CBCS SCHEME

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18CV824

Eighth Semester B.E. Degree Examination, July/August 2022
Rehabilitation and Retrofitting

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Explain how Freeze and Thaw on concrete causes deterioration of concrete structures. **(10 Marks)**

b. Explain the following terms :
(i) Repair. (ii) Maintenance. (iii) Rehabilitation.
(iv) Retrofitting. (v) Strengthening **(10 Marks)**

OR

2 a. Write short notes on Durabiity of concrete and Acid attack. **(08 Marks)**

b. Explain the evaluation of structural damages to the concrete structural elements due to earthquake. **(12 Marks)**

Module-2

3 a. Explain the step by step Damage Assessment Procedure. **(08 Marks)**

b. What is destructive testing systems? Why load tests are usually carried? **(04 Marks)**

c. Explain the penetration technique. **(08 Marks)**

OR

4 a. Write the objectives of rapid structured assessment. Explain the rapid assessment procedure. **(12 Marks)**

b. List the common methods used in construction industry for semi-destructive testing systems. **(08 Marks)**

Module-3

5 a. Explain the effects due to climate and temperature. **(08 Marks)**

b. Explain the cathode protection. **(06 Marks)**

c. What are the effects due to corrosion? Write the Anode and Cathode reactions. **(06 Marks)**

OR

6 a. Explain the corrosion Inhibitors. **(08 Marks)**

b. Explain the design and construction errors of concrete structures. **(12 Marks)**

Module-4

7 a. Discuss the importance of maintenance of structures. **(08 Marks)**

b. Explain Beam Jacketing Technique, with sketches. **(12 Marks)**

OR

8 a. Explain externally bonding technique. **(12 Marks)**

b. What is the process involved in near surface mounted technique. **(08 Marks)**

Module-5

9 a. What is carbon fibre reinforced polymer? **(06 Marks)**

b. Explain the types of special motors. **(10 Marks)**

c. What are the properties of Epoxy resins? **(04 Marks)**

OR

10 a. What is Sisal Fibre and write its properties? **(08 Marks)**

b. What is shoring and under Pinning? Explain its types. **(12 Marks)**

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ANSWER KEY

Module-1

1 a. Explain how Freeze and Thaw on concrete causes deterioration of concrete structures. (10 Marks)

Freeze-thaw disintegration or deterioration conditions are present.

(a) Freezing and thawing temperature cycles within the concrete

(b) Porous concrete capillaries that absorbs water

Mechanism

· As the temp. of a critically saturated concrete is lowered during cold weather, the freezable water held in the capillary pores of the cement paste and aggregates expands upon freezing. If subsequent thawing is followed by refreezing the concrete is further expanded, so that repeated cycles of freezing and thawing have a cumulative effect.

· The freezing water contained in pore structure expands as it is converted into ICE.

· The expansion causes localized tension forces that fracture the surrounding concrete matrix.

· The first stage is the development of fine closely spaced cracks parallel to the edge of the exposed concrete.

· The cracks soon become filled with a dark and are commonly called D cracks

・As the deterioration continues small pieces of concrete between the cracks separate from the body of concrete.

・Hydraulic structures are vulnerable to freezing and thawing. Exposure in such areas as the top walls, piers, parapets and slabs enhances the vulnerability of concrete to the harmful effects of repeated cycles of freezing and thawing.

・The use of dicing chemicals on concrete surfaces may also accelerate damage caused by freezing and thawing and may lead to pitting and scaling.

Preventive measures:

・Low water cement ratio

・Air entraining agent

・Flat surface provide proper drainage

・Durable aggregates

Rate of freezing

・Increased porosity

・Increased moisture

・Reduced rate of air entrainment

・Increased rate of freeze and thaw cycle Aggregates with increased rate of absorption

1 b. Explain the following terms: (i) Repair (ii) Maintenance (iii) Rehabilitation (iv) Retrofitting (v) Strengthening (10 Marks)

(i) Repair

Repair is an action that improves or replacing the functionality of a member of the structure or correcting the defects in a building or structure to an acceptable standard.

(ii) Maintenance

The act of keeping something in good condition by checking or repairing it regularly.

(iii) Rehabilitation

Rehabilitation of a building means returning a building or a structure to a useful state by means of repair, modification, or alteration.

・It is related to the strength aspect of structures.

・To bring back the position and condition of the structure by considering the strength aspect.

(iv) Retrofitting

The process of strengthening of structure along with the structural system, if required so as to comply all relevant codal provisions in force during that period.

(v) Strengthening

The process of increasing the load-resistance capacity of a structure or a portion.

OR

2 a. Write short notes on Durabiity of concrete and Acid attack. (08 Marks)

Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties.

