LABORATORY MANUAL FOR STRUTURAL ENGINEERING

Subject Code: CEP 2101

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LIST OF EXPERIMENTS

EXPERIMENT NO. 01

Determination of the compressive strength of concrete using Rebound Hammer

AIM: To determine the compressive strength of concrete by using rebound hammer.

THEORY: The method is based on the principle that the rebound of an elastic mass depends on thehardness of the surface against which mass strikes. When the plunger of rebound hammer is pressedagainst the surface of the concrete, the spring-controlled mass rebounds and the extent of suchrebound depends upon the surface hardness of concrete. The surface hardness and therefore therebound is taken to be related to the compressive strength of the concrete. The rebound value is readoff along a graduated scale and is designated as the rebound number or rebound index. Thecompressive strength can be read directly from the graph provided on the body of the hammer.

APPARATUS:

a) Schmidt Rebound Hammer.
b) Test Specimen.

PROCEDURE:

The general operation of the Rebound Hammer test is shown in Figure 1.1, it consists of the following steps:

1. Hold the instrument firmly so that the plunger is perpendicular to the test surface.
2. Gradually push the instrument toward the test surface until the hammer impacts. After impact, maintain pressure on the instrument and, if necessary, depress the button on the side of the instrument to lock the plunger in its retracted position.
3. Read the rebound number on the scale to the nearest whole number and record therebound number.
4. Take nine readings from each test area. No two impact tests shall be closer together than 25 mm (1 in).
5. Examine the impression made on the surface after impact, and if the impact crushes or breaks through a near-surface air void, disregard the reading and take another reading.

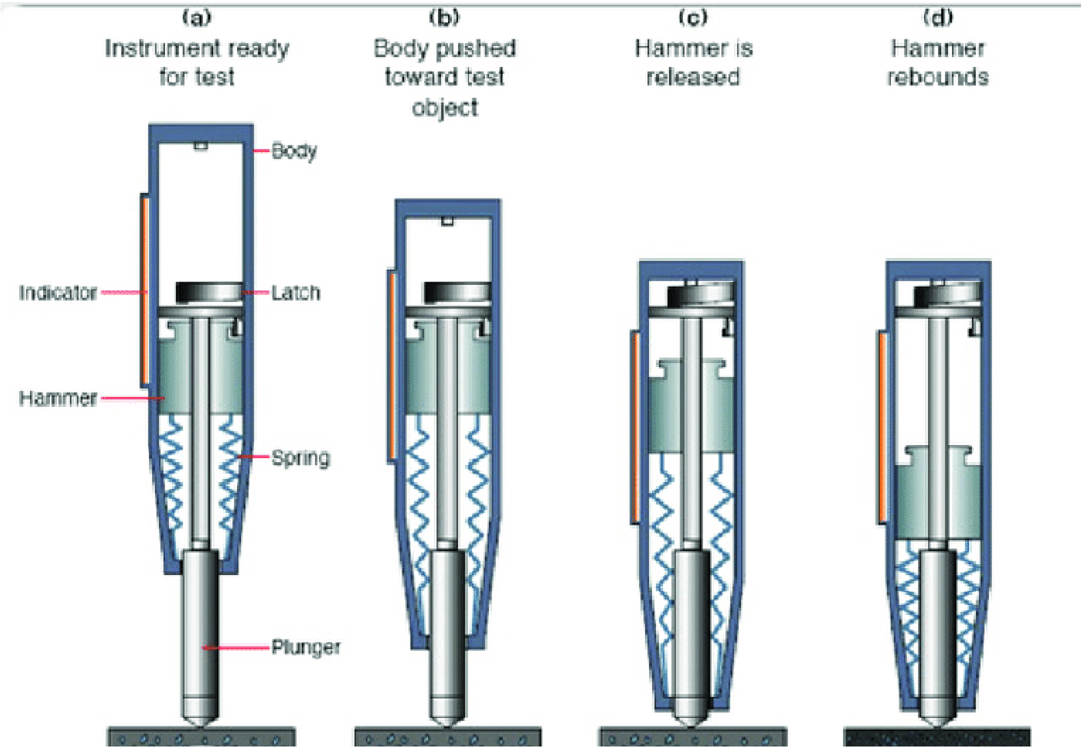

Figure 1.1 Operation of Rebound Hammer

OBSERVATIONS:

Specimen	Rebound Number	Average	Compressive Strength

Table 1.1 Observation Table.

