Iat 2 Questions

1.	Explain in detail the goal of damage assessment and investigation process?
2.	Briefly describe destructive, non-destructive, and semi-destructive testing.
3.	What are surface and structural cracks? Briefly discuss.
4.	What does corrosion mean? Describe its mechanisms and prevention in detail.
5.	Describe how mistakes in design and construction affect the rehabilitation of a structure.

IAT 2 SOLUTIONS

1. Explain in detail the goal of damage assessment and investigation process? (10)

- Damage Assessment is the process for determining the nature and extent of the loss, suffering, and/or harm to the community resulting from a natural, accidental or human-caused disaster.
- Damage assessment is an important tool for retrospective and prospective analysis of disasters to assimilate the extent of impact of a disaster.
- This forms the basis for future disaster preparedness and preventive planning.
- Damage takes place due to natural or man-made causes. Even structures built in recent past have shown extensive damage and distress due to various causes, giving rise to problems both investigation and repair
- Diagnosis of the damage is of greatest importance. Before remedies can be correctly prescribed, the illness must be properly diagnosed.
- Damage Assessment is a preliminary onsite evaluation of damage or loss caused by an accident or natural event. Damage assessments records the extent of damage, what can be replaced, restored or salvaged. It may also estimate the time required for repair, replacement and recovery.
- Damage assessment is an integral part of facilitating effective and efficient response by government agencies and other organizations. Good damage assessment would start the ball rolling for effective response and relief operations such as evacuation, sheltering, search and rescue, mass casualty management, etc.

- Local damage assessment plays a critical role in your community's response and recovery following a hazard event. The information gathered by the damage assessment-response team provides a snapshot of the situation detailing the extent and location of damages.

- This information is evaluated to determine the needs of the survivors and the community as a whole. Thus, the damage assessment sets the tone for the entire response operation and drives the recovery process.

- Damage assessment helps your community set priorities for response activities such as search and rescue, as well as for recovery operations such as removal of| storm debris and rebuilding or repair of infrastructure.

- It also helps identify Deeds for additional resources from local, State, and Federal agencies and provides some of the documentation necessary for applying for these avenues of assistance

- Damage assessment can also help you identify mitigation opportunities and Create a mitigation plan that will make your community more disaster-resistant for the next hazard event

Rapid Structural Safety Assessment

- The objective for the rapid structural Safety assessment is to quickly inspect and evaluate the concrete structure and determine if the damaged structure is unsafe for personnel within the building and rescue personnel accessing the building.

- Two primary concerns need to be considered when performing this assessment of the structure that has sustained structural damage.

- This includes a quick evaluation of the building structural components (eg, beams, columns, decking, etc.) and of the building non-structural components (eg, structural debris, partitions, ceilings, glass, pipe anchoring, electrical/mechanical equipment anchoring, etc.).

- If there are any visual signs of structural and/or non-structural damage, then the specific building area needs to be isolated, secured, and marked as UNSAFE.

- The on-scene commander should be informed and the area remained in this UNSAFE condition, until a structural engineer proves otherwise.

- The rapid structural damage assessment would note the major failures within the structure including the major structural elements of beams, columns, roof and floor decks.
- Typical failures would be found at the connections of the major structural elements, or at elements that no longer have adequate vertical support (e.g.. unsupported roof and floor decks that are now cantilever elements.)
- Indications would include cracking, spalling (i.e., loss of concrete from an exterior surface), and/or complete loss of all or part of a structural element.
- The on-scene commander should be notified immediately of the risk, and the area secured and marked UNSAFE.

Damage assessment provides situational awareness and critical information on:

- *Type, scope and severity of the event*
- *Impact on individuals and communities*
- *Additional resource needs*
- *Justification for disaster declaration*
- *Emergency public information*
- *Future hazard mitigation projects*

2. Briefly describe destructive, non-destructive, and semi-destructive testing. (10)

Basic methods of crack detection of concrete structures

Cracks in concrete can be detected by using

- Destructive tests
- Semi- Destructive tests
- Non- Destructive tests

The following methods, with some typical applications, have been used for the NDT of concrete:

- Visual inspection, which is an essential precursor to any intended non-destructive test. An experienced civil or structural engineer may be able to establish the possible cause(s) of damage to a concrete structure and hence identify which of the various NDT methods available could be most useful for any further investigation of the problem.

