age from newly paved to 8 years old at the start of the study, resulting in data covering pavement surfaces with ages up to 15 years old.

WHAT WAS OUR GOAL?

The goal was to complete the acoustical and ride-quality performance analysis of the asphalt pavements that had been tested in previous years and continue monitoring the noise performance over time to develop noise models for use in the pavement management system.

Caltrans

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Analyzing the Noise Quality of Different Pavement Types

WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center at Davis, studied the latest six years of data gathered from California pavements surfaced with four typical Caltrans asphalt mixes to assess how certain properties, such as macrotexture and permeability, affect tire-pavement noise, ride quality, and durability. The researchers also reviewed data from pavement sections with experimental mixes. The team evaluated how effective open-graded mixes are in reducing noise compared with other asphalt surface types, which included dense- and gap-graded mixes.

As part of the study, the researchers investigated the effects of air and pavement temperature and tire characteristics on the measured noise level in terms of on-board sound intensity. New wide spot laser equipment was installed to collect profiles on longitudinally textured surfaces. The list of selected quieter pavement test sections was modified to produce a more balanced experiment design of texture types, ages, traffic levels, and rainfall.

WHAT WAS THE OUTCOME?

The researchers used the data collected over the years to develop and improve statistical models to predict the functional life of the four surface mix types. Caltrans can use these predictions to inform policy decisions, update the pavement management system, and perform life-cycle cost analysis. The research findings indicate that the mix with the longest noise-reducing performance is rubberized open-graded asphalt.

WHAT IS THE BENEFIT?

Traffic noise affects the quality of life of those who use the roads and those who live near them. This study produced an extensive database that can be used to produce quieter, longer lasting pavement in California.

LEARN MORE

To view complete reports:
http://www.dot.ca.gov/research/researchreports/reports/2013/CA13-2375_FinalReport.pdf

http://www.dot.ca.gov/research/researchreports/reports/2013/CA13-2600_FinalReport.pdf

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Research Results

Asphalt Rubber Binder Testing and Acceptance

A dynamic shear rheometer with a concentric cylinder geometry can measure the performance properties of asphalt rubber binders

Pavement

JANUARY 2016

Project Title:
Rubber Binder Testing and Acceptance

Task Number: 2558

Start Date: March 1, 2013

Completion Date: September 30, 2014

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

Each year the United States disposes of nearly 300 million tires, most of which end up in landfills with the consequent environmental impacts. To reduce dumping, one solution is to grind old tires into crumbs and add them to asphalt binder to produce rubberized hot mix asphalt. In California, recycled crumb rubber is generally added to asphalt binders.

The Superpave Performance Grading system is commonly used to test the performance properties of asphalt binders. The testing procedure uses a dynamic shear rheometer (DSR) with a parallel plate geometry that is not suitable for asphalt rubber binders because the gap between the plates cannot accommodate the crumb rubber particles. Therefore, instead of the Superpave parameters, the current Caltrans specification for testing asphalt rubber binders focuses on measuring the viscosity at the plant using a handheld rotational viscometer. Although viscosity is an important parameter for assessing the workability of the binder and hence the mix, it does not directly correlate to the in-service performance of the asphalt rubber binder within rubberized hot mix asphalt (R-HMA). In addition, because of the particulate phase of the asphalt rubber binders, viscosity measurements alone lack sufficient accuracy to completely describe their complex properties.

New test procedures and equipment that can evaluate the performance characteristics of asphalt rubber binders are needed to ensure good performance in the field, aid pavement design, and establish contract acceptance criteria for asphalt rubber binders.

WHAT WAS OUR GOAL?

The goal was to develop new test procedures and equipment that can evaluate the performance characteristics of asphalt rubber binders.

Waste tires

Caltrans

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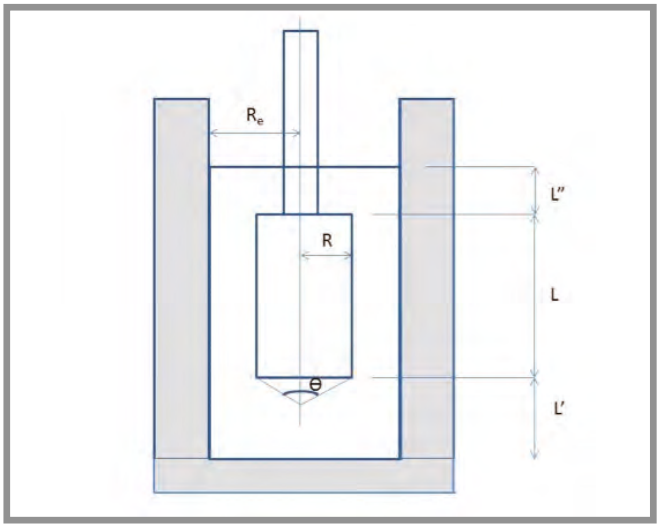
WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center, tested samples using a DSR with a concentric cylinder geometry and compared the results to a DSR with a parallel plate geometries. The researchers prepared conditioned samples in the laboratory using short-term aging via thin film oven and long-term aging via pressurized aging vessel. The research team evaluated the ability of the concentric cylinder geometry to test neat binders, polymer modified binders, rubber modified (terminal blend) binders, and asphalt rubber binders. The study conducted a thorough statistical evaluation of the repeatability and reproducibility of the new concentric system.

WHAT WAS THE OUTCOME?

The interim results indicated that the concentric cylinder and parallel plate geometries had no significant differences in terms of the performance properties of rubber modified and asphalt rubber binders with fine crumb rubber particle sizes (<250 Qm). However, the correlations between results from the two geometries became increasingly weaker as the crumb rubber particle size (up to 2 mm) increased, indicating that the parallel plates did not perform as well with larger particle sizes. The proposed alternative geometry for measuring the rheological properties of asphalt rubber binder is considered feasible.

This research has also set the stage for Task 2671, during which contract acceptance criteria for asphalt rubber binders for the new DSR system will be established.



The proposed DSR concentric cylinder measuring system for evaluating asphalt binders has two cylinders: the inner cylinder is called the bob and the outer cylinder is called the cup.

WHAT IS THE BENEFIT?

Recycling scrap tires benefits the environment and reduces landfills, but using crumb rubber requires effective methods for testing the performance of asphalt rubber binders. The study results will help develop contract acceptance criteria for these binders based on engineering properties. Establishing a targeted performance grading system minimizes the risk of designing and constructing R-HMA mixes with poor performance and durability.

LEARN MORE

To view the complete report:
www.ucprc.ucdavis.edu/PDF/UCPRC-TM-2014-02.pdf

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Research Results

Blending Effects of Recycled Asphalt Pavement on New Asphalt Binders

How aged asphalt binders alter the properties of new asphalt binders

Pavement

JANUARY 2016

Project Title:
Blending Effects of Recycled Asphalt Pavements on Virgin Binders

Task Number: 2565

Start Date: April 1, 2013

Completion Date: September 30, 2014

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

Using reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS) in new asphalt mixes is expected to reduce construction costs, conserve natural resources, and limit dumping of pavement materials in landfills. However, including a high percentage of RAP and RAS requires engineering adjustments to accommodate the aged, stiffer binder, which in turn requires quantifying the degree of blending between the aged and new binders, the performance grade of the blended binder, and the positive and negative impacts on short- and long-term performance.

Current methods for assessing the properties of blended binders use either chemical extraction and recovery of the aged binder or prediction based on the Hirsch model. The extraction and recovery method is not desirable because of the unknown effects of the chemical solvents on the binder. The Hirsch model requires assumptions regarding blending RAP and RAS binders with the new binder. A new analysis procedure for estimating a composite binder's rheological properties by testing mortars and fine aggregate mixes using established Superpave equipment is needed.

WHAT WAS OUR GOAL?

The goal was to develop and validate a simple procedure to assess recycled asphalt's contribution to composite binder properties using standard Superpave testing equipment.

Fine aggregate matrix specimens

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Blending Effects of Recycled Asphalt Pavement on New Asphalt Binders

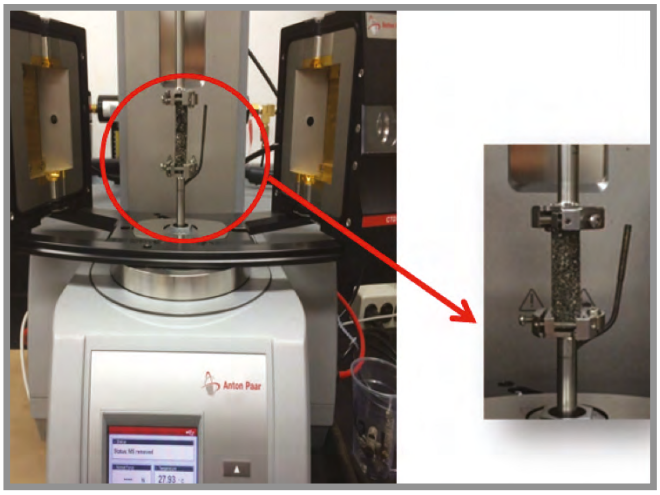
Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center at Davis, created a simplified procedure to investigate the effects of RAP and RAS on the performance grade of new asphalt binders. The team also developed an experimental design plan to evaluate the effects of the RAP and RAS type, source, quality, characteristics, and percentage. The researchers evaluated the rheological properties of these composite binders, accounting for short-term and long-term aging with respect to the performance in the field. A statistical analysis on the results was performed.

WHAT WAS THE OUTCOME?

The results indicate that testing asphalt mortar is probably limited to binder replacement rates from RAP not exceeding 25%. Preliminary results from fine aggregate matrix testing suggest that this method is both repeatable and reproducible and that representative results can be obtained from dynamic shear rheometer tests on fine aggregate matrix specimens. This test approach could be suitable for determining the performance grade of the blended binder and to obtain an indication of a mix's likely performance. The findings will be used to prepare a research plan to assess the performance properties of mixes containing large quantities of RAP and RAS in Task 2676.



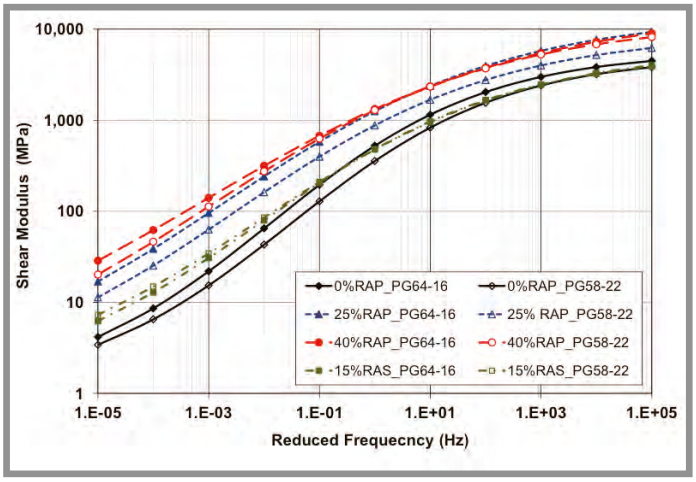
Testing fine aggregate matrix specimens in a dynamic shear rheometer

WHAT IS THE BENEFIT?

When designed properly, asphalt concrete mixes containing relatively large quantities of recycled asphalt can provide similar performance to conventional mixes using new materials. Using reclaimed asphalt reduces the demand for virgin materials to produce asphalt, offering a potentially sustainable option that could lower production costs.

LEARN MORE

To view the complete report:
www.ucprc.ucdavis.edu/PDF/UCPRC-TM-2014-06.pdf



Shear modulus curves of fine aggregate matrix mixes containing various percentages of RAP and RAS

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Research Results

Implementing a New Pavement Management System

PaveM software analysis tool helps pavement designers better predict performance, consider what-if scenarios, and invest dollars wisely

Pavement

FEBRUARY 2016

Project Title:
Complete Quality Assurance on Automated Pavement Condition Survey and Ground Penetrating Radar Contracts

Task Number: 2354

Start Date: November 1, 2011

Completion Date: November 30, 2014

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
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WHAT WAS THE NEED?

The California state highway system, more than a half-century old, is showing its age. Caltrans must continually monitor and maintain the system, which encompasses over 50,000 lane miles and carries nearly 35 million vehicles per year. To target future repairs and projects that do the most good for the least amount of money, Caltrans is employing various technological approaches to assess and inventory pavement needs. Developing analytic and predictive models requires data on the pavement structure, including the types of materials used and layer thickness, and how the condition of the surface changes over time.

WHAT WAS OUR GOAL?

The goal was to develop a pavement management system that provides decision-makers data to support efficient spending and resource allocation strategies for pavement building, preservation, and rehabilitation projects.

Using ground-penetrating radar to collect roadway information

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WHAT DID WE DO?

To develop the pavement management system, PaveM, Caltrans worked with the University of California Pavement Research Center to gather the necessary data to establish an inventory of the underlying pavement structure—layer thicknesses and material types—and the surface condition of the entire state highway network. The project used ground-penetrating radar (GPR) to collect the structural information at highway speeds. The researchers then verified the GPR data by comparing samplings to blind test sections that were extensively cored and measured with a more accurate walking GPR unit. PaveM also incorporates data from the annual Caltrans automated highway pavement condition survey (APCS), which collects pavement surface condition data at highway speeds using lasers and cameras. This data is collected annually and is used to develop the pavement distress prediction models. The researchers confirmed the information by comparing the pavement videos to results from crack recognition software.

WHAT WAS THE OUTCOME?

The quality assurance tests showed that the airborne GPR method provided accurate substructure data for the entire network. The substructure information was not available in the past, but with new GPR data, more accurate performance modeling can be done. The APCS data has been scripted to feed directly into the PaveM software. Districts can now view digital photos of the pavements, along with the analyzed cracking, rutting, and roughness values. The research team developed two software programs during the QA effort that are useful for pavement designers when determining a project's pavement structure. iGPR takes the processed GPR data and displays the layer thickness and pavement type along the route lane-by-lane. The iCore program vets the core data taken from a pavement section and then enters it into the iGPR program for comparison to the GPR data.

iGPR display for I-5 in Siskiyou County

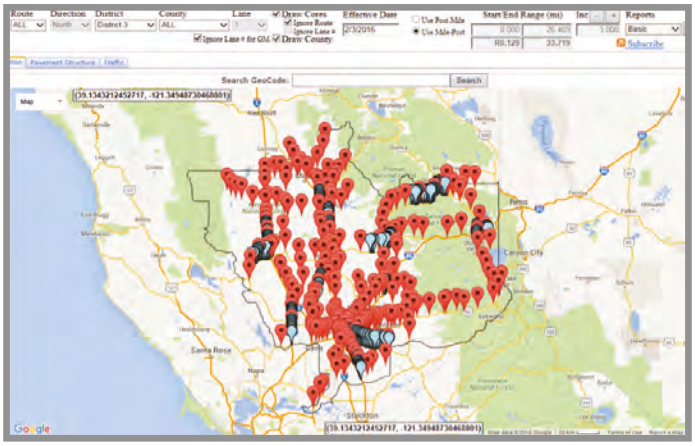
WHAT IS THE BENEFIT?

PaveM analysis enables Caltrans to implement a proactive approach for prioritizing, preserving, rehabilitating, and maintaining existing highway pavements. Pavement designers can use PaveM to recommend the best pavement strategies, predict how long the pavement will last, and select the most cost-effective treatments. As more pavement condition data is collected, Caltrans can develop more accurate pavement performance prediction models for the many climate regions, traffic conditions, and pavement types in California.

LEARN MORE

To view district-based route selections on iGPR, visit *www.ucprc.ucdavis.edu/iGPR.*

To view route-based route selections on iGPR, visit *www.ucprc.ucdavis.edu/iGPR/Default.aspx?iGPR=false&DistrictBasedUI=false.*



Core locations in District 3

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Research Results

Life-Cycle Analysis of Cool Pavement

What is the long-term environmental cost of changing to more reflective pavement to mitigate urban heat islands?

Pavement

JANUARY 2016

Project Title:
Use of Environmental Life Cycle Analysis to Develop Tools and Recommend Practices to Reduce Environmental Impact (Sustainable Pavements)

Task Number: 2580

Start Date: July 1, 2013

Completion Date: November 30, 2014

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
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WHAT WAS THE NEED?

The built environment in urban areas can cause the temperature to be warmer than the surrounding undeveloped areas, a phenomenon described as an urban heat island. Urban heat island effects occur across the year and particularly in the summer. Urban heat islands affect air quality, energy consumption to cool buildings, public health, and human comfort. The prevalence of surfaces that absorb and retain energy from the sun and a lack of vegetation are contributing factors. To address the causes and effects of urban heat islands, the Heat Island Group at Lawrence Berkeley National Laboratory (LBNL) promotes the science and implementation of cool community strategies, such as using more reflective materials for roofs, pavements, and cars. The LBNL's Cool Pavement project focuses on reducing pavement temperatures by increasing the albedo—or reflectivity—of the pavements used for roads, parking lots, and other surfaces. The albedo of pavement surfaces differs greatly based on the materials used in construction. The hypothesis is that if large areas of pavement are changed to be more reflective, sending more sunlight back into the atmosphere, less air conditioning would be used, reducing energy consumption, and thereby reducing global warming. However, to achieve a more complete picture of the consequences of changing pavements in metropolitan areas requires also considering the environmental effects and energy consumption involved in constructing and maintaining new cooler pavements.

WHAT WAS OUR GOAL?

The goal was to provide a full life-cycle analysis of changing the pavement albedo in urban areas to address global warming, energy use, and selected air pollutants.

Thermal infrared (left) and visible (right) images of a road with light and dark segments. The infrared image shows that the light segment (bottom) is about 17°C (30°F) cooler than the dark segment (top). (Image courtesy of Larry Scofield, APCA)

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WHAT DID WE DO?

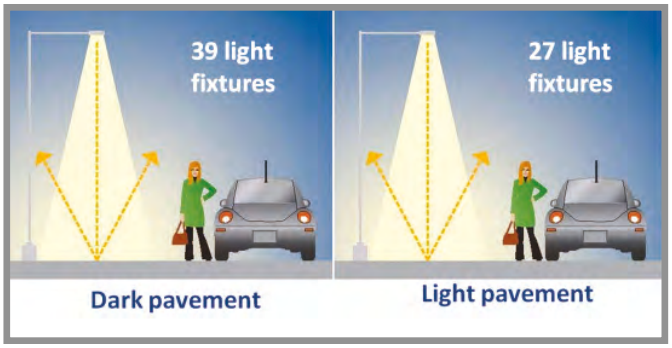
Caltrans, in partnership with the University of California Pavement Research Center and thinkstep, a sustainability consulting company, provided input on the life-cycle effects of cool pavements, such as the energy consumption and emissions required to produce, transport, construct, and maintain different types of pavement. The researchers also provided information on albedo measurements, local government pavement treatment practices, and other factors that contribute to the life-cycle analysis.

WHAT WAS THE OUTCOME?

LBNL developed a software tool that incorporates the full life-cycle analysis to better understand how changing pavement surfaces in urban areas affects global warming. The software uses building energy modeling completed by LBNL, climate modeling completed by the University of Southern California, and the work of the UCPRC and thinkstep.

WHAT IS THE BENEFIT?

