Repair & Rehabilitation of Civil Engineering Structures

Unit- I

Q.1) Explain in brief, the effect of temperature in deterioration of concrete structures.

Ans: -

The effect of temperature on concrete structures can lead to deterioration of the concrete.

Key points about the effect of temperature on concrete structures:

i. High temperatures can cause thermal degradation of concrete, which can lead to a loss of mechanical and physical properties of concrete.

ii. Abrupt temperature changes can cause cracking and spalling due to thermal shock, and aggregate expansion can also produce deterioration.

iii. Above 212º F, the cement paste begins to dehydrate (loses chemically combined water of hydration), which gradually weakens the paste and paste-aggregate bond.

iv. Both thermal damage and chemical damage increase with temperature, while Young's modulus and compressive strength decrease with temperature.

v. The hydration products of concrete do not obviously decompose under 400°C, but when the temperature exceeds 400°C, the calcium hydroxide (CH), C-S-H gel, and calcium carbonate ($CaCO_3$) of concrete decompose, resulting in a decline of the concrete's strength.

vi. High-temperature vapor pressure, temperature stress, difference in thermal expansion coefficient between aggregate and paste, and thermal decomposition of hydration products are the main reasons for concrete degradation at high temperatures.

Q.2) Explain in brief, the effect of Alkali aggregate reaction in deterioration of concrete structures.

Ans: -

Alkali aggregate reaction (AAR) is a chemical reaction between alkalis in the concrete and reactive components of the aggregates.

Key points about the effect of alkali aggregate reaction in the deterioration of concrete structures:

i. Alkali aggregate reaction can cause expansion and cracking of concrete over a period of many years.

ii. Alkali aggregate reaction has two forms: alkali-silica reaction (ASR) and alkali-carbonate reaction (ACR).

iii. In ASR, aggregates containing certain forms of silica will react with alkali hydroxide in concrete to form a gel that swells as it adsorbs water from the surrounding cement paste or the environment. These gels can induce enough expansive pressure to damage concrete.

iv. ACR is relatively rare because aggregates susceptible to this phenomenon are less common and are usually unsuitable for use in concrete for other reasons.

v. Most of the structures severely cracked by AAR are exposed to the weather or are in contact with damp soil. This is because sufficient presence of moisture is essential for a significant amount of expansion to occur.

vi. High content of alkali in the concrete is also essential for AAR to occur.

vii. Alkali aggregate reaction can cause considerable expansion, which can lead to significant damage to concrete structures.

Q.3) Write short notes on Causes of cracks in concrete.

Ans: -

Cracking is one of the most common problems in concrete structures.

Causes of cracks in concrete:

i. **Shrinkage:** Shrinkage is one of the major causes of cracking in hardened concrete. In drying shrinkage, the volume of concrete is gradually decreased and if the component is restrained against free movement, tensile stresses are developed which causes cracks.

ii. **Temperature changes:** Temperature changes can cause expansion and contraction of concrete, which can lead to cracking.

iii. **Chemical reaction:** Chemical reactions between the concrete and certain substances can cause cracking.

iv. **Poor construction practices:** Adding excessive water to the mix, lack of curing, poor compaction, using low-grade materials, unreasonable placements of construction joints, etc. are responsible for cracking in concrete.

v. **Errors in design and detailing**: Errors in design and detailing can cause cracking in concrete structures.

vi. **Corrosion of reinforcement:** Corrosion of reinforcement can cause cracking in concrete structures.

vii. **Permeability of concrete**: Permeability of concrete can cause cracking in concrete structures.

viii. **Topsoil and subsurface earth layer erosions:** Topsoil and subsurface earth layer erosions can cause cracking in concrete slab floors.

Q.4) Write short notes on Preventive methods to avoid creation of cracks.

Ans: -

Preventive measures can be taken to avoid the creation of cracks in concrete structures.

a. **Reduce water content in concrete**: Proper concrete mix design and use of quality materials can help reduce the water content in concrete, which can minimize the amount of cracking.
b. **Avoid calcium chloride admixtures**: Calcium chloride admixtures can accelerate the setting time of concrete, which can increase the risk of cracking.
c. **Prevent extreme changes in temperature**: Extreme changes in temperature can cause expansion and contraction of concrete, which can lead to cracking.
d. **Consider using a shrinkage-reducing admixture**: Shrinkage-reducing admixtures can help reduce the amount of shrinkage in concrete, which can minimize the amount of cracking.
e. **Warm the subgrade before placing concrete on it during cold weather**: Cold weather can cause concrete to set too slowly, which can increase the risk of cracking.
f. **Consider using synthetic fibers to help control plastic shrinkage cracks**: Synthetic fibers can help control the amount of shrinkage in concrete, which can minimize the amount of cracking.
g. **Good design and construction practices**: Good design and construction practices can minimize the amount of cracking and eliminate or control the visible large cracks by minimizing the restraint using.
h. **Proper joint placement:** Proper joint placement can help reduce or prevent shrinkage cracks.
i. **Proper curing:** Proper curing can help reduce the amount of shrinkage in concrete, which can minimize the amount of cracking.

