DEPARTMENT OF CIVIL ENGINEERING
UNDER TEQIP- II INNITIATIVE

CENTER OF EXCELLENCE

NON DESTRUCTIVE TESTING LABORATORY

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P.E.S. COLLEGE OF ENGINEERING

List of equipments

1. Schmidt Rebound hammer
2. Ultra sonic Pulse velocity (Pundit® Lab(+))
3. Corrosion Analysis equippment
4. Cover Meter and Rebar Detectors (Profometer® PM-6)
5. Bosch GDB 180 WE Professional core cutter

LIST OF Research works and consultancy conducted

1. M.Tech thesis entitled “ Case study on Cracks and its pattern in Monolithic structure”
2. To carry out stability analysis for the buildings in and around Mandya for further construction.

1. Schmidt Rebound hammer

The operation of rebound hammer is shown in the fig.1. When the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass with a constant energy is made to hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness, is measured on a graduated scale. This measured value is designated as Rebound Number (rebound index). A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value.

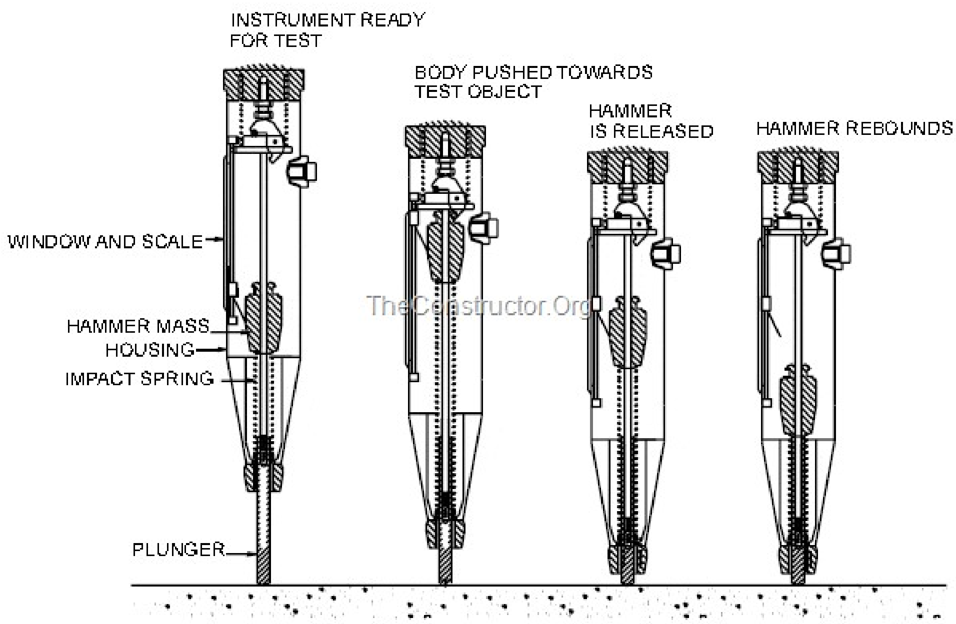

Fig.1.Operation of the rebound hammer

1.1 Objective of Rebound Hammer Test

As per the Indian code IS: 13311(2)-1992, the rebound hammer test have the following objectives:

1. To determine the compressive strength of the concrete by relating the rebound index and the compressive strength
2. To assess the uniformity of the concrete

3. To assess the quality of the concrete based on the standard specifications
4. To relate one concrete element with other in terms of quality

Rebound hammer test method can be used to differentiate the acceptable and questionable parts of the structure or to compare two different structures based on strength.

1.2 Principle of Rebound Hammer Test

Rebound hammer test method is based on the principle that the rebound of an elastic mass depends on the hardness of the concrete surface against which the mass strikes. The operation of the rebound hammer is shown in figure-1. When the plunger of rebound hammer is pressed against the concrete surface, the spring controlled mass in the hammer rebounds. The amount of rebound of the mass depends on the hardness of concrete surface.

Thus, the hardness of concrete and rebound hammer reading can be correlated with compressive strength of concrete. The rebound value is read off along a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.

1.3 Procedure for Rebound Hammer Test

Procedure for rebound hammer test on concrete structure starts with calibration of the rebound hammer. For this, the rebound hammer is tested against the test anvil made of steel having Brinell hardness number of about 5000 N/mm2.

