STRUCTURAL HEALTH MONITORING BY USING NON DESTRUCTIVE TESTING METHODS

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ABSTRACT

In India having lot of old monumental structures, reservoirs, dam, and religious buildings. The existing buildings are needed to find out the life time without disturbing the structures. Adopting NDT methods to can access easily the health monitoring of the structures with low cost. In this experimental work gives a combined test method for the health assessment by a suitable correlation of rebound test and upv test along to the compressive testing machine. A correction factor can be used for quick assessment of quality of the concrete by rebound hammer. It is a simple and reliable test for accessing old monumental place with economic cost.

Keywords: Rebound Number, UPV waves, ANALOG signals, carbonation Number.

I-INTRODUCTION

The main purpose of establishing standard procedures for nondestructive testing of concrete structures is to qualify and study the material properties of in-situ concrete without intrusively examining the material properties. There are simple techniques that are currently being examining for the NDT materials. In recent years, innovative NDT methods, which can be used for the assessment of existing structures, have become available for concrete structures. But those structures are still not established for regular inspections. This paper clearly to study the applicability, performance, availability, complexity and restrictions of NDT.(3) Roam B.P.O (2002) has stated in general, the purpose of NDT will fall into one of the following category Sanjeev Kumar Verma,et., al (2013)studied the Testing and quality checkup are important at varies stages during the life of a structures. To uniformly maintain the civil infrastructures, engineers required new methods of inspection.(11)Determination of material properties,Detection,Characterizations,locations and sizing of discontinuities or defects.(1) HishamY. Qasrawi etal (2003) has found that the ultrasonic pulse velocity tester is introduced as a tool to indicate basic initial cracking of concrete surfaces and hence to introduce a threshold limit for possible failure of the structures. (6)Zarqa and Jordan (2003) has investigated the Experiments using ultrasonic pulse velocity tester have been carried out, under the laboratory conditions, on different concrete specimens loaded in compression up to failure conditions occur. Special plots, showing the relation between the velocity through concrete and stress during loading are to be evaluated. According to Pratt D.G and Lawrence j. (1990), non-destructive testing (NDT) methods Techniques used in order to obtain information about the property or the internal conditions of an object without damaging the structures. (2)Sivasubramanian k, Jaya K.P.Neelamegam. M (1992) learning about the reinforcement position in concrete components is essential as they are a very important component structure provided to offer ductility and tensile strength to the concrete. (5)Arni's (1992) study the uncertainties of the probe penetration and rebound hammer test. It was found that exposed length can be used to estimate compressive strength. (3)Malhotra and curette (2011) studied the characterization of moisture content will leads the pulse velocity waves on the structures.

II-TEST METHODOLOGY

2.1 Rebound hammer

Before starting of a test, the rebound hammer should be tested against the specimen (anvil), to get reliable results. The testing specimen should be of steel having Brinell hardness number of about 5020 N/mm^2. The supplier to manufacturer of the rebound hammer should give the range of readings on the anvil suitable for various types of rebound hammer for taking a readings, the rebound hammer should be held at right angles to the surface of the structure. The test carried on horizontally to vertical surfaces and vertically upwards or downwards on horizontal surface on concrete structures. If the situation is different as per demands, the hammer can be held at intermediate angles also, but in all case, the rebound hammer will be changed for the same concrete. The following characterize should be observed during testing

✓ The surface should be even, neat and dry

✓ Before testing, the loosely adhering scale should be scratch off with a grinding wheel or stone.

✓ The test should not be conducted on rough surfaces resulting from ,

✓ incomplete action

✓ Loss of grout, palled or tooled surfaces.

✓ The point of impact should be at least 20mm away from edge or shape discontinuity.

2.2 Ultrasonic Pulse velocity:

This type of results can be used

✓ To check the uniformity of concrete

✓ To detect cracking and voids inside the concrete

✓ To control the quality of concrete and concrete products by comparing results to a similarity made concrete

✓ To detect the conditions and deterioration of concrete

✓ To detect the depth of a surface voided- cracks

✓ To calculate the strength.

