FY 2012/13

Annual Research Program Highlights

DRISI

Caltrans Division of Research,
Innovation and System Information

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Caltrans Research Program

FY 2012/13 Annual Research Program Highlights

Caltrans

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

Fiscal year 2012/13 was a year of new beginnings and opportunities as the Division of Research and Innovation and the Division of Transportation System Information merged to become the new Division of Research, Innovation and System Information (DRISI), allowing the two divisions to combine their resources to provide Caltrans with the research and data solutions needed to make informed decisions that improve California's transportation system.

The merger introduced a new reporting structure and leadership. The Research and Deployment Steering Committee, established in 2003 to define the research priorities and guide project selection, transferred its functions to the Caltrans Executive Board, which consists of deputy and district directors. With the Caltrans Executive Board's leadership and strategic direction, DRISI can better extend its research services across Caltrans programs and districts and ultimately increase implementing the research results and products throughout the state.

Expanding and diversifying our research program

As we shared in last year's annual report, research staff will work toward a better understanding of the cross-functional benefits of individual research tasks to leverage the research program's contribution toward Caltrans strategic goals and objectives. This year, we developed our first cross-functional research roadmap—system performance management—to identify the common challenges and shared concerns within the areas of integrated corridor management, travel demand management, and data collection and information dissemination. We collaborated with five Caltrans programs and four districts to analyze the existing system performance management research portfolio; define the strategic problem statements, objectives, and themes; and validate them with Caltrans technical experts. We plan to continue working with more programs and districts to develop other cross-functional roadmaps.

Achieving excellence together

DRISI continues to foster and strengthen partnerships with our programs, districts, and academic partners. In September 2012, DRISI, Caltrans District 2, and the Western Transportation Institute at Montana University won the Best New Innovative Product, Service or Application award for developing and sponsoring the Western States Rural Transportation Technology Implementers Forum at the 2012 National Rural Intelligent Transportation Systems (ITS) Conference. The forum is an annual event where implementers of rural ITS technologies have the opportunity to share technical information on best practices and field deployment experiences with fellow professionals from across the western United States.

Looking ahead

As we pursue our purpose for the new merged division, we will align our strategic direction to ensure that our research supports the goals and objectives of the Caltrans strategic management plan and continue to deliver solutions to address transportation challenges. We are determined to realize our potential as a unified and outstanding Division of Research, Innovation and System Information.

COCO BRISENO, *Chief*
Division of Research, Innovation and System Information

Caltrans

DRISI provides solutions and knowledge that improve California's transportation system.

Research Program Administration

In FY 2012/13, DRISI managed a $24.7 million program to deliver customer-focused research that addresses transportation needs across California. Funding comes from the State Planning and Research (SP&R) Part II and the State Highway Account (SHA).

SP&R Part II, administered by the Federal Highway Administration (FHWA), is the federal funding source for Caltrans research, providing $12.6 million (51%) of the FY 2012/13 research budget. These funds are used to research new knowledge areas; adapt findings to practical applications by developing new technologies; and transfer these technologies, including the process of dissemination, demonstration, training, and adoption of innovations. DRISI allocates SP&R Part II funds to support the national research program, which includes the National Cooperative Highway Research Program (NCHRP) and the Transportation Research Board (TRB). SP&R Part II also funds state-specific transportation research tasks categorized as Caltrans functional research.

SHA is the state funding source for Caltrans research, providing $12.1 million (49%) of the budget. The state budget act authorizes SHA, which is a transportation funding source generated from the state tax on motor vehicle fuels. SHA monies are used to:

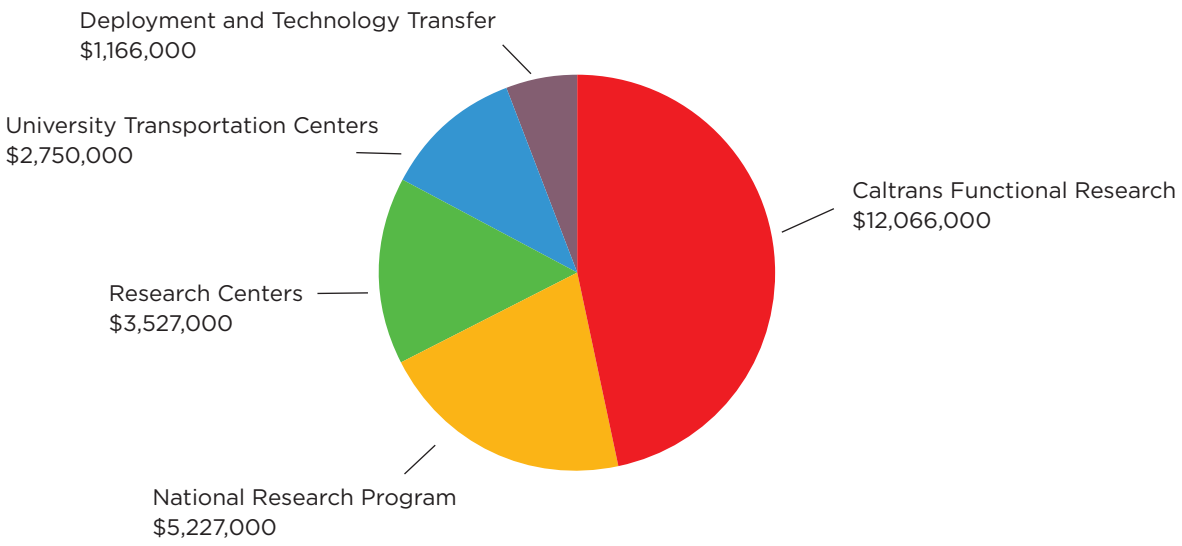
- Provide 20% matching to the SP&R Part II funds
- Invest in research centers
- Fund university transportation centers
- Support deployment and technology transfer of research results and products

Caltrans Functional Research

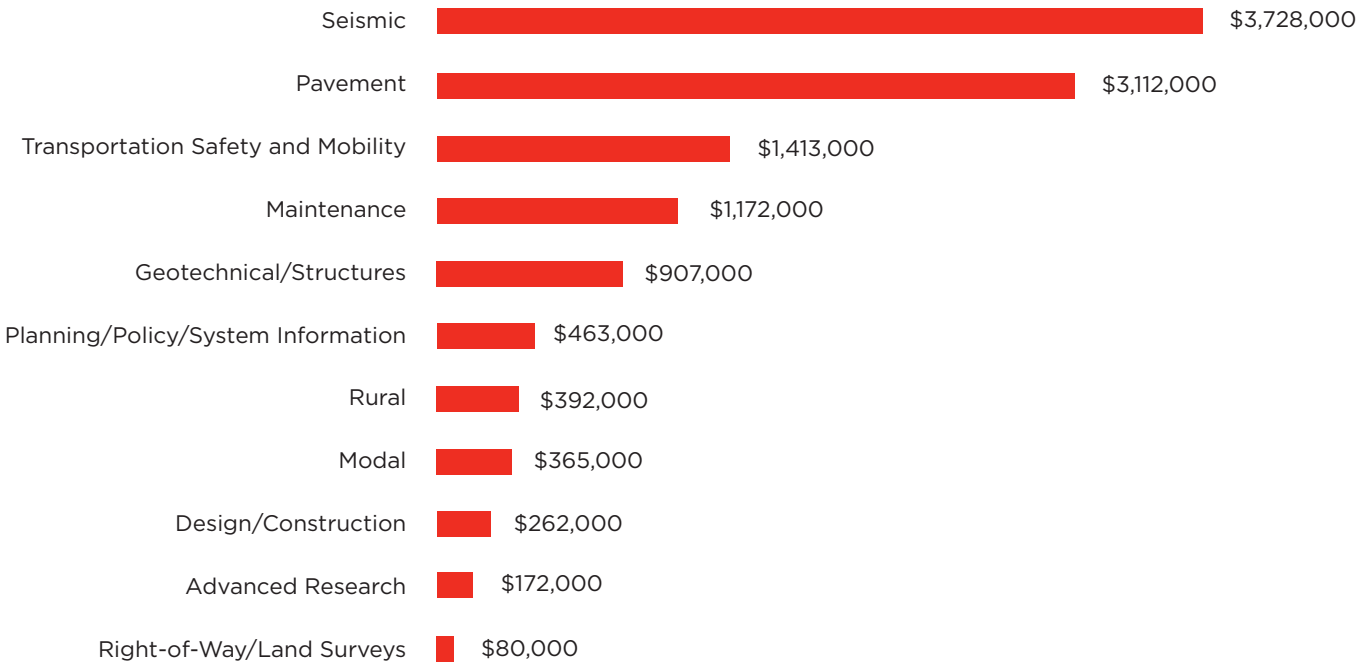
DRISI managed 201 research tasks in various functional areas, of which 40 tasks were completed in FY 2012/13. For a summary of completed research tasks, see pages 26–35.

DRISI's research tasks and funding amounts are organized by functional areas to align with Caltrans functional programs.

Allocation of FY 2012/13 Research Funds



Distribution of Caltrans Functional Research Funds

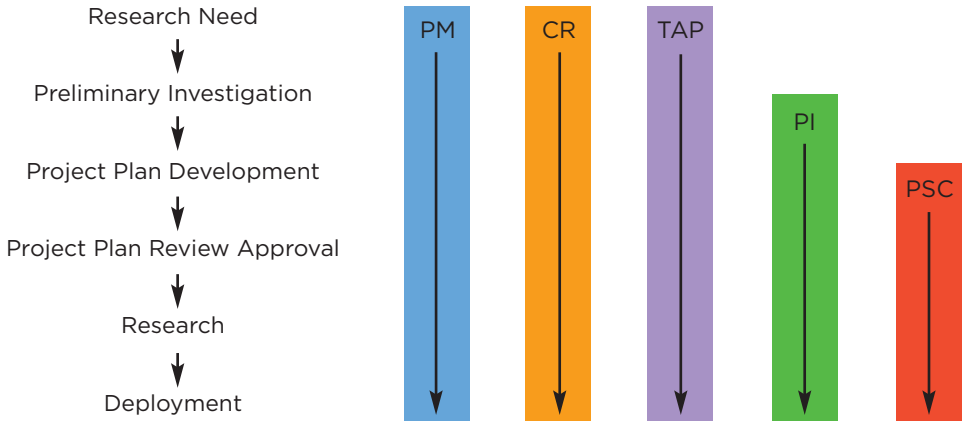


Research Program Development

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 are also the leads of the 10 program steering committees (PSC). The PSCs adopt an agenda for a multiyear integrated research program, develop program-level research priorities, and support the deployment and implementation of research products. Each PSC includes at least one technical advisory panel (TAP), which includes technical experts from the various divisions and districts. The TAP suggests, reviews, and ranks the problem statements and preliminary investigation requests.

In conjunction with other Caltrans divisions, DRISI project managers propose new research projects annually in January. The PSCs and DRISI management review the proposals in February. Each PSC lead prioritizes their respective proposals in March, and the RDAC approves the annual portfolio in April.

Research Process and Roles



Project manager (PM)
Caltrans staff member with full authority and responsibility, delegated by the appropriate division chief, to produce the intended results on schedule and within budget and keep the project sponsors, customers, 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.

Technical Advisory Panel (TAP)
Each TAP has a vital role in reviewing problem statements, ranking preliminary investigations, recommending preliminary investigations, and providing recommendations for continuing and new projects.

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

Program steering committee (PSC)
Each PSC has a vital role in establishing new research projects. PSC membership consists of division chiefs, district representatives, and relevant external partners.

National Research Programs

Caltrans partners with national transportation organizations, including the TRB and NCHRP. 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. In FY 2012/13, Caltrans staff actively participated on 117 highway, 10 freight, and 3 airport cooperative research project panels (see pages 7–9).

Research Support Partnerships

DRISI collaborates with university-based research centers to deliver applied research. Each research center offers specialized technical expertise, state-of-the-art research facilities, equipment, and materials. More information about the following research centers is on pages 10–21:

- Advanced Highway Maintenance and Construction Technology
- California Traffic Management Laboratories
- Pacific Earthquake Engineering Research
- Partners for Advanced Transportation Technology
- University of California Pavement Research Center

University Transportation Centers

In FY 2012/13, DRISI provided state match funding for the University of California Transportation Center (UCTC) and the Mineta National Transit Research Consortium (MNTRC) (see pages 22–25).

These internationally recognized centers of excellence, fully integrated within institutions of higher learning, provide a vital source of leaders prepared to meet the nation's need for safe, efficient, and environmentally sound movement of people and goods. These 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, and transportation planning.

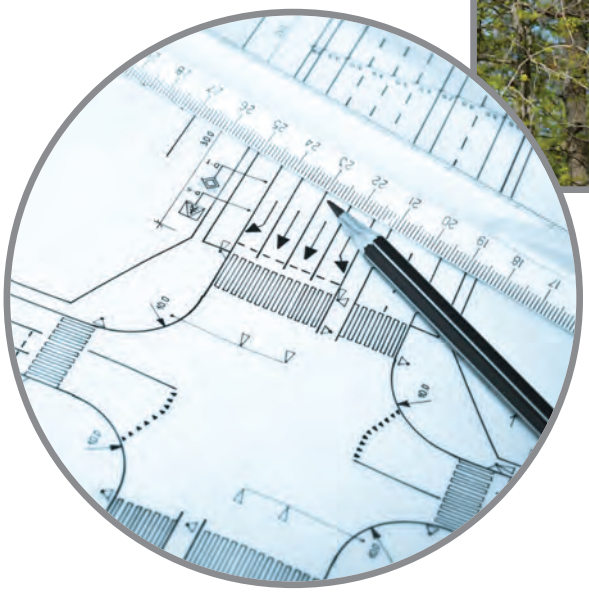
The MNTRC, led by the Mineta Transportation Institute (MTI) at California State University, San Jose, provides expertise on alternative fuels, safety and security, public policy, finance, workforce development, livable communities, environmental sustainability, economic competitiveness, new modes, and other critical factors essential to sustainable mobility.

The UCTC, led by the University of California, Berkeley, focuses on environmental sustainability, economic competitiveness, and livability and the connections between them. This investment will lead to important research that addresses the multitude of policy and technological challenges that the transportation sectors of California and other southwestern states face.

Deployment and Technology Transfer

To inform and engage our customers and partners, DRISI developed tools and methods to disseminate research results and promote the program's services:

- **Deployment plans** identify the challenges, opportunities, and strategies in making research results and products available.
- **Research notes** provide an overview of research in progress to a general audience. Released at the beginning of a research task, the notes describe the research need, methodology, goal, benefits, milestones, and next steps.
- **Research results** communicate to a general audience what was accomplished with the research. They summarize the need, goal, methodology, outcome, and benefits.
- **Annual highlight reports** summarize DRISI's activities and completed research over the past year.
- **Research connections events** throughout the year bring researchers, customers, and stakeholders together to hear about the latest research results and activities. These gatherings provide a forum for Caltrans staff, adopters, and researchers to exchange knowledge and keep up with technological and regulatory developments.
- **Workshops** provide customers, partners, and researchers an opportunity to discuss issues and recommend approaches and solutions to different challenges.



National Research Programs

TRANSPORTATION RESEARCH BOARD

The Transportation Research Board (TRB) is the major national multimodal transportation organization that brings practitioners and researchers together to solve critical transportation problems. TRB provides an information infrastructure that is designed to serve the nation's highly decentralized transportation system in which no single organization dominates. With more than 200 committees, almost every transportation mode and topic is represented in the standing committee structure. Each committee proposes research, shares research findings, sponsors special activities, and provides a forum for transportation professionals to discuss current and future transportation issues. Caltrans has representatives on 49 of the committees.

TRB's core program budget was $16.17 million in 2012, with approximately 46% funded by the state departments of transportation. The remainder comes from federal agencies, other transportation organizations, and TRB self-generated revenue. With a contribution of $512,960 in 2012, Caltrans was able to leverage $32 in research-related activity for every $1 invested.

This investment in TRB and the pooled funding it represents is mission critical, enabling Caltrans to:

- Have a voice in setting national research priorities and agendas
- Continue to have access to the user-oriented research
- Avoid duplication of research efforts
- Support the uniform, practical, and common-sense application of transportation research results
- Continue to develop a more enlightened and informed 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 them stimulating and professionally rewarding opportunities to participate in efforts that will 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. 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)

Caltrans staff members actively participated on 117 highway, 10 freight, and 3 airport cooperative research project panels in fiscal year 2012/13, giving California a voice in shaping the scope and direction of these large projects. See the appendices for the active cooperative research projects with Caltrans panel membership.

Fifty-one projects were selected for funding in the NCHRP 2014 program. Of these, 21 were of high value to Caltrans, and 8 currently have Caltrans staff serving on the project panels. These 21 projects have a value of $8.35 million. By participating in the NCHRP as project panel members and as a member of the Standing Committee on Research and Research Advisory Council, Caltrans is able to influence national projects to directly benefit California.

Four cooperative research projects from which California benefited are highlighted below.

NCHRP Project 10-76, NCHRP Report 738

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_738.pdf

Evaluating Pavement Strategies and Barriers for Noise Mitigation

This project created the most comprehensive benefit-cost analysis study of traffic noise mitigation strategies to date. The researchers developed a methodology that considers the acoustic and economic features of pavements and sound barriers. Federal code did not recognize quiet pavement as an approved noise mitigation strategy, because it is thought that pavements quickly became louder with age and thus did not provide the predictable and permanent noise reduction of noise barriers. Caltrans' work in the past decade has demonstrated that pavements can be a viable strategy for lowering roadside noise levels in a predictable manner. On-Board Sound Intensity measurement technology—a process developed at Caltrans and adopted as AASHTO Standard TP-76—and Caltrans data were used in a modified version of the FHWA's traffic noise model. The methodology developed in this research provides a means of evaluating pavement strategies and barriers together for feasibility, reasonableness, effectiveness, acoustic longevity, and cost effectiveness. The methodology can be used immediately under the latest FHWA policy regarding feasibility and reasonableness, thus giving Caltrans and other DOTs more options for mitigating traffic noise.

NCFRP Project DF020, NCFRP Report 26

http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_026.pdf

Guidebook for Developing Sub-national Commodity Flow Data

Commodity flow data is a critical resource for transportation planning at state, regional, and local jurisdictional levels and in corridors (collectively called sub-national levels). Sources for commodity flow data at the national level are of limited application to sub-national planning because they lack the appropriate geographic detail for flow origins and destinations. State DOTs, such as Caltrans, require a variety of tools to tailor existing commodity flow data for their specific needs and must develop additional sources of data. This report includes resources and guidance for making the best use of generally available national data sources, helps identify commonly available local data sets with which to enhance commodity flow data, and describes how to conduct shipper and carrier surveys.

NCHRP 03-96, NCHRP Report 191

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w191.pdf

Analysis of Managed Lanes on Freeway Facilities

The Highway Capacity Manual (HCM) includes methodologies for analyzing freeway facilities, but it does not address managed lanes. This project developed a performance measurement, analytical methodology framework for freeway facilities that have both managed and general purpose lanes for inclusion in the HCM. The FREEVAL-ML software tool was developed to support the new methodology. The methodology will be mainstreamed into industry standards for traffic analysis, and Caltrans and other agencies can use the information to plan facilities and determine the pricing strategy to manage demand. Including performance assessment and operational analysis of managed lanes in the HCM enhances its usefulness to engineers, designers, planners, and decision-makers in California.

NCHRP 24-34, NCHRP Report 761

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_761.pdf

Risk-Based Approach for Bridge Scour Prediction

Load and resistance factor design (LRFD) incorporates state-of-the-art analysis and design methodologies with load and resistance factors based on the known variability of applied loads and material properties. The goal of this project was to determine if this approach could be applied in the design of waterway crossings and the anticipated scour conditions. This project provided tables of probability values (scour factors) that engineers can use to associate the estimated scour depth with a probability of exceedance for a design event. It is then up to the design engineer to select the desired level of reliability for the given scour conditions. This research is an important first step in elevating the scour calculations and design with an LRFD methodology.

Drift accumulation on a single bridge pier (photo courtesy of Ayres Associates)

Schematic of Barrier 2 and Example at I-5 Seattle Washington (Source: Google Earth)

Research Support Partnerships

ADVANCED HIGHWAY MAINTENANCE AND CONSTRUCTION TECHNOLOGY RESEARCH CENTER

The AHMCT Research Center performs research leading to the development of innovative technologies, data, and methods for highway and civil infrastructure, with a focus on improving safety, mobility, and reliability, achieving lean operations, and minimizing environmental impacts.

AHMCT's mission is to enhance safety, mobility, lean operations, reliability, and the environment through research leading to the development and deployment of innovative technologies, data, and methods for highway and civil infrastructure construction, maintenance, and operations.

WHAT IS THE NEED?

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 recent advances in automation and robotics, information technology, sensing, mechatronics, design and sustainability, lifecycle and cost-benefit analysis, and advanced communication and computer technologies. Making all construction and maintenance tasks data driven and based on complete lifecycle considerations can improve the safety, mobility, efficiency, and stewardship of Caltrans operations.

WHAT IS THE GOAL?

The short-term goal is to evaluate and deploy new and advanced technologies in existing Caltrans operations and perform the necessary training for the Caltrans workforce to benefit from the technology improvements. The long-term goal is to gather data and develop methods that help maintain Caltrans' national and international leadership in highway maintenance, construction, and operation technology and in achieving its goal of safe and efficient delivery of people, goods, services, and information in California.

WHAT DID THEY DO?

Example projects include:

Evaluation of the Construction Zone Enhanced Enforcement Program (COZEEP) and Highway Maintenance Zone Enhanced Enforcement Program (MAZEEP)
This research evaluated the effectiveness of the presence of CHP officers in work zones to reduce speeding and increase safety for workers and motorists. In a short period of time, AHMCT researchers developed a deployable testing methodology and collected data on California highways, including metropolitan and rural areas.

Intelligent Roadway Information System (IRIS) in Caltrans Districts 1, 2, 5, and 10
AHMCT researchers demonstrated the application of IRIS, an advanced traffic management system (ATMS) based on open standards, open software, and off-the-shelve hardware that was developed by the Minnesota Department of Transportation. This approach can greatly reduce ATMS deployment and maintenance costs, allowing communities with less funds to implement an ATMS. AHMCT provided maintenance and enhancements to IRIS, continued support for deployment in District 10, and deployed it in Districts 1, 2, and 5.

Mobile Terrestrial Laser Scanning
AHMCT researchers are working with the Caltrans Office of Land Surveys to study mobile terrestrial laser scanning and its applicability for surveys, pavements, bridge structures, roadside assets, and other Caltrans applications areas. The work includes developing best practices, methods for accuracy improvements, and tools for feature and attribute extraction.

Fleet In-Vehicle Data Acquisition System (FIDAS) Technical Support and Testing
AHMCT assisted Caltrans in executing a GPS vendor rodeo, with 15 vendors participating. AHMCT helped develop specifications used in a bidding pilot study of 200 vehicles. The study included monthly pilot fleet utilization (distance traveled, total fuel usage, and average fuel mileage), vehicle idling time, and estimated idling fuel consumption, along with speeding violation data. A cost-benefit study is being developed as part of the research.

Evaluation of the TowPlow System
AHMCT is evaluating TowPlow, a steerable, trailer-mounted plow that can remove two lanes of snow. TowPlow offers efficiency gains, because one vehicle can plow the equivalent of two vehicles.

Evaluation of the Epoke System
AHMCT is evaluating Epoke, a high-efficiency sand, salt, and brine delivery system, to provide better material transport out of the hopper, disperse dry or wet material as needed, and provide highly controllable and precise dispersion. Epoke is also expected to improve deicing methods for snow and ice removal.

WHAT WAS THE OUTCOME?

In the area of safety, AHMCT-led research has provided data to improve the safety of highway work zones and develop best practices in using COZEEP and MAZEEP on California highways. Mobile terrestrial laser scanning allows surveyors to collect grade data without being on foot on the highways as well as gather the data at much higher speeds and accuracy. AHMCT research on using the open source IRIS led to the development of an ATMS tailored to Caltrans requirements and for use in rural areas. Rural implementations have now been deployed in Caltrans Districts 1, 2, 5, and 10. Several other projects to be completed in upcoming years are providing a framework that can make an impact on Caltrans operations. Because all AHMCT projects are conducted in coordination with Caltrans technical advisory groups, each project adds to the experience base of the Caltrans workforce.

WHAT IS THE BENEFIT?

The research on work zone safety has provided data that can improve the safety of highway workers and the traveling public. Caltrans currently spends approximately $28.3 million for COZEEP and $7.1 million for MAZEEP annually. The research results and data helps develop best practices for the most effective utilization. AHMCT conducted training and workflow integration for the mobile terrestrial laser scanning technology, resulting in a savings of approximately $10,000 per project for over 100 projects in one year. The deployment of the IRIS-ATMS implementation in Districts 1, 2, and 5 has not only provided access to a fully integrated transportation management system for rural districts but has also saved these districts over $1 million per year compared to implementing a full-blown commercially available ATMS.

LEARN MORE

http://ahmct.ucdavis.edu

CALIFORNIA TRAFFIC MANAGEMENT LABORATORIES

CTMLabs is an instrumented transportation operations environment linked to university labs that provides real-world development, testing, and evaluation of emerging technologies and applications and serves as a testing ground for California and national intelligent transportation system (ITS) efforts.

CTMLabs mission is to provide Caltrans a safe and secure transportation research environment to transform research products from the laboratory to a real-time field operational setting and the ability to address the institutional, technical, and philosophical barriers of introducing innovative technologies into the management of complex transportation systems.

WHAT IS THE NEED?

CTMLabs solves problems that are critical to the continued development and operation of Caltrans traffic management practices. CTMLabs evaluates issues regarding roadway infrastructure, transportation operation training platforms, field traffic device installations, connected engineering models, and simulation applications that communicate and interact with each other.

CTMLabs, which operates under the direction of the University of California, Irvine Institute of Transportation Studies, is set up to:

- Accelerate deployment through advanced technology research
- Demonstrate the readiness of advanced systems
- Implement and evaluate operations of an integrated multijurisdictional, multiagency transportation operations system

CTMLabs provides a testbed based on real-time, computer-assisted traffic management and communication. The transportation operations system supports traffic management personnel by integrating network-wide traffic information (both surface street and freeway) in a real-time environment. CTMLabs has direct links to Caltrans District 12 and the Irvine traffic management centers (TMCs) and gathers real-time data from the area freeways and major arterials for research.

WHAT IS THE GOAL?

The CTMLabs evaluates ITS products and services that support Caltrans customer divisions and other DRISI partners by providing field operational tests and traffic management strategies.

WHAT DID THEY DO?

CTMLabs has three main components:

- UC Irvine lab, which includes an enhanced simulation environment
- UC Irvine Detector Testbed, comprising the I-405 detector testbed, Irvine arterial street testbed, and mobile TMC
- Berkeley Highway Laboratories, located on I-80 in Emeryville

These components support research technology transfer, including:

- Transferring research technologies and tools to Caltrans operations
- Providing a state-of-the-art, fully instrumented facility to train about 60 Caltrans traffic management personnel and CHP operators
- Incorporating advances in communication technology into the TMCs

With assistance from Caltrans, the CTMLabs research team identified the following research projects and focused on integrating the tools as live applications accessible via the CTMLabs website:

- **TMC Performance Evaluation**—Evaluates TMC operations using data available from the Caltrans District 12 activity logging application and the Caltrans Performance Measurement System (PeMS).
- **Accident Risk Analysis**—Estimates the risk of different kinds of collisions at any location using standard loop data.
- **California Vehicle Activity Database**—Estimates the amount of truck traffic on highways and arterials based on data from PeMS, weigh-in-motion stations, and the Highway Performance Measurement System.
- **Ramp Metering Evaluation Platform**—Evaluates the operation of ramp meters based on real-time and historical field data.
- **Inductive Signature Performance Evaluation**—Provides system performance measures using section-based traffic measures obtained through matching inductive signatures from vehicles traversing adjacent detector stations.

These tools were incorporated into separate websites, accessible through a centralized web portal that provides general information about CTMLabs products, services, and data. It also includes a common, map-based application page that allows customers to explore the various value-added data made available by each CTMLabs application. In addition, a web-based system for managing the projects and tracking problems and their resolutions over time was developed.

WHAT WAS THE OUTCOME?

The new applications were made available to a broader audience for evaluation and possible further development as tools that can be integrated into Caltrans daily operations. Each application website, which was built using a combination of off-the-shelf and custom software, went through several cycles of testing and deployment as new requirements were added. Testing revealed that including the map-based search application did not meet the needs of the customers who were more interested in the actual applications rather than the raw data upon which they are based. As a result, the final CTMLabs website includes common web applications, together with application websites that represent technology transfer deployments carried out at the CTMLabs research center.

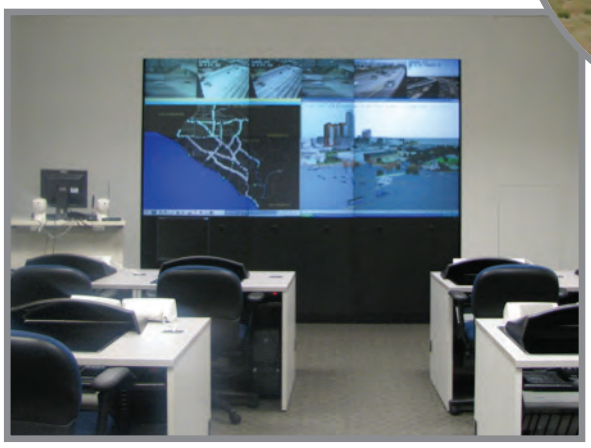
WHAT IS THE BENEFIT?

CTMLabs tests and evaluates emerging ITS products and services prior to wide-scale deployment and extensive resource expenditures. CTMLabs is built on the technical expertise and institutional relationships developed over time to transform research products from the lab to a real-time field operational setting. The CTMLabs work benefits Caltrans by developing and moving the products of DRISI's traffic management research to operational status, as well as providing training to Caltrans traffic management personnel.

LEARN MORE

www.ctmlabs.net

Video cameras and loops at the Sand Canyon overcrossing at the I-405 detector testbed



CTMLabs UC Irvine training facility

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER LIFELINES PROGRAM

The PEER–Lifelines program is a partnership between lifeline providers that share a common interest in improving the characterization of seismic hazards. PEER is a multi-institutional research and education center focused on the development of performance-based earthquake engineering methods and design tools.

The program's mission is to better characterize potential threats due to severe ground shaking, fault rupture, soil liquefaction, and tsunami inundation.

WHAT IS THE NEED?

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 roughly an equal number of local agency–owned bridges face that seismic risk. Caltrans' priority is to protect life safety and ensure that the roadways and bridges can support emergency response and regional recovery efforts. To achieve these goals economically, an accurate characterization of the potential threats is necessary. Some locations are more vulnerable than others because of their proximity to active faults or poor soil conditions, so an improved understanding of where these high-risk locations are and how large the seismic demands might be allows for more-focused and cost-effective mitigation efforts.

WHAT IS THE GOAL?

The Lifelines program seeks to develop statistical models that characterize earthquake-related hazards and incorporate these models into Caltrans design procedures to advance cost-effective mitigation strategies.

WHAT DID THEY DO?

Ground-shaking hazards
The Lifelines program updated the next generation attenuation (NGA) ground-motion prediction equations that were developed by Lifelines in 2008. Since the development of the original NGA models, several large magnitude earthquakes occurred that were well recorded, providing an opportunity to improve the NGA models. NGA-2 also addressed the need for models to predict the vertical component of ground motion as well as near-fault ground motion and the potential for ground motion to be larger in some directions than others.

Tsunami hazards
Until recently, assessing the potential threat of tsunamis on a particular bridge relied on inundation maps developed for emergency planning purposes. While these maps are appropriate for selecting evacuation routes, they do not reflect how waves of a particular size are to occur and the risks involved. To address this lack of information, the Lifelines Program developed a methodology for calculating tsunami hazards using a similar probabilistic framework for ground-shaking hazards and produced a probabilistic tsunami hazard mapping of the California coastline. The mapping was performed in partnership with the California Geological Surveys Tsunami Hazard Program.

Input for time-history analysis
With the advancement of structural analysis software, it is easier to perform time-history analysis of our bridge structures, regarded as the most accurate representation of a bridge's behavior. Time-history analysis requires ground-motion records that represent the seismic hazard for a particular location. Although Lifelines has developed tools for selecting earthquake records, a common problem is the lack of large magnitude records to select from as well as the need to consider pulse type records that might occur at locations near an active fault. Lifelines is developing methods to create synthetic earthquake records that will be indistinguishable from "real" records and be suitable for time-history structural analysis.

WHAT WAS THE OUTCOME?

The NGA-2 models were completed and released for review by the seismological and engineering community in May 2013. Following review, these models will be incorporated into the next release of National Hazard Maps (2015) and incorporated into the next version of ARS Online.

The California coastline tsunami hazard mapping was completed in October 2013 and has been incorporated into Caltrans Earth for use by design staff.

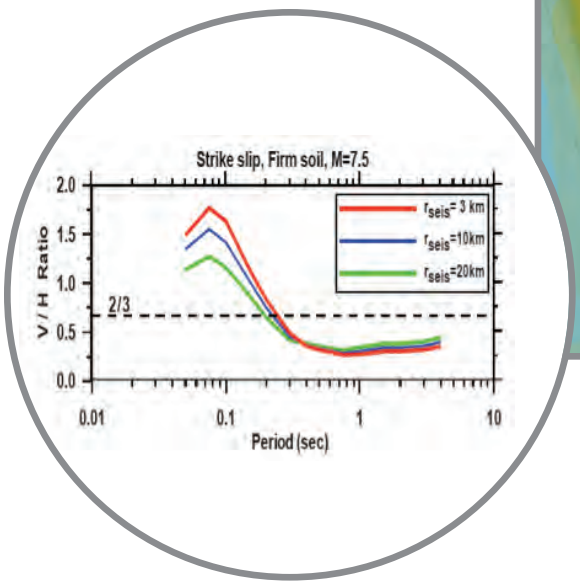
The first synthetic ground-motion model, suitable for locations beyond 20 km from a fault, was completed in May 2011. Improvements to this model and additional application to near-fault locations is ongoing, with expected completion in June 2014.

WHAT IS THE BENEFIT?

The PEER–Lifelines program's efforts to better characterize seismic hazards enables Caltrans' seismic mitigation spending to be smart, well focused, and cost effective.

LEARN MORE

http://peer.berkeley.edu



Ratio of vertical to horizontal response spectra (Bozorgnia)

975-year tsunami hazard (San Diego)

PARTNERS FOR ADVANCED TRANSPORTATION TECHNOLOGY

PATH, a research and development center at the University of California, Berkeley Institute of Transportation Studies, is a leader in Intelligent Transportation Systems (ITS) research. In close collaboration with Caltrans, PATH executes a diverse portfolio of multidisciplinary transportation research projects with its staff, UC Berkeley faculty, and students.

PATH's mission is to develop solutions that address the challenges of California's surface transportation systems through advanced ideas and technologies, with a focus on deploying these solutions throughout California.

WHAT IS THE NEED?

The PATH research center is a critical component in the statewide ITS research program, focusing on improving mobility and safety with advanced ideas, technologies, and deployment. PATH provides Caltrans the tools needed to meet its safety and mobility goals by conducting leading-edge research, evaluating and conducting controlled experiments and field operational tests, and developing public, private, and academic partnerships using the expertise of knowledgeable and experienced ITS research staff.

WHAT IS THE GOAL?

PATH develops solutions to the problems of California's surface transportation systems through cutting-edge research. It harnesses the knowledge of transportation researchers and works in conjunction with experts in the fields of information technology, electrical engineering, mechanical engineering, economics, transportation policy, and behavioral studies.

WHAT DID THEY DO?

During FY 12/13, PATH research center staff provided continuous expert advice and technical support in developing new research concepts in accordance to Caltrans' strategic research plan and research directions. Some of the activities that PATH was involved in include:

- Led field operational tests evaluating travelers' responses to real-time traveler information, collision warning, and vehicle assist and automation systems using bus drivers and drivers from the general public. PATH has managed the acquisition, archiving, and confidentiality of driver data while making it accessible to researchers who need to analyze the data to identify important aspects of driver behavior. These projects have covered diverse applications with different requirements, such as forward collision warnings for bus drivers, cooperative adaptive cruise control, intersection decision support and collision warning, and alerts about slow traffic ahead.
- Managed technical reporting system and publications, and prepared the following reports:
    - > Annual status of research
    - > PATH biannual report
    - > Intellimotion newsletters
- Identified synergistic ventures between state- and national-level research programs in ITS, and solicited and secured external funding from both public and private sources (nationally and internationally) to leverage Caltrans core research project resources. PATH served as a liaison between Caltrans staff and other agencies at the local, national, and international level, and presented ongoing and completed ITS research. These meetings included the U.S. Department of Transportation (DOT), California Department of Motor Vehicles (DMV), Google, the ITS joint program office, as well as Ford, Nissan, Hyundai, Nokia, INRIA, IFSTTAR, University of Alberta, Tsinghua University, Los Angeles County MTA, Contra Costa Transit Authority, and Rensselaer Polytechnic Institute. Some highlights from these ventures include:
    - > Multiple meetings with international visitors from France, Canada, Japan, and China regarding future research cooperation, as well as hosting post-doctoral researchers at PATH.
    - > Meetings with domestic technology providers about opportunities to collaborate in the Caltrans Connected Corridors pilot demonstration project. Prominent among these meetings was Nokia and data supplier company Navteq.

  - > Meetings with the DMV and Google's automated vehicle project in terms of DMV obligations to license these vehicles and their operators for open road use. PATH delivered a presentation on the experience and developed concept papers and a proposal for DMV consideration.
  - > Participation in a webinar reviewing the U.S. DOT's INFLO (Intelligent Network Flow Optimization) project, which is defining connected vehicle applications for improving highway mobility.
  - > Demonstrations of research results regarding cooperative adaptive cruise control (Nissan, DOT, Caltrans)
  - > Participation in the ITS World Congress, providing opportunities to meet with international participants as well as U.S. DOT representatives to learn about international trends in the ITS arena.
- Participated in committees, conferences, and review boards on ITS topics, and interacted with staff from local, state, and federal agencies, such as ITS California, ITS America (including National Rural ITS), and the Transportation Research Board, as well as private entities, to prepare proposals to leverage research funding.
- Worked with communication technologies for vehicle control, traffic mobility, and safety applications. PATH implemented the first U.S. Dedicated Short Range Communication (DSRC) hotspots and the first DSRC corridor testbed under the auspices of the California Vehicle Infrastructure Initiative project. PATH actively continued conducting research in vehicle-vehicle and vehicle-infrastructure systems in cooperation with the Institute of Electrical Engineers and Society of Automotive Engineers, and participated in standardization activities associated with DSRC and the International Organization for Standardization for collision warning and control assistance systems. PATH designed and experimentally implemented the original cooperative collision warning system for General Motors.
- Focused on advancing state-of-the-art traffic management and traveler information systems, producing results that can be implemented in the field. One system that has received heightened attention is active traffic management control strategies that can contribute to improved traffic performance using strategies such as variable speed limit, variable speed advisory, coordinated ramp metering, and dynamic routing in case of incidents.
- Organized numerous research summits and end-of-project presentations.