Durability is defined as the capability of concrete to resist weathering action, chemical attack and abrasion while maintaining its desired engineering properties. It normally refers to the duration or life span of trouble-free performance. Different concretes require different degrees of durability depending on the exposure environment and properties desired. For example, concrete exposed to tidal seawater will have different requirements than indoor concrete.

Concrete will remain durable if:

- The cement paste structure is dense and of low permeability
- Under extreme condition, it has entrained air to resist freeze-thaw cycle.
- It is made with graded aggregate that are strong and inert
- The ingredients in the mix contain minimum impurities such as alkalis, Chlorides, sulphates and silt.

Durability of Concrete depends upon the following factors

- Cement content
- Compaction
- Curing
- Cover
- Permeability

Acid attack:

・Concretes made of Portland cement (OPC) are highly alkaline with pH values normally above 12.5 and are not easily attacked by acidic solutions.

・ As the pH of the solution decreases the equilibrium in the cement matrix is being disturbed, and the hydrated cement compounds are essentially altered by hydrolytic decomposition which leads to the severe degradation of the technical properties of the material.

・At pH values lower than 12.5 portlandite is the first constituent starting dissolution.

・ If pH decreases to values lower than stability limits of cement hydrates, then the corresponding hydrate loses calcium and decomposes to amorphous hydrogel.

• The final reaction products of acid attack are the corresponding calcium salts of the acid as well as hydrogels of silicium, aluminium, and ferric oxides.

• The solubility of Al_2O_3 and Fe_2O_3 depends on the pH value of the acting solution, while SiO_2 is insoluble in acidic solutions except in HF

2 b. Explain the evaluation of structural damages to the concrete structural elements due to earthquake. (12 Marks)

The shaking of the earth, because of the movements of plates beneath the crust of the earth, is called an earthquake.

An earthquake is an abrupt movement or tremor of the earth's crust that is initiated below or at the surface. The damage is the maximum close to the epicentre, the point from where the vibrations are initiated.

Vibration of the structure in response to ground shaking at its foundation is the concern of the structural engineer, and which is taken into account by codal provisions of the

different seismic resistant design codes. However, these codes do not include any provision due to other effects, which may even exceed that due to vibration, as the procedure of their estimation and the needed steps for the de engineering discipline. Even then, it is essential that the structural engineer should be aware of the different seismic hazards in order to advise the client of potential damage involved in selecting sites in such zones. Hence, the first step in the design procedure of a future structure should be the analysis of the suitability of the site selected with proper consideration for the potential of any one of the following types of damage.

The different 'Direct' and 'Indirect' seismic effects are as follows.

Direct effects:

• Ground failures, which include Surface faulting, Vibration of soil (or effects of seismic waves), Ground cracking, Liquefaction, Ground lurching, Differential settlement, Lateral spreading and Landslides.

A) Damage due to surface faulting:

These damages to buildings and facilities along the fault scarps vary widely from completely demolished houses to rupture of the foundations, tilting of the foundation slabs and walls. Sometimes houses also have minor damage.

(B) Damage due to liquefaction:

The instability of the soil in the area affected by internal seismic waves can cause significant damage. The mechanical characteristics of the soil layers, the depth of the water table and the intensities and duration of the ground shaking influence the soil response. Deposits of loose granular materials if present in the site may be compacted by the ground vibrations induced by the earthquake. This will cause large settlement and differential settlements of the ground surface. Further, the compaction of the soil may result in the development of excess hydrostatic pore water pressures of sufficient

magnitude to cause liquefaction of the soil, resulting in settlement, tilting and rupture of structures. The seismic-resistant design provisions of most codes only assure an effective design and construction of structures against damage due to the possible vibratory response of the structure to the shaking introduced at their foundation by the ground. However, it may not be possible to have success in all such cases. The only option remains in those areas is to prohibit the construction of building structures there.

(C) Damage due to ground shaking:

Integrated field inspection and post damage due to earthquake shaking is one of the most effective means of having expertise knowledge on seismic response with a view to improving the state of the art and of the practice in seismicresistant design and construction. Such integrated inspection and an addition to the soil conditions mentioned above, the seismic performance of a structure is very sensitive to type of foundation; configuration of the structure; structural material; and design and construction detailing.

(D) Damage due to sliding of superstructure on its foundation:

One of the basic guidelines in the seismic of structures is that the whole structure a unit, and that the superstructure be tied or anchored foundation.

(E) Damage due to Structural Vibration:

The inertia forces develop during the vibratory response of a structure to earthquake ground shaking whose intensity depends on the product of the mass and acceleration. Hence, it is of the utmost importance to reduce the mass of the structure to a minimum. It is obvious that timber is the most efficient earthquake-resistant material for low traditional structural materials aluminium. However, provision of proper lateral bracing and tying of all components together from the roof down to the foundation are to be followed.

