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Integrity Assessment Techniques

MAB1033 Structural Assessment & Repair
Prof. Dr. Azlan Abdul Rahman
Universiti Teknologi Malaysia (UTM)

Introduction

Integrity assessment involves either,

- Determination of localised integrity of a particular element, or
- General assessment of behaviour of entire structure.

Reasons for Integrity Assessment

- Assessment of fire damage or other accidental damage.
- Assessment of effects of overloads.
- Detection of delaminations.
- Detection of construction defects.
- Identification of hidden construction details.

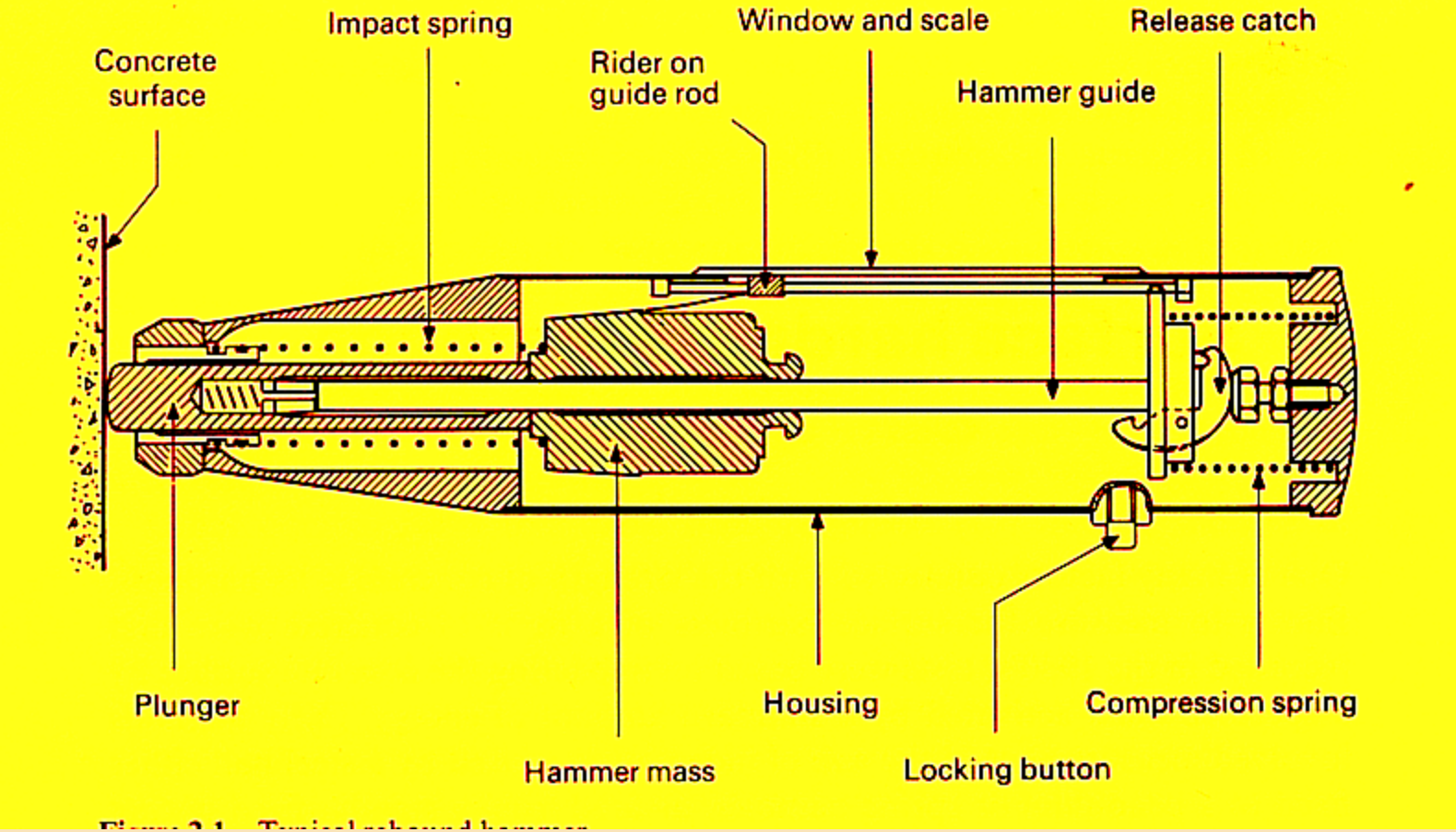
Range of Testing Methods

- Rebound Hammer (surface hardness)
- Ultrasonic Pulse Velocity (UPV)
- Dynamic Response
- Radiography
- Radiometry
- Thermography
- Radar

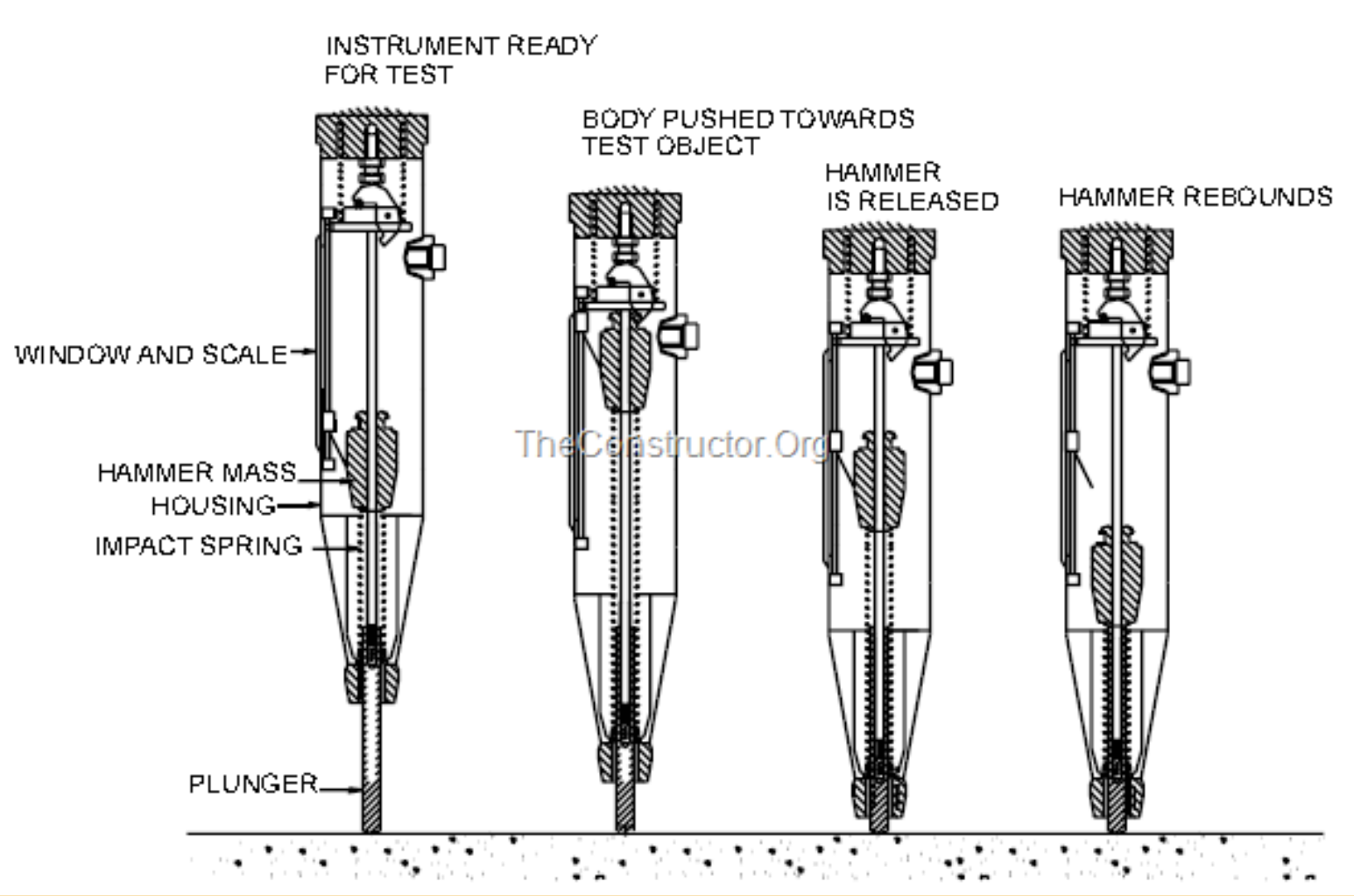
Surface Hardness Test

- A Rebound (or Schmidt) Hammer consists of a mass impacting the concrete surface with a standardized energy and causing localized crushing.
- The amount of rebound of the mass is measured & expressed as a ‘rebound number’.
- A quick & simple test but not recommended for absolute strength assessment.
- Strength correlations provided with the equipment should only be used when confirmed by calibration trials for the condition of use.