Q.5) Explain the physical process of deterioration Freezing & Thawing & Wetting & Drying.

Ans: -

Freezing and thawing, as well as wetting and drying, are physical processes that can cause deterioration of concrete structures.

Freezing and Thawing:

i. When water freezes, it expands about 9%.
ii. As the water in moist concrete freezes, it produces pressure in the capillaries and pores of the concrete.
iii. This pressure can cause the concrete to crack and spall, which can lead to further damage.

iv. Concrete subjected to alternating freezing and thawing is damaged due to the expansion of frozen water.

v. Moisture is collected in the voids that result from the freezing and thawing process, which can lead to further damage.

Wetting and Drying:

i. Wetting and drying can cause concrete to expand and contract, which can lead to cracking and spalling.

ii. When concrete is wet, it absorbs water and expands.

iii. When the concrete dries, it contracts and can crack.

iv. This process can be exacerbated by temperature changes, which can cause the concrete to expand and contract more rapidly.

Unit- II

1) Explain in brief types of NDT & the advantages and disadvantages of Non Destructive Tests.

Ans: -

Non-destructive testing (NDT) is a method of testing materials without destroying them.

Types of NDT methods:

a. **Visual inspection**: This is the most common technique, which involves visually examining the surface of the material for defects or irregularities.
b. **Ultrasonic testing**: This method uses high-frequency sound waves to detect internal defects in materials.
c. **Radiographic testing**: This method uses X-rays or gamma rays to detect internal defects in materials.
d. **Magnetic particle testing**: This method uses magnetic fields to detect surface and near-surface defects in ferromagnetic materials.
e. **Liquid penetrant testing**: This method involves applying a liquid to the surface of the material, which penetrates into any surface defects and is then removed to reveal the defect.

Advantages of Non-destructive Testing:

i. The material properties will not be altered after testing.
ii. It provides reliable and accurate results.
iii. It is safe for the people who are doing the test.
iv. It can save time and money in the product evaluation cycle.
v. It can be used to detect flaws in an in-process machine part.
vi. It is harmless to humans.

Disadvantages of Non-destructive Testing:

i. Purchase costs may be preventative, so renting can be a preferable option.
ii. Due to load applications, the material gets damaged.
iii. Sometimes there might be a lack of depth sizing.
iv. On some occasions, linear defects may be missed.
v. Trained operators are needed.
vi. It can be relatively expensive.

2) Explain in brief, about the ultra-sonic pulse velocity test for concrete structures.

Ans: -

The ultrasonic pulse velocity (UPV) test is a non-destructive test used to examine the homogeneity, quality, cracks, cavities, and defects in concrete structures.

i. The UPV test is an in-situ, non-destructive test to check the quality of concrete and natural rocks.

ii. The strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure or natural rock formation.

iii. This test is conducted by passing a pulse of ultrasonic through concrete to be tested and measuring the time taken by pulse to get through the structure.

iv. Higher velocities indicate good quality and continuity of the material, while slower velocities may indicate concrete with many cracks or voids.

v. The transducer, clock, oscillation circuit, and power source are assembled for use.

vi. After calibration to a standard sample of material with known properties, the transducers are placed on opposite sides of the material.

vii. Pulse velocity is measured by a simple formula.

viii. The UPV test can be used to evaluate the quality and homogeneity of concrete materials, identify voiding, honeycombing, cracking, and other defects, identify areas of low-quality concrete, and define the size and shape of a defect by using multiple test paths.

ix. The UPV test is portable and easy for testing.

3) Explain how the corrosion in steel is measured in concrete structures.

