Non Destructive Evaluation of Concrete Structures

Acoustic Methods: Diagnostics of Reinforced Concrete Bridges

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Overview

- Introduction to NDE
- Overview of Acoustic Emission
- Reinforced Concrete Bridges & AE
- Cases Studies
- Analysis & Discussion
- Conclusion

Nondestructive Evaluation

Techniques to assess concrete homogeneity and quality without disturbing or damaging the specimen under control.

NDE techniques are characterized as follows:

- Active or passive
- Surface (or near surface) or volumetric

Examples of NDE Methods

- Visual Inspection
  - 1st stage of concrete evaluation
  - very useful but limited
  - qualitative results

- Rebound Hammer
  - surface hardness test
  - relationship between rebound number & concrete strength?
  - quickest, simplest & cheapest NDE test

Examples of NDE Methods

- Thermography
  - • technique to obtain an image distribution over the surface of an object due to temperature differences
  - • special camera with infra-red radiation
  - • damage & energy related condition of building
- Pachometer

  locate bar position & cover thickness

- Radiography
  - • high energy gamma-ray source
  - • check bar condition & void location in concrete

Acoustic Emission

- It is a passive NDE technique
- Acoustic Emissions:
  - stress waves caused by sudden internal stress redistribution
  - detected by sensors
  - location calculation

Acoustic Emission Parameters

- Arrival time
- Peak amplitude
- Rise-time (time interval between first threshold crossing and peak amplitude)
- Signal duration (time interval between first and last threshold crossing)
- Number of threshold crossings (counts) of the threshold

- Energy (integral of squared (or absolute) amplitude over time of signal duration)

Reinforced Concrete Bridges & AE

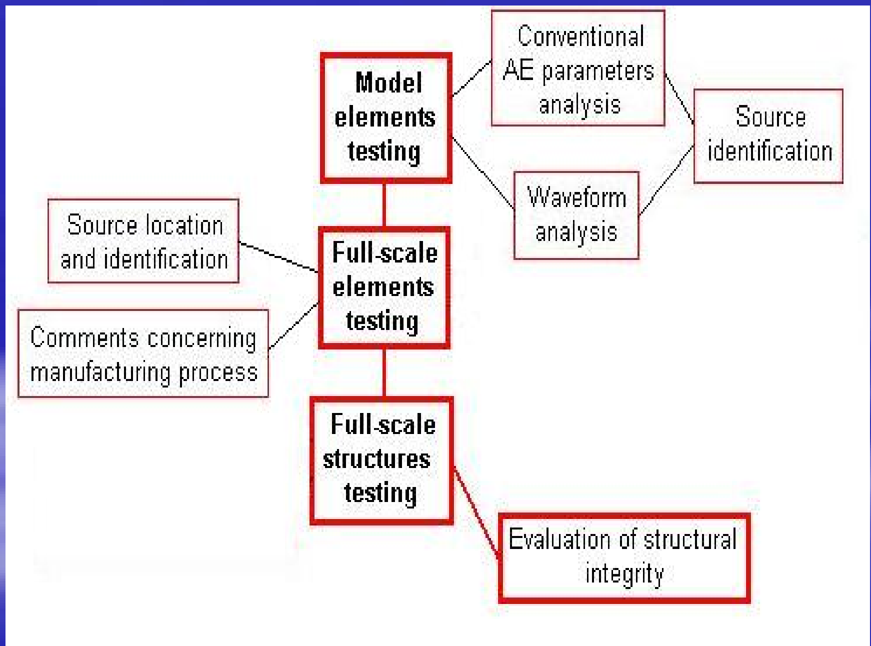
"*31.4 % of our bridges are rated structurally deficient or functionally obsolete. It will require $80 billion to eliminate the current backlog of bridge deficiencies and maintain repair levels*." [ASCE 1998 Report]

Knowledge of current state of the structures is crucial to determine the best repair program taking into account availability of resources.

→ NDE: techniques that are fast, economic, reliable & non-damaging!

Reinforced Concrete Bridges & AE

Not just if the bridge is damaged but also the extent of the damaged area.



Tests performed in the lab to have a better understanding of the AE parameters & AE test setup.

