Remote Scour Assessment Using Infrasound

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BUILDING STRONG®

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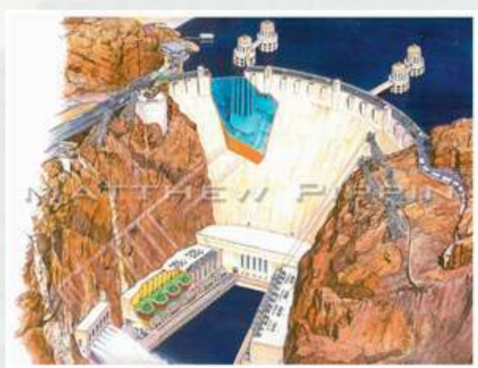
Objectives

Persistent standoff assessment and monitoring for the purpose of stability analysis, load ratings, structural health monitoring and failure phenomenon analysis in both military and civil works applications utilizing infrasound.

Provide military planners, O&M providers, and civil authorities real time tools to enhance decision making capabilities.

CIVIL
Unknown Infrastructure
Mobility Concerns
Capacity Development
Aging Infrastructure
Structural Resiliency
Risk & O&M Priority

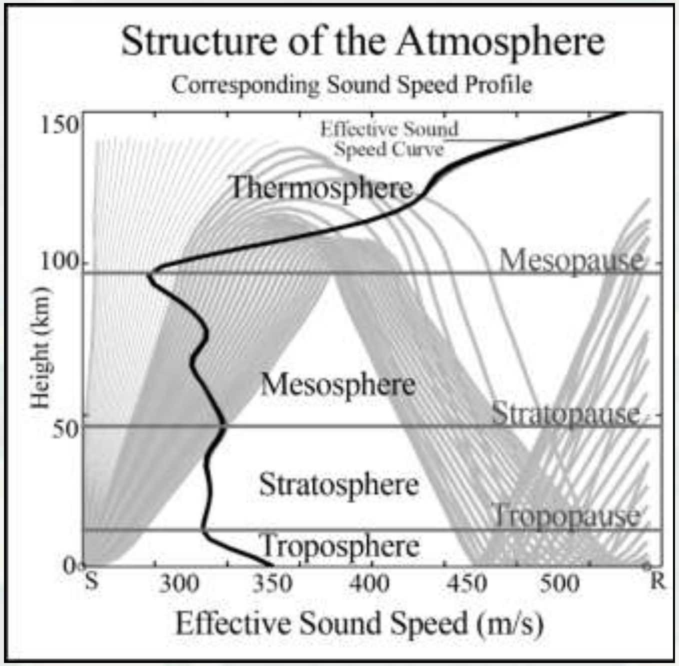


MILITARY
Transportation infrastructure
Underground Facilities
Route reconnaissance
Vehicle movement and identification
Massing of forces
Battle damage assessment

Infrasonic Sensing

Remote sensing using infrasound utilizes numerical modeling capabilities and experimental test data to develop experimentally validated simulations of infrasonic structural coupling.

- Exploit signatures infrasound/low frequency acoustics (0.01 – 150 Hz)
- Use portable seismic-infrasound-acoustic-meteorological arrays to provide real-time data and awareness at distances between 15 to 200 km.
- The combination of HPC and desktop modeling techniques couples above-and-below ground structures to accurate meteorological conditions to simulate source signatures and propagation effects over realistic terrain.
- Teams at ERDC have conducted research using infrasound as a means of remotely assessing infrastructure.
- Previous studies on the Little Piney Bridge at Ft. Leonard Wood, MO detected the modes of the bridge to be 2 Hz, 6 Hz, and 13 Hz.

