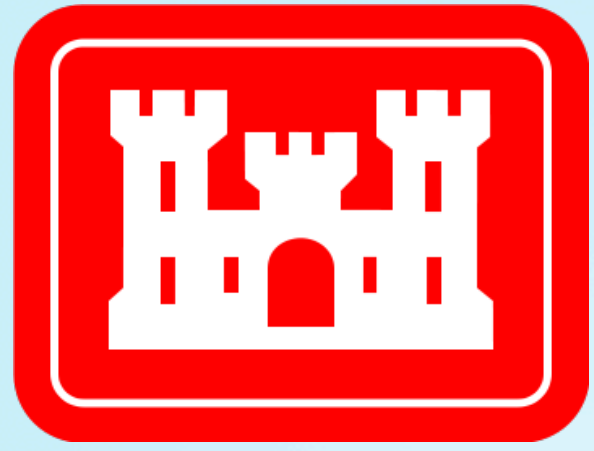


Infrasound Assessment of the Roller Compacted Concrete Dam: Case Study of the Portugues Dam in Ponce, PR



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Introduction: The U.S. Army Corps of Engineers is currently investigating the use of infrasound sensors to monitor the health of concrete dam structures. Infrasound is low-frequency (2-20 Hz) acoustic energy and is capable of propagating many kilometers from the source structure. Large infrastructure, such as dams, emits such signals at their natural or driven frequencies of vibration, providing an indication of the structural condition.

Field investigations have been completed at the Portugues Dam, in Ponce, Puerto Rico. This dam is the first single-centered roller compacted concrete (RCC) thick arch dam constructed by the Corps in the United States.

