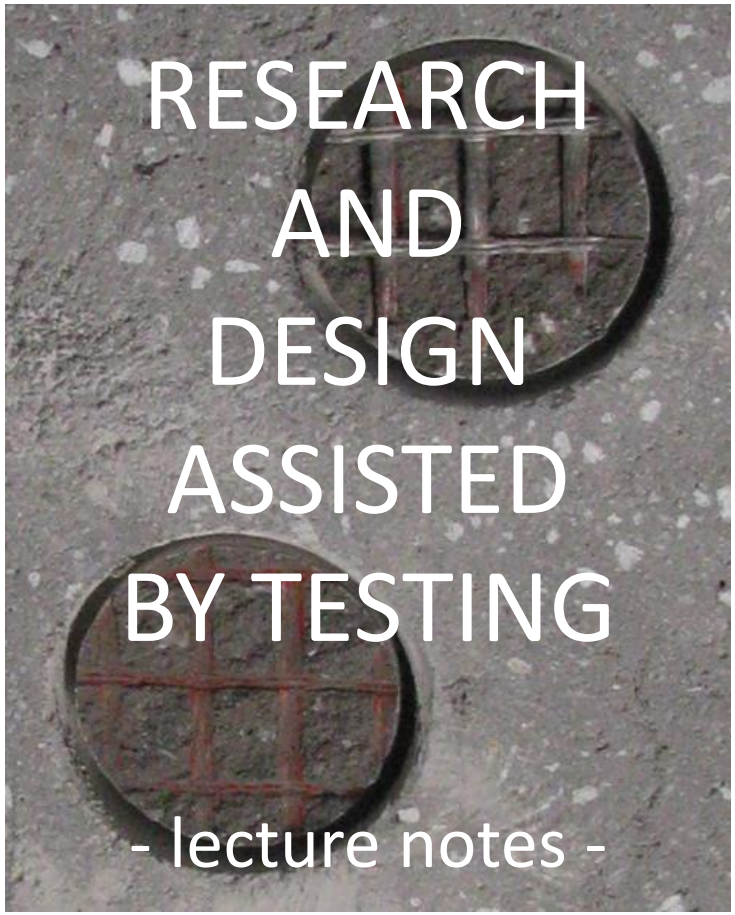

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2017

- Malhotra V.M. , CarinoN.J., Handbook on Nondestructive Testing of Concrete, CRC PRESS, 2004, ISBN 0-8031-2099-0

- Bungey J. H. , Millard S. G. , Grantham M. G., Testing of concrete in structures, Taylor & Francis, 2006, ISBN10: 0–415–26301–8

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- SHM http://www.shmlive.com/

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- ISIS and SAMCO Educational Module 5: An Introduction to Structural Health Monitoring

AIMS OF IN-SITU TESTING

1. **CONTROL TESTING** CARRIED OUT BY THE

- *CONTRACTOR*

OR

- *CONCRETE PRODUCER*

TO INDICATE ADJUSTMENTS NECESSARY TO ENSURE AN ACCEPTABLE SUPPLIED MATERIAL.

→ BULLETINS

MINISTERUL DEZVOLTĂRII REGIONALE ŞI TURISMULUI
INSPECTORATUL DE STAT ÎN CONSTRUCŢII

AUTORIZAŢIE

T.S. LABORATOR DE GRADUL I

Nr. 2428
Data: 10.01.2012

Se autorizează Laboratorul: "LABORATOR DE ANALIZE ŞI ÎNCERCĂRI ÎN CONSTRUCŢII - LABORATOR CENTRAL - GRAD I - UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA"
aparţinând "UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA"
C.I.F. RO13847750
având sediul social în JUD. CLUJ, LOCALITATEA CLUJ-NAPOCA, Str. Memorandumului, Nr. 28,
pentru efectuarea de încercări şi verificări de laborator, în profilurile şi pentru încercările din anexă.
Standard de referinţă SR EN ISO/CEI 17025:2005/AC:2007.

INSPECTOR GENERAL

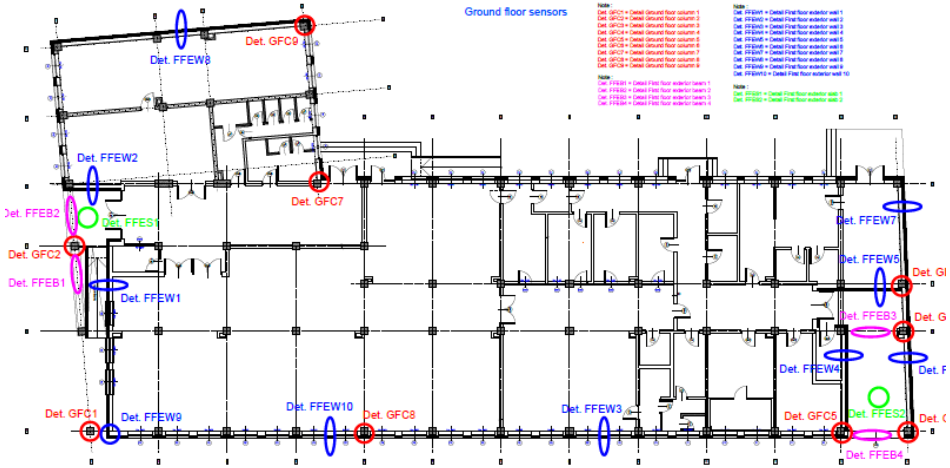
AIMS OF IN-SITU TESTING

2. **COMPLIANCE TESTING** IS PERFORMED BY
OR PERFORMED FOR

- *THE ENGINEER* ACCORDING TO AN AGREED PLAN

- *TO JUDGE* COMPLIANCE WITH THE SPECIFICATION

→ BULLETINS / REPORTS



(Bungey, 2006)

AIMS OF IN-SITU TESTING

3. **SECONDARY TESTING** IS CARRIED OUT ON
   - HARDENED CONCRETE IN THE STRUCTURE
   - EXTRACTED FROM THE STRUCTURE.

THIS MAY BE REQUIRED WHEN:

- there is doubt about the reliability of control and compliance results
- they are unavailable results
- the results are inappropriate
- the structure is old, damaged or deteriorating

All testing which is **not planned before** construction will be in this category, although **long-term monitoring** is also included.

(Bungey, 2006)

NEED FOR TESTING IN/OF STRUCTURES

- PROPOSED **CHANGE** OF USAGE OR **EXTENSION** OF A STRUCTURE

E. I. Factory → store
Store → factory
Residential building→ banc

Structural extensions: horizontal or vertical

- ACCEPTABILITY OF A STRUCTURE FOR **PURCHASE** OR **INSURANCE**

'BOOK OF THE CONSTRUCTION'

NEED FOR TESTING IN/OF STRUCTURES

- MEMBERS KNOWN OR SUSPECTED TO CONTAIN **MATERIAL** WHICH DOES **NOT MEET SPECIFICATIONS**, OR WITH **DESIGN/EXECUTION FAULTS**

BRICK TYPE ACC/EFFICIENT ?

PROJECT CONFORMITY ?

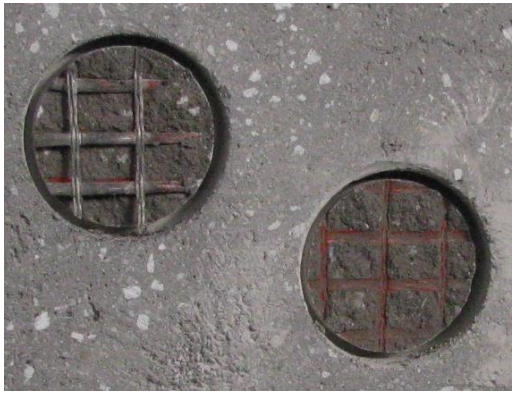
NEED FOR TESTING IN/OF STRUCTURES

- **ASSESSMENT** OF THE **QUALITY** OR **INTEGRITY** OF APPLIED REPAIRS/STRENGTHENING

- **MONITORING** OF STRENGTH DEVELOPMENT IN RELATION TO **CURING**, **PRESTRESSING** OR **LOAD** APPLICATION

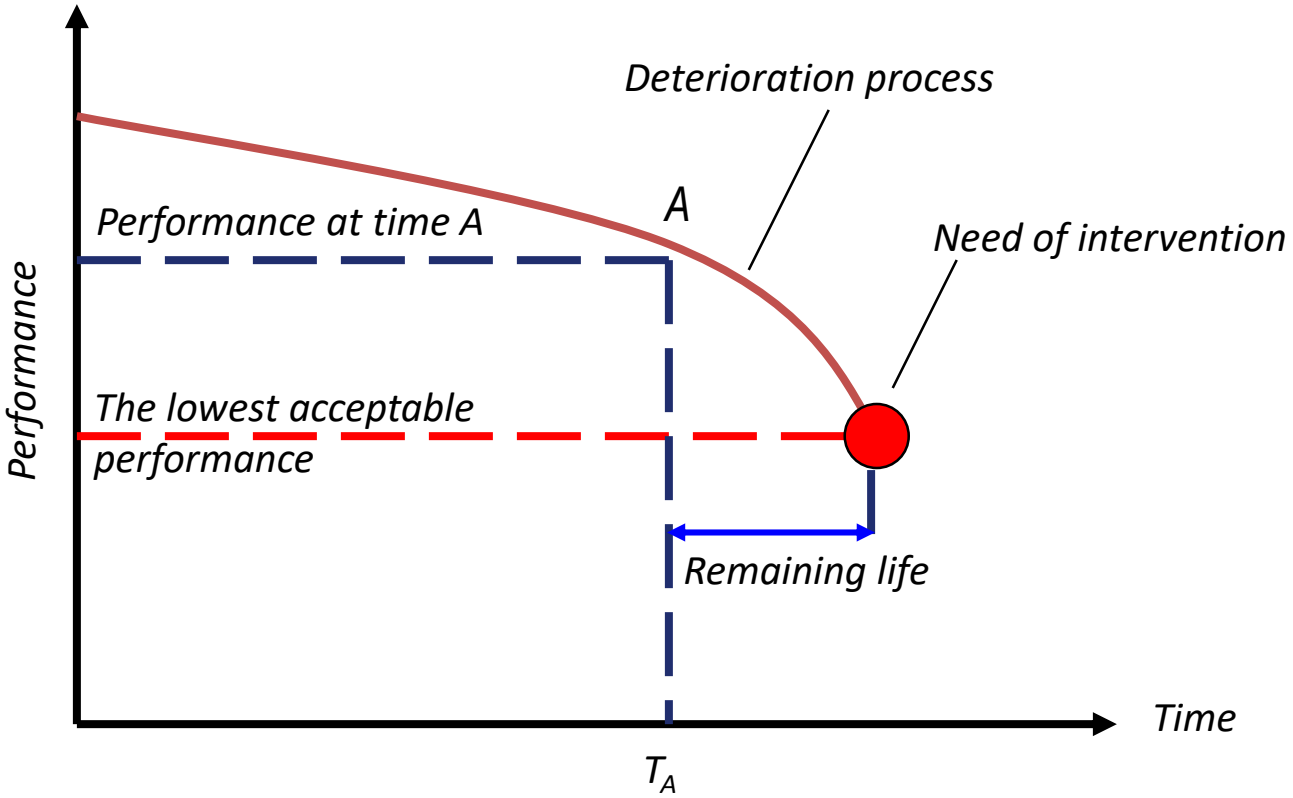
- **MONITORING** LONG-TERM **CHANGES IN MATERIALS PROPERTIES** AND **STRUCTURAL PERFORMANCE**

- **ASSESSMENT OF CAUSE** AND EXTENT **OF DETERIORATION** AS A PRELIMINARY TO THE DESIGN OF REPAIR OR REMEDIAL SCHEMES

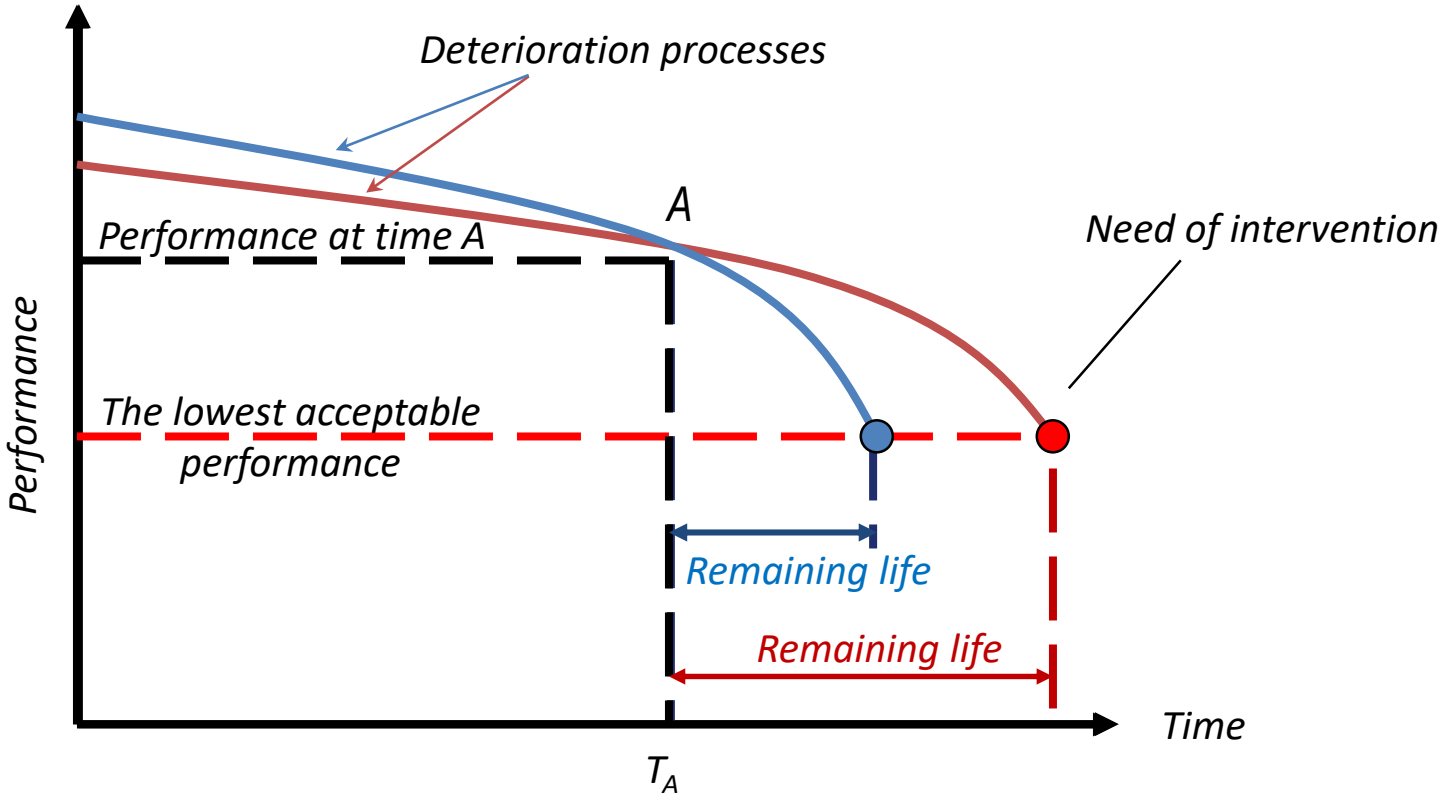


(Bungey, 2006)

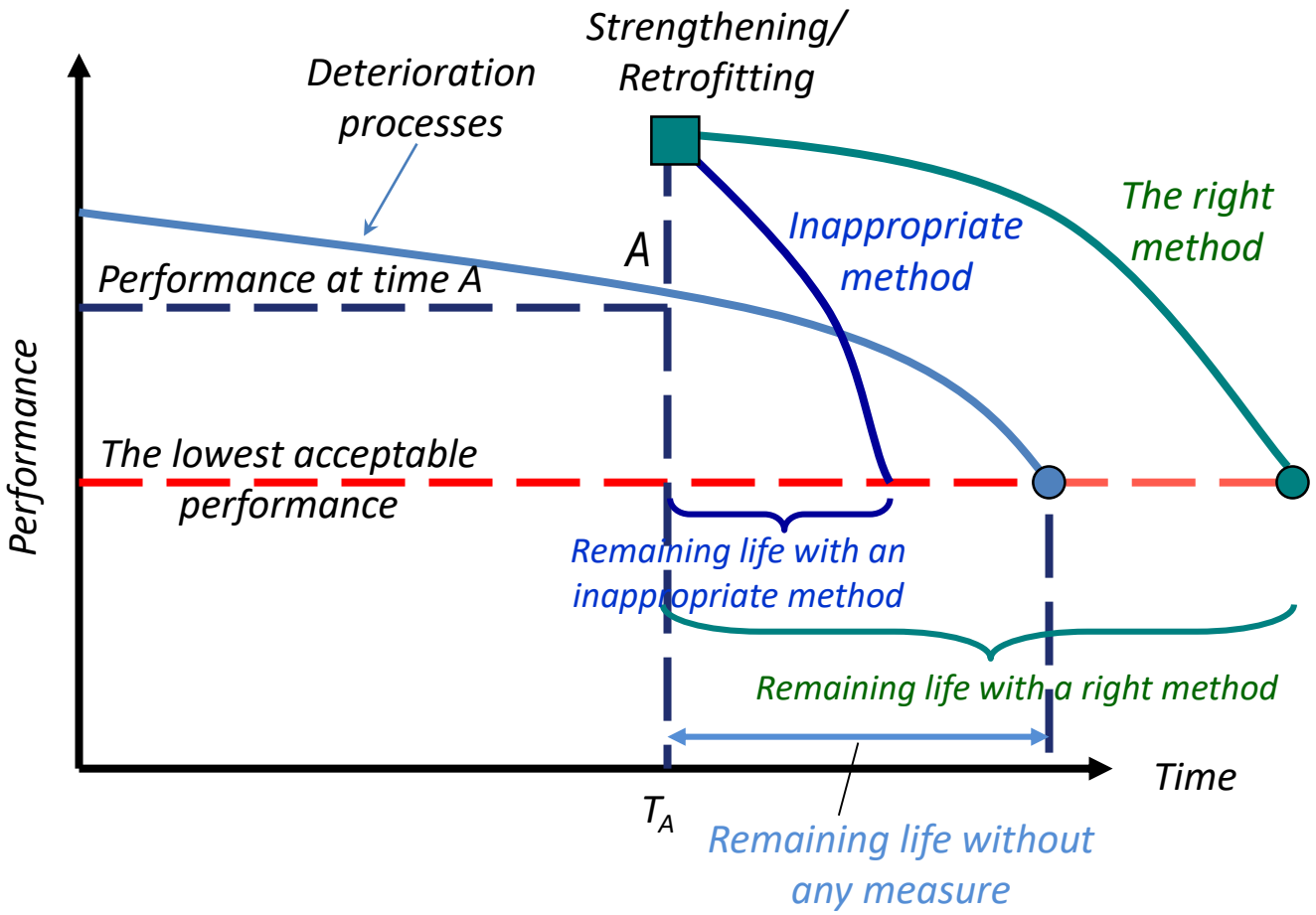
DETERIORATION PROCESS IN GENERALLY



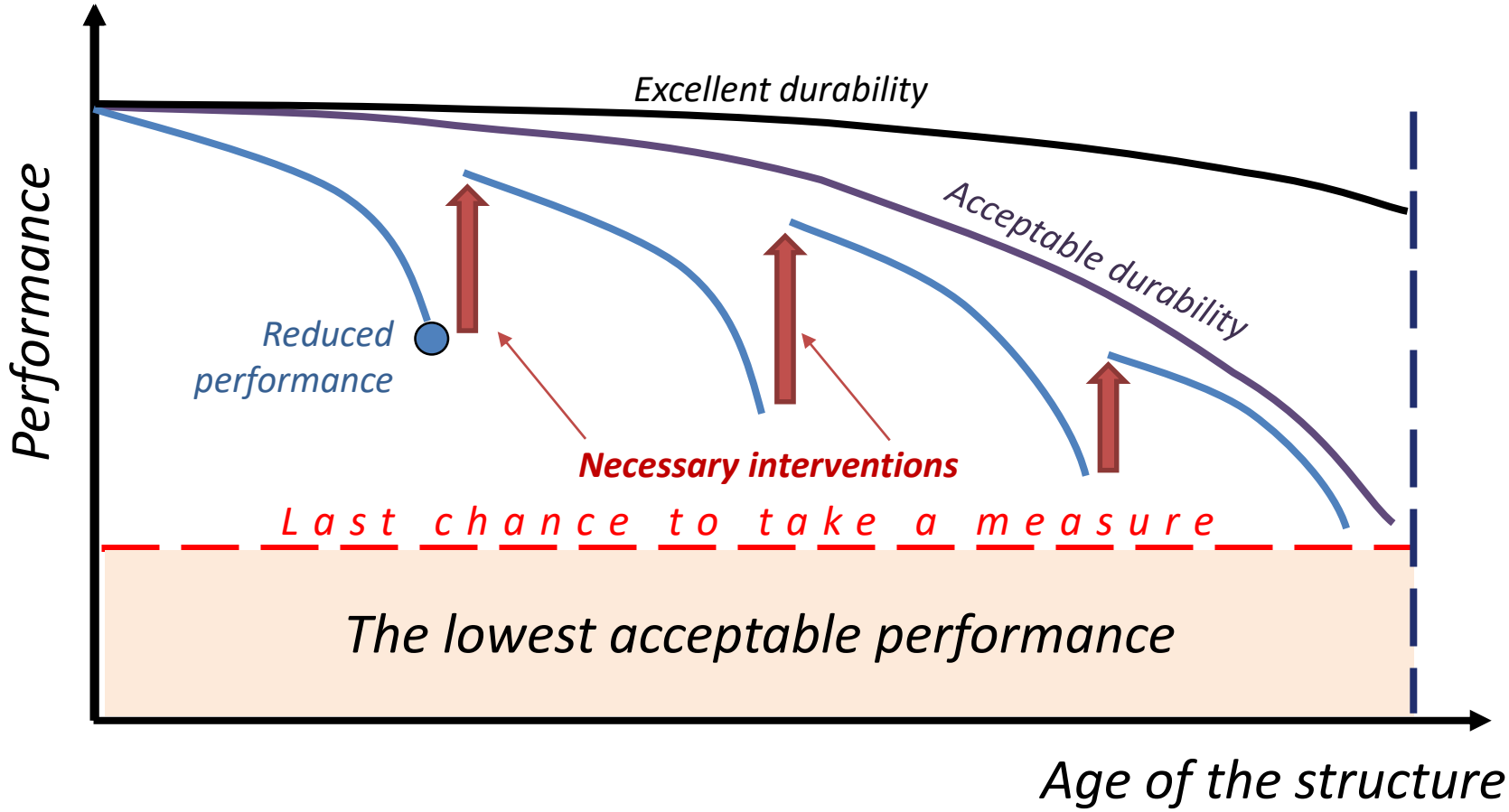
DETERIORATION PROCESS IN GENERALLY



DETERIORATION PROCESS IN GENERALLY – IMPORTANCE OF A PROPER INTERVENTION



DETERIORATION PROCESS IN GENERALLY



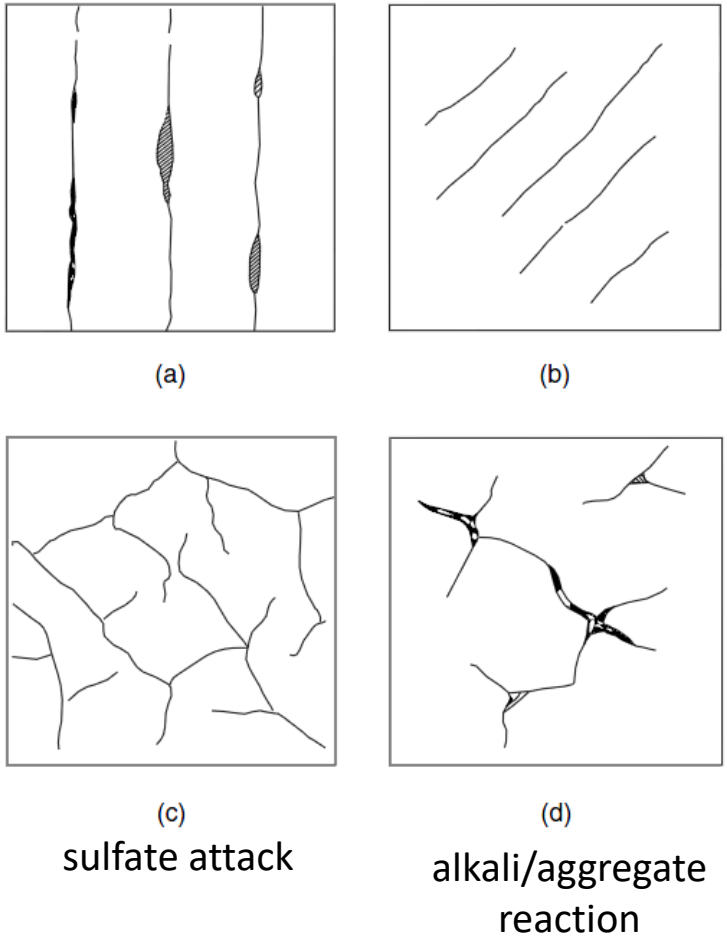
TYPE OF INVESTIGATIONS

INVESTIGATIONS ON MATERIALS

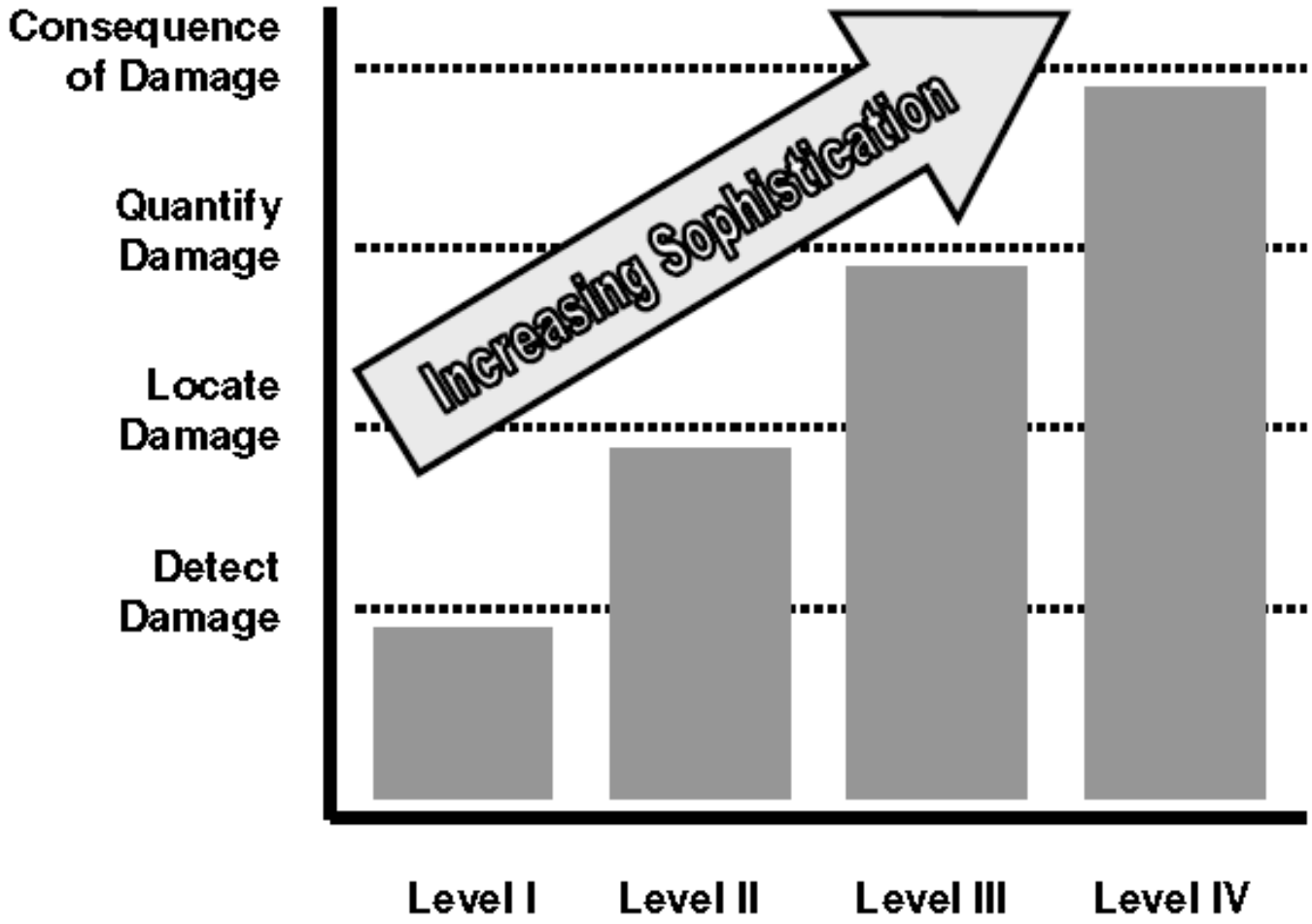
- DETERMINATIONS ON STRENGTHS
- PHYSICAL DETERMINATIONS
- CHEMICAL DETERMINATIONS
- OTHER DETERMINATIONS

INVESTIGATIONS ON STRUCTURES

- STUDY OF CRACKING OR CRACKS
- DEFORMATION MEASURING
- STRESS MEASURING
- STRUCTURAL INTEGRITY
- OTHER DETERMINATIONS



INVESTIGATION LEVELS

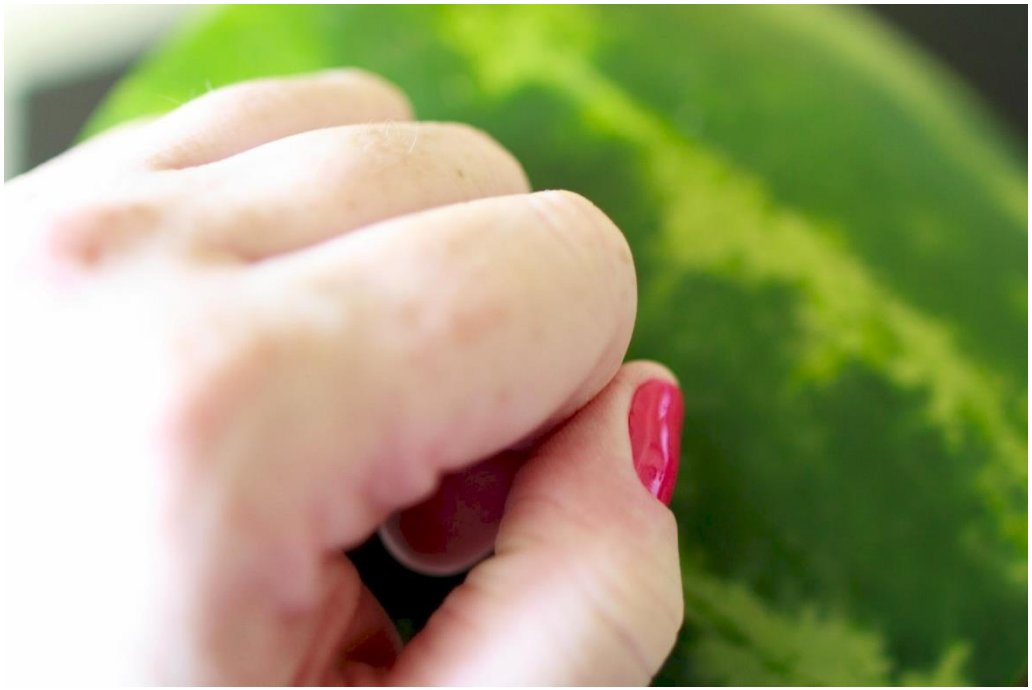


(ISIS, 2006)