The Rebound Hammer



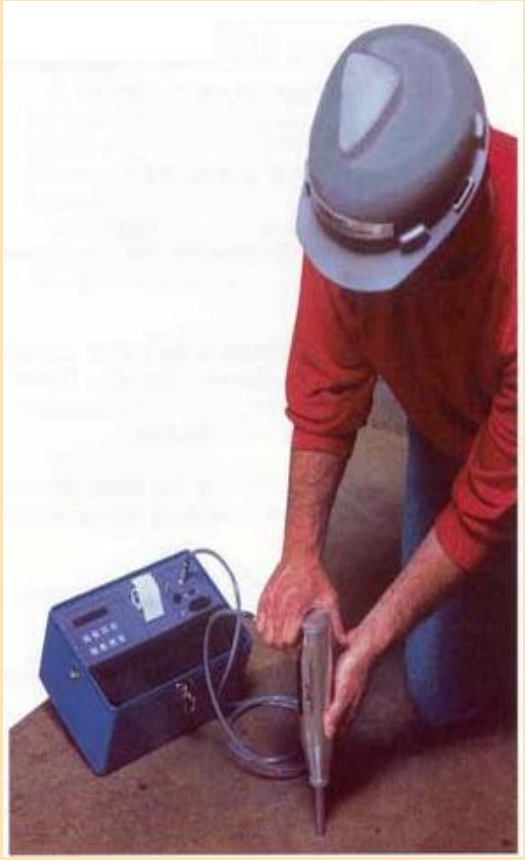
The Rebound Hammer



The Rebound Hammer

Conventional Rebound Hammer

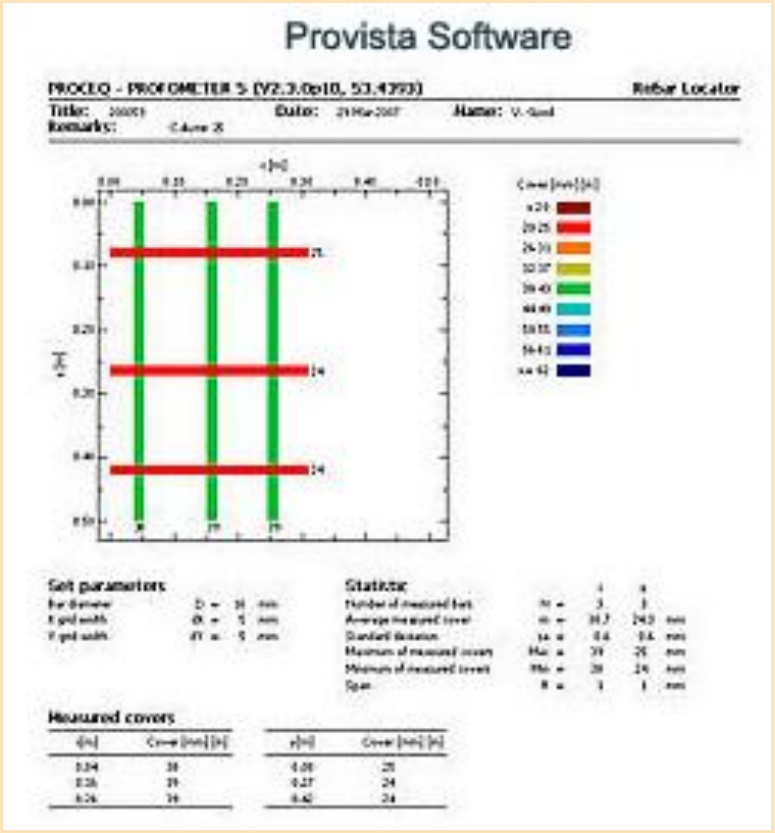
Calibration Anvil



Digital Rebound Hammer in Use

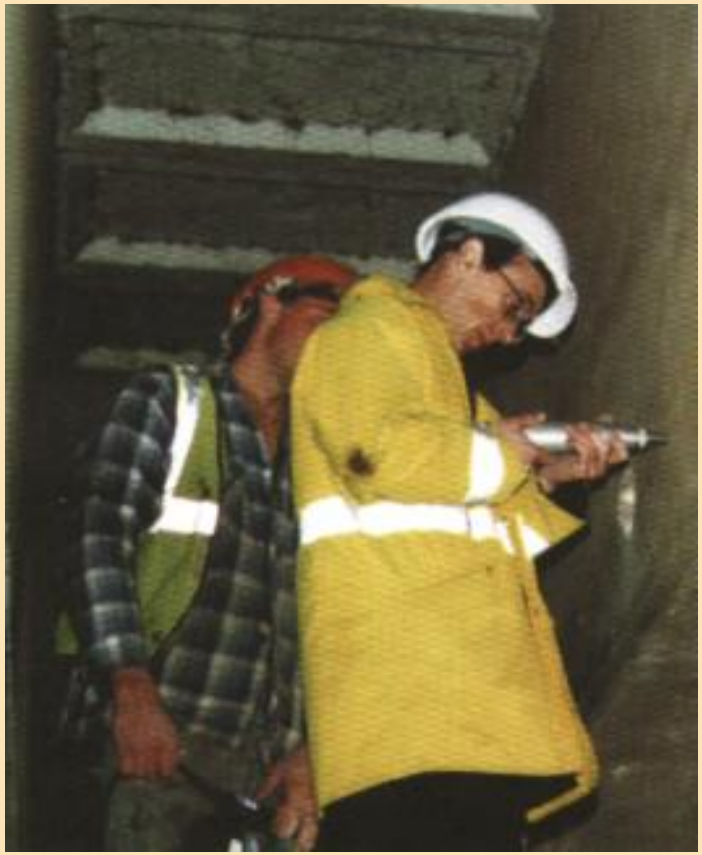
The Rebound Hammer

Digitalized Rebound Hammer



Use of the Rebound Hammer

Rebound Hammer Test



The Rebound Hammer (contd.)

- Results of rebound hammer are affected by conditions within 30mm of the surface & may be greatly influenced by localized carbonation hardening in concrete > 3 months old & member rigidity.
- Use is most reliable in determination of uniformity of young concrete with CoV of 4% on good concrete.
- Details of test described in BS1881 Part 202.

Rough Guide on Rebound Hammer

Rebound Hammer Nos.	Probable Concrete Strength (N/mm2)	Concrete Quality Assessment
< 25	20	Poor
25 – 35	20 – 30	Intermediate
> 35	> 30	Sound