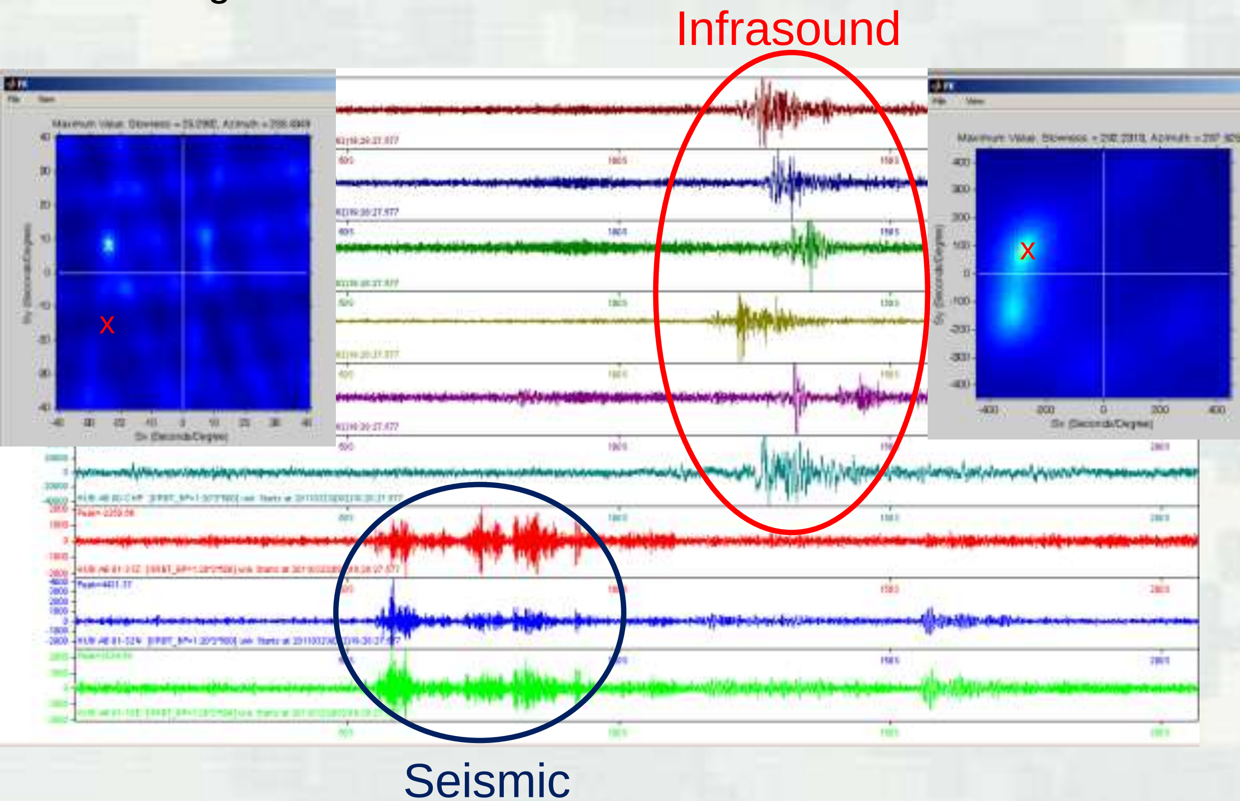


Structural Health Monitoring

March 23, 2011
Event time ~ 2:30 p.m.

Seismic and Infrasound arrays localized the initial impact

- Infrasound signature showed a ‘smearing’ of energy that tracks with the surface of the river south of the bridge.
  - vortex eddies
  - increase in force against the eastern bank related to a change in river flow.



Scour Detection—
On-Site Assessment and Monitoring

Civilian Practice

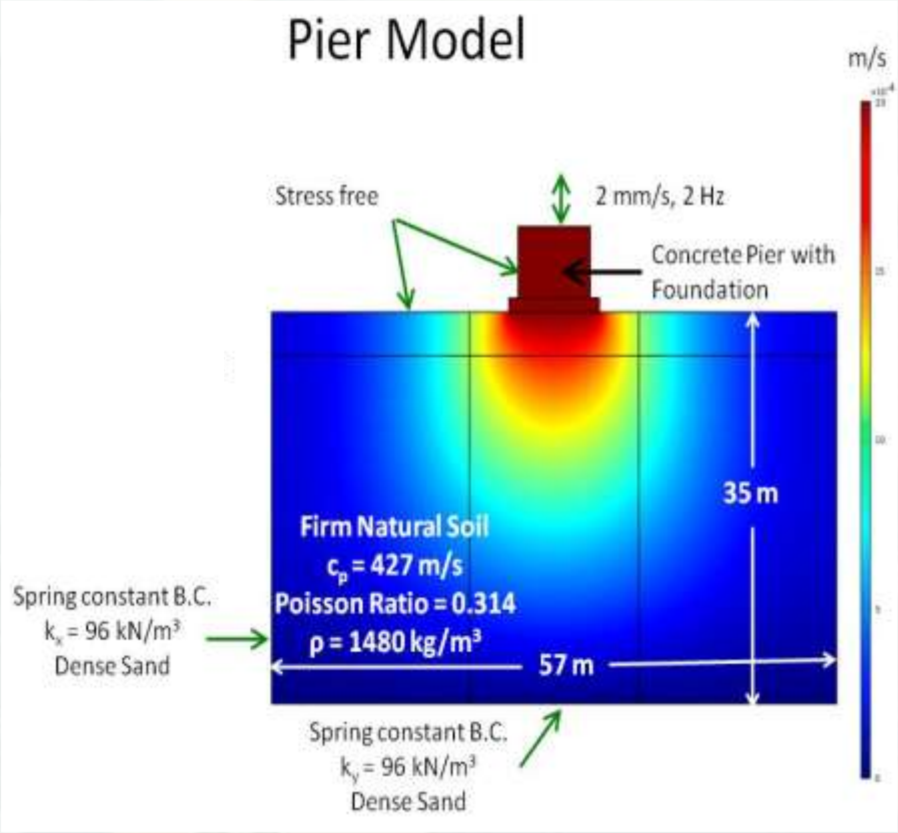
- Civilian on-site monitoring and assessment is an in-depth process governed by the National Bridge Inspection Standards.
- All bridges are inspected every two years, as required by law.

