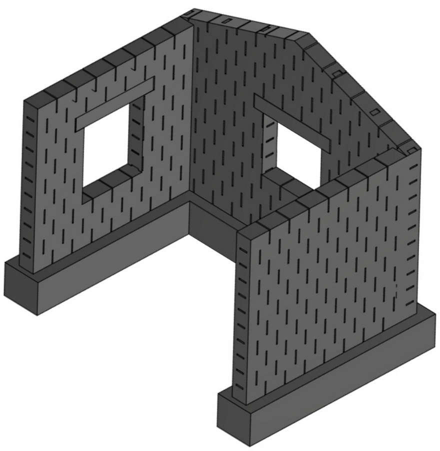
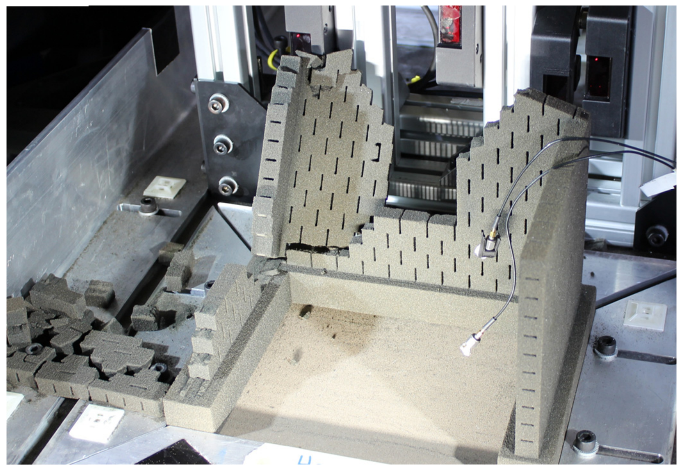
PEER Blind Prediction Contest of Shaking Table Tests on 29 Masonry Model Structures





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Introduction

The ETH Zurich, the NTU of Athens, and PEER invite the earthquake engineering community to participate in a blind prediction contest where the response of a small-scale physical model of a masonry structure to a bin of ground motions is sought.

Previous contests have shown that the response of a masonry structure to a given ground motion is hard to predict. This is not a surprise, as the response of masonry involves rocking motion and it has been shown that it is often impossible to predict the response even of a solitary rocking block. However, it is much easier (and still highly useful) to predict the statistics of the response of a rocking block to a bin of excitations.

To this end, this contest will focus on the response of 1:15 scaled physical models of a masonry 3-wall structure. The specimens were tested on a shaking table within the ETH geotechnical centrifuge to preserve the similitude of stresses and were excited by 29 ground motions. A virgin specimen was used for each excitation. The specimens were 3D printed using binder jet technology. Notches were printed to emulate masonry joints, as this approach has been shown to be efficient in creating physical models that behave very similarly to masonry under low axial loads.

The purpose of the contest is to evaluate the performance of the numerical models in predicting the dynamic behavior of a masonry structure when material and component level behavior is given. In parallel, the usefulness of calibrating numerical models on ambient vibration measurements will be explored.

To this end, two quantities are sought: The probability of collapse of at least one wall and the displacement of the top of the North wall.

The contest has two phases. Phase 1 follows the common blind prediction process: the contestants are given the geometry, material properties, component test results, and ground motion excitations, and they are expected to predict the test outcomes. After submitting their predictions at the end of Phase 1, the contestants will be asked in Phase 2 to update their predictions based on ambient vibration measurements (corresponding to the ETH Zurich structural lab conditions) or other structural identification test results that will be provided to them. The time history of accelerations and displacements recorded at different locations of the specimens will be provided.

The contest is open to all those in earthquake engineering, from industry practitioners to the academic community, including students. The winners will be announced on the PEER website. Results will be presented anonymously except for those of the “winning” entries.

