SKAB2012 / SEAA2012
Civil Engineering Laboratory 1

C4: NON-DESTRUCTIVE TESTING (NDT)

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Introduction

- **Concrete** are tested for two main purposes, for control of quality and to check its compliance with specifications.

- The usual way of testing concrete is by means of casting cubes and then crushing them.

- The quality of concrete and the strength of concrete structures in the field is checked and tested by **non-destructive testing (NDT) methods**.

Non-Destructive Testing (NDT)

- **Non-destructive testing (NDT)** methods are used to **determine hardened concrete properties** and to evaluate the condition of concrete without causing damage.

- NDT are carried out during and after construction to check the quality of works.

- It is used to **obtain the compressive strength and other properties of concrete** from the existing structures.

Types of NDT method

The common types of non-destructive tests which are usually conducted are:

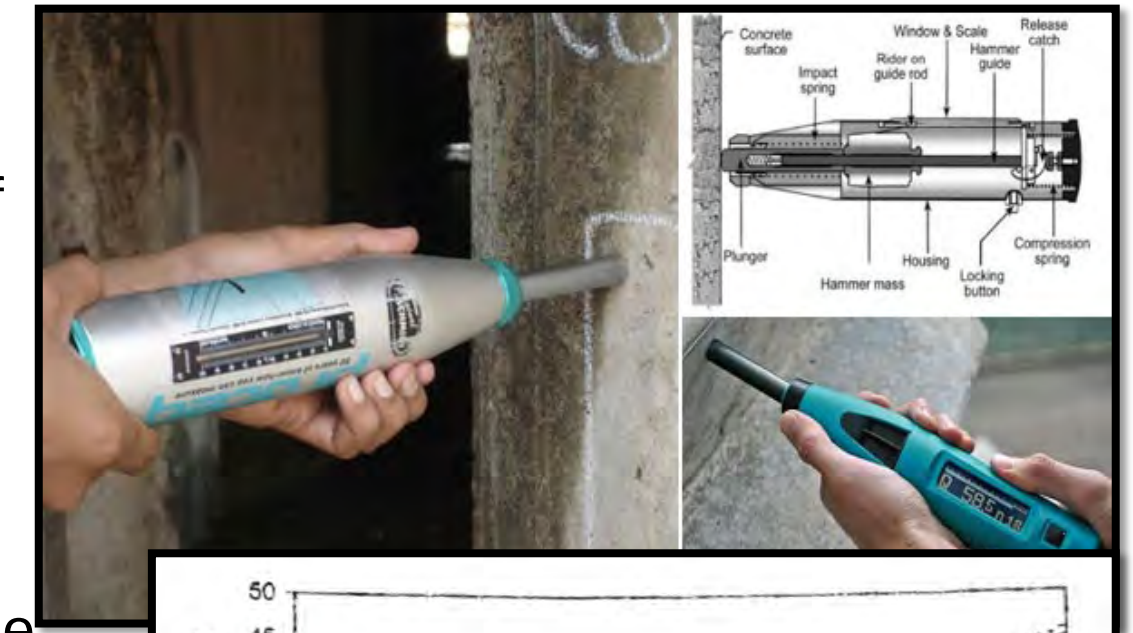
1) Cover Meter Test
2) Rebound Hammer Test (Schmidt's hammer)
3) Ultrasonic Pulse Velocity Test (Pundit Test)