After the rebound hammer is tested for accuracy on the test anvil, the rebound hammer is held at right angles to the surface of the concrete structure for taking the readings. The test thus can be conducted horizontally on vertical surface and vertically upwards or downwards on horizontal surfaces as shown in figure below

If the rebound hammer is held at intermediate angle, the rebound number will be different for the same concrete.

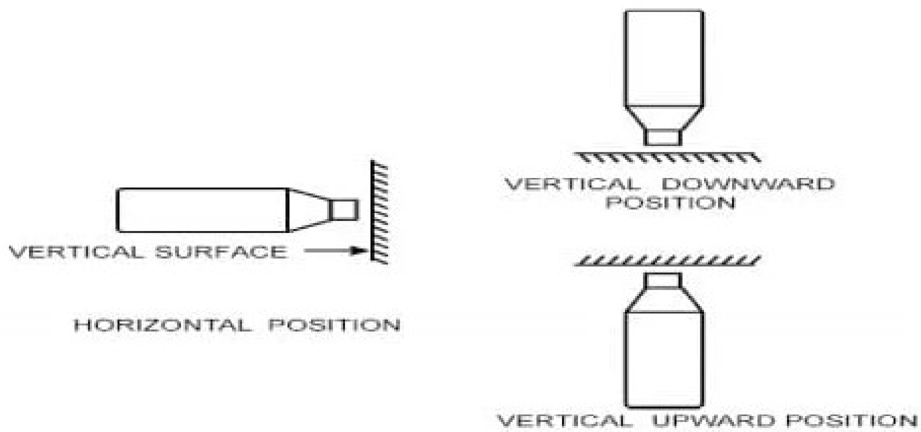

Fig.2.Rebound Hammer Positions for Testing Concrete Structure

The impact energy required for the rebound hammer is different for different applications. Approximate Impact energy levels are mentioned in the table-1 below for different applications.

Sl.No	Applications	Approximate Impact Energy for Rebound Hammer in Nm
1	For Normal Weight Concrete	2.25
2	For light weight concrete / For small and impact resistive concrete parts	0.75
3	For mass concrete testing Eg: In roads, hydraulic structures and pavements	30.00

1.4 Points to Remember in Rebound Hammer Test

1. The concrete surface should be smooth, clean and dry.
2. Ant loose particles should be rubbed off from the concrete surface with a grinding wheel or stone, before hammer testing.
3. Rebound hammer test should not be conducted on rough surfaces as a result of incomplete compaction, loss of grout, spalled or tooled concrete surface.
4. The point of impact of rebound hammer on concrete surface should be at least 20mm away from edge or shape discontinuity.
5. Six readings of rebound number is taken at each point of testing and an average of value of the readings is taken as rebound index for the corresponding point of observation on concrete surface.

1.5 Correlation between compressive strength of concrete and rebound number

The most suitable method of obtaining the correlation between compressive strength of concrete and rebound number is to test the concrete cubes using compression testing machine as well as using rebound hammer simultaneously. First the rebound number of concrete cube is taken and then the compressive strength is tested on compression testing machine. The fixed load required is of the order of 7 N/ mm2 when the impact energy of the hammer is about 2.2 Nm.

The load should be increased for calibrating rebound hammers of greater impact energy and decreased for calibrating rebound hammers of lesser impact energy. The test specimens should be as large a mass as possible in order to minimize the size effect on the test result of a full scale structure. 150mm cube specimens are preferred for calibrating rebound hammers of lower impact energy (2.2Nm), whereas for rebound hammers of higher impact energy, for example 30 Nm, the test cubes should not be smaller than 300mm.

The concrete cube specimens should be kept at room temperature for about 24 hours after taking it out from the curing pond, before testing it with the rebound hammer. To obtain a correlation between rebound numbers and strength of wet cured and wet tested cubes, it is necessary to establish a correlation between the strength of wet tested cubes and the strength of dry tested cubes on which rebound readings are taken.

A direct correlation between rebound numbers on wet cubes and the strength of wet cubes is not recommended. Only the vertical faces of the cubes as cast should be tested. At least nine readings should be taken on each of the two vertical faces accessible in the compression testing machine when using the rebound hammers. The points of impact on the specimen must not be nearer an edge than 20mm and should be not less than 20mm from each other. The same points must not be impacted more than once.

