



Commonly Used NDT Methods

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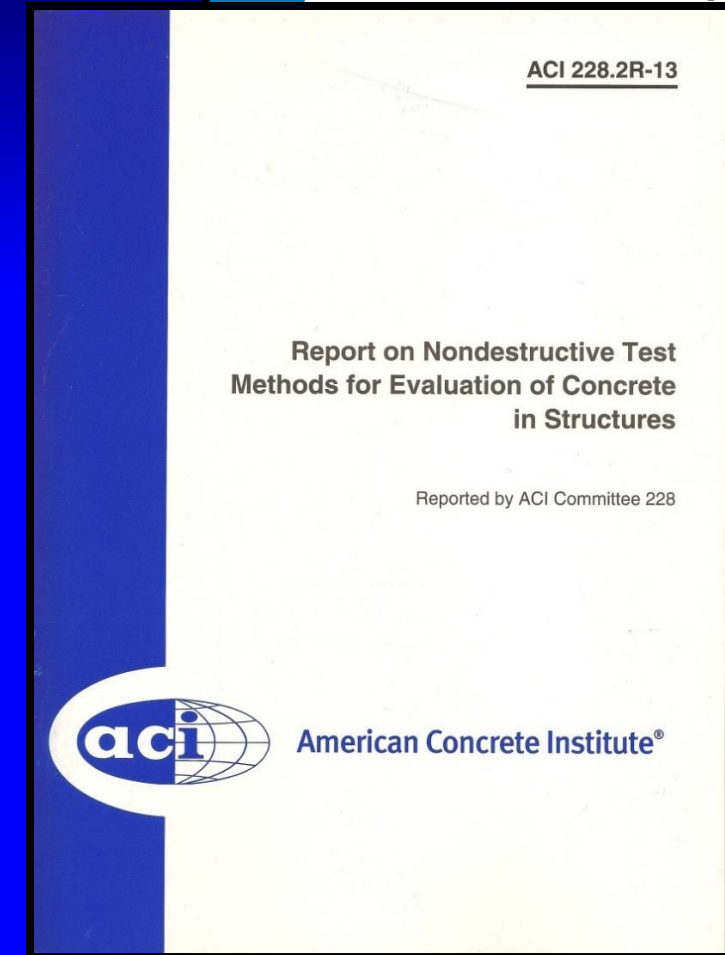


NDT Methods

- Examine specific characteristic or condition of concrete (or reinforcement) in a structure
- Conducted at a particular time or periodically (progression of deterioration)
- Typically focus on particular regions of structure
- Are "active" methods (apply controlled stimulus, measure response)

ACI Committee 228

- Has separated NDT techniques into two groups
 - Methods to estimate in-place concrete strength (surface damage is possible)—ACI 228.1R
 - Methods for characteristics other than strength—ACI 228.2R ←