Cooler pavements can help mitigate the effects of urban heat islands. When making pavement choices to increase reflectivity and thereby reduce temperatures, it is important to understand the entire life cycle to gain a complete understanding of the long-term environmental effects and consequences.



Reflective pavements can reduce the need for street lighting at night. (Image courtesy of Stark 1986)

LEARN MORE

Report forthcoming.

Clear resin binder (Image courtesy of ESI.info)

Light chip seal (Image courtesy of qiaoxinguan.com)

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Research Results

Developing Partnerships in Concrete Pavement Research

Concrete consortium facilitates scientific development and technology transfer

Pavement

DECEMBER 2015

Project Title:
Technology Transfer Concrete Consortium, TPF-5(159)

Task Number: 1662

Start Date: January 9, 2008

Completion Date: March 31, 2015

Product Category: New or improved technical standard, plan, or specification

Task Manager:
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WHAT WAS THE NEED?

Across the nation, state departments of transportation (DOT) need to design and build concrete pavements that last longer, address environmental concerns, and provide a higher level of user satisfaction. Achieving improved pavements involves using innovative materials, new methodologies, and optimized construction technologies and practices. The most efficient way to foster new technologies and practices is to develop partnerships among experts from state DOTs, the Federal Highway Administration (FHWA), universities, and industry. The Technology Transfer Concrete Consortium provides the participating agencies a forum for collaboration.

WHAT WAS OUR GOAL?

The goal was to promote collaboration among state and national agencies to identify, support, facilitate, and fund concrete research and technology transfer initiatives.

Technical tour in Nevada, spring 2015. The consortium provides participating states the opportunity to observe new developments in concrete paving and the implementation of new technologies.

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WHAT DID WE DO?

Caltrans participated in this national forum of over 25 state highway agencies led by the Iowa DOT to collaborate on and exchange technical expertise regarding new initiatives in concrete materials and pavement-related issues. The National Concrete Pavement (CP) Technology Center served as the lead research institution.

All efforts of the Technology Transfer Concrete Consortium focused on these project activities and deliverables:

- Identify and guide the development and funding of technology transfer materials, such as summaries and training materials
- Review the CP Road Map initiatives and provide feedback to the FHWA, industry, and the CP Technology Center on those initiatives
- Provide research ideas to funding agencies
- Identify and instigate needed research projects
- Develop pooled fund research studies for solutions to concrete and concrete pavement issues
- Act as a technology exchange forum for the participating entities

The Technology Transfer Concrete Consortium provides a forum for collaboration.

WHAT WAS THE OUTCOME?

National forums have been held regularly twice a year at various locations. The consortium provides participating states the opportunity to be a part of new developments in concrete paving and the implementation of new technologies. Some of the work completed included a publication on long-life concrete and recommendations for standardizing dowel load transfer systems for jointed concrete roadway pavements. State highway agency requirements for dowel baskets vary widely. Adopting a standard set of dowel basket designs reduces manufacturer setup and production costs and allows manufacturers to maintain a larger inventory of fewer varieties, resulting in lower costs and fewer production delays.

A new pooled fund study has been established for the next fiscal year in which Caltrans will participate.

WHAT IS THE BENEFIT?

Through collaboration, the Technology Transfer Concrete Consortium helps shorten the time it takes for scientific research to be implemented. New approaches and technologies are developed and tested more quickly and cost effectively. The consortium encourages standardization, making decision-making and production more efficient. Participants benefit from sharing expertise and experiential knowledge.

LEARN MORE

Presentations, meeting minutes, and project products are available at the National Concrete Pavement Technology Center's website:
www.cptechcenter.org/technical-library/TTCC-NCC-search

Tour of a Nevada cement plant

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Research Results

Private Sector Road-Freight Logistics and Roadway Preservation

The interdependency between private freight companies, public transportation agencies, and California's infrastructure and economy benefits from collaboration and sharing information

Planning/ Policy/ Programming

FEBRUARY 2016

Project Title:
Logistics Augmentation of the Pilot Study Investigating the Interaction and Effects for State Highway Pavements, Trucks, Freight, and Logistics

Task Number: 2482

Start Date: February 12, 2013

Completion Date: September 30, 2014

Product Category: New or improved business practice, procedure, or process; processed data/database

Task Manager:
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WHAT WAS THE NEED?

Freight transport is the cornerstone of California's economy as well as the nation. The state supplies more than 50% of the country's agricultural goods, and about 40% of freight enters and exits the United States through California's sea, land, and air gateways. The predominant mode of transporting freight in California is by road, with 78% of the state's communities connected exclusively by road. While California's economy is dependent on trucking to move goods within the state and beyond its borders, privately owned freight companies rely on the capacity and performance of publicly owned roads to remain competitive. Despite the importance of this interdependence, the divergent roles and purposes of the two sectors hamper collaboration. Public agencies need to focus their resources and efforts on managing, maintaining, and improving these roadways for the general well-being of all travelers, taking into account safety and environmental impacts. Freight companies require an efficient and reliable highway infrastructure, yet public agencies can encounter difficulties in acquiring information about private sector operations, in part because of a company's concerns that sharing operational information might compromise its competitive advantage. In addition, increasing freight volumes are speeding up infrastructure deterioration and congestion, which affects all transportation modes. This study on road-freight logistics is part of a multiphase project to investigate the interaction between the movement of goods and the maintenance and preservation of the state's highway system and the economic repercussions.

National truck freight flows to and from California in 2007

WHAT WAS OUR GOAL?

The goal was to identify and examine the interdependencies of the public and private sectors that affect road-freight transportation in California to support economic analysis, roadway preservation, and long-range transportation planning.

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WHAT DID WE DO?

Caltrans collaborated with the University of California Pavement Research Center to investigate the private-sector strategic, operational, and tactical decisions and perspectives that are affected by the condition, capacity, performance, and regulation of California's roadways. The study focused on 2 out of the 10 identified goods movement-dependent industry sectors—agriculture, forestry, and fishing and transportation and warehousing—working with one company from each sector to develop case studies. Anonymity of the private sector participants was maintained, and a strong partnering relationship was established for future interaction and consultation.

WHAT WAS THE OUTCOME?

This pilot study presented a methodology to analyze how and when road infrastructure and regulation influence supply chain vulnerability for the different industries. The case studies describe the interdependence of public sector and private sector decisions. The data and information gathered support Caltrans freight-related efforts, including implementation of the California Freight Mobility Plan and meeting mandated federal and state legislation and policies. The project also supports the work of other agencies, such as the California Air Resources Board's development of the Sustainable Freight Initiative.

Estimated freight flows into and out of California in 2011

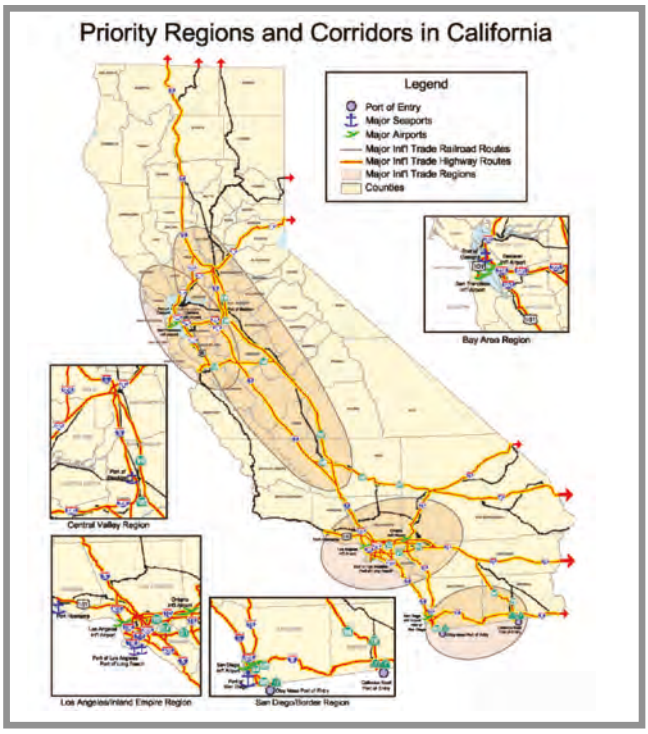
WHAT IS THE BENEFIT?

Growing freight volumes and the increasing demands on freight transportation systems to be reliable, cost-efficient, time-efficient, and flexible have highlighted the importance of the interdependence between the public and private sector in providing the market with the essential freight systems it requires. Yet trucking also affects the performance and lifespan of public roadways used by all travelers. Caltrans must make critical cost-benefit decisions for maintaining the highway system network and all modes of transportation. The partnering relationship established between Caltrans and the private firms in the case studies provide a potential opportunity for ongoing research collaboration that contribute to the interdependency of freight, pavement, vehicles, and the economy.

LEARN MORE

To view the complete report:
www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2014-02.pdf

To view a compilation of executive summaries of the various stages of this project:
www.ucprc.ucdavis.edu/PDF/UCPRC-SR-2014-01.pdf



Priority freight regions and corridors in California

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Research Results

Analyzing How Road Roughness Affects Trucking and Freight

Data on the interaction of truck freight, vehicles, and pavement supports long-range planning, economic analysis, and pavement management and preservation

Planning/ Policy/ Programming

FEBRUARY 2016

Project Title:
Pilot Study Investigating the Interaction and Effects for State Highway Pavements, Trucks, Freight, and Logistics

Task Number: 2603

Start Date: November 15, 2011

Completion Date: September 30, 2014

Product Category: New or improved business practice, procedure, or process; processed data/database

Task Manager:
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WHAT WAS THE NEED?

As a major gateway for shipped goods and a center for agricultural production, freight movement is crucial to the economy of California. Most of the state's freight is transported by trucks, affecting the condition and shortening the lifespan of the state's highway system. In turn, road conditions impact the freight industry. Deteriorating road quality increases vibrations, which can damage goods, require more vehicle maintenance, cause delays, and make it more difficult to comply with noise and emission regulations, ultimately translating to a higher cost of moving goods. Making informed decisions regarding the cost of managing and preserving the pavement network requires going beyond the pavement to include broader economic affects, such as how deteriorating road conditions affect the price of goods and California's economy and the general traveling public. As part of this multiphase study, data was needed to analyze how pavement, trucks, and freight interact as a system to, support more expansive cost-benefit analysis, and inform pavement policies and practices.

WHAT WAS OUR GOAL?

The goal was to collect data and information to enable economic assessment of the effects to freight movement and operations from decisions regarding the management and preservation of California's pavement network.

Conducting field measurements for transporting tomatoes to a California processing facility to evaluate the connection between road roughness and damaged produce

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Analyzing How Road Roughness Affects Trucking and Freight

WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center, studied the interaction of the pavement-vehicle-freight system through computer simulations, field measurements, and case study interviews with two private firms. The analysis indicated the effects of road roughness, such as damage to sensitive produce, greenhouse gas emissions, route selection and avoidance, tire wear, and vehicle repair and maintenance costs. The researchers developed maps to show the connection of road roughness and the various effects.

WHAT WAS THE OUTCOME?

Caltrans and other agencies can use the data and information to support freight program plans and mandated requirements related to transportation planning. The research results contribute to economic evaluations, identify challenges to the various stakeholders, and explore problems, operational concerns, and strategies that go beyond the pavement. The findings provide input for planning and economic models to calculate the direct effects of ride quality on specific routes and help form pavement policies and strategic recommendations regarding pavement roughness, design, construction, and preservation. The study's investigation of roughness impacts on freight and trucks produced information that enabled one company to perform a benefit-cost assessment comparing the potential cost savings from paying to repair a frequently traveled road instead of accumulating ongoing costs for truck repairs.

Laboratory testing of damage to tomatoes from imposed vibrations

WHAT IS THE BENEFIT?

Understanding the relationship between roadway roughness and vehicle operating costs, freight damage, and logistics helps transportation agencies evaluate the effects of freight movement on specific routes and use the information to enhance road pavement design, maintenance, and preservation. Private companies can use the data to calculate vehicle operating costs and potential negative impacts on goods caused by specific routes to aid route planning. The data and information supports statewide planning to improve the efficiency of freight transport and support California's economy.

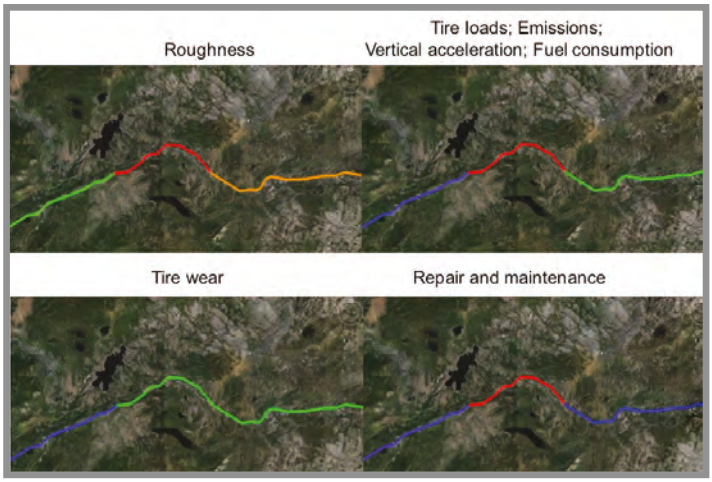
LEARN MORE

To view the final reports for this multiphase study:
Tasks 1–6,
www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2012-06.pdf

Tasks 7 and 8,
www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2013-08.pdf

Tasks 9–11,
www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2014-01.pdf

For a compilation of the executive summaries:
www.ucprc.ucdavis.edu/PDF/UCPRC-SR-2014-01



Maps show the effect of pavement roughness on vehicle responses, tire wear, and repairs and maintenance
Red = Most negative
Orange and Green = Moderate
Blue = Most positive

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Research Results

Exploring a Road Charge for California

California researches the feasibility of replacing the gas tax with a road charge

Planning/ Policy/ Programming

JANUARY 2016

Project Title:
Road Usage Charge Initial Study

Task Number: 2656

Start Date: March 7, 2014

Completion Date: December 30, 2014

Product Category: New or improved policy, rule, or regulation

Task Manager:
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Contract Manager
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WHAT WAS THE NEED?

The current method for financing road maintenance and construction is through excise taxes paid on the amount of fuel purchased at the pump. However, since 2006, gas tax revenues have declined significantly as a result of more fuel-efficient vehicles. Investment in transportation is now about 30% of what is necessary to meet the needs of the state's 50,000 lane miles of roads. As gas tax revenues dwindle, federal policymakers have had to divert billions from the general fund and other non-transportation funds to pay for states' infrastructure, putting increasing pressure on identifying new, viable transportation financing mechanisms. A road charge—a fee based on the number of miles driven—is an alternative method to generate revenue for transportation. Road usage charge systems have been proposed in the United States and other countries, but the only two live programs worldwide are in Oregon and New Zealand.

In 2014, Governor Brown signed into law Senate Bill (SB) 1077, which requires California to design and implement a statewide pilot program to study the implications of a road charge model by January 1, 2017. The legislation required the California Transportation Commission (CTC) to create a 5-member Road Charge Technical Advisory Committee (TAC) to study alternatives to the gas tax, gather public comment on issues and concerns related to the pilot program, and make recommendations regarding its design and evaluation. Based on recommendations from the TAC, the California State Transportation Agency (CalSTA) will implement a pilot program to identify and evaluate issues related to a road charge program.

WHAT WAS OUR GOAL?

The goal was to gather background research surrounding a road charge to better understand the revenue concept and further investigate alternate methods of collecting revenues to finance the long-term repair, maintenance, and improvement of California's roadways.

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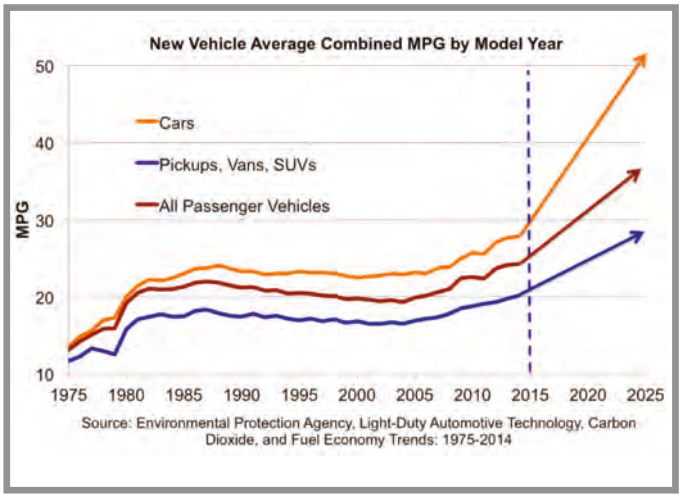
WHAT DID WE DO?

Pursuant to SB 1077, the CTC began convening monthly TAC meetings throughout the state to discuss various policy and technical issues related to the design and implementation of a road charge pilot program. The legislation provided policy, design, and privacy protection guidance to assist in designing a pilot program to test road charging in California.

WHAT WAS THE OUTCOME?

The initial research consisted of updating the preliminary investigation completed by Caltrans. In addition, deliverables included creating plans for outreach, communications, potential demonstration options, and strategic implementation. Caltrans was requested to provide technical support to the TAC, CTC, and CalSTA for the road charge pilot program process. Caltrans used this research to secure funding and resources for the pilot program through the 2015–16 annual budget process.



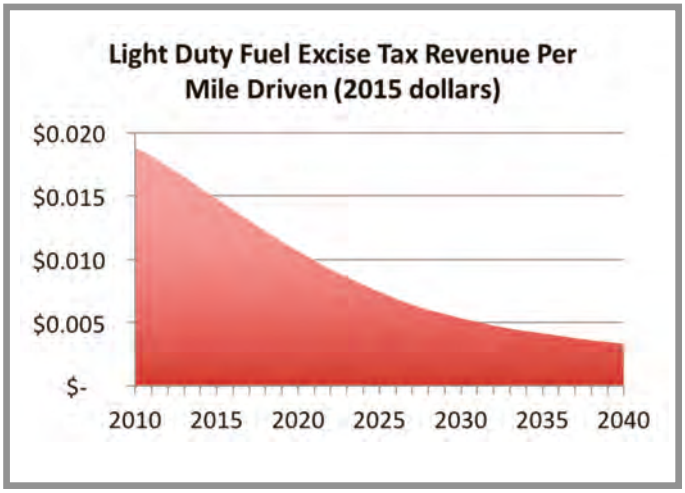
Average miles per gallon of new vehicles by model year

WHAT IS THE BENEFIT?

A well-maintained and efficiently operating transportation system is critical for California's economy and quality of life. The revenues currently available for highways and local roads are inadequate to preserve and maintain the existing infrastructure and to provide funds to reduce congestion and improve safety. The gas tax is no longer an effective method for meeting California's long-term revenue needs as cars and trucks become more fuel efficient and alternative sources of power are introduced. A road charge directly links revenues with usage, potentially providing a more reliable source of funding to maintain and improve the state's roads in the long term.

LEARN MORE

For the latest information about the progress of the road charge pilot, visit *www.californiaroadchargepilot.com*.