Military Operations

- On-site assessment in military operations is often cursory due to:
  - Time constraints
  - Lack of equipment for proper scour assessment
  - Potential hostilities
- Adapting civilian practice is impractical.

Model Development - Little Piney River Railroad Bridge

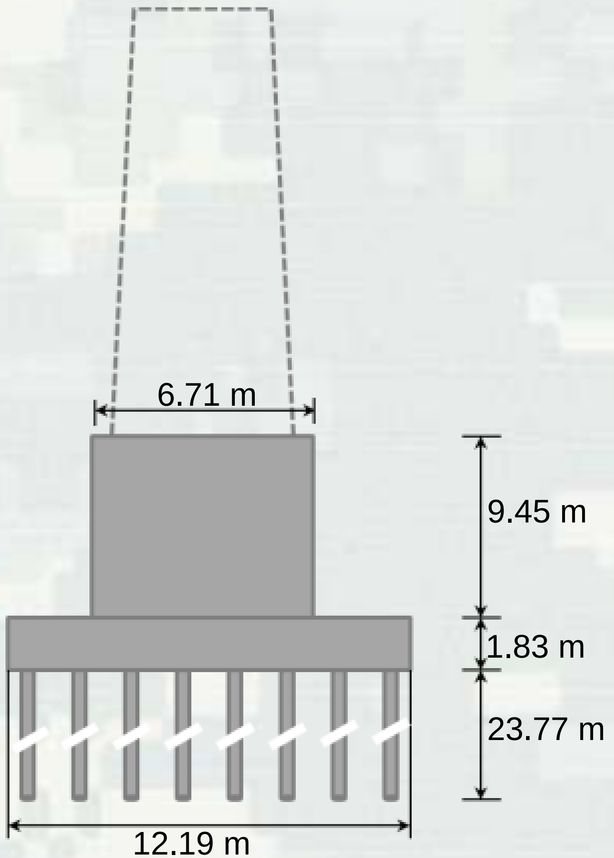
- The concrete piers were modeled in 2-D plane strain;
- Loaded with a prescribed velocity (corresponding to the load produced from a train moving across the bridge);
- Tested with two different soil types to determine if scour depth would cause variation in the fundamental modes of the bridge;
- Scour conditions were modeled as incremental removal of 0.5 m of overburden to the bottom of the footing.



