



**Technical Note – Bridge
Inspections and Ratings**
(Full Article)

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SYNOPSIS

In response to the August 1, 2007 collapse of the I-35W Bridge over the Mississippi River, there has been heightened public interest in bridge safety and in the condition of the highway bridges in California. About 3000 of the 24,000 bridges in California have been categorized as structurally deficient. Many persons mistakenly believe this implies that they are not safe. This article will describe some of the terms and procedures used in the federally sponsored Highway Bridge Program. Several examples will be given that illustrate the concepts for bridges accessing Terminal Island in Los Angeles and Long Beach. These bridges are some of the larger ones in Southern California. They are not typical; they are large steel bridges. Most California bridges are smaller and constructed with concrete. These were chosen because I am more familiar with them. They are: Vincent Thomas and Schulyer Heim on SR 47 and the Gerald Desmond on the future extension of the I-710. The Gerald Desmond Bridge was thoroughly inspected by State and County staff in April 2007 and no serious imminent deficiencies were found. However, the bridge was rated as structurally deficient. The US Department of Transportation on August 2, 2007 issued a "Fact Sheet on the I-35W Bridge Collapse" which stated:

"Structurally deficient means there are elements of the bridge that need to be monitored and/or repaired. The fact that a bridge is "deficient" does not imply that it is likely to collapse or that it is unsafe. It means they must be monitored, inspected and maintained. Most "deficient" bridges are left open to traffic while it undergoes maintenance and repair. If inspectors find unsafe conditions they will restrict access or close the bridge."

The Port of Long Beach recently completed the first phase of a repair program to correct deficiencies identified in the previous bridge inspection. The condition of the bridge deck, the riding surface, had been rated as "critical", level 2. If the condition had been rated as "imminent failure", level 1, inspectors would have recommended that the bridge be closed. The recent repairs are expected to raise this rating to "serious", level 3.. The structure is strong enough to allow overweight trucks by permit. The bridge can be kept in operation until a planned larger replacement bridge is open. The bridge is regularly inspected by Caltrans and the LA County Department of Public Works (LADPW). The Port has contracted with LADPW to conduct the initial repairs. On August 7, 2007 the LA County Board of Supervisors directed staff to report within 60 days on the condition of all bridges that they

inspect and prepare recommended actions to the bridge owners. Factors affecting bridge life such as truck weighs, typical failure mechanisms, and inspection techniques will also be described. This article will emphasize aspects of interest to transportation engineers and planners.

**NATIONAL BRIDGE INSPECTION PROGRAM /
BRIDGE RATINGS**

Federal law requires that every public highway bridge be inspected every two years. The Federal Highway Administration (FHWA) funds Caltrans to inspect all bridges in California. Caltrans and local governments each own about 12,000 bridges. Local bridges in Los Angeles County are inspected by the Los Angeles County Department of Public Works (LADPW) under contract with Caltrans. Bridge inspection reports are delivered to the bridge owners, Caltrans, and the FHWA. Bridge ratings are published in a National Bridge Inventory (NBI). The Caltrans website lists the sufficiency ratings for local bridges, see: <http://www.dot.ca.gov/hq/structur/strmaint/sr.htm>

The National Bridge Inventory (NBI) is used for preparing the eligible list of bridges for Federal-aid funding and for allocating bridge funds to states. Each bridge is rated on three scales: a sufficiency rating (SR) (a number between 0 – 100) and whether it structurally deficient (SD) or functionally obsolete (FO). The Sufficiency Rating (SR) is used primarily for prioritizing grant applications under the "Highway Bridge Program" (HBP). The rating measures the current ability of the bridge to meet functional and structural design standards established by FHWA. To be eligible for HBP funding a bridge must have a SR less than 80 and also be rated either SD or FO. If the SR is between 50 – 80 the bridge is eligible for rehabilitation funding. If the SR is less than 50 the bridge is eligible for rehabilitation or replacement funding. Since September 2006 HBP funds can also be used for bridge preventive maintenance. During Federal Fiscal Years FFY 98 – 2006, California received a total of \$500 million under non-discretionary part of the Highway Bridge Program. Caltrans often has to reprogram these funds due to the inability of local agencies to timely advance projects primarily due to lacking local match funds. The required local match was recently from 20% to 11.47% .

The method for determining the Sufficiency Rating and whether bridges are Structurally Deficient or Functionally Obsolescent are described in a FHWA publications and its updates, see : " Recording and Coding Guide for the Structure Inventory and Appraisal of the Nations Bridges", Report No. FHWA-PD-96-001. The table below presents a very short summary.