Projected fuel tax revenue in cents per mile driven, adjusted for inflation

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Research Results

Sharing Transportation Asset Management Resources and Ideas

The exchange of asset management knowledge and expertise among transportation agencies across the country makes better use of limited resources

Planning/ Policy/ Programming

JANUARY 2016

Project Title:
2014 Transportation Asset Management (TAM) Conference and Training on Implementation Strategies, TPF-5(275)

Task Number: 2515

Start Date: August 1, 2012

Completion Date: January 1, 2015

Product Category: Improved decision support tool

Task Manager:
Scott Williams
Project Manager
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WHAT WAS THE NEED?

Transportation asset management involves maintaining, upgrading, and operating transportation assets throughout their lifecycle to maximize their benefits. To address the changes in today's transportation environment, new technology advances, and the impact of climate change and extreme weather events, better decision-making based on well-researched information is needed to effectively work with limited resources. Every state possesses transportation assets and generates knowledge on how to manage them. Many state and local transportation organizations are interested in implementing asset management and meeting to share management strategies, systems, and tools. The National Conference on Transportation Asset Management provides a forum for the transportation sector to synthesize, share, and disseminate knowledge and experience so that others can benefit.

WHAT WAS OUR GOAL?

The goal was to provide a forum for communication and information sharing among member states, discuss research needs, and exchange technology and knowledge regarding transportation asset management.

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WHAT DID WE DO?

The Transportation Research Board and the American Association of State Highway and Transportation Officials, with support from the Federal Highway Administration's Office of Asset Management, hosted the 10th National Conference on Transportation Asset Management from April 28–30, 2014, in Miami, Florida. The Iowa Department of Transportation served as the TPF sponsoring agency. Participants came from all 50 states and international locations, representing state departments of transportation, metropolitan planning organizations, local transit agencies, universities, and research institutions. The conference provided transportation agencies a forum to identify successful strategies for implementing transportation asset management principles. Experts in their fields described how to apply asset management concepts to pavement and bridge assets and nontraditional assets, such as traffic management systems and data resources, how to integrate data science to improve decision-making, and how to adapt to climate change in terms of its effect on infrastructure.

WHAT WAS THE OUTCOME?

The conference addressed these six major areas:

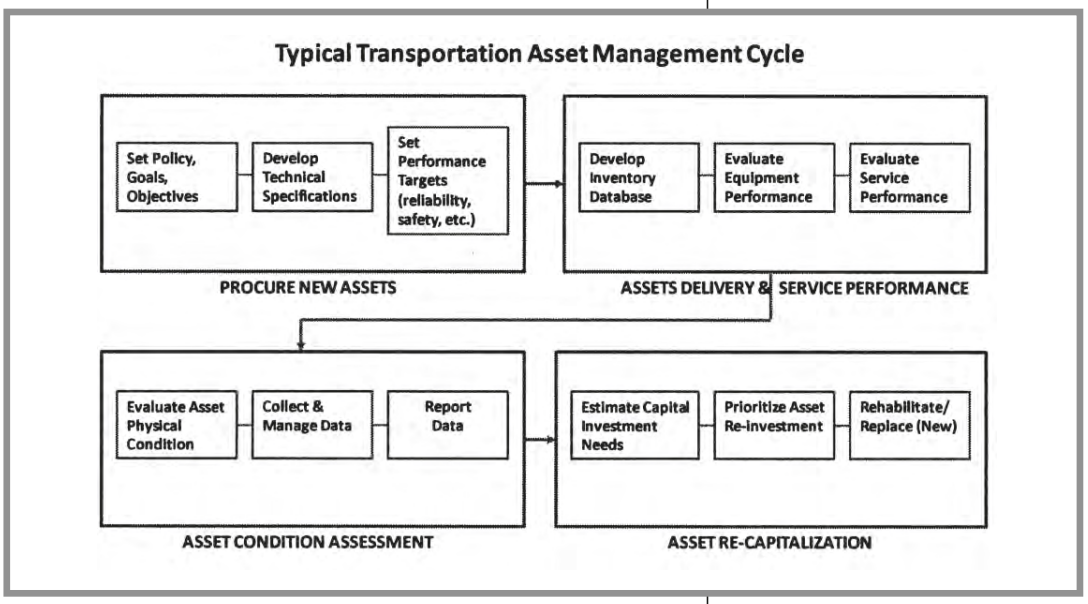
- Establishing, using, and monitoring asset management plans—Developing plans to meet government mandates and identifying ways to use the plans to improve existing practices
- Implementing within and across organizations—Understanding and overcoming barriers by improving communication within and across organizations to improve decision-making and investment planning
- Tools and technology to assist decision-making—Staying on top of emerging practices, methods, and tools for collecting data, making informed choices, managing risk, and analyzing trade-offs
- Performance measures for asset management—Implementing asset management performance measures
- Transit state of good repair—Analyzing current operations and management standards and sources of financial support for repair initiatives
- Adaption to extreme weather events and climate change—Addressing how climate change and extreme weather events affect system assets

WHAT IS THE BENEFIT?

Today's transportation needs cover a broad array of assets and technologies. Asset management offers transportation professionals the tools, processes, and information to make sound investment decisions and effectively manage these assets to improve longevity. States participating in the transportation asset management consortium can share resources, technology, and ideas and prevent the duplication of efforts. The workshops and conference enable transportation agencies to work in partnership and establish an asset management agenda for the next several years.

LEARN MORE

For information on the 2014 conference and presentations: *http://onlinepubs.trb.org/onlinepubs/conferences/2014/AssetManagement2014/Program.pdf*



Flow and approach to challenges in each phase of the asset management cycle

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Research Results

Cross-State Collaboration on Roadway Maintenance Practices

The No Boundaries project promotes resource sharing among states to research and deploy maintenance innovations

Research Support

DECEMBER 2015

Project Title:
No Boundaries Roadway Maintenance Practices, TPF-5(239)

Task Number: 2186

Start Date: January 10, 2011

Completion Date: June 30, 2015

Product Category: New or improved tool or equipment

Task Manager:
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Transportation Engineer
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WHAT WAS THE NEED?

To improve facilities and maintain an aging infrastructure with fewer resources demands innovative technologies and practices. Fostering these advances and integrating the products into the day-to-day practices of state departments of transportation (DOT) requires research, time, and money. The time and dollars can be more effectively put to use by not investing in research that has already been performed by another state DOT. By pooling resources, state DOTs can more cost-efficiently identify and evaluate maintenance innovations and improve business practices.

WHAT WAS OUR GOAL?

The goal was for the participating state DOTs to work collectively to identify and implement improved maintenance practices and products, saving time and money by eliminating separate investments in the same research.

Truck-mounted lifting device automates traffic barrel pickup operations and removes crews from the path on oncoming traffic. It has cut sprains and strains by half, decreasing lost work time and potential claims.

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Cross-State Collaboration on Roadway Maintenance Practices

Research Results

WHAT DID WE DO?

Led by the Missouri DOT, Caltrans, along with the Georgia, Iowa, Mississippi, Ohio, Pennsylvania, and Washington DOTs, participated in the No Boundaries project. The member state DOTs identified and shared their implemented maintenance innovations, including the following.

- Advanced control system herbicide sprayer
- All-terrain rotary tree trimmer
- Concrete deck repair trailer
- Data-driven traffic paint reflectivity program
- Debris removal tool
- Epoxy injection of bridge decks
- Maintenance Leadership Academy training classes
- Mobile work zone barrier
- Pavement contrast striper
- Recycling used tires program
- Tandem-axle dump truck
- Truck-mounted attenuator panic lights
- Truck-mounted lifting device
- Weed control barrier

WHAT WAS THE OUTCOME?

The consortium has provided the technical exchange needed to advance the application and benefits of maintenance innovations. A public website that keeps members and other agencies up to date and centralizes information regarding the various products was developed.

CRMCrete weed control barrier, made from readily available recycled products, blocks weed growth under guardrails, reducing recurring maintenance activities, such as herbicide application, pruning, and mowing.

WHAT IS THE BENEFIT?

No Boundaries helped promote promising, ready-to-deploy maintenance innovations implemented by the member states. The various agencies saved time and money by not duplicating the same research while also benefitting from other states' experiences. The project provided a forum for state DOTs to share information, support technology transfer, and develop deployment plans. The collaboration provided essential verification that new products and practices can be successfully integrated into current maintenance programs and make a positive difference.

LEARN MORE

For details about the implemented practices, visit *http://noboundaries-roadmaintenance.org*

To view the final report:
www.pooledfund.org/Details/Study/468

Jarraff all-terrain rotary tree trimmer lets the operator remain in an enclosed cab safely away from cutting blades and falling debris.

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Research Results

Developing and Promoting Intelligent Transportation Systems in Rural Environments

COATS supports interstate collaboration to investigate technology that addresses rural transportation challenges

Rural

NOVEMBER 2015

Project Title:
California and Oregon Advanced Transportation System (COATS) V

Task Number: 1752

Start Date: September 16, 2011

Completion Date: August 14, 2014

Product Category: New or improved business practice, procedure, or practice; new or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
Sean Campbell
Senior Transportation Engineer, Electrical
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WHAT WAS THE NEED?

Since 1998, the California Oregon Advanced Transportation Systems (COATS) program encourages regional, public, and private sector cooperation between California and Oregon organizations to facilitate and maximize the planning and implementation of Intelligent Transportation Systems (ITS) in a rural bi-state area extending from south of Redding, California to north of Eugene, Oregon. COATS serves as an incubator for technological innovation, with each phase focusing on particular projects. Numerous systems and approaches have been developed and evaluated over the years, providing information on which to base future deployment decisions. Several initial systems are still in place, addressing the concerns they were designed to answer.

As COATS and its products have matured, Washington and Nevada have witnessed the benefits. For Phase V, the COATS region now encompasses the Western States Rural Transportation Consortium (WSRTC), which includes California, Nevada, Oregon, and Washington.

Chain-up delay tracking for trucks using Bluetooth wireless technology on I-5 north of Redding developed during COATS Phase V.

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Developing and Promoting Intelligent Transportation Systems in Rural Environments

Research Results

WHAT WAS OUR GOAL?

The goal was to improve rural travel by promoting technology transfer, using Bluetooth readers to estimate chain-up area delays, synthesizing information on automated safety warning devices, and developing guidance for the planning of regional Integrated Corridor Management (ICM).

WHAT DID WE DO?

COATS Phase V focused on four areas.

- Survey of Western States Safety Warning Devices—Addressed the absence of an inventory of deployed safety warning systems, which alert drivers of hazardous conditions, such as ice and high winds, by documenting where various devices are located across western states and their function.
- Regional ICM Planning—Examined existing ICM efforts in the WSRTC region, summarized each state's Emergency Operations Center protocols and plans, and reviewed the U.S. Department of Transportation's ICM planning approach.
- Chain-up Delay Tracking with Bluetooth—Identified locations to deploy Bluetooth loggers to estimate travel time and delay through the affected area.
- Western States Rural Transportation Technology Implementers Forum—Delivered high-quality technology transfer and networking opportunities to professionals working in designing and maintaining ITS technologies in rural environments.

Original COATS region, which has now expanded to rural areas of Nevada and Washington

WHAT WAS THE OUTCOME?

The projects completed during COATS Phase V contribute to the future development and deployment of systems and approaches that will benefit rural areas. The chain-up delay tracking project identified the sites needed to provide sufficient data to accurately determine delay. The list of in-place safety warning devices allows practitioners to learn about the benefits of available systems and avoid past pitfalls. The regional ICM planning work addressed the absence of information in a rural context. The development of a regional ICM planning process has provided a framework to identify alternative routes in the event that a corridor is closed or has restricted traffic flow. The WSRTC fosters the opportunity to pursue efforts geared toward outreach and technology transfer.

WHAT IS THE BENEFIT?

COATS provides a forum for member agencies to work together to produce a multimodal transportation network that benefits travelers, movement of freight, economic activity, and transportation systems operators. It promotes increased safety, mobility, traveler comfort, environmental quality, and operational efficiency and productivity. The collaboration leverages research activities in a coordinated manner to respond to rural transportation issues among western states related to technology, operations, and safety.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2014/final_report_task_1752.pdf

For more information about COATS, visit:
www.westernstates.org/Projects/COATS/Default.html

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Research Results

Benchmarking Bridge Pile Performance

Data from recent earthquakes helps refine design procedures for bridge pile foundations

Seismic

NOVEMBER 2014

Project Title:
Benchmarking Recently Developed Procedures for Designing Pile Foundations in Laterally Spreading Ground

Task Number: 2421

Start Date: November 30, 2011

Completion Date: July 31, 2014

Product Category: Improved design guidelines; improved technical specification

Task Manager:
Charles Sikorsky
Research Program Manager
charles.sikorsky@dot.ca.gov

WHAT WAS THE NEED?

Caltrans has been developing procedures for estimating pile performance during lateral spreading events. Recent earthquakes in Japan (2011), Chile (2010), and New Zealand (2010 and 2011) provide case studies of earthquake-induced damage that are relevant to California. The earthquakes occurred in economically viable countries with advanced seismic engineering codes comparable to California. Comparing bridge design specifications to actual performance during seismic events will help confirm the accuracy of the new procedures and reveal areas that need improvement.

WHAT WAS OUR GOAL?

The goal is to benchmark recently developed procedures for designing pile foundations in liquefaction-induced lateral spreading.

WHAT DID WE DO?

Caltrans, in partnership with Oregon State University, analyzed and compared the performance of three bridges during recent earthquakes: the Mihama Bridge in Japan, the South Brighton Bridge in New Zealand, and the Mataquito Bridge in Chile. The researchers first calculated each bridge's pile performance before the earthquake—as an engineer would when initially designing the bridge. The predictions were then compared to observed bridge pile performance as result of the seismic events to check the applicability of the design guidelines and benchmark the procedures in the areas of ground displacement and pile damage by bending moments.

Japan earthquake 2011

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WHAT WAS THE OUTCOME?

Based on the information available, the benchmarking produced a number of recommendations. However, to ensure accuracy, the researchers need more comprehensive data sets with soil information, structural details, earthquake recordings, and damage assessment. Since starting the comparisons, more data from the three earthquakes has become available, which could expose weaknesses in the current procedures and lead to more robust analysis methods. The procedures work well for small bridges with modest pile groups. For larger pile groups, the assumption of a "super pile" is problematic.

WHAT IS THE BENEFIT?

Much can be learned by assessing real-world examples of seismic events. The initial comparisons between the computed and observed performance of the bridges highlight potential refinements to the Caltrans design procedures. Based on these three case studies, the current Caltrans method performs reasonably well, but more benchmarking efforts should be carried out to further confirm the strength of the Caltrans method.

LEARN MORE

www.dot.ca.gov/research/researchreports/reports/2014/CA15-2421_FinalReport.pdf

Comparison of estimated displacement with measured bridge displacement

Bridge	Estimated ground displacement (cm)	Estimated pile head displacement (cm)	Observed ground displacement (cm)	Observed abutment displacement or deflection (cm)
Mataquito Bridge, Chile	4–10 (PGA = 0.461) 3.5–8 (PGA = 0.390)	1.5–6.1	N/A	Less than 2 cm ~20 cm
South Brighton Bridge, New Zealand	11–20	10–20	N/A	N/A
Mihama Bridge, Japan	4–13.5	3.2–7.4	1–18	

Comparison of estimated bending moments

Bridge	Estimated maximum bending moment (kN–m)	Yield bending moment (kN–m)	Allowable bending moment (kN–m)
Mataquito Bridge, Chile	38,099–55,815	45,000	62,920
South Brighton Bridge, New Zealand	2,186–2,204	1,200	2,200
Mihama Bridge, Japan	75,083–119,154 (using estimated ground displacement) 77,245–131,014 (using observed ground displacement)	130,000	161,258

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Research Results

Improving Shear Key Performance in Multi-Frame Bridges

Proposed method lowers construction costs of multi-frame bridges while increasing their seismic safety

Seismic

FEBRUARY 2016

Project Title:
Development of a Rational Design Method for Shear Keys at In-Span Hinges in Multi-Frame Highway Bridges

Task Number: 2424

Start Date: June 1, 2012

Completion Date: August 31, 2014

Product Category: New or improved technical standard, plan, or specification

Task Manager:
Charles Sikorsky
Research Program Manager
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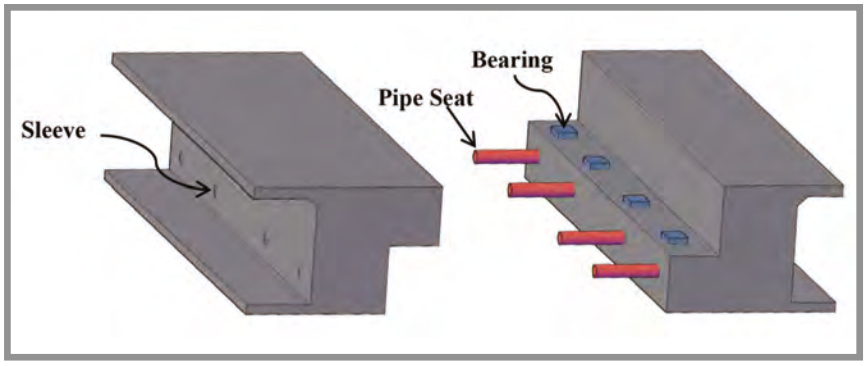
WHAT WAS THE NEED?

Long, concrete box-girder highway bridges are often constructed as multiple frames that are separated by in-span hinges in their superstructure. This multi-frame bridge system, widely used for long bridges in California, simplifies construction by facilitating post-tensioning of the bridge superstructure and lowering the effects of creep deformation in long bridges. It also allows for longitudinal thermal expansion and contraction. When designing multi-frame bridges, the adjacent frames are connected with shear key members placed in in-span hinges to preserve the integrity of the entire bridge during a seismic event. Caltrans has standardized a shear key detail—a pipe/cable shear key—that performs both as a transverse shear key and longitudinal restrainer. However, the capacity and stiffness of this detail had not been fully investigated. A method to ensure a safe and cost-effective design of shear key elements in multi-frame bridges was needed.

WHAT WAS OUR GOAL?

The goal was to better understand the seismic response of multi-frame bridges in the transverse direction and develop a rational, data-driven, and simple design method for in-span shear keys.



Pipe seat extenders in a typical in-span hinge

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Improving Shear Key Performance in Multi-Frame Bridges

WHAT DID WE DO?

Caltrans, in partnership with the University of Connecticut Department of Civil and Environmental Engineering, conducted approximately 7,700 nonlinear response history analyses on high-fidelity models of a large set of prototype bridges using OpenSees simulation software. The team reviewed 52 two-, three-, four-, and five-frame bridges with single, extended pile-shaft and two-column bents. The researchers designed the prototype bridges in accordance to the Caltrans Seismic Design Criteria v1.7. They generated a suite of ground motions representing the design acceleration response spectrums used for nonlinear time history analyses. The large dataset from these analyses was processed, summarized, and interpreted to identify trends and correlations. To study the force-deformation relationship of the pipe/cable shear key detail, the researchers developed a refined 3D finite-element model and validated it using the data from experiments previously performed at the University of Nevada, Reno.

WHAT WAS THE OUTCOME?

The results provide a better understanding of the complex seismic response of multi-frame bridges and proposed a methodology for estimating seismic demands on shear keys. The study also produced reference values for the capacity of steel pipe shear keys. The analyses demonstrated that the pipe shear key detail is very ductile under lateral loading and maintains resistance under large transverse displacements. The lateral capacity and stiffness of the pipe shear key varies with the size of the longitudinal gap. Cyclic loading can significantly reduce the element's lateral stiffness. The effect of variation of tensile forces in cable restrainers on the lateral resistance is negligible.