MODES OF INVESTIGATION

INSTINCTIVE

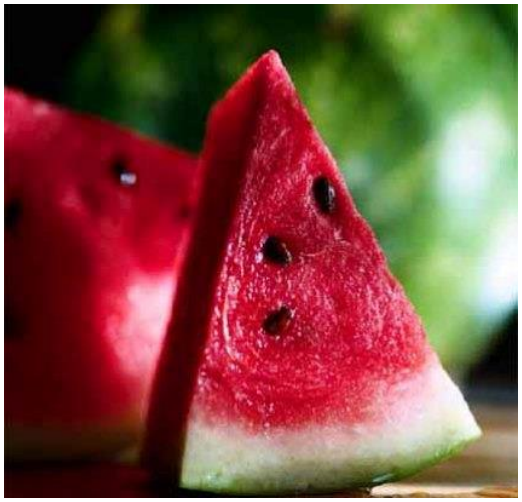
- SURFACE HARDNESS
- COLOR



INSTINCTIVE

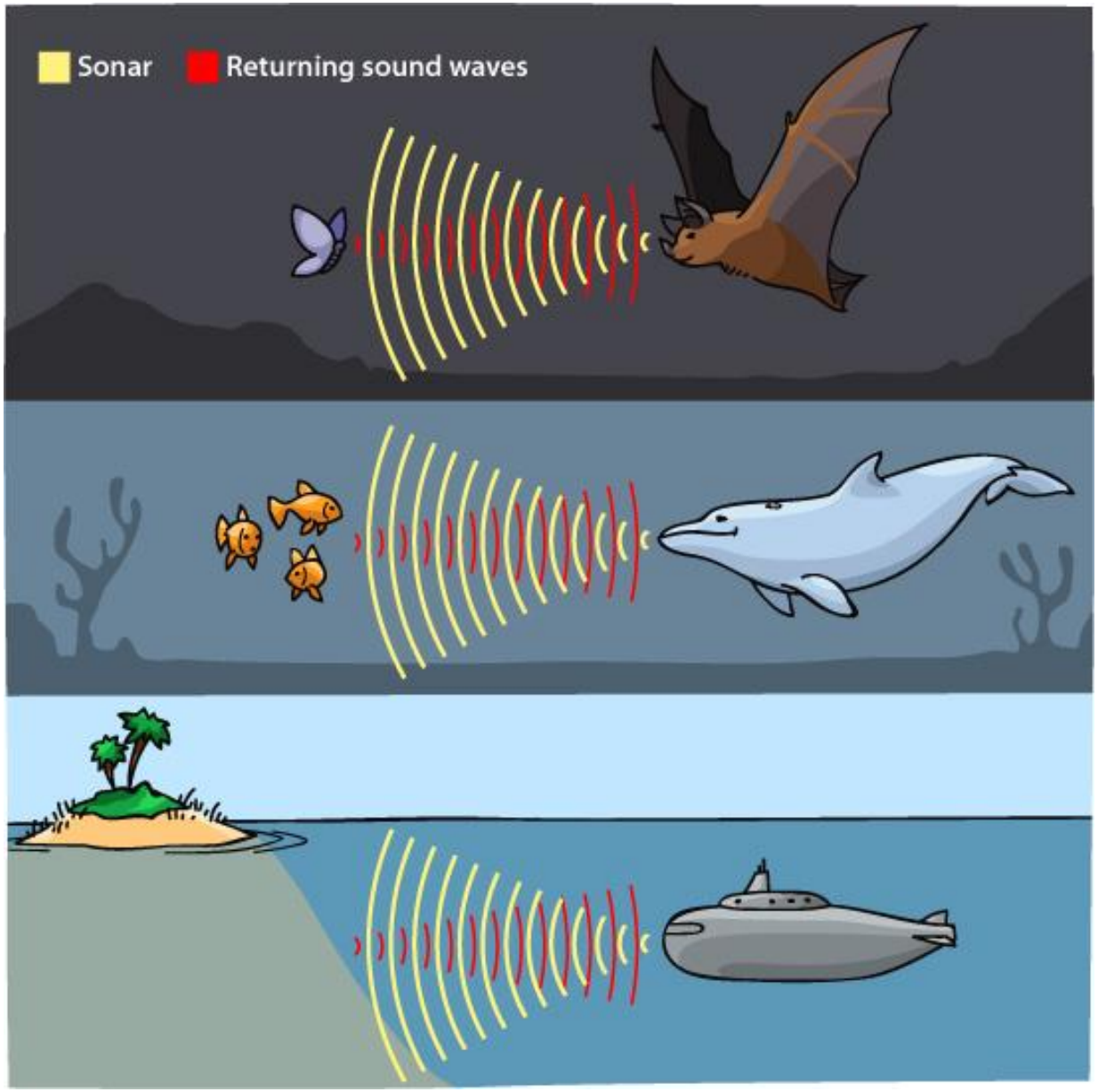
CORE:

- COLOR
- ASPECT
- DENSITY
- SMELL
- HARDNESS
- COMPACTNESS



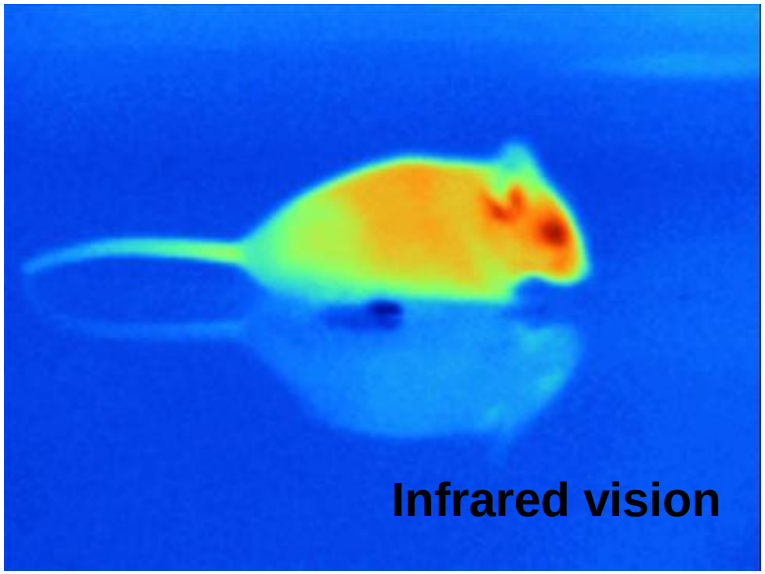
INSTINCTIVE

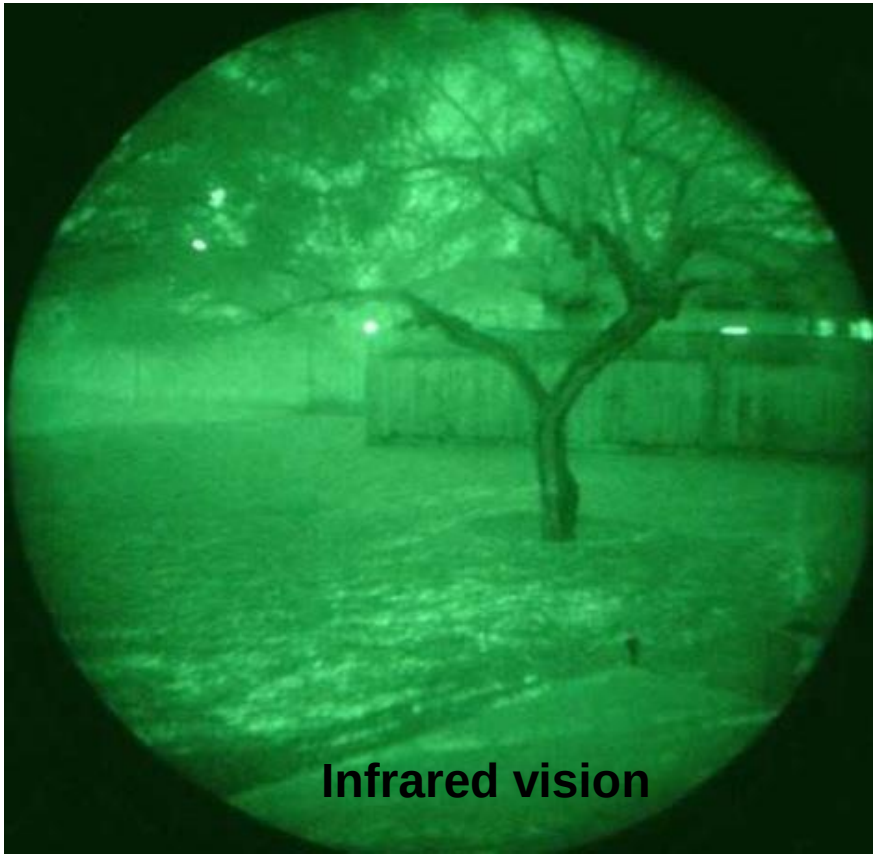
- DISTANCE
- NUMBER
- SIZE
- POSITION



INSTINCTIVE

- TEMPERATURE
- SIZE
- NUMBER





AVAILABLE TEST METHODS

- **NON-DESTRUCTIVE METHODS**, DEFINED AS **NOT IMPAIRING THE PERFORMANCE OF THE ELEMENT OR MEMBER** UNDER TEST, AND WHEN APPLIED TO CONCRETE IS TAKEN TO INCLUDE METHODS WHICH CAUSE LOCALIZED SURFACE ZONE DAMAGE

- **METHODS REQUIRING SAMPLE EXTRACTION,** MOST COMMONLY IN THE FORM OF **CORES** DRILLED FROM THE CONCRETE, WHICH MAY BE USED IN THE LABORATORY FOR STRENGTH AND OTHER PHYSICAL TESTS AS WELL AS VISUAL, PETROGRAPHIC (MINERAL CONTENT) AND CHEMICAL ANALYSIS.

(Bungey, 2006)

PRINCIPAL TEST METHODS

INVESTIGATION	TEST
CORROSION OF EMBEDDED STEEL	**COVER DEPTH**
	CARBONATION DEPTH
	CHLORIDE CONCENTRATION
	RESISTIVITY

(Bungey, 2006)

INVESTIGATION	TEST
CONCRETE QUALITY AND DURABILITY	**SURFACE HARDNESS**
	ULTRASONIC PULSE VELOCITY
	RADIOGRAPHY / RADIOMETRY
	RELATIVE HUMIDITY
	PERMEABILITY
	ABSORPTION
	SULFATE CONTENT
	PETROGRAPHIC (MINERAL CONTENT)
	AIR CONTENT
	CEMENT TYPE AND CONTENT
	ABRASION RESISTANCE

(Bungey, 2006)

INVESTIGATION	**TEST**
CONCRETE STRENGTH	**CORES**
	PULL-OUT
	PULL-OFF
	PENETRATION RESISTANCE
	MATURITY

(Bungey, 2006)

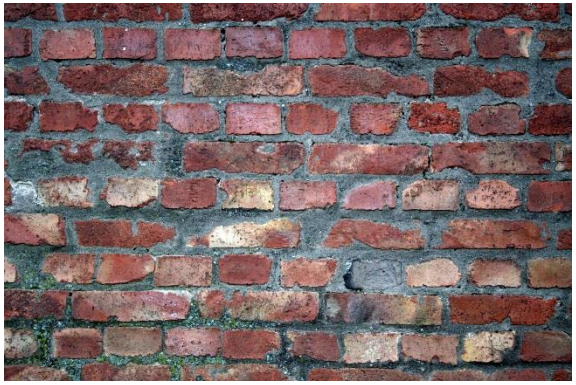
INVESTIGATION	TEST
INTEGRITY AND PERFORMANCE	DYNAMIC RESPONSE
	THERMOGRAPHY
	RADAR
	REINFORCEMENT LOCATION
	STRAIN OR CRACK MEASUREMENT
	LOAD TEST

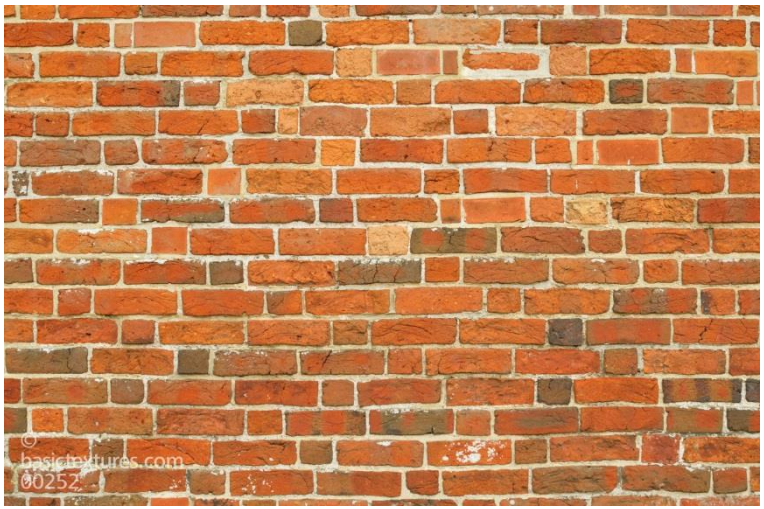
(Bungey, 2006)

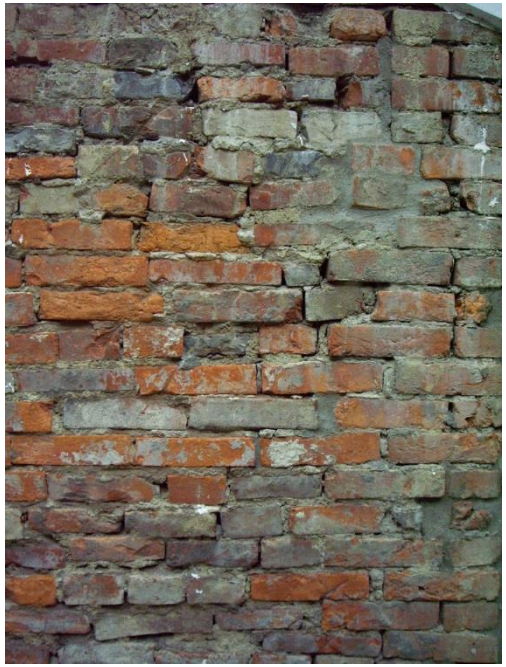
VISUAL INSPECTION

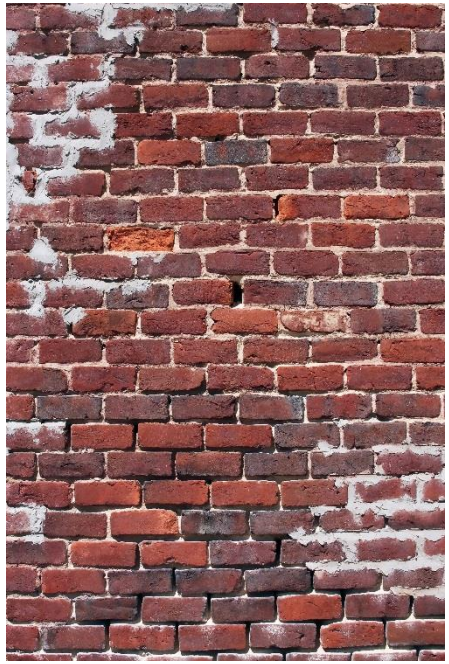
→This **can** often **provide valuable information** to the well-trained eye ☺:

- QUALITY OF WORKS – verticality, color, thickness, width, solid, compact, deformed









VISUAL INSPECTION

→This **can** often **provide valuable information** to the well-trained eye ☺:

- QUALITY OF MATERIALS

VISUAL INSPECTION

→This **can** often **provide valuable information** to the well-trained eye ☺:

- SEGREGATION / HONEYCOMBS

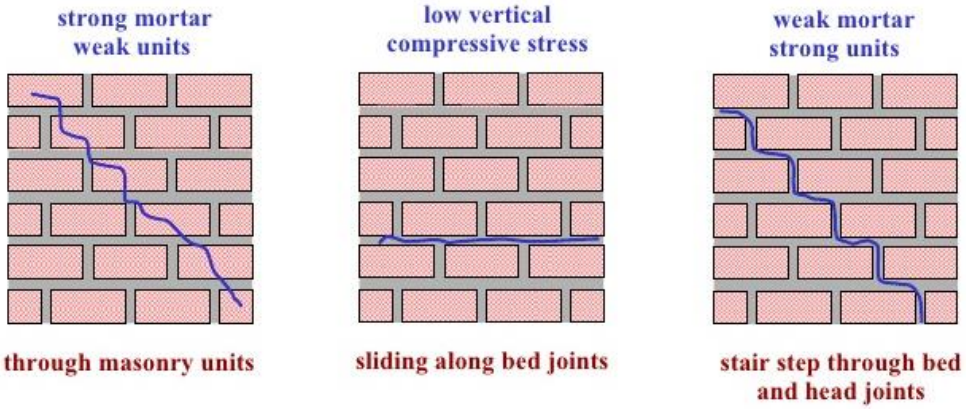
Honeycombs : *are the hollow spaces and cavities left in concrete mass on surface or inside the concrete mass which is caused by the mortar not filling the spaces between the coarse aggregate particles.*

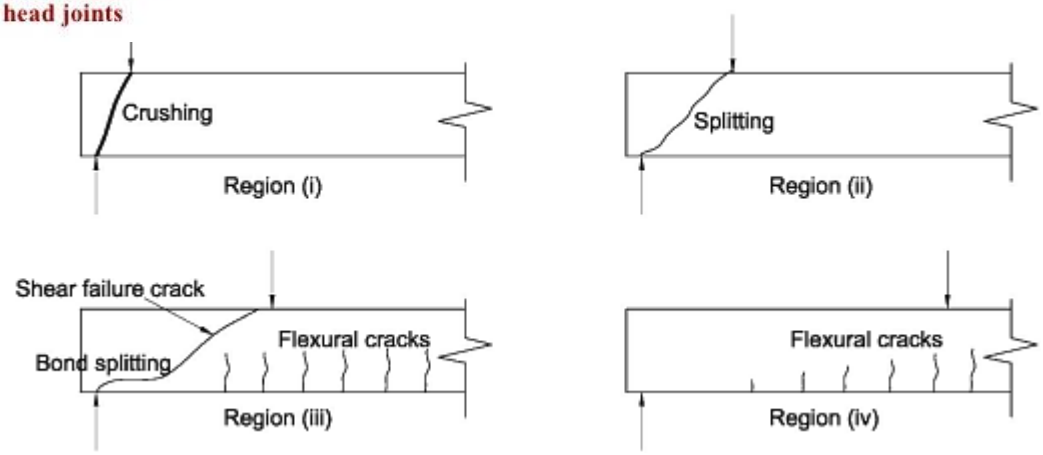
Causes*: poor workability, poor grading of aggregates, grout leak, movement of formwork, improper compaction, improper cover and placement of rebars.*

VISUAL INSPECTION

→This **can** often **provide valuable information** to the well-trained eye ☺:

- VARIOUS TYPES OF CRACKING (SHRINKAGE, CORROSION, BENDING, EXCESSIVE DEFORMATION/DEFLECTIONS)





VISUAL INSPECTION

→This **can** often **provide valuable information** to the well-trained eye ☺:

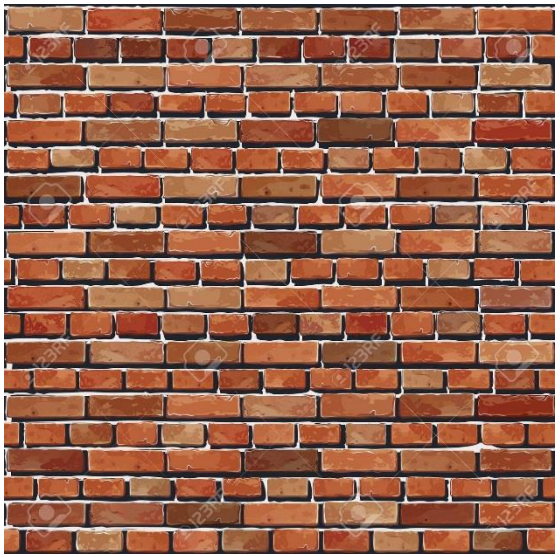
- SPALLING OF CONCRETE from fire, freeze-thaw, rebar corrosion, stresses

VISUAL INSPECTION

→This **can** often **provide valuable information** to the well-trained eye ☺:

- UNIFORMITY OF CONCRETE SURFACE TEXTURE AND COLOR VARIATIONS

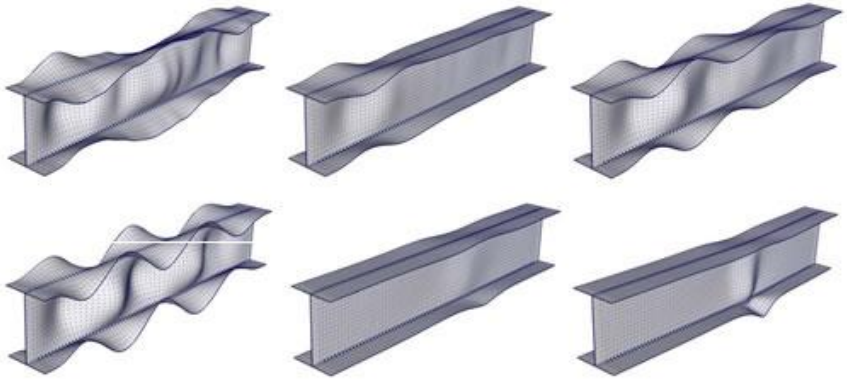





VISUAL INSPECTION

→This **can** often **provide valuable information** to the well-trained eye ☺:

- STRUCTURAL DEFORMATIONS – deflections, buckling, rotations



DIAGNOSIS OF DEFECTS AND DETERIORATION

(Bungey, 2006)

CAUSE	SYMPTOMS			AGE OF APPEARANCE	
	cracking	spalling	erosion	early	long-term
REINFORCEMENT CORROSION	X	X			X
CHEMICAL ATTACK	X	X	X		X
FROST DAMAGE	X	X	X	X	
FIRE DAMAGE	X	X		X	
FREEZE–THAW		X	X		X
INTERNAL REACTIONS	X	X			X
THERMAL EFFECTS	X	X		X	X
SHRINKAGE	X			X	X
CREEP	X	X			X
SETTLEMENT	X			X	x
PHYSICAL DAMAGE	X	X	X	X	X
STRUCTURAL DEFICIENCY	X	X		X	X

(Bungey, 2006)

DURABILITY TESTS → CHARACTERISTICS

METHOD	COST	SPEED OF TEST	DAMAGE
COVER MEASUREMENT	LOW	FAST	NONE
CARBONATION DEPTH	LOW	FAST	MINOR
CHLORIDE CONTENT	LOW	FAST	MINOR
RESISTIVITY	MODERATE	FAST	MINOR/NONE
ABSORPTION	MODERATE	SLOW	MODERATE/MINOR
PERMEABILITY	MODERATE	SLOW	MODERATE/MINOR
MOISTURE CONTENT	MODERATE	SLOW	MINOR
CHEMICAL	MODERATE/HIGH	SLOW	MODERATE
RADIOGRAPHY	HIGH	SLOW	NONE
PETROGRAPHIC	HIGH	SLOW	MODERATE

(Bungey, 2006)

STRENGTH TESTS → CHARACTERISTICS

METHOD	COST	SPEED OF TEST	DAMAGE	REPRESEN-TATIVENESS	RELIABILITY OF ABSOLUTE STRENGTH CORRELATIONS
CORES	HIGH	SLOW	MODERATE	MODERATE	GOOD
PULL-OUT	MODERATE	FAST	MINOR	NEAR SURFACE ONLY	MODERATE
PENETRATION	MODERATE	FAST	MINOR	NEAR SURFACE ONLY	MODERATE
PULL-OFF	MODERATE	FAST	MINOR	NEAR SURFACE ONLY	MODERATE
ULTRASONIC PULSE VELOCITY	LOW	FAST	NON	GOOD	POOR
SURFACE HARDNESS	VERY LOW	FAST	UNLIKELY	SURFACE ONLY	POOR
MATURITY	MODERATE	CONTINUOUS	VERY MINOR	GOOD	MODERATE

COMMENTS

LOW ACCURACY AND LOW PRECISION

LOW ACCURACY BUT HIGH PRECISION

HIGHER ACCURACY BUT LOWER PRECISION

HIGH ACCURACY AND HIGH PRECISION

(www.npl.co.uk)

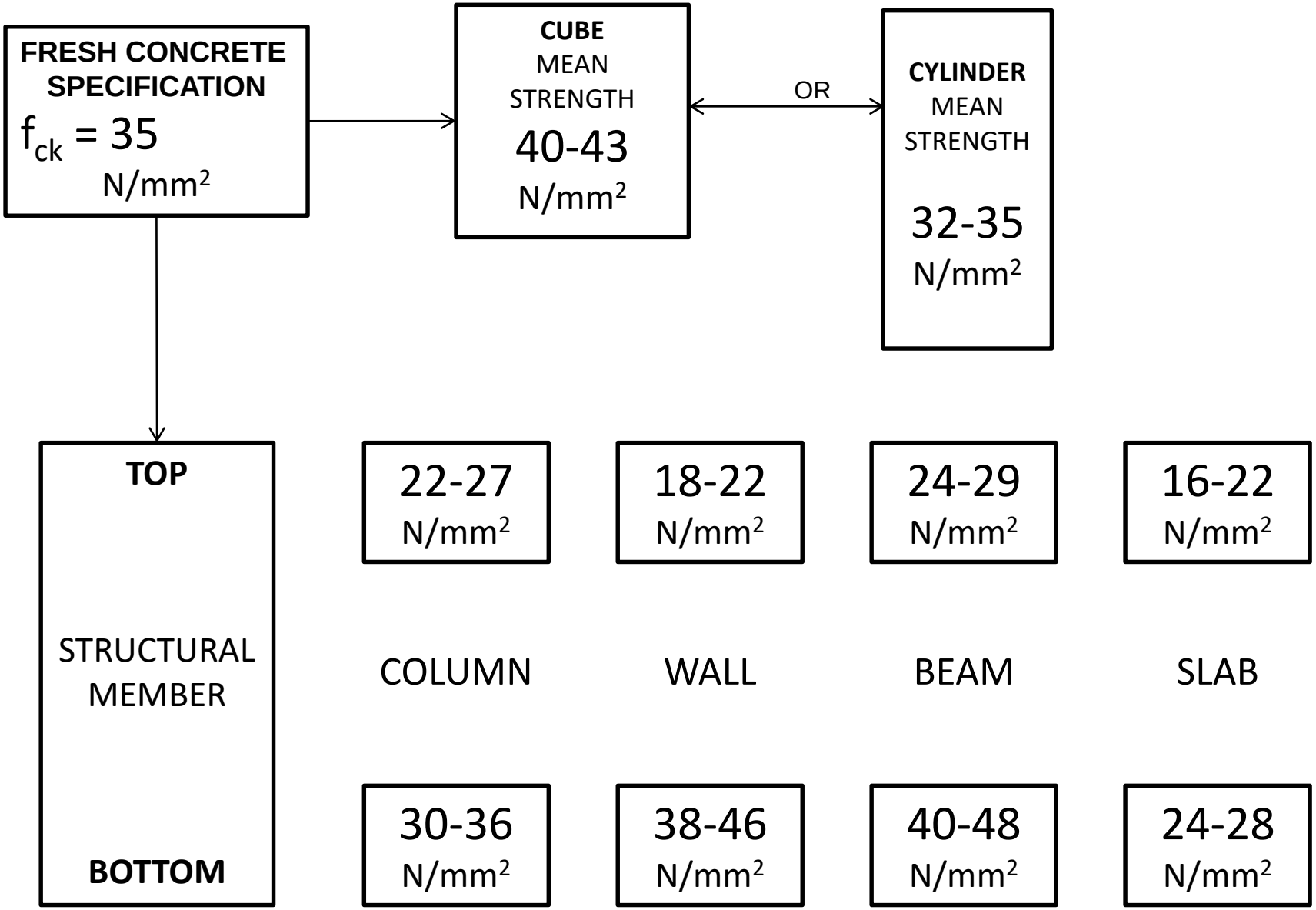
NUMBER OF TESTS

(Bungey, 2006)

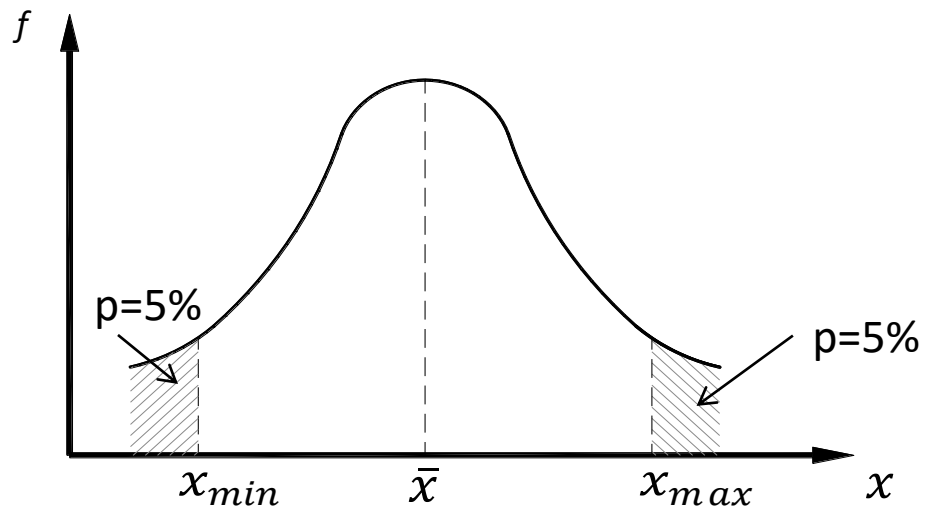
TEST METHOD	NO. OF INDIVIDUAL TEST RECOMMENDED AT A LOCATION
'STANDARD' CORES	3
SMALL CORES	9
SCHMIDT HAMMER	12
ULTRASONIC PULSE VELOCITY	9
PULL-OUT	4
WINDSOR PROBE	3
PULL-OFF	6

(Bungey, 2006)

TYPICAL RELATIONSHIP BETWEEN STANDARD SPECIMEN AND IN-SITU STRENGTH



ACCURACY OF TEST RESULTS



$$c_v = 100\frac{S}{\bar{x}}$$

$$S = \sqrt{\frac{(x-\bar{x})^2}{n-1}}$$

$$\bar{x} = \frac{\Sigma x}{n}$$

$$x_{min\,/max} = \bar{x} \pm tS = \bar{x}(1 \pm t \cdot c_v)$$

$$t = f(n, p\%)$$

S - standard deviation
$\bar{x}$ - mean value
c_v - coefficient of variation (COV)
t - coefficient

Test method	*Typical COV for individual member of good quality construction (in %)*	*Best 95% confidence limits on strength estimates (in %)*
Cores – standard	10	±10 (3 specimens)
– small	15	±15 (9 specimens)
Pull-out	8	±20 (4 tests)
Internal fracture	16	±28 (6 tests)
Pull-off	8	±15 (6 tests)
Break-off	9	±20 (5 tests)
Windsor probe	4	±20 (3 tests)
Ultrasonic pulse velocity	2.5	±20 (1 test)
Rebound hammer	4	±25 (12 tests)

(Bungey, 2006)

