

Introduction to Nondestructive Testing



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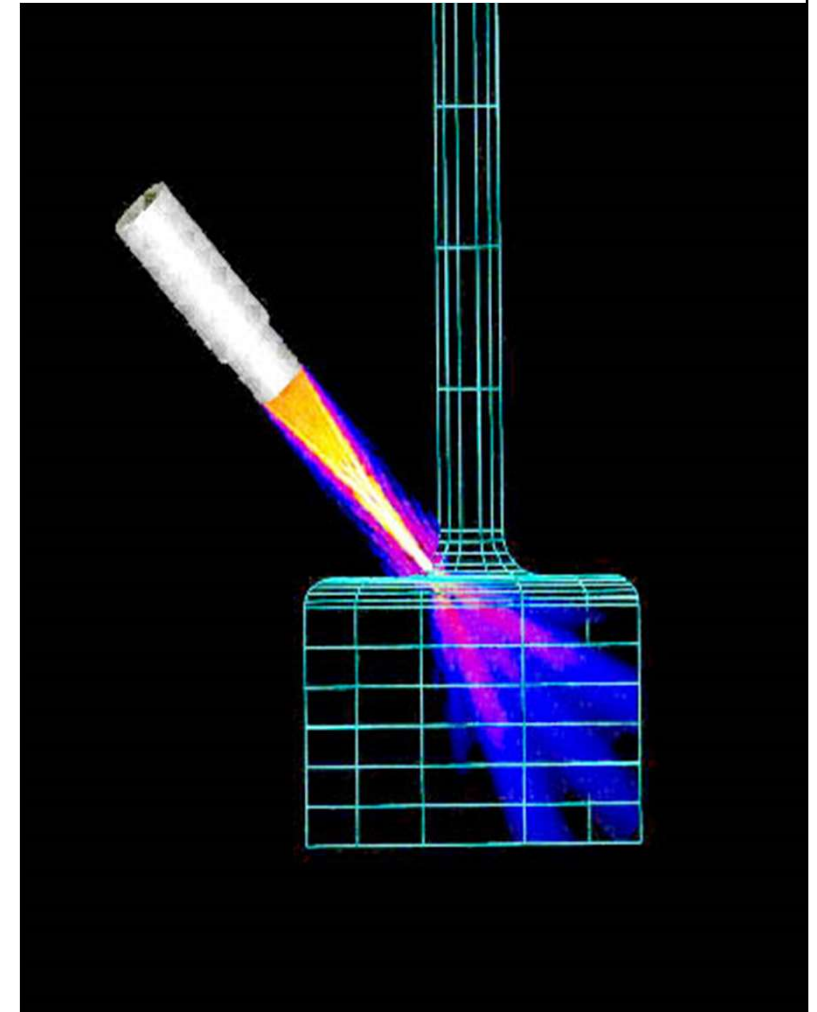
Introduction

- **Concrete - Materials**
- **Quality of concrete**
- **Testing in Laboratory**
- **Non Destructive Testing**
- **Repair / Rehabilitation / Restoration**

Introduction to NDT

- **Definition**

The use of noninvasive techniques to determine the integrity of a material, component or structure or quantitatively measure some characteristic of an object.



i.e. Inspect or measure without doing harm.

Introduction

- NDT methods – more than 7 decades.
- Considerable developments have taken place.
- Considered as powerful method for evaluating concrete structures with respect to strength, durability and quality of hardened concrete.
- Can detect crack depth, progressive deterioration, voids, location of reinforcement, cover concrete, etc.

Introduction

- NDT methods – relatively simple to perform.
- But the analysis and interpretation of results are not so easy.
- In NDT some properties of concrete are measured. These are used to estimate the strength, elastic behaviour and durability of the material.

Introduction

- Comprehensive laboratory correlations have to be established between 'strength parameters' to be predicted and the 'results of in-situ NDT'. This is to be done for the field materials.
- In addition to NDT, Semi Destructive Testing (SDT) are also performed.

Commonly adopted NDT methods

- Rebound Hammer Test
- Ultrasonic Pulse Velocity Test
- Rebar Locator Test (Cover meter test)
- Corrosion Analysis Test
- Resistivity Meter Test
- Impact Echo/Pulse Echo Test
- Ground Penetrating Radar Test

Commonly adopted SDT methods

- Concrete Core Test
- Capro Test
- Windsor Probe Test
- Load Test for Flexure Member
- Load Test for Piles

Commonly adopted OTHER methods

- Carbonation Test
- Chloride Determination Test
- Sulphate Determination Test
- Determination of pH

Commonly adopted NDT methods

Rebound Hammer



Types of Rebound Hammer

- Type N

Impact energy = 2.207 N-m (0.225 kg-m)

Ordinary building and bridge constructions.



Types of Rebound Hammer

- Type NR

Impact energy = 2.207 N-m (0.225 kg-m)

Has a special recording device.



Types of Rebound Hammer



Type N Rebound Hammer –DIGI Schmidt

Types of Rebound Hammer

- Type L

Impact energy = 0.735 N-m (0.075 kg-m)

Used for testing thin walled (< 100 mm) or small components and also cast stone components sensitive to impact.

- Type LR

Impact energy = 0.735 N-m (0.075 kg-m)

Has a special recording device.

Types of Rebound Hammer

- Type L and Type LR



Types of Rebound Hammer

- Type LB

Impact energy = 0.735 N-m (0.075 kg-m)

For the continuous control of the quality of burnt clay material and tile products.



Types of Rebound Hammer

- Type M

Impact energy = 29.43 N-m (3 kg-m)

For determining the strength of mass concrete and for testing the quality of concrete road pavements and airfield runways.

Types of Rebound Hammer

- Type P pendulum-type hammer

Impact energy = 0.883 N-m (0.09 kg-m)



Types of Rebound Hammer

- Type P pendulum-type hammer

Well suited for testing mortar joints of brick walls, plasterwork and surfacings.

For concrete of low strength (cube compressive strength 5 to 25 N/mm²) type P gives better results than the types N and L.

Rebound Hammer – Type N



- Schmidt Hammer is designed specifically for the Non Destructive Testing of in-situ concrete structures.

Rebound Hammer – Type N

Specifications

- **Measuring Range : 10 to 70 N/mm²**
- **Impact energy : 2.207 N-m**
- **Case dimensions : 140 x 114 x 324 mm**
- **Net Weight : 1.6 kg**
- **Shipping Weight : 1.8 kg**
- **IS Code : IS 13311 (Part 2) – 1992**

Rebound Hammer

Testing Principle

- Load device by pressing the tip of the impact plunger against a solid surface.
- Slide the plunger out the housing until it is fully extended.



Testing Principle

- The plunger is pressed against the surface to be tested which fires a percussion weight against the rear of the plunger & rebounds.

