Better, safer bridges for when the earth shakes

In regions across the nation, bridge engineers know that the next major seismic event is coming—maybe tomorrow, maybe centuries from now. DOTs have the critical charge of designing for earthquakes and protecting the lives of travelers.

NCHRP and AASHTO work closely to advance seismic design for bridges. This means not only redefining seismic design through AASHTO specifications but also responding to trends in bridge design and fabrication techniques like accelerated bridge construction.

> "The AASHTO guide specifications are helping our state continue to push forward with seismic isolation."

Advancing seismic isolation design

The use of isolation bearings, such as sliding or other specialty bearings, can be a powerful tool in protecting bridges from catastrophic failure during earthquakes. Michael Keever, California DOT's chief of the Office of Earthquake Engineering, says his agency has found significant value in the *AASHTO Guide Specifications for Seismic Isolation Design, 3rd edition*, developed through NCHRP Project 20-07, Task 262. "Caltrans is now retrofitting two large and significant bridges in the San Francisco Bay Area using seismic isolation design," he says. "The AASHTO guide specifications are helping our state continue to push forward with seismic isolation. With the updated guidance and well-developed design examples presented in this publication, we will be looking to incorporate seismic isolation on additional types of bridges in California."

> "*NCHRP Report 472* was instrumental in capturing some of the latest thinking in seismic bridge design."

California has reported significant cost savings through the use of seismic isolation design, making this additional guidance for wider deployment particularly welcome. "We found that the costs of seismic retrofitting went down an order of magnitude using isolation compared with using traditional retrofitting techniques," Keever says. "We have also calculated cost savings for some new structures designed with seismic isolation design."

Washington State DOT is another advocate of seismic isolation and the NCHRP-funded guidance. Jugesh Kapur, state bridge and structures engineer for WSDOT, says, "The AASHTO seismic isolation guide specs have been extremely useful to us. Seismic isolation isn't a solution for all bridges, but for those where it makes sense—notably ones with massive trusses and heavy pier loads—we make excellent use of it. The Aurora Avenue Bridge in Seattle, a huge truss in the city, is a good example of where we put large friction pendulum bearings to work."

Modern thinking for seismic design

Just as seismic design needs vary from bridge to bridge, they can also vary from state to state. Richard Pratt is chief bridge engineer for Alaska Department of Transportation & Public Facilities, and in his role as chair of the AASHTO Highway Subcommittee on Bridges and Structures' Technical Committee T-3 on seismic design, Pratt recognizes that there is not a one-size-fits-all solution when it comes to seismic design. "*NCHRP Report 472* [*Comprehensive Specification for the Seismic Design of Bridges*] was instrumental in capturing some of the latest thinking in seismic bridge design, most notably the use of a displacement-based design approach rather than the traditional force-based R-Factor method," he says. "Nevertheless, at the time of the report's publication in 2002, it became clear that not all states were ready to depart from current seismic design standards."

The Aurora Avenue Bridge in Seattle was seismically retrofitted with base isolation bearings. (Image courtesy of WSDOT)

However, for states interested in moving to the new techniques, *NCHRP Report 472*

(continued)

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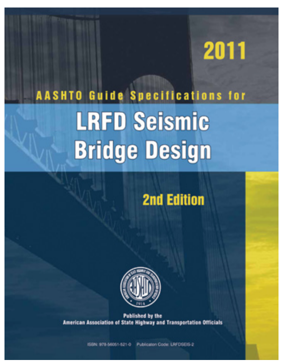
Selected publications based on NCHRP seismic bridge design research	Year	NCHRP Project
NCHRP Report 472: Comprehensive Specification for the Seismic Design of Bridges	2002	12-49
AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition	2006	20-07, Task 193
AASHTO Guide Specifications for Seismic Isolation Design, 3rd Edition	2010	20-07, Task 262
NCHRP Report 681: Development of a Precast Bent Cap System for Seismic Regions	2011	12-74
NCHRP Report 698: Application of Accelerated Bridge Construction Connections in Moderate-to-High Seismic Regions	2011	12-88

> "As we move into using ABC for multispan bridges, seismic design becomes much more of a concern, making *NCHRP Report 698* particularly relevant to us."

proved a vital resource. Josh Sletten, structures design manager for Utah DOT, says, "In Utah, we adopted *Report 472* right when it came out in 2002. It best met our needs even though it wasn't an AASHTO standard."