WHAT WAS THE OUTCOME?

The successful partnership between PATH and Caltrans enables Caltrans to look for new and creative ways to enhance the performance of its complex transportation system through state-of-the-art research and by moving the findings out of the lab and into the field.

WHAT IS THE BENEFIT?

Caltrans benefits from PATH's multidisciplinary research program, which includes ITS research. Working closely with Caltrans staff, PATH was instrumental in identifying potential synergistic ventures between state and national research programs, soliciting and securing external funding from a variety of sources to leverage the core research support funded by Caltrans, providing outreach, and serving as a liaison between Caltrans and other agencies.

LEARN MORE

www.path.berkeley.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, chemistry, and others, with research programs at both the University of California, Berkeley and UC Davis. It conducts leading-edge research, providing expertise in pavement-related issues and assisting Caltrans in meeting its stewardship and delivery goals.

UCPRC's mission is to provide leading-edge research by evaluating and conducting controlled field and laboratory experiments and deliver Caltrans expertise in pavement-related issues.

WHAT IS THE NEED?

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. The UCPRC is a multi-disciplinary, multi-campus research program that provides expertise in areas that Caltrans requires in order to maintain this critical transportation infrastructure.

WHAT IS THE GOAL?

Goals for the center include implementing mechanistic-empirical design; improving pavement performance; incorporating recycling and sustainability; developing quieter pavements; improving construction practices and project delivery; implementing smoothness; improving preservation; and developing a pavement management system.

WHAT DID THEY DO?

Mechanistic-Empirical Design

The UCPRC developed and helped implement two flexible (asphalt) pavement design computer programs, CalBACK and CalME, which model pavements based on engineering mechanics (mechanistic) and observed (empirical) California conditions and materials. CalBACK calculates the stiffness of the underlying layers from falling weight deflectometer tests through back calculation. CalME is a pavement design software that takes the back calculation results and determines strategies to replace the existing roadway based on the criteria that the engineer sets, such as design life and recycling. CalME can also analyze pavements for preservation, new pavement designs, and forensic investigations. The programs reflect Caltrans' 2005 decision to pursue mechanistic-empirical methods and the February 2012 Issue Memo, *Transition to Mechanistic-Empirical (ME) Flexible Pavement Design*. UCPRC's research and development was pivotal to achieving these Caltrans goals.

Improving Pavement Performance

UCPRC developed long-life strategies for flexible and rigid pavements using ME design, applying performance-related specifications, and validating with Heavy Vehicle Simulator (HVS) testing. Developing long-life flexible pavement has led to a transitioning (in progress) from the traditional Caltrans asphalt mix design method to Superpave methods (the new national mix design method, the first major change in the Caltrans asphalt mix design procedure in 40 years.

Recycling and Sustainability

- UCPRC developed a Lifecycle Analysis framework for evaluating environmental, cradle-to-grave aspects of pavement-related products and processes.
- Analysis, laboratory, and HVS testing validated the specifications for asphalt mixes using recycled tires.
- Laboratory and HVS testing provided the data for developing guidelines for using foamed asphalt to recycle the full-depth of flexible pavements.

Quieter Pavements
For several years, the UCPRC has collected the data needed for the Caltrans Quieter Pavement Policy by monitoring noise and pavement performance. Monitoring is ongoing on flexible and rigid pavements and bridge decks to update the policy and validate models for predicting changes in noise levels over time.

Construction Practices and Project Delivery
- UCPRC tested the constructability and short-term effects of warm mix asphalt in terms of pavement rutting and moisture sensitivity in pilot projects.
- It developed the CA4PR (Construction Analysis for Pavement Rehabilitation Strategies) construction productivity and scheduling software using Caltrans construction data. CA4PRS enables comparison of alternatives to reduce traffic delay, shorten construction schedules, and reduce costs.
- Data was collected from field and HVS studies for improving subgrade stabilization.

Smoothness
For several years, researchers measured pavement data at field sections that involved many types of construction to develop a California smoothness specification. Updates to the smoothness specification and Caltrans evaluation of industry concerns about the specification will be enabled from ongoing monitoring and studying the effects of pre-overlay treatments on subsequent pavement smoothness.

Preservation
The UCPRC developed new design and analysis models for thin overlays for pavement preservation by evaluating field projects, laboratory testing, and HVS test results. Data was collected from field and laboratory studies for flexible overlays using terminal blend rubber for preservation. Evaluating the variability of materials in different locations around California is part of the ongoing study.

Pavement Management System
Development of a new Caltrans Pavement Management System is a major ongoing project for UCPRC and includes the following:
- Development of the engineering configuration for the new pavement management system software, PaveM, by working closely with Caltrans engineers and managers and with a software consultant. Results include decision trees, pavement treatments, performance models, and benefit equations. UCPRC is updating the engineering configuration as new data becomes available.
- Statements of work and contract requirements for establishing the baseline of pavements through Ground Penetrating Radar (GPR) and ongoing Automated Pavement Condition Surveys (APCS). UCPRC developed new methods and provided quality assurance in both contracts and is providing ongoing support. UCPRC also provided essential data for Finance Letter FL #06, which led to initiating development of a new pavement management system.
- New performance models for the new pavement management system.

The FHWA software RealCost calculates the lifecycle costs associated with pavements, but had gaps that required evaluation and improvement before it could be used for Caltrans projects. UCPRC developed additional algorithms and spreadsheets for estimating costs. Data was collected and incorporated into the *Life-Cycle Cost Analysis Procedures Manual* for Caltrans. Updates of the manual and the RealCost software for project-level analysis is ongoing based on feedback from existing versions, new analysis using ME design programs, and pavement management system data.

WHAT WAS THE OUTCOME?

Mechanistic-Empirical Design
Projects on I-5 and I-80 have been designed using CalBACK and CalME, and training of Caltrans District engineers is complete. For information on the ME software, visit *www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/Software.html*.

Improving Pavement Performance
Long-life strategies for flexible and rigid pavements have been constructed in several Caltrans Districts. The strategies have also been incorporated into the Caltrans *Life-Cycle Cost Analysis Procedures Manual* (*www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/LCCA_index.html)*.

Recycling and Sustainability
The Life-Cycle Analysis framework helps evaluate the cradle-to-grave aspects of pavements. UCPRC assisted in designing the specifications for asphalt mixes using recycled tires. It also developed guidelines for using foamed asphalt for full-depth recycling of flexible pavements (*www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/PDF/FDR-FA_Design_Guide_06-05-12_final.pdf*).

Quieter Pavements
New, quieter, and more durable asphalt mixes for pavement surfaces were developed. Caltrans Structures Bridge Deck Texture Policy was established with data from bridge decks that was collected during field noise measurement studies.

Construction Practices and Project Delivery
An acceptance process for new warm mix asphalt products was developed based on pilot projects and by UCPRC working with a joint Caltrans and industry task group.
- CA4PRS has been implemented on several major projects in different districts. Training has been provided to several districts and is available online. The software, which continues to be enhanced, has been implemented by the FHWA for use nationwide.
- UCPRC, in conjunction with Cal Poly San Luis Obispo and California State University Long Beach, developed guidelines for subgrade stabilization. For information about the pavement software, see *www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/Software.html* or *www.fhwa.dot.gov/research/deployment/ca4prs.cfm.*

Smoothness
Current Caltrans specifications for smoothness were developed with data measured by UCPRC. A California smoothness calibration process involving testing the operators and the equipment was established through ongoing development at UCPRC.

Preservation
- New design and analysis models for thin overlays for pavement preservation have been incorporated into the ME design computer program, CalME. Models to design pavements using recycled rubber tires are included.
- New specifications for flexible overlays using terminal blend rubber for preservation were developed and will be implemented soon.

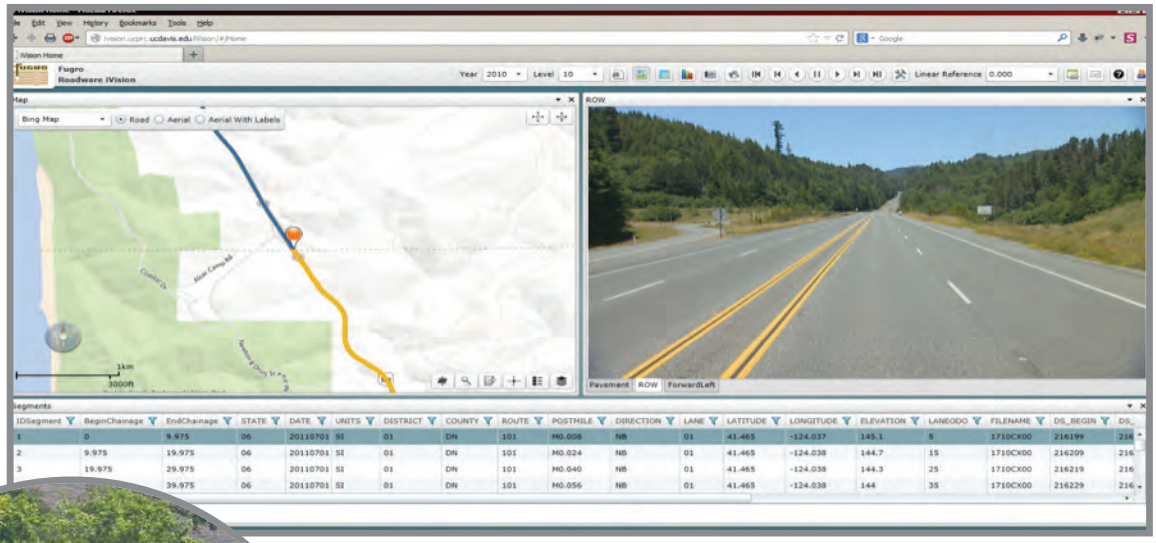
Pavement Management System
- PaveM, a functioning pavement management system, has been implemented and training is currently being conducted in the districts. The statewide GPR collection effort has been completed, and the data is displayed through the web-based program, iGPR. The Automated Pavement Condition Survey (APCS) has two years of data that have been uploaded to PaveM.
- The Caltrans version of RealCost has been implemented, and training sessions for the districts have been completed. The *Life-Cycle Cost Analysis Procedures Manual* has been developed and distributed with the RealCost training. To view the manual, go to *www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/LCCA_index.html*.

WHAT IS THE BENEFIT?

The UCPRC provides the expertise to improve Caltrans construction, maintenance, and management of its pavement infrastructure. Four long-life asphalt pavement jobs have been constructed in California using the ME design codes and the LCCA analysis. Other states and countries are currently evaluating the ME codes for their use. The Life Cycle Analysis work is being incorporated within the FHWA Sustainability Highways Initiative. The construction software CA4PRS is a featured FHWA software tool and available to all states. Californians will enjoy smoother highways because a smoothness specification is required of all paving jobs. All equipment for measuring smoothness will be required to be certified at the Caltrans certification center. Funds allocated to highways will be optimized as a result of the new pavement management system that is being rolled out to the districts. Pavement engineers can evaluate various budget scenarios to better improve our highways in an efficient manner.

LEARN MORE

www.ucprc.ucdavis.edu



iVision software for the APCS

Foamed asphalt recycling project

University Transportation Centers

UNIVERSITY OF CALIFORNIA TRANSPORTATION CENTER

The University of California Transportation Center (UCTC) is a multi-campus organization headquartered at the University of California, Berkeley that carries out basic and applied research. UCTC's mission is to advance U.S. technology and expertise through the mechanisms of education, research, and technology transportation, with a focus on environmental sustainability, economic competitiveness, and livability and the connections between them.

WHAT IS THE NEED?

The UCTC is a consortium of six University of California campuses (Berkeley, Davis, Irvine, Los Angeles, Riverside, and Santa Barbara) and four California State University affiliate members (Pomona, Sacramento, San Bernardino, and San Luis Obispo). UC Berkeley leads the consortium, which was awarded a $3.4 million Region IX grant from the United States Department of Transportation (U.S. DOT). The UCTC focuses on environmental sustainability, economic competitiveness, and livability, and the connections between them. Although advancing each of these objectives is important in and of itself, the UCTC recognizes that the three areas are intertwined and often co-dependent. This investment will lead to important research that is relevant to the multitude of contemporary policy and technological challenges that the transportation sectors of California and other southwestern states face.

WHAT IS THE GOAL?

The UCTC aims to be the go-to organization for federal modal administrations, California agencies, and policymakers throughout Region 9 seeking well-informed advice, carefully designed research investigations, and rapid-response studies on these and related topics.

WHAT DID THEY DO?

Over the years, the UCTC has performed a variety of research projects on behalf of Caltrans by supporting the activities of the Divisions of Mass Transportation and Rail and Transportation Planning. This report highlights a few of the research projects accomplished.

Performance Measures for Complete Streets
www.dot.ca.gov/hq/tpp/offices/ocp/complete_streets.html
Because of this research, two important actions were taken in California in 2008: Assembly Bill 1358, The Complete Streets Act, was passed by the state legislature, and Caltrans issued Deputy Directive 64-R1, The Complete Streets - Integrating the Transportation System. Both actions require that facilities for walking and bicycling be provided on all roadways owned and maintained by Caltrans, excluding limited-access facilities.

Providing safe mobility for all users, including motorists, bicyclists, pedestrians, and transit riders, contributes to the Caltrans mission and vision of "Improving Mobility Across California."

Long-term implementation of this policy is intended to result in:

- More options for people to go from one place to another
- Less traffic congestion and greenhouse gas emissions
- More walkable communities with healthier, more active people
- Fewer barriers for older adults, children, and people with disabilities

Economically, Complete Streets can help revitalize communities, and they can give families the option to lower transportation costs by using transit, walking, or bicycling, rather than driving to reach their destination. Caltrans is actively engaged in implementing its Complete Streets policy in all planning, programming, design, construction, operations, and maintenance activities and products on the state highway system.

WHAT WAS THE OUTCOME?

The research findings point to a number of safety and mobility issues to consider when promoting Complete Streets. They include:

- Wider travel lanes are associated with higher driving speeds, which are associated with more accidents and severe injuries.
- Eighty-five percent of pedestrian fatalities occur on non-local streets, such as arterials and collectors.
- Urban arterials with "main street" characteristics have a lower number of pedestrian injuries than those with a commercial strip character.
- Pedestrian countdown signals encourage safer crossing behaviors.
- Pedestrian safety increases when more pedestrians are present.
- Pedestrians' perceived levels of service decrease as the width of driveway intersection crossings and the amount of traffic on adjacent roadways increase.
- The presence of bicycle facilities directly increases the percentage of bicycle commuters.
- Perceptions of cycling safety increases with every additional mile of bicycle lane in a city.
- A highly connected bicycle network is positively associated with the number of bicyclists in a city.

WHAT IS THE BENEFIT?

The research evidence, plus a review of best practices, suggests that Caltrans' Complete Streets efforts should focus on urban arterials and key objectives, including reducing pedestrian and bicyclist injury and fatality rates; reducing the number of pedestrian and bicycle collision hotspots; increasing the perceived safety of walking and biking; designing urban arterial projects in accordance with Complete Streets principles; increasing the number of Caltrans personnel knowledgeable about and trained in Complete Streets.

Other UCTC research includes:

- Traffic Impacts of Variable Pricing on the San Francisco–Oakland Bay Bridge, California
  www.uctc.net/research/papers/UCTC-FR-2013-02.pdf
- Multimodal Travel and the Poor: Evidence from the 2009 National Household Travel Survey
  www.uctc.net/research/papers/UCTC-FR-2013-08.pdf
- Bike-and-Ride: Build It and They Will Come
  www.uctc.net/research/papers/UCTC-FR-2012-16.pdf
- Up in the Air: Urban Design for Light Rail Stations in Highway Medians
  www.uctc.net/research/papers/UCTC-FR-2012-06.pdf
- Getting the Prices Right: An Evaluation of Pricing Parking by Demand in San Francisco
  www.uctc.net/research/papers/UCTC-FR-2013-03.pdf

LEARN MORE

www.uctc.net

MINETA NATIONAL TRANSIT RESEARCH CONSORTIUM

The Mineta National Transit Research Consortium (MNTRC) consists of nine universities, led by San Jose State University's (SJSU) Mineta Transportation Institute (MTI), to carry out transit-related research. The center's mission is to advance U.S. transit technology and expertise through the mechanisms of education, research, and technology transfer with a focus on transportation policy, technology, and management issues.

WHAT IS THE NEED?

In January 2012, the MTI was selected as the lead institution for a nine-university transit consortium funded by the Federal Transit Administration (FTA) via the Research and Innovative Technology Administration of the United States Department of Transportation (U.S. DOT) and tasked with delivering solutions that improve public transportation. The new organization became the MNTRC. The other eight universities are Bowling Green State University, Grand Valley State University, Howard University, Penn State University, Rutgers University, University of Detroit Mercy, University of Nevada Las Vegas, and University of Toledo.

WHAT IS THE GOAL?

The MNTRC's goal is to expand and synergize each partner's unique abilities and expertise to respond collectively to national transit-related research needs. The MNTRC conducts research to meet the U.S. DOT's strategic goals of safety, state of good repair, economic competitiveness, livable communities, and environmental sustainability.

WHAT DID THEY DO?

2012 Census of California Water Transit Services
The U.S. Bureau of Transportation Statistics conducts a nationwide census of ferryboat operators for the U.S. DOT. The Federal Highway Administration (FHWA) asked the Caltrans Division of Local Assistance to gather data regarding ferry operations under the Moving Ahead for Progress in the 21st Century Act (MAP-21). MAP-21 includes a new formula program for ferryboats and ferry terminal facilities eligible under 23 USC 129(c), which authorizes federal participation in toll roads, bridges, tunnels, and ferries. The research team compiled a spreadsheet and accompanying maps of ferryboats, routes, operators, and related characteristics, such as ownership (public or private), daily trip counts, regulation of fares, terminal locations (street address and coordinates), boarding statistics, and route segment lengths.

To view the *2012 Census of California Water Transit Services* report: *http://transweb.sjsu.edu/project/1133.html*

Legislative Implementation Assistance for the MAP-21 FTA 5310 Program
FTA Section 5310, Enhanced Mobility of Seniors and Individuals with Disabilities program, will have new percentages and splits under MAP 21 that could impact how it is administered: 60% to a large urbanized area (UZA), 20% to a small UZA, and 20% to rural, with large UZAs given the option to be designated recipients with the state's concurrence. The Caltrans Division of Mass Transportation (DMT) administers the FTA Section 5310 program, so they enlisted MTI to initiate and facilitate the necessary statewide discussions with large UZAs and Metropolitan Planning Organizations (MPOs). Questions surrounding this action remain and might dictate the path forward.

Other MNTRC research includes:

- Assessing Importance and Satisfaction Judgments of Intermodal Work Commuters with Electronic Survey Methodology *http://transweb.sjsu.edu/project/1127.html*
- California Voting and Suburbanization Patterns: Implications for Transit Policy *http://transweb.sjsu.edu/project/1105.html*
- Measuring the Performance of Livability Programs *http://transweb.sjsu.edu/project/1126.html*

- What Do Americans Think About Federal Tax Options to Support Public Transit, Highways, and Local Streets and Roads? Results from Year Four of a National Survey
  http://transweb.sjsu.edu/project/1228.html
- Rail Security: Critical Insights and Applications
  http://transweb.sjsu.edu/project/1261.html

WHAT WAS THE OUTCOME?

The ferryboat data can be linked to Caltrans Earth software for further analysis. Where relevant, the report includes a brief description of the expansion plans of ferry service providers.

The research for the FTA Section 5310 program is ongoing. The Caltrans DMT is collaboratively developing a vision for the administrative deployment of the large UZA apportionment, determining and developing formal template documents, memorandums of understanding, and other agreements that might need to be deployed beginning in the 2014 federal fiscal year. At least one paper will be submitted to a refereed conference. Results of the project will also be disseminated through the MTI website.

WHAT IS THE BENEFIT?

By having comprehensive details about each commuter and non-commuter water transit operator in the state of California, Caltrans was able to respond to the FHWA's request for information regarding water transit service in the state.

Due to the changing nature of FTA Section 5310 program funding and the continued "devolution" of FTA funding from states to MPOs, this project could be of substantial benefit to states and regional governments across the nation as they work to make a smooth transition of responsibilities. The structure of this new partnership arrangement could be used as a guide for other states as they adjust to MAP-21's requirements.

LEARN MORE

http://transweb.sjsu.edu/mntrc

Research Task Summary

The Research Task Summary lists selected research tasks completed in FY 2012/13 and scheduled to be completed in FYs 2013/14 and 2014/15 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. Each task lists the Caltrans internal tracking number (Task ID), task title, DRISI manager, and start and end dates. 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 2012/13

Research tasks scheduled to be completed in FYs 2013/14 or 2014/15

Design/Construction

Task ID	Task Title	DRISI Manager	Start Date	End Date	Page #
0645	**Development and Testing of a Low-Profile Barrier**	**Her, Vue**	**2/2/04**	**3/31/12**	**38**
1094	**Effects of Transportation Corridor Features on Driver and Pedestrian Behavior and on Community Vitality**	**Gwynne, Gloria**	**7/1/06**	**6/28/13**	**40**
2405	Evaluate Photo Speed Enforcement in California Work Zones	Ghotb, Hassan	5/31/12	9/30/14	-
0918	Development of Aesthetic, Low-Maintenance Guardrail System Alternatives	Caldwell, Christopher	9/1/05	10/1/14	-

Design/Construction TPF

Task ID	Task Title	DRISI Manager	Start Date	End Date	Page #
2455	Watershed Modeling System License Renewal Agreement, TPF-5(265)	Chung, Haniel	1/9/12	4/30/14	-
2454	Surface-water Model System, TPF-5(266)	Chung, Haniel	1/9/12	6/30/14	-
2294	Enhancements to the FHWA-FST2DH Two-dimensional Hydraulic Model, TPF-5(248)	Chung, Haniel	1/12/11	11/30/14	-

Environmental TPF

Task ID	Task Title	DRISI Manager	Start Date	End Date	Page #
1578	FHWA Traffic Noise Model: Version 3.0 Software and Training, TPF-5(158)	Hunt, Harold	7/1/07	12/31/13	-
1579	Tire/Pavement Noise Research Consortium, TPF-5(135)	Hunt, Harold	7/1/07	12/31/14	-

Geotechnical/Structures

Task ID	Task Title	DRISI Manager	Start Date	End Date	Page #
2416	California State University, Fresno: Seismic Responses of MSE Walls Using Accelerated Alternative Backfill Materials with Recycled Tire Shreds and Lightweight Expanded Aggregates	Lee, Peter	5/16/12	7/16/13	-

Geotechnical/Structures

Task ID	Task Title	DRISI Manager	Start Date	End Date	Page #
2418	University of California, Los Angeles: Comparative Study of Model Predictions and Data from Caltrans/CSMIP Bridge Instrumentation Program: A Case study on the Eureka-Samoa Channel Bridge	Lee, Peter	6/25/12	11/1/13	-
2573	Comparison of Live Load Distributions on Underground Structures between Design Truck and Design Tandem in HL93	Lee, Peter	3/1/13	12/31/13	-
2578	Calibration of LRFD Geotechnical Axial (Tension and Compression) Resistance Factors for Driven Piles and Drilled Shafts	Lee, Peter	3/1/13	12/31/13	-
2577	Soil-Structure Interaction Factors for Underground Structures using Caltrans Standard Installations	Lee, Peter	3/1/13	12/31/13	-
2574	Investigation of the Condition of Multi-Span Post-Tensioned Box Girder Tendons	Lee, Peter	3/1/13	12/31/13	-
2572	Experimental Studies for Box Girder General Anchorage Zone Reinforcing	Lee, Peter	3/1/13	12/31/13	-
2122	California Permit and Fatigue Truck Load Development and Calibration	Sah, Kamal	7/22/11	4/30/14	-
1946	Enhancement of National Load and Resistance Factor Design Codes for California Bridge Design: Hinge Curl Research	Sah, Kamal	7/11/11	6/1/14	-
1944	Integrated Guidelines for Extending Service Life of Bridge Decks	Sikorsky, Charles	7/1/11	6/30/14	-
2346	Control of Shrinkage Cracks in HPC Bridge decks	Sikorsky, Charles	4/20/11	6/30/14	-
1929	Pacific Earthquake Engineering Research Center (PEER) - Lifeline Partnership Phase 3	Shantz, Tom	1/4/11	6/30/14	-
2107	Nondestructive Damage Evaluation of Viscous Dampers, Lead Rubber Bearings and Friction Pendulum Bearings	Sikorsky, Charles	7/1/10	7/31/14	-
2489	Passive Force-Displacement Relationships for Skewed Abutments, sol. 1312	Sikorsky, Charles	3/20/12	9/30/14	-
2493	Interaction of MSE Abutments with Superstructures Under Seismic Loading (Phase I)	Sikorsky, Charles	1/9/12	11/30/14	-
2129	Pilot Field Deployment of the Fiber Reinforced Polymer Composite Snaplock Sign Structure	Sikorsky, Charles	12/1/10	12/30/14	-
2109	Calibration of the Comite Euro-International du Beton Equations for Creep and Shrinkage Prediction to Improve the Bridge Design	Sikorsky, Charles	7/1/10	12/31/14	-
2316	Steel Girder End Panel Shear Resistance	Sikorsky, Charles	12/1/11	12/31/14	-
2342	Creep and Shrinkage Effects On Columns	Sikorsky, Charles	4/20/11	12/31/14	-
2181	Compliance Crash Testing of the Caltrans Type 26 Bridge Rail (732SW)	Whitesel, David	2/3/12	12/31/14	-
2111	Geophysical Methods for Determining the Geotechnical Engineering Properties of Earth Materials	Owen, Bill	4/1/13	3/31/15	-
2560	Evaluate the Development Length for Headed Steel Reinforcing Bars	Sikorsky, Charles	2/1/13	4/30/15	-
2540	Experimental Validation of Soil Arching for Retaining Wall Pile Foundations	Sikorsky, Charles	11/9/12	5/29/15	-
2426	Lateral Load Tests of an Existing Large CISS Shafts Embedded in Soft Clay at 5th Avenue OH Viaduct in Oakland CA	Sikorsky, Charles	6/1/12	5/30/15	-
2456	Bridge Strong Motion Instumentation	Hipley, Pat	6/29/12	6/28/15	-
1805	Corridor-Scale Landslide Hazard Mapping: Conversion of CGS Hazard Maps	Roblee, Cliff	7/1/11	6/30/15	-

Geotech TPF

Task ID	Task Title	DRISI Manager	Start Date	End Date	Page #
0366	**Updating "A Guide to Standardized Highway Lighting Pole Hardware," front funded (formerly SPR-3(103)), TPF-5(002)**	**Buendia, Robert**	**1/1/90**	**12/31/12**	**42**
2024	Enhancement of Welded Steel Bridge Girders Susceptible to Distortion-Induced Fatigue, TPF-5(189)	Lee, Peter	7/1/08	8/31/13	-
0260	Soil Mixing Methods for Highway Applications, TPF-5(001)	Jang, David	7/1/01	9/30/13	-
1010	Structural Acoustic Analysis of Piles, TPF-5(140)	Hunt, Harold	9/14/05	12/31/13	-
2347	Imaging Tools for Evaluation of Gusset Plate Connections in Steel Truss Bridges, Sol - 1302, TPF-5(259)	Johnson, Michael	4/20/11	6/30/14	-
2401	Shaking Table Testing to Evaluate Effectiveness of Vertical Drains for Liquefaction Mitigation, TPF-5(244)	Shantz, Tom	7/7/11	6/30/14	-
1729	In-Situ Scour Testing Device, TPF-5(210)	Ng, Steve	1/1/08	9/30/14	-
2403	Bridge Pier Scour Research, TPF-5(211)	Flora, Kevin	10/19/11	12/31/14	-

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1103	**Research, Identify, and Implement How to Reduce Trash on the Roadside**	**Meline, Bob**	**8/1/07**	**9/30/12**	**44**
1723	**Validation of Rehabilitation Strategies to Extend the Service Life of Concrete Bridge Decks**	**Sahs, Steve**	**10/1/08**	**6/30/13**	**46**
2249	**Evaluation of COZEEP and MAZEEP Officers Use in Caltrans Construction and Maintenance Work Zones**	**Ghotb, Hassan**	**7/8/11**	**9/30/13**	**48**
2248	**Hydrogen Fuel Cell Powered Lighting Trailer Evaluation**	**Ghotb, Hassan**	**1/1/11**	**9/30/13**	**50**
1535	First Responder Support Systems Testbed (FiRST)	Gerges, Ramez	6/3/07	11/29/13	-
2215	Deployment Support and Caltrans' Implementation of the Sealzall Machine	Lofton, Arvern	7/1/10	12/31/13	-
2220	Evaluation and Development of High Flow Vacuum Systems for Roadway and Roadside Litter Collection	Lofton, Arvern	7/1/10	6/14/14	-
2338	Continued Evaluation of Pothole Patching Equipment, Materials and Processes	Lofton, Arvern	7/1/12	6/14/14	-
1810	Field Operations for GPS assisted Winter Maintenance Vehicles	Baumeister, Larry	6/29/09	9/28/14	-
2337	Tioga 120 Pass Clearing (Eastern Side)	Baumeister, Larry	12/15/11	9/30/14	-
2299	Mobile Real-Time Information System for Snow Fighter Supervisors—System Design and Test	Nguyen, Ha	5/24/12	11/30/14	-
2335	Improved Deicing Methods for Snow and Ice Removal: Epoke Evaluation	Baumeister, Larry	4/1/12	12/14/14	-
2543	Validation of Polyester Concrete Rehabilitation Strategy to Extend the Service Life of Concrete Bridge Decks	Sahs, Steve	7/1/13	6/30/15	-

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1050	Underwater Inspection of Bridge Substructures Using Underwater Imaging Technology, TPF-5(131)	Johnson, Michael	11/30/05	6/30/14	-
2473	Clear Roads Winter Highway Operations, TPF-5(218)	Baumeister, Larry	5/18/12	9/30/14	-

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1910	**Planning Tool for Airport Access Phase II**	**Law, Frank**	**5/1/11**	**5/15/13**	**52**
2274	BART Air Freight Phase 2	Hanson, Matt	11/15/10	10/31/13	-
2508	Field Operational Tests of Vehicle-Assist and Automation System Using Full-size Public Transit Buses	Sun, Sonja	6/1/12	5/31/14	-
1912	Bay Area Airport Disaster Recovery Plan	Tyner, Patrick	6/1/12	5/31/14	-
2333	BRT Person Throughput-Vehicle Congestion Tradeoffs	Mizuno, Bradley	6/25/12	11/24/14	-
2461	Smart Travel Choices—Field Operational Tests	Sun, Sonja	12/21/12	12/31/14	-
2499	Pricing Your Way to Operational Efficiency: One-Way Electric Vehicle Carsharing in San Diego	Justice, Robert	5/18/12	5/30/15	-

Pavement

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1874	**Laboratory Evaluation of Thin and Modified Asphalt Overlay Mix Design Procedures, SPE No. 4.21**	**Holland, Joe**	**7/1/08**	**10/31/11**	**54**
1886	**Extended Applications of Rehabilitation Construction Productivity Analysis Products (CA4PRS), SPE No. 3.11**	**Lim, David**	**7/1/08**	**10/31/12**	**56**
2385	**PPRC11 SPE 4.41.2: Laboratory and Accelerated Pavement Testing of Gap-Graded Rubberized Mixes (Hot Mix Asphalt and Warm Mix Asphalt) for the Department of Resources Recycling and Recovery (CalRecycle)**	**Holland, Joe**	**5/17/11**	**5/15/13**	**58**
2362	**PPRC11 SPE 3.25: Improved Methodology for Mix Design of Open-Graded Friction Courses**	**Sadraie, Hamid**	**5/1/12**	**6/30/13**	**60**
2482	PPRC11 SPE 4.44: Pilot Study Investigating the Interaction and Effects for State Highway Pavements, Trucks, Freight, and Logistics	Nokes, Bill	1/31/12	8/31/13	-
2603	PPRC11 SPE 4.44: Pilot Study Investigating the Interaction and Effects for State Highway Pavements, Trucks, Freight, and Logistics (continuing from Task 2482)	Nokes, Bill	1/31/12	8/31/13	-
2558	PPRC11 SPE 4.45: Rubber Binder Testing and Acceptance	Sadraie, Hamid	3/1/13	3/1/14	-
2550	PPRC11 SPE 4.47: Chip Seal Project in San Luis Obispo	Holland, Joe	2/4/13	3/3/14	-
2261	Hauling the Caltrans' Heavy Vehicle Simulators	Rodriguez, Alfredo	6/11/12	6/10/14	-
2354	PPRC11 SPE 3.28: Complete QA on Automated Pavement Condition Survey and GPR contracts	Holland, Joe	11/1/11	6/30/14	-
2380	PPRC11 SPE 3.21: Implementation of New Quieter Pavement Research	Lim, David	11/1/11	6/30/14	-
2601	PPRC11 SPE 3.21: Implementation of New Quieter Pavement Research (Continuing from Task 2380)	Lim, David	11/1/11	6/30/14	-
2371	PPRC11 SPE 3.20: Life-Cycle Cost and Environmental Life-Cycle Analysis for Composite Pavements	Lim, David	11/1/11	6/30/14	-
2352	PPRC11 SPE 4.32: Early-age Cracking Performance	Lim, David	11/1/11	6/30/14	-
2376	PPRC11 SPE 4.37: Use Environmental LCA to Develop Tools and Recommend Practices to Reduce Environmental Impact	Holland, Joe	4/1/12	9/30/14	-
2580	PPRC11 SPE 4.48: Use Environmental LCA to Develop Tools and Recommend Practices to Reduce Environmental Impact (Sustainable Pavements)	Holland, Joe	4/1/13	9/30/14	-

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2500	PPRC11 SPE 3.29: Training Materials for new Pavement Management System	Holland, Joe	5/14/12	9/30/14	-
2364	PPRC11 SPE 3.24: Certification of Inertial Profilers Used in PMS and Construction Monitoring	Holland, Joe	1/2/12	9/30/14	-
2375	PPRC11 SPE 4.39: Monitoring of Selected Quieter Pavement Test Sections	Lim, David	11/1/11	9/30/14	-
2600	PPRC11 SPE 4.39: Monitoring of Selected Quieter Pavement Test Sections (continuing from Task 2375)	Lim, David	11/1/11	9/30/14	-
2310	PPRC11 SPE 4.30: Coefficient of Thermal Expansion in PCC Pavement Design and Specification	Lim, David	11/1/11	9/30/14	-
2374	PPRC11 SPE 4.36: Recycling of Rubberized HMA in RAP and FDR Projects and with Warm Mix Technologies	Sadraie, Hamid	5/1/12	9/30/14	-
2565	PPRC11 SPE 4.46: Blending Effects of Recycled Asphalt Pavements on Virgin Binders	Sadraie, Hamid	4/1/13	9/30/14	-
2356	PPRC11 SPE 3.18: Updated Standard Materials Library	Sadraie, Hamid	7/1/11	9/30/14	-
2357	PPRC11 SPE 3.27: Update Life-Cycle Cost Analysis Manual with New Performance Data	Holland, Joe	11/1/11	12/31/14	-
2358	PPRC11 SPE 4.43: Performance Modeling Using New Caltrans PMS Data	Holland, Joe	11/1/11	12/31/14	-
2363	PPRC11 SPE 4.42: Effects of Milling and Other Repairs on Smoothness of Overlays	Holland, Joe	5/1/12	12/31/14	-

Pavement TPF

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0220	**Pavement and Research Technology (4 State Consortium), Pooled Fund SPR-3(074)**	**Samadian, Michael**	**7/7/01**	**12/31/12**	**62**
0768	**Pavement Tools Consortium, A Web-Based Training System, TPF-5(090)**	**Holland, Joe**	**1/1/90**	**6/30/13**	**64**
1134	Design and Construction Guidelines for Thermally Insulated Concrete Pavements, TPF-5(149)	Lim, David	1/1/07	9/30/13	-
0887	Development of Performance Properties of Ternary Mixes; Pooled Fund TPF-5(117)	Buendia, Robert	1/1/90	12/31/13	-
1133	Recycled Unbound Pavement Materials (MnROAD Study), TPF-5(129)	Lim, David	5/25/07	12/31/13	-
2188	Performance of Recycled Asphalt Shingles in Hot Mix Asphalt, TPF-5(213)	Lim, David	2/17/10	12/31/13	-
1583	Consortium of Accelerated Pavement Testing and Technical Exchange Partnership, TPF-5(127)	Holland, Joe	3/30/07	12/31/13	-
0375	Pavement Reconstruction Scheduling Software (CA4PRS), SPR-3(098)	Samadian, Michael	10/1/00	6/30/14	-
2020	Improving the Foundation Layers for Concrete Pavements, TPF-5(183)	Lim, David	6/19/08	6/30/14	-
0570	Improving the Quality of Pavement Profiler Measurement, TPF-5(063)	Rodriguez, Alfredo	9/26/02	9/30/14	-
0231	Pavement Subgrade Performance, SPR-2(208)	Rodriguez, Alfredo	1/1/01	11/30/14	-
1662	Technology Transfer Concrete Consortium, TPF-5(159)	Lim, David	1/9/08	6/30/15	-
2606	PAV TPF: Demonstration of Network Level Pavement Structural Evaluation with Traffic Speed Deflectometer, Sol. 1346	Lee, James	6/3/13	6/30/15	-

Planning/Policy/System Information

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2243	**Spatially Focused Travel Data and Analysis**	**Justice, Robert**	**12/16/11**	**7/30/13**	**68**
2200	Non-Motorized Travel: Analysis of the 2009 NHTS California Travel Survey Add-On Data	Justice, Robert	8/1/11	12/31/13	-
2387	Near-Term Transportation Energy and Climate Change Strategies	Tyner, Patrick	3/27/12	12/31/13	-
2329	Deployment of Prior HOV Lanes Research Results in Developing Analysis Tools for New Managed Lanes Projects	Justice, Robert	4/1/12	3/31/14	-
2430	Field Test of Mobile Survey Project for Data Collection	Mizuno, Bradley	4/1/13	3/31/14	-
2330	Developing a Model to Quantify Emissions from Heavy-Duty Construction Equipment as Related to Job Site Activity Data	Tyner, Patrick	4/30/12	4/30/14	-
1919	Commercialization of Alternative Fuel (E85) Monitoring System	Ibrahim, Majed	9/8/10	6/30/14	-
2432	Evaluation of Mobile Survey Project	Mizuno, Bradley	4/1/14	3/31/15	-
2309	Next STEPs: Scenarios and Transition Strategies	Tyner, Patrick	6/18/12	6/14/15	-

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2260	**Executive Workshops on Strategies and Best Practices for State Departments of Transportation to Support Commercialization of Electric Vehicles and Infrastructure, TPF-5(250)**	**Tyner, Patrick**	**1/1/11**	**12/31/12**	**70**
2300	**2012 Multi-State Transportation Asset Management Implementation Workshop, TPF-5(245)**	**Williams, Scott**	**1/25/11**	**4/30/13**	**72**
2515	2014 Transportation Asset Management Conference and Training on Implementation Strategies, TPF-5(275)	Williams, Scott	8/1/12	1/1/15	-