1.6 Interpretation of Rebound Hammer Test Results

After obtaining the correlation between compressive strength and rebound number, the strength of structure can be assessed. In general, the rebound number increases as the strength increases and is also affected by a number of parameters i.e. type of cement, type of aggregate, surface condition and moisture content of the concrete, curing and age of concrete, carbonation of concrete surface etc.

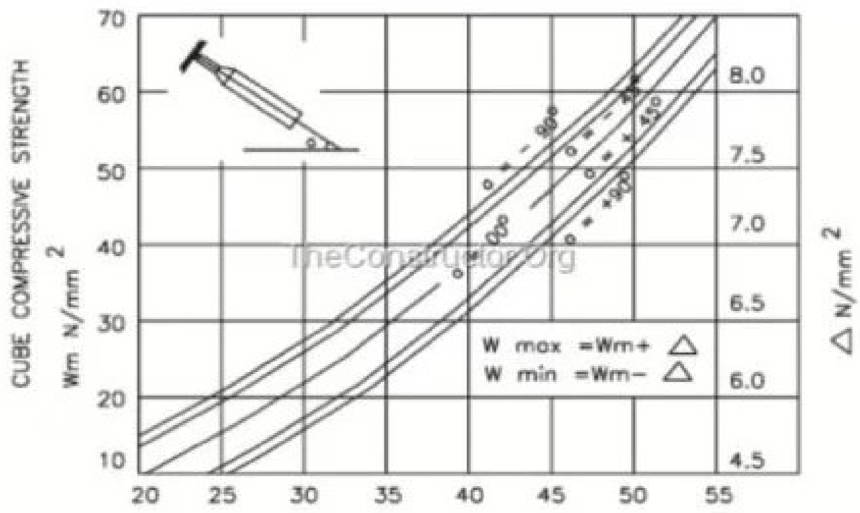

Fig.3.Relationship Between Cube Strength and the Rebound Number

Moreover the rebound index is indicative of compressive strength of concrete up to a limited depth from the surface. The internal cracks, flaws etc. or heterogeneity across the cross section will not be indicated by rebound numbers.

Table-2 below shows the quality of concrete for respective average 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
0	Delaminated

Table.2. Quality of Concrete for different values of rebound number

As such the estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in a structure is ± 25 percent. If the relationship between rebound index and compressive strength can be found by tests on core samples obtained from the structure or standard specimens made with the same concrete materials and mix proportion, then the accuracy of results and confidence thereon gets greatly increased.

1.7 Advantages and Disadvantages of Rebound Hammer Test

The advantages of Rebound hammer tests are:

1. Apparatus is easy to use
2. Determines uniformity properties of the surface
3. The equipment used is inexpensive
4. Used for the rehabilitation of old monuments

The disadvantages of Rebound Hammer Test

1. The results obtained is based on a local point
2. The test results are not directly related to the strength and the deformation property of the surface
3. The probe and spring arrangement will require regular cleaning and maintenance
4. Flaws cannot be detected with accuracy

1.8 Factors Influencing Rebound Hammer Test

Below mentioned are the important factors that influence rebound hammer test:

1. Type of Aggregate
2. Type of Cement
3. Surface and moisture condition of the concrete
4. Curing and Age of concrete
5. Carbonation of concrete surface

1.8.1 Type of Aggregate

The correlation between compressive strength of concrete and the rebound number will vary with the use of different aggregates. Normal correlations in the results are obtained by the use of normal aggregates like gravels and crushed aggregates. The use of lightweight aggregates in concrete will require special calibration to undergo the test.

1.8.2 Type of Cement

The concrete made of high alumina cement ought to have higher compressive strength compared to Ordinary portland cement. The use of supersulphated cement in concrete decrease the compressive strength by 50% compared to that of OPC.

1.8.3 Type of Surface and Moisture Condition

The rebound hammer test work best for close texture concrete compared with open texture concrete. Concrete with high honeycombs and no-fines concrete is not suitable to be tested by rebound hammer. The strength is overestimated by the test when testing floated or trowelled surfaces when compared with moulded surfaces.

Wet concrete surface if tested will give a lower strength value. This underestimation of strength can go lower to 20% that of dry concrete.

1.8.4 Type of curing and age of concrete

As time passes, the relation between the strength and hardness of concrete will change. Curing conditions of concrete and their moisture exposure conditions also affects this relationship. For concrete with an age between 3days to 90 days is exempted from the effect of age. For greater aged concrete special calibrated curves is necessary.