Module-2

3 a. Explain the step by step Damage Assessment Procedure. (08 Marks)

The following steps are necessary to highlight the problem and to take appropriate remedial action

1. Physical Inspection of damaged structure like crack formation and spalling of concrete.
2. Preparation and documenting the damages.
3. Collection of samples and carrying out tests both in-situ and in lab.
4. Studying the documents including structural aspects.
5. Estimation of loads acting on the structure.
6. Estimate of environmental effects including soil structure interaction.
7. Diagnosis (Identification of problem by examination)
8. Taking preventive steps not to cause further damage.
9. Retrospective analysis to get the diagnosis confirmed.
10. Assessment of structural adequacy.
11. Estimation on future use.
12. Remedial measures necessary to strengthen and repairing the structure.
13. Post repair evaluation through tests.
14. Load test should be carried out to study the behaviour of structure.
15. Choice of course of action for the restoration of structure.

3 b. What is destructive testing systems? Why load tests are usually carried? (04 Marks)

- To access the quality af concrete with complete disturbance of concrete (loaded up to failure).
- In destructive testing (or destructive physical analysis, DPA) tests are carried out to the specimen's failure, in order to understand a specimen's performance or material behaviour under different loads.
- These tests are generally much easier to carry out, yield more information, and are easier to interpret than non-destructive testing.
- Destructive testing is most suitable, and economic, for objects which will be mass produced, as the cost of destroying a small number of specimens is negligible.
- It is usually not economical to do destructive testing where only one or very few items are to be produced (for example, in the case of a building).
- Analyzing and documenting the destructive failure mode is often accomplished using a high-speed camera recording continuously (movie-loop) until the failure is detected.
- Detecting the failure can be accomplished using a sound detector or stress gauge which produces a signal to trigger the high-speed camera.
- These high-speed cameras have advanced recording modes to capture almost any type of destructive failure.
- After the failure the high-speed camera will stop recording.
- The capture images can be played back in slow motion showing precisely what happen before, during and after the destructive event, image by image.
- The various destructive tests are: Compression strength of concrete, Flexural strength of beam, Split tensile strength of cylinder

3 c. Explain the penetration technique. (08 Marks)

OR

4 a. Write the objectives of rapid structured assessment. Explain the rapid assessment procedure (12 Marks)

- 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.

The rapid structural assessment should be performed in the following order:

- Review the entire outside of the structure.
- Enter the building only if necessary to determine extent of damage.
- Determine what degree of damage found in the structural and non-structural elements.
- Secure all areas that need to be isolated and post UNSAFE signage.

4 b. List the common methods used in construction industry for semi-destructive testing systems. (08 Marks)

- This system of testing is employed to access the quality of concrete in its damaged state with partial disturbance of surrounding concrete.
- Partially destructive tests are used for assessing the in-situ concrete strength.
- These tests cause localised damage, which do not cause any loss in the performance of the structure.
- All Tests in this group are surface zone tests which require assess to only) one exposed concrete face compared to core test.

- The accuracy may not be as good but estimation of strength is immediately available and the testing is a less destructive and damaging.

Common methods of semi-destructive testing

- Penetration techniques (Windsor probe test)
- Pull-out and Pull-off tests
- Core sampling and testing
- Break off test
- Permeability test
- Resistivity survey
- Carbonation and pH value test
- Chloride content test
- Abrasion resistance test

Module-3

5 a. Explain the effects due to climate and temperature. (08 Marks)

Effects due to climate

- The lack of durability of concrete on account of freezing and thawing action of frost is not of great importance to Indian conditions.
- The gel pores are 50 small that water in them dons freeze at normal winter temperatures. As water, when freezing expands by 9% of its volume, excess water in the capillaries has to move.

- Since the cement paste is relatively impermeable high pressures are necessary to move the excess water even over quite small distances.
- For normal strength concrete, it has been found that movement of the order of 0.2mm is sufficient to require pressures which approach the tensile strength of the paste.
- Concrete can be protected from freeze-thaw damage by the entrance of the appropriate quantities of air distributed through the cement paste, with spacing between bubbles of not more than about 0.4mm.
- The air bubbles must remain partially empty, so that they can accommodate the excess water moved to them.
- This will generally be the case, since the bubbles constitute the coarsest pore system, and are therefore the first to, most moisture as the concrete dies.

Effects due to temperature

- Temperature variation will cause changes in the concrete volume. When the temperature increases the volume of this concrete increases and when the temperature Alls the concrete contracts.
- In the concrete is unrestricted then the volume changes will not create too many consequences but generally the concrete always restrained by foundations, reinforcement or connecting members, due to this the change in volume will produce significant stress in concrete and that may cause crack.
- At high temperature, the cement paste will shrink due to dehydration of calcium silicate hydrate (C-S-H), while the aggregate will expand for normal aggregate concrete.