CALCULATION:

The compressive strength of the specimen can be obtained from the Figure 1.2 and the quality of the specimen can be interpreted using Table 1.2.

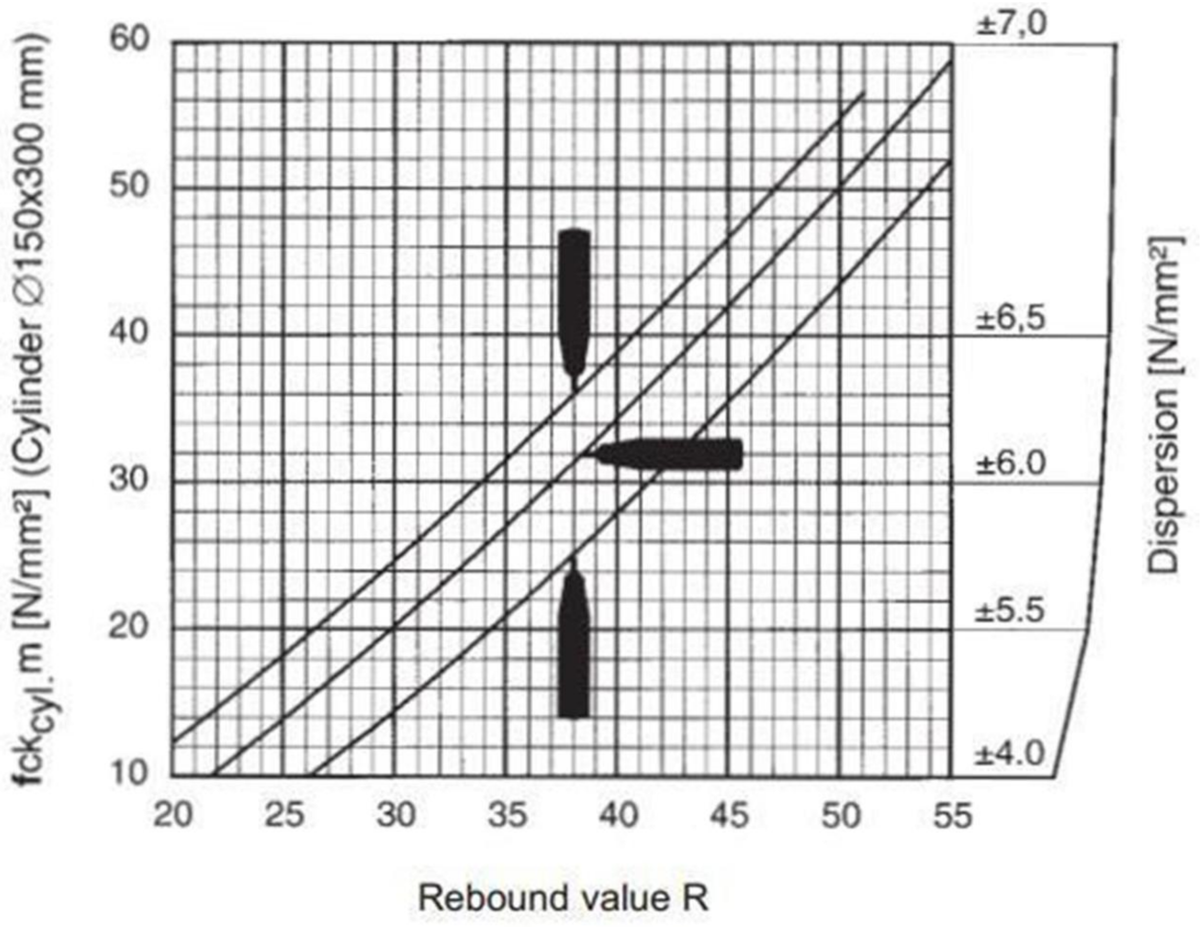

Figure 1.2: Chart for determining Compressive Strength using Rebound Number.

