Description of Phase 2

The contestants are asked in Phase 2 to update their models and predictions using acceleration measurements from a hammer impact test. The time history of accelerations recorded at different locations of the structure during the hammer tests are provided. Additionally, a system identification has been conducted and is available for use at the discretion of the participants. Contestants are free to utilize the provided data using any method of their choice.

Structural Identification Tests

One specimen, which is identical to the 29 tested buildings, was tested under impact load applied using a plastic hammer. The impact load was applied in the direction shown in Figure 1. It was applied by hammering the steel plate to which the specimen was fixed. The hammering point roughly aligned with the centre of the building. The acceleration response of the structure was recorded using an array of accelerometers. Eight (8) accelerometers were placed on the specimen (Figure 2), in addition to one accelerometer on the steel plate to which the specimen was fixed. 11 hits were applied.

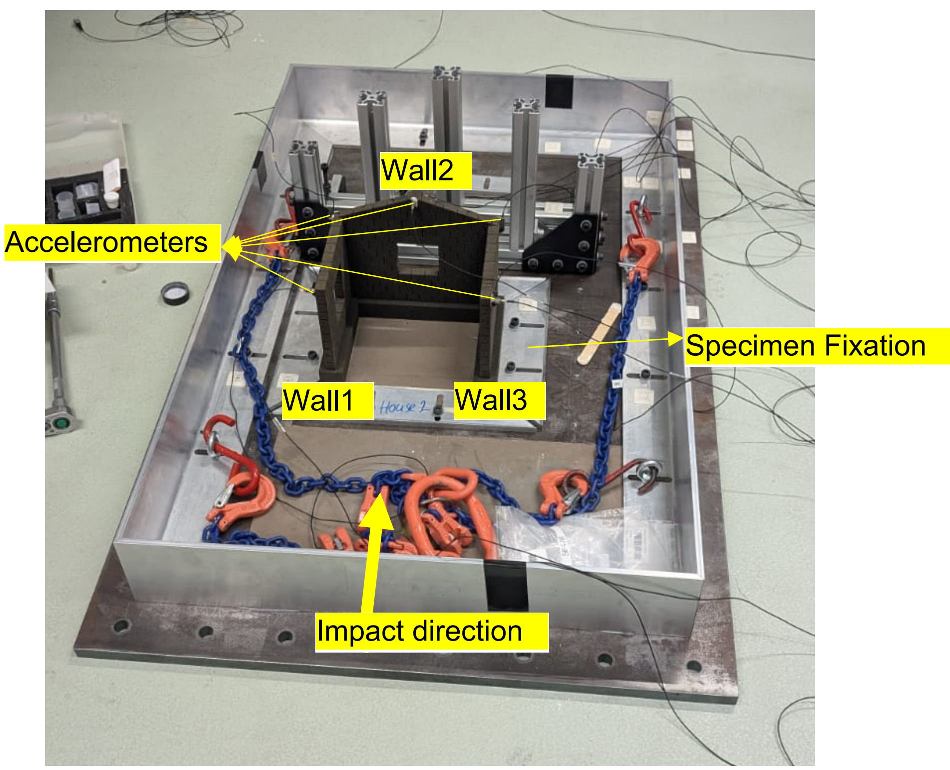

Figure 1. Hammer test setup.

