Non-Destructive Testing

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Non-Destructive Testing

What is NDE?

Non-**D**estructive **E**valuation;
Non-Destructive Testing;
Non-Destructive Inspection.

Destructive tests provide ***direct*** and accurate information about something (material properties, location of flaws, etc.)
but…..

Non-destructive tests provide indirect information,
but…..

Common Examples of NDE

Mechanical wave propagation

Ultrasonic image of fetus

Electromagnetic wave propagation

RADAR systems for air traffic control

Penetrating radiation

Medical X-ray

Heat diffusion

Infra-red images of houses (check insulation)

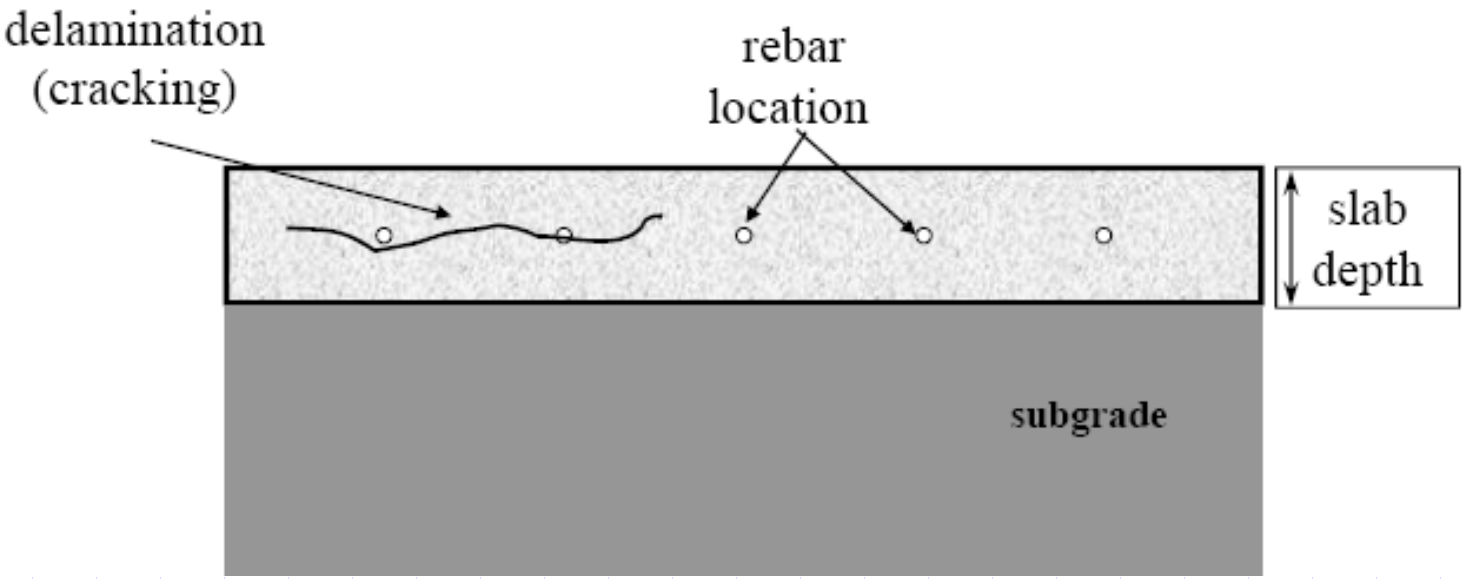
etc.

Many different types of phenomena are used, some more "direct" than others

Why NDE

Need to determine:

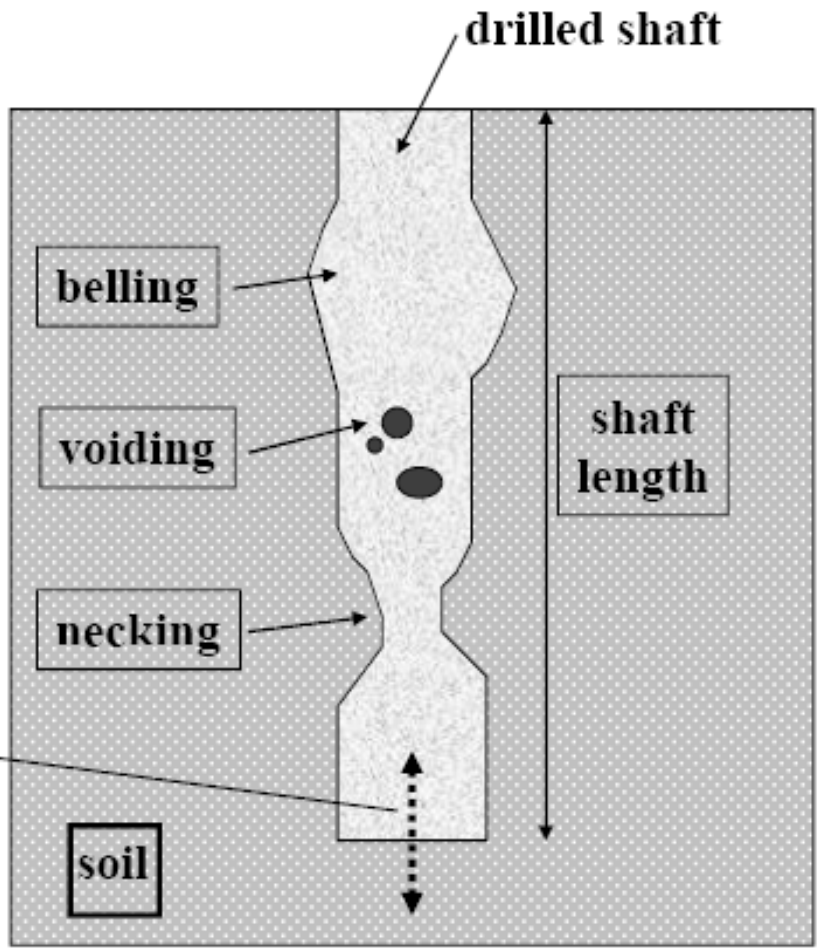
- location and type of internal defects (cracks and voids)
- size (depth, length) of structure