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

Table 1.2 Quality of concrete using Rebound Number.

RESULT AND CONCLUSIONS:

1. The average rebound number of the specimen is ___________.
2. The average compressive strength of the specimen is ______________.

PRECAUTIONS: (Discuss about the precautions to be taken while conducting this experiment)

QUESTIONS:

EXPERIMENT NO. 02

Determination of the quality of concrete using Ultrasonic Pulse Velocity

AIM: To determine the quality of concrete by using the Ultrasonic Pulse Velocity (UPV).

THEORY: The underlying principle of assessing the quality of concrete is that comparatively higher velocities are obtained when the quality of concrete in terms of density, homogeneity and uniformity is good. In case of poor quality, lower velocities are obtained. If there is a crack, void or flaw inside the concrete which comes in the way of transmission of the pulses, the pulse strength is attenuated and it passes around the discontinuity, thereby making the path length longer. Consequently, lower velocities are obtained. The actual pulse velocity obtained depends primarily upon the materials and mix proportions of concrete. Density and modulus of elasticity of aggregate also significantly affect the pulse velocity.

APPARATUS:

a) Ultrasonic pulse velocity apparatus consisting of:
    i. Electrical pulse generator.
    ii. Amplifier.
    iii. Electronic timing device.
b) One pair of transducers.

PROCEDURE:

The general operation of the Ultrasonic Pulse Velocity (UPV) test consists of the following steps:

1. In this test method, the ultrasonic pulse is produced by transducer which is held in contact with one surface of concrete member under test. After traversing a known path length (L) in the concrete, the pulse of vibration is converted into an electrical signal by the second transducer held in contact with the other surface of the concrete member and an electronic timing circuit enables the transit time (T) of the pulse to be measured. The pulse velocity (V) is given by V = L/T.
2. The natural frequency of the transducers should preferably be within the range of 20 to 150 kHz. Generally high frequency transducers are preferable for short path lengths and low frequency transducers for long path lengths. Transducers with a frequency 50 to 60 kHz are useful for most all around application.

3. In general, for enhancing smooth contact between transducer and concrete surface, medium such as petroleum jelly, grease, liquid soap and kaolin glycerol paste are used. If the concrete surface is rough, it is required to make the concrete surface smooth and then place the transducer.
4. A minimum path length of 150 mm is recommended for the direct transmission method and a minimum of 400 mm for the surface probing method along the unmoulded surface.
5. Pulse velocity will not be influenced by the shape of the specimen, provided its least lateral dimension (i.e., its dimension measured at right angles to the pulse path) is not less than the wavelength of vibrations.
6. For the pulse of 50 Hz frequency, this corresponding to a least lateral dimension of 80 mm.

OBSERVATIONS:

There are three ways of measuring the pulse velocity through the concrete:

1. **Direct method**: The direct method (cross-probing) is preferred wherever access to opposite sides of the component is possible.

2. **Semi-direct method**: The semi-direct method is preferred where two sides access is possible but these sides are not opposite sides.

3. **Indirect method**: The surface (indirect) method is the least satisfactory and should only be used when access to only one surface is possible. This method only indicates the quality of concrete and is influenced by the presence of reinforcement parallel to the surface.

Sl No.	Method of testing	Length (mm)	Time (µs)	Velocity (mm/µs)	Average Velocity (mm/µs)	Quality of Concrete

Table 2.1 Observation Table.

CALCULATION:

The quality of concrete in terms of uniformity, incidence or absence of internal flaws, cracks and segregation, etc,indicative of the level of workmanship employed, can thus be assessed using Table 2.2 given below, which have been evolved for characterizing the quality of concrete in structures in terms of the ultrasonic pulse velocity.