Right of Way and Land Surveys

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1746	Professional Capacity Building for Communication Systems Phase II	Perez, Jose	6/27/11	10/31/13	-
1846	Responder Study Phase III: Enhancements, Specifications and Deployment	Clark, Melissa	7/1/12	6/30/14	-
1752	COATS Phase V—WTI	Campbell, Sean	9/16/11	8/14/14	-
2328	Hand-Held Diagnostic Controller for ITS Field Maintenance	Campbell, Sean	4/1/13	12/31/14	-
2283	WeatherShare Phase III: Visualization Tools	Campbell, Sean	7/1/12	6/30/15	-

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1759	Rural Traveler Information Needs Assessment and Pilot Study Phase II—Western States Rural Transportation Consortium, Task Order for Task 2246, TPF-5(241)	Campbell, Sean	10/1/11	9/30/14	-

Seismic

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2253	**Utilization of Strong Motion Data for Toll Bridge Damage Assessment**	**Sheng, Li-Hong**	**6/1/08**	**8/31/12**	-
2290	**Seismic Performance of Precast Bridge Columns with Grouted Couplers**	**Lee, Peter**	**7/11/11**	**8/31/12**	**76**
2241	**Strong Motion Instrumentation Program**	**Hipley, Pat**	**12/1/08**	**9/1/12**	**78**
2161	**SC Solutions—Archive Toll Bridge ADINA Models**	**Mitchell, Steve**	**2/1/10**	**12/31/12**	**80**
2270	**Development of Improved Guidelines for Seismic Analysis and Design of Earth Retaining Structures**	**Lee, Peter**	**10/25/10**	**12/31/12**	**82**
2349	**The Effect of Live Load on the Response of Seismic Response of Bridges**	**Kartoum, Allaoua**	**4/27/09**	**1/31/13**	**84**
2041	**Assessment and Reliability of Seismic Response Modification Devices In-Services**	**Sikorsky, Charles**	**7/18/08**	**5/1/13**	**86**
1983	**OSU: Vulnerability of California's Bridges to Tsunamis: Phases I and II**	**Lee, Peter**	**7/1/07**	**5/28/13**	**88**
2189	**Maintain California Bridge Strong Motion Instrumentation Systems**	**Hipley, Pat**	**6/30/10**	**6/1/13**	**78**
2149	**The Feasibility of Using Buckling-Restrained Braces for Long Span Bridges**	**Sikorsky, Charles**	**11/30/09**	**6/30/13**	**90**
2170	**Development of Improved Procedures for Seismic Design of Earth-Retaining Structures on Conventional and Pile Foundations**	**Lee, Peter**	**5/31/10**	**6/30/13**	**92**
2296	**Resilient Bridges: Replaceable Structural Fuses for Post-Earthquake Accelerated Bridge Construction/Repair under Continued Service—Phase I: Analytical Investigation**	**Sikorsky, Charles**	**1/1/11**	**6/30/13**	**94**
2421	Benchmarking Recently Developed Procedures for Designing Pile Foundations in Laterally Spreading Ground	Sikorsky, Charles	11/30/11	11/30/13	-
2176	Seismic Performance of Next-Generation Bridges	Lee, Peter	12/2/09	12/31/13	-
2240	Required Embedment Length of Column Rebar Cage into Type II Shafts	Sikorsky, Charles	1/24/08	12/31/13	-
2179	Repair of Bridge Columns that Suffered Fractured Longitudinal Steel Reinforcement During a Seismic Event	Sikorsky, Charles	6/13/11	3/31/14	-
2266	Guidelines for Nonlinear Seismic Analysis of Ordinary Bridges: Version 2.0	Lee, Peter	5/15/12	5/14/14	-
2264	Development and Verification of Concrete Models for Pier Walls and Hollow Columns (Analytical Phase)	Sikorsky, Charles	10/1/10	5/31/14	-
2291	High-Resolution Seismic Monitoring of Bay Area Bridges	Hipley, Pat	11/1/10	6/30/14	-
2171	The Stiffness Provided by Girders, Decks, and Soffits Framing into Integral Bent Caps	Lee, Peter	6/29/11	6/30/14	-
2425	Nonlinear Lateral Performance of Skew Abutments	Lee, Peter	6/1/12	6/30/14	-
2281	Seismic Design of Column-Footing Connections with Pipe-Pin Hinges for Accelerated Bridge Construction	Lee, Peter	7/11/11	6/30/14	-

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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	6/1/12	6/30/14	-
1793	Deployment and Implementation Support for ShakeCast	Turner, Loren	3/30/11	6/30/14	-
2280	Calibration of Probabilistic Damage Control Approach for Seismic Design of Bridges	Lee, Peter	7/11/11	8/31/14	-
2420	Seismic Assessment of Cut and Cover Tunnels	Sikorsky, Charles	11/30/11	9/30/14	-
2287	Analytical and Experimental Development of Bridges with Foundations Allowed to Uplift During Earthquakes	Lee, Peter	5/1/12	11/30/14	-
2263	Evaluation and Improvement of Design Methods and Details for Shear Keys and Stem Walls in Bridge Abutments	Sikorsky, Charles	10/1/10	11/30/14	-
2419	Efficient Nonlinear Time History Analysis of Ordinary Bridges	Sikorsky, Charles	11/30/11	11/30/14	-
2423	Performance of the Column-to-Shaft Pin Connections in Type-II Shafts	Lee, Peter	6/1/12	12/30/14	-
2265	Seismic Performance of Connections That Facilitate Accelerated Bridge Construction	Sikorsky, Charles	10/1/10	12/30/14	-
2173	Impact of Inspection Tube Placement on Structural Performance of CIDH Piles	Sikorsky, Charles	1/22/10	12/31/14	-
2417	Concrete-Filled Tube Bridge Pier Connections for Accelerated Bridge Construction	Lee, Peter	5/18/12	3/15/15	-
2429	Innovative Method in Determining the Internal Axial Tensile Force in Bridge Eye Bars	El-Azazy, Saad	6/1/12	6/30/15	-

Transportation Safety and Mobility

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1205	**District 8 High Occupancy Vehicle Facility Performance Analysis**	**Nguyen, Tam**	**12/1/08**	**11/30/12**	**98**
1665	**Statewide High Occupancy Vehicle Facility Performance Analysis**	**Nguyen, Tam**	**5/1/09**	**12/31/12**	**100**
2207	**Strategies for Reducing Pedestrian and Bicyclist Injury at the Corridor Level**	**Kwong, Jerry**	**6/1/10**	**5/31/13**	**102**
1546	**C1 Loop Detector Reader/Analyzer**	**Palen, Joe**	**4/23/07**	**6/28/13**	**104**
1726	**Upgrade the Video Vehicle Detector Verification System**	**Slonaker, John**	**6/1/08**	**6/30/13**	**106**
2087	**AR: Bluetooth Travel Time System**	**Palen, Joe**	**3/19/09**	**6/30/13**	**108**
2062	**Augmented Speed Enforcement Part 1 of 2 Western Transportation Institute**	**Nguyen, Ha**	**12/1/09**	**6/30/13**	**110**
2146	**Augmented Speed Enforcement Part 2 of 2 UC Berkeley PATH**	**Nguyen, Ha**	**6/30/10**	**6/30/13**	**112**
1795	**Evaluation of High Potential Areas for Truck Overweights and Accidents**	**Ibrahim, Majed**	**6/15/10**	**9/30/13**	**114**
2272	Field Test the Effectiveness of Adaptive Traffic Control for Arterial Signal Management	Slonaker, John	10/18/11	12/30/13	-

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2223	Coordination of Freeway Ramp Meters and Arterial Traffic Signals Field Operational Test	Mazdiyasni, Paul	4/7/10	12/31/13	-
1940	Trip-Generation Rates Methodology for Smart-Growth Land-Use Projects	Williams, Scott	11/3/08	12/31/13	-
2209	Pedestrian Safety Improvement Program	Kwong, Jerry	6/1/10	3/31/14	-
2302	Action Item 8.09: Develop a Plan to collect Pedestrian Infrastructure and Volume Data for Future Incorporation into Caltrans Accident Surveillance and Analysis System Database	Hassas, Roya	11/1/11	5/31/14	-
2293	Enhancement and Technical Support of Intelligent Roadway Information System in Caltrans Districts 1, 2, 5, and 10	Hassas, Roya	1/1/11	5/31/14	-
1934	Weave Analysis Matrix and Microsimulation Methodology Refinement	Nguyen, Tam	6/1/12	6/13/14	-
2206	Crash Attenuator Data Collection and Life-cycle Tool Development	Her, Vue	7/1/10	6/14/14	-
2245	Quick Clearance for Major Traffic Incidents—Baseline Study	Clark, Melissa	9/1/10	6/30/14	-
1798	Develop Options for a California Weigh in Motion Test Facility	Ibrahim, Majed	7/21/11	6/30/14	-
2307	California IntelliDrive Test Bed Upgrade (State Portion)	Siddiqui, Asfand	5/1/11	6/30/14	-
2297	California IntelliDrive Test Bed Upgrade (Federal Portion)	Siddiqui, Asfand	9/29/11	6/30/14	-
2165	San Diego Integrated Corridor Management, Phase 3 Demonstration and Evaluation	Aboukhadijeh, Hassan	8/4/10	10/31/14	-
2292	Preparations for Field Testing of Combined Variable Speed Advisory and Coordinated Ramp Metering for Freeway Traffic Control—Phase I	Aboukhadijeh, Hassan	9/22/11	12/31/14	-
1208	Information Clearinghouse, Including an Expert System	Alkadri, Mohamed	7/1/08	12/31/14	-
2536	Clean, Green, and Smart Corridor Development—MCOM Advance Adoption of Alternative Fuel Commercial Vehicles	Hanson, Matt	7/1/13	12/31/14	-
2317	Development of Safety Performance Functions for California	Kwong, Jerry	2/1/13	2/28/15	-
2234	Dedicated Short Range Communications for Work Zones and Major Incident Management	Gwynne, Gloria	4/4/11	6/30/15	-
1831	Truck Access and Parking: Improved Parking Information and Reservations for Truckers	Hanson, Matt	7/1/08	6/30/15	-
2257	Work Zone Injury Data Collection and Analysis	Ikram, Hamid	8/4/11	6/30/15	-
2486	Crash Testing Support 2012	Jewell, John	1/1/12	6/30/15	-

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2081	Urban Mobility Study, 2009 continuation—TTI, TPF-5(198)	Perez, Jose	7/1/09	8/31/13	-
2061	Support for Research and Deployment of System Ops Applications of VI, TPF-5(206)	Siddiqui, Asfand	3/31/09	6/30/14	-
2579	Support of Research and Deployment of System Ops Applications of VII, TPF-5(206)	Siddiqui, Asfand	6/1/13	6/30/14	-
0788	Traffic Control Devices, TPF-5(065)	Yazdan, Fred	1/1/06	6/30/14	-
0230	Traffic Management Center Consortium, SPR-2(207), TPF-5(052)	Clark, Melissa	2/1/00	9/30/14	-

Research Support

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1052	UC Davis Sustainable Transportation Center	Azevedo, Christine	6/1/07	9/30/13	-
1053	University Enterprises Corporation at CSUSB	Azevedo, Christine	5/14/07	9/30/13	-
0862	Mineta Transportation Institute for Surface Transportation Policy Studies	Azevedo, Christine	7/1/05	9/30/13	-
0863	University of California Transportation Center	Azevedo, Christine	7/1/05	9/30/13	-
2459	The Mineta National Transit Research Center	Azevedo, Christine	2/1/12	9/30/13	-
2610	California's Integrated Border Approach Study	Williams, Scott	6/3/13	9/30/13	-
2436	Evaluation of Microtrenching Effect on Shoulder and Pavement Performance, 04-Son-1 PM 34.62 to 44.55	Holland, Joe	1/1/12	10/31/13	-
2414	Evaluation of the Efficacy of Some Promising Algorithms for Damage Detection, Location, and Quantification in Seismic Response Modification Devices and Flexible Bridges	Azevedo, Christine	11/28/11	12/31/13	-
2604	Statewide Transportation Infrastructure Needs Assessment Stakeholder Workgroup Support Services	Kanzler, Tori	5/1/13	4/30/14	-
2284	AHMCT Research Program 2011–2014	Meline, Bob	6/1/11	6/14/14	-
2437	AHMCT Research Program Management	Meline, Bob	12/12/11	6/15/14	-
2438	AHMCT Research Program Technical Support	Meline, Bob	12/12/11	6/15/14	-
2439	AHMCT Research Program Administration and Outreach	Meline, Bob	12/12/11	6/15/14	-
2440	AHMCT Research Program Deployment Support	Meline, Bob	12/12/11	6/15/14	-
1785	Partners for Advanced Transportation Technology	Mazdiyasni, Paul	11/4/09	6/30/14	-
2585	Transportation Research Board Core Services 2014–2015	Zaniewski, Pete	7/1/13	6/30/14	-
2460	UCTC 2.0	Azevedo, Christine	2/1/12	9/30/14	-
2406	PPRC11 SPE 2.1a: Develop and Manage Partnered Pavement Research Program	Holland, Joe	6/20/11	9/30/14	-
2407	PPRC11 SPE 2.1b: Regional Deflection Calibration Center: Upgrade Research Support Space	Holland, Joe	6/20/11	9/30/14	-
2408	PPRC11 SPE 2.1c: Upgrade Capabilities of HVS	Holland, Joe	6/20/11	9/30/14	-
2409	PPRC11 SPE 2.1d: Equipment: Upgrade Capabilities for Laboratory and Field Testing	Holland, Joe	6/20/11	9/30/14	-
2410	PPRC11 SPE 2.3: Provide Advice to Caltrans on Pavement Technology	Holland, Joe	6/20/11	9/30/14	-
2592	National Cooperative Highway Research Program Annual Agreement 2013–2014	Zaniewski, Pete	10/1/13	9/30/14	-
2282	Innovative Transportation	Araya, Juan	3/16/12	2/28/15	-
2549	Organizational Assessment	Cooks, Yvonne	3/21/13	3/20/15	-

Research Support TPF

Task ID	Task Title	DRISI Manager	Start Date	End Date	Page #
1938	Transportation Research Program Management Database, TPF-5(181)	Hunt, Harold	1/12/10	12/31/13	-
2186	No Boundaries Roadway Maintenance Practices, Sol 1272, TPF-5(239)	Ikram, Hamid	1/10/11	7/1/14	-
2252	Transportation Library Connectivity and Development, TPF-5(237)	Azevedo, Christine	1/3/11	6/30/15	-


ROAD
CLOSED
ROAD
CLOSED

FY 2012/13 Research Results Summaries

For this report, DRISI selected 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*. For more information about a specific task, contact the task manager listed.

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Research Results

Designing a Low-Profile Barrier for Planted Medians

Low-profile barriers protect motorists from hitting trees and shrubs while improving the aesthetics of low-speed highways

Design/ Construction

DECEMBER 2013

Project Title:
Development and Testing of a Low-Profile Barrier

Task Number: 0645

Start Date: February 2, 2004

Completion Date: July 15, 2013

Product Category: New equipment, plan, and specification

Task Manager:
Vue Her
Transportation Engineer
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WHAT WAS THE NEED?

Several Caltrans districts have requested to plant trees in the medians of low-speed highways to improve aesthetics. However, plantings with an expected mature size greater than 4 inches must be either shielded with a barrier or removed. To not use barriers, trees must be a minimum of 30 feet from the roadway, which is usually not possible in urban environments. Full-size barriers defeat the purpose of the landscaping by reducing the visibility of the trees or shrubs.

Installing a nicely designed, low-profile barrier to protect plantings would allow for better visibility and maintain the aesthetics. Nonproprietary, low-profile barriers suitable for shielding trees in the medians of low-speed highways are not commercially available. Research also showed that little work had been done to develop a barrier that addressed the issues of aesthetics and maintenance and met the test criteria of the National Cooperative Highway Research Program (NCHRP) Report 350 guidelines.

WHAT WAS OUR GOAL?

The goal was to develop a permanent, low-maintenance, crashworthy, low-profile barrier that provides good see-through characteristics for motorists and can be used with or without soil backing on the non-traffic side.

The barrier is 18 inches high and mounted on a concrete footing installed in a soil bed, with posts spaced 10 feet apart.

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Designing a Low-Profile Barrier for Planted Medians

Research Results

WHAT DID WE DO?

Caltrans developed a nonproprietary, permanent, low-profile, narrow barrier that can be used with or without soil backing on the non-traffic side. The final design also accommodated the request for openings in the barrier to provide a more see-through appearance. The barrier is 18 inches high and mounted on a concrete footing installed in a soil bed. The completed barrier was 100 feet long, with posts spaced 10 feet apart.

The barrier was tested as a Test Level 2 (TL-2) longitudinal barrier under the National Cooperative Highway Research Program (NCHRP) Report 350 guidelines. The researchers performed two full-scale tests using the following vehicles to determine whether the barrier meets the NCHRP criteria of safely redirecting vehicles in a collision:

- 2,000-kg pickup truck impacting the barrier at 43.5 mph (70 km/h) at 25 degrees
- 820-kg small car impacting the barrier at 43.5 mph (70 km/h) at 20 degrees

The testing also evaluated the level of maintenance required after a major impact.

Excavation for barrier installation

WHAT WAS THE OUTCOME?

The tests were successful in meeting the criteria and submitted to the Federal Highway Administration for approval. The damage to the barrier was cosmetic and did not require immediate repair, if any.

The researchers recommended that the reinforcing steel configuration of the barrier footing be redesigned to reduce the amount of rebar to reduce cost and installation time. It is also recommended that pavement overlays not be allowed unless enough surface grinding is done to offset the overlay thickness.

WHAT IS THE BENEFIT?

The low-profile barrier allows municipalities to landscape environments with trees along low-speed state highways where they are currently prohibited or require a full-height barrier, improving roadway aesthetics. The barrier protects motorists if they run off the road. The Caltrans barriers reduce project permit delays for local agencies because the design has already been approved. In addition, other median barriers can be installed on the barrier footing, giving municipalities different options, such as a solid-face barrier.

LEARN MORE

To view the complete report:
www.dot.ca.gov/newtech/researchreports/reports/2012/california_low_profile_barrier_final_report.pdf

Crash-testing the barrier

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Research Results

Improving Safety and Community Vitality with Roadside Design Features

Complete Street concepts support multiple modes of transportation, attracting people and improving economic vitality

Design/ Construction

DECEMBER 2013

Project Title:
The Effects of Transportation Corridor Features on Driver and Pedestrian Behavior and on Community Vitality

Task Number: 1094

Start Date: April 1, 2007

Completion Date: December 31, 2012

Product Category: New guidelines and process and new decision support tool

Task Manager:
Gloria Gwynne
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WHAT WAS THE NEED?

Transportation departments across the country have committed to implementing Complete Streets principles of making arterial highways public places that reflect the needs of the community and multimodal transportation networks. In 2008, Caltrans issued Deputy Directive 64-R1, *Complete Streets – Integrating the Transportation System*, which mandates providing cycling and walking facilities along Caltrans roadways. Design elements, such as the width of vehicle lanes, the presence of bicycle lanes, landscaping, and public seating, give visual cues to the users of arterial highways by demonstrating which needs have been prioritized and what type of behavior is expected, such as vehicle speed. To better incorporate Complete Streets elements and ensure that they are successful requires a robust system of performance measures to evaluate environmental stewardship, non-motorized safety and mobility, and economic vitality.

WHAT WAS OUR GOAL?

The goals were to explore the relationship between landscape and roadside features and user safety, behavior, and economic vitality of an area and to create a framework of performance measures for pedestrian and cyclist safety and mobility and environmental sustainability.

Landscaped and well-maintained urban arterials encourage drivers, pedestrians, cyclists, and transit riders to visit the area, improving vitality and safety.

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Improving Safety and Community Vitality with Roadside Design Features

Research Results

WHAT DID WE DO?

To evaluate the effect of Complete Streets concepts, Caltrans, in partnership with the University of California, Berkeley Safe Transportation Research and Education Center, examined numerous studies addressing the effects of design features on user safety, walkability, bikability, environmental quality, and community and economic vitality. Based on the findings of the literature review, the research team developed performance measures to make the design of urban arterials more accommodating to non-motorized travelers.

The researchers field-tested the performance measures for validity and reliability by gathering data from two key urban arterial highways: San Pablo Avenue in a number of cities in the east San Francisco Bay Area, and Santa Monica Boulevard in Los Angeles and West Hollywood. The analyses reviewed various street design features; rates of pedestrian, cyclist, and driver injuries and fatalities; jurisdictional policies pertaining to non-motorized transportation; and user perceptions of safety and mobility. The research included intercept surveys conducted along the study highways.

WHAT WAS THE OUTCOME?

Landscaped and well-maintained urban arterials encourage drivers, pedestrians, cyclists, and transit riders to visit the area, improving the economic vitality along the corridor. The mix of factors that affect safety on an urban highway is complex, with vehicle speed causing the most impact, and landscaped medians having almost no measured impact. Some findings show limits to when combinations of design features should be used, because they can increase collisions. For example, multiple potential visual obstructions in the intersection sight triangle can increase pedestrian collisions. Countdown pedestrian signals can impact both bicycle and pedestrian injury collisions.

Agencies that aggressively pursue pedestrian and bicycle improvements in transportation plans tend to have a greater number of these facilities than those agencies that do not, indicating that policies and plans do positively affect the design of highways. Caltrans and other agencies can use the proven performance measures to aid prioritization of projects. Planners can use the literature review, guidance on developing Complete Street plans, and findings on design features as tools to design optimal roads for living communities.

WHAT IS THE BENEFIT?

Complete Streets principles benefit Californians in multiple ways, including safer and more convenient roadways for those who walk, bicycle, or use transit. Enhanced beauty encourages more people to choose active transportation, providing greater health benefits and increasing safety due to the principle of safety in numbers. Offering alternative, safe means of transportation reduces traffic congestion and auto-related pollution. Building Complete Streets makes fiscal sense: When bicycle lanes, landscaping, transit amenities, and safe crossings are integrated into the initial design of a project, costly retrofits are avoided. Providing for multimodal transportation from the beginning has immediate benefits to roadway infrastructure by providing instant alternatives to driving within a community.

LEARN MORE

To read the literature review:
www.dot.ca.gov/research/researchreports/reports/2008/final_report_task_1094.pdf

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2012/2012-12-task_1094.pdf

Design elements need to be placed to not obstruct the view of drivers approaching intersections.

Well-planned arterials allow for safe bicycle travel.

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Research Results

Updating the Guide for Highway Lighting Pole Hardware

A new electronic guide provides the latest specifications and allows for timely updates

Geotechnical/ Structures

NOVEMBER 2013

Project Title:
Updating "Guide to Standardized Highway Lighting Pole Hardware"

Task Number: 0366

Start Date: February 2, 2002

Completion Date: March 29, 2013

Product Category: Improved technical standard, improved manual, improved decision support tool

Task Manager:
Robert Buendia
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WHAT WAS THE NEED?

Caltrans, as well as other state departments of transportation, rely on federally approved standards for all types of roadside materials and technology, such as guardrails, crash cushions, small sign supports, luminaire supports, and bridge railings, when purchasing for highway and bridge construction projects. These standards are developed and published by the national Task Force 13 (TF13), a joint committee of representatives experienced in transportation. These guides, which essentially serve as catalogs, have helped standardize technical specifications and criteria for the roadside hardware industry.

In 1980, TF13 published *A Guide to Standardized Highway Lighting Pole Hardware*. Much of the information in the 1980 guide is now obsolete: It does not reflect current requirements nor include materials currently being used. A Transportation Pooled Fund (TPF) study was formed to update the guide and create an electronic version.

WHAT WAS OUR GOAL?

The goal was to update the guide for luminaire supports and develop an online version that can be easily and continually updated with the latest information.

Caltrans

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Updating the Guide for Highway Lighting Pole Hardware

Research Results

WHAT DID WE DO?

Caltrans, as part of the pooled fund study lead by the Wyoming Department of Transportation and in partnership with other states, accomplished the following tasks:

- Obtained and reviewed relevant research and testing information completed since 1980
- Identified all items related to lighting and signal poles to include in the updated guide, such as concrete, fiber-reinforced plastic, and wood
- Requested standard pole details from all states and determined which information to include, reviewing all crash-worthy systems in use as well as new hardware expected to be used in the future
- Developed a web-based content management system incorporating the data gathered
- Developed a process for continuously updating the guide

WHAT WAS THE OUTCOME?

The updated guide has been converted to the same digital format used by the other TF13 guides. The online format facilitates searching, and it is easy to update and maintain. Instructions on how to use the guide, submit data for inclusion, and maintain it are included. All luminaire support systems in the guide meet the American Association of State Highway and Transportation Officials (AASHTO) *Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals* and the FHWA eligibility requirements for federally funded projects.

Users can easily get information about a manufacturer and search for products that meet specific criteria.

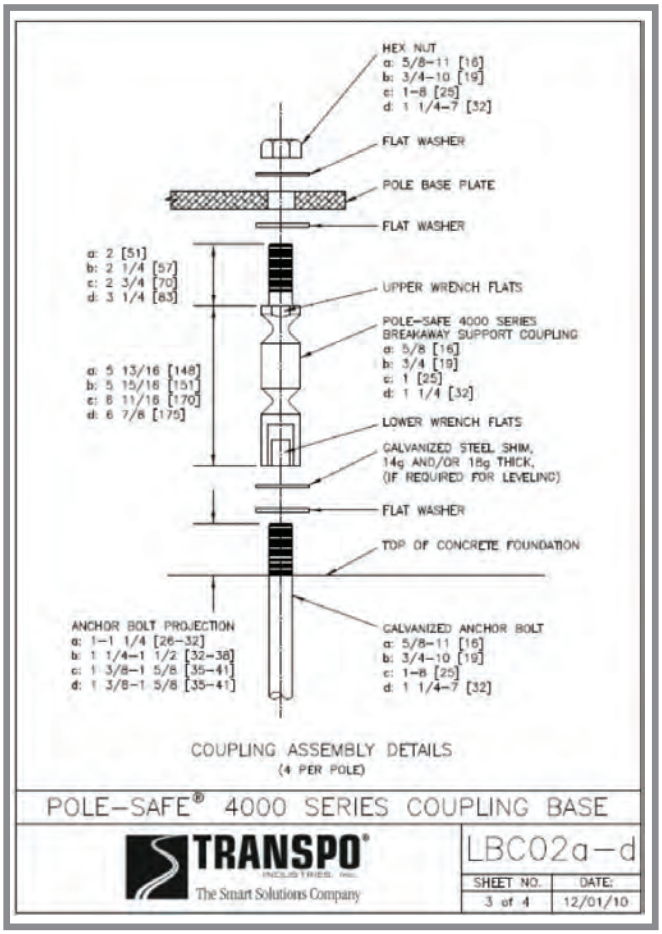
WHAT IS THE BENEFIT?

The online *Guide to Standardized Highway Lighting Pole Hardware* allows Caltrans, other agencies, and consultants to quickly and efficiently get the most current information and specifications for luminaire projects. All states having access to the same information contributes to defining standards that translate to increased safety, reliability, and consistency. The ability to perform ongoing updates means that the latest information is available so that the public will have the most current and safest highway lighting pole facilities.

LEARN MORE

For more information on this TPF:
www.pooledfund.org/Details/Study/124

To view the online version of the guide:
http://guides.roadsafellc.com



The online guide includes components specifications.

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Research Results

Developing Safer Methods for Removing Roadside Garbage

Debris removal lift attachment improves litter collection and worker safety

Maintenance

NOVEMBER 2013

Project Title:
Research, Evaluation, and Implementation of Methods to Reduce Roadside Trash

Task Number: 1103

Start Date: August 1, 2007

Completion Date: September 30, 2012

Product Category: New equipment and improved process

Task Manager:
Bob Meline
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WHAT WAS THE NEED?

Litter and illegal dumping on California's highway roadsides has become such a problem that, in 2006, Caltrans created the Litter Abatement Plan (Litter Plan), a comprehensive approach that addresses education, maintenance, and enforcement approaches to reduce litter.

One component of the Litter Plan is garbage collection. Most litter is collected and bagged by volunteers of the Adopt a Highway program or probationers, with Caltrans staff administering the programs and picking up the bags and debris. Removing the garbage from the roadway is primarily done by manual labor. Typically, a truck pulls over next to the bags, and a worker exits the vehicle to throw them into the truck. Because the time spent at any location is minimal, protective shoulder closures are not used. Workers are on foot at the road edge and vulnerable to passing traffic. They are also subject to physical injuries from lifting heavy debris. Solutions are needed to help with the collection to reduce staff exposure to traffic and injuries from handling and lifting the bags and debris.

WHAT WAS OUR GOAL?

The goal was to develop a low-cost solution to improve litter and debris collection.

The debris removal attachment fits on existing vehicles.

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Developing Safer Methods for Removing Roadside Garbage

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center, evaluated the current process for collecting and handling litter and debris. The team reviewed different methods, including dedicated debris removal vehicles, which increase productivity and safety by removing workers from the roadside, but are expensive to purchase, maintain, and operate. Their complexity requires specifically trained crews, which can hinder implementation within typical maintenance operations.

As a solution, the researchers designed and built a debris removal attachment (DRA) that fits on existing vehicles in the Caltrans fleet with minimal modifications and impact to the truck's current functions. The DRA lifts bagged litter and debris into the truck. It is operated from the truck cab, reducing worker exposure to traffic. The DRA prototype was tested in the lab and in the field.

WHAT WAS THE OUTCOME?

The system can lift up to 100 pounds and functioned in limited field testing with an adequate cycle time. The DRA is a low-cost alternative to purchasing dedicated vehicles, attaches to existing trucks, and only requires an electrical power connection to the truck, making it easier to move and use. Additional development and testing is needed for field use by maintenance crews.

WHAT IS THE BENEFIT?

Litter has a negative effect on environmental, social, and economic issues. The DRA is an innovative, low-cost, modular solution to collecting debris on state roadways. It improves the efficiency and safety of litter collection for cleanup crews, reducing lifting injuries and worker exposure to traffic. Using existing Caltrans trucks would enable multiple units to be purchased, allowing more areas to be serviced more frequently to achieve litter-free highways.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2012/final_report_task_1103.pdf

For more information about the project:
http://ahmct.ucdavis.edu/?projects=debris-removal-attachment

Caltrans DRV deployment in 2007

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Research Results

Extending the Service Life of Concrete Bridge Decks

Testing rehabilitation techniques to maintain highway bridge decks

Maintenance

NOVEMBER 2013

Project Title:
Validation of Rehabilitation Strategies to Extend the Service Life of Concrete Bridge Decks

Task Number: 1723

Start Date: July 1, 2008

Completion Date: June 30, 2013

Product Category: New simulation and improved decision support tool

Task Manager:
Steve Sahs
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WHAT WAS THE NEED?

Deterioration of highway bridge decks—the driving surface—is an ongoing concern for transportation agencies across the country. The deck's concrete is subject to cracking, affecting its lifespan. Currently, the standard design life for a highway bridge is 75 years, but the service life of the deck is 40 years or less. Replacing a deck is difficult, unreliable, and expensive.

The standard method of controlling cracks is using high molecular weight methacrylate (HMWM). The preferred full deck rehabilitation strategy is a polyester overlay. However, the long-term effectiveness of these techniques has not been fully validated nor has the optimum time to apply the treatments been established in terms of preservation and economic return.

WHAT WAS OUR GOAL?

The goal was to determine the effectiveness of methacrylate in extending the longevity of bridge decks and what is the best timing and condition to apply rehabilitation and preservation treatments.

Edge of decks clamped to tester to simulate box girder frame

Full-scale decks cast to Caltrans specifications

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WHAT DID WE DO?

To research the effectiveness of methacrylate overlays on top of cracked decks without removing the cover concrete, Caltrans, in partnership with the Montana State University Western Transportation Institute, engineered and assembled a simulator to test concrete decks built to Caltrans specifications. Eight full-sized deck panels (four sets) were cast and fixed to a support structure to model a box girder configuration, the design used for many California bridges. The researchers used an automated, 20-kip rolling wheel load simulator to replicate actual traffic loads on the panels (up to 2,000,000 load cycles). They applied HMWM to three panel sets at different traffic levels—simulating various stages of bridge deck deterioration—to determine whether treatments have an increased effectiveness based on time of application. One panel set was used as an untreated control.

The research addressed:

- Load cycle versus deterioration data for optimizing the timing of rehabilitation strategies
- Parameters that affect the success of each rehabilitation strategy
- Effectiveness of methacrylate on strength and durability of cracked bridge decks under rolling loads

WHAT WAS THE OUTCOME?

The researchers evaluated performance according to the cracking behavior and flexural stiffness of the test panels over time. Based solely on traffic-induced stresses and not environmental-induced deterioration, performance comparisons generally indicated that later applications of HMWM result in greater structural benefit. This result was most evident in the deck panels that were treated at 1,000,000 load cycles and then trafficked for an additional million load cycles. The test panels treated at earlier times also showed a benefit, but to a much lesser extent.

WHAT IS THE BENEFIT?

California has a highway bridge inventory of over 12,300 structures, and Caltrans spends millions of dollars every year to maintain and rehab them. Knowing when to apply a deck rehab method at the most beneficial bridge age and deck condition to extend its longevity can provide substantial cost savings. The engineering results of this study will be used to further test and compare different methods and evaluate the cost benefits.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/Caltrans_Bridge_Deck_HMWM_Rehabilitation_Final_Report.pdf

Testing being performed with a 20,000 pound rolling load

LCPE Instruments recording deflection

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Research Results

Using CHP to Manage Traffic in Highway Work Zones

The presence of CHP officers in work zones reduces speeding and increases safety

Maintenance

DECEMBER 2013

Project Title:
Evaluation of COZEEP and MAZEEP Officers Use in Caltrans Construction and Maintenance Work Zones

Task Number: 2249

Start Date: July 8, 2011

Completion Date: September 2013

Product Category: New guidelines

Task Manager:
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Project Manager
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WHAT WAS THE NEED?

Approximately 2.5% of all collisions on California highways occur around Caltrans work zones. Between 2007–2011, 243 people were killed and 10,657 more injured as a result of these collisions, with direct medical costs reaching $800 million per year.

To control traffic and maintain speeds at the posted limits, Caltrans contracts with the California Highway Patrol (CHP) to support the Construction Zone Enhanced Enforcement Program (COZEEP) and Maintenance Zone Enhanced Enforcement Program (MAZEEP). The goal of these programs is to create a safer environment for workers and reduce traffic collisions in work zones. Research indicates that motorists reduce traffic speed when CHP officers are present, but it is not clear what are the optimum deployment methods and operational procedures to enforce compliance and achieve the best safety outcome.

WHAT WAS OUR GOAL?

The goal was to determine the most effective way to deploy CHP officers in work zones to reduce traveling speeds and develop methods to evaluate collision data to assess whether speed reduction improves the safety of highway work zones.

Pre-test safety briefing with Caltrans and CHP

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Using CHP to Manage Traffic in Highway Work Zones

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Advanced Highway Maintenance and Construction Technology Research Center and CHP, conducted field tests using different work zone configurations and varying numbers of CHP units in both rural and urban settings, during construction at nighttime and maintenance during daylight hours. Commercially available iCone™ hardware was used to monitor speeds.

The researchers compared baseline data—no CHP units present—to data from the following CHP configurations:

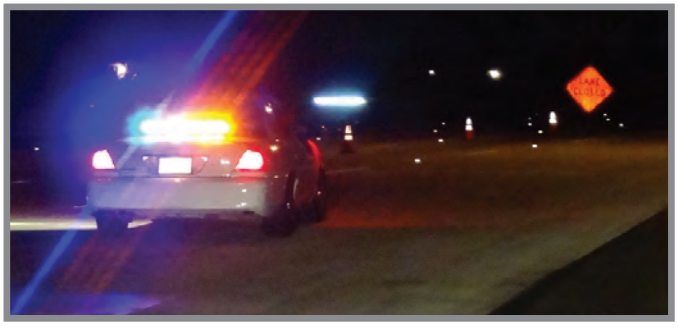
- One CHP unit stationed before the workers
- One CHP unit stationed before the workers and one near the end of the work zone
- One CHP unit stationed before the workers, one beyond the workers, and one near the end of the work zone

Computer simulations were used to further evaluate the presence of CHP officers on collision outcomes.

WHAT WAS THE OUTCOME?

The presence of CHP in the work zone slows traffic on the average of 5–7mph. However, if a CHP unit is located only before the workers, drivers often speed up after passing the workers. When multiple CHP units are used, drivers generally maintain the slower speed until passing the last unit. The effectiveness of using CHP is highly dependent on the geometry of the work zone: If drivers can see all CHP units in the work zone, they maintain the slower speed throughout the work zone.

Simulations show that if speeds are reduced 5–7 mph at a work zone, injury severity could be reduced 28%–40%, and 23%–28% of all collisions could be prevented.



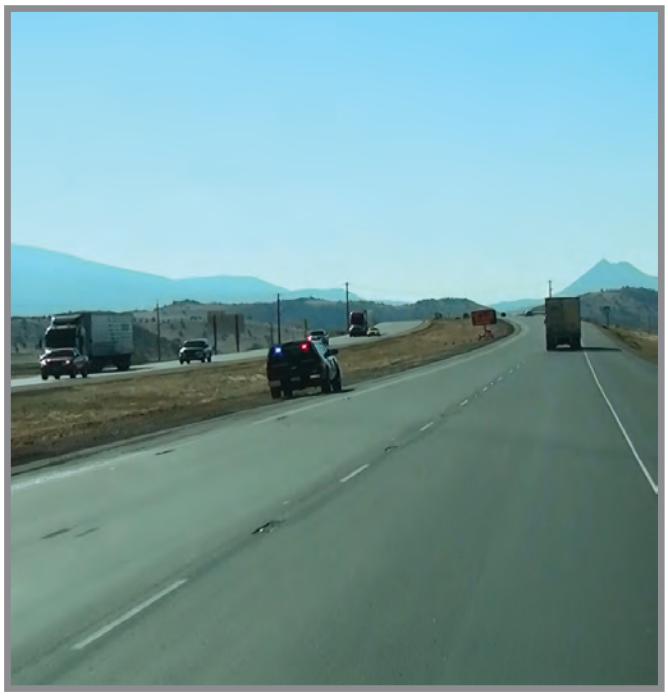
COZEEP night testing near San Diego

WHAT IS THE BENEFIT?

Reducing speeds lowers the frequency or severity of crashes in work zones, thereby making work zones a safer place to work. The presence of CHP officers motivates drivers to slow down, especially when they are stationed throughout the work zone. COZEEP and MAZEEP are effective programs in improving safety for both workers and motorists.

LEARN MORE

The final report will be available early 2014 at:
www.dot.ca.gov/research/researchreports/dri_reports.htm



MAZEEP testing near Mt. Shasta

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Research Results

Using Hydrogen Fuel Cell–Powered Lighting Trailers for Night Work

Evaluating the performance of hydrogen-powered generators in work zones

Maintenance

NOVEMBER 2013

Project Title:
Hydrogen Fuel Cell–Powered Lighting Trailer Evaluation

Task Number: 2248

Start Date: January 2, 2011

Completion Date: September 30, 2013

Product Category: Evaluation of new commercial products to determine if they meet Caltrans needs

Task Manager:
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WHAT WAS THE NEED?