Test method	*Typical COV for individual member of good quality construction (in %)*	*Best 95% confidence limits on strength estimates (in %)*
Cores – standard	10	±10 (3 specimens)
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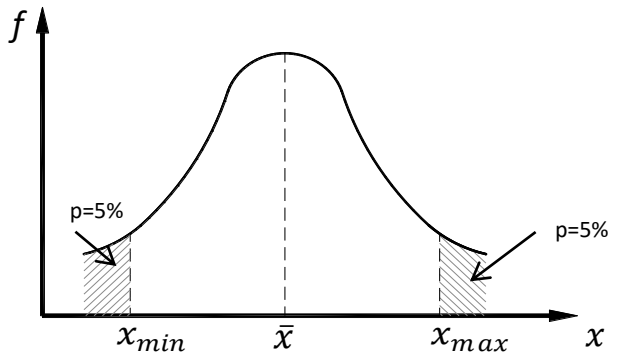


$$c_v = 100\frac{S}{\bar{x}}$$

$$S = \sqrt{\frac{(x-\bar{x})^2}{n-1}}$$

$$x_{min\,/max} = \bar{x} \pm tS = \bar{x}(1 \pm t \cdot c_v)$$

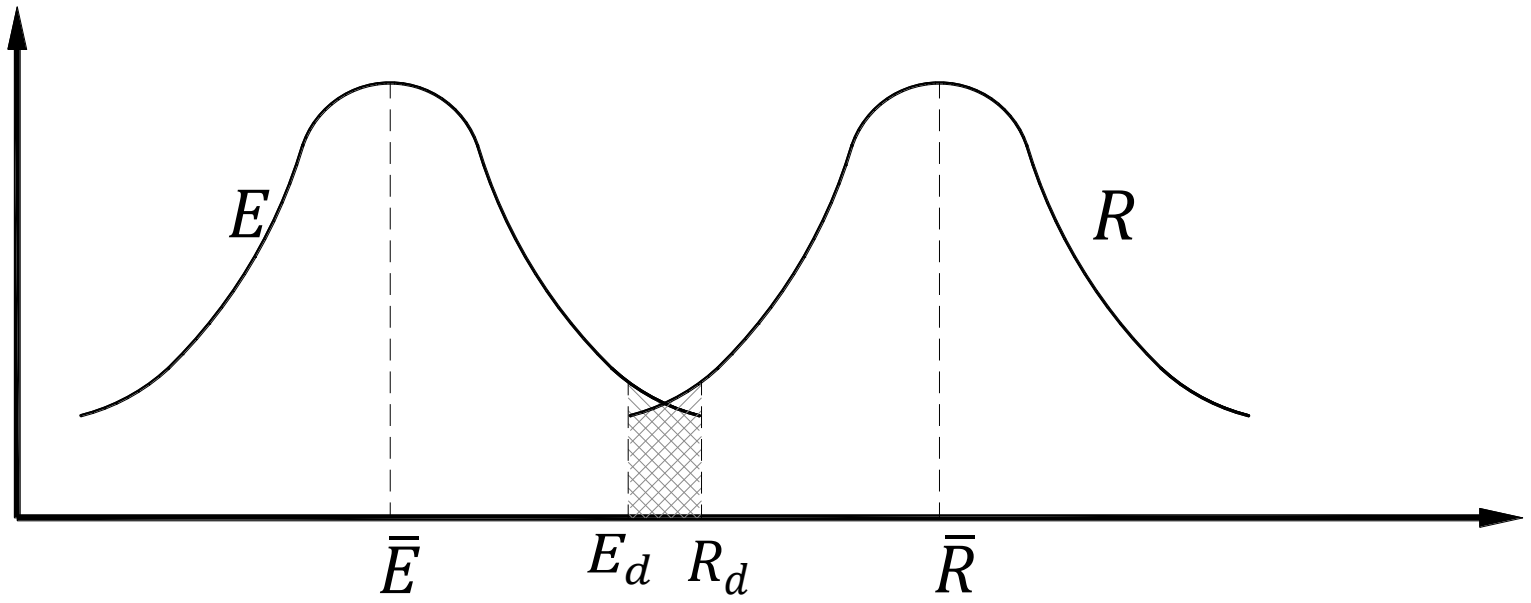
$$t = f(no., p\%)$$

$$\bar{x} = \frac{\Sigma x}{n}$$

In ULS general condition for capacity test is :

$$\underbrace{E_d}_{\max} \leq \underbrace{R_d}_{\min}$$

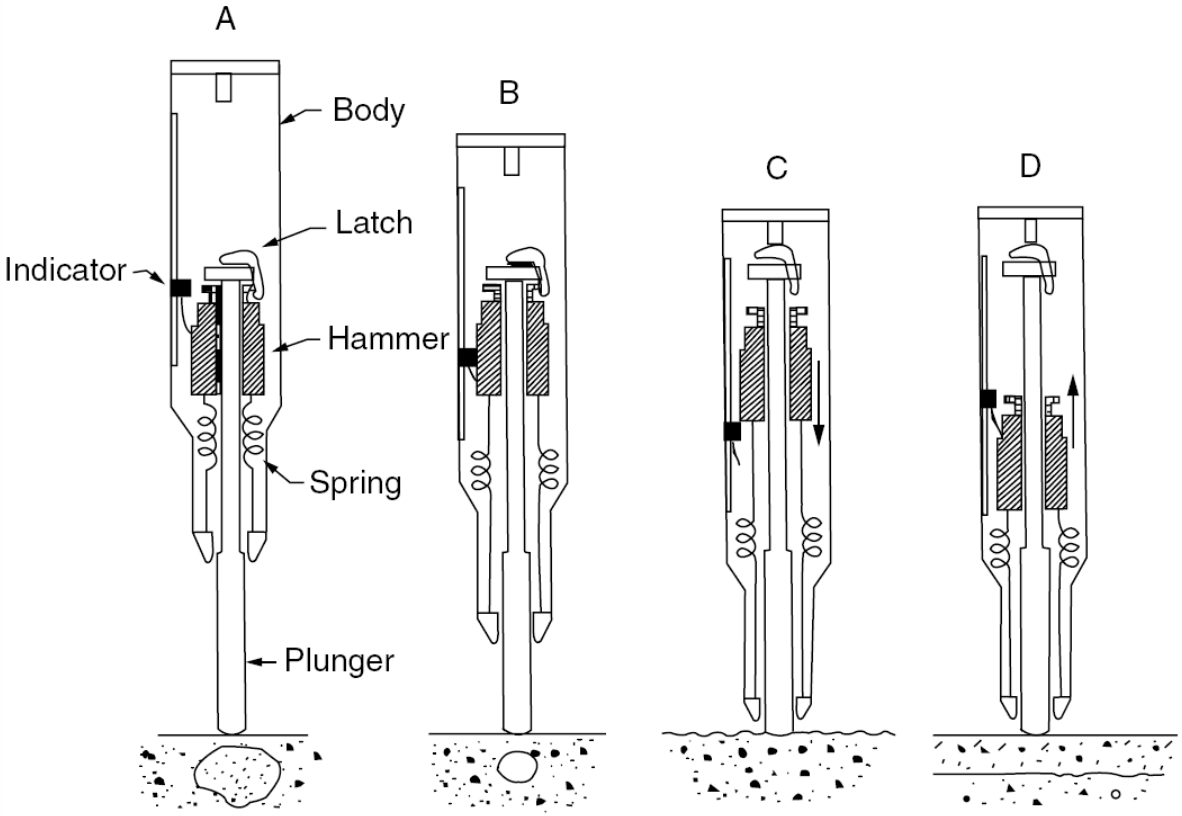
design value of the a effects (loads) ≤ design value of the capacity (strength)



5% x 5% = 2.5‰ → from 2000 elements could be considered <u>failure</u> of 5 elemente

(Malhotra, 2004)

1. SURFACE HARDNESS METHOD USING SCHMIDT REBOUND HAMMER



	Type N	Type NR	Type L	Type LR
Measurement range	10 - 70 N/mm^2			
Impact energy	2.207 Nm		0.735 Nm	
Element thickness	≥ 100mm		≤ 100mm	

1. SURFACE HARDNESS METHOD USING SCHMIDT REBOUND HAMMER

→ true rebound value and excellent repeatability
→ high measurement accuracy
→ The rebound value requires no angular correction

(Proceq)

1. SURFACE HARDNESS METHOD USING SCHMIDT REBOUND HAMMER

The results of the Schmidt rebound hammer are affected by:

1. Smoothness of test surface
2. Size, shape, and rigidity of the specimens
3. Age of test specimens
4. Surface and internal moisture conditions of the concrete
5. Type of coarse aggregate
6. Type of cement
7. Type of mold
8. Carbonation of the concrete surface
9. Stress state and temperature

1. SURFACE HARDNESS METHOD USING SCHMIDT REBOUND HAMMER

Applications and limitations:

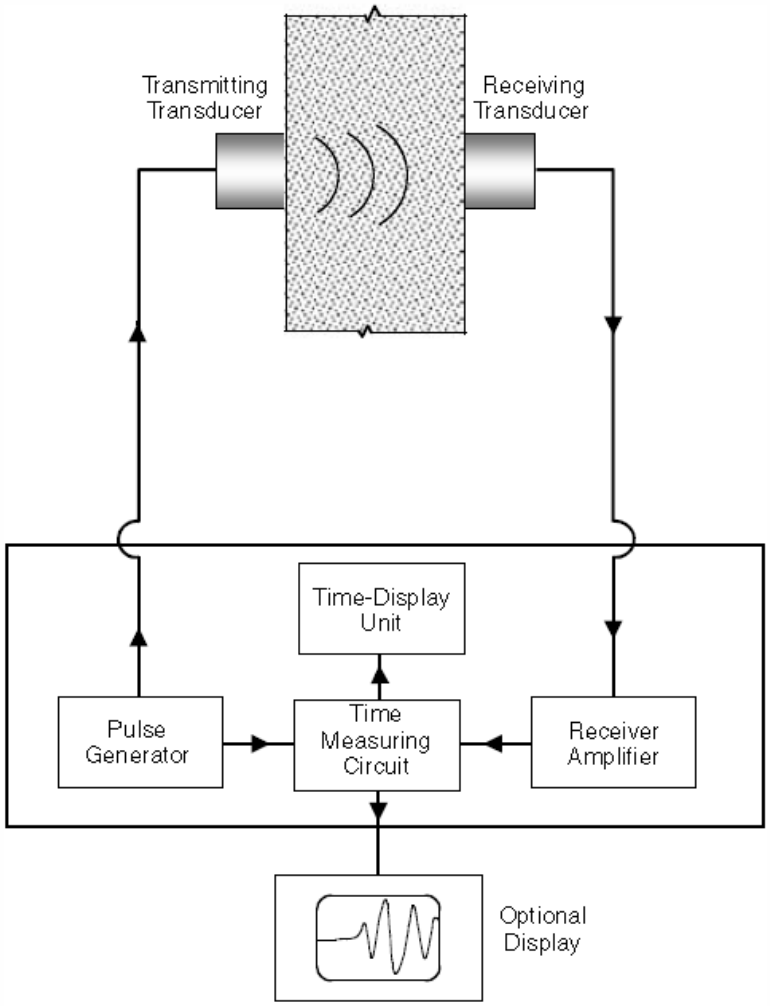
1. Checking the uniformity of concrete quality
2. Comparing a given concrete with a specified requirement
3. Approximate estimation of strength
4. Abrasion resistance classification.

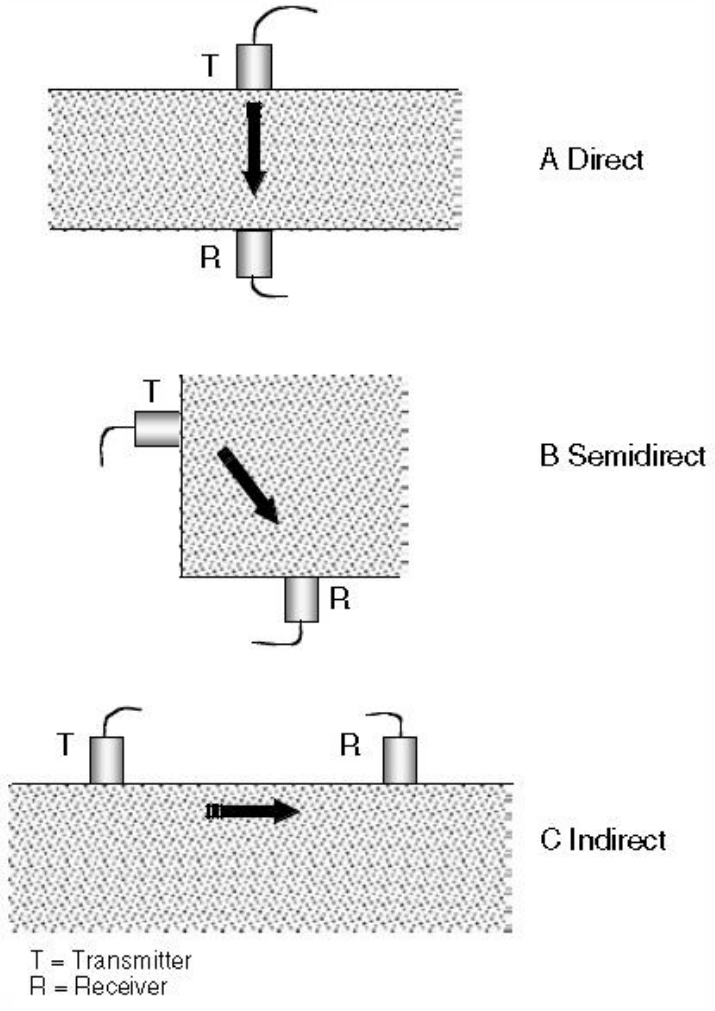
(Malhotra, 2004)

2. THE ULTRASONIC PULSE VELOCITY METHOD

Functioning

$$V = \frac{L}{\Delta t}$$

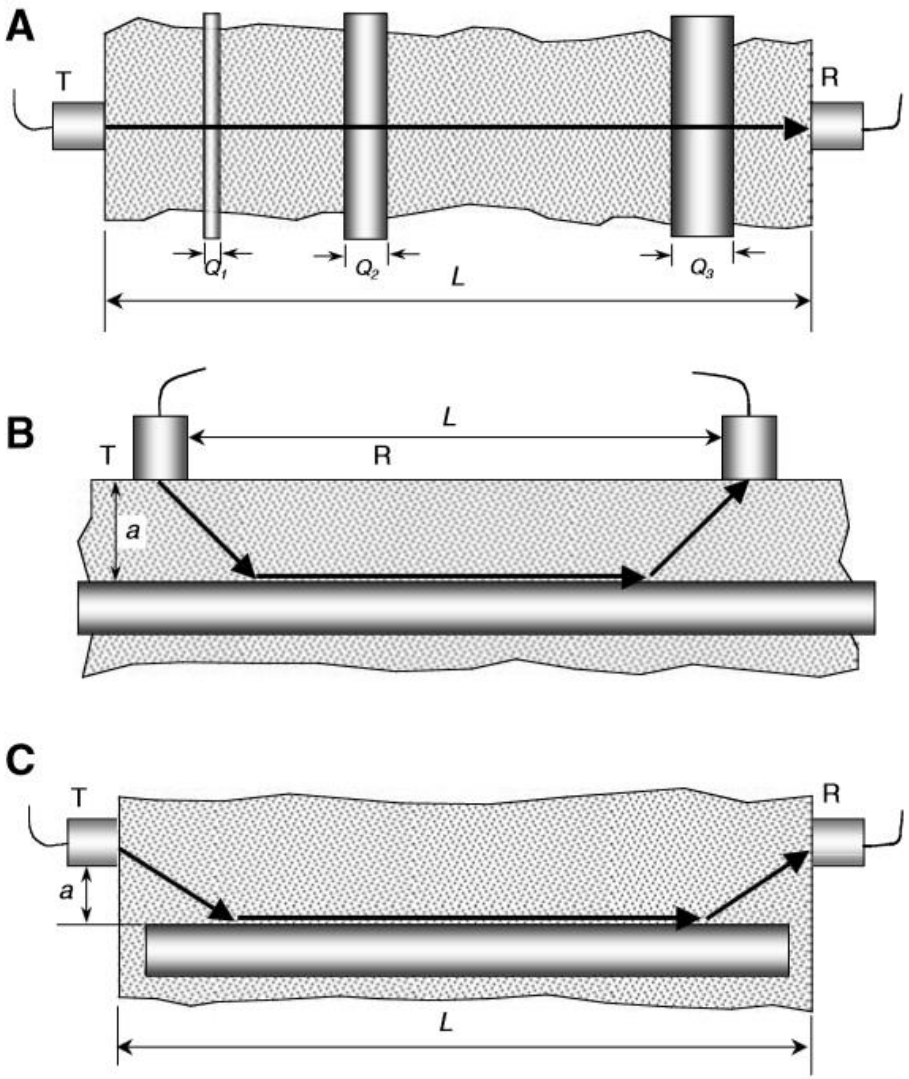




Common transducer: 54kHz with D=50mm

(Malhotra, 2004)

2. THE ULTRASONIC PULSE VELOCITY METHOD



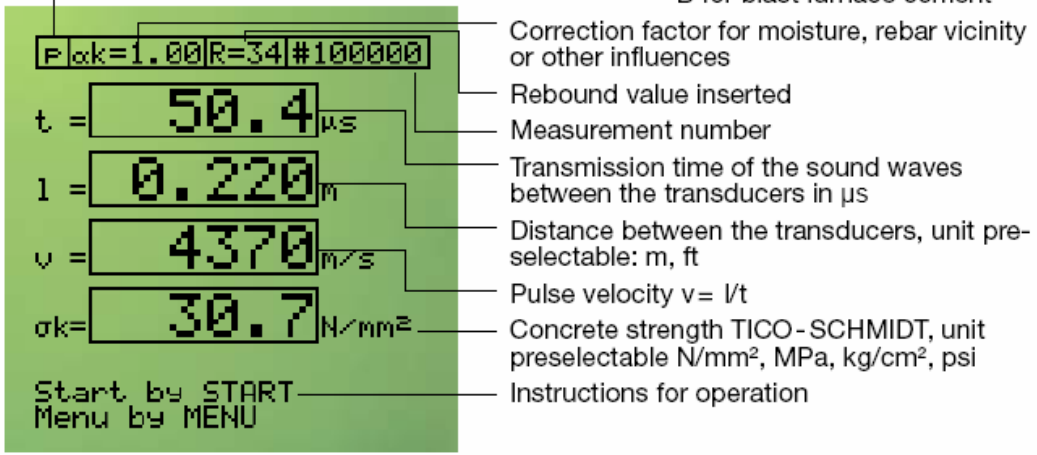
The pulse velocity measured in **reinforced concrete in the vicinity of reinforcing bars is often higher than in plain concrete** of the same composition. This is because the compressional pulse velocity in steel is 1.4 to 1.7 times that in plain concrete, the first pulse to arrive at the receiving transducer travels partly in concrete and partly in steel.

The increase in pulse velocity depends on:

- **concrete cover**
- **dimensions and no. of the reinforcing bars**
- **bars orientation with respect to the propagation path**
- **pulse velocity in the surrounding concrete**

(Proceq, 2011)

2. THE ULTRASONIC PULSE VELOCITY METHOD



2. THE ULTRASONIC PULSE VELOCITY METHOD

Factors affecting pulse velocity:

1. Aggregate Size, Grading, Type, and Content
2. Cement Type, Water–Cement Ratio, Admixtures
3. Age of Concrete
4. Transducer Contact
5. Temperature of Concrete
6. Moisture and Curing Condition of Concrete
7. Path Length
8. Size and Shape of a Specimen
9. Level of Stress, Stress history
10. Presence of Reinforcing Steel :
    - Axis of bars parallel to pulse path
    - Axis of bars perpendicular to the pulse path

(Malhotra, 2004)

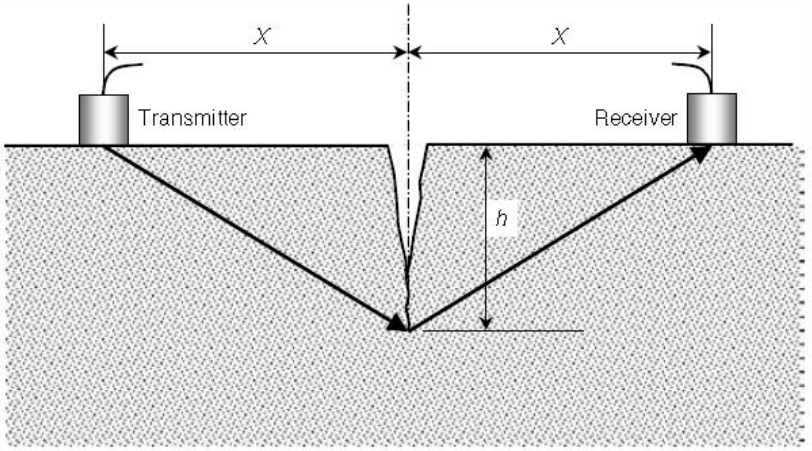
2. THE ULTRASONIC PULSE VELOCITY METHOD

Laboratory applications:

1. Monitoring of experiments - strength development
   - deterioration
   - cracks

In-situ applications:

1. Measurement of concrete uniformity
2. Strength estimation
3. Detection of cracking and honeycombing
4. Assessment of concrete deterioration
5. Measurement of layer thickness
6. Measurement of elastic modulus
7. Strength development monitoring
8. Ultrasonic Imaging



$$h = \frac{x}{T_2}\sqrt{T_1^2 - T_2^2}$$

x – distance to the transducer from the crack
T_1 – transit time around the crack
T_2 – transit time along the surface of the same type of concrete without any crack

Accuracy: **±15-20% → if the composition is known + probes**
±20-30% → if the composition is unknown
±30-40% → missing information

3. COMBINED METHODS

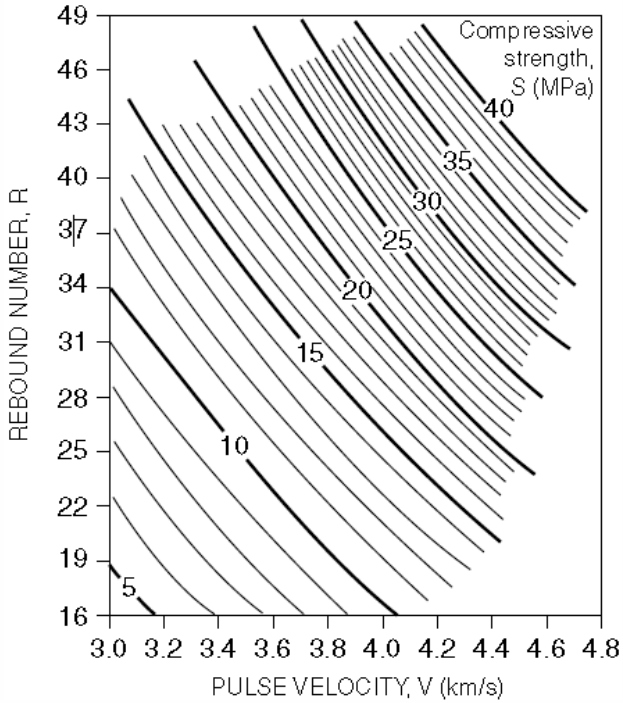
Combination of the methods:- Ultrasonic Pulse Velocity
- Hardness Measurement Techniques using rebound (Schmidt) hammer

Advantages:

- higher accuracy than a simple method
- not need to know maturity of concrete
- less influence by the variation in cement dosage or cement type, or

Applications :

1. Evaluation the in situ properties of concrete
2. Determination of concrete uniformity
3. Determination grade of compaction



Accuracy:±10-15% → if the composition is known + probes
±15-20% → if the composition is known
±25-35% → missing information

(I. Făcăoaru)

4. MATURITY METHOD

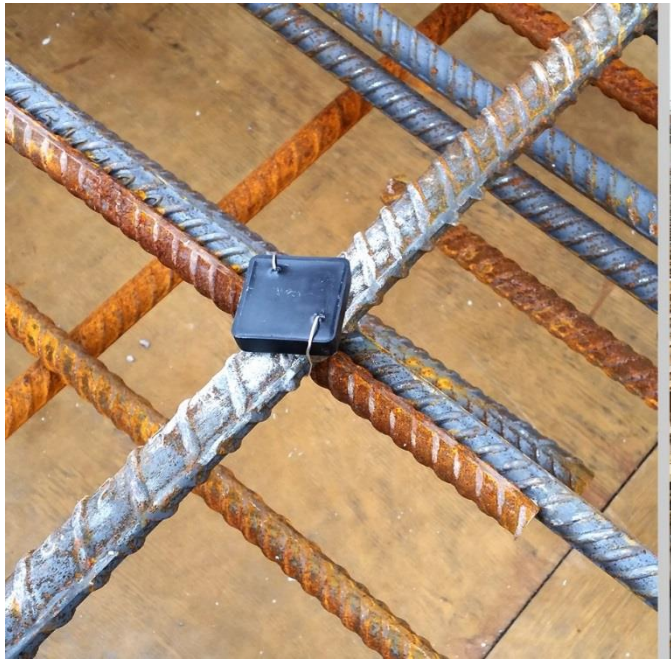
Waterproof wireless sensor for monitoring the temperature of concrete from fresh stage to hardened stage

→ **maturity-based strength estimation of concrete**

Real time monitoring of temperature →

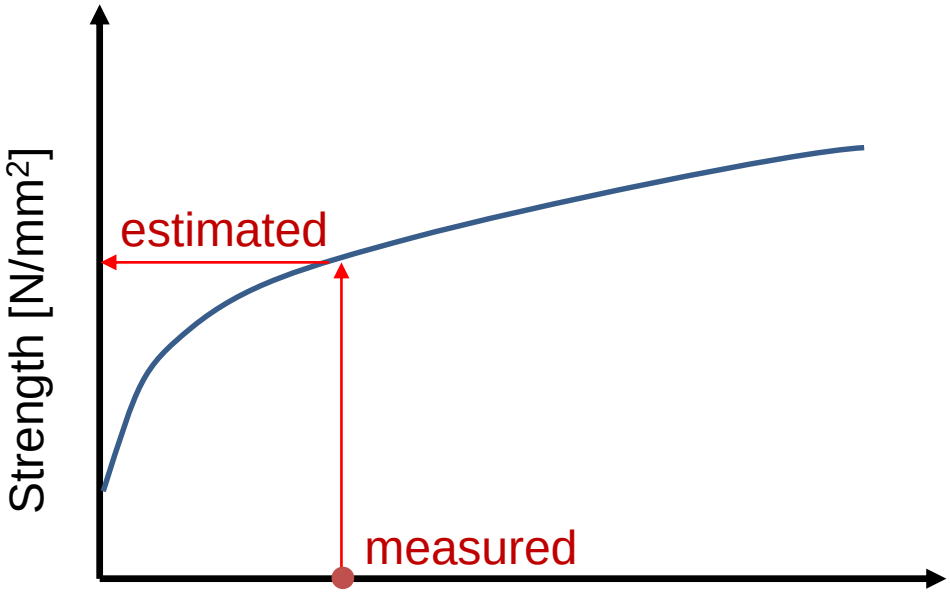
- optimizing the formwork removal time
- application of load on the structure
- adjusting the curing temperature of concrete onsite (heating and cooling processes)
- laboratory tests schedule

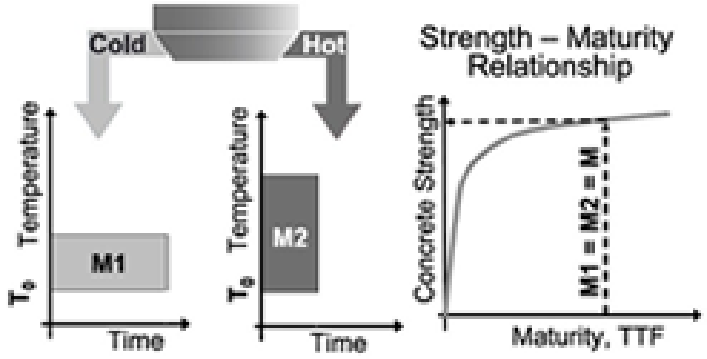
4. MATURITY METHOD



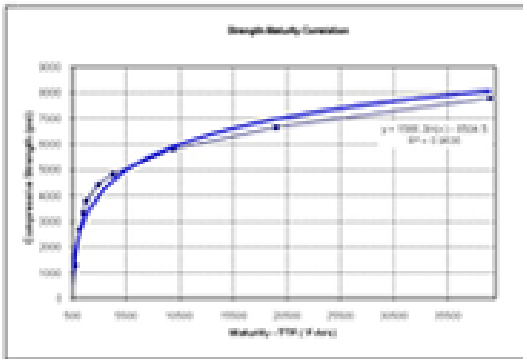
(Giatec Scientific)

4. MATURITY METHOD



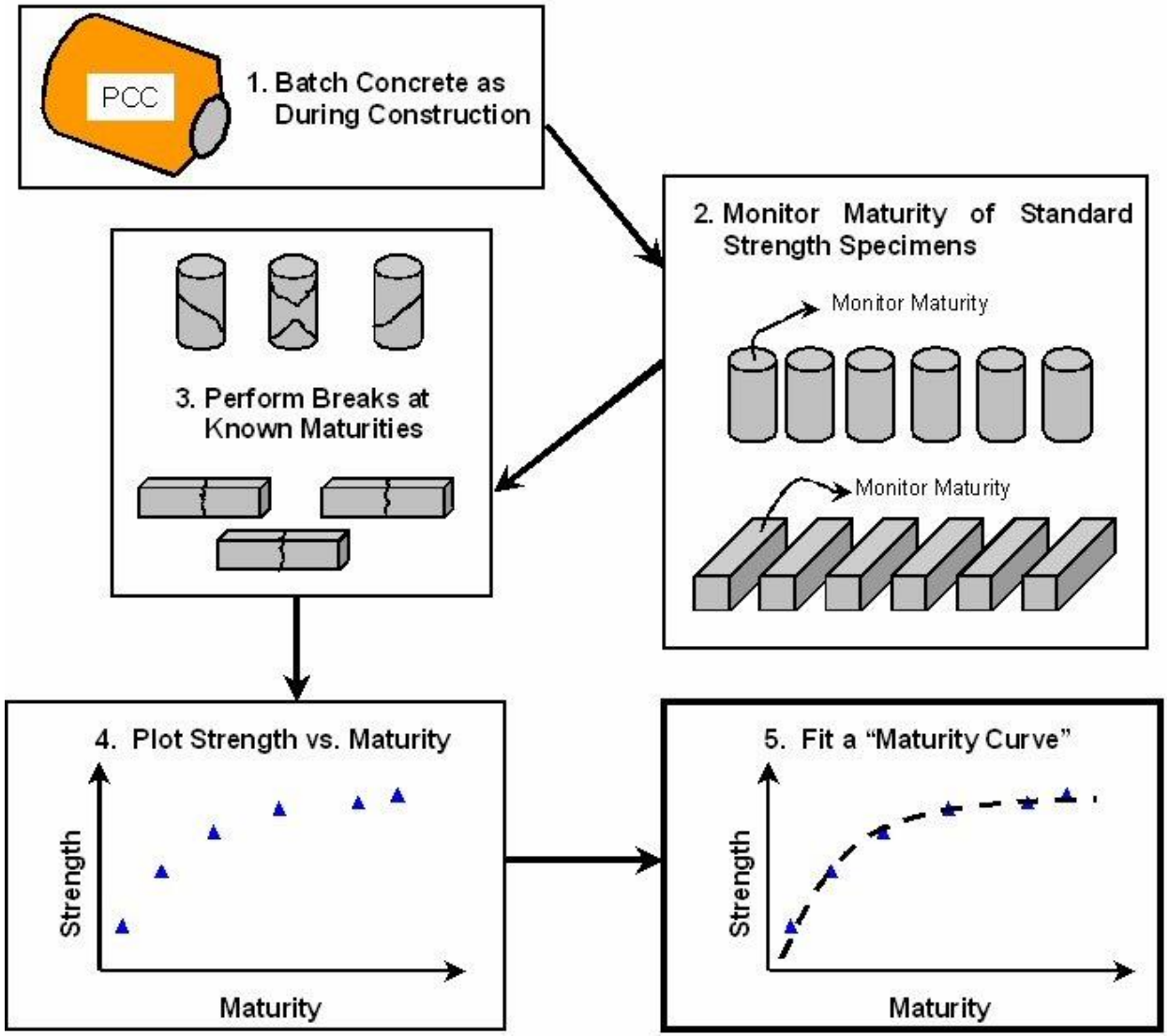


Concept of Maturity Method



Maturity Method Curve

4. MATURITY METHOD



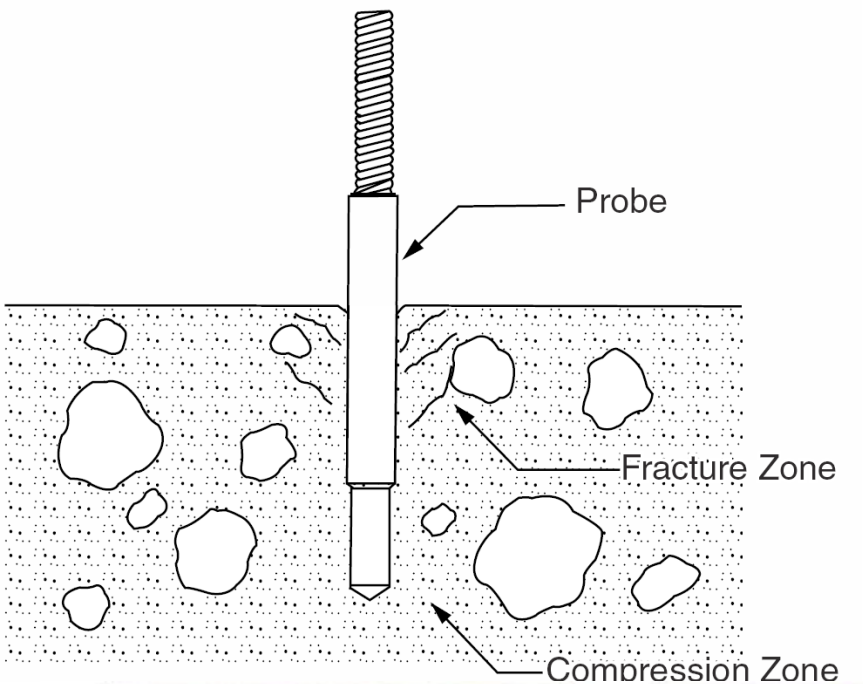
(www.worldoftest.com)