Little Piney River Railroad Bridge

Model Development – I-20 Bridge

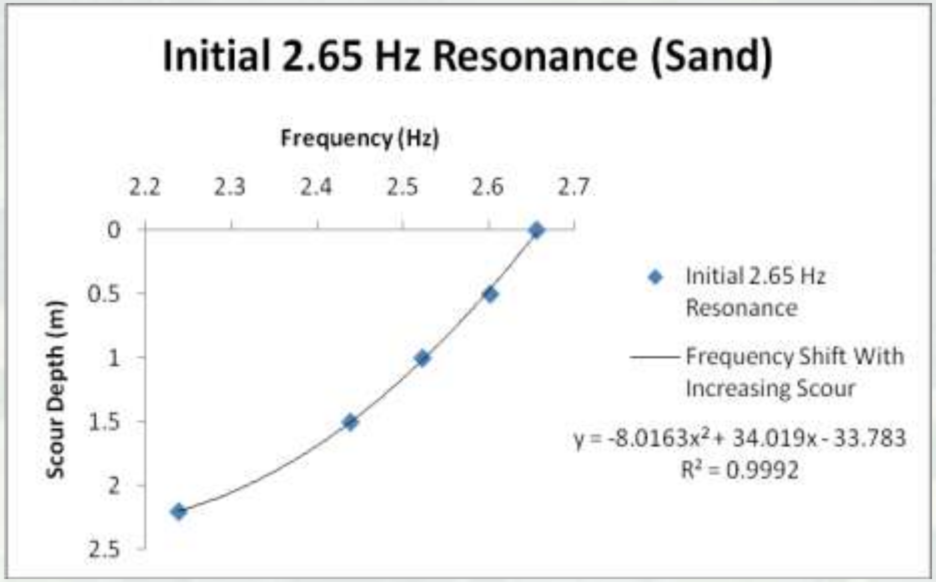
- A simplified model of the pier was modeled along with the design loads for this bridge;
- Modeled in 2-D plain strain condition along the longitudinal axis;
- Tested with the same two soil types as the Little Piney River Bridge;
- The degree of scour varied from a zero scour condition to a total scour condition (6.0 m of exposed pile) in 0.5 m increments.

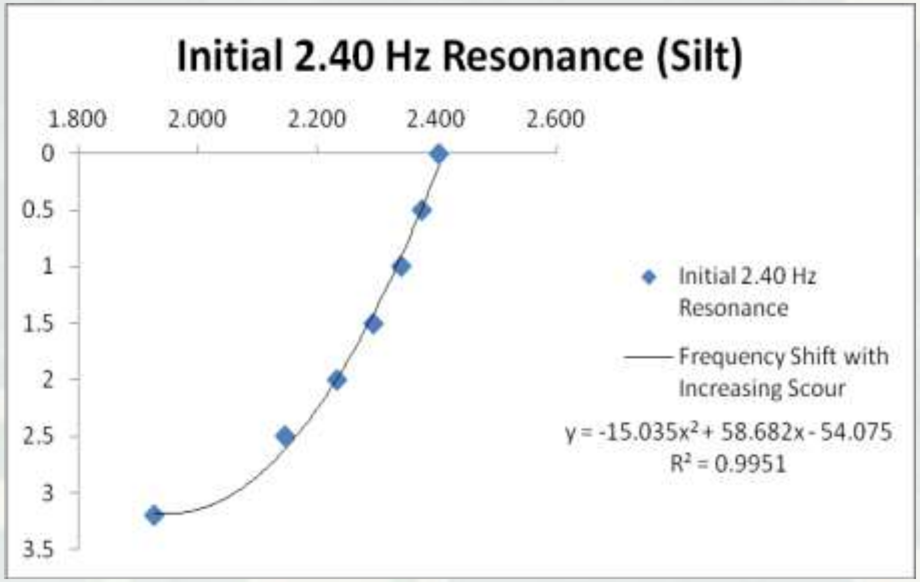


Interstate 20 Bridge

Little Piney River Bridge Results

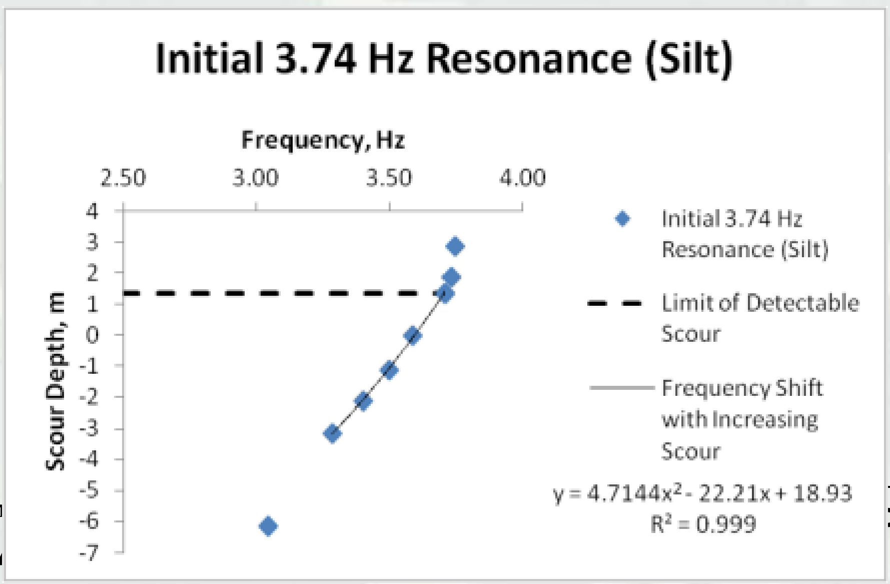
- The highest degrees of variability in eigenfrequencies:
  - **Dense Sand**: 2.65, 5.5, 7.66, 11.09, and 13.51 Hz;
  - **Silt:** 2.40, 4.33, 6.02, and 12.40 Hz.
  - These correspond to the frequencies detected for the railroad truss in the original study.