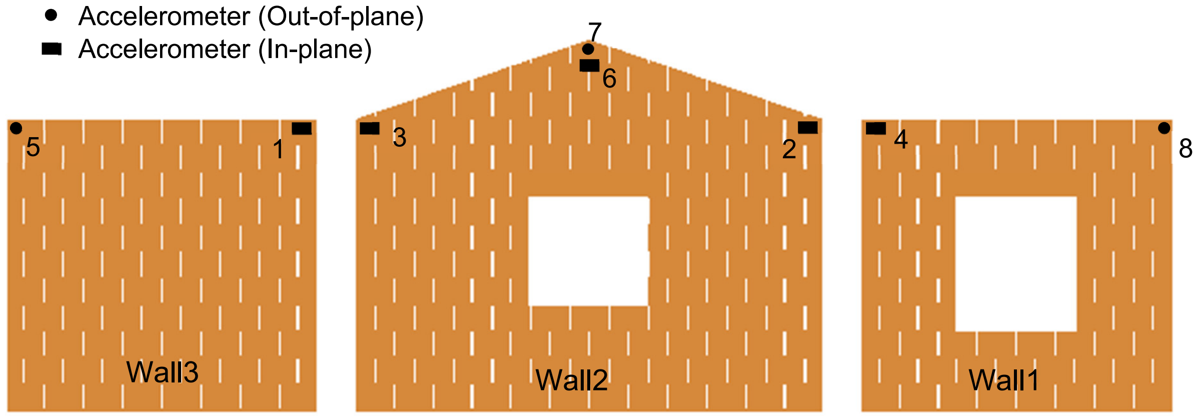

Figure 2. Instrumentation layout.

The acceleration data are provided in the Sheet named "Hammertest_acceleration_data(g)" of the Excel document *Phase2_Data.xlsx*. This document is available under the header *Phase 2* in Input Data.

Column A provides recorded acceleration of the steel plate in [g] in the impact direction.

Columns B-I provide measured accelerometer data in [g] for the eight accelerometers shown in Figure 2.

Sampling rate is 1600 Hz. A low-pass Butterworth filter with a number of poles and cut-off frequency of 32 and 1200 Hz, respectively, was applied to the data.

Identification of vibration modes

While the contestants are free to use the provided data using any method, this section describes the system identification method used by the organizers and provides the corresponding natural dynamic characteristics identified. Contestants are welcome to use these characteristics to update their models at their discretion or perform their own identification using the acceleration data provided.

A MATLAB code was developed that performs an operational modal analysis (OMA) to identify dynamic properties (natural frequencies, damping ratios, mode shapes) of a structure using output-only vibration data. Natural frequencies and damping ratios were derived from the eigenvalues, while mode shapes were obtained by projecting eigenvectors through the output matrix. Subspace-based state-space identification ('n4sid' algorithm) was used. For the 'n4sid' algorithm, the input '*u*' is empty, indicating output-only analysis (in MATLAB: *u* = [ ]*)*. A model order of 10 states ('nx = 10') was determined using optimal order selection using the 'n4sid algorithm' in MATLAB. This means five modes were identified. Multivariable Output Error State Space, MOESP, weighting was used for robust estimation.

Figure 3 depicts a bar plot of the modal shape amplitude at each sensor location for each mode. Additionally, it shows the calculated eigen frequencies and damping ratios for the five identified modes. The mode shape data are provided in the Sheet named "Mode shapes" of the Excel document *Phase2_Data.xlsx*. This document is available under the header *Phase 2* in Input Data.

Figures 4-8 plot the mode shapes using different views: 3D perspective, XY, YZ, and XZ projections of the mode shapes. The plotted values correspond to the real part of the complex eigenvectors resulting from the n4sid algorithm. The modal eigen frequencies and damping ratios are also provided in these figures.