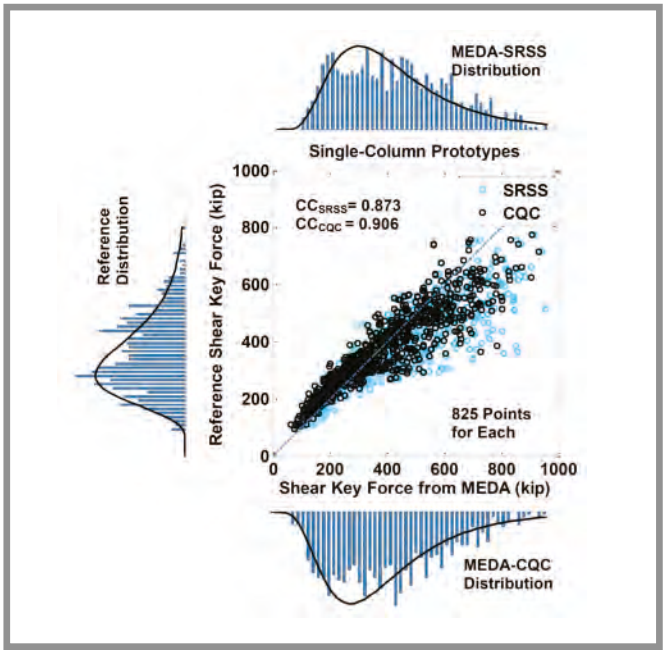
WHAT IS THE BENEFIT?

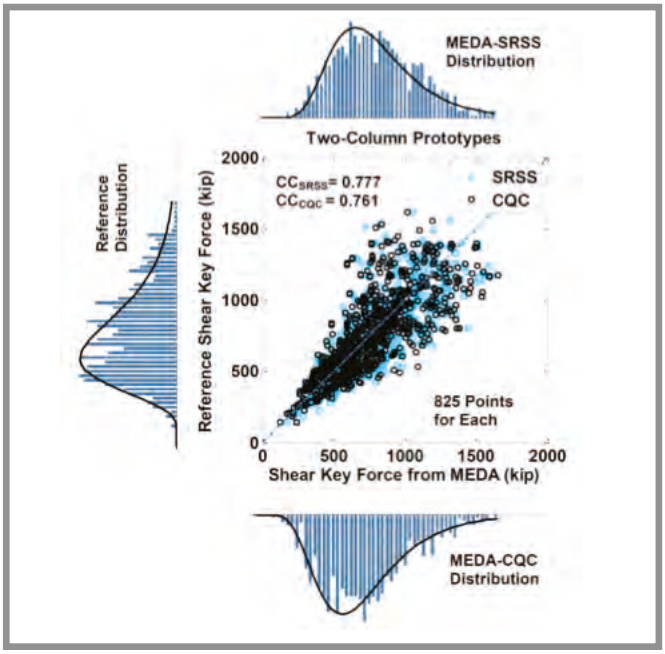
Because of a lack of data, bridge designers have taken a conservative approach when designing in-span shear keys, adding to construction costs and construction complexities, and in many cases, limiting the application of the multi-frame bridge system despite its major benefits. The study enhances the current design practice for bridge columns, superstructures, and in-span hinges of multi-frame bridges. The proposed method lowers the overall cost of construction by eliminating some design uncertainties while increasing the seismic safety of multi-frame bridges.

LEARN MORE

To view the reports for the entire study:
www.dot.ca.gov/newtech/researchreports/reports/2014/CA15-2424_FinalReport_Part_1.pdf

www.dot.ca.gov/newtech/researchreports/reports/2014/CA14-2424_FinalReport_Part_2.pdf





Comparison of the estimated shear key forces from the proposed method with reference forces from analyses (left, single-column bridges; right, two-column bridges)

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Research Results

Seismic Performance of Mechanically Stabilized Earth Bridge Abutments

Numerical modeling shows minimal seismic impact of bridge abutment structures consisting of geosynthetic-reinforced soil

Seismic

JANUARY 2016

Project Title:
Interaction of GRS Abutments with Bridge Superstructures under Seismic Loading

Task Number: 2493 and 2298

Start Date: January 9, 2012

Completion Date: November 30, 2014

Product Category: New or improved technical standard, plan, or specification

Task Manager:
Charles Sikorsky
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WHAT WAS THE NEED?

Mechanically stabilized earth (MSE) walls have been successfully used for decades across the United States primarily as retaining walls that support on-ramps. Their popularity is due to low construction and maintenance costs, rapid construction, and good overall performance. More recently, many states are constructing bridge abutments using MSE techniques. In these applications, the bridge superstructure is supported by a small footing that bears directly on the MSE embankment structure. Compared to typical abutments that rely on driven or drilled piles for bearing support, the MSE abutment offers substantial savings due to simplified construction and the elimination of deep foundations. Geosynthetic-reinforced soil (GRS) is the next step, which reduces the concrete footing required and modifies the MSE embankment to take more of the bridge load directly from the deck. GRS bridge abutments have performed well under static loading conditions. However, to implement this technology in seismic-prone regions, research is needed to evaluate their performance, including vertical settlement during shaking. This study was partially funded by Transportation Pooled Fund (TPF) 5(276) to offset the cost of near-full-scale shake table testing and numerical simulation.

WHAT WAS OUR GOAL?

The goal was to determine whether GRS abutments are viable in regions prone to strong earthquakes by conducting numerical modeling simulations to investigate the seismic performance.

Bridge abutment at the Estribo Francisco Mostazal site after the 2010 Maule earthquake

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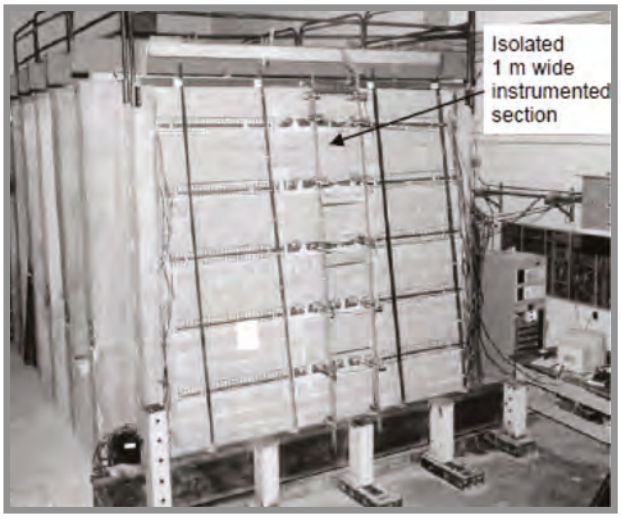
Seismic Performance of Mechanically Stabilized Earth Bridge Abutments

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, San Diego School of Engineering, conducted numerical studies using FLAC-2D (finite difference) and ABAQUS (finite element) software. The researchers validated FLAC-2D for static analysis using published field measurements for the Founders/Meadows GRS bridge abutment in Denver, Colorado. The team then conducted numerical simulations using FLAC-2D and ABAQUS to predict settlement and lateral displacement for a GRS abutment subjected to the Newhall Station ground motion record from the California 1994 Northridge earthquake. Results from the two programs showed good agreement. The researchers also compared numerical simulation results with measured data for seismic tests of a full-scale MSE wall on the UC San Diego large outdoor shake table, funded via TPF-5(276). Numerical results for this latter study indicated that FLAC-2D overestimated wall displacement measurements for this large-scale test.

The researchers then conducted numerical simulations using FLAC-2D to study the seismic response of GRS abutments supporting a 150-foot bridge for the Northridge record with ground motion applied in both the longitudinal and transverse directions. The team performed parametric studies to investigate the effects of several design parameters, including reinforcement spacing, reinforcement stiffness, reinforcement length, soil cohesion, soil friction angle, bridge load, earthquake ground motion record, and bearing pad friction coefficient on the seismic response of GRS abutments in the longitudinal direction. They also evaluated the effectiveness of soil shear keys to reduce seismic-induced lateral movement of a bridge seat in the transverse direction.



Full-scale GRS retaining wall facility

WHAT WAS THE OUTCOME?

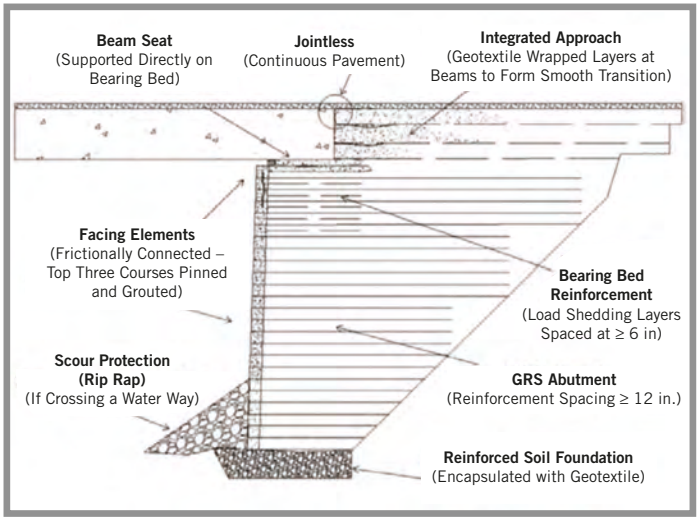
GRS bridge abutments could be a viable option for single-span bridges in California. The numerical results indicated that seismic-induced settlements of a bridge seat on a GRS abutment are small—about 0.65 inches—for the Northridge-Newhall Station ground motion record. Corresponding seismic-induced lateral displacements of the bridge seat were 2.5 inches or less. Reinforcement stiffness and soil cohesion had a large influence on these displacements. Soil shear keys were shown to be effective in reducing lateral displacement of the bridge seat in the transverse direction. Based on these numerical results, the next step is to conduct shake-table testing to further evaluate the seismic performance and support the development of design guidelines.

WHAT IS THE BENEFIT?

GRS abutments can be built in weeks instead of months, due to the ease of construction and the use of readily available materials and equipment. A reduced construction schedule translates into less exposure around work zones, improving safety. They also provide environmental advantages, because less steel and concrete are needed.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA15-2493_FinalReport.pdf



Example cross-section of a GRS bridge abutment

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Research Results

Confinement Effects of Hollow Bridge Columns

Modifications to confinement models improves the accuracy of seismic design

Seismic

FEBRUARY 2015

Project Title:
Understanding the Confined Concrete Behavior on the Response of Hollow Bridge Columns

Task Number: 2264

Start Date: October 14, 2010

Completion Date: December 15, 2014

Product Category: New or improved technical standard, plan, or specification; improved model

Task Manager:
Charles Sikorsky
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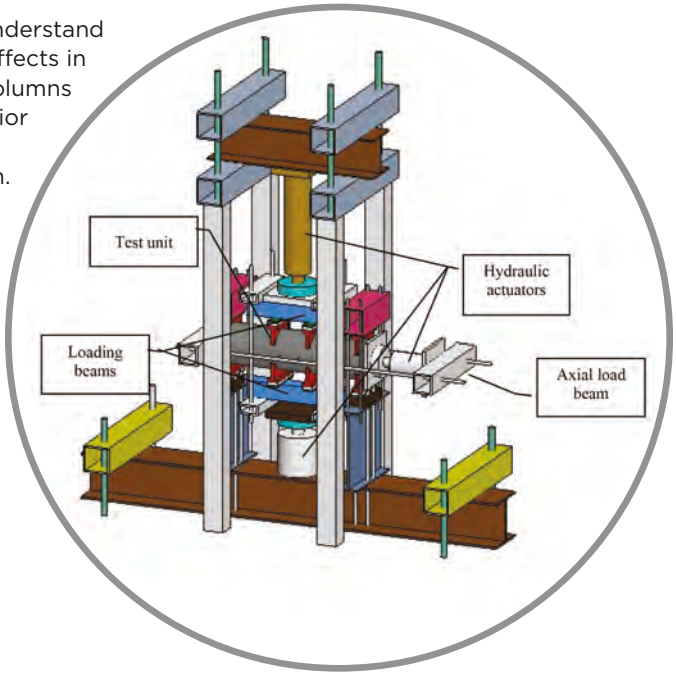
WHAT WAS THE NEED?

In seismic design practice, hollow concrete columns offer unique advantages for bridge construction, especially with tall piers, because of reduced seismic mass, efficient use of materials, and greater strength-to-mass and stiffness-to-mass ratios when compared to solid concrete columns. The reduced seismic mass can improve the overall structural behavior due to the decrease in inertia forces generated during an earthquake. The decreased inertia force makes the column design efficient and contributes to reducing the overall structural cost. However, the behavior of confined concrete in hollow concrete is not well understood, resulting in conflicting findings. A systematic investigation on the confined concrete behavior in hollow concrete columns has not been undertaken. Instead, the confinement models developed for solid concrete sections have been used.

WHAT WAS OUR GOAL?

The goal was to understand the confinement effects in hollow concrete columns and seismic behavior and how to design and reinforce them.



Schematic of the test setup

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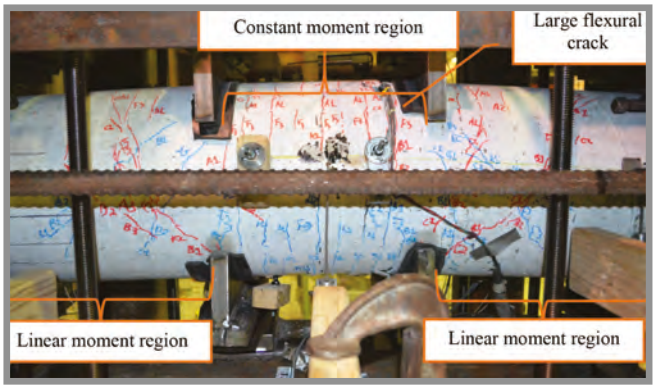
WHAT DID WE DO?

Caltrans, in partnership with the Iowa State University Department of Civil, Construction and Environmental Engineering, investigated the confined concrete behavior in hollow concrete columns using small-scale experimental and detailed analytical studies. The researchers evaluated the flexural behavior of hollow concrete columns when confined with one or two layers of reinforcement. They examined the applicability of current confined concrete models and subjected 16 small-scale columns to a combination of axial and lateral loads, with the section shape, wall thickness, axial load ratio, and loading type as the main variables. The researchers proposed preliminary seismic design guidelines and provided an example.

WHAT WAS THE OUTCOME?

Based on the results of the analytical and experimental investigations, the column with two layers of confinement reinforcement connected with cross ties is the most effective at confining the concrete wall. However, the layers should not be equal in quantities, as assumed in the past. Additional longitudinal reinforcing bars are also needed closer to the inner concrete wall surface. This detail is cumbersome and difficult to construct, making it more labor-intensive and costly.

A hollow concrete column confined with a single layer could be designed to achieve limited displacement ductility. The inside concrete wall is not confined, while the concrete near the outside face experiences reduced confining pressure from the outer layer of reinforcement compared to solid columns. To address the reduced confinement effectiveness, the researchers proposed a modification factor to a widely used confined concrete model in current seismic design practice, expressed as a function of wall thickness-to-section diameter ratio for circular sections and is conservatively defined as a constant for square sections.



Close-up of test region

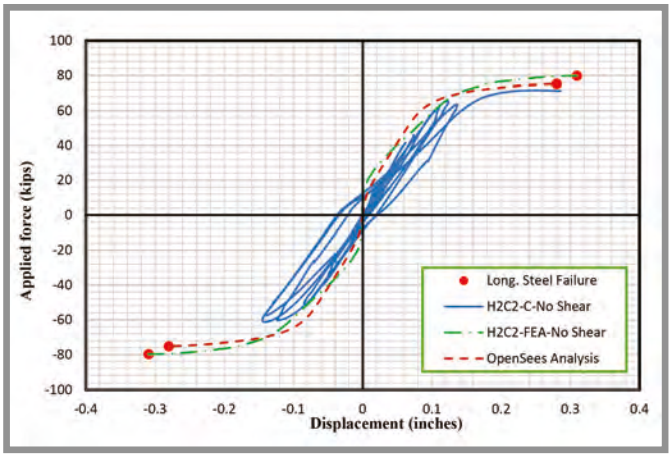
Based on small scale tests, the experimental study indicated that hollow concrete columns experience much more shear deformation compared to solid columns. Therefore, the researchers suggest considering the shear component carefully when designing the columns to accurately define member displacement and ductility. Lastly, further large-scale experimentation is needed to validate the performance of square hollow columns with a single reinforcement layer and the shear capacity of hollow columns. This additional work would provide more efficient design guidance for hollow columns.

WHAT IS THE BENEFIT?

The experiments revealed that the confinement effects in hollow concrete columns differ from assumptions made in the past. Engineers have a good understanding of the lateral load response of hollow columns. The proposed modified model for hollow concrete columns confined with a single layer of transverse reinforcement improves the accuracy of seismic design and analyses. Bridge designers now have preliminary design guidance to aid in the design of hollow columns.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA15-2264_FinalReport.pdf



Measured force-displacement response of specimen H2C2-C with shear deformation removed compared to analytical envelope response

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Research Results

Seismic

Enhancing ShakeCast to Improve Post-Earthquake Response

ShakeCast V3 provides bridge inspection prioritization information to responders within minutes following an earthquake

NOVEMBER 2015

Project Title:
ShakeCast V3—An Enhanced Tool for Post-Earthquake Response

Task Number: 1793

Start Date: March 30, 2011

Completion Date: December 31, 2014

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
Loren Turner
Senior Transportation Engineer
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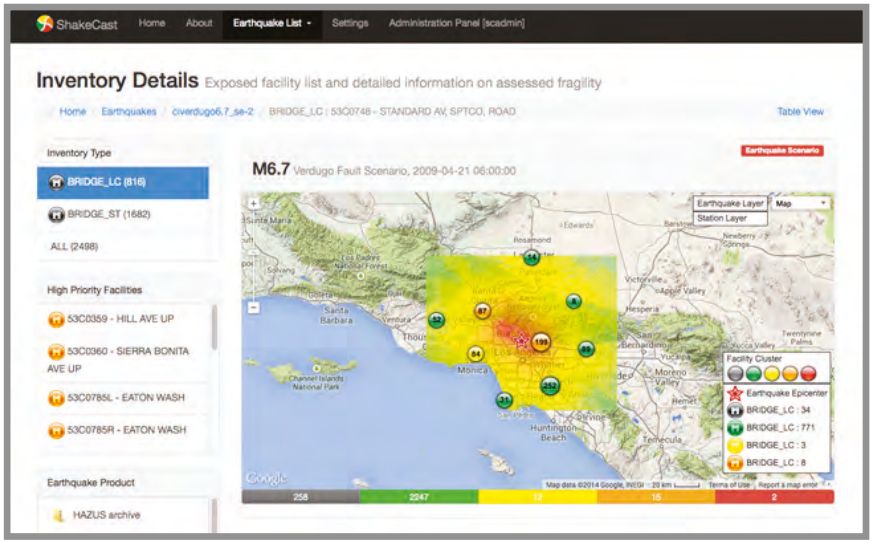
WHAT WAS THE NEED?

