

Geotechnical/  
Structures

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Project Title:  
Bridge Rapid Assessment Center for  
Extreme Events (BRACE2)

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## Bridge Rapid Assessment Center for Extreme Events (BRACE2)

Real-time estimates of bridge damage during major earthquakes

### WHAT IS THE NEED?

Caltrans operates 7 toll bridges in the San Francisco Bay Area. Each of these bridges includes seismic sensors that are mounted at key locations on the bridge. During an earthquake these sensors measure horizontal and vertical acceleration and transmit this data to the California Geologic Survey (CGS) for processing. CGS creates data reports for major events and Caltrans later uses this data to validate the structural model used to design or seismically retrofit the bridge.

There are several areas for improvement with our current practice. First, the transfer and processing of seismic data is too slow to utilize in the immediate assessment of a bridge following an earthquake. Second, sensor and telemetry technology are rapidly advancing. While the sensors used on Caltrans bridges are very rugged and reliable, they are very expensive to install and maintain. Finally, validation of a bridge's structural model using CGS recorded sensor data requires a substantial effort usually involving contracting with engineering consultants.

### WHAT ARE WE DOING?

Through the PEER-Bridge Program, Caltrans is contracting with UC Berkeley to develop the Bridge Rapid Assessment Center for Extreme Events (BRACE2), a trial implementation center that will monitor the Hayward 580/238 Separation bridge 24/7. Under this task, communication and processing infrastructure will be established that enables monitoring in real-time. State-of-the-art structural models will be developed for the trial bridge and will be used to develop simpler fragility algorithms that can provide damage estimates in real-time. These estimates will be provided to Caltrans via a limited access web site to support decision-



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knowledge that improves  
California's transportation system

making regarding bridge closure and inspection. Efficient updating of bridge models using recorded sensor data will also be developed. Another objective of the task is to estimate structural responses and fine tune modeling parameters of 4 other existing bridges using historic sensor data. The goal of the study is to capture varies influence parameters critical to bridge responses from recorded data.

## WHAT IS OUR GOAL?

The primary goal of BRACE2 is to demonstrate the viability of the Rapid Assessment Center concept through trial implementation on the Hayward 580/238 Separation. A future goal, the developed technologies and monitor center viability from this project can be used for implementation to Bay Area toll bridges.

## WHAT IS THE BENEFIT?

Bridges represent a major public investment and the closure of one or more of these bridges has a substantial detrimental impact on regional travel times. However, system and component assessment of bridges are complicated and inheritably difficult. As the first step to establish a viable bridge monitoring center, BRACE2 will use state-of-the-art communication, computation, and sensor technology to provide real-time assessment of the structural condition of the trial bridge immediately following an earthquake. These assessments can help avoid unnecessary closures when damage is light and identify the location and severity when damage is heavy. Sensor data will also be used to validate and update structural models and possibly result in improvements in bridge design. If the trial implementation proves successful, these same techniques and technologies can be applied to other bridges in Caltrans inventory.

## WHAT IS THE PROGRESS TO DATE?

BRACE2 was executed as a task order through the PEER-Bridge Program. Project started on August

01, 2020 for a duration of 30 months. The research team has begun bridge model development for the Hayward 580/238 Separation using OpenSees. Currently, development of the hardware, software, and data communication infrastructure of the monitor center is in progress. The team is also working with Center for Engineering Strong Motion Data (CESMD) to soon establish real-time sensor data transfer from bridge site to the monitor center at Berkeley Richmond Field Station.

Development of global bridge model for Hayward 580/238 is completed. Determination of component modeling strategy and column damage limit states is under development in the form of a Decision-Making Platform. Hardware infrastructure and data transfer of the system is completed. Development of Real-time sensor data processing platform and set up cloud server and FEM simulations is completed. Bridge recorded data can be directly transferred from site to BRACE2 system.

A one (1) year no cost extension to the project has been granted. The time extension will be used to improve the practicality of the application platform and user interface. An interface has been implemented which allows decision makers to interact with sensor records that have been received using the real-time application program interface. An application platform has been implemented which invokes structural model of Hayward bridge in real-time upon the receipt of new sensor data. The application platform has been implemented to receive the output of the bridge model upon the completion of an analysis and assemble an evaluation report on conditional assessment of the bridge components.

Ongoing work with Geotechnical experts to determine foundation and structure interaction models is underway. Development of optimization algorithm for bridge response parameters is ongoing. Refinement of the application platform is ongoing.

IMAGE

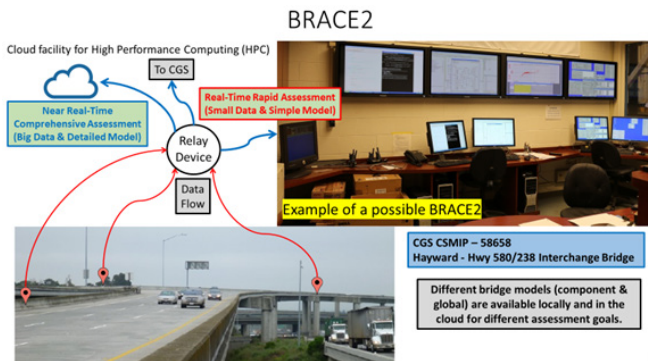


Image 1: Illustration of monitoring center operational framework

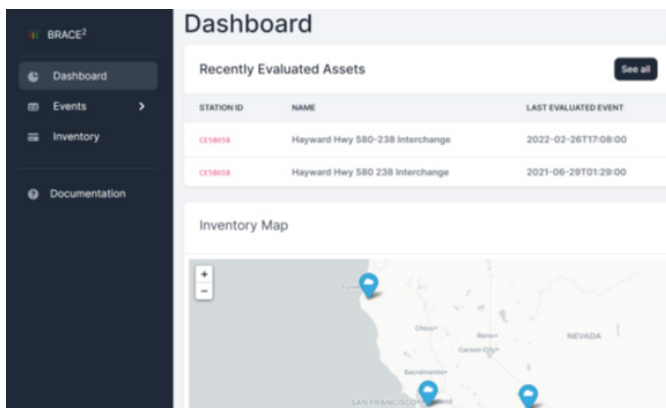


Image 2: General decision-making interface of the BRACE2 application platform

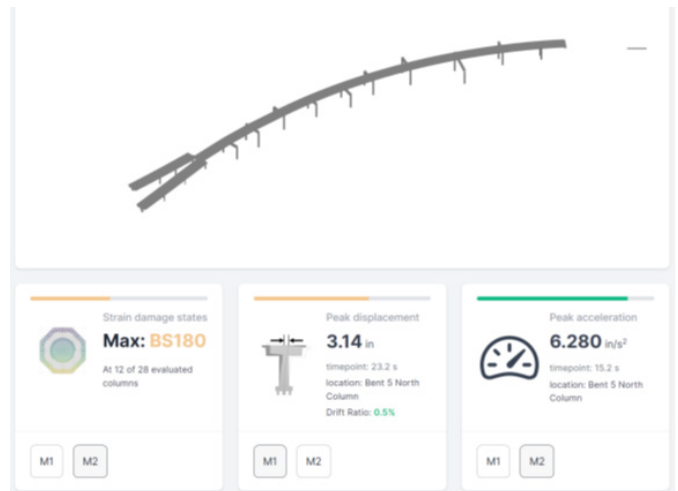


Figure 3: An evaluation page presenting the metrics obtained for Hayward bridge asset at a sample event

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