Ans: -

Corrosion of steel in concrete structures can be measured using various techniques.

a. **Half-cell potential measurement:** This method involves measuring the electrical potential difference between a reference electrode and a steel reinforcement electrode in concrete. The potential difference is an indicator of the corrosion activity of the steel.

b. **Linear polarization resistance (LPR) method**: This method measures the corrosion rate of embedded steels by measuring the corrosion current or corrosion penetration rates. From this measurement, metal loss predictions can be made.

c. **Macro cell current measurement:** This method measures the current flow between two or more steel reinforcement electrodes in concrete. The current flow is an indicator of the corrosion activity of the steel.

d. **Visual survey:** A visual survey of a corroding structure provides valuable information as to whether the corrosion of rebar is really a cause of distress or there is some other cause.

4) Explain about the Rebound Hammer method of testing concrete structures.

Ans: -

The Rebound Hammer method is a non-destructive testing method used to measure the compressive strength of concrete structures.

i. The Rebound Hammer method is often necessary to test concrete structures after the concrete has hardened to determine whether the structure is suitable for its proposed use.

ii. Rebound hammer is used for compressive strength of concrete.

i. The Rebound Hammer consists of a spring-loaded steel hammer that when released strikes a steel plunger in contact with the concrete surface.

ii. The spring-loaded hammer travels with a consistent and reproducible velocity.

iii. The rebound distance of the steel hammer for the steel plunger is measured on a linear scale attached to the frame of the instrument.

iv. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete.

v. The hardness of the concrete and rebound is related to the compressive strength of the concrete.

vi. The bounce is measured from the scale, and it is called the rebound number or rebound index.

vii. The Rebound Hammer method is a straightforward test and can get the results immediately without any problematic calculation.

viii. The Rebound Hammer test is suggested in the following scenarios: need to check the strength of an old structure, to find out whether an existing building element needs any repair and rehabilitation work to be done.

ix. Before doing the test, the rebound hammer should be calibrated through a testing anvil and ensure the result is trusty.

x. The Rebound Hammer method is a non-destructive testing method.

5) What is Rebar locator? Explain its principle & applications.

Ans: -

A rebar locator is a handheld device used to locate rebar's buried in concrete structures such as roads, bridges, dams, and tunnel walls.

These devices use electromagnetic induction technology to detect the presence of rebar's buried in concrete without having to physically touch the rebar.

Principle:

i. Rebar locators use magnetic fields to detect the presence of iron within concrete structures.
ii. These devices use electromagnetic induction technology to detect the presence of rebar's buried in concrete without having to physically touch the rebar.
iii. The rebar locator is designed to work with rebar's ranging from 3/8 inch to 2 inches.

Applications:

i. The main use of rebar locators is to complete a non-destructive investigation of the concrete.
ii. Rebar locators are used to locate rebar, reinforcing rods embedded in concrete slabs, beams, and columns.
iii. Rebar locators are used to find rebar's buried in concrete structures such as roads, bridges, dams, and tunnel walls.
iv. Rebar locators are used to estimate the size and depth of concrete cover.
v. Cover meter test is a non-destructive test which is used to specify the location of reinforcement bars in concrete and determine the exact position of the rebar.
vi. A reliable estimation of rebar location, concrete cover thickness, and rebar diameter can be obtained using rebar locators and cover meters.
vii. Rebar locators are used to assess the quality of concrete structures and to prevent any future damage to the reinforcing materials.

Unit- III

1) Explain in brief, types & the causes of failures in buildings.

Ans: -

Building failures can be either a partial or complete collapse of the structure.
They can be classified into different categories for better understanding.

Types of building failures:

- **Construction Failure of Building:**

i. This type of failure occurs when the structure is not constructed in a reasonable workable manner.

ii. This could result in the failure of the building.

iii. When the standard building codes are not followed, numerous defects, including cracks and deformation, occur.

- **Functional Failure of Building:**

i. These are failures due to the structural degradation of the structure.

ii. These failures occur due to the aging of the building, wear and tear, and lack of maintenance.

- **Foundation Failure:**

i. Foundation failures refer to both the failure of the structural elements of the foundation such as footings or piles, and the failure of the soil.

ii. The first type of failure occurs as a result of overloading on the foundation.

iii. Whereas the latter results due to negligence when choosing the right location for the foundation or loss of bearing strength because of adjacent work.

- **Cracks in Concrete Buildings:**

i. Cracks in concrete buildings have several causes.

ii. They may show total extent of damage or problems of greater magnitude.

iii. They may represent critical structural distress, lack of durability, or they might influence appearance only.

iv. The importance of cracks dependent on the nature of cracking and type of structure.

- **Structural Failures:**

i. Structural failures can happen for many reasons, but the results are very often devastating.

ii. They can happen due to poor construction practices, improper structural design and specifications, poor maintenance, movement due to chemical reactions, and other factors.