After a major earthquake, one of Caltrans's most critical tasks is to determine the condition of bridges and roadway corridors in the region. Timely response is important to ensure public safety, guide emergency vehicle traffic, and re-establish critical lifeline routes. In the past, identifying the structures that needed to be assessed could take hours, delaying inspection teams from getting to work. In 2005, Caltrans worked with the United States Geological Survey (USGS) to develop ShakeCast, a software tool that evaluates the ground shaking at a facility site with unique vulnerability thresholds established for that facility for earthquakes greater than magnitude 4.0. Within 10 minutes of the event, ShakeCast sends a list of facilities sorted by inspection priority to the designated Caltrans responders.

As technology continues to evolve, it's important to keep ShakeCast current and expand its features to deliver improved and tailored bridge, building, and roadway status information to emergency responders.



New ShakeCast V3 web interface

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Enhancing ShakeCast to Improve Post-Earthquake Response

WHAT WAS OUR GOAL?

The goal was to develop an enhanced version of ShakeCast to accommodate a broader range of facility types and disseminate more informative and accurate messages to Caltrans responders.

WHAT DID WE DO?

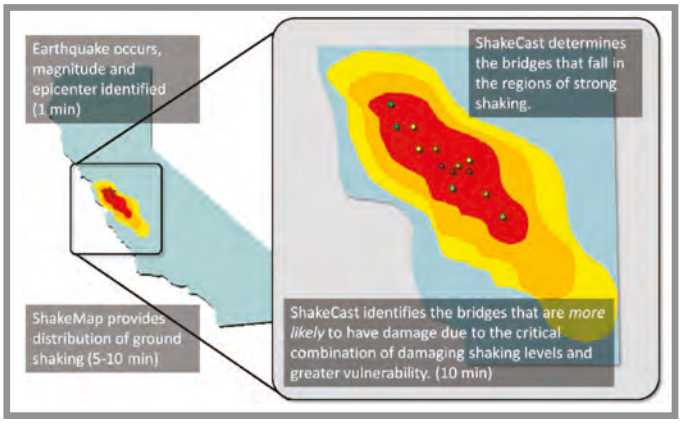
Caltrans, in partnership with USGS, enhanced ShakeCast to meet transportation-focused needs. The requirements included:

- Full statistical interpretation of facility fragility models in analysis and reporting
- Component-based fragility analysis framework
- Information regarding landslide and liquefaction hazards
- Analysis of multiple facility types on a single system
- More accurate representation and analysis of facilities in maps as multidimensional objects rather than just points

During development, the team tested about 13,000 state bridges, 12,900 local bridges, 380 maintenance buildings, and numerous landslide prone roadway corridors.

WHAT WAS THE OUTCOME?

ShakeCast v3 is more robust and expands the scope of situational awareness by assessing more types of facilities, implementing more rigorous vulnerability functions, and enhancing the delivery of information and products through a revised web application interface.



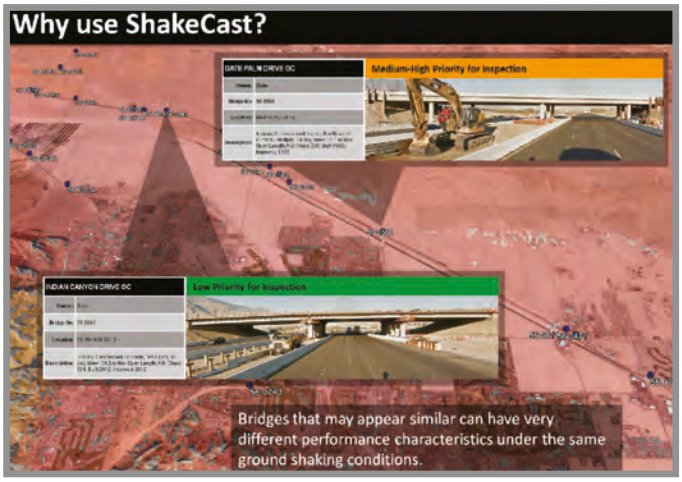
Sequence of ShakeCast analysis steps

WHAT IS THE BENEFIT?

By focusing inspection efforts on the most damage-susceptible infrastructure, ShakeCast v3 helps Caltrans responders make informed decisions and take quick action to ensure safety, restore system functionality, and minimize losses. This awareness improves communication within Caltrans and between agencies. A faster, better coordinated, and more effective emergency response helps save lives and facilitate a rapid restoration of network functionality and traveler mobility. Other public service organizations, such as the Los Angeles Unified School District and BART, have also learned from and adopted ShakeCast products piloted under Caltrans's initiative.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2014/final_report_task_1793.pdf



ShakeCast identifies bridges within zones of strong shaking that are more likely to have sustained damage.

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Research Results

Seismic

Designing Concrete-Filled Tube Column-to-Cap Connections

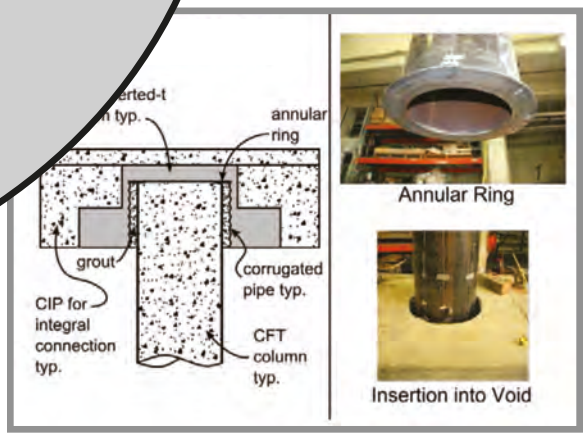
New column connections facilitate accelerated bridge construction in high seismic locations

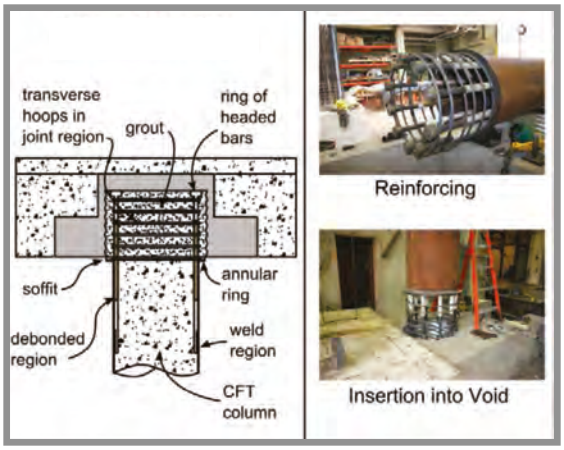
WHAT WAS THE NEED?

Concrete-filled tubes (CFT) are composite structural elements that provide strength and stiffness. The steel tube serves as formwork and reinforcement to the concrete fill, negating the need for reinforcing cages, elaborate shoring, and temporary formwork. CFTs are an efficient alternative to conventional reinforced-concrete construction, facilitating accelerated bridge construction (ABC) and reducing material and labor costs. Despite their structural advantages, the use of CFTs has been limited in seismic regions due a lack of practical connection details, large-scale testing, and design equations.

WHAT WAS OUR GOAL?

The goal was to develop CFT column-to-cap beam connections capable of sustaining cyclic, nonlinear deformation demands while minimizing damage and degradation to facilitate ABC in seismic regions.





Proposed connection types

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Designing Concrete-Filled Tube Column-to-Cap Connections

Research Results

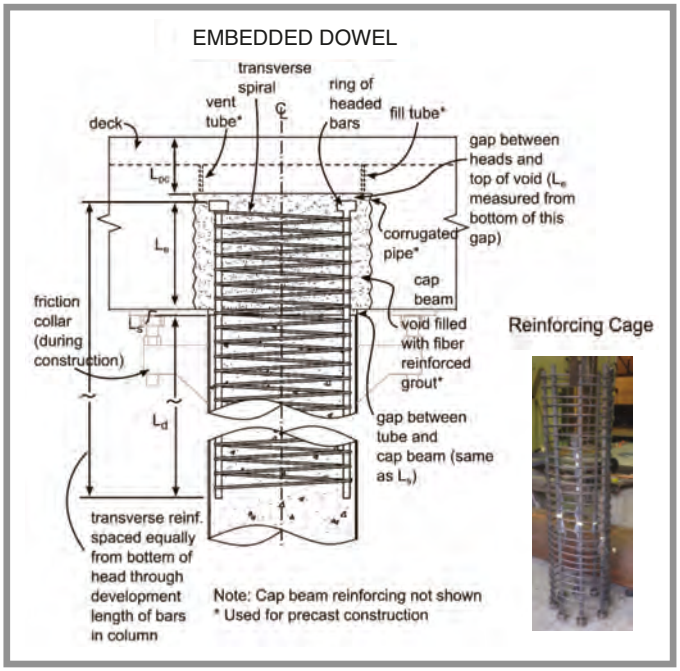
WHAT DID WE DO?

Caltrans, in partnership with the University of Washington Department of Civil and Environment Engineering, tested new CFT column-to-cap beam connections using a monotonically increasing cyclic loading protocol. The three proposed connection types included embedded CFT, welded dowel, and embedded dowel. For the facilitation of ABC, all connection types used a grouted detail with a single void cast into a precast beam.

For the embedded CFT connection, an annular flange was welded to the top of the steel tube to provide anchorage and transfer stress to the concrete and reinforcing in the cap beam. The CFT component controls the strength and ductility.

The welded dowel connection used a series of vertical-headed reinforcing bars welded to the inside of the tube and developed into the cap beam. The reinforcement ratio of the longitudinal bars, which extend from the column into the cap beam, controls the strength while the confinement controls the ductility.

The embedded dowel connection consisted of a more traditional reinforced concrete dowel connection, with both transverse and longitudinal reinforcing extended from the CFT column into the cap beam as a short inner cage. The reinforcing ratio and moment arm of the longitudinal reinforcing controlled the strength, and local confinement controlled the ductility. Construction of this connection would require a friction collar to temporarily support the cap beam.



WHAT WAS THE OUTCOME?

All specimens exhibited sufficient strength and ductility while limiting damage to the cap beam for both the longitudinal and transverse directions. The overall behavior emulated cast-in-place construction. Some damage states and failure modes observed during testing include the following.

Embedded CFT connection—Tube buckling observed at 3.5% drift, but no strength degradation. Tube tearing initiated at 7.5%. The test was stopped at 9% drift as tube tearing propagated around the base of the column. Traditional columns typically achieve 8% to 10% drift in such tests.

Welded dowel connection—The specimen was tested cyclically to 9% drift with no strength degradation or bar buckling. A monotonic push was conducted to 12% drift with no influence on strength. Very limited cap beam damage observed.

Embedded dowel connection—The specimen was cycled to 8.75% drift with no strength degradation. At 9% drift, reinforcing bars at the extreme fibers fractured. The remainder of the reinforcing bars fractured in subsequent cycles. The test was stopped at 12% drift. Very limited cap beam damage observed.

WHAT IS THE BENEFIT?

CFTs are not widely used in bridge construction in the United States because of the lack of practical, economical, and standardized seismic connection details with design procedures. The experimental results from this research were used to develop a preliminary design equation in AASHTO LRFD format for CFT column-to-cap connections that perform well under seismic conditions. Using these prefabricated bridge elements can expedite construction, decrease overall costs, and minimize the impact on traffic.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA15-2417_FinalReport.pdf

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Research Results

Designing Cap Connections for Precast Girders

New girder-to-cap connections perform well under seismic conditions, facilitating accelerated bridge construction

Seismic

JANUARY 2016

Project Title:
Seismic Performance of Connections that Facilitate Accelerated Bridge Construction

Task Number: 2265

Start Date: October 1, 2010

Completion Date: May 31, 2015

Product Category: New or improved technical standard, plan, or specification

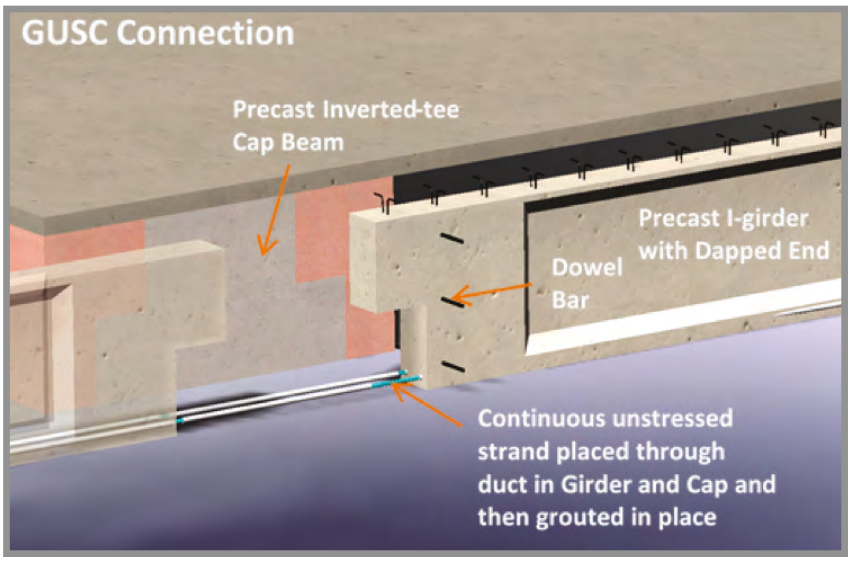
Task Manager:
Charles Sikorsky
Research Program Manager
charles.sikorsky@dot.ca.gov

WHAT WAS THE NEED?

One of the most common ways to incorporate accelerated bridge construction (ABC) methods is to use prefabricated elements. However, precast concrete connections to bent caps have at times experienced post-elastic damage when subjected to earthquake loading, largely due to the connections to the girders. To take advantage of the cost- and time-saving benefits of ABC methods in seismic regions, reliable connection details for precast concrete members must be developed.

WHAT WAS OUR GOAL?

The goal was to investigate the seismic response and overall moment capacity of a variety of precast concrete girder-to-cap connections for accelerated bridge construction in high seismic regions.



Grouted unstressed strand connection

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WHAT DID WE DO?

Caltrans, in partnership with Iowa State University, investigated connections for dapped-end I-shaped precast girders to inverted-tee cap beams and connections for precast bulb-tee girders to rectangular cap beams. The researchers evaluated six different girder-to-cap connection details. The team researched a grouted unstressed strand connection (GUSC) and a looped unstressed strand connection (LUSC) for joint regions between dapped-end I-shaped girders with end blocks and precast inverted-tee beams using a 50% scale test unit. The other four options, an extended strand bent with free end (ESBF), end platen (ESSP), extended strand lapped splice (ESLS), and extended strand mechanical splice (ESMS), were tested for connections between bulb tee girders with no end blocks and rectangular cast-in-place cap beams, using 40% scale test units. In addition to the gravity load effects, the researchers subjected the test units to simulated horizontal and vertical seismic action to verify positive and negative moment resistance along with vertical shear resistance at the girder-to-cap beam interface.

WHAT WAS THE OUTCOME?

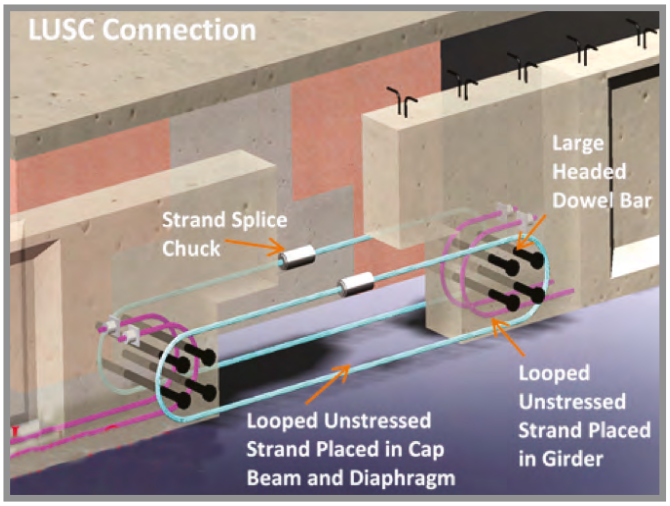
All the connection details demonstrated elastic super-structure behavior at shear and moment demands beyond the expected column plastic hinging when subjected to horizontal and 0.5g vertical seismic loadings. The successful response confirmed that the proposed details are viable, structurally sufficient ways to implement precast I-girders and bulb-tee girders in high seismic regions. If the precast I-girder or bulb-tee girder does not include an end block or dapped end at the girder-to-cap interface, additional cap beam or diaphragm stirrups need to be detailed to fit alongside the girder web and between the top and bottom girder flanges at the connection interface to prevent spalling. Because the shear friction generated by the dowel bars in the diaphragm is a critical part of the positive moment transfer mechanism, similar proportions as used in this project are recommended for the dowel bar locations in all girder-to-cap connections.

WHAT IS THE BENEFIT?

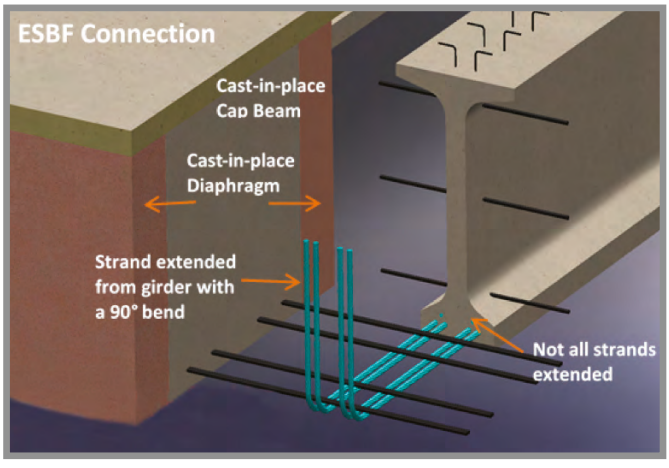
All the tested connection details provided seismically adequate integral connections, with each approach presenting different advantages and disadvantages. Having multiple options for precast girder-to-cap beam connections enables California designers to better implement ABC methods. Using unstressed portions of prestressing strands in the connection design, particularly those extended from prestressed girders, reduces costs and improves construction flexibility. The large-scale experimental validations confirmed that the connections can withstand seismic motion, eliminating the need for designing columns with more costly fixed supports at their base when using precast girders.

LEARN MORE

For more information about the project:
http://sri.cce.iastate.edu/abc-seismic



Looped unstressed strand connection



Extended strand bent with free end connection

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Research Results

Optimizing Bent Cap Capacity Design

Better calculations for bent cap strength can reduce reinforcement costs and improve seismic performance

Seismic

JANUARY 2016

Project Title:
Structural Behavior of Column-Bent Cap Beam-Box Girder Systems in Reinforced Concrete Bridges Subjected to Gravity and Seismic Loads

Task Number: 2171

Start Date: June 29, 2011

Completion Date: June 15, 2015

Product Category: New technical standard and specification

Task Manager:
Peter Lee
Research Contract Manager
PLee@dot.ca.gov

WHAT WAS THE NEED?