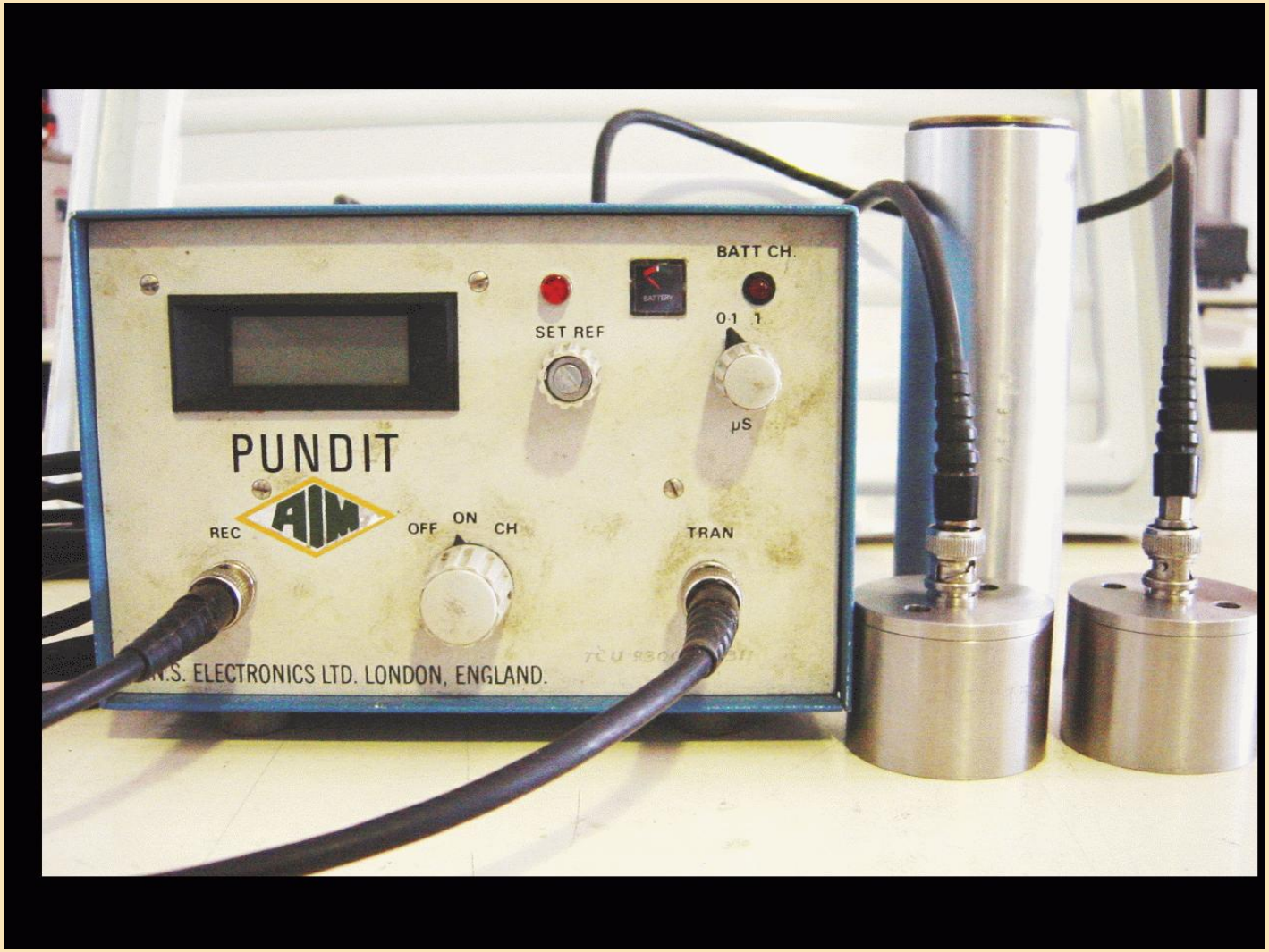
Factors Affecting Rebound Hammer Test

- Mix characteristics
- Concrete maturity
- Moisture conditions
- Nature of surface finish
- Instrument orientation (horizontal, vertical etc.)
- Surface carbonation hardening
- Inadequate member rigidity
- Test located on aggregate particle at the surface.
- Reinforcement close to the surface.

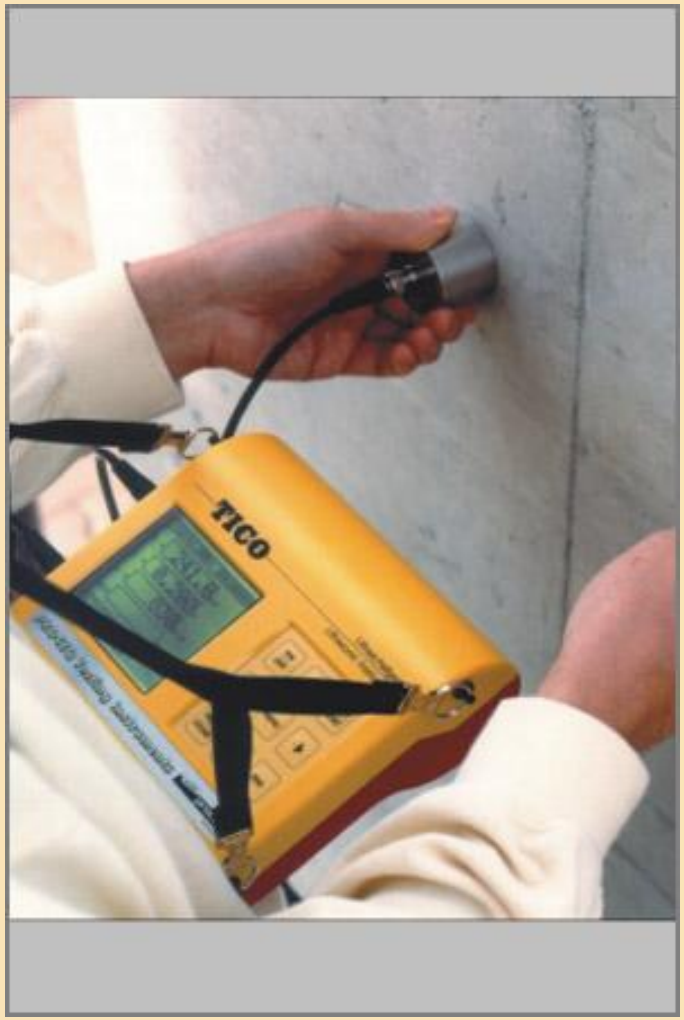
Ultrasonic Pulse Velocity

- Measurements are made of the transit time of a high-frequency pulse (typically 54kHz) over a measured path length between transducers placed on the concrete surface
- Well established method, quick & reflects the characteristics of the interior of a concrete member.
- UPV test method is well documented in BS 1881 Part 203.

