L. D. COLLEGE OF ENGINEERING, AHMEDABAD (GTU)

8th Semester Civil Engineering - PDDC 2013 Batch

Subject Code & Name: X80605 - Repairs and Rehabilitation of Structures

Assignment

1. Explain the causes of distress in structures.
2. What is the meaning of durable concrete? What are the test performed to check the durability?
3. Clearly distinguish the three terms: Repair, Rehabilitation and Retrofitting
4. Write short note on Foamed Concrete.
5. Write short note on Sulphur infiltrated concrete
6. Elaborate the use of polymer concrete.
7. How Vacuum concrete will be made up? Elaborate its uses
8. Explain the terms: Strengthening, Restoration, repair and Retrofitting.
9. Explain the term durability of concrete and factors affecting it.
10. Explain the term permeability of concrete and factors affecting it.
11. Enlist the methods of corrosion protection. Explain any one of them.
12. List out various Non-Destructive Test (NDT) used to determine strength of existing structure. Explain any one of them.
13. Explain the Significance of quality control. What are the recommendations given in I.S.456-2000 to produce good quality concrete?
14. Explain concrete repairing by grouting.
15. Explain Temperature effect on concrete.
16. What do you understand by sulphate attack on concrete? Discuss the factors responsible for it. How does it affect RCC elements?
17. What are the main objectives of condition assessment of structure?
18. Write the significance of cracking of concrete. What are the major causes of cracking in concrete and how can it be prevented?
19. Enlist Common design and construction errors.
20. Explain shoring and underpinning technique for foundation rehabilitation.
21. Differentiate between the following
    A. Rehabilitation & Retrofitting
    B. Porosity & Permeability
    C. Micro-Crack & Macro Crack
    D. Plastic Shrinkage & Drying Shrinkage
22. What is the importance of the field and laboratory testing for damage assessment of the structure?
23. Which are the distinct stages to be recognized while taking up any repair work.
24. What is meant by Jacketing? Discuss repair and strengthening of columns by Jacketing.

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Assignment.1

Q.1 Explain the causes of distress in structures. Explain any one in detail.

Distress means damage.

Concrete may suffer distress or damage during its life period due to a number of reasons Because of the varying conditions under which it is produced at various locations, the quality of concrete suffers occasionally either during production or during service conditions resulting in distress

\# causes of distress of concrete

(1) structural causes
- → excessive applied loads
- → Environmental loads
- → Accidents
- → subsidences etc

(2) Errors in design and detailing

(3) Poor Construction practices

(4) Construction overloads

(5) Drying Shrinkage

(6) Thermal Stress

(7) Chemical reactions

(8) Weathering

(9) Corrosion

In addition to the distress in hardened concrete, the plastic concrete may also suffer damage due to

- Plastic shrinkage
- settlement cracking

(2) Early removal of formwork
- Improper design of formwork

Errors in design & detailing

(1) Inadequate structural design :-
The common errors of structural designare

→ Errors in load calculations
→ For the design of foundation, SBC of soil is assumed without conducting plate load test or other tests.
→ Design not confirming to IS:456-2000 and IS 1893-1984 guidelines.
→ Load transfer path in the structure is not properly understood by the designer.
→ Design with many cantilevers and projected balconies
→ Shear wall is not designed in the multistorey framed structure.
→ In the ground floor storey for parking only columns are provided without walls resulting in 'soft storey'.
→ Stiffness of the structures in both directions is different, resulting in 'torsion' during earthquake
→ Lack of knowledge using structural design softwares like STAAD PRO, ETAB, STRUD ETC.

Q.1 What is the meaning of durable concrete? What are the test performed to check the durability?

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. Different concretes require different degrees of durability depending on the exposures environment and properties desired.