For seismic bridge design, according to the capacity design philosophy, all damage during extreme events is directed to the bridge columns, which are designed to be ductile to prevent brittle modes of failure and overall collapse. On the other hand, the bridge superstructure, joints, and bent cap beams, designated as capacity-protected members, are designed to remain elastic when the columns reach their over-strength capacity. Applying this capacity design philosophy requires calculating the moment capacity of the superstructure components, such as the bent cap beams. Determining integral bent cap beam capacity is difficult in reinforced-concrete, box-girder bridges because the box-girder soffit and deck slabs contribute to the cap beam capacity that results in a flanged bent cap beam section. Obtaining a reliable estimate provides two benefits: The possibility to reduce reinforcement in the cap beam for seismic capacity and reduce damage to the superstructure component by increasing the effectiveness and reliability of the column retrofit. In addition, box-girder soffit and deck slabs contribute to the integral cap beam capacity of stiffness. An accurate bent cap stiffness determination, as contributed by the box girders, is essential for status quo bridge modeling, which uses line elements for the bridge components. The current Caltrans Seismic Design Criteria need to be evaluated to determine reliable calculations for bent cap beam capacity and stiffness in terms of the effectiveness of bridge analysis, evaluation, design, repair, and retrofitting.

WHAT WAS OUR GOAL?

The goal was to investigate the behavior of bridge column-superstructure systems to recommend the capacity of the integral cap beams in reinforced-concrete box-girder bridges.

Cap beam, box-girder, column subassembly before bidirectional cyclic tests (left). Identical column repaired using a rapid carbon-fiber-reinforced polymer method during testing (right).

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Optimizing Bent Cap Capacity Design

WHAT DID WE DO?

Caltrans performed a bidirectional cyclic test on a one-quartered-scaled model of the cap beam, box-girder, column subassembly, designed according to the Caltrans Seismic Design Criteria provisions to verify the capacity design approach. The plastic hinge in the subassembly column failed, but the bent cap beam and superstructure remained elastic. The researchers investigated the effectiveness of repairing the damaged column using a rapid carbon-fiber–reinforced polymer (CFRP) method, which was successful in partially restoring the subassembly capacity and increasing the stiffness of the damaged subassembly in transverse and longitudinal directions. The researchers then retrofitted the column of an identical subassembly with CFRP repair to try to migrate the damage from the column to the bent cap beam, quantify the box-girder contribution to the bent cap beam capacity, and evaluate the effectiveness of a CFRP retrofit. The team created a 3D finite element model and calibrated the model using the test results. This finite element model was used to explore the effect of reducing the bent cap reinforcement on overall system behavior and to investigate the box-girder contribution at higher levels of bent cap demands.

WHAT WAS THE OUTCOME?

Some of the findings produced by this research include:

- The 12 x slab thickness (t_s) code value for the integral bent cap effective slab width in the bridge transverse direction is unnecessarily conservative. Instead, a value of 18 t_s is recommended for the box-girder soffit and deck slab contributions to the integral bent cap stiffness and strength.
- Transverse deck and soffit slab tension reinforcement within the revised effective slab width should be included in the bent cap capacity estimation.
- The bridge dead and live (traffic) loads typically govern the bent cap beam load and resistance factor design. Any additional reinforcement required for seismic design is added to increase the bent cap beam capacity to ensure that it is larger than 1.2 times the column capacity. The box-girder slab contribution must be accurately considered to avoid unnecessary use of bent cap reinforcement.
- An accurate bent cap capacity estimate should be an integral part of the repair and retrofit designs for resilient infrastructure to avoid undesirable failure modes, leading to prolonged downtime and uneconomical post-event repair in extreme earthquake events. An accurate estimate is particularly critical for older bridges that were not designed using the strong-beam weak-column capacity approach.

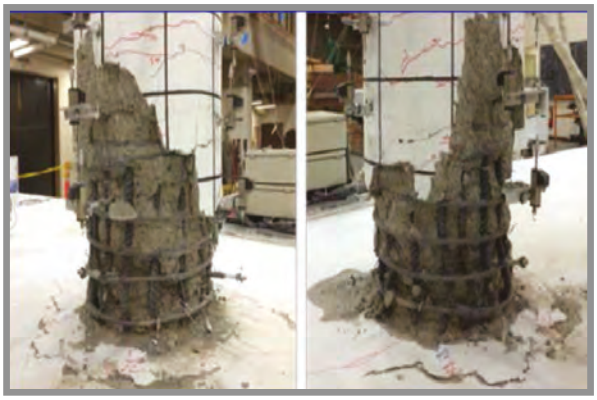
WHAT IS THE BENEFIT?

Based on the updated estimate of the integral bent cap beam effective slab width, structural and bridge engineers can reduce bent cap beam reinforcement needed to withstand a seismic event, leading to savings in construction costs. The updated parameters enable structural engineers to better identify the flanged section and compute the capacity and stiffness of the line elements that represent the bent cap beams in their analytical models.

LEARN MORE

To view the complete reports:
http://www.dot.ca.gov/research/researchreports/reports/2015/CA16-2171A_FinalReport.pdf

http://www.dot.ca.gov/research/researchreports/reports/2015/CA16-2171B_FinalReport.pdf



Column damage after cyclic tests

Cap beam concrete crushing and column flexural cracks (CFRP jacket removed) after hybrid simulation tests

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Research Results

Crash Attenuator Life-Cycle Costs

Collecting data to assess the long-term cost-effectiveness of different attenuators

Transportation Safety and Mobility

JANUARY 2016

Project Title:
Crash Attenuator Data Collection and Life-Cycle Tool Development

Task Number: 2206

Start Date: July 1, 2010

Completion Date: December 31, 2014

Product Category: Processed data or database

Task Manager:
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Transportation Engineer
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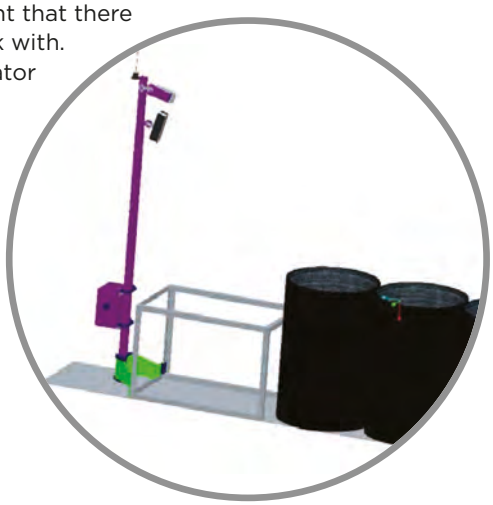
WHAT WAS THE NEED?

Crash attenuators prevent motorists from colliding with hazards in or near the roadway by encouraging drivers to decelerate or redirect the vehicle, reducing the risk to the occupants and other nearby vehicles. Crash attenuators offer different levels of performance and have a wide range of costs. Attenuators are designed to be hit, so repairs or removal must be considered as part of the overall cost. Repair costs fluctuate greatly based on the type of impact, the parts needed, and how accessible the location is. A cost is also associated with the need to control or limit traffic to complete the work. A new class of attenuators that are easier to reset in place cost more upfront, but are less expensive to maintain. The cost-benefit of these class attenuators is often overlooked because the focus is on the initial expense rather than long-term upkeep.

A better understanding of the life-cycle costs will help Caltrans determine the least expensive option over a period of time, reducing overall costs. This study was a continuation of the project *Crash Attenuator Usage Along Travelways and in Work Zones* during which a methodology was developed to appraise the annual maintenance costs based on the attenuator location, including labor, parts, and traffic control during repair. The software tool CAL-Cost was developed to populate life-cycle costs using existing data from Caltrans maintenance databases and district records. The severity of damage to an attenuator during a crash facilitates better understanding of long-term costs. However, it became apparent that there was a lack of existing data to work with. A strategy to collect crash attenuator data to develop a database was needed.

WHAT WAS OUR GOAL?

The goal was to devise a strategy to collect data from existing crash attenuators to develop a database to better determine life-cycle costs.



Video data collection system

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Advanced Highway Maintenance and Construction Technology Research Center, configured a video camera system that was capable of recording crash attenuator activity. When the attenuator was hit, an installed accelerometer triggered the video camera to record. The data was automatically uploaded via a cellular modem and later analyzed. After meeting with a few districts and evaluating site locations, the researchers selected three crash attenuators to monitor as a test.

WHAT WAS THE OUTCOME?

The collected video data supplemented existing impact and repair data from the Caltrans maintenance database, which combined helped to populate the CAL-Cost decision-support tool. Engineers can evaluate different crash attenuator products per a specific site in terms of their life-cycle costs.

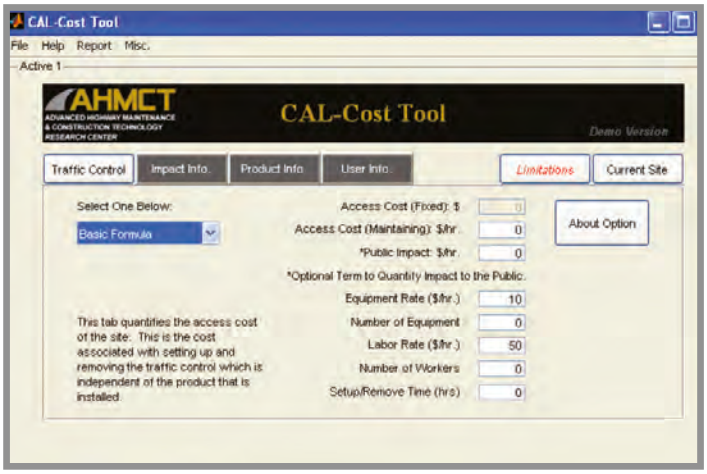
Video camera view

WHAT IS THE BENEFIT?

Because crash attenuators are designed to be hit, their in-service costs need be taken into consideration, in addition to their initial cost. Calculating the life-cycle cost of an attenuator prior to purchase can result in long-term cost savings. This data aids engineers in selecting the most cost-effective crash attenuator per location based on long-term costs, including traffic control, maintenance, and replacement parts.

LEARN MORE

To view the complete report:
http://ahmct.ucdavis.edu/pdf/UCD-ARR-14-06-14-05.pdf



CAL-Cost helps engineers evaluate the life-cycle costs of crash attenuator products for a specific site.

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Research Results

Improving Clearance Time for Major Traffic Incidents

Implementing appropriate traffic incident management tools and strategies can shorten response time

Transportation Safety and Mobility

JANUARY 2016

Project Title:
Quick Clearance for Major Traffic Incidents

Task Number: 2245

Start Date: September 1, 2010

Completion Date: December 31, 2014

Product Category: New or improved business practice, procedure, or process

Task Manager:
Melissa Clark
Transportation Engineer, Electrical
melissa.clark@dot.ca.gov

WHAT WAS THE NEED?

After a major traffic incident, quick response and clearance are important for the safety of those involved and to minimize the resulting congestion. Prompt medical care, efficient removal of damaged vehicles, and rapidly addressing potential hazardous materials or unsafe conditions requires coordination and shared protocols. Major incidents—those that need more than 30 minutes to clear—are the largest contributor to congestion after capacity constraints. In addition, secondary incidents caused by unsuspecting approaching motorists can increase both the number and severity of injuries. For these reasons, the Federal Highway Administration has established a 90-minute clearance time. In California, however, the average clearance time is over three hours. It is critical to investigate the causes of the extended clearance times to propose appropriate solutions for traffic incident management (TIM).

WHAT WAS OUR GOAL?

The goal was to identify and implement strategies to reduce the clearance time of major incidents.

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Improving Clearance Time for Major Traffic Incidents

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology program, examined TIM operations throughout the state, distinguishing the differences in managing safe and quick incident clearance activities among rural and urban districts and differing geographical regions. Based on input and data collected from Caltrans, California Highway Patrol, and other stakeholders, the researchers identified sources of delay and recommended appropriate TIM tools and strategies shown to be successful in reducing incident clearance times.

WHAT WAS THE OUTCOME?

The study pinpointed various causes for prolonged clearance times, some connected to working with other agencies and contractors. Hazardous material spills and damage to utilities can add many hours to the clearance time due to the delayed response from hazmat specialists or the utility company. Recent changes in Caltrans policy of limiting employees storing maintenance equipment and vehicles at home also have resulted in delayed response because of the added travel time to pick up equipment from the Caltrans location before responding to an incident. Response times differ between rural and urban areas. Each district has considerations to take into account, such as the time needed to drive distances in sparsely populated regions or divert traffic during peak travel times. The research initiated recommendations to improve TIM practices and communication among responders and proposed holding regularly scheduled meetings and workshops to review ongoing problems and keep responders up to date on best practices.

Date	County	Route	Duration	Causes
3/7/2012	Kern	5	17:29	Big rig brake fire, hauling HAZMAT
11/29/2011	Kern	5	15:16	Jack-knife big rig on off-ramp
4/25/2011	Kern	58	14:06	Car vs. Big Rig head on collision, fatalities
2/24/2011	Tulare	65	12:58	Transformer falls into roadway
7/12/2011	Kern	119	12:20	Power line pole falls onto roadway
8/27/2011	Kern	119	11:39	Power lines fall onto roadway
3/29/2011	Kern	5	11:05	Big rig on fire carrying HAZMAT
4/8/2011	Tulare	99	10:47	Big rig crashes in work zone loses cargo
6/15/2011	Kern	178	10:27	Ruptured gas line in work zone
7/17/2011	Fresno	99	10:14	Police pursuit results in pedestrian fatality

Sample qualitative examination of the 10 worst incidents in Caltrans District 6

WHAT IS THE BENEFIT?

Adopting a comprehensive incident clearance program that incorporates appropriate operational procedures, addresses the issues of equipment and infrastructure, and establishes laws and policies enhances the safety of responders and motorists while reducing incident-related congestion and delay. Decreasing the major incident clearance times statewide increases reliability throughout the transportation system.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2014/final_report_task_2245.pdf

District	Average	Median 50th Percentile	95th Percentile	Standard Deviation	Number of Samples
3	3:23	2:12	9:12	3:41	178
4	3:19	1:43	12:56	4:04	145
6	4:39	3:41	10:58	3:12	128

Overall incident duration in hours and minutes of major incidents per Caltrans district

Responding to major incidents can require extra equipment and waiting for specialists.

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Improving Safety Detection Methods to Identify High-Collision Locations

Expanding the conventional safety performance functions for roadway segments, intersections, and ramps more accurately identifies sites with safety problems to prioritize improvements

Transportation Safety and Mobility

FEBRUARY 2016

Project Title:
Methods for Identifying High Collision Concentrations for Identifying Potential Safety Improvements

Task Number: 2317

Start Date: February 1, 2013

Completion Date: January 31, 2015

Product Category: New or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
Jerry Kwong
Project Engineer
jerry.kwong@dot.ca.gov

WHAT WAS THE NEED?

Identifying sites that require safety improvements must be accurate, otherwise scarce resources are wasted on sites incorrectly classified as high-collision areas, while locations that would benefit from safety improvements might not be flagged. Collisions alone are not adequate predictors of safety risk areas. Other factors, such as facility type, roadway geometry, and traffic volumes, play important roles in determining if a location has a safety problem. These factors need to be incorporated into safety performance equations to help Caltrans assess its entire network and spend on improvements efficiently and effectively.

WHAT WAS OUR GOAL?

The goal was to develop safety performance functions for roadway segments, intersections, and ramps to improve the method of detecting high-collision concentration locations.

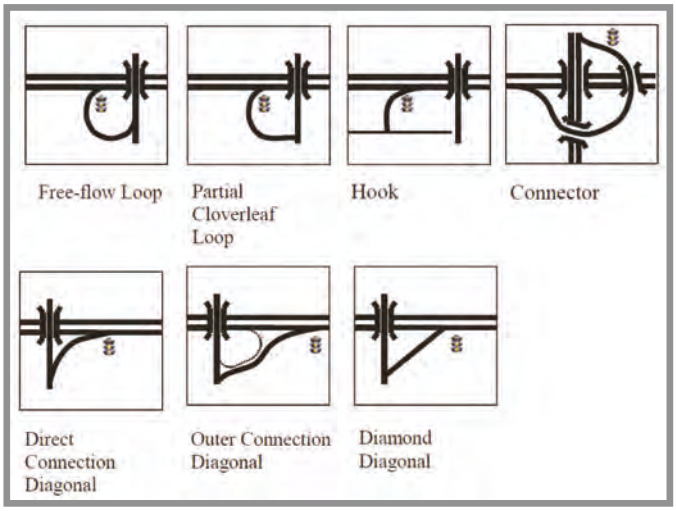
Caltrans provides a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability.

Improving Safety Detection Methods to Identify High-Collision Locations

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Institute of Transportation Studies, developed safety performance functions (SPF) for roadway segments, intersections, and ramps on the entire Caltrans network using historical crash and geometric data from 2005–10. To develop the SPFs, the state network was scanned for complete geometric and traffic volume data. Over 13,000 centerline miles of road segments, 17,000 intersections, and the entire ramp system with metered subsets were evaluated. The researchers devised two statistical models. Type 1 SPFs use the length of the roadway segment and the average daily traffic as predictors. The type 2 equation addresses roadway geometrics in addition to traffic volume, and in the case of intersections, includes a traffic control parameter. For ramps, the type 2 SPFs incorporate variables for metering, HOV lanes, and the ramp configuration. The SPFs also consider the severity of the incident, such as property damage only, complaint of pain, visible injury, severe injury, and fatality. The researchers conducted model transferability tests to evaluate parameter stability across years.



Ramp metering system configuration types

WHAT WAS THE OUTCOME?

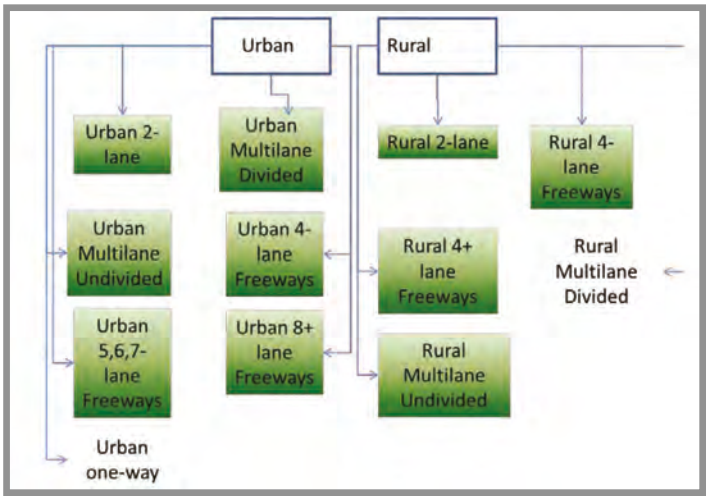
The project developed 60 type 1 SPFs for roadway segments and 60 type 2 SPFs for the five major severity outcomes. For the network's 17,000 intersections, the researchers developed 12 type 1 and type 2 SPFs, and another 12 SPFs for the ramp system. When comparing the type 1 and type 2 SPFs for predictive effectiveness, the research found that the type 2 SPFs provided better measures.

WHAT IS THE BENEFIT?