2) Discuss the various testing methods use in diagnostic of Cracks

Ans: -

There are various testing methods used in the diagnostic of cracks in structures.

a. Modal Test Data:

i. Measured vibration frequencies and mode shapes are used in an identification process to identify the cracked element based on a simple reduced stiffness model.

b. Manual Crack Detection:

i. Analyzing and identifying cracks is the most vital step in the construction process.

ii. The manual crack detection process will take longer and will require a trained professional to identify the cracks.

c. Non-Destructive Evaluation (NDE):

i. Currently applied methods for crack detection and characterization include periodic visual inspections and non-destructive evaluation (NDE).

ii. NDE techniques include ultrasonic testing, radiography, magnetic particle inspection, and eddy current testing.

d. Ultrasonic Guided Waves:

i. Another commonly used technique for detection of cracks in structures is the group of ultrasonic guided waves.

ii. This technique is used for detecting cracks in plates or rods.

e. Image Processing:

i. Crack detection can be made using image processing techniques.

ii. This technique involves capturing images of the structure and analyzing them to detect any cracks.

f. Laser-Quick Non-Destructive Method:

i. Conventionally, defects in concrete structures are detected using the acoustic test called the "hammering method" performed by certified professionals.

ii. A new technique involves using a laser-quick, non-destructive method to detect cracks in concrete structures.

3) Explain in brief, various methods of concrete crack repair.

Ans: -

There are various methods of concrete crack repair that can be used depending on the type and nature of the cracks.

a. Epoxy Injection:

i. This method is used for cracks as narrow as 0.002 inch (0.05 mm).

ii. The technique generally consists of establishing entry and venting ports at close intervals along the cracks, sealing the crack on exposed surfaces, and injecting the epoxy under pressure.

iii. Epoxy injection has been successfully used in the repair of cracks in buildings, bridges, dams, and other types of concrete structures.

b. Routing and Sealing:

i. This method involves cutting a groove or channel in the concrete surface near the crack and filling it with a sealant.

ii. The sealant is then allowed to cure and harden, effectively sealing the crack and preventing further damage.

c. Grouting:

i. This method involves injecting a cement-based grout into the crack.

ii. The grout fills the crack and hardens, effectively sealing the crack and preventing further damage.

d. Stitching:

i. This method involves drilling holes on either side of the crack and installing metal stitching pins.

ii. The pins are then grouted into place, effectively stitching the crack together and preventing further damage.

e. Drilling and Plugging:

i. This method involves drilling holes into the concrete near the crack and inserting a grout plug.

ii. The plug is then allowed to cure and harden, effectively sealing the crack and preventing further damage.

4) Explain in brief, the Epoxy Injection method of crack repair.

Ans: -

Epoxy injection is a method used for repairing concrete cracks as narrow as 0.002 inches (0.05 mm).

a. Cleaning and Drying:

i. The first step is to clean and dry the opening of the crack.

ii. This allows the epoxy to bond properly to the concrete.

b. Mixing and Preparing Epoxy Resin:

i. Next, the epoxy resin is mixed and prepared according to the manufacturer's instructions.

c. Applying Epoxy Resin:

i. The epoxy resin is then applied to the crack using a special injection gun.

ii. The resin is injected under pressure through entry and venting ports established at close intervals along the cracks.

iii. The crack is sealed on exposed surfaces to prevent the resin from leaking out.

d. Curing and Hardening:

i. Finally, the epoxy is allowed to cure and harden.

ii. The resin hardens and seals the crack from the inside.

5) Enlist and explain the various equipment use in diagnostic and repair of Cracks.

Ans: -

Equipment used in the diagnostic and repair of cracks:

a. EMAT-C and UT-C Inspection Technologies:

i. These technologies can be used to detect and size cracks for a variety of engineering structures.

ii. Handheld devices and robotic systems are used to perform these inspections.

b. Crack Gauge:

i. A crack gauge is used to diagnose foundation issues, determine if they are structural or not, and aid in the decision-making for the appropriate concrete or block wall repair method.

ii. It is used to accurately measure movement displacement in the horizontal and vertical axis across concrete cracks in floors and walls.

iii. It is a preferred tool for any field engineer.

c. Embedded Sensors:

i. Embedded sensors are used for early crack detection of reinforced concrete structures.

ii. These sensors can detect cracks in structures such as plates or rods.

d. Vibration Measurement Equipment:

i. Vibration measurement equipment is used to detect cracks in structures using modal test data.

ii. Measured vibration frequencies and mode shapes are used in an identification process to identify the cracked element based on a simple reduced stiffness model.

e. Non-Destructive Evaluation (NDE) Equipment:

i. NDE equipment is used for crack detection and characterization.

ii. These include periodic visual inspections and non-destructive evaluation techniques such as ultrasonic testing, radiography, magnetic particle inspection, and eddy current testing.

