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UTC Spotlight

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Joint-Effort Mobile Bridge Load-Capacity Evaluation Invention is "a Hit"

Timing couldn't be better for Rutgers Center for Advanced Infrastructure and Transportation (CAIT) to be spreading the use of a new portable bridge evaluation device—THMPER™—that could revolutionize how America's 600,000 plus bridges are regularly assessed, rated, and prioritized for repair or replacement.

Volume and load demand on much of the U.S. surface transportation system exceeds what it was designed to carry. This, and inevitable aging, is especially hard on bridges. According to the American Society of Civil Engineers (ASCE) *2017 Infrastructure Report Card*, the average age of U.S. bridges is 43 years, and 56,007 are rated structurally deficient.

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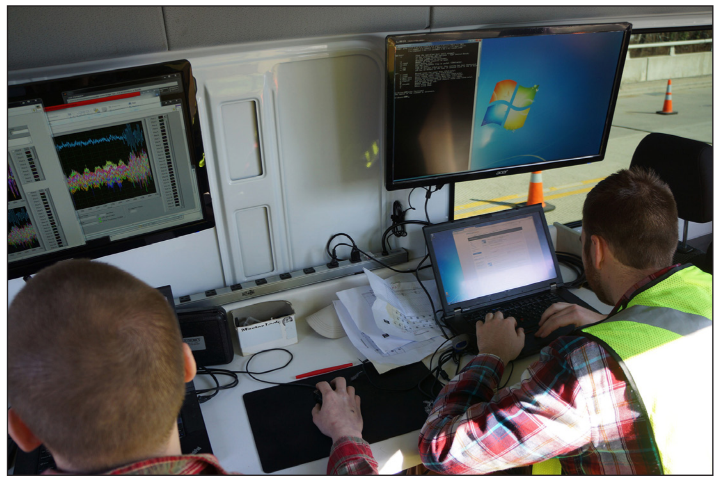
The THMPER™ impact trailer and sensors, rolling "control center," and custom software suite record the bridge's vibration response and process test data on the spot. Faster, cheaper, and with less traffic disruption than other methods, THMPER could revolutionize how bridge load ratings are determined.

Typically, bridges are inspected every two years as well as routinely evaluated for their safe load-carrying capacity. Sometimes, erring on the side of caution, owners will designate a maximum weight for vehicles crossing a bridge they believe is compromised. In some cases such a "posting" is appropriate, but in others a bridge may have more than sufficient load-capacity to handle heavier vehicles (e.g., emergency vehicles) than simplified estimates indicate.

Recognizing this disparity, the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Bridge Evaluation* permits owners to use more advanced



David Masceri/Rutgers CAIT

THMPER feeds data to the van that serves as a mobile data processing lab. Using specialized software, engineers calibrate a refined FE model, which indicates how much a bridge can safely carry.

estimating methods, including modal impact testing, refined analysis, and calibration of finite element (FE) models; however, in the past these have been cost-prohibitive.

THMPER™ is the first portable rapid-testing device that uses all three methods (modal impact testing, refined analysis, and FE model calibration), plus THMPER™ takes it all on the road, with custom software and a mobile data processing lab. This tool determines bridge load-ratings accurately, faster, more economically, and with less traffic disruption than conventional methods, thereby removing cost barriers that previously kept bridge owners from applying the more refined capacity-estimation methods on a wide scale.

As its name infers, THMPER™ delivers a forceful impact to the bridge with a drop weight, generating a free vibration response in the bridge—its response reveals a lot about its load-carrying capacity.

"It's somewhat analogous to plucking a guitar string and then recording its distinct vibration profile," Franklin Moon, Ph.D., explains. "We 'thump' the bridge at predetermined, spatially distributed locations and capture the frequency of

How THMPER™ measures up against other methods

Technology	Method	Est. prep time	Est. test time	Est. report time	Access equip needed?	Bridge closure
Quasi-static with displacement transducers	Ambient monitoring	5–10 days	2–5 days	3–5 days	Yes	Only underside
	Load testing	5–10 days	1 day	3–5 days	Yes	Partial, 2 hrs
Dynamic	Ambient vibration	5–7 days	2–5 days	5–7 days	Yes	Only underside
	MIMO impact	5–7 days	1 day	5–7 days	Yes	Partial, 2 hrs
	THMPER	**Under 1 day**	**30 mins/span**	**1 day**	**No**	**Slowdowns only**

Table comparing THMPER to other testing methods.

the vibrations and the shapes the bridge assumes at which frequencies. These data give us important performance measures related to stiffness and mass, which in turn tell us how truck loads are distributed to key elements."

Sensors record the response, or dynamic signature, of the structure and feed the data directly to the control van, where the data are processed and used to calibrate a refined FE model, which indicates how much a bridge can safely carry.

"THMPER™ does a really good job at picking up a key aspect of the bridge response in the torsional and so-called butterfly mode, i.e., how the girders share the load transversely. The *Manual for Bridge Evaluation* references all the methods and practices we're combining here. We're packaging it in a really efficiently and cost effectively, but fundamentally it's not very different than the standards established and accepted by AASHTO," says Moon.

THMPER™ can test a 100-foot three-lane bridge in about 45 minutes and evaluate an estimated 300-plus bridges per year at about 25 percent the cost of current testing methods. It provides quantitative data that accurately represents a bridge's load capacity and minimizes traffic disruption.

To date, THMPER™ has been used to assess more than 30 bridges in Delaware, Maryland, New Jersey, Pennsylvania, Oregon, and Washington under pilot programs with federal, state, and local transportation agencies.

ASCE recognized the value and ingenuity of THMPER™, awarding it 2016 Charles Pankow Award for Innovation.

David Mascer/Rutgers CAIT

THMPER uses quantitative data to calculate a bridge's load capacity accurately, quickly, and with less traffic disruption.

About This Project

The Targeted Hits for Modal Parameter Estimation and Rating (THMPER™) was conceived in 2010 by Ph.D. Franklin Moon, and fellow Ph.Ds, John DeVitis, David Masceri, and Emin Aktan, while teaching at Drexel University and working with CAIT on the Federal Highway Administration's Long-Term Bridge Performance Program. Moon joined Rutgers School of Engineering faculty in January 2016.

Moon received initial funding for THMPER™ under a grant from the National Institute for Standards and Technology's Technology Innovation Program (NIST-TIP) while he was teaching at Drexel University. He collaborated with Pennoni Associates, Inc. and Intelligent Infrastructure Systems in addition to Rutgers CAIT.

For more information on THMPER™ or to inquire about testing, contact Dr. Franklin Moon. http://cait.rutgers.edu/cait/franklin-moon