Safety performance equations are used to identify locations with a high concentration of incidents and dictate how Caltrans allocates funding for safety improvements. To avoid spending money on locations that are not dangerous (false positives) and to ensure that money is spent on locations that would benefit from the investment in safety improvements (false negatives) requires improving the accuracy of SPFs by incorporating site-specific factors beyond just the number of collisions. Caltrans can use the SPFs developed, which provide more predictive capabilities, to prioritize safety improvements and more efficiently target high-collision concentration locations.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA15-2317_FinalReport.pdf



Type 1 and type 2 SPF modeling architecture

DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Enhancing IRIS Transportation Management Software

IRIS provides an alternative, low-cost, integrated advanced traffic management system for rural districts

Transportation Safety and Mobility

JANUARY 2016

Project Title:
Enhancement and Technical Support of Intelligent Roadway Information System (IRIS) in Caltrans Districts 1, 2, 5 and 10

Task Number: 2293

Start Date: June 1, 2011

Completion Date: December 31, 2014

Product Category: New or improved tool or equipment

Task Manager:
Melissa Clark
Transportation Engineer, Electrical
melissa.clark@dot.ca.gov

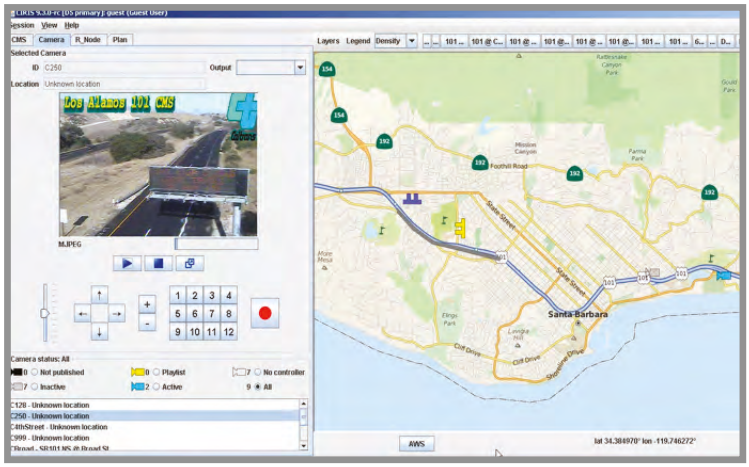
WHAT WAS THE NEED?

An advanced traffic management system (ATMS) provides real-time information on highway conditions to detect traffic incidents, manage traffic flow, and disseminate traveler information, helping traffic managers improve mobility and safety. However, most ATMS programs are not well suited for rural districts in terms of features, functionality, and cost. As a result, rural areas often address their needs by combining disparate solutions that have different management, administrative, and operating requirements, which can be expensive and challenging to maintain. Rural districts need a unified ATMS that is specifically designed for a rural environment.

The Minnesota Department of Transportation (MnDOT) developed the open-source Intelligent Roadway Information System (IRIS) software and made it freely available in 2007, making it easier and more affordable to tailor a unified ATMS for rural districts. As an initial test, Caltrans successfully deployed IRIS in Stockton, Caltrans District 10. A pilot with limited ATMS features was also tested in Districts 1, 2, and 5. To continue the success and adoption of IRIS, more functionality needed to be added.

WHAT WAS OUR GOAL?

The goal was to enhance IRIS features and functionality and expand its use to other rural districts.



Controllable closed-circuit TV (CCTV) camera within IRIS alongside a display of Intelligent Transportation System elements on an integrated map

Caltrans

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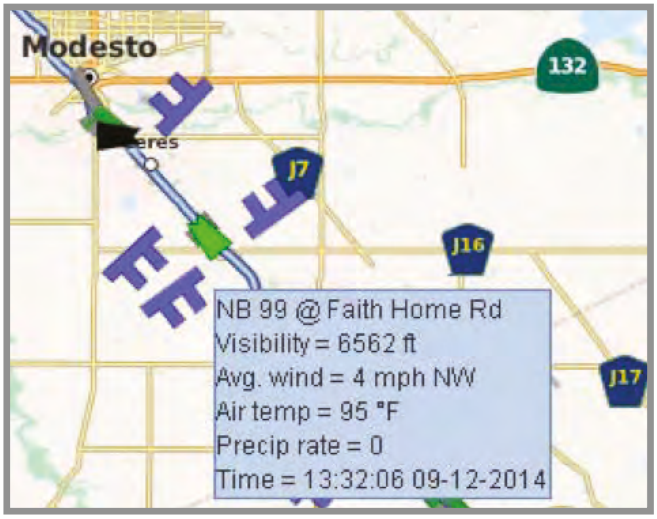
WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Advanced Highway Maintenance and Construction Technology Research Center and MnDOT, incorporated more features to IRIS and streamlined the build and deploy process. As part of the open-source effort, some of the features now available to partnering agencies include:

- Device drivers
- Automated warning system
- Testing
- CMS message library
- Google Earth output using the Keyhole Markup Language
- Road weather information system map integration
- CCTV features
- Reporting enhancements

WHAT WAS THE OUTCOME?

Deployment of IRIS to Caltrans Districts 1, 2, 5, and 10 was successful. The number of traffic management software applications and servers in the four districts has been reduced, with IRIS assuming the roles. The improved and simplified build and deploy process facilitates adoption and makes it easier to train new developers. Through knowledge transfer from the research team, supporting IRIS has transitioned to a third-party contractor. Caltrans District 3 is expected to be the next district to implement part of the IRIS system.



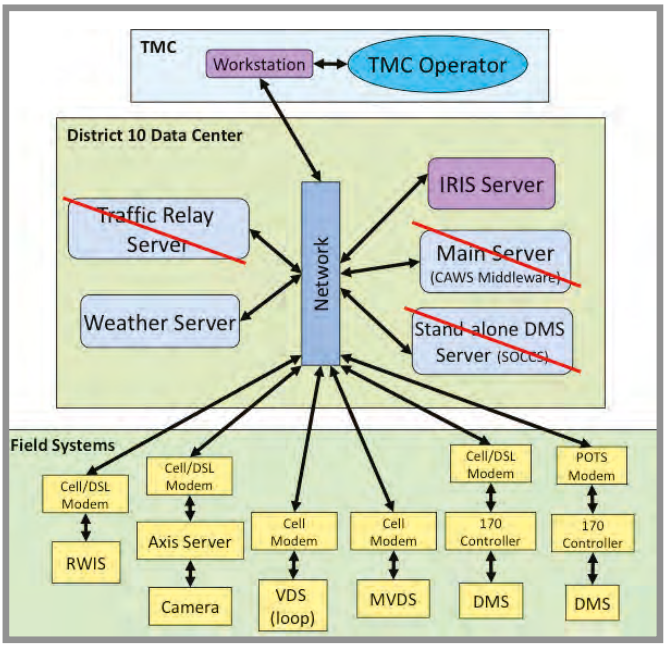
Automated warning system that includes a road weather information system and warning thresholds

WHAT IS THE BENEFIT?

Rural areas need a unified ATMS that is designed for their traffic requirements and environment. IRIS offers rural districts a robust, unified, traffic management program that is extensible, scalable, and reliable. Traffic management operators can centrally manage traffic devices and applications from a single, integrated interface at a fraction of the cost of a full ATMS running in urban areas. The open-source software enables collaboration among government agencies, universities, and private companies, and reduces life-cycle costs by approximately 72%, as compared to the previous ATMS.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2014/final_report_task_2293.pdf



Caltrans District 10 architecture before and after IRIS was deployed

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Research Results

Integrated Traffic Management for the San Diego County I-15 Corridor

ICM strategies optimize the movement of people and goods

Transportation Safety and Mobility

JANUARY 2016

Project Title:
San Diego Integrated Corridor Management (ICM), Phase 3 Demonstration and Evaluation

Task Number: 2165

Start Date: August 4, 2010

Completion Date: June 30, 2015

Product Category: New or improved decision support tool, simulation, model, or algorithm (software); new or improved business practice, procedure, process

Task Manager:
Jose Perez
Transportation Engineer, Electrical
jose.perez@dot.ca.gov

WHAT WAS THE NEED?

Traffic congestion is a serious and growing problem, particularly in major metropolitan areas. Much of the congestion is in critical metropolitan corridors that link activity centers and carry high volumes of people and goods. The current practice in corridor management is fragmented because different agencies are responsible for freeways, surface streets, and transit systems. Efforts to reduce congestion have generally focused on individual networks, with little or no operational or institutional coordination among them. The availability of intelligent transportation systems technologies and a commitment of transportation network partners to work together now make it possible to transform the way corridors are operated and managed. Integrated Corridor Management (ICM) strategies use cutting-edge technology to operate and manage individual transportation systems as a unified network, proactively managing congestion and improving mobility along major transportation corridors.

WHAT WAS OUR GOAL?

The goal was to improve the movement of people and goods through corridors by developing a unified traffic management system that integrates the operations of the individual transportation networks and optimizes the corridor transportation system as a whole.

ICM project area along a 20-mile stretch of the I-15 corridor

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WHAT DID WE DO?

Caltrans, in partnership with the University of California Partners for Advanced Transportation Technology program, worked with the San Diego Association of Governments (SANDAG) to provide technical management, software and systems development, and expertise on transportation technology innovations and applications to foster the successful design, development, implementation, and evaluation of the ICM system for the I-15 corridor. The project covers a 20-mile section of I-15 north of SR 52 in San Diego to SR 78 in Escondido, including major arterial routes a few miles east and west of I-15 and the transit agencies that operate within the corridor. This third stage of this multi-phased project sponsored by the federal Integrated Corridor Management Initiative involved demonstrating and evaluating the I-15 ICM system. The I-15 ICM system applies predictive algorithms and real-time modeling tools to forecast traffic across multiple networks and recommend response plans to manage anticipated congestion.

WHAT WAS THE OUTCOME?

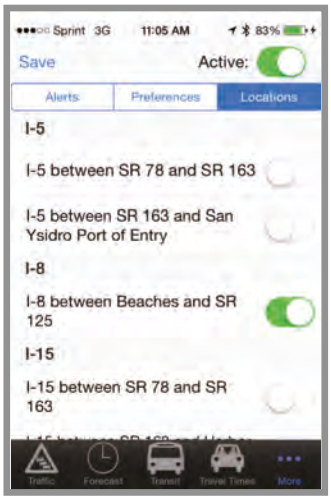
The I-15 ICM system can identify incidents and unusual congestion events to develop traffic management strategies that integrate freeway, arterial, and transit operational elements. For example, the ICM system coordinates the use of freeway ramp meters and arterial traffic signals to improve day-to-day conditions or to route traffic around major incidents. It can implement recommended strategies automatically or following approval by the relevant system operators. The system has also demonstrated the feasibility of using a microscopic traffic simulation model in a real-time operational environment to forecast corridor operations under alternative scenarios.

WHAT IS THE BENEFIT?

With ICM, metropolitan areas can achieve more efficient movement of people and goods along transportation corridors by taking advantage of technological advances and promoting multi-agency and multimodal coordination. The deployment of the I-15 ICM system demonstrates that corridor performance can be improved using existing capacity by mitigating congestion using real-time response and control.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA15-2165_FinalReport.pdf



Users can get alerts for specific locations with the free 511 San Diego mobile application and view traffic in real time.

The mobile app provides estimated travel times and traffic flow.

DRISI

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Research Results

Collecting Work Zone Injury Data

Information on the cause of incidents facilitates planning safer work zone operations

Transportation Safety and Mobility

JANUARY 2016

Project Title:
Work Zone Injury Data Collection and Analysis

Task Number: 2257

Start Date: August 4, 2011

Completion Date: June 30, 2015

Product Category: Processed data or database; new or improved decision support tool, simulation, model, or algorithm (software)

Task Manager:
Hamid Ikram
Transportation Engineer
hamid_ikram@dot.ca.gov

WHAT WAS THE NEED?

Work zone–related injuries and fatalities are a major safety concern in California and nationwide. According to the Federal Highway Administration, one work zone–related injury occurs every 14 minutes, and one fatality occurs every 15 hours, resulting in an average of 96 injuries and 1.6 fatalities per day. Work zone accidents and injuries have a high cost, including medical fees, loss of life, property damage, lost earnings, travel delay, vocational rehabilitation, administrative costs, legal fees, pain, and diminished quality of life. Based on five years of data for California, the average yearly cost of all work zone incidents is approximately $382 million.

Various ideas to prevent work zone incidents have been considered, such as keeping workers in vehicles, changing driver behavior with publicity campaigns, using more full road closures, or working at night when traffic is reduced. But data to justify a particular mitigation measure is unavailable. Although databases and data sources exist, such as the Statewide Integrated Traffic Records Systems (SWITRS) based on California Highway Patrol crash reports and the Caltrans Traffic Accident Surveillance and Analysis System (TASAS), they report only locations and outcomes, not causes. To address the causes, more information is needed about the incidents, the severity of the injuries, contributing factors, and resulting property damage. In addition, methods to estimate the associated costs and remedies can be useful.

WHAT WAS OUR GOAL?

The goal was to create a comprehensive database of work zone incidents to better analyze the nature and causes and facilitate safer work zone planning.

The Work Zone Injury Database contains detailed information from traffic collision reports.

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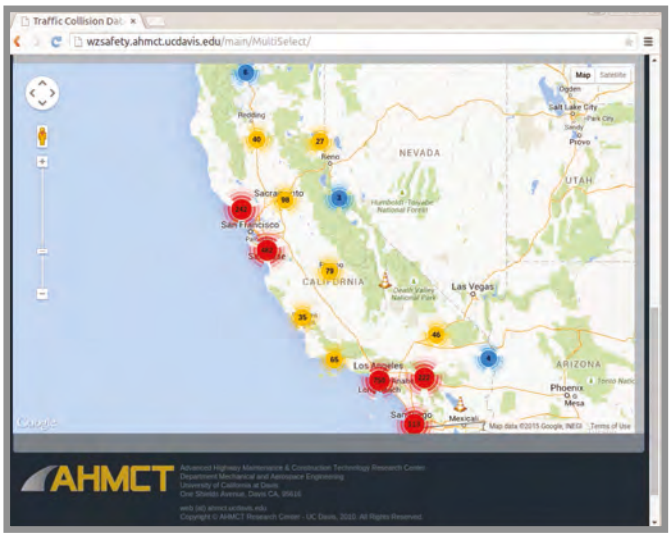
WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center, extracted and classified traffic collision report data on incidents occurring near work zones from 12 Caltrans districts between 2006 and 2010. The researchers codified the report information in terms of contributing factors and outcomes, designed to allow analysis of the data for planning and managing work zone operations to improve worker and motorist safety.

WHAT WAS THE OUTCOME?

The comprehensive database based on five years of data includes the information needed to develop mitigation measures. It provides answers on what kind of incidents occur in work zones and the cause. Can some injuries and fatalities be avoided by using a barrier system, and if so, how and where?



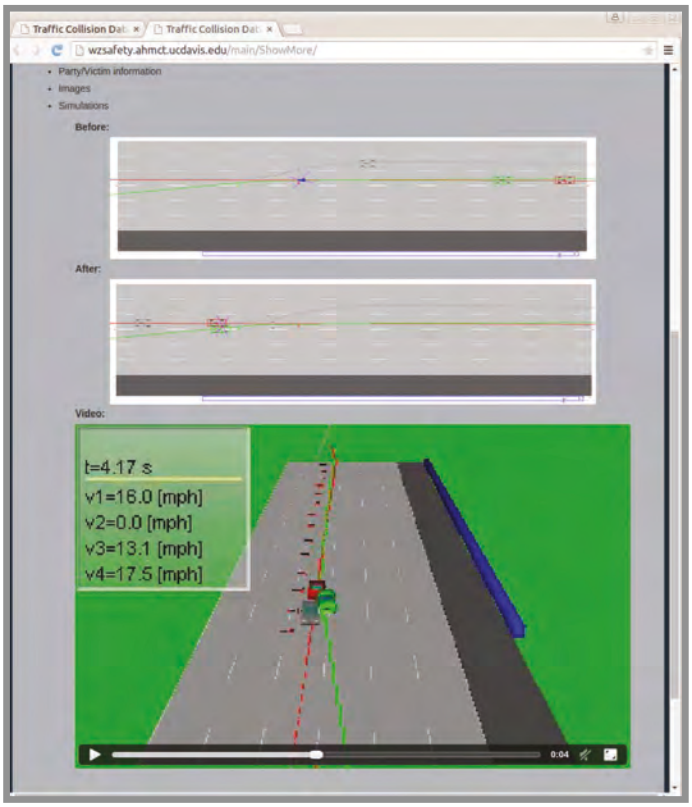
Mapping searched reports to accident locations

WHAT IS THE BENEFIT?

This data-driven, decision-support tool facilitates safer work zone planning and management. Caltrans can also evaluate the cost-benefit of different work zone protection systems. Safer work zones benefit Caltrans operators and the traveling public.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA16-2257_FinalReport.pdf



Output of a PC-CRASH simulation

Appendix 1: Caltrans Membership on TRB Committees

The Transportation Research Board (TRB) promotes innovation and progress in transportation through research. TRB is one of seven program units of the National Academies of Sciences, Engineering, and Medicine, which provides independent, objective analysis and advice to the nation and conducts other activities to solve complex problems and inform public-policy decisions. The program is supported by state transportation departments, federal agencies, including the component administrations of the U.S. DOT, and other organizations and individuals interested in the development of transportation.

Caltrans staff who served in FY 2014/15 on the following TRB standing committees, subcommittees, and task forces. Subcommittees are denoted by a number in parenthesis following the committee number. Task forces are denoted by the letter "T" following the committee number. Standing committee chairs are in bold.