Some important degradation mechanisms in concrete structures include the following

(1) Freeze-thaw damage (physical effects, weathering)
(2) Alkali-aggregate reactions (chemical effects)
(3) Sulphate attack (chemical effects)
(4) Microbiological induced attack (chemical effects)
(5) Corrosion of reinforcing steel embedded in concrete (chemical effects)
(6) Carbonation of concrete
(7) Chloride induced.
(8) Abrasion (physical effects)
(9) Mechanical loads (physical effects)

Durability tests

(1) Corrosion tests
(2) Absorption and permeability
(3) Test for Alkali Aggregate reaction
(4) Abrasion resistance tests
(5) Rebar Locator test

Q. Write short note on formed concrete. (Jan. 19 CA)

If a sufficient portion of concrete is removed. It can best be replaced with concrete placed in forms. This concrete can be placed without a bonding agent and without grout on the prepared surface of the old concrete. US bureau of reclamation suggest that this method should be used.

(1) When the depth of the repair exceeds 150 mm.
(2) For holes extending right ~~through~~ through the concrete section.
(3) For holes in unreinforced concrete with area greater than 0.1 m2 and over 100 mm deep.
(4) For holes in reinforced concrete which have an area greater than 0.03 m2 and which extend deeper than the reinforcement.

There are some essential requirements that apply to use of formed concrete as a replacement material, regardless of its location in the structure.

(1) The concrete should be made from the best possible materials and with the lowest possible water/cement ratio.
(2) To keep shrinkage to a minimum, the aggregate size should be largest as can be accommodated and the water content as low as possible.
(3) The mix should be designed so that no bleeding occurs in order to ensure that the replacement material remains in intimate contact with old concrete located above it.

(e) Forms must be robust and firmly fixed so that they withstand and applied pressure and do not allow grout leakage.

(f) Old concrete, against which new concrete is to be placed, must be sound, completely clean and saturated and the surface must be free ~~from~~ from moisture.

PM-19

Q.5 b Write Short note on "Sulphur infiltrated concrete"

In the Past, attempts have been made to use Sulphur as a binding materials instead of cement. Sulphur is heated to bring it into molten condition to which coarse and fine aggregates are poured and mixed thoroughly on cooling, this mixture gave Fairly good strength, exhibited acid resistance and chemical resistance, but it proved to be costlier than ordinary cement Concrete.

Recent studies shows that sulphur impregnation into open cavity porous concrete improve its strength. It is reported that Compressive strength of about 100 mpa could be achived in about 2 days time. The quantity of sulphur used in this method is also comparatively less making the process economical.

A coarse aggregate of size 10 mm and down well graded, and commercial sulphur of purity 99.9% are used. A water cement ratio of 0.5 or more may be adopted.

The test specimens after 28 hours of moist curing, dried in heating cabinet for 24 hours at 121°C. Then the dried specimens are placed in a containers of molten sulphur at 121°C for 3 hours specimen are removed from the containers, wiped clean of sulphur and cooled at room temperature for 1 hour.

The sulphur infiltrated concrete shows high resistance to freezing and thawing, high resistance to corrosion, and improvement in water impermeability.

Teacher's Signature :

Applications

- Precast roofing elements, Fencing posts, Sewer pipes
- Railway sleepers.
- For industrial applications, where high Corrosion resistance is required.
- Precast concrete units are cheaper than commercial concrete.

Q-3 Elaborate the use of polymer concrete. 8 marks

05.05.16

The applications of polymer impregnated concrete are as follows

(1) Prefabricated structural elements :- The technique of polymer impregnation is ideally suited for precast concrete elements, owing to higher strength, much thinner sections and light weight could be used which enables ease handling and erection. Thus can be used in high rise buildings without much difficulties.

(2) Surface impregnation of bridge decks :- The purpose of impregnating the bridge decks is to render them impervious to the intrusion of moisture, Chloride ions and deicing chemicals.

(3) Hydraulic Structures :- The effect of cavitation and erosion in dams and other hydraulic structures can be counteracted. The conventional repairs of the damaged concrete are expensive and huge losses may be caused due to loss of benefits from power generation, irrigation, flood control etc. for such cases the repairs by polymer-impregnation is much beneficial.

(4) Marine works :- PFC possess high surface hardness, low permeability and higher resistance to chemical attack. Which are the most desirable properties of concrete to be used in marine works.

(5) Desalination plants :- The material used in the construction of fresh distillation vessels has to withstand the corrosive effects of distilled waters, brine and vapour. Carbon steel vessels are costly. Use of RCC in the construction of vessels has proved to be economic.

