Bridging the Gap

Restoring and Rebuilding the Nation's Bridges

American Association of State Highway and Transportation Officials

AASHTO

The Voice of Transportation

July 2008

I-35W BRIDGE COLLAPSE

AFTERMATH

August 1, 2007
The Interstate 35W (I-35W) Bridge collapses shortly after 6:00 p.m., killing 13 people and injuring 144 more.

August 2, 2007
U.S. Secretary of Transportation Mary E. Peters announces that $5 million in federal relief aid will be made available to clear debris, set up detours, and begin repair on the bridge. She calls on all states to immediately inspect their deck-truss bridges and requests the Department of Transportation's Inspector General to assess the National Bridge Inspection Program.

August 4, 2007
Congress passes H.R. 3311 authorizing $250 million to help rebuild the bridge.

August 6, 2007
President George W. Bush signs H.R. 3311 into law.

August 8, 2007
Addressing the National Transportation Safety Board's initial conclusions that the bridge collapse may have been caused by the weight of construction equipment and materials on the bridge, Secretary Peters directs the Federal Highway Administration (FHWA) to issue guidance strongly recommending that states ascertain that the weight of construction equipment and materials in place for ongoing or future work not exceed a bridge's load limit.

August 10, 2007
Secretary Peters advances $50 million in emergency relief funds for recovery and cleanup costs, part of the $250 million authorized by Congress.

September 5, 2007
Testifying before the House Transportation and Infrastructure Committee, Malcolm Kerley, Chair of the AASHTO Highway Subcommittee on Bridges and Structures, states, "Since August 1, in compliance with federal requests, every state has reviewed or is in the process of re-inspecting its steel deck truss bridges. Based on the reports of this review, we can say that these bridges are safe."

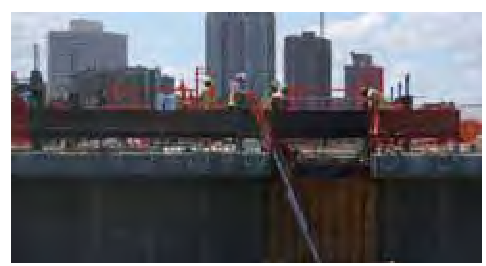
NEW BEGINNINGS

August 3, 2007
Minnesota Department of Transportation (MnDOT) announces the selection of a project manager to lead the reconstruction of the I-35W bridge.

August 4, 2007
MnDOT issues a Request for Qualifications for a Design-Build Contract for the I-35W replacement project, and opens a website on the bridge collapse and subsequent rebuilding efforts.

August 23, 2007
MnDOT releases the Request for Proposal for a new bridge to five design-build teams.

August 24, 2007
MnDOT announces a series of open houses to allow citizens to comment on construction of the new bridge.



September 10, 2007
U.S. Senator Patty Murray (D-WA), Chair of the Senate Appropriations Transportation, Housing, and Urban Development Subcommittee, adds $1 billion to the transportation appropriations bill for bridge replacement and rehabilitation. The additional obligation limitation is passed by Congress in late December.

September 14–18, 2007
MnDOT receives four proposals from Ames/Lunda, C.S. McCrossan, Flatiron/Manson, and Walsh Construction/American Bridge.

September 19, 2007
MnDOT opens the financial proposals publicly and releases the average proposal evaluation technical scores and each team's estimated number of days to complete the new bridge.

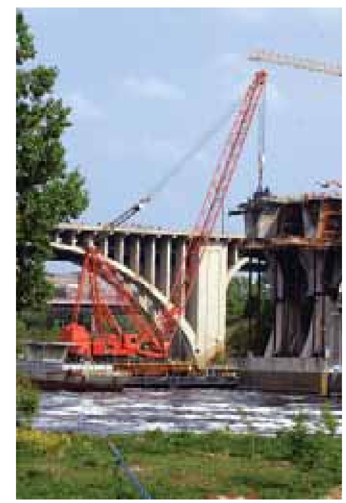
October 5, 2007
The Minneapolis City Council and Mayor R.T. Rybak unanimously pass a resolution approving MnDOT's proposed layout for the new bridge.

October 8, 2007
MnDOT awards the $264 million contract for construction of a new bridge to Flatiron/Manson, which agrees to complete that project no later than December 24, 2008.

October 30, 2007
House Transportation and Infrastructure Committee Chairman James Oberstar (D-MN) introduces the National Highway Bridge Reconstruction and Inspection Act of 2007, H.R. 3999, calling for strengthened bridge inspection standards and processes and increased investment in the reconstruction of structurally deficient bridges on the National Highway System

November 1, 2007
After a lawsuit opposing the bridge work is dismissed by the courts, actual construction of the new bridge starts.

November 5, 2007
"H" beam pile driving on the new bridge commences.



January 15, 2008
The National Transportation Safety Board, in an interim report, announces that an error in the original design process for the bridge led to undersized gusset plates in some of that structure's main trusses. The NTSB report Safety Recommendation H-08-1 addresses load capacity calculations for non-load-path-redundant steel truss bridges. In response, FHWA issued a Technical Advisory strongly recommending bridge owners check the capacity of gusset plates as part of the load rating calculations for existing and new non-load-path redundant steel truss bridges.

March 14, 2008
Approximately half the concrete needed for the new bridge has been poured by this date.

May 21, 2008
The Minnesota state legislature's Joint Committee to Investigate the Bridge Collapse releases its Investigative Report. It states any conclusions about the cause of the collapse are premature until the NTSB has issued its own report.

June 19, 2008
The Minnesota Department of Transportation issues a news release advising that the new Interstate 35W bridge in Minneapolis will be finished ahead of schedule. "I am pleased to announce that the I-35W Bridge project will be complete sometime between mid-September and mid-October, more than two months ahead of schedule," said Tom Sorel, Transportation Commissioner. "The project is already more than 70 percent complete." Construction crews work in 12-hour shifts around the clock, hoping to collect up to $27 million in incentive pay for early completion.

Front cover photo courtesy of Rhode Island Department of Transportation.
Time line photos courtesy of David Gonzalez, Minnesota Department of Transportation.

Message from Tom Sorel

Commissioner, Minnesota Department of Transportation

On August 1, 2007, Minnesota suffered a tragedy of historic proportions when the Interstate 35W bridge collapsed. Our hearts continue to go out to the victims, families and others affected by the collapse. And we recognize that the tragedy, although local, affected the entire nation as the safety of the nation's bridges was questioned and placed in a spotlight never before experienced.

Much has happened in this past year in Minnesota and across the country. We all await the final report from the National Transportation Safety Board on the cause of the collapse. Their findings likely will have nationwide impact in ensuring bridge safety.

The Minnesota Department of Transportation, and I am sure everyone in the transportation community, is dedicated to never letting such a disaster happen again.

Much already has been done to help restore confidence in the safety of Minnesota's infrastructure through inspection programs, gusset plate reviews and funding plans; and most notably the reconstruction of the new I-35W bridge.

We have witnessed an unprecedented spirit of cooperation to respond to and recover from this disaster. Minnesota and the nation rallied together to restore confidence, repair hearts and rebuild a bridge. We are grateful to all levels of government for their coordination and cooperation.

The accelerated rebuilding of the new I-35W bridge is evidence of this unprecedented cooperation.

As we look toward the opening of the new bridge, we remember with respect the events of one year ago and we will try to demonstrate how a resilient state and nation can indeed recover from such a tragedy.

Photo courtesy of David Gonzalez, Minnesota Department of Transportation.

Introduction

Almost a year ago, we as a nation were stunned and saddened by the tragic bridge collapse in Minneapolis that took 13 lives, injured 144 others, and disrupted the life of a great city.

In the intervening year we have watched with pride the way in which federal, state, and city transportation agencies, contractors, and construction teams have worked night and day to bring to life a new bridge, unsurpassed in technology and design.

Also in the past year we in the transportation industry have looked even more closely at the safety and sustainability of America's 590,000 bridges for today and into the future.

This report was developed by the men and women of the state departments of transportation to share that inside look with you.

It talks about:

- How states cope with aging bridges;
- New technologies that have advanced the science of bridge inspections;
- The life of a bridge, and how it can be extended;
- Signature bridges that symbolize America's communities;
- The truth about the resources we have to sustain our bridges, and the investment gap that must be closed.

It also relates real-life stories from Texas to Washington State about ways in which lives have been changed by the opening or closing of a bridge.

There is something about a bridge that stirs our spirits and captures our imaginations. Perhaps that is why a failure such as what happened in Minnesota is so crushing, and the resulting work toward a new beginning is so uplifting. On the anniversary of this tremendous loss, let us look forward to what America can still achieve.

John Horsley
Executive Director

Top Five PROBLEMS for BRIDGES

1. **Age and Deterioration** The nation has a generation of Baby Boomer Bridges, constructed in the 1950s and 1960s, that need major repair or replacement. Usually built to last 50 years, the average bridge in this country today is 43 years old. While safe to travel, almost one in four bridges is either structurally deficient and in need of repair, or functionally obsolete and too narrow for today's traffic volumes.

2. **Congestion** The nation cannot fix its congestion problems without fixing its bridge problems. The nation's bridges have become chokepoints on the country's freeway system, particularly at interchanges and major river crossings. The top 10 highway interchange bottlenecks cause an average of 1.5 million truck hours of delay each year. Much of the cost to improve highway interchanges is directly related to the construction of bridges and overpasses that separate and elevate lanes of traffic.

3. **Soaring Construction Costs** The dollars available for bridges, in fact for all categories of highway and transit investment, are buying less and less in the marketplace. With oil nearly quadrupling in price in the past four years, construction costs have soared. The costs of steel, asphalt, concrete, and earthwork have risen by at least 50 percent. Thirty months of unprecedented construction inflation are forcing state officials to delay important bridge replacement projects.

4. **Maintaining Bridge Safety** Nearly every state faces funding shortages which prevent them from applying the kind of ongoing preventive maintenance, repair, and replacement that would keep their bridges sound indefinitely.

5. **New Bridge Needs** The staggering costs of new bridges and their related interchanges prevent many states from building the bridge mega-projects that are needed to address congestion and serve economic growth. Massive costs far outweigh available resources.

Top Five SOLUTIONS for BRIDGES

1. **Investment** All levels of government—federal, state, and local—will have to significantly increase transportation investment if the nation is to preserve what has been built and ensure the modernization essential for future growth. A significant portion of that additional investment would be needed to improve, expand, and widen bridges on the nation's highways.

2. **Research and Innovation** The safety, longevity, and economy of U.S. bridges are being constantly improved by innovations in design, materials, and technology. Using such advances, a new generation of safe and long-lasting bridges can be built and the life of existing bridges extended. Research on bridge design, materials, and preservation must be continued.

3. **Systematic Maintenance** Through systematic, long-term management systems, states can produce stable conditions for the entire inventory of bridges for the lowest life-cycle cost. The goal is to find the right balance between fixing immediate problems, conducting preventive maintenance, and periodically replacing a reasonable number of old bridges to keep the health of its bridge population stable.

4. **Public Awareness** The Minneapolis bridge collapse on August 1, 2007 was a wake-up call that focused national attention on the importance of the bridges that America takes for granted. Awareness is the first step to a national commitment to increase investment in transportation infrastructure.

5. **Financial Options** Meeting the nation's bridge needs will require at least two forms of financing options. In metropolitan areas, where major new bridges are needed to accommodate heavy volumes of traffic, tolling can play a significant role in financing costs. In other areas, however, state and local transportation agencies will need to rely on an overall increase in tax revenues to make possible the bridge preservation investments needed.

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Executive Summary

Facing the Facts about America's Bridges

The I-10 Mississippi River Bridge at Baton Rouge.
Photo courtesy of Kian Yap, Louisiana Department of Transportation.

At the anniversary of the August 1, 2007, Minnesota bridge disaster, Americans no doubt will be wondering about the status of the nation's 590,000 bridges. Carrying hundreds of thousands of commuters and other traffic as well as much of the nation's commerce, bridges are the fundamental backbone of this country's economy. At the same time, however, bridges are so common that they melt into the backdrop of everyday life, and their importance in the functioning of our society is often overlooked.

The collapse of the Interstate 35 West Bridge in Minneapolis cost the lives of 13 people and injured 144 more. Failures such as the one in Minneapolis are extremely rare, with the majority being attributed

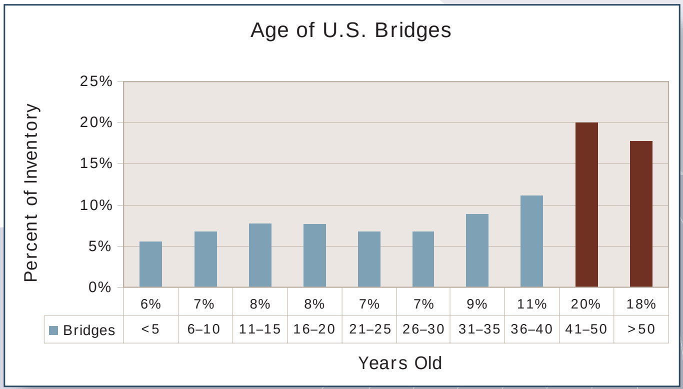
Photo courtesy of David Gonzalez, Minnesota Department of Transportation

to naturally occurring events such as floods and earthquakes or man-made events such as bridges struck by barges. Rigorous state inspections combined with decades of repair have created a reliable and safe bridge system.

Aftermath and a New Beginning

Looking back at that tragic event, the response of federal, state, and local governments was remarkable. On August 2, standing with Minnesota Governor Tim Pawlenty at the site of the collapse where heroic efforts were still underway to assist in the recovery, U.S. Department of Transportation Secretary Mary Peters announced the award of $5 million in federal relief. She also called on all states to immediately inspect their steel deck-truss bridges, the type of structure involved in the Minnesota collapse. On August 4, Congress authorized $250 million to rebuild the bridge. That same day Minnesota DOT (MnDOT) issued a Request for Qualifications for a Design-Build Contract for the I-35W replacement project.