The UPV Equipment

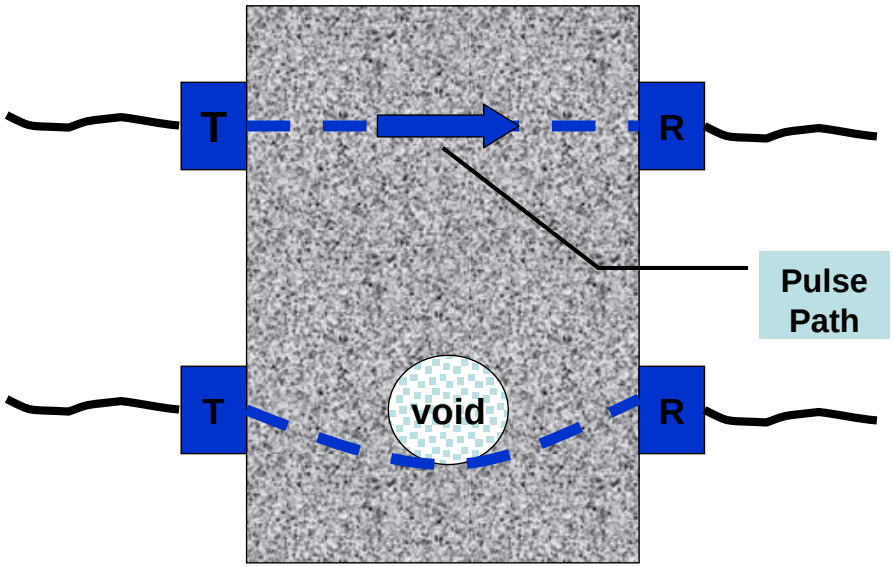


Modern Version of PUNDIT



Principle of Pulse Measurement

The UPV Measurement



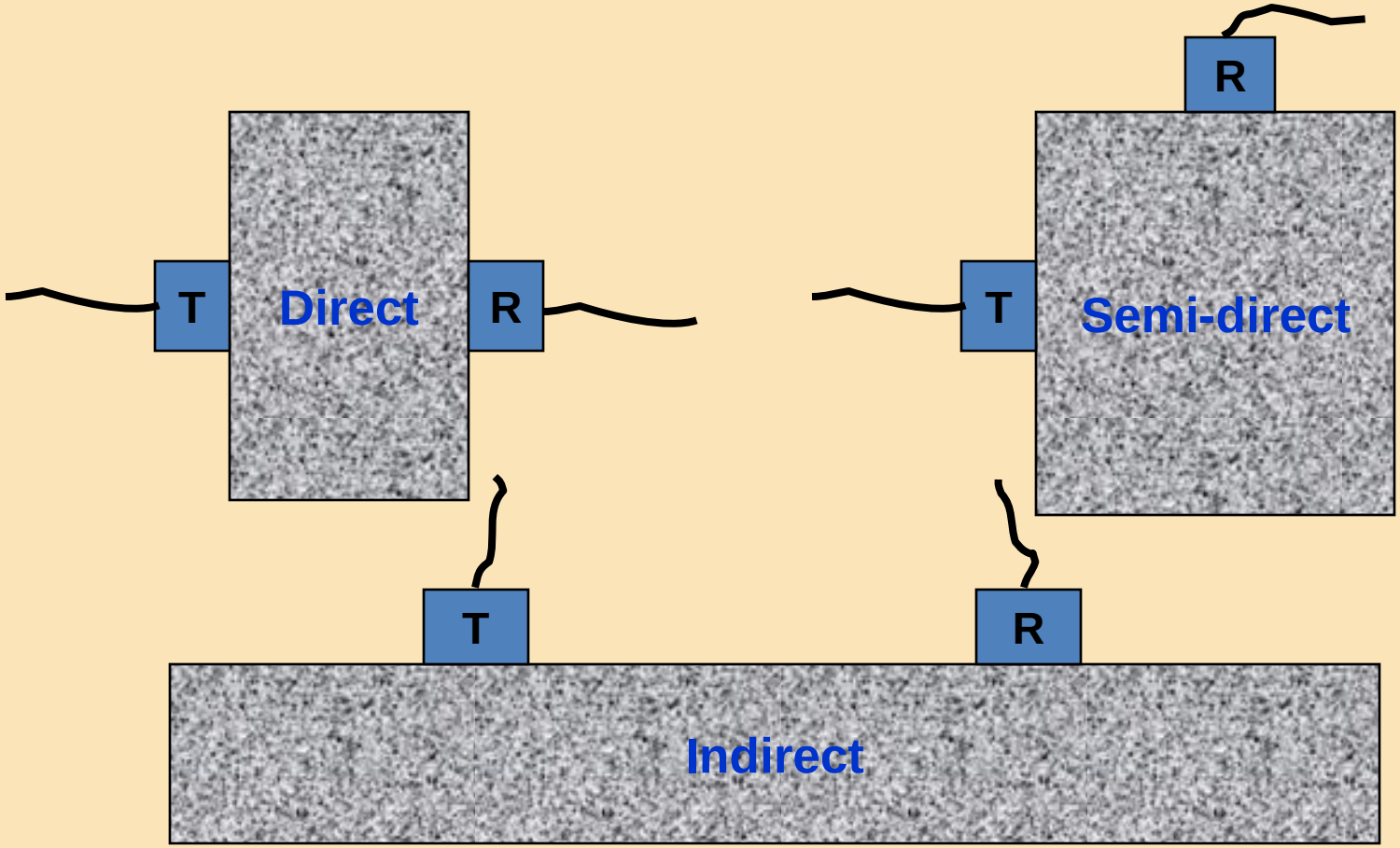
The Pulse Velocity

$$\text{Pulse Velocity (km/sec)} = \frac{\text{Path Length (m)}}{\text{Transit Time (microsec)}}$$

Rough Guide UPV

Pulse Velocity (km/sec)	Probable Concrete Quality
> 4.5	Excellent
3.5 – 4.5	Good
3.0 – 3.5	Fair (Doubtful)
2.0 – 3.0	Poor
< 2.0	Very Poor

Direct UPV Measurements



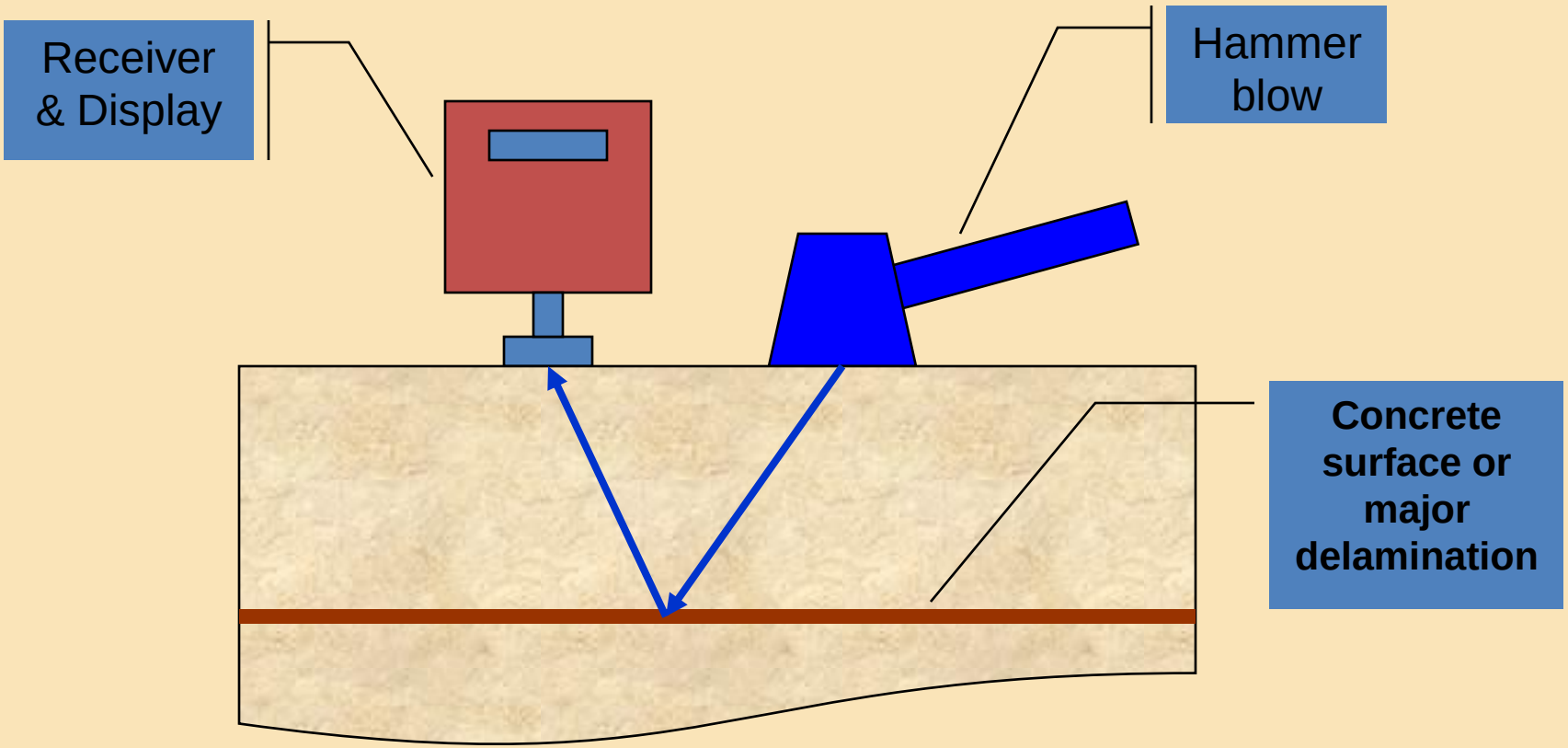
UPV Measurement (contd.)

- Most reliable applications are for determination of concrete uniformity & the location of internal defects.
- Strength estimation may be possible with the aid of correlation charts.
- Access is required to opposite faces of the concrete member for the most reliable results & surface staining may result from use of couplants.
- Erroneous results may be caused by : poor surface coupling, internal air-filled cracks or voids, reinforcement bars, small path length or small lateral dimensions.
- Corrections may be made for the presence of reinforcing bars close to the pulse path if unavoidable.
- A 2% change in UPV if often regarded as indicative of a significant difference in concrete properties.

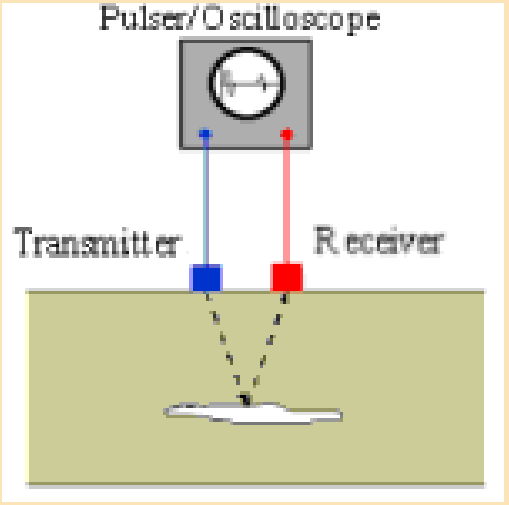
Dynamic Response : Pulse Echo Tests

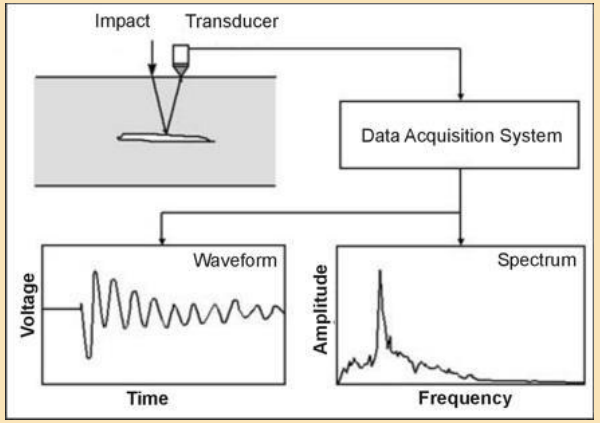
- Involves the measurement at a concrete surface of the internally reflected shock waves from a single hammer blow or similar impact on the surface.
- An accelerometer placed on the concrete surface is used to monitor stress waves resulting from the impact & the output is displayed visually as a digital reading of the amplitude using simple hand-held equipment or oscilloscope.
- Pulse-echo technique using instrumented hammer is well-established in the field of pile testing and are widely used to assess length & uniformity.