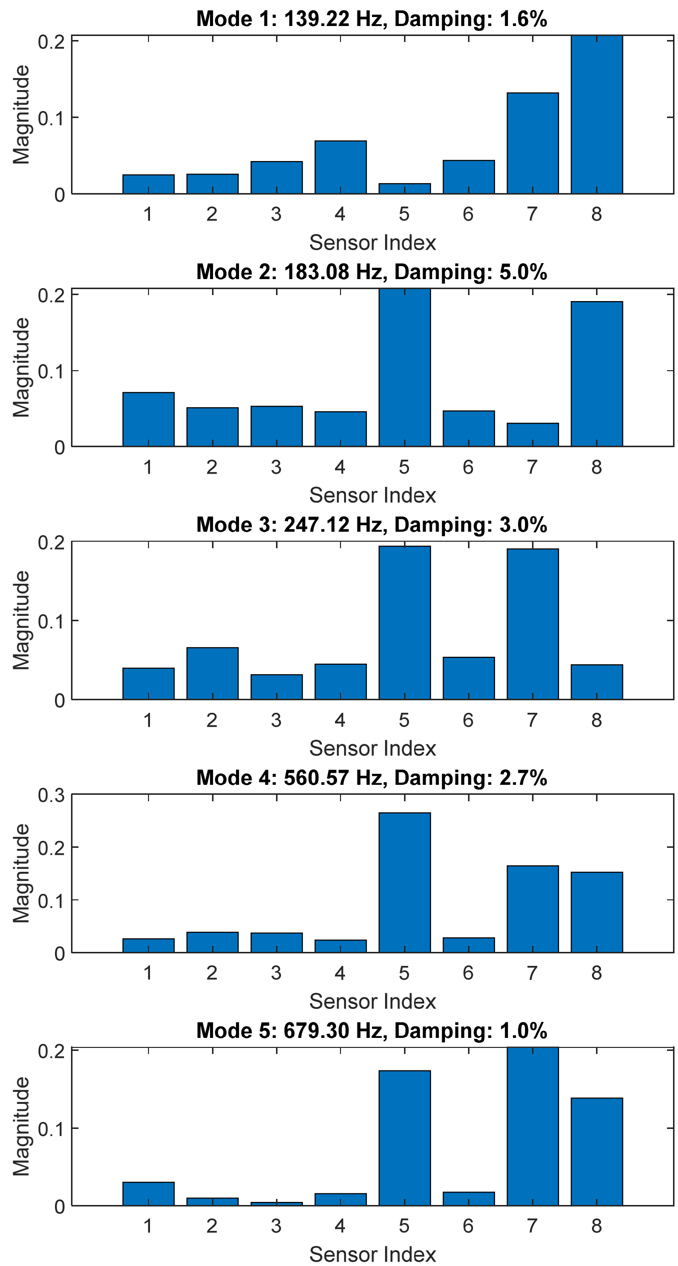

Figure 3. Summary of eigenvectors.

Mode 1: 139.22 Hz, damping = 1.6%

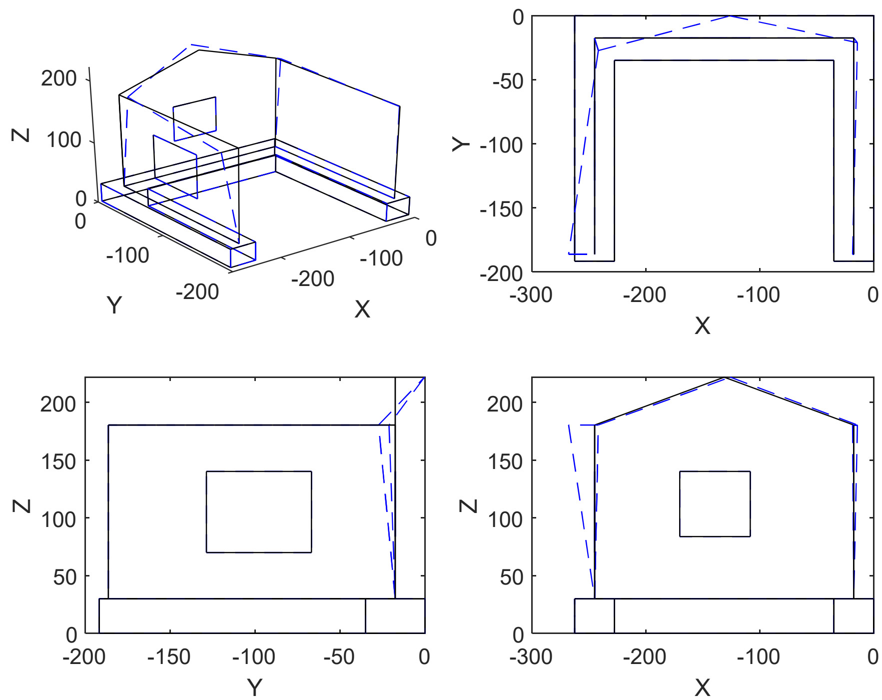

Figure 4. Mode shape for mode 1.