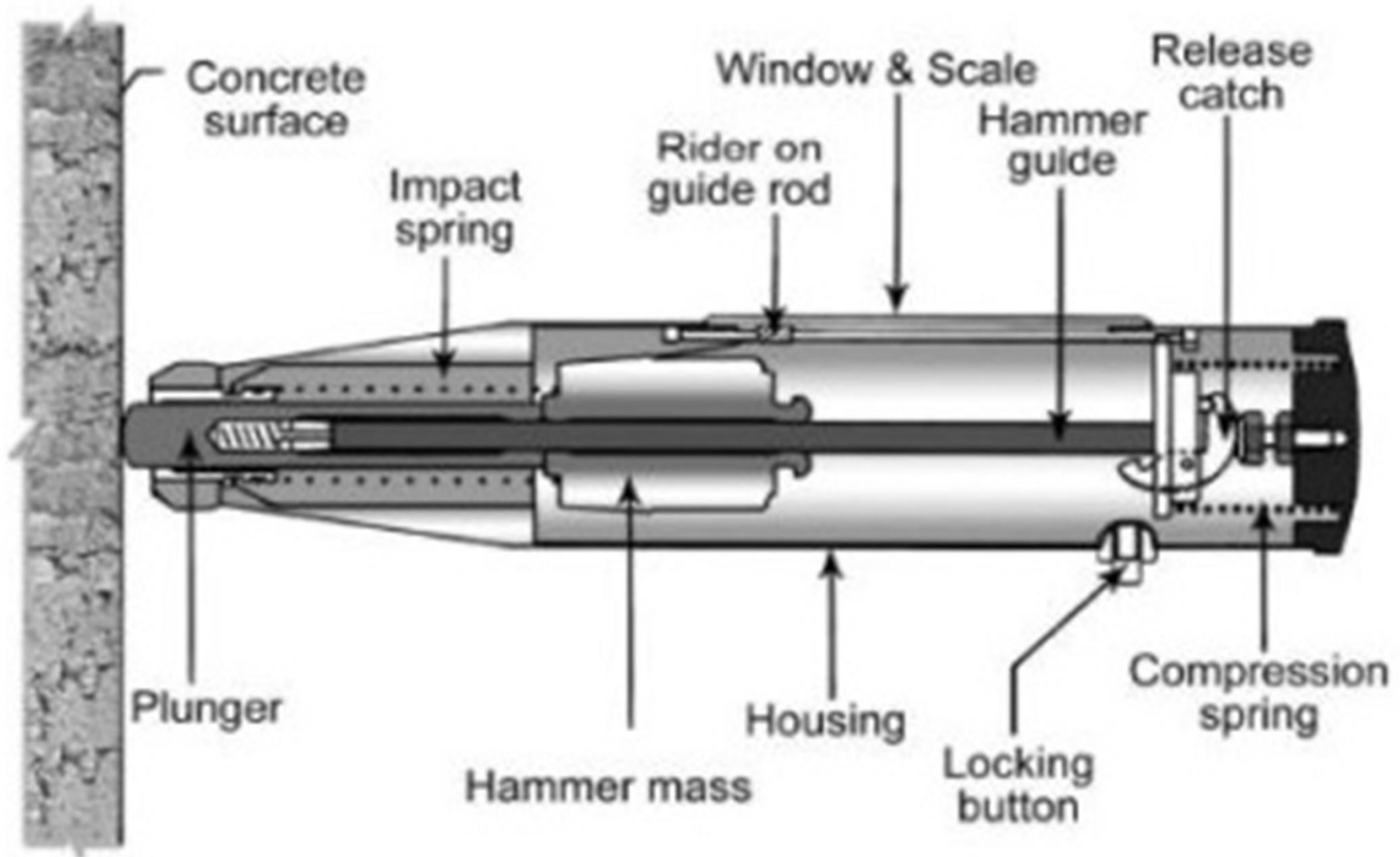


Testing in Progress

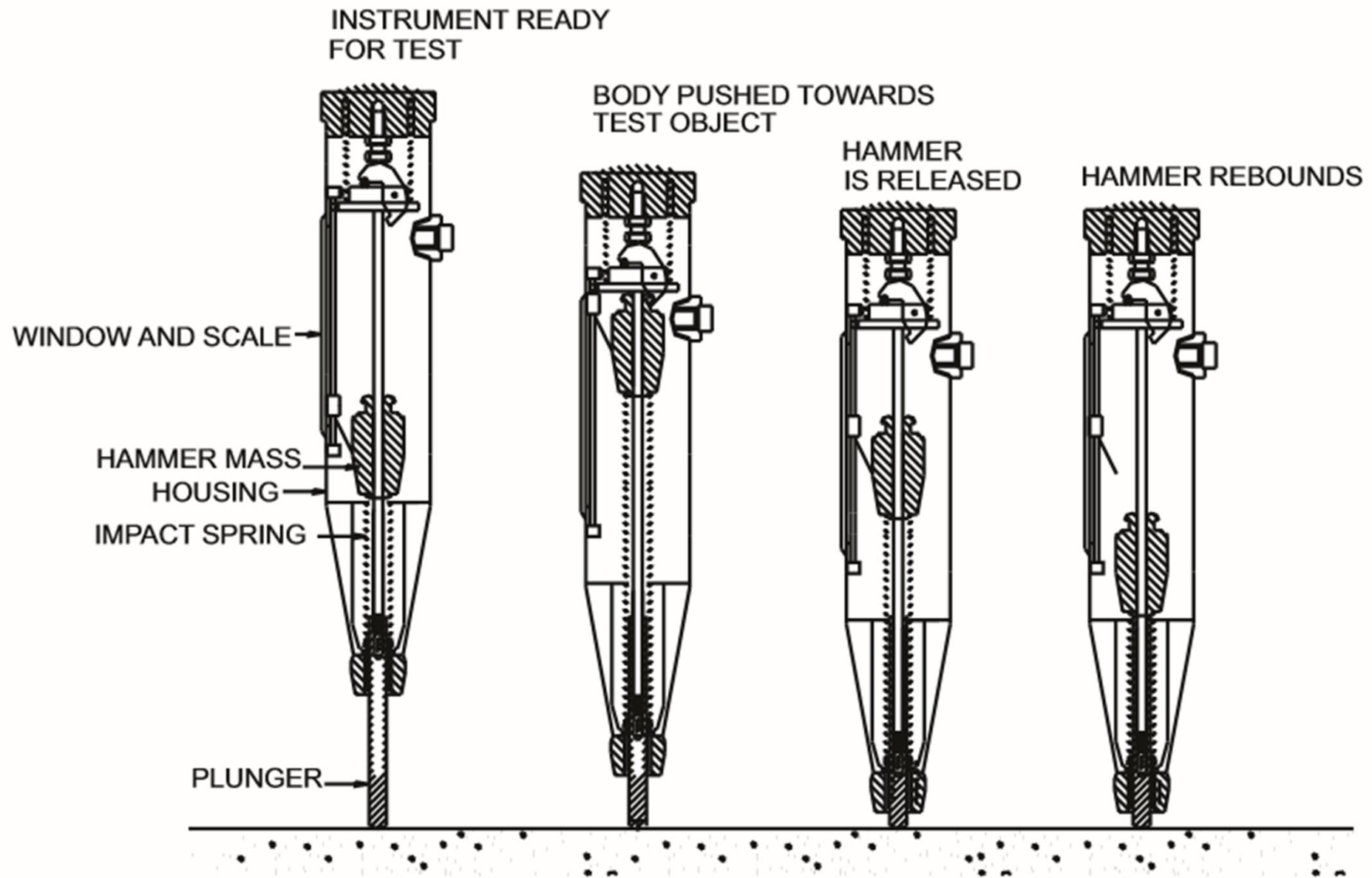


Testing in Progress





Section of Rebound Hammer

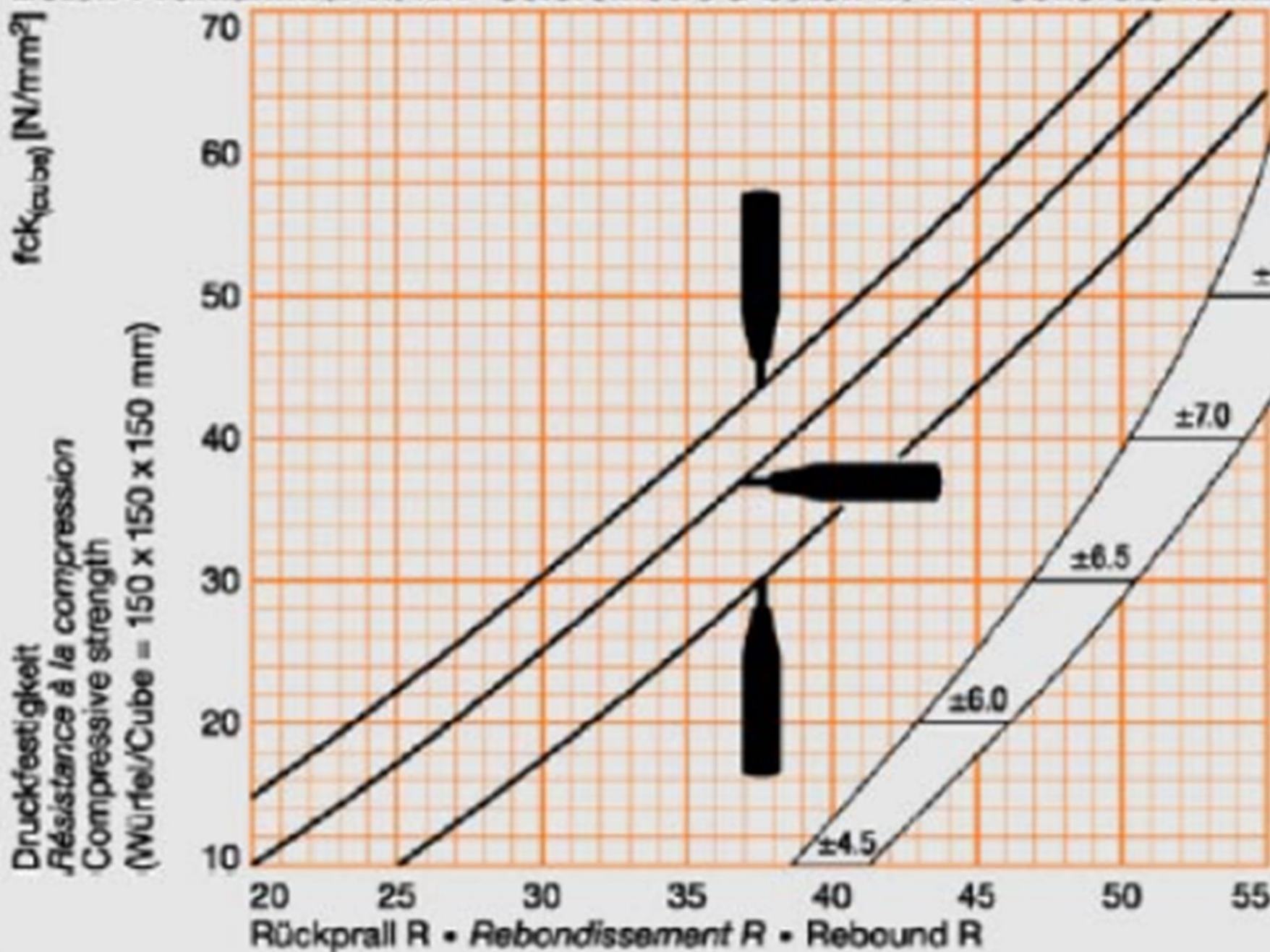


Schematic diagram of operation of rebound hammer

Testing Principle

- The maximum height of rebound is recorded on a scale.
- This value is converted to a compression strength via conversion tables.

Beton-Prüfhammer N/NR • Scléromètre à béton N/NR • Concrete Hammer N/NR



Betonalter 14 bis 56 Tage
Age du béton 14 à 56 jours
Age of concrete 14 to 56 days

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Rebound Hammers



Rebound Hammer

Factors influencing test results

A. Mix characteristics

1. Cement type
2. Cement content
3. Coarse aggregate type

B. Member characteristics

- 1. Mass**
- 2. Compaction**
- 3. Surface type**
- 4. Age, rate of hardening and curing type**
- 5. Surface carbonation**
- 6. Moisture condition**
- 7. Stress state and temperature**

Factors influencing test results ... *Contd.*

- Each of these factors will affect the readings obtained.
- Estimation of concrete strength will be valid only if they are all standardized for the concrete under test and for the calibration specimens.

Calibration Curve

- The influences of the variables described above are so great that it is very unlikely that a general calibration curve relating rebound number to strength, as provided by the equipment manufacturers, will be of any practical value.

Calibration ... Contd.

Strength calibration is based on

- the particular mix under investigation, and
- the mould surface, curing and age of laboratory specimens

Unless these conditions correspond **as closely as possible** to the in-place concrete, the calibration curves cannot give the correct interpretation.

Calibration of Rebound Hammer

- It is essential that correct functioning of the rebound hammer is checked regularly using a standard steel anvil of known mass.
- If the rebound hammers used for in-situ testing are not regularly checked against a standard anvil, the reliability of results may suffer.



Influence of moisture on strength

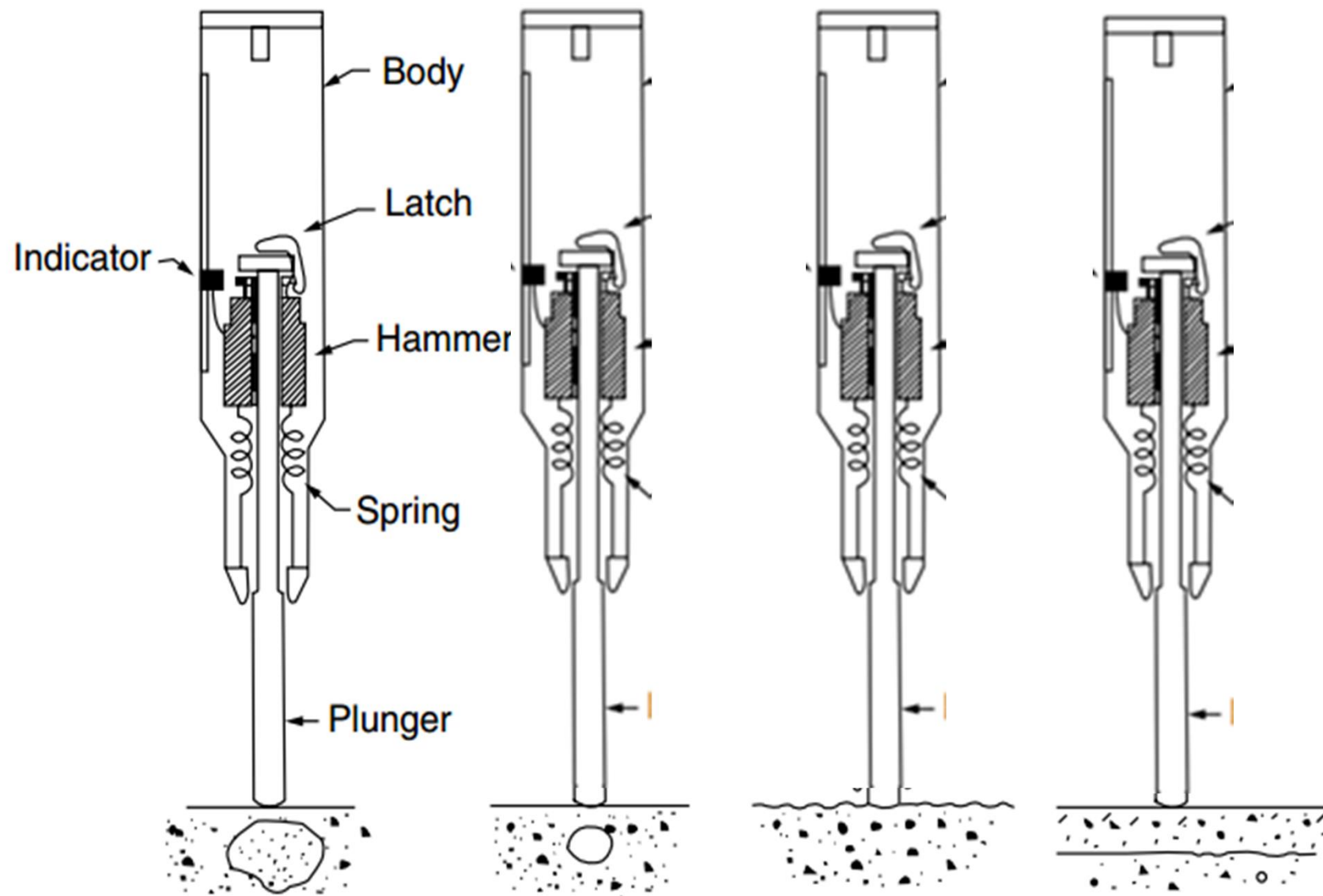
- It is well established that the strength of a cube tested wet is likely to be about 10% lower than the strength of a corresponding cube tested dry.
- Since rebound measurements should be taken on a dry surface, it is recommended that wet cured cubes be dried in the laboratory for 24 hours before test.

Minimum readings and position

- When the total number of readings (n) taken at a location is > 10, the accuracy of the mean rebound number is likely to have a confidence of > 95%.
- The rebound numbers should not be taken too close to the edge of the members, i.e., they should be atleast 20 mm away from the boundary.

Location of testing

- The test location within the member is important when interpreting results.
- The test yields information about a thin surface layer only.
- Voids or defects present at large depths do not influence the test results.



Rebound values depend on the hardness of concrete surface

Gives only surface hardness

- Results are unrelated to the properties of the interior since the readings are taken on the surface.
- Results are not regarded as reliable on concrete more than three months old unless special steps are taken for allowance of age effects and surface carbonation.

Factors influencing surface hardness

- **Age of concrete**

New concrete with moist surface generally has a relatively softer surface, resulting in lower than normal rebound.

In very old and dry concrete the surface will be harder than the interior, giving rebound values some what higher than normal (carbonation).

Factors influencing surface hardness

- Carbonation of concrete surface

Carbon dioxide, which is present in the air at around 0.3 per cent by volume, dissolves in water to form a mildly acidic solution.

This forms within the pores of the concrete, and reacts with the alkaline calcium hydroxide forming insoluble calcium carbonate.

Factors influencing surface hardness

- **Carbonation of concrete surface**

The pH value then drops from more than 12 to about 8.5.

It consumes alkalinity and reduces pore water pH to the 8–9 range.

Hence, steel remains no longer passive.

Factors influencing surface hardness

- Carbonation of concrete surface

Surface carbonation of concrete significantly affect the rebound hammer test results.

In old concrete where the carbonation layer can be upto 20 mm thick, the strength may be overestimated by 50%.

Average rebound number & quality of concrete

Average Rebound Number	Quality of concrete
> 40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
< 20	Poor concrete
0	Delaminated

Applications and Limitations

- **Checking the uniformity of concrete quality**
- **Comparing a given concrete with a specified requirement**
- **Approximate estimation of strength**
- **Abrasion resistance classification.**

Ultrasonic Pulse Velocity (UPV)



Ultrasonic Pulse Velocity

- The first reports of the measurement of the velocity of mechanically generated pulses through concrete appeared in the USA in the mid 1940s.
- Velocity depends primarily upon the elastic properties of the material and is almost independent of geometry.

Ultrasonic Pulse Velocity

- The potential value of this approach was apparent, but measurement problems were considerable.
- In France, a few years later this led to the development of repetitive mechanical pulse equipment.

Ultrasonic Pulse Velocity

- At about the same time work was undertaken in Canada and the United Kingdom using electro-acoustic transducers, which were found to offer greater control on the type and frequency of pulses generated.