1.8.5 Carbonation on Concrete Surface

A higher strength is estimated by the rebound hammer on a concrete that is subjected to carbonation. It is estimated to be 50% higher. So the test have to be conducted by removing the carbonated layer and testing by rebound hammer over non-carbonated layer of concrete.

2. Ultra sonic Pulse velocity Pundit® Lab(+)

A pulse of ultrasonic (> 20 kHz) longitudinal stress waves is introduced into one surface of a concrete member by a transducer coupled to the surface with a coupling gel or grease. The pulse travels through the concrete and is received by a similar transducer coupled on the opposite surface. The transit time of the pulse is determined by the instrument. The distance between the transducers is divided by the transit time to obtain the pulse velocity. The longitudinal pulse velocity, *Cp*, of an elastic solid is a function of the elastic constants (modulus of elasticity, E, and Poisson's ratio, ν) and the density, ρ.

$$C_p = \sqrt{\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}}$$

The UPV test method is governed by various standards including ASTM C597, BS 1881:203, and EN 12504-4. The test method is totally nondestructive and it is possible to repeat the test at the same point at different times to monitor change of UPV with time.

The figure to the right illustrates different conditions that may be encountered when testing an element using the UPV method. At the top, the path between the transducers is through solid concrete, and the travel time would be the shortest. Below that is the case where there is an internal pocket of porous concrete, such as honeycombed concrete. The pulse is scattered as it travels though the contiguous portions of the honeycombed concrete. As a result, the actual travel path is longer than the distance between the transducers and the pulse travel time is longer. This results in a reduced pulse velocity. In the next case, the transducers are located so that the direct travel path is near the edge of a crack. The pulse cannot travel across a concrete-air interface, but it is able to travel from the transmitter to the receiver by diffraction at the crack edge. Because the travel path is longer than the distance between the transducers, the apparent pulse velocity is lower than through sound concrete. In the lowermost case, the pulse is reflected completely by the crack, and travel time is not measurable.

Precision and Accuracy

The UPV test is highly repeatable. For tests of sound concrete, the coefficient of variation for repeated measurements at the same location is 2 %. The accuracy of the pulse velocity depends, in part, on the accuracy of the measured distance between the transducer faces.

Model

The **PUNDIT Lab+**. is capable of investigating the structural integrity of concrete, ceramics and refractory, timber, and other materials. The instruments include the following features:

- Light, portable, rugged, simple to operate
- USB rechargeable battery and 110/240 VAC 50/60 Hz power supply
- Large, highly visible LCD display
- USB and oscilloscope outputs
- Large range of transducer options (24 kHz to 500 kHz)
- Auto ranging transit time display; up to 9999 µs
- Transit time resolution of 0.1 µs
- Integrated received waveform display on instrument
- Integrated gain stage
- Measure transit time, pulse velocity, and elastic modulus (with shear wave transducer)
- Five transmitter voltage options; 125V, 250 V, 350 V, 500 V, or AUTO
- Operating temperature range for transducers is -10 to 60 ºC
- Pundit Link software for data transfer to computer, remote control of instrument settings, and exporting data

Technical details

1. Display unit,
2. 2transducers (54kHz),
3. 2 BNC cables 1.5 m, couplant,
4. verification rod, battery charger with USB-cable, 4x AA(LR6) batteries,
5. Pundit Link software,

3. CORRION METER

The Canin+ is the fastest instrument for corrosion analysis, offering a practical, cost-effective approach to the investigation of reinforced concrete. Corrosion analysis with the Canin+ allows a rapid, comprehensive test of the site and provides a fast assessment of locations where corrosion is likely to take place. Unit includes: Canin+ indicating device , adjustable, padded carrying strap, protection sleeve for display instrument, transfer cable, USB-serial adapter, operating instructions, carrying case, Canin+ rod electrode with spare parts, electrode cable, bottle with copper sulphate ($CuSO_4$) 250g, Canin ProVista PC software on memory stick

Application

Concrete concepts uses the Canin+ Corrosion Analyzing Instrument to collect potential field data on active corrosion in buildings such as multi-story car parks where damage occurs due to de-icing salts dripping from cars. This data is used together with concrete cover measurements using Profometer and chloride distribution measurements. Analysis of the data allows corrective maintenance to be localized.