Principle of Pulse Echo



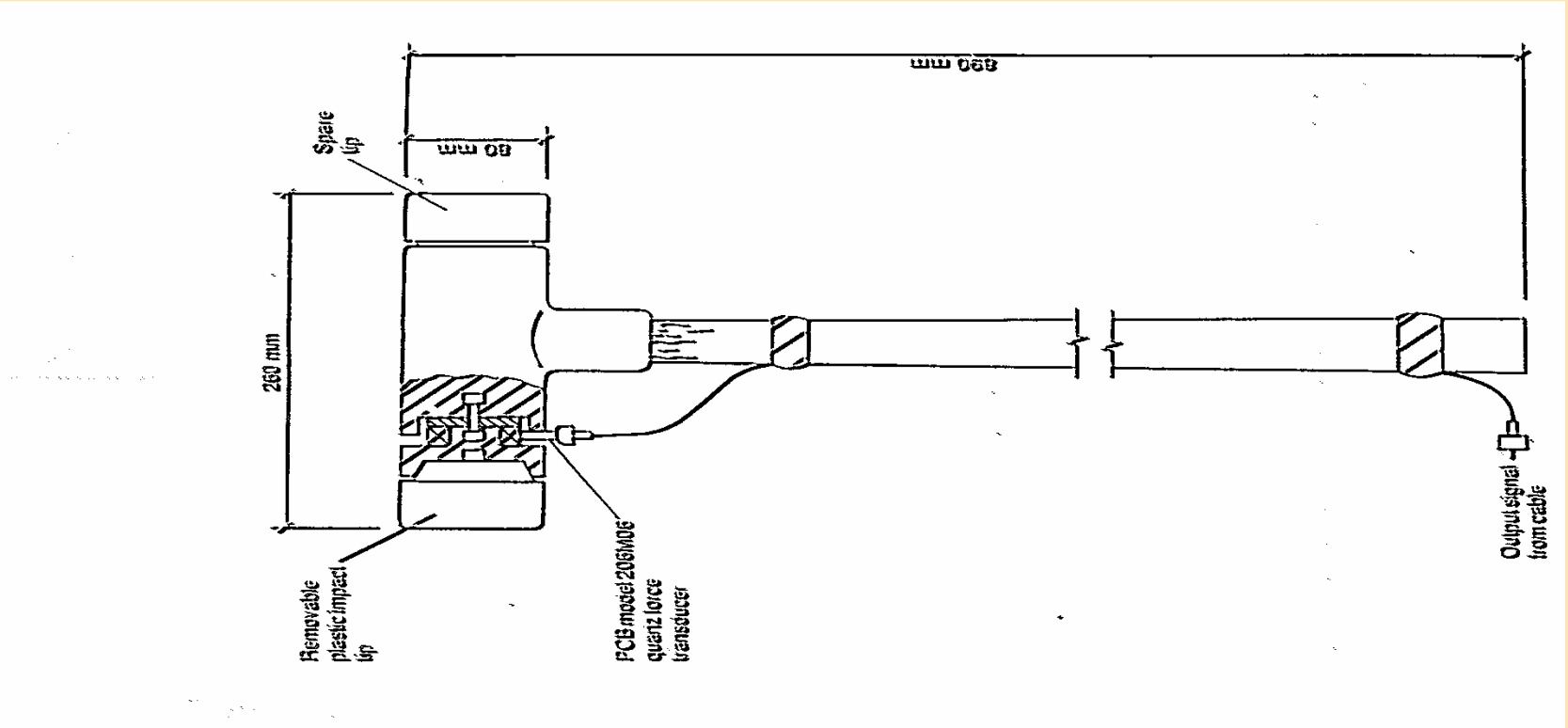
Pulse Echo / Impact Echo



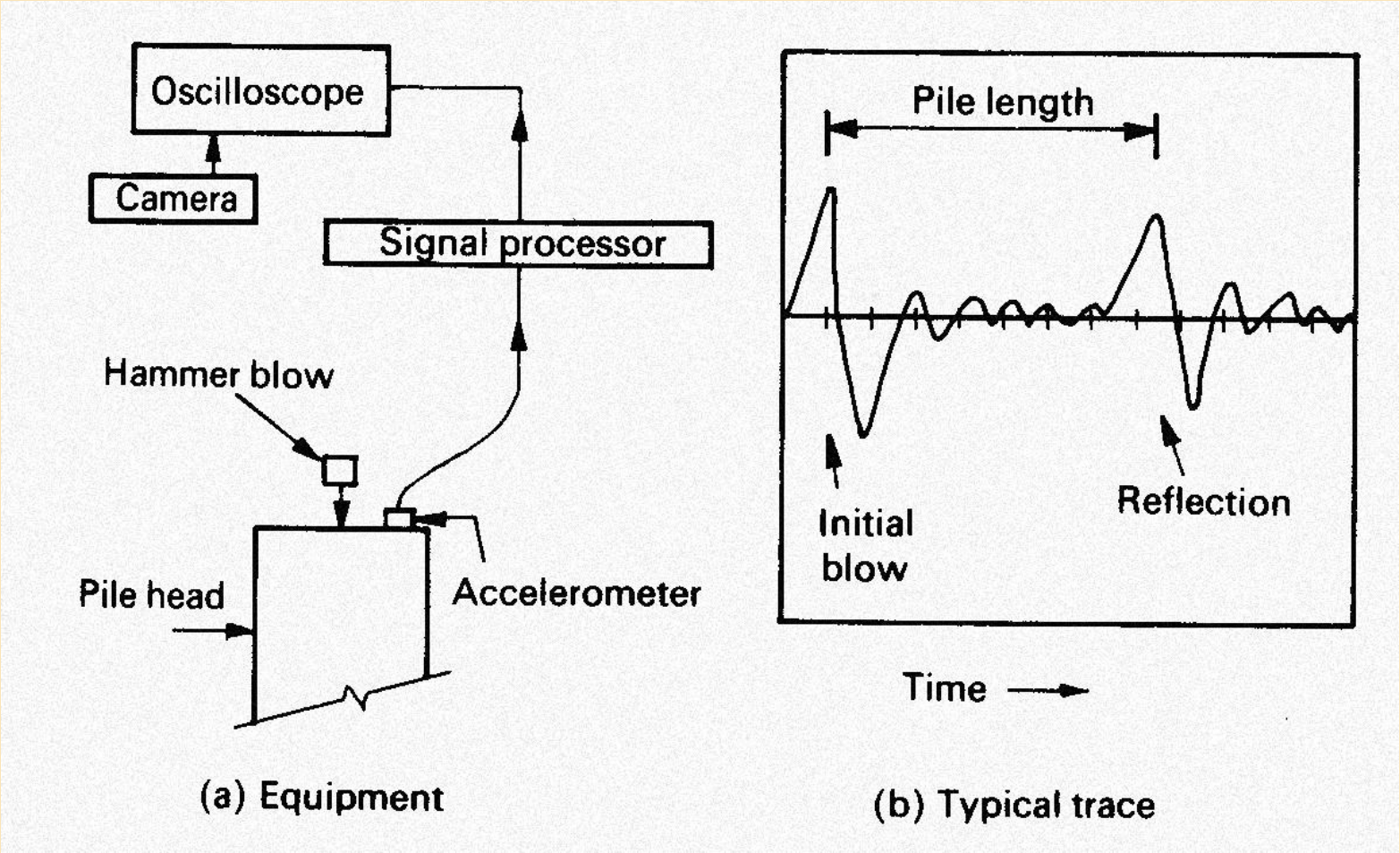


Impact Echo

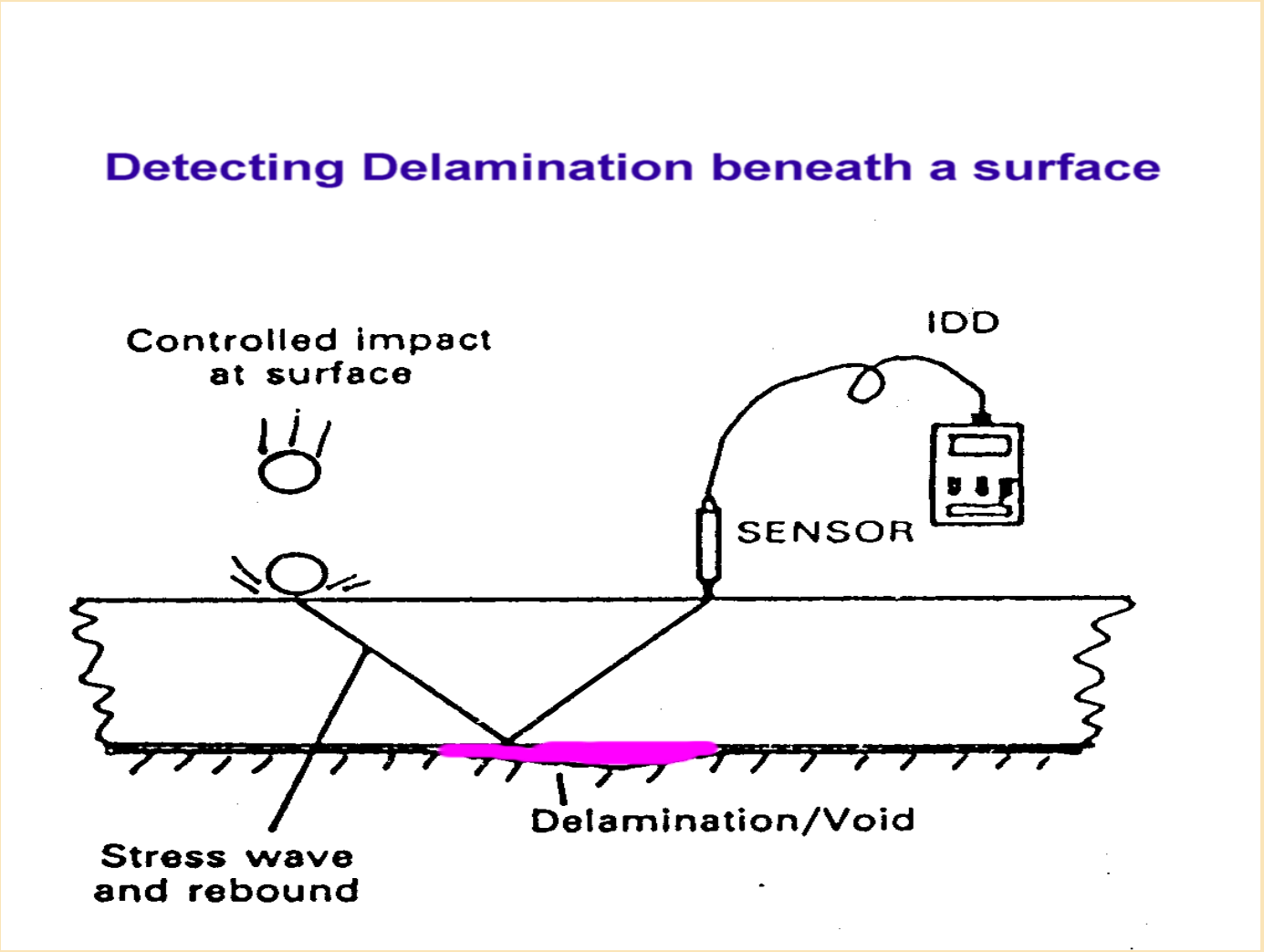
Instrumented Hammer



Pile Integrity Assessment



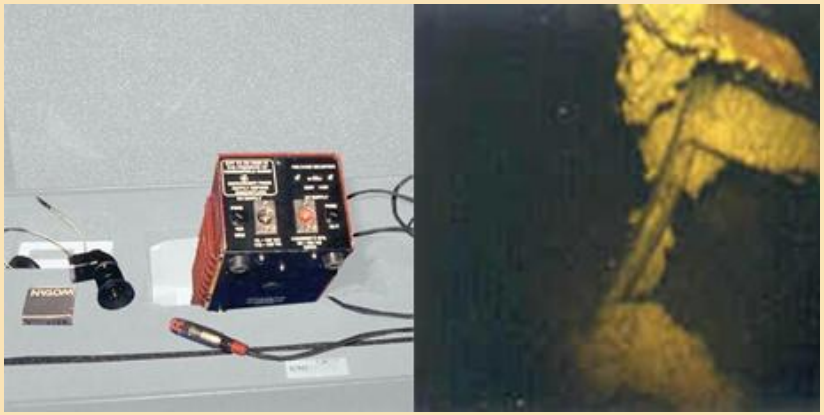
Delamination or Flaw Detection



Other Flaw-Detection Methods

Ultrasonic Flaw Detection Method

Acoustic Emission

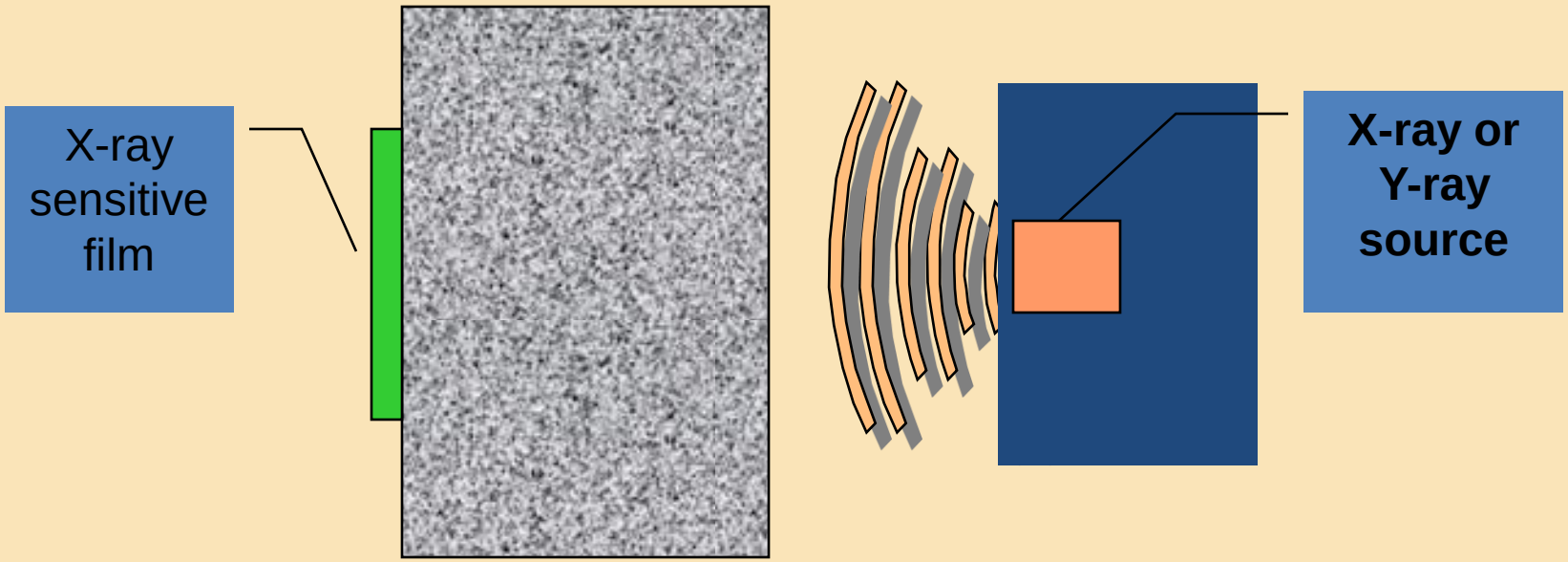


