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Assessment of Concrete Strength on Structure Using Non Destructive Testing

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Abstract: *Non-destructive testing is a descriptive term used for the examination of materials and components in such way that allows materials to be examined without changing or destroying their usefulness. NDT is a quality assurance management tool which can give impressive results when used correctly. It requires an understanding of the various methods available, their capabilities and limitations, knowledge of the relevant standards and specifications for performing the tests. NDT techniques can be used to monitor the integrity of the item or structure throughout its design life. Damage to a structure may occur due to a lot of natural and artificial causes like earthquakes, tsunamis, etc. Instead of demolishing the whole building, such damages can be repaired and rehabilitated up to a certain range for future use within its life span.*

I. INTRODUCTION

Cement concrete is the most extensively used material for construction of different types of structures or components such as buildings, bridges and shell roofs and also for precast products such as pipes, poles, sleepers, etc. in the past and even at the present times, too much emphasis is placed on concrete compressive strength rather than on environmental factors, which is known to affect concrete durability. Construction activities account for a major component of the budget of our country. A very large part of the infrastructure in our country is made of concrete, providing the basis of economic and social development. These are often damaged due to ageing, environmental agents, overloading, vibrations and other causes. A great variety of damage situations can occur, as micro cracking and cracking due to material and structural damage, material discontinuity and surface degradation.

Non-destructive testing (NDT) methods are techniques used to obtain information about the properties or internal condition of an object without damaging the object. Non-destructive testing is a descriptive term used for the examination of materials and components in such way that allows materials to be examined without changing or destroying their usefulness. NDT is a quality assurance management tool which can give impressive results when used correctly. It requires an understanding of the various methods available, their capabilities and limitations, knowledge of the relevant standards and specifications for performing the tests. NDT techniques can be used to monitor the integrity of the item or structure throughout its design life.

The greatest disadvantage of the conventional methods of testing concrete lies in the fact that in-situ strength of the concrete can not be obtained without damaging the actual structure. Also the test specimens are destroyed, once the test is performed and subsequent testing of the same specimens is not possible. Thus the effect of prolonged curing, weathering action and other time dependent characteristics can not be correctly calculated. No matter how well a concrete mix is designed, there are variations in mixing conditions, amount of compaction or curing conditions at site which cause the variations in the final product. The variability between the batches of concrete of the same mix proportion is assessed by testing test specimens under load in the laboratory. Such tests enable the variability of constituents of the mix to be controlled, but they can not take into account the differences of compaction and actual curing conditions between the test specimens and the corresponding concrete in a structure. It is these differences, which are difficult to assess by conventional strength tests, Also, conventional method of testing is not sufficient to predict the performance of the structures under adverse conditions e.g. exposure to liquid, gas, and chemicals radiation, explosion, fire, extreme cold or hot weather, marine and chemical environment. All such severe exposure conditions may induce deterioration in concrete and impair the integrity, strength and stability of the structure. Thus, conventional strength test does not give idea about the durability and performance of the actual concrete in the structure. This gave the impetus to the development of non-destructive methods for testing structural concrete in-situ.

Thus, NDT methods are extremely valuable in assessing the condition of structures, such as bridges, buildings, elevated service reservoirs and highways etc.

II. METHOD OF INVESTIGATION

The investigation work consisted of

- Visual observation
- Rebound hammer and ultrasonic testing on columns and brace beams for assessing the integrity of concrete
- Core sampling and testing for estimating the compressive strength
- Documentation of results

III. VISUAL OBSERVATION

A detailed visual inspection was carried out for all the structural members of the building. Documentation of visual damage was recorded consisted of minor and major cracking, Honey Combs, spalling of cover concrete with exposure of reinforcement in severely corroded members, etc. Visual observation and documentation of the damaged concrete members of the building has been made through photographic documentation.

IV. IN-SITU TESTS

The following Non Destructive and partially destructive tests were conducted to collect data for the assessment of the condition of the building.

- Rebound Hammer test
- Ultrasonic pulse velocity test
- Core sampling and testing

V. REBOUND HAMMER TEST

This is a surface hardness test and consists essentially of impacting the concrete surface in the standard manner. This is achieved by activating a mass by a given energy and measuring the indentation or rebound. The most commonly and widely used instrument is a "Rebound Hammer". The test procedure consists of applying the hammer on the concrete surface and observing the values in the digital display form. Before applying the hummer, if the surface is not even, the surface of the concrete is necessarily to be cleaned and smoothened. The procedure of determining the rebound values has been specified in IS-13311(Part-ll). It should be noted that the rebound values reflect the concrete quality up to a depth of 50 mm from the surface of the number. However, the Rebound Hammer values provide a quick inexpensive means of checking the quality of concrete. It has many serious limitation, which should be recognized. The main factors that affect the readings are as follows

- Size and age of concrete
- Surface texture
- Concrete mix characteristics
- Carbonated concrete, and
- Moisture content

In any practical situation, it is very unlikely that the strength prediction can be made to an accuracy better than ± 25%. The calculation of Coefficient of variation may yield an indication of concrete uniformity. If the coefficient of variation is 4% of test results on individual member, it corresponds to good quality of concrete construction. The application of surface hardness measurement can be used for checking the uniformity of concrete, comparing a given concrete with a specified requirement, approximate estimation of strength by using laboratory calibrated graphs and abrasion resistance classification.