<p>Sufficiency Rating $0\% < \text{Sufficiency Rating} = S_1 + S_2 + S_3 - S_4 < 100\%$ S_1 (Structural Adequacy and Safety) = 55% Max Depends on: Superstructure, Substructure, Culverts, Inventory Rating</p>
<p>S_2 (Serviceability, Functional Obsolescence) = 30% Max Depends on: Lanes on Structure, ADT, Roadway Width, Structure Type, Bridge Roadway Width, VC Over Deck, Deck Condition, Structural Evaluation, Deck Geometry, Underclearance, Waterway Adequacy, Roadway Alignment, STRAHNET Highway Designation</p>
<p>S_3 (Essentiality for Public Use) = 15% Max Depends on : Detour Length, ADT, STRAHNET Highway Designation</p>
<p>S_4 (Special Reductions) = 13% Max Depends on: Detour Length, Traffic Safety Features, Structure Type Main</p>

A bridge will be rated structural deficient (SD) if the condition of one the three main bridge subsystems: the deck (riding surface), super structure (structure that supports the deck), or substructure (support columns and foundation) or a culvert that runs under the bridge receives a condition level rating of 4 or less out of 9. A bridge can also be rated structurally deficient it is limited to loads below legal truck weights. A bridge with an ADT > 5000 that is limited to trucks weighing less than 35,700 pounds would be rated structurally deficient. Exposed foundations in a waterway in need of erosion protection are a condition level 4.

A bridge will be rated functionally obsolete if the deck geometry, under clearances or approach alignment receives a condition level of 3 or less out of 9. For example a four lane freeway with a roadway width of 55.8 feet would receive a condition level rating of 3. If the width were 72 feet, the condition level would be 9. A bridge on an arterial with an underclearance less than 14 feet would receive a rating code of 3 out of 9. An approach roadway would be rated condition level 3 out of 9 if the horizontal or vertical curvature causes substantial reductions in speed. A bridge that is rated structurally deficient will not be rated for functional obsolescence. The I-35W Bridge in Minnesota had a sufficiency rating in the 50s and was rated structurally deficient. The following briefly discusses the conditions and ratings of each of the Terminal Island bridges and the impact of heavy truck loads on these bridges.

VINCENT THOMAS BRIDGE

The Vincent Thomas Bridge was constructed in 1963 by and is owned by Caltrans. It is entirely within the Port of Los Angeles. It has a sufficiency ration of 56.7. It links SR 47 to I-110. Permit loads are allowed.

SCHULYER HEIM BRIDGE

The Schulyer Heim Bridge is a lift bridge built by the Navy in 1948, transferred to the Port of Long Beach, and subsequently transferred to Caltrans in the 1970s. It is part of State Route 47. Caltrans and the Alameda Corridor Transportation Authority (ACTA) are currently conducting a study to replace the lift bridge with a fixed bridge with a 47 foot vertical clearance over the Cerritos Channel. The estimated cost of the replacement bridge and elevated truck expressway between the new bridge and Pacific Coast Highway is \$728 million. The existing bridge has not been seismically upgraded. Caltrans is planning to seismically retrofit the bridge approaches this year, a \$7 million project. The sufficiency rating of the existing bridge is 27.9.

GERALD DESMOND BRIDGE

The Gerald Desmond Bridge was constructed by the Port of Long Beach in 1968. The Port owns the bridge and is responsible for its maintenance. It will be included in the planned extension of the I-710 Freeway to Terminal Island. Approval and funding are being sought for a larger replacement. It was seismically retrofitted in 1997, and the roadway was widened from four to five lanes in 2002. There are now three lanes up and two lanes down in each direction. This accommodates the many heavy trucks moving slowly up the 6% grades and resolved a problem with two on-ramps being too close to each other. Several configurations were evaluated by Caltrans prior to accepting my three up two down proposal. Safety has increased. There were on average 13 traffic collisions per year prior to installation of the fifth lane. Since completion there have been 6 traffic collisions per year. Current traffic volumes are over 55,000 vehicles per day with 30% trucks. Congestion on the bridge has decreased. The 2005 PierPass Program which shifted about an additional 1/3 of truck trips to the off-peak hours has also reduced congestion. More than \$30 million in federal funds were used for these two projects. In 2004 nets were installed under the bridge over roadways to prevent falling concrete chips, some weighing up to four pounds, from injuring personnel. The **current** sufficiency rating for the Gerald Desmond Bridge is 43.