Non-Destructive Testing

Deep foundations
(drilled shafts)

In addition, to length and defects, interested in stiffness of shaft system



Non-Destructive Testing for Strength

Ref. ACI 228.1R-95

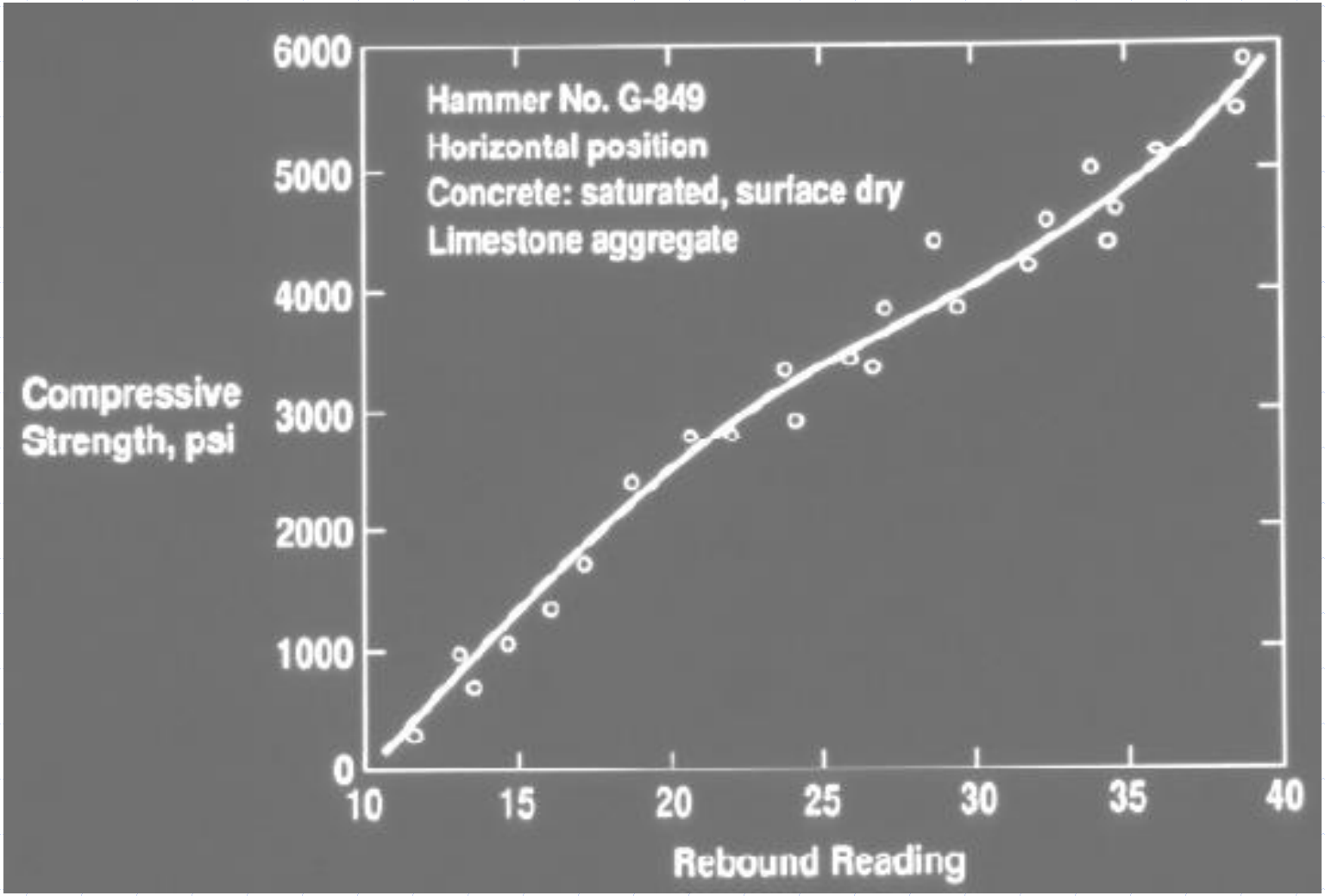
AVAILABLE NDT TESTS

1. REBOUND HAMMER	HARDNESS
2. WINDSOR PROBE	PENETRATION
3. PULSE VELOCITY	MODULUS & DENSITY
4. BREAK-OFF	FLEXURAL STRENGTH
5. PULL-OUT	COMPRESSIVE STRENGTH
6. COMBINED	OFTEN #1 AND #3

