Condition Assessment of the Structures by Non-destructive Evaluation Techniques

[By Editorial Office, Dr. Fixit Institute]

1.0 Introduction

To assess the integrity of old or new concrete and reinforcement, non-destructive testing is one of the most powerful and reliable tool. The need to conduct non-destructive testing for condition assessment of the RCC structures has grown considerably in recent times, due to increase in the number of structures showing signs of distress. Non-destructive Testing (NDT) is fast, easy-to-use on site and relatively less expensive. It can be used for the following:

- To test actual structure instead of representative cube sample
- To test any number of points and any location
- As a quality control tool
- To assess the structure for various distressed conditions
- For damage assessment due to fire, chemical attack, impact, age, etc.
- To detect cracks, voids, fractures, honeycombs and weak locations
- To monitor progressive changes in the properties of concrete, reinforcement, etc.
- To assess overall stability of the structure
- To monitor repair and rehabilitation systems
- To scan for reinforcement location, stress locations.

2.0 Investigation of Reinforced Concrete Deterioration

Experience has shown that a number of testing methods are of proven value in determining the extent of deterioration of a concrete structure and in identifying those areas where remedial measures are necessary. While the list of tests discussed herewith is not exhaustive, it does include most of the common tests as well as some known techniques. A systematic approach has to be adopted for condition evaluation of the structures. A visual inspection should be carried out to understand the basic nature of defects, cracks, etc. followed by some specific non-destructive tests. This helps to find out the exact cause of defects and to provide proper solutions for repair; otherwise repetition takes place to repair the same structure again and again without understanding the nature of defects.

2.1 Approach Methodology

Any investigation can conveniently be split into three stages.

Stage 1 - An initial survey to identify the cause of the problems.

Stage 2 - An extension of the stage 1 survey, perhaps using a limited number of techniques to identify the extent of the defects revealed by stage 1.

Stage 3 - Localized investigation by partial destructive tests to reinforce the test results as carried out in stage 2.

The advantages of such an approach are clear. In the stage 1 survey, work can be carried out on selected areas showing typical defects but choosing these, as far as possible, from areas with simple access i.e. ground level, roof level, from balconies, etc. Occasionally, a light weight scaffold tower or an electrically powered hydraulic lift can be used to advantage. One or more areas, apparently free from defect, will also be examined in this initial survey as it is frequently found that by comparing good areas with bad ones, the reasons for the problem emerge by simple comparison.

In stage 2, once the defects have been identified, it is often necessary to quantify the extent of the problems. This may be as simple as carrying out NDT test such as a cover meter survey over the whole structure, where low cover has been identified as the problem, to the application of one or more of the other techniques described below.

In stage 3, some partial destructive tests may be carried out by taking core samples without cutting the reinforcing bar. The reinforcing bar position can be located by a bar locator/ cover meter. The core samples can be used for compressive strength and chemicals tests such as carbonation, chlorides and sulphates.

2.2 Visual Survey

After collecting as much background data as possible, any testing problem should begin with a thorough visual survey of the structure. This may conveniently be recorded on a developed elevation giving particular attention to the following defects:

- Cracks or crazing
- Spalling
- Corrosion of steel and rust staining
- Hollow surfaces
- Honeycombing due to poor compaction or grout loss
- Varying colour or texture
- Areas in which remedial finishing work had already been carried out
- External contamination or surface deposits
- Wet or damp surfaces

Throughout the course of any investigation colour photographs should be taken of points of particular interest.

In recent years, significant advances have been made in non-destructive testing techniques, equipment and methods which should be carried out after the visual inspection. The various tests and their utility are discussed in the following sections.

The structural diagnostic services are rendered broadly in three stages as shown in Figure 1.

3.0 Selection of Non-destructive Testing Method

Type of tests to be carried out and their purposes such as non destructive testing, extraction of samples and laboratory tests are given in Table 1. Sampling plan indicating the tests and samples quantity, test and sampling locations and rational behind the sampling sizes and locations should be in accordance with the standards. The test and sampling plan would need to address the objectives of the investigation, findings from the visual survey and any limitations and constraints.