Caltrans and its contractors use diesel-powered trailers with metal halide lights for illumination during night work. The diesel units are noisy and have relatively high emissions. The lights also do not illuminate the area consistently and cause glare. The central area is brightly lit, but the light diminishes toward the periphery of the work area. If the lights are not carefully aimed in the work area to avoid the adjacent traveled way, drivers experience glare.

New hydrogen fuel cell–powered trailers with plasma or LED lights could be a beneficial replacement for the diesel-powered units. They are quiet, have zero emissions, provide better light distribution, and cause less glare for both nearby drivers and workers.

WHAT WAS OUR GOAL?

The goal was to evaluate whether lighting trailers powered with hydrogen fuel cells are suitable for use in Caltrans work zones.

Performing chain control using the hydrogen light trailer

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Using Hydrogen Fuel Cell–Powered Lighting Trailers for Night Work

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center, conducted numerous laboratory and field tests to evaluate how the hydrogen fuel cell trailers held up under different weather and transport conditions. The tested light tower was made available through a project funded by the Department of Energy Fuel Cell Technologies Office Market Transformation Program and Boeing.

Night field testing included guardrail repairs, bridge inspections, which require frequent moving of the trailer, mountain shoulder maintenance, and chain control operations in below-freezing temperatures. Maintenance requirements, refueling needs, and lifecycle costs were also examined. The initial tests used plasma lights, which proved to not withstand the vibration while transporting the trailer to and from work zones. The researchers then equipped the lighting trailer with LED lights, which performed well. The researchers evaluated all aspects of the light to see if they meet the quality and patterns required in work zones.

WHAT WAS THE OUTCOME?

The hydrogen-powered system performed well in all field tests. Caltrans maintenance staff was able to operate the system after one brief training session. The unit equipped with LED lights exceeded the performance of the diesel trailers in the following areas:

- Ease of use from startup to shutdown during stationary and towing operations
- No need to wait for the lights to cool before lowering the tower, as is required for metal halide lights
- Longer use—fuel cell operates 100 or more hours compared to 40 hours for the diesel unit, especially if fewer than four LED lights were used
- Better light color and distribution
- No daily maintenance or preoperational checks required
- No monthly or other periodic oil or filter changes or engine tune-ups
- Low noise levels (43 dBA for the fuel cell versus 65dAB for the diesel engine), allowing workers to communicate with each other as well as better hear adjacent traffic, improving safety in the work zone

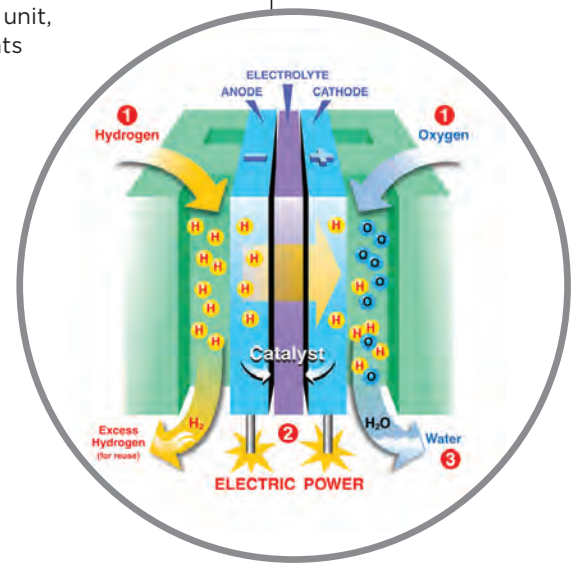
WHAT IS THE BENEFIT?

Compared to diesel, the hydrogen fuel cell–powered lighting trailer performs better and offers safer conditions for both workers and motorists. However, California currently has only five publically accessible hydrogen refueling stations. Mobile refueling is available, but is expensive. Hydrogen-powered trailers at this time are not practical, unless they are being operated near one of the hydrogen refueling stations. Due to the limited access to hydrogen fuel, it is recommended that Caltrans and its contractors continue to use diesel generators for lighting night work. Adopting hydrogen-powered trailers needs to wait until the availability of fueling stations increases.

LEARN MORE

The final report will be available June 2014.

Night guard rail repair



Fuel cell operation

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Research Results

Improving Planning for Airport Ground Access Projects

The Intermodal Airport Ground Access Planning Tool promotes a consistent method to analyze projects for airport ground access

Modal

DECEMBER 2013

Project Title:
A Combined Quantitative and Qualitative Approach to Planning for Improved Intermodal Connectivity at California Airports, Phase II

Task Number: 1910

Start Date: June 15, 2011

Completion Date: May 15, 2013

Product Category: New decision support tool, model, and algorithm (software)

Task Manager:
Frank Law
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WHAT WAS THE NEED?

Transportation to and from airports encompasses a wide range of modes—private vehicles, taxis, shared-ride vans, rental cars, public transit, and scheduled airport bus services—and many of these modes are not represented in regional travel demand models. Airport ground access projects are equally diverse, ranging from extending urban rail systems, such as the Bay Area Rapid Transit (BART) extension to the San Francisco International Airport, building automated people-mover links to nearby rail stations, such as the elevated Oakland Airport Connector, to expanding airport access roadways and parking facilities. Caltrans, airport authorities, and regional transportation planning agencies need an efficient and consistent method to simplify and standardize the process of analyzing airport ground access projects for effective decision-making regarding selection and funding.

WHAT WAS OUR GOAL?

The goal was to develop a user-friendly planning tool that provides a transparent and consistent approach to planning and analyzing airport ground access projects.

Oakland Airport Connector—an automated people-mover link from the BART Coliseum/ Oakland Airport station
Source: bart.gov

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology (PATH) program, developed the Intermodal Airport Planning Tool (IAPT), which allows planners to define multiple projects and project variants, predict changes in mode use from intermodal airport ground access projects, and compare their performance in terms of passenger trips by mode, vehicle miles of travel, and air quality emissions. The core of the IAPT is a model that typifies airport ground access mode choice by air passengers. The IAPT provides an intuitive user interface to perform the analysis and manage the large amount of data required. Users can select the airports to include in the analysis and specify projects at each airport. To analyze a project, users can view how the choice of access mode changes based on the service levels of different modes, such as transit fares, driving costs, and travel time. This mode choice model can be customized for different airports or regions.

The resulting data can be exported in a comma-separated value format and opened in spreadsheet or database management programs for further analysis or incorporation in reports. Project definitions and other data entered by the user are stored as text files so that they can be used in other applications.

IAPT helps transit agencies plan and analyze airport ground access projects.

WHAT WAS THE OUTCOME?

The IAPT facilitates managing the extensive data required for analysis. Different projects and scenarios across airports can be compared and assessed how they can potentially impact traffic as part of regional airport system planning. The IAPT, which runs on Microsoft Windows XP and Windows 7, is available to airport authorities, transportation planning agencies, consulting firms, and other interested parties. It includes test data and mode choice model specification files for the San Francisco Bay Area with which users can test the software.

WHAT IS THE BENEFIT?

The IAPT reduces the work involved in analyzing airport ground access projects, allowing more project scenarios to be evaluated. It provides more consistent and systematic analysis of different projects, leading to better project design and selection decisions. The tool is available to encourage use by planning agencies.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/final_report_65a0421_task_1910.pdf

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Research Results

Evaluation of Open-Graded Friction Course Mix Designs

Recommending changes to open-graded mix designs to improve longevity

Pavement

DECEMBER 2013

Project Title:
Laboratory Evaluation of Thin and Modified Asphalt Overlay Mix Design Procedures

Task Number: 1874

Start Date: July 1, 2008

Completion Date: October 31, 2011

Product Category: Improved business practice and procedure

Task Manager:
Hamid Sadraie
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WHAT WAS THE NEED?

Open-graded friction courses (OGFCs) improve skid resistance, particularly in wet weather, and reduce tire and pavement noise. The OGFC mix, which is applied as a thin layer on the pavement surface, increases the friction and permeability of the road. The higher permeability allows water to drain into and away from the surface quickly, reducing the dangers of spraying, splashing, and hydroplaning during wet weather and improving the friction. In addition, the higher permeability absorbs sound, making OGFCs a good choice for noise-sensitive areas.

OGFCs consist of a single size of coarse aggregate, a small portion of fine aggregate, high asphalt binder content, and a large percentage of air voids. This structure makes OGFCs more prone to raveling. The longevity of OGFCs depend on a number of factors, such as traffic, climate, construction quality, and mix design. The goal of a mix design is to determine the optimum mixture gradation, binder content, compaction, and air voids. To improve the longevity of OGFCs, the National Center for Asphalt Technology (NCAT) proposed a comprehensive approach for OGFC mix design.

WHAT WAS OUR GOAL?

The goal was to evaluate the NCAT mix design method, identify any problems, and recommend improvements.

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Evaluation of Open-Graded Friction Course Mix Designs

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center (UCPRC), performed laboratory tests based on the NCAT mix design method using different asphalt binders and aggregates. The researchers selected three asphalt binders, two from a refinery in Bakersfield, and one from a refinery in Modesto, and three aggregate samples with different properties from northern, central, and southern California—Sacramento, Watsonville, and San Gabriel, respectively. The team evaluated the mix design method with regards to:

- Optimum gradation
- Optimum binder content
- Compaction of laboratory specimens
- Asphalt absorption
- Draindown and durability
  (Draindown is when asphalt binder runs off the aggregate after mixing while it is still hot and temporarily stored or being transported to the construction site.)

The researchers used the results of the laboratory tests to recommend improvements to the NCAT's mix design approach.

WHAT WAS THE OUTCOME?

The NCAT OGFC mix design is a rational method but had shortcomings in terms of selecting the optimum gradation. The researchers proposed revised procedures to improve the mix design and suggested that OGFC compaction be controlled by the specimen height rather than by the number of gyrations. It was found that it is not necessary to specify the upper limit of the air-void content if a compacted mix can meet the performance specifications for permeability, durability, and moisture sensitivity. The results also indicated that binder type and grade selection are important to balance draindown and durability.

WHAT IS THE BENEFIT?

Open-graded mixes improve skid resistance and reduce pavement noise. However, the mix design method being used had some shortcomings that could reduce longevity. The NCAT approach enhances the performance, providing longer lasting open-graded friction courses.

LEARN MORE

For more information about OGFC:
www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/Flexible_Pavement.html

Aggregate samples from northern (left), central (middle), and southern (right) California

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Research Results

CA4PRS Software Improves Rehab Pavement Projects

Training workshops get engineers familiar with the CA4PRS management and analysis tool for designing cost-effective pavement rehab strategies

Pavement

NOVEMBER 2013

Project Title:
Extended Applications of Rehabilitation Construction Productivity Analysis Products (CA4PRS)

Task Number: 1886

Start Date: May 4, 2009

Completion Date: October 31, 2011

Product Category: Improved software, business practice, decision support tool, model, and simulation

Task Manager:
David Lim
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WHAT WAS THE NEED?

The CA4PRS (Construction Analysis for Pavement Rehabilitation Strategies) tool helps designers and engineers plan and estimate the schedule and cost of pavement rehabilitation or reconstruction projects. Users can review various combinations of design, construction, and traffic management considerations to develop an effective strategy to minimize disruption and costs. The software's scheduling module estimates highway project duration, incorporating alternative strategies for pavement designs, lane-closure tactics, and contractor logistics. The traffic module quantifies the impact of construction work zone closures on the traveling public in terms of road user cost and time spent in queue.

CA4PRS was developed by the University of California Pavement Research Center (UCPRC) in 2002 through a Federal Highway Administration pooled-fund, multistate consortium. Many successful case studies have demonstrated the software's capabilities and benefits, stimulating ongoing requests to add analysis functions and provide technical support and training on practical implementation. The pooled-fund study was able to cover the functional enhancements, while this project focused on developing training and resources on how to use CA4PRS to implement actual highway projects.

WHAT WAS OUR GOAL?

The goal was to provide Caltrans district engineers and planners with training and technical support to use CA4PRS software to design and plan actual highway projects.

The CA4PRS software improves planning rehab projects, reducing the time needed for road closures.

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CA4PRS Software Improves Rehab Pavement Projects

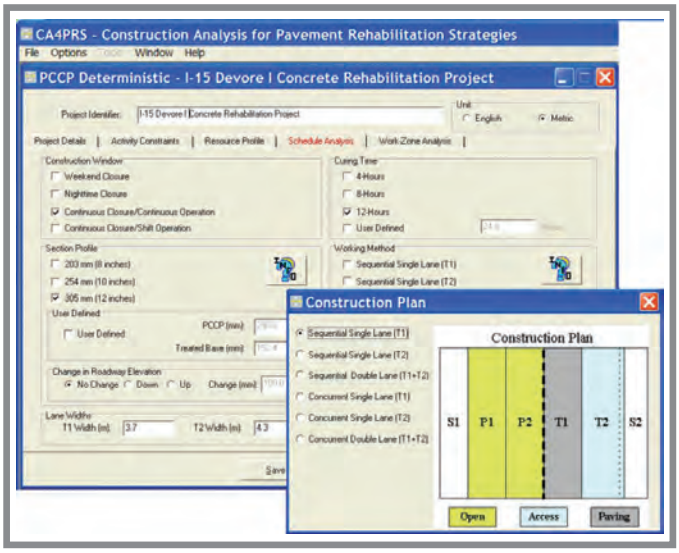
Research Results

WHAT DID WE DO?

The research team delivered hands-on training and workshops to Caltrans district engineers and planners. Project-specific workshops assisted staff in using the various software functions, including analysis to develop initiation documents and establish the most effective design choices for their highway rehabilitation projects.

Some of the rehab projects that used the software tool were:

- US-101 Ukiah (District 1) concrete pavement slab replacement
- I-5 Sacramento (District 3) asphalt pavement rehab
- I-5 Redding (District 3) concrete pavement rehab
- I-80 Sacramento (District 3) concrete pavement rehab
- SR-99 Elk Grove (District 3) asphalt pavement rehab
- I-5 Colusa (District 3) asphalt pavement rehab
- I-680 Walnut Creek (District 4) pre-cast concrete slab replacement, crack-and-seat overlay
- I-15 Riverside (District 8) concrete pavement rehab
- I-5 Stockton (District 10) continuously reinforced concrete pavement rehab



CA4PRS user interface

WHAT WAS THE OUTCOME?

The results demonstrated that using CA4PRS supports Caltrans' goal to efficiently deliver quality transportation projects and to maximize transportation system performance. CA4PRS enables users to analyze project schedules, costs, and potential traffic delays faster and more effectively than traditional methods. Some of the benefits that the engineers gained from learning how to use CA4PRS include:

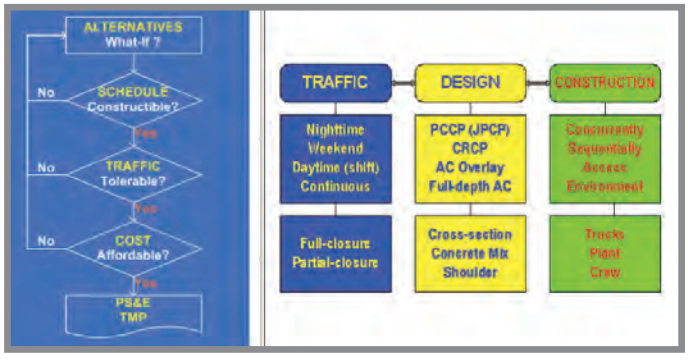
- Reduced the time required to develop the design, construction schedule, and traffic management options
- Improved construction staging and more effective traffic management plans
- Lessened work zone–related vehicle delays in urban locations with high passenger volumes and on rural roadways carrying heavy freight

WHAT IS THE BENEFIT?

Highway rehabilitation projects often cause congestion, safety problems, and limited access for road users. It is also challenging to find economical ways to repair deteriorating roadways in metropolitan areas while keeping the traveling public as safe as possible and minimizing disruptions for local communities and surrounding businesses. CA4PRS speeds up pre-construction analysis, enabling engineers to compare more alternatives in a shorter time and find the most effective solutions for a transportation project with confidence. CA4PRS minimizes inconvenience and maximizes affordability.

LEARN MORE

For information about the development and uses of CA4PRS:
www.dot.ca.gov/research/roadway/ca4prs/index.htm



CA4PRS compares rehab alternatives as what-if scenarios based on various parameters in terms of traffic, design, and cost.

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Research Results

Evaluating the Performance of Rubberized Warm Asphalt Mixes

RWMA technology uses less energy, improves working conditions, and extends paving opportunities

Pavement

DECEMBER 2013

Project Title:
Laboratory and Accelerated Pavement Testing (APT) of Gap-Graded Rubberized Mixes (Hot Mix Asphalt and Warm Mix Asphalt) for the Department of Resources Recycling and Recovery (CalRecycle)

Task Number: 2385

Start Date: May 17, 2011

Completion Date: May 15, 2013

Product Category: Evaluation of new commercial products to determine if they meet Caltrans' need and improved processes

Task Manager:
Joe Holland
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WHAT WAS THE NEED?

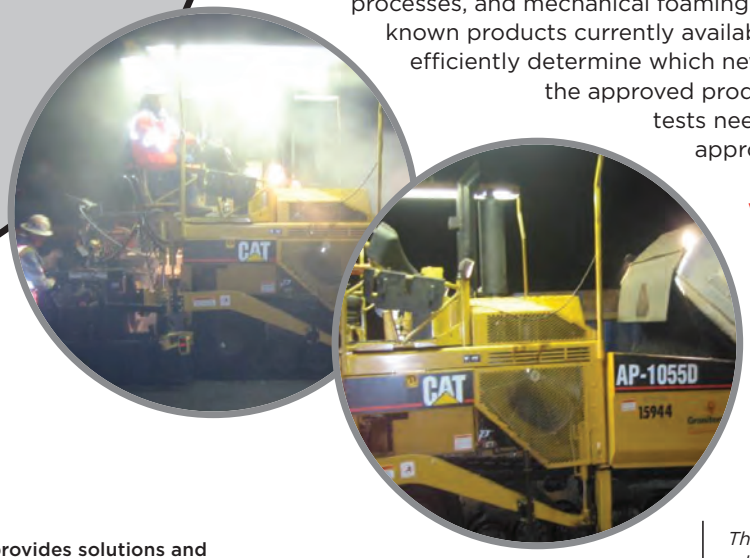
Rubberized, hot mix asphalt (RHMA) is commonly used for pavement construction for its durability and noise reduction. However, producing RHMA requires high temperatures and a high-emission, energy-intensive process. It also cannot be applied during cold weather, limiting the paving season.

The development of rubberized, warm mix asphalt (RWMA) addresses some of the shortcomings of RHMA and provides several benefits, including less smoke emissions and the ability to sustain longer hauls and be used in cool weather. But it was not known whether RWMA performs as well as RHMA in terms of its resistance to rutting and cracking. The level of air quality improvement also needed to be quantified to ensure that they meet the standards set in restricted areas.

New WMA technologies are still being introduced. Currently, four WMA categories exist—organic additives, inorganic additives, chemical foaming processes, and mechanical foaming processes—with more than 20 known products currently available in the United States. To more efficiently determine which new technologies Caltrans can add to the approved product list, new simplified laboratory tests need to be developed and the appropriate criteria identified.

WHAT WAS OUR GOAL?

The goal of this research was to evaluate the rutting and fatigue cracking resistance of RWMA and quantify the air quality improvements that the technology offers.



The hot mix (left) generates smoke emissions, while the warm mix (right) exposes workers to less fumes and heat.

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Evaluating the Performance of Rubberized Warm Asphalt Mixes

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California Pavement Research Center (UCPRC), tested and compared the rutting resistance of both RWMA and RHMA using a Heavy Vehicle Simulator (HVS). The HVS tests were then correlated to less costly laboratory tests that are being developed as a means to evaluate future RWMA products. Lab tests were used to assess the fatigue resistance of both types of mixes.

To measure air quality, the team used both field testing and laboratory testing. The field testing involved a novel method of applying a canopy over the just-dumped asphalt mix and extracting the air samples over time. The researchers developed a laboratory test method that simulated the mixing of the asphalt in the plant production. The gases were extracted and examined in an environmental laboratory.

To test the noise level reduction and duration, rubberized sections were extracted from a previous pavement noise study and evaluated.

Paving with RHMA (left); working with RWMA (right)

WHAT WAS THE OUTCOME?

The rutting resistance of the RWMA mixes tested was similar to RHMA. Under HVS testing, RWMA initially showed slightly faster rutting, but within a few weeks the behavior was essentially the same as RHMA.

The fatigue characteristics between RHMA and RWMA were basically the same, but RWMA offers the benefit that high compaction can be achieved at lower temperatures. Higher compaction results in a longer fatigue life.

The air quality studies indicated that RWMA mixes produce less noxious gases than RHMA due to the lower production and placement temperatures. In addition, during the construction of the test sections, it was discovered that RWMA mixes are more workable on the job site than the RHMA mixes. RHMA mixes are very stiff and do not allow for much adjustment after the mat has been put down.

WHAT IS THE BENEFIT?

RWMA mixes perform as well as or better than hot mixes, and offer additional productivity and environmental benefits. RWMA can withstand longer hauls, so production plants can be more centralized. Its workability at lower temperatures allows for paving in cool weather, extending the work season. Workers are also exposed to less fumes and heat. The air quality improvements also allow rubberized mixes to be used in cities and areas with restrictions on emissions.

LEARN MORE

To view the complete report:
www.ucprc.ucdavis.edu/pdf/UCPRC-SR-2013-03.pdf

Testing hot mix and warm mix asphalt pavements

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Research Results

Testing New Open-Graded Friction Course Mix Designs

Ensuring that the new methodology meets performance requirements

Pavement

DECEMBER 2013

Project Title:
Improved Methodology for Mix Design of Open-Graded Friction Courses

Task Number: 2362

Start Date: May 1, 2012

Completion Date: June 30, 2013

Product Category: Improved business practice, procedure, and process and new tool

Task Manager:
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WHAT WAS THE NEED?

Open-graded friction courses (OGFCs) improve skid resistance, particularly in wet weather, and reduce tire noise. The OGFC mix, which is applied as a thin layer on the pavement surface, increases the friction and permeability of the pavement. For the OGFC mix design, Caltrans uses California Test 368, Optimum Bitumen Content for Open Graded Friction Course. This test procedure has several disadvantages and needs to be revised.

To improve the longevity of OGFCs, the National Center for Asphalt Technology (NCAT) proposed a comprehensive approach for OGFC mix design. Caltrans considered the NCAT's new approach in the revisions of California Test 368 and developed a new method for OGFC mix design in partnership with the University of California Pavement Research Center (UCPRC). The new mix design method required calibration through more laboratory testing to ensure that it delivers the design requirements in terms of air-void content and performance. After the mix design is calibrated, it is necessary to test that the method delivers a suitable optimum binder range.

WHAT WAS OUR GOAL?

The goal was to calibrate the new OGFC mix design method to ensure that it delivers the design requirements and incorporates the performance test results in the design chart.

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Testing New Open-Graded Friction Course Mix Designs

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the UCPRC, developed a test plan to evaluate 10 OGFC mixes produced from the following:

- Three binder types (a performance graded PG 64-10, a polymer-modified PG 76-22 PM, and a terminal blend asphalt rubber PG 64-28 TR)
- Two aggregate types (alluvial and volcanic)
- Two gradations (coarse and fine)

The researchers measured the volumetric properties of these materials and mixes. The new OGFC mix design method was used to determine three trial binder contents. To ensure that the method delivers a suitable optimum binder range, the results of three performance tests were then incorporated:

- Draindown, which measures the binder's potential to drain off of the aggregate during transport from the plant to the construction site
- Cantabro, a measurement of durability
- Hamburg wheel-tracking device, which measures rutting performance and moisture sensitivity

The researchers also studied the effect of fines content (with a maximum size of 75 Qm) on the performance of open-graded mixes.

WHAT WAS THE OUTCOME?

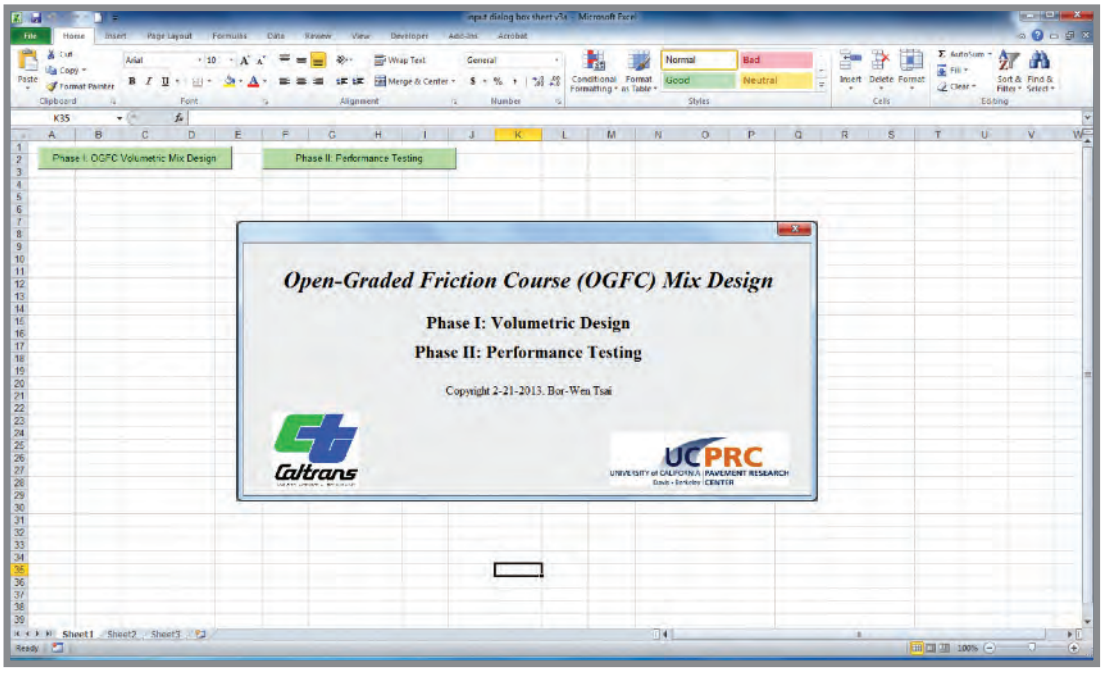
The new OGFC mix design method was verified. The process was enhanced by the development of an Excel macro, an easy-to-use tool to assist and ensure that the volumetric requirements and the performance specifications are met. The macro determines the optimum binder range according to the results of the draindown, Cantabro, and Hamburg wheel-tracking device tests. It was also demonstrated that an increase in the fines content improves the results of these performance tests; therefore, the fines content should be a part of OGFC performance specifications.

WHAT IS THE BENEFIT?

OGFCs will be used throughout California's roadways as appropriate. They improve skid resistance, particularly in wet weather, and generate less noise from tire-pavement interaction. Modifying the OGFC mix design increases its longevity and improves performance. The calibration of the new OGFC mix design method ensures that the desired air-void content is achieved and the performance specifications are met.

LEARN MORE

The final report will be available June 2014.



The new Excel macro for OGFC mix design

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Research Results

Collaborating on Pavement Research Technology

Four-state consortium pools resources identify and solve critical issues affecting pavement construction and maintenance

Pavement

DECEMBER 2013

Project Title:
State Pavement Technology Consortium, SPR-3 (074)

Task Number: 0220

Start Date: July 1, 1999

Completion Date: December 31, 2012

Product Category: New and improved standards, plans, and specification; new and improved manual, handbook, guidelines, and training; new and improved business practices, procedures, and processes; new and improved decision support tools, simulations, models, and algorithms (software)

Task Manager:
Michael Samadian
Senior Supervising Transportation Engineer
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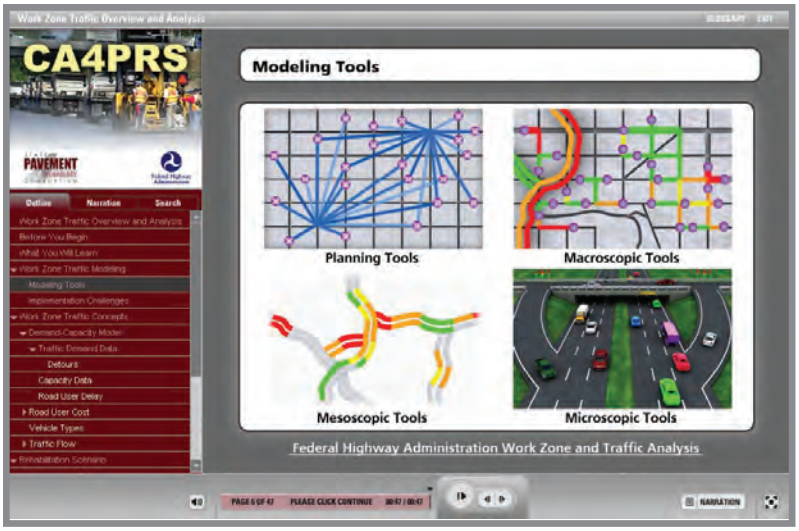
WHAT WAS THE NEED?

Caltrans partnered with three other states—Minnesota, Texas, and Washington—to pool funds and resources to develop effective and efficient research solutions that address the problems that California is facing with today's aging roadway system.

Each of the participating states of the State Pavement Technology Consortium (SPTC) provided funding for technical staff and university researchers to participate in project meetings focused on sharing information, identifying critical issues of mutual interest, and developing plans for joint research and testing. This consortium also offered the opportunity for technology transfer of the latest developments in the design, construction, reconstruction, and maintenance of highway pavements.



The CA4PRS (Construction Analysis for Pavement Rehabilitation Strategy) software tools are used globally to help planners and designers optimize pavement construction costs.

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WHAT WAS OUR GOAL?

The goal was to improve pavement infrastructures by collaborating with other states for information sharing, research, and technology transfer.

WHAT DID WE DO?

The SPTC focused on sharing knowledge, best practices, and technologies that have been deployed by other states and industries to improve pavement infrastructures. The approach was to combine knowledge with research and know-how through academia, industry, state departments of transportation (DOTs), and the Federal Highway Administration's efforts to explore new pavement products and technology that were ready to be deployed. The SPTC collaborated to produce products, technology, and standards of practice that increased efficiency, improved longevity, and brought safer roadway systems to the participating states. Tasks were assigned to the participating DOTs and academia to bring back for discussion and analysis in subsequent meetings.

WHAT WAS THE OUTCOME?

The SPTC developed numerous products, technologies, tools, and standard practices through knowledge sharing and collaboration. Examples of these achievements include the following.

- Developed the CA4PRS (Construction Analysis for Pavement Rehabilitation Strategy) decision support tool. This software is widely used nationally and internationally to help planners and designers optimize pavement construction costs.
- Established groundwork for developing standards for construction of foamed asphalt, an in-place, flexible pavement rehabilitation strategy that transforms existing asphalt concrete into a stabilized base for a new pavement surface layer.
- Collaborated with users nationally to identify shortcomings of the Mechanistic-Empirical (ME) Pavement Design software, which led to developing CalME, ME software to analyze and design new flexible pavements and rehabilitate existing pavements.
- Trained Caltrans staff on new software, product standards, pavement material selections, and construction techniques through seminars in classroom settings and by distributing papers and fact sheets.

WHAT IS THE BENEFIT?

Participating in collaborative research brings in outside knowledge, innovative technology, and products that benefited the state. The consortium allowed Caltrans to share resources and maximize funding by pooling with other states to accomplish projects more efficiently and effectively.

LEARN MORE

For information about the SPTC:
www.pooledfund.org/Details/Study/144

The CalME tool can analyze the use of different materials in the context of climate and load inputs and determine the cost.

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Research Results

Consolidating and Sharing Pavement Resources and Tools

New online website provides training tools and a broad pavement knowledgebase of resources, methods, and practices

Pavement

DECEMBER 2013

Project Title:
Pavement Tools Consortium

Task Number: 0768

Start Date: January 1, 2004

Completion Date: June 30, 2013

Product Category: New decision support tool and software

Task Manager:
Joe Holland
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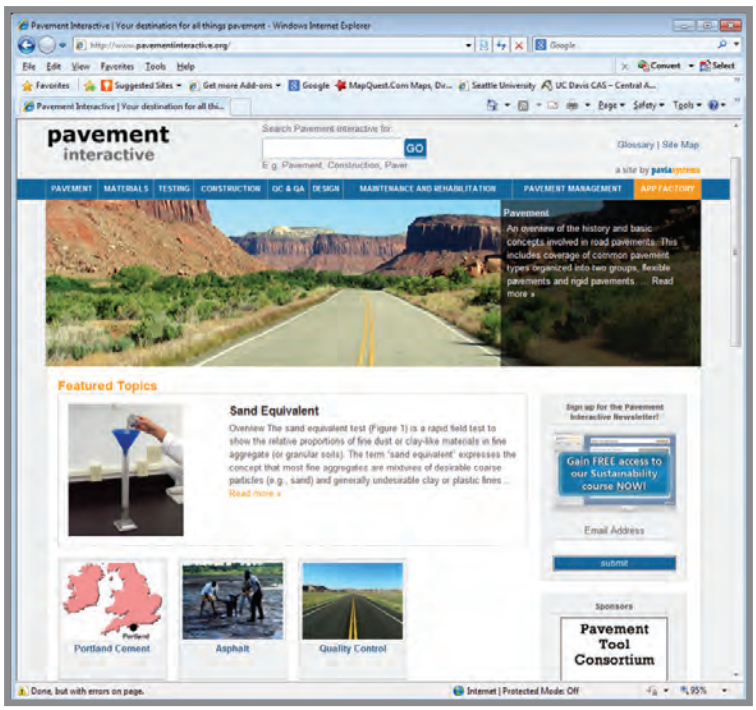
WHAT WAS THE NEED?

State departments of transportation (DOTs) and other agencies across the country have developed tools, fine-tuned processes, and acquired knowledge about pavement. Consolidating this information online enables the pavement community to share resources and knowledge and reduce duplication of efforts and research. A website can provide a ready reference on paving topics, the ability to look up methods and practices, self-directed learning tools, and links to additional resources.

The Pavement Tools Consortium (PTC) is a partnership between several DOTs, the Federal Highway Administration, and the University of Washington that formed to develop and provide computer-based tools to enhance pavement-related training and improve communication within the broader pavement community.



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WHAT WAS OUR GOAL?

The goal was to develop an online warehouse of pavement knowledge and computer-based pavement tools to assist the pavement community in training and construction operations.

WHAT DID WE DO?

The PTC developed the Pavement Interactive website, which provides pavement information and tools. In addition to many pavement-related articles, the following web-based tools are available.

HMAView software—This pavement management tool is used to track hot-mix paving projects. Users can enter data and customize views. Consortium members have access to the source code for agency or company-specific modifications.

Interactive Pavement Guide—Consortium members can easily add local content to continually expand and improve the guide, which can be produced in languages other than English.

Computer simulations—Users can take advantage of virtual simulations to model pavement construction, such as the virtual roller, for training, examining what-if scenarios, or visualizing possible problems.

Distance learning content—The pavement tools aid distance learning. The content and tools supplement existing training venues.

Computation software—Software, such as EverFE (finite-element analysis tool for plain-jointed concrete pavements) and EverFlex (finite-element analysis tool for flexible pavement), are available. Documentation and training are provided, if requested. EverFE has been used for several Caltrans pavement research projects.

WHAT WAS THE OUTCOME?

The Pavement Interactive website provides a one-stop shop for general pavement information and the latest research results from the contributing states. It includes information for historical pavements, materials, testing procedures, construction, quality control and assurance, design, maintenance and rehabilitation, and pavement management. Consortium members have access to software tools.

WHAT IS THE BENEFIT?

The website allows consortium members to share information and research, rather than each state spending funds on similar projects. The information and tools are easy to access, maintain, and upgrade. Those involved in designing and constructing pavements, from DOTs, contractors, inspectors, and engineers, benefit from the information and tools provided by the website. With everyone on the same page, transportation agencies can provide the traveling public longer lasting pavements.

LEARN MORE

To view the Pavement Interactive website:
www.pavementinteractive.org

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Caltrans Division of Research, Innovation and System Information

Research Results

Building California's Hydrogen Highway

Increased fuel capacity allows hydrogen-fuel vehicles to drive longer distances

Planning/ Policy/ System Information

DECEMBER 2013

Project Title:
Developing a Hydrogen Transportation Infrastructure

Task Number: 2204

Start Date: May 24, 2011

Completion Date: October 31, 2012

Product Category: Improved tool and equipment

Task Manager:
Patrick Tyner
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WHAT WAS THE NEED?

In 2004, Governor Arnold Schwarzenegger issued Executive Order S-07-04 to initiate the California Hydrogen Highway Network. The mission was to ensure that motorists would have access to hydrogen fueling stations along California's roadways. This initiative worked in concert with Assembly Bill 32, the Global Warming Solutions Act of 2006, which established goals and targets to reduce greenhouse gas emissions from all sources throughout California. To help meet these goals, the Schatz Energy Research Center (SERC) at Humboldt State University (HSU) designed and built a hydrogen fueling station to learn about this new technology and demonstrate the potential benefits associated with hydrogen-fueled vehicles. The fueling station began operating in 2008 with a storage capacity of 420 bar (6,000 pounds per square inch). However, newer fuel cell vehicles now have 700-bar storage tanks, increasing the driving range from 200 miles to 400 miles. Upgrading the station's fueling capacity allows vehicles to drive from Arcata to other fueling stations in Sacramento and the San Francisco Bay Area, linking the state's northernmost fueling station to the rest of California's Hydrogen Highway.

WHAT WAS OUR GOAL?

The goal was to upgrade the HSU hydrogen transportation fueling station with a state-of-the-art, 700-bar fueling system to evaluate the station's operational capabilities and analyze vehicle performance in day-to-day use.

HSU hydrogen fueling station

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WHAT DID WE DO?

Caltrans, in partnership with SERC, upgraded the HSU station to 700-bar fuel capacity. As part of the fueling upgrade, the researchers designed a safe, code-compliant working space and aesthetically pleasing hydrogen fueling station. To get the hydrogen gas to 700 bar, an additional compressor pumps hydrogen gas from the existing 420-bar storage tank and dispenses the fuel directly into the vehicle's tank to 700 bar. This "slow-fill" method eliminates the need for new, expensive storage vessels. SERC obtained a Fuel Cell Hybrid Vehicle-Advanced (FCHV-adv) from the University of California, Berkeley Transportation Sustainability Research Center to test fuel cell vehicles in day-to-day use. The researchers tracked fill performance data, along with dispensing pressure and ramp rates (the volume per minute rate at which the fuel is dispensed). Additionally, a driving log was used to record driver, vehicle, and refueling information.

WHAT WAS THE OUTCOME?

The station can completely fuel higher capacity vehicles, increasing the commuting distance—the FCHV-adv can now reach the San Francisco Bay Area on a single tank of hydrogen. With hydrogen-fueled vehicles now operating regularly on a key segment of the state's highway system, Caltrans can access travel data and operational information to assess future highway infrastructure needs, vehicle and station performance, and issues concerning hydrogen fuel. This assessment also helps Caltrans decision-makers evaluate the potential use of hydrogen fuel in its own vehicle fleet.

