Cascading Effects of 2011 Tohoku Earthquake to Structural Damages of Bridges

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Background and Motivation:

The March 11, 2011 Japan disaster represents a typical example of cascading events (main shock, tsunami and aftershocks) that may provide a rare opportunity to identify and develop important research agenda.

In collaboration with research partners from Japan and Taiwan, and additional support from FHWA, an international cooperative project is established on cascading effects of extreme events through this RAPID grant. This poster briefly describe the initial study carried out at MCEER, University at Buffalo.

Interested Bridges in Japan:

Fig. 1 Photo of damaged piers at the Tsuya River (Photo courtesy of S. Dashti)

Simplified Bridge System:

Detailed bridge design and damage information is now being collected by our research partners in Japan. Due to the lack of real bridge information, the following bridge substructure is assumed for preliminary analysis.

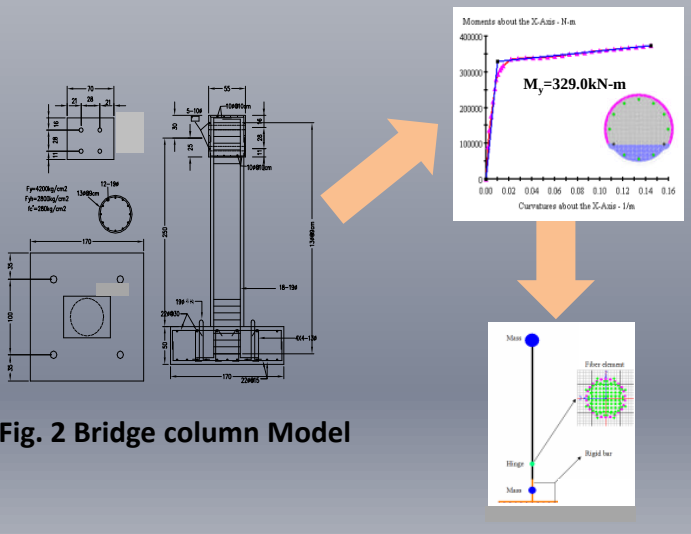
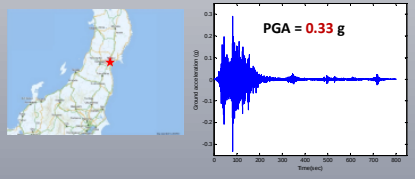


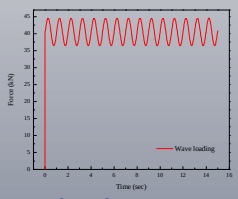
Fig. 2 Bridge column Model

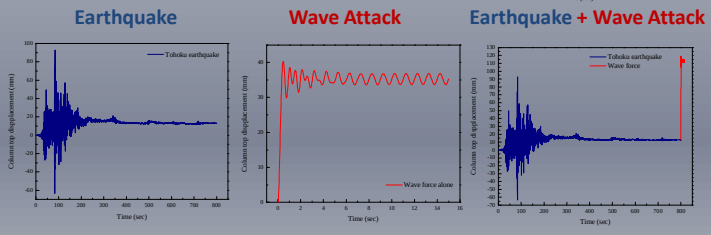
Analysis Results:

Earthquake record from Tohoku University:



Wave force simulation:





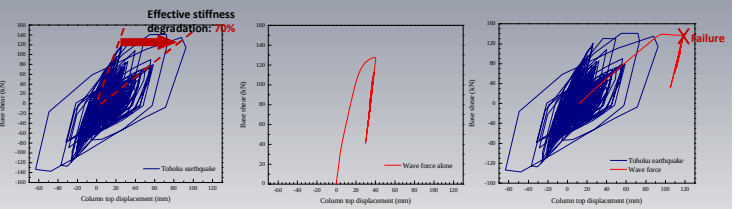
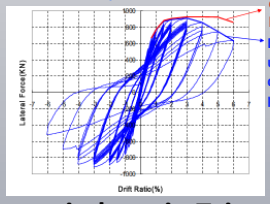


Fig. 3 Analysis results

Long Duration Earthquake Effect:

Loading Protocol

Drift(%)		0.25	0.375	0.5	0.75	1.0	1.5	2.0	3.0	4.0	5.0	6.0
Conventional Protocol	Number of Cycle	2	2	2	2	2	2	2	2	2	2	2
Long Duration Protocol		45	30	30	20	20	15	15	10	3	1	1



Typical envelop response under the conventional loading protocol

Envelop response under the long duration loading protocol

Fig. 4 Experiment carried out in Taiwan

It is found that the column under the long duration protocol shows a significantly greater stiffness and strength degradation than a typical response under the conventional load protocol.

Preliminary Investigation Suggests:

- Many research opportunities exist to quantify cascading effects of earthquake and tsunami wave force
- Research efforts should be further expanded to other extreme event combination, such as earthquake + earthquake (long duration earthquakes), earthquake + vessel collision, earthquake + scouring, etc.

Acknowledgements: This study is supported by NSF (CMMI 1138585) and FHWA (DTFH 61-08-C-00012). International cooperation from research partners in Japan (K. Sugiura of Kyoto University and Y. Kitane of Nanoga University) and in Taiwan (Y.C. Ou of National Taiwan University of Science and Technology) is gratefully acknowledged.