Boroscope for Internal Examination

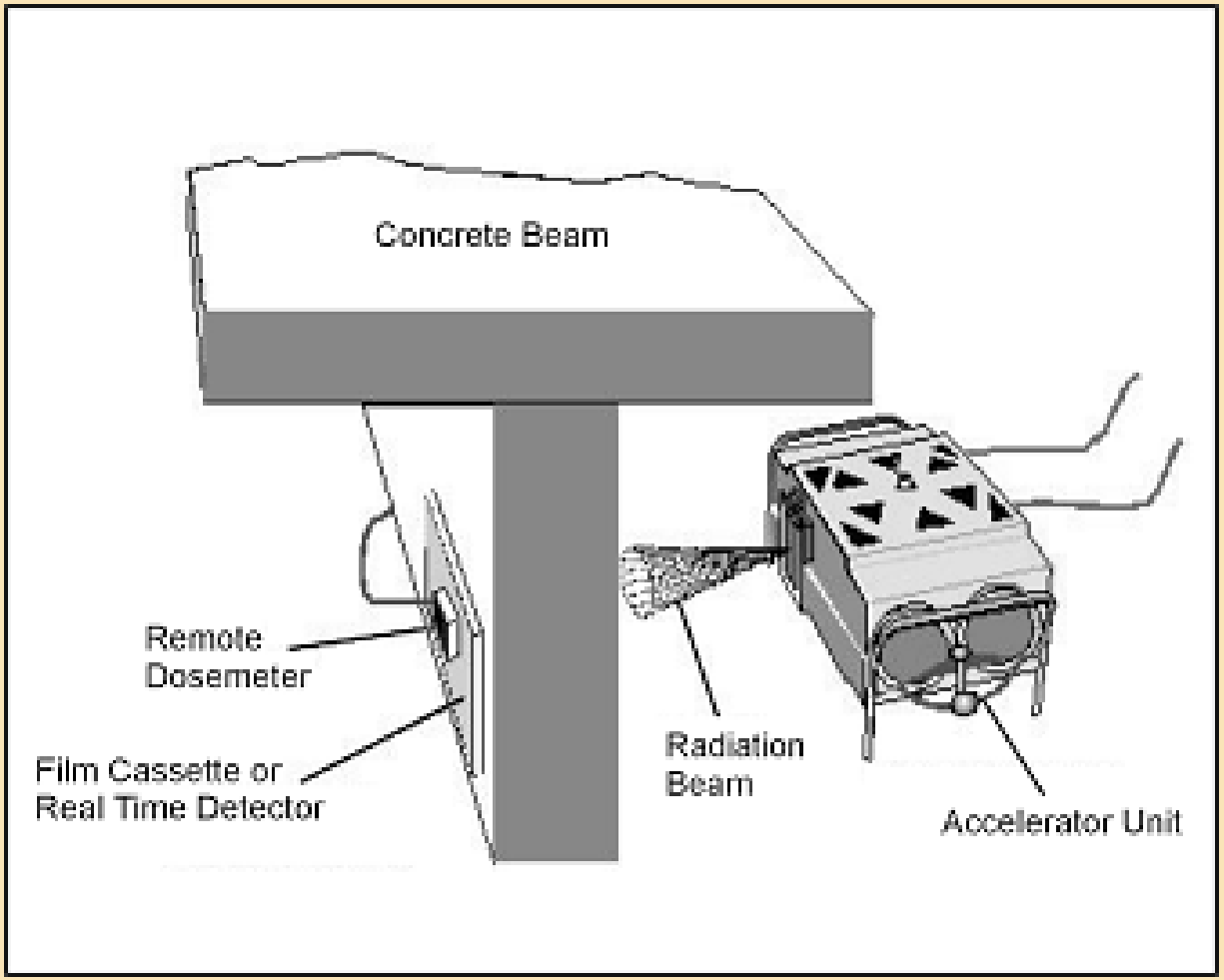
Radiography

- This provides a ‘photograph’ of the interior of a concrete member indicating variations in density.
- A beam of gamma ray is directed through the concrete towards a film held against the opposite face (max. thickness 500mm)
- Voids, poor compaction & reinforcement can be located.
- Details of technique in BS1881 Part 205.

Principle of Radiography