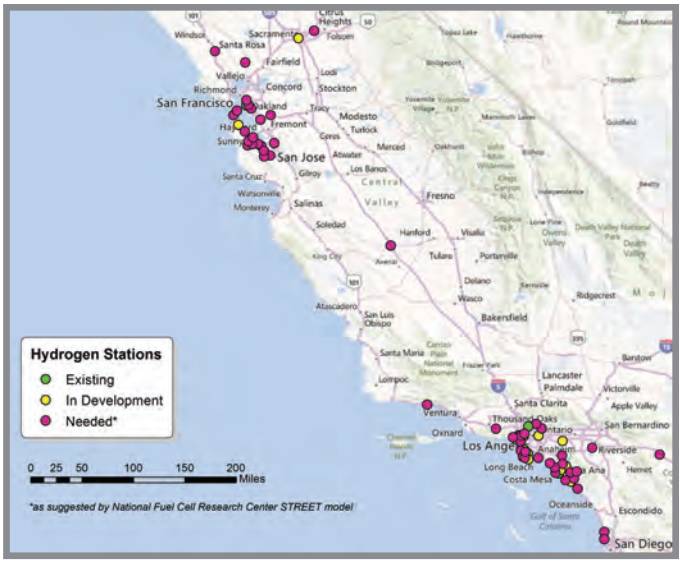
HSU hydrogen fueling station with the Toyota FCHV-adv and hydrogen-powered Prius

WHAT IS THE BENEFIT?

Hydrogen-fueled vehicles can reduce greenhouse gases and potentially provide California with a more efficient and sustainable transportation system. The upgrade of the HSU station helps expand the Hydrogen Highway. The analysis of alternative fuels, vehicles, and the infrastructure that would support them assists Caltrans decision-makers in making effective policy and project choices that will best benefit the state and the traveling public.

LEARN MORE

For more information on the research:
www.schatzlab.org/projects/hydrogen/h2stn.html



California has 13 research hydrogen fueling stations, 9 public stations, and an additional 18 that have been funded and are expected to be operational in the next few years.

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Research Results

Developing Methods for Collecting Spatially Focused Travel Behavior

Localized travel surveys inform decisions on land use and urban infill projects

Planning/ Policy/ System Information

FEBRUARY 2014

Project Title:
Spatially Focused Travel Survey Data Collection and Analysis: Closing Data Gaps for Climate Change Policy

Task Number: 2243

Start Date: December 16, 2011

Completion Date: July 30, 2013

Product Category: Improved decision support tool

Task Manager:
Bob Justice
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WHAT WAS THE NEED?

California Senate Bill (SB) 375—the Sustainable Communities and Climate Protection Act of 2008—requires that the state's metropolitan planning organizations develop strategies that integrate transportation, land use, and housing policies to reduce vehicle usage and greenhouse gas emissions. To help decision-makers estimate, model, and forecast the state's travel needs, the California Household Travel Survey is conducted every 10 years to collect information on travel behavior. These estimates are based on averaged travel behavior responses collected from metropolitan areas and larger regions. However, the current travel diary surveys provide limited information on the effect of small-area land use policies, such as infill development and transit-oriented land uses near stations. Understanding how the characteristics of these communities influence travel behavior is important to inform policies on integrating transportation and land use planning and bringing housing and job growth into transit-oriented, mixed-use, and compact communities.

WHAT WAS OUR GOAL?

The goal was to develop methods of collecting spatially focused travel data to improve policy and funding decisions regarding travel service, land use, and infrastructure enhancements.

Light rail in Pasadena
Source: Digital Media Pro/ Shutterstock.com

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Developing Methods for Collecting Spatially Focused Travel Behavior

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Irvine Institute of Transportation Studies, conducted 300–600 travel diary surveys in neighborhoods near two rail transit corridors in Los Angeles—the subway Red Line and light rail Gold Line—to examine the effect of land use factors on reducing vehicle miles traveled (VMT) in small neighborhoods and assess whether these areas depart from the regional, averaged land-use-travel data. The corridors were chosen based on population density, job accessibility, concentration of local businesses, distance to employment sub-centers, and distance to transit. The study areas are approximately a half mile from center to edge, a size that corresponds to the scale of redevelopment opportunities, transit station development, and infill projects.

WHAT WAS THE OUTCOME?

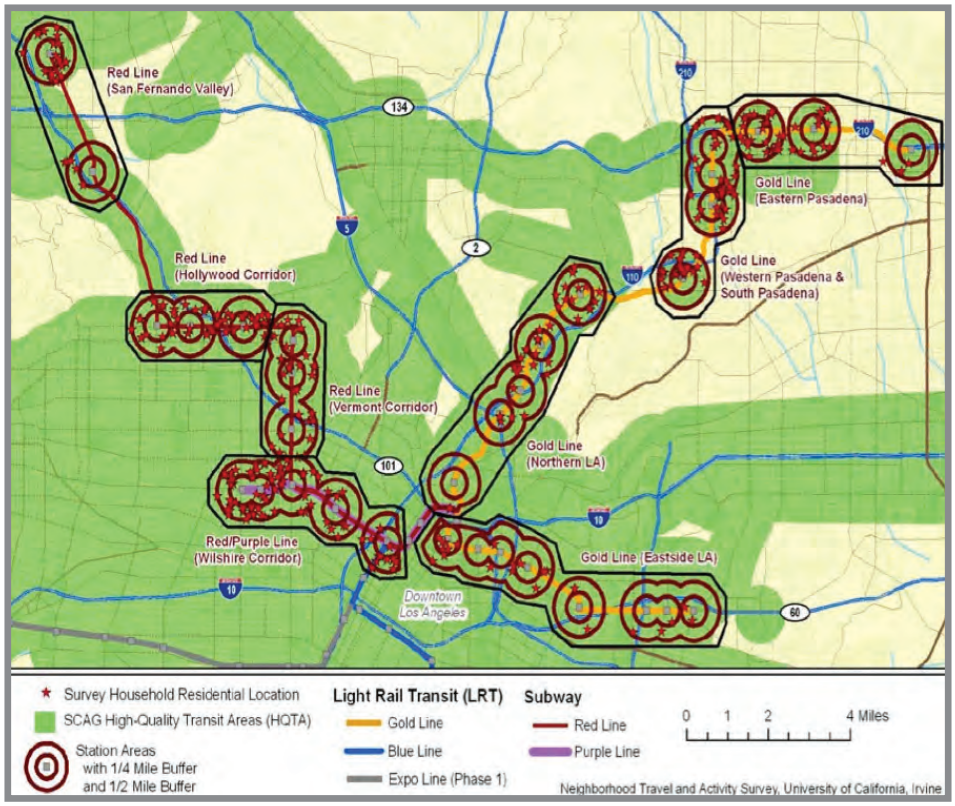
The methods developed advanced efforts toward low-cost, rapid travel data collection that can be used in before-and-after transportation program evaluations in the future. The survey responses suggested differences in walking, transit, and passenger vehicle travel behavior associated with residing in areas with different built environment, land use, and transit access characteristics. Based on the countywide sample, households in areas with higher employment accessibility tended to have more walking travel and lower VMT. Households within 1.5 miles of a rail transit station had more transit ridership, and this relationship was strongest for households within 0.5 miles of a rail transit station. Households within 0.5–1.0 miles of a station had more walking travel, while households with higher levels of transit service had lower household VMT.

WHAT IS THE BENEFIT?

This research pioneered methods to obtain spatially focused travel data to inform current debates about how land use influences vehicle miles of travel. The results expanded the understanding of land use and travel relationships and the importance of collecting localized data to help policymakers make more informed decisions regarding integrating transportation and land use planning in mixed-use, compact communities. Collecting data that focuses on local land use can help close the gap between travel data, knowledge, and policy.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/final_report_contract_65a0438_task_2243.pdf



Study areas and location of households who completed the travel diary survey

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Research Results

Developing a State Highway Infrastructure for Electric Vehicles

Partnering with other states to share knowledge about implementing EV projects

Planning/ Policy/ System Information

DECEMBER 2013

Project Title:
Workshops on Strategies and Best Practices for State Departments of Transportation to Support Commercialization of Electric Vehicles (EV) and Infrastructure TPF-5(250)

Task Number: 2260

Start Date: January 1, 2011

Completion Date: December 31, 2012

Product Category: New handbook, guidelines, and tool

Task Manager:
Patrick Tyner
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WHAT WAS THE NEED?

Electric vehicle (EV) technology has the potential to reduce polluting vehicle emissions and help move away from a dependence on oil. The U.S. Department of Energy has targeted several states, including California, to participate in or host transportation electrification projects. California, in addition to Arizona, the District of Columbia, Florida, Michigan, New York, Oregon, Tennessee, Texas, Virginia, and Washington, will serve as test beds for EV technologies. Through these grant awards, local public-private partnerships will collaborate on plans to deploy EVs and the charging infrastructure, a strategy that helps reduce U.S. petroleum dependency and build a clean transportation future.

Transportation agencies, such as Caltrans, public officials, and public policy-makers, need to be prepared to capitalize on the upcoming investment in EV deployment and the infrastructure to support the vehicles. To avoid duplication of efforts, ensure consistency, and maximize the funding resources, the departments of transportation (DOTs) in the participating states are collaborating and sharing research, policies, and practices on implementing an EV infrastructure.

WHAT WAS OUR GOAL?

The goal was to foster partnerships with other states to collaboratively address the opportunities and challenges in developing and implementing an EV infrastructure on state highways.

Caltrans

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Developing a State Highway Infrastructure for Electric Vehicles

Research Results

WHAT DID WE DO?

Caltrans management met with other executive-level representatives from different states regarding the planning and deployment of EVs and the supporting infrastructure on state highways. The two workshops—held in Berkeley, California and Raleigh, North Carolina—investigated current practices and identified knowledge needs to help DOTs build their capacity and capabilities to work with private partners, as well as federal, state, and local officials.

WHAT WAS THE OUTCOME?

The workshops produced a report that addressed models that DOTs can implement to pursue and incentivize EV deployment. It defined different levels of "readiness to engage," with an action plan for each level and the appropriate policies and best practices. The information collected from the workshops was also incorporated into the Center for Climate and Energy Solutions (C2ES) Plug-in Electric Vehicle Action Tool, which helps DOTs determine their EV goals and chart a path for accomplishing them.

Caltrans has installed electric vehicle charging stations like this statewide.

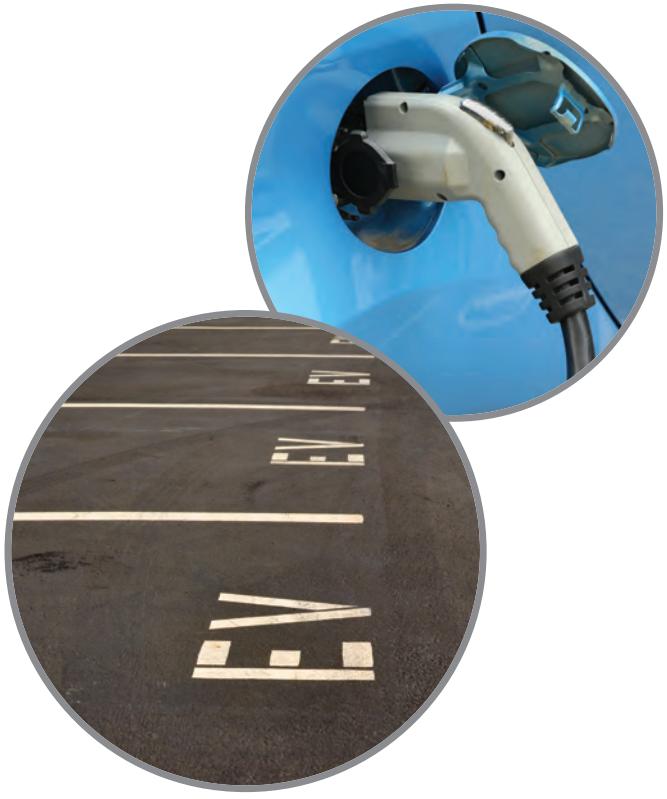
WHAT IS THE BENEFIT?

The timing of this effort works in concert with Governor Jerry Brown's Executive Order B-16-2012, which directs California to "encourage the development and success of zero-emission vehicles to protect the environment, stimulate economic growth and improve the quality of life in the State." The workshop interactions and cross-state collaboration provided important insights on how to integrate EV development into the planning process, avoid pitfalls and other obstacles, and successfully deploy an EV infrastructure on California highways.

LEARN MORE

To read about the results of the workshops and the Electric Vehicle Action Tool:
www.c2es.org/docUploads/pev-action-tool.pdf

To read about the initiative to integrate EVs with the U.S. electrical grid:
www.c2es.org/initiatives/pev/action-plan-report



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Research Results

Transportation Asset Management Multistate Collaborative Workshop

Workshops facilitate the knowledge and exchange of transportation management information among states

Planning/ Policy/ System Information

JANUARY 2013

Project Title:
2012 Multi-State Transportation Asset Management (TAM) Implementation Workshop, TPF-5(245)

Task Number: 2300

Start Date: January 25, 2011

Completion Date: April 30, 2013

Product Category: Improved business practices, policies, and decision support tools

Task Manager:
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WHAT WAS THE NEED?

Transportation asset management involves maintaining, upgrading, and operating transportation assets through their lifecycle to maximize their social benefits. To effectively address the changes in today's transportation environment, new technology advances, and limited resources, better decision-making based on well-researched information and well-defined objectives is needed.

Every state possesses transportation assets and generates knowledge on how to manage them, yet the transportation sector lacks a systematic approach to synthesize, share, and disseminate this information so that others can benefit. Defining common management strategies, systems, and tools requires investigation, training, and technology transfer. Many state and local transportation organizations are interested in implementing asset management—to date, more than 25 states have undertaken several forms of the initiative. State transportation departments need a forum to share information and learn how to better implement asset management.

WHAT WAS OUR GOAL?

The goal was to provide a conduit for sharing information and enhancing the practical knowledge of member states to improve asset management implementation.

Managing the breadth of transportation assets is critical for maintaining the health of the system cost effectively.

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WHAT DID WE DO?

The Federal Highway Administration (FHWA) retained Caltrans, in partnership with the Transportation Research Board (TRB), to provide workshops for member states participating in the transportation asset management consortium to learn and review issues associated with implementing asset management and share best practices and strategies for overcoming challenges. One workshop focused on how to communicate preservation needs to transportation organizations and the general public to bring the crucial issue of maintenance to the forefront and build broad support. Another workshop explored through real-world examples how to increase innovation to maximize results and deliver more with less funding. Member states also worked together to organize the TRB-sponsored 2012 Asset Management conference.

WHAT WAS THE OUTCOME?

The TRB and the American Association of State Highway and Transportation Officials, with support from the FHWA's Office of Asset Management, hosted the 9th National Conference on Transportation Asset Management from April 16–18, 2012, in San Diego, California. The conference, attended by 30 state departments of transportation and 20 metropolitan planning organizations, provided transportation agencies a forum to identify successful strategies for implementing transportation asset management principles. Speakers described how to apply asset management concepts to pavement and bridge assets and nontraditional assets, such as traffic management systems and data resources.

The conference addressed four major areas:

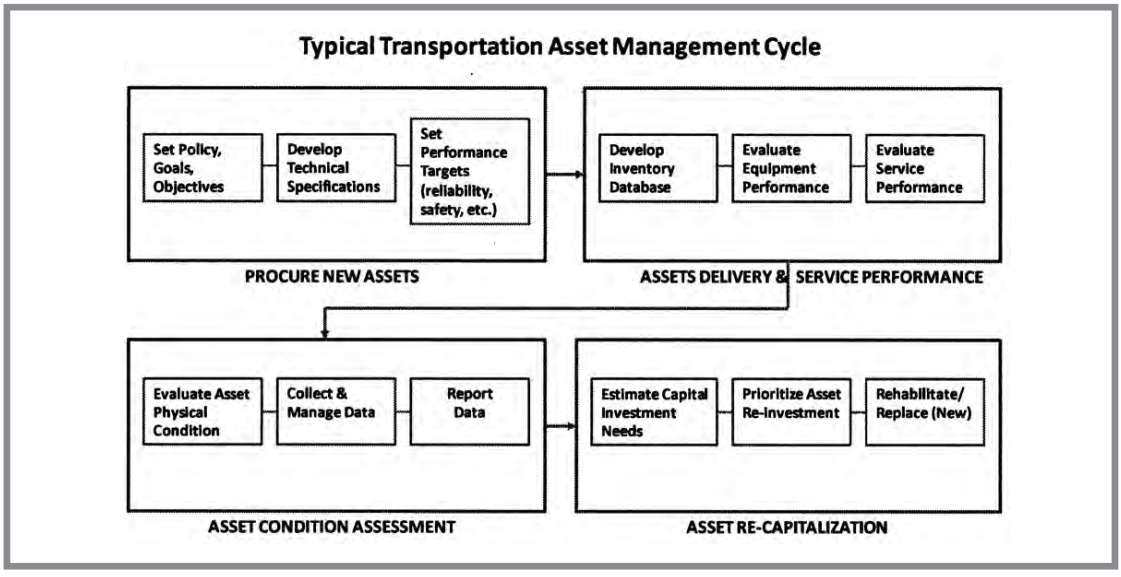
- Implementation—How to account for risk, and develop and implement systematic improvements and tools.
- Beyond pavements and bridges—Examined aspects that distinguish geotechnical and ancillary structures, signs, and sidewalks assets from pavement and bridges and how agencies can manage these assets through similar strategic principles.
- Good practices for managing and operating pavement and bridge assets—Reviewed successful asset management initiatives to improve decision-making.
- State of transit repair—Analyzed the U.S. transit system in terms of current operations and management standards and sources of financial support for repair initiatives.

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 shared resources and ideas to prevent the duplication of efforts. The workshops and conference enabled transportation agencies to work in partnership and establish an asset management agenda for the next several years.

LEARN MORE

For information on the 2012 conference and presentations: *www.cvent.com/events/9th-national-conference-on-transportation-asset-management/event-summary-6bd59c28b3bf4628a9ff70aa674ccbfc.aspx*



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

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Research Results

Designing an Automated Safety Warning System Controller

A standardized automated controller for processing roadside data provides motorists timely and reliable notifications about traffic and weather conditions

Rural

NOVEMBER 2013

Project Title:
Automated Safety Warning System Controller

Task Number: 1750

Start Date: April 1, 2010

Completion Date: March 14, 2013

Product Category: New equipment

Task Manager:
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WHAT WAS THE NEED?

California has many different warning systems on the state's highways to disseminate safety notifications, such as changeable message signs, Highway Advisory Radio, and flashing beacons. These warning systems depend on data collected from sensors and other detection systems. The data is then interpreted in a Transportation Management Center (TMC) or maintenance shop, and staffers make decisions about whether to issue a warning. This dependency on human interaction can slow the timely activation of a warning. Because rural TMCs are usually not staffed 24 hours a day, activating warnings or information systems can be further delayed. In addition, during severe weather, communication lines to a remote site might not be reliable, affecting the decision-making process to issue roadway warnings.

The implementations of the various warning systems are not standardized. Each system uses a controller that is customized to a particular physical and electrical layout. The lack of standardization of controllers poses implementation, maintenance, and communication challenges, especially when the warning systems are located in remote locations.

WHAT WAS OUR GOAL?

The goal was to develop a standardized Automated Safety Warning System Controller (ASWSC) that can collect and analyze roadside sensor data and issue related warning messages and signals.

A changeable message sign activated by the ASWSC

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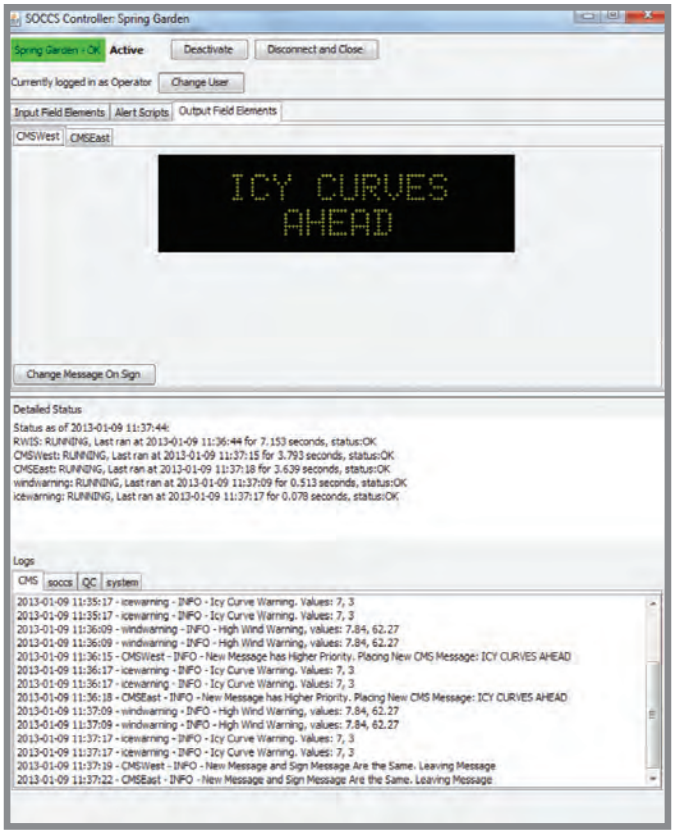
WHAT DID WE DO?

Caltrans, in partnership with the Western Transportation Institute at Montana State University, Bozeman, designed an ASWSC using commercial, off-the-shelf, Linux-based hardware and open source software. After extensive laboratory testing, a prototype was deployed in Caltrans District 2 on Highway 70 at the Spring Garden site near Quincy, which is prone to icy conditions. The researchers used the system to collect data from the surface sensors on that section of the road and alert drivers of ice.

The controller can be remotely managed and includes programming and scripting capabilities for implementing best practice algorithms for condition analysis and actuating corresponding warning signals and messages. The algorithm developed can be configured to meet the needs of a specific site based on geometrics and the microclimate of the surrounding area.



Operator's interface to the ASWSC

WHAT WAS THE OUTCOME?

The ASWSC's detailed time-stamped logging allowed the team to compare the data with other systems and confirm that the ASWSC was performing as expected. System performance information will be used for future enhancements and modifications. The final research phase, scheduled for 2014, will incorporate Caltrans Traffic Accident Surveillance and Analysis System (TASAS) data to determine if incidents were reduced by implementing this system.

WHAT IS THE BENEFIT?

The ASWSC monitors road and weather conditions and updates the warning systems accordingly without constant human intervention, improving traveler safety with more timely and relevant warning messages. The controller can interface with a variety of field sensors, elements, and safety warning systems, which streamlines operations and is more cost-effective than maintaining a multitude of disparate implementations. Using off-the-shelf equipment and open source software makes the ASWSC an economical solution. The ability to remotely access the controller reduces service costs. TMC operators and field engineers can adjust decision thresholds in response to changing weather, road, and incident conditions to further improve traveler safety.

LEARN MORE

For more information and updates about the ASWSC system, visit *http://westernstates.org/Projects/Controller/Default.html*

Map of Spring Garden ASWSC equipment

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Research Results

Testing the Performance of Grouted Couplers for Bridges

Precast columns assembled with grouted couplers pass seismic tests

Seismic

MARCH 2014

Project Title:
Seismic Performance of Precast Bridge Columns with Grouted Couplers

Task Number: 2290

Start Date: July 11, 2011

Completion Date: May 31, 2012

Product Category: New technical standards and specifications

Task Manager:
Peter Lee
Research Contract Manager
Email Address:
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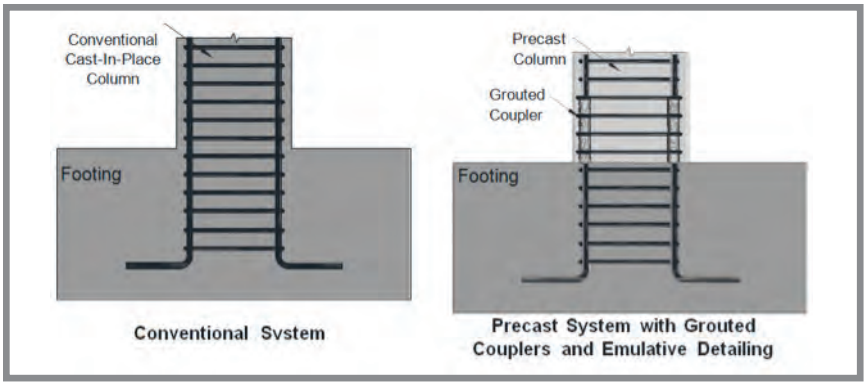
WHAT WAS THE NEED?

Accelerated bridge construction (ABC), which relies on prefabricated structural elements that can be rapidly assembled at the construction site, has gained momentum as an alternative to traditional cast-in-place construction. ABC can speed up construction, thereby reducing costs and lessening the impact on the environment and traveling public. Despite the advantages, ABC has not been widely implemented in areas prone to seismic activity because of the uncertainty of how the connections used to join precast elements, particularly the column connections, perform during an earthquake. After an earthquake, the columns must be able to maintain the stability of the bridge for public safety.

Grouted couplers have been successfully used to join precast elements for more than 30 years in high-rise building construction in Asia. A grouted coupler consists of a ductile cast-iron sleeve that is filled with high-strength grout and joins two reinforcing bars placed within the sleeve. Precast column members with grouted coupler connections have great potential for ABC projects in high-seismic zones because they can be assembled rapidly, and the reinforcement details are similar to conventional bridge columns. However, research on how these connections perform under seismic loading in bridge columns designed with U.S. standards is not available.



Comparison between conventional and precast systems with grouted coupler connections

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Testing the Performance of Grouted Couplers for Bridges

Research Results

WHAT WAS OUR GOAL?

The goal was to determine whether grouted couplers used to join precast column elements can withstand the loads and deformations that occur in a strong earthquake.

WHAT DID WE DO?

Caltrans, in partnership with the University of Nevada, Reno Center for Civil Engineering Earthquake Research, constructed three bridge column specimens to test under cyclic loads until they failed. Two columns were fitted with grouted coupler connections in a plastic hinge at the column-footing joint. The third column, used as the benchmark, consisted of conventional reinforced concrete. The researchers tested various grouted coupler devices to failure under static and dynamic uniaxial loading. They used the results to develop computer simulation models to evaluate the behavior of the connections.

WHAT WAS THE OUTOME?

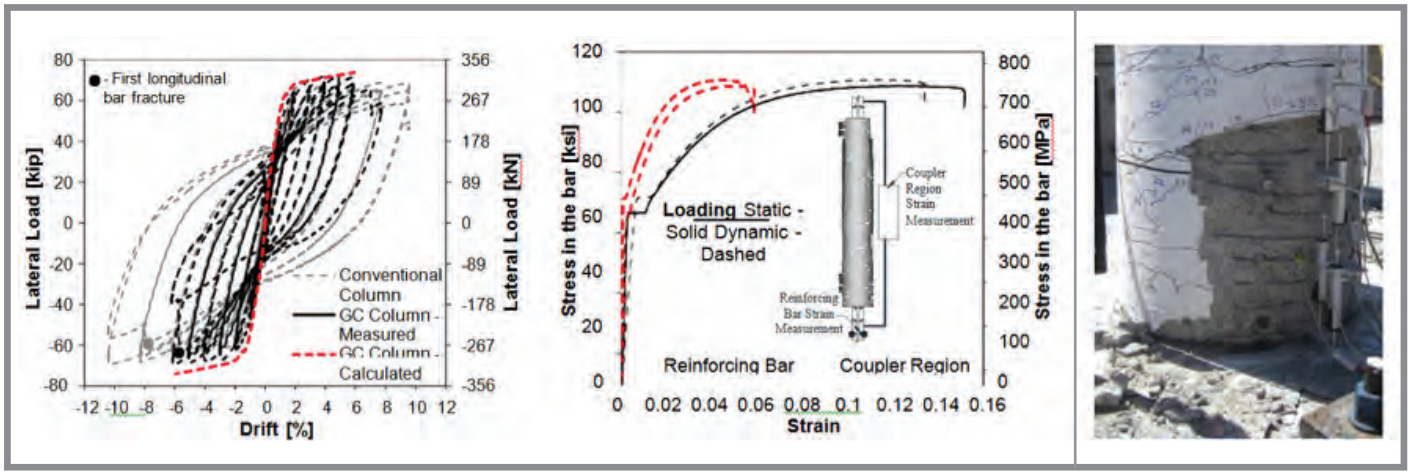
The results indicate that columns with grouted coupler connections behave similar to reinforced concrete columns. The grouted coupler devices changed the stiffness and strength to the area of the column, altering the overall behavior of the column member. Although the mode of failure was the same, the failure locations differed between grouted coupler and conventional columns, indicating that the presence of the grouted coupler devices changed the plastic hinge formation in the precast columns. The couplers themselves sustained no damage. The computer models developed to calculate the response of the grouted coupler columns supported the experimental results.

WHAT WAS THE BENEFIT?

Accelerated bridge construction has the potential to offer numerous advantages, from minimizing traffic delays and mitigating noise and air pollution, to cutting costs and enhancing construction site safety. This research shows that precast columns utilizing grouted couplers can achieve ductile response in seismically active areas. However, they might not be as resilient as cast-in-place columns. Caltrans is continuing to research ways to improve ABC connection methods to maximize ductile design and resiliency of ABC bridge systems.

LEARN MORE:

To view the complete report:
www.dot.ca.gov/hq/esc/earthquake_engineering/Research_Reports/vendor/un_reno/Final_Report_65A0425.pdf



Behavior of grouted couplers and their connections (left to right): Force-displacement response of conventional and grouted coupler columns; tensile stress-strain response from individual couplers; damage of a grouted coupler column-footing connection at 6% drift

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Research Results

Instrumenting Bridges to Capture Seismic Activity

Sensors advance the understanding of how bridges react to major seismic events

Seismic

JANUARY 2014

Project Title:
California Bridge Strong Motion Instrumentation Program

Task Numbers: 2189 & 2241

Start Date: July 2009

Completion Date: June 2013

Product Category:
Processed data and database

Task Manager:
Pat Hipley
Research Contract Manager
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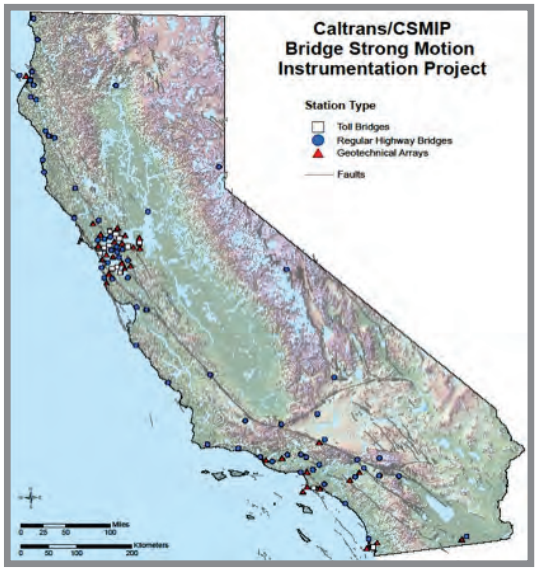
WHAT WAS THE NEED?

Since the 1989 Loma Prieta earthquake, Caltrans has expanded efforts to install bridge sensors and downhole arrays throughout the state to assess bridge performance during a major earthquake and evaluate bridge conditions following the event. Motion sensors record the magnitude and duration of shaking over time. Downhole geotechnical arrays, which are buried at varying depths and geologic layers near bridge piers, measure acceleration to gather local site amplification data.

The number of sensors installed at each structure ranges from up to 200 for long-span toll bridges to as few as 6 for small bridges. Each sensor is a complex electronic device, networked within a system equipped with amplifiers, batteries, and recording devices. If the electrical grid is not working, the system runs on battery power. The batteries must be replaced every three or four years. The bridge sensors are robust and weather-resistant, and many have been operating for more than 20 years. However, vandalism, particularly copper wire theft, and equipment damage from nearby construction does occur. A comprehensive, ongoing program of oversight and vigilant maintenance is critical to keeping the seismic instruments functional at all times.

WHAT WAS OUR GOAL?

The goal was to monitor and maintain the existing inventory of seismic instruments installed on the state's bridges and to continue installations on bridges and tunnels.



Location of bridges and downhole arrays

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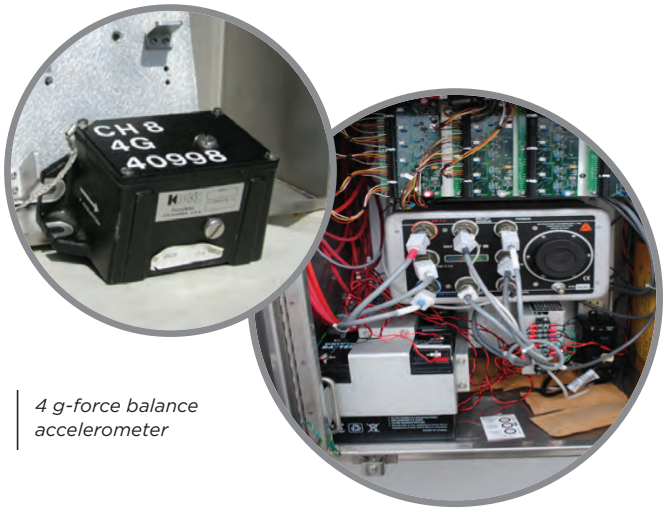
Instrumenting Bridges to Capture Seismic Activity

WHAT DID WE DO?

Caltrans, in partnership with the California Geological Survey, placed strong-motion bridge sensors on highway and toll bridges to record deck torsion, column deflection, vertical roadway movement, rocking of large footings, and the opening and closing of hinges during a strong earthquake. The researchers compared longitudinal and transverse motion data with current modeling techniques to improve future modeling assumptions. They also assessed the functional health of the strong-motion sensors and geotechnical arrays installed on more than 100 bridges throughout the state. The instrumented bridges are checked every few months via phone lines. When problems are detected, repair teams are dispatched to the site to restore the system to full operational capacity.

WHAT WAS THE OUTCOME?

All toll bridges located in densely populated areas near active faults were instrumented. The sensor readings are now part of a database to assist in quickly assessing bridge conditions following an earthquake. The data has also been used to calibrate and refine computer modeling techniques to better capture the true structural response of large bridges and overcrossings. The readings help pinpoint the structural members that have yielded during a strong shaking event, movement that might not be apparent during a routine inspection but can be important for large underwater piers. In addition, existing sensors, recorders, and system batteries were monitored, replaced, and repaired. Vast amounts of data collected from previously recorded seismic motions were processed and archived for future design use.



4 g-force balance accelerometer

Data recording system

WHAT IS THE BENEFIT?

An inventory of seismically monitored bridges is critical to maintaining public safety in a state prone to earthquakes. Using instrumention to observe how different types of bridges—from simple two-span overpasses, large single-column connectors, to multimillion dollar toll bridges—react to major seismic events gives seismologists and bridge engineers a better understanding of how various structural configurations respond to strong seismic shaking. Strong motion data also reveals valuable near-real-time information on ground-shaking levels and loss assessment for emergency responders. The collected data leads to improved design and build practices and analytical approaches for seismic modeling.

Drilling a downhole array at the Napa River bridge

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Research Results

Seismic Monitoring for Bay Area Toll Bridges

Updating the analytical models for the new Benicia-Martinez and Carquinez bridges

Seismic

JANUARY 2014

Project Title:
Archive Toll Bridge ADINA Models

Task Number: 2161

Start Date: January 25, 2010

Completion Date: December 31, 2012

Product Category:
New and improved models and software

Task Manager:
Steve Mitchell
Research Contract Manager
steve.mitchell@dot.ca.gov

WHAT WAS THE NEED?

Caltrans established the Toll Bridge Seismic Retrofit Program after the 1989 Loma Prieta earthquake, installing strong-motion sensors on the toll bridges and below ground nearby to monitor and assess their vulnerability. As part of the retrofit program, a finite element analytical model was designed for each bridge using the commercial software program ADINA (Automatic Dynamic Incremental Nonlinear Analysis). Each model was tailored to a particular bridge. Each one was designed by a different team using differing modeling assumptions, so natural inconsistencies are built into the modeling process. The ADINA models for each bridge must be updated to have them conform with the current software. Updated retrofit models have already been completed for seven of the state's nine toll bridges.

WHAT WAS OUR GOAL?

The goal was to convert two Bay Area toll bridge retrofit models to the latest version of ADINA software.

Benicia-Martinez bridge

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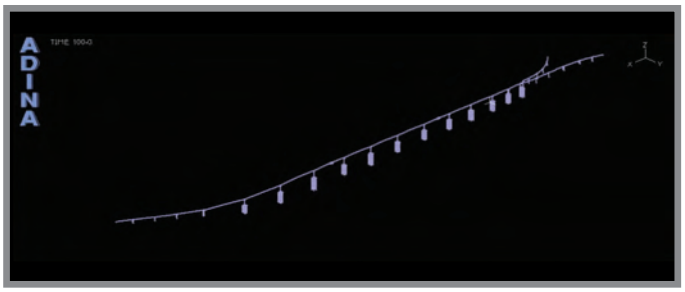
WHAT DID WE DO?

Caltrans, working with analytical and geotechnical engineering consultants, updated the ADINA models for the new Carquinez and Benicia-Martinez bridges. In addition, the team modified an existing analysis system that manages the vast amount of data obtained from the seismic sensors, enabling Caltrans to produce time-history motions and analyses for the bridges. The analysis system, generated during a previous contract, allows researchers to use Strong Motion Instrumentation Program (SMIP) motions to generate model-specific, time-history motions, which are then used as inputs to the ADINA models.

WHAT WAS THE OUTCOME?

Caltrans completed the ADINA analysis upgrades and system modifications for the state's last two toll bridges, maximizing the ability to more fully and accurately use the SMIP data on the state toll bridges to determine bridge response and evaluate seismic safety.



ADINA model of the Benicia-Martinez bridge

ADINA model of the Carquinez bridge

WHAT IS THE BENEFIT?

The updated ADINA analytical models for California's toll bridges allows Caltrans to more accurately:

- Analyze toll bridges after a large earthquake
- Predict regions of possible damage on the archived bridges
- Direct maintenance crews to vulnerable areas
- Assess a bridge's functional capacity
- Validate the existing ADINA models
- Plan future seismic retrofit work through the models
- Support future research using strong-motion data from long-span bridges

Carquinez bridge

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Research Results

Seismic

Improving the Design of Earth-Retaining Walls

New geotechnical and structural design procedures enhance the longevity and safety of retaining wall structures

DECEMBER 2013

Project Title:
Improved Guidelines for Earth-Retaining Structures

Task Number: 2270

Start Date: June 1, 2011

Completion Date: May 31, 2012

Product Category: Improved guidelines and new models

Task Manager:
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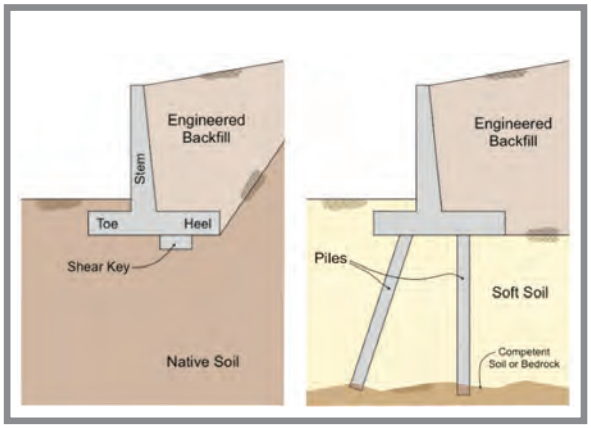
WHAT WAS THE NEED?