2.3Ultrasonic pulse Velocity Tester:

The equipment should be calibrated before starting the observation and at the test to ensure the accuracy of the measurement and performance of the equipments. It is proceed by measuring transit time on a standard calibration rod supplied along with the equipment. A platform to staging of suitable height should be hoisted to have an access to the measuring locations. The location of measurement should be point-out and numbered with chalk or similar thing prior to actual measurements (pre decided locations).

2.3.1Transducers:

The direction of maximum energy is propagated is normally at the right angles to the face of the transmitting transducers, it is also possible to detect pulse which have traveled through the concrete into enormous direction. The transducer find the arrival of component of the pulse which arrives earliest. This is generally the leading edge of the longitudinal vibrations. It is possible, therefore, to make the measurements of pulse velocity by placing the two transducers in the following manners.

(a)Direct Transmission (opposite faces)-

This arrangement is the most preferred arrangement in which transducers are kept towards opposite to each other on opposite faces of the concrete surfaces. The transmitting pulse energy between transducers to receiver is maximum in this arrangement. The accuracy of velocity value is governed by the accuracy of the path length measurement. Most care should be taken for accurate measurement of the same. The transducer-receiver used is spread as thinly as possible to avoid any end effects resulting from the different velocities of pulse in couplant and concrete.

(b)Semi-direct Transmission:

In this method is used when it is not possible to have direct pass to transmission (may be due to limited uses). Here, consider less sensitive as compared to direct transmission arrangement. There may be small decreases in the origin of path length measurement, still it is found to be sufficiently accurate. This arrangement is otherwise similar to direct transmission.

(c) Indirect or Surface Transmission:

This type of transmission should be used when only one face of the concrete is accessible (when remaining two

Arrangements are not possible).It is the least sensitive out of three arrangements. For a given path length, the receiving transducer get signal range about 2% or 3% of amplitude that produced by compared to direct transmission and almost this arrangement gives pulse velocity readings which are usually influenced by the surface concrete. Which is often having different composition from that below surface concrete.Therefore, the test results may not be correct representative of all mass of concrete structures? The indirect pulse waves are invariably lower than the direct velocity on the same concrete surfaces. This difference may from 5% to 20% depending on the quality of the concrete. If it is practicable, site measurements should be made to determine this different surface on the structures. It is the main factor that ensure the layer of smoothing medium should be as thin as possible. Couplant like petroleum jelly, grease, soft soap and kaolin or glycerol paste are used as a coupling medium between transducer and concrete. Uneven or rough surfaces should be smoothened using carbo-random stone before placing the transducers. Alternatively, a smoothing lamina such as quick setting epoxy resin or plaster can also be used, but the adhesion between concrete surface and smoothing medium has to be ensured so that the pulse is propagated with minimum losses into the concrete. Transducers are then placed towards the concrete surface and hold manually. It is important that only a very thin layer of coupling medium segregates the surface of the concrete from its contacting transducer. The distance between the measuring points should be accurately noted. The similar repeated readings of the transit time should be observed at least to get a minimum value is obtained. The ultrasonic pulse absorbs on the surface of the material, the maximum energy is propagated at right angle to the direct face of the transmitting transducers and best results are obtained. When the receiving transducer is placed to the opposite face of the concrete member known as Direct Transmission. This velocity can be taken by Direct Transmission, semi-direct Transmission and Indirect or Surface Transmission. Probably, Direct Transmission is measured being more reliable and standardized. The size of aggregates influences the pulse velocity readings. The small path length should be 100mm for concrete in which the nominal maximum size of aggregate is 20mm or less and 150mm for aggregates size between 20mm and 40mm. Reinforcement, if present. Should be avoided during the pulse velocity in steel is 1.9 more than the concrete. In certain conditions, the first pulse to arrive at the receiving transducer travel partly in concrete and partly in steel. The apparent increase in pulse velocity depends upon the linearity of the readings to the reinforcing bars, the diameter and numbers of bars their orientation with respect to the path of propagation length. It is intimated that the influence of reinforcement is generally small if the bars runs in the direction right angle to the pulse path for bar diameter less than 12mm. But if percentage of steel is quite high or the axis is parallel propagation, then the correction factors has to be applied to the measured readings. The nil time correction is equal to the travel time between the transmitting and receiving transducers when they are moved combined together.