6) Discuss poor construction practices in construction Industries.

Ans: -

Poor construction practices in the construction industry can lead to various issues and defects in the building.

a. Dropping the Mix through Too Great a Height in Placing:

- Chutes or pipes should be used in such cases to avoid poor construction methods.

b. Poor Construction Methods and Poor Workmanship:

- This can lead to awful practices in concrete construction, such as unsafe working at heights, improper curing, insufficient concrete compaction, and lack of formwork support.

c. Low-Quality Materials:

- The use of low-quality materials can lead to poor quality in building projects.

d. **Lack of Proper Contractor Supervision of the Work**:

- Lack of proper supervision can lead to poor workmanship and inadequate quality control.

e. No Quality System:

- The absence of a quality system can lead to poor quality in building projects.

f. Lack of Project Auditing:

- Lack of project auditing can lead to poor quality control and inadequate supervision.

g. Inadequate Planning and Scheduling:

- This can lead to poor productivity on construction projects, lack of collaboration and communication between stakeholders on the project, idle time wasted by having to wait on materials and supplies to be delivered or for prior work to be completed.

Unit- IV

1) What is the purpose of admixtures? Explain about Water Reducing Admixtures.

Ans: -

Admixtures are added to concrete to modify its properties and make it more suitable for specific applications. Water reducing admixtures (WRAs) are one type of admixture that is commonly used in the construction industry.

Purpose of Water Reducing Admixtures:

i. Water reducing admixtures are used to increase the strength and workability of concrete and to reduce cost.
ii. They are primarily used to reduce the water-cementitious content of concrete, thus increasing strength.
iii. In some cases, they can be used to increase the workability or slump of the concrete providing for easier placement.
iv. Properties and Benefits of Water Reducing Admixtures:
v. Water reducing admixtures increase the workability at low water-cement ratios.
vi. They reduce the viscosity of the paste, resulting in a greater slump.
vii. They neutralize surface charges on cement particles and cause all particles to carry like charges.
viii. They reduce flocculation of the cement particles and allow for better dispersion.
ix. They increase the initial concrete compressive strength.
x. They make concrete more pumpable and easier to place.

2) Explain in brief about the test to find the depth of Carbonation.

Ans: -

Carbonation is a process that occurs in concrete when carbon dioxide from the air reacts with the cement paste. The depth of carbonation is an important parameter to assess the durability of concrete structures.

a. Carbon Test:

i. Carbon Test is a new method of sampling that is based on collecting the powder during a perforation carried out using a common percussion drill.
ii. A collecting device (picker) is used to optimize the powder flow.
iii. This method is simple, cost-effective, quick, and practical.

b. Phenolphthalein Test:

i. The phenolphthalein test is a simple and cheap method of determining the depth of carbonation in concrete.

ii. It involves cutting a part of concrete and spraying it with a 0.2% solution of phenolphthalein.

iii. The carbonated part will have no color change, while the uncarbonated part will turn pink.

c. Laboratory Test:

i. The laboratory test involves preparing an indicator solution of 1% phenolphthalein in ethanol.

ii. The test is performed on freshly exposed concrete surfaces.

iii. The depth of carbonation is determined by measuring the distance from the surface to the point where the color change occurs.

3) What is the type of admixtures? Explain about Retarding Admixtures.
Ans: -

Admixtures are components that are added to concrete before or during mixing to change one or more of the properties of the concrete in its plastic or hardened form. There are different types of admixtures used in concrete, and they are classified based on their functions.

Types of admixtures:

a. Water Reducing Admixtures:

i. Water reducing admixtures are used to reduce the amount of water needed to achieve the required slump of concrete.

ii. They increase the workability of concrete at low water-cement ratios.

b. Retarding Admixtures:

i. Retarding admixtures slow down the rate of hydration of cement in its initial stage and increase the initial setting time of concrete.

ii. They are used to place concrete in hot climates when long travel times are expected or, in cases of emergency, when placement is delayed.

iii. They are also commonly used for mass concrete pours to prevent cold joints.

c. Accelerating Admixtures:

i. Accelerating admixtures increase the rate of early strength development and shorten the curing time.

ii. They are used in cold weather to speed up the setting time of concrete.