Shmidt Hammer

- ASTM C 805
- Measures surface hardness
- Need many readings
- Calibrate to actual materials
- Orientation of hammer
- Used to assess: uniformity, zones of poor quality, deterioration, strength development

Rebound Number vs Compressive Strength

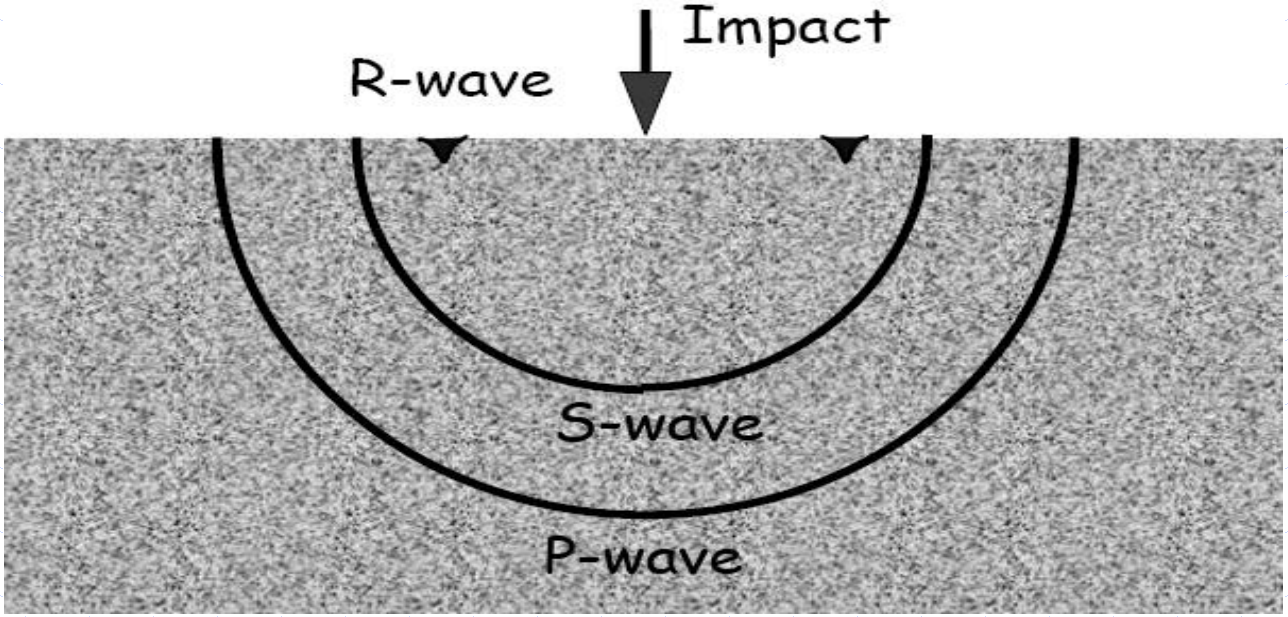


NDT other than Strength

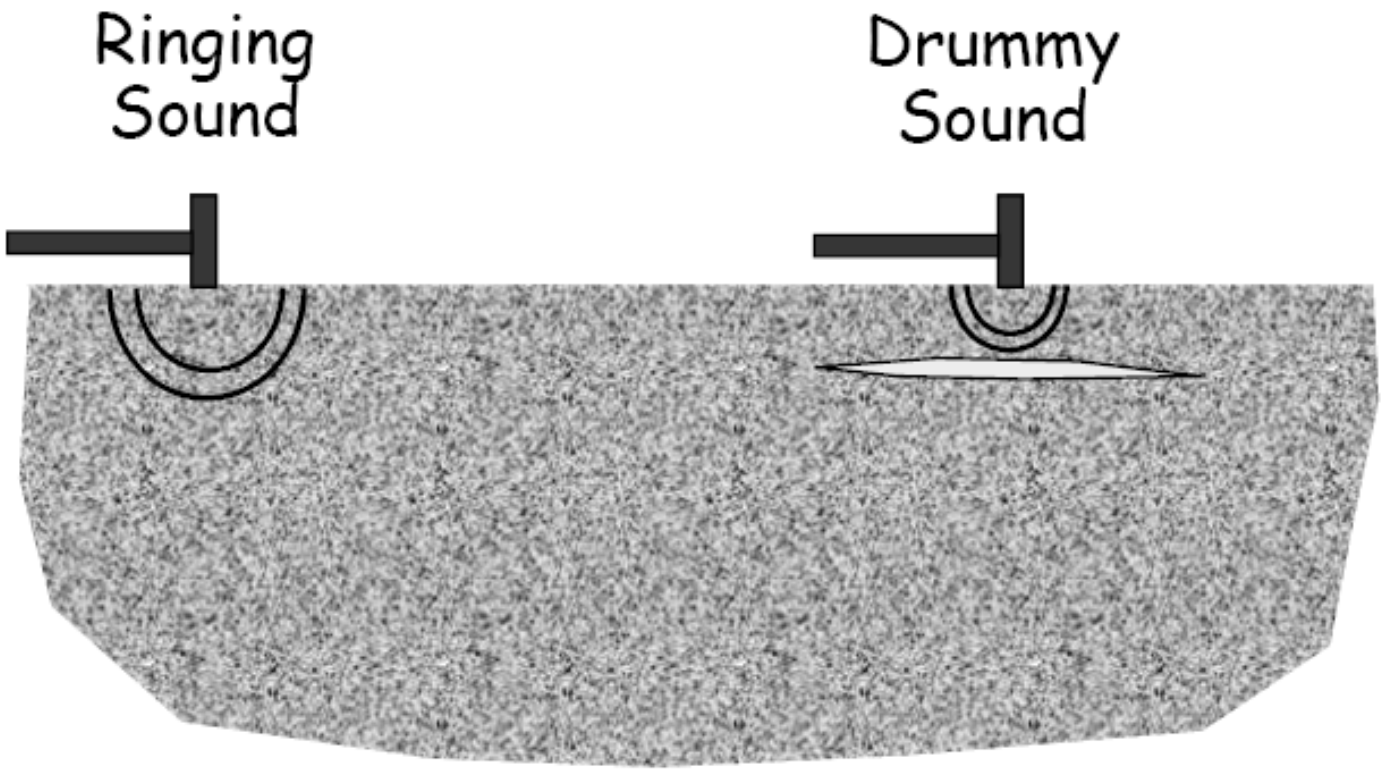
- Member thickness
- Presence of defects
- Location and condition of reinforcement
- Surface penetrability