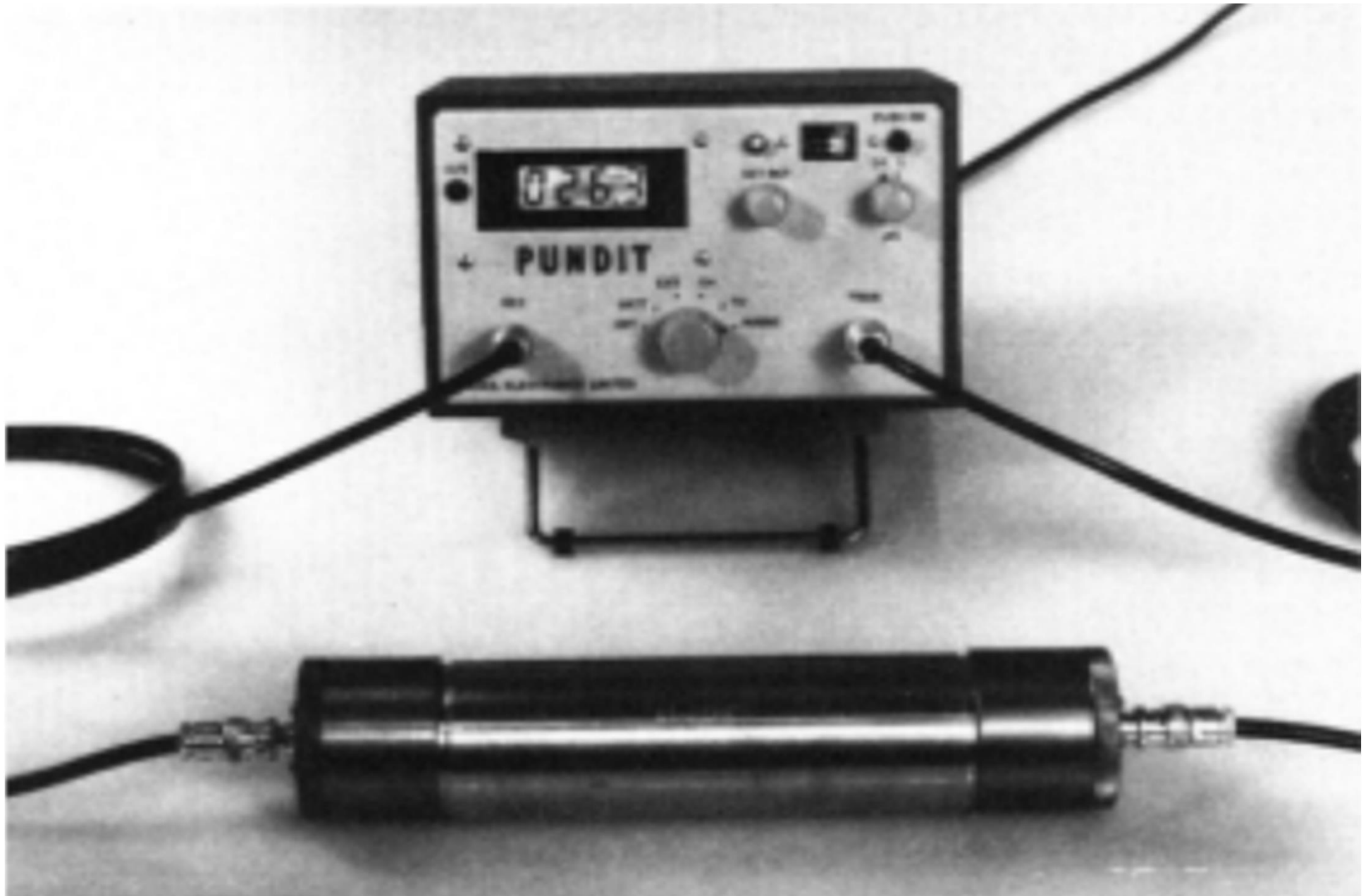
Ultrasonic Pulse Velocity

- This form of testing developed into the modern ultrasonic method, employing pulses in the frequency range of 20–150 kHz which are generated and recorded by electronic circuits.

Ultrasonic Pulse Velocity

- Concrete testing is thus at present based largely on pulse velocity measurements using through-transmission techniques.
- The method has become widely accepted around the world.
- Commercially produced robust lightweight equipment are suitable for site as well as laboratory use.

Earlier Equipment



Recent Equipment



$\alpha k=1.00$ $R=34$ #100000

$t = 50.4 \mu s$

$l = 0.220 m$

$v = 4370 m/s$

$\sigma k = 30.7 N/mm^2$

Start by START
Menu by MENU

Display Data
#100000

$t = 50.4 \mu s$
 $l = 0.220 m$
 $v = 4370 m/s$
 $\sigma k = 30.7 N/mm^2$
 $\alpha k = 1.00$
 $R = 34$
Portland

Select by ↓
End by END

Specifications of UPV

Memory:	Nonvolatile, up to 250 measured values
Display:	128 x 128 pixel LCD graphic
Measuring Range:	Approx. 15 to 6550 μ s
Resolution:	0.1 μ s
Voltage Pulse:	1 kV
Pulse Rate:	3/s
Impedance at Input:	1 M Ω
Transducers:	54 kHz with 5 ft. (1.5 m) BNC cables, two included
Temperature Range:	-0° to +60° C
Battery Operation:	30 hours with 6 AA (LR 6) batteries, 1.5 V
Case Dimensions:	325 x 295 x 105 mm (12.8" x 11.6" x 4.15")
Weight:	Net 3 kg (6.6 lbs.); Shpg. 5.4 kg (12 lbs.)

Equipment

- Consisting of a pulse generator and a pulse receiver.
- Pulses are generated by shock-exciting piezo-electric crystals, with similar crystals used in the receiver.
- The equipment is robust and is provided with a carrying case for site use.

Equipment

- The time taken for the pulse to pass through the concrete is measured by electronic measuring circuits.
- The display is a four-digit liquid crystal and gives a direct transit time reading in microseconds.
- The measuring equipments are accurate to ± 0.1 microseconds.

Ultrasonic Pulse Velocity (UPV)

- If the method is properly used, a considerable information about the interior of a concrete member can be obtained.
- Since the range of pulse velocities relating to practical concrete qualities is relatively small (3.0–4.8 km/s), great care is necessary, especially for site usage.

Transducer arrangement

Three basic ways in which the transducers may be arranged:

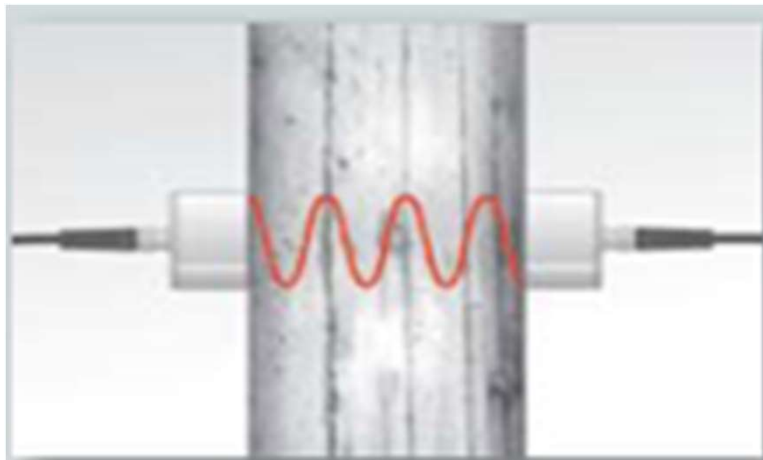
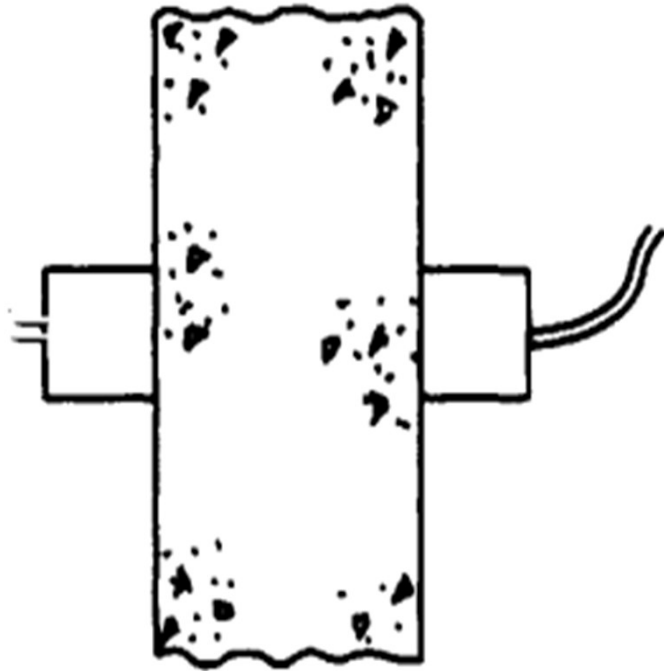
- Opposite faces (direct transmission)
- Adjacent faces (semi-direct transmission)
- Same face (indirect transmission)

The type of pulse waves received by the transducer changes in each of these cases

Opposite faces (direct transmission)

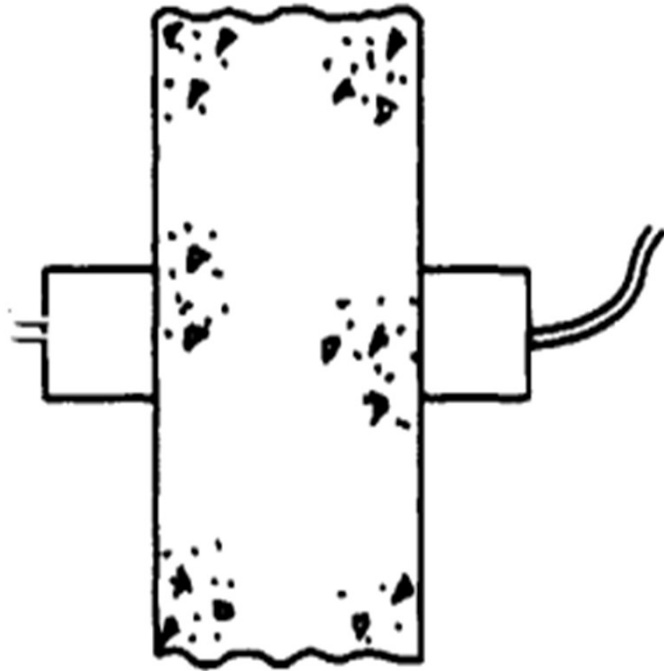


Opposite faces (direct transmission)

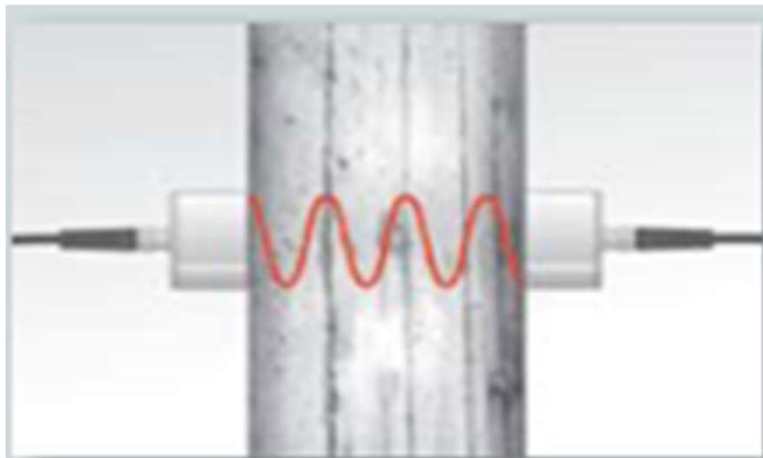


- Longitudinal waves with particle displacement in the direction of travel (also known as compression waves)
- Most important since these are the fastest and generally provide more useful information.

