TECHNIQUES FOR REPAIR & PROTECTION METHODS

Non-destructive Testing Techniques, Epoxy injection - Shoring, underpinning. Corrosion protection techniques - Corrosion inhibitors, Corrosion resistant steels - Coating of reinforcement, Cathodic protection.

NON-DESTRUCTIVE TESTS

The material is tested without causing any damaged to the structure.

Types:

* Rebound hammer for strength of concrete
* Ultrasonic pulse velocity apparatus for crack detection
* Magnetic detector for locating reinforcement bars and measuring thickness cover.
* Extensometer & template microscope for measuring crack width
* Pressure transducer, hydraulic force for measuring loads or pressure.

* Strain gauge, results for strain measurement
* Vibration measuring equipment
* Rebound hammer test
* Load test
* Carbonation test
* Ultrasonic pulse velocity test
* Half-cell potential test
* Pull out test

REBOUND HAMMER TEST

* When the plunger of rebound hammer is pressed against the surface of a concrete mass, constant energy is applied on the concrete surface to rebound back.
* The extension of rebound is measured on a graduated scale; It is a measure of surface hardness.
* It is designated as rebound number
* Lower rebound value shows low strength and low stiffness concrete.
* This test is to measure surface hardness and compressive strength of concrete
* Rebound hammers measure the elastic rebound from the surface of concrete.
* The rebound value indicated by the hammer relates to the Compressive strength of Concrete. They are available in two varieties. regular and pendulum type.

The pendulum type hammer is applicable to low strength concrete such as light weight concrete and to weak masonry blocks

Rebound & penetration measures the surface hardness of concrete. Surface hardness is proportional to comp. strength.

The procedure test is given in IS 13311 : 1992 part 2.

Avg. rebound	Quality of concrete
>40	Very Good
30-40	Good
20-30	Fair
< 20	Poor
0	very poor.

ULTRASONIC PULSE VELOCITY TEST

Procedure of the test is given in IS 13311:1992

* Ultrasonic scanning is to qualitatively assess the homogeneity and integrity of concrete. With this technique following can be assessed.

* qualitative assessment of strength of concrete, its graduation in different locations of structural members and plotting the same.

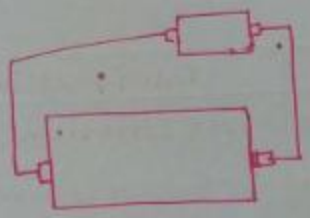
* Any discontinuity in CIS like cracks, cover concrete delamination

* Depth of surface cracks

Test Result	Interpretations
1. High UPV, high rebound number	Not corrosion prone
2. Medi UPV, low rebound numbers	Surface delamination, low quality of surface concrete
3. Low UPV, high rebound nos	Not corrosion prone, However to be confirmed by chemical tests, pH Carbonation.
4. Low UPV, Low rebound numbers	Corrosion prones + requires chemical & electrochemical tests.

Ultrasonic pulse velocity method is the measurement of the transmit time of an ultrasonic pulse blw the transmitter & receiver. If the distance blw them is known the velocity of the pulse can be determined. The more dense & strong the concrete being tested, the higher the velocity of pulse.

To test concrete, contact blw the concrete and the transmitter & receiver is made with a coupling agent such as petroleum jelly. The velocity of sound waves through the concrete is reduced by the presence of voids or cracks.



CORE TEST:

* When the grade of Concrete used to be checked for poor quality If the results of Cube Strength tests is not Satisfied Core test to find the real compressive strength or load test to be Carried out.

Cores are Cut by means of a rotary cutting tool with diamond bits.

The Cut cylinder specimen is with uneven ends. The core should then be soaked in water, capped with molten sulphur to make its ends plane, parallel, at right angle and then tested in compression in a moist condition as per Codal provisions.