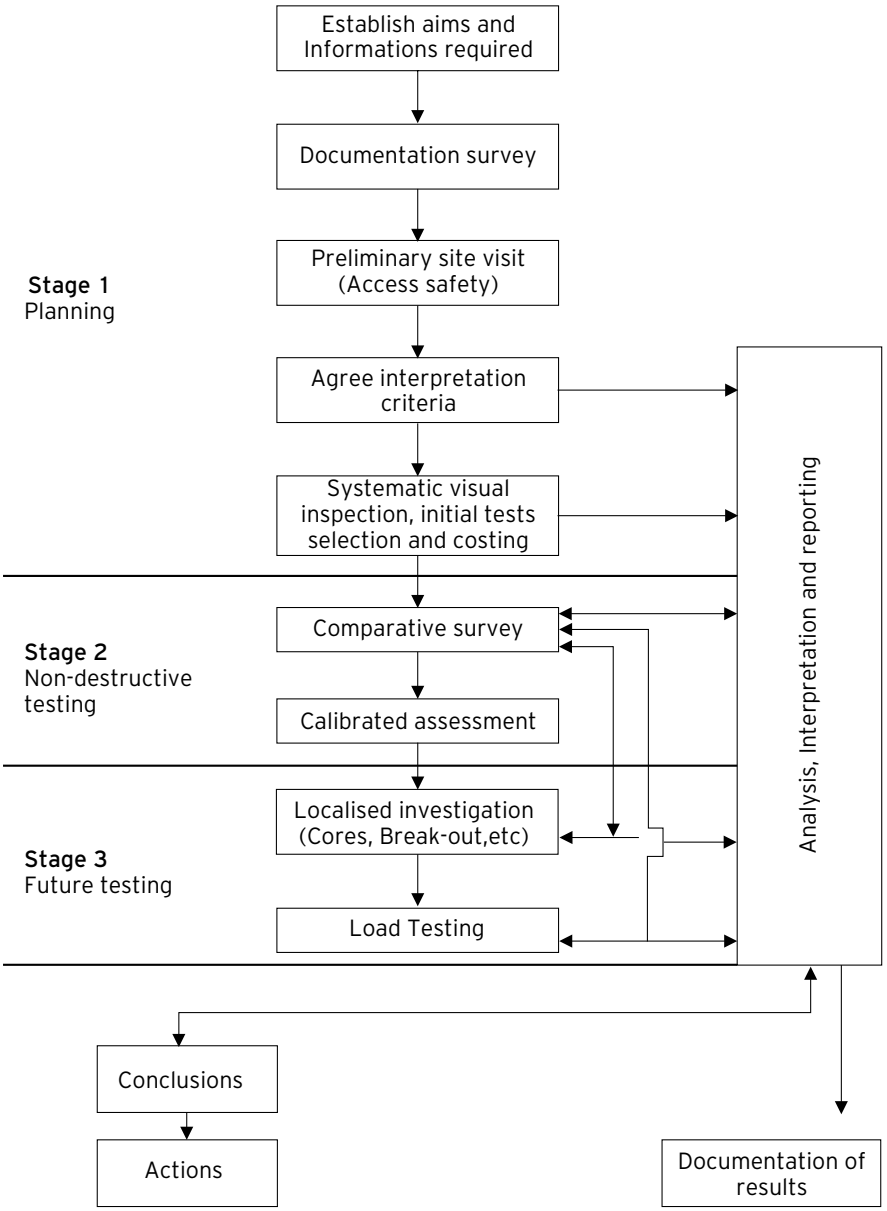

Fig. 1: Three stage approach of condition assessment of the structures

Table 1: Tests and test methods

Parameter	Test / Method
CONCRETE	
Compressive strength	Rebound Hammer Windsor probe Ultrasonic Pulse Velocity Core Capo Pull out Combined methods
Flexural Strength	Break - off
Direct tensile strength	Pull- off
Concrete Quality, Homogeneity Honeycombing, voids,	Ultrasonic Pulse Velocity Pulse echo Endoscopy Gamma Ray Radiography
Damages – Fire/ blast	Rebound Hammer Ultrasonic Pulse Velocity
Cracks – water tanks/ pavements	Ultrasonic Pulse Velocity Acoustic Crack Detector Dye Penetration Test X – ray Radiography Gamma Ray Radiography Thermal imaging Crack scope
STEEL	
Location, cover, size	Re bar locator, Bar–sizer
Corrosion	Half-cell Potential Resistivity Carbonation Chloride Content
Condition	Endoscope/ Borescope
INTEGRITY & PERFORMANCE	Tapping Pulse–echo Acoustic emission Radar Petrography Load Test

4.0 Preparation of Report

The comprehensive report of the condition survey of the building is prepared based on the visual inspection and NDT results as given in Table 2.

The report should include information collected from the occupants, detailed description of the building, condition of various internal and external RCC members with critical photographs, condition of various non-structural elements with critical photographs and NDT and core sample test results and extent of defects/ distress and their causes.

Table 2: A standard dignosis report format

Sl. No	Element	Location/ Identity	Defect Observed	Results from NDT	Remarks
1.					

5.0 Recommendations

Based on the visual inspection and NDT results correlation between different results/ observations should be carried out. The summary of all results including acceptance guides, if available should be provided. It should include variability of results and statistical data. Where appropriate, a separate compilation of results for different structural elements, categories of structures, should be provided along with statistical analysis. The serviceability assessment or remnant life assessment, durability etc should also be calculated. The overall condition assessment of the structures/ buildings should be categorized as follows:

- C1 : The building is structurally unsafe and has been found to be in extremely dangerous condition. This building needs to be vacated immediately and demolished.
- C2 (A) : Only a portion of this building is in extremely dangerous condition (not repairable and worthy of demolition), while other portion can be repaired or strengthened. This building need not be vacated completely. The extremely dangerous portion should be cordoned off.
- C2 (B) : The building has been found to be dangerous (need major repairs/ strengthening urgently, but need not be vacated).
- C3 : The building condition is satisfactory (need minor repairs).

Recommendations should be given for further testing if test results are inconclusive. Finally suitable repair, protection, restoration, strengthening techniques along with their materials and method statements should be recommended. Also future maintenance and inspection schedules should be recommended.

6.0 Conclusion

Non-destructive testing has not yet been adopted as routine testing. Whenever there are some problems with cement/ concrete strength and finish, then NDT is used only as a rescue tool. Now the time has come to use these NDT techniques as routine testing to have more effective quality control. The main advantage of this testing is to assess the in-situ quality of concrete. These techniques help to decide the acceptability of the concrete structure. NDT has become mandatory testing, in addition to cube testing, in some parts of the world. In India some Govt. agencies have included NDT as mandatory testing, in addition to cube testing. All other agencies, RCC consultants, Municipal Corporations, etc. should specify these tests in their tenders as an additional quality control tool. Municipal corporations can make use of these tests to check the stability of old, distressed and unsafe structures.