Report on Methods
for Estimating In-Place
Concrete Strength

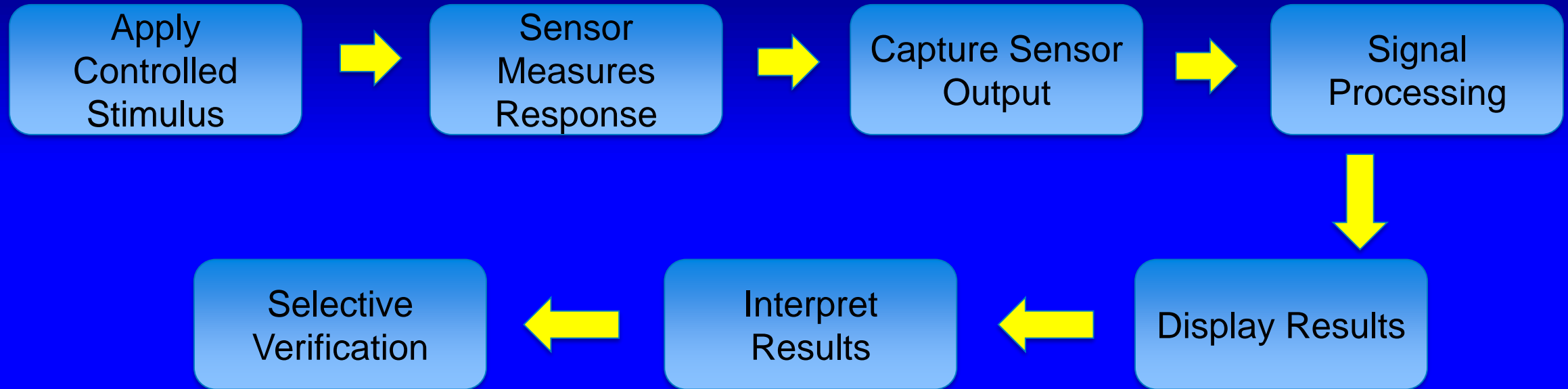
ACI 228.2R-13

Report on Nondestructive Test
Methods for Evaluation of Concrete
in Structures

Reported by ACI Committee 228

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NDT Methods: Typical Methodology

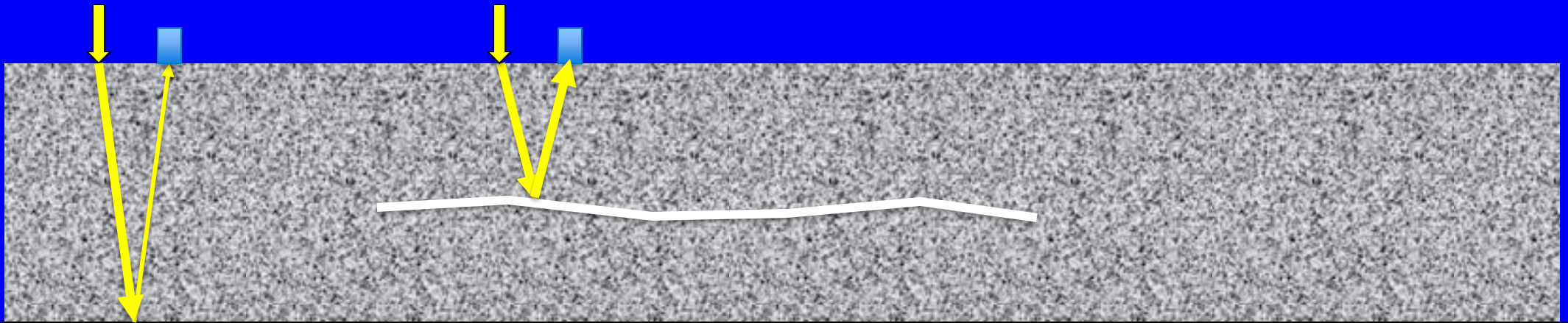


Stimulus and Factors Affecting Response

Stimulus	Factors affecting response	Methods
Stress pulse Transducer or impact	Elastic constants (E,v) and density (acoustic impedance)	UPV, impact-echo, impulse-response, ultrasonic shear wave tomography, ...
High-energy electromagnetic radiation	Density	Gamma or Xray radiography
Low energy, radio frequency electromagnetic pulse	Dielectric constant (air = 1, concrete 4-10, water = 80, metal = infinite)	Ground penetrating radar
Low frequency electromagnetic field	Electrical conductivity or magnetic permeability	Covermeters (eddy current or magnetic reluctance)
Thermal pulse	Thermal conductivity	Infrared thermography

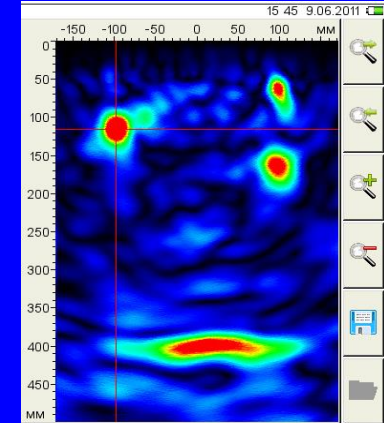
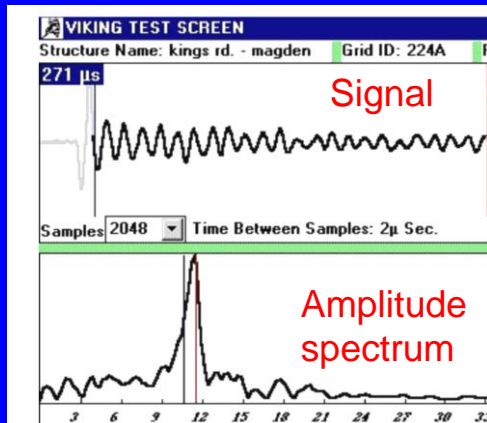
Stress-Wave Methods