In Congressional testimony on September 5, Malcolm Kerley, Virginia's Chief Engineer and Chair of AASHTO's Subcommittee on Bridges and Structures, reported that, "Since August 1, in compliance with federal requests, every state has reviewed or is in the process of re-inspecting its steel deck-truss bridges. Based on the reports of this review, we can say that these bridges are safe." On October 8, MnDOT awarded a $264 million contract for construction of a new bridge to Flatiron/Manson, which agreed to complete the project no later than December 24, 2008. On June 18, 2008, MnDOT announced that the new bridge may be completed two months ahead of the promised delivery date.



	<5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–50	>50
Bridges	6%	7%	8%	8%	7%	7%	9%	11%	20%	18%

Baby Boomer Bridges Show Their Age

Unfortunately, the future health of the nation's bridges is at a turning point. Usually built to last 50 years, the average bridge in this country today is 43 years old—and nearing the need for replacement. Almost one in four bridges, while safe to travel, is either structurally deficient, in need of repair, or functionally obsolete, which means they are too narrow for today's traffic volumes.

State departments of transportation are responsible for maintaining almost half of the nation's bridges. Yet even with inspections, improved materials, and ingenious repairs, nearly every state faces funding shortages that will prevent them from ongoing, stable investment in preventive maintenance, repair, and replacement. When repair is impossible, load limits and closings are the only options to ensure the public's safety, which, in turn lead to added congestion, delays, and hardships for those living at either side.

In September 2009, the federal law that authorizes funding for the nation's transportation system will expire. During the next 15 months, discussions in Congress, the new Administration, and in the State Capitols of this nation will be focused on defining priorities and funding for the next decade of transportation needs.

Despite the attention brought to bear on the condition of the nation's bridges as a result of the tragic collapse in Minneapolis, funding for repair, maintenance, and replacement has grown less certain. The Highway Trust Fund, which is the primary funding source for all federal aid for highways and bridges, is on the verge of massive shortfalls. Without new revenue, these shortfalls in 2010 could force a 50 percent reduction in funding below today's already inadequate investment levels.

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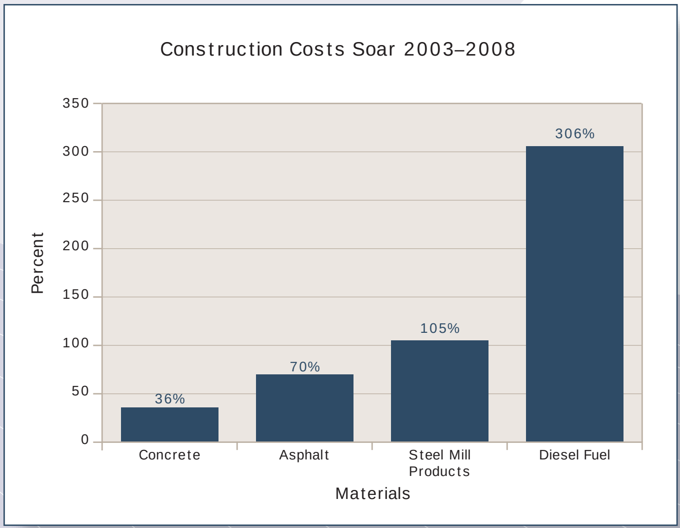
This report, *Bridging the Gap*, addresses:

- How states cope with aging bridges;
- New technologies that have advanced the science of bridge inspections;
- The life of a bridge and how it can be extended;
- Signature bridges that symbolize America's communities; and
- The truth about the resources we have to sustain our bridges, and the investment gap that must be closed.

States Simply Cannot Keep Up with Bridge Maintenance

Because the states manage the Interstate Highway System and National Highway System, more than 73 percent of *all* traffic and 90 percent of *all truck* traffic travels over state-owned bridges. The U.S. Department of Transportation's 2006 *Condition and Performance Report* (C&P), notes that more than $12.4 billion would be needed annually to actually improve bridge conditions on the federal-aid eligible system to a level that would help



Workers operate concrete pump in the building of the I-94 Business loop of Memorial Bridge North Dakota. *Photo courtesy of Mike Kopp, North Dakota Department of Transportation, 2008.*

relieve congestion and reduce accidents.

To address bridge needs, states use federal funds, as well as substantial funding from state and local resources. Because states consider bridge safety to be such a priority, they spend dramatically more money on bridges than is provided under the federal Bridge Program. To illustrate, in 2004 the federal Highway Bridge Program provided $5.1 billion to the states for bridge rehabilitation. However, in that year the states spent this amount plus an additional $1.5 billion in other federal highway aid. State and local funding added another $3.9 billion for bridge repairs. As a result, $10.5 billion was invested in bridge improvements by all levels of government. The U.S. DOT's C&P report concluded that if spending continued only at this level, 20 years later the backlog in needed bridge investment would remain at over $34 billion.

At the same time, states are finding that dollars available for bridges, in fact for all categories of highway and transit investment, are buying less and less in the marketplace. With oil nearly quadrupling in price in the past four years, construction costs have soared. The costs of steel, asphalt, concrete and earthwork have risen by at least 50 percent. Thirty months of unprecedented construction inflation are forcing state officials to delay important bridge replacement projects.

Needed: A National Commitment to Significant Investment in Transportation Infrastructure

The National Surface Transportation Policy and Revenue Study Commission estimates that the United States should be investing about $225 billion annually for the next 50 years on all modes of transportation. Today, the U.S. is spending about 40 percent of that.

According to data from the FHWA, it would cost $140 billion in 2006 dollars to immediately repair every bridge that is deficient in the country. Since immediate total repairs would be impossible to undertake, that cost would increase with inflation over time.

All levels of government—federal, state and local—will have to significantly increase transportation investment if the nation is to preserve what has been built and to ensure the transportation modernization essential for future growth. A significant portion of that additional investment would be needed to improve, expand and widen bridges on the nation's highways, its railroads and on its dedicated transit and commuter rail lines.

All levels of government—federal, state and local—will have to significantly increase transportation investment if the nation is to preserve what has been built and to ensure the transportation modernization essential for future growth.

The Nation Cannot Fix Its Congestion Problems Without Fixing Its Bridge Problems

The nation's bridges have become chokepoints on the country's freeway system, particularly at interchanges and major river crossings. Between 1995 and 2004 annual travel on the Interstate Highway System grew by 28 percent, at the same time that the system was expanded by only one-half of one percent. Truck travel nearly doubled in the past 20 years and is projected to double again by 2035, adding significantly more loads to the already heavily traveled bridge system.

Bridge inspector examines high beam on the I-29 Overpass at 52nd Avenue South in Fargo, North Dakota.
Photo courtesy of Terry Wiklund, North Dakota Department of Transportation, 2008.

Snooper truck inspection.
Photo courtesy of Duluth Shipping News.

Most of the nation's traffic and the vast majority of its truck freight, travel on the nation's major routes—the Interstate Highway System, the National Highway System and the urban freeways. The NHS represents only 4 percent of the nation's busiest roads and bridges, but carries 40 percent of all traffic and 75 percent of heavy truck traffic.

The staggering costs of new bridges and their related interchanges dwarf original construction costs. New bridges are needed to address congestion in major urban areas, but state and local officials are at a loss as to how to raise the massive amount of funds necessary for construction.

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Innovation and Technology Are Adding to Bridge Safety

To ensure the safety of the nation’s bridges, every state conducts a thorough and continual bridge inspection and rehabilitation program. Federal regulations require that, with some exceptions, bridges over 20 feet in length be inspected every 24 months by trained and qualified bridge inspectors. States often develop more detailed programs appropriate to unique circumstances.

Advances in technology such as electronic gauges are also enhancing the ability of inspectors to assess bridge conditions. New materials are now available for bridge building such as high-strength steel, high-performance concrete, rustproof components and fiber-reinforced polymer composites.

The nation’s departments of transportation face a frustrating contradiction. They have better engineering, materials and construction techniques than ever before, ensuring that a new generation of safe and longer-lasting bridges can be built for the future. Without a national commitment to bridge investment, however, states will face painful trade offs to keep the nation’s bridges safe and the American public moving.

Chapter 1

Keeping America's Bridges Safe and Sound

Every day Americans drive millions of miles across the country's 590,000 bridges with little thought about the structures. Bridges are so common that they melt into the backdrop of everyday life.

Supporting each of those bridges are not just piers and beams, but an entire network of engineers, inspectors, management systems, diagnostic equipment and inspection protocols to ensure their safety.

With the anniversary of the Minnesota bridge disaster, Americans no doubt will be wondering about the safety of the nation's bridges. State departments of transportation (DOTs) devote thousands of employees and billions of dollars annually to measure, assess, maintain and repair the nation's bridges to keep them safe and sound.

As a result, bridge failures are extremely rare. Of the few bridge collapses in recent decades, the large majority are attributed to external events such as ship collisions or major fires, or natural disasters such as earthquakes or hurricanes. According to the National Transportation Safety Board, in the past 20 years approximately 47 deaths have been attributable to bridge failures.

To state DOTs, any fatality or any bridge failure is unacceptable. That is why they inspect their bridges, invest in new diagnostic equipment and constantly strive to advance bridge design and materials.

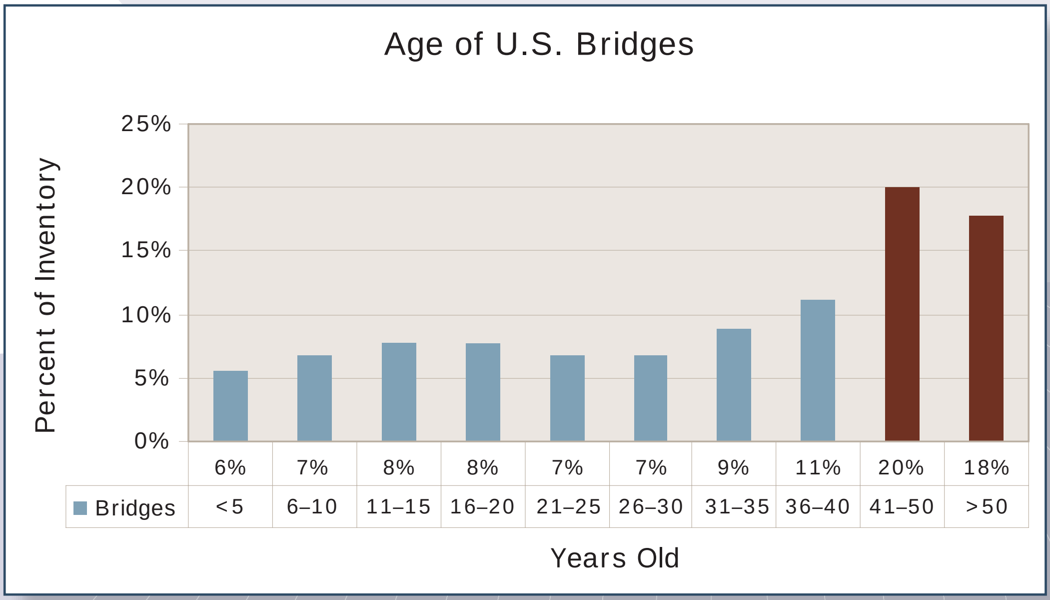
Wearing Down the Nation's Bridges

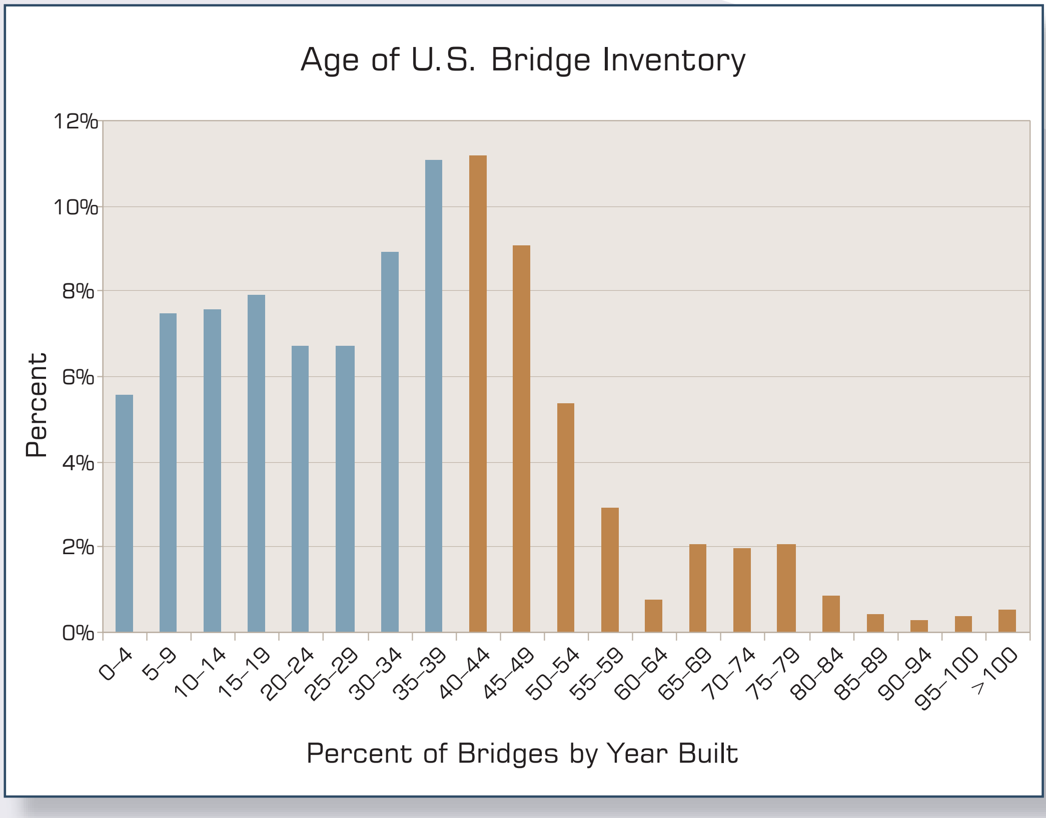
Traffic and age are two primary factors wearing down America's bridges.