Pulse Velocity (km/s)	**Quality of concrete**
>4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
<3.0	Doubtful

Table 2.2 Quality of concrete using UPV.

RESULT AND CONCLUSIONS:

The Ultrasonic Pulse Velocity of the specimen is __________ and the quality of the concrete is said to be _____________________.

PRECAUTIONS: (Discuss about the precautions to be taken while conducting this experiment)

QUESTIONS:

EXPERIMENT NO. 03

Determination of rebar details using Profometer

AIM: To determine reinforcement details within a concrete structure using a Profometer (Rebar locator).

THEORY: The rebar locator works on the principle of electromagnetic induction. When passed over a concrete surface, it emits electromagnetic waves that interact with the metal rebar, causing a signal response. By analysing the signal, the device can pinpoint the location of the rebar and help assessthe clear cover.

APPARATUS:

a) Rebar locator apparatus.
b) Concrete specimen with embedded reinforcement bars.

PROCEDURE:

The general operation of the Proformeter (Rebar Locator) consists of the following steps:

1. Switch on the rebar locator and calibrate without electromagnetic interference. Adjust the predefined settings based on the design data.
2. Hold the rebar locator firmly and parallel to the concrete surface. The indicator of the profometer shows the presence and location of rebar when it passes through it and shows the depth at which the rebar is present.
3. When the locator detects a rebar, mark the locations directly on the concrete surface. Record the depth information provided by the locator.
4. To ensure that the entire testing area is covered overlapping scan lines are drawn.
5. Create a record of the locations and depths of the marked rebar, including their orientation (horizontal or vertical).

OBSERVATIONS:

Sl No.	Specimen	No of main bars	Clear cover (mm)	Stirrup spacing (mm)

Table 3.1 Observation Table.

RESULT AND CONCLUSIONS:

The rebar locator test successfully identified and marked the location of reinforcement bars within the concrete structure. This information can be crucial for construction, renovation, or structural assessment purposes.

PRECAUTIONS: (Discuss about the precautions to be taken while conducting this experiment)

QUESTIONS:

EXPERIMENT NO. 04

Determination of Resistivity of concrete using Resipod

AIM: To determine the resistivity of concrete structure by using resipod.

THEORY: The resistivity of concrete varies over a complete structure due to a variety of changing site conditions from day to day so that other methods, like half-cell potential or impact testing, should be combined to ensure the data. Generally, the probability of the steel corrosion increases, the concrete resistivity deceases. Electrical resistivity is one of the practical problems of concrete resistivity testing is to ensure the good electrical contact between the electrodes and concrete surface. In this method, 4 electrodes are located in a straight line on the concrete surface at same spacing. A low frequency alternating current is flow between the two outer electrodes and the voltage drop between the inner electrodes is recorded.

Resistivity measurements can be used to estimate the possibility of corrosion. When the electric resistivity of the concrete is low, the likelihood of corrosion increase. The likelihood of corrosion of the reinforcements can be obtained from Table 4.1 given below.

Resistivity	**Remarks**
≥100k Ω	Negligible risk of corrosion
50 to 100 k Ω	Low risk of corrosion
10 to 50 k Ω	Moderate risk of corrosion
≤10 k Ω	High risk of corrosion

Table 4.1 Likelihood of corrosion

APPARATUS:

c) Resipod.
d) Concrete specimen.

PROCEDURE:

The general operation of the Resipod test consists of the following steps:

1. Power on the resipod and calibrate with the calibration scale.
2. The concrete surface should be clean, and it shouldn't be coated with any electrically insulating material. By using rebar locator, it determines the rebar grid under the

concrete surface and marked the grid over the surface. In case the concrete is completely dry, it will be difficult to take measurement as the current is carried by ions in pore liquid. Thus, it is compulsory to make the surface wet.