Similarly, Lucero Mesa, seismic design support engineer for South Carolina DOT, describes how the report had an impact in her state: "In South Carolina, we developed our own state seismic design specifications for highway bridges, drawing in part from the findings of NCHRP Project 12-49 and *NCHRP Report 472*. Our specifications follow the performance-based design approach, which we believe provides a better insight into actual structural behavior and a more consistent level of seismic protection for our bridges."



NCHRP research was central to the development of the AASHTO guide specs on seismic bridge design. (Image courtesy of AASHTO)

Advanced alternatives in the guide specifications

NCHRP Report 472 has had a lasting effect on seismic design. With the support of NCHRP and the contributions of AASHTO SCOBS Technical Committee T-3 members, many of the report findings were incorporated into the *AASHTO Guide Specifications for LRFD Seismic Bridge Design*, first published in 2009. The guide specs featured approved design alternatives to requirements in AASHTO's *LRFD Bridge Design Specifications*.

Alaska, like Utah, Washington and other states, has adopted the AASHTO guide specs. "We feel that displacement-based design presented in the guide specs is a more realistic, more modern way of approaching bridge design," says Pratt. "It's good to have this as an approved alternative design approach." The guide specs offer right-sized solutions for less seismically active states as well. "The guide specs offer low-level, no-analysis designs—simple detailing that doesn't require any additional engineering or computer modeling," he adds. "This helps low-seismic states address seismic design with relative ease."

Other states, including California and South Carolina, use many of the same techniques described in the guide specs, modified to meet those states' unique requirements.

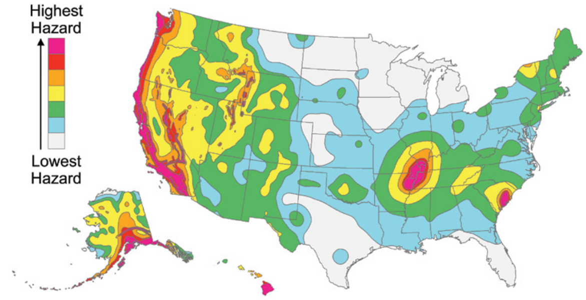
Accelerating construction in seismic zones

Given these developments in the last decade alone, seismic design is clearly still evolving, and NCHRP is keeping pace with the latest trends. For example, accelerated bridge construction has come into its own in the last decade. ABC offers an array of savings—reduction in costs, construction times, and traveler delays—and it is a featured technology promoted by FHWA's Every Day Counts initiative. Yet seismic activity represents a significant challenge: How does a DOT safely design for seismic events using ABC?

Two 2011 publications, *NCHRP Report 698: Application of Accelerated Bridge Construction Connections in Moderate-to-High Seismic Regions* and *NCHRP Report 681: Development of a Precast Bent Cap System for Seismic Regions*, are providing the guidance that will enable transportation agencies in seismic areas to deploy ABC while meeting seismic design requirements.

Sletten describes Utah's experience: "ABC is rapidly changing. We went from precasting elements in 2000 all the way to moving entire bridges into place by 2007. As we move into using ABC for multispan bridges, seismic design becomes much more of a concern, making *NCHRP Report 698* particularly relevant to us. It will be the baseline for additional research here in Utah."

Caltrans' Keever similarly calls out the timeliness of NCHRP research in this area: "There is a big push for ABC in our state. We're in the process now of developing standardized details for California bridges, and we'll be referencing *NCHRP Report 681* as we perform additional research and develop standard ABC details."



The National Seismic Hazard Map reveals that seismic bridge design can help address concerns from coast to coast. (Image courtesy of the U.S. Geological Survey)

To the north, Washington State recently completed a bridge along Interstate 5 that was all precast, including the segmental columns, the cross beams, and the superstructure. "Every little bit of these NCHRP studies guides us and helps us take additional steps with new ABC implementation in our highly seismic region," says Kapur. "The more research that is done—whether NCHRP research or our own state research to address specific concerns—the more confidence we have in using precast elements."

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For more information about any of these publications, visit NCHRP's website (www.trb.org/nchrp) or AASHTO's online bookstore (bookstore.transportation.org).

NCHRP research helps California advance accelerated techniques in seismic areas. (Image courtesy of Caltrans)

ACKNOWLEDGEMENT OF SPONSORSHIP Work was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program, which is administered by the Transportation Research Board of the National Academies.