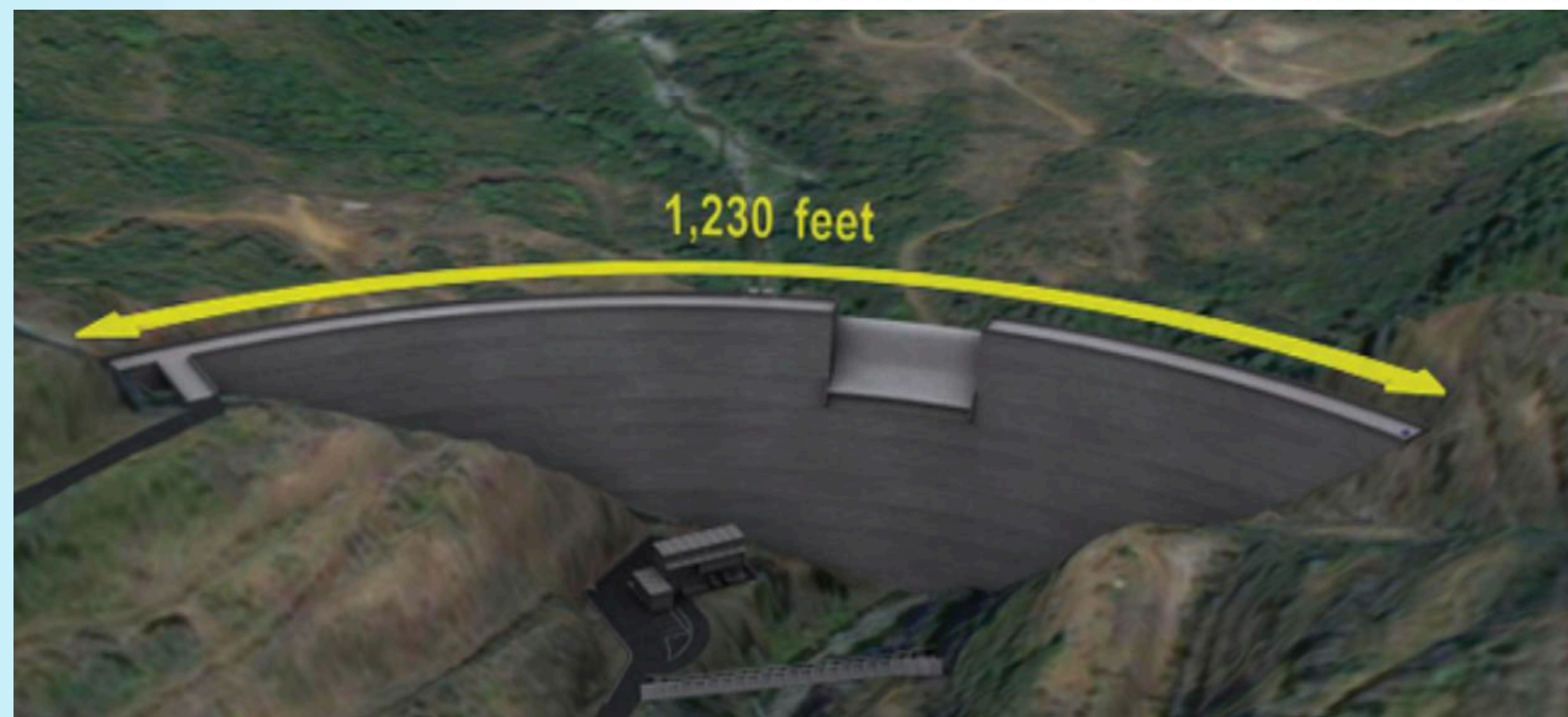


Figure 1. Rendering aerial view of the Portugues Dam

Problem: Remote assessment of infrastructure for reconnaissance or battle damage has historically depended upon satellite imagery or information revealed by boots on the ground.

Solution: Use infrasound acoustics in combination with seismic, meteorological and audible acoustic methods to determine fundamental modes of movement for bridges without line of site or direct involvement by personnel



Figure 2. Seismic-Infrasound-Acoustic-Meteorological (SIAM)

Modeling: A finite element model (FEM) of the dam and surrounding bedrock was developed in COMSOL to determine the fundamental modes of vibration.