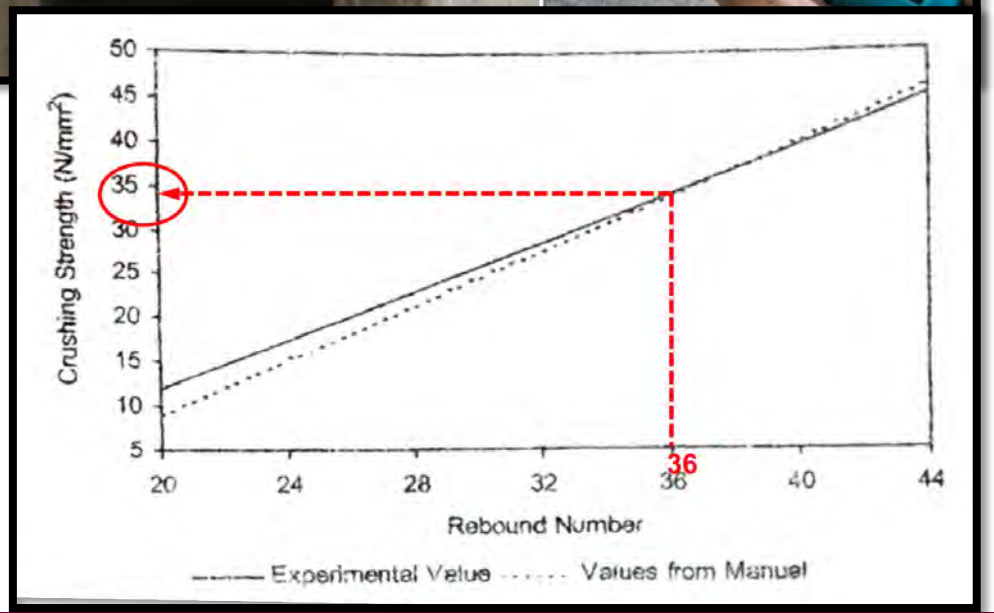
Cover Meter Test

1) This test is used to determine the concrete cover and location of embedded rebars.
2) The instrument is based on the magnetic technique & is calibrated for different purposes.
3) The location and estimation of bar diameter is needed to be identified in existing structures where drawing may not be available.
4) When a detector/scanner unit is moved along the concrete surface, a beep indicates that the unit is located directly above a reinforcing bar. The meter shows the exact location of reinforcement.

Rebound Hammer Test

1) It is used to evaluate the surface hardness of concrete.
2) It is a quick method for assessing the quality of concrete based on surface hardness indicated by the Rebound number.
3) This equipment works based on the spring-controlled hammer slides on a plunger within a tubular housing.
4) The hammer is forced against the surface of the concrete by the spring and the distance of rebound is measured on a scale.
5) A higher rebound value indicates the higher strength / surface hardness of concrete.





Ultrasonic Pulse Velocity Test

1) It is used for testing concrete strength in-situ, to determine the uniformity of concrete in and between members.

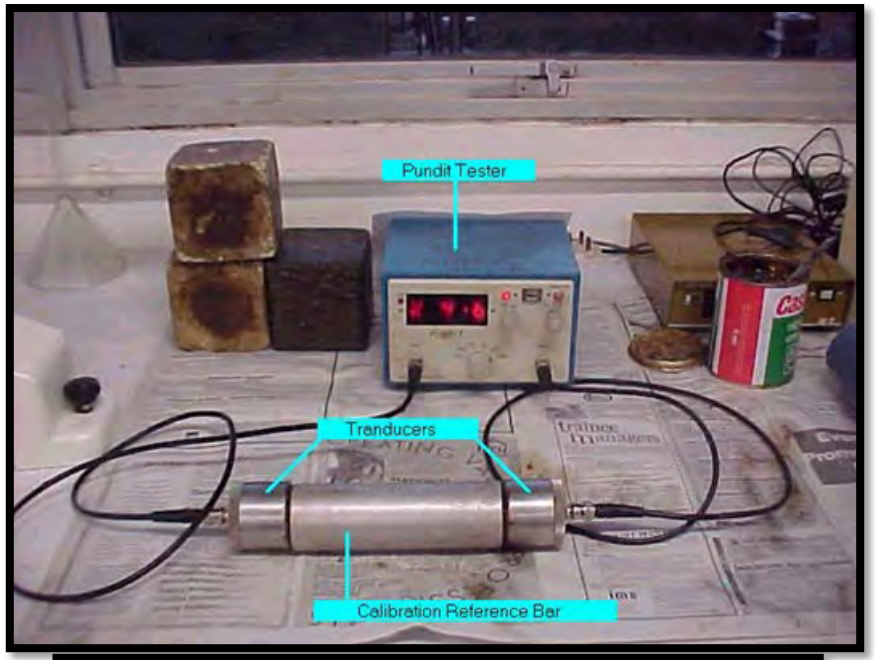
2) To determine the presence of honeycombs, voids and cracks.