Retaining walls are an essential element in highway construction, but earlier seismic design guidelines, based on the Mononobe-Okabe (M-O) equations, do not address passive pressures, which determine the resisting force at the toe of standard, semi-gravity retaining walls and at the wall face for pile-supported cantilever walls. More sophisticated limit-equilibrium methods for determining the passive pressures for general cohesion and friction backfills exist, but they do not take inertial effects into account. New design criteria that incorporate backfill inertia and cohesion into an accurate model are needed to mitigate the potential for retaining wall failures during an earthquake.

WHAT WAS THE GOAL?

The goal was to develop updated design guidelines for earth-retaining structures, incorporating new safety and serviceability standards to address known shortcomings.



Caltrans cantilever reinforced concrete retaining walls are typically built with a shear key (left) or supported on piles (right).

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Los Angeles Department of Civil and Environmental Engineering, incorporated a Log-Spiral-Rankine Model, which is based on the log-spiral limit equilibrium approach for building earth-retaining structures. A physics-based, mathematically rigorous model, the Log-Spiral-Rankine Model offers a more complete picture of the problem than previous limit equilibrium models. The researchers incorporated backfill inertia and cohesion into the model, verifying the accuracy of those extensions using advanced numerical finite-element methods and existing centrifuge and field test data.

A wide variety of earth-retaining systems exist. This effort focused on semi-gravity retaining structures, which include reinforced concrete, cast-in-place, and cantilever retaining walls. Structural behaviors of non-gravity cantilever and anchored retaining walls were also investigated. If the native soil is weak, it is recommended to add piles to meet the bearing and overturning demands. If native soils have adequate bearing capacity, or seismic demand is low, a shear key provides ample restraint against lateral sliding.

Precast concrete crib walls

WHAT WAS THE OUTCOME?

The Log-Spiral-Rankine Model explicitly accounts for the magnitude of earthquake acceleration, structure height, backfill soil properties, such as internal friction angle and cohesion, and the mobilized interface friction angle between the backfill and earth-retaining structure.

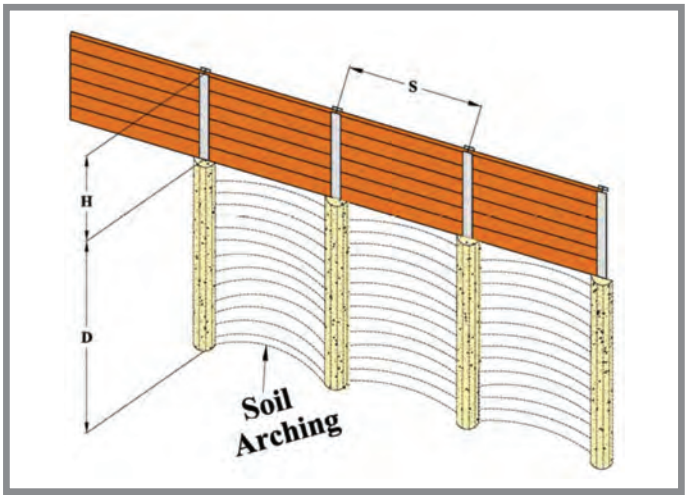
Step-by-step design procedures, including two examples for the design of cantilever retaining walls supported by a spread footing and a pile foundation, were developed. New safety guidelines specify how to design earth-retaining structures to withstand lateral earth and water pressures, the effects of surcharge loads, self-weight of the wall, and earthquake loads. Serviceability requirements are also addressed, including adequate structural capacity with acceptable movements, adequate foundation capacity with acceptable settlements, and the overall stability of slopes adjacent to walls.

WHAT WAS THE BENEFIT?

Earth-retaining structures are an important component of California's transportation infrastructure. To repair, replace, or retrofit these structures can be costly and labor intensive. These new guidelines provide a more comprehensive and rational design approach to improve earth-retaining structure performance during a seismic event.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/final_report_65a0413_task_2270.pdf



Soldier piles with arching

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Research Results

Developing Seismic Criteria to Account for Bridge Traffic

Study finds that bridge traffic can have a neutralizing effect in an earthquake

Seismic

FEBRUARY 2014

Project Title:
The Effect of Live Load on the Seismic Response of Bridges

Task Number: 2349

Start Date: April 30, 2009

Completion Date: October 31, 2012

Product Category:
New technical standard

Task Manager:
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Research Contract Manager
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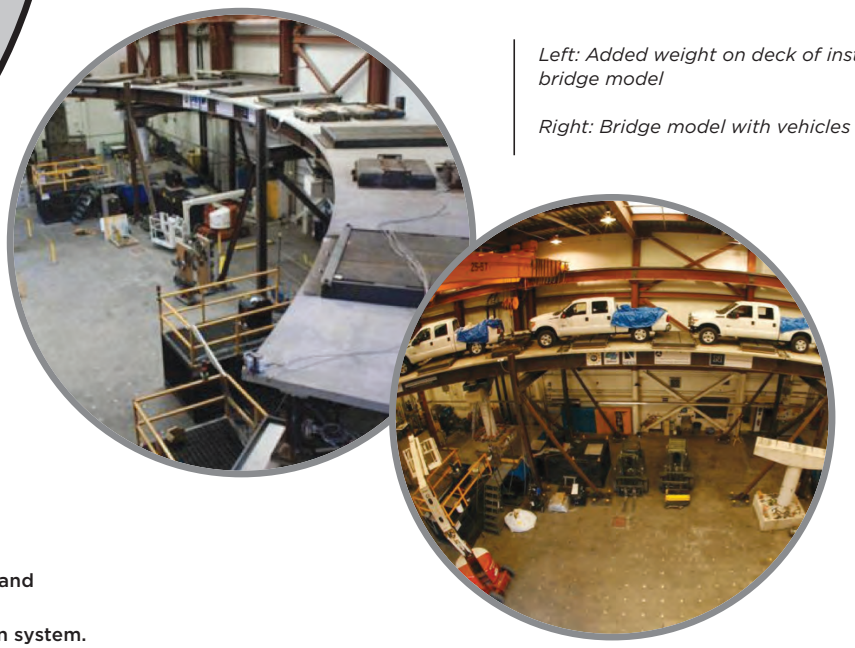
WHAT WAS THE NEED?

Seismic design specifications for bridges generally do not address live load—moving traffic—criteria, in part because earthquake-related damage directly associated with live loads has not been observed. With the increase of traffic over the past few decades, it is likely that far more vehicles will be on a bridge during an earthquake than was previously predicted. Design criteria for long-span bridges have been developed on a case-by-case basis, but no current seismic criteria address live-load effects for ordinary standard bridges in California. The effect of vehicles on bridges during large earthquakes has been a contentious issue because it is not well understood. Reliable research is needed to understand the influence of traffic on bridge performance during an earthquake.

WHAT WAS OUR GOAL?

The goal was to study how live loads affect highway bridges during an earthquake.



Left: Added weight on deck of instrumented bridge model

Right: Bridge model with vehicles

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Developing Seismic Criteria to Account for Bridge Traffic

WHAT DID WE DO?

Caltrans, in partnership with the University of Nevada, Reno Department of Civil and Environmental Engineering, studied the effect of live loads on the seismic response of bridges. Researchers conducted multiple shake table tests on a large-scale model of a three-span steel girder bridge with a high degree of curvature. Six trucks were loaded on the model, which spanned four shake tables. The performance data was compared against a benchmark experiment without live loads. Analysts developed a 3-D finite element model of the bridge and live load and calibrated it against the experimental results. The model was then used to determine if the observations extended to bridges and trucks of varying mass.

WHAT WAS THE OUTCOME?

For the bridge tested, the study shows that live load can beneficially change the behavior of a bridge during an earthquake. Live load reduced the demand in the structure, as indicated by a decrease in displacements, accelerations, and internal forces. The presence of live load also delayed the formation of cracks and concrete spalling in the columns, reduced column damage, and lessened girder uplift at the abutments and degradation of column stiffness. However, study results also showed the beneficial effect of live load diminished as the shaking amplitude increased.

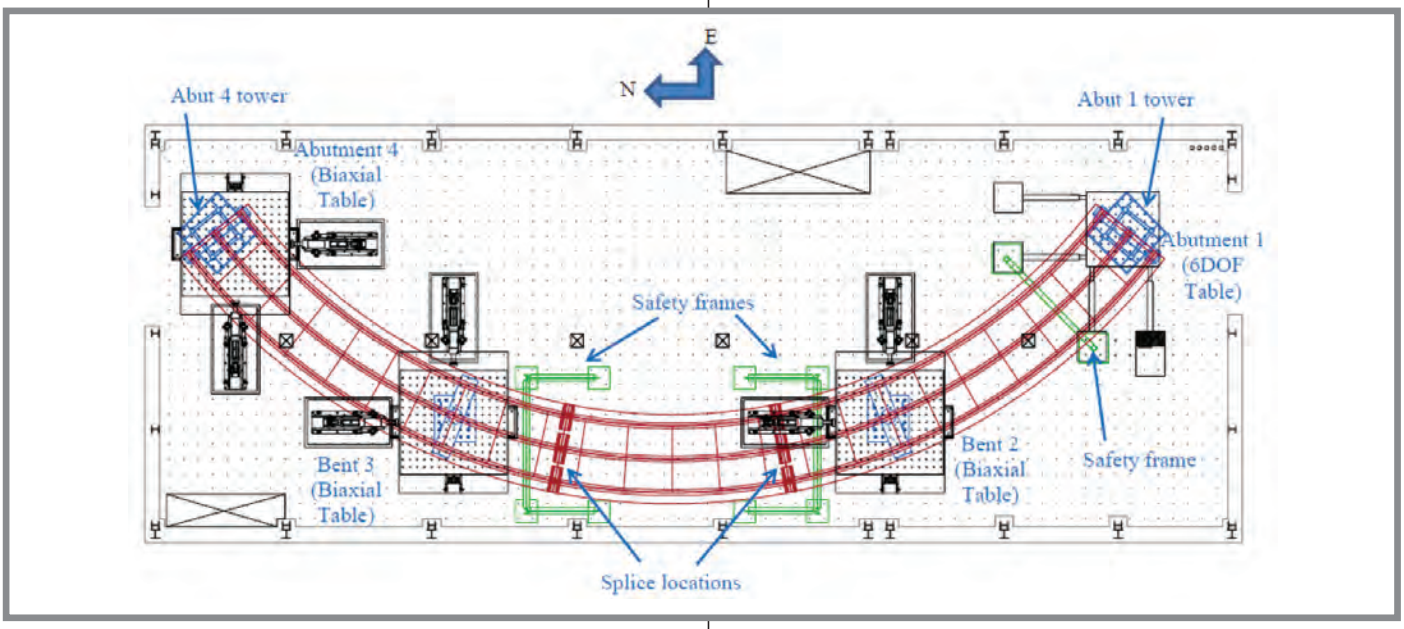
The 3-D finite element model for vehicle-bridge interaction replicated this behavior well. Although this model could be further refined, it is considered sufficiently accurate for use in live-load effect studies. The study resulted in recommendations concerning the influence of live load on seismic response and how these effects can be included in the seismic analysis and design of bridges. More importantly, it demonstrated that current design guidance is adequate because the bridges do not suffer adverse effects from the live load.

WHAT IS THE BENEFIT?

Bridges built in seismically prone regions in major population centers carry more traffic than decades ago—much of it heavy commercial trucks. Yet seismic design specifications generally do not include the effect that live loads has on bridges, because few studies have focused on this issue. Reliable experimental studies that test live load effects on various types of bridges under varying conditions will lead to improved understanding, resulting in refined bridge seismic design specifications. Because this work verified the adequacy of current guidance material regarding live load traffic on a standard bridges, no additional design or construction costs are needed.

LEARN MORE

To view the complete report:
www.dot.ca.gov/hq/esc/earthquake_engineering/Research_Reports/vendor/un_reno/59A0695/59A695_Final%20Report.pdf



Horizontally-curved bridge model plan

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Research Results

Assessing In-Service Seismic Response Modification Devices

New algorithm evaluates the performance of viscous dampers and isolation bearings

Seismic

JANUARY 2014

Project Title:
Assessment and Reliability of Seismic Response Modification Devices In-Service

Task Number: 2041

Start Date: June 25, 2008

Completion Date: January 31, 2013

Product Category: New model and algorithm

Task Manager:
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Research Program Manager
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WHAT WAS THE NEED?

Caltrans has pursued a comprehensive program of bridge seismic retrofit over the past three decades to ensure public safety, bringing bridges up to the latest seismic standards to prevent collapse during an earthquake. As part of that retrofit effort, a separate program was established for long-span toll bridges, which present unique challenges as the state's largest and most complex bridges structures. Although the retrofit program for conventional bridges is technically feasible for toll bridges, it would be costly as well as create long-term traffic disruption to the public.

An innovative strategy that is more efficient for toll bridges was implemented using seismic response modification devices, such as viscous dampers and seismic isolation bearings. As part of this implementation, Caltrans sponsored the development of a unique facility to test commercially available response modification devices at the loads and speeds—70 inches per second—expected during an earthquake. Since then, numerous devices have been tested, and an extensive library of basic performance characteristics has been developed. However, the tests conducted were limited to new devices. What was lacking was performance data during a seismic event after the device had been in service for 10 or more years.

WHAT WAS OUR GOAL?

The goal was to develop and validate an approach for monitoring the performance of devices in service and develop deterioration models to improve the correlation between device performance and bridge structure performance.

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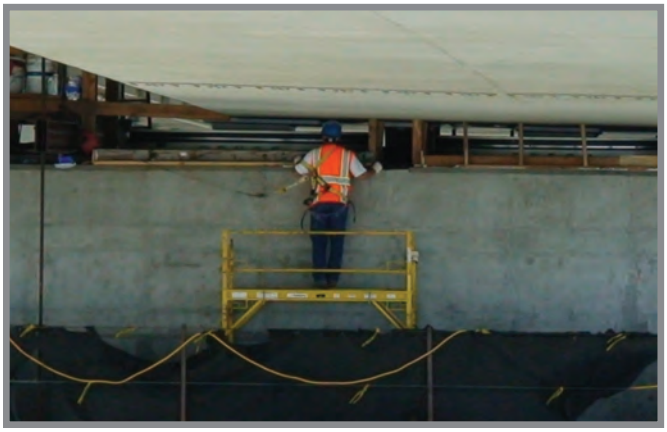
Assessing In-Service Seismic Response Modification Devices

Research Results

WHAT DID WE DO?

Caltrans, in partnership with University of California, San Diego and Texas A&M University, developed a structural health monitoring (SHM) algorithm to detect changes in seismic response modification devices installed on bridges. The algorithm assesses the performance degradation of conventional structural components and installed isolators and energy dissipaters based on changes in the structure's modal characteristic. Evaluating performance change is a two-step procedure. First, suspected damage or a change in response is located on the structure, which is then followed by quantifying the change. The researchers validated localization results through data obtained from numerical models and limited data sets collected from these bridges. The results have been promising in terms of localizing changes in both the structure and the seismic response modification device.

To further improve the reliability of the approach, the researchers studied the durability and wear characteristics of rod bearings and seals in viscous dampers. Many laboratory tests on different devices provided a large data set that was analyzed to identify the critical performance parameters of devices under realistic loading conditions. Similar studies were completed on friction pendulum and lead rubber bearings to increase the limited knowledge available for full-scale devices. This included a comprehensive numerical study to investigate the effects of vertical load, velocity, and repetition of motion for these devices.



WHAT WAS THE OUTCOME?

Applying the structural health monitoring procedure to recorded data from bridge networks confirmed the suspected changes of the performance of the installed dampers. The evolution of the degradation in time and the forensic study of the involved devices suggested the existence of a critical combination of device characteristics and service-loading conditions that requires more careful monitoring and development of specific inspection and maintenance plans. The proposed models, validated during laboratory tests for friction pendulum and lead-rubber bearings, indicate the need for improved testing protocols for device characterization and updated acceptance criteria.

WHAT IS THE BENEFIT?

Caltrans bridge engineers have a tool to monitor bridge and device performance on properly instrumented structures. This information will aid engineers in developing better project and material specifications.

LEARN MORE:

To view the complete report:
www.dot.ca.gov/hq/esc/earthquake_engineering/Research_Reports/vendor/uc_san_diego/201305/Final_Report_59A0657_CA13-2041.pdf

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Research Results

Are California's Bridges Vulnerable to a Tsunami?

Developing models to measure the impact of tsunami forces on coastal bridges

Seismic

MARCH 2014

Project Title:
Tsunami Forces on Selected California Coastal Bridges

Task Number: 1983

Start Date: March 1, 2011

Completion Date: February 28, 2013

Product Category:
New technical standard

Task Manager:
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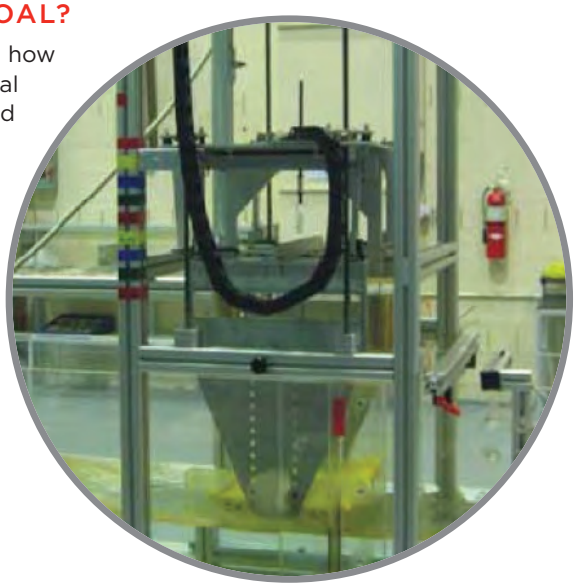
WHAT WAS THE NEED?

Past studies have examined how bridges perform during earthquakes, hurricanes, and storm surges, but few comprehensive studies have measured tsunami forces on coastal bridges. Some bridges that have withstood earthquakes were later washed away after a tsunami hit, indicating that current design specifications might not provide bridges with sufficient resilience to resist tsunami loads. Most investigations have been either surveys that explained the failure mechanisms after a tsunami or small-scale experimental studies that oversimplified wave types and bridge configurations. Each tsunami contains multiple wave types, from a solitary wave to a complex pattern of breaking waves, all of which can impose a wide range of loads on bridges.

Tsunami-resistant design criteria for coastal bridge superstructures that address factors such as how large a wave is required to cause a bridge collapse and whether existing box girder bridges are vulnerable to damage from tsunamis is needed.

WHAT WAS OUR GOAL?

The goal was to determine how vulnerable California coastal bridges are to tsunamis and how to modify design codes to mitigate or avoid extensive damage.



Measuring hydrodynamic loads on inundated bridge decks

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Are California's Bridges Vulnerable to a Tsunami?

WHAT DID WE DO?

Caltrans, in partnership with the Oregon State University School of Civil and Construction Engineering, measured the effect of tsunami loads on five California coastal bridges. The researchers calculated the maximum horizontal and vertical loading on a bridge superstructure in a tsunami. Both the initial impact and total inundation time periods were considered, with the entire process modeled in simulations.

Tsunami flow durations usually span hours. To capture the behavior of the structure under several impacts and inundations over the full duration, multiple time periods were analyzed. For each tsunami flow condition, the forces and moments were computed for four selected time periods containing initial impact, occurrence of the maximum tsunami water velocity, occurrence of the maximum tsunami momentum flux, and occurrence of the maximum tsunami mass flux.

The researchers developed finite-element (FE) analysis codes to compute tsunami loading on the selected bridges and validated the outcomes using experimental results of hydrodynamic loads on inundated bridges. The team used tsunami input data sets provided by Caltrans to generate the tsunami flow field in the vicinity of the bridges. Tsunami horizontal and vertical forces and moment time histories were obtained using the FE codes.

Location of Malibu Lagoon Bridge

WHAT WAS THE OUTCOME?

The researchers developed formulas to estimate tsunami loading on bridges. Comparisons between numerical results from simulations and the estimated forces provided some data to evaluate bridge vulnerability. The research recommends conducting large-scale, wave-tank testing to validate and calibrate these equations.

Tsunami-bridge interactions generally occur in two phases: the initial impact between tsunami water with the seaward side of the bridge cross-section, and the phase in which the tsunami has completely inundated the bridge. The team learned that the initial stage includes a combination of horizontal and uplift forces. Maximum uplift force at the first wave impact occurs when the water reaches the top of the bridge barrier, just before it flows onto the bridge deck. During that stage of loading, horizontal and uplift forces gradually increase, causing the overall maximum uplift force to occur when the bridge superstructure is already inundated. The next step is to conduct wave-tank studies to validate the analytical work.

WHAT IS THE BENEFIT?

Determining the vulnerabilities of California's coastal bridges to tsunamis is a first step to avoiding bridge failures. A reliable tsunami-resistant design criterion for coastal bridges is crucial. The equations developed are analytical predictions to determine tsunami loading on bridges, enabling Caltrans to assess if coastal superstructures are vulnerable to tsunamis and how tsunami loads compare in magnitude to forces generated by strong shaking.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/final_report_65a0384_task_1983.pdf

Fourteen simulations were performed on the Malibu Lagoon box-girder bridge.

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Research Results

Validating Buckling-Restrained Brace Performance for Long-Span Bridges

Buckling-restrained braces offer an alternative to viscous dampers for mitigating seismic damage to long-span bridges and reduce maintenance costs

Seismic

JANUARY 2014

Project Title:
The Feasibility of Using Buckling-Restrained Braces for Long-Span Bridges

Task Number: 2149

Start Date: July 1, 2010

Completion Date: November 30, 2012

Product Category: New design guidelines and test protocol

Task Manager:
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Research Program Manager
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WHAT WAS THE NEED?

Buckling-restrained braces (BRB) may be a viable alternative to improve the seismic performance of bridges in active seismic areas, replacing the viscous-fluid dampers used to retrofit long-span bridges. When subjected to ambient bridge motion, viscous dampers tend to deteriorate faster due to the continuous movement of the bridge from traffic, raising questions about their reliability during a significant seismic event.

BRBs consist of a slender steel core supported by a concrete casing to prevent buckling under axial compression. While they are reliable at dissipating energy as demonstrated by protocols developed for the building industry by the American Institute of Steel Construction (AISC), those requirements are insufficient for bridge applications.

WHAT WAS OUR GOAL?

The goal was to investigate the feasibility of replacing viscous-fluid dampers with buckling-restrained braces on long-span bridges and develop acceptance criteria for BRBs.

Installing a buckling-restrained brace on a bridge

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Validating Buckling-Restrained Brace Performance for Long-Span Bridges

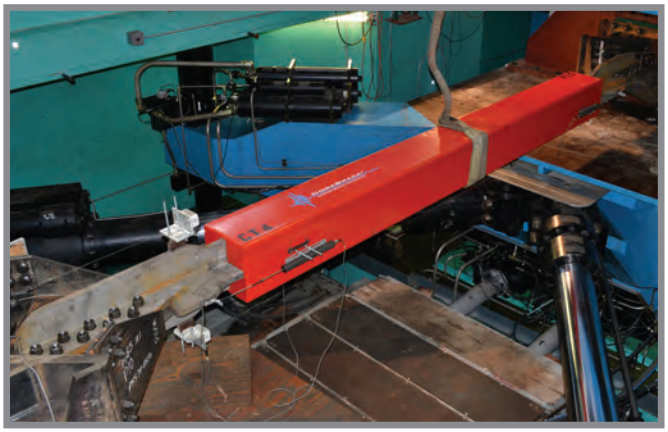
Research Results

WHAT DID WE DO?

Given the complexity of long-span steel truss bridges and bridge-specific design guidelines for these types of structures, the researchers performed extensive analytical modeling to identify the expected structural response during an earthquake. Bilinear BRB elements replaced viscous damper elements as part of a parametric study to identify the BRB parameters required for seismic response mitigation.

The bridge used in the case study is situated directly over a major fault, causing the pre-established site-specific design earthquake to be a near-fault, pulse-type ground motion, which is common for many long-span bridges in California. This scenario presents an important new structural application and seismic environment for BRBs. A near-fault event is characterized by a pulse of high ground velocity that results in inelastic cyclic demands on a bridge. These demands are explicitly neglected in existing AISC provisions.

The researchers physically verified the ability of BRBs to sustain these near-fault demands and validated the new loading protocols. The test matrix included braces fabricated with A304 stainless steel to utilize the superior ductility and corrosion properties and specimens tested at high strain rates to investigate the dynamic effect on BRB performance.



Left and right: Lab testing BRBs

WHAT WAS THE OUTCOME?

The analytical results show that replacing viscous dampers with BRBs is economical, feasible, and beneficial for bridge applications. However, retrofitting other bridge structural elements might still be required. Loading protocols for qualifying BRBs for use on many existing near-fault, long-span bridges have been developed. Using these protocols, full-scale testing of six commercially available BRBs demonstrated their ability to deliver the large strain (= 0.05 in/in) demand under both pseudo-static and dynamic rates.

WHAT IS THE BENEFIT?

The need for economical solutions that require low maintenance, yet provide sufficient structural resistance for bridge structures is critical. Agreement between the analytical studies and the full-scale testing results has demonstrated the feasibility of using existing BRB technology on long-span bridges. Additional work is required to confirm whether BRBs can replace viscous-fluid dampers without the need for additional bridge retrofitting.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2011/final_report_ca12-2149.pdf

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Research Results

Improving Seismic Guidelines for Earth-Retaining Walls

Testing the seismic performance of retaining structures in various soil types

Seismic

MARCH 2014

Project Title:
Seismic Earth Pressures on Retaining Structures in Cohesive Soils

Task Number: 2170

Start Date: June 30, 2010

Completion Date: June 1, 2013

Product Category: Improved specification

Task Manager:
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Research Contract Manager
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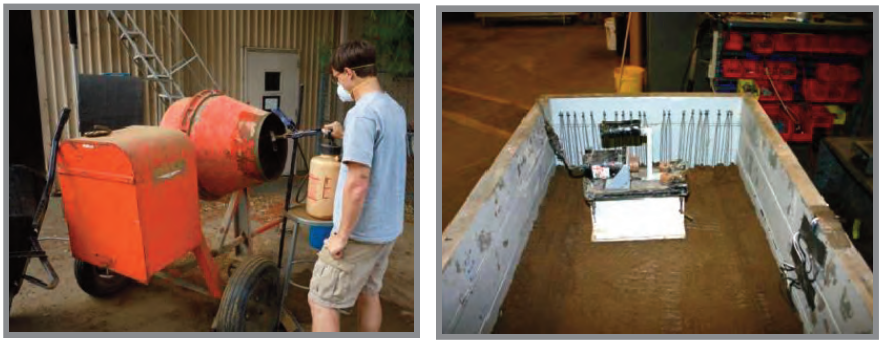
WHAT WAS THE NEED?

Earth-retaining structures along California highways are essential to the operational maintenance of underground facilities and the transportation infrastructure. While observed seismic failures of modern retaining structures have been rare, these structures were built using methods that date back to the 1920s. Geotechnical engineers are interested in evaluating the performance of current design approaches to learn more about the dynamic behavior of retaining structures built over different soil types. Testing the range of soils underlying the state's existing retaining structures—from dry granular sands to compacted, cohesive clays—will provide a more refined and accurate picture of the situation in the field.

WHAT WAS OUR GOAL?

The goal was to develop new seismic guidelines for earth-retaining structures in cohesive and noncohesive soil types.



Construction of level ground model: soil mixing and cantilever wall on north end

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Improving Seismic Guidelines for Earth-Retaining Walls

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Department of Civil and Environmental Engineering, conducted scaled centrifuge model experiments. Two related projects measured the seismic response of retaining walls on models containing cohesive clays and dry, granular cohesionless backfills, using structures with varing degrees of stiffness. Centrifuge experiments included a scaled 6-meter basement wall and a scaled 6-meter freestanding cantilever wall with level and sloping backfill. The model bases were subjected to ground motions of multiple intensities.

Numerical models calibrated with the soil properties determined from laboratory tests produced consistent agreement with the centrifuge experiments, capturing the most important aspects of the seismic responses, including ground motion propagation and dynamic soil structure interactions.

WHAT WAS THE OUTCOME?

A dual approach combining centrifuge experiments and numerical modeling generated new recommendations for designing more seismically robust retaining structures. The data provided insight into the dynamic interaction between retaining structures and varying soil backfills. The recommended next step is to instrument and test full-scale structures using a variety of backfill soils and collect performance data to characterize the response of earth-retaining structures to seismic pressures. This information will help validate some of the developed design equations.

Construction of sloping backfill model

WHAT IS THE BENEFIT?

Studies that focus on understanding the seismic behaviors of the varied soil conditions underlying California's retaining structures lead to rational design guidelines for future earth-retaining structures. Despite being built in earthquake-prone areas using methodologies nearly a century old, the state's retaining structures have performed well, and researchers report few if any structural failures following recent earthquakes. Geotechnical engineers want to understand this apparent paradox and explain why retaining structures have been able to withstand even severe earthquakes, despite being built in a wide range of soil types.

LEARN MORE:

To view the complete report:
www.dot.ca.gov/hq/esc/earthquake_engineering/Research_Reports/vendor/uc_berkeley/Final_Report_65A0367_Cohesive.pdf

Construction of sloping backfill model

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Research Results

Analytical Investigation of Replaceable Structural Fuses for Bridges

Structural fuses dissipate seismic energy while maintaining the integrity of other key bridge elements

Seismic

JANUARY 2014

Project Title:
Resilient Bridges: Replaceable Structural Fuses for Post-Earthquake Accelerated Service, Phase I: Analytical Investigation

Task Number: 2296

Start Date: June 27, 2011

Completion Date: March 3, 2013

Product Category: New design guideline

Task Manager:
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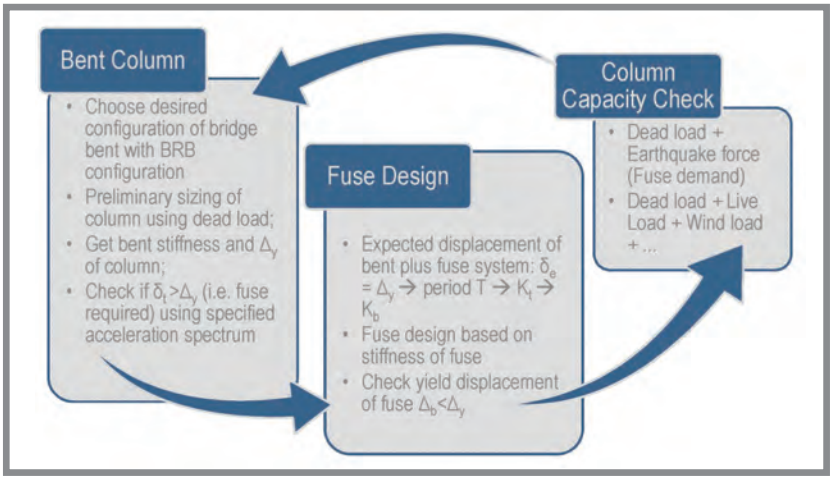
WHAT WAS THE NEED?

Existing seismic bridge design procedures for columns focus on maintaining sufficient ductile response to provide lateral load resistance and prevent bridge collapse in the event of an earthquake. However, even when the bridge remains standing after an earthquake, damage due to inelastic deformation sustained during the earthquake can be severe enough to compromise the structural integrity of the columns. While well-detailed, ductile-reinforced concrete columns are expected to perform well, when there is damage, repairs are labor intensive, expensive, and time consuming, sometimes requiring lengthy bridge closures. Developing a structural fuse system that uses accelerated bridge construction pier concepts can expedite bridge repairs, reduce closures, and limit the disturbance to local residents.

WHAT WAS THE GOAL?

The goal was to investigate the feasibility of using replaceable structural fuses as part of the bridge substructure to dissipate the seismic energy without compromising column safety.



Design flowchart of bridge bent with buckling-restrained braces

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Analytical Investigation of Replaceable Structural Fuses for Bridges

Research Results

WHAT DID WE DO?

To study the feasibility of using structural fuses, Caltrans, in partnership with researchers at the University of Buffalo, compared various types of structural fuses, including buckling-restrained braces (BRB), steel plate shear walls, and triangular-added damping and stiffness devices. They found that the BRB provided the most practical and economical solution as a structural fuse. The BRB can effectively dissipate seismic energy while keeping bridge columns intact. A typical BRB consists of a slender steel core supported by a concrete casing to prevent buckling under axial compression.

Initially, the researchers conducted simple static pushover analyses using fundamental capacity design principles to investigate seismic demands on the columns for two proposed bridge bent (pier) configurations: a two-concrete-filled tube column and a box-pier column. Comparison of theoretical and actual pushover curves in both cases showed good results, indicating that bridge bent behavior was consistent with the data predicted by the structural fuse concept.

To further validate this concept analytically, the research team conducted more complicated nonlinear time history analyses to verify the behavior of the bridge bents, comparing those results to the response predicted by the design procedure, elastic response spectrum, and pushover analysis. They sized the BRBs to meet the structural fuse objectives for managing seismic lateral loads for the proposed bridges, formulated design installation procedures, and developed proposed design specifications for connecting the BRBs to other structural members of the concrete bridge bents.

WHAT WAS THE OUTCOME?

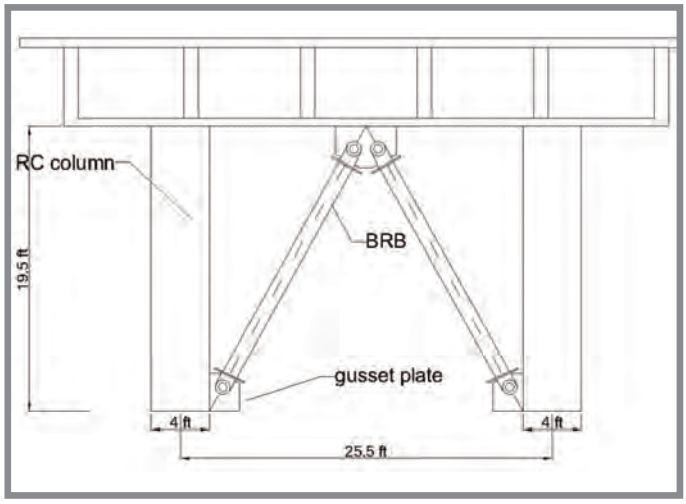
Structural fuses that use BRBs offered the most practical solution with the widest range of applications. Structural fuse systems effectively dissipate energy in select structural elements, separate from the gravity-load-resisting columns, so damage is limited to the sacrificial structural fuses, and the columns remain elastic and intact.

WHAT WAS THE BENEFIT?

Recent earthquakes have shown the vulnerability of bridges to seismic events and the price of bridge failures as a function of costly repairs, traffic delays, and public safety. The analytical results show that installing structural fuses with BRBs in bridge bents add a protective element to bridge columns experiencing seismic events. Because structural fuses are disposable and easily replaced, they provide an economical, low-maintenance solution to protect bridge substructures.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/final_report_task_2296.pdf



Transverse bridge bent with inverted-V BRBs

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Research Results

Developing a Left-turn Assist System for Signalized Intersections

Intersection collision avoidance systems help drivers maneuver cross traffic

Transportation Safety and Mobility

DECEMBER 2013

Project Title:
Cooperative Intersection Collision Avoidance System (Phase II)

Task Number: 1037

Start Date: May 6, 2010

Completion Date: August 31, 2012

Product Category: New tool and equipment

Task Manager:
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Transportation Engineer Electrical
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WHAT WAS THE NEED?

Over 25% of all U.S. intersection-related collisions—about 200,000 collisions annually—are attributed to left turns made against oncoming traffic, referred to as left turn across path of opposite direction or LTAP/OD. Two-thirds of the LTAP/OD collisions occur at signalized intersections.

Cooperative intersection collision avoidance systems (CICAS) have the potential to help drivers maneuver through cross traffic and intersections using vehicle-based and infrastructure-based technologies and communications systems, such as dedicated short-range communications (DSRC), to relay warnings to equipped vehicles. Caltrans, as part of the U.S. Department of Transportation CICAS Signalized Left Turn Assistance (SLTA) initiative, has been researching infrastructure-based systems that provide information to drivers to judge the gaps in oncoming traffic when performing a left turn, as well as inform them of the presence of pedestrians and cyclists.

WHAT WAS OUR GOAL?

The goal was to assess the technical feasibility of implementing a CICAS-SLTA system to increase safety and reduce collisions and evaluate the human factors in receiving and acting on information and warnings.

Test equipment used during the Richmond Field Station experiments

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Developing a Left-turn Assist System for Signalized Intersections

Research Results

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology (PATH) program, implemented a CICAS-SLTA system and tested driver attitudes and behavior in terms of gap acceptance. The researchers evaluated vehicle positions, speeds, and zones of conflict for left turns. They also studied the components needed for the vehicle detection, pedestrian, and bicyclist sensor suites.

To assess the CICAS-SLTA system, the researchers put four test drivers representing a range of driving styles through LTAP-OD maneuvers. While another vehicle was approaching the intersection from the opposite direction, the drivers decided whether to turn in front of or behind the approaching vehicle As the drivers made these decisions, their predicted post-encroachment time (PET) was monitored, and the PET value was compared with the driver's action and expressed opinion about whether the maneuver merited an urgent or cautionary alert from the system.

WHAT WAS THE OUTCOME?

Analysis of the data from prior and recent field tests demonstrates that using predicted PET as the criterion for judging the hazard level associated with left-turn maneuvers is effective. In the pilot tests, the driver opinions agreed 78% of the time with the alert thresholds that were recommended as a function of the predicted PET value, validating the overall alert approach. In the cases where there was not complete agreement about the alert level, the disagreements were small and explainable, and some have been resolved by parameter value adjustments.

The DSRC radio system is able to broadcast the threat levels for the intersection to the approaching vehicles. The driver's DSRC system receives the information, and the in-vehicle computer can then associate the threat estimate with the location and direction of travel and decide which level of warning to give the driver.

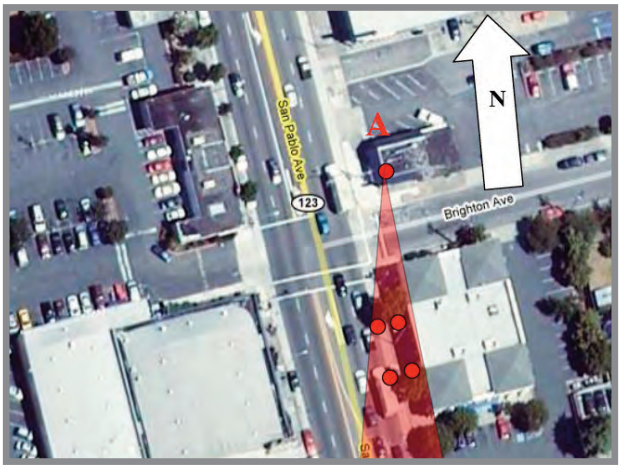
WHAT IS THE BENEFIT?