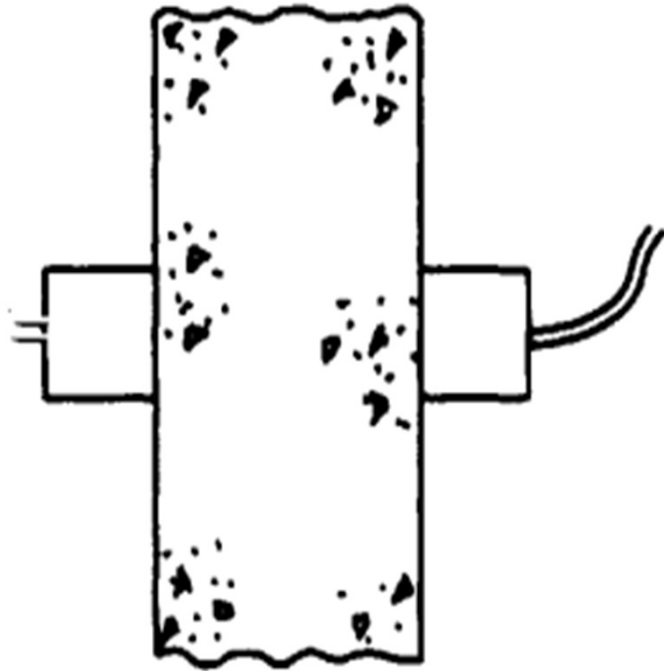
Opposite faces (direct transmission)



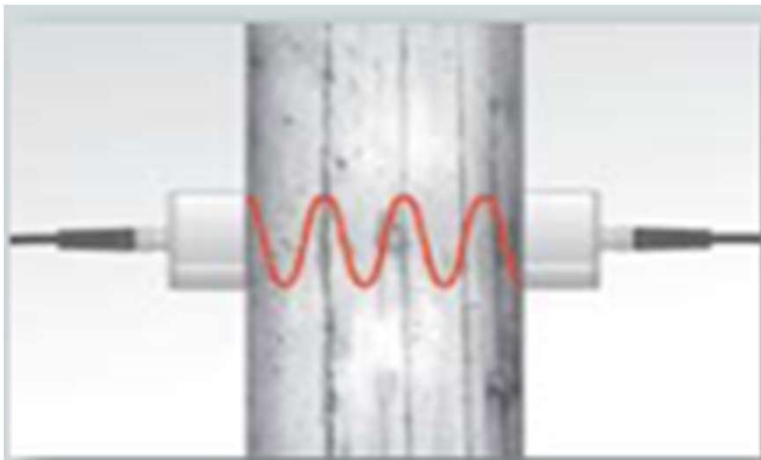
- The maximum pulse energy is transmitted at right angles to the face of the transmitter.
- This is the most reliable from the point of view of transit time measurement



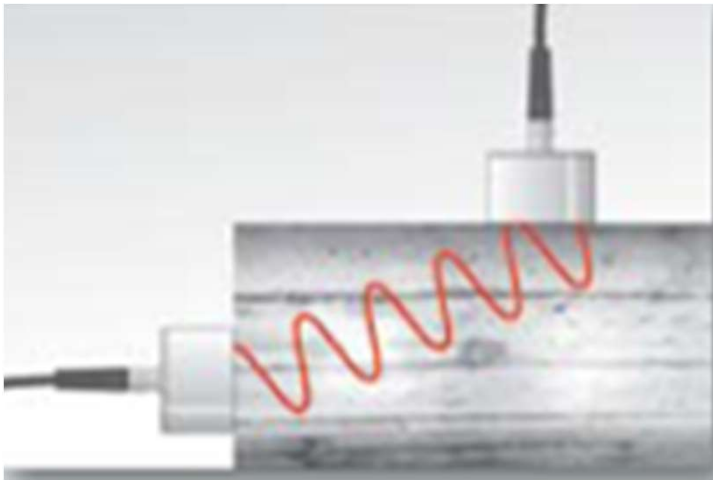
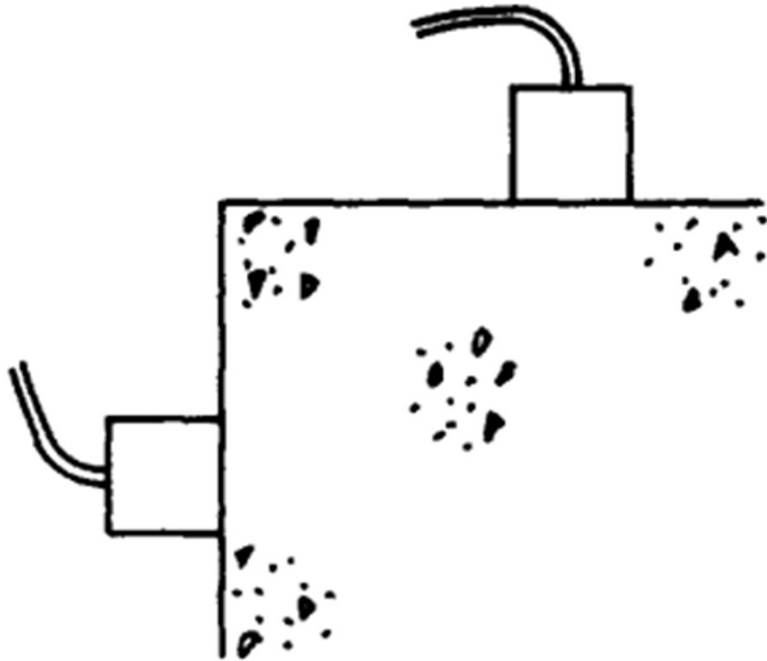
Opposite faces (direct transmission)



- The path is clearly defined and can be measured accurately.
- This approach should be used wherever possible for assessing concrete quality.

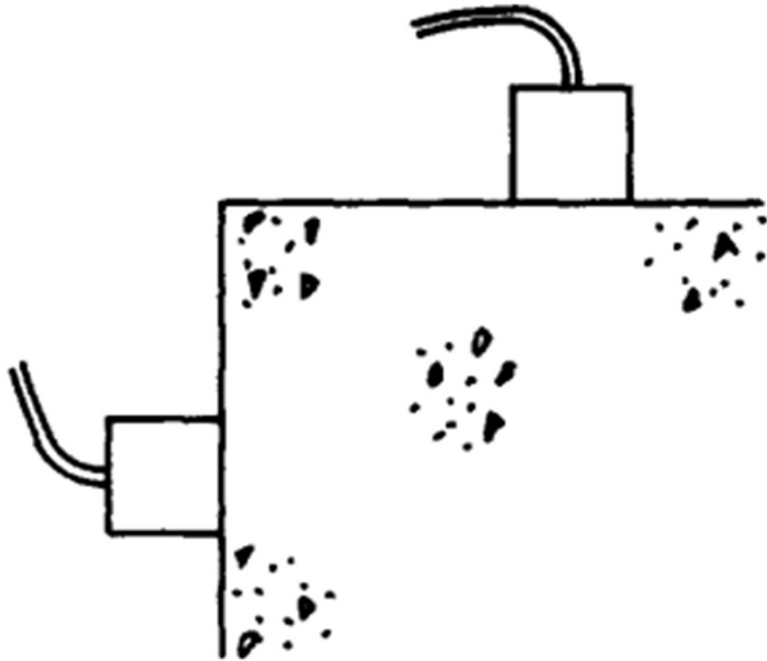


Adjacent faces (semi-direct transmission)

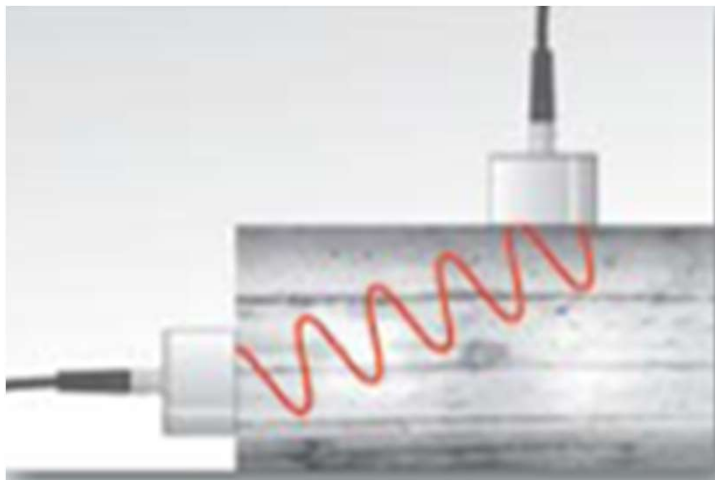


- Shear or transverse waves with particle displacement at right angles to the direction of travel are less faster.

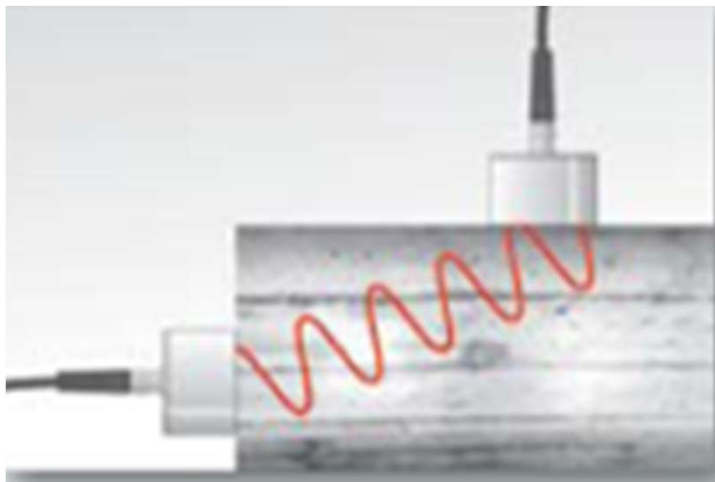
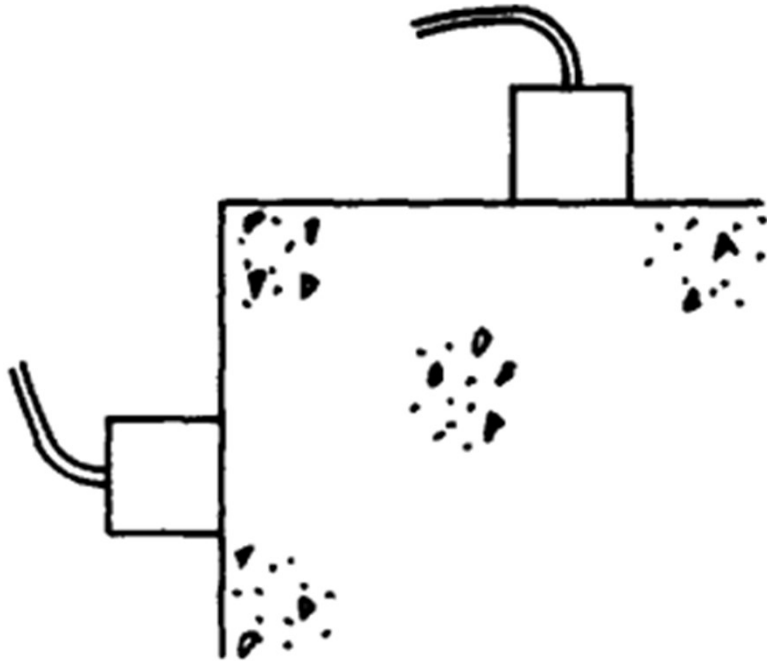
Adjacent faces (semi-direct transmission)



- Can be used sometimes satisfactorily if the angle between the transducers is not too great, and if the path length is not too large.

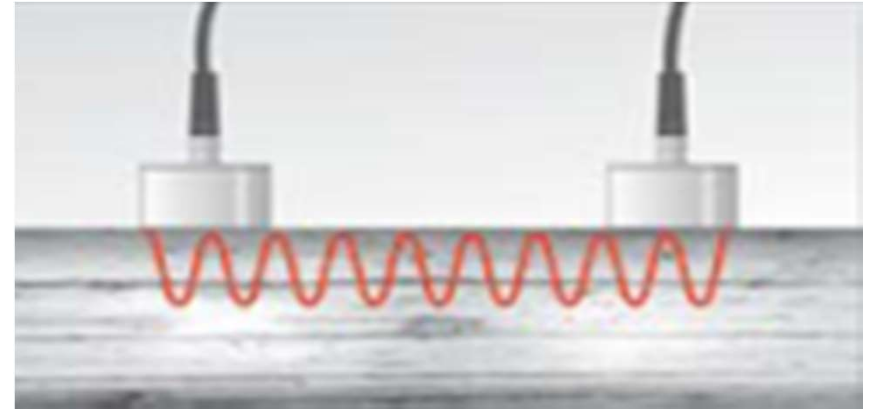
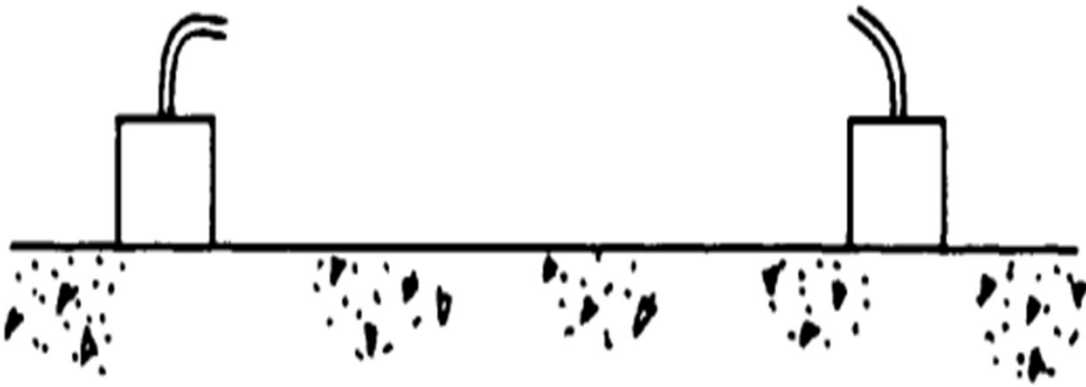


Adjacent faces (semi-direct transmission)



- The sensitivity will be smaller.
- The path length is generally regarded as distance from centre to centre of transducer faces.