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Input Data and Characterization Tests

1. Information and details regarding the masonry structure, applied motions, and the test setup can be found on the contest website. Drawings are provided in SI units.
2. Bulk material characterization tests included uniaxial compression tests with different loading protocols and four-point bending tests on beams. Details of the material characterization tests are provided in the file *BulkMaterialTests.pdf* under Input Data. The corresponding data are provided in the file *BulkMaterialTestData.zip* under Input Data.
3. Wall-level characterization tests included vertical compression tests with different loading protocols and shear-compression tests (combined axial compression and horizontal cyclic loading). Details of the component-level characterization tests are provided in the file *ComponentTesting.pdf* under Input Data. The corresponding data are provided in the file *ComponentTestingData.zip* under Input Data.
4. The tests were conducted using a unidirectional shaking table mounted at the ETH Zurich beam centrifuge located at the ETH geotechnical centrifuge center (ETH GCC). Displacement and

acceleration data were acquired using an array of lasers and accelerometers, respectively. The sampling rate was 4800Hz. A sample test video is available in *CentrifugeTestCollage.mp4* under Input Data. It should be noted that this video does not correspond to any of the 29 tested specimens, but to a similar specimen tested in an earlier feasibility study (Elmorsy et al. 2024).

5. The ground motion input files, which can be found in *GMinput.zip* under Input Data, contain the acceleration time histories as measured on the shaking table surface in g units with a sampling rate of 4800 Hz. A low-pass Butterworth filter with 32 poles and a corner frequency of 250 was applied to the recorded motions. To preserve similitude of stress, the acceleration and duration of the records were scaled. Since the length scale S_L was equal to 1/15, the time scale was set to S_T = S_L = 1/15 (scaled down by 15), and the corresponding acceleration scale S_a was equal to 15 (scaled up by 15). The provided motions are already filtered and scaled, therefore they are ready to be used for predicting the response.

Quantities to be Predicted, Submission, and Evaluation Criteria

1. Contestants are expected to predict the responses for a total of 29 motions/structures.
2. The contestants must use the contest submittal spreadsheet *Contestantsubmittalspreadsheet.xlsx* under Rules and Submission to submit their results. In this file, they must provide their prediction of the following two parameters:
   a. Whether the structure failed or did not fail. Note that collapse of at least one wall is considered failure.
   b. The absolute value of the maximum top displacement (out-of-plane displacement, in the shaking direction: North-South direction) of the North wall (Point A, Figure 1) with respect to the base of the structure (δ_{max}).

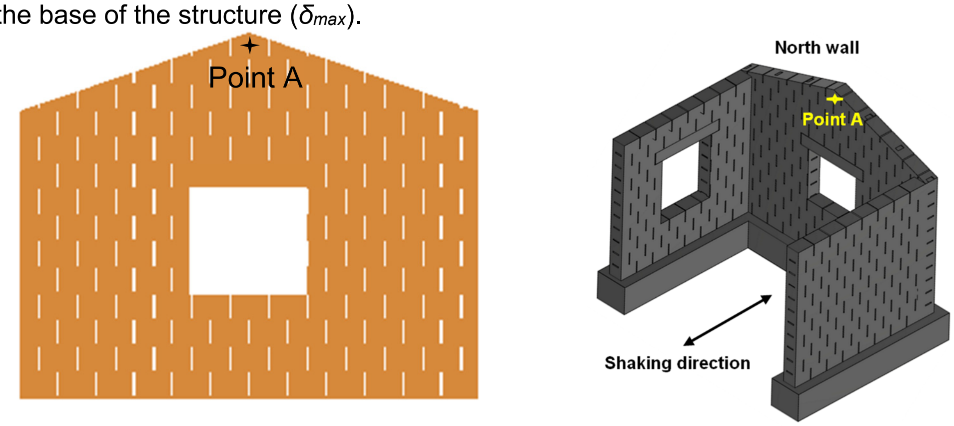

Figure 1. Point A, at which the maximum top displacement of the North wall is to be calculated.

