Visual Inspection of Concrete Structure

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Visual inspection is one of the most versatile and powerful of the NDT methods, and it is typically one of the first steps in the evaluation of a concrete structure. Visual inspection can provide a wealth of information that may lead to positive identification of the cause of observed distress. However, its effectiveness depends on the knowledge and experience of the investigator. Broad knowledge in structural engineering, concrete materials, and construction methods is needed to extract the most information from visual inspection.

Before performing a detailed visual inspection, the investigator should develop and follow a definite plan to maximize the quality of the record data. Visual inspection has the obvious limitation that only visible surface can be inspected. Internal defects go unnoticed and no quantitative information is obtained about the properties of the concrete. For these reasons, a visual inspection is usually supplemented by one or more of the other NDT methods, such as by concrete test hammer, ultrasonic concrete tester and partial destructive testing by drilling cores and testing them for compressive strength.

Optical magnification allows a more detailed view of local areas of distress. Available instrument range from simple magnifying glasses to more expensive hand-held microscope. A very useful tool for crack inspection is a small hand-held magnifier with a built-in measuring scale on the lens closet to the surface being viewed. With such a crack comparator the width of surface opening cracks can be measured accurately. Identification of cracks in a concrete structure is given in table-1.

Table-1: Non-Structural cracks which can occur in concrete:

Type of Cracking	Common Location	Cause of Cracking	Remedy	Time of Appearance	Fig. No.
Plastic Settlement	Top of columns, slabs	Excess bleeding	Reduce bleeding	10 min to 3 h	a
Plastic shrinkage	RCC slabs	Rapid early drying	Prevent	30 min to 6 h	b

			evaporation just after casting		
Early thermal contraction	Thick walls and slabs	Rapid cooling	Reduce heat and insulate	1 day to 2 or 3 weeks	
Long term drying shrinkage	thin wall and slabs	Inefficient joints	Reduce water content, Improve curing	Several weeks or month	C/1, C/2
Crazing	Slabs	Rick mixes over travelling, poor curing	Improve curing and finishing	1 to 7 day	
Corrosion of reinforcement	Column and beams	Inadequate cover, poor quality concrete	Eliminate the listed cause	more than 2 years	d
Alkali aggregate reaction	Deep location	Reactive aggregate and high alkali cement	Eliminate the listed cause	More than 5 years	e
Sulphate Attack	Members expose to sulphate attach	Soluble sulphates as SO_3 in soil and ground water	Ref. table 4 IS: 456-2000	—	f

TESTING CONCRETE BY TAPPING METHOD

As part of visual inspection the strength of concrete may be roughly obtained by tapping method. However, this may not be treated as substitute of cube testing. Tapping an object with a hammer is one of the oldest form of non-destructive testing based on stress-wave propagation. The method is subjective, as it depends on the experience of the operator, sounding is a useful method for detecting near-surface delimitations.

In the tapping method the strength of concrete may be determine either from its hardness when scratched with a metal "pencil" or a chisel, or from the character of the sound when struck with a hammer, or from the character of the mark left after a hammer blow.

The tapping method is not very exact but it is simple and can be easily applied for an approximate determination of the strength of concrete. On the concrete to be tested a smooth surface about 100×100 mm is chosen and cleaned with a wire brush. Then a hammer 300-400 gms in mass is struck against the concrete from elbow height directly or through a metal worker's chisel placed at right angles to the tested surface. The size of the mark left by the hammer or the chisel and the sound of the hammer stroke are indicative of the strength of concrete. Ten blows of average force are made at different points on the specimen. Results, exceeding low, are disregarded. Approximate values of the strength of concrete obtained from these tests are given in table.2.

The tapping method is used for an approximate determination of strength of concrete, because the force of the blow and the accompanying sound vary greatly depending on subjective factors.

Table-2. Strength of concrete by tapping method:

Strength of concrete (N/mm^2)	Test Results		
	Blow of hammer (0.4 kg) upon concrete surface	Blow of hammer (0.4kg) upon chisel placed at right angles to concrete surface	Scratching by chisel
Blow 6.0	Sound-toneless deep dent with crumbling edges	Chisel is easily driven into concrete	Concrete cuts easily and crumbles
6-10	Sound-slightly toneless. Dent has smooth edges, concrete crumbles	Chisel can be driven into concrete deeper than 5 mm	Visible scratches 1-1.5 mm deep
10-20	Sound-clear whitish mark remains	Thin scales split off round the mark	Visible scratches no deeper than 1 mm
Over 20	Sound-ringing metallic mark-visible	Mark is not very deep	Barely visible scratches

VISUAL INSPECTION OF FIRE DAMAGE CONCRETE

Visual observation of spalling and colour change aided by surface tapping is the principle method of assessment of fire damage. Conclusive results may be obtained by hammer test, ultrasonic pulse velocity measurement, drilling of cores and testing them for compressive strength. Finally, if required by load testing of structure. For detail investigation testing of steel and chemical analysis of concrete samples may be carried out.