- ❑ Exposure to high temperature mainly to fire will result in crack in concrete but the time of exposure should sufficiently high.
- ❑ When the tensile strain of concrete exceeds its tensile strength capacity due to differential volume, it will crack.
- ❑ The liberation of the heat of hydration of cement causes the internal temperature of concrete to raise during the initial curing period, se that is usually slightly warmer than its surroundings.
- ❑ Any restraint on the free contraction during cooling will result in tensile stresses which are proportional to the temperature change, coefficient of thermal expansion, effective modulus of elasticity and degree of restraint.

- The common effects of temperature on concrete are:
  - ❑ Removal of evaporable water
  - ❑ removal of combined water
  - ❑ alteration of cement paste
  - ❑ disruption from disparity of expansion and resulting thermal stress
  - ❑ alteration of aggregates
  - ❑ change of the bond between aggregate and paste

5 b. Explain the cathode protection. (06 Marks)

Cathodic protection is a method to control the corrosion of steel in contaminated concrete that works by making the embedded reinforcing steel cathodic. When the steel becomes cathodic, hydroxyl ions are accumulated around it making it passive for longer time. The reinforcing steel is electrically connected to another metal that becomes the anode

with or without the application of an external power supply. The cathodic protection systems that work in the absence of an external power supply and in the presence of a less noble metal (like zinc) to act as anode are referred to as sacrificial passive systems. In case of an impressed current cathodic protection, an external power supply is used to force a small amount of electric current through the reinforcing steel to counteract the flow of current caused by the corrosion process. A metal, like platinum, serves as anode which corrodes at a very slow rate. Cathodic protection is used to protect almost any type of reinforced concrete structure, including horizontal slabs, walls, towers, beams, columns and foundations. However, this method has the following limitations:

- Cathodic protection does not replace corroded steel
- Impressed current cathodic protection systems are not recommended for general usage on prestressed concrete structures because hydrogen produced can make the high-strength steels brittle in nature
- Passive sacrificial systems can be used for post- tensioned structures after detailed corrosion analysis
- Electrical continuity of the reinforcing steel and ionic conductivity of concrete must be confirmed during system installation.

5 c. What are the effects due to corrosion? Write the Anode and Cathode reactions. (06 Marks)

Effects

Corrosion has direct effects on reinforced concrete structures. It weakens the structure; reduces the bonding strength of the materials, limits the ductility, and reduces the shear capacity of the buildings.

- Weakness of structures

- Reduced bonding strength
- It causes fatigue
- Reduced ductility
- Reduced shear capacity

A moist concrete matrix forms an acceptable electrolyte and the steel reinforcement provides the anode and cathode. Electrical current flows between the cathode and anode, and the reaction results in an increase in metal volume as the Fe(Iron) is oxidized into Fe(OH), and Fe(OH), and precipitates as Fe OH (rust).

The electrochemical equations as given below:

$Fe \rightleftharpoons 2e^- + Fe^{++}$ (ANODE)

$1/2O_2 + H_2O + 2e^- \rightleftharpoons 2(OH^-)$ $Fe(OH)_2$ (CATHODE)

$4Fe(OH)_2 + 2H_2O + O_2 \longrightarrow 4Fe(OH)_3$ RED RUST

$3Fe + 8OH^- \longrightarrow Fe_3O_4 + 8e^- + 4H_2O$ BLACK RUST

OR

6 a. Explain the corrosion inhibitors. (08 Marks)