On an annual basis, more than 3 trillion vehicle miles of travel occur over bridges, with 223 billion miles of that travel occurring in trucks. Truck miles have nearly doubled in the past 20 years and are projected to grow steadily, adding significantly more loads to the already heavily traveled bridge system. Overall, freight volumes will grow from 16 billion tons today to 31 billion by 2025, with trucks continuing to carry approximately 60 percent of that tonnage on the nation's highways and bridges.

The states are responsible for about 48 percent of the nation's 590,000 bridges, including nearly all of the large, complex structures. Because the states manage the Interstate Highway System and National Highway System, more than 73 percent of all traffic is on state-owned bridges, and an estimated 90 percent of all truck traffic.

Not only have traffic volumes increased dramatically, but the nation's bridges also are aging. The Interstate Highway System building boom from the mid-1950s to the mid-1970s led to the greatest bridge-building period in history. Many of those structures are approaching 50 years old and represent a sizeable need for additional investment—no matter how diligently they have been maintained.





The number of structural repairs needed on bridges increases proportionally with their age. Data from the National Bridge Inventory demonstrate how structural repair needs increase as bridges approach their 40th year. Today, about 50 percent of all bridges, when measured in terms of area, are between 35 and 55 years of age. While 50 years ago the nation faced an historic period of bridge construction, today it faces an historic period of bridge repair and reconstruction.

The nation's Baby Boomer bridges are showing their age. The state DOTs are keeping these bridges safe with diligent inspections, improved materials and ingenious repairs. However, maintenance alone cannot sustain these bridges. A significant new investment and national commitment is necessary to protect these invaluable assets.

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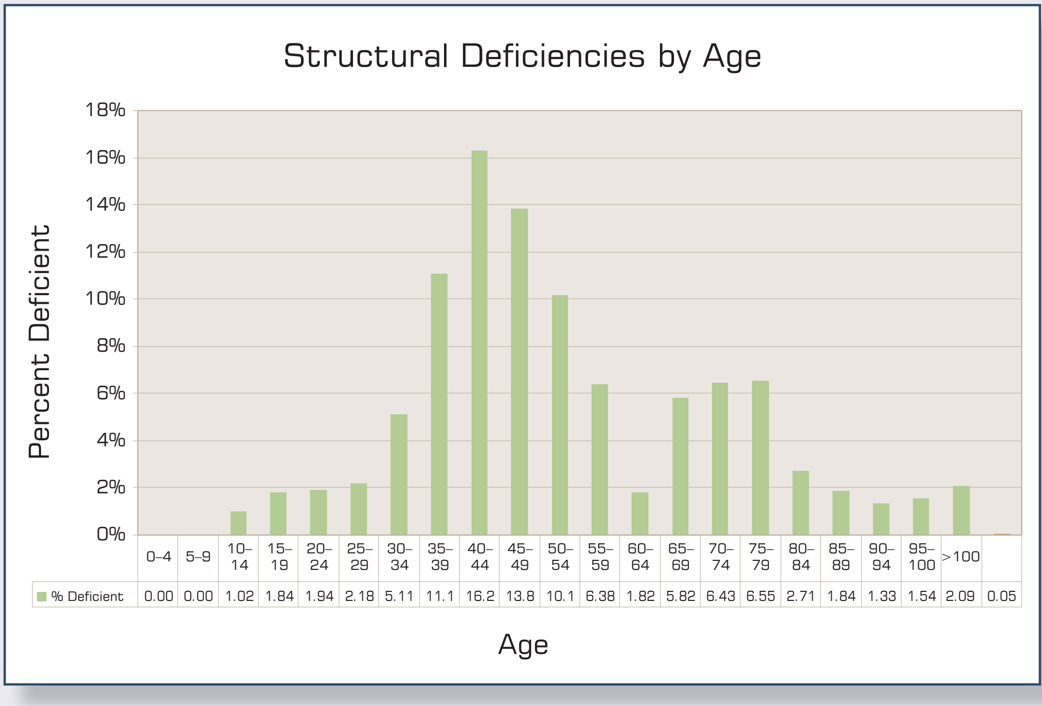
A Record of Progress Is Jeopardized by Rising Costs

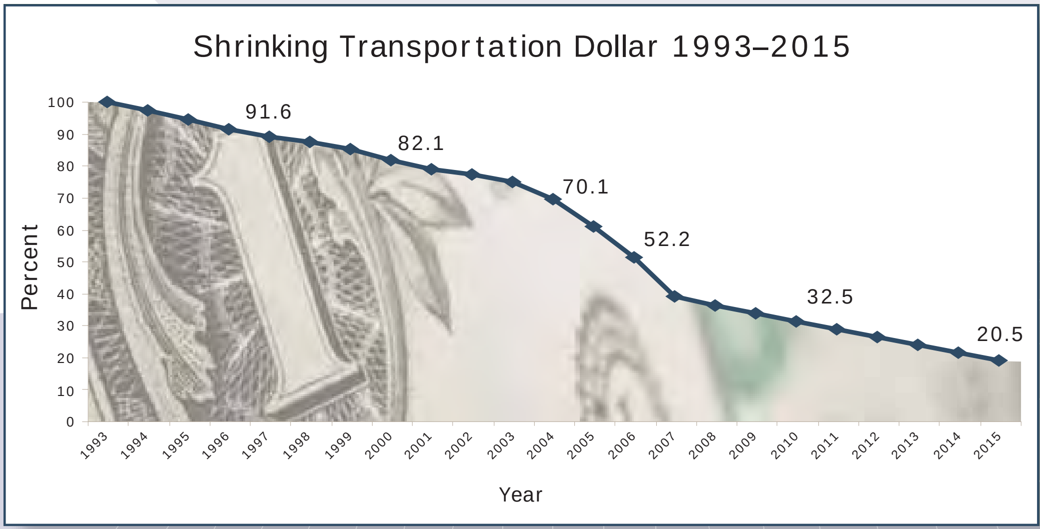
For more than a decade, the nation's departments of transportation were making steady progress on the nation's bridge inventory—at least when measured in terms of structural repairs. From 1994 to 2004, bridge conditions in both rural and

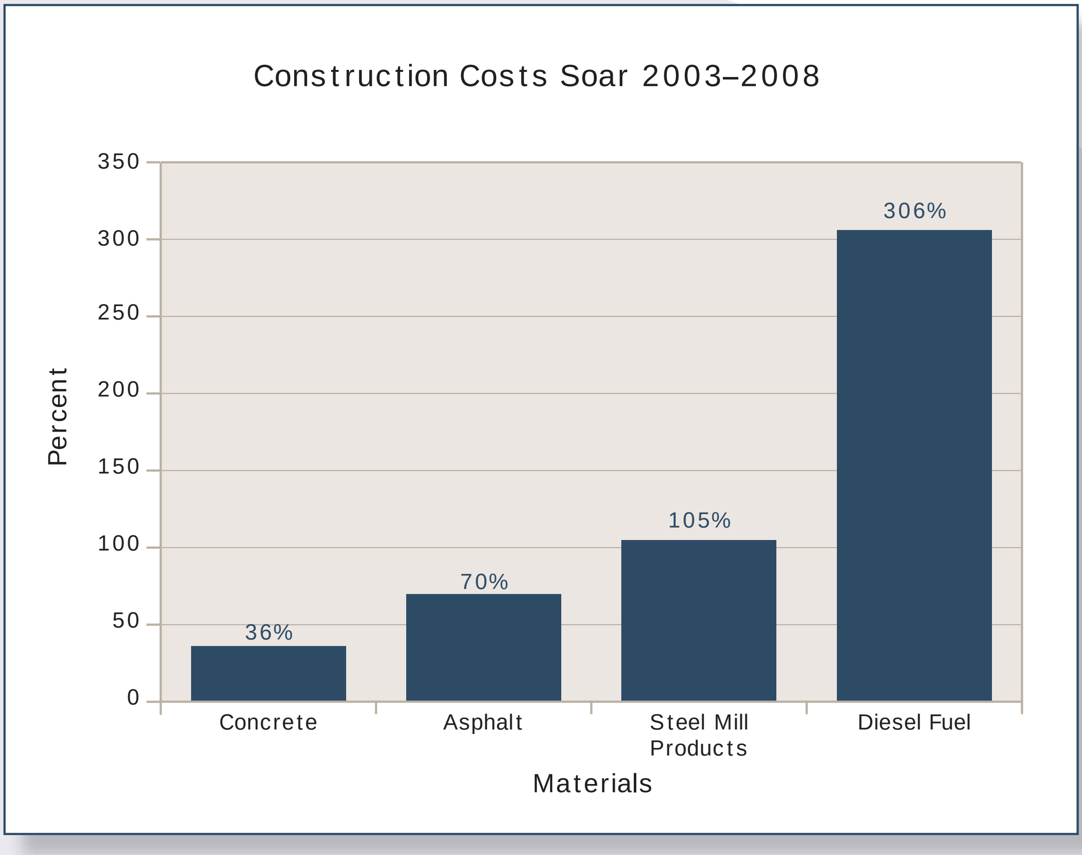


Age	0–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85–89	90–94	95–100	>100
% Deficient	0.00	0.00	1.02	1.84	1.94	2.18	5.11	11.1	16.2	13.8	10.1	6.38	1.82	5.82	6.43	6.55	2.71	1.84	1.33	1.54	2.09	0.05

urban areas steadily improved. The U.S. DOT reported that overall deficiencies, and structural deficiencies declined in every road category, although functional obsolescence has remained relatively static. In 2001, 10 percent of all the nation's bridges needed some type of structural improvement, while by 2007 that had dropped to 8.4 percent.

But this progress in improving bridge conditions is now jeopardized by unprecedented inflation in construction costs. With oil nearly quadrupling in price in the past four years, construction costs have soared. Asphalt prices have increased by 70 percent in the past five years, and diesel fuel, used for





the operation of heavy construction equipment, is up by 63 percent in only a year. Overall, the costs of steel, asphalt, concrete, and earthwork have risen by at least 50 percent. In some places, such as Hawaii, they have doubled. This has seriously eroded the states' ability to undertake planned construction projects at a time when so many bridges are in need of rehabilitation.

> The nation's bridge builders have created the largest inventory of bridges in the history of the world and have done so with great reliability and safety. However, that inventory is aging at a significant rate during a time of unprecedented cost increases. How to sustain this bridge inventory at safe and satisfactory levels is a critical issue for the nation

Summary

The nation's bridge builders have created the largest inventory of bridges in the history of the world and have done so with great reliability and safety. However, that inventory is aging at a significant rate during a time of unprecedented cost increases. How to sustain this bridge inventory at safe and satisfactory levels is a critical issue for the nation.

Bridges Move People

Mississippi: Bay St Louis and Biloxi Bay Bridges: A Symbol of Hope and Recovery

On August 29, 2005, Hurricane Katrina hit the Mississippi Gulf Coast leaving in its wake a level of destruction the likes of which had not been seen before. Katrina unleashed more than $1 billion in damages to Mississippi's transportation infrastructure alone. Two main bridges, the Biloxi Bay and Bay St Louis, were lost, impacting the daily lives of thousands people in and around the communities they served.

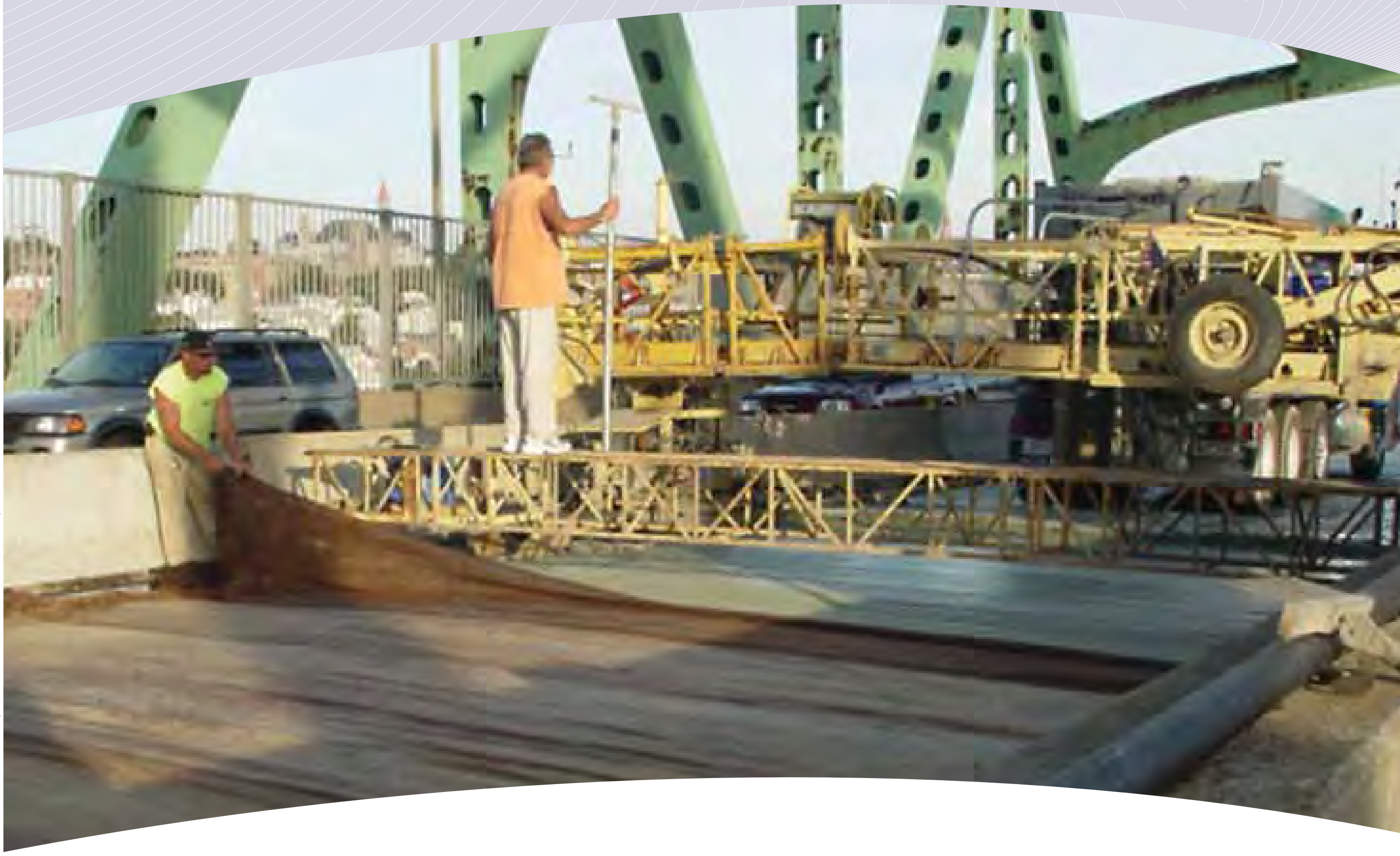
Traffic congestion became a nightmare as vehicles were forced to detour around the destruction to reach jobs, schools, and grocery stores. People like Mayor Chipper McDermot of Pass Christian, Mississippi, had to drive 55 miles round trip to get his children to school and back.