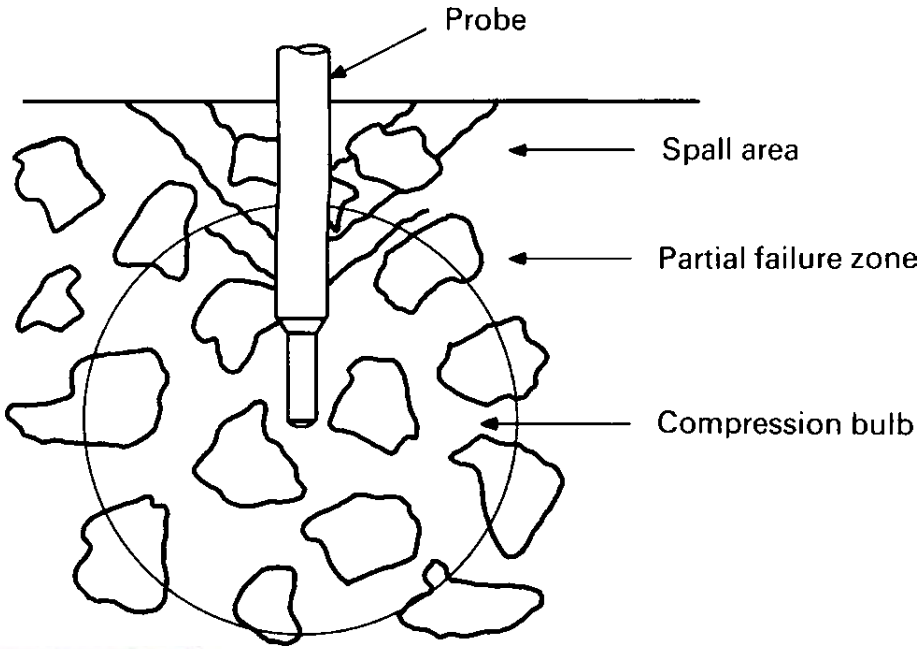
4. PENETRATION RESISTANCE METHOD → WINDSOR PROBE

Windsor HP Probe - ASTM C-803

(Bungey, 2006)

4. PENETRATION RESISTANCE METHOD → WINDSOR PROBE

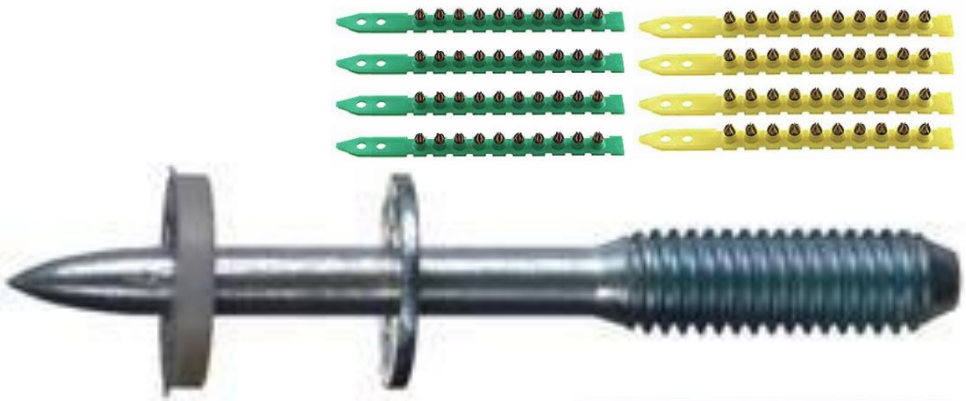




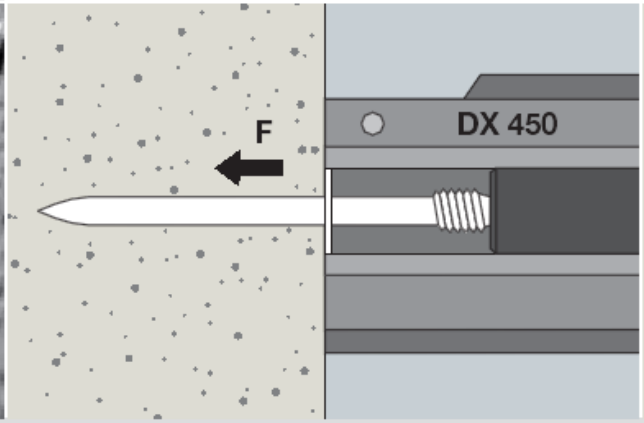
(Hilti, 2011)

4. PENETRATION RESISTANCE METHOD → Hilti DX 450-SCT

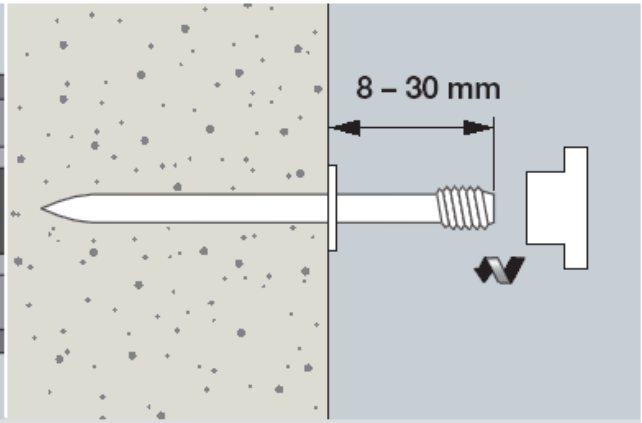
SCT = Sprayed Concrete Testing



The time factor is critical with sprayed



Using a Hilti DX 450-SCT tool, ten threaded

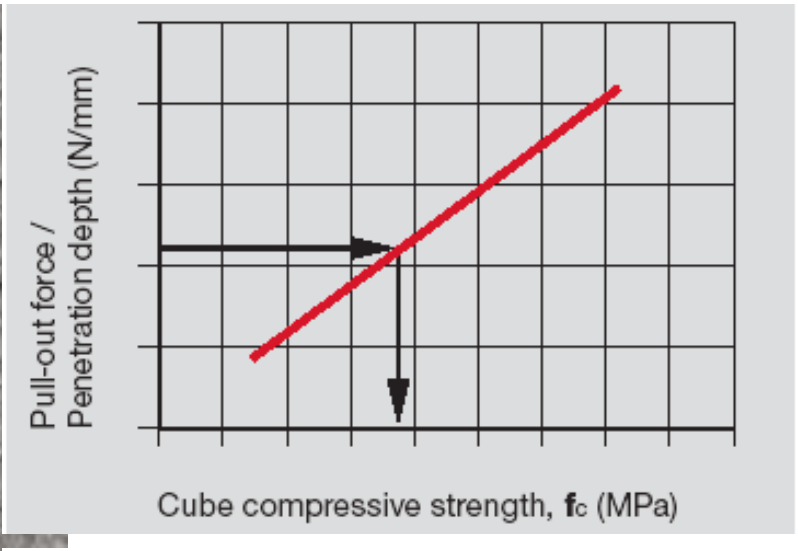


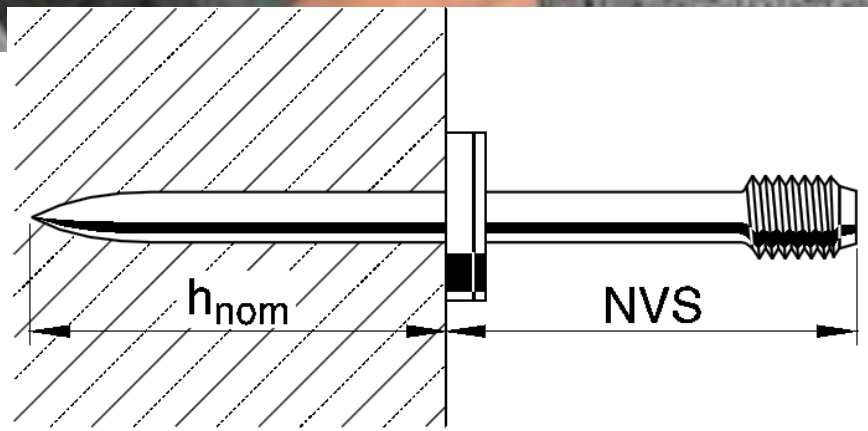
The threaded stud's depth of penetration –

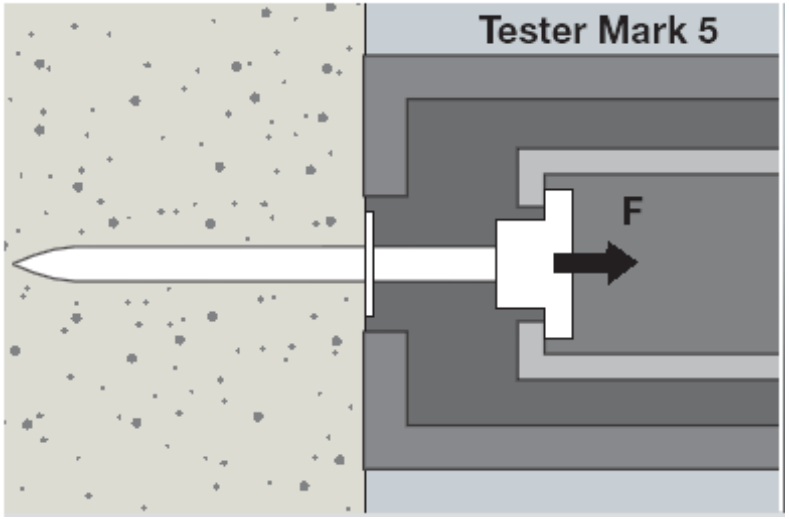
(Hilti, 2011)

4. PENETRATION RESISTANCE METHOD → Hilti DX 450-SCT

SCT = Sprayed Concrete Testing





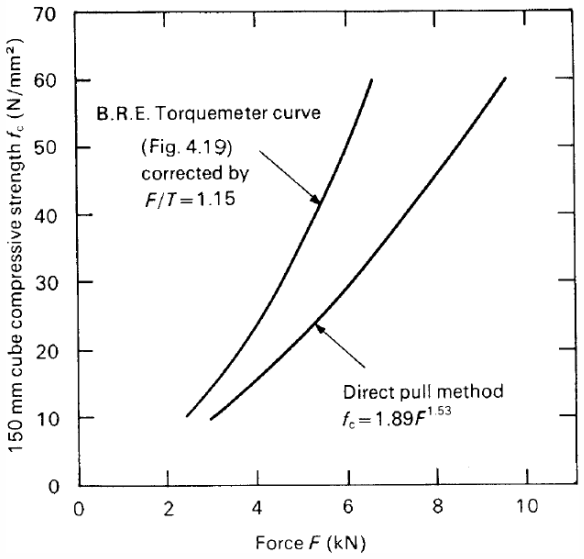


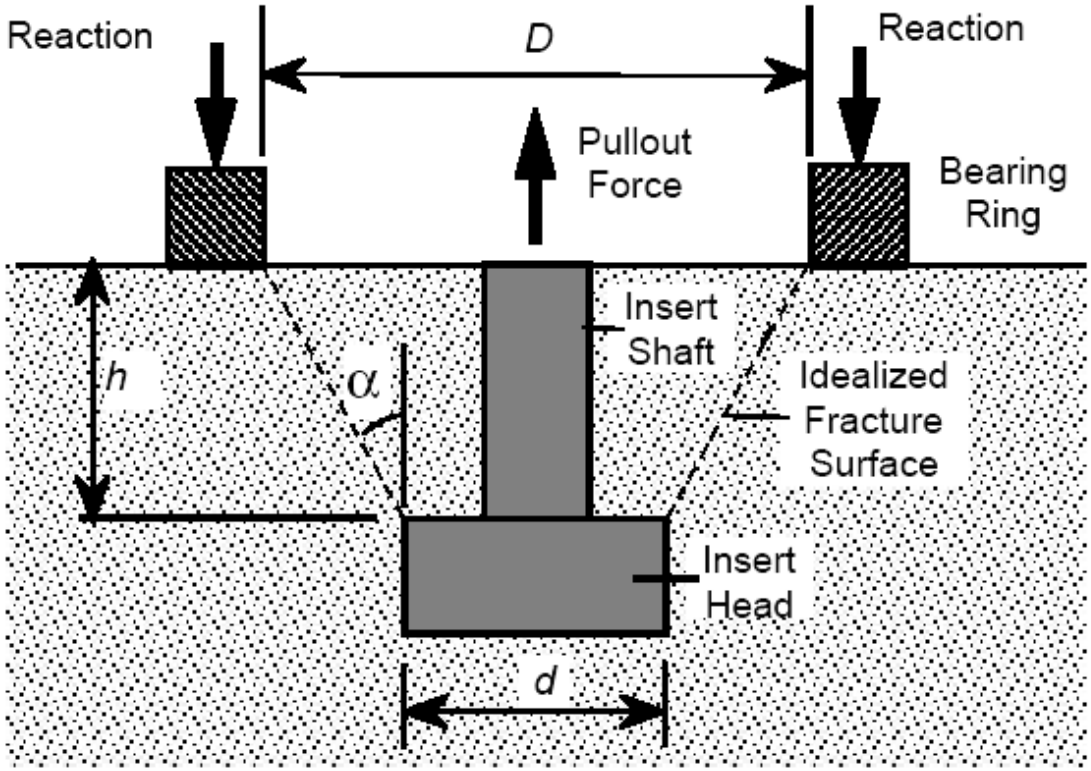
(Malhotra, 2004)
(Bungey, 2006)

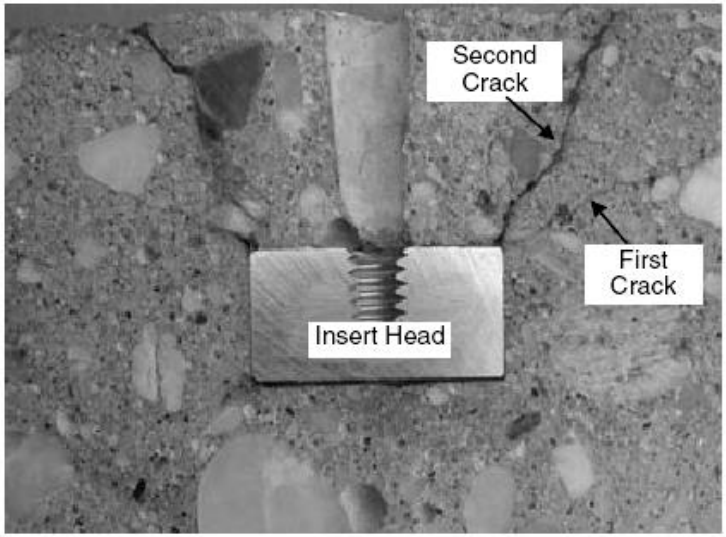
5. PULL-OUT TEST METHOD

2 categories:

a) cast-in-place pull-out test



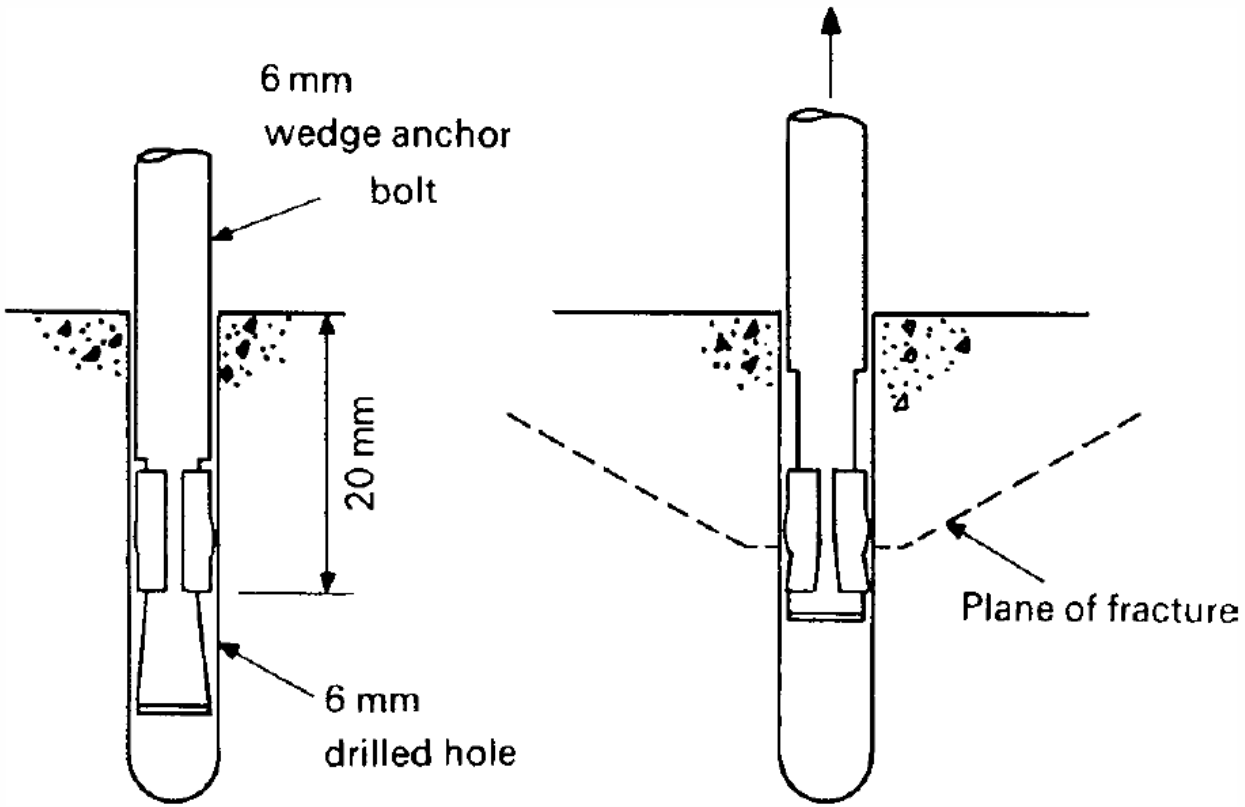




(Bungey, 2006)

5. PULL-OUT TEST METHOD

b) **Post-Installed pull-out test**

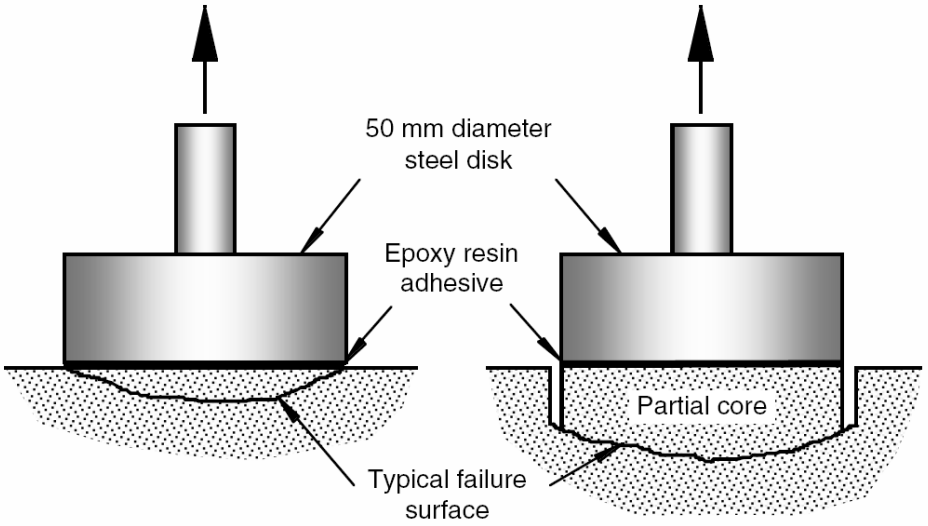


(Proceq, 2011)

5. PULL-OUT TEST METHOD → equipment

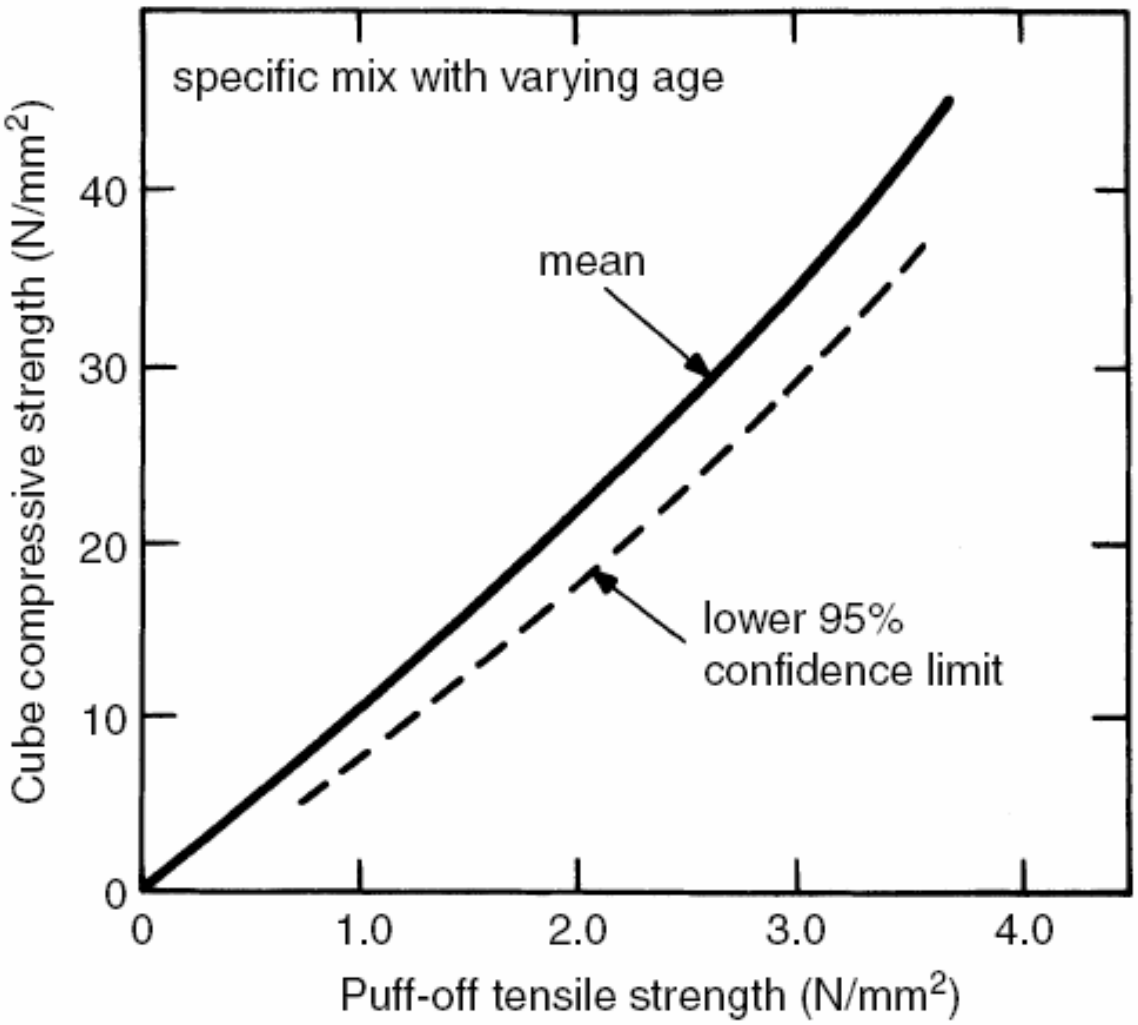
(Malhotra, 2004; Proceq, 2011)

6. PULL-OFF TEST METHOD



(Bungey, 2006)

6. PULL-OFF TEST METHOD



7. TESTS ON CORES – cutting and testing

Diameter and height of the cores by different standards:

- $D > 3 \times d_{max,aggreg}$ (British and American standards)
- $D_{min} = 100mm$, $D_{opt} = 150mm$
- Accuracy decrese if $d_{max,aggreg} / D_{core}$ increse
- If $d_{max,\ aggreg} > 25mm \rightarrow D_{min} > 100mm$
- $H/D = 1.0 \div 2.0$

7. TESTS ON CORES – cutting and testing

NP 137 - 2014

- No of cores → $n = 42/d$ (d – core diameter)
- Core diameter → $d \geq 3\phi_{max}$ (ϕ_{max} – maxim aggregate diameter)
- Minim diameter → $d_{min} = 50$ mm (recommended by SR EN 13791)
- Recommended diameter → $d_{opt} = 100$ mm
- Core height → $d \leq h \leq 2d$

7. TESTS ON CORES – cutting and testing

1) Visual inspection : - type, size and distribution of the aggregates
- holes, defects, cracks
- compaction

2) Cutting and edge correction

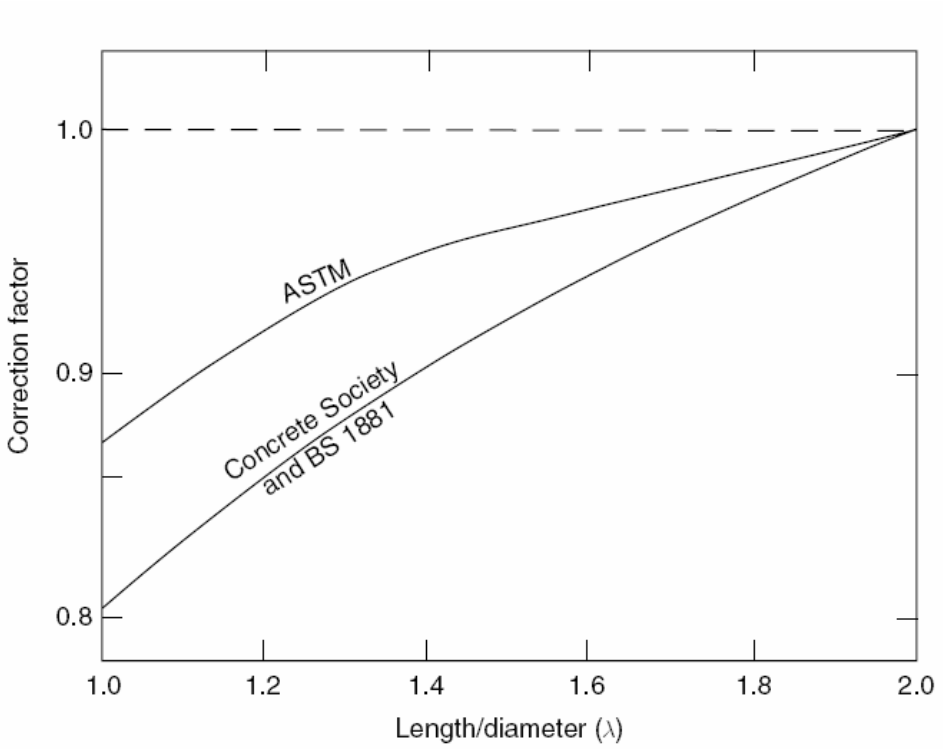
3) Determination of the density

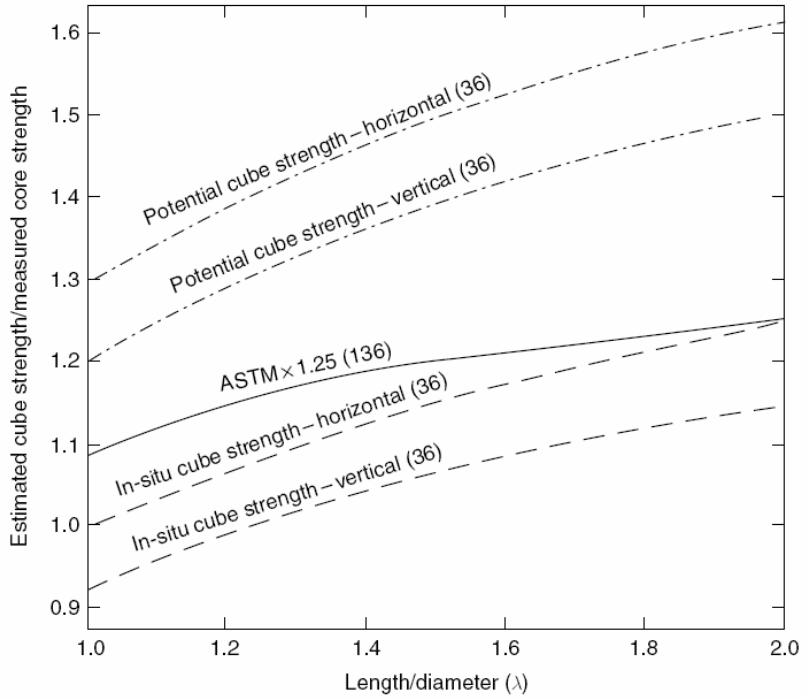
4) Determination of the compression strength

- Variables:
  - H/D
  - D
  - coring direction
  - correction method and material
  - intersected reinforcements

7. TESTS ON CORES – cutting and testing

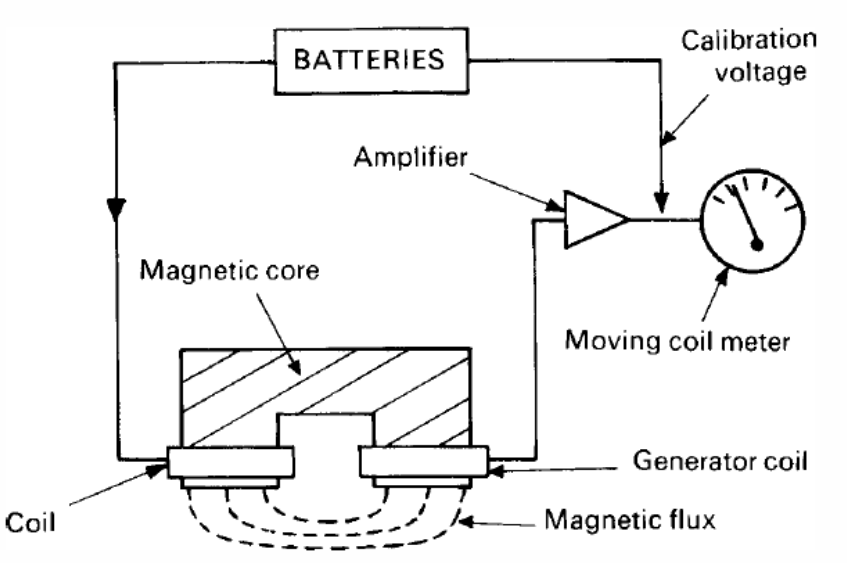
Result corrections and interpretations

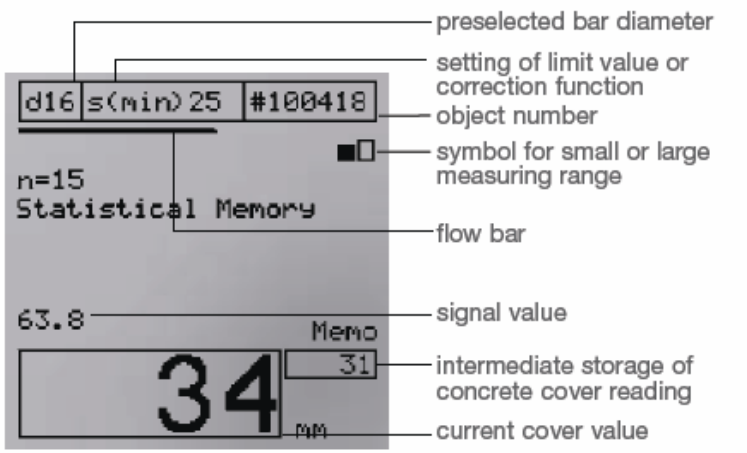




(Proceq, 2011)