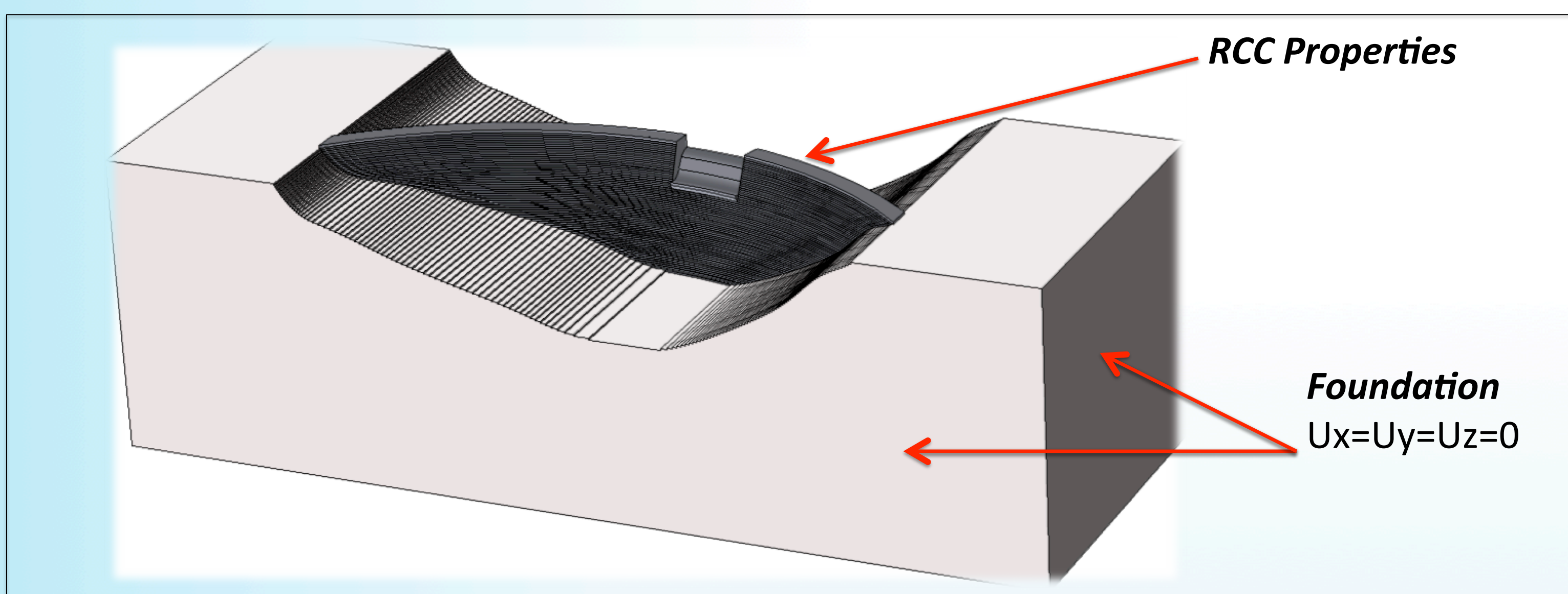


Figure 3. Linear -Elastic Structural Model of the Portugues Dam

COMSOL Analytical Results: Eigenfrequencies of the dam for the first fundamentals mode of vibration.

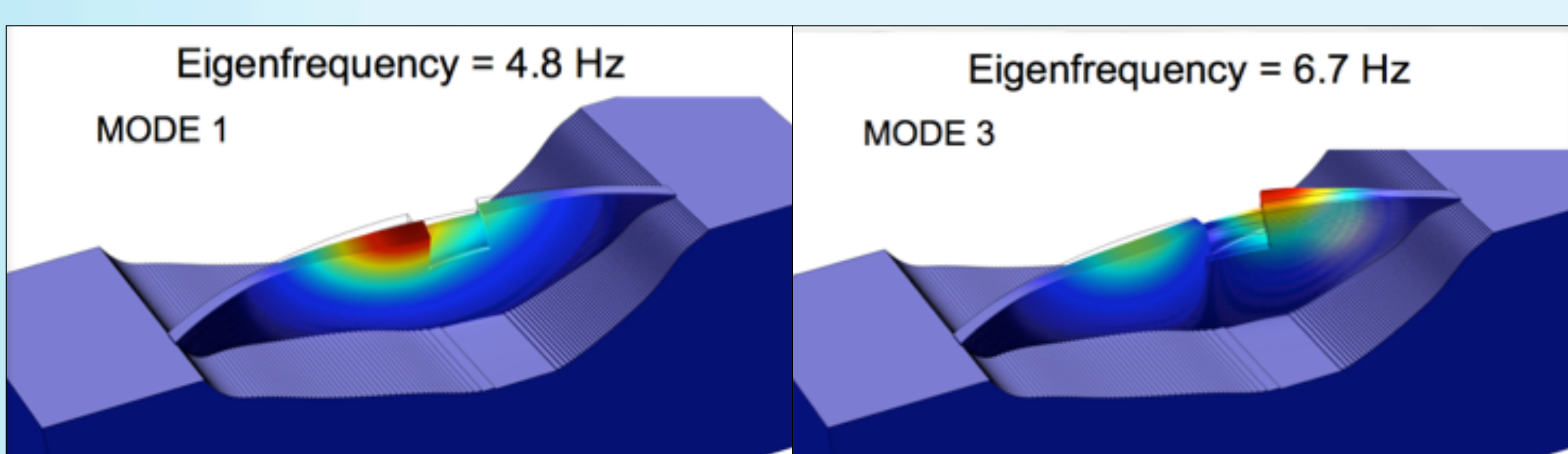


Figure 4 . Finite Element Analysis - Structural Model

Testing: Infrasound array responses were collected at remote locations near and away from the dam. The tests completed at Portugues Dam were the first ever performed on a RCC dam, and present a unique opportunity for evaluating an infrasound array's ability to capture information at remote locations that infer (pre and after event) structural response characteristics.