Same face (indirect transmission)

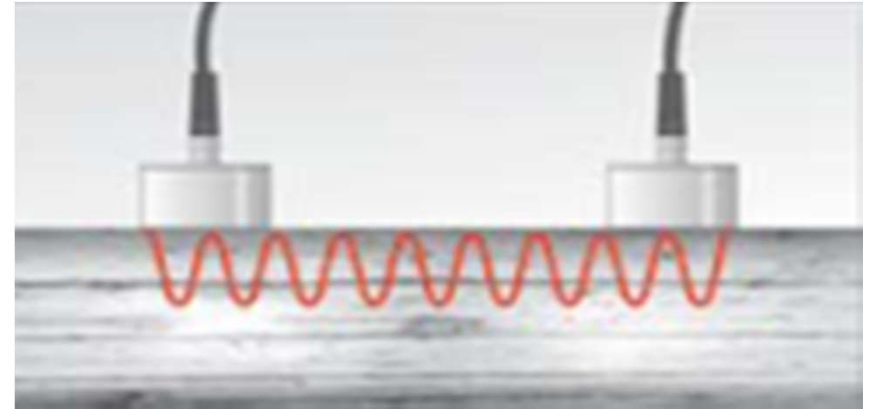
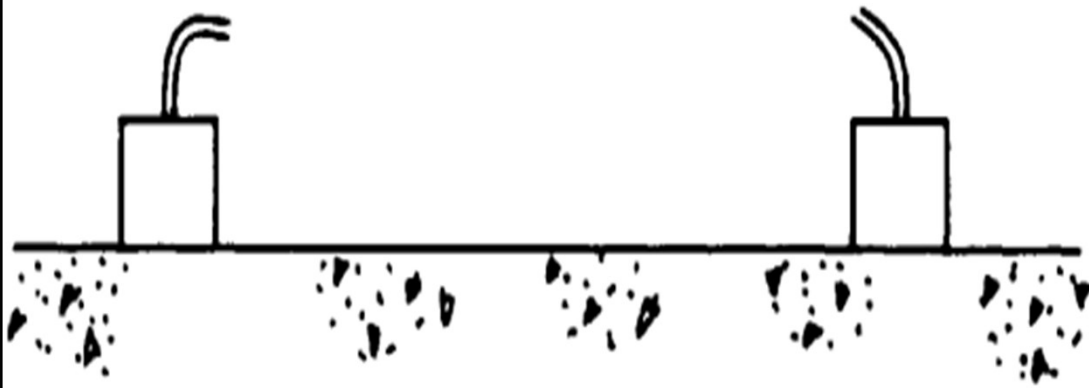


- Surface waves having an elliptical particle displacement are the slowest.

Same face (indirect transmission)

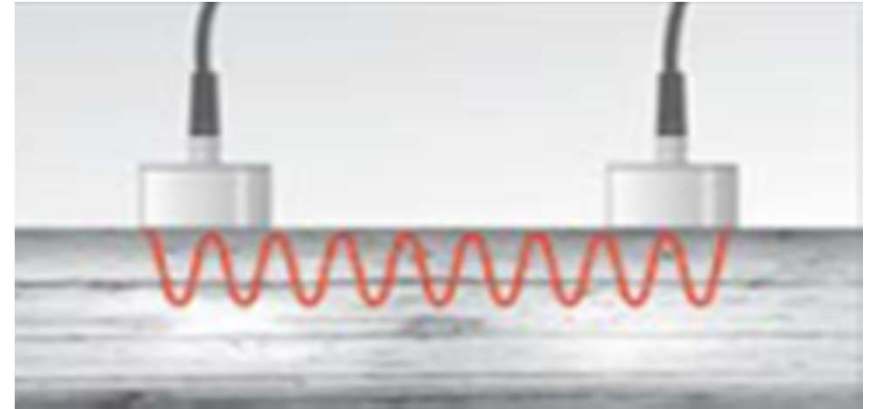
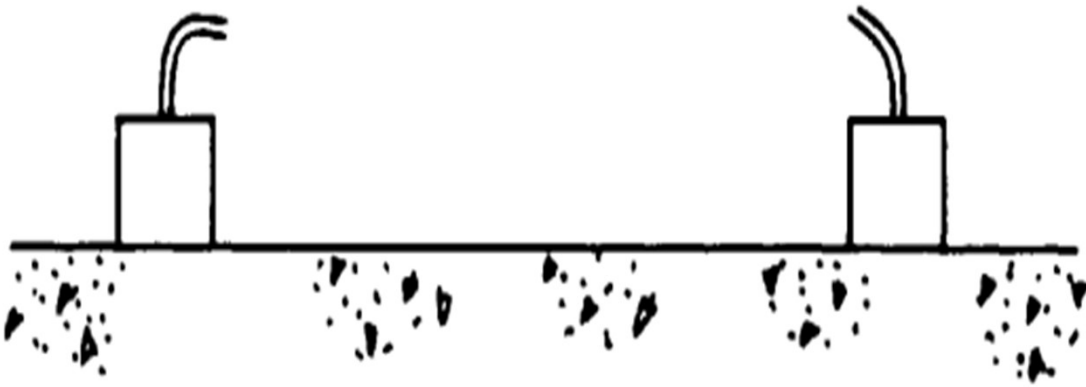


Same face (indirect transmission)



- The indirect method is definitely the least satisfactory, since the received signal amplitude may be less than 3% of that for a comparable direct transmission.

Same face (indirect transmission)



- The pulse velocity will be predominantly influenced by the surface zone concrete, which may not be representative of the body
- The exact path length is uncertain.

Ultrasonic Pulse Velocity

Pulse velocity tests can be carried out on both laboratory-sized specimens and completed concrete structures.

Factors affecting measurement:

- There must be smooth contact with the surface under test; a coupling medium such as thin film of oil, petroleum jelly, liquid soap or grease is mandatory.

Ultrasonic Pulse Velocity

- It is desirable for path lengths to be at least 300 mm in order to avoid any errors introduced by heterogeneity.
- There is an increase in pulse velocity at below-freezing temperature owing to freezing of water; from 5 to 30° C pulse velocities are not temperature dependent.

Ultrasonic Pulse Velocity

- The presence of reinforcing steel in concrete has an appreciable effect on pulse velocity. It is therefore desirable and often mandatory to choose pulse paths that avoid the influence of reinforcing steel or to make corrections if steel is in the pulse path.

Ultrasonic Pulse Velocity

Velocity criterion for concrete quality grading (IS 1311 - Part 1)

Sl. No.	Pulse velocity in cross probing (km/sec)	Concrete quality grading
1	Above 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	Below 3.0	Doubtful

Ultrasonic Pulse Velocity

- UPV method is an ideal tool for establishing uniformity of concrete.
- Large differences in pulse velocity is indicative of defects or deterioration in concrete.
- High pulse velocity readings are generally indicative of good quality concrete.

Why UPV ?

- Evaluating the uniformity within a member
- Locating internal voids and cracks
- Estimating severity of deterioration
- Estimating depth of fire damage
- Evaluating effectiveness of crack repairs
- Identifying anomalous regions in drilled cores
- Estimate early-age strength (with correlation)

REBAR LOCATER



REBAR LOCATER

- This meter, with its integral sensor can be held in one hand, and provides the unique ability to indicate the position of reinforcing bars.



REBAR LOCATER

- The Rebar Locator features probes that allows one to measure shallow and deep ranges.
- This instrument can locate the size and orientation of bar, as well as indicate concrete cover.
- Generally used along with UPV and Core cutting equipment.

REBAR LOCATER- Equipment

- **Range** : Shallow - up to 100mm
Deep - up to 185mm
- **Accuracy** : Better than $\pm 2\text{mm}$ or
 $\pm 5\%$ for cover
- **Bar Sizing**: 8-40mm better than
 ± 1 bar size
- **Display** : LCD with backlight

REBAR LOCATER- Equipment

- **Memory** : 1,60,000 objects
- **Data Output** : RS232 or USB adapter
- **Power Supply** : 1.5V (6 nos.), 45 hr operation;
30 hr with backlight
- **Dimensions** : 415 x 500 x 125mm
- **Weight** : 4.2kg

CORROSION ANALYSIS INSTRUMENT

CANIN+ with Rod Electrode



CORROSION ANALYSIS INSTRUMENT

- The CANIN+ Corrosion Analyzing Instrument highlights corrosion activity before rust becomes visible.
- Early detection is a key factor in preventing an unanticipated structural failure.

Equipment

- Battery operation six LR 6 (AA) batteries, 1.5 V for up to 60 h (or 30 h with activated backlight)
- Display 128 x 128 pixel graphic LCD with backlight
- Case dimensions : 580 x 480 x 210 mm
- Net weight : 10.6 kg
- Shipping weight : 14 kg

The Canin+ corrosion analyzing instrument

- Half-cell corrosion potential method -
Accurate field potential measurements aid
in detecting active corrosion in rebars.
- The test surface is divided into grids of
uniform size.

The Canin+ corrosion analyzing instrument

- The voltage is recorded at points in the centre of these grids.
- If the voltage recorded is more than -200 mv it indicates that the reinforcements are already corroded.

The Canin+ corrosion analyzing instrument

- In order to satisfy individual testing needs, the Canin+ is available individually with a rod electrode, wheel electrode and/or Wenner probe configurations or as a complete system with all components.

Rod Electrode



The copper sulphate electrode for corrosion analysis is ideal for localized measurements.

Best for measuring surface areas below 20m² (200 sq. ft)



One-Wheel Electrode allows for fast scanning of larger surfaces. Best for corrosion analysis of horizontal areas up to 100m²(1,000 sq. ft.) plus vertical and soffit areas



The 4-wheel Electrode - Provides the fastest measurement. Best for measuring large horizontal areas over 100m²(1,000 sq. ft.)

Features

- Immediate presentation of test area and reading directly on the instruments display
- Upto 240 measurement values are displayed at a time in easy-to read grey-scale
- Menu-driven approach facilitates simple operation using just nine functions keys

Features

- Total memory for 2,35,000 readings which can be stored
- Allows downloading, presenting and editing data measured by the Canin+ half-cell instrument
- New features such as a backlight display and faster processing of data

Applications

- Canin+ is ideally suited for assessment of corrosion potentials on areas of all sizes
- This is made possible by the selectable grid size
- The wheel electrode, in particular, makes it easy to rapidly cover larger areas

RESISTIVITY METER



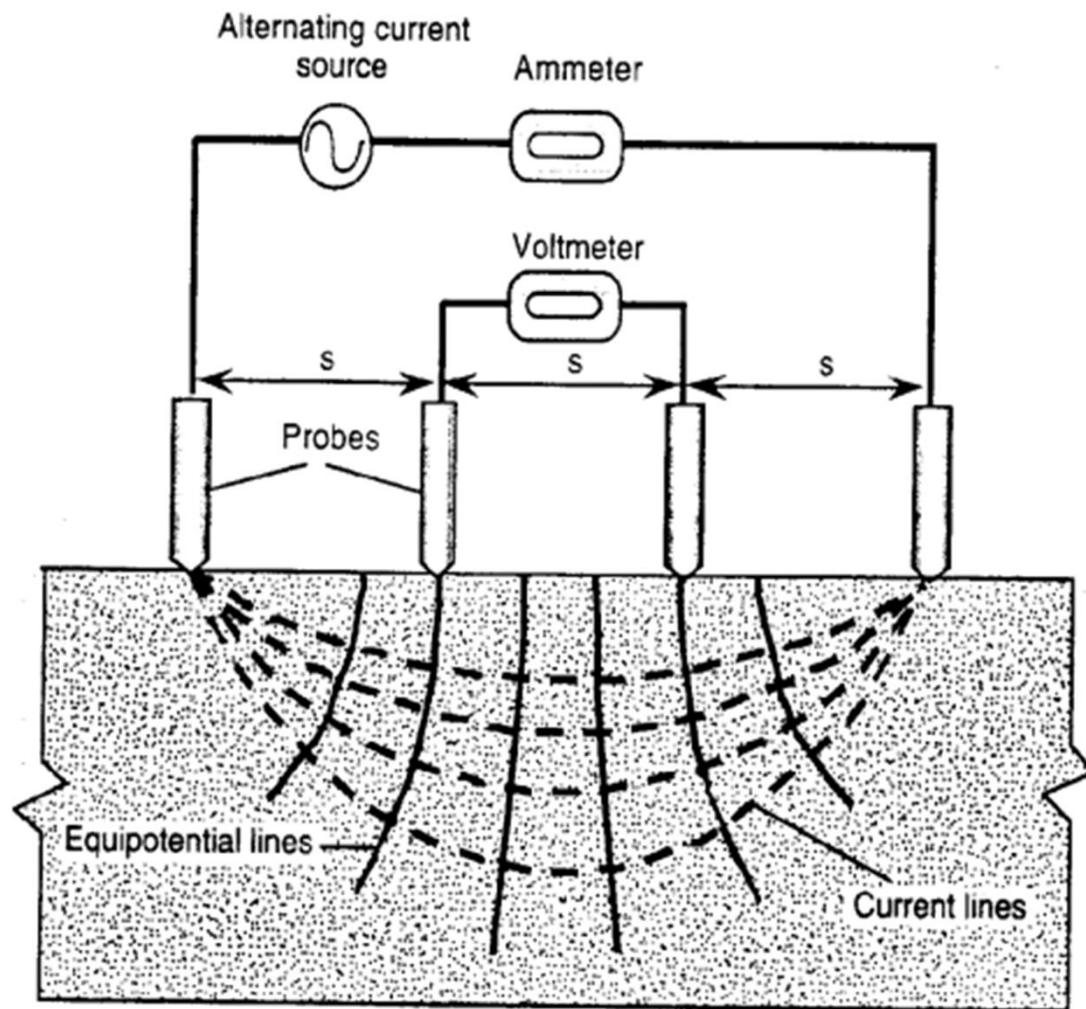
RESISTIVITY METER

- Concrete resistivity method - the instrument measures the specific electrical resistivity of concrete.
- Surface resistivity measurement provides extremely useful information about the state of a concrete structure.