Principle of Stress Wave Propagation

- Stress waves in a solid are analogous to sound waves in air
- Produced by impact or high-frequency transducers (analogous to a speaker)
- Different types of waves
- Stress waves are reflected at interfaces



Sounding

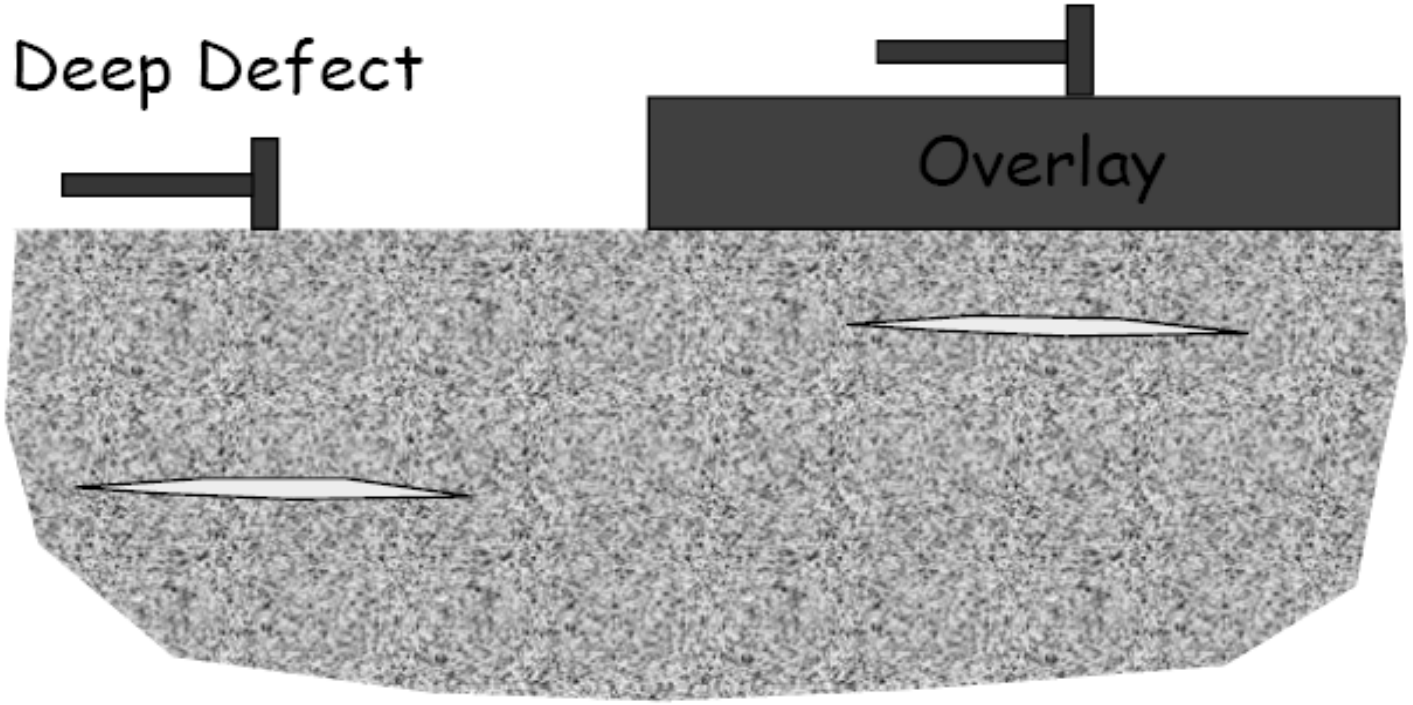