- Half-cell electrical potential method, used to detect the corrosion potential of reinforcing bars in concrete.
- Schmidt/rebound hammer test, used to evaluate the surface hardness of concrete.
- Carbonation depth measurement test, used to determine whether moisture has reached the depth of the reinforcing bars and hence corrosion may be occurring.
- Permeability test, used to measure the flow of water through the concrete.
- Penetration resistance or Windsor probe test, used to measure the surface hardness and hence the strength of the surface and near surface layers of the concrete.
- Covermeter testing, used to measure the distance of steel reinforcing bars beneath the surface of the concrete and also possibly to measure the diameter of the reinforcing bars.
- Radiographic testing, used to detect voids in the concrete and the position of stressing ducts.
- Ultrasonic pulse velocity testing, mainly used to measure the sound velocity of the concrete and hence the compressive strength of the concrete.
- Sonic methods using an instrumented hammer providing both sonic echo and transmission methods.
- Tomographic modelling, which uses the data from ultrasonic transmission tests in two or more directions to detect voids in concrete
- Impact echo testing, used to detect voids, delamination and other anomalies in concrete.
- Ground penetrating radar or impulse radar testing, used to detect the position of reinforcing bars or stressing ducts.
- Infrared thermography, used to detect voids, delamination and other anomalies in concrete and also detect water entry points in buildings.

Situations where NDT is an option to consider for investigation of in situ concrete

- to investigate the homogeneity of concrete mixing
- lack of grout in post tensioning ducts
- to determine the density and strength of concrete in a structure
- to determine the location of reinforcing bars and the cover over the bars
- to determine the number and size/diameter of reinforcing bars
- to determine the extent of defects such as corrosion
- to determine the location of in-built wiring, piping, ducting, etc.
- to determine whether internal defects such as voids, cracks, delaminations, honeycombing, lack of bonding with reinforcing bars, etc. exist in concrete
- to determine if there is a bond between epoxy bonded steel plates and concrete members.

3. What are surface and structural cracks? Briefly discuss. (10)

Type of Crack	Causes	Character/Signs
Non-Structural Crack	– Moisture changes – Thermal movement – Elastic deformation – Creep – Chemical reaction – Foundation movement and settlement of soil – Vegetation	– Building materials expand on absorbing moisture and shrink on drying – These are generally reversible – The cracks are superficial or cosmetic and are usually found on the plaster or mortar renderings of buildings – The cracks tend to be thin hairline cracks, mostly 1-2mm wide. – Cracks appear at corners of doors and window frames where inherent weaknesses within the structure are present. The cracks are most often vertical to diagonal
Structural Crack	– due to incorrect design – faulty construction – Overloading – Differential Settlement(Due to poor soil bearing capacity)	– Extensive cracks of Foundations walls, beams, columns or slabs particularly due to displacement. – Structure become unsafe due to partial or complete collapse of building – Continuous horizontal cracks which appear on walls indicating signs of displacement. – Vertical cracks which are sig-nificantly wider at the top or bottom could indicate heaving or settlement.

4. **What does corrosion mean? Describe its mechanisms and prevention in detail. (10)**

Corrosion in concrete is induced by the generation of the electrochemical potentials in following ways: 1. When two different metals are present in concrete, such as steel rebars, aluminium conduit pipes, or when significant variation exist in surface characteristics of the steel, formation of composition cell can occur. 2. Concentration cells may be formed near reinforcing steel because of the differences in the concentration of dissolved ions, such as alkalies and chlorides (Figure 1)[8]. The following reactions occur at anode and cathode [9]. Anode: $Fe \rightarrow Fe^{2+} + 2e$

FeO.(H2 O)x (Rust)