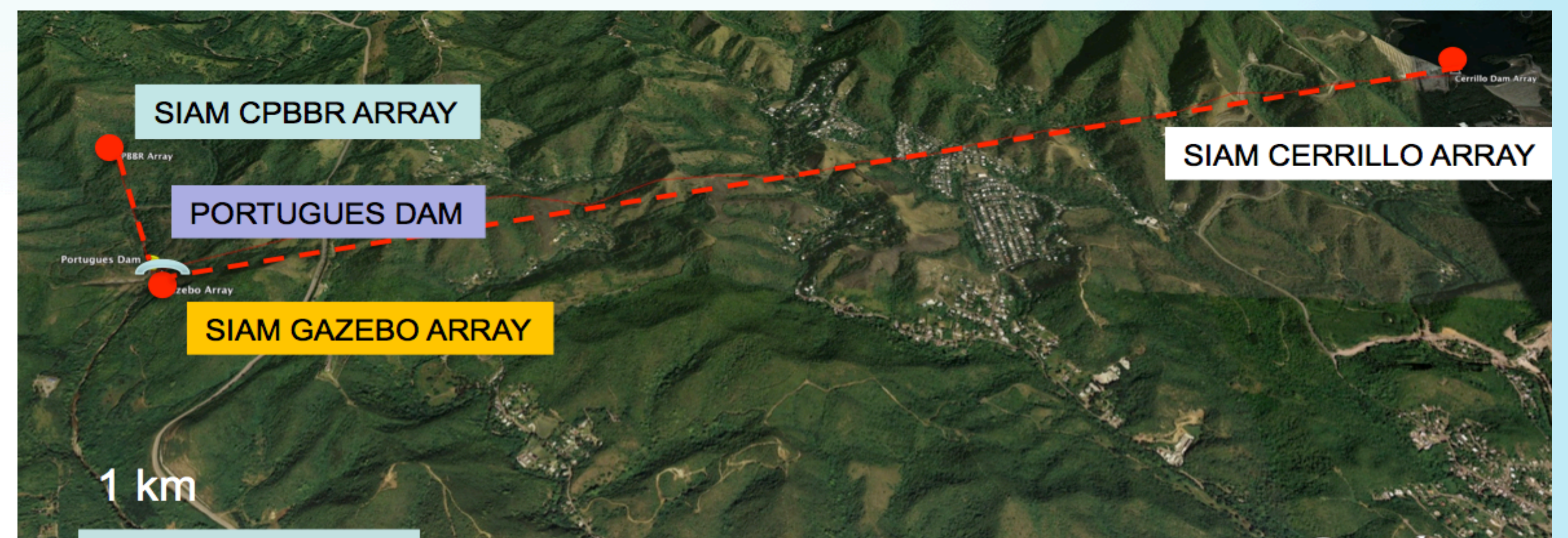


Figure 5. Locations of the SIAM arrays

A cold-gas-thruster (CGT) was used to induce broadband, transient behavior in the dam-foundation-reservoir system.