Measuring Delamination

- Chain drag
- Electro-mechanical device

Limitations of Sounding

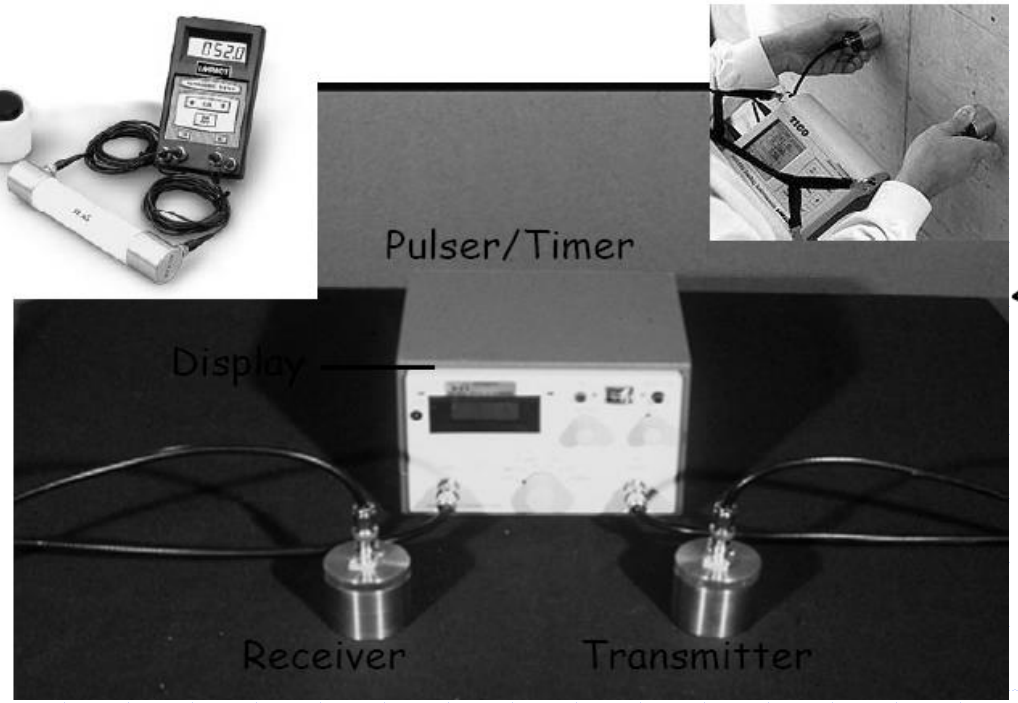
Detection is difficult when:

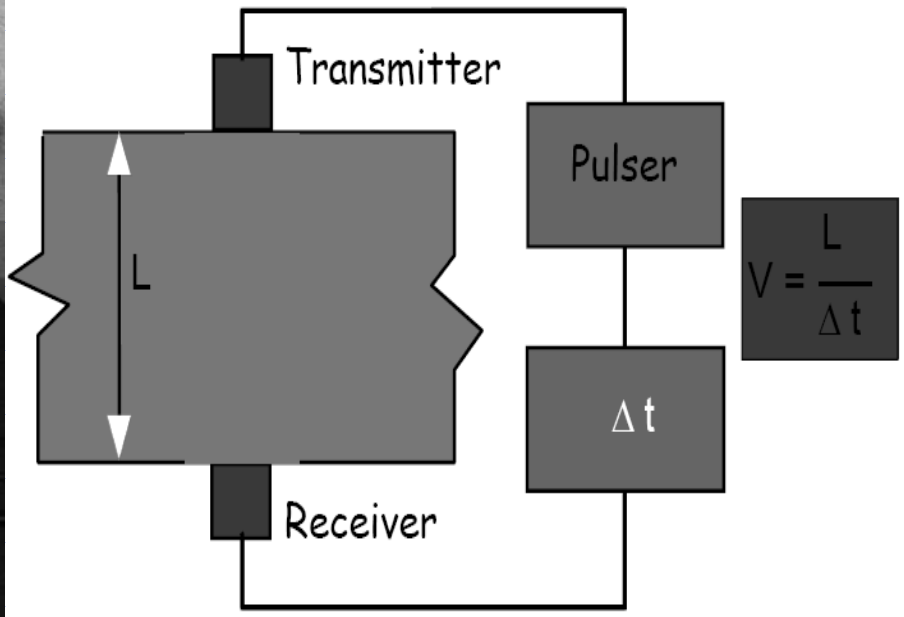


Ultrasonic through Transmission

Ultrasonic Pulse Velocity (ASTM C 597)