d. Air-Entraining Admixtures:

i. Air-entraining admixtures are used to introduce microscopic air bubbles into concrete.

ii. They improve the workability of concrete and increase its resistance to freeze-thaw cycles.

e. Superplasticizers:

i. Superplasticizers are used to increase the workability of concrete without increasing the water-cement ratio.

ii. They are used in high-strength concrete and in concrete that needs to be placed in difficult conditions.

f. Mineral Admixtures:

i. Mineral admixtures are added to concrete to improve its properties.

ii. They include fly ash, slag cement, and silica fume.

g. Chemical Admixtures:

i. Chemical admixtures are used to modify the properties of concrete.

ii. They include water-reducing admixtures, retarding admixtures, accelerating admixtures, air-entraining admixtures, and superplasticizers.

4) Explain in brief about the Acoustical emission methods.

Ans: -

Acoustic Emission (AE) is a non-destructive testing (NDT) method that monitors the transient stress waves generated by the rapid release of energy from localized sources. AE testing detects and interprets the acoustic events resulting from crack processes and can identify, locate, and display a beginning damage to the tested object within a very short time.

a. How it Works:

i. AE testing works by mounting small sensors onto a component under test.

ii. The sensors convert the stress waves into electrical signals, which are relayed to an acquisition PC for processing.

iii. The waves are captured when the component is submitted to an external stimulus, such as high pressures, loads, or temperatures.

iv. As the damage grows in the component, there is a greater release of energy.

v. Acoustic emission can be thought of as tiny earthquakes that occur in the material.

b. Frequency Range:

i. The frequency of AE testing of metallic objects is in the range of ultrasound, usually between 100 and 300 kHz.

c. Passive Technique:

i. AE testing is a passive, receptive technique analyzing the ultrasound pulses emitted by a defect right in the moment of its occurrence.

ii. In contrast to the ultrasound technique, one does not measure the response to an artificial and repeatable acoustic excitation of the test object.

iii. Instead, the sound signals produced by defects are evaluated, and every growth of a defect is a unique event and can't be exactly reproduced again.

d. Dynamic Technique:

i. The AE analysis is a dynamic technique.

ii. AE occurs when a crack grows or when crack borders rub against each other.

iii. AE testing detects and interprets the acoustic events resulting from these crack processes.

5) Discuss use of steel plates in repair and rehabilitation.

Ans: -

Steel plates are commonly used in repair and rehabilitation of structures due to their strength and durability.

a. Bonding of Steel Plates:

i. A new method has evolved that involves bonding of steel plates to the surfaces of members to be rehabilitated.

ii. This method has been used successfully in the repair and strengthening of concrete and masonry structures.

b. Strengthening of Frame Beams:

i. The frame beam is strengthened by sticking steel method, which can meet the requirements of flexural and shear strength and is convenient for rehabilitation and retrofitting.

c. Repair and Strengthening of Reinforced Concrete Members:

i. One of the most common methods for repair and strengthening of reinforced concrete members is using steel plates.

ii. It can be described as a type of external reinforcement that is used to increase the load-carrying capacity of the member.

d. Repair of Steel Bridges:

i. Steel bridges have the potential to achieve service lives well over 100 years.

ii. The ability to repair damaged structural steel members in place, often without the need for temporary shoring, has generated interest in heat straightening.

iii. Standard techniques and procedures are provided for heat straightening, partial member replacement, and repair of other defects.

e. Rehabilitation of Fatigued Steel Plates:

i. CFRP (Carbon Fiber Reinforced Polymer) has become the dominant rehabilitation material for the repair of steel structures.

ii. Studies exploring the performance of CFRP repaired steel have strongly indicated its potential as a rehabilitation material.

iii. Majority of these studies steel plates utilize the "beach marking" technique to investigate and quantify the crack propagation.

6) Write a short note on Fiber Reinforced Polymer and its application in repair.

Ans: -

Fiber Reinforced Polymer (FRP) composites are lightweight, high strength, corrosion-resistant materials that have been used to strengthen and retrofit deteriorated or deficient structures, especially concrete structures.

a. Reinforcement of Concrete Structures:

i. FRP composites are used as reinforcement of concrete structures either as repairs or strengthening.

ii. They can be used to increase the load-carrying capacity of the structure and improve its durability.

b. Underwater Repair with Composites:

i. FRP composites are used for underwater repair of structures.

ii. They are lightweight, high strength, and corrosion-resistant materials that can withstand harsh underwater environments.

c. Replacement or Retrofit of Existing Steel or Concrete Bridges:

i. FRPs have been used to repair, replace, or retrofit existing steel or concrete bridges.

ii. They are used in new footbridge and highway bridges.

d. Strengthening of Concrete Structures:

i. FRP composites are used to strengthen concrete structures.

ii. They can be used to increase the flexural and shear strength of the structure and improve its durability.