The core sample is used for the following

* Strength & density determination
* Depth of Carbonation of Concrete
* Chemical analysis
* Water / gas permeability
* Petrography analysis

PROBE PENETRATION TEST

Probe Consists

- → A gun powder activated driver
- → Hardened alloy rod probe
- → Loaded Cartridges
- → A depth gauge

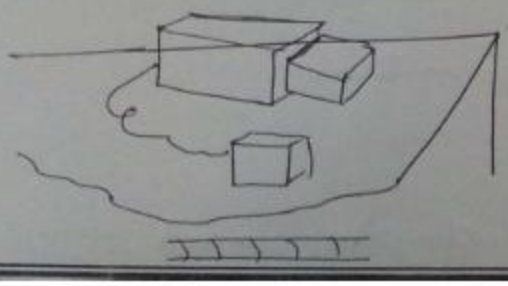
The probe is fired into the concrete by the gun powder actuated driver. The exposed length of probe is measured by a calibration depth gauge. Concrete strength is defined by penetration depth.

Probe penetration techniques works on the principle of resistant to penetration of a probe. In this technique a probe is shot into the concrete with a definite amount of energy. The depth of penetration is related to compressive strength of concrete.

ELECTRO MAGNETIC TECHNIQUES

Electro magnetic techniques are used to detect the depth of rebar. As such this can be done by magnetic reluctance or electro magnetic current

In the magnetic reluctance method, the presence of rebar increases the electro magnetic flux in the U-magnet & this is detected by the meter. In the Eddy current technique, the magnetic field in a coil induces Eddy currents in the rebar. This Eddy Current generates a magnetic field of its own that interferes with the main magnetic field. The change in inductance of the coil is then measured using the meter. Such probes are commonly used for rebar locating devices such as Pachometer. A schematic diagram of the use of a pachometer is



EPOXY INJECTION

Epoxy or polymer in liquid form injected at suitable pressure through the cracks in concrete with proper surface sealing of the visibility of the cracks is an effective method of reducing, controlling or eliminating leakage through cracks in concrete. skilled man power with professional technical application in the successful solution for grouting or pressure injection is applied.

Epoxies are highly tensile of viscous which pass through fount flow paths when injected.

EPOXY RESINS

Epoxy resins are used for the following purposes

* The bond plastic concrete to a hardened conc. surface
* To bond two rigid materials.
* For patch work
* For applying a coating over concrete surface to give

Colour, resistance to penetration of water & chemicals and resistance to abrasion.

Epoxy resins are excellent binding agents. The low viscosity resins can be injected into small cracks. The higher viscosity are used as coating and for filling larger openings or holes.

EPOXY MORTAR

The epoxy mortar is made using epoxy resin, sand, cement & water. The resin is added as an additional binder. It has high comp strength, high tensile strength and low modulus of elasticity. The polymer particles join and form chain link reinforcement, increasing the tensile strength of mortar. There is greater plasticity and reduction in shrinkage stress.

SHORING

The shoring depends on the specific project and type of underpinning envisaged. However, a few common techniques of shoring are discussed below.

RAKING SHORE

Raking shore are used to support external walls from going out-of-plumb during the underpinning operation. A typical raking shore for a three-storey building is s.i.f.

The wall of one building can be supported by the wall of the adjacent building by providing 'flying' shores the distance b/w the two building should be small for effective shoring. Flying shores cannot support the weight of the wall. However they prevent building and out of plane movement of the wall.

UNDER PINNING

Once underpinning is selected as the retrofit strategy the method of underpinning and temporary support should be worked out. The methods of underpinning are described here.

Underpinning Continuous Strip foundations

Generally, a masonry wall can be unsupported over a length of 1 to 1.5m Shows the sequence of the pits for underpinning. The segments are numbered 1 to 6 based on the sequence. The work can simultaneously proceed on segment having the same number. After the excavation, concrete is placed in the pit up to a depth of 75 to 100mm from the underside of existing foundation

Any gap b/w the new concrete & the existing foundation can be filled with expanding mortar. Horizontal reinforcing bars of short lengths can be provided longitudinally b/w the segment polymeric agents, provided b/w adjacent segments, improve the bond. After the pit is completed it is worthwhile to undertake pressure grouting to fillup any void b/w segments.

Piror pile group foundation may be desirable method of underpinning at deep excavation sites. First the load on the existing foundation is relieved by inserting needle beams as explained in the previous section next additional beams are provided to transfer the load from the existing foundation on the piers or pile groups. The beams can be inserted in one of the following ways.