Both bridges reopened last year and McDermot says "We've been reconnected to our past and our future. People are coming back to their homes now and those that stayed can get to places faster and safer than we did before. I'm very pleased," Mayor McDermot said.

Bridge festivals were held to mark the opening of the bridges, and thousands of people from the newly re-linked communities came out to celebrate this milestone in the recovery of the Gulf Coast. "I never thought a chunk of concrete would look so good. It brings tears to my eyes." Chuck Breath, a Bay St. Louis resident, said of the new bridge.

Chapter 2

The Struggle to Hold Aging Bridges Together



The Braga Bridge.
Photo courtesy of Massachusetts Department of Transportation.

On March 17, 2008, inspectors for the Pennsylvania Department of Transportation discovered a widening crack in the pier of a bridge carrying Interstate 95 through Philadelphia. Immediately, they closed the interstate and began two days of emergency repairs.

"For those two days, 184,000 vehicles a day were forced on to side streets, and the national media carried pictures of the multi-lane interstate completely devoid of vehicles while nearby streets were jammed," PennDOT Secretary Allen Biehler later told Congress.

Philadelphia pier crack.
Photo courtesy of Pennsylvania Department of Transportation.

PennDOT Secretary Allen Biehler gives press conference about the state of Pennsylvania's bridges.
Photo courtesy of Pennsylvania Department of Transportation.

A month earlier, the Secretary said, a rural bridge in north central Pennsylvania, the Route 53 Irvona Bridge, was closed for a week after a routine inspection showed the steel beams needed immediate repairs.

In February 2008, the Birmingham Bridge which crosses the Monongahela River in Pittsburgh had to be closed for just over three weeks after two spans moved because of problems with the bridge's rocker bearings. During the closure, 23,000 vehicles a day had to find alternate routes.

Biehler told a Congressional committee that PennDOT has tripled its annual bridge investment since 2003 for a total of $3.8 billion in repairs on 1,381 bridges. Despite this investment and because of the system's age, the number of structurally deficient bridges has grown, from 5,587 to 6,034. In July 2008, Pennsylvanian leaders authorized a $350 million bond issue to repair 411 bridges.

Clearly, Secretary Biehler and his counterparts are struggling to hold together an aging inventory of bridges.

I-25 deteriorating girder.
Photo courtesy of New Mexico Department of Transportation

Missouri DOT Director Pete K. Rahn and Missouri Governor Matt Blunt inspect a bridge.
Photo courtesy of Missouri Department of Transportation.

In Missouri, of the 10,240 bridges on the state bridge system, some 1,093 are rated in serious or poor condition. Through a "Safe and Sound" bridge initiative, MoDOT Director Pete K. Rahn grouped 800 bridges into one package of projects which a contractor must not only build but finance. "The team will bring all the bridges up to good condition by the end of 2012 and will maintain them in good condition for at least 25 years," said Rahn. Although the total construction cost of the program will be between $600 million and $800 million, the contractor will provide the financing through private activity bonds. Through this approach, the state will be able to fix 800 bridges in five years, while it normally could afford to fix only 40 per year.

The nation's departments of transportation and their bridge engineers face a frustrating contradiction. They have better engineering, materials and construction techniques than ever before but stretched resources force them to make painful trade-offs to keep their bridges safe. They use emergency repairs, load limits and even closings as last-ditch efforts to protect the public.

What kind of investment gaps are states facing?

- Pennsylvania has asked the federal government for authorization to toll Interstate 80 to generate funds for highways and bridges, and Governor Edward G. Rendell has asked the Legislature to approve a proposed $12.8 billion, 75-year lease of the Turnpike to a private entity to generate a new annual funding stream for transportation.

How Are Bridge Conditions Rated?

According to the National Bridge Inspection Standards (NBIS), ratings are used to describe an existing bridge or culvert compared with its condition if it were new. Bridges are rated from 0 (failed condition) to 9 (excellent) on their "general" condition and on the condition of their primary components. The following components are rated:

- The bridge deck, including the wearing surface;
- The superstructure, including all primary load-carrying members and connections; and
- The substructure, including the abutments and all piers.

A condition rating of 4 or less on one of these items classifies a bridge as structurally deficient.

To be eligible for federal aid to replace a bridge, it must have a sufficiency rating of less than 50 and be either functionally obsolete or structurally deficient. To be eligible for repair, a bridge must have a sufficiency rating of less than 80. In both instances, federal aid must be matched by a state/local contribution. In the case of bridge repairs, if federal aid is used to repair a bridge, a jurisdiction cannot apply for federal assistance for any further repairs to this bridge for 10 years

What Does That Term Mean?

Bridge Sufficiency Rating

A bridge sufficiency rating includes a multitude of factors: inspection results of the structural condition of the bridge, traffic volumes, number of lanes, road widths, clearances, and importance for national security and public use, as examples.

The sufficiency rating is calculated by using a formula defined by the Federal Highway Administration. This rating indicates a bridge's sufficiency to remain in service. The formula places 55 percent of its value on the structural condition of the bridge, 30 percent on its serviceability and obsolescence, and 15 percent on whether it is essential to public use.

The point calculation is based on a 0–100 scale and compares the existing bridge to a new bridge designed to current engineering standards.

The bridge's sufficiency rating provides an overall measure of the bridge's condition and is used to determine eligibility for federal funds.

Functionally Obsolete

Of the nation's 590,000 bridges, a total of 73,000, about 12 percent, are rated as functionally obsolete.

A functionally obsolete bridge is one that was built to standards that are not used today. **These bridges are not automatically rated as structurally deficient, nor are they unsafe.** Functionally obsolete bridges are those that do not have adequate lane widths, shoulder widths, or vertical clearances to serve current traffic demand, or those that may be occasionally flooded.

A functionally obsolete bridge is similar to an older house. A house built in 1950 might be perfectly acceptable to live in, but it does not meet all of today's building codes. Yet, when it comes time to consider upgrading that house or making improvements, the owner must look at ways to bring the structure up to current standards.

Structurally Deficient

Of the nation's 590,000 bridges, some 80,000 are rated as structurally deficient, about 13 percent.

Bridges are considered structurally deficient if:

- Significant load-carrying elements are found to be in poor condition due to deterioration, or
- The adequacy of the waterway opening provided by the bridge is determined to be extremely insufficient to the point of causing intolerable traffic interruptions.

Every bridge constructed goes through a natural deterioration or aging process, although each bridge is unique in the way it ages.

The fact that a bridge is classified under the federal definition as "structurally deficient" does not imply that it is unsafe. A structurally deficient bridge, when left open to traffic, typically requires significant maintenance and repair to remain in service and eventual rehabilitation or replacement to address deficiencies. To remain in service, structurally deficient bridges are often posted with weight limits to restrict the gross weight of vehicles using the bridges.

U.S. Bridges Per State, December 2007

	Number of Bridges	Structurally Deficient	Functionally Obsolete	Total Number of Deficient Bridges	Percentage of Total
Alabama	15,881	1,899	2,158	4,057	25.5%
Alaska	1,229	155	179	334	27.2%
Arizona	7,348	181	600	781	10.6%
Arkansas	12,531	997	1,908	2,905	23.2%
California	24,184	3,140	3,837	6,977	28.8%
Colorado	8,366	580	824	1,404	16.8%
Connecticut	4,175	358	1,042	1,400	33.5%
Delaware	857	20	112	132	15.4%
District of Columbia	245	24	128	152	62.0%
Florida	11,663	302	1,692	1,994	17.1%
Georgia	14,563	1,028	1,888	2,916	20.0%
Hawaii	1,115	142	358	500	44.8%
Idaho	4,104	349	452	801	19.5%
Illinois	25,998	2,501	1,840	4,341	16.7%
Indiana	18,494	2,030	2,004	4,034	21.8%
Iowa	24,776	5,153	1,455	6,608	26.7%
Kansas	25,461	2,991	2,372	5,363	21.1%
Kentucky	13,637	1,362	2,928	4,290	31.5%
Louisiana	13,342	1,780	2,180	3,960	29.7%
Maine	2,387	349	468	817	34.2%
Maryland	5,127	388	980	1,368	26.7%
Massachusetts	5,018	585	1,987	2,572	51.3%
Michigan	10,923	1,584	1,304	2,888	26.4%
Minnesota	13,067	1,156	423	1,579	12.1%
Mississippi	17,007	3,002	1,315	4,317	25.4%
Missouri	24,071	4,433	3,108	7,541	31.3%
Montana	4,980	473	541	1,014	20.4%
Nebraska	15,475	2,382	1,241	3,623	23.4%
Nevada	1,705	47	156	203	11.9%
New Hampshire	2,364	383	358	741	31.3%
New Jersey	6,448	750	1,501	2,251	34.9%
New Mexico	3,850	404	294	698	18.1%
New York	17,361	2,128	4,518	6,646	38.3%
North Carolina	17,783	2,272	2,787	5,059	28.4%
North Dakota	4,458	743	249	992	22.3%
Ohio	27,998	2,862	4,001	6,863	24.5%
Oklahoma	23,524	5,793	1,614	7,407	31.5%
Oregon	7,318	514	1,155	1,669	22.8%
Pennsylvania	22,325	5,802	3,934	9,736	43.6%
Rhode Island	748	164	232	396	52.9%
South Carolina	9,221	1,260	808	2,068	22.4%
South Dakota	5,924	1,216	261	1,477	24.9%
Tennessee	19,838	1,325	2,776	4,101	20.7%
Texas	50,271	2,186	7,851	10,037	20.0%
Utah	2,851	233	254	487	17.1%
Vermont	2,712	500	467	967	35.7%
Virginia	13,417	1,208	2,234	3,442	25.7%
Washington	7,651	400	1,661	2,061	26.9%
West Virginia	7,001	1,058	1,515	2,573	36.8%
Wisconsin	13,798	1,302	789	2,091	15.2%
Wyoming	3,030	389	231	620	20.5%
Puerto Rico	2,146	241	822	1,063	49.5%
Totals	**599,766**	**72,524**	**79,792**	**152,316**	**25.4%**

Source: National Bridge Inventory, Federal Highway Administration

- Maine recently forecast that if it doesn't increase bridge investment by $50 million to $60 million annually, it will face an increasingly deteriorated bridge inventory. "Even at this level of investment, it is anticipated that bridge closures would need to occur on some low-priority, redundant bridges," says the Maine report. In June 2008, legislators increased vehicle registration fees and approved a $160 million bonding program to repair Maine's bridges.

North view of Brent Spence Bridge overlooking Cincinnati skyline.
Photo courtesy of Ohio Department of Transportation.

Local Governments Also Contend with Constant Bridge Repairs

States own 48 percent of the nation's bridges, comprising 75 percent of the total deck area and carrying 87 percent of traffic. There are approximately 21,000 high-volume bridges which have more than 40,000 vehicle crossings each day, with 90 percent of those in urban areas.

Local governments—counties and municipalities—also own and maintain 300,444 bridges, constituting nearly a quarter of the total deck area, and carrying 12 percent of bridge traffic. Nearly a third of these bridges were rated structurally deficient (17 percent) or functionally obsolete (12 percent).

"Counties own 219,000 bridges, spanning rural and urban areas," said Larry E. Naake, Executive Director of the National Association of Counties. "Most travel starts and ends on local roads and we are in a constant cycle of maintenance and repair. Our bridges are obviously the linchpin in our entire system, but keeping these bridges safe and passable is becoming more and more difficult as construction costs soar and revenues fall."

In testimony before the House Committee on Transportation and Infrastructure last fall, Kathleen Novak, Mayor of Northglenn, Colorado, and Vice President of the National League of Cities, said that "allowing our bridges to deteriorate is a national calamity waiting to happen. The tragedy in Minneapolis reminds us that investment in our transportation system cannot be put aside to the future. Maintenance and continuous investment in improvements requires a renewed financial commitment at all levels of government and a long-term, comprehensive national plan for the future."

Schematic rendering of Arch Bridge.
Photo courtesy of Iowa Department of Transportation.

- The Oregon DOT is in the midst of a $1.3 billion program to replace nearly 300 critical bridges after a series of emergency repairs in the early 2000s alerted the public to the looming needs.

New Bridges Needed, Funding Unsure

In nearly every region of the country, states are planning for major bridge needs amidst uncertainty over when or if the construction funds will be available. New bridges are needed to relieve congestion and build new corridors in rapidly growing areas not adequately served by the Interstate Highway System.