Cathode: ½O2 +H2 O+2e- →2OH

Some parameters are essential to initiate corrosion. Presence of oxygen, humidity (electrolyte) are the two important parameters without which corrosion is not possible.[10,11,12]. The rate of corrosion is slow if the amount of water or oxygen is limited. Presence of humidity, moisture and oxygen acts as catalyst for corrosion to occur, forming more OH- thereby producing more rust component Fe(OH)- [8,12]. Following reactions (Eq1 to 3.) represent the formation of the rust after the iron dissolution occurs at the anodic sites in the reinforcement [10] (Table 1). Fe2++2OH− → Fe(OH)2 (Ferrous Hydroxide)

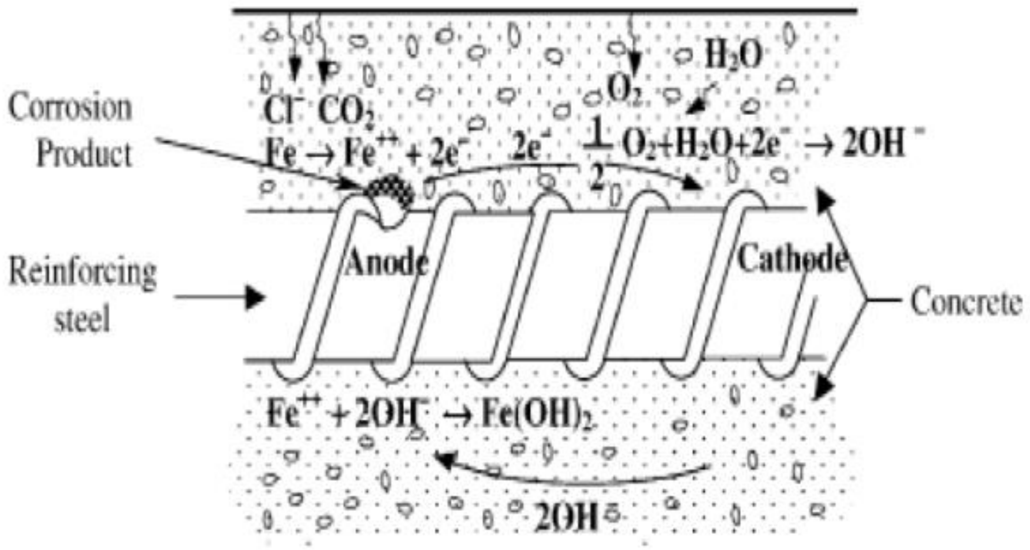

Figure 1: Electrochemical process of corrosion of steel in concrete – a simplified model.

4Fe(OH)2 +2H2 O+O2 → 4Fe(OH)3 (Ferric Hydroxide)

2Fe(OH)3 → 2H2 O+Fe2 O3 · H2 O (Rust)

Concrete protection methods for steel reinforcement in concrete are needed due to corrosion. It is a natural process that converts a refined metal into a more chemically stable form such as oxide, hydroxide, or sulfide. It is the gradual destruction of materials (usually a metal) by chemical and/or electrochemical reaction with their environment. Corrosion in concrete steel reinforcement degrades the useful properties of materials and structures including strength, appearance and permeability to liquids and gases. Many structural alloys corrode merely from exposure to moisture in air, but the process can be strongly affected by exposure to certain substances. Corrosion can be concentrated locally to form a pit or crack, or it can extend across a wide area more or less uniformly corroding the surface.

The two most common contributing factors leading to steel reinforcement corrosion are;

(i) Chloride attack – localized breakdown of the passive film on the steel reinforcement of concrete by chloride ions

The passivity provided by the alkaline conditions can be destroyed by the presence of chloride ions, even though a high level of alkalinity remains in the concrete. The chloride ion can locally de-passivate the metal and promote active metal dissolution. Chlorides react with the calcium aluminate and calcium aluminoferrite in the concrete to form insoluble calcium chloroaluminate and calcium chloro ferrites in which the chloride is bound in non-active form. However, the reaction is never complete and some active soluble chloride always remains in equilibrium in the aqueous phase in the concrete.