8. DETERMINATION OF CONCRETE COVER DEPTH AND REBAR LOCATION

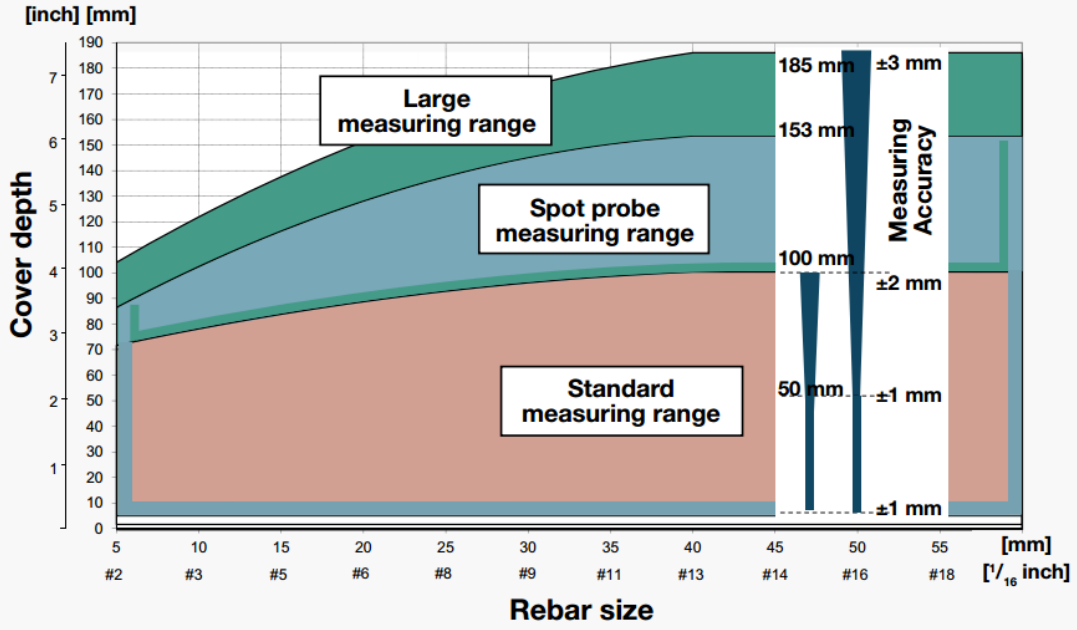




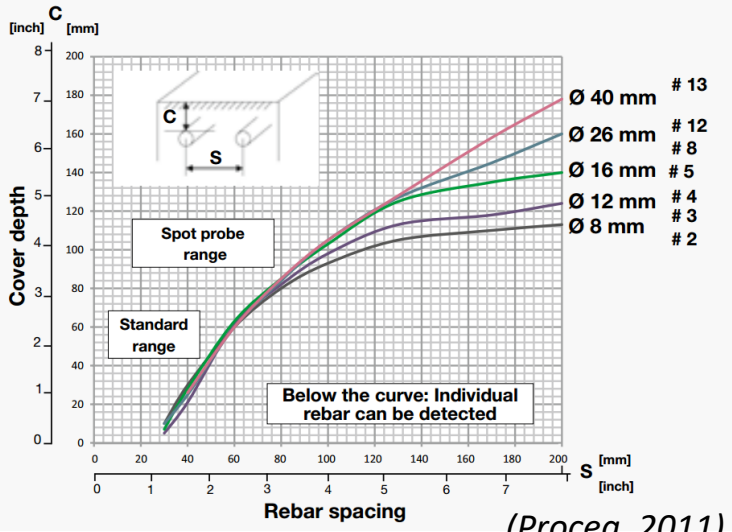
(Proceq, 2011)

8. DETERMINATION OF CONCRETE COVER DEPTH AND REBAR LOCATION

The Profometer Measuring Range



Unsurpassed Resolution



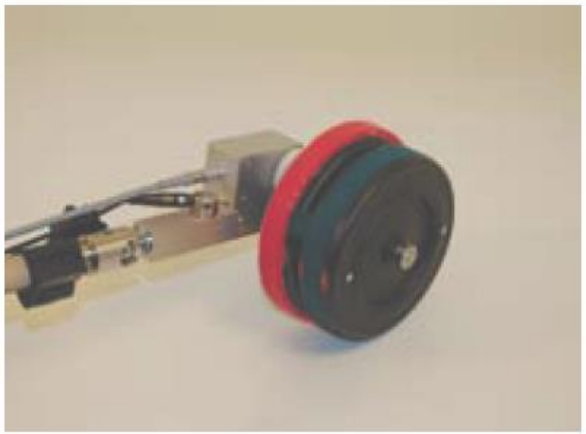
(Proceq, 2011)

(Proceq, 2011)

9. DETERMINATION OF THE REINFORCEMENT CORROSION

→ CORROSION ANALYSIS WITH THE HALF-CELL POTENTIAL METHOD: ACCURATE FIELD POTENTIAL MEASUREMENTS AID IN DETECTING ACTIVE CORROSION IN REBARS

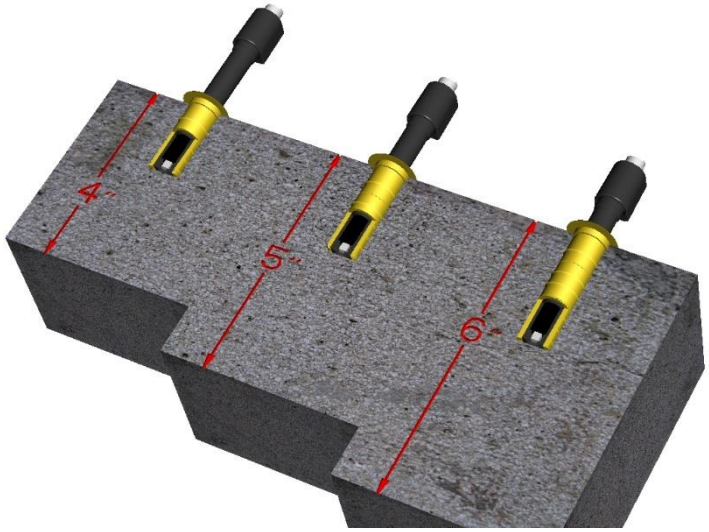
Standard half cell rod electrode



Wheel electrode with moistening wheel for continuous wetting up to a length of 200m (650ft). Linear distance recorder with travel direction detection. Automatic measure-ment at pre-selected intervals.

Four-point Wenner probe

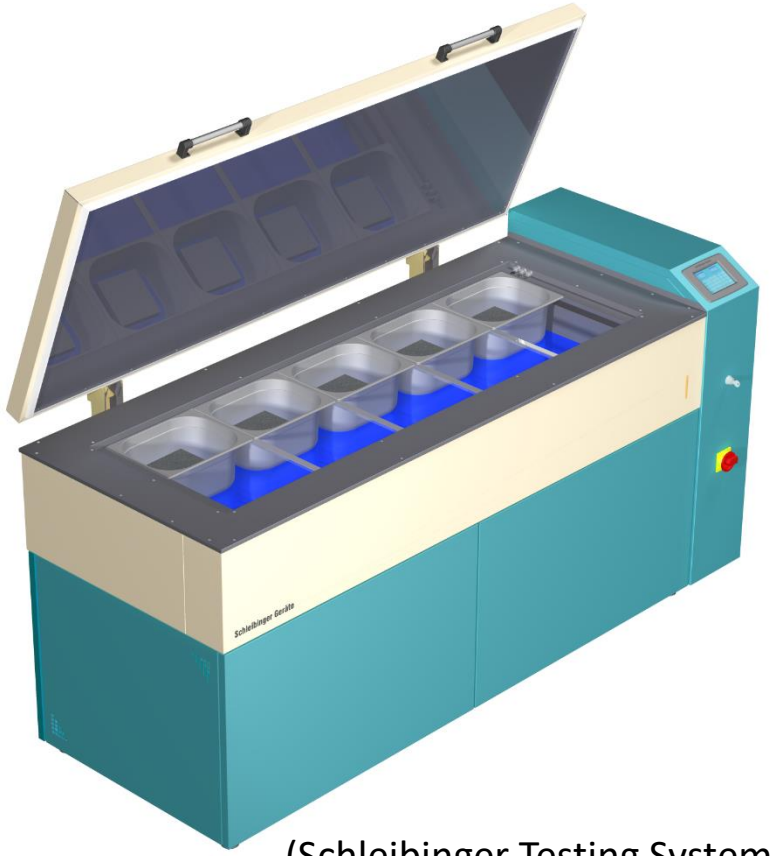
10. MOISTURE MEASUREMENT



11. ABSORPTION AND PERMEABILITY TESTS

→ two-chamber vacuum cell and a pressure regulator, which ensure that an air flow at right angles to the surface is directed towards the inner chamber. This permits the calculation of the permeability coefficient kT on the basis of a simple theoretical model

11. TESTS FOR FREEZE–THAW RESISTANCE



(Schleibinger Testing Systems)

(brickandtile.org)

The test specimens are placed in a solution of sodium chloride (NaCl) to stress the surface. The result gives an estimate for the resistance to freeze-thaw cycling for the concrete being tested.

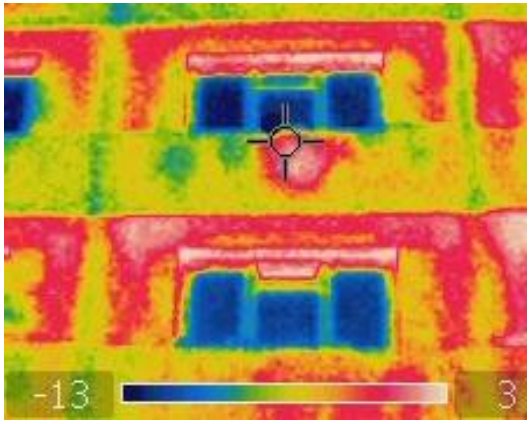
In connection with de-icing salt, the frost attack is considerably stronger.

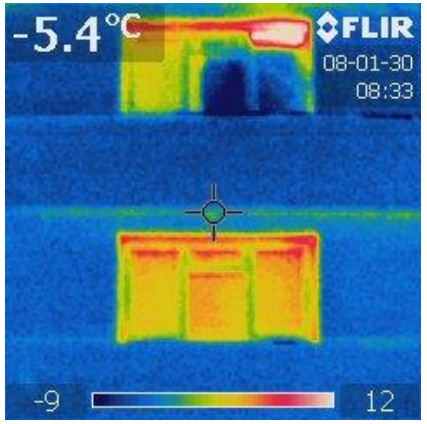
EN 12390-9

10. ABRASION RESISTANCE TESTING

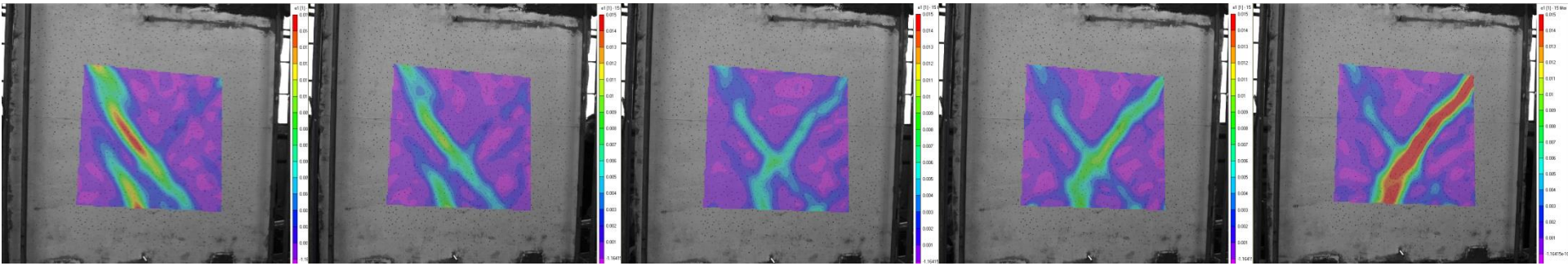
10. ABRASION RESISTANCE TESTING

11. INFRARED THERMOGRAPHY





12. OPTICAL DEFORMATION MEASUREMENT TECHNIQUE



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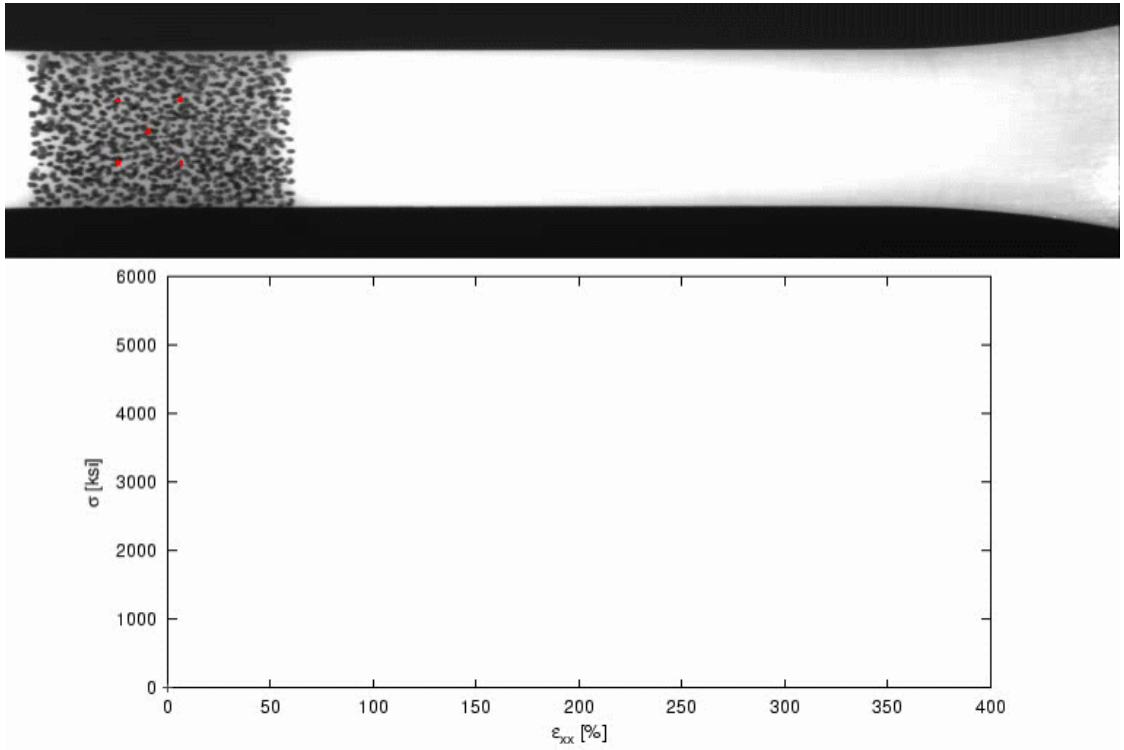

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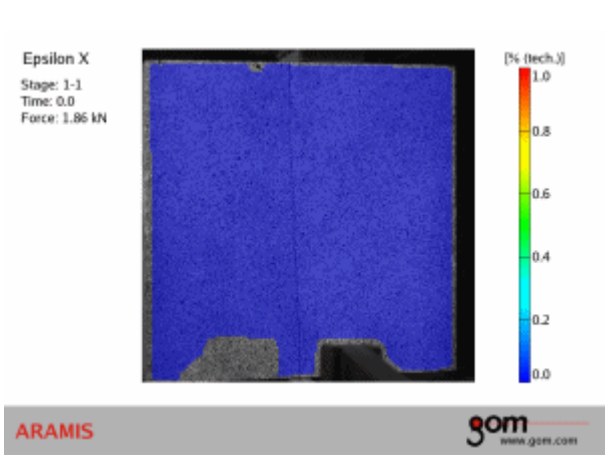
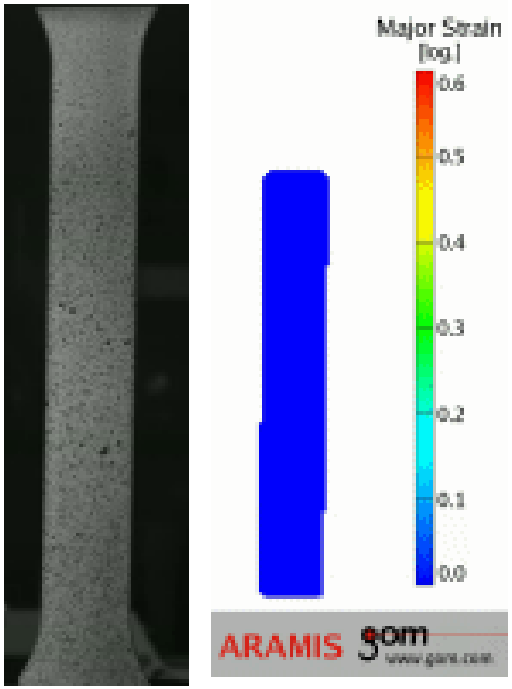
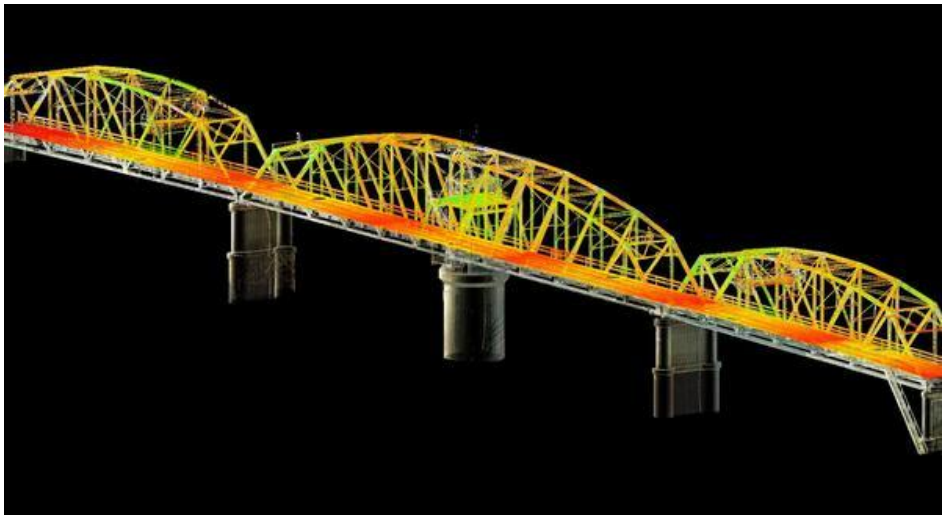
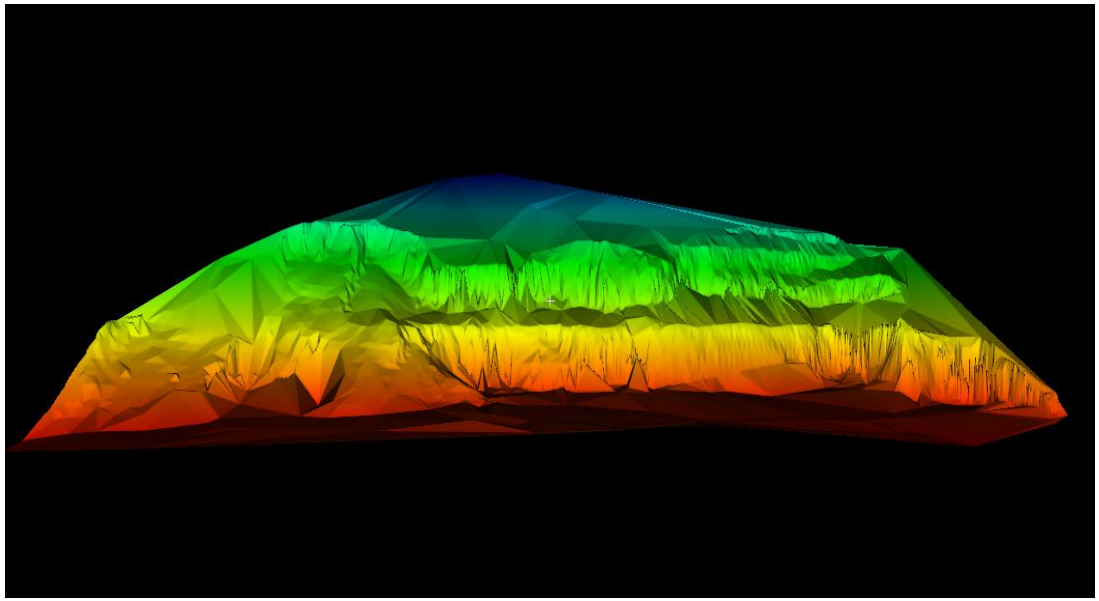