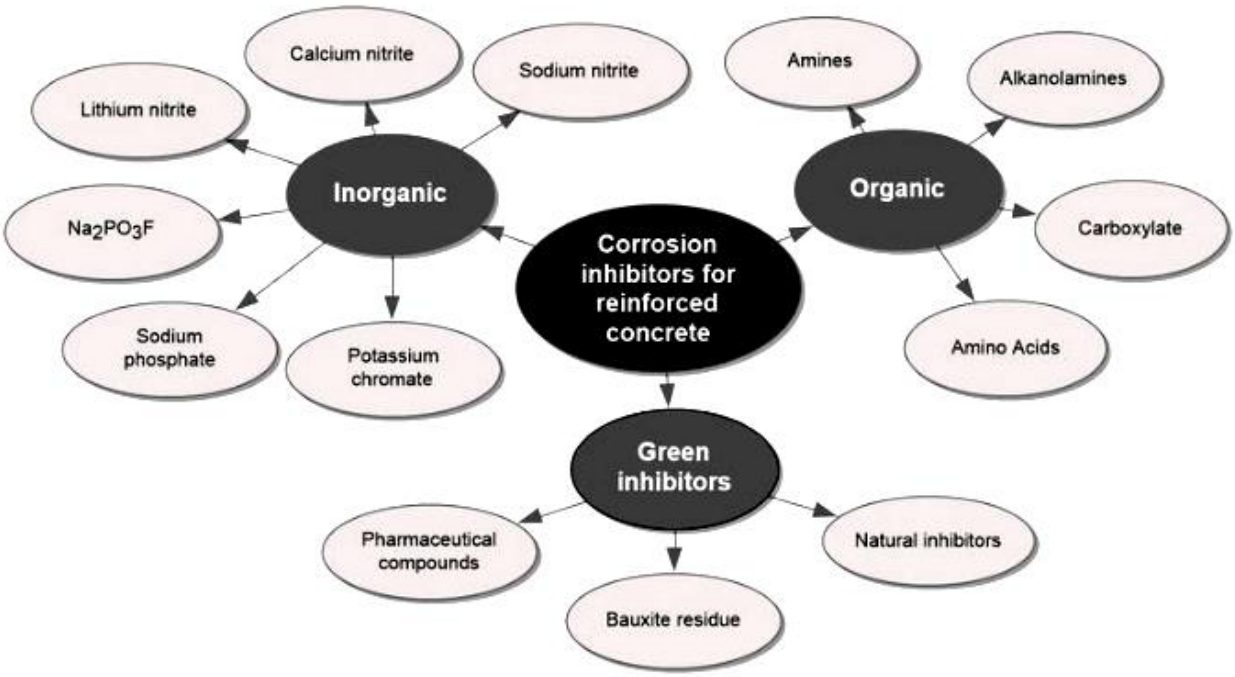
Corrosion inhibitors, which are added to the concrete at the time of mixing, are used to prevent the onset of corrosion in R/C. mechanisms: by increasing the threshold concentration for aggressive species necessary for corrosion to occur or by reducing the rate of corrosion once corrosion has begun.

Corrosion inhibitors, whether admixed or surface applied, exist in three basic forms: anodic inhibitors, cathodic inhibitors, and mixed inhibitors. Anodic inhibitors minimize

the anodic component of the corrosion process while cathodic inhibitors minimize the cathodic component. Mixed inhibitors prevent both the anodic and cathodic reactions. By forming a film on the steel, coating the surface of the steel, or by reacting with the chloride ions, the interaction between the chloride ions and steel will be prevented.

Types of Corrosion Inhibitor

- Cathodic Inhibitor
- Anodic Inhibitor
- Volatile Corrosion Inhibitor
- Mixed Inhibitors



6 b. Explain the design and construction errors of concrete structures. (12 Marks)

Design errors

Design errors may be divided into two general types:

1. Those resulting from inadequate structural design

2. Those resulting from lack of attention to relatively-minor-design details.

Each of the two types of design errors is discussed below.

(1) Inadequate structural design

(a) Mechanism: The failure mechanism is simple the concretes exposed to greater stress than it is capable of carrying or it sustains greater strain than its strain capacity.

(b) Symptoms. Visual examinations of failures resulting from inadequate structural design will usually show one of two symptoms.

1. First, errors in design resulting in excessively high compressive stresses will result in spalling. Similarly, high torsion or shear stresses may also result in spalling or cracking.

2. Second, high level stresses will result in cracking.

(c) Prevention Inadequate design in prevented by through and careful review of all design calculations. Any rehabilitation method that makes use of existing concrete structural members must be carefully reviewed

(2) Poor design details

- A structure may be adequately designed to meet loading and other overall requirements, poor detailing may result in localized concentrations of high stresses in otherwise satisfactory concrete.
- These high stresses may result in cracking that allows water or chemicals, access to the concrete. In other Cases pour design detailing may simply allow water to pond on a structure, resulting in saturated concrete.

- In general, poor detailing does not lead directly to concrete flute; rather, it contributes to the action of one of the other causes of concrete deterioration .

Construction Errors

- Failure to follow specified procedures and good practice or outright carelessness may lead to a number of conditions that may be grouped together as construction errors.

- Most of these errors do not lead directly to failure or deterioration of concrete.

- Instead, they enhance the adverse impacts of other mechanisms. Each error will be briefly described along with preventative methods.

- In general, the best preventive measure is a thorough knowledge of what these construction errors-are, plus an aggressive inspection program.

- It should be noted that errors of the type are equally as likely to occur during repair of rehabilitation projects as they are likely to occur during new construction.

a) Adding water to concrete. Water is usually added to concrete in one or both of the following circumstances

- First, water is added to the concrete in a delivery truck to increase slump and decrease emplacement effort. This practice will generally lead to concrete with lowered strength and reduced durability. As the w/c of concrete increases, the strength and durability will decrease.