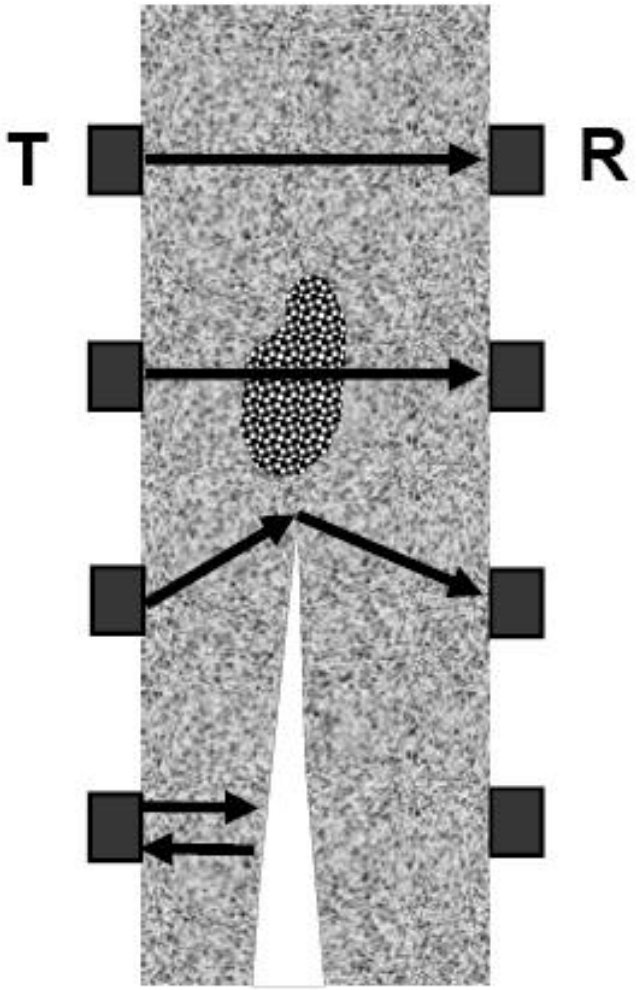
Measure travel time of ultrasonic pulse over known path length





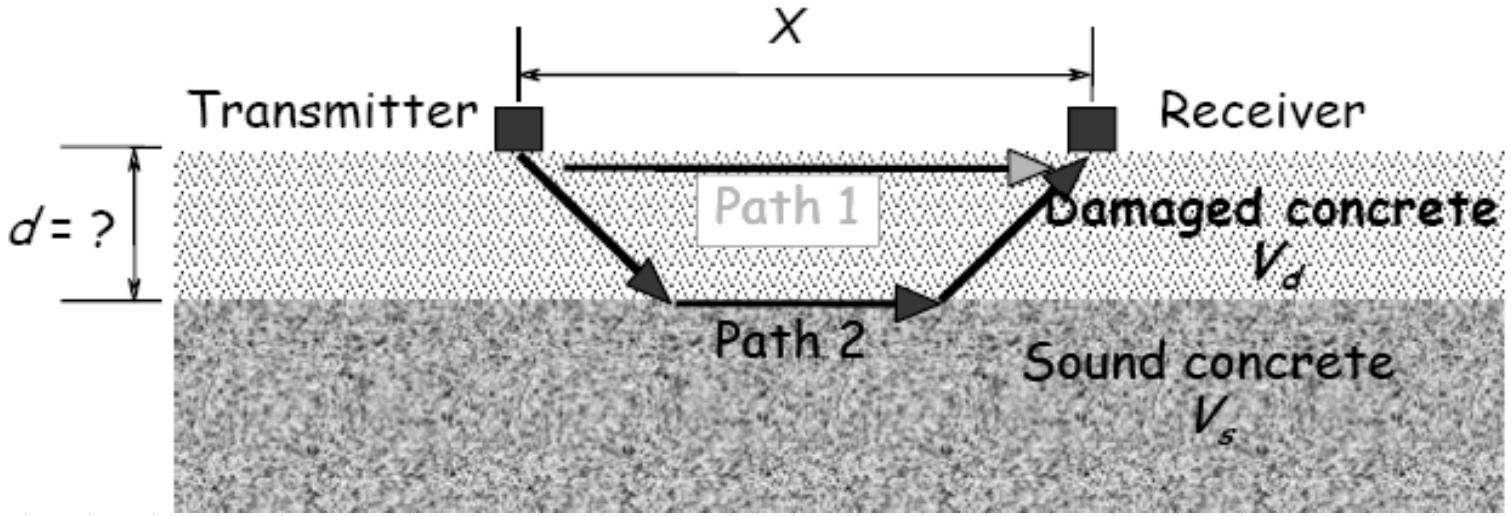
Ultrasonic through Transmission

- Presence of "defects" increases travel time (lower speed)
- Reliable measurement requires access to opposite sides of member



Surface Method

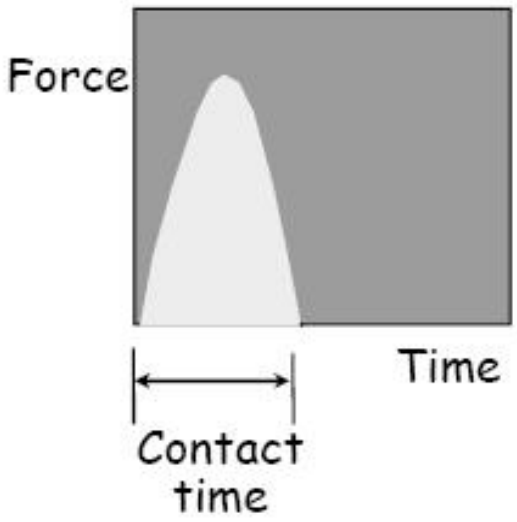
- Measure travel time as a function of distance, X, between transducers
- Determine depth of interface, d
- Requires faster wave speed in bottom layer