2.4.1Calculation of pulse velocity

A pulse is produced vibration by an electro acoustical transducer, which is placed on contact with one surface of the concrete member to the test. Then traversing a known path length (L) of the concrete, the pulse of vibration is changed into an electrical signal by a second transducer for electro-acoustical, and electronic time circuit access the transit time (T) of the pulse measured. So that t he pulse velocity is given by,

$$V = L / T$$

Where,

V = Pulse velocity,

L = Path length,

T = Time taken by the pulse to traverse the path length.

3. PROFOMETER (5+ REBAR LOCATOR)

To ensure satisfactory working of profometer and to get accurate results, it should be calculated before doing the operations and at the last of the test. For this purpose, test block provided and the recorded values should match with the standard values prescribed on the test block. Path measuring device and spot probes are placed together used for path length direction and scanning of rebars. These are connected with profometer with cables and are moved on the concrete surface to scanning of the rebar and measuring the spacing. As soon as the bar is located, it is marked on the concrete surface. The diameter probe is used for measuring the diameter of bars. It is also connected with profometer by one cable. After finding out the location of rebar, the probe is placed on the parallel to bar axis four readings are displayed and mean value of these readings 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 probes above a rebar or the nearest to it, it gives an audio signal through a short beep and visual display on the display unit. Simultaneously, the measured concrete cover is stored in memory. For carrying out this test, the proper access is essential. For this purpose, proper staging, ladder or suspended platforms may be provided. Before real scanning, marking is done with chalk on the concrete surface by dividing it into panels of equal areas.

3.2 MEASURING PROCESS

This function can be used to locate rebars, measure concrete covers and determine bar diameters. The cover values can be stored under object numbers if the diameters is unknown enter approximately 16mm.

3.2.1 DETECTING INSUFFICIENT CONCRETE COVER:

To locating the rebars and measuring the concrete cover.

For locating the rebars, the diameter setting is not as important as for measuring the cover. In the case of double layer arrangements of rebars, always start the location with the 1st layer. If the rebar of the first layer are too close to each other, it is likely to be not possible to locate the bars of the next layer. Move the probe from a starting position in one direction. Observe the locating aids: current concrete cover, flow bar, (short) beep, baritone, signal value. As long as the flow bar shifted to the right parallel to the approaching a rebar. If the flow bar stops moving, the probe is directly over the rebar axis. If the axis-line of the probe has overshot the rebar axis. Somewhat, acoustic and visual indication is given in the short beep and by in the current cover display field. At the same time, the flow bar moves to the left and the cover is temporarily stored in the field. When having activated the audible locating aid, the audio frequency suddenly raises to the probe approaches a rebar. In this operation mode the cover of the scanned rebar is also temporarily stored in the field. In the order of loud noises from the surfaces circumstances, use the headset to hear the acoustic signals. The bar direction can be detected by moving the probe in the direction of its longitudinal axis along the rebar. Make sure that the signal readings are taken and the current cover remains as constant as possible. Here, the spacing between the bars of the other layers of the mesh can also be located more easily. This particularly applies to the bars of the second layer. The value displayed for the cover of a bar of the first layer can vary by a few millimeters depending on the whether the measurement is made over the point at which two bars cross or between the bars of the second layer.

With a preselected limit reading, the probe can be moved at a maximum search speed of 0.25 m/s without having any interruption to measure the thickness continuously. If the current cover displayed is less than the limit ranges, an acoustic alarm sounds. If the probe is over the bar is indicated in the current concrete cover in the display field. If the rebars of the 1st layer run in a vertical direction, the travel paths must be positioned horizontally with the selected grid spacing in vertical direction. Move the mobile probe along these paths. The smallest concrete cover measured in a grid field is displayed and stored automatically as grey scale.