Without the comprehensive potential field and concrete cover measurements, the building contractor would be obliged to replace all of the concrete in order to ensure the durability of the concrete structures. In practical examples in such car parks, the concrete replacement programme was reduced by up to 85%.

4. PROFOMETER

Adequate cover to reinforcement is required in any reinforced concrete structure to prevent corrosion and to improve durability of structure. To calculate actual strength of concrete structures, the number of reinforcing bars, their condition of corrosion, cover to reinforcement, and grade of concrete is required. In the case of old structures, when the detailed drawings are not available, it becomes very difficult to compute the strength of the structure which is required for the strengthening scheme of the structure. Sometimes, the strength of concrete structures are to be checked to permit higher load and in absence of reinforcement details it becomes very difficult to take a decision.

To overcome all these problems, the methods have been developed for investigation and evaluation of concrete structures. **Profometer** is a small versatile instrument for detecting location, size of reinforcement and concrete cover. This instrument is also known as **rebar locator**. This is a portable and handy instrument which is normally used to locate the reinforcement on LCD display. This instrument is available with sufficient memory to store measured data. Integrated software is loaded in the equipment for carrying out and printing statistical values.

The equipment is quite handy and weighing less than two kgs. It works on normal batteries and thus does not require any electrical connection.

Objective of Profometer Test:

This test is used to assess the location and diameter of reinforcement bars and concrete cover. This equipment can be used effectively for evaluation of new as well as old structures. The method can be used both for quality control as well as quality assurance.

Principle of Profometer Test:

The instrument is based upon measurement of change of an electromagnetic field caused by steel embedded in the concrete.

Methodology of Profometer Test:

To ensure satisfactory working of profometer and to get accurate results, it should be calibrated before starting the operations and at the end of the test. For this purpose, test block provided with the instrument should be used. To check the calibration accuracy, the size and cover of the reinforcement of the test block is measured at different locations on test block and the recorded data should match with the standard values prescribed on the test block.

Path measuring device and spot probes are together used for path measurements and scanning of rebars. These are connected with profometer with cables and are moved on the concrete surface for scanning the rebars and measuring the spacing. As soon as the bar is located, it is displayed on the screen. Once the bar is located, it is marked on the concrete surface.

Diameter probe is used for measuring the dia of bars. It is also connected with profometer by one cable. After finding out the location of rebar, the dia probe is placed on the bar parallel to bar axis. Four readings are displayed and mean value of these readings is taken as diameter of bar.

Depth probe of the profometer is used to measure the cover. It is also connected with profometer by cable and is placed exactly on the bar As soon as, the depth probe is above a rebar or nearest to it, it gives an audio signal through a short beep and visual display. Simultaneously, the measured concrete cover is stored in memory.

For carrying out this test, the proper assess is essential. For this purpose, proper staging, ladder or a suspended platforms may be provided. Before actual scanning, marking is done with chalk on the concrete surface by dividing it into panels of equal areas.

Advantages and Limitations:

This is a purely non-destructive test for evaluation of concrete structures particularly old structures. The methods is very fast and gives quite accurate results if the reinforcement is not heavily congested. The equipment is very light and even one person can perform the test without any assistance.

5. Bosch GDB 180 WE Professional core cutter Technical data

Additional data

Rated input power*	**2,000W**
No-load speed*	**900/2,800rpm**
Tool holder*	**1 1/4" UNC**
Weight	5.2kg
Drilling range	180mm
Tool dimensions (width)	108mm
Tool dimensions (length)	481mm
Tool dimensions (height)	294mm
Suitability	Wet drilling in concrete

Drilling range, bench-mounted

Concrete, possible range	180mm
Masonry, possible range	180mm

Total vibration values (Drilling in concrete)

Vibration emission value ah	4.8m/s²
Uncertainty K	1.5m/s²

* Highlighted Data

The A-rated noise level of the power tool is typically as follows: Sound pressure level 88 dB(A); Sound power level 99 dB(A). Uncertainty K= 3 dB.

ADVANTAGES

The compact powerhouse for drilling holes of up to 180 mm in concrete

- Powerful 2000 watt motor for breakthroughs in reinforced concrete up to 180 mm
- Long lifetime due to robust design and gearbox with oil-bath lubrication
- Wet and dry application; both hand-held and stand-mounted.