Table- 3: Visual observation of fire-damaged concrete structure

Changes in fire-damaged concrete:	
<300^{0}C Boundary cracking alone	
250-300^{0}C	Aggregate colour changes to pink to red
300^{0}C	Paste develops a brown or pinkish colour
300-500^{0}C	Serious cracking in paste
400-450^{0}C	Portlandite converts to lime
500^{0}C	Change to anisotropic paste
500-600^{0}C	Paste changes from red or purple to grey
573^{0}C	Quartz gives a rapid expansion resulting from a phase

	change from alpha to beta quartz
600-750^{0}C	Limestone particles become chalky white
900^{0}C	Carbonates start to shrink
950-1000^{0}C	Paste changes from grey to buff
Change in aggregate	
250-300^{0}C	Aggregate colour changes to pink to red
573^{0}C	Quartz gives a rapid expansion resulting from a phase change from alpha to beta quartz
600-750^{0}C	Limestone particles become chalky white
900^{0}C	Carbonates start to shrink
Changes in the paste	
300^{0}C	Paste develops a brown or pinkish colour
400-450^{0}C	Portlandite converts to lime
500-600^{0}C	Paste changes from red or purple to grey
950-1000^{0}C	Paste changes from grey to buff

CONCLUSIONS:

1. Visual inspection is a very powerful NDT method. Its efficiency, however, is to a large extent governed by the experience and knowledge of the investigator. A broad knowledge of structural behaviour, materials, and construction methods is desirable. Visual inspection is typically one aspect of the total evaluation plan, which will often be supplemented by a series of other NDT methods or invasive procedures.
2. Visual features may be related to workmanship, structure serviceability and material deterioration, and it is particularly important that the engineer be able to differentiate between the various types of cracking which may be encountered.
3. Visual inspection will also provide the basis of judgment relating to access and safety requirements. There are already frightening examples where public safety has been put at risk due to lack of simple regular visual inspection.

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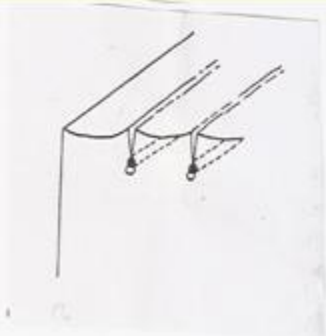
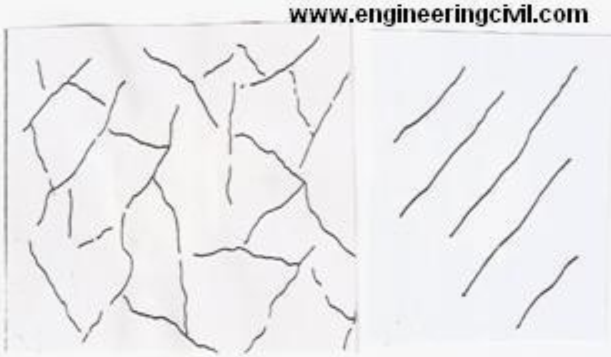
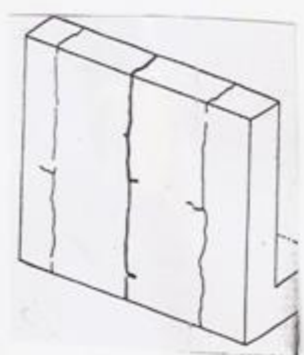


a. Plastic Settlement

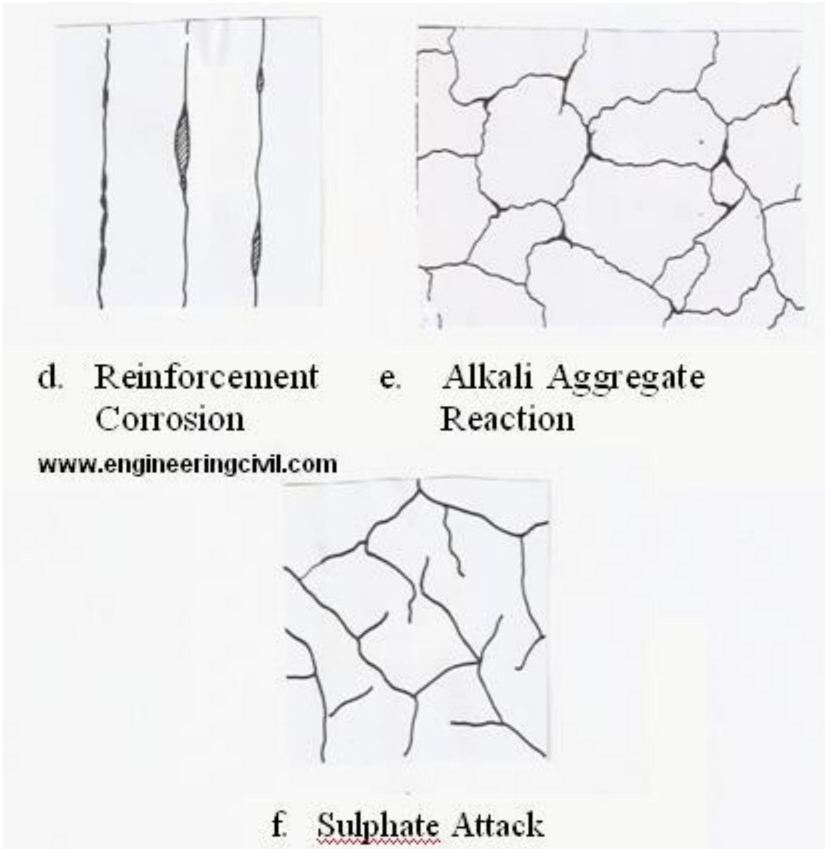


b. Plastic Shrinkage



C1. Restrained Drying Shrinkage

C2. Unrestrained Drying Shrinkage



d. Reinforcement Corrosion

e. Alkali Aggregate Reaction

f. Sulphate Attack

We at engineeringcivil.com are thankful to ***Sir Kaushal Kishore*** *for submitting his research paper on "****Visual Inspection of Concrete Structure"*** *to us. This will be of great help to all civil engineers.*

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