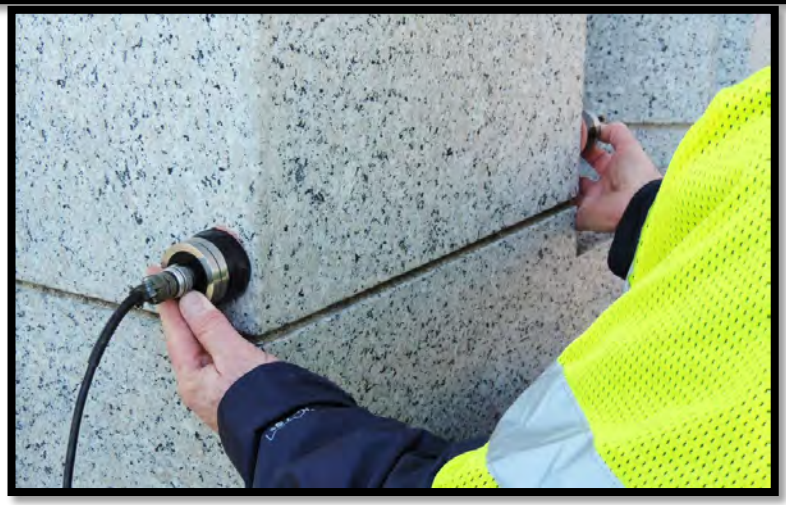
3) To estimate the rate of hardening and strength development of concrete in the early stages to determine when to remove formwork.

Ultrasonic Pulse Velocity Test

4) It measures the time of travel of an ultrasonic pulse passing through the concrete.
5) The equipment consist of a pulse generator and a pulse receiver.
6) The time taken for the pulse to pass through the concrete is measured by electronic measuring circuits.
7) Ultrasonic Pulse Velocity = Path length / Time

8) This velocity in concrete can be related to the uniformity of concrete.
9) If large differences in pulse velocity are found within a structure, it means that defective concrete is present.





Objectives

Electromagnet Cover Meter Test

1. To determine the depth of concrete cover and orientation of reinforcement bars in a beam.

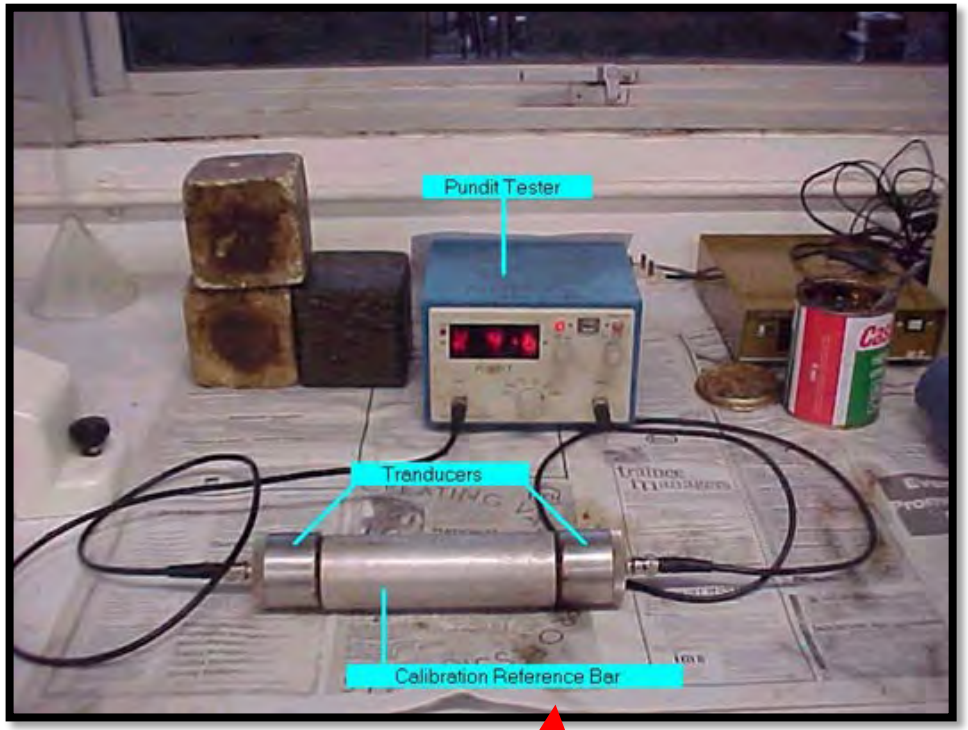
Rebound Hammer Test (Schmidt Hammer)

1. To estimate the strength of concrete.
2. To measure the uniformity of concrete

Ultrasonic Pulse Velocity Test (Pundit test)

1. To estimate the strength and the elastic modulus of concrete mix.
2. To determine the quality and homogeneity of concrete.
3. To determine the existence of flaws, voids, and cracks in concrete.