13. 3D LASER SCANNING

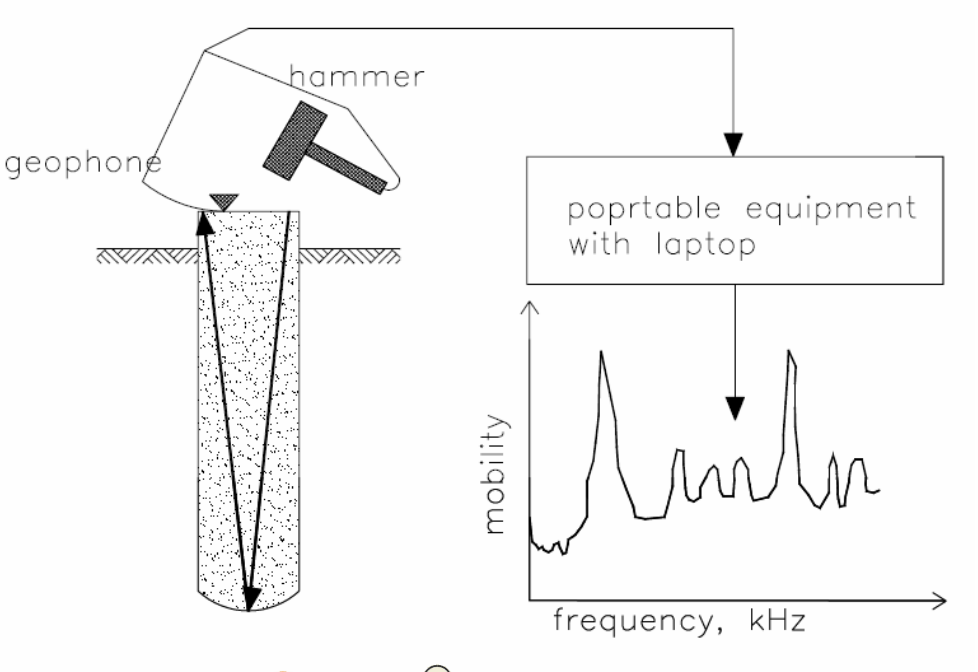


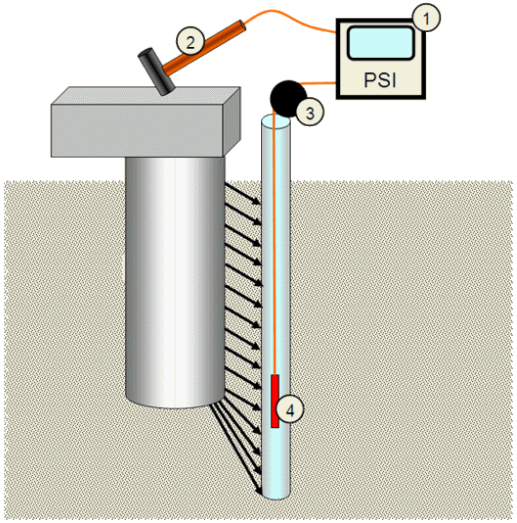
13. 3D LASER SCANNING

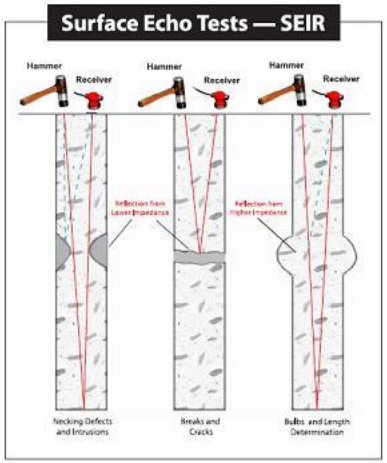


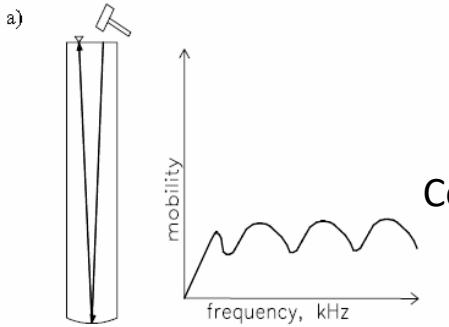
Calcule de volumetrie în cariere

14. INTEGRITY TESTING ON PILOTS

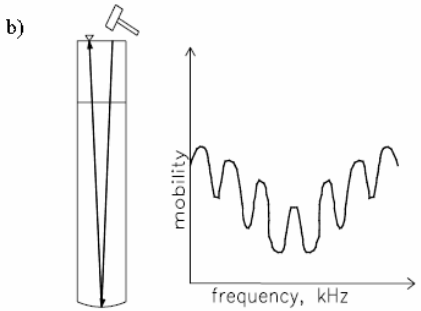




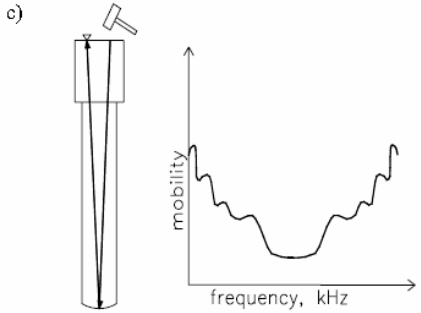




Continue pilot

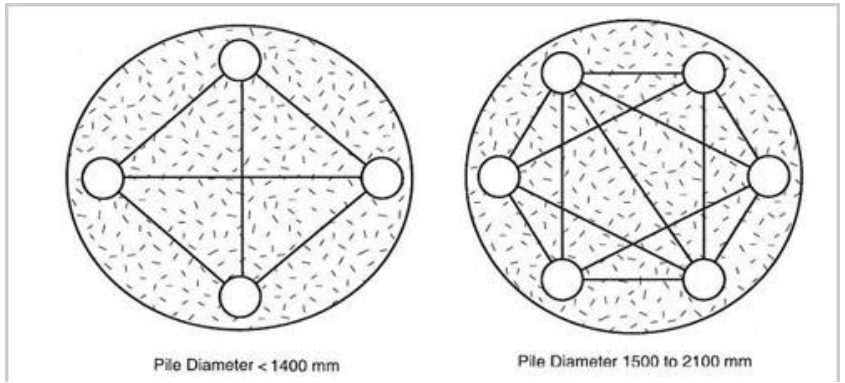


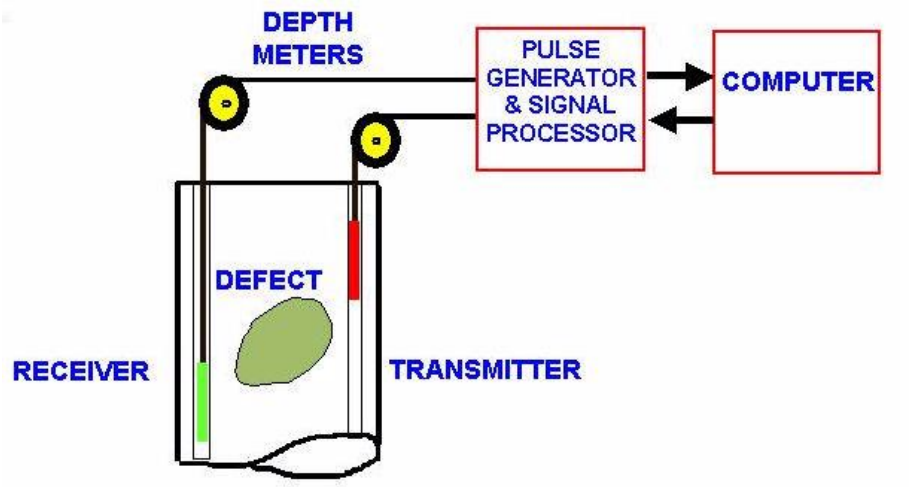
Variation in the concrete quality



Variation of the pilot cross section

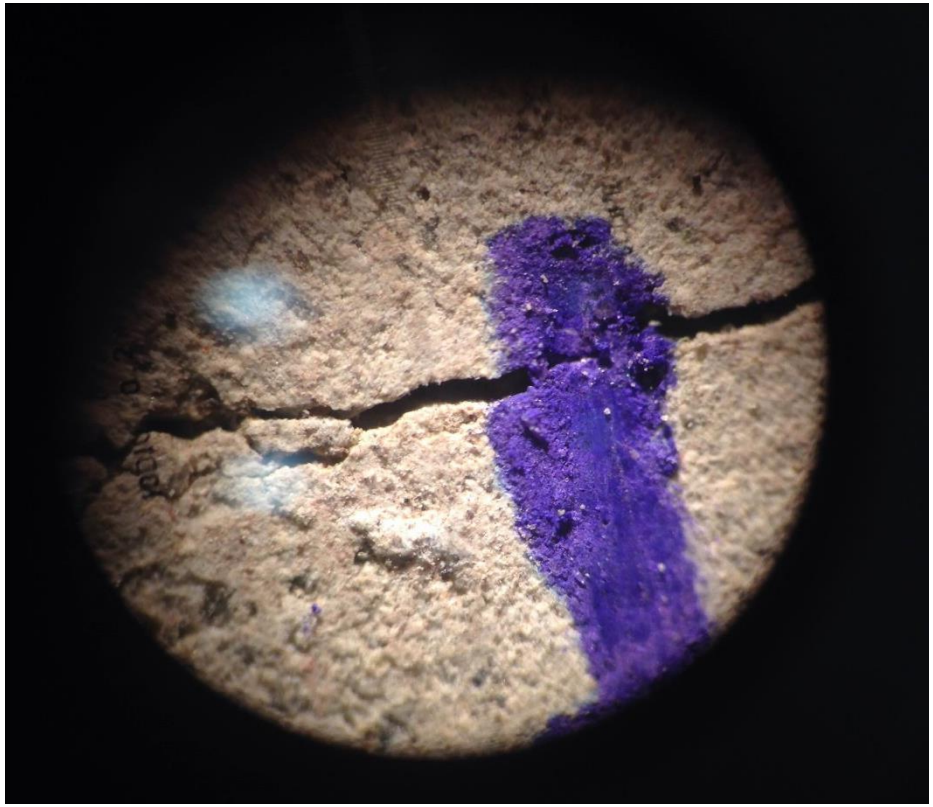
14. INTEGRITY TESTING ON PILOTS

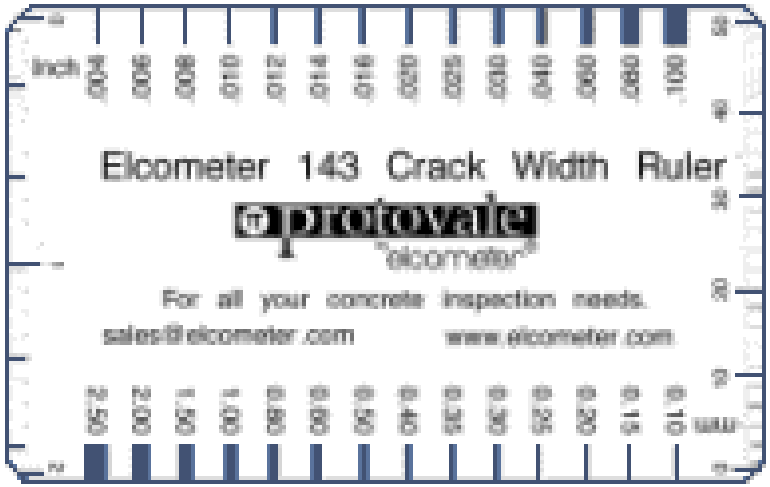




15. OTHER PERFORMANCE AND INTEGRITY TESTS

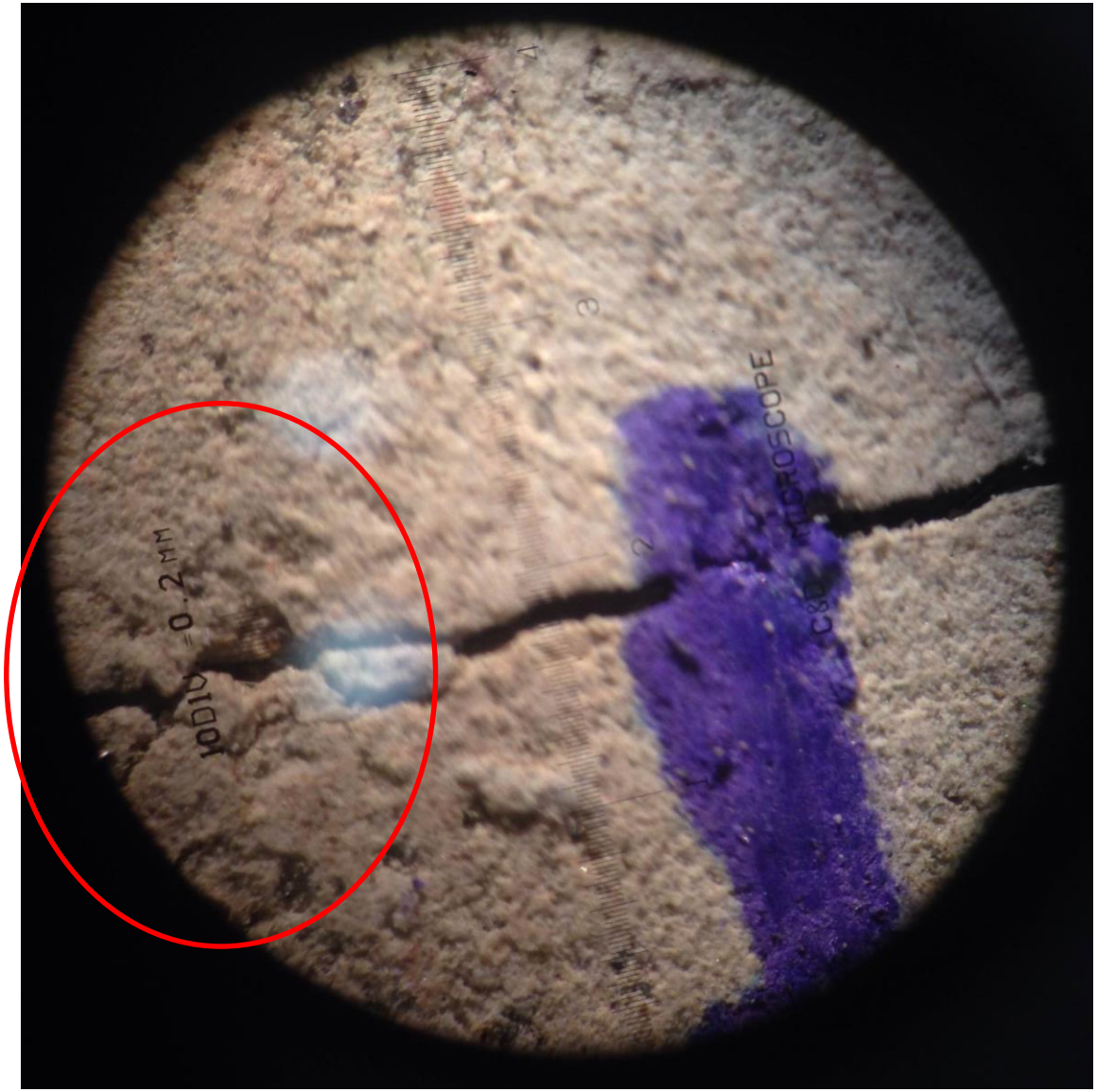
-CRACK OPENING





15. OTHER PERFORMANCE AND INTEGRITY TESTS

-CRACK OPENING



15. OTHER PERFORMANCE AND INTEGRITY TESTS

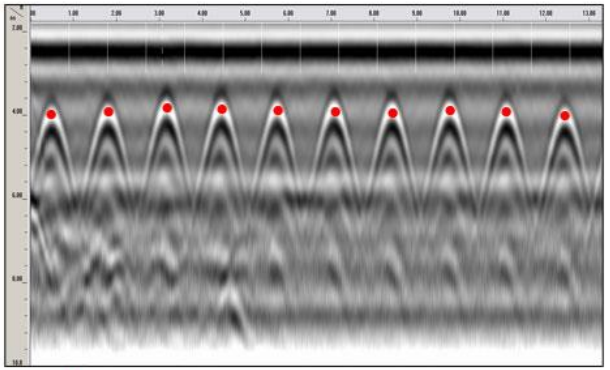
-GROUND PENETRATING RADAR (GPR)

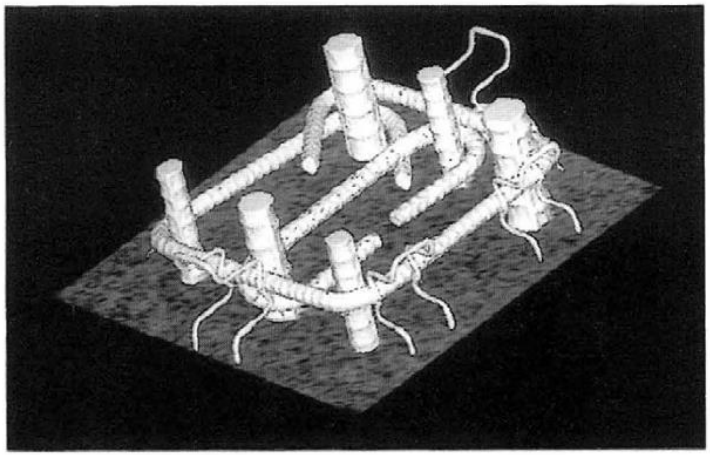
-DYNAMIC RESPONSE TESTING

-RADIOGRAPHY AND RADIOMETRY

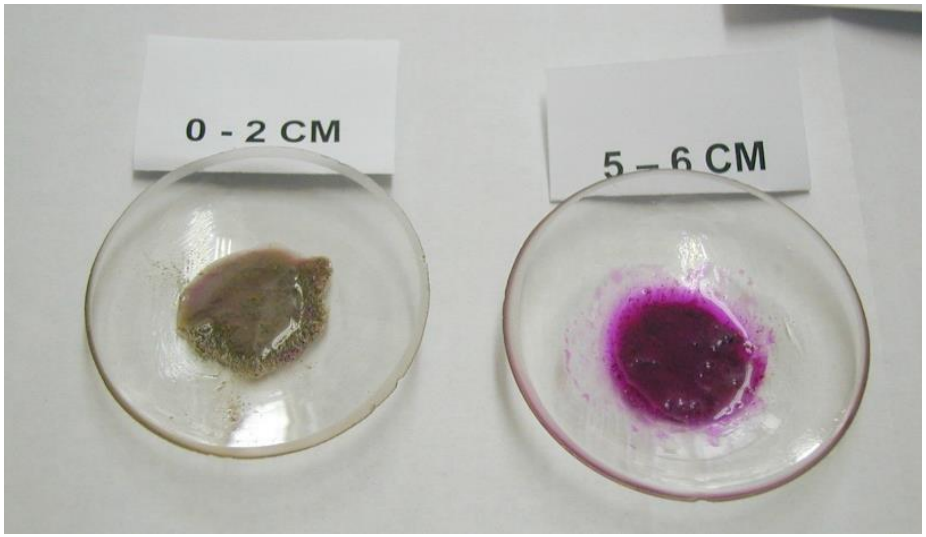
-VIDEO ENDOSCOPY

-ETC...





16. CARBONATION TEST



→ **Phenolphthalein** (indicator in base titrations)
- pink - purplish red → pH > 8…12
- colorless → pH < 8.2

(Balaguru, 2009)

17. REAL SCALE ON-SITE

PUSH-DOWN TEST CONFIGURATION

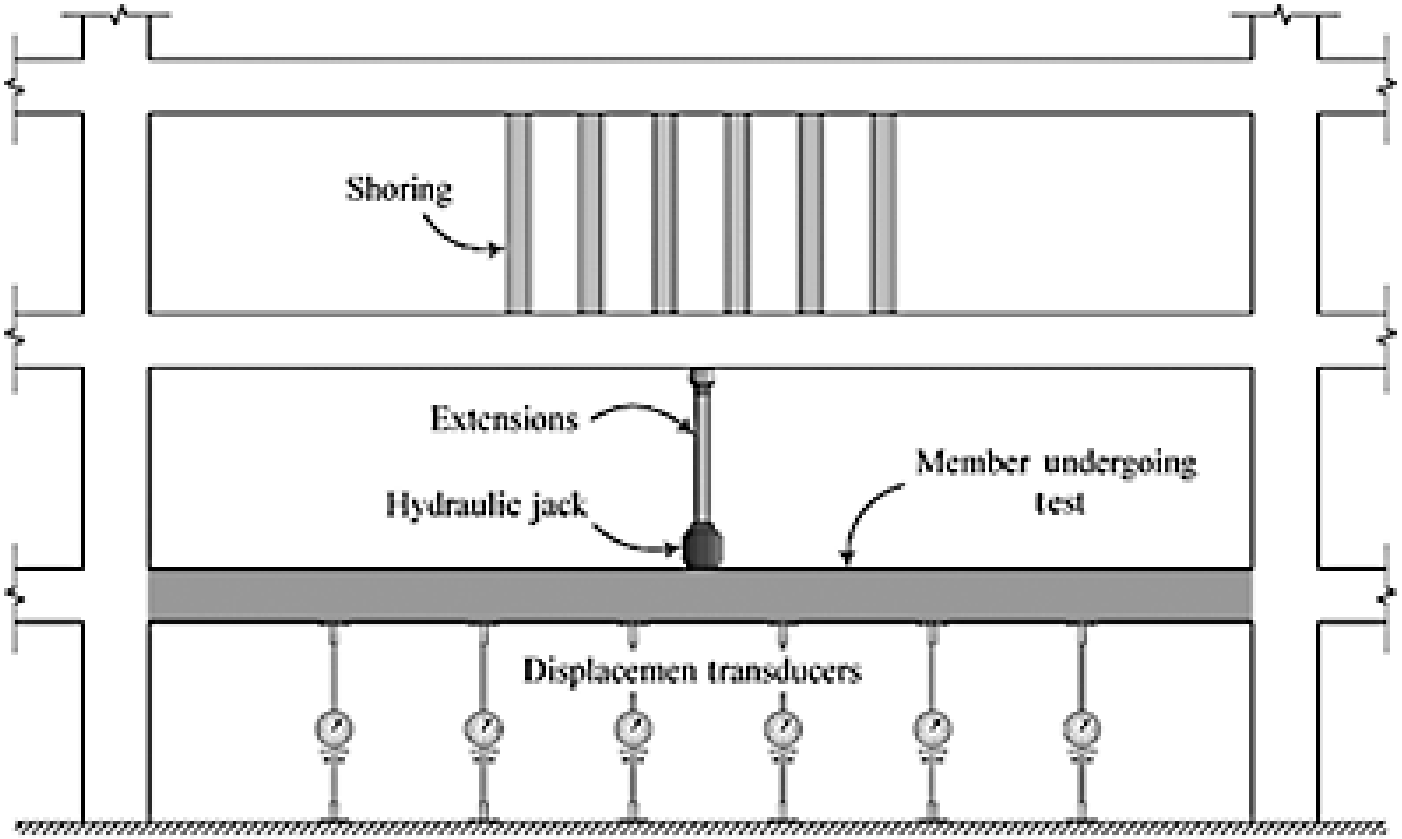
Setup time: mediu

Requirements: hydraulic jack and pump, extensions to ceiling, shoring of above floor

Load variation: Easy

Reaction: Shored floor(s) above test member

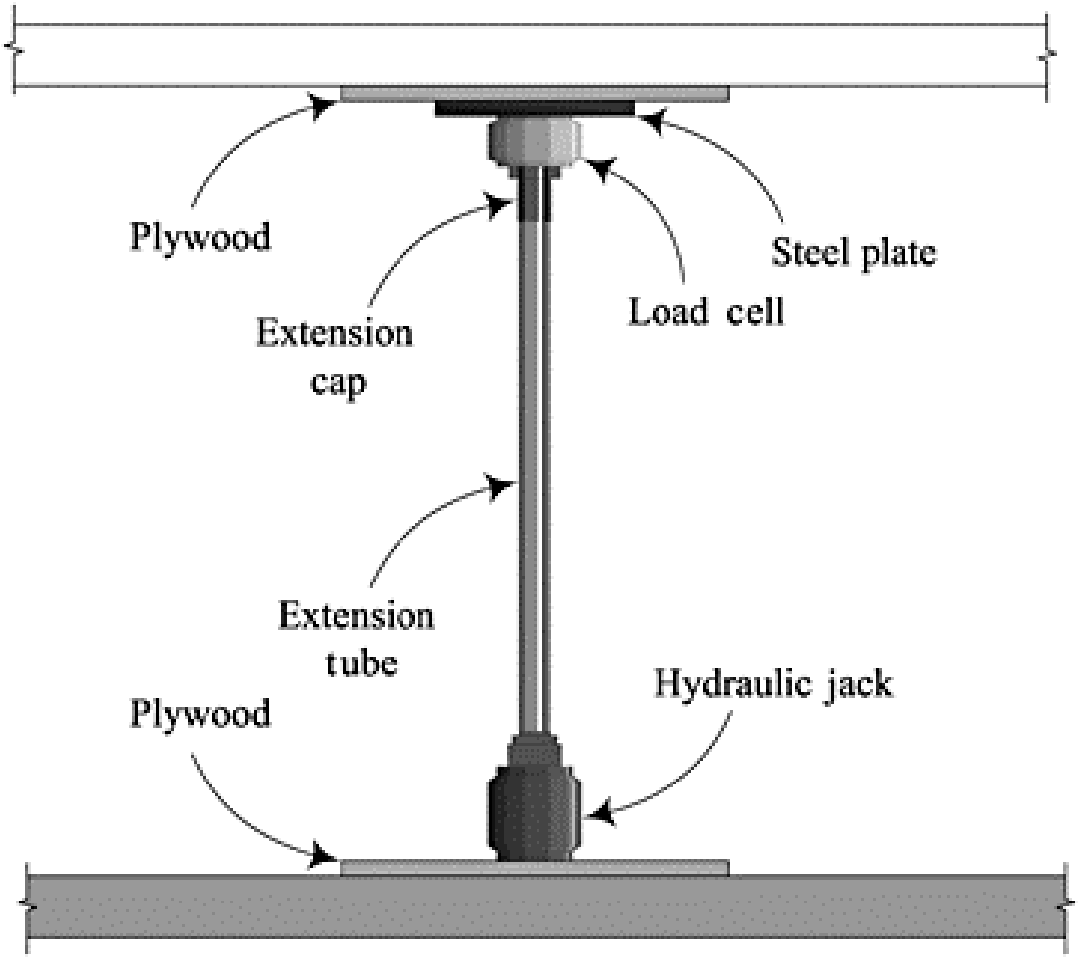
Limitations: Requires floor(s) above for reaction



(Balaguru, 2009)

17. REAL SCALE ON-SITE

PUSH-DOWN TEST CONFIGURATION

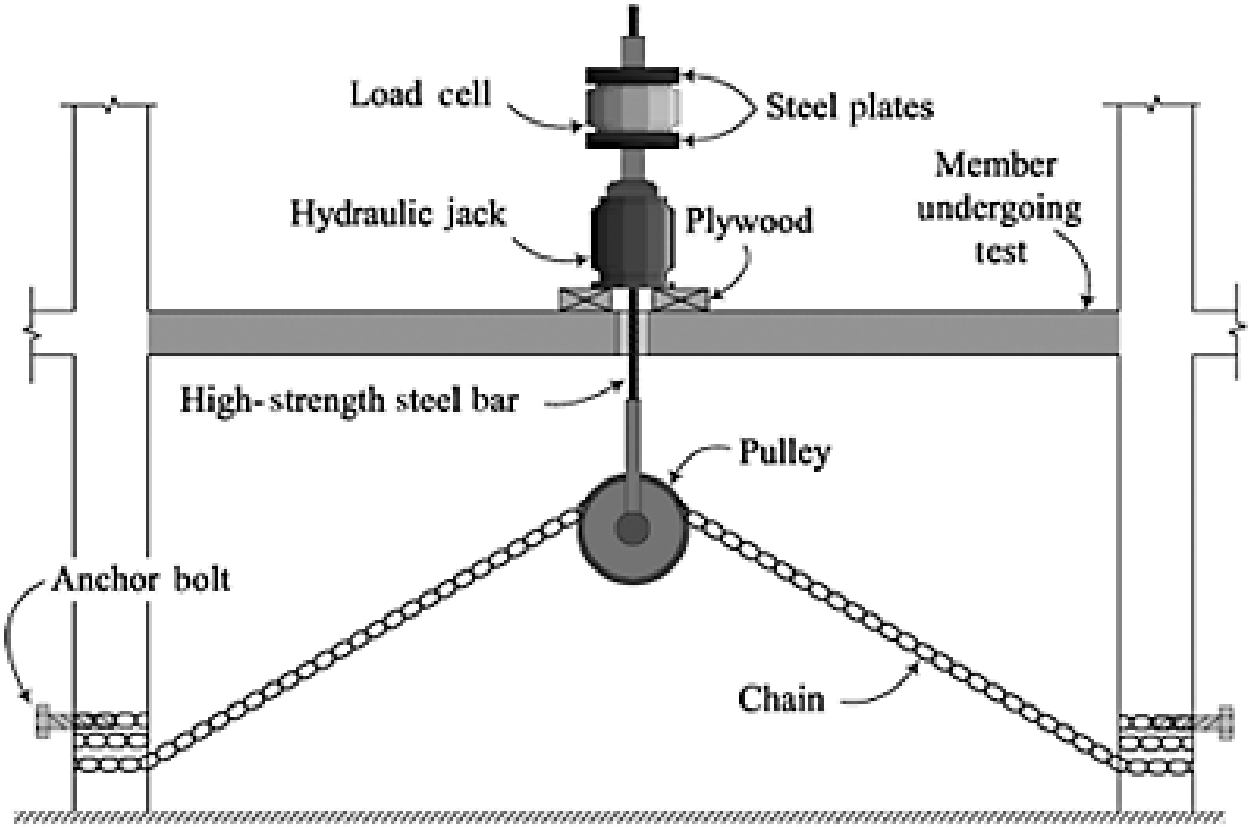


(Balaguru, 2009)

17. REAL SCALE ON-SITE

PULL-DOWN TEST METHOD WITH A **FIXED REACTION**

Timp de pregătire: mediu
Cerințe: pompă hidraulică, găuri în elemente, cablu, ancoraje
Variația încărcării: ușoară
Reacțiune: greutate proprie structură
Limitări: încărcare aplicată în funcție de structură și ancoraje

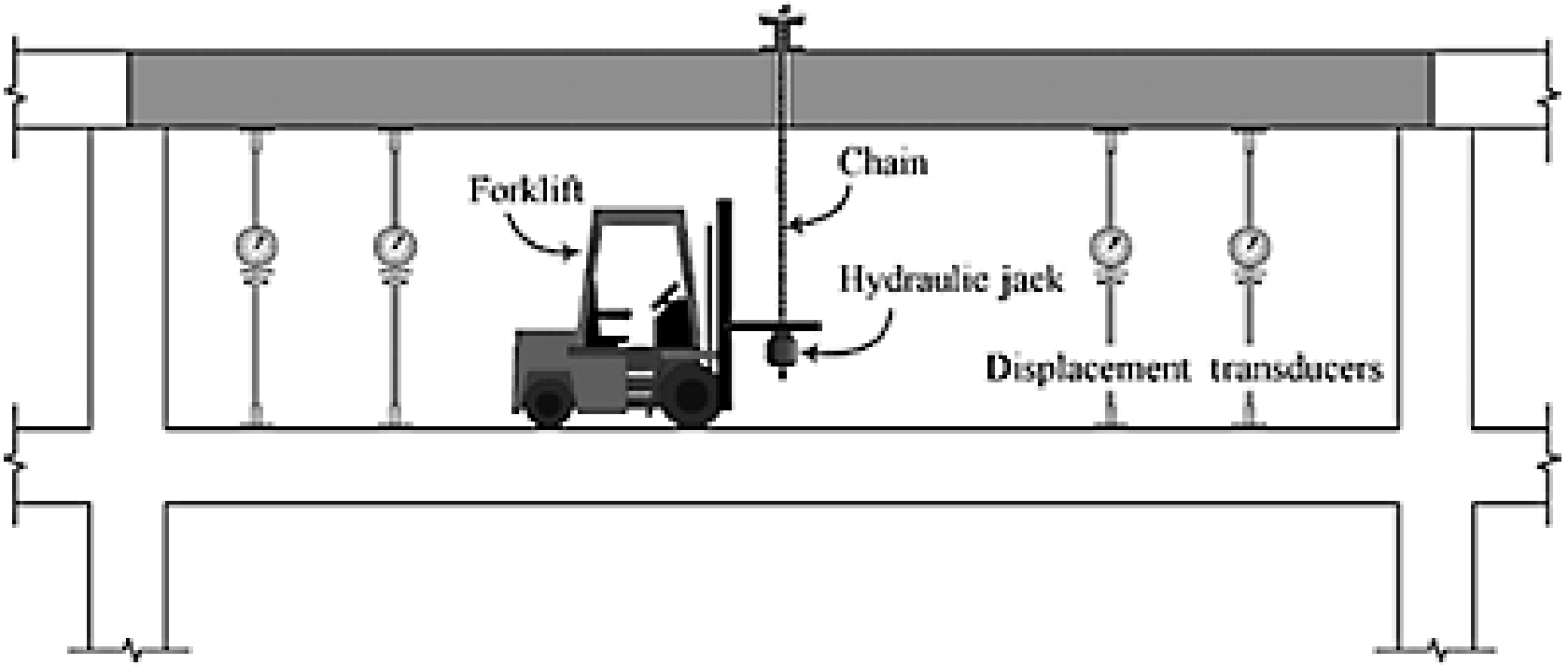


(Balaguru, 2009)

17. REAL SCALE ON-SITE

PULL-DOWN TEST CONFIGURATION WITH A **MOBILE REACTION**

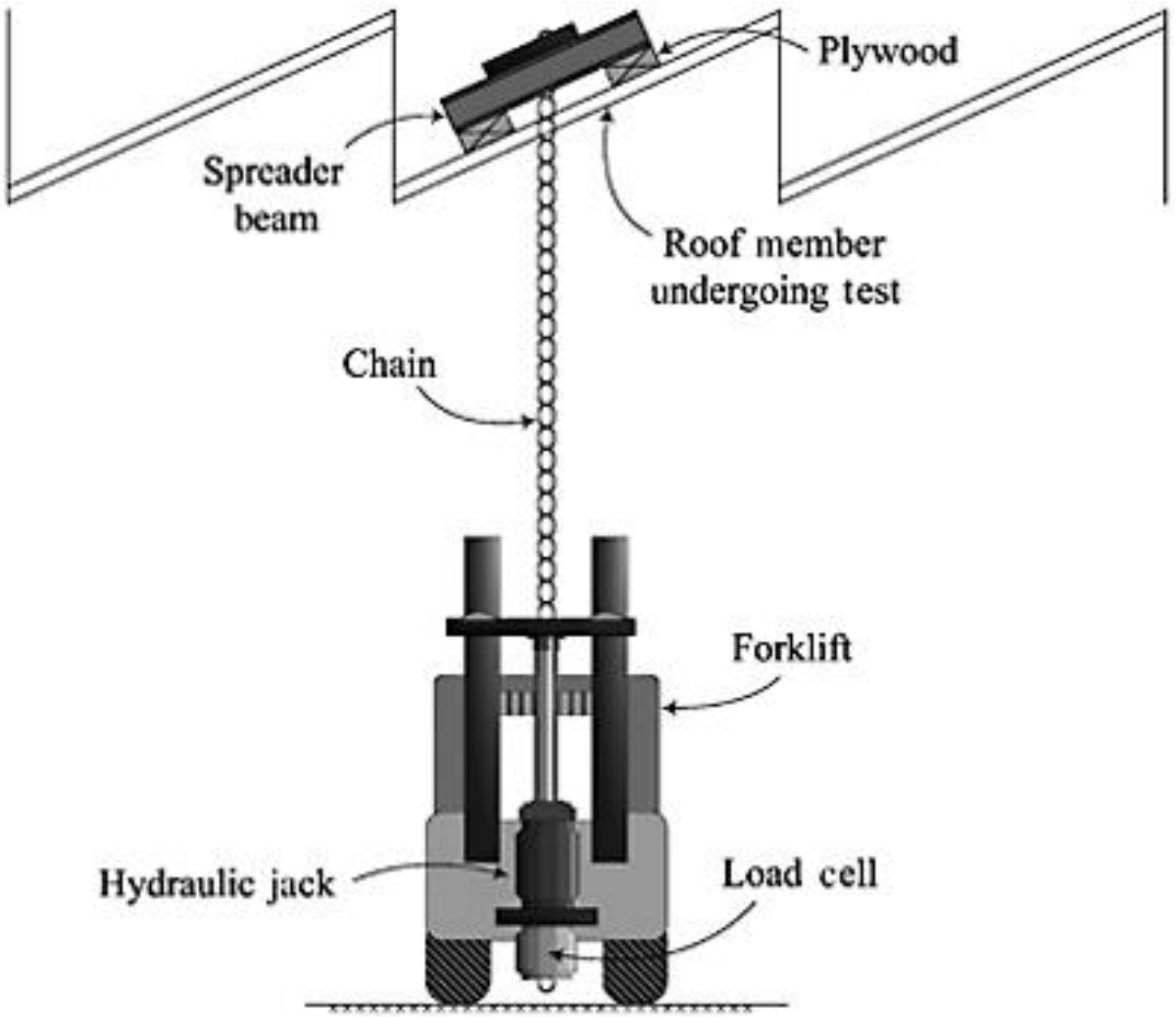
Timp de pregătire: mediu
Cerințe: pompă hidraulică, găuri în elemente, cablu, motostivuitor
Variația încărcării: ușoară
Reacțiune: greutate proprie structură
Limitări: încărcare aplicată relativ mică



(Balaguru, 2009)

17. REAL SCALE ON-SITE

PULL-DOWN TEST CONFIGURATION WITH A **MOBILE REACTION**

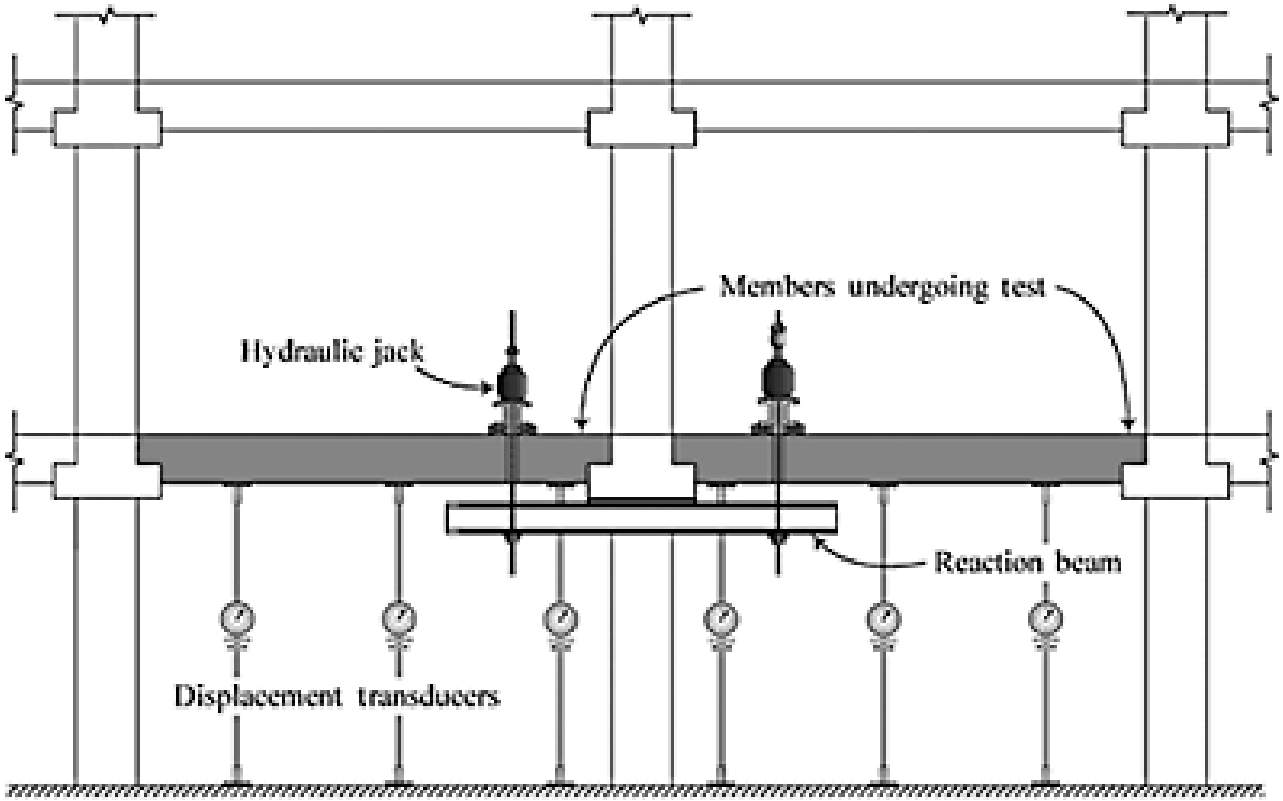


(Balaguru, 2009)