After having finished one row, the cursor jumps to the second row edges and the arrow direction changes automatically. The indicating device operates in the same way if the travel paths are positioned vertically, i.e. if the measuring is performed in directions y. If a hindrance prevents the measurements, then shift the measurement to the size of obstacle. Individual values can be deleted by positioning the cursor on the respective value and pressing the print/store key for two seconds. Then expand the object opened last in the x and y direction on new pages comprising 240 measured values. For all previous objects, measured values can only be entered in pages that are not yet full. If the measurement cannot be started in the top left corner (x and y = 0) then to choose the starting position in the concrete surface. To confirm the reservation to set a grey scale symbol in the second row using the PRINT/STORE key...

4 .HALFCELL POTENTIAL METHOD

In this method, the apparatus consist of copper-copper sulfate electrode with a high –current voltmeter. Form this arrangement the positive terminal is connected to the reinforcement and the negative terminal is attached with the copper-copper sulfate half cell. A maximum voltmeter is used so that very little current flows through the circuit.

The half –cell makes electrical touch with the concrete by means of a porous plug and a sponge that is moistened with a wetting solution (such as liquid detergent).If the bar is corroding, electrons would tend to flow from the bar to the half-cell.at the half-cell, the electrons are used in a reduction in the copper ions in the copper solution into copper atoms in the rod. The method of half-cell potential measurements normally involves the measuring the potential of the embedded reinforcing bar connected to a concentrate to half-cell placed on the concrete surface and the voltmeter is attached through the half-cell apparatus. The negative terminal values indicate the corrosion in it surfaces. It may need to drill a minimum hole to enable electrical contact with the reinforcement in the member under the surface. It is important to recognize that the use and interpretation of the results obtained from the test require the protective or decorative coatings applied to the concrete. The half cell is usually a copper/copper sulphate or silver/silver chloride cell but the other combinations are used. In some circumstances, useful measurements can be obtained between two half-cell on the concrete surfaces. ASTM C876-91 plot a standard test method for Half-Cell Potential of Uncoated Reinforcing steel in concrete.

Risk of corrosion against the potential difference reading is given below:

Potential difference levels(mv)	Changes of re-bar being corroded
Less than -500	Visible evidence of corrosion
-350 to -500	95%
-200 to -350	50%
More than -200	5%

Table 4.1.Rate of corrosion limit

5 -TEST RESULTS AND DISCUSSIONS

5.1. REBOUND HAMMER TEST:

5.1.1. PREPARATION OF SPECIMEN:

5 Cubes were cast, targeting at different mean strengths. Further, the cubes were cured on different number of days to satisfy the availability of a wide range of compressive strength attained by these cubes. Size of each cubes 150 x 150 x 150 mm.

5.1.2. TESTING OF SPECIMEN:

10 readings (rebound numbers) were obtained for each cube, at different locations on the surface of the specimen. The cube was divided into grid blocks of equal spacing and 10points were marked at equal intervals for taking the rebound hammer test. The cubes were then given a load of 7N/mm^2 (as specified by the IS 13311) in the Compression Testing Machine and the Rebound Values were obtained. The cubes were then loaded up to their ultimate stress and the Breaking Load was obtained.

The tables lists is given below for the Rebound numbers (Rebound index),Mean Rebound value, Standard Deviations, the Dead Load on the texture at the time of testing of surfaces, the Breaking Load, the Predicted Compressive Strength as per the Rebound Hammer and the actual compressive strength obtained by the compression testing machine.

FIG 4.1.Rebound hammer testing of column

5.2. Ultrasonic Pulse Velocity Testing Machine:

5.2.1Preparation of specimen:

Cubes were prepared to targeting at different mean strengths. Further, the cubes were cured for different days to predict the availability of a wide range of compressive strength attained by these cubes. Size of each cubes was 150x150x15mm.

5.2.2. Testing of Specimen:

3 readings of Ultrasonic Pulse Velocity (USPV) were obtained for each cube.

The cubes were then given a load of 7 N/mm^2 (as specified by the IS 13311) in the Compression Testing Machine and the USPV were obtained.

The cubes were then loaded up to their ultimate stress and the Breaking Load was obtained.

The following table gives the USPV in each specimen with their mean velocity, the Dead Load, the Breaking Load and the actual Compressive Strength as obtained by the Compression Testing Machine.