3. Along with the predictions, contestants should submit a technical report of 5-20 pages electronically as a PDF document in ASCE journal format. Contents of the report may include text, figures, and tables that describe the model, utilized software platform, materials, elements, solution algorithms, assumptions, discussion of the analysis results, and summary of key results beyond those in the spreadsheet. ASCE Journal format can be downloaded from Rules and Submission. The technical report should be submitted at the end of Phase 2.
4. Contestants may be individuals or teams. Each contestant must declare to be in one of these two categories in the submission spreadsheet:
   i. Researcher (including faculty, postdocs, and students, and other researchers)
   ii. Practicing Engineer
5. The following system, based on Bachmann et al. (2018), will be used to determine the winning team:

An Empirical Cumulative Distribution Function (CDF) will be plotted based on the submitted maximum displacement values δ_{max}. The cdfplot MATLAB function will be used to construct the Empirical CDF. More info can be found at https://ch.mathworks.com/help/stats/cdfplot.html

An Empirical CDF will also be plotted for the recorded data from the tests. The error Err_1 will be computed as the absolute value of the maximum vertical distance between the submitted data CDF and the measured data CDF, also known as the Kolmogorov-Smirnov Distance (Figure 2). The distance will be measured based on the stair-like plot generated by the MATLAB cdfplot function. In case the contestants choose to submit results for less than 29 ground motions/structures, we will construct an empirical CDF plot based on the data that we receive and then interpolate it.

A second error term, Err_2, will be calculated as the absolute value of the difference between the test probability of failure (number of failed specimens/total number of specimens) and the predicted probability of failure.

The total error will be computed as the sum $Err_1 + Err_2$. The team with the smallest total error will be declared the winner in each contestant category. If there are sufficient (based on the judgment of the evaluation committee) participants in each category, there will be one winner for each of the two categories. Otherwise, no distinction will be made between the two categories in announcing the winners.

<u>**Note:**</u> the contestants do not need to submit CDF plots, but only the δ_{max} vector. CDFs will be constructed by the blind prediction competition organizing committee based on the procedure described above.

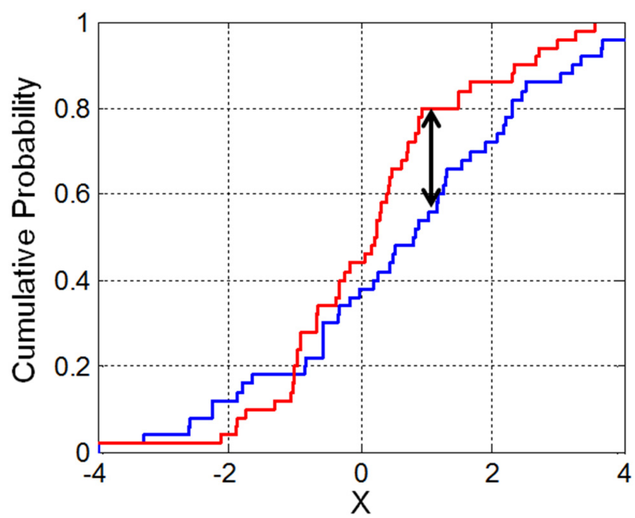

Figure 2. Demonstration of the Kolmogorov-Smirnov distance

General Rules

1. One individual may only be involved in one single submission. If an individual is part of a team, that individual cannot participate in the competition separately as an individual.
2. Contestants from ETH Zurich, NTU Athens, and the University of California Berkeley, who are involved in the conduct of the tests and organization of the competition, are not allowed to participate.
3. Contestants should submit their results for Phase 1 before June 16th. Ambient vibration measurements will be provided to the contestants on June 17th and they will be asked to submit their updated

predictions in Phase 2 until July 17th. Winners in each category and each phase will be notified by July 31st. Except for category winners, all submittals will be kept anonymous.

4. Questions about the blind prediction contest or details of the structure or input motions can be submitted to peer_center@berkeley.edu by May 30th for Phase 1 and by July 2nd for Phase 2. Questions and answers will be posted regularly under Q&A.

References

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