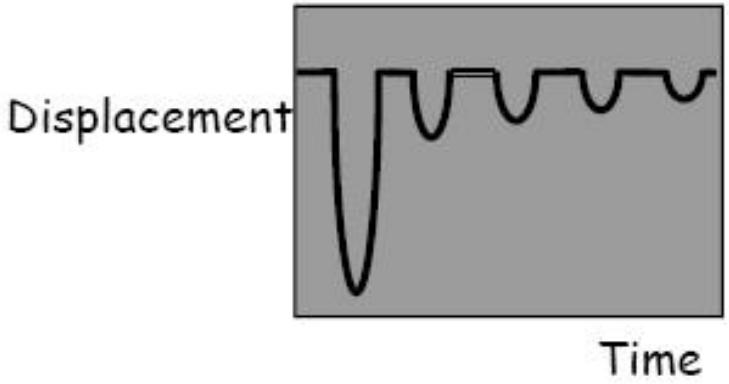


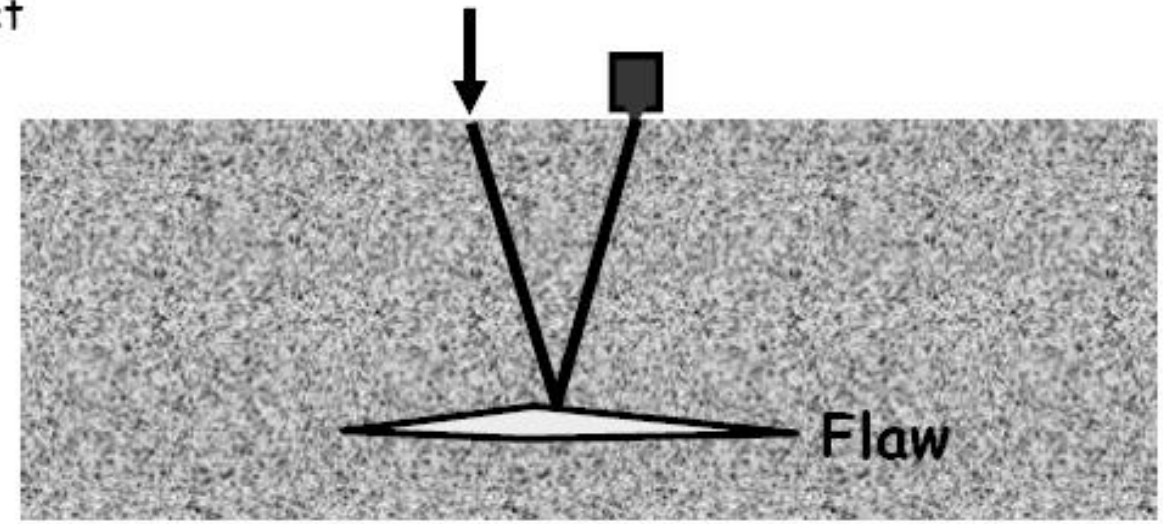
Impact-Echo Method

- Impact used to generate stress waves
  - Short duration < 100 μs
- Transducer adjacent to impact point monitors surface motion (waveform)
  - High fidelity, displacement sensor
- Frequency analysis of recorded waveforms to establish presence and depth of flaw
  - Waveform analyzer
  - PC-based system