Fig 5.1 Testing Specimen USPV

5.3. PROFOMETER

<u>5.3.1DETERMINING THE BAR DIAMETER:</u>

(Determining the Diameters without Correction)

For precise the determination of the Bar Diameter, it is important that are no unnoticed influence that could for Falsify the result, therefore select the place on the structure where there is a sufficient spacing between the bar. If the Spacing are too small a resulting value will be large.

To Observe the Bar diameter in the first and second layer, the minimum spacing a and b as soon in tab:

Select the measures W statistics function.

Carry out the reset procedure and also change the surface of the concrete structures.

Place the Prob parallel over the bar and press ↑ key for next layer.

The measured bar diameter (d) is displayed.

Fig 5.2.Testing of Cover Thickness using Scanlog.

Fig 5.3. Testing of pre-sample specimen

5.4. HALF-CELL POTENTIAL TEST:

5.4.1Arrangement of surface:

In this test is mainly used for measuring the corrosion activity in the reinforcing bar to relative to a reference of half-cell placed on the concrete surface.

And also gives the empirical measurement of the potential difference in the concrete surfaces.

5.4.2. MONITORING OF SURFACE:

✓ Measurements are made in rectangular pattern.

✓ The spacing measurements is generally chosen by the unknown values. It should be less than 150 mv with minimum spacing so that at least 100 Mv between the readings.

✓ The area is larger than 150.2 mv voltage limit is direct proportion of an area of high corrosion initiation activity.

✓ A direct electrical connection made in the middle of reinforcing steel with a compression braced brazing or welding a protruding rod.

✓ To get the lower electrical resistance connection, the rod should be scraped or brushed before connecting to the reinforcing bar.

✓ It may require to drill into the concrete to outside of a reinforcing bar.

✓ The bar is connected directly to the positive terminal of the voltmeter.

✓ One end is connected to the half-cell and the other end to the negative terminal of the voltmeter.

✓ Under that half cell reading is fluctuates with time when placed in the contact with the concrete.

✓ If the fluctuations appears whole concrete surface is made wet or partly wet only the spots where the half-cell is to be held on the monitoring surfaces.

✓ The electrical half-cell potentials are recorded to the nearest 0.01V correcting for temperature if the temperature is outside the range 22.2 ± 5.5ºc.

Fig 5.4 Half- cell potential in the pre-positioning the Transducers

6. INTERPRETATION OF RESULTS

6.1. Rebound Hammer:

After obtaining the correlation between compressive strength and rebound number, the strength of concrete can be assessed. In general, the rebound number increases as the strength increases and also affected by a number of parameter. i.e., type of cement, type of aggregate, surface condition and moisture content, age and curing of concrete, carbonation of concrete surface etc, the internal cracks, flaws etc. or heterogeneity across the cross section will not be indicated by rebound numbers.

As such that the estimation of strength of concrete by rebound hammer method should not be held to be very accurate and probable accuracy of prediction of concrete strength in a structure is ± 25 %. The rebound hammer showed erratic result when the compressive strength was below 15 N/mm^2.

If it is above 15 N/mm^2 the predicted compressive strength varied almost linearly with the actual compressive strength.

Average rebound number	**Concrete quality grading**
Greater than 40	Very good hard layer
30 o 40	Good layer
20 o 30	Fair
Less than 20	Poor concrete

Table 6.1 Conditions of quality concrete grading

<u>6.2 Ultrasonic Pulse Velocity Tester:</u>

This type of tester is mainly consider for concrete can be related to its density and modulus of elasticity. It is mainly based upon the materials and mix proportions used in making concrete as well as to assess the method of batching, cleaning and compacting of concrete. In this case concrete is not compacted thoroughly and having separation, cracks or elongation, the pulse velocity will be smaller as compare to the good concrete, although the same materials and mix proportions are used.

