NDE2002 predict. assure. improve.
National Seminar of ISNT
Chennai, 5. – 7. 12. 2002
www.nde2002.org

NEED FOR NON-DESTRUCTIVE TESTING (NDT) OF REINFORCED CONCRETE & VARIOUS ND TESTS

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Even though concrete is one of the most widely used construction material, the manner in which it is presently prepared & used to form structures, leaves many a things to be desired. This may mostly be attributed to lack of proper quality control & supervision during the course of construction. Often safety & durability of structures are given the go-by by permitting poor quality of construction. When one builds a structure, it has to perform satisfactorily over the reasonably expected life.

At present the test used mainly as a basis of quality control is compression testing of cubes & it represents the potential strength of the concrete used. The main parameters determining the quality of concrete are its composition, compaction & curing. At the most it can be ensured that the composition of concrete going into the cubes & that going into the structure is the same; there may be some scope of differences in this case also. However, the methods of compaction & curing may be & usually are different for the cubes & the structural members. This is why the results obtained on cubes may not truly represent the quality of concrete in the structure.

Hence the need for Non-destructive Testing (NDT).

Type of ND Tests

1. Rebound Hammer Test

This is basically a surface hardness test & should be used only on concrete where the surface has not carbonated as the results tend to be very high & unrealistic on a carbonated surface. Hence it should be used for younger concrete than for older one. In case of old concrete the carbonated layer should be chipped off or grounded to expose the core concrete & then the hammer test should be conducted. The rebound is affected if the surface is moist.

2. Ultrasonic Pulse Velocity (UPV) Test

This test is conducted for assessing the quality & integrity of concrete by passing ultrasound waves through the specimen / RCC member under test. This test can also be used to determine the presence of honeycombs, voids, cracks etc. The instrument consists of a transmitter & a receiver (two probes). The time of travel for the wave to pass from the transmitter to the receiver when kept opposite to each other is recorded in the ultrasonic instrument. The distance between the two probes (path length) can be physically measured.

Hence Ultrasonic Pulse Velocity = Path length / Time

This velocity in concrete can be related to its compressive strength.

3. Electrical Resistivity Test

This test is carried out to assess the quality / uniformity of concrete at various depths. The instrument consists of a four probe device. Electrical current is passed through the outer probes & the potential drop is measured by the inner probes. From the current & voltage drop measurements, the resistivity of concrete can be measured. This resistivity can be related to quality of concrete.

Electrical resistivity = 2(pi)aE/i (in kilo-ohm cm)

where
- pi = 22 / 7 = 3.14
- a = distance between probes
  - = 5 cm in the 1st set of readings
  - = 10 cm in the 2nd set of readings
- E = potential difference between inner two probes in mV
- i = current passed through outer probes in microamp

The penetration of current depends upon the distance between the probes. Various sets of readings are taken.

The electrical resistivity for a homogeneous material is constant.

When the RCC members to be tested are covered with costly finishes like marble, granite etc. this test can be used without having to remove such finishes.

Apart from quality / strength of concrete it can also give information about the total thickness of the specimen under test & the backing material (in case of tunnel lining or pavements where only one surface is available for testing & no other test can give the said information). The backing material could be concrete, water, air or rock in case of tunnel lining.

4. Half-cell Potential Test

This test can give the probability of corrosion activity taking place at the point where the measurement of potentials are taken from a half-cell, typically a copper-copper sulphate half-cell. An electrical contact is established with the exposed steel & the half-cell is moved across the surface of concrete for measuring the potentials.

5. Cover Meter Test

This test is useful for the determination of concrete cover, location of embedded rebars & estimation of size of embedded rebars. The instrument is based on the magnetic technique & is calibrated for different purposes. The cover thickness is important from the point of view of estimation of initiation of corrosion.
The location & estimation of bar diameter becomes useful in structures where there are no structural drawings available.

6. Carbonation Depth Measurement

The quality of cover concrete holds the key to the process of corrosion initiation. Hence when the cover concrete is carbonated the process of corrosion enhances due to the reduction in the alkalinity surrounding the rebars. The estimation of carbonation depth thus helps in predicting the period of protection from corrosion.

7. Chlorides (as Cl) Determination Test

Apart from (or after) the carbonation of concrete, the natural protection to steel is lost & thus the chlorine present in the atmosphere is free to attack the embedded steel. Above a threshold value of chlorine ions along with degree of alkalinity of concrete, the rate of corrosion increases. Hence it becomes important to estimate the chlorine ion content to comment on the corrosion of steel.

8. In-situ Water Permeability Test

This instrument is useful for comparing different grades of concrete depending on the permeation of water through the concrete. It consists of a chamber that can be sealed after filling water. After keeping the desired level of pressure, as the water penetrates the pressure drops & a micrometer screw gauge fitted with the instrument is used to keep the pressure constant. The penetration of the screw gauge is used to determine the penetration of water in volume.

9. Core Test

This is a partially destructive test that is used to co-relate the various other properties of the concrete viz. UPV, electrical resistivity, rebound number etc. It is customary to take cores of 4 inch diameter for compressive strength determination.

Concrete core drilling for strength determination is again dependent upon various factors for reliability. The conversion of concrete core (typically 3 or 4 inch diameter core) strength into “150 mm saturated cube” strength depends upon :

1. effect of coring
2. shape factor
3. size effect
4. direction of coring w.r.t. placing of concrete
5. h/d ratio

With so many factors contributing to the final “150 mm saturated cube” strength, the strength variation may be + / - 10% - 15%. However, it can be used to confirm the results of UPV differing largely in the values & also for co-relation. Hence the UPV & core results should be judiciously used, interpreted & co-related.

The Non-destructive Testing (NDT) should however be carried out by agency having sound & sufficient knowledge & experience in this field as well as behaviour of concrete.