Committee Number	Committee Title	Committee Member	Committee Member's Division
E0000	Executive Committee	Malcolm Dougherty	Director
A0010	International Cooperation	Zhongren Wang	Maintenance
A0030T	Data for Decisions and Performance Measures (task force)	Coco Briseno	Executive
AB010T	Knowledge Management (task force)	Michelle Tucker	Human Resources
ABC10	Strategic Management	Ramamohan Bommavaram	District 04 Program / Project Management
ABC20	Management and Productivity	Cristiana Rojas	Executive
ABG10	Conduct of Research	Coco Briseno	Executive
ABG30	Technology Transfer	Joseph Horton	Research, Innovation and System Information
ABJ20	**Statewide Transportation Data and Information Systems**	**Coco Briseno, Chair**	**Executive**
ABJ60	Geographic Information Science and Applications	Chad Baker	Research, Innovation and System Information
ABJ90	Freight Transportation Data	Douglas MacIvor	Transportation Planning
ABR10	Critical Transportation Infrastructure Protection	Herby Lissade	Maintenance
ABR20	Logistics of Disaster Response and Business Continuity	Herby Lissade	Maintenance
ADA10	Statewide Multimodal Transportation Planning	Katie Benouar	Transportation Planning
ADA10(2)	Statewide Travel Demand Forecasting (subcommittee)	Douglas MacIvor	Transportation Planning
ADC50	Historic and Archeological Preservation in Transportation	Anmarie Medin	Environmental Analysis
ADC70	Transportation Energy	LaNae Van Valen	Transportation Planning
ADD55T	Arterials and Public Health (task force)	Zhongren Wang	Maintenance
AFB10	Geometric Design	Zhongren Wang	Maintenance
AFB40	**Landscape and Environmental Design**	**Keith Robinson, Chair**	**Design**
AFD10	Pavement Management Systems	Zhongren Wang	Maintenance
AFD20	Pavement Monitoring and Evaluation	Dulce Feldman	Maintenance
AFD20	Pavement Monitoring and Evaluation	Hamid Sadraie	Research, Innovation and System Information
AFD40	Full-Scale Accelerated Pavement Testing	Nicholas Burmas	Research, Innovation and System Information

Committee Number	Committee Title	Committee Member	Committee Member's Division
AFD50	Rigid Pavement Design	Dulce Feldman	Maintenance
AFD70	Pavement Rehabilitation	Robert Hogan	Maintenance
AFD80	Strength and Deformation Characteristics of Pavement Sections	Hamid Sadraie	Research, Innovation and System Information
AFF10	General Structures	Susan Hida	Engineering Services
AFF50	Seismic Design and Performance of Bridges	Thomas Ostrom	Engineering Services
AFH50	Portland Cement Concrete Pavement Construction	Dulce Feldman	Maintenance
AFH60	Flexible Pavement Construction and Rehabilitation	Joseph Peterson	Engineering Services
AFK50	Characteristics of Asphalt Paving Mixtures to Meet Structural Requirements	Hamid Sadraie	Research, Innovation and System Information
AFP30	Soil and Rock Properties	Chris Risden	Engineering Services
AFS20	Geotechnical Instrumentation and Modeling	Anoosh Shamsabadi	Engineering Services
AFS30	Foundations of Bridges and Other Structures	Sharid Amiri	Engineering Services
AHB15	Intelligent Transportation Systems	Greg Larson	Research, Innovation and System Information
AHB20	Freeway Operations	Ali Zaghari	District 07 Operations
AHB35	Managed Lanes	Joseph Rouse	Traffic Operations
AHB45	Traffic Flow Theory and Characteristics	Koohong Chung	District 04 Traffic Operations
AHB45	Traffic Flow Theory and Characteristics	Zhongren Wang	Maintenance
AHB55	Work Zone Traffic Control	Theresa Drum	Maintenance
AHB70	Access Management	Marc Birnbaum	Traffic Operations
AHB80T	System Simulation (task force)	Diane Jacobs	Transportation Planning
AHD35	Bridge Management	Michael B. Johnson	Maintenance
AHD37	**Bridge Preservation**	**Michael B. Johnson, Chair**	**Maintenance**
AHD60	**Maintenance Equipment**	**Lisa Kunzman, Chair**	**Equipment**
AHD65	Winter Maintenance	Joseph Horton	Research, Innovation and System Information
AL060	Eminent Domain and Land Use	Joann Georgallis	Legal
AL070	Tort Liability and Risk Management	Jeanne Scherer	Legal
ANB75	Roundabouts	Jerome Champa	Traffic Operations
AR020	Passenger Rail Equipment and Systems Integration	Stanton Hunter	Rail
AT015	Freight Transportation Planning and Logistics	Diane Jacobs	Transportation Planning
B0122B	Long-Term Bridge Performance (LTBP) Committee: Expert Task Group for Bridge Evaluation and Monitoring	Charles Sikorsky	Engineering Services
B0136	Committee for Review of USDOT Truck Size and Weight Study	Susan Hida	Engineering Services

Appendix 2: Caltrans Membership on NCHRP Project Panels

Administered by TRB, the National Cooperative Highway Research Program (NCHRP) is a forum for coordinated and collaborative research that addresses issues integral to the state departments of transportation and transportation professionals at all levels of government and the private sector. The NCHRP provides practical, ready-to-implement solutions to pressing problems facing the industry. Caltrans staff who served in FY 2014/15 on the following NCHRP project panels.

Project Number	Project Title	Panel Member	Panel Member's Division
D2110	AASHTO Manual on Subsurface Investigations, Manual Update	William Owen	Engineering Services
D1910	AASHTO Partnering Handbook, Second Edition	Ken Solak	Construction
D1086	Alternate Bidding of Pipe Materials	Brian Syftestad	Construction
D1083	Alternative Quality Systems for Application in Highway Construction	Jon Tapping	High Speed Rail Authority
D0396	Analysis of Oversaturated Traffic Flow Conditions and Managed Lanes on Freeway Facilities	Marco Ruano	District 07 Operations
D03119	Application of MASH Test Criteria to Breakaway Sign and Luminaire Supports and Crashworthy Work Zone Traffic Control Devices	Van Her	Traffic Operations
D1911	Applying Risk Analysis, Value Engineering, and other Innovative Solutions for Project Delivery	Troy Tusup	Design
D1547	Assessment of Geometric Design Policies and Processes	Dale Widner	District 02 Environmental
D2073	Best Practices on Accelerating Project Delivery: Conception to Completion	Charles Fielder	District 01 Director
D1286	Bridge System Reliability for Redundancy	Susan Hida	Engineering Services
D205936	Catastrophic Transportation Emergency Management Guidebook	Herby Lissade	Maintenance
D2437	Combining Individual Scour Components to Determine Total Scour	Kevin Flora	Maintenance
D1424	Convincing the Stakeholders: Developing a Guide for Communicating Maintenance and Preservation Needs	Steve Takigawa	Executive
D205950	Costing Asset Protection: An All-Hazards Guide for Transportation Agencies (CAPTA) - Update and Implementation	Dana Hendrix	Maintenance
D03101	Costs and Benefits of Public-Sector IntellDrive Deployment	Greg Larson	Research, Innovation and System Information
D1908	Costs of Alternative Finance Systems	Rachel Falsetti	Construction
D0378	Crossing Treatments at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities	Jim De Luca	Traffic Operations
D1426	Culvert and Storm Drain Inspection Manual	Parviz Lashai	Maintenance
D03105	Design Guidance for Interchange Loop Ramps	Zhongren Wang	Maintenance
D1297	Design Guidelines for Field Deployment of CFRP Prestressed Beams	Jim Gutierrez	Engineering Services
D1097	Detection and Remediation of Soluble Salt Contamination Prior to Coating Steel Highway Structure	John Rogers	Maintenance
D1429	Developing a Consistent Coding and Training System for Emergency Structure Inspections	Herby Lissade	Maintenance
D1077	Developing Guidelines for GPS (Geographical Positioning System) Controlled Construction Machine Guidance and Required CADD Software	Jesus Mora	Design
D1088	Developing Precision and Bias Statements for AASHTO Standard Methods of Test TP 98 and TP 99	Bruce Rymer	Environmental Analysis
D0399	Development and Application of Access Management Guidelines	Marc Birnbaum	Traffic Operations

Project Number	Project Title	Panel Member	Panel Member's Division
D1748	Development of a Strategic National Highway Infrastructure Safety Research Agenda	Jeanne Scherer	Legal
D0890	Development of a Transportation Asset Management Gap Analysis Tool to Complement the AASHTO TAM Implementation Guide	Coco Briseno	Executive
D2438	Development of Bridge Foundation Movement Criteria	Amir Malek	Engineering Services
D1605	Development of Cost-Effective Treatments of Roadside Ditches to Reduce the Number and Severity of Roadside Crashes	Karen Jewel	District 11 Traffic Operations
D1756	Development of Crash Reduction Factors for Uncontrolled Pedestrian Crossing Treatments	Brian Alconcel	District 03 Operations
D12106	Development of Guidelines for Performance-Based Seismic Design	Thomas Ostrom	Engineering Services
D0385	Development of Guidelines for the Use of Simulation and Other Models in Highway Capacity Analyses	Troy Arseneau	District 01 Maintenance & Operations
D0224	Economic Productivity and Transportation Investment Priorities	Barry Padilla	Transportation Planning
D0888	Effective Project Scoping Practices to Improve On-Time and On-Budget Delivery of Highway Projects	Marlon Flournoy	District 03 Planning & Local Assistance
D0947	Engineering Properties/Field Performance of Warm Mix Asphalt Technologies	Cathrina Barros	Engineering Services
D08101	Enhanced Truck Data Collection and Analysis for Emissions Modeling	Joanne McDermott	Transportation Planning
D08100	Environmental Justice Analyses When Considering Toll Implementation or Rate Changes	Chris Schmidt	District 11 Planning
D0878	Estimating Bicycling and Walking for Planning and Project Development	Chris Schmidt	District 11 Planning
D20100	Estimating the Return on Investment in Transportation Asset Management Systems and Practices	Steve Guenther	Executive
D1766	Evaluation of Opposite Direction Crashes and Appropriate Countermeasures	Robert Peterson	District 04 Construction
D1766	Evaluation of Opposite Direction Crashes and Appropriate Countermeasures	Cristiana Rojas	Executive
D2533	Evaluation of the Methodologies for Visual Impact Assessments	Keith Robinson	Design
D0948	Field versus Laboratory Volumetrics and Mechanical Properties	Kee Foo	Maintenance
D0897	Finding and Using Data to Identify and Evaluate Corridors for Transporting Multi-state, Multi-modal Oversize/Overweight Freight	Vahid Nowshiravan	Transportation Planning
D205953	FloodCast: A Framework for Enhanced Flood Event Decision Making for Transportation Resilience	Herby Lissade	Maintenance
D1287	Fracture-Critical System Analysis for Steel Bridges	Lian Duan	Engineering Services
D20103	Guidance for Development and Management of Sustainable Information Portals	Loren Turner	Research, Innovation and System Information
D0721	Guidance for the Management of Traffic and Safety Assets	Agustin Rosales	Maintenance
D1305	Guide for Utilization Measurement and Management of Fleet Equipment	Lisa Kunzman	Equipment
D1085	Guidebook for Construction Manager-at-Risk Contracting for Highway Projects	Raymond Tritt	Design
D0893	Guidebook on Agency Risk Management Strategies, Methods, and Tools	Michelle Tucker	Human Resources
D2444	Guidelines for Managing Geotechnical Risks in Design-Build Projects	Kristina Assouri	Legal
D2444	Guidelines for Managing Geotechnical Risks in Design-Build Projects	Joseph Dongo	Design
D1556	Guidelines for Selecting Ramp Design Speeds	Louis Betancourt	Project Management

Project Number	Project Title	Panel Member	Panel Member's Division
D20101	Guidelines to Incorporate the Costs and Benefits of Adaptation Measures in Preparation for Extreme Weather Events and Climate Change	Charles Fielder	District 01 Director
D0146	Handbook for Pavement Design, Construction, and Management	William Farnbach	Maintenance
D1285	Highway Bridge Fire Hazard Assessment	Kenneth Brown	Maintenance
D1559	Horizontal Sightline Offset Design Criteria, Exceptions, and Mitigation Strategies	Zhongren Wang	Maintenance
D2030	IDEA (Innovations Deserving Exploratory Analysis)	Joseph Horton	Research, Innovation and System Information
D20102	Impacts of Connected and Automated Vehicles on State and Local Transportation Agencies	Greg Larson	Research, Innovation and System Information
D2010202	Impacts of Transit System Regulations and Policies on CV/AV Technology Introduction	Prakash Sah	Research, Innovation and System Information
D2090	Improving Access to Transportation Information	Coco Briseno	Executive
D2097	Improving Findability and Relevance in Transportation Information	Chad Baker	Research, Innovation and System Information
D0896	Integrating Goods and Services Movement Commercial Vehicles in Smart Growth Environments	Joanne McDermott	Transportation Planning
D2089	Intellectual Property Stewardship Guide for Transportation Departments	Lawrence Orcutt	Equipment
D0884	Long Distance and Rural Travel Transferable Parameters for Statewide Travel Forecasting Models	Douglas MacIvor	Transportation Planning
D0383	Low-Cost Improvements for Recurring Freeway Bottlenecks	Karla Sutliff	Executive
D2535	Managing Rights-of-Way for Biomass Generation and/or Carbon Sequestration	Keith Robinson	Design
D2545	Mapping Noise Source Heights for Highway Noise and Barrier Analysis	Bruce Rymer	Environmental Analysis
D0152	Mechanistic-Empirical Model for Top-Down Cracking of Asphalt Pavement Layers	Wilfung Martono	District 04 Environmental
D2552	Meteorological Effects on Roadway Noise	Bruce Rymer	Environmental Analysis
D1076	Methodologies for Evaluating Pavement Strategies and Barriers for Noise Mitigation	Bruce Rymer	Environmental Analysis
D0899	Methodology for Estimating the Value of Travel Time Reliability for Truck Freight System Users	Barry Padilla	Transportation Planning
D1294	Minimum Flexural Reinforcement Laboratory Testing	Don Nguyen-Tan	Engineering Services
D0151	Model for Incorporating Slab/Underlying Layer Interaction into the MEPDG Concrete Pavement Analysis Procedures	Dulce Feldman	Maintenance
D0397	Modifications to HCM Signal Analysis to Support Reliability Assessment and Maintenance of Signal Timing	David Gamboa	Construction
D2082	Next Generation of the FHWA Transportation Pooled Fund (TPF) Website	Roberto Buendia	Research, Innovation and System Information
D0871	Optimum Life-Cycle Analysis of Maintainable Assets	Raymond Tritt	Design
D206300B	Performance Measurement Tool Box and Reporting System for Research Programs and Projects	Lawrence Orcutt	Equipment
D1082	Performance Related Specifications (PRS) for Pavement Preservation Treatments	Nicholas Burmas	Research, Innovation and System Information

Project Number	Project Title	Panel Member	Panel Member's Division
D0950	Performance-Related Specifications for Asphaltic Binders Used in Preservation Surface Treatments	Kee Foo	Maintenance
D1423	Practical Bridge Preservation Actions and Investment Strategies	Paul Cooley	Maintenance
D2550	Prioritization Procedure for Proposed Road-Rail Grade Separation Projects along Specific Rail Corridor	Joanne McDermott	Transportation Planning
D1536	Procedure for Determination of the Joint Probability of Design Peak Flows at Confluences	Kevin Flora	Maintenance
D0153	Proposed Enhancements to Pavement ME Design: Improved Consideration of the Influence of Subgrade and Unbound Layers on Pavement Performance	Medhi Parvini	Maintenance
D1432	Proposed Revisions to the AASHTO Movable Bridge Inspection, Evaluation and Maintenance Manual. 1st Edition, 1998	Alan Torres	Engineering Services
D205948	Protection of Transportation Infrastructure from Cyber Attacks	Rene Garcia	Maintenance
D1298	Recommended Guidelines for Prefabricated Bridge Elements and Systems Tolerances and Dynamic Effects of Bridge Moves	Dorie Mellon	Engineering Services
D0959	Relating Asphalt Binder Fatigue Properties to Asphalt Mixture Fatigue Performance	Hamid Sadraie	Research, Innovation and System Information
D2065	Research for the AASHTO Standing Committee on Public Transportation	Jila Priebe	Mass Transportation
D2436	Scour at the Base of Retaining Walls and Other Longitudinal Structures	Charles Ineichen	Maintenance
D125901	Seismic Design of Geosynthetic-Reinforced Soil (GRS) Bridge Abutments with Flexible Facing	Hernan Perez	Engineering Services
D1816	Self-Consolidating Concrete for Cast-in-Place Bridge Components	Madhwesh Raghavendrachar	Engineering Services
D0952	Short-Term Laboratory Conditioning of Asphalt Mixtures	Cathrina Barros	Engineering Services
D2547	Strategies to Reduce Agency Costs and Improve Benefits Related to Highway Access Management	Marc Birnbaum	Traffic Operations
D2084	Streamline and Simplify Right-of-Way Procedures and Business Practice	Mark Weaver	District 04 Right of Way and Land Surveys
D2548	Streamlining Project Level Air Quality Analysis through Development of New Tools/Interfaces	James Elder	Design
D1293	Structural Testing and Design Methodology for Single Column-Single Shaft Foundation Considering the Flexural Capacity of Steel Casing	Amir Malek	Engineering Services
D2059	Surface Transportation Security Research	Herby Lissade	Maintenance
D205939	Synthesis of Airport Closings and Emergency Evacuation Problems	Herby Lissade	Maintenance
D205932	Transportation Guide for All-Hazards Emergency Evacuation	Diana Gomez	High Speed Rail Authority
D0861	Travel Demand Forecasting: Parameters and Techniques	Bljan Sartipi	District 04 Director
D205951B	Update of a Guide to Emergency Response Planning at State Transportation Agencies	Herby Lissade	Maintenance
D205951A	Update of Security 101: A Physical Security Primer for Transportation Agencies	Herby Lissade	Maintenance
D1543	Update of the TRB Access Management Manual	Marc Birnbaum	Traffic Operations
D03109	Update Section 2B.07 of MUTCD-Multi-way Stop Control (Unsignalized Intersection Control Warrants/Criteria)	Roberta McLaughlin	Traffic Operations
D1550	Update to TRB Special Report 214: Designing Safer Roads—Practices for Resurfacing, Restoration and Rehabilitation	Dale Widner	District 02 Environmental
D1761	Work Zone Crash Characteristics and Countermeasure Guidance	Theresa Drum	Maintenance

Appendix 3: Caltrans Membership on NCFRP Project Panels

Administered by TRB, the National Cooperative Freight Research Program (NCFRP) conducts research and disseminates timely findings that inform investment and operations decisions affecting the performance of the freight transportation system. Caltrans staff who served in FY 2014/15 on the following NCFRP project panels.

Project Number	Project Title	Panel Member	Panel Member's Division
DF041	Capacity and Level of Service Analysis for Trucks	Douglas MacIvor	Transportation Planning
DF039	Creating Publicly Available Measures of Freight Trucking Activity	Diane Jacobs	Transportation Planning
DF02501	Estimating Freight Generation Using Commodity Flow Survey Microdata	Douglas MacIvor	Transportation Planning
DF034	Evaluating Alternatives for Landside Transport of Ocean Containers	Diane Jacobs	Transportation Planning
DF044	Factors Influencing Freight Modal Shift	Douglas MacIvor	Transportation Planning
DF025	Freight Trip Generation and Land Use (Jointly Funded as NCHRP B8-80)	Douglas MacIvor	Transportation Planning
DF020	Guidebook for Developing Sub-national Commodity Flow Data	Diane Jacobs	Transportation Planning
DF032	Impact of Smart Growth on Metropolitan Goods Movement	Douglas MacIvor	Transportation Planning
DF038	Improving Freight System Performance in Metropolitan Areas	Chad Baker	Research, Innovation and System Information
DF026	Strategies for Measuring the Costs of Freight Transportation	Douglas MacIvor	Transportation Planning
DF030	Web-Based Simulation Tool for Shared-Use Rail Corridors	Chad Baker	Research, Innovation and System Information

Appendix 4: Caltrans Membership on ACRP Project Panels

Administered by TRB, the Airport Cooperative Research Program (ACRP) is an industry-driven, applied research program that develops near-term, practical solutions to problems faced by airport operators. Caltrans staff who served in FY 2014/15 on the following ACRP project panels.

Project Number	Project Title	Panel Member	Panel Member's Division
DA0213	Guidebook of Practices for Improving Environmental Performance at Small Airports	Philip Crimmins	Aeronautics
DA0247	Assessing Aircraft Noise Conditions Affecting Student Learning - Case Studies	Philip Crimmins	Aeronautics
DA1103	Synthesis of Information Related to Airport Problems	Gary Cathey	Aeronautics

Appendix 5: Caltrans Membership on TCRP Project Panels

Administered by TRB, the Transit Cooperative Research Program (TCRP) is an applied, contract research program that develops near-term, practical solutions to problems facing transit agencies. Caltrans staff who served in FY 2014/15 on the following TCRP project panels.

Project Number	Project Title	Panel Member	Panel Member's Division
TA36	Command-Level Decision Making for Transit Emergency Managers	Rene Garcia	Maintenance

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