The quality of concrete in terms of uniformity can be assessed by using the following guidelines:

Pulse velocity (m/s)	**Conditions**
Above 4570	Excellent
3660 to 4570	Generally good
3050 to 3660	Questionable
2130 to 3050	Generally poor
Below 2130	Very poor

Table 6.2 criterion for concrete quality grading (as per IS 13311 (Part 1):1992)

Since real value of the pulse velocity in concrete depends upon on a number of parameters, so the criterion for assessing the quality of concrete is purely based on the pulse velocity is valid to the general extent. The quality of concrete is usually specified in terms of strength and it is therefore, sometimes helpful to use ultrasonic pulse velocity measurements to give an actual compressive strength.

The relationship is proportion of ultrasonic pulse velocity and strength is affected by a number of factors including age, curing conditions, moisture conditions, mix proportions, type of aggregate and type of cement.

However, if details of materials and mix proportions adopted in the particular structure are available, then the estimate of concrete strength can be made by establishing suitable correlation between the pulse velocity values and the compressive strength values of concrete texture surfaces made with same material and mix proportions, under environmental conditions. The estimated strength may be vary from the actual strength by ± 20 percent. So that the correlation is obtained may not suitable for grade concrete or made with different types of material.

6.3 PROFOMETER (5+ REBAR LOCATOR)

In this process, more accurate results may be obtained. When the horizontal bars are calibrated between the vertical bars, the third individual bar appears to be thinner than the other two horizontal bars.

The profometer is generally used for the depth measuring cover range with main proportion to the clear cover areas, etc.

6.4. HALF-CELL POTENTIAL METHOD:

It is mainly constrained over the half-cell electrode potentials to the reflect the characterize on the electrode environment. So that the interpretation is complicated when the concrete is saturated with water, where the concrete is carbonated to the depth of the reinforcing steel, where the steel is coated and under many other conditions. For this technique, additional testing also required such as analysis for carbonation, metallic coatings and halides. If the concentrations of chloride can reduce the ferrous ion concentration at a steel anode thus lowering the potential.

In this method is investigated by conjunction with other test, it has been found helpful when investigating concrete contaminated by salts.

Advantages and limitation:

This is a purely non-destructive test for evaluation of concrete structure particularly for old structures.

The methods is very fast and give 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.

It is easily transported from one place to required field.

Limitations:

- ✓ The concrete surface has to be smooth(not cracked, scarred, or uneven),
- ✓ The concrete surface has to be free of water-impermeable coatings or overlays,
- ✓ The cover depth has to be less than 100mm to 110mm.
- ✓ The reinforcing steel should not be epoxy coated or galvanized,
- ✓ The steel has to be monitored direct contact with the concrete.
- ✓ The reinforcement cannot be cathodically protected.
- ✓ The ambient temperature should be 5 to 40ºc.
- ✓ The surface area should be free from visible moisture.

Drawbacks:

The equipment is not being manufactured in India and needs to be imparted. Some of the Indian Firms are marketing the instrument and this is costly equipment.

CONCLUSION

The structural health testing by NDT methods such as USPV and Rebound Hammer testing methods. It becomes very useful for giving warning to the service life of the structures and deterioration of the structures provided the periodical monitoring of the same member of the structures is being carried out.

Since the concrete is heterogeneous and tests are affected due to different factors such as age of the concrete, carbonation depth, reinforcement, cracks and voids inside the concrete, a combined test helps for assessment the strength and durability.

The experimental investigation showed that a good inter-relation exists between compressive strength, rebound hammer and ultrasonic pulse velocity.

Finally rebound hammer should access to determine the compressive strength of the structures. Ultrasonic pulse velocity is the ideal NDT method to save the deterioration in the structures and to determine the service life of the structures.

Considerable engineering judgment is needed to properly evaluate a measurement. Misinterpretation is possible when poor contact is made.

For example, in some cases it is not possible to identify corroded reinforcing bar of the poor quality concrete structures. Almost, it is possible to identify poor quality concrete which could be the cause of reinforcing bar problems. The poor quality concrete permits the changes of moisture and oxygen to the reinforcing bars, and hence corrosion occurs.

When variations in properties of concrete that affect the test results, (especially in opposite directions), the use of one method alone would not be sufficient to study and evaluate the required property.