- Propagating stress wave reflects at interface where there is a change in acoustic impedance (wave speed * density)
- Acoustic impedance of air ≈ 0 ; total reflection at air interfaces



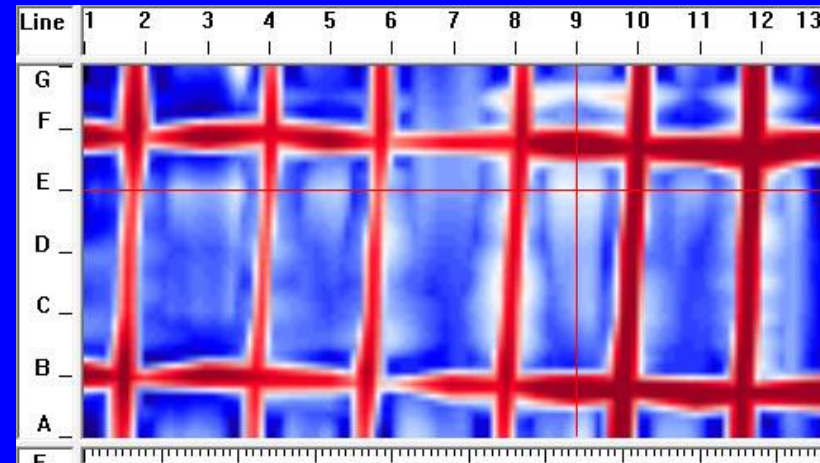
Different Principles for Defect Detection

Method	Stress Wave	Principle	Output
Impact-echo – information at test point	P-wave (impact)	Multiple reflection of P-wave between test surface and internal reflecting interface (resonance condition)	Convert signal to frequency domain, determine the depth frequency, compute depth: $d = \frac{C_p}{2f}$
Ultrasonic shear-wave tomography – information below antenna	S-wave (multiple transducers)	Measure pulse travel times between pairs of transducers	Travel time used to reconstruct 2-D image showing locations of reflecting interfaces below antenna



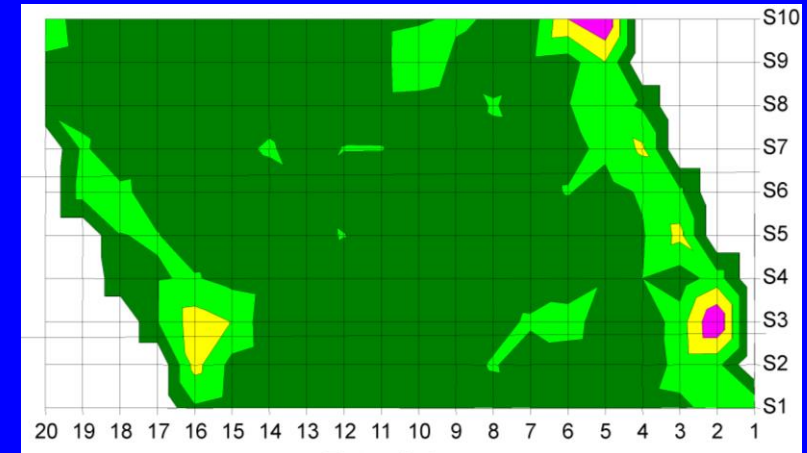
Ground Penetrating Radar

- Total reflection from embedded metal targets (reinforcement, conduit, electrical cables); difficult to detect voids in reinforced concrete
- Computed image from 2-D scan identifies bar locations; apparent diameters not real



Impulse-Response

- Layout test grid (0.5 to 2 m)
- Hammer impact excites flexural modes
- Transducer measure surface motion
- Signal processing computes frequency response function (FRF)
- Characteristics from FRFs are compared to identify anomalous test locations (contour plot)
- Rapid screening to identify locations for closer examination (other NDT or invasive)



Selecting NDT Method

- What is purpose of testing?
 - Voids, cracking, deterioration, corrosion
- How large is the testing area?
- Which methods are best suited for task?
- Are personnel qualified in using the methods and interpreting the results?

Thank You For Your Attention



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