Apparatus



1. Reinforced concrete beam
2. Electromagnet cover meter
3. Rebound hammer
4. Ultrasonic pulse test equipment.

Experiment Procedures – Test 1

(Electromagnet Cover Meter)

To determine the position of main reinforcement:

1) Lightly press the detector unit on the top surface of the beam.
2) Aligned the arrow mark on the detector unit with the main reinforcement of the beam (Fig 2C4-3).
3) Move the unit along the width of the beam until the meter shows the lowest reading accompanied by high pitch sound. The highest pitch shows the exact location of reinforcement. This indicates that the main bar is directly below the unit.
4) Mark the position on the top surface of the beam.
5) Move the unit in the same direction to trace the other main reinforcement bars.

Experiment Procedures – Test 1

(Electromagnet Cover Meter)

To determine the position of shear bar:

1) Lightly press the detector unit on the front surface of the beam.
2) Aligned the arrow mark on the detector unit with the shear reinforcement of the beam.
3) Move the unit in the horizontal direction until the meter shows the lowest reading accompanied by high pitch sound. The highest pitch indicates the exact location of reinforcement.
4) Mark the position of the bar on the surface of the beam.

Experiment Procedures – Test 1

(Electromagnet Cover Meter)

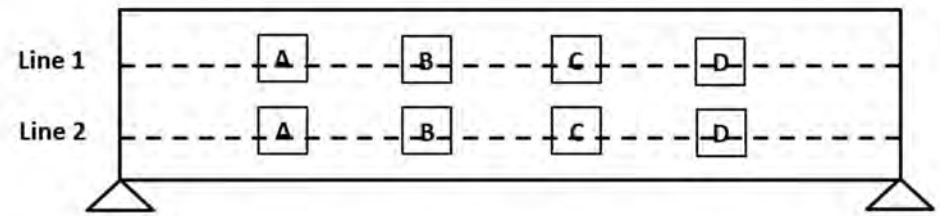
To determine the concrete cover of the beam:

1) To determine the concrete cover for the main reinforcement, move the detector from top to bottom on the front surface of the beam.
2) Mark the position where the meter shows the lowest reading indicating the position of the reinforcement, from which the cover can be determined.

Experiment Procedures – Test 2

(Rebound Hammer Test)

1) Draw small boxes along Line 1 and 2 and mark them as A, B, C, and D at the front surface of the beam to show the positions of testing.
2) Press the plunger against the surface of the concrete at position A on Line 1. Upon release, the hammer rebounds.
3) Record the rebound number in Table 2C4-1 in the lab sheet. Take four more readings at position A.
4) Repeat the test at the other positions B, C,
5) Take at least five readings for each position
6) Repeat step (2) to (5) for Line 2 and record rebound number in Table 2C4-2.



REBOUND HAMMER (SCHMIDT HAMMER) WORKSHEET

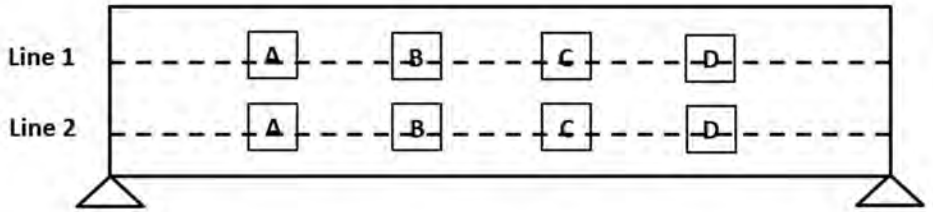
Table 2C4-1

Line 1	A	B	C	D
1	41	43	34	37
2	30	35	46	45
3	35	43	29	38
4	32	41	42	36
5	40	36	40	40
Total				
Average				
Range				

Experiment Procedures – Test 3

(Ultrasonic Pulse Velocity Test)

1) Carry out the test at positions marked A, B, C, and D for both Line 1 and 2 as in Rebound Hammer Test.
2) Spread grease on the surface of the tran to enhance surface contact with the conc
3) Place the transmitter on the marked posi and the receiver on the opposite side of t beam.
4) Record the time taken for the ultrasonic p to travel from the transmitter through the thickness of the beam to the receiver, in 2C4-3.