Intersection collision avoidance systems use both vehicle-based and infrastructure-based technologies to help drivers approaching an intersection understand the state of activities within that intersection. CICAS technology can improve safety for motorists, pedestrians, and cyclists by warning drivers of the risk of collision.

LEARN MORE

To learn more about the CICAS initiative:
www.its.dot.gov/cicas

Prototype driver-vehicle interface in an instrumented test vehicle



Sensor placement near the intersection of Brighton Avenue and San Pablo Avenue

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Research Results

Evaluating the Operational Performance of District 8 HOV Lanes

Comparing limited-access and continuous-access HOV lanes to improve traffic flow

Transportation Safety and Mobility

DECEMBER 2013

Project Title:
High Occupancy Vehicle (HOV) System Analysis Tools—District 8 HOV Facility Performance Analysis

Task Number: 1205

Start Date: December 1, 2008

Completion Date: November 30, 2012

Product Category: New guidelines and new decision support tool, simulation, and model

Task Manager:
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Project Engineer
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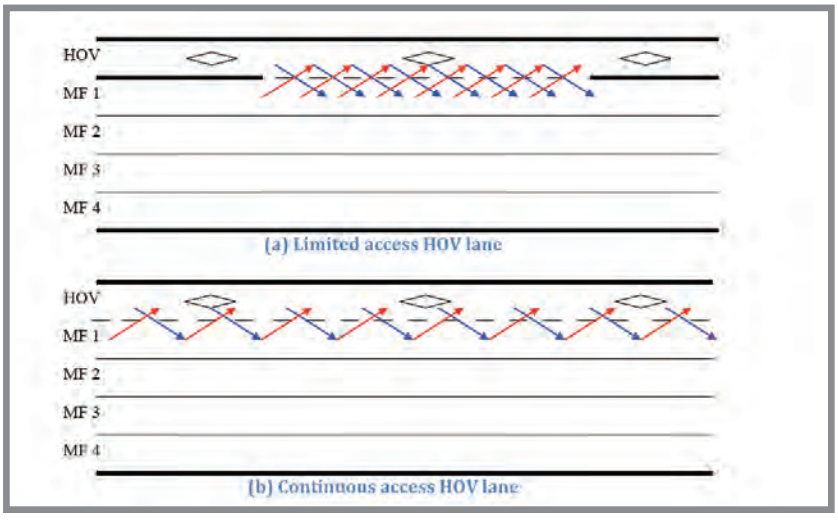
WHAT WAS THE NEED?

High occupancy vehicle (HOV) lanes are an integral part of the California highway system, so it is important to ensure that they are meeting their purpose of improving mobility, trip time reliability, and air quality. California has two basic types of HOV lanes—limited access and continuous access. This research addressed mobility by comparing which HOV access type is better for overall freeway performance, focusing on the HOV facilities in Caltrans District 8.

WHAT WAS OUR GOAL?

The goal was to develop methodologies to assess the operational performance of HOV facilities and determine the pros and cons of limited-access versus continuous-access lanes.



Continuous-access and limited-access HOV lanes

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Evaluating the Operational Performance of District 8 HOV Lanes

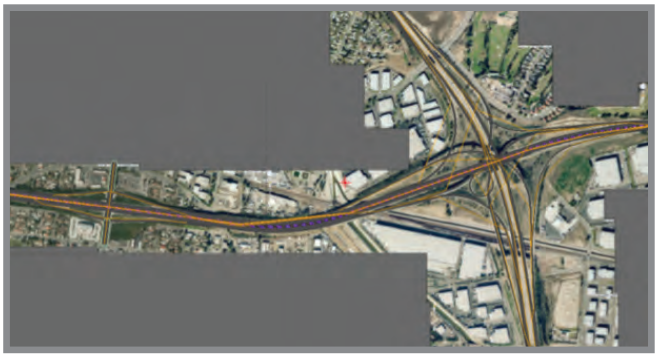
Research Results

WHAT DID WE DO?

To compare the operational performance of limited-access and continuous-access HOV facilities in District 8, Caltrans, in partnership with the University of California, Riverside Center for Environmental Research and Technology, used five different research methodologies to gain a comprehensive view:

- Corridor-level analysis using field data from the Performance Measurement System (PeMS) and District 8's 2008 HOV Monitoring Report Statistics
- Regression analysis to estimate the impact of the lane access type on freeway throughput based on data of statewide HOV facilities
- Video collected in the field to examine the lane-changing behavior of each access type
- Simulation tool to compare performance under different congestion levels
- Before-and-after study of SR-60 in Moreno Valley, where the HOV facilities were converted from full-time limited access to part-time continuous access

Lane change data extracted from video footage using a software tool developed in this research



Portion of the simulated freeway network of SR-91 and I-15 in Riverside County

WHAT WAS THE OUTCOME?

The data collected indicated that the District 8 HOV facilities operated at a good level of service. All facilities, except for those on SR-91, maintained a travel speed of greater than 45 mph during peak hours for at least 75% of the time. The SR-91 facilities experienced delays partly due to bottlenecks around the ingress and egress areas. The regression models consistently showed that the HOV lane access type would have a significant effect on the maximum throughput of a freeway segment, and that a freeway with a limited-access HOV lane would accommodate higher maximum throughput than a continuous-access lane, if all other geometric characteristics are the same.

For limited access, most lane changes occurred within the first half of the ingress or egress area. Lane changes between the continuous-access HOV lane and the adjacent lane were smoother than the limited access because motorists had a larger time gap. When simulating the freeway network, both access types had similar average travel speeds when uncongested (greater than 50 mph). When mildly congested (travel speed of 35–50 mph), the continuous-access lanes had higher average travel speeds.

After SR-60 was converted to part-time continuous access, the eastbound direction carried more vehicle miles and had higher travel speeds. The HOV violation rates increased, while the number of collisions decreased.

WHAT IS THE BENEFIT?

California has an extensive network of HOV facilities, which will continue to grow in the coming years. HOV access plays an important role in maintaining traffic flow. Based on the findings, both limited-access and continuous-access HOV lanes have advantages. The limited-access lanes have buffered sections that separate the traffic flow from the adjacent lane, resulting in higher freeway throughput. Continuous-access lanes spread out lane changing, reducing major traffic disturbances that can cause delays. HOV facilities could improve traffic by combining these advantages, such as use continuous access for most of the corridor to achieve higher average travel speed, but strategically place buffers at critical freeway segments—for example, around non-HOV-related bottlenecks and ramp merges—to facilitate higher throughput on those segments.

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To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2012/final_report_task_1205.pdf

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Research Results

Evaluating the Performance of High Occupancy Vehicle Lanes

Does the HOV lane access configuration affect traffic flow?

Transportation Safety and Mobility

DECEMBER 2013

Project Title:
High Occupancy Vehicle (HOV) System Analysis Tools: Statewide HOV Facility Performance Analysis

Task Number: 1665

Start Date: May 1, 2009

Completion Date: December 31, 2012

Product Category: New guidelines and new decision support tool, simulation, and model

Task Manager:
Tam H. Nguyen
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WHAT WAS THE NEED?

High occupancy vehicle (HOV) lanes are a cost-effective and environmentally-friendly option to move travelers through congested routes. California has the most extensive high occupancy vehicle lane network compared to any other state in the country, with currently over 1,500 lane-miles. In California, the two most common types of HOV lanes are continuous access, prevalent in Northern California, and buffer-separated, limited access, prevalent in Southern California. To assess the effectiveness of HOV facilities in controlling congestion, Caltrans evaluated whether there is a performance difference between the two access types in Caltrans districts 4, 7, and 12 and if converting from limited access to continuous access results in operational improvements.

WHAT WAS OUR GOAL?

The goal was to evaluate whether the type of access to HOV lanes affected operational performance and if changing the access type improved traffic flow in Caltrans districts 4, 7, and 12.

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WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley and UC Irvine, evaluated the operational performance of HOV facilities in the San Francisco Bay Area, Los Angeles County, and Orange County. The researchers evaluated highway traffic data to identify the operating characteristics of HOV and general purpose lanes. Key performance measures—speed differential, vehicles miles traveled, and passenger miles traveled—were calculated on a system-wide basis to offer comparisons by corridor, region, and access type. The researchers also compared the performance of HOV facilities in Orange County before and after the access type was converted from limited to continuous using computer simulations and real-world data.

WHAT WAS THE OUTCOME?

Limited-access and continuous-access HOV facilities generally perform at a comparable level in terms of speed differential, vehicle miles traveled, and passenger miles traveled. However, some of the study sites are influenced by operational characteristics that are uniquely associated with individual corridors.

Converting a HOV lane from limited access to continuous access is site-specific and influenced by the local geometric attributes and associated traffic patterns. For most study sites, the conversion led to a slightly lower throughput and better performance during the dissipation of congestion. All the study sites experienced more HOV violations and HOV lane changes. Some segments had increased traffic weaving after the conversion from limited access to continuous access. At certain freeway junctions, such as a freeway-to-freeway HOV direct connector, limited-access configurations can be beneficial in preventing or discouraging last-second traffic weaving maneuvers and safely channeling traffic flows for better performance.

WHAT IS THE BENEFIT?

Based on the findings, both limited-access and continuous-access HOV lanes have advantages. The limited-access lanes have buffered sections that separate the traffic flow from the adjacent lane, resulting in higher freeway throughput. Continuous-access lanes spread out lane changing, reducing major traffic disturbances that can cause delays. HOV facilities could improve traffic by combining these advantages, such as have continuous access for most of the corridor to achieve higher average travel speed, but have buffers strategically placed at critical freeway segments—for example, around non-HOV-related bottlenecks and ramp merges—to facilitate higher throughput on those segments.

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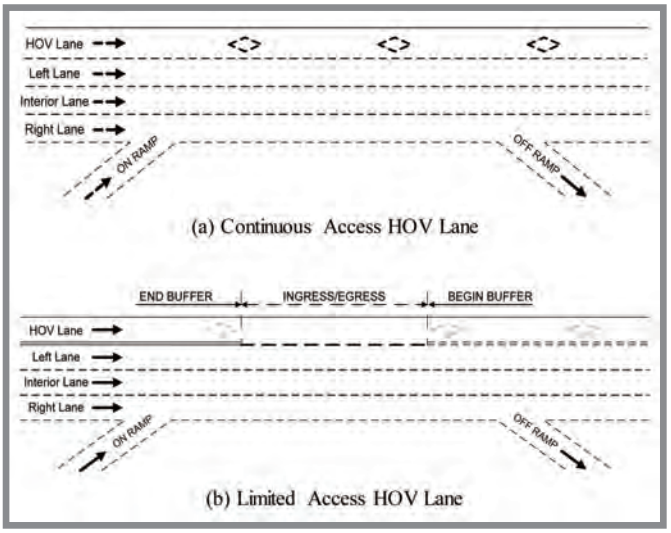
To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2012/final_report_task_1665.pdf



Two access configurations for HOV lanes

Study sites

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Research Results

Reducing Pedestrian and Cyclist Injuries Along Urban Highways

Using a systemic method helps proactively identify and improve high-collision areas for pedestrians and cyclists

Transportation Safety and Mobility

DECEMBER 2013

Project Title:
Strategies for Reducing Pedestrian and Bicyclist Injury at the Corridor Level

Task Number: 2207

Start Date: June 1, 2011

Completion Date: May 31, 2013

Product Category: New decision support tool

Task Manager:
Jerry Kwong
Transportation Engineer Electrical
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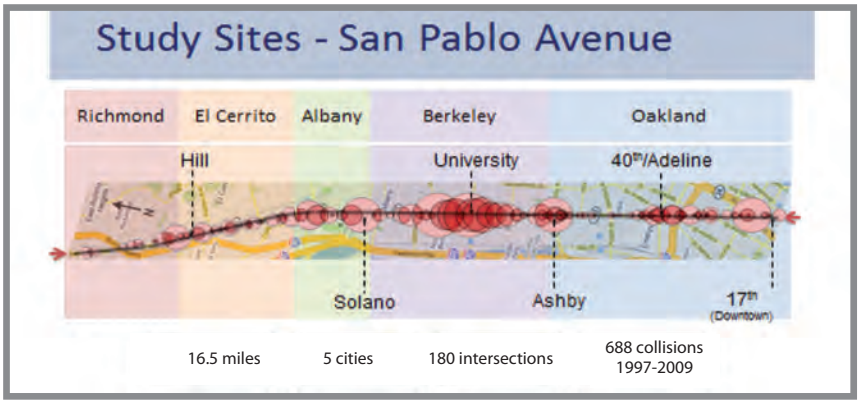
WHAT WAS THE NEED?

Injury collisions involving pedestrians and cyclists are more severe than collisions between motorists and account for one-fifth of all fatalities in California. To improve the safety for these most vulnerable road users, it is critical to determine the causal factors and identify the appropriate safety measures. Urban arterials are especially prone to pedestrian and cyclist injuries. These high-trafficked roadways typically consist of controlled intersections, divided lanes, mixed land use, and multimodal users. Although urban arterials comprise just 2% of California's highway system, they experience 22% of the pedestrian injuries.

Two approaches are used to allocate safety resources. One is based on addressing hotspots—locations with a high concentration of collisions. The predominate case-by-case hotspot approach responds to a specific problem and directs resources to that area. Another method is a systemic approach, which classifies collisions to ascertain whether the causes are attributed to shared infrastructure characteristics. Used in conjunction with the hotspot method, the systemic approach can proactively identify locations that share the same high-risk characteristics and then recommend countermeasures for implementation across the state highway network, lowering the per-site costs.



This stretch of SR 123 has six major intersections with high numbers of pedestrians and cyclists.

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WHAT WAS OUR GOAL?

The goal was to develop a tool to support a systemic approach to identify infrastructure characteristics that are high risk for pedestrians and cyclists and provide guidance for specifying appropriate safety measures across the highway network in a more efficient, cost-effective manner.

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Safe Transportation Research and Education Center, developed a database that uses the systemic method for analyzing the commonalities of collisions with pedestrians and cyclists to identify appropriate improvements for areas with a similar infrastructure.

A 16.5-mile section of San Pablo Avenue (SR 123), an arterial corridor that passes through five cities and varies greatly in land use, was chosen as a study area. SR 123 runs from Oakland's downtown business district through local retail, mixed residential, to a Richmond shopping center with mega-retail stores, crossing 180 intersections that are on average 484 feet apart. A database of all pedestrian and cyclist collisions was constructed using the Statewide Integrated Traffic Records System (SWITRS), which is maintained by the California Highway Patrol. The systemic safety method identifies the type of location, which is based on the site's features, the type of collision, and appropriate countermeasures.

SPA Crash Map (2005-2009)	Location type 1: Unsignalized; >35mph; Narrow	2: Unsignalized; >35mph; Wide	3: Unsignalized; <35mph; Narrow	4: Unsignalized; <35mph; Wide	5: Signalized; >35mph; Narrow	6: Signalized; >35mph; Wide	7: Signalized; <35mph; Narrow	8: Signalized; <35mph; Wide	
127 Sites	54	8	8	21	20	7	2	7	
Crash type 1: Right turning vehicle	2			1	5	3		2	13
2: Unsafe speed		1				1			2
3: Pedestrian right of way; In crosswalk	6		1		8	1	1	3	20
4: Pedestrian violation; In crosswalk	1	1			3			1	6
5: Pedestrian violation; Not In crosswalk	3	1			2	1		1	8
6: Other	10	1		2	3	1	1		18
	22	4	1	3	21	7	2	7	67

The systemic hotspot identification matrix shows the number of occurrences of each collision type at each location type.

WHAT WAS THE OUTCOME?

The data is assembled in a matrix that gives a snapshot of which types of collisions are occurring on which types of facilities, helping to identify systemic hotspots and provide guidance about the possible countermeasures to improve safety for pedestrians and bicyclists along urban arterials.

WHAT IS THE BENEFIT?

Focusing only on hotspots can be more costly in terms of injuries and budget compared to taking a systemic approach to proactively address which type of facilities and infrastructure tend to generate more collisions and prevent locations from becoming hotspots by applying the appropriate safety measures. Systemic improvements are generally more cost effective based on economy of scale. The systemic approach is also valuable for facilities that have a relatively low frequency of collisions, such as rural roads, and are therefore less likely to be identified as hotspots and be considered for safety improvements.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/final_report_65A0407.pdf

SPA Crash Map (2005-2009)	Location type 1: Unsignalized: >35mph: Narrow	2: Unsignalized: >35mph: Wide	3: Unsignalized: <35mph: Narrow	4: Unsignalized: <35mph: Wide	5: Signalized: >35mph: Narrow	6: Signalized: >35mph: Wide	7: Signalized: <35mph: Narrow	8: Signalized: <35mph: Wide
127 Sites	54	8	8	21	20	7	2	7
Crash type 1: Right turning vehicle	6, 7, 12	6, 7, 12	7, 12	3, 7, 12	1, 2, 6, 7, 8, 9, 10, 11	1, 2, 3, 6, 7, 8, 9, 10, 12	1, 2, 7, 8, 9, 10, 12	1, 2, 3, 7, 8, 9, 10, 12
2: Unsafe speed	6, 12	3, 6, 11, 12	--	--	1, 2, 6, 8, 9, 10, 11	1, 2, 3, 6, 8, 9, 10, 11, 12	--	--
3: Pedestrian right of way; In crosswalk	12	3, 11, 12	7, 12	3, 7, 11, 12	5, 8, 12	3, 5, 8, 11, 12	5, 8, 12	3, 5, 8, 11, 12
4: Pedestrian violation; In crosswalk	12	3, 11, 12	12	3, 11, 12	1, 2, 5, 8, 9, 12	1, 2, 3, 5, 8, 9, 12	1, 2, 5, 8, 9, 12	2, 3, 5, 8, 9, 11, 12
5: Pedestrian violation; Not In crosswalk	4, 7, 12	3, 4, 7, 11, 12	4, 7, 12	3, 4, 7, 11, 12	1, 2, 4, 5, 7, 8, 9, 12	1, 2, 3, 4, 5, 7, 8, 9, 12	1, 2, 4, 5, 7, 8, 9, 12	1, 2, 3, 4, 5, 7, 8, 9, 12
6: Other								

Possible countermeasures for each collision type at each location type are included.

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Research Results

C1 Traffic Detector Reader and Analyzer

New hardware tool helps diagnose problems with traffic detectors

Transportation Safety and Mobility

DECEMBER 2013

Project Title:
C1 Traffic Detector Reader/Analyzer

Task Number: 1546

Start Date: April 23, 2007

Completion Date: June 28, 2013

Product Category: New equipment

Task Manager:
Joe Palen
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WHAT WAS THE NEED?

Efficiently managing and operating California's highway system requires accurate, timely, and reliable information on traffic speed and flow. This information is derived from data collected throughout the state by either loop detectors installed in the pavement or roadside side-fire radar. However, many of the traffic sensors do not operate properly, making the data unreliable. To maximize the return on the investment made in these traffic detectors, tools are needed that can diagnose and fix the problems.

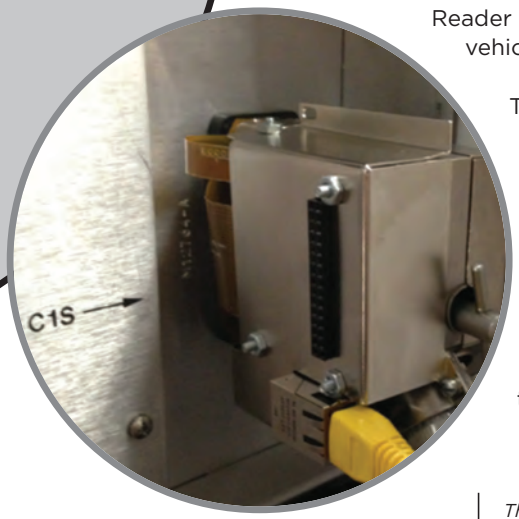
WHAT WAS OUR GOAL?

The goal was to create a hardware tool to help troubleshoot and diagnose problems with traffic detectors so that they can be fixed.

WHAT DID WE DO?

The researchers developed the C1 Traffic Detector Reader and Analyzer (C1 Reader), which consists of a flexible cable that taps into the existing C1 cable and connector that carry the detector's signal outputs to the traffic signal controller where they are processed. In this manner, the C1 Reader does not interfere with the normal operation of the vehicle detection system.

To install the C1 Reader, a technician simply removes the C1 cable from its connector, slides the flexible C1 Reader cable over the connector pins, and then reconnects the C1 cable to the connector. The C1 Reader converts the raw detector data to digital format and transmits it through a wired or wireless Internet interface back to a remote data server, where it is stored in a database. A technician can then use the VideoSync software tool, which was developed simultaneously under a different task, to evaluate the performance of the vehicle detection system.



The C1 Reader attaches to the left side of the existing C1 connector. The flexible cable taps into the signals in the C1 connector.

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WHAT WAS THE OUTCOME?

The C1 Reader collects higher quality traffic data, because it uses the detector's raw output rather than the aggregated data of the vehicle detection system. The higher quality data enables Caltrans to:

- Improve detector accuracy by enabling better calibration
- Diagnose detector anomalies in real time
- Derive accurate speed and vehicle classifications from single loop installations

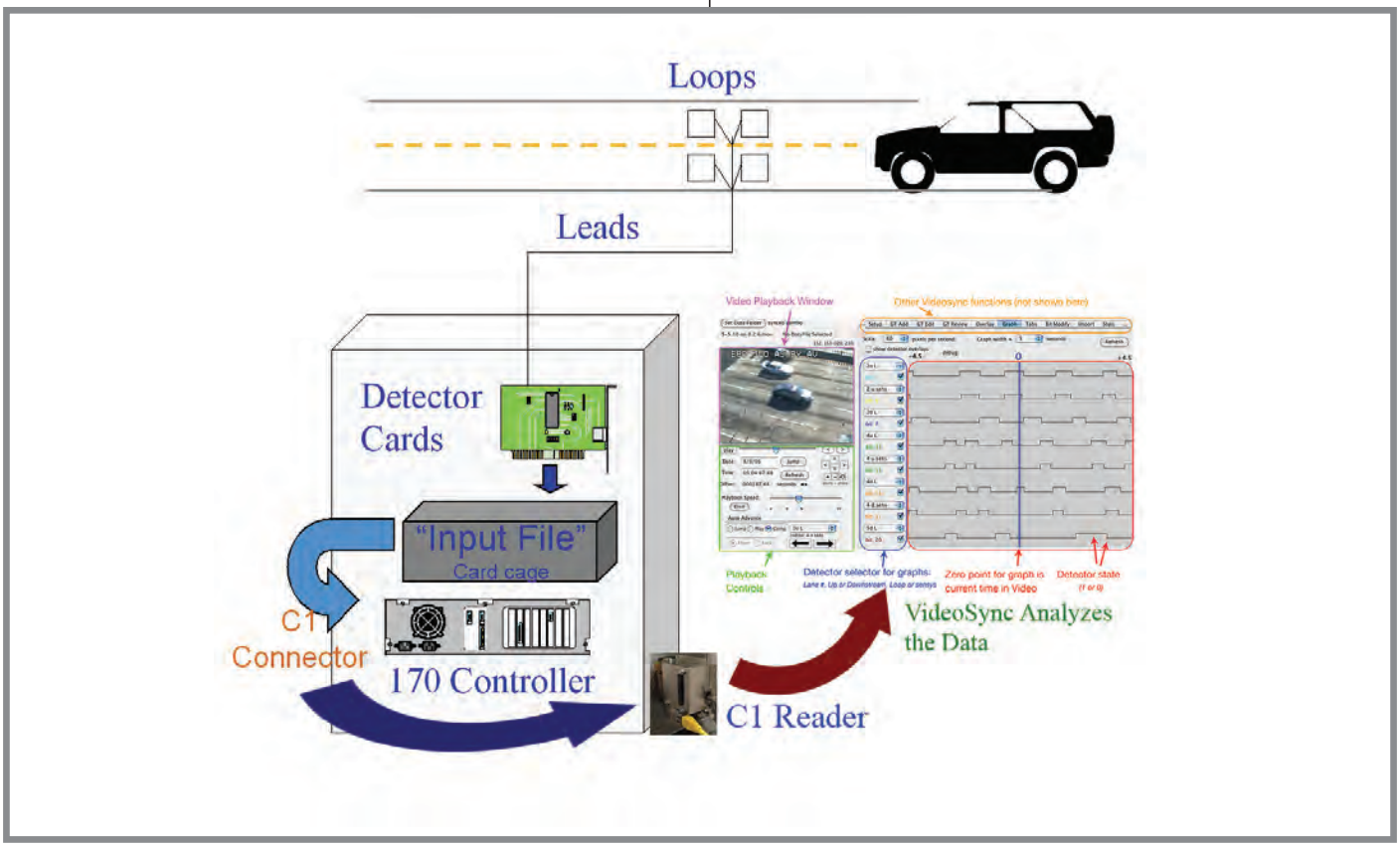
The next phase of the project will reduce the space needed around the C1 connector, because some signal controller models did not have enough clearance to fit the C1 Reader between the connector and controller frame. It will also be designed to use the electrical power of the signal controller rather than the more challenging Power over Ethernet approach in the current design. With these changes, the next version of the C1 Reader should be ready for deployment after additional field testing.

WHAT IS THE BENEFIT?

The statewide vehicle detection system provides important data to help assess and manage roadway usage, traffic flow, and congestion. The C1 Reader, when combined with the VideoSync software tool, enables Caltrans to troubleshoot and diagnose problems with vehicle detection stations so that they can be quickly repaired. These diagnostic tools also allow installers to verify and validate the correct operation of a new vehicle detection station when it is being turned on for the first time so that it can be put immediately to use. The new tools maximize the investment in the vehicle detection stations by making sure that they are operating correctly.

LEARN MORE

To view the research:
www.dot.ca.gov/research/operations/loopreader/index.htm



The C1 Reader collects the sensor data and transmits it to the VideoSync program.

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Research Results

Upgrading the Video Vehicle Detector Verification System

Enhancements improve tool for testing the accuracy of vehicle detection equipment

Transportation Safety and Mobility

JANUARY 2014

Project Title:
Upgrade the Video Vehicle Detector Verification System (V2DVS)

Task Number: 1726

Start Date: June 1, 2008

Completion Date: June 30, 2013

Product Category: Improved equipment and decision-support tool to evaluate new commercial products to determine if they meet Caltrans' needs

Task Manager:
John Slonaker
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WHAT WAS THE NEED?

The accurate detection of the presence, speed, and length of vehicles on roadways is critical for effective roadway congestion management and safety. Caltrans uses vehicle detection sensors to measure traffic volume and control signalized intersections and ramp meters. Real-time detection is also necessary for automated driver information systems. Typically, in-pavement inductive loops are used, but newly developed out-of-pavement and wireless in-pavement detection systems can be quicker to install and cheaper to maintain.

Each detection method has advantages and limitations and can yield different results, making a particular system appropriate for some applications but inappropriate for others. In some traffic situations, the sensors occasionally fail to detect, falsely detect, or multiple detect individual vehicles. These errors tend to cancel each other when the data is aggregated into bins, as is common practice, but much more information can be gleaned from individual vehicle records, both in real time and in post-processing. Data for individual vehicles is also needed to know how these detectors perform in different situations to optimally specify equipment for particular detection requirements and environments.

V2DVS equipment cabinets with pole-mounted vehicle detectors and bridge-mounted cameras and vehicle detectors

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Initially, compiling individual detection data required manually comparing each event record to video ground-truth, which is a labor-intensive process that is practically impossible for large datasets. Caltrans had developed the Video Vehicle Detector Verification System (V2DVS) to address this issue, however, the initial release measured only count accuracy, and not speed or occupancy.

WHAT WAS OUR GOAL?

The goal was to improve the V2DVS by adding the capability to quantitatively measure and compare detector speed and occupancy accuracy to help traffic engineers choose the appropriate equipment for a given application.

WHAT DID WE DO?

Caltrans, in partnership with the California Polytechnic State University Electrical and Computer Engineering Department, updated the V2DVS to capture more information. The original system that was installed on I-405 in the California Traffic Management Laboratory (CTMLabs) Detector Testbed was modified by installing new motherboards, power supplies, video cards, and disk drives in the six field machines—one for each lane of the test site. The server and user interface software were rewritten to accommodate the new functionality. The researchers used the upgraded V2DVS to test selected out-of-pavement and wireless in-pavement detection systems, along with duplex inductive loop detectors, located in the Detector Testbed on I-405 in Irvine. Data collection was performed over a three-hour period across the six lanes comprising heavily and moderately congested, as well as free flow, conditions. Over 22,000 individual vehicle events were captured. The researchers also documented how to set up the V2DVS for detector testing.

V2DVS equipment cabinets: Detection equipment (left); field PCs, one for each lane (center); server (right)

WHAT WAS THE OUTCOME?

The V2DVS can quantitatively compare the accuracy of count, speed, and occupancy data generated by detectors with outputs compatible with standard 170 and 2070 controllers. It also offers improved automated comparative analysis based on the new adaptive weighted consensus filter. Preliminary analysis suggests that the inductive loops outperform the other detectors by all metrics, which is not surprising, because the accuracy of the detection system is directly proportional to the sensor's proximity to and alignment with the traffic being measured. The results help assess the tradeoff between accuracy and ease of installation and maintenance.

WHAT IS THE BENEFIT?

Inductive loop detectors are more accurate but also more expensive to install and maintain. The enhanced V2DVS provides traffic engineers additional needed information to assess whether the performance characteristics of a less expensive detection system is an appropriate solution for a given application. Being able to evaluate the accuracy of different equipment leads to the judicious implementation of detection systems in terms of value and effectiveness.

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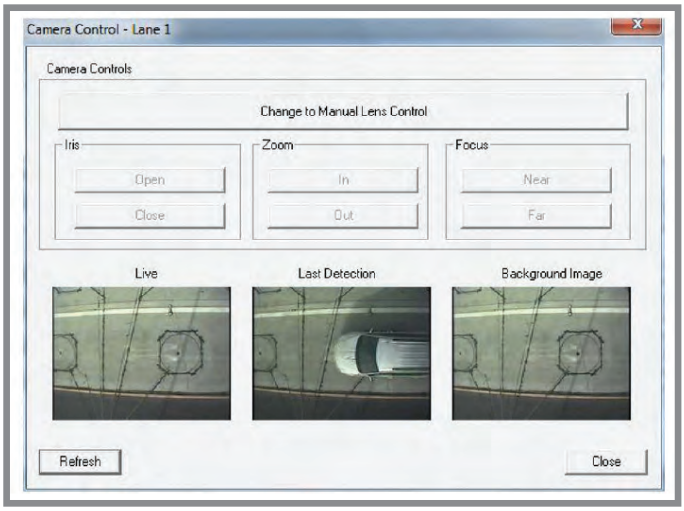
To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2012/2012-03_task_1726-tsm.pdf



Remote Camera Control window

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Research Results

Measuring Travel Time Using Bluetooth Readers

Bluetooth readers reduce costs for measuring traffic flow

Transportation Safety and Mobility

DECEMBER 2013

Project Title:
Bluetooth/Wi-Fi Travel Time Measurement System

Task Number: 2087

Start Date: March 19, 2009

Completion Date: June 30, 2013

Product Category: New equipment

Task Manager:
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WHAT WAS THE NEED?

Travel time is a key consideration for most travelers when deciding if and when to embark on a trip and which route to use, especially when passing through areas with known congestion, where travel time can vary widely. Caltrans has been collecting speed, volume, and occupancy data at vehicle detection stations for several decades. Recently, it began using this data to derive travel time information and placing it on roadside changeable message signs and the Internet. Motorists have come to rely on this real-time travel information.

Currently, travel time is extrapolated through a complex algorithm of calculating the average traffic speed between points and then estimating the time needed to travel between the points. The sensors used to detect speed require accurate calibration to generate reliable data and are expensive to install and maintain. In addition, many areas do not have enough functioning traffic detectors or have gaps in sensor coverage. Caltrans needs an affordable and reliable travel time measurement system that can be quickly and easily deployed anywhere. Bluetooth technology has the potential to generate accurate travel time with minimal deployment costs.

Installing Bluetooth readers typically takes no more than 5–10 minutes per site. If the reader contains a battery-powered unit, it can be mounted almost anywhere.

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Measuring Travel Time Using Bluetooth Readers

Research Results

WHAT WAS OUR GOAL?

The goal was to develop a simple, inexpensive system using Bluetooth technology to accurately and reliably measure real-time travel flow along roadways to inform motorists of travel times and help reduce congestion.

WHAT DID WE DO?

Caltrans developed a methodology that uses the unique electronic signatures of Bluetooth devices carried by travelers or built into vehicles to measure a motorist's actual travel time. Bluetooth readers installed on the roadside pick up the device's signature as the vehicle passes by and stores it in a database so that it can be reidentified at another point on the roadway. To protect personal privacy, the database does not associate the electronic signature with any person or institution. After the travel time is determined, the information has no more value and is deleted from the database. The Bluetooth reader was designed to use solar power so that is not dependent on an installed power source, offering greater versatility for placement.

During testing, the Bluetooth readers were typically mounted directly to roadside signal controller cabinets, which provided both power and back-haul communications. The readers measured travel time for a variety of roadway types, from 10-lane urban freeways to 2-lane rural roads.

WHAT WAS THE OUTCOME?

The Bluetooth reader was able to reidentify 5% to 10% of the passing vehicles between any two points, yielding a statistically valid representation of the true travel time. Reducing travel time is the primary incentive for high-occupancy vehicle (HOV) lanes. The field test data showed that the travel time was measured so accurately that it is possible to calculate HOV travel time savings compared to the adjacent non-HOV lanes.

For the next generation, the researchers will add flexible solar panels that wrap around light poles to simplify the installation. Wireless communications using cell phone modems will also be included to make the Bluetooth readers self-contained devices that do not require connections for either power or communications. This design approach enables the readers to be quickly installed at any location.

WHAT IS THE BENEFIT?

Motorists rely on real-time travel information to determine departure times, routes, and whether to take advantage of public transportation. Providing travel time data can reduce congestion and help use roadways more efficiently. Bluetooth technology offers reliable and accurate data to calculate travel time, and readers can be quickly and easily installed. The Bluetooth readers can be used in harsh environments where it has been difficult and expensive to set up other forms of round-the-clock traffic detection. They also allow Caltrans to measure travel times on signalized arterial roadways, which has not previously been possible.

LEARN MORE

For more information about the research:
www.dot.ca.gov/research/operations/bluetooth_web_page/intro.html

Posted travel times on changeable message signs is popular with the traveling public.

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Research Results

Warning System for Vehicles Speeding in Work Zones

Smart traffic drums detect speeding vehicles to improve safety in work zones

Transportation Safety and Mobility

DECEMBER 2013

Project Title:
Augmented Speed Enforcement System Prototype Development

Task Number: 2062

Start Date: December 1, 2009

Completion Date: June 30, 2013

Product Category: New tool and equipment

Task Manager:
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WHAT WAS THE NEED?

Although fewer vehicle miles are traveled in rural areas than urban areas, rural areas have approximately 42% more fatal collisions. Speeding and other aggressive behavior are primary contributing factors. Studies have shown that higher collision rates occur at highway locations that temporarily set lower speed limits, such as work zones. Work zone collision rates are especially high on rural two-lane, two-way highways. To address this issue, Caltrans proposed an innovative safety program that is consistent with the objectives of the U.S. Department of Transportation to reduce speed-related collisions with coordinated speed management systems.

WHAT WAS OUR GOAL?

The goal was to develop a practical method for use in rural work zones to detect speeding vehicles and slow down traffic to provide a safer environment for workers and the traveling public and reduce the number and severity of collisions.

The smart drums are placed next to orange traffic cones to indicate the work zone lane closure. The drums flash and send a warning signal when they detect a vehicle exceeding the speed limit.

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Warning System for Vehicles Speeding in Work Zones

WHAT DID WE DO?

Caltrans, in partnership with the Montana State University Western Transportation Institute (WTI), developed a warning system consisting of 28 orange smart drums positioned adjacent to orange cones to mark the work zone lane closure. When the system detects a vehicle that is exceeding the speed limit, the orange lights on top of the drums flash, warning the driver to slow down. The flashing lights also alert workers that a vehicle is speeding through the work zone. If the vehicle speed is above a set speed, the system activates a pager system that also warns the workers of the speeding vehicle. The researchers tested the smart traffic drum system for four weeks on SR 152 near Los Banos.

The University of California, Berkeley Partners for Advanced Transportation Technology (PATH) program also developed a warning system, which was evaluated separately and in conjunction with the WTI system. The PATH system is described in the Research Results for task 2146.

WHAT WAS THE OUTCOME?

The smart drums were able to detect speeding vehicles and synchronously flash warning lights. The pagers vibrated at the detection of a vehicle traveling 20 mph over the speed limit. The speed data collected shows that the system reduced drivers' speed by about 5% (1.7 mph) compared to the baseline speed established before the drums were deployed. When the drums were used in conjunction with the PATH system, vehicle speeds were reduced by approximately 8% (2.4 mph). Researchers found that deploying and retrieving the system daily was labor intensive. Further work is needed to develop a system that workers can easily and quickly deploy.

Frame capture of speeding vehicle

WHAT IS THE BENEFIT?

Rural areas often have less staffing and law enforcement to help control traffic speed in work zones and must instead rely on signage and other methods to slow motorists down. The smart drum speed enforcement system causes drivers to reduce their speed when they see the flashing lights. The lights also warn workers that speeding vehicles are approaching, giving them time to take precautions. The combined effect of slowing traffic and warning workers can reduce the number and severity of collisions in work zones.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/final_report_task_2062b.pdf

Outdoor light pattern testing

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Caltrans Division of Research, Innovation and System Information

Research Results

Slowing Down Vehicles in Rural Work Zones

Portable speed-enforcement system detects and warns speeding vehicles using license plate identification

Transportation Safety and Mobility

DECEMBER 2013

Project Title:
Augmented Speed Enforcement

Task Number: 2146

Start Date: June 30, 2010

Completion Date: June 30, 2013

Product Category: New tool and equipment

Task Manager:
Ha Nguyen
Transportation Engineer, Electrical
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WHAT WAS THE NEED?

Although fewer vehicle miles are traveled in rural areas than urban areas, rural areas have approximately 42% more fatal collisions. Speeding and other aggressive behaviors are primary contributing factors. Studies have shown that higher collision rates occur at highway locations that temporarily set lower speed limits, such as work zones. Work zone collision rates are especially high on rural two-lane, two-way highways. To address this issue, Caltrans proposed an innovative safety program that is consistent with the objectives of the U.S Department of Transportation Research and Innovative Technology Administration to reduce speed-related collisions with coordinated speed management systems.

WHAT WAS OUR GOAL?

The goal was to develop a practical method to lower vehicle speeds in rural work zones to provide a safer environment for workers and the traveling public and reduce the number and severity of collisions.