3. An appropriate connection should be maintained between the instrument and concrete surface to get reliable and accurate results. Therefore, before taking reading dip the resipod in water several times to get accurate reading.
4. Once the resipod's reservoirs are filled with water it is ready to use. Now place the resipod on the already prepared wet concrete surface and push it over the surface. The resipod start measuring the flow of current and the screen will start blinking.
5. Once the stable reading has been achieved, Press the HOLD button (present over the top) for 3 sec to freeze actual measurements on the screen

OBSERVATIONS:

Sl No.	Specimen	Resistivity	Remarks

Table 4.2 Observation Table.

RESULT AND CONCLUSIONS:

The average resistivity obtained for the specimen is ____________ and the risk of corrosion is _____________________________.

PRECAUTIONS: (Discuss about the precautions to be taken while conducting this experiment)

QUESTIONS:

EXPERIMENT NO. 05

Corrosion rate of a rebar using electro-chemical Half Cell Potentiometer

AIM: To determine the Corrosion rate of a rebar using electro-chemical Half Cell Potentiometer

THEORY: Corrosion analyzer is based on electro-chemical process to detect corrosion in the reinforcement bars of structure. It represents a galvanic element similar to a battery, producing an electrical current, measurable as an electric field on the surface of concrete. The potential field can be measured with an electrode known as half-cell. The electrical activity of the steel reinforcement and concrete leads them to be considered as one half of battery cell with the steel acting as one electrode and concrete as electrolyte.

The name half-cell surveying derives from the fact that one half of the battery cell is considered to be the steel reinforcing bars and surrounding concrete. The electrical potential of a point on the surface of steel reinforcing bar can be measured comparing its potential that of copper ‐ copper sulphate reference electrode/silver- silver nitrate reference electrode on the surface. The positive terminal of the voltmeter is attached to the reinforcement and the negative terminal is attached to the copper-copper sulphate half-cell. If there is any corrosion in the bars, the excess electrons in the bar would tend to flow from the bar to the half-cell. Because of the way the terminals of the voltmeter are connected in the electrical circuit, the voltmeter indicates a negative voltage.

The measured half-cell potential is the open circuit potential, because it is measured under the condition of no current in the measuring circuit. A more negative voltage reading at the surface predict that the embedded bar has more excess electrons, therefore, indicates that a higher possibility of corrosion in bars. The half-cell potential readings are indicative of the probability of corrosion activity of the reinforcing bars located beneath the copper-copper sulphate reference cell. However, this is true only if the reinforcing steel is electrically connected to the bar attached to the voltmeter. The probability of corrosion can be estimated from the Half cell potential using the data given in Table 5.1.

Half-Cell Potential (mV)	**Probability of corrosion**
<200	90% (No corrosion)
200 to 350	50% (Uncertain)
>350	>90% (Possibility of corrosion activity)

Table 5.1 Probability of corrosion estimated from Half-Cell potential.

APPARATUS:

e) Voltmeter.
f) Copper-Sulphate reference electrode.

PROCEDURE:

1. The negative and positive wires are connected into the voltmeter. And then the copper sulphate reference electrode is connected to the positive end of the voltmeter.
2. The negative end of the potentiometer is connected to the visible reinforcement of a concrete and it should be made sure that the reinforcement is interconnected to reinforcement of the area to beobserved.
3. The surface to be observed is then wetted and readings are taken at a grid around 50cm interval.
4. The Half Cell potential measured is then checked for probability of corrosion using the data given in Table 5.1.