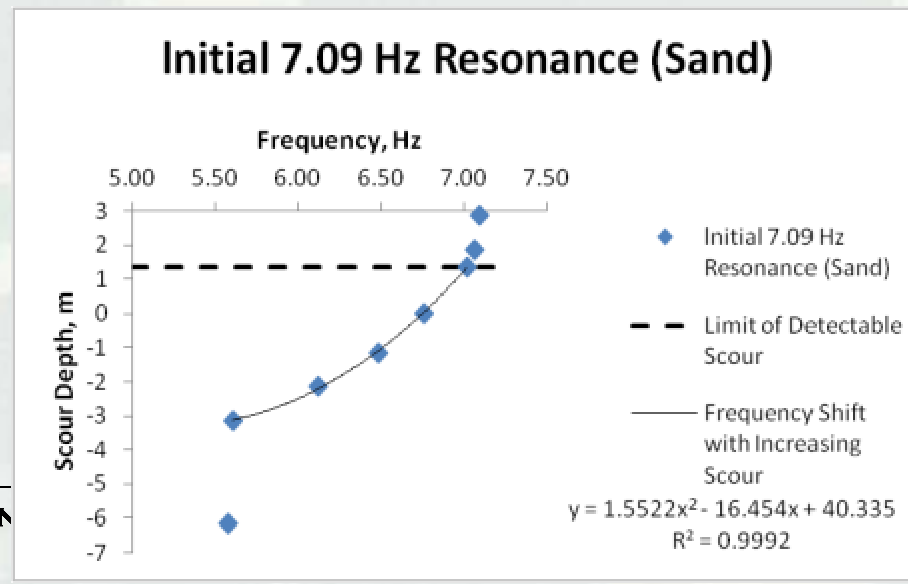




Results—Interstate 20 Bridge

- The highest degrees of variability in eigenfrequencies:
  - **Dense Sand**: 5.01, 7.09, 10.66 Hz, and 10.91 Hz;
  - **Silt:** 3.74 Hz (*no other modes having detectable changes*).
- Clear demarcation is visible (1.36 m) for both soil types.
  - Correlates to the upper bound of detectable scour.
- Beyond 3.0 m change in resonance is minimal regardless of additional scour depth.
  - Hypothesized to correspond to pile buckling capacity.





Implications for Remote Sensing

- Results of this study indicate that detection of scour around bridge piers or at abutments could be possible using detectable changes in fundamental vibrational frequency of the bridge caused by scour.

- For both the shallow and deep foundation cases, **the lower frequencies provided the best correlation between modal variation and increasing scour depth.**

- Provides true remote sensing potential even in denied areas and for military operations.

Implications for Remote Sensing

Civilian Monitoring

- Monitoring is currently limited to one discrete point in time while scour is actually cyclical in nature.
- Remote monitoring could provide a more accurate view of change in scour depth and could be conducted more frequently to develop a scour trend with time.
- Initial results show that the scour depth will vary with frequency change for different soil types.
- Single infrasound system can continuously monitor multiple sites without additional equipment/manpower.

Military Operations

- For bridges in military operations, remote detection of scour would greatly enhance the confidence in analysis of a bridge when an on-site reconnaissance is not possible (whether due to lack of time and/or equipment or potential hostilities).
- Infrasound has the potential to provide a means of more accurately assessing bridges and potential hazards caused by scour in denied areas.

Questions?