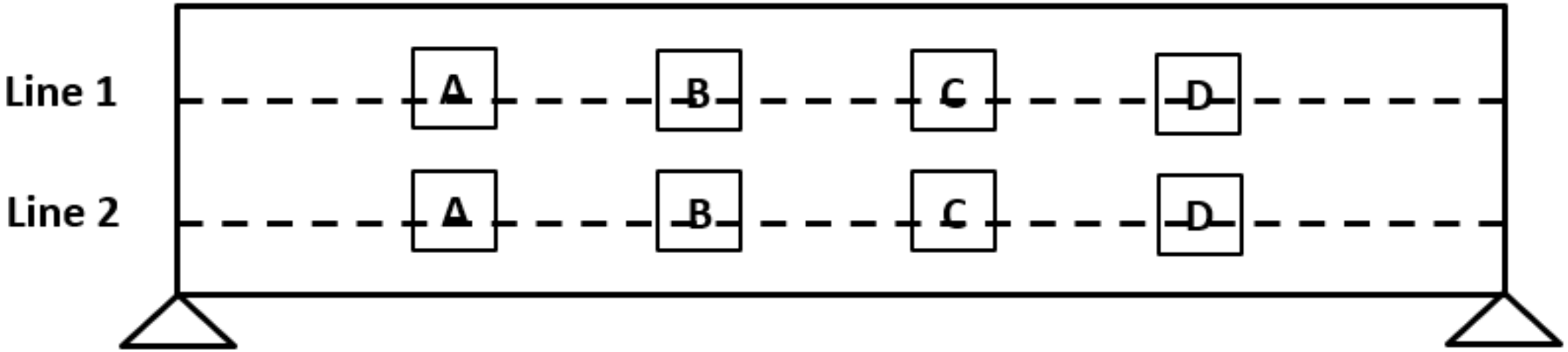
ULTRASONIC PULSE VELOCITY (UPV) WORKSHEET

Table 2C4-3

Position	Line 1			Line 2		
	Column	Time (μs)	Velocity (km/s)	Column	Time (μs)	Velocity (km/s)
1	A	43.7		A	45.4	
2	B	46.8		B	43.0	
3	C	46.0		C	48.4	
4	D	44.8		D	43.9	
	Total			Total		
	Average			Average		

Data Collection

REBOUND HAMMER (SCHMIDT HAMMER) WORKSHEET



Sample of reinforced concrete beam (200 x 500 mm)

Data Collection

REBOUND HAMMER (SCHMIDT HAMMER) WORKSHEET

Table 2C4-1

Line 1	A	B	C	D
1	*41*	*43*	*34*	*37*
2	*30*	*35*	*46*	*45*
3	*35*	*43*	*29*	*38*
4	*32*	*41*	*42*	*36*
5	*40*	*36*	*40*	*40*
Total				
Average				
Range				

Data Collection (cont.)

REBOUND HAMMER (SCHMIDT HAMMER) WORKSHEET

ABSTRACT OF "AVERAGE AND RANGE"

Table 2C4-2

Position	Line 1			Line 2		
	Column	Average	Range	Column	Average	Range
1	A			A		
2	B			B		
3	C			C		
4	D			D		

Calculate:

- Grand Total
- Number of Results (n)
- Global Average (ẍ)
- Standard Deviation (SD)
- Coefficient of Variance (CV)

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

$$CV = \frac{SD}{\bar{x}} \times 100\%$$

Data Collection (cont.)

ULTRASONIC PULSE VELOCITY (UPV) WORKSHEET

Table 2C4-3

Position	Line 1			Line 2		
	Column	Time (μs)	Velocity (km/s)	Column	Time (μs)	Velocity (km/s)
1	A	*43.7*		A	*45.4*	
2	B	*46.8*		B	*43.0*	
3	C	*46.0*		C	*48.4*	
4	D	*44.8*		D	*43.9*	
	Total			Total		
	Average			Average		

Calculate:

- Ultrasonic Pulse Velocity (UPV) = $\frac{\text{beam width}}{\text{time}}$ (km/s)

- Grand Total
- Number of Results (n)
- Global Average ($\ddot{x}$)
- Standard Deviation (SD)
- Coefficient of Variance (CV)