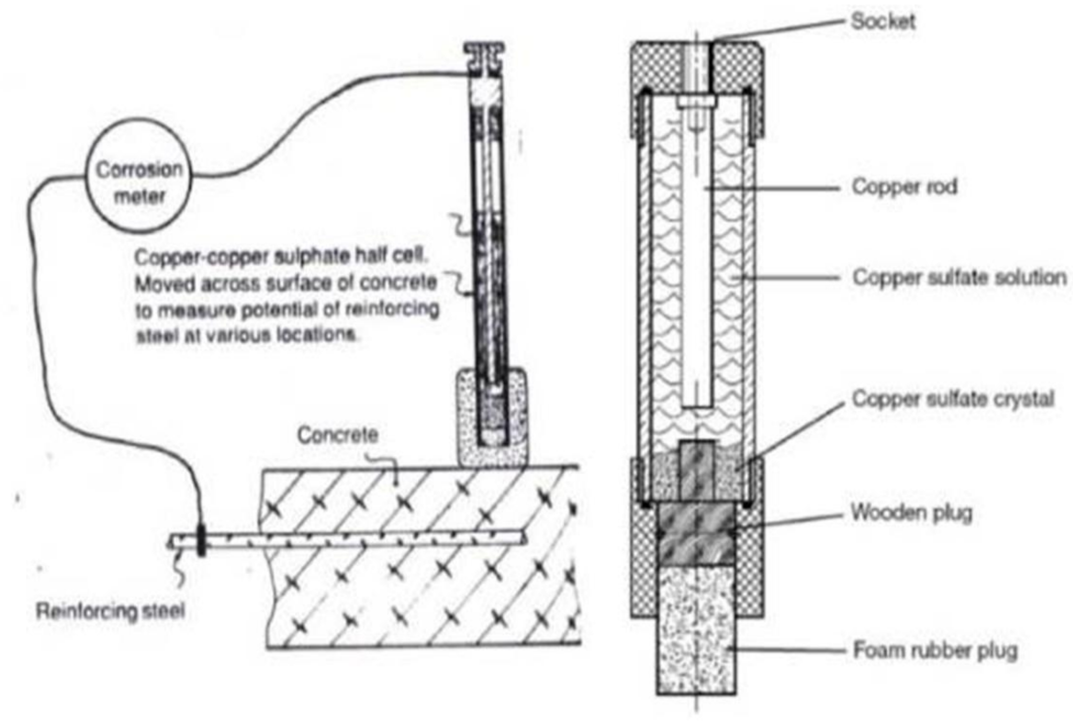

Fig 5.1. Half Cell Potentiometer

OBSERVATIONS:

Sl No.	Specimen	Half Cell Potential (mV)

Table 5.2 Observation Table.

RESULT AND CONCLUSIONS:

The average of the obtained half-cell potential is _______________. This implies that, there is ______________________________ present in the reinforcement.

PRECAUTIONS: (Discuss about the precautions to be taken while conducting this experiment)

QUESTIONS:

EXPERIMENT NO. 06

Pile Integrity Test

AIM: To determine the length and quality of pile.

THEORY: The Pile Integrity Test (PIT) is a common Non-Destructive testing procedure for quality control and quality assurance in deep foundation construction. The test can be used to identify physical defects (voids or discontinuity) in piles, or determine unknown length of existing deep foundations.

PIT belongs to the family of shaft head impact tests, where the response of the impact made on the head of pile is recorded by a motion transducer and used for analysis.

APPARATUS:

a) Hand held hammer.
b) Accelerometer.
c) Pile Integrity Testing apparatus.

PROCEDURE:

1. Ensure the mounting surface is clean, flat and free from any irregularities that could affect the accelerometer's performance.
2. Apply suitable adhesive to securely attach the accelerometer to the surface.
3. Hold the instrument firmly so that the accelerometer is perpendicular to the test surface.
4. After the accelerometer is installed, pick several points around the accelerometer and hammer lightly at the points.
5. The PIT instrument automatically records the wave through the pile length.
6. The pile length can be obtained by measuring the distance between two highest waves and the integrity can be checked using the shape of the wave.

OBSERVATIONS:

Sl No.	Specimen	Pile Length

Table 6.1 Observation Table.

RESULT AND CONCLUSIONS:

The pile length obtained from the PIT apparatus is _____________.

The shape of the compressive wave shows that the pile has ______________________.

PRECAUTIONS: (Discuss about the precautions to be taken while conducting this experiment)

QUESTIONS: