

BRIDGE INSPECTION & MANAGEMENT IN CALIFORNIA

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Abstract

This paper provides an overview of the California Department of Transportation (Caltrans) Bridge Management Program including inspection and investigations; special investigations including NDE/NDT technology; data management; prioritization and programming decision making; accomplishing bridge maintenance work; rehabilitation and replacement programs; and measuring performance.

Introduction

California – the Golden State - boasts a growing, diverse population of 38 million people. For more than 50 years, California has embodied a spirit of innovation and entrepreneurship that has given birth to new technologies and industries while building the eighth largest economy in the world.

The backbone of the economic miracle that is California has been the construction, operation and maintenance of the finest highway system in the world. Caltrans is helping propel California's economic engine by spearheading \$9.5 billion worth of construction work that is supporting more than 170,000 jobs in this state.

Today, that system of highways and bridges safely and reliably carries millions of people and dependably delivers commerce to and from every corner of the state, the nation and the world. Not only is the work we are doing in California important to economic recovery, it's critical to America's economic strength in the worldwide economy as products that flow into and out of this country rely on a fully-functional nationwide transportation system. What we all do in the transportation business is important.

The California Department of Transportation is responsible for maintaining more than 15,000 centerline miles (50,000 lanes miles) of pavement and 12,600 bridges on the state highway system.

Taking care of its bridge inventory has been a critical part of California's success in making sure its transportation program continues to deliver reliable service year after year. In 1927, state leaders initiated a study to determine and document the condition, safe load carrying limits and other restrictions of each public bridge in the state and to develop progress reports with work recommendations. Out of that effort was born California's bridge inspection and maintenance program.

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Inventory

The California Department of Transportation, as the owner and operator of the state highway system, is responsible for the protection and preservation of the state's bridge inventory which has an estimated replacement value of more than \$52 billion.

California's bridge inventory is aging with about two-thirds of structures on the state highway system having been built between 1950 and 1980. Approximately 92% of California's state highway bridges are concrete, 7% steel with timber and composite materials comprising the remainder. Concrete box girders are the most common bridge type.

Bridge Program Goals

California's bridge inspection and maintenance program has five goals:

1. To ensure the safety of the traveling public as required by Federal and State Law.
2. To manage the bridge assets to an agreed level of service.
3. To collect inventory and condition data
4. To recommend needed repairs, rehabilitation and/ or replacement
5. To determine safe load carrying capacity of each structure.

Structure Maintenance & Investigations

As part of the Caltrans Division of Maintenance, the Structure Maintenance & Investigations (SM&I) organization is charged with ensuring the structural integrity of the 12,600 state highway bridge inventory and 12,500 bridges owned by local government agencies.

The SM&I staff performs bridge inspections and engineering investigations in accordance with federal regulations, makes repair work recommendations; investigates hydraulic problems and scour potential; determines the safe load carrying capacity of all bridges; reviews and approves encroachment permits and air space lease proposals for state-owned structures; manages the State's bridge funding programs; delivers plans specifications and estimates for maintenance and rehabilitation on state-owned bridge projects; and coordinates the protective coating work on more than 800 steel state-owned highway bridges. SM&I is also the Department lead responsible for responding to any type of bridge related emergency including earthquakes, floods, over height vehicles, and tanker fires.

There are over 180 bridge engineers, structural steel technicians and support staff in six offices within SM&I. Those offices are listed below.

1. The Executive Office located in Sacramento.
2. The Office of Structure Investigations, North located in Sacramento is responsible for performing bridge inspections of all types on State and Locally-owned structures in the upper 49 counties of the State.
3. The Office of Structure Investigations, South located in Los Angeles is responsible for performing bridge inspections of all types on State and

Locally-owned structures in the lower 9 counties of the State and maintenance repair design of state owned bridges in the southern part of the State.

4. The Office of Toll Bridge Investigations located in Oakland is responsible for the inspection, maintenance repair design and general custodianship of the major toll bridges in San Francisco bay area.
5. The Office Specialty Investigations and Bridge Management located in Sacramento is responsible for the special Fracture Critical and Underwater Investigations for specified bridges statewide. It also manages the Statewide Bridge Preservation Program (Capital Funded) and the Statewide Bridge Maintenance Program, and is responsible for the data management for all bridges in the state.
6. The Office of Structural Design and Analysis is located in Sacramento and provides design services for bridge repair projects, establishes the safe load carrying capacity for all bridges and reviews encroachment and transportation permits. In addition, hydrologic and hydraulic evaluations and investigations are also performed for all existing bridges over waterways by this office.

