Testing Techniques

A number of non-destructive, partially destructive and destructive techniques for assessment of concrete structure and to predict the cause of deterioration of the concrete in the existing structures are available. Interest in the field of Non-Destructive Testing (NDT) of structure is increasing worldwide. These NDT techniques can be broadly classified into following four groups:

1.3.1.1. Strength Tests

- Schmidt Hammer Test
- Ultrasonic Pulse Velocity
- Pull out and Pull off Tests
- Break off
- Core Test
- Windsor Probe
- Pulse Eco Technique

1.3.1.2 Durability Tests

- Corrosion Tests
- Absorption and Permeability
- Test for Alkali Aggregate Reaction
- Abrasion Resistance Tests
- Rebar Locator Test

Performance and Integrity Tests

- Infrared Thermography Test
- Radar Test
- Radiography and Radiometry Tests
- Acoustic Emission
- Optical Fibre Test
- Impact Echo Tests
- Load Testing test
- Dynamic Response
- X-Ray Diffraction

1.3.1.4 Chemical Tests

- Carbonation test
- Suphate Determination Test
- Chloride Determination Test
- Thermoluminescence Test
- Thermo gravimetric analysis Test
- Differential Thermal analysis
- Dilatometric Test

With these tests it would be possible to know in-situ strength/quality of concrete to precise identify the damage and causes of the deterioration of the structure, to predict the residual life measures to enhance the life of the structure.

Details of few of the tests, which are commonly used in practice, are described below,

1. Schmidt Hammer Test

Schmidt Hammer Test is a quick method for assessing the quality of concrete based on su hardness indicated by the rebound number. If the strength of concrete is high, then the rebound number is also high.

The principal of this test is that when the plunger of rebound hammer is pressed against surface of the concrete the spring controlled mass rebounds and the extent of such rebound depends upon the surface hardness of the concrete. The surface hardness and therefore the rebound number is taken to be related to compressive strength of the concrete. Rebound number values also depend on angle of measurement.

2. Ultrasonic Pulse Velocity test

Ultrasonic Pulse Velocity (USPV) method is being extensively used to assess the quality concrete. This test is generally used for measurement of concrete uniformity, determination of cracking and honeycombing, and assessment of concrete deterioration. Strength estimation is qulititative assessed.

The principal of USPV measurement involves sending electro-acoustic pulse through a concrete path and measuring the transit time taken, for a known distance. Pulse velocity is then, computed. Tn pulse velocity depends mainly on elastic modulus of concrete. Any factor, which influences the modulus of elasticity of concrete, will also affect its pulse velocity. The direct method of testing is the more reliable from the point of view of transmittance measurement, as maximum pulse energy is transmit at right angles to the face of transmitter.

3.Carbonation Test

Concrete is having micro-pores and these pores are filled with liquid, having PH –value as high 12.5. Thus, concrete is alkaline in nature. This alkaline of the concrete is due to (OH) ions in pore water, which are produced by the dissolution of $Ca(OH)_2$ from the solid phase of the cement gel into pore water and from the caustic alkalis present namely potassium and sodium oxides. Carbonation of the concrete is the reaction of $Ca(OH)_2$ with the atmospheric CO_2, and its conversion into $CaCO_3$. The reaction lowers the pH-value of the pore water to about 8.3. The outer zone of concrete is affected first out due to the passage of time, carbonation proceeds deeper into the mass as carbon dioxide diffuses inwards from the surface. If carbonation depth becomes equal to cover of concrete, steel reinforcement is then prone to corrosion damage.

By carbonation test, we measure the carbonated depth of concrete. To determine the depth of carbonation drilling of a hole is done in stages and the phenolphalein solution is sprayed in it after every stage. As soon as the color of the concrete becomes pink, drilling is stopped and the depth of the hole measured.

4. Core Test

Core test is one of the best methods to assess the strength of the concrete in reinforced concrete construction. Compression testing and petrographic examination of cores, cut from hardened concrete, is a well established and most reliable method enabling visual inspection of the interior regions and direct estimation of the strength. The results obtained from the other nondestructive tests are generally verified using core test.

5. Rebar Locator Test

By this test, bar diameter, cover to reinforcement, spacing of reinforcement, number of reinforcing bars and any discontinuity in the reinforcing bars can be detected. This test is performed using cover meter which is based on electro-magnetic theory.

6. Chloride Determination Test

Small amount of chlorides will normally be present in the concrete. Higher amount of chlorides may give rise to potential of corrosion risk. Quantity of chlorides in the concrete is generally determined chemically and is expressed in terms of percentage of chlorides by weight of concretes.

Thermo gravimetric and Dilatometric test, differential thermal analysis tests, Thermolumine scene test etc are some of the sophisticated tests for assessment of the residual concrete strength.

7. Thermo gravimetric and Dilatometric Tests

Thermo gravimetric and Dilatometry may be used to assess temperature attained by concrete. As the concrete undergoes irreversible chemical changes during fire there would be weight loss at about 500^{0}C. Using thermogravity curces the temperature attained during fire can be obtained. In dilatometric test, shrinkage of concrete due to process of dehydratrion is detected. By compaction expansion with temperature lines that represents dialometric curves for fire damaged concrete and unaffected concrete, the probable temperature to which concrete was subjected can be established.

8. Thermoluminescene Test

Thermoluminescene test was proposed by placid and elaborated by chew. This method is useful in finding out the temperature history of concrete exposed to a temperature range from 300^{0}C to 500 ^{0}C. This method utilizes the concept that the intensity of emission of visible light on heating versus temperature curve for a particular material depends on its thermal and radiation history. Temperature versus thermoluminescence curve of the fire affected sample may be compared with that of unaffected sample for comparison of exposures to the given temperature.

Differential thermal Analysis Tests

Differential thermal Analysis test is based on measurement of temperature curve of the concrete samples accompanying the irreversible physic, chemical transformation at a temperature, heated in surface. This method consists of heatng of sample in platinum crucible with a thermocol embedded in it. The time temperature curve of sample is compared with that of crucible containing in material or without my samples. The differential thermal analysis of concrete samples are conducted pulverized sample of mortar obtained from sound and unsound concrete with granular size of the concrete passing a sieve of 150 microns and retained on 75 microns sieve.

1.4 Causes of Deterioration:

The following are the causes of failure of structure:

a) Occurrences incidental to construction stage. This could be attributed to

1. Local settlement of sub grade.
2. Movement of formwork.
3. Vibrations.
4. Internal settlement of concrete suspension.
5. Setting Shrinkage.
6. Premature removal forms.

b) Drying Shrinkage

c) Temperature stresses – This may be due to

1. Difference in temperatures between the inside of the building with its environment.
2. Variation in internal temperature of the building or structure.

d) Absorption of moisture by concrete

e) Corrosion of reinforcement – This could be caused by

1. Entry of moisture through cracks or pores.
2. Electrolytic action

f) Aggressive action of chemical

g) Weathering action

h) Action of shock waves

i) Erosion

j) Poor design details at

1. Re-entrant corners

2. Changes in cross section

3. Rigid joints in precast elements

4. Deflections

This lead to
1. Leakage through joints

2. Inadequate drainage

3. Inefficient drainage slopes

4. Unanticipated shear stresses in piers, columns and abutments etc

5. Incompatibility of materials of sections

6. Neglect in design

k) Errors in design
l) Errors in earlier repairs
m)Overloading
n) External influences such as
1. Earthquake

2. Wind

3. Fire

4. Cyclones etc.