* Support the wall for the full length b/w the piers
* Insert the beams into openings made in the foundation & supporting them on piers

* Insert precast concrete blocks into the opening made in the foundation & make it continuous b/w the piers.

After connecting the piers to the inserted beams, the needle beams can be carefully removed to transfer the load to piers

Corrosion protection Techniques

Corrosion of reinforcement is the electrochemical degradation of steel in concrete. It occurs when the passivity of the steel is destroyed by Carbonation or by chloride ions. Electrochemical cells develop when steel corrodes in concrete, a potential diff exists blw the anodic half-cell areas & the cathodic half-cell on the surface of the concrete & measuring the potential diff blw the reinforcing steel and wet sponge on the concrete surface. The reference cell connects the concrete surface to a high-impedance voltmeter, which is also connected electrically to the reinforcing steel mat. The voltmeter then reads the potential difference at the test location. These readings are taken on a grid basis & converted into potential gradient mapping.

It is generally agreed that the half cell potential measurements can be interepreted as follows.

* Less negative than 0.2V indicates a 90%. probability of no Corrosion.
* Blw 0.2 & − 0.35 V. Corrosion activity is un certain
* More negative than 0.035 volts is indicature of a greater than 90%. probability that corrosion is occuring.

If positive readings are obtained, it usually means that insufficient moisture is available in the concrete & the readings are not valid. These tests do not indicate the rate of corrosion. the measurement only manifest the potential for corrosion at the time of measurement. These half cell methods cannot detect corrosion in post-tensioned strands, nor can they detect corrosion when reinforcing steel is dis Continuous from the voltmeter. However half cell measurements are often useful because they are easy to perform, and results can be delivered quickly at relatively low costs.

Corrosion inhibitors

A corrosion inhibitor is an admixture that is used in concrete to prevent the metal, embedded in concrete form cording. There exists various types of inhibitors like Cathode, Anode, mixed & Dangerous safe.

In the high pH of concrete the steel is protected by a passivating layer of ferric oxide, on the surface of steel

Passivity is the result of formation of a highly protective but very thin and quite invisible film on the surface of metal or an alloy, which makes it more fine. However the passivating layer also contains some ferrous oxide, which can initiate corrosion, when the chloride ions reach the steel. The nitrite ions present in corrosion inhibiting admixture will oxidize the ferrous oxide.

Passivating layer even in the presence of chlorides

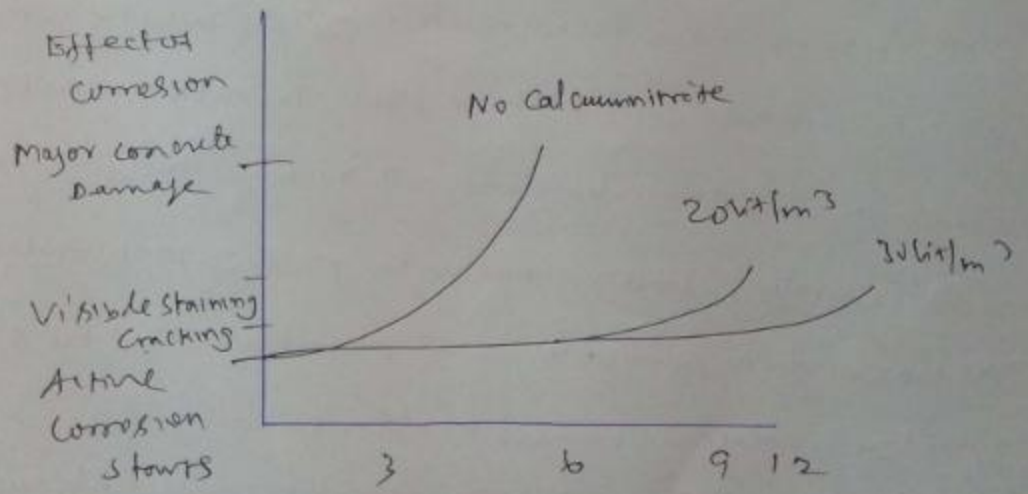
The concentration of nitrite must be sufficient, to cope up with the continuing ingress of chloride ion.

