UNIT II
SOUND WAVE AND ITSAPPLICATIONS

CHAPTER-04
Non-destructive Testing

Non-destructive Testing

- Non-destructive testing (NDT) is the technique of determining the quality of a product without impairing its properties in any way.

- Non-destructive testing can be applied to both old and new structures.

- For new structure, the main objective is quality control or the resolution of doubts about the quality of materials or construction.

- The testing of existing structures is usually related to an assessment of structural integrity or adequacy.

OBJECTIVES OF NON-DESTRUCTIVE TESTING

- Assessment of the quality of the product or concrete in relation to standard requirements.
- Quality control of pre-cast units.
- Monitoring of strength development in relation to formwork removal, cessation of curing, prestressing, load application or similar purpose.
- Removing uncertainties about the acceptability of the material supplied, owing to apparent noncompliance with specification.

OBJECTIVES OF NON-DESTRUCTIVE TESTING Contd…

- Confirming the doubt concerning the workmanship involved in batching, mixing, placing, compacting, or curing of concrete.
- Determining the locations of cracks, voids, honeycombing, and similar defects within a concrete structure.
- Searching the location of suspected deterioration of concrete or products in a structure due to overloading, fatigue, external or internal chemical attack, fire, explosion, and environmental impact.
- Assessing any proposed change in a structure for its insurance or for change of ownership.

TYPES OF DEFECTS

1. Cracking

- ✓ *Dormant*
- ✓ *Active*
- ✓ *Fine, medium, and wide cracks*

2. Spalling

Important Causes for Spalling are;

- ✓ *Concentrated eccentric external load producing highly stressed narrow compression zone.*
- ✓ *Corrosion of steel embedded in concrete.*
- ✓ *Freeze–thaw effect of entrapped water*
- ✓ *Chemical reactions, efflorescence, and repeated wetting and drying.*

3. Rain Damage

✓*Heavy rain may cause pitted surface or eroded surface on a concrete structure.*

4. Blistering

✓ *Blisters occur when the fresh concrete surface is sealed by trowelling trapping air or bleed water under the surface.*

5. Staining

✓*Staining is mainly caused by efflorescence.*

6. Honeycombing

✓*It occurs as a result of poor compaction, or if a bony mix is used with not enough sand*

7. Dusting

✓*Such defect is caused when finishing work is done on the concrete before bleed water has dried out or due to inadequate curing.*

6. Construction and Design Defects

- ✓*Choice of wrong wall thickness*
- ✓*Out of plumb of walls*
- ✓*Defective joint and bonds*
- ✓*Lack of movement joints*
- ✓*Misalignment of joints*
- ✓*Failure to connect inserting walls and columns*
- ✓*Improper drainage path causing staining.*
- ✓*Poor layout that causes excessive torsion.*
- ✓*Selection of inadequate diaphragm stiffness for distributing lateral shear.*
- ✓*Cracking below beams due to inadequate gap for deflection.*

METHODS OF NON-DESTRUCTIVE TESTING

Some important techniques are as follows :

- Liquid penetration method
- Dye penetration method
- Radiographic testing
- Ultrasonic inspection method
- Pulse echo method
- Magnetic particle testing
- Eddy current testing

Liquid Penetration Method

- Liquid penetration method is one of the simplest and low-cost method of testing.
- In this test, liquid is applied uniformly on the surface to be tested.
- When liquid comes into contact with dry concrete, it is absorbed by the surface defects such as minute cracks and pinholes, and gets trapped.
- Now developer is used to record the surface defects.
- Liquid penetration method is frequently used in detecting the cracks in turbine blades, smoothness of the surface, minor and middle type surface cracks, etc.

Dye Penetration Method

- Dye penetration inspection (DPI) is the low-cost inspection method used to locate surface breaking defects in all non-porous materials (metals, plastics or ceramics).
- The penetrant may be applied to all non-ferrous materials; however, for inspection of ferrous components, magnetic particles inspection is preferred.
- This method is used to detect casting and forging defects, cracks, leaks in new products and fatigue cracks on inservice components.

Dye Penetration Method Continued ……

- Principle of this method is based on capillary action, when low surface tension fluid penetrates into clean and dry surface-breaking discontinuities.

- According to the selection of sensitivity levels, different types of penetrants are used in this method.

- Liquid penetration has the following limitations:

(i) This test is very sensitive to changes in quality and to correlate with the observed weathering behaviour.

(ii) This method is not applicable for porous and honeycombed concrete.

Radiographic Testing

- Radiographic testing is used to determine the position of cables, voids in grouting, and in situ density of concrete.