Inspection

The foundation of the bridge inspection program is grounded on the requirements of the National Bridge Inspection Standards (US Code of Federal Regulations 23 CFR 650). California uses element level inspection protocols, visual and non-destructive testing techniques to assess the condition of each bridge on regular intervals between two to five years. The interval is based on the minimum federal requirements as well as a risk assessment of each bridge that considers type, actual condition, and redundancy of the structure and the judgment of the inspector.

Ensuring the safety and reliability of California's bridges is achieved through an ongoing effort of routine, fracture critical and underwater inspections performed by licensed engineers and specially trained structural steel inspectors. Federal regulations require that routine inspections be conducted every two to four years, fracture critical inspections every two years and underwater inspections every five years.

Routine Inspections

During routine inspections, inspectors who are licensed engineers look for any signs of distress that could compromise the structural integrity of a bridge. These inspectors assess the structural condition of the bridge, looking for any indications of potential problems. They examine the bridge deck – the riding surface- looking for cracks or other signs of distress. The inspectors, drawing on their expertise, can tell if cracks are superficial or signal something more serious. The conditions are documented, monitored, and repairs recommended if necessary. Inspectors also may order additional investigation if needed, such as NDE techniques or taking core samples of the concrete deck in for testing to the Caltrans laboratory to document and determine the extent of cracking etc.

The same process is followed on the superstructure—the structural members that support the deck. The Inspectors, relying on their knowledge and expertise and

using their trained eyes to identify any signs of distress. They will climb piers and use sophisticated equipment to access structural members of the bridge. Again, conditions are documented and repairs recommended as needed.

Finally, inspectors examine the surround areas and the substructure—the foundation of the bridge—looking for any signs of deterioration. As with the deck and superstructure, conditions of the substructure are documented and repairs recommended in a bridge inspection report.

Fracture Critical Inspections

A nine member team of engineers and structural steel inspectors is responsible for inspecting more than 1,000 state and local agency steel structures. A fracture critical bridge has a steel member whose failure could cause a portion of or the entire bridge to collapse. The I-35 West Bridge that collapsed in 2007 in Minnesota was a fracture critical bridge.

All areas of fracture critical bridges are required to be inspected visually, within arms reach, every 2 years with the aid of lift equipment or an under bridge inspection truck to place the inspector within arms reach of the fracture critical element. Many times fracture critical inspections utilize non-destructive testing equipment to help find cracks in critical members that can be invisible to the naked eye.

Underwater Inspections

Caltrans employs a full commercial certified underwater inspection team to perform bridge inspections and to respond to emergencies such as ship collisions with bridges.

SM&I's 11-member Underwater Inspection Team is responsible for ensuring the structural integrity of the supporting piers for more than 530 bridges including major bay crossings like the San Francisco-Oakland Bay, the Richmond-San Rafael and the San Diego-Coronado bridges. Inspectors look for any damage and scouring of bridge piers.

Underwater inspections of bridge piers are conducted in waterways from the Pacific Ocean and the state's major rivers to the California Aqueduct. These underwater inspections are designed to detect any loss of strength or the potential of scouring on bridge piers below the water surface.

Non-Destructive Testing

Safety is enhanced through these inspections and by "rating" bridge components, such as the deck, superstructure, and substructure, and by the use of non-destructive evaluation (NDE) methods and other advanced technologies. Visual inspection is the primary method and technique used to perform bridge inspections in California. Type, location, accessibility, and condition of a bridge, as well as type of inspection, are some of the factors that determine what methods of inspection practices are used. When problems are detected, or during the inspection of critical areas, more advanced NDE tools are employed. On occasion, destructive tests are conducted to evaluate specific areas or materials of concern, or to help identify appropriate corrective work.

The inspection team utilize many NDE methods for steel structures such as liquid penetrant testing (PT), ultrasonics (UT), eddy current (EC), radiography (RT) and magnetic particle testing, strain gauging, acoustic emission (AE), and x-ray technology.

Methods utilized during inspections of concrete structures include impact echo, infrared thermography, ground penetrating radar, and strain gauges for concrete structures and elements.