- In the second case, water is commonly added during finishing of flatwork. This practice leads to sealing, crazing and dusting of the concrete in service.

b) Improper alignment to formwork

- Improper alignment of the food will lead to discontinuities as the face of concrete. While these discontinuities are unsightly at all circumstances the occurrence may be more critical in areas that are subjected to high velocity than of water, where cavitations erosion may be induced, or in lock chambers where to rubbing" surfaces must be straight.

(c) Improper consolidation.

- Improper consolidation of concrete may result in a variety of defects, the most common being bug holes, honeycombing, and cold joints.

- Bug holes are formed when small pockets of air or water are trapped against the forms. A change in the mixture to make it less "sticky as the use of small but worked near the form has been used to help eliminate bug holes, Honeycombing can be reduced by inserting the vibrator more frequently, insetting the vibrator as close as possible to the form face without touching the form, und slower withdrawal of the vibrator.

Module 4

7 a. Discuss the importance of maintenance of structures. (08 Marks)

Importance of Maintenance various aspects of Inspection

- Improves the life of structure

- Improved life period gives better return on investment

- Better appearance and aesthetically appealing

- Leads to quicker detection of defects and hence remedial measures

- Prevents major deterioration that leads to collapse

- Ensures safely to occupants
- Ensures feeling of confidence by the user

Daily Routine Maintenance

- Basically an inspection oriented and may not contain action to be taken
- Help in identifying major changes, development of cracks, identifying new cracks etc
- Inspection of all essential items by visual observation
- Check on proper function of sewer, water lines, wash basins, sinks etc
- Check on drain pipes from roof, during rainy season

Weekly Routine Maintenance

- Electrical Accessories
- Flushing sewer line
- Leakage of water line

Monthly Routine Maintenance

- Cleaning Doors, windows, etc
- Checking Septic Tank/Sewer
- Observation for cracks in the elements
- Cleaning of overhead tanks

Yearly Routine Maintenance

- Attending to small repairs and white washing
- Painting of steel components exposed to weather
- Check of displacements and remedial measures

7 b. Explain beam jacketing technique with sketches. (12 Marks)

Jacketing has been considered as one of the important methods for strengthening and repairing of RC beams. Jacketing of RC beams is done by enlarging the existing cross section with a new layer of concrete that is reinforced with both longitudinal and transverse reinforcement.

- Materials, like conventional concrete and mortar, epoxy mortar, grout, and latex-modified mortar and concrete, are used as encasement materials. For jacketing, the void between the form and the existing member is filled using pumping, tremie, or preplaced aggregate concrete.
- Jacketing is particularly used for the repair of deteriorated columns, piers, and piles and may easily be employed in underwater applications. The method is applicable for protecting concrete, steel, and timber sections against further deterioration and for strengthening.
- Permanent forms are preferred where protection against weathering, abrasion, and chemical pollution is desired. The collar provides increased shear capacity for the slab, and it decreases the effective length of the column. Architecturally collars are considered better than jacketing but performing the same structural function.
- Before applying jackets or collars, all deteriorated concrete must be removed, cracks must be repaired, existing reinforcement must be cleaned, and surfaces must be prepared. The surface preparation improves the bond of the newly placed materials with the existing structure, which is difficult for underwater repairs. For underwater conditions, a plastic shell may be applied at the splash zone to help minimize abrasion.

- A drawback of jackets and collars is that they occupy space that was earlier available for other uses. Timber, cardboard and corrugated steel forms may be used as temporary or permanent forms. Permanent fiberglass, rubber, and fabric forms have gained considerable popularity because they provide resistance to chemical attack after the repair is complete.
- Jacketing used for purposes other than covering the deteriorated concrete and providing lateral confinement, such as to bear longitudinal loads, needs special considerations. The existing column may have undergone full shrinkage and most of the creep and also has elastic strains due to carried loads, whereas the shrinkage and creep of the new material has to occur.
- The load transfer to jacketing is also a big issue. It is better to use jacking to release the load on the member before jacketing, to use non-shrinking materials for jacketing and to hammer steel shims at the transfer points of the jacketing after curing. If the material used for jacketing is cement mortar or concrete, the cement content must be exactly according to the requirements; both excessive and less cement contents may be dangerous.
- Use clean, stable and the largest possible size aggregates. In order to reduce shrinkage, control the temperature of the materials and the immediate surroundings during placing and curing. Use of admixtures such as plasticizers, air-entraining agents, retarders, accelerators and waterproofing admixtures is more beneficial in repair than even the ordinary construction. Expanding mortars / concretes can be made by adding aluminum powder to the matrix to overcome the setting shrinkage and some part of the drying shrinkage.
- The use of iron fillings or powder can also perform this function if moisture and air are available. In case grout is used for filling the forms, it is allowed to settle for about 20 minutes after fulfilling and then is filled to overflowing condition. The top of the jacket must be finished with pneumatically projected or hand placed concrete.