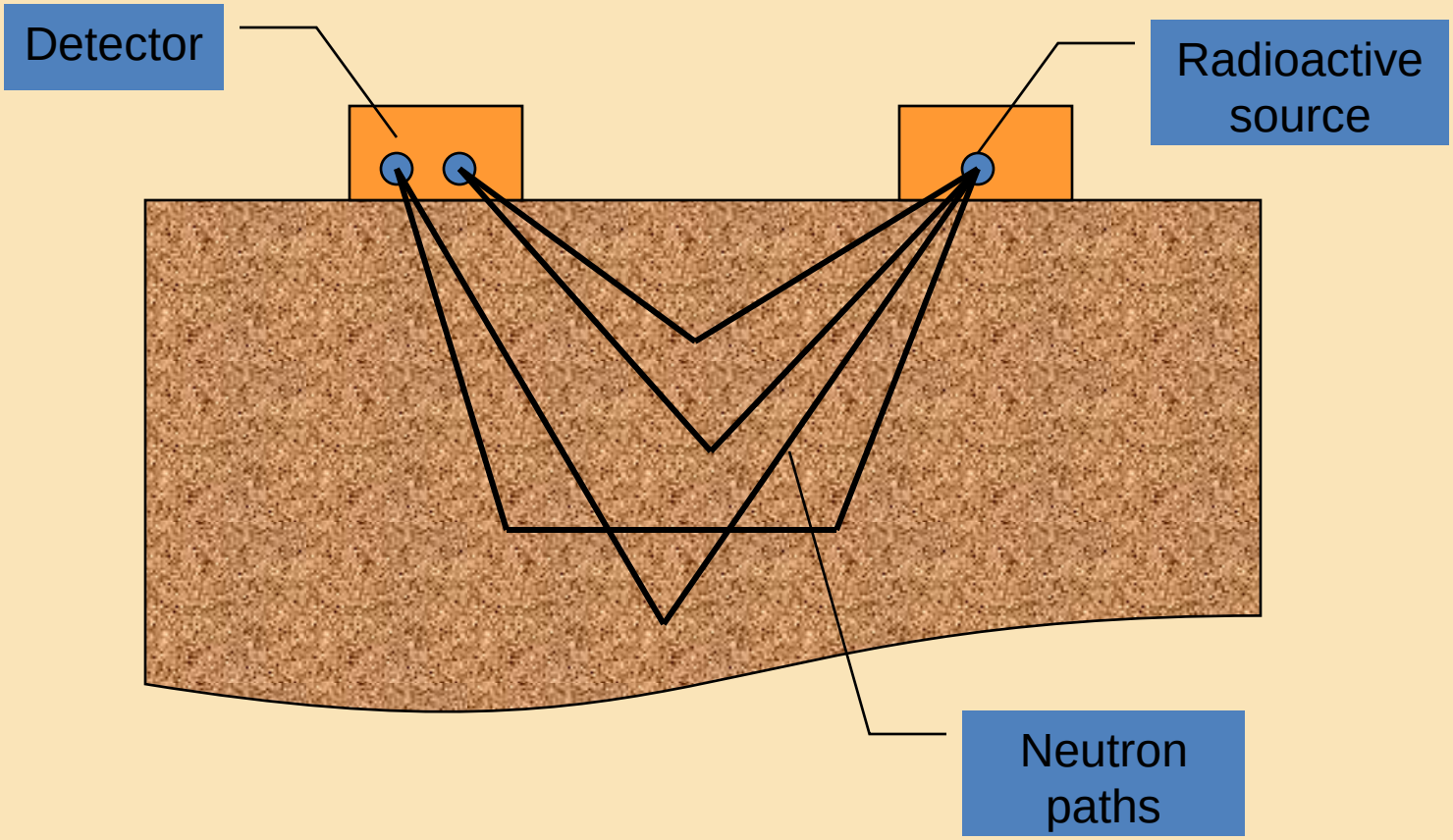
High Energy Radiography



Radiometry

- A beam of gamma rays is directed at the concrete & the intensity of radiation emerging is measured by means of a Geiger counter to indicate concrete density.
- Direct measurement may be made of radiation passing through a concrete body up to 600mm thick.
- In backscatter method, radiation is reflected back to the same surface. Easier to perform.