Mode 2: 183.08 Hz, damping = 5.0%

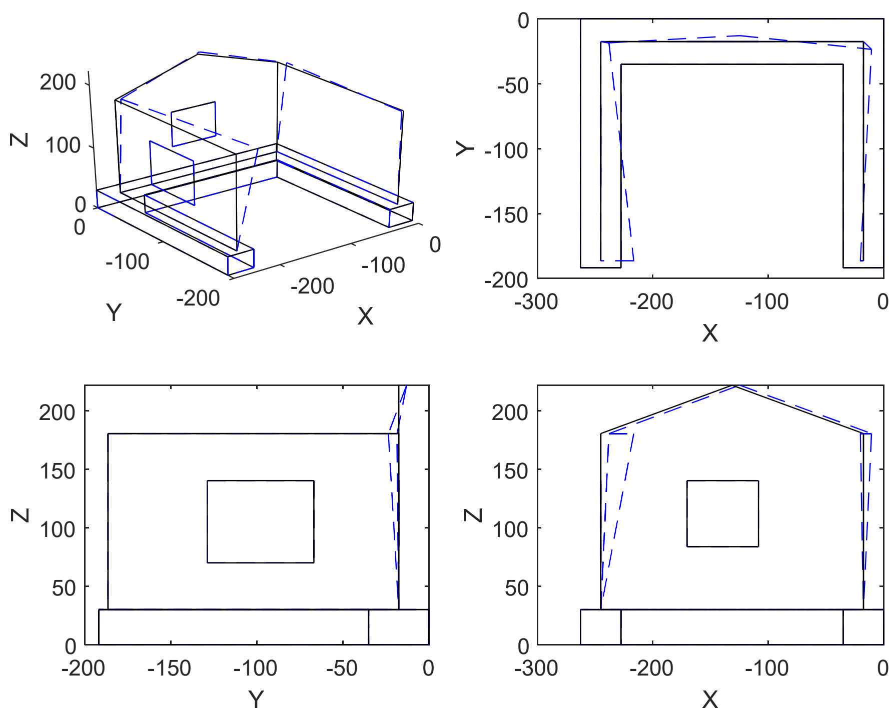

Figure 5. Mode shape for mode 2.

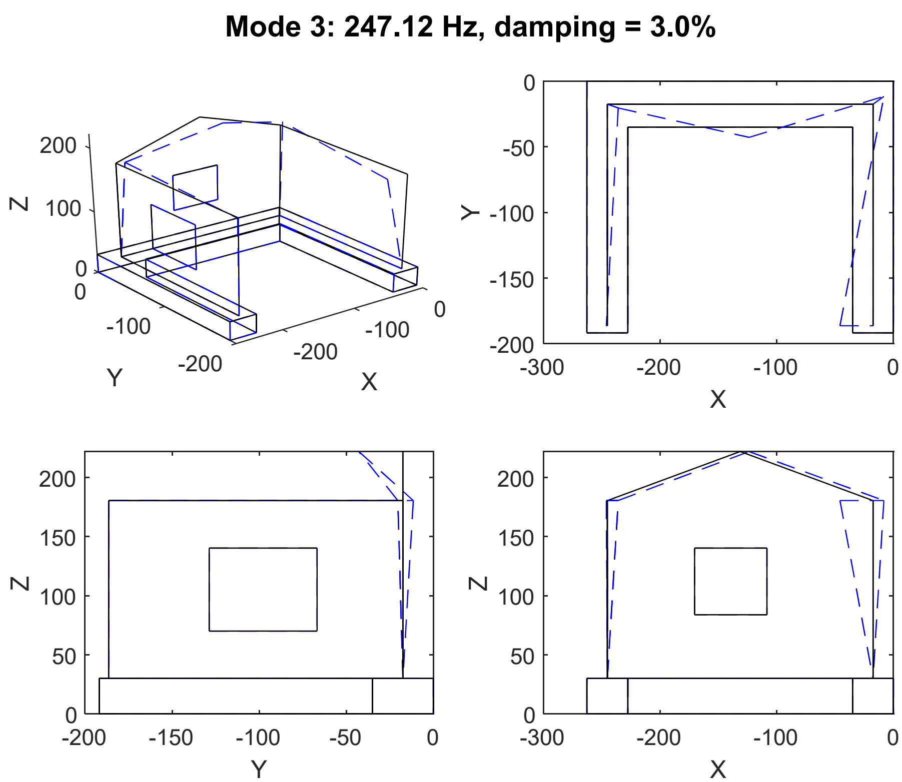

Figure 6. Mode shape for mode 3.