Unit- V

1) Explain in brief about Grouting.

Ans: -

Grouting in civil engineering refers to the injection of pumpable materials into a soil or rock formation to change its physical characteristics. It is one of the ways ground water can be controlled during civil engineering works. Grout may also be used in the formation of pile foundations, ground anchors, under-reaming, underpinning, in road construction, dam construction, and other applications.

a. Types of Grouting:

i. **Chemical Grouting:** Used to fill voids in soil or rock mass with a grout fluid at a low injection pressure to strengthen and/or reduce permeability.

ii. **Permeation Grouting**: Filling of voids in a soil or rock mass with a grout fluid at a low injection pressure to strengthen and/or reduce permeability.

iii. **Structural Grouting:** Used to fill the gaps between concrete and rock structures and fill the voids between mined materials.

b. Advantages of Grouting:

i. Provides additional strength to a building's foundation and structure.

ii. Repairs cracks in concrete, fills gaps in tiles, seals joints, and stabilizes soils.

iii. Increases the load-bearing capacity of soil by compacting soils, thus providing support for piles and retaining walls, as well as building foundations.

c. Process of Grouting:

i. Grouting involves the injection of pumpable materials into a soil or rock formation.

ii. Different materials may be used for grouting depending upon factors such as the soil or rock type and the area to be grouted.

iii. The basic process is the same: the soil or rock is injected with fluid grout which sets and reduces or eliminates permeability.

2) Explain in brief about Underpinning

Ans: -

Underpinning is the process of strengthening the foundation of an existing building or other structure. It may be necessary for a variety of reasons, such as the original foundation not being strong or stable enough, the usage of the structure has changed, or the properties of the soil supporting the foundation may have changed.

a. Purpose of Underpinning:

i. Strengthening and reinforcing an existing foundation of a structure.

ii. Extending the depth and breadth of the foundation to distribute its weight more evenly.

iii. Improving the foundation and ground condition to carry more load.

b. Methods of Underpinning:

i. **Geometric underpinning:** Used to strengthen the foundation by increasing its depth and breadth.

ii. **Underpinning by grouting:** Used to strengthen the soil by introducing an expanding filler.

iii. **Underpinning by piling:** Used to strengthen the foundation by driving piles into the ground.

c. Advantages of Underpinning:

i. Provides additional strength to the foundation of the structure.

ii. Prevents further damage to the structure due to foundation settlement.

iii. Increases the load-carrying capacity of the foundation.

d. Process of Underpinning:

i. Underpinning is a technique that needs to be done with much care and careful supervision of the work.

ii. Incorrect approach, procedures, methods, etc., could lead to failures of the structure.

iii. Underpinning is mostly done for the existing structure.

iv. The excavation of the soil is carried out in phases referred to as pins.

v. Underpinning may be accomplished by extending the foundation in depth or breadth so it either rests on a more supportive soil stratum or distributes its load across a greater area.

3) Explain in brief about Jacketing.

Ans: -

Jacketing is a method of encasing an existing structural member with new material. It is a structural retrofitting and strengthening technique where the size of an existing section is either increased or restored to its original size using a thin layer of concrete or some other suitable material like carbon or glass fibers, or plates.

a. Purpose of Jacketing:

i. To increase the strength of structural members like beam-column slabs, etc.

ii. To restore the original dimensions of the structural member.

iii. To increase bearing load capacity following a modification of the structural design or to restore structural design integrity due to a failure in the structural member.

b. Types of Jacketing:

i. Reinforced concrete jacketing: Constructed either with cast-in-place concrete or shotcrete.

ii. Steel jacketing: Constructed with steel plates.
iii. Fiber-reinforced jacketing: Constructed with carbon or glass fibers.
iv. Near Surface-mounted Fiber Reinforced Polymer Concrete: Constructed with a composite material wrap.
v. Shape memory alloy wire jacketing: Constructed with shape memory alloy wire.
vi. Combination of any two: A combination of two or more jacketing methods can be used.

c. Advantages of Jacketing:

i. Increases the strength and seismicity of the building member.
ii. Restores the original dimensions of the structural member.
iii. Increases the load-carrying capacity of the structural member.

d. Process of Jacketing:

i. Jacketing is the process whereby a section of an existing structural member is restored to original dimensions or increased in size by encasement using suitable materials.
ii. A steel reinforcement cage or composite material wrap can be constructed around the damaged section onto which Shotcrete or cast-in-place concrete is placed.
iii. The jacketing material is applied to the surface of the structural member, and it is allowed to cure.

