A Fresh Look at Impulse Response as a Form of NDT for Concrete Bridge Decks

presented by

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Background:

- Originally developed for deep pile foundations
- Currently most commonly used in aircraft manufacturing
- Since the 1980s applied to concrete plate like structures (ASTM C1740)
  - Poorly consolidated sections
  - Voids in supports
  - Delaminations caused by corrosion in reinforcing steel
**Principle:**
- Impulse signal is recorded and transformed to frequency domain
- Response signal is recorded and transformed to frequency domain
- Dividing these response frequency by the impulse frequency gives ‘Mobility’

\[ \text{Mobility}(\omega) = \frac{\text{Response}(\omega)}{\text{Impulse}(\omega)} \]

Source: ASTM C1740-10

A FRESH LOOK AT IMPULSE RESPONSE
Case Study:

• Steel-concrete composite deck girder bridge in NJ

• Six, Two-span cont. deck slabs, each 36 ft long

• Two lanes
• Total length = 216’
• Road width = 30’
• Age: 25 years

• Severe deterioration/ delamination of the concrete deck, steel reinforcement corroded

• IR performed on a 2’ x 2’ grid on 5 of 6 deck slabs
Testing System:

• PCB Instrumented Hammer

• Accelerometer
  – Used for flat response at low frequencies

• DAQ system

• Post Processing System
ASTM C1740-10 Parameters:

- **Average Mobility**
  - Average mobility value from 100 to 800 Hz

- **Dynamic Stiffness**
  - Inverse of the slope of the mobility from 0 to 40 Hz

Source: ASTM C1740-10
ASTM C1740-10 Parameters:

- Mobility Slope
  - Slope of mobility from 100 to 800 Hz

Source: ASTM C1740-10
ASTM C1740-10 Parameters:

- Peak-Mean Mobility Ratio
  - Ratio of the peak mobility from 0 to 100 Hz, and the ‘Average Mobility’

![Graph showing mobility vs frequency with labels Void below slab and Good support. Source: ASTM C1740-10]
Current Standard:

- Inconsistent definition of parameters
- Mobility in frequency domain is not uniquely defined
- Idealized Mobility plot is difficult to observe
- Qualitative and relative

![Graph: Mobility vs Frequency](image)

ASTM C1740-10

Concrete Bridge Deck Test (2011)
New Approach:

- Same testing procedure; different post-processing
- Transform Mobility spectrum back into time domain
- Use mobility time signal to find parameters that theoretically characterize the concrete
New Parameters:

- Maximum Mobility Amplitude
  - Large values indicate low stiffness, possibly due to delaminations
- Exponential Rate of Decay
  - Large values of $\alpha$ suggest high damping, possibly due to delaminations
Maximum Mobility Amplitude Results (Example: deck 4):
Exponential Rate of Decay Results (Example: deck 4):
Continuing Research:
• Continue evaluating new approach and parameters

• Testing other effects:
  • Proximity of impact to accelerometer
  • Magnitude of impact
  • Repeatability
  • Slow Dynamics

• Verification of results during deck repair in August 2012

• Combining with other methods (ultrasonic) to confirm results and locate depth of delaminations
Questions?