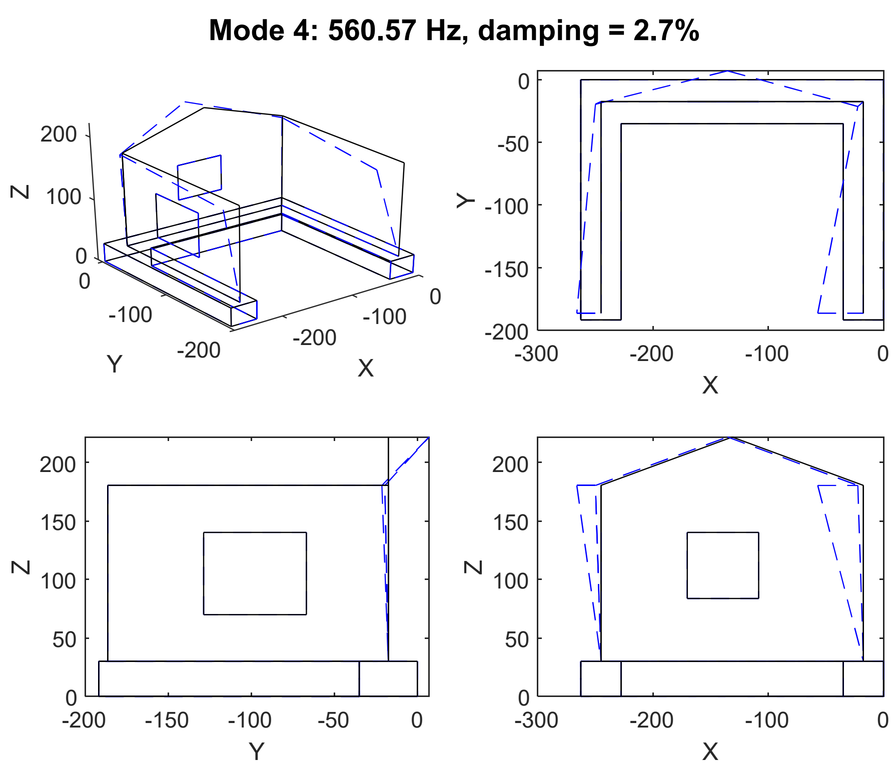

Figure 7. Mode shape for mode 4.

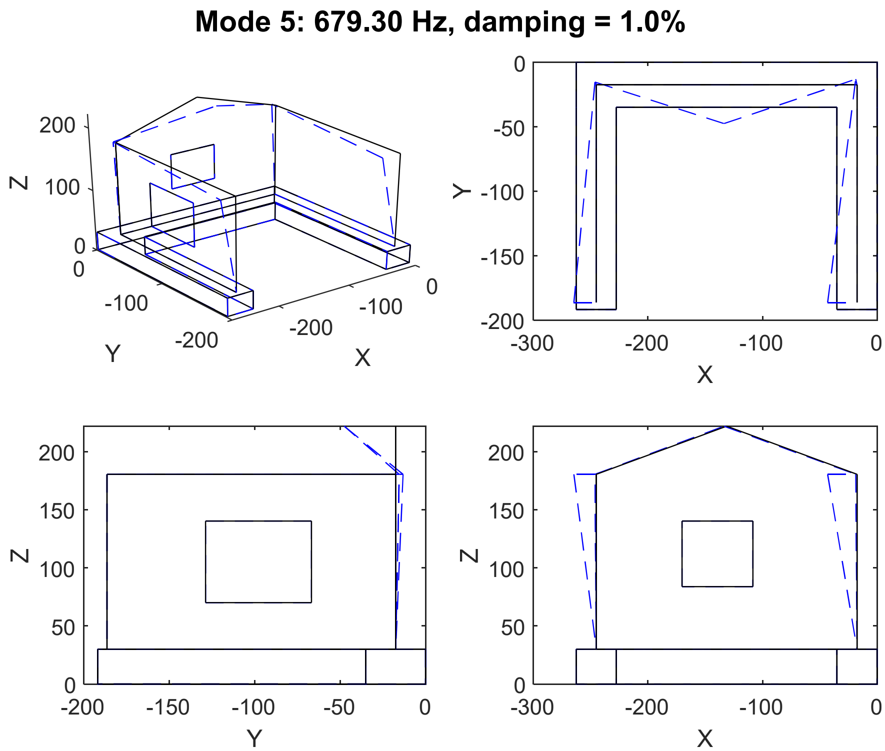

Figure 8. Mode shape for mode 5.