17. REAL SCALE ON-SITE

CLOSED-LOOP TEST CONFIGURATION

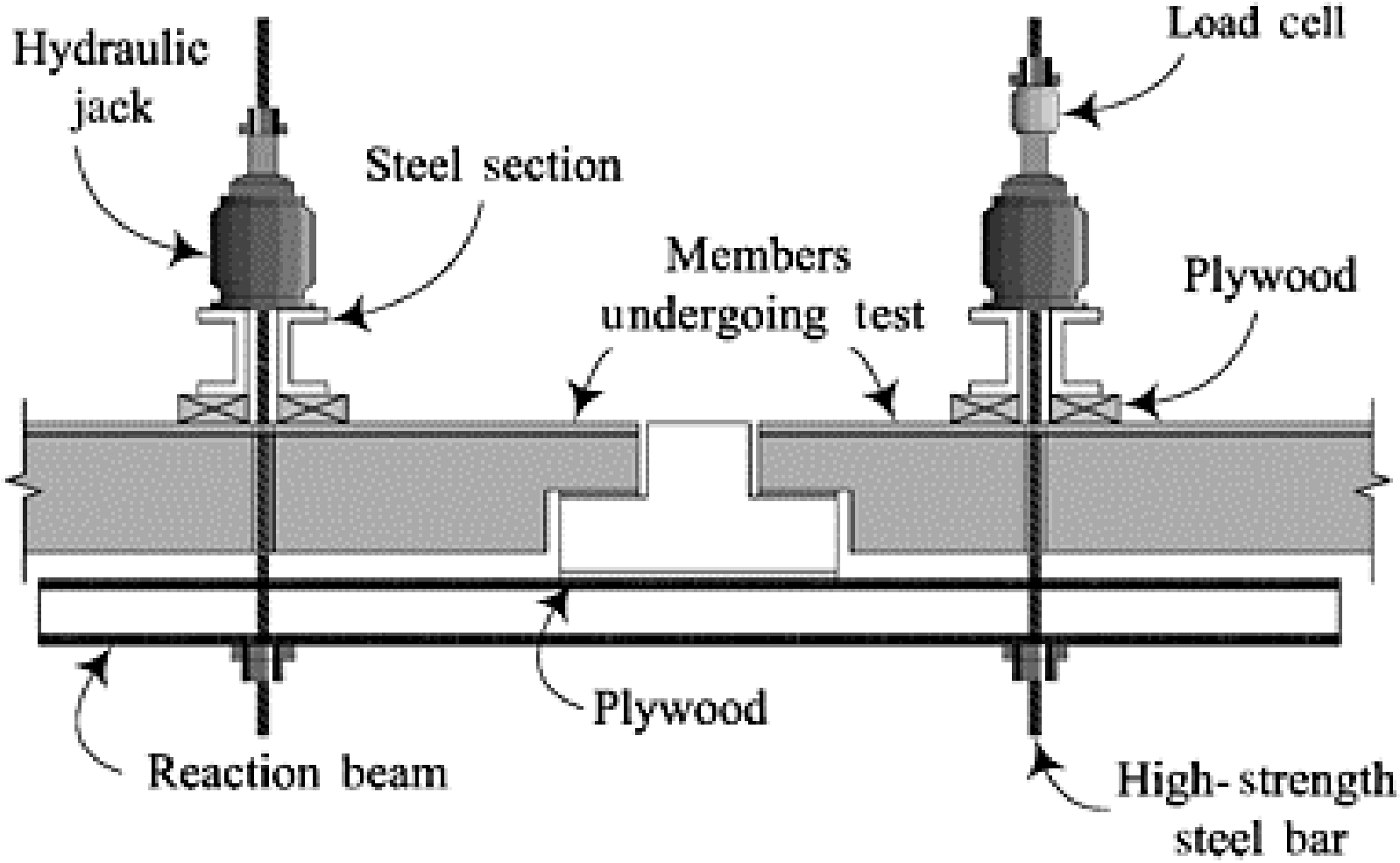
Timp de pregătire: lung
Cerințe: 2 pompe hidraulice, găuri în elemente, cabluri, grinzi de reacțiune
Variația încărcării: ușoară
Reacțiune: element intermediar între elementele testate
Limitări: locația și magnitudinea încărcării în funcție de proprietățile grinzii de reactiune



(Balaguru, 2009)

17. REAL SCALE ON-SITE

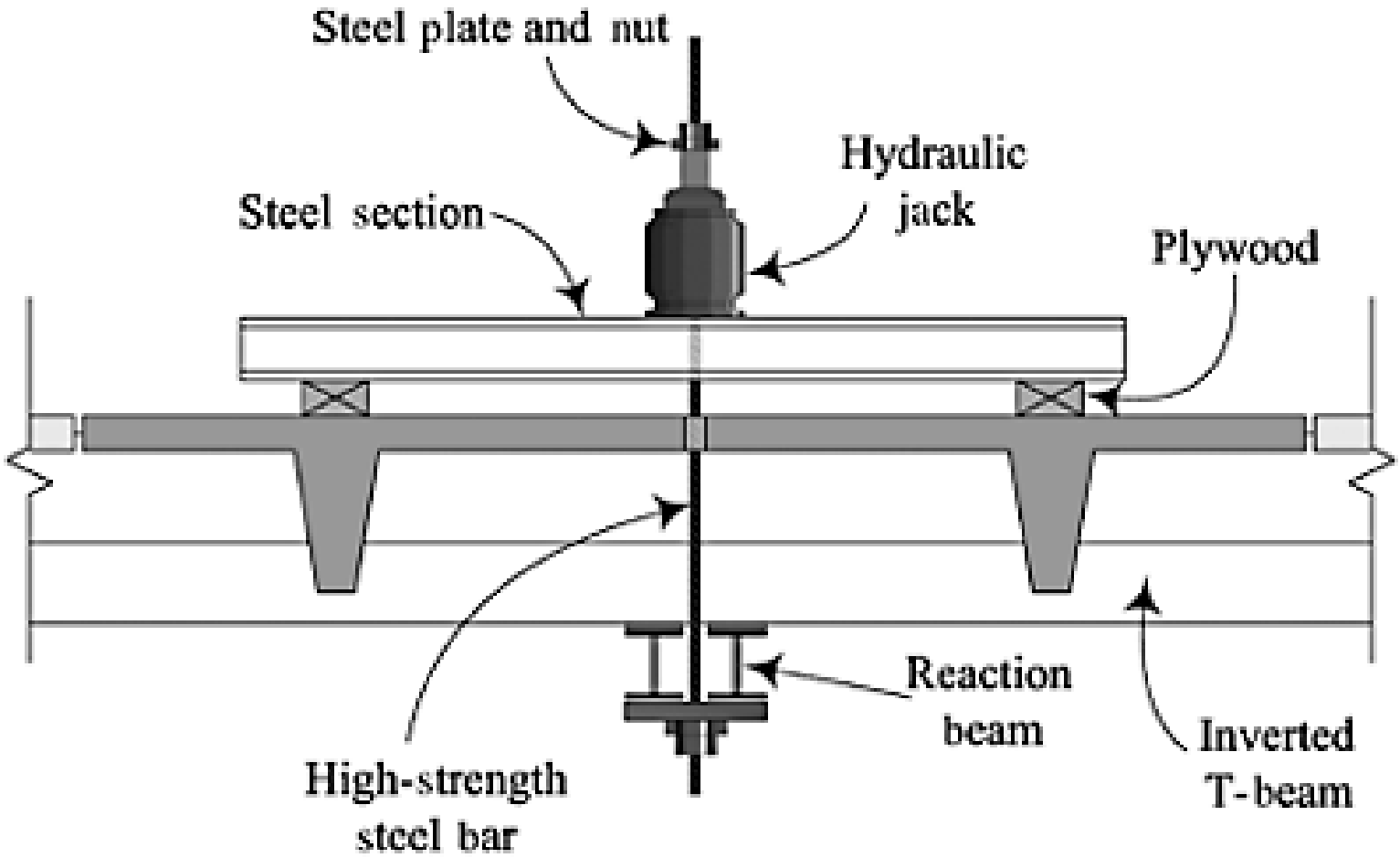
CLOSED-LOOP TEST CONFIGURATION



(Balaguru, 2009)

17. REAL SCALE ON-SITE

CLOSED-LOOP TEST CONFIGURATION

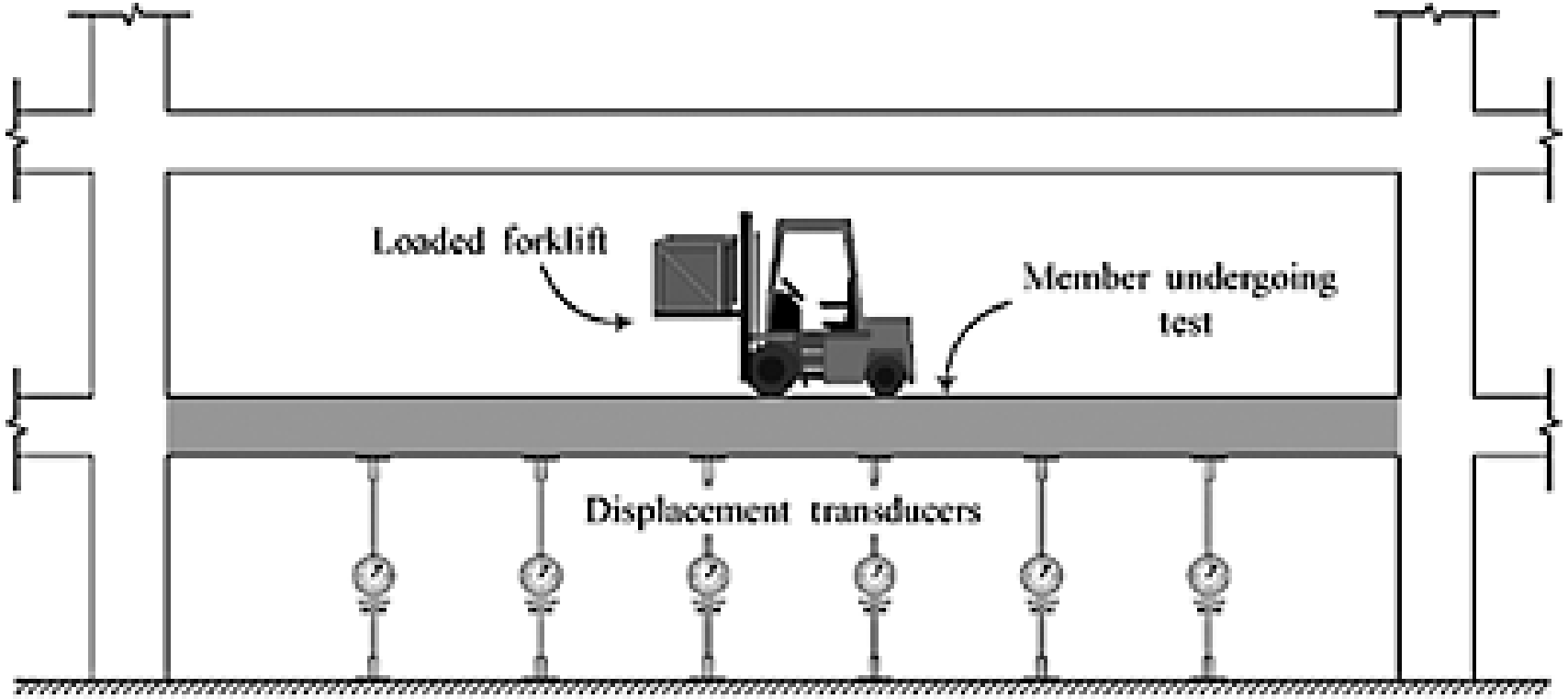


(Balaguru, 2009)

17. REAL SCALE ON-SITE

VEHICLE-LOADED TEST CONFIGURATION

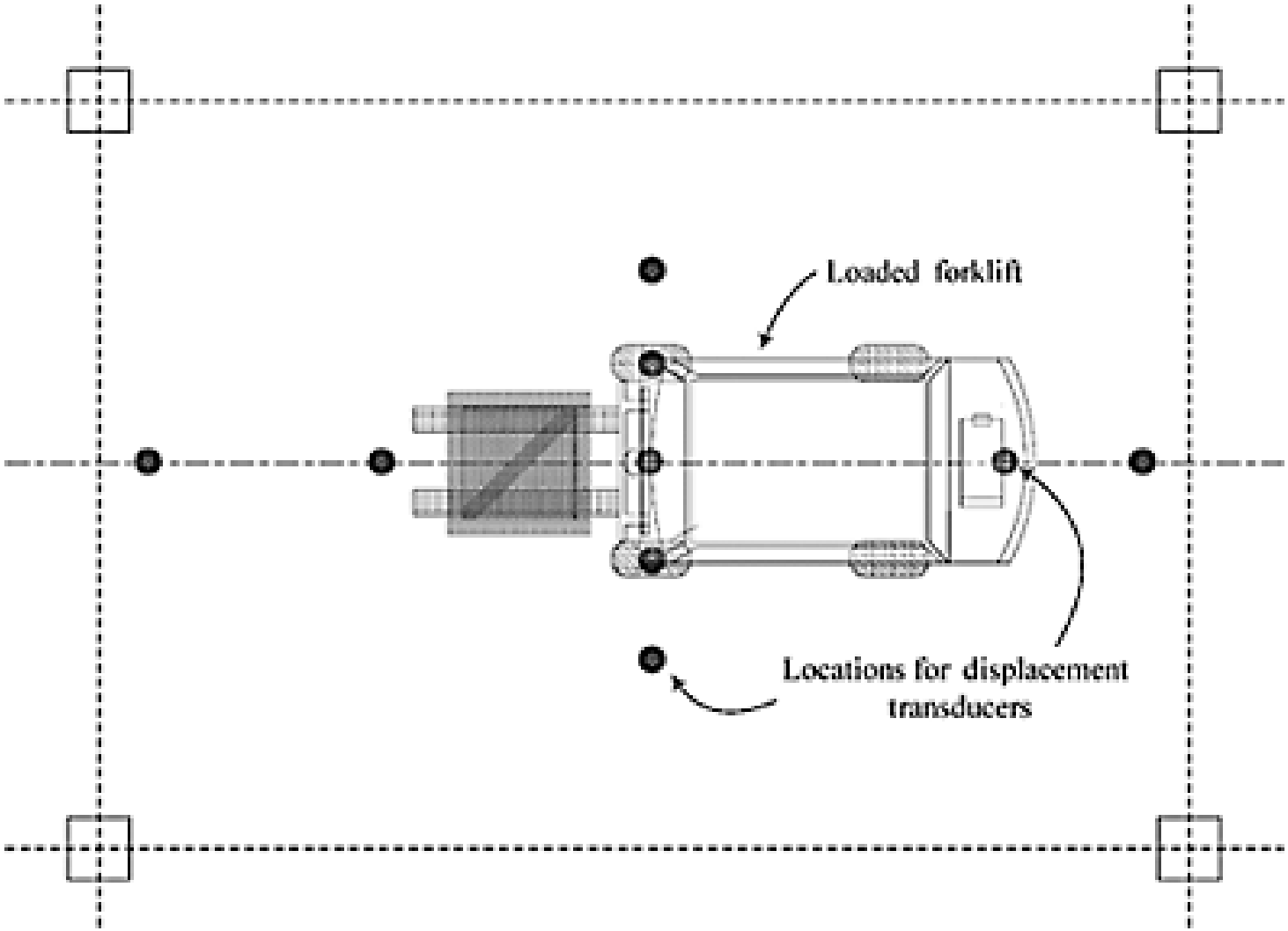
Timp de pregătire : scurt
Cerințe: vehicule, greutăți
Variația încărcării: cu dificultate
Reacțiune: nu se aplică
Limitări: variația încărcării este îndelungată



(Balaguru, 2009)

17. REAL SCALE ON-SITE

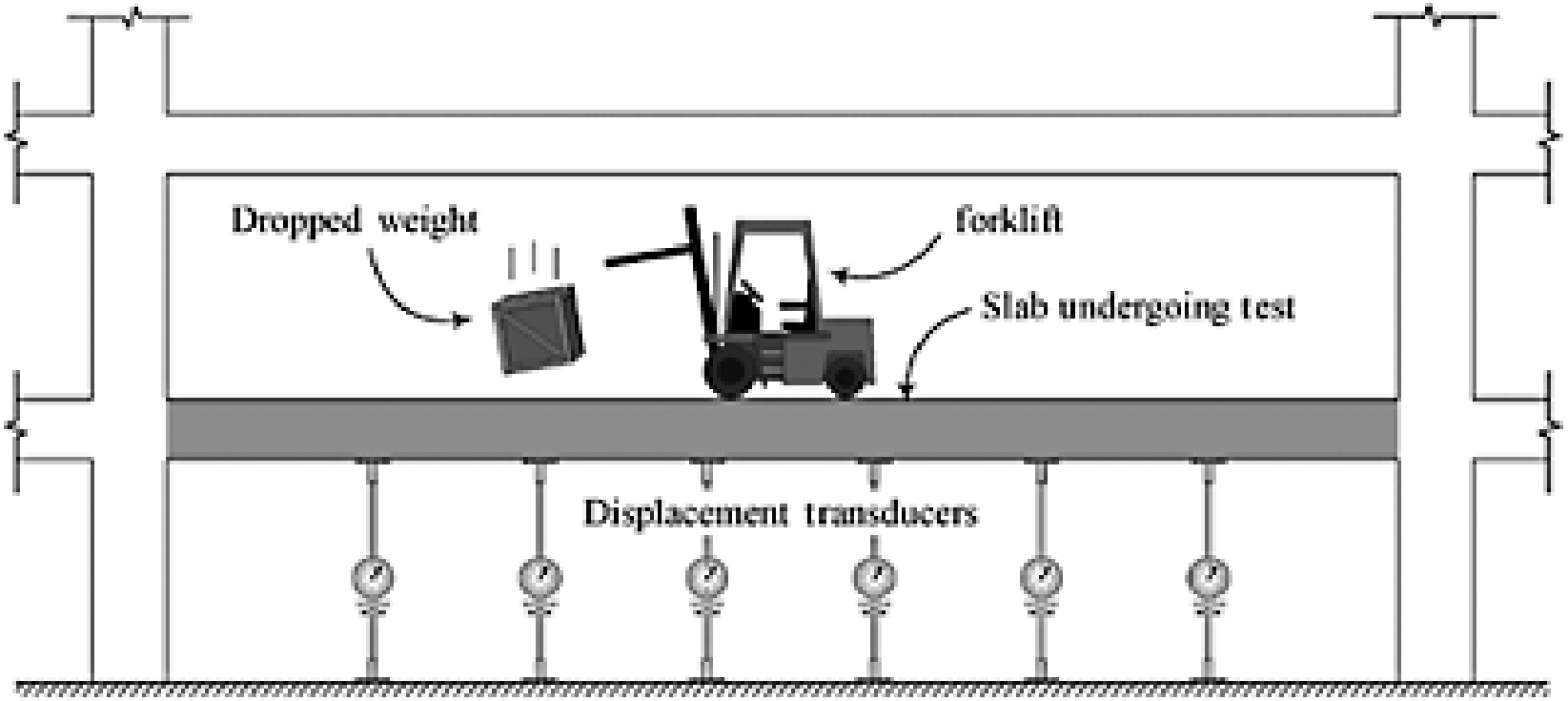
VEHICLE-LOADED TEST CONFIGURATION



(Balaguru, 2009)

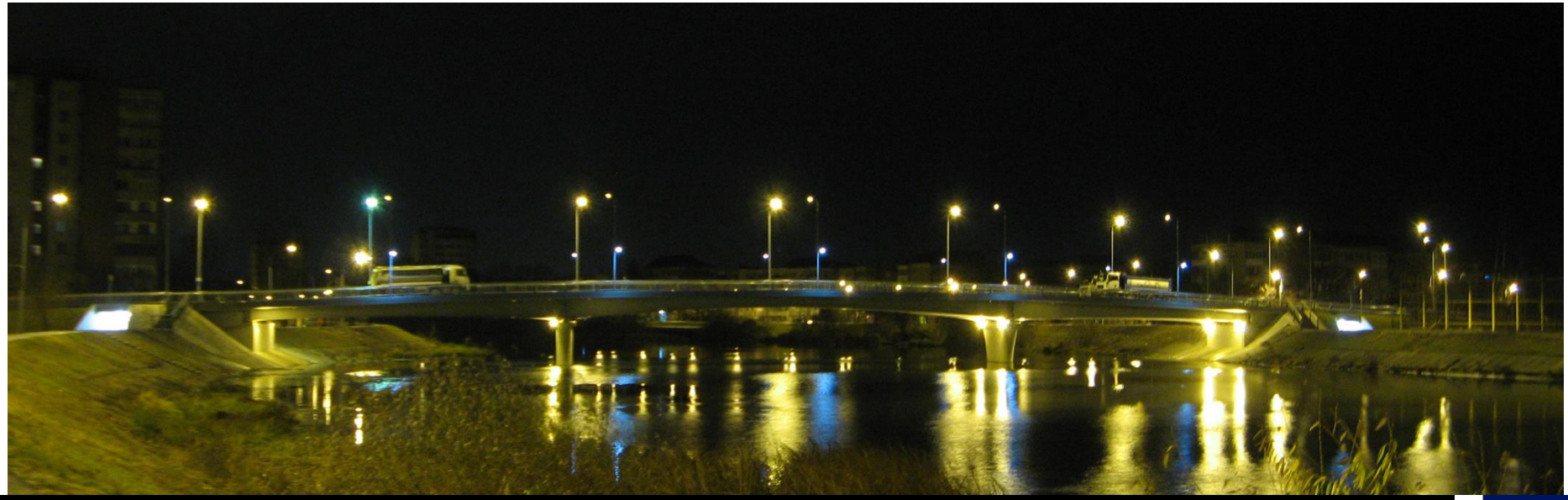
17. REAL SCALE ON-SITE

LOAD TEST CONFIGURATION FOR A **DROPPED WEIGHT**



17. REAL SCALE ON-SITE

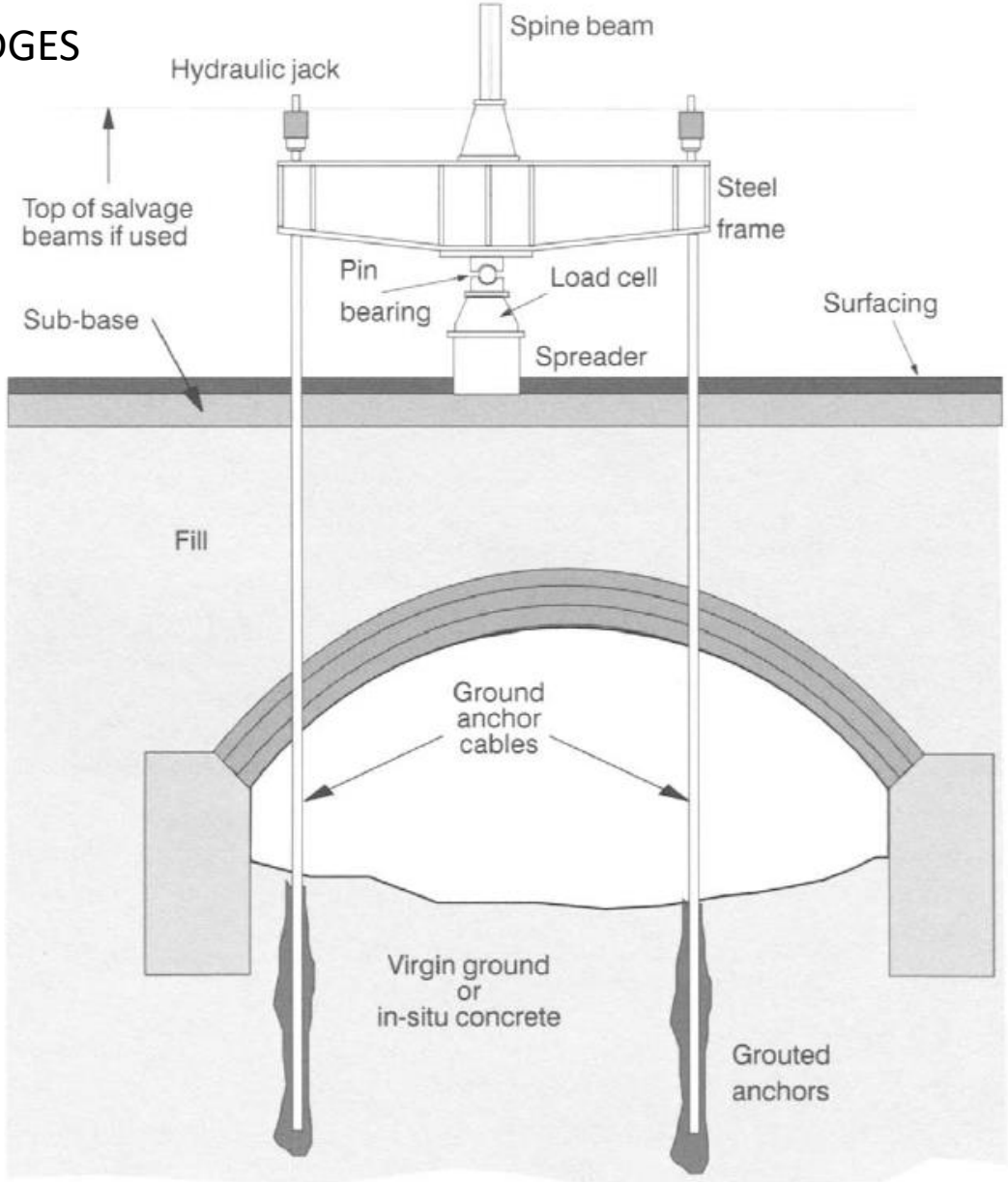
VEHICLE-LOADED TEST CONFIGURATION → BRIDGES



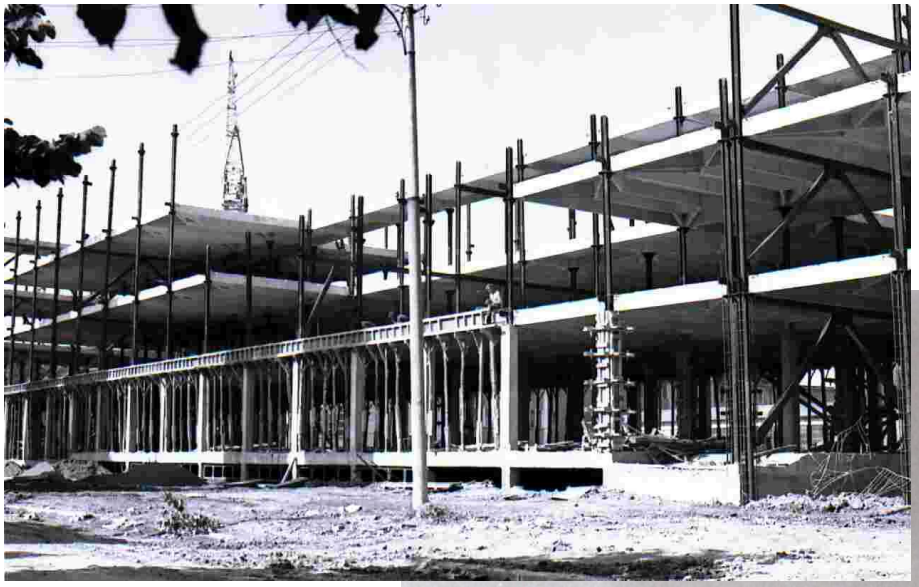
(Ryall M.J.)