RESISTIVITY METER

- It suggests the likelihood of corrosion and the corrosion rate.
- Studies have shown that there is a direct correlation between resistivity and chloride diffusion rate.

RESISTIVITY METER



RESISTIVITY METER

- This is based on the classical four electrode system in which four equally spaced electrodes are electrically connected to the concrete surface.
- The two outer electrodes are connected to a source of alternating current.
- The two inner electrodes are connected to voltmeter.

METHODOLOGY - RESISTIVITY METER

- The set of four probes are fitted with super conductive foam tips (kept moist) to ensure full contact on irregular surfaces.
- Once the probes are kept in contact with the concrete surface, the LCD display will indicate the resistivity directly on the screen.

RESISTIVITY METER

- The limits of possible corrosion are related with resistivity as under:
- With $\rho > 12 \text{ KW-cm}$ Corrosion is improbable
- With $\rho = 8 \text{ to } 12 \text{ KW-cm}$ Corrosion is probable
- With $\rho < 8 \text{ KW-cm}$ Corrosion is fairly sure



where ρ (rho) is the resistivity

RESISTIVITY METER

The versatility of the method can be seen in these example applications:

- Estimation of the likelihood of corrosion
- Indication of corrosion rate
- Correlation to chloride permeability
- Identification of areas within a structure most susceptible to chloride penetration
- Determination of zonal requirements for cathodic protection systems

RESISTIVITY METER

Limitations

- The method is slow because it covers small area at a time
- The system if used in combination with half - cell potentiometer gives better indication of corrosion in reinforced concrete

Impact Echo Test



Impact Echo Test



- Here, an impacting device such as a hammer is struck on the concrete surface.

Impact Echo Test

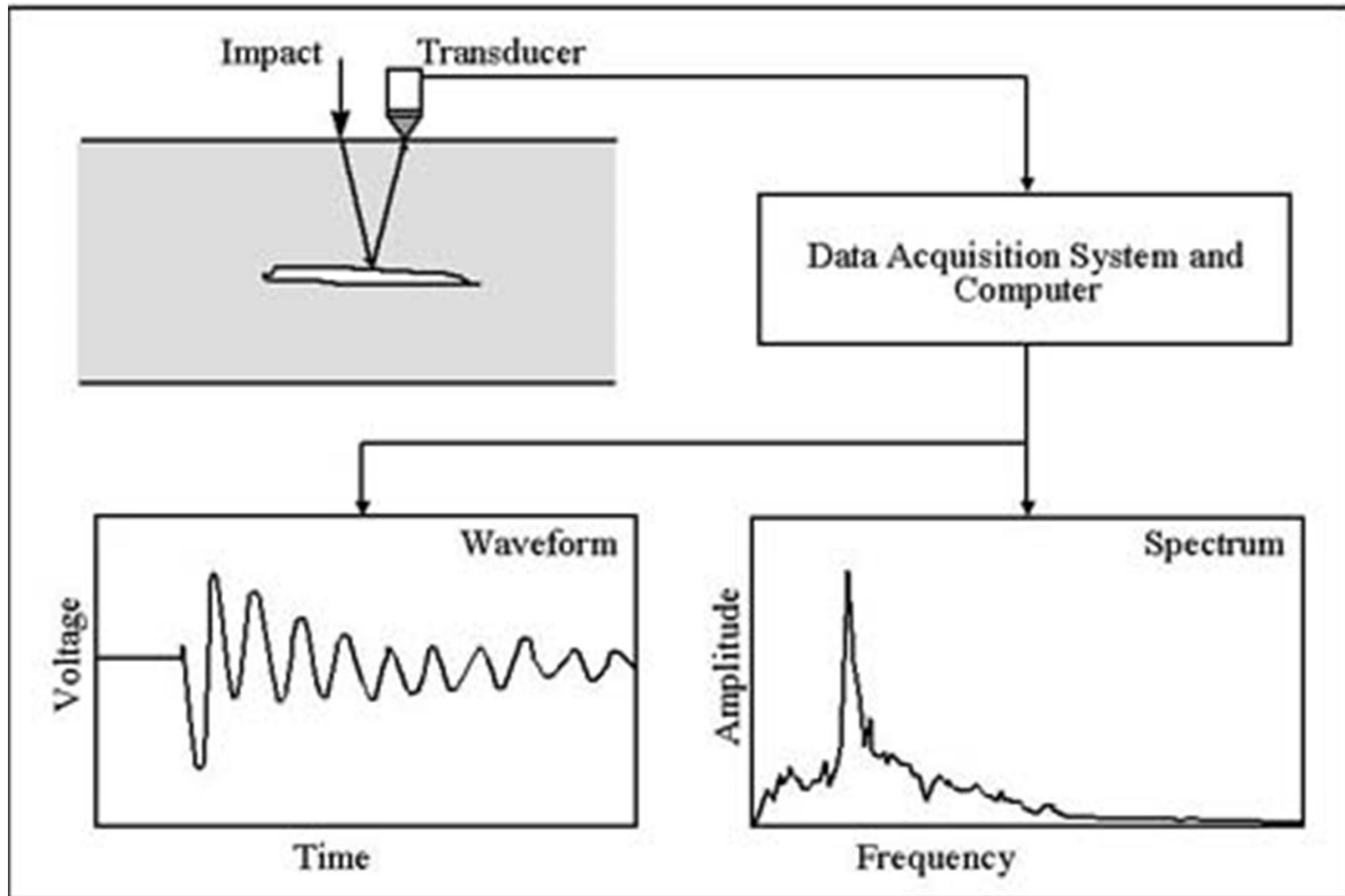


- The sound waves that reflect off from voids or discontinuities are picked up by a recovery receiving probe and conveyed to a signal processor.

Impact Echo Test

- This wave form is analysed in the signal processor, and amplitude and travel time of waves are evaluated for the determination of homogeneity and integrity of concrete.

How Impact-Echo Works ?

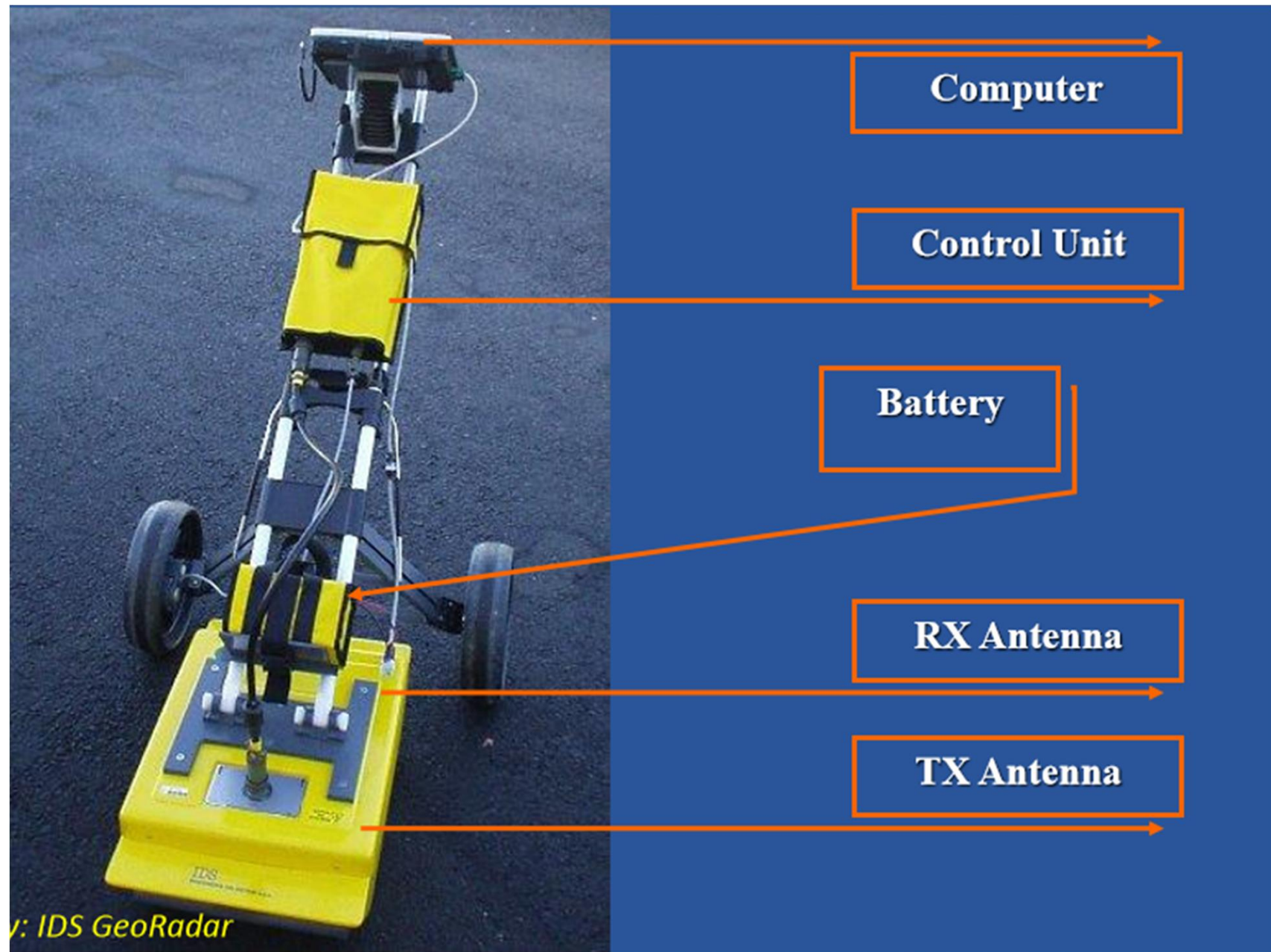


Ground Penetrating RADAR (GPR)



RADAR – RAdio **D**etection **A**nd **R**anging

Ground Penetrating Radar (GPR)



Ground Penetrating Radar (GPR)

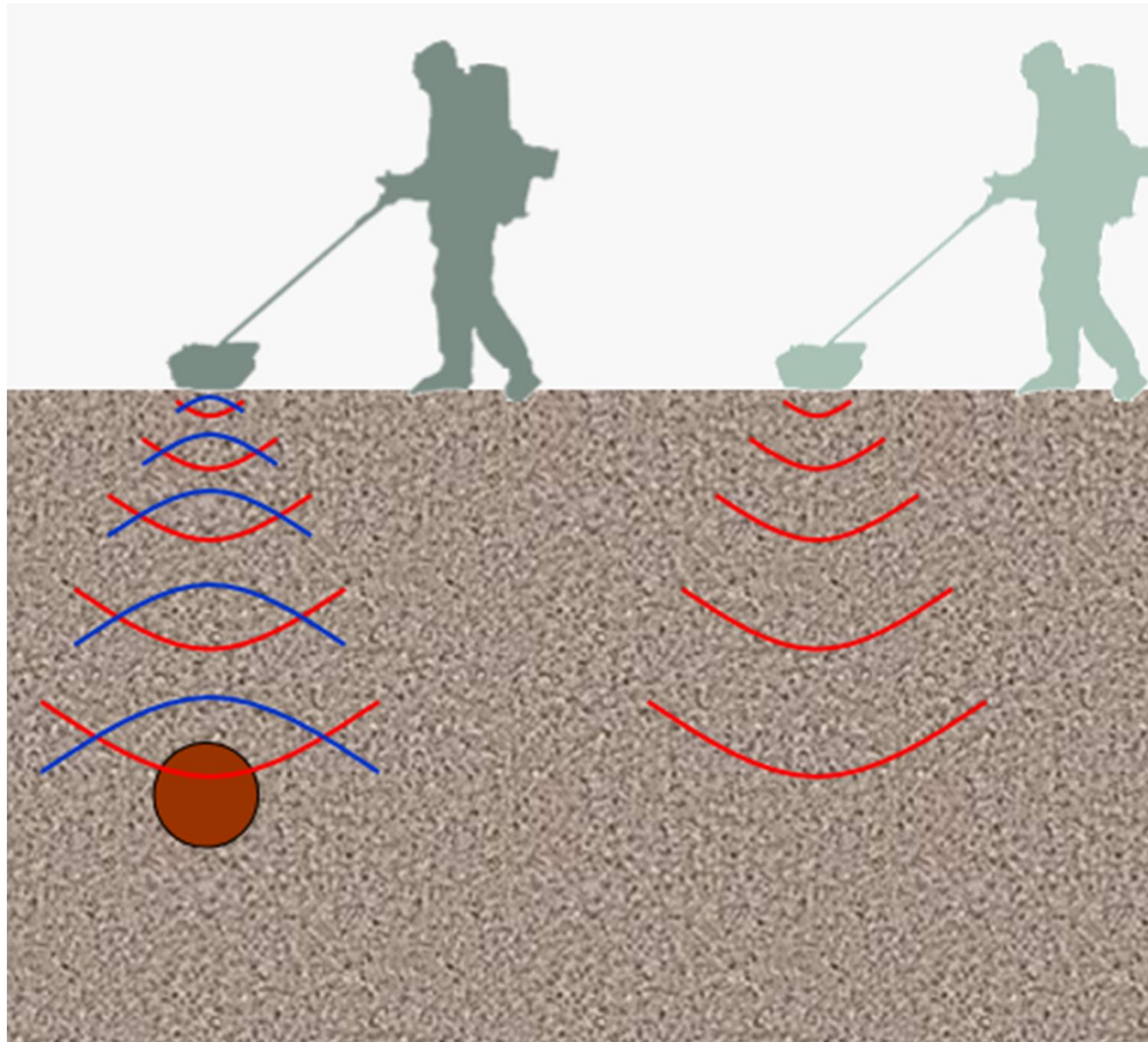
- Equipment normally consists of :-
 - A transmitter
 - A receiver antenna
 - A RADAR control unit
 - Suitable data storage and control devices



Ground Penetrating Radar (GPR)

- GPR is a geo-physical method that uses radar pulses to image subsurface.
- It uses high frequency polarised radio waves for transmitting them into ground.
- When the wave hits a buried object or a boundary with different dielectric constants, the receiving antenna records variations in the reflected return signal.