- Time-domain performance indicators



Figure 6. Cold Gas Thruster (CGT) used at the Portugues Dam

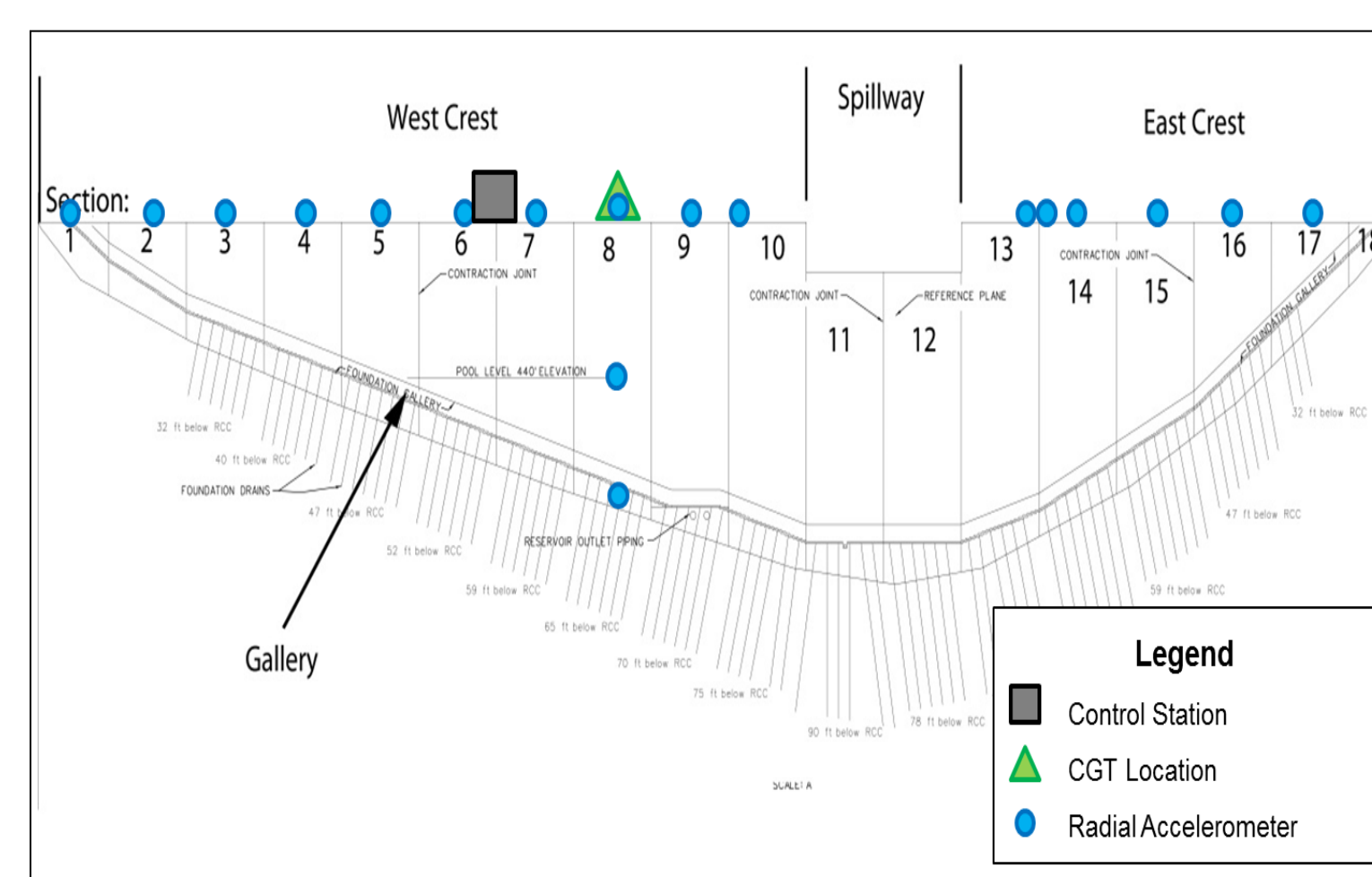


Figure 7. Accelerometers Layout

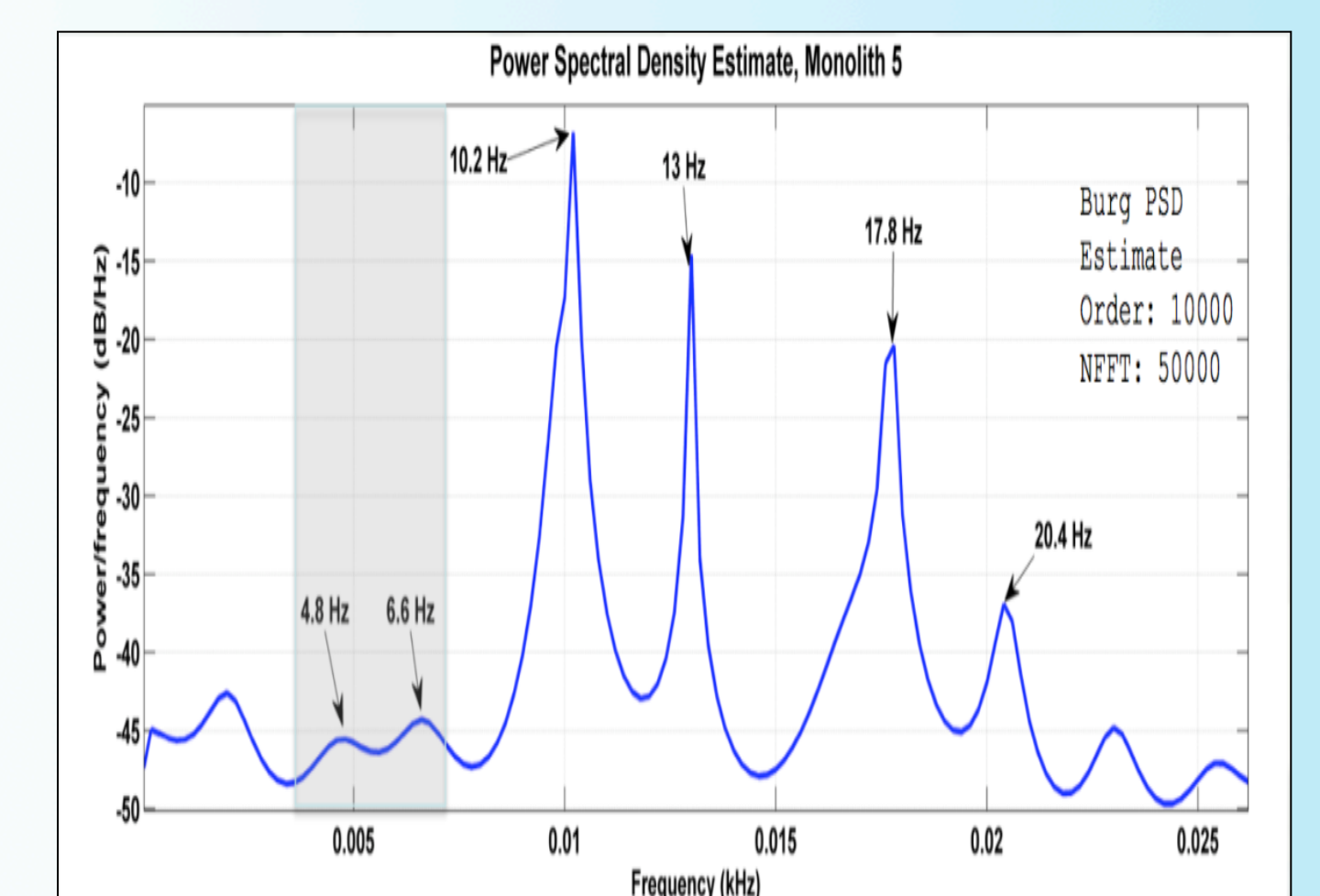


Figure 8. PSD from accelerometer at monolithic #5

An array of accelerometers (measuring in the radial direction) along the crest of the dam was used to collect the dam's response to the CGT loading.

Results: The graph below shows data recorded by each of the infrasound arrays around the time of a CGT blast. Each array features five different infrasound sensors, and the arrays are located 0.78 km, 6.15 km, and .14 km from the CGT, respectively.