The vehicle's license plate and speed are displayed on the changeable message sign.

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Slowing Down Vehicles in Rural Work Zones

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Berkeley Partners for Advanced Transportation Technology (PATH) program, developed and implemented a speed enforcement system that includes a radar system that detects vehicle speed, a camera system that captures a photograph of the vehicle and its license number, a changeable message sign (CMS) to post advisories, a portable display device for CHP officers, and wireless communication links that use dedicated short-range communication (DSRC) and cellular networks. DSRC and cellular communication links are required to transmit the data to the CMS, officers, and a central server.

The system works as follows:

- The radar detects a vehicle's speed, the camera captures a photograph, and automatic license plate number recognition is performed.
- The vehicle's speed and license plate number are transmitted through a DSRC link and displayed on the portable CMS that is placed about 1,000 feet ahead, advising the driver to reduce speed if over the speed limit threshold. The personalized message, which includes the vehicle license number, encourages the driver to observe the speed limit in the work zone.
- The data, including the speed, license plate number, and photograph, are also transmitted via a cellular connection to a back-end server. Enforcement officers in the vicinity of the work zone can access the data with any standard web browser.
- The data is stored and archived on the back-end server. The back-end server allows remote monitoring and diagnosis of the operational status of the speed camera.

WHAT WAS THE OUTCOME?

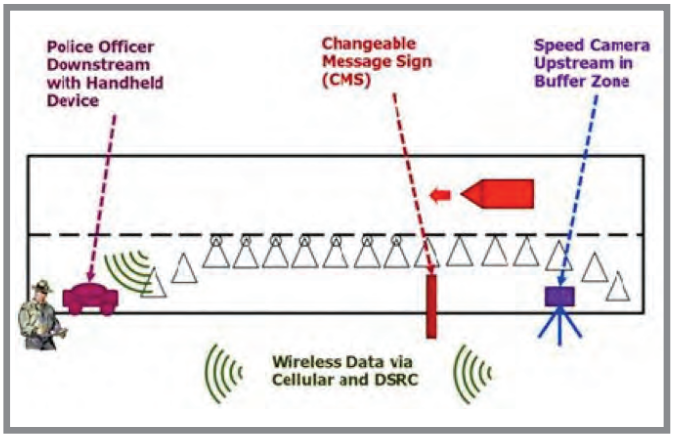
The field tests showed that the system reduced the number of vehicles traveling over 65 mph in the work zone by 6.1%, relative to baseline conditions. The system tested was a prototype and provided a successful proof of concept. Further development is needed to harden and develop the system so that maintenance staff in the field would be able to use it.

WHAT IS THE BENEFIT?

Rural areas often have fewer operators to help control traffic speed in work zones and must instead rely on signage and other methods to slow motorists down. Displaying the motorist's license plate number and speed through personal messaging encourages the driver to reduce the speed, making the work zone area safer.

LEARN MORE

The final report will be available early 2014 at:
www.dot.ca.gov/research/researchreports/dri_reports.htm



Speed-enforcement system captures a vehicle's license plate and speed to provide the driver a directed message on the CMS to slow down in the work zone.

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Caltrans Division of Research, Innovation and System Information

Research Results

Preventing Overweight Trucks on the Roadways

Overweight commercial trucks damage the highway infrastructure and are at higher risk for collision

Transportation Safety and Mobility

OCTOBER 2013

Project Title:
Evaluate High-Potential Areas for Overweight Trucks and Truck Accidents in California

Task Number: 1795

Start Date: July 9, 2011

Completion Date: October 3, 2013

Product Category: New algorithm and decision support tool

Task Manager:
Majed Ibrahim
Project Manager
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WHAT WAS THE NEED?

Commercial trucks that weigh beyond the allowed limit have more serious collisions than legally loaded trucks or automobiles, posing a danger to the drivers and the traveling public. Overweight trucks often drive on roadways that were not created nor rated for the weight they carry, thereby incurring major maintenance costs. Caltrans has weigh-in-motion (WIM) systems and commercial vehicle enforcement facilities (CVEF) on California roadways to monitor commercial trucks, but drivers of overweight trucks often take advantage of alternative routes to bypass the weigh facilities. To reduce the number of overweight trucks on the roadways and to assist the California Highway Patrol (CHP) in enforcing truck-related laws, techniques to identify possible bypass routes and where to locate new weigh facilities are needed.

WHAT WAS OUR GOAL?

The goal was to identify locations that would benefit from having weight enforcement facilities to reduce the number of overweight trucks on highways and lower truck-related collisions.

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Preventing Overweight Trucks on the Roadways

Research Results

WHAT DID WE DO?

Caltrans identified and analyzed areas of high truck traffic volumes that have few or no weight-enforcement facilities. The locations of existing stations were mapped, along with the areas of high truck volumes and truck collisions, to determine if there is a correlation between the location of weight facilities and the sites experiencing high volumes and collisions.

The research team performed the following tasks to develop a strategy for future deployment of weight facilities:

- Identified high-risk areas by evaluating truck-related collisions
- Identified attributes in high-risk areas to help predict potential hazardous areas
- Identified areas with high truck traffic that have low levels of enforcement or few commercial vehicle enforcement facilities
- Developed algorithms to identify likely routes to place weight facilities to mitigate truck drivers' bypassing behavior
- Used case studies to refine and verify the bypass route identification algorithms

WHAT WAS THE OUTCOME?

The analysis revealed 15 high truck traffic areas that lack weight enforcement facilities. These areas were recommended as candidates for future implementations. A prioritized list was developed to assist Caltrans and CHP in determining areas for enhanced enforcement.

WHAT IS THE BENEFIT?

Overweight commercial trucks pose a hazard to the drivers and the traveling public, as well as accelerate the wear and tear of California's roadways. Installing more weigh facilities in highly traveled areas, especially on identified bypass routes, helps enforce commercial trucking laws. Weight enforcement decreases the number of overweight trucks on the highways, reducing the number of truck-related accidents and maintenance and repair costs.

LEARN MORE

The final report will be available June 2014.

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Caltrans Division of Research, Innovation and System Information

Research Results

Guardrail Modifications to Improve Safety

The taller Midwest Guardrail System better protects motorists in today's higher vehicles

Transportation Safety and Mobility

JANUARY 2014

Project Title:
Midwest States Pooled Fund Crash Test Program SPR-3(017): Retest of the Asymmetrical MGS (Midwest Guardrail System) Transition

Task Number: 1009

Start Date: January 1, 2003

Completion Date: August 14, 2013

Product Category: New technical standard, plan, and specification

Task Manager:
David Whitesel
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WHAT WAS THE NEED?

State departments of transportation across the country use strong-post, W-beam guardrail systems to prevent errant vehicles from leaving the roadway and encountering safety hazards. The existing W-beam barriers, which measure 27 5/8" to the top of the rail, were developed years ago and did not envision today's vehicles that have a higher center of gravity. To meet the National Cooperative Highway Research Project (NCHRP) 350 Test Level 3 safety conditions, the taller Midwest Guardrail System (MGS) was designed as part of the Midwest States Pooled Fund Program. The non-proprietary MGS uses nearly all the same components as a conventional guardrail, but is engineered for today's higher passenger vehicles. It has been successfully tested with curbs and over long spans.

It is common practice to use W-beam guardrails along highway segments and to use a stiffened thrie beam guardrail in a transition region near the end of a bridge. W-beam guardrails tend to be more flexible than bridge railings, so a transition is added between the rail systems to provide structural continuity. A W-beam to thrie-beam transition had been developed for the MGS system, but previous crash testing efforts with passenger-size and small car sedans had mixed results, and performance with light truck vehicles was not evaluated. The transition element was modified and needed to be evaluated under the current federal safety standards.

WHAT WAS OUR GOAL?

The goal was to evaluate the safety performance of the redesigned W-beam to thrie-beam transition element for the taller MGS developed to address the size of today's vehicles.

Testing the performance of the guardrail

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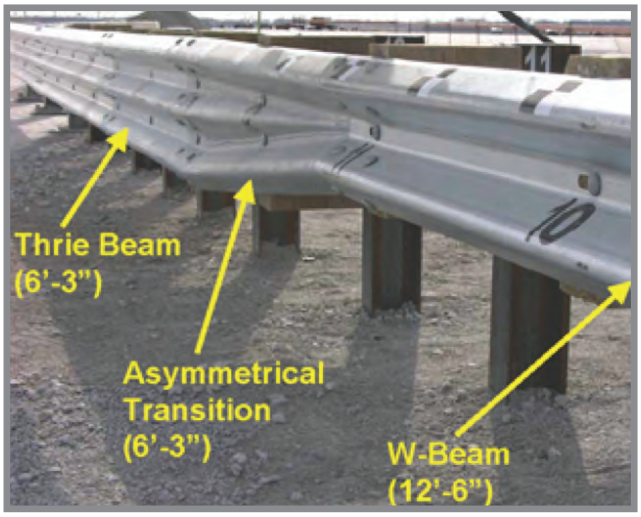
WHAT DID WE DO?

Caltrans partnered with 17 state departments of transportation to design and test the MGS transition system. Caltrans monitored the researchers' work and provided comments during development. The research included four full-scale vehicle crash tests, three with a 3/4-ton pickup truck and one with a small car. Due to vehicle rollover in the first pickup truck test, the transition was redesigned as an asymmetrical W-beam to thrie beam, and the height of the W–beam was increased to the MGS height of 31 inches. The safety performance of the asymmetrical MGS W-beam to thrie-beam transition element was determined to be acceptable according to the NCHRP criteria. After the research was concluded, the Caltrans team worked with the traffic operations division to adopt the new plans and specifications.

WHAT WAS THE OUTCOME?

The new transition design is compliant with federal crash testing safety guidelines and can now be used on the national highway system.



Asymmetrical W-beam to thrie-beam transition

WHAT IS THE BENEFIT?

By joining this pooled fund, Caltrans was able to leverage the group's expertise to improve California's roadside safety systems along highways and rural routes with a minimal investment. The new guardrail is more robust than existing designs and meets federal safety requirements. Caltrans can now install this new system on the state highways.

LEARN MORE

For information about the pooled fund project:
www.pooledfund.org/Details/Study/162

To view the complete report:
http://engineering.unl.edu/specialty-units/mwrsf/MwRSF-Downloads/MGS/TRP-03-167-07.pdf

The redesigned guardrail is engineered for today's higher passenger vehicles.

Appendix 1: Active NCHRP Projects with Caltrans Panel Membership

Project Number	Title	Panel Member	Division	Role	Start Date	End Date
D0146	Handbook for Pavement Design, Construction and Management	William K. Farnbach	Maintenance – Pavement	Member	2009	2012
D0148	Incorporating Pavement Preservation into Mechanistic Empirical Design Guide	Imad Basheer	Maintenance – Pavement	Member	2010	2013
D0151	Characterizing Slab/Base Friction for Improved Concrete Pavement Design	Dulce Rufino Feldman	Maintenance – Pavement	Member	2012	2015
D0152	Calibrated, Mechanistic-Based Models for Top-down Cracking of Hot Mix Asphalt Layers	Wilfung Martono	District 4 Water Quality	Member	2013	2016
D0224	Incorporating Economic productivity Gains into Benefit-Cost Analysis for Transportation Investment Projects	Barry Padilla	Planning	Member	2012	2013
D0362	Guidelines for Accessible Pedestrian Signals	Craig A. Copelan	Traffic Operations	Member	2001	2013
D0390	Operation of Traffic Signal Systems in Oversaturated Conditions	Ahmad Rastegarpour	Traffic Operations	Member	2008	2012
D0396	Analysis of Oversaturated Traffic Flow Conditions and Managed Lanes on Freeway Facilities	Marco Ruano	District 7 Traffic Operations	Member	2009	2012
D0399	Development and Application of Access Management Guidelines	Marc Birnbaum	Traffic Operations	Member	2009	2013
D0437	Long-Term Performance of Epoxy Adhesive Anchors	Madhwesh Raghavendrachar	Engineering Services	Member	2009	2013
D0438	Developing a Laboratory Test for Determining the Initial Retroreflectivity Level of Glass Beads in Pavement Markings	Mitch Gipson	Engineering Services	Chair	2009	2012
D0720	Technical Guidance for Traffic Incident Management Performance Measurement Implementation	Larry Wooster	Traffic Operations	Member	2013	2014
D0721	Guidance for the Management of Traffic and Safety Assets	Augustin Rosales	Maintenance	Member	2013	2014
D0866	Trip-Generation Rates for Infill Land Use Developments in Metropolitan Areas of the U.S.	Terry L. Parker	Planning	Chair	2008	2013
D0877	Developing Regional Historic Contexts for Post World War II Housing	Andrew C. Hope	District 4 Office of Cultural Resource Studies	Member	2010	2012
D0878	Estimating Bicycling and Walking for Planning and Project Development	Chris Schmidt	District 11 Planning – Public Transportation	AASHTO Monitor	2010	2013
D0881	Collecting Accurate Motorcycle Travel Data to Reduce Rising Fatalities on the Nation's Highways	Mitchell Prevost	Traffic Operations	Member	2011	2013
D0884	Long Distance and Rural Travel Transferable Parameters for Statewide Travel Forecasting Models	Douglas MacIvor	Transportation System Information	Member	2011	2012

Project Number	Title	Panel Member	Division	Role	Start Date	End Date
D0888	Project Planning and Scoping to Improve the Execution of Highway Projects	Marlon Flournoy	Planning	Member	2012	2014
D0890	Development of a Transportation Asset Management Cap Analysis Tool to Complement the AASHTO Transportation Asset Management Implementation Guide	Coco Briseno	Research, Innovation and System Information	Member	2013	2014
D0893	Guidebook on Agency Risk Management Strategies, Methods, and Tools	Michelle Tucker	Administration – Risk Management	Member	2013	Pending
D0899	Truck Freight Benefit Methodology Development—Phase 2	Barry Padilla	Planning	Member	2013	Pending
D0948	Field vs. Laboratory Volumetric and Mechanical Properties	Kee Y. Foo	Maintenance	Member	2009	2014
D0950	Performance-Based Specification for Binders Used in Chip Seals	Kee Y. Foo	Maintenance	Chair	2011	2014
D0952	Short-Term Laboratory Conditioning of Warm Mix Asphalt	Cathrina Barros	Engineering Services	Member	2012	2014
D0953	Asphalt Foaming Characteristics for Warm Mix Asphalt Applications	Joe Peterson	District 3 Construction	Member	2012	2014
D1076	Methodologies for Evaluating Pavement Strategies and Barriers for Noise Mitigation	Bruce C. Rymer	Environmental Analysis	Member	2008	2012
D1077	Developing Guidelines for Global Positioning	Jesus Mora	Design	Member	2009	2013
	System Controlled Construction Machine Guidance and Required CADD Software					
D1082	Performance Related Specifications for Pavement Preservation Treatments	Nicholas I. Burmas	Research, Innovation and System Information	Member	2010	2013
D1083	Alternative Quality Systems for Application in Highway Construction	Jon Tappping	Construction	Member	2010	2013
D1084	Modulus-Based Construction Specification for Compaction of Earthwork and Unbound Base Materials	Terrie Bressette	Engineering Services	Member	2010	2014
D1085	A Guidebook for Construction Manager-at-Risk Contracting for Highway Projects	Ray Tritt	Design	Member	2011	2013
D1086	Alternate Bidding of Pipe Materials	Charles C. Fielder	District 1	Member	2011	2014
D1086	Alternative Bidding of Pipe Materials	Brian Syftestad	Construction	Member	2011	2014
D1088	Determining the Influence of Road Surfaces on Vehicle Noise at Locations Adjacent to a Roadway: Precision and Bias Statements	Bruce C. Rymer	Environmental Analysis	Member	2012	2015
D1090	Guidance for Complying with Environmental Protection Agency Effluent Limitation Guidelines for Construction Runoff	Scott McGowen	Environmental Analysis	Member	Pending	Pending
D1092	Risk Assessment of Materials Inspection, Testing and Acceptance Practices	Daniel Speer	Engineering Services	Member	2013	2015
D12101	Recommended AASHTO Load and Resistance Factor Design Specifications and Method of Structural Analysis for Bridge Structures with Energy Dissipation Mechanism in Their Columns	Ron Bromenschenkel	Engineering Services	Member	Pending	Pending

Project Number	Title	Panel Member	Division	Role	Start Date	End Date
D1281	Evaluation of Fatigue on the Serviceability of Highway Bridges	Barton J. Newton	Engineering Services	Chair	2008	2012
D1281	Evaluation of Fatigue on the Serviceability of Highway Bridges	Lian Duan	Transportation System Information	Member	2008	2012
D1283	Calibration of Load and Resistance Factor Design—Concrete Bridge Design Specifications for Serviceability	Susan E. Hida	Engineering Services	Chair	2009	2013
D1285	Roadway Bridges Fire Hazard Assessment	Kenneth R. Brown	Maintenance	Member	2010	2013
D1286	Bridge System Safety and Redundancy	Susan E. Hida	Engineering Services	Member	2010	2013
D1287	Development of System Fracture Analysis Methods for Fracture Critical Steel Bridges	Lian Duan	Transportation System Information	Member	2011	2014
D1293	Structural Testing and Design Methodology for Single-Column, Single-Shaft Foundation Considering the Flexural Capacity of Steel Casing	Amir Malek	Engineering Services	Member	2013	2016
D1294	Minimum Flexural Reinforcement Laboratory Testing	Don L. Nguyen-Tan	Engineering Services	Member	2013	2016
D1297	Guide Specification for the Design of Concrete Bridge Beams Prestressed with CFRP Systems	Jim Gutierrez	Engineering Services	Member	2013	2016
D1298	Guidelines for Tolerances for Prefabricated Bridge Elements and Systems	Dorie Mellon	Engineering Services	Member	2014	Pending
D1304	Guidelines for the Development of Highway Ops Equipment Replacement Life Cycle	Lisa M. Kunzman	Equipment	Member	2014	Pending
D1422	NCHRP Effective Removal of Pavement Markings	Linus K. Motumah	Maintenance	Member	2010	2013
D1423	Quantify the Information Necessary to Guide Bridge Preservation Decisions	Paul Cooley	Maintenance	Member	2011	2015
D1424	Convincing the Stakeholders: Developing a Guide for Communicating Maintenance and Preservation Needs	Steve Takigawa	Maintenance	Member	2011	2012
D1426	Culvert and Strom Drain Inspection Manual	Parviz Lashai	Maintenance	Member	2012	2014
D1428	Condition Assessment of Bridge Post-Tensioning and Stay Cable Systems Using Nondestructive Evaluation Methods	Robert A. Reis	Engineering Services	Member	2012	2015
D1429	Developing a Consistent Coding and Training System for Emergency Structure Inspections	Herby Gerald Lissade	Maintenance	Member	Pending	Pending
D1432	Proposed Revisions to the AASHTO Movable Bridge Inspection, Evaluation, and Maintenance Manual	Alan Torres	Engineering Services	Member	Pending	Pending
D1433	Guidelines for Including Pavement Preservation in Life Cycle Cost Analysis	William K. Farnbach	Maintenance – Pavement	Member	2014	Pending
D1539	Superelevation Criteria for Horizontal Curves on Steep Grades	Antonette C. Clark	Design	Member	2010	2013
D1540	Designing the Roadway Transition from Rural Highways to Urban-Suburban Highways or Streets	Kazim Mamdani	District 11 Design	Member	2010	2012

Project Number	Title	Panel Member	Division	Role	Start Date	End Date
D1541	Updated Headlamp Design Criteria for Sag Vertical Curves	Brian Frazer	Design	Member	2010	2012
D1543	Update of the TRP Access Management Manual	Marc Birnbaum	Traffic Operations	Member	2011	2013
D1544	Mobile Light Detection and Ranging Standards for Transportation Agencies	Thomas Taylor	Information – Technology Security	Chair	2011	2015
D1547	An Assessment of Geometric Design Policies and Processes	Dale Widner	District 2 Design	Member	2013	2015
D1549	Geometric Design Guidelines for Managed Lanes	Joseph Rouse	Traffic Operations	Member	Pending	Pending
D1550	Guidelines for Integrating Safety and Cost-Effectiveness into Resurfacing, Restoration, and Rehabilitation Projects	Dale Widner	District 2 Design	Member	2013	2015
D1605	Development of Cost Effective Treatments for Roadside Ditches to Reduce the Number and Severity of Roadside Crashes	Karen M. Jewel	District 11 Traffic Operations	Member	2010	2014
D1748	Development of a Strategic National Highway Infrastructure Safety Research Agenda	Jeanne E. Scherer	Legal	Member	2010	2013
D1749	Noteworthy Practices in Crash Reporting and Safety Programs on Indian Tribal Reservations	Charles C. Fielder	District 1	Chair	2011	2014
D1754	Consideration of Roadside Features in the Highway Safety manual	Craig A. Copelan	Traffic Operations	Member	2011	2014
D1756	Development of Crash Reduction Factors for Uncontrolled Pedestrian Crossing Treatments	Brian Alconcel	Traffic Operations	Member	2012	2014
D1761	Effect of Work Zone Crash Risks and Guidance on Countermeasures	Theresa Drum	Maintenance	Chair	2012	2015
D1769	Development of Strategic Plan for Transforming Traffic Safety Culture	Joe Horton	Research, Innovation and System Information	Member	Pending	Pending
D1813	Specification and Protocols for Acceptance Tests of Fly Ash Used in Highway Concrete	Thomas A. Pyle	Maintenance	Member	2007	2012
D1815	High-Performance, High-Strength Lightweight Concrete for Bridge Girders and Decks	Ric Maggenti	District 4 Engineering Services	Member	2007	2012
D1816	Self-Consolidating Concrete for Cast-in-Place Concrete Bridges and Tunnels	Madhwesh Raghavendrachar	Engineering Services	Member	2011	2014
D2005	Synthesis of Information Related to Highway Problems	Richard D. Land	Design	Member	1967	Ongoing
D2006	Legal Problems Arising Out of Highway Programs	Joann Georgallis	Legal	Member	1968	Ongoing
D2007	Research for AASHTO Standing Committee on Highways	Richard D. Land	Design	Member	1968	Ongoing
D2030	Innovations Deserving Exploratory Analysis	Michael D. Miles	District 7	Member	1992	Ongoing
D2059	Surface Transportation Security Research	Herby Gerald Lissade	Maintenance	Member	2002	Ongoing
D205932	All-Hazards Emergency Evacuation Guide for State Departments of Transportation	Diana L. Gomez	Traffic Operations	Member	2002	2012

Project Number	Title	Panel Member	Division	Role	Start Date	End Date
D205933	Pre-Planned Recovery and Accepted Practices for Replacement of Transportation Infrastructure	Herby Gerald Lissade	Maintenance	Chair	2002	2012
D205936	Catastrophic Transportation Emergency Management Guidebook	Herby Gerald Lissade	Maintenance	Chair	2002	Ongoing
D205939	Synthesis of Airport Closings and Emergency Evacuation Problems	Herby Gerald Lissade	Maintenance	Member	2002	Ongoing
D205948	Effective Practices for the Protection of Transportation Infrastructure from Cyber Incidents	Rene T. Garcia	Homeland Security	Member	2002	2014
D206300B	Performance Measurement Tool Box and Reporting System for Research Programs and Projects	Lawrence H. Orcutt	Research, Innovation and System Information	Member	2010	2014
D2065	Research for the AASHTO Standing Committee on Public Transportation	Jila Priebe	Planning	Member	2004	Ongoing
D206800A	United States Domestic Scan Program	Nancy L. Chinlund	Research, Innovation and System Information	Member	2004	Ongoing
D2068A	Best Practices for Addressing Access and Parking Needs of Non-Resident Users of Rail and Intermodal Transportation Station in Transit-Oriented Developments	Jila Priebe	Mass Transportation	Member	2004	Ongoing
D2082	Next Generation of FHWA Transportation Pooled Fund Website	Roberto E. Buendia	Research, Innovation and System Information	Member	2009	2012
D208302	Expediting Future Technologies for Enhancing Transportation System Performance	Marco Ruano	District 7 Traffic Operations	Member	2009	2013
D208306	Effects of Socio-Demographics on Travel Demand	Judy Lang	Traffic Operations	Member	2010	2013
D2084	Streamline and Simplify Right-of-Way Procedures and Business Practices	Mark L. Weaver	District 4 Right-of-Way and Land Surveys	Member	2010	2013
D2089	Intellectual Property Stewardship Guide for Transportation Departments	Lawrence H. Orcutt	Research, Innovation and System Information	Member	2011	2013
D2090	Improving Access to Transportation Information	Coco Briseno	Transportation System Information	Member	2011	2013
D2093	Development of Transportation Technology Transfer Primer on Best Practices	Mohamed AlKadri	Research, Innovation and System Information	AASHTO Monitor	2012	2013
D2097	Improving Findability and Relevance in Transportation Information	Chad T. Baker	Transportation System Information	Member	2014	Pending
D2098	A Knowledge Management Primer for Transportation Agencies	Cris Rojas	Administration	Member	2014	Pending
D2227	Roadside Safety Analysis Program Update	Randy Hiatt	Traffic Operations	Member	2009	2012
D2228	Criteria for Restoration of Longitudinal Barriers: Phase II	Armando Garcia	District 11	Member	2012	2014

Project Number	Title	Panel Member	Division	Role	Start Date	End Date
D2229	Performance of Longitudinal Barriers on Curves and Super-Elevated Roadway Sections	John R. Jewell	Research, Innovation and System Information	Member	2011	2014
D2434	Risk-Based Approach for Bridge Scour Prediction	Steve Ng	Engineering Services	Chair	2010	2013
D2435	Quantifying Long-Term Performance of Draped and Flexible Fence Rockfall Protection Systems Rockfall Fence Testing Guidelines	John D. Duffy	District 5	Member	2012	2013
D2436	Scour at the Base of Retaining Walls and Other Longitudinal Structures	Charles Ineichen	Maintenance	Member	2012	2015
D2437	Combining Individual Scour Components to Determine Total Scour	Kevin Flora	Maintenance	Member	2012	2015
D2438	Load and Resistance Factor Design Calibration of Differential Bridge Support Settlement	Amir Malek	Engineering Services	Member	2012	2015
D2533	Evaluation of the Methodologies for Visual Impact Assessments	Keith A. Robinson	Design	Chair	2010	2012
D2534	Improving FHWA's Traffic Noise Model by Expanding its Acoustical Capabilities and Applications	Bruce C. Rymer	Environmental Analysis	Member	2011	2013
D2535	Managing Rights-of-Way for Biomass Generation and/or Carbon Sequestration	Keith A. Robinson	Design	Chair	2011	2013
D2539	Developing Environmental Performance Measures and a Methodology for Incorporation into Performance Management Programs	Cindy Adams	Environmental Analysis	Member	2012	2014
D2541	Guidance for Achieving Volume Reduction of Highway Runoff in Urban Areas	Scott McGowen	Environmental Analysis	Chair	2012	2013
D2542	Bridge Runoff Treatment Analysis and Treatment Options	Keith Jones	Environmental Analysis	Member	2012	2013
D2545	Mapping Truck Noise Source Heights for Highway Noise and Barrier Analysis	Bruce Rymer	Environmental Analysis	AASHTO Monitor	2013	Ongoing
D3101	Support for the AASHTO IntellDrive Strategic Plan	Greg A. Larson	Research, Innovation and System Information	Member	2011	2014
D3102	Auxiliary Turn Lane Design Guidance and Policy Upgrades	Larry Moore	Design	Member	2011	2013
D3105	Developing Design Criteria for Cost-Effective Multi-Lane Loop Ramp Design	Zhongren Wang	Traffic Operations	Member	2012	2015
D3109	Update Section 2B.07 of Manual on Uniform Traffic Control Devices— Multi-Way Stop Control	Roberta McLaughlin	Traffic Operations	Member	2013	2014

Appendix 2: Active NCHRP Projects with Caltrans Panel Membership

Project Number	Title	Panel Member	Division	Role	Start Date	End Date
DA0247	Assessing Aircraft Noise Conditions Affecting Student Learning-Case Studies	Philip Crimmins	Aeronautics	Member	Pending	Pending
DA0409	Assessing the Risks Associated with Maintaining Existing Airfield Separations at Older Urban Airports	Gary C. Cathey	Aeronautics	Member	2009	2013
DA1103	Synthesis of Information Related to Airport Problems	Gary C. Cathey	Aeronautics	Member	2005	Ongoing

Appendix 3: Active ACRP Panels with Caltrans Panel Membership

Project Number	Title	Panel Member	Division	Role	Start Date	End Date
DF020	Resources and Procedures for Developing Local and Specific Freight Corridors Commodity Flow Databases	Diane Jacobs	District 7 Transportation System Information	Member	2009	2013
DF025	Freight Generation and Land Use	Douglas MacIvor	Transportation System Information	Member	2009	2012
DF02501	Estimating Freight Generation Using Commodity Flow Survey Microdata	Douglas MacIvor	Transportation System Information	Chair	2012	2014
DF026	Strategies for Measuring the Costs of Freight Transportation	Douglas MacIvor	Transportation System Information	Member	2010	2012
DF032	Impact of Smart Growth on Metropolitan Goods Movement	Douglas MacIvor	Transportation System Information	Member	2010	2012
DF034	Alternative Technologies for Container Freight	Diane Jacobs	District 7 Transportation	Chair	2011	2013
DF038	Metropolitan Frameworks for Freight Project Delivery	Chad T. Baker	Transportation System Information	Chair	2012	2014
DF039	Creating Publicly Available Measures of Freight Trucking Activity	Diane Jacobs	District 7 Transportation System Information	Chair	2012	2013
DF041	Capacity and Level of Service Analysis for Trucks	Doug MacIvor	Transportation System Information	Member	2012	2014
DF044	Factors Influencing Freight Modal Shift	Doug MacIvor	Transportation System Information	Member	2013	2015

Appendix 4: National Committees with Caltrans Membership

Committee Title	Committee Member	Caltrans Division	Committee Role
AASHTO Board of Directors	Malcolm Dougherty	Executive	Member
Access Management	Marc Birnbaum	Traffic Operations	Member
Bridge Management	Michael B. Johnson	Engineering Services	Member
Committee for Review of U.S. DOT Truck Size and Weight Study	Susan Hida	Engineering Services	Member
Committee for the 10th National Conference on Transportation Asset Management	Garth Hopkins	Planning	Member
Committee on Implementing Research from SHRP 2	Malcolm Dougherty	Executive	Member
Council on Fiscal Management and Accounting	Clark Paulsen	Budgets	Member
Critical Transportation Infrastructure Protection	Herby Gerald Lissade	Maintenance	Member
Emerging and Innovative Public Transport and Technologies	Jane Perez	Mass Transportation	Member
Eminent Domain and Land Use	Joanne Georgallis	Legal	Member
Engineering Geology	John Duffy	Geology	Member
Environmental Issues in Transportation Law	David McCray	Legal	Member
Expert Task Group for Bridge Durability and Preservation	Barton J. Newton	Engineering Services	Member
Expert Task Group for Bridge Evaluation and Monitoring	Charles Sikorsky	Engineering Services	Member
Freeway Operations	Diana Gomez	Traffic Operations	Member
Freight Transportation Data	Doug MacIvor	Planning	Member
Freight Transportation Planning and Logistics	Diane Jacobs	System Information	Member
Geometric Design	Jerry Champa	Traffic Operations	Member
Highway Capacity and Quality of Service	Kevin Hanley	Design	Member
Highway Safety Performance	Craig Copelan	Traffic Operations	Member
Historic and Archeological Preservation in Transportation	Anmarie Medin	Environmental Analysis	Member
Intelligent Transportation Systems	Greg Larson	Research, Innovation and System Information	Member
Landscape and Environmental Design	Keith Robinson	Design	Member
Long-Term Bridge Performance Committee	Richard D. Land	Executive	Member
Maintenance and Operations Personnel	Lawrence H. Orcutt	Equipment	Member
Maintenance and Preservation	Michael B. Johnson	Engineering Services	Member
Maintenance and Preservation	Lisa Kunzman	Equipment	Member
Maintenance Equipment	Lisa Kunzman	Equipment	Chair
Managed Lanes	Joseph Rouse	Traffic Operations	Member
Modeling for the Design, Construction, and Management of Geosystems	Anoosh Shamsabadi	Engineering Services	Member
National Transportation Product Evaluation Program	Lawrence H. Orcutt	Equipment	Member
NCHRP Review Panel 3	Joe Horton	Research, Innovation and System Information	Member
Oversight Committee for SHRP 2	Malcolm Dougherty	Executive	Member

Committee Title	Committee Member	Caltrans Division	Committee Role
Passenger Rail Equipment and System Integration	Stanton Hunter	Rail	Member
Pavement Management Systems	Peter Vacura	Maintenance	Member
Pavement Rehabilitation	Robert Hogan	Maintenance	Member
Portland Cement Concrete Pavement Construction	Dulce Rufino Feldman	Maintenance	Member
Research Advisory Committee	Coco Briseno	Research, Innovation and System Information	Member
Rigid Pavement Design	Dulce Rufino Feldman	Maintenance	Chair
Roadside Maintenance Operations	Jack Broadbent	Design	Member
Section Pavement Management	Dulce Rufino Feldman	Maintenance	Member
Seismic Design and Performance of Brides	Mike Keever	Engineering Services	Chair
SHRP 2 Technical Coordinating Committee for Capacity Research	Kome Ajise	Executive	Member
Special Committee on Transportation Security and Emergency Management	Steve Takigawa	Executive	Member
Special Committee on Transportation Security and Emergency Management	Herby Gerald Lissade	Maintenance	Member
Special Task Force on Data for Decisions and Performance Measures	Coco Briseno	Research, Innovation and System Information	Member
Standing Committee on Highway Traffic Safety	Jessie Bhullar	Traffic Operations	Member
Standing Committee on Highways	Karla Sutliff	Engineering Services	Member
Standing Committee on Performance Management	Coco Briseno	Research, Innovation and System Information	Member
Standing Committee on Performance Management	Rachel Falsetti	Programming	Member
Standing Committee on Planning	Kome Ajise	Executive	Member
Standing Committee on Public Transportation	Jila Priebe	Mass Transportation	Member
Standing Committee on Public Transportation	Brian Travis	Planning	Member
Standing Committee on Public Transportation	Jane Perez	Mass Transportation	Member
Standing Committee on Rail Transportation	Emily Burstein	Information Services	Member
Standing Committee on Rail Transportation	Bill Bronte	Rail	Vice-Chair
Standing Committee on Research	Steve Takigawa	Executive	Member
Standing Committee on the Environment	Dale Jones	Planning	Member
Standing Committee on the Environment	Scott McGowen	Environmental Analysis	Member
Standing Committee on the Environment	Anmarie Medin	Environmental Analysis	Member
Standing Committee on the Environment	Gina Moran	Planning	Member
Standing Committee on the Environment	Jay Norvell	Environmental Analysis	Member
Statewide Transportation Data and Information Systems	Coco Briseno	Research Innovation and System Information	Member
Steel Bridges	Barton J. Newton	Engineering Services	Member
Structures	Mike Keever	Engineering Services	Member
Subcommittee on Air Quality	Mike Brady	Planning	Member

Committee Title	Committee Member	Caltrans Division	Committee Role
Subcommittee on Air Quality	Pete Conn	Environmental Analysis	Member
Subcommittee on Bridges and Structures	Lian Duan	Research Innovation and System Information	Member
Subcommittee on Bridges and Structures	Susan Hida	Engineering Services	Non-voting Member
Subcommittee on Bridges and Structures	Mike Keever	Engineering Services	Non-voting Member
Subcommittee on Bridges and Structures	Barton J. Newton	Engineering Services	Member
Subcommittee on Community and Cultural Resources	Anmarie Medin	Environmental Analysis	Member
Subcommittee on Construction	Mark Leja	Construction	Member
Subcommittee on Design	Kevin Hanley	Design	Member
Subcommittee on Design	Richard D. Land	Executive	Vice-Chair
Subcommittee on Highway Transport	James Anderson	Traffic Operations	Member
Subcommittee on Information Systems	Ann Barsotti	Information Technology	Member
Subcommittee on Information Systems	Doug Kempster	Information Technology	Member
Subcommittee on Internal and External Audits	William Lewis	Audits and Investigations	Member
Subcommittee on Legal Affairs	Ron Beals	Legal	Member
Subcommittee on Maintenance	Tony Tavares	Maintenance	Member
Subcommittee on Materials	Phil Stolarski	Engineering Services	Member
Subcommittee on Natural Systems and Ecological Communities	Scott McGowen	Environmental Analysis	Member
Subcommittee on Organizational Management	Kevin Hanley	Design	Member
Subcommittee on Personnel and Human Resources	Cris Rojas	Administration	Member
Subcommittee on Public Affairs	Tamie McGowen	Public Affairs	Member
Subcommittee on Right-of-Way and Utilities	Rene Fletcher	Right-of-Way and Land Surveys	Member
Subcommittee on Right-of-Way and Utilities	Don Grebe	Right-of-Way and Land Surveys	Member
Subcommittee on Right-of-Way and Utilities	Brent Green	Right-of-Way and Land Surveys	Member
Subcommittee on Right-of-Way and Utilities	Suzette Shellooe	Right-of-Way and Land Surveys	Member
Subcommittee on Safety Management	Yin-Ping Li	Local Assistance	Member
Subcommittee on Safety Management	Thomas Schriber	Traffic Operations	Non-voting Member
Subcommittee on Safety Management	Jeanne E. Scherer	Legal	Member
Subcommittee on Systems Operation and Management	Monica Kress	Traffic Operations	Member
Subcommittee on Systems Operation and Management	Greg Larson	Research, Innovation and System Information	Member
Subcommittee on Systems Operation and Management	Lawrence H. Orcutt	Equipment	Member

Committee Title	Committee Member	Caltrans Division	Committee Role
Subcommittee on Systems Operation and Management	Joan Sollenberger	Planning	Member
Subcommittee on Traffic Engineering	Janice Benton	Traffic Operations	Member
Subcommittee on Traffic Engineering	Robert Copp	Traffic Operations	Member
Subcommittee on Transportation Communication	Tamie McGowen	Public Affairs	Member
Subcommittee on Transportation Finance Policy	Norma Ortega	Finance	Member
Synthesis of Information Related to Airport Problems	Gary C. Cathey	Aeronautics	Member
Task Force on the Logistics of Disaster Response and Business Continuity	Herby Gerald Lissade	Maintenance	Member
Task Force on Understanding New Directions for the National Household Travel Survey	Sarah Chesebro	Planning	Member
Task Group for Urban Freeway Models Validation	Nicholas Compin	Planning	Member
Technology Implementation Group	Richard D. Land	Director's Office	Member
Tort Liability and Risk Management	Jeanne E. Scherer	Legal	Member
Traffic Flow Theory and Characteristics	Koohong Chung	Traffic Operations	Member
Transportation Asset Management	Coco Briseno	Research, Innovation and System Information	Member
Transportation History	Craig Copelan	Traffic Operations	Member
Transportation Law	Anthony Samson	Legal	Member
Transportation-Related Noise and Vibration	Bruce Rymer	Environmental Analysis	Member
Travel Survey Methods	Sarah Chesebro	Planning	Member
Work Zone Traffic Control	Theresa Drum	Maintenance	Member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