Data Analysis / Calculation

1) Use the results from the cover meter readings to detail the reinforcement in the beam showing its front elevation and a cross section as shown in **FIGURE 2C4-2**.
2) Determine the strength of concrete (using graphs provided in **FIGURE 2C4-9**) from the rebound numbers and the pulse velocity.
3) Attached the complete calculation example for one set of data.
    a) Standard Deviation (SD)
    b) Coefficient of Variance (CV)
    c) Ultrasonic Pulse Velocity (UPV) $= \frac{\text{distance}}{\text{time}}$ (km/s)

$= \frac{\text{beam width}}{\text{time}}$ (km/s)

Data Analysis / Calculation

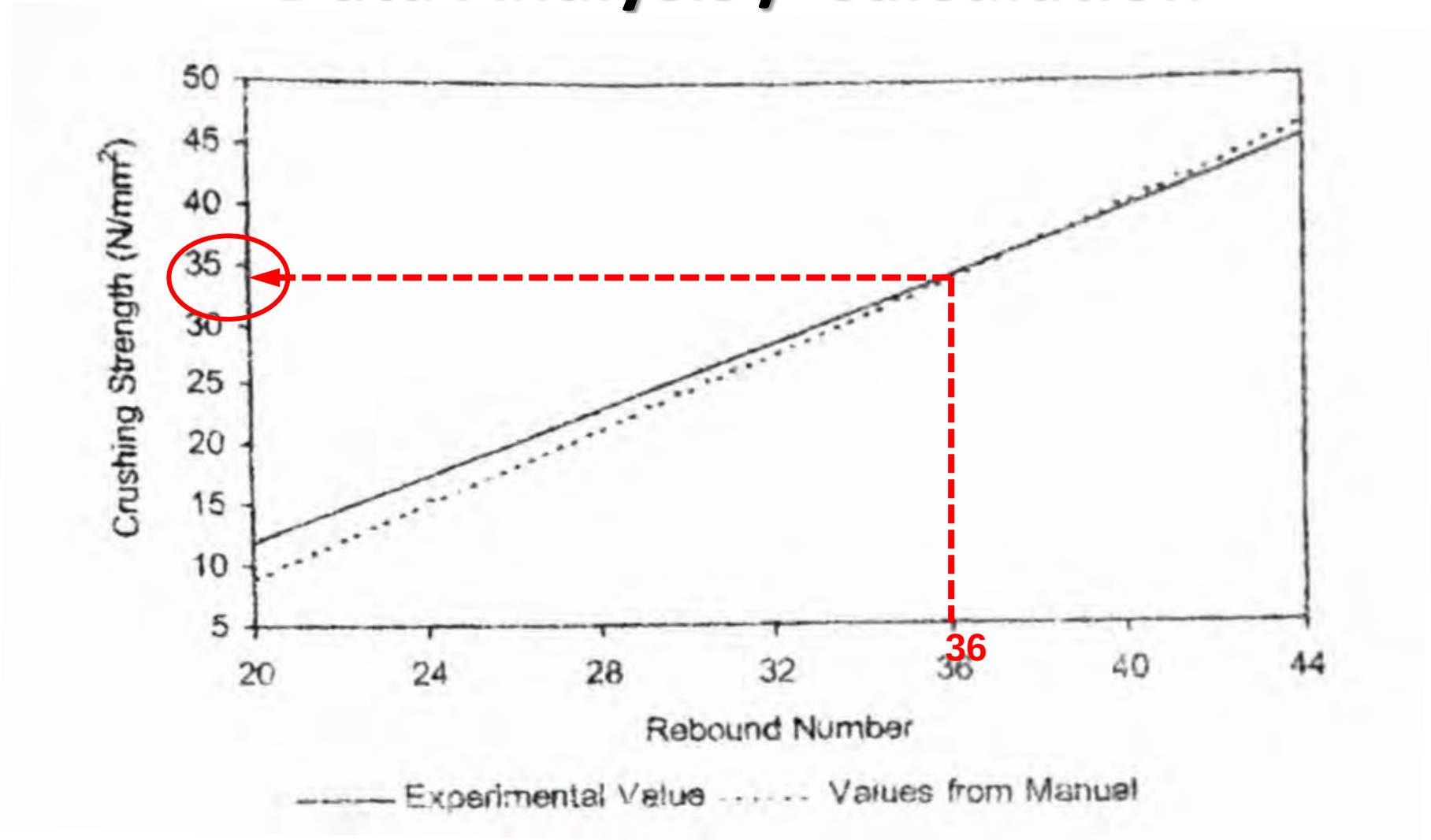


FIGURE 2C4-9: GRAPH OF CRUSHING STRENGTH AGAINST REBOUND NUMBER FOR ALL GRADES

Data Analysis / Calculation

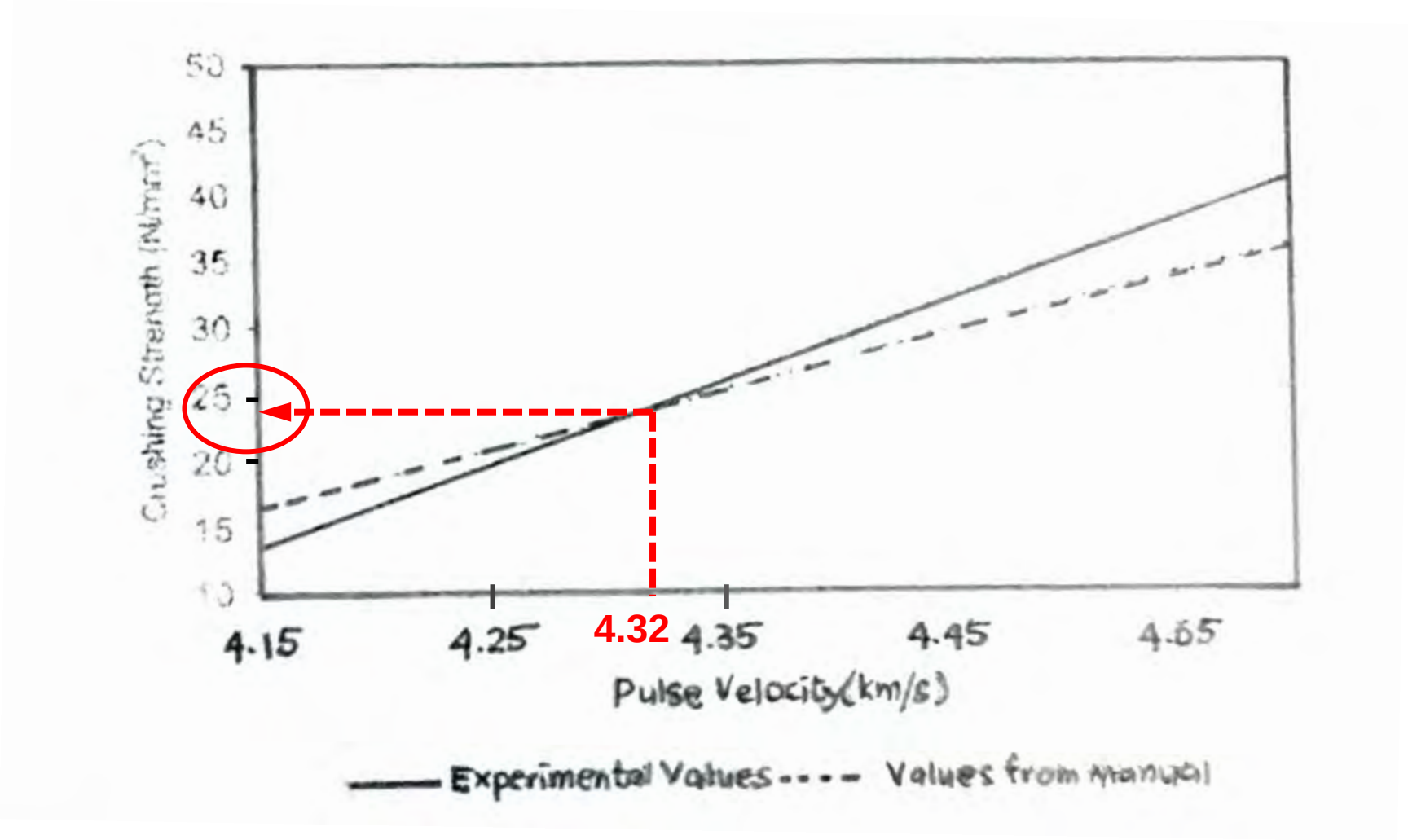


FIGURE 2C4-9: GRAPH OF CRUSHING STRENGTH AGAINST PULSE VELOCITY FOR ALL GRADES

Discussion and Conclusion

- Discuss the questions below and write a conclusion.

Questions:

1) Compare the results of the concrete strength from the rebound hammer test and the pulse velocity test. Discuss on the results.
2) Give your comment for each non-destructive test that had been carried out.

Thank You

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