- The Quad Cities region of Iowa and Illinois is separated by the Mississippi River. The existing bridges are too narrow for the traffic volumes and have become an impediment to the development and convenience of the region's population. The citizens and DOTs from both states have agreed upon a state-of-the-art new arch bridge but are uncertain when the $1 billion will be available to construct it.
- In Corpus Christi, the Texas Department of Transportation is conducting an environmental impact statement to help determine how to replace the aging 50-year-old steel bridge which exists there. It estimates that a new structure could cost $500 million to $600 million and take as long as 2015 to open, once funding is determined.
- Similar stories exist for the proposed Great River Bridge between Arkansas and Mississippi, the Louisville Bridges, the Brent Spence Bridge in Cincinnati and the new Mississippi River Crossing in St. Louis.

Chapter 3

States Respond Quickly to Bridge Disasters

Iowa 24 Bridge near Fort Atkinson.
Photo courtesy of Iowa Department of Transportation and Public Facilities.

When a bridge failure halts traffic and disrupts lives, states time and again have responded with speed and ingenuity to restore lives back to normal.

The MacArthur Maze, California

At 3:42 a.m. on Sunday, April 29, 2007, the driver of a tanker, truck carrying 8,600 gallons of fuel lost control on a freeway overpass in Oakland, California, and the vehicle flipped onto its side and exploded. Flames shot hundreds of feet into the air—engulfing the roadway deck above the burning vehicle. As temperatures in the inferno soared, the deck section buckled and fell.

Damage to MacArthur Maze overpass.
Photo courtesy of Caltrans.

The overpass was part of a freeway complex that leads to and from the heavily used San Francisco–Oakland Bay Bridge. When word of the overpass closure reached area commuters, they were sure that months of congestion lay ahead as the California Department of Transportation (Caltrans) restored the damaged roadway.

Not only the fire-destroyed section—known as the 580 connector—but also the roadway it crashed onto, the Highway 880 connector, had to be checked for safety and possible reconstruction. Later on the day of the wreck, California Governor Arnold Schwarzenegger made a declaration of emergency that allowed the use of streamlined contracting and environmental procedures. Officials estimated that it would take 50 days to reopen the 580 connector.

Twenty-six days later, the section was back in service—thanks to Caltrans' immediate response, and use of incentives to bring in a contractor who recognized that for the driving public, time was money. The *San Francisco Chronicle* named Caltrans Director Will Kempton, "California's best new hire of the 21st Century."

Caltrans set an outside deadline for reconstruction of June 26, then promised a bonus of $200,000—to be capped at $5 million—for every day earlier than that date that the project was brought to completion. Although bids on the project ran as high as $6.4 million, the job was awarded to C.C. Myers Inc., which put in a bid for $867,075—the lowest bid—and won the full $5 million bonus by getting the work done so quickly.

Missouri Replaces Jefferson Street Bridge in 37 Days

On November 27, 2007, a fiery tanker crash and explosion near the Jefferson Street Bridge on U.S. route 54 Eastbound closed one of three major arteries in Central Missouri. A detour was established immediately. Within two days, damaged signs, pavement, striping and guardrail that had been damaged by the extreme heat from the fuel fire were replaced.

But the bridge suffered major damage—warped bridge railings, severe damage to concrete, fractures in underdeck and columns. On November 29, the decision was made to replace the structure. That same day design plans were started for the new bridge and were completed in six calendar days. On December 5, eight days after the explosion, an emergency contract was awarded to the Pace Construction Company of St. Louis, with incentives to encourage completion by January 7, 2008. Total project cost $1.2 million.

Construction began on December 7 and on January 3, four days ahead of schedule, the bridge was opened. Missouri DOT Director Pete Rahn said, "The challenge that was given to (our contractor) and our team at MoDOT was that we wanted this bridge repaired in an unreasonably fast time. And that's exactly what they've accomplished."

Tankers ablaze after a collision and explosion near the Jefferson Street Bridge in Central Missouri.
Photo courtesy of Missouri Department of Transportation.

Reconstruction of the Interstate 40 Bridge in Webber Falls, Oklahoma after it was damaged by a runaway barge.
Photo courtesy of Oklahoma Department of Transportation.

Oklahoma Interstate 40 Bridge Opens in Record Time

On May 26, 2002, the Interstate 40 Bridge at Webbers Falls, Oklahoma was destroyed when an Arkansas River barge went off course and struck its support columns. Each day the bridge was out of service cost the regional economy $430,000. Traffic had to be detoured 57 miles eastbound and 12 miles westbound, and motorists several states away were warned to avoid the area.

Getting the bridge back in service would normally have taken six months. Instead, Oklahoma DOT Director Gary Ridley recognized the urgency of restoring service, and used an incentive contract to get the bridge back in service just 65 days after it was struck and 47 days after construction began. U.S. Secretary Mary Peters at the ceremony dedicating the newly opened bridge stated, “I salute the people in the public and private sectors who worked so hard to restore this vital link in America’s transportation system in record time.”

Each of these examples demonstrates the critical role bridges play in daily commuting and commerce and the urgency of restoring failed or damaged structures. When put to the test, state departments of transportation and their contractors delivered.

Chapter 4

Scarce Resources Make for Difficult Choices

Photo courtesy of Pennsylvania Department of Transportation.

Nearly every state faces funding shortages that prevent them from ongoing, stable investment in preventive maintenance, repair and replacement.

Although bridge engineers know how to manage bridges so that they stay sound indefinitely, nearly all states lack the money to do so. As a result, they must carefully balance the conditions of their bridges against the public's need for safety.

Although bridge engineers know how to manage bridges so that they stay sound indefinitely, nearly all states lack the money to do so.

A Safety Net, Not a Solution

The Maine Department of Transportation illustrates this dilemma. It is diligently inspecting each bridge and ordering maintenance, repair or closure as necessary to keep the public safe. However, it is seeing overall conditions deteriorate since it can replace only 14 bridges annually and between 30 and 40 bridges need replacement each year.

"Though Maine has programs and processes in place to assure bridge safety, they are more of a 'safety net'—not a sustainable solution," according to a report *Keeping Our Bridges Safe*, published by the Maine DOT last November. "We are falling behind in bridge preservation and replacement at an increasing rate. The age and deterioration of our bridge infrastructure is becoming critical, and without a significant infusion of funding, Maine DOT will be forced to post and close an increasing number of bridges, which will significantly impact the economic vitality of the state.

"In summary, there are only two ways to protect public safety over the long term: Repair or replace poor bridges and preserve fair bridges before they become poor, *or* continue to close bridges when their condition warrants. With over 2,000 bridges in fair or poor condition, Maine's economy cannot afford to have the highway network become unconnected, nor can we allow unsafe bridges to stay open. Without a balanced, sustainable bridge work plan, load postings and closures will be the only 'safety net' left."

The state legislature of Maine recently approved additional funds dedicated to bridges.

The Tennessee Department of Transportation reports, "we have been impacted by rising materials costs and fewer federal revenues than anticipated as well as relatively flat state revenue returns. This requires us to look at the most cost-effective way of addressing our structurally deficient bridges. There are three key areas of our bridge management program that we look at with these bridges: repairs, rehabilitation, and replacement. In some instances, it is possible to extend the life of the bridge by rehabilitating the structure and we have opted to rehabilitate rather than replace it due to the limited funds. Those bridges are still

A diver inspects a bridge piling. To the left, the diver has placed steel rebar, which reinforces the bridge's concrete piling, around the pressure-washed and cleaned piling. A new pile jacket will be placed around it.
Photo courtesy of North Carolina Department of Transportation

scheduled for replacement. However, by rehabilitating the bridge we are able to safely extend the life of the structure in lieu of the more expensive total replacement. We also elevate some bridges to annual inspections rather than inspecting them every two years. No projects have been cancelled due to a lack of funding, however some projects have been delayed until a new fiscal year because of funding concerns."

The National Surface Transportation Policy and Revenue Study Commission estimates that the United States should be investing about $225 billion annually for the next 50 years on all modes of transportation. Today, the U.S. is spending about 40 percent of that. A significant portion of that additional investment would be needed to improve, expand and widen bridges on the nation's highways.

Sparsely populated and dry Nevada has only 1,045 state bridges, one of the lowest numbers in the nation. Despite the state's relatively strong economy, sound bridge inspection history and its relatively young infrastructure, the Nevada DOT still is very concerned about the long-term health of its bridge inventory. It uses the state-of-the-art Pontis® bridge management system to assess its inventory and predict needed investment levels.

The state DOT has a $134 million backlog of bridges needing repair or replacement, despite the overall health of its inventory. It knows that it needs to increase its average level of expenditure incrementally each year through 2019 in order to keep its inventory in its current condition. Despite sound planning and diligent inspection, the ability to make these needed investments will depend on many factors beyond its control. Affecting its available funds will be the impact of inflation, declining fuel tax receipts caused by high fuel prices, uncertain federal funding, and competition for resources for needed pavement and safety projects.

How the Nation Pays for Bridges

Meeting the needs of the nation's bridges requires funding from federal, state, and local agencies.

- In 2004, the federal Highway Bridge Program provided some $5.1 billion to the states for bridge repair and rehabilitation.
- States also applied another $1.5 billion from other federal spending categories to bridge improvements.
- State and local funding added another $3.9 billion for bridge repairs.
- As the FHWA reports, in 2004, a total of $10.5 billion was invested in bridge improvements by all levels of government.
- However, the U.S. DOT's 2006 *Conditions and Performance Report* states that an annual investment of $12.4 billion would be needed to improve bridge conditions.

Construction and completed bridges at intersection of Interstate 35 and Loop 340 in Waco.
Photo courtesy of Stan A. Williams, Texas Department of Transportation.

National Needs Dwarf Resources

Bridge rehabilitation needs dwarf the amount of funds currently available and compel states to remain in a "triage" mode of managing deficiencies as best they can for the next foreseeable decades.

The U.S. Department of Transportation's 2006 *Conditions and Performance Report* notes that $8.7 billion in capital investment annually is needed to maintain bridge conditions at current levels and $12.4 billion would be needed to actually improve "conditions" to a level that would help relieve congestion and reduce accidents.

However, it is impossible to totally separate bridge needs from the adjacent highway needs. Expanding highways without widening bridges is impossible. Interchanges are the most common highway congestion chokepoint. Each interchange relies on bridges to separate and elevate lanes of traffic. By looking only at repairing structural deficiencies or addressing current width insufficiencies, it would be easy to underestimate how much the nation needs to be investing.

According to data from the FHWA, it would cost $140 billion in 2006 dollars to immediately repair every bridge that is deficient in the country. This estimate is based upon the amount of bridge area considered deficient as of December, 2007, multiplied by the cost per square meter for bridge replacement, estimated at $1,550 per square meter.

Using that methodology, it would cost roughly $48 billion to "repair" structurally deficient bridges and $91 billion to "modernize" functionally obsolete bridges that are no longer adequate to serve traffic.

Since immediate total repairs would be impossible to undertake, this price tag would undoubtedly increase with inflation over time.

The Rio Grande Gorge Bridge being inspected after the I-35W bridge collapse in Minneapolis.
Photo courtesy of New Mexico Department of Transportation

The National Surface Transportation Policy and Revenue Study Commission estimates that the United States should be investing about $225 billion annually for the next 50 years on all modes of transportation. Today, the U.S. is spending about 40 percent of that. A significant portion of that additional investment would be needed to improve, expand and widen bridges on the nation's highways.

The U.S. DOT's *Conditions and Performance Report* estimated the existing backlog of investment needs for bridges was approximately $65 billion. In other words, "$65 billion could be invested immediately in a cost-beneficial fashion to replace or otherwise address currently existing bridge deficiencies." At the $10.5 billion spending level in 2004—the backlog should have been reduced by about half over 20 years.

By comparison, the total highway investment backlog or economically justifiable improvements stood at $430 billion in 2004.

These estimates, however, could not foresee the incredible increases in bridge construction costs that have taken place since 2004. Those increases significantly reduce the progress that can be made in meeting the nation's bridge needs.

But the future of federal funding is uncertain. In the short-term, a shortfall in the Highway Trust Fund could result in a federal funding reduction of 34 percent in FY 2009, unless Congress takes action. Even if that is remedied, without new revenue, the Trust Fund could only support a $20 billion Federal-aid Highway Program in 2010, half the current funding level.

Future Funding Prospects Troubling

Federal funding accounted for 63 percent of the money spent on bridge rehabilitation and repair in 2004, with state and local governments providing the rest.

But the future of federal funding is uncertain. In the short-term, a shortfall in the Highway Trust Fund could result in a federal funding reduction of 34 percent in FY 2009, unless Congress takes action. Even if that is remedied, without new revenue, the Trust Fund could only support a $20 billion Federal-aid Highway Program in 2010, half the current funding level.

State and local transportation funding is also likely to be hard-hit, as those governments cope with reduced tax revenues as fuel, sales and property tax income decline.

State examples further demonstrate the magnitude of the nation's bridge needs:

- The Texas DOT has estimated that it would need to invest approximately $1 billion annually or, about $12.5 billion overall when inflation is considered, to bring at least 90 percent of its bridges to a "good or better" rating within 10 years. Total federal funding to Texas is about $2.5 billion annually for all highway needs.
- Tennessee estimates $1 billion is needed to remedy the structural deficiencies on state bridges, with another $741 million needed for locally owned bridges.
- Pennsylvania has estimated it would cost $14 billion to repair just its structurally deficient bridges, not including bridges that need to be widened for increasing traffic.
- New Mexico estimates it has some $220 million in bridge needs, but can fund only about $13 million per year.
- Oklahoma estimates that $2.5 billion would be necessary to replace 626 bridges on the state system. That is currently not funded.

An increasing number of states are concluding that a decline in the quality of their bridge inventory will be inevitable if additional investments are not made. To protect the public, states will be forced to put weight limits on many bridges and close others outright unless they can fund the necessary investment levels. These closures and postings will impede commerce and decrease the efficiency of the nation's transportation network.