Case Studies

1- Bryte Bend Bridge

- Location: I-80 traffic over Sacramento River
- Structure: steel boxes, max. span 112.8 m
- Problem: Active cracks
- Test Setup: 6 sensors 375 kHz
- Results: Comparison before & after repair. Less energy release

Case Studies

2- Oregon Bridge

- Location: I-5 traffic over the Columbia River between Portland Oregon and
  Vancouver Washington
- Structure: 2 separate bridge/ 3 lanes each 3,528 ft long each
- Problem: Crack activity, location of cracks
- Test Setup: 5 sensors 175 kHz
- Results: satisfactory results & conform with previous tests results

Case Studies

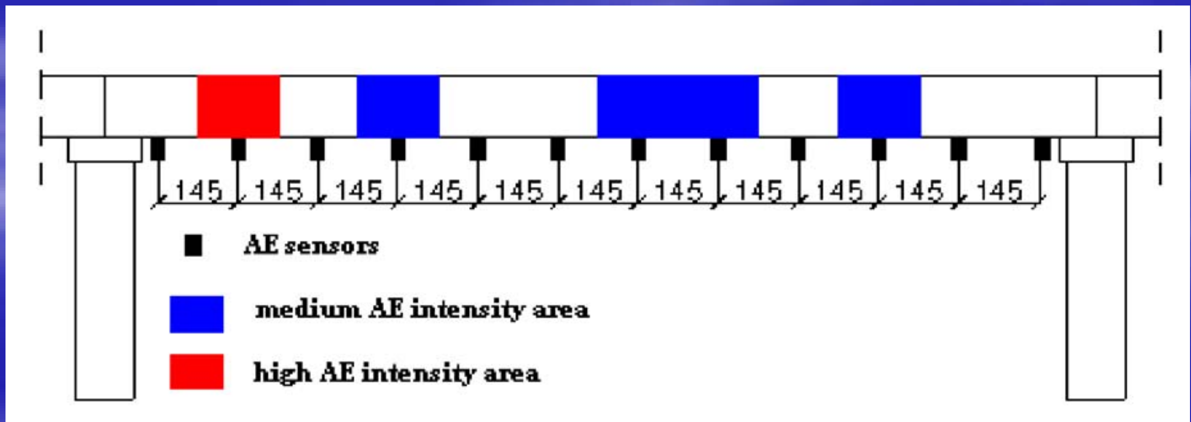
3- A-Bridge

- Location: unknown
- Structure: post-tensioned beams
- Problem: serious damages
- Test Setup: 12 sensors 55 kHz
- Results: high AE hits & energy release in one of the beam. Conform to visual inspection

Case Studies

4- B-Bridge

- Location: unknown
- Structure: pre-stressed beams
- Problem: determine location of seriously damages beams
- Test Setup: 12 sensors 55 kHz, zonal location performed
- Results: one of the beams was highly damaged & needed to be repaired



Case Studies

5- Aging Dock

- Location: unknown surrounded by water
- Structure: reinforced concrete bridge
- Problem: determine structural integrity of bridge
- Test Setup: 3 sensors @ full load
- Results: crack width 0.8 mm & high AE hits indicating serious damages due to corrosion of reinforcement.

Case Studies

6- Brandysek Bridge

- Location: R7 expressway between Prague & Slany
- Structure: reinforced concrete bridge, 13550 ft
- Problem: determine structural integrity of bridge
- Test Setup: many sensors, 1MHz
- Results: no high frequency was found. Little corrosion. Results were verified when the bridge was reconstructed

Analysis & Discussion

Bridge	Structure	Location	Sensors	Threshold	Problem	Results
Bryte	R/C 112.8 m	Sacramento River	6 @ 375 kHz	33 dB	Effect of retrofit	High energy reduction
Oregon	2 bridges each 3,528 ft	Columbia River	5 @ 175 kHz	40 dB	Location of active cracks	Accurate results
A	Post-tensioned	---------------	12 @ 55 kHz	55 dB	Evaluation during loading	Bridge to be repaired or reinforced
B	Pre-stressed	---------------	12 @ 55 kHz	40 dB	Evaluation during loading	Presence of active cracks
Aging	R/C	---------------	------------------	-------------	AE activity in repaired vs. unrepaired	AE activity in some beams
Brandysek	Pre-stressed	Prague & Slany	1 MHz	-------------	Verification of results	No serious corrosion problem

Analysis & Discussion

- The threshold value is crucial to obtain accurate results.
- In most of the tests results were compatible with previous tests
- Additional tests required to obtain quantitative results

Advantages of AE

- Detects activities inside of materials that are active
- Direct contact with reinforcement not required
- Localization is made easy through time differential of signals
- AE monitors continuously in real time, thus security measures can be taken immediately

Disadvantages of AE

- High purchase cost
- Used for one project at a time
- Other NDE methods are needed to provide quantitative results
- Signal discrimination and noise reduction are difficult

Conclusion

- Cheapest NDE method is visual inspection
- NDE gives valuable information about the quality of concrete if used properly
- Improvements to provide more accurate results

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