Impact-Echo Method







Application of Impact-Echo Method

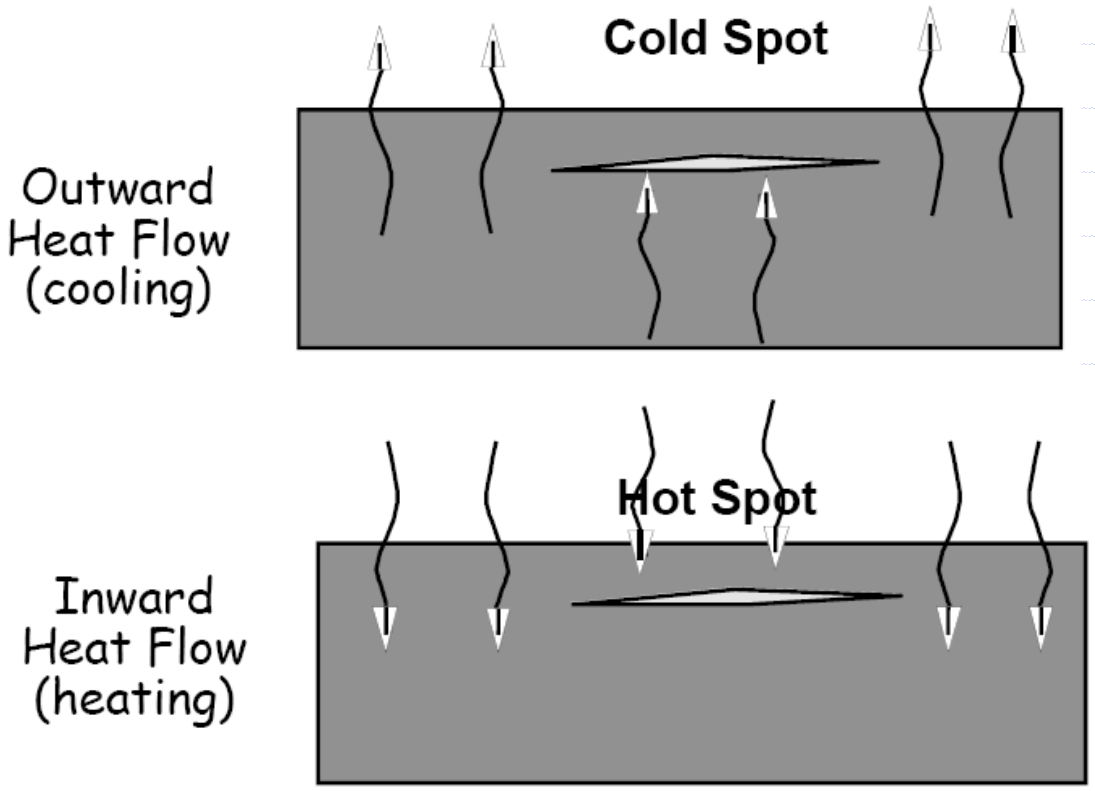
- Voids or honeycombing
- Delaminations (at reinforcement, asphalt/concrete interface, overlay, repair)
- Depth of surface-opening cracks
- Member thickness (ASTM C 1383)
- Voids in grouted tendon ducts

Elastic Stress Wave Methods

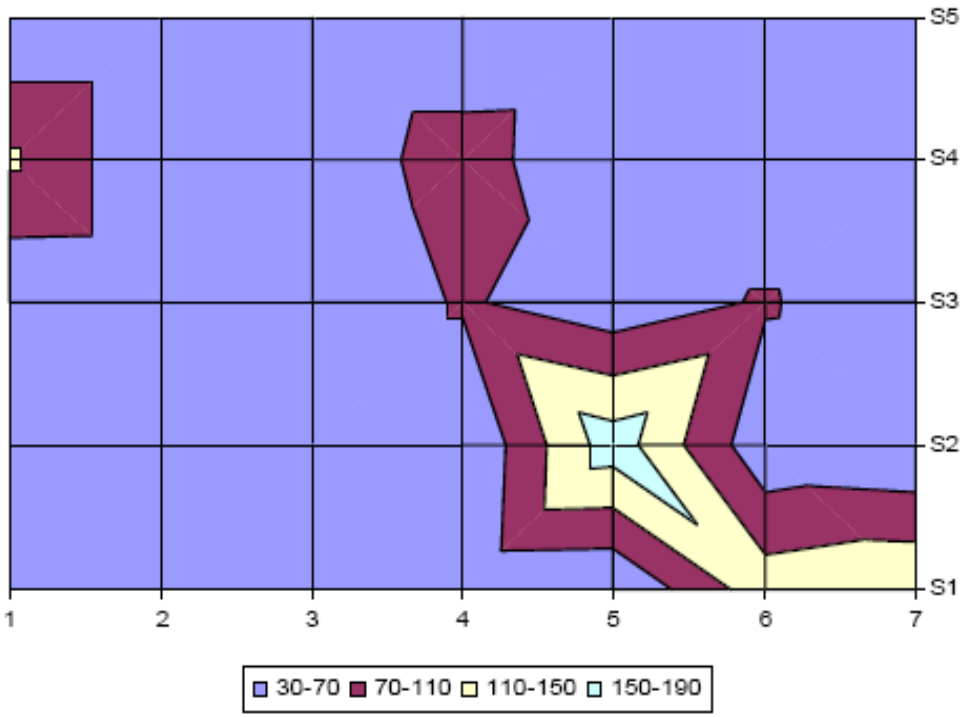
Method	Advantage	Limitations
Ultrasonic through transmission	Portable equipment; easy to use	Access to opposite sides; the indirect method not understood well; no information on depth
Impact echo	Access to one side only; information on depth; detect various defects; commercially available equipment; standard test method	Experienced operator; limited member depth
Spectral analysis of surface waves	Elastic constants of layered systems; one side	Experienced operator; complex data analysis

Infrared Thermography (ASTM D 4788)

- Presence of internal "flaw" alters heat flow through material and results in hot or cold spots on the surface.



Honey Combing Detection



Applications of Infrared Thermography

- Delaminations in bridge decks and reinforced pavements
- Requires proper weather conditions (solar radiation, cloud cover, wind speed, moisture)
- Interference due to surface conditions (emissivity)
- Near surface detection

Evaluation of Reinforcement

- Covermeter
  - Location
  - Cover
  - Size
- Half-cell potential
  - Likelihood of active corrosion
- Polarization Resistance
  - Corrosion rate

Corrosion Evaluation

- Half-cell potential
  - Indicator of likelihood of corrosion
- Electrical resistivity
  - Affects corrosion rate
- Polarization resistance
  - Indicator of corrosion rate
- Chloride content
  - Depassivation