Market Street Bridge: Ain't Nothin' Closed But the Bridge

by Robin Derryberry, President, North Chattanooga Council of the Chamber of Commerce

A two-year closing of a major downtown bridge is reason for concern.

Will local businesses close? Will traffic slow to a crawl during rush hour? Will patrons stop going to area restaurants and salons? In the case of the Market Street Bridge in Chattanooga, Tennessee, the answer to all of these questions was, "No!"

When one of the nation's oldest bascule bridges closed in the fall of 2005 for a two-year renovation, members of the North Chattanooga Council of the Chamber of Commerce formed a team to come up with a strategy to keep business humming and positive attention on the project.

A website (www.MarketStBridge.com) provided weekly updates and photographs about the work being done. Activities were planned to draw visitors to the North Chattanooga area, and they started on the first day of demolition with the "Ain't Nothin' Closed but the Bridge" march and festival across the bridge. The construction contracting team was the last to cross the bridge and started demolition at the end of the parade (on a Sunday). That effort set the tone for the entire project.

The culmination was the grand re-opening of the Market Street Bridge with an equally high-level of public engagement. A multi-course gourmet dinner was served on the bridge to over 300 guests, followed by dancing under the stars. The next day, the bridge turned into an open air market for local merchants to sell their products and for the public to get an "up close" look at the structure. When it was time to open the bridge to traffic, the first official vehicle across was an electric shuttle which showed the Market Street Bridge was geared up and ready for the future with more than a nod to the past.

The Market Street Bridge opened in August 2007, two months ahead of schedule.

Chapter 5

Inspecting and Managing the Nation's Bridges

The Rio Grande Gorge Bridge.
Photo courtesy of New Mexico Department of Transportation.

To ensure the safety of the nation's bridges, every state conducts a thorough and continual bridge inspection and rehabilitation program. Federal regulations require that, with some exceptions, bridges over 20 feet in length be inspected every 24 months by trained and qualified bridge inspectors. In addition to following the federal inspection standards, states often develop more detailed programs appropriate to unique circumstances.

The *Washington State Bridge Inspection Manual*, for example, has 374 pages of precise instructions about how to inspect the state's bridges and how to properly record the thousands of pieces of data about each component of its nearly 3,000 state bridges.

Bridge inspections are exacting and detailed. Inspectors with hardhats, safety harnesses and a variety of tools climb, crawl, touch, ping on steel with hammers or even wade through streams to inspect their bridges. Some use ropes and rigging like mountain climbers to scale towers. Often they dangle from long booms in bucket trucks or "snoopers" to inspect members. Some even dive underwater in SCUBA gear and use sonic devices to test the soundness of underwater piers and abutments.

Inspection records track conditions over time and allow engineers to judge the rate at which structures are deteriorating—or to gauge how well improvements have performed.

Data also feeds computerized forecasting systems that can help extrapolate decades into the future how the entire system of bridges in a state will perform. These computer systems can conduct "what if" scenarios that allow the engineers to estimate the health of their bridge inventories under differing funding levels and treatment approaches.

Technology Sees Beyond Human Eyes

Advances in technology are enhancing the ability to assess bridge conditions.

- New Mexico, Pennsylvania, and other states use ultrasonic testing to "see" inside of the steel pins that often hold together components of older steel bridges. The National Highway Institute within the Federal Highway Administration offers a four-day course in which engineers are updated on the latest technology used to inspect the approximately 200,000 steel bridges in the United States. The use of ultrasonic devices and other state-of-the art technologies allows them to assess components of bridges that are not visible, or are embedded deep within the steel structure.

- States have experimented with infrared wavelength scanners that span the bridge deck and use thermal imaging to detect defects deep within the concrete. For more than a decade, states have used Ground Penetrating Radar on their bridge decks. A vehicle drives over the bridge and emits

An engineer tests a bridge pin using ultrasonic technology.
Photo courtesy of Federal Highway Administration.

short pulses of radar images that "bounce" back to sensors. These sensors can interpret the signal to determine if rust is corroding the steel rebar within the bridge or if gaps or voids have developed within the concrete.

- The Iowa DOT has used a variety of electronic devices to test bridge conditions and to provide an analytical comparison to the field observations of its own engineers. It has used strain gauges, "accelerometers" which measure vibrations, and displacement transducers to measure the "flex" or deflection of the bridges under truck loadings. It also utilizes a Scour Watch system which uses real-time rainfall and stream-flow data. This data is automatically used to measure and predict stream flow and to compare that flow against the safe amounts that its bridges can accommodate. If the volume of water reaches certain levels, the system automatically warns the engineers who then visit the bridge for an immediate assessment. Any potential danger can result in immediate closure of the bridge and inspection after the flood waters recede.

- The Florida Department of Transportation deploys a scour monitoring device that uses temperature sensors in a pile driven adjacent to a pier. Any changes in the temperature can automatically alert them to the potential that the bridge foundation is threatened by exposure through scouring.

- New Mexico has deployed three fiber-optic strain gauges on concrete beams to test the technology.

- In Washington State the DOT is measuring miniscule changes in bridge height to detect any settlement on bridges, gathered through Global Position System data that is bounced off satellites.

Photo courtesy of David Gonzalez, Minnesota Department of Transportation.

Through these methods, bridge inspectors are using the results of their personal training and experience as well as technology-enhanced detection to inspect the nation's bridges. Any unusual findings will result in closing a bridge for emergency repairs. Much more typically, the findings are fed into management systems which then order routine maintenance to address any potential deficiencies that are found.

Inspection Data Guides Bridge Decisions

The data collected on bridge conditions is critical to systematic, long-term approaches to managing the bridge inventory. The goal is finding the right balance between fixing immediate problems, conducting preventive maintenance and periodically replacing a reasonable number of old bridges to keep the health of its bridge population stable. This Asset Management approach produces stable, long-term conditions for the entire inventory of bridges for the lowest life-cycle cost.

Computerized or other systematic forecasts develop optimum strategies combining preventive maintenance, reactive maintenance to short-term deficiencies, and the periodic replacement of bridges that are no longer economical to repair.

Nevada typifies how a DOT seeks to optimize its scarce dollars to sustain the highest level of conditions over time. Nevada DOT is fortunate to have had sound maintenance practices and a relatively young bridge inventory because of its more recent "Sun Belt" development. But the DOT is taking a forward look by using its bridge management system to develop a mix of funding strategies to keep this $1.7 billion worth of bridge assets in good condition indefinitely.

It has adopted the following strategies to sustain its bridge conditions:

- Replace or rehabilitate structurally deficient bridges before they become hazardous or need to be posted for load limits to a point they inconvenience the user;

Nevada Spaghetti Bowl in Henderson
Photo courtesy of Nevada Department of Transportation

- Replace or rehabilitate functionally obsolete bridges before they become an impediment to users;
- Seismically retrofit bridges that do not meet earthquake resistance standards; and
- Apply timely repairs to structures as deficiencies are identified.

This approach has led to the following budgeting and investment recommendations for the state over the next 10 years.

Funding to Support Nevada's Repair Strategy ($ in millions)

System	Corrective Maintenance	Rehabilitation	Replacement	Seismic Retrofit	Total
Interstates/ Principal Arterials	$14.5	$10.0	$0.0		**$24.5**
Principal Arterials	$4.3	$9.8	$0.6		**$14.7**
Minor Arterials	$3.8	$2.4	$0.0		**$6.2**
Major Collectors	$4.3	$2.1	$2.7		**$9.1**
Minor Collectors/Local	$1.1	$1.1	$2.6		**$4.8**
Statewide				$75.0	**$75.0**
Total	**$28.0**	**$25.4**	**$5.9**	**$75.0**	**$134.3**

Nevada has followed the path of many states and laid out a logical, long-term series of options for how it can manage its bridge inventory given various financial scenarios. It illustrates how one state DOT manages the invaluable asset of a state's bridge inventory, once the state has the necessary resources to pay for preventive maintenance, repair, rehabilitation and replacement as they are needed.

Summary

Inspecting and maintaining the nation's bridges requires both experience and technology. Managing the nation's bridges for the future requires both sophisticated forecasting and resources to keep them safe.

Bridges Move People

Texas: The Queen Isabella Causeway— An Economic Lifeline

The Queen Isabella Causeway, in Southern Texas "is a true lifeline" says Dan Quandt, Executive Director of the South Padre Island Convention and Visitors Bureau. The 5,000 people who call South Padre Island home depend on it for the delivery of all their food, medicines and supplies and to get their children to school. An average of 25,000 people—residents, tourists and workers—inhabit the island on any given day.

The Queen Isabella Causeway is their primary evacuation route should a hurricane threaten. "When we talk about connections between people, we're talking about bridges," Quandt said. South Padre Island lost its only connection with the mainland on September 15, 2001, when a barge collided with a bridge support sending three 80-foot sections of the causeway into the water. Unaware of the collapse several motorists drove their vehicles into the water below. Eight people died, and three were rescued. Thousands were stranded on the island and private charter boats and other water craft took part in the massive evacuation.

The economic impact to the South Padre Island was enormous. Not only were customers and employees cut off from businesses the collapse severed the island's telephone lines, which ran under the causeway. Phone, fax, internet, and ATM banking services were lost. Island businesses estimated that they lost nearly $87 million in sales during the two months the causeway was closed for repairs.

"The big push right now is to get a second causeway built to the mainland." Quandt says. "We're in a hurricane zone and we learned a lesson on what happens if we lose our lifeline to the mainland. A new causeway will reduce evacuation times, decrease traffic congestion, and spur economic development," Quandt said.

Chapter 6

Innovation Adds to Bridge Safety

The Arthur Ravenel Jr. Bridge.
Photo courtesy of South Carolina Department of Transportation.

Bridge technology is in a state of constant change as engineers test new materials, new design and construction methods and inspection techniques to ensure the continued safety of the nation's bridges.

Much of the experimentation takes place under the federal Innovative Bridge Research and Construction and Deployment programs. These $142 million programs have funded projects in nearly every state. These projects advance the state of the art by:

- Developing new, cost-effective and innovative materials;
- Reducing maintenance and life-cycle costs;
- Creating faster, safer construction techniques;

Long-Term Research Aims to Increase Understanding of Wear

Another ambitious 20-year federally funded research effort is the Long-Term Bridge Performance Program (LTBP). The objective of the LTBP program is to collect, document, and make available high-quality quantitative performance data on a representative sample of bridges nationwide. Data will be collected through detailed inspections and evaluations, supplemented by a limited number of continuously monitored structures and forensic autopsies on decommissioned bridges. In the latter years of the program, the collected data will be analyzed to develop improved knowledge about bridge performance and degradation, better design methods and performance predictive models, and advanced management decision-making tools.

Specifically, the anticipation is that the LTBP program will provide a better understanding of bridge deterioration due to corrosion, fatigue, weather and exposure, and loads. The program also will provide information about the effectiveness of current maintenance and improvement strategies, and should lead to improving the operational performance of bridges with the potential to reduce congestion, delay, and crashes.

- Developing bridges to withstand natural disasters such as earthquakes and floods; and
- Developing "non-destructive" testing materials to "see" inside beams and piers without dismantling them.

States also pool their own resources through the National Cooperative Highway Research Program to address a wide range of needed research.

From Alaska to Florida, the states are experimenting in highly controlled efforts to find ways to make bridges stronger and safer.

- In Alaska, the DOT is testing a new method of "seismic retrofit" on the substructure of the 1,250-foot-long Kodiak Harbor Channel Bridge.
- In Florida, the DOT is experimenting with several strategies to combat rusting and corrosion of the "rebar" or the strengthening structural steel that runs through concrete bridge decks and piers. They are using stainless steel-clad rebar, and fiber-reinforced polymer composites in the pilings and bridge decks to prevent future corrosion damage.
- In Iowa, the DOT is testing fiber-reinforced polymers to replace deteriorated concrete decks as well as to build entire new bridges. In addition, it is using high-performance concrete and steel to build new structures that will be carefully monitored for their cost, strength and durability.
- On the campus of the University of California at San Diego, the California Department of Transportation plans to construct a 450-foot-long cable-stayed bridge using carbon-fiber-reinforced-polymer composites. It will include two lanes for motor vehicles as well as two bike lanes, a walkway and utility tunnels.

Kodiak Harbor Channel Bridge seismic retrofit.
Photo courtesy of Alaska Department of Transportation and Public Facilities.

- In Maine, the DOT is wrapping fiber-reinforced polymer composites around old, un-reinforced concrete abutments on the Androscoggin River Bridge in the town of Mexico.

A new array of materials is now available for bridge building such as high-strength steel, high-performance concrete, rust-proof components and fiber-reinforced polymer composites. New technology includes electronic gauges to monitor the bridges in real time for stresses, strains, the “scouring” of water at their bases and for the weight of passing trucks.

Kings Stormwater Channel Bridge on Route 86 in Riverside County is constructed of non-traditional and composite materials.
Photo courtesy of http://hpwren.ucsd.edu.

The advancement of bridge building is a combination of caution and innovation. One good example is the Kings Stormwater Channel bridge on California State Route 86. The bridge on the highly traveled NAFTA truck corridor is innovative in that it uses carbon-fiber-reinforced epoxy tubes filled with concrete instead of traditional concrete and steel piers. It also has a carbon-fiber deck, which is lighter and faster to construct than a concrete deck. The University of California at San Diego researchers tested full-scale models of the bridge in the laboratory before the California DOT authorized construction. Today, it is wired with nearly 100 gauges, which are monitored by researchers to meticulously track its performance.

Mammoth efforts are underway to address the most common causes of bridge failures—floods, earthquakes and the damaging of bridges by collisions with barges and trucks.

Coping with the Assaults of Nature

Mammoth efforts are underway to address the most common causes of bridge failures—floods, earthquakes and the damaging of bridges by collisions with barges and trucks.

A study of bridge failures in the United States between 1989 and 2000 found that floods and the "scouring" of support piers and abutments in large storms accounted for 53 percent of failures, while collisions caused another 12 percent.