Ground Penetrating Radar (GPR)

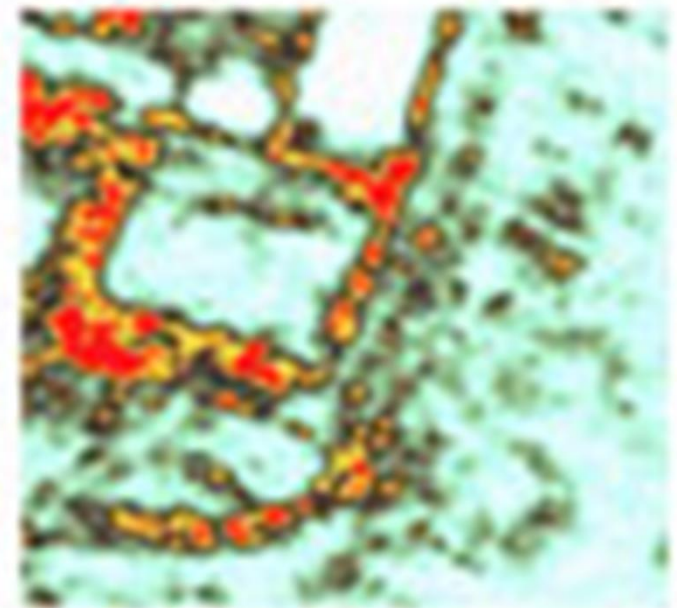
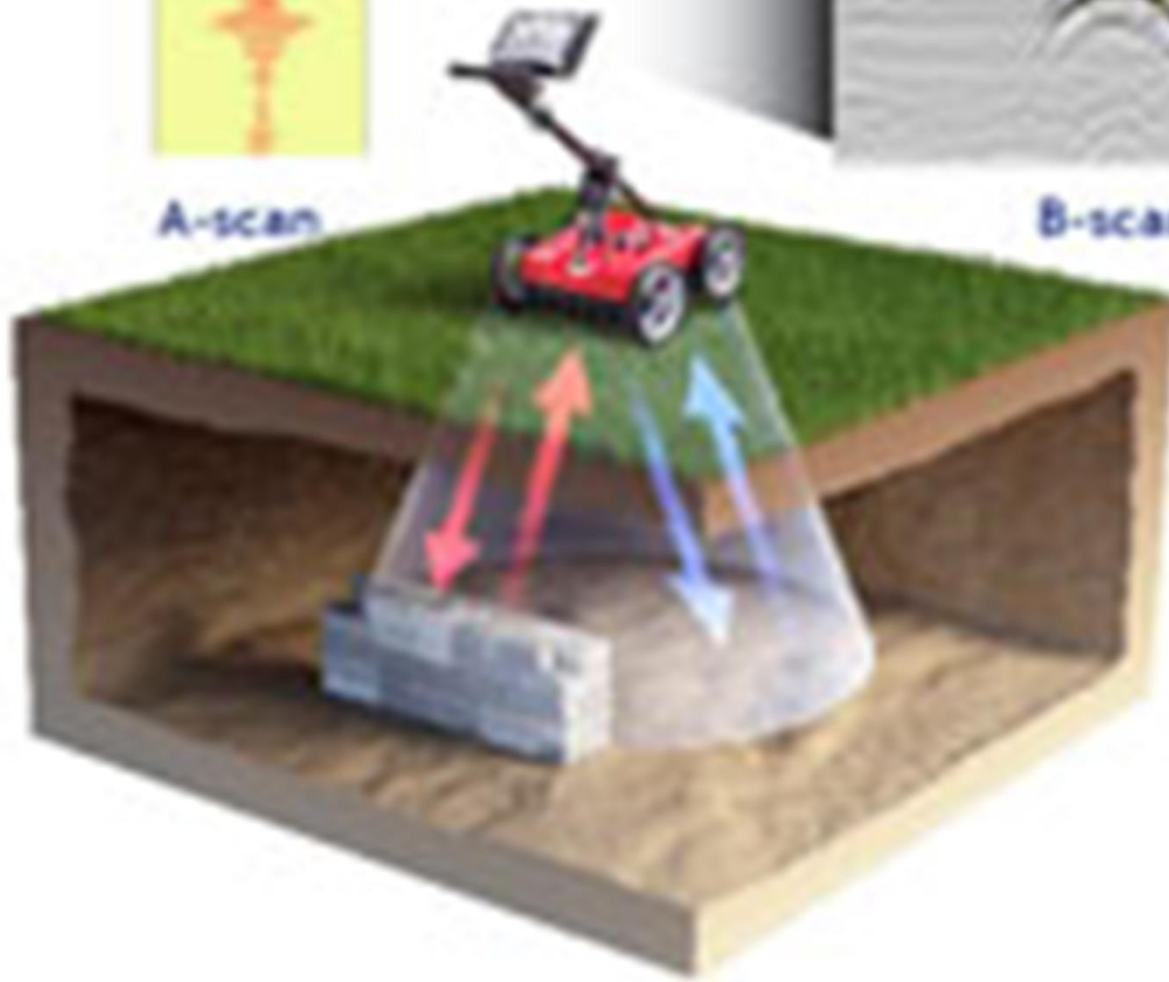




A-scan



B-scan



C-scan

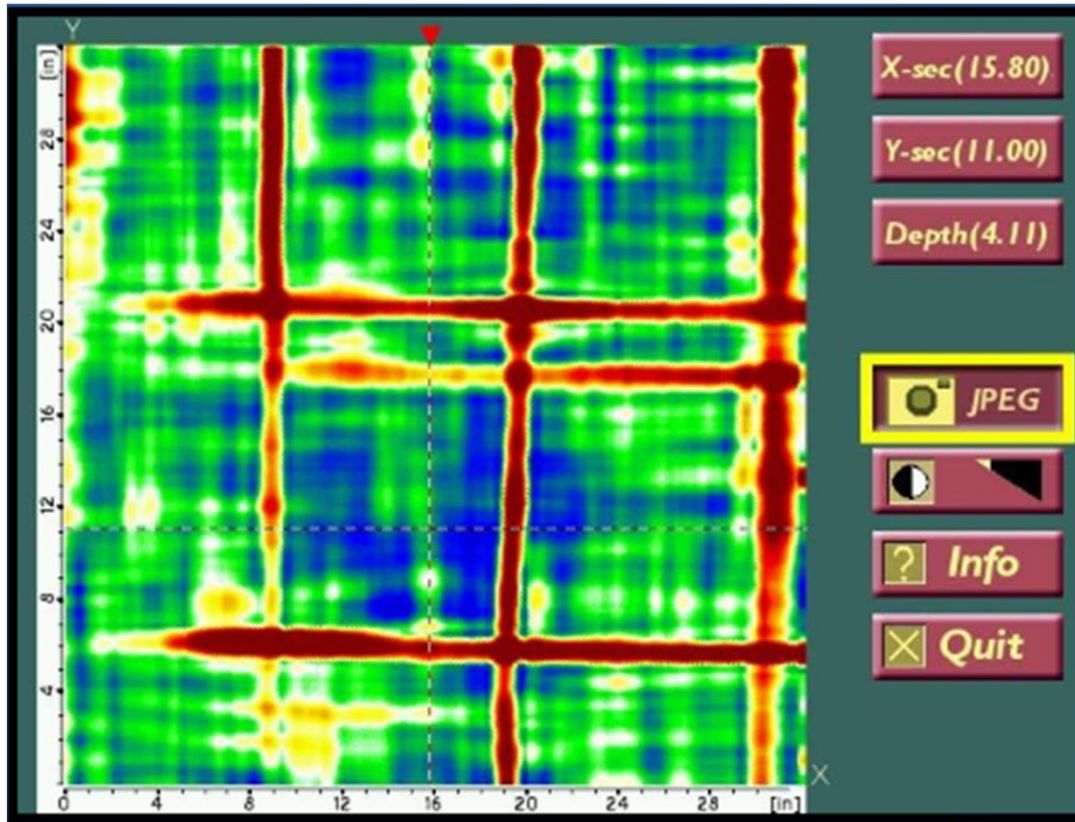
Ground Penetrating Radar (GPR)

- Ground Penetrating Radar (GPR) Systems can accurately and nondestructively "see" through solid pavement materials, such as asphalt, concrete and soil to detect subsurface objects and determine the condition and thickness of the material examined.

Ground Penetrating Radar (GPR)

- GPR can be used to collect information on sub-surface elements in roads, bridges, sports grounds, golf courses, cemeteries and in RC structures.
- It can accurately locate metallic and non-metallic reinforcements and pipes below concrete slabs.
- It can also detect flaws in concrete structures.

Mapping deterioration zones in reinforced concrete, consistent with corrosive environment & related damage such as delaminations and spalls

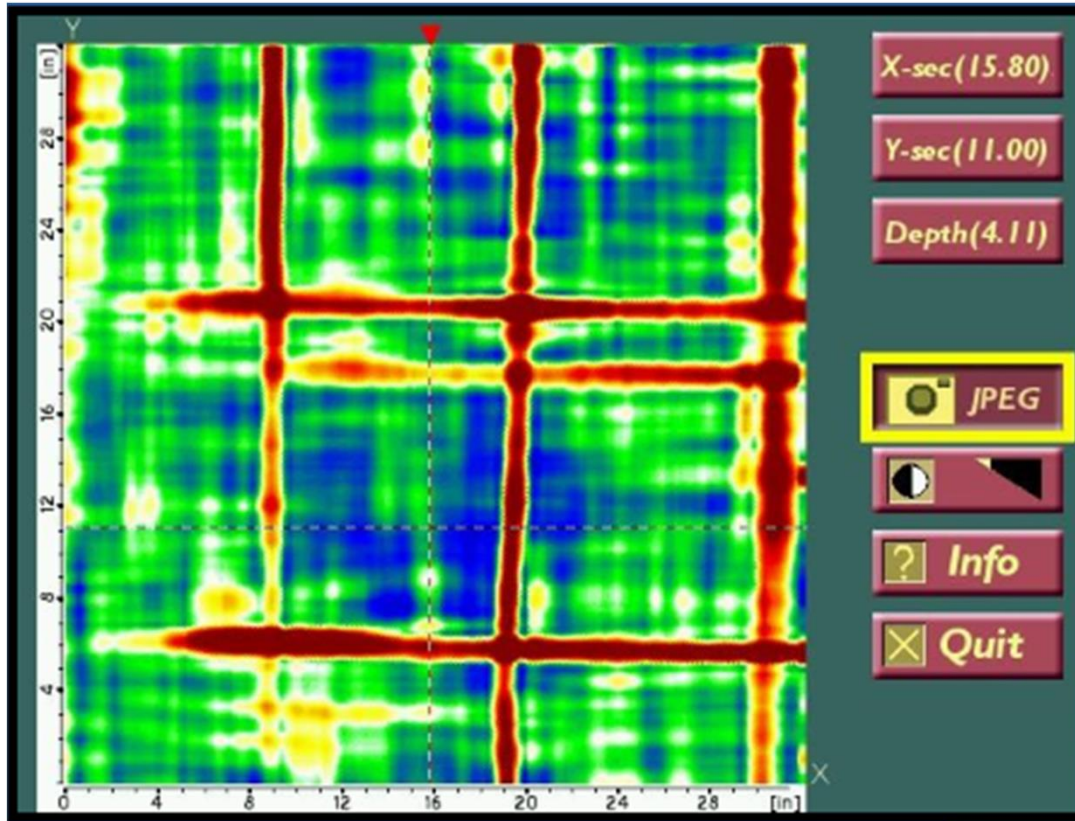


Rebar and tension cable location and depth

Slab thickness on grade and suspended



Location of non-metallic and metallic conduits and other embedded non-structural features such as fiber networks, in-floor heating elements, and plumbing



Detection of voids and variations in the concrete matrix



Some applications of GPR are :-

- Determining concrete thickness and cover concrete.
- Evaluation of bridge decks and pavements.
- Locating rebars, post tensioned cables, conduits, metal pipes and PVC pipes.
- Locating pipes, water lines, storm water and sewer systems buried in soil.
- Detecting irrigation and septic field systems, under ground storage tanks and under ground utilities.

Ground Penetrating Radar (GPR)

- GPR is an ideal technology for detection of bridge deck delaminations, voids, subsurface moisture accumulation and the thickness of asphalt pavement layers

All at highway speeds!