Load Ratings and Transportation Permits

The Bridge Ratings and Analysis Branch are responsible for establishing the safe load carrying capacity for all bridges and reviewing all overweight transport permits.

The unit completed 126 load rating analyses during the 2008/09 Fiscal Year, reviewed nearly 200 extra legal truck loads weighing more than 250,000 pounds. More than a third of these loads were more than 800,000 pounds. They also successfully routed one super load of more than one million pounds and four super loads of nearly one million pounds. All five loads were transformers.

The four loads of nearly one million pounds were manufactured in Southeast Asia, shipped to the Port of San Diego and transported to a storage facility in El Centro. The transformer weighting more than one million pounds was brought by rail from Houston to Fontana in San Bernardino County. The transformer was transported over California's road network to the Mexico/California border for eventual delivery to a new natural gas power plant in Rosarito, Mexico that will supply power to Tijuana and San Diego.

Bridge Data and Management

SM&I serves as the repository of data and information about every state and local agency bridge in the state. This information includes a historical record of the condition of each bridge on the state highway and local road networks, including all the as-built engineering plans and all completed bridge inspection reports. Bridge inspection reports are prepared following each inspection. These inspection reports provide a living history of each structure. Our library of information contains more than one million documents and gives engineers easy access to the entire structural history of each bridge in California

Bridge needs arise from the deterioration of bridge components, vulnerabilities to scour and seismic forces, changing safety standards and emergencies/accidents involving bridges.

Bridge Inspection Reports serve as the basis for initiating repairs in a timely and cost effective manner to ensure that each bridge is safe and well maintained.

Caltrans uses the AASHTOWare Pontis Bridge Management System and other tools to help evaluate the needs and prioritize repairs to maximize the benefit of available preservation dollars. Caltrans employs a life cycle cost analysis approach to compare alternatives at the project level.

Caltrans has recently begun a movement to a utility based benefit cost analysis approach that can combine physical condition and risk into a single utility that can be objectively compared across bridges.

Bridge Maintenance Design

There are four maintenance design units in SM&I, two in Sacramento and one each in Los Angeles and Oakland. A total of 32 design engineers and structural design technicians are responsible for delivering plans, specifications and estimates for a variety of bridge deck, superstructure and substructure structure preservation and repair projects.

The projects include methacrylate deck treatments and polyester overlays, joint seals, bridge rail repairs and foundation protection work. During the 2008/09 fiscal year, SM&I designers delivered engineering plans for more than \$135 million to repair 983 bridges around the state.

Research

SM&I is actively involved in advancing the science of engineering to extend the service life and reliability of the state's bridges. In conjunction with the Caltrans Division of Research and Innovation, SM&I is involved in a variety of structural research efforts including the effectiveness of deck rehabilitation strategies and the use of sonar imaging to validate the structural integrity of bridge piers.

Preserving the Bridge Inventory

California has an ambitious bridge preservation program designed to extend the reliable, productive service of the state's bridges. The preservation effort is comprised of three main components: Caltrans inspection and maintenance crews, major maintenance contract projects and the State Highway Operation and Protection Program (SHOPP).

Work recommendations are generated from information collected through bridge inspections. The work recommendations are addressed by the bridge crews or programmed into projects to fix joint seals, methacrylate deck crack sealing, bearing replacements, painting, polyester concrete overlays and replacing approach slabs.

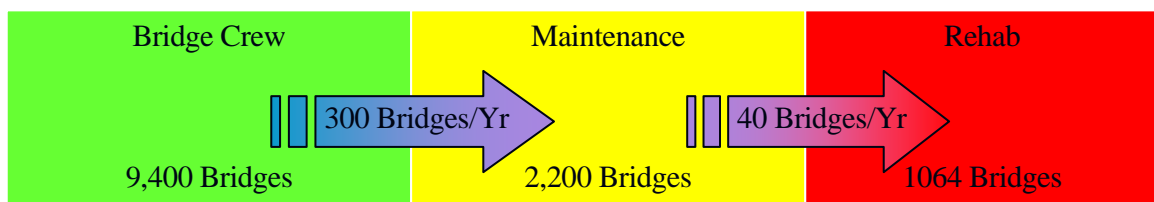
Projects are prioritized to address the most pressing needs first to ensure continued reliability of the system. Peer reviews are conducted by SM&I engineering staff on all bridge replacement and major repair project exceeding \$4 million to make sure that the recommended repair strategy is the best engineering and most cost effective alternative.