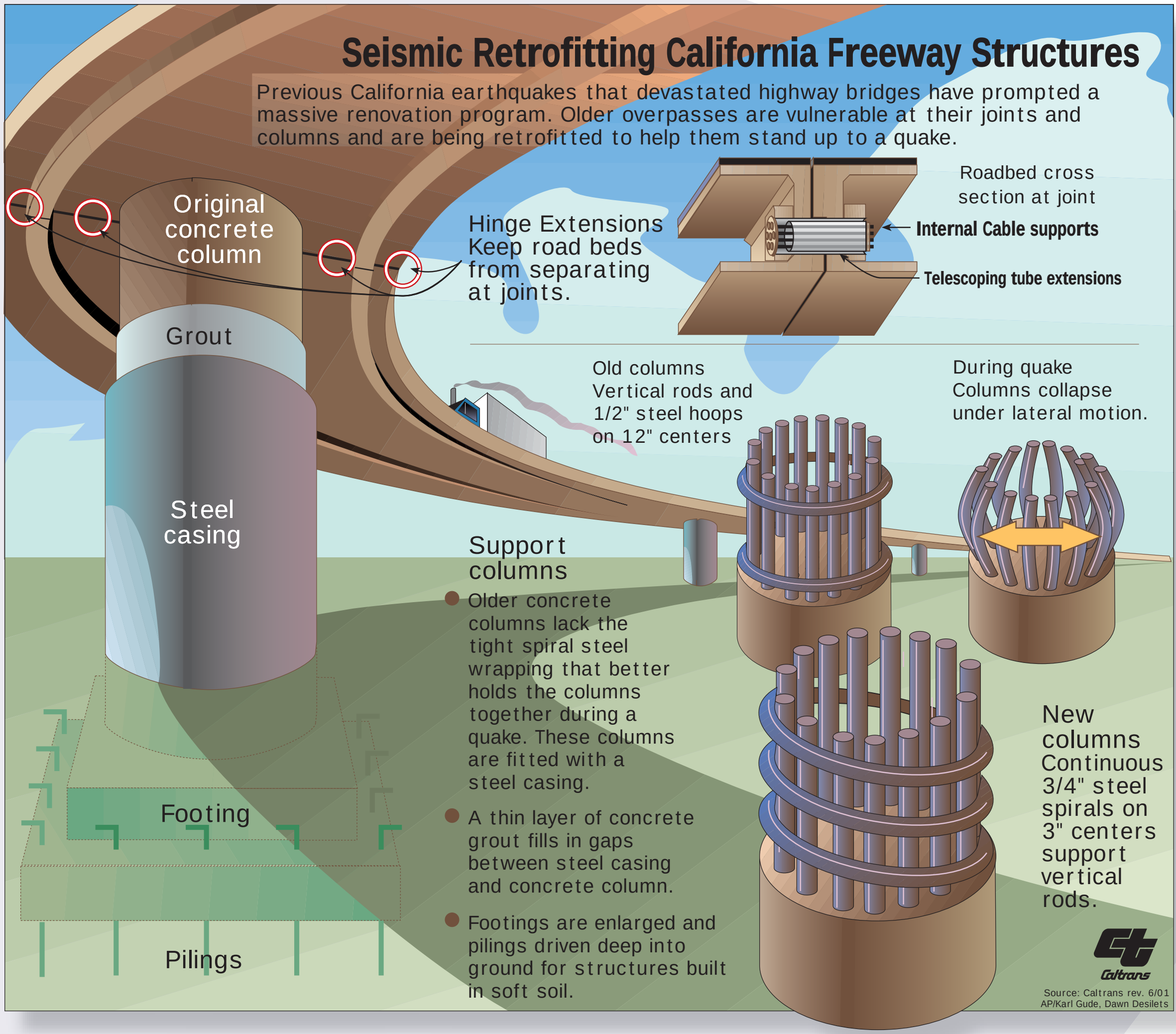
Earthquakes

The FHWA Resource Center Structures team reports that the 6.4 magnitude San Fernando Earthquake in California in 1971 prompted increased attention to seismic design and detailing, triggering today's modern seismic design codes. This earthquake collapsed or damaged 60 bridges and two hospitals in southern California. Since the development of new seismic design methods, billions of dollars have been spent on retrofitting older bridges, and new bridges built after 1971 include integral seismic enhancements.

Depending on the seismic zone in which the structure is located, the retrofit could be as simple as securing girders to the substructure with cable restrainers or extending the area upon which beams sit to give more support when they shake in an earthquake.

The California DOT pursued a comprehensive seismic retrofit program following the 1971 San Fernando Earthquake. As a result, during the 1994 Northridge Earthquake in southern California, which had a magnitude of 6.7, almost all seismically retrofitted structures were undamaged or only sustained minor damage that was quickly repaired.

Seismic retrofit bridge: a viaduct in Washington State.
Photo courtesy of Washington Department of Transportation.



Seismic Retrofitting Freeway Structures
Photo courtesy of Caltrans.

Similarly Washington State DOT completed its seismic retrofit program prior to the 2001 Nisqually Earthquake, which had a magnitude of 6.7. Again, many retrofitted structures were undamaged or sustained only minor damage that was quickly repaired.

Floods

The Federal Highway Administration and its state partners have developed extensive strategies to identify bridges that could be damaged by flooding. The most common problem during floods is that piers and abutments of bridges are undermined when intense flows wash away the earthworks surrounding them. Engineers in recent years have developed software and evaluation methods to predict such potential events. They also have developed enhanced training for inspectors, issued new standards and have enhanced modern designs to prevent scouring.

Rendering of the Skyway Bridge in Tampa Bay, Florida.
Rendering courtesy of FIGG Engineering.

Engineers are using many counter-measures that tend to fall into three categories: 1) they alter the stream flow to direct the strongest currents around the critical structure components; 2) they either armor the bridge with rock or other material to withstand the current; or 3) they redesign the structure to strengthen the bridge components within the streambed.

Collisions

Finally, bridges built today are more protected from collisions than in the past. Barriers are built around piers in navigable channels to ensure that ships cannot reach them. The Sunshine Skyway in Tampa, Florida, replaced an earlier steel structure that collapsed when struck by a barge. The new bridge's piers are surrounded by "dolphins," or the large, low barriers that protect its piers. They are designed to withstand the impact of a ship and keep the bridge safe.

New AASHTO Bridge Publications On the Way

Advancements in bridge safety continue to evolve. AASHTO is releasing two new publications this year as approved by the Subcommittee on Bridges and Structures at their 2008 annual meeting: a new edition of the *AASHTO Vessel Collision Design of Highway Bridges Guide Specifications* and a new *Guide Specifications for Bridges Vulnerable to Coastal Storms*, which deals with hurricane forces and flooding.

Summary

The safety, longevity and economy of U.S. bridges are being constantly improved by innovations in design, materials and technology. Using such advances, a new generation of safe and long-lasting bridges can be built, given the resources.

Bridges Move People

Demonbreun Street Bridge.
Photo courtesy of Tennessee Department of Transportation.

Tennessee: Demonbreun Street Bridge—Bringing a Community Together

by Gayle Fuson; Courtesy of *The Tennessean*

In a sense, I'm a bit sorry to see work on the Demonbreun Street bridge over the Gulch come to an end.

I'm going to lose contact with a lot of friends whom I've gotten to know over the last three years—and I'll miss out on my Thursday morning Krispy Kreme doughnut fix.

When the old Demonbreun bridge was condemned, I thought I faced my worst nightmare. I'm the chief financial officer at Bohan Advertising/Marketing, and the old bridge was connected to our building at 12th Avenue and Demonbreun.

Yes, the bridge and the building were one—bolted together and separable only with considerable effort, lots of noise, and perhaps some actual danger. I figured productivity would go out the window faster than the construction dust would come in.

As everything turned out, my worst nightmare never happened.

The people building the bridge—engineers, contractors, government officials—needed a place to meet for regular discussion, and my company had a conference room just the right size.

Every Thursday morning for months on end, we had a passel of visitors come in for a confab. I provided the doughnuts and coffee.

As we opened our doors to them, they opened themselves to us.

We in the building got a firsthand education in how a bridge is built. The construction team got to talk regularly with people who were interested in what they did for a living.

This isn't to say everything was rosy. Employees were uprooted from their offices. There were days when the jack-hammering wouldn't stop. There were water leaks of mysterious origin.

We took everything in stride and often with a sense of humor. We had our work to do, regardless of outside distractions and inconveniences. And the bridge builders had their job to do, which was to build "our" bridge.

Yes, we feel it's ours—sort of a family project built with all our friends at Metro Public Works, Ray Bell Construction, Gresham & Smith, and the Tennessee Department of Transportation, consummate professionals every one.

Can coffee and doughnuts build a bridge? Not really, but they can be the bond between two disparate groups of people and teach them communication, compassion, humor, and understanding.

Chapter 7

Bridges and Congestion

Adding further to the compelling need for bridge investment is the fact that the nation cannot fix its congestion problems without fixing its bridge problems.

Most of the nation's traffic and the vast majority of its truck freight travel on the nation's major routes—the Interstate Highway System, the National Highway System and the urban freeways. The Interstate Highway System alone carries an estimated 24.5 percent of all miles traveled on U.S. highways, even though it comprises about 1 percent of all public road miles.

In 2006, the Interstate Highway System turned 50, and it is showing its age. Its 46,747 miles carried an estimated 727 billion

vehicle miles of travel in 2004. Between 1995 and 2004 annual travel on the Interstate Highway System grew by 2.8 percent, at the same time that the system was expanded by only one-half of one percent. As a result, congestion has significantly increased on the Interstate Highway system and its 55,315 bridges. Nearly 12 percent of the rural Interstate bridges and 21 percent of the urban Interstates bridges were considered “functionally obsolete,” which means they are too narrow for today’s traffic volumes.

The Texas Transportation Institute’s 2007 *Annual Urban Mobility Report* notes that annual hours of delay per traveler in major urban areas rose from 21 hours in 1982 to 43 in 1995 to 54 in 2005, an increase of 157 percent in 23 years. Between 2004 and 2005, delays increased 3 hours, showing how quickly we are being stymied in traffic.

Interchanges are the first component of a freeway to become congested. The movements of merging, lane changing, and exiting cause traffic to slow down, conflict and become congested when volumes exceed design capacity.

Much of this delay occurs at interchanges—and much of the interchange improvement costs are a direct result of the bridges that separate and elevate the lanes of freeway traffic. It is this “grade separation” that lies at the heart of modern freeway design, freeway speed, freeway safety and freeway convenience. Interchanges are the first component of a freeway to become congested. The movements of merging, lane changing, and exiting cause traffic to slow down, conflict and become congested when volumes exceed design capacity.

In 2005, the FHWA Office of Transportation Policy Studies commissioned a study entitled, *An Initial Assessment of Freight Bottlenecks on Highways*. This report looked at the magnitude and costs of highway delays to the nation’s commerce. It noted that about 40 percent of all delays are caused by recurring congestion, while 60 percent are non-recurring, such as weather, accidents or construction. Using a conservative figure of $32.15 per hour for the value of truck delay costs, the study estimated that there is an annual cost of $7.8 billion a year from bottlenecks involving trucks. Nearly half of this total delay was attributable to interchanges, with the rest attributable to steep grades or signalized intersections on major arterial routes.

Interchange Bottlenecks Delay Commerce

The study found that the top 10 highway interchange bottlenecks cause an average of 1.5 million truck hours of delay each year. Of the top 227 bottlenecks, more than 170 of them result in more than 250,000 hours of delay annually. This delay is especially acute at international trade gateways and hubs, such as New York, Los Angeles, Chicago, Dallas-Fort Worth, Denver and Atlanta. The top ten in terms of annual hours of delay for trucks are listed in the following chart.

Top Ten Highway Interchanges That Cause Truck Delays

		Annual Hours
1.	I-90 at I-290 in Buffalo	1,661,900
2.	I-285 at I-85 in Atlanta	1,641,200
3.	I-17 at I-10 in Phoenix	1,608,500
4.	I-90 at I-290 in Chicago	1,544,900
5.	San Bernardino Freeway	1,522,800
6.	I-94 at I-90 in Chicago	1,512,900
7.	I-285 at I-75 in Atlanta	1,497,300
8.	SR 142 at SR 2 in Los Angeles	1,489,400
9.	I-77 at Tyron Road in Charlotte	1,487,100
10.	Long Beach Freeway	1,380,000

Costs High for Major Bridge Replacement

Fixing these and other bottlenecks depends upon a massive reconstruction and expansion of freeway interchanges, ramps, overpasses and bridges. This work will require significant investments, far exceeding their original costs.

One recent example is the Woodrow Wilson Bridge on the I-95/I-495 beltway around Washington. This original bridge across the Potomac River was constructed with four lanes in 1961. The structure was planned to carry 75,000 vehicles daily within 20 years but exceeded that volume within its first eight years. The new bridge consists of 12 lanes, with eight of them as general purpose and

Woodrow Wilson Bridge
Photo courtesy of Virginia Department of Transportation

Marquette Interchange construction.
Photo courtesy of Wisconsin Department of Transportation.

the remainder as high-occupancy vehicle lanes. Because of its close proximity to adjacent interchanges, four nearby interchanges also needed to be reconstructed to flow into the wider bridge. The overall cost was projected to be $2.524 billion.

In Milwaukee, the Marquette Interchange handled nearly a third of all the state's truck volume when measured by the value of shipments. The major routes in Wisconsin funnel through Milwaukee, the state's largest city, and down into Chicago. The interchange of I-94, I-43, and I-794 carried a disproportionate share

Oakland Bay Bridge allows for greater volumes of traffic.

Rendering of the proposed Downtown Louisville Bridge and proposed East End Louisville Bridge, between Kentucky and southern Indiana
Photo courtesy of Kentucky Department of Transportation

of the state's traffic and truck volumes, with daily volumes exceeding 300,000 vehicles daily. To separate these movements, add interchange capacity and alleviate congested ramps, a much more complex four-level interchange was necessary at a total cost of $810 million. The original interchange built in 1968 cost $33 million.