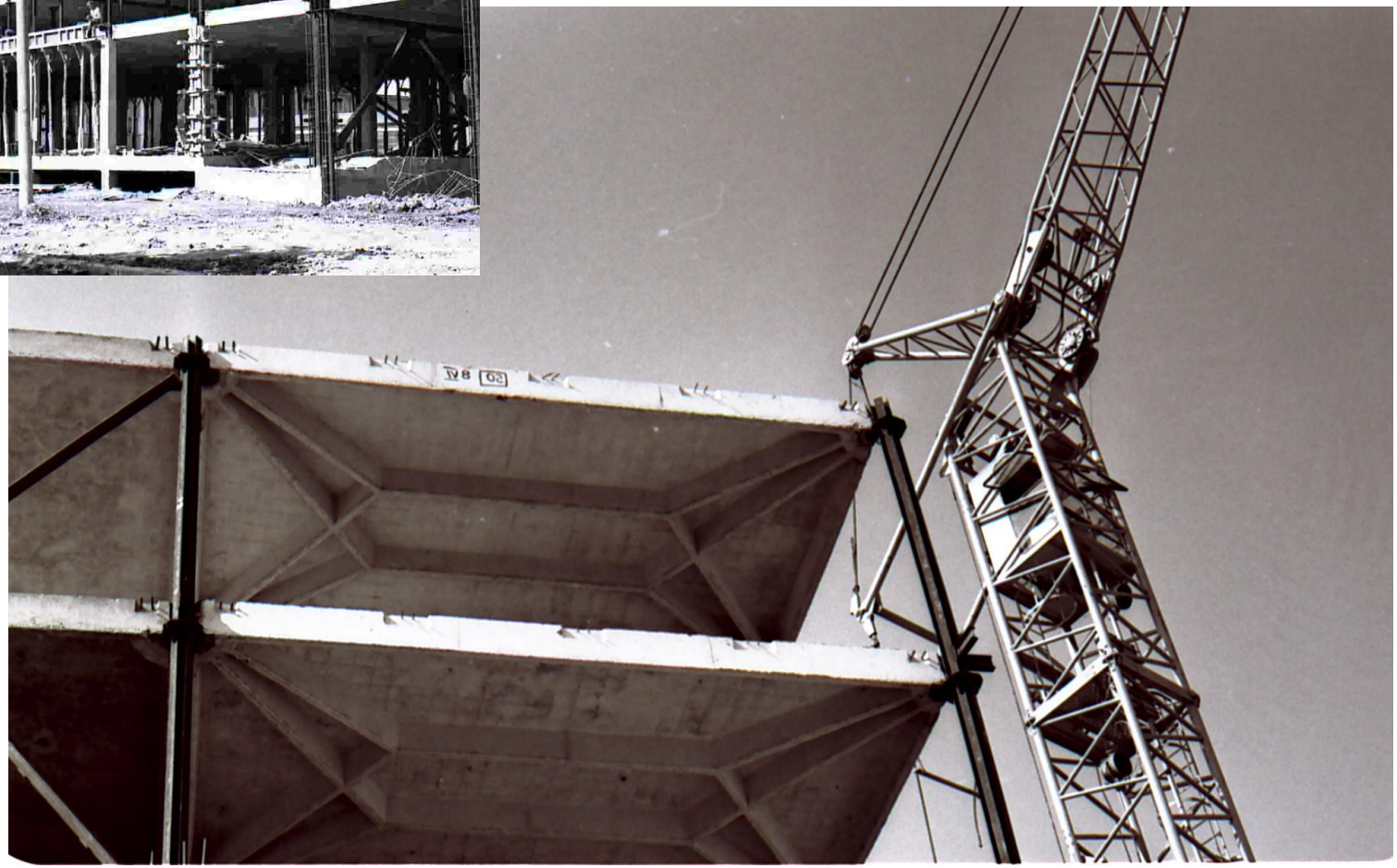
17. REAL SCALE ON-SITE

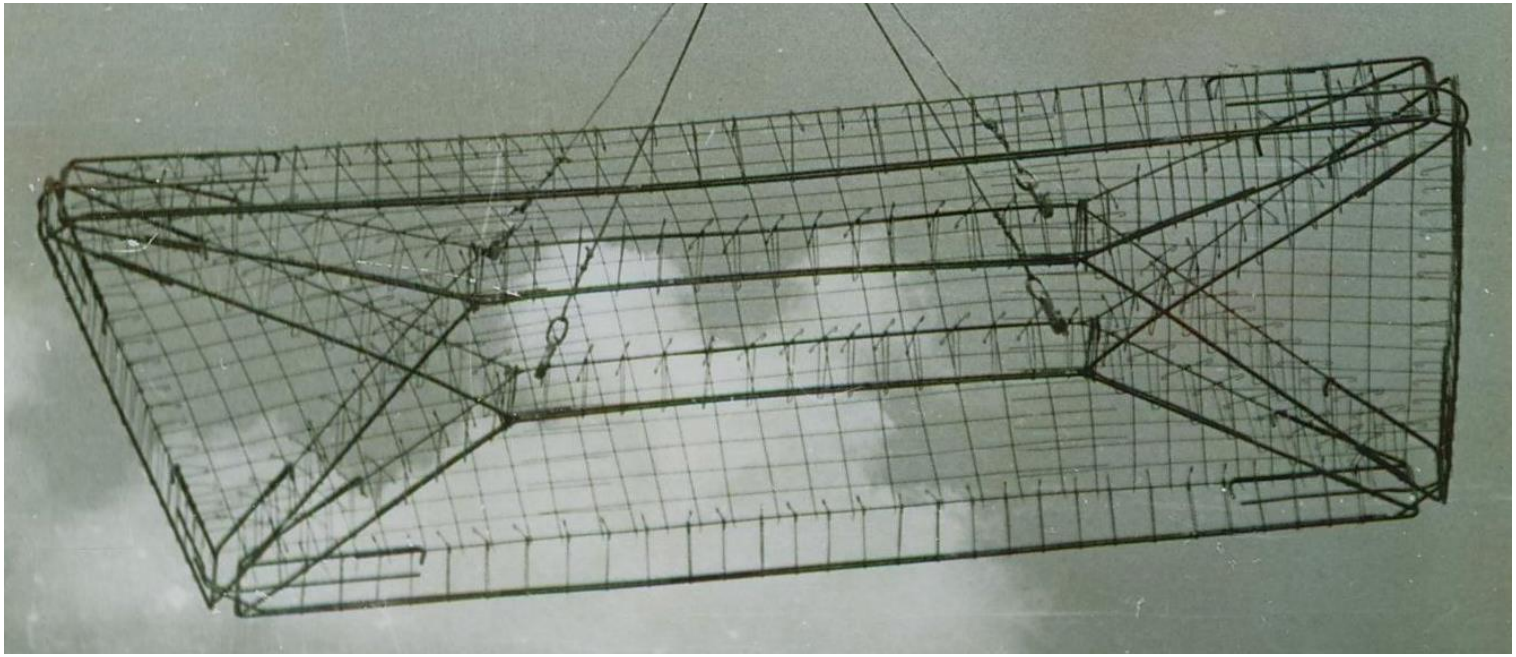
LOAD TEST CONFIGURATION → BRIDGES

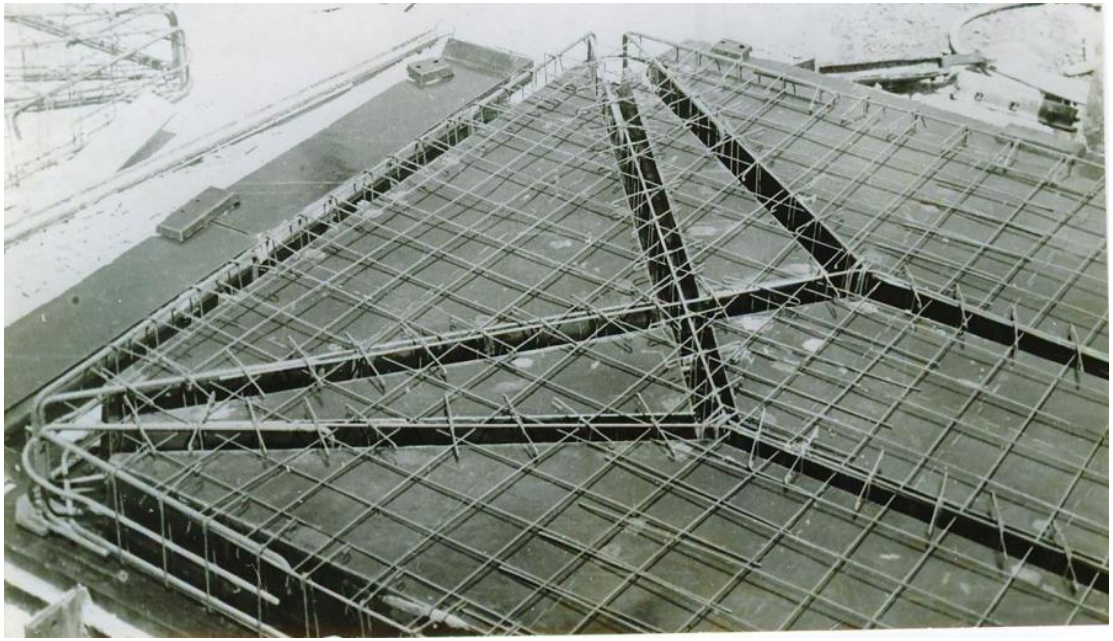


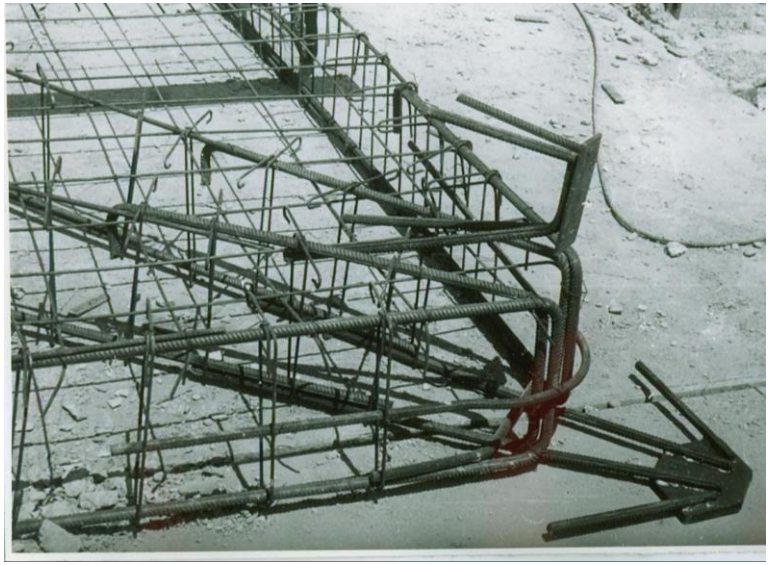
17. REAL SCALE ON-SITE





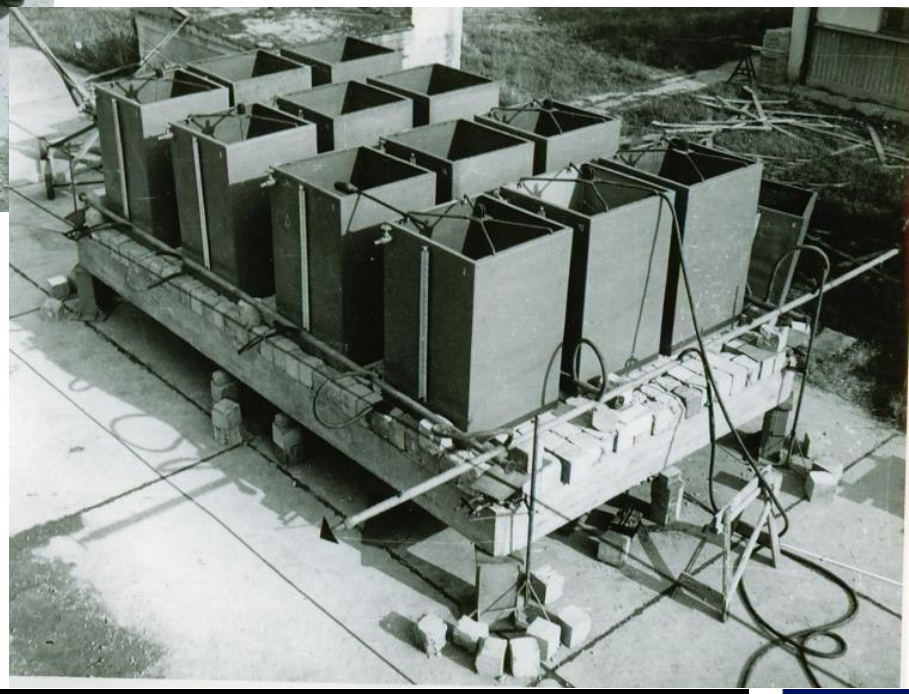






17. REAL SCALE ON-SITE

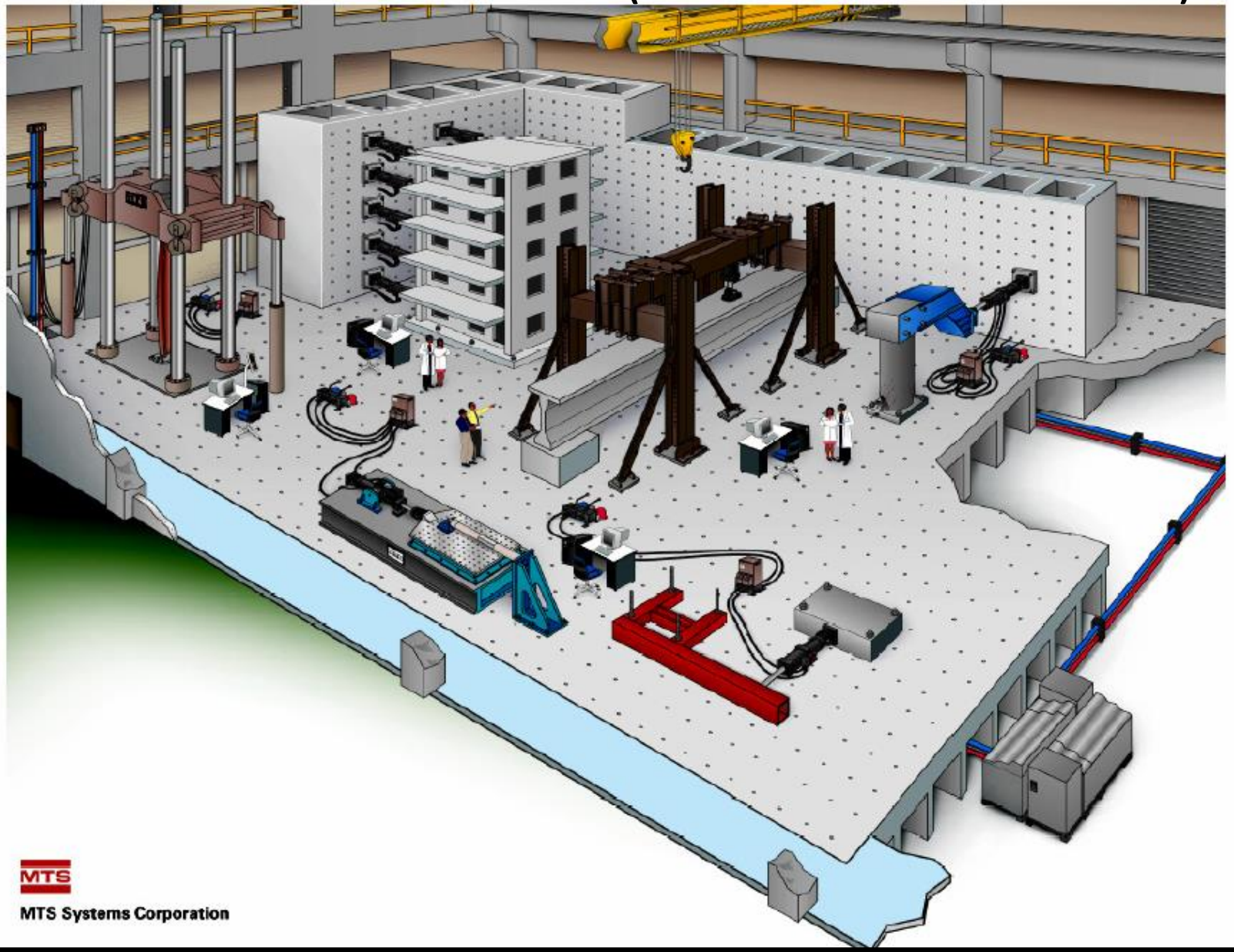
17. REAL SCALE ON-SITE



17. REAL SCALE ON-SITE

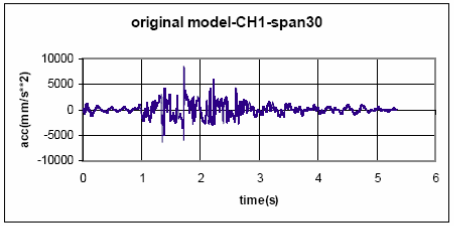
LOAD TEST CONFIGURATION → BRIDGES

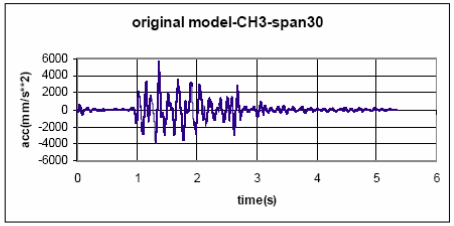
18. LOAD TESTING IN RESEARCH LABS (FULL SCALE OR REDUCED SCALE)

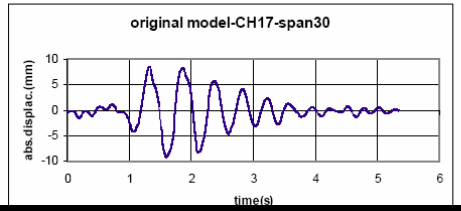


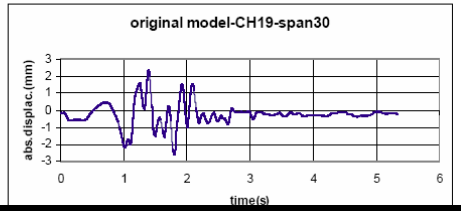
18. LOAD TESTING IN RESEARCH LABS - REDUCED SCALE)

Mustafa Pasha mosque constructed in scale 1:6









0.2g ÷1.5g

18. LOAD TESTING IN RESEARCH LABS - REDUCED SCALE)

0.2g ÷1.5g

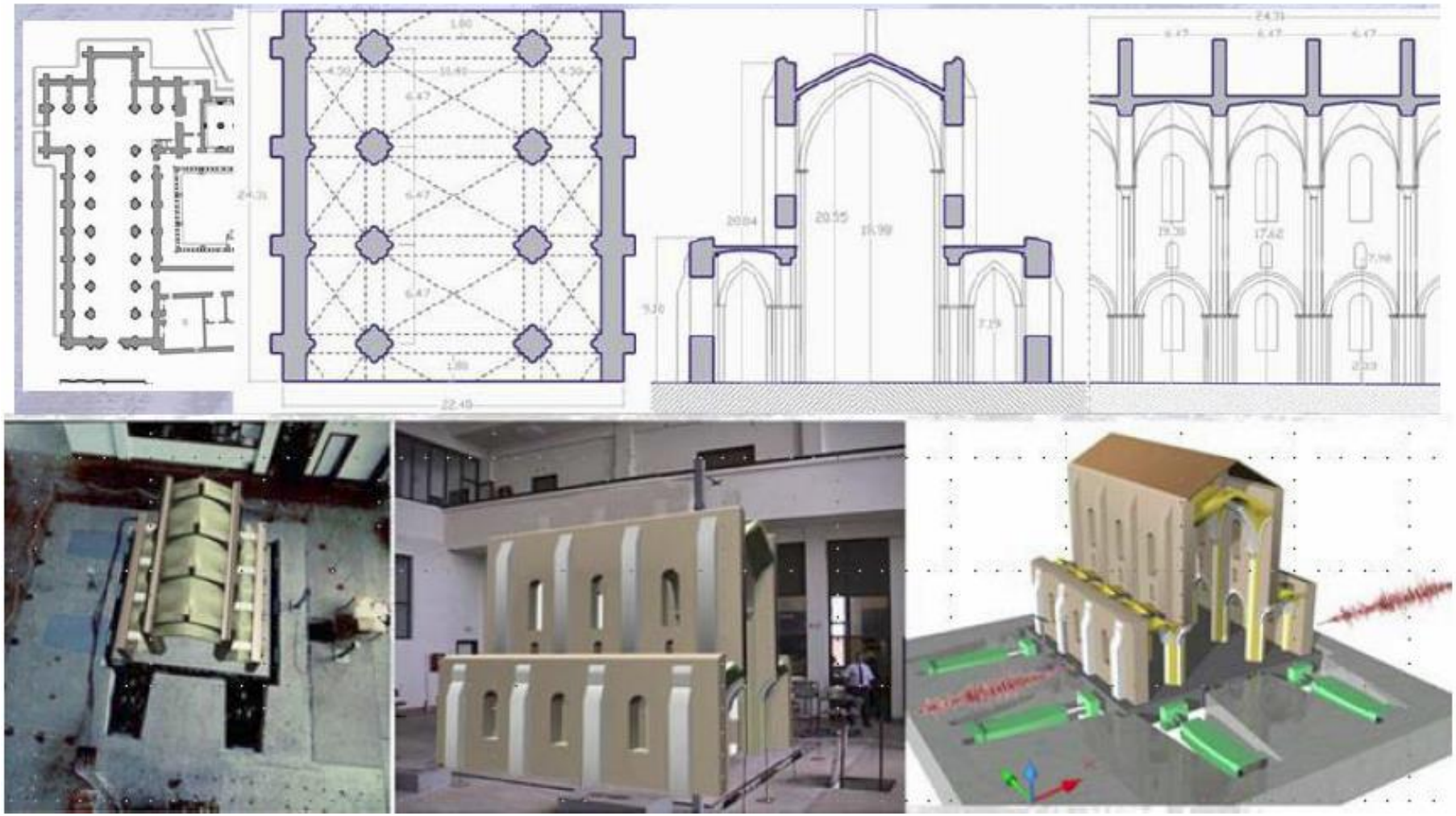
18. LOAD TESTING IN RESEARCH LABS - REDUCED SCALE)

(Mazzolani)

18. LOAD TESTING IN RESEARCH LABS - REDUCED SCALE)

Catedrala Fossanova

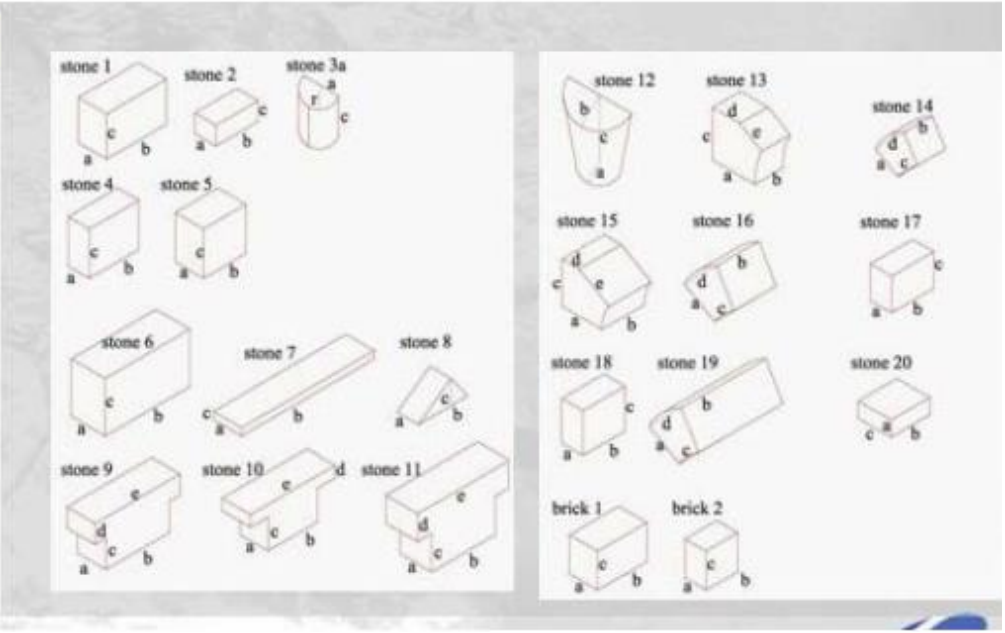
18. LOAD TESTING IN RESEARCH LABS - REDUCED SCALE)

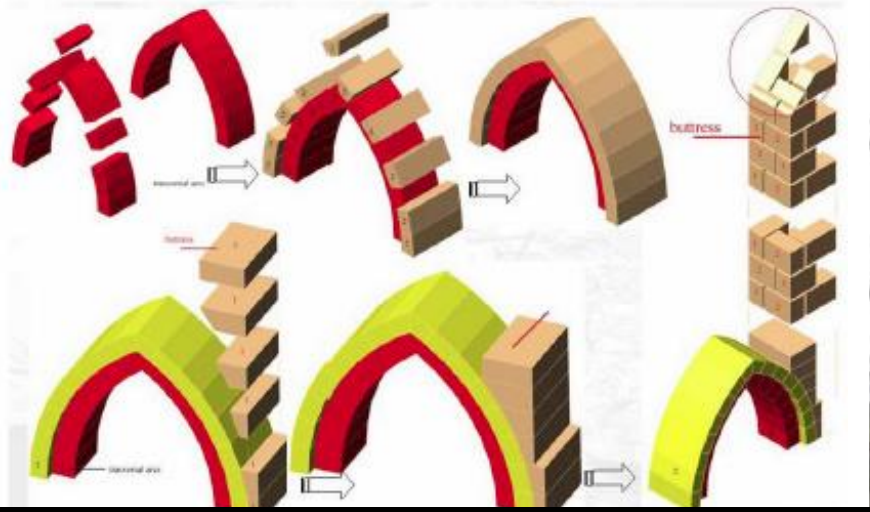


Scara 1: 5.5

18. LOAD TESTING IN RESEARCH LABS - REDUCED SCALE)

element	color	a	b	c	d	e	r	n° element
		cm	cm	cm	cm	cm	cm	
stone 1		8	17	11	-	-	-	360
stone 2		6	12	5	-	-	-	11712
stone 3a		10	-	9	-	-	5	512
stone 4		6	14	12	-	-	-	64
stone 5		8	12	12	-	-	-	128
stone 6		10	24	14	-	-	-	96
stone 7		8	37	2	-	-	-	24
stone 8		6	14	6.5	-	-	-	140
stone 9		8	18	7.5	5	24	-	160
stone 10		8	14	8	3	24	-	146
stone 11		9	18	9	6.5	26	-	120
stone 12		6	9	16.5	-	-	-	8
stone 13		12	8	12.85	7.7	8.7	-	32
stone 14		7.3	8	5.5	8.2		-	40
stone 15		11.35	12	11.5	4.8	9.8	-	32
stone 16		9.8	12	7.8	12.9	-	-	40
stone 17		6	12	9	-	-	-	2328
stone 18		5.7	11.35	14.4	-	-	-	240
stone 19		6	6.8	24	-	-	-	48
stone 20		9	4	11	-	-	-	278
brick 1		8	14	10	-	-	-	56
brick 2		6	9	10	-	-	-	112

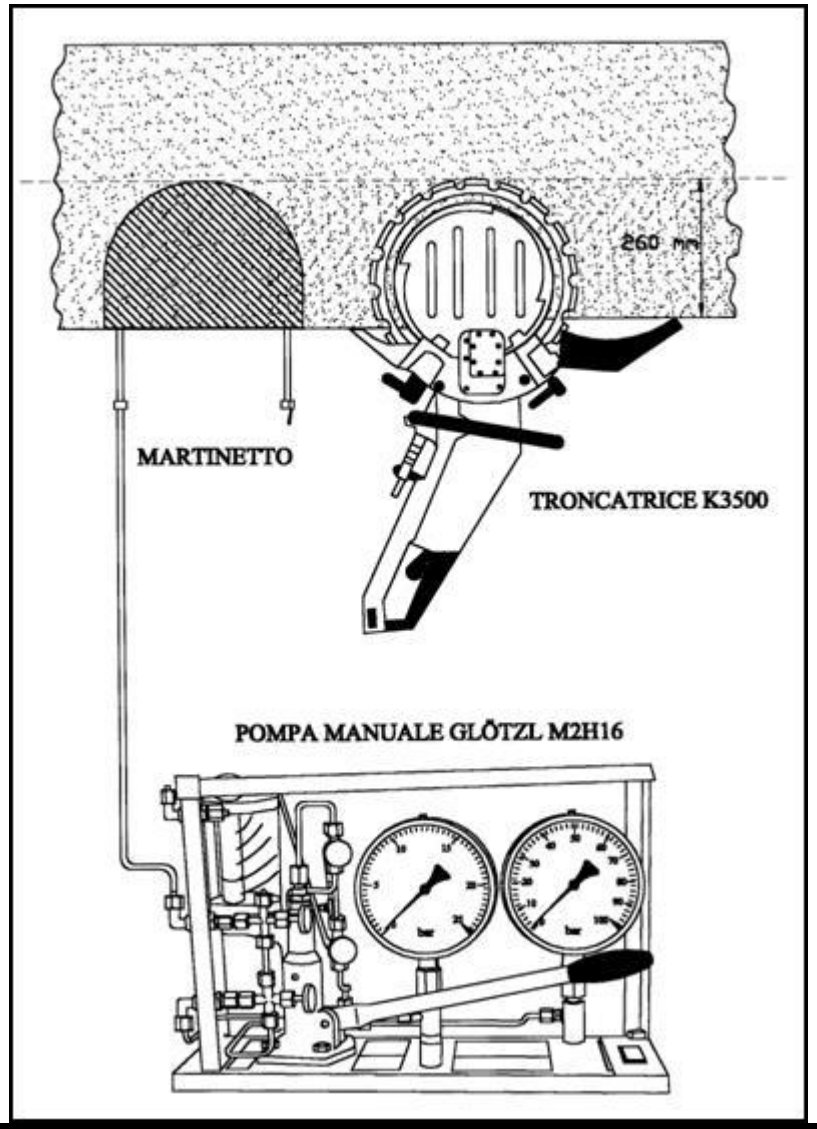


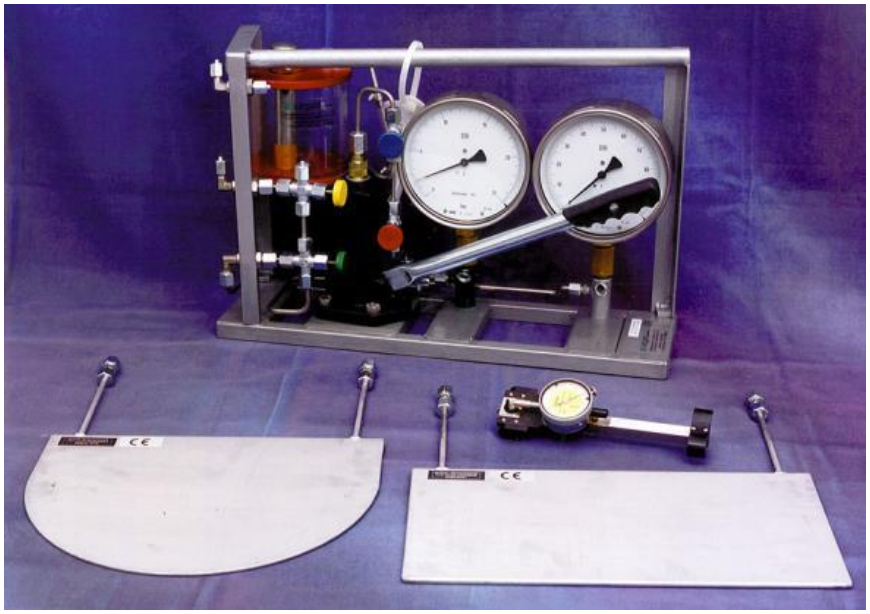


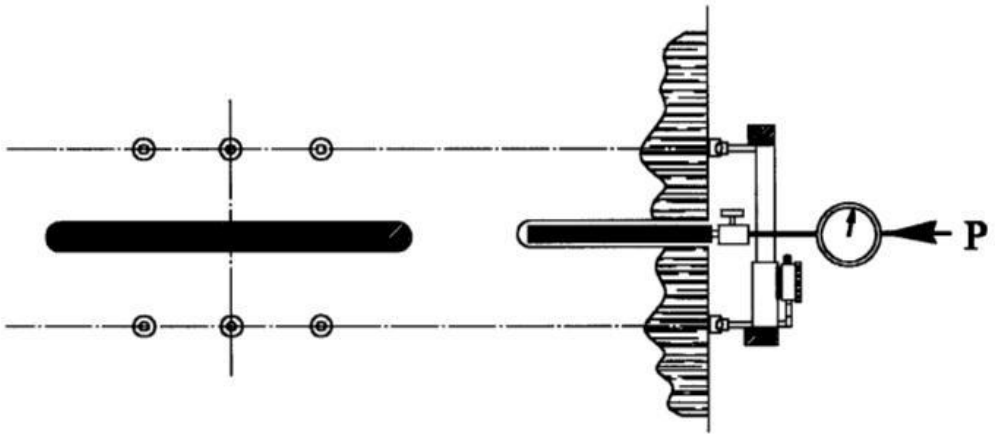
18. LOAD TESTING IN RESEARCH LABS - REDUCED SCALE)

(Boviar)

19. TEST ON MASONRY USING FLAT JACK



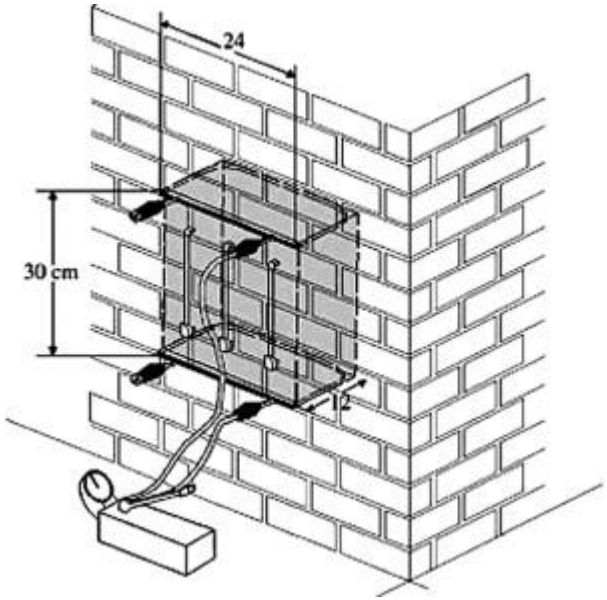




(Boviar)

19. TEST ON MASONRY USING FLAT JACK

FLAT JACKS → 3500 KN



(Proceq)

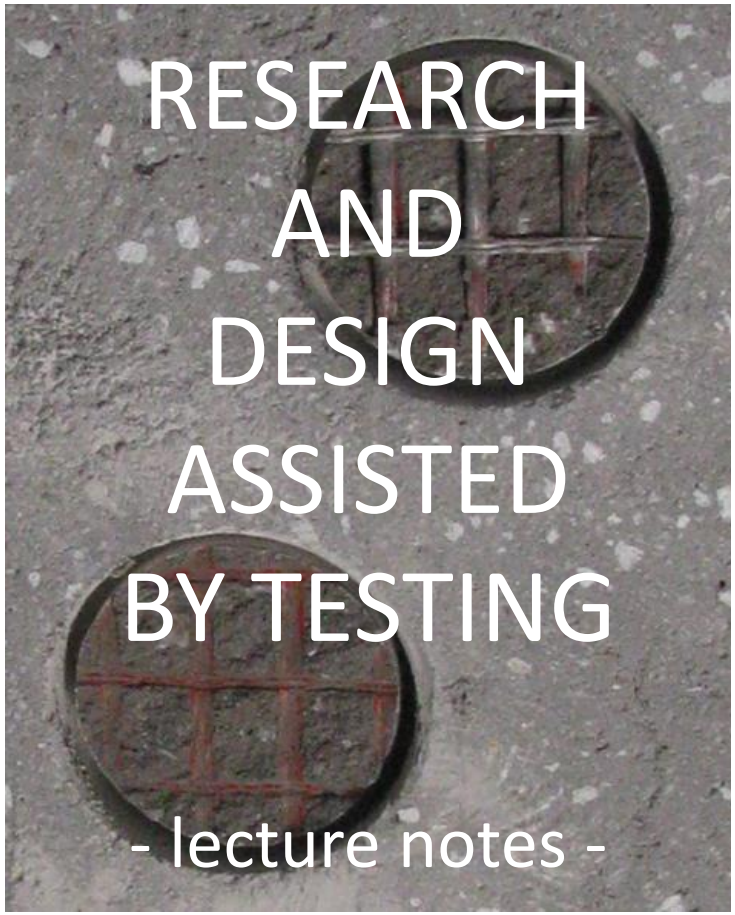
19. TEST ON MASONRY USING SCHMIDT OS-120 PENDULUM HAMMERS

→ lightweight concrete (LC)
gypsum boards
mortars in masonry joints

(Proceq)

20. TEST ON METALS USING ECQUOTIP

Hardness Testers
- Brinell
- Rockwell
- Shore
- Vickers
- Rockwell C



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Web: http://www.ct.upt.ro/users/TamasNagyGyorgy/index.htm

Office: A219

THANK YOU FOR YOU ATTENTION!