Caltrans invests \$67 million annually for inspection, bridge maintenance and bridge painting crews. The inspection effort is augmented by bridge maintenance crews performing minor repairs such as filling potholes on bridge decks and repairing minor bridge rail damage. They also respond to emergencies such as filling holes in a bridge deck to restore traffic service on a temporary basis until a permanent repair can be completed.

Bridge Paint crews are responsible for painting more than 800 steel bridges around the state. There are permanent painting crews assigned to some of the large Bay crossings such as the San Francisco-Bay Bridge. There also are general crews responsible for painting the other steel bridges up and down the state.

Caltrans is investing an additional \$93 million annually for major maintenance contract projects. These projects are designed to protect the bridges and extend their service life. Approximately 23% of California's bridge inventory, 2,844 bridges, have major maintenance repair work recommendations pending.

Bridges like all physical assets will deteriorate over time and require maintenance, rehabilitation or replacement. The graphic below depicts the rate of progression of bridges from good (green) to fair (yellow) to poor condition (red).



The wear and tear of highway traffic, weather, and movement cause approximately 300 bridges to change from good to fair condition and another 40 bridges change from needing maintenance work to needing rehabilitation.

Caltrans bridge preservation approach is a three prong attack that strives to counteract deterioration:

1. Bridge crews employed by Caltrans address minor preservation very quickly to keep bridges in the green.
2. Major maintenance contracts are required when the scope of the work exceeds what the crews can do.
3. Major maintenance contracts are designed to delay or prevent the progression into the costly red rehabilitation/replacement area.

Major rehabilitation or replacement is required to address the bridges in the red area.

Measuring performance

The United States government uses inspection data compiled by Caltrans engineers to calculate a complex formula called the sufficiency rating to determine federal bridge program funding eligibility. The sufficiency rating combines the condition and functional adequacy data collected on every bridge into a single aggregate number. Sufficiency rating values range from 0 (low) to 100 (high). If the sufficiency rating on a bridge is 50 or less and it is designated as "structurally deficient" or "functionally obsolete" the bridge qualifies for federal replacement funding. A low sufficiency rating number does not necessarily mean that the bridge is in need of repair.

Caltrans identifies prudent repair and rehabilitation projects taking into consideration many factors that may not be fully captured by these federal designations and ratings. For example, none of the federal designations or ratings take into consideration the need for seismic strengthening. Caltrans relies on the recommendations from its field assessments and analyses to develop repair projects. These repairs may be minor and assigned to Caltrans maintenance crews or they may be more involved and require further analysis or planning studies to determine the appropriate course of action. Caltrans utilizes bridge management system software tools that can forecast deterioration and conduct life cycle cost analyses along with multi-disciplinary peer reviews to develop our ultimate projects. Project decisions are made on a bridge-by-bridge basis.

Crews are measured on their ability to retire identified work within specified time frames. The Caltrans Five Year Maintenance Plan tracks the number of bridges requiring maintenance contracts and the SHOPP measures the number of distressed bridges with rehabilitation or replacement needs.

Emergency response

Structures Maintenance and Investigations (SM&I) is the lead engineering responder to all emergencies involving existing state highway structures.

Operating from its three offices: Sacramento (North), Oakland (Toll Bridges), and Los Angeles (South), SM&I engineers are responsible for all matters involving the structural integrity of any highway structure damaged in natural disasters, accidents such as high load hits or other incidents. In the event of a disaster, the official damage report is prepared, stamped and signed by a licensed civil engineer at SM&I. The damage report is included in the Caltrans Bridge management database (SMART), which is maintained by SM&I.

Damage information is shared with the California Office of Emergency Services, which has responsibility for directing the statewide response to all disasters in the Golden State and the Caltrans Division of Maintenance which coordinates the response of maintenance forces around the state.

SM&I engineers have been at the forefront in responding to some of the most noteworthy natural disasters in the past 20 years including the 1989 Loma Prieta and 1994 Northridge earthquakes, the 2008 collapse of the MacArthur Maze connector ramp in Oakland due to a tanker truck fire and the collision of an oil tanker into the protective sheathing around one of the San Francisco-Oakland Bay Bridge's piers that resulted in one of the worst environmental catastrophes in state history.