Therefore, the use of more than one yields more reliable results. For example, the increase in moisture content of concrete increases the ultrasonic pulse velocity and also decreases the rebound number.

Utmost, using both methods together will reduce the errors produced by using any one method alone to evaluate the concrete.

Attempts have been done to relate rebound number and ultrasonic pulse velocity to concrete strength. The Schmidt hammer provides an inexpensive, simple and quick method of obtaining concrete strength. But, in case accuracy is limited from ± 15to ± 20 percent is possible only for specimens cast cured and tested under conditions for which simulation curves have been established. The results are affected by number of factor such as smoothness of surface, size and shape of specimen, moisture condition of the concrete, class of cement composition and also coarse aggregate, extent of carbonation of surface.

The pulse velocity method is an uniform tool for expressing whether concrete is uniform. It can be used that on both existing structures under construction. Generally, if large differences in pulse velocity are found within a structure for no appear reason, there is strong to presume that defective or deteriorated concrete is present.

Fairly good correlation can be obtained from cube compressive strength and pulse velocity. Due to this relations to enable the strength of structural concrete to be predicted within ± 20 percent, provided the types of aggregates and mix proportions are constant. In summary, the ultrasonic pulse velocity tests have a great potential for concrete control, particularly for establishing uniformity and detecting cracks or defects. Also, measurements were not accurate and representative when compared to the cubes used to construct the graph. From those of the combined methods produces results that lie close to the true values when compared with other methods.

Many factors could affect the cover measurement. Among them, bar diameter setting and range setting (low or high) in the profometer have a greater affect than the other factors explored in the study.

Setting to actual bar diameter will give more accurate results than setting to be assumed initial bar diameter. It is desirable to obtain the information on bar diameter in the concrete startup cover measurement in order to achieve more accurate results.

“High” range settings should only be used when “low” range probe is not capable of detecting the reinforcing bars. If the cover measurement is required for thick concrete cover structural elements, a proper calibration should be carried out prior to actual cover measurement.

It may require to drill a small hole enable electrical contact with the reinforcement in the member under testing, and surface preparation may also be required.

This technique is most likely to be used for assessment of the durability of reinforced concrete members where corrosion of reinforcement is suspected. Reported uses include the location of areas of high range of reinforcement corrosion danger in offshore structures, bridge decks and abutments. Used in combinations with other test, it has been found helpful in the contaminated salts intrusion activity investigation process.

REFERENCES:

1. Akashi. T, and Amasaki, S.(1984), “Study of the stress waves in the plunger of a rebound hammer at the time of impact”. In situ / Non destructive Testing of concrete, ACI SP-82, Detriot (1984),pp. 19-34.

2. Alldred JC,(1995),improvement to the orthogonal method for determining reinforcing bar diameter using a profometer. Proceedings of the sixth international conference on structural repair-95, London, 1995, volume 2, Engineering press,11-5.

3. Amasaki, A.CAJ Proc Cem conc 45(1991), Estimation of strength of concrete Structures by the rebound hammer,pp.345-351.

4. BS 1881: Part 202, 1986: Recommendations for surface Hardness Tests ny the Rebound Hammer, BSI, UK (1986).

5. Civil Engineering Construction Review, August 1998 Edition (Non destructive testing of concrete).

6.Hisham Y. Qasrawi (2003), “Concrete strength by combined non destructive methods”, Civil Engineering Department, College of Engineering, Applied Science University, Amman 11931, Jordan.

7. IS 13311(Part-1):1992 Non Destructive Testing of Concrete methods of test, Part-1, Ultrasonic Pulse Velocity.

8 .IS 13311(Part-2):1992 Non Destructive Testing of Concrete methods of test, Part-2, Rebound hammer

9. Malhotra, V.M, and Carino, N.J, (2nd edition), “Handbook on Non-Destructive Testing of concrete”.

10. McCann, D.M. and Forde, M.C. (2001), Review of NDT methods in the assessment of concrete and masonary structures, NDT and E-international, 34, pp 71-84.

11. Sanjeev Kumar Verma, et. al (2013)studied the Testing and quality checkup are important at varies stages during the life of a structures