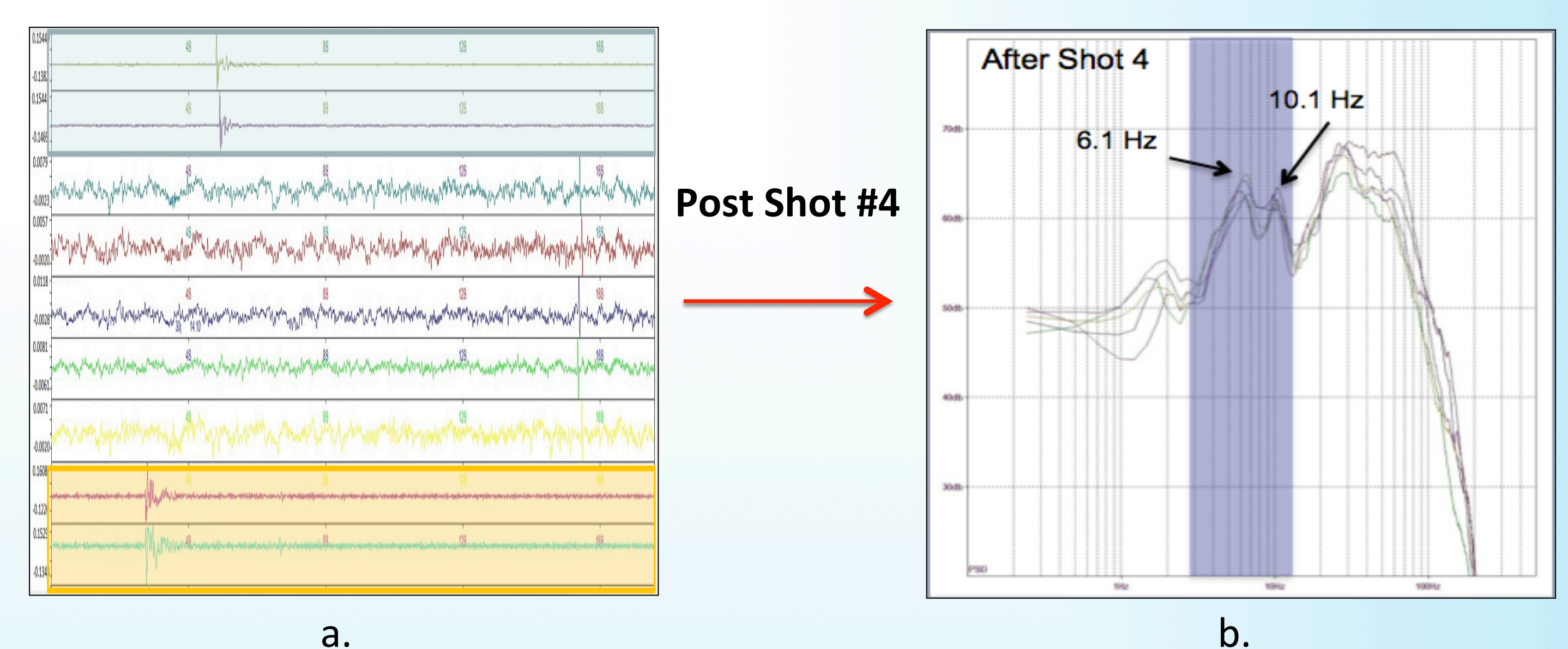


Figure 9. a. Infrasound (IML) sensors data for shot 4
b. Power Spectral Density Analysis

Conclusions: Results from COMSOL Multiphysics analysis agree with the Infrasound field experimental data and were used to validate to SIAM array data.

References:

- M. McKenna, et al., "Analysis of the Acoustic Response of a Rail Road Bridge," COMSOL Conference, October 2009.
- M. McKenna, et al., "Infrasound Measurements of Railroad Bridge," IMAC XXVI Conference and Exposition on Structural Dynamics, 2008.