OR

8 a. Explain externally bonding technique. (12 Marks)

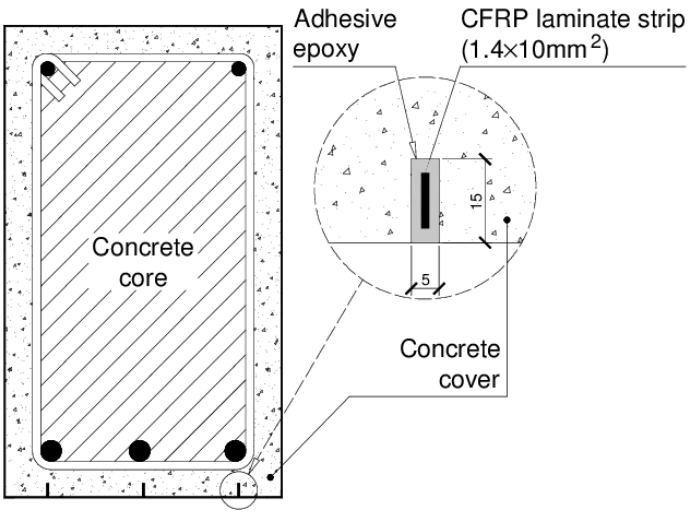
- Strengthening of reinforced concrete beams with FRP reinforced systems (FRP plate or strips) have been utilize from around 1980s. FRP systems can be used for increasing shear strength of reinforced concrete beams by completely or partially wrapping FRP systems around reinforced concrete member.
- Since, most of reinforced concrete beams are constructed monolithically with other continuous members such as slabs or walls, therefore complete wrapping of FRP plates is not possible in most cases. Directing FRP fibers perpendicular to potential shear cracks is effective in providing extra shear strength.
- Moreover, enhancing shear strength might lead to flexural failure which is more ductile failure hence more desired compare with brittle shear failure. The additional shear strength achieved by applying FRP plates or strips depends on number of factors such as beam geometry, existing concrete strength, and applied wrapping scheme. There are three main types of FRP systems which includes Aramid, Glass, and Carbon FRPs
- Generally, the structural performance of reinforced concrete or masonry elements strengthened with FRCM systems is comparable to similar elements strengthened with FRP systems. FRCM systems can be used for flexural and shear strengthening of concrete and masonry elements, or to provide confinement to concrete columns.
- In reinforced concrete beams and flat slabs, FRCM systems can be used to increase the flexural strength, by placing it on the tension zone with the primary direction of the fabric in the direction of the tensile stresses (along the span of the beam or slab).

- FRCM systems can also be used as shear reinforcement in beams. This is accomplished by fully wrapping or U wrapping the beams at the critical sections with the primary direction of the fabric in the transverse direction.
- Strengthening of columns with FRCM systems requires wrapping around the column, with the primary direction of the fabric in the direction transverse to the axial load. Strengthening of masonry walls is accomplished using a bi-directional fabric mesh to provide flexural and shear resistance due to the combined action of out-of-plane and in-plane loads.

8 b. What is the process involved in near surface mounted technique. (08 Marks)

- The technique of near-surface mounted reinforcement for strengthening concrete structures is currently being developed as an alternative to externally bonded fibre composite materials. The process involves cutting a series of shallow grooves in the concrete surface in the required direction. The depth of the groove must obviously be less than the cover so that the existing reinforcement is not damaged.
- The grooves are partially filled with epoxy mortar into which pultruded carbon fibre composite rods or strips are pressed. The remainder of the groove is then filled with epoxy mortar and the surface levelled. The approach can be used to increase the flexural (bending) of beams and slabs, or the shear capacity of beams. It can also be used for strengthening concrete masonry walls.
- As the fibre composite material is embedded in the concrete, it is less susceptible to damage, for example by fire or vandalism, than material bonded to the surface. It is obviously very appropriate for strengthening the top surfaces of slabs, where externally bonded fibre composites would require a protective layer; damage may be caused to the composite if it is necessary to remove the protective layer at a later date.
- A further potential advantage of the technique over the use of externally bonded fibre composite is that no preparation of the concrete surface is required. Clearly

one limitation on the technique is the need to have sufficient cover to the existing reinforcement to allow the grooves to be cut without the risk of damaging the steel.



Module-5

9 a. What is carbon fibre reinforced polymer? (06 Marks)

Carbon fiber-reinforced polymers (CFRPs) include epoxy, polyester, nylon and vinyl. However, the fibers often include glass or aluminum in addition to carbon. This material variation provides strength and rigidity to CFRP.