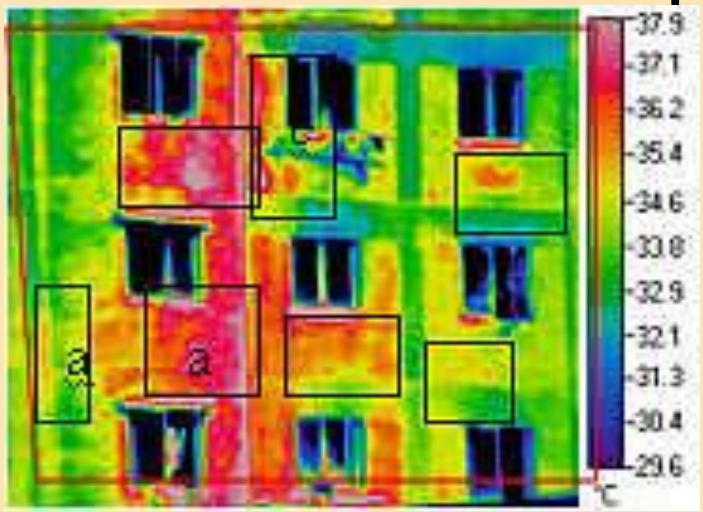
Radiometry : Backscatter Method



Thermography

- Based on measurement of surface temperature differentials on concrete member while heating or cooling.
- Infra-red measurement techniques are necessary to detect & record small temperature differentials.
- The method does not require contact with the concrete surface & can be used with measurement equipment some distance away provided that effects of extraneous heat sources can be avoided.
- Applications : detection of delamination in bridge decks; location of moisture or major ducts or voids within walls or slabs; evaluation of pavements.

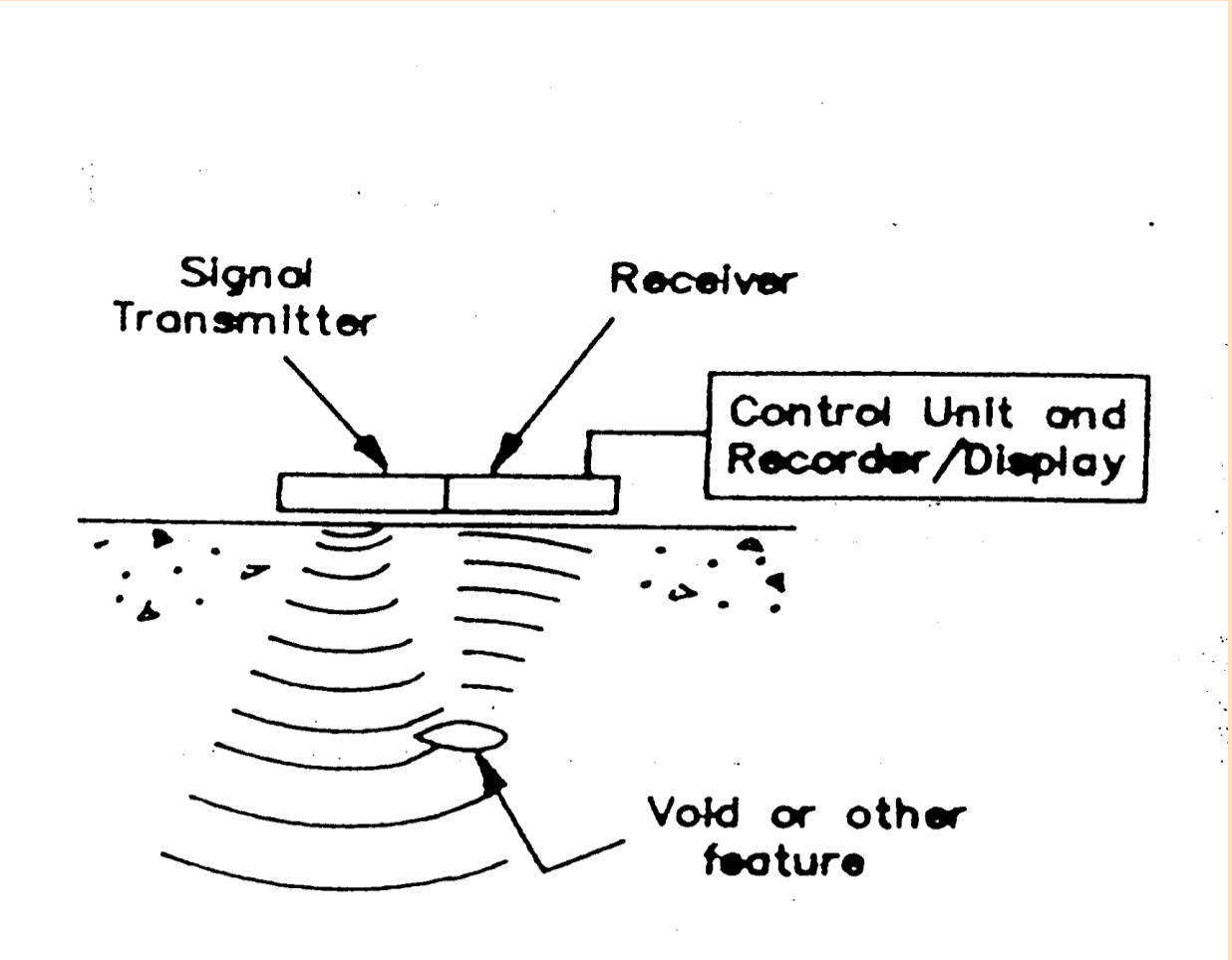
Infrared Thermography for Building Inspection



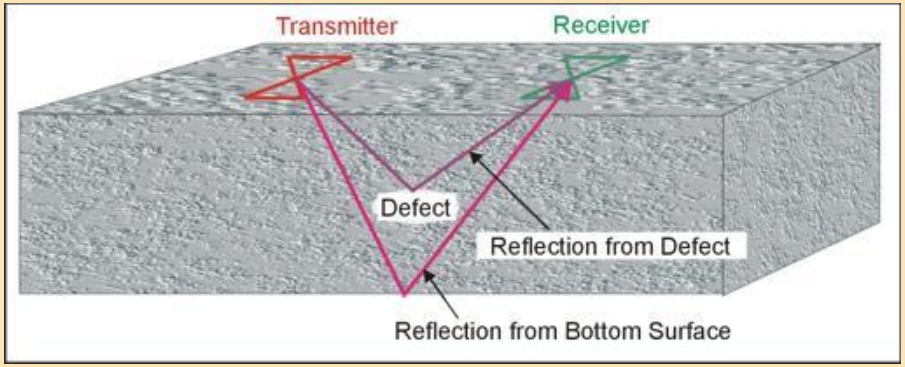
Radar Method

- Specialized surface-penetrating radar scanning equipment may be used to identify reinforcing bars, voids, delaminations, ducts & similar features.
- Equipment consists of transmitting & receiving antennae together with a control unit & recorder.
- Resolution obtained depends on frequency used (1 GHz is typically used for investigating concrete up to 500mm thick).
- Results either provided in the form of graphic recorder trace, or as colour display with facilities for signal processing to aid interpretation (based on pattern recognition).

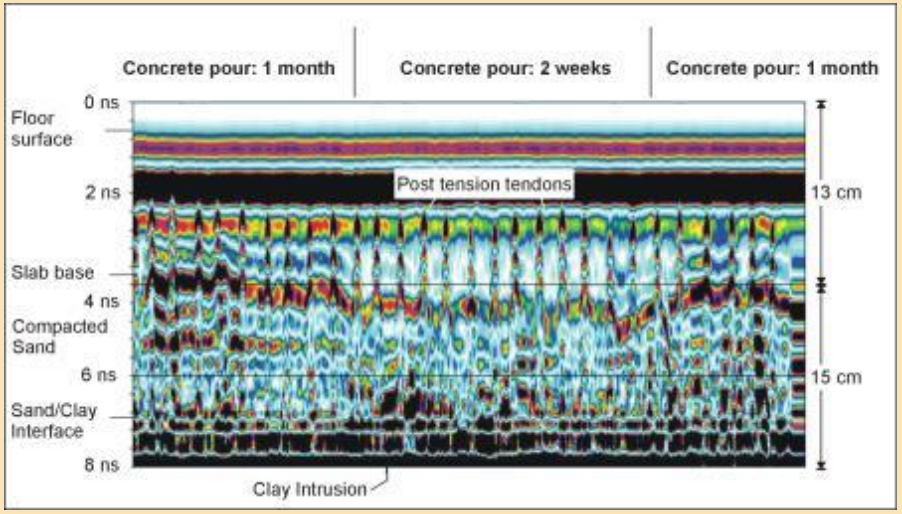
Principle of Surface Penetrating Radar



Ground Penetration Radar (GPR)



Ground Penetrating Radar system over a defect.



Plot of Ground Penetrating Radar data from a post-tension tendon survey.

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Terima Kasih