The March 2005 inspection report on this bridge identified several major, but correctable deficiencies. The concrete deck was rated as being in a "critical condition" (level 2 out of 9), primarily due to large area of damaged surface. There were the many spalls (pot holes) and broken expansion joint steel fingers. If

the condition rating had been an “imminent failure condition” (level 1 out of 9), the inspectors would have recommended that the bridge be closed. The substructure was rated as good (level 7 out of 9). There was no rating for pier protection since they are not in the water. The superstructure was rated as poor (level 4 out of 9). This is primarily the result of advanced corrosion at a few locations. Pack rust, a thick layer of rust that can bend mating steel members, is cited at three locations plus at many of the rocker bearings (where the superstructure connects to a metal plate on top of a support column). No significant cross section loss was observed due to corrosion on major steel members. However, corrosion will occur at a more rapid rate due to the poor paint condition and this must be closely monitored. Another key deficiency was many corroded suspension cable socket keeper plates (they restrain the ends of the suspension cables from horizontal movement). The bridge does not have shoulders and its grade is greater than 5%. This would justify a rating as functionally obsolete. However, the FHWA rating systems does not rate a bridge for functional obsolescence if it is already rated as structurally deficient.

I was the project manager on the first phase of repair work by LADPW under contract to the Port which was completed on July 29. Nine weekend days of partial and full bridge closures were required. Most of the work had to be done during daylight. LADPW repaired all of the critical items that had been identified: over 70 out of 104 suspension cable socket keeper plates, 120 potholes (spalls) in the concrete deck, 30 broken expansion joint steel fingers, and a recently damaged expansion joint on the connector from the southbound I-710. A program to monitor the durability of the deck repairs has been established, which includes the marking of bridge pier (support column) numbers on the median barrier. The ride on the bridge has been greatly improved. When repairing the 120 concrete deck spalls, no significant corrosion was observed of the deck steel reinforcing bars. Additional work performed by other contractors during the bridge closures included: new traffic striping, upgrading of the speed feedback signs, and repair of the street lights. Repair of the upper and lower suspension cable socket keeper plates required crews to access parts of the bridge that are not thoroughly covered in normal inspections. The LADPW bridge workers did not report any unexpected conditions in these less accessible areas.

APRIL 2007 INSPECTIONS

In April 2007 two inspections of the Gerald Desmond Bridge were performed: the normal biennial inspection by LADPW and a more intensive Fracture Critical Member inspection by Caltrans. The normal biennial inspection relies mostly on visual inspection and tapping areas that the inspector can reach with a hammer. The Fracture Critical inspection examines

pins and other details whose failure could result in collapse. It requires specialized equipment. The frequency of these inspections is being increased from every five years to every two years. In each inspection several critical members are sampled, within a 10 year period every critical element is inspected. Caltrans uses ultrasonic (high frequency sound similar to a sonogram) testing to reveal hidden cracks in pins, and liquid dye and ultraviolet light to make suspected cracks more visible.

TRUCK WEIGHTS

Federal and state law limits the weights of motor vehicles on highways to 80,000 pounds. Heavier and oversize vehicles that can not be broken into smaller loads are allowed by permit. Each bridge is given a rating by bridge engineers as to the maximum size permit load that it can carry. Trucks cause more wear to roads and bridges than cars. Millions of repetitions of heavy loads on a bridge can lead to metal fatigue cracks. Inspectors monitor for these cracks.

BRIDGE WEAR AND TEAR

There are 1620 structurally deficient bridges on the California state highway system with approximately 95% of the bridges designated as structurally deficient due to minor cracks in the concrete deck or the condition of the paint. Pennsylvania DOT defines preventive maintenance as a planned strategy of cost-effective treatments applied at the proper time to preserve and extend the useful life of a bridge. Some of the bridge maintenance activities that provide the biggest benefit for the smallest level of investment generally include: eliminating deck joints in old bridges, repairing or installing new expansion dams on bridge decks, repairing bridge decks, maintaining proper deck drainage, restoring or replacing bridge bearings, repairing or replacing bridge approach slabs, repairing bridge beam ends and beam bearing areas, and bridge painting.

LIMITATIONS AND SUCCESS OF INSPECTIONS

For an existing bridge inspectors are limited by what they can reach. Test equipment can be used to help reveal cracks and corrosion in steel and concrete. Non-destructive test equipment can be used to measure the strength of existing decks or beams. Newer bridges sometimes include strain gauges and corrosion sensors that can be remotely monitored. Since the start of the National Bridge Inspection Program in 1971 less than four bridges out of 600,000 have collapsed unexpectedly without being impacted by an earthquake, barge, fire, or truck. FHWA and State DOT's are developing and testing additional inspection methods.