- Depending on the choice of radiations, there are three methods used for testing of concrete, viz.,
  - X-ray radiography
  - *γ-ray radiography*
  - *γ -ray radiometry.*

Principle

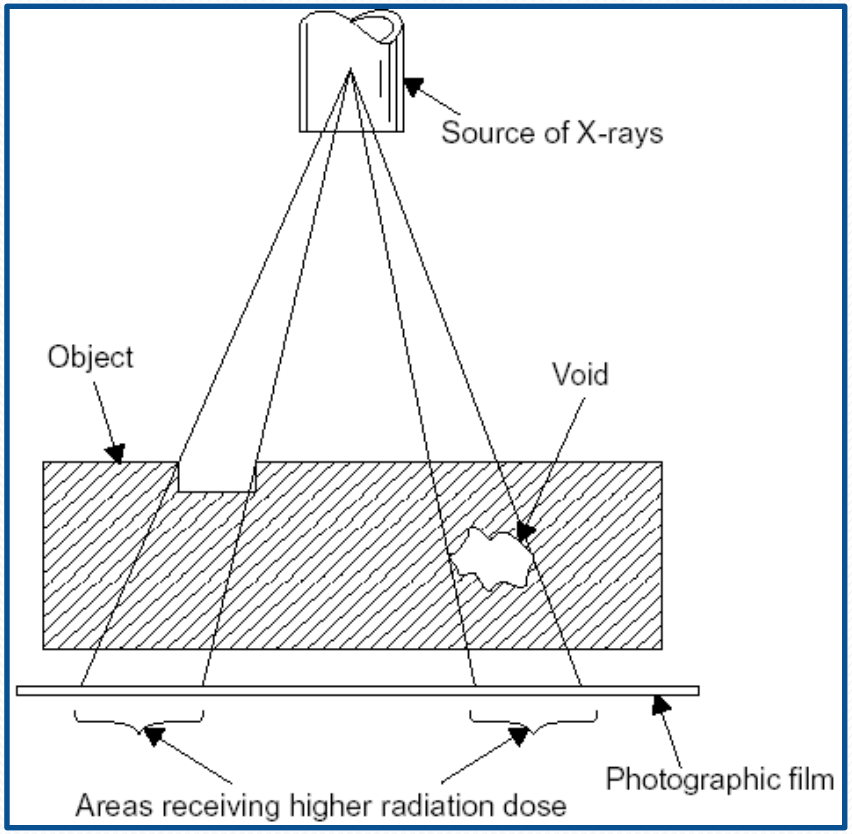
The intensity of a beam of X-rays or gamma rays suffers a loss of intensity while passing through a material, according to the relation

$$I = I_0 e^{-\mu x}$$

where *I is the intensity of transmitted radiation*, I_0 *is the intensity of incident radiation, m is the attenuation* coefficient, and *x is the thickness of object.*

Inspection Method (Procedure)

- Three steps are used in the inspection method of radiographic test.
- Suitable radiation (X-ray or gamma ray) is allowed to pass through the structure under examination.
- Impression or image of defects in structure are obtained on a photographic plate.
- Film is examined by different exposures.



Limitations

(i) It is expensive.

(ii) It requires stringent safety precautions.

(iii) It is also limited by the member thickness (maximum upto 600 mm).

Ultrasonic Inspection Method

In this method an ultrasonic pulse is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete under test.

Principle

The velocity of ultrasonic waves are different in different medium observed by simple equation

$$v = \frac{L}{T}$$

where v is the longitudinal pulse velocity, L is the path length, and T is the time taken by the pulse to traverse that length.

Different Methods

Direct method: The direct method is preferred wherever access to opposite sides of the component is possible.

Semi-direct method: The semi-direct method is used wherever access to different but not opposite sides of the component is possible.

Indirect method: The surface method or indirect method is least satisfactory and should be used when access to only the surface is possible

Limitations

- Variation of concrete temperature may affect the pulse velocity.

The increase in the moisture content in concerete increases the pulse velocity.

- The pulse velocity measured in reinforced concrete in the vicinity of reinforcing bars is usually higher than in plain concrete of the same composition.
- For highly stressed concrete, pulse velocity may be reduced due to the development of microcracks.

Pulse Echo Method

Pulse echo method is used for locating defects such as voids, cracks, fracture, crack growth, metallurgical change, and zone of deterioration.

Principle

The principle of this method is based on the interaction of acoustic waves with the internal structure of the object under examination.

Apparatus Required

- *Normal probe: It serves the purpose of both* transmitter and receiver.
- *Preamplifier, filter, and processor: The signal detected at normal probe* is amplified by preamplifier unit. Unwanted signal (if any) are filtered by filtering unit. Processor is used to display this signal in terms of desired scale.
- *Display unit: Display unit is used to realise the typical trace between the time and intensity of* reflected pulse from the object under test.

Schematic Diagram of Pulse echo Method of Testing