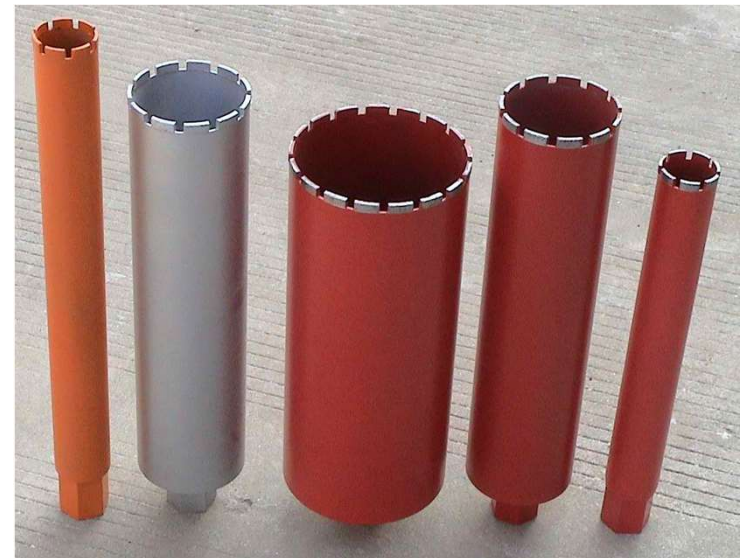
Commonly adopted SDT Methods



**CONCRETE CORE
CUTTER**

CONCRETE CORE CUTTER

- Vibration-free, precise and robust instruments
- Drilling Tools have diamond bits
- Wet drilling or dry drilling
- Effective, low-vibration economical working



GDB 1600 WE- DIAMOND CONCRETE CUTTER



- **Dia. : In concrete: 30-82 mm**
In masonry: 52-132 mm (with suction head)
- **Power input : 1600 W**
- **No-load Speed: 1st & 2nd gear : 980 & 2400 rpm**
- **Weight : 5.9 kg**

GDB 2500 WE - DIAMOND CONCRETE CUTTER



- **Drilling Dia. Concrete : 32-212 mm**
- **Drilling stroke : 500 mm**
- **Power input : 2500 W**
- **No-load speed : 1st & 2nd gear 410 & 900 rpm**
- **Weight : 5.9 Kg**

S 500 A - DRILL STAND

- **Drill Stroke : 500 mm**
- **Column length : 1000 mm**
- **Weight : 12.5 kg**



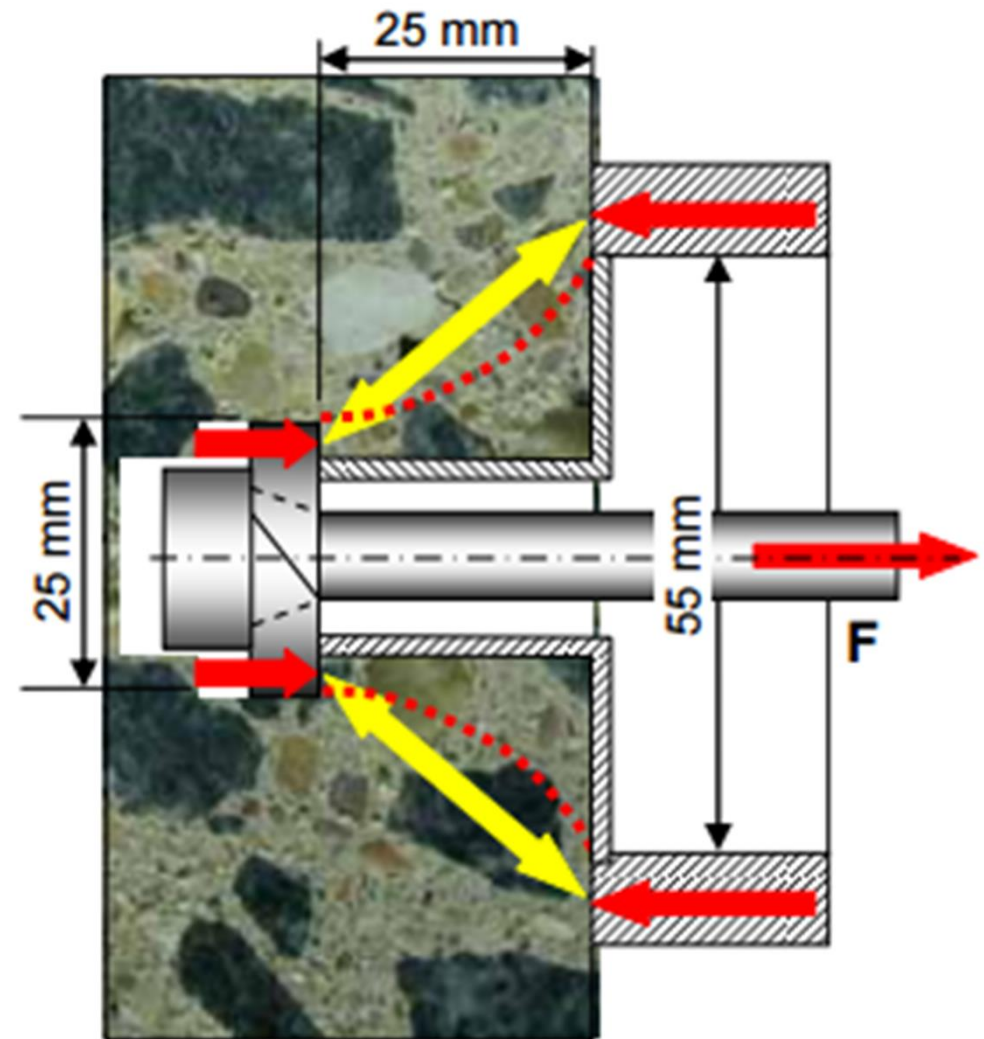


CAPO TEST



CAPO TEST

- In this method, appropriate dia and depth of holes are made using a specific tool.
- The specially designed tool with enlarged mouth will be driven into the hole and thoroughly fastened.





CAPO TEST

- Then the insert will be pulled off with a hydraulic system.
- The required force to pull the insert along with concrete is measured & correlated with calibration chart to assess the strength of concrete.



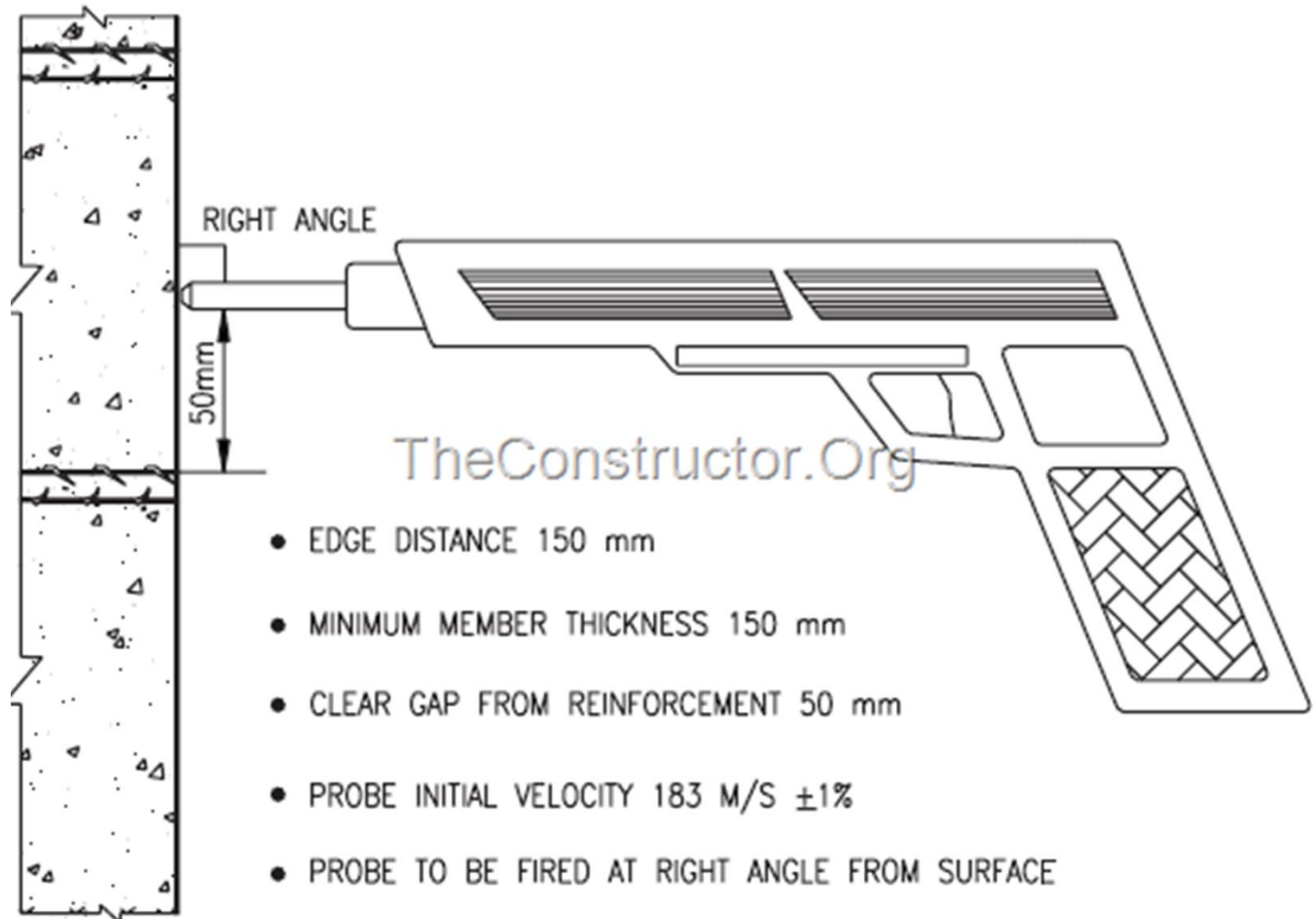
Generally conducted when the core test cannot be conducted.

Windsor Probe Test



Windsor Probe Test

A standard steel
pin is driven in
to the concrete
surface with a
special gun
operated by
spring charge.



Windsor Probe Test

- The depth of penetration is measured.
- Since the depth of penetration is inversely proportional to compressive strength, the device provides a fast and safe way to find the strength of concrete.



Windsor Probe Test

- One should be very careful while using this device as there will be chances of causing injury to the neighbouring person if it is not held properly during testing.

Load Testing of Structures

- If NDT and SDT results fail to give satisfactory information regarding the strength and quality, then load test will be conducted and it is the most acceptable test. For flexural members
- Subjected load = Full DL + 1.25 x Imposed Load
- Deflection due to imposed load is recorded
- After 24 hours, Imposed Load is removed
- Recovery of deflection is also calculated

Load Testing of Flexure Structures

Instruments used in Load testing :-

- **Deflectometers**
- **LVDTs (Linearly Varying Displacement Transducers)**
- **Sand bags**
- **Water ponding**
- **Trucks carrying measured loads (for bridge decks)**







Commonly adopted Other Methods

Tests for Carbonation of Concrete

- Carbonation of concrete in cover results in loss of protection to the steel against corrosion.
- The depth of carbonation can be measured by spraying the freshly fractured concrete surface with a 0.2% solution of phenolphthalein in ethanol.



Tests for Carbonation of Concrete

- Since Phenolphthalein is a pH indicator, the magenta (pink colour) area presents uncarbonated concrete and the remaining (colourless) portion, the carbonated area.



Tests for Carbonation of Concrete

- The change in colour occurs at around pH 10 of concrete.
- The test must be applied only to freshly exposed surfaces, because reaction with atmospheric carbon dioxide starts immediately.
- Relating carbonation depth to concrete cover is one of the main indicators of corrosion.

Test for Chloride Content in Concrete

- The presence of chloride in the concrete is the contributory factor towards corrosion of reinforcement.
- Portable equipments are available in the market, which can be used for rapid on site measurement of chloride content of concrete.
- The chloride content of concrete can also be determined by chemical analysis of concrete in the laboratory.

Test for Chloride Content in Concrete

- A rotary percussion drill is used to collect a pulverized sample of concrete and a special acid extracts the chlorides.
- Different samples are obtained from different concrete depths, to establish the chloride contamination in the concrete.

Test for Sulphate Content in Concrete

- The quantity of sulphates in concrete is determined generally by well defined **chemical analysis** in the laboratory.
- This test will be carried out on the concrete samples collected from the members at different depths.
- The results are expressed in terms of percentage of sulphates by weight of concrete.

Test for Sulphate Content in Concrete

- Presence of high amount of sulphates will result in reaction of calcium present in cement with sulphates.
- This results in expansion and disruption of concrete - leads to corrosion of rebars.

Determination of pH

- The level of pH in concrete is determined generally by well defined chemical analysis in the laboratory.
- This test will be carried out on concrete samples collected from the members (at different depths).
- The level of pH in concrete will indicate the status of corrosion of rebars in concrete.

Concluding Remarks

- The availability of wide range of NDT devices has made it easier to monitor quality or distress or durability of concrete structures.
- The NDT devices have proved to be reliable and invaluable.

Concluding Remarks

- Depending on the requirement, any two or more tests are to be conducted to get the required information regarding the quality / strength of concrete.
- Interpretation of test results requires competent persons to arrive at acceptable evaluation of concrete regarding its quality and strength.



Thank You

Questions ?