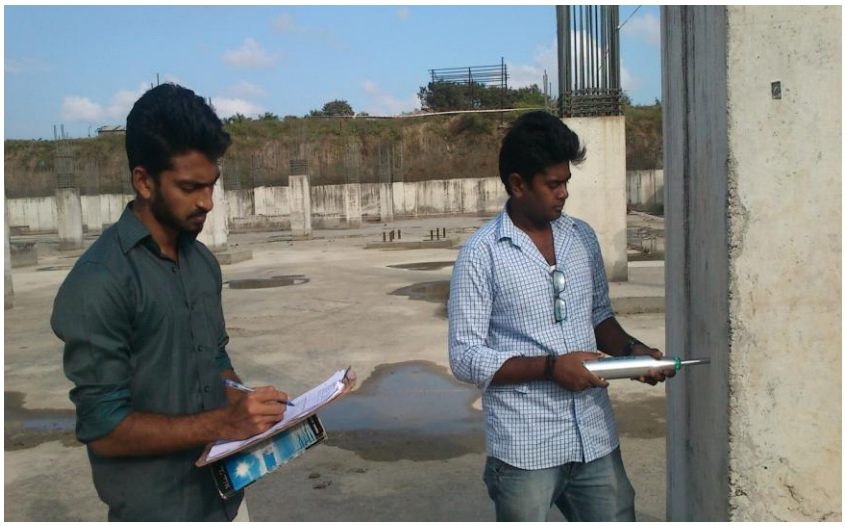

Fig .1 Rebound Hammer Test

VI. ULTRASONIC PULSE VELOCITY (UPV) TEST

Ultrasonic Pulse Velocity test is basically a wave propagation test and consists of transmitting ultrasonic pulses of 50 - 60 kHz frequency through a concrete medium and measuring the travel time of ultrasonic pulses for known or measured length. The length divided by time gives the velocity which can be correlated to concrete quality. Based on correlation graphs, approximate estimation of concrete compressive strength can also be made with a variation of ± 20%. UPV values can also be suitably interpreted to assess qualitatively the condition of concrete with regard to homogeneity, uniformity and integrity etc. The procedure for determining UPV values has been specified in IS-13311 (Part-I).

As the primary objective of the investigation was to assess the condition of the in- situ concrete, the ultrasonic pulse velocity test was chosen and adopted. For path length below 2.00 m, 54 kHz frequency transducer is suitable and for path length of 2 m and above, 24 kHz frequency transducer is found to be more suitable.

Fig. 2 Ultra-Sonic Pulse velocity Test

VII. CORE SAMPLING AND TESTING {PARTIALLY DESTRUCTIVE TEST (PDT)}

The Rebound Hammer test and ultrasonic pulse velocity test give indirect evidence of concrete quality where as a more realistic assessment of concrete can be made by core sampling and testing. The cores can be tested for compressive strength, chemical analysis, petrography examination etc. Normally 75 mm to 100 mm diameter cores are used for compression testing. The cores should have a length/diameter ratio between 1.0 and 2.0. The number of cores required will depend upon the purpose of testing. However, the number of cores must be sufficient to be representative of concrete under examination as well as to provide a strength estimate of

acceptable accuracy. Cores were extracted by means of rotary cutting tool with diamond bits. The base should have a solid support to prevent relative movement. Water supply should be continuous to lubricate the cutter and applied pressure should be uniform. The core drilling operation was carried out in the following manner.

- The presence of steel reinforcement was identified using a rebar locator.
- The location is selected to ensure avoidance of reinforcement
- The core drilling machine was brought and fixed on the marked location using anchor bolts.
- After ensuring that the bit was in the right location, the drilling operation was carried out.

After reaching the required depth, the drilling operation was stopped, the drilled core was extracted and identification mark was made.

Fig 3 Core Sampling Test

VIII. CONCLUSIONS

The equivalent cube compressive strength of M35 grade is in the range of 33.2 N/mm2 and 42.2 N/mm2 For M55 grade concrete, the compressive strength is about 61 N/mm2 approximate to about 25%.

From the results of the core sample tests, it is known that the concrete quality that was used in the building has been reduced over the years and it now lies between a good and medium concrete which doesn't require retrofitting as of now. Proper maintenance has to done in order to maintain its strength and durability. Our main aim is to make sure that the building is safe for further progress in the construction and hence we have suggested repair techniques in order to strengthen the structure and increase its life. Reconstruction of the building had to be incorporated in case there had been heavy damage to the structure. Since the damage is very limited and almost nil, retrofitting can help to strengthen the building.

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