(ii) Carbonation – general breakdown of passivity by neutralization of steel reinforcement of concrete by reaction with atmospheric carbon dioxide

Carbon dioxide, which is present in the air at around 0.3 percent by volume, dissolves in water to form a mildly acidic solution. This forms within the pores of the concrete, here it reacts with the alkaline calcium hydroxide forming insoluble calcium carbonate. The carbonation process moves as a front through the concrete, on reaching the reinforcing steel, the passive layer decays when the pH value drops below 10.5. If the carbonated front penetrates sufficiently deeply into the concrete to intersect with the concrete reinforcement interface, protection is lost and, since both oxygen and moisture are available, the steel is likely to corrode.

5. 5. Describe how mistakes in design and construction affect the rehabilitation of a structure. (10)

Cracks in concrete are caused due to following factors.

- One of the main causes of cracks in concrete is the cooling and contraction due to setting of concrete. Volume change and stresses due to shrinkage are independent of any external load or stress applied.
- Cracks may develop in a smaller section attached to a large section due to differential expansion and contraction. Therefore a joint should be provided at the change of section. There is more possibility of cracking of fixed members than those which are free to expand and contract as simply supported beams.
- Repeated expansion and contraction or alternate wetting and drying which may result in gradual disintegration of poor concrete.
- Rapid drying due to hot weather and high speed winds or absorption ofwater from the concrete by wooden forms also a cause of cracking inconcrete.

Therefore the form work on which fresh concrete is placedmust be damped, or it should be waterproof so that it does not absorbwater from fresh concrete.

- Loose form work can also lead to cracks in concrete. so form work should be of adequate strength to bear the pressure of the wet concrete without swelling, spreading or any movement.
- Concentration of tensile reinforcement at square openings or re-entrant angles (as in corners of door and window openings) causes cracks. This can be avoided by suitably placing reinforcements having adequate covering. Sufficient thickness of concrete should be given at the points where bars are bent up and anchored.
- Minute cracks on the tension side of a reinforced concrete member are unavoidable due to poor tensile strength of concrete as compared to steel and which must crack when steel reinforcement taken its load.
- Those cracks, however, should be fine enough for moisture penetration to prevent corrosion of the reinforcement.
- Hair cracks are the result of unequal shrinkage of the surface concrete and the mass behind it. Delayed finishing and final floating of concrete can avoid these cracks up t o a certain limit.
- Surface cracks are also caused by surface dressing with a mortar having too rich in cement. Too much water, insufficient curing, or from over trowelling. One method of avoiding such hair cracks is to remove the surface skin of the concrete by brushing it with a stiff brush soon after setting.
- Contraction of concrete is more harmful than expansion as it sets up tensile stresses in the structure, particularly those with a large surface area and thus form cracks. Such contracting cracks may be prevented by inserting reinforcement near the surface. Closely spaced reinforcement of small diameter and near the surface is more effective than large diameter bars further apart from the surface.

TYPES OF DESIGN ERRORS

1. Inadequate Structural Design
2. Poor Design Details
   - A. Abrupt Changes in Section
   - B. Insufficient Reinforcement at Corners and Openings
   - C. Inadequate Provision for Deflection
   - D. Inadequate Provision for Drainage
   - E. Insufficient Travel in Expansion Joints
   - F. Incompatibility of Materials
   - G. Neglect of Creep Effect
   - H. Rigid Joints Between Precast Units
   - I. Unanticipated Shear Stresses in Piers, Columns, or Abutments
   - J. Inadequate Joint Spacing in Slabs

TYPES OF CONSTRUCTION ERRORS

1. Adding Water to Concrete
2. Improper Alignment of Formwork
3. Improper Consolidation or Compaction of Concrete
   A. Bug Holes
   B. Honeycombing
   C. Over-consolidation
4. Improper Curing
5. Improper Location of Reinforcement Steel
6. Movement of Formwork
7. Premature Removal of Shores or Reshores
8. Settling of Concrete
9. Settling of the Subgrade
10. Vibration of Freshly Placed Concrete
11. Improper Finishing of Flat Concrete Surface