In Oakland, California, the Oakland Bay Bridge connecting with San Francisco actually was a complex network of bridges and a tunnel originally built for $77 million in 1936. Today, more than 270,000 vehicles per day use the route, which carries Interstate 80. Because of a much larger structure, the need for seismic protections, and other reasons, the new main span was bid at $1.43 billion. Construction currently is under way.

In Louisville, Kentucky, two new bridges across the Ohio River into Indiana have been estimated at $4.1 billion and will take until 2024 to complete, according to current schedules. Upstream in Cincinnati, the Brent Spence Bridge carries both I-71 and I-75 over the Ohio River between Cincinnati and northern Kentucky. Originally built in two levels with three lanes in each direction, the new bridge will need to have at least five additional lanes in each direction. The costs are estimated between $2 billion and $3 billion depending upon the alternative chosen.

Summary

The nation's bridges have become chokepoints on the country's freeway system, particularly at interchanges and major river crossings. The staggering costs of the new bridges and their related interchanges dwarf original construction costs. Many major U.S. cities that want to build new structures are at a loss as to how to raise the massive amounts necessary for their construction.

Tae Jung Kim, Min Kim, and Soo Jin Kim own Sam's Cafe on the Tacoma Tideflats. The Murray Morgan Bridge (background) is closed to vehicle traffic, keeping many potential customers from dining at Sam's.

Washington State: Sam's Cafe— Cut Off from Its Customers

The hectic lunch hour at Sam's Cafe lasts only about 30 minutes now that the Murray Morgan Bridge is closed to vehicle traffic.

"We lost our regular customers from downtown (Tacoma)," said Soon Jin Kim, co-owner of the little burger joint on the wrong side of the bridge.

The Washington State Department of Transportation closed the 1911 bridge in October 2007 due to safety concerns.

On one side of the bridge is a bustling downtown, thousands of workers, residents, and potential Sam's Cafe patrons. On the other side, known as the Tideflats, are Port of Tacoma businesses and Sam's Cafe.

It wouldn't be accurate to describe the Port area as desolate, but it's certainly isolated.

"They don't want to drive around to get to us," Kim said of downtown residents and workers. That's because a restaurant that is a stone's throw from the city center is now a 10- to 15-minute drive.

"It's inconvenient," she said, "and gas prices are so high."

Although the bridge closure has cost Sam's Cafe some customers, Kim said there's only been a slight decline in business. Fortunately, Kim said, more employees of Tideflats businesses and the Port of Tacoma are eating at Sam's because they, too, don't want to drive around to get downtown.

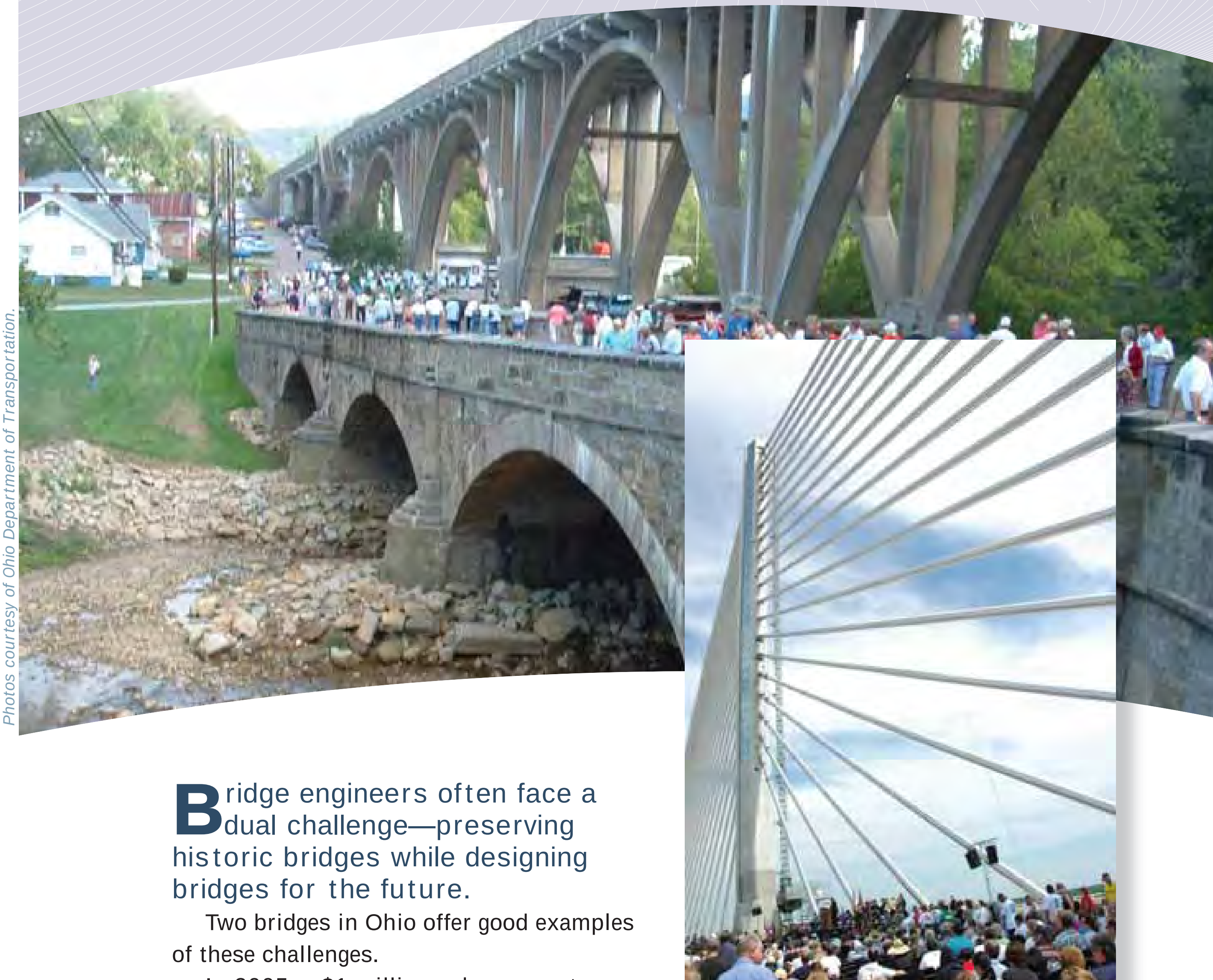
"Thank God," she said.

Kim says skyrocketing gas prices and a weak economy are likely to hurt her bottom line as much as the bridge closure.

"All small businesses are hurting," Kim said. "Hopefully, maybe it will get better."

Chapter 8

Preserving the Past, Building for the Future



Blaine Bridge and the Veterans' Glass City Skyway (inset).
Photos courtesy of Ohio Department of Transportation.

Bridge engineers often face a dual challenge—preserving historic bridges while designing bridges for the future.

Two bridges in Ohio offer good examples of these challenges.

In 2005, a $1 million enhancement project provided by the Ohio DOT repaired the 1828 stone arch Blaine Bridge, one of a handful of stone "S" bridges remaining in Ohio from the original National Road, which was built from Cumberland, Maryland to the then-western frontier in Illinois. They were called "S" bridges because they actually

An Evolution of Technology

The history of American technology can be traced through its bridges. Bridges evolved from wood and stone to iron, steel and then concrete. Steel trusses represented the rising dominance of the American steel industry. Beginning in the 1870s and continuing through the 1930s, steel was the most common bridge building material. The truss was one of the most common types of structures. Departments of transportation have inventoried these historic bridges, documented their pasts and try to preserve them for the future when they are not on high-volume roads where their use would pose a risk to the public.

curve to bring the road to a crossing perpendicular to the stream below.

In 2007, citizens of Toledo jogged and strolled across the newly opened Veterans Glass City Skyway. Their new $234 million cable-stayed bridge represented the largest and most complex project ever undertaken by the Ohio DOT. It was a concrete segmental bridge, which meant it was built from pre-cast concrete sections, which were hoisted up and tied together with internal cables. Its tower rises 380 feet above the Maumee River and is lit with colored, low-energy LED lighting, which can change color to celebrate the seasons.

These two projects represent the twin spectrums facing state bridge engineers today. They work to save and preserve historic bridges. At the same time, they are building a new generation of what will become the historic bridges of the future.

And occasionally, bridge engineers use elements from today's new technology to preserve the bridges of the past.

- Engineers at the Iowa Department of Transportation worked with researchers from Iowa State University to study the use of remote sensing to protect the "Bridges of Madison County." They installed flame detection devices,

The Chesapeake & Ohio Canal flows under the stone masonry arch of the Wisconsin Avenue Bridge in the busy Georgetown area of Washington, DC. The towpath beside the canal serves as a footpath and recreation resource. The original wrought-iron railing dates back to 1831.
Photo courtesy of FHWA, Public Roads Magazine, March/April, Vol. 68, No. 5.

infrared cameras and fiber-optic strain gauges on one of the covered bridges. These will monitor the bridges for fire or other potentially damaging events and immediately notify law enforcement of suspicious activity. Similar technology protects covered bridges in Illinois.

- In the historic Georgetown section of Washington, DC, the Federal Highway Administration worked with other federal agencies to preserve the 1831 Wisconsin Avenue Bridge. The stone arch still carries daily traffic but was deteriorating under the load. An innovative solution of inserting stainless steel rebar into the structure without altering its appearance provided a safe and historically compatible solution.

- The Pennsylvania DOT is helping to preserve the 1913 Chester Spring Road stone arch in Chester County. The greater Philadelphia area has the country's largest collection of stone arches. PennDot has developed a management plan to preserve and protect these arches whenever possible.

Similarly, states from Maine to California are preserving their covered bridges, such as the Hoffman Bridge in Oregon. Approximately 900 covered bridges remain in the United States, while at one time there were more than 14,000, according to the FHWA *Covered Bridge Manual*. Annually the Federal Highway Administration's Covered Bridge Program provides about $9 million for preservation and research regarding the protection of the remaining covered bridges. In addition, the State DOTs regularly invest their own enhancement funds into the preservation of historic bridges, as do local officials.

Veterans' Glass City Skyway in Toledo, Ohio.
Photo courtesy of Ohio Department of Transportation

Cooper River Bridge.
Photo courtesy of Rob Thompson, South Carolina Department of Transportation.

Technology, New Materials Inspire a New Generation of Bridges

Today, bridge designers have new materials and technology with which to build a new generation of structures. The Toledo bridge is like many modern structures that use high-performance concrete and stainless steel to build stronger, longer spans for much less cost than older materials would have allowed. Its tall pylon is elegant but strong using 10,000 pound-per-square inch high-performance concrete. The tower has a modern stainless steel “cradle” atop it which routes more than 1,500 miles of special steel cable. In these cable-stayed bridges, the massive anchorages of conventional suspension bridges are avoided because the large deck spans balance on either side of the tower, saving costs.

The Cooper River Bridge in Charleston, SC, is another example of strength, safety and aesthetics made possible by modern materials and technology. The diamond towers rise 575 feet into the air thanks to high-performance concrete.

Rendering of the Mike O’Callaghan-Pat Tillman Memorial Bridge that will be built between Nevada and Arizona near the Hoover Dam.
Photo courtesy of Nevada Department of Transportation

Completed Tacoma Narrows Bridge.
Photo courtesy of Washington Department of Transportation.

The towers anchor 128 steel cables, each of which can hold 500 tons. The Cooper River Bridge is the longest cable-stayed bridge in America and has replaced the old, narrow truss seen in the background.

Another example is in the arid canyons surrounding the Hoover Dam between Arizona and Nevada. When it was constructed in the 1930s, a roadway was built on top of the dam, which has since become a traffic bottleneck. The new Hoover Dam Bypass is made possible by the elegant Colorado River Bridge. The first 1,060-foot concrete arch is the centerpiece of a 2,000-foot-long bridge, which will span the Black Canyon about 1,600 feet south of the dam. When completed in 2010, the bridge and bypass will save significant travel time and expedite trade throughout the region.

The Natchez Trace Bridge in Williamson County, Tennessee, used a first-of-its kind concrete arch design to reduce piers and other impacts across the scenic mountain valley. The use of the new design allowed the construction impacts to be minimized while also creating a new landmark that complements its beautiful surroundings.

The new bridges allow a degree of safety unknown in the past. Even in seismically active areas such as northern California, new, massive, iconic structures can be constructed with new techniques and materials to withstand earthquakes as never before. The East Span of the new San Francisco-Oakland Bay Bridge Project represents a state-of-the art marriage of safety, technology and aesthetics. The new bridge is designed to include

> Today, bridge designers have new materials and technology with which to build a new generation of structures.

bearings and shafts that can absorb the movement of an earthquake while protecting the massive new bridge. The bearings and shafts are designed to be replaced after an earthquake. These sacrificial components will absorb the shock and movement of the quake while leaving the bridge undamaged.

The East Span also represents the world's longest Self-Anchored Suspension bridge. Traditional suspension bridges generally have two cables anchored into massive concrete structures called anchorages set into the ground. The two anchorages usually hold both ends of the cables, much as two sets of people playing tug-of-war stretch a rope between them. From the taut cable, the bridge deck can be suspended. In the new Self-Anchoring Suspension of the East Span, the anchorages are not needed since the bridge cables are anchored into the bridge deck itself.

Worker on site of I-94 business loop construction of Memorial Bridge North Dakota.
Photo Courtesy of Mike Kopp, North Dakota Department of Transportation.

Summary

U.S. transportation agencies are simultaneously protecting the historic bridges of the past while also creating a new generation of signature spans that will serve as icons for decades into the future. These new bridges represent the best of modern technology, materials, engineering and construction techniques. They illustrate how it is possible to build safe, efficient structures while at the same time complementing their surroundings. These investments will serve their communities for decades to come and become the new symbols for their communities.

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