4) Explain in brief about Shotcreting & Nailing.

Ans: -

Shotcreting is a process of application of concrete to the surface by the ejection of concrete from the nozzle by compressed air adhering to the hydraulics principles. It is a pneumatically applied mortar or concrete that is transported by a hose. When the sprayed material is put to the surface, it plugs gaps and voids, and it can be used for a variety of applications.

Shotcreting:

i. Shotcreting is the process of application of concrete to the surface by the ejection of concrete from the nozzle by compressed air adhering to the hydraulics principles.
ii. Shotcrete is a mortar or high-performance concrete conveyed through a hose and pneumatically projected at high velocity onto a backing surface.
iii. Shotcrete is an all-inclusive term for spraying concrete or mortar with either a dry or wet mix process.
iv. Shotcrete may be used to distinguish wet-mix from the dry-mix method.

Types of Shotcreting:

a. **Wet Process Shotcreting:** Involves the mixing of cement and water to form a slurry that is then pumped through a hose to the nozzle where compressed air is introduced to spray the material onto the surface.
b. **Dry Process Shotcreting:** Involves the mixing of dry cement and sand to form a dry mix that is then fed through a hose to the nozzle where water is introduced to create a wet mix that is sprayed onto the surface.

Advantages of Shotcreting:

i. Shotcreting is a widely accepted and used way of placing material that is cementitious in nature for a vast variety of applications.
ii. Shotcreting is particularly used for the construction of curved surfaces.
iii. Shotcreting can be used effectively to save time where thin sections and large areas are involved.

Nailing:

i. Nailing is a technique used to stabilize slopes and excavations.
ii. Nails are installed into the ground at an angle and grouted in place to provide additional support.
iii. Nails can be made of steel or fiberglass and can be installed in a variety of soil types.

5) Explain under water repair with respect to following point
i) Materials used for repair
ii) Process of underwater repair
Ans: -

i) Materials used for repair: -

Underwater repair is a process of repairing concrete structures that are submerged in water. The following materials are used for underwater repair:

a. **Aqua seal Epoxy System:** It is an underwater epoxy coating and repair system.
b. **Speed Crete Blue Line:** It is a rapid-setting, cement-based repair mortar for underwater.
c. **Aqua Bond Underwater Epoxy Repair Adhesives:** It is a professional, two-part hybrid epoxy designed for long-lasting repairs.
d. **Preplaced Aggregate Concrete:** It is used for large repair works where the load-carrying capacity of that element must be regained.
e. **Tremie Concrete:** It is used for the repair of underwater concrete.
f. **Pumped Concrete and Grout**: It is used for the repair of underwater concrete.

g. **Epoxy Grouting:** It is used for the repair of underwater concrete.

h. **Epoxy Injection:** It is used for the repair of underwater concrete.

i. **Hand Placement:** It is used for the repair of underwater concrete.

j. **Concrete with Anti-Washout Admixtures:** It is used for the repair of underwater concrete.

ii) Process of underwater repair: -

Underwater repair is a specialized and highly technical part of concrete repair technology. The following steps are involved in the process of underwater repair:

a. Preparation for Repair:

i. The deteriorated area of the underwater structure should be cleared from both marine growth and loose concrete before repairing procedures are begun.

ii. Based on the number of damages, the boundary of the spalled area should be saw-cut to a depth of 1.2-2 cm.

b. Formworks:

i. Proper formwork support should be provided for the repair area.

c. Repairing Underwater Concrete:

i. After proper preparation of the repair area and providing proper formwork support, a suitable repair method with respective material is used to rehabilitate the structure.

ii. For large repair works, where the load-carrying capacity of that element must be regained, the repair method must bring a new load path around the damaged areas.

d. Final Inspection of Repairs:

i. The final inspection of repairs should be done to ensure that the repair is properly done.

ii. The following methods and materials are used for the repair of underwater concrete:

iii. Preplaced Aggregate Concrete

iv. Tremie Concrete

v. Pumped Concrete and Grout

vi. Plastic jackets and underwater-curable, epoxy-resin systems

vii. Epoxy Grouting

viii. Epoxy Injection

ix. Hand Placement

x. Concrete with Anti-Washout Admixtures.