The properties of CFRP are dependent on the ratio of fiber to polymer, the types of additives and the matrix structure.

Carbon fiber-reinforced polymers have the best strength-to-weight ratio of all construction materials. They are commonly used in the following industries:

- Aerospace
- Automotive
- Civil engineering

- Sporting goods

Despite having a high strength-to-weight ratio, one structural disadvantage is its relatively low fatigue endurance limit. Therefore, a sufficient safety limit must be factored in when it is used in applications that may present significant risk to humans or the environment in the event of a premature failure.

9 b. Explain the types of special mortar. (10 Marks)

Following are tile various types of special mortars which are used for certain conditions:

1. Fire-resistant mortar
2. Lightweight mortar
3. Packing mortar
4. Sound-absorbing mortar
5. X-ray shielding mortar

1. Fire-resistant mortar: This mortar is prepared by adding aluminous cement to the finely crushed powder of fire-bricks. The usual proportion is 1 part of aluminous cement to 2 parts of powder of fire-bricks. This mortar is fire-resistant and it is therefore used with fire-bricks for lining furnaces, fire places, ovens, etc.

2. Lightweight mortar: This mortar is prepared by adding materials such as saw dust, wood powder, etc. to the lime mortar or cement mortar. Other materials which may be added are asbestos fibres, jute fibres, coir, etc. This mortar is used in the sound-proof and heat-proof constructions.

3. Packing mortar: To pack oil wells, special mortars possessing the properties of high homogeneity, water resistance, predetermined setting time, ability to form solid water-

proof plugs in cracks and voids of rocks, resistance to subsoil water pressure, etc. have to be formed.

4. Sound-absorbing mortar: To reduce the noise level, the sound-absorbing plaster is formed with the help of sound-absorbing mortar. The bulk density of such a mortar varies from 6 to 12 kN/m3 and the binding materials employed in its composition may be Portland cement, lime, gypsum, slag, etc. The aggregates are selected from lightweight porous materials such as pumice, cinders, etc.

5. X-ray shielding mortar: This type of mortar is used for providing the plastering coat to walls and ceiling of X-ray cabinets. It is a heavy type of mortar with bulk density over 22 kN/m3. The aggregates are obtained from heavy rock and suitable admixtures are added to enhance the protective property of such a mortar.

9 c. What are the properties of Epoxy resins? (04 Marks)

- Resistance to chemicals, particularly alkaline environments
- Heat resistance
- Adhesion to a variety of substrates
- High tensile, compression, and bend strengths
- Low shrinkage during curing
- High electrical insulation and retention properties
- Corrosion resistance
- Cures under a wide range of temperatures
- Resistance to fatigue

OR

10 a. What is Sisal Fibre and write its properties? (08 Marks)

Sisal fiber is derived from leaves of plant. It is usually obtained by machine decortications. The strands are usually creamy white, average from 80-120 cm in length and 0.2 - 0.4 mm in diameter and are lustrous in appearance. The World production is about 3000,000 tones.

Properties of Sisal Fiber:

1. Sisal Fiber is exceptionally durable with a low maintenance with minimal wear and tear.
2. It is Recyclable.
3. Sisal fibers are obtained from the outer leaf skin, removing the inner pulp.
4. It is available as plaid, herringbone and twill.
5. Sisal fibers are Anti static, does not attract or trap dust particles and does not absorb moisture or water easily.
6. The fine texture takes dyes easily and offers the largest range of dyed colors of all natural fibers.
7. It exhibits good sound and impact absorbing properties.
8. Its leaves can be treated with natural borax for fire resistance properties.

10 b. What is shoring and under Pinning? Explain its types. (12 Marks)

Shoring

Shoring is employed to prevent a damaged structure due to foundation settlement or other reasons from collapse. It is also used to provide temporary supports to a structure which is being remodeled or where alterations of adjacent foundations are being carried out.

Shoring may be provided externally or internally or from both sides of the wall. For light loads or temporary shores generally limber is used whereas for supporting heavier loads steel beams or braced sections are employed. Sometimes concrete or masonry is also used for shoring.

The shores are classified in the following types based on their supporting characteristics:

- Raking Shores,
- Horizontal or Flying Shores,
- Vertical or Dead Shores.

Underpinning:

At times it is essential to replace or strengthen the foundation of an existing structure. The operation of providing this is known as underpinning. The art of underpinning structures is as old as that of building itself.

Earlier underpinning was carried out mainly because of settlement of structure as a result of inadequate foundations. Remedial underpinning is done to provide additional foundation strength to an inadequately supported structure which may be settling or in danger of collapse.

Precautionary underpinning cannot be always avoided, as it becomes essential the construction of new foundations deeper than those of the existing building.

Types:

- Pit method
- Pile method