Calcium nitrite corrosion inhibitor comes in a liquid form containing about 30% calcium nitrite solids by weight

The more corrosion inhibitor is added the longer the onset of corrosion will be delayed.

Since most structures in a chloride environment reach a layer of about 7 kg of chloride ion per m^3 during their service life, use of less than 15 lit/m^3 of Calcium nitrite solution is not recommended.

Adding calcium nitrite increases this corrosion threshold when you as 20 lit/m^3 corrosion will not begin until over 7.7 kg/m^3 of chlorides present in the concrete @ rebar.



Corrosion Resistant Steel

It is found that susceptibility of mild steel to corrosion is not significantly affected by composition, grade or level of stress. Hence substitute steel for corrosion resistance must have a significantly different composition. Based on some success in atmospheric corrosion. Weathering steels of the corten type were tested in concrete.

They did not perform well in moist concrete, containing chlorides. It is observed that weathering corrode in similar concrete environments, those causing corrosion of high-yield steel. They noted that although the total amount of corrosion was less than would occur on high yield steel under similar conditions, deep localized pitting developed, which could be more structurally

weakening

Stainless steel reinforcement has been used in Special applications, especially as fitments in precast resistance was shown by austenitic stainless steel in all the environments. In which they were tested, but the observations of some very minor pitting in the presence of chlorides lead to the warning that service corrosion ~~susp~~ susceptibility was not evaluated in the test program.

High titanium alloy bar is being used in some countries. This bar is grouted into holes, drilled into the marble slabs, and the grouts are based either on portland cement or Epoxy.

Coatings for steel

Simple cement slurry coating is a cheap method for temporary protection against rusting of bars in storage.

Central electro chemical research institute (CECRI), Karaikudi have suggested a method for prevention of corrosion in steel reinforcement in concrete. The steps involved in this process are.

Derusting

phosphating

Cement coating

Sealing

Galvanized reinforcement

Derusting :-

The Reinforcement are cleaned with a derusting solution. This is followed without delay by leaning the rods, with wet waste cloth and cleaning powder. The rods are then rinsed in running water & air dried.

Phosphating

- phosphating jelly is applied to the bars (with fine brush
- The jelly is left for 45-60 mins. and then removed by wet cloth an inhibitor solution is then brushed

Over the phosphated surface.

Cement Coating

Slurry is made by mixing the inhibitor solution. with portland cement and applied on the bar. A sealing solution is brushed after the rods are air cured. The sealing solution has an insite curing effect. The second coat of slurry is then applied and the bars are air dried.

Sealing

Two coats of sealing solution are applied to bars in order to seal the micro-pores of the cement coated and to make it impermeable to corrosive salts.

This is patent method evolved by CECRI. and licence is given to certain agencies. Some how or other, this method has not become very popular. Some experienced consultants and engineers doubt the effectiveness of this method.

CATHODIC PROTECTION

Cathode protection is one of the effective, well known and extensively used methods for prevention of corrosion in concrete structures in more advanced countries. Due to high cost & long term monitoring required for this method. It is not very much used in India.

The cathode protection comprises of application of impressed current, to an electrode laid on the concrete, above steel reinforcement. This electrode serves as anode and the steel reinforcement, which is connected to the negative terminal of a DC source acts as cathode.

In this process, -ve chloride ions, which are responsible for the damage of the passivating film, are drawn away from the vicinity of steel towards the anode, where they are oxidized to form chlorine gas.

The other recent development in corrosion control method are Re-alkalization & De-salination. The re-alkalisation process allows to make the concrete alkaline again & passivate the reinforcement steel, by electro chemical method. This brings back the lost alkalinity of concrete of sufficiently high level to reform & maintain the passive layer on the steel.

In the desalination process, the chloride ions are removed from the concrete, particularly from the vicinity of the steel reinforcement by certain electrical method to re-establish the passive layer of steel.

It appears that the application of cathodic systems for protection of concrete structures, offers some real hope to conc. technologist, but the field remains open for the introduction of innovative methods to overcome problems of both technique & cost.