(6) Nuclear power plants: The Nuclear vessels are required to withstand high temperatures and provide shield against radiations. At present heavy weight concrete is being used for this purpose which is not very effective. PSC possess very low permeability, high strength and marked durability provide an answer to these problems.

Q.1 How vacuum concrete will be made up? Discuss its uses? pg. 184 (A2)

It is well known that high water/cement ratio is harmful to overall quality of concrete whereas low water/cement ratio does not give enough workability for concrete to be compacted hundred percentage. higher workability and higher strength or very low workability and higher strength do not go hand in hand. Vacuum process of concreation enables to meet this conflicting demand. This process helps a high workable concrete to get high strength.

In this process, excess water used for higher workability is withdrawn by means of vacuum pump immediately after placing of concrete. The process when properly applied, produces concrete of good quality.

The duration of treatment depends upon the water-cement ratio and quantity of water to be removed. It generally ranges from 1 to 15 minutes for slabs varying in thickness from 25 mm to 125 mm. This treatment is not very effective for water cement ratio below 0.40

The ~~uses~~ advantages of vacuum treatment are

(1) It permits removal of formwork at an early age to be used in other repetitive work.

(2) If vacuum concrete bonds very well with old concrete.

(3) There is considerable increase in strength and quality of concrete.

(4) The resistance to wear and abrasion is increased.

Applications :-

(1) Production of precast plain and reinforced concrete elements in mass production in factories.

(2) Construction of thin concrete walls, partition walls and slabs.

(3) Resurfacings and repairs of road pavements.

Q.3 Explain the term

(1) **Strengthening :-** The process of increasing the load-resistance capacity of a structure or portion.

(2) **Restoration :-** The process of re-establishing the materials, form and appearance of a structure.

(3) **Repair :-** The process of replacing or correcting the deteriorated, damaged or faulty materials, components or elements of a structure.

(4) **Retrofitting :-** The process or strengthening structure along with the structural system, it required so as to comply all relevant codal provisions in force during that period.

Q.4 **What are the main objectives of condition assessment of structure ? Explain any two conditional survey in detail ?**

=> Condition assessment of the structures is the systematic and logical examination of the structure to identify the need and cause of distress. The examination could include a number of activities like visual inspection, checking of designs, drawings, construction records, previous investigation records sampling, Field and laboratory testing, documentation and service precaution.

The objective of the condition assessment will include the following

(1) To provide insight in to the current condition of the structure i.e to identify the cause and source of observed distress.

(2) To assess the extent and development of the deterioration.

(3) To assess the influence of the deterioration on the safety and life expectance of the structure. i.e determining the residual ~~strength~~ strength of the structure and its possibility of being repaired.

(4) To accurately assess the scenario of concrete in terms of its physical, chemical and electro-chemical properties.

(5) To prioritise the repair of the distressed elements in order of the seriousness of the deterioration.

(6) To chart out an effective and economical feasible concrete repair program.

condition assessment and evaluation can be broadly classified into two main levels.

(1) Preliminary investigation
(2) detailed investigation

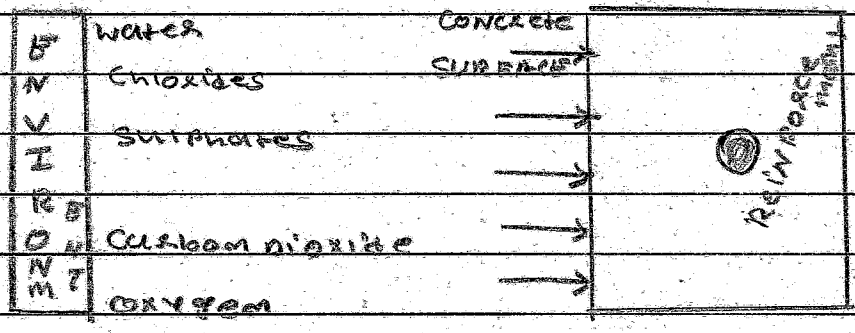
(1) Preliminary investigation

The preliminary investigation as a part of the condition assessment helps to understand the past record of the structure in terms of the distress and repairs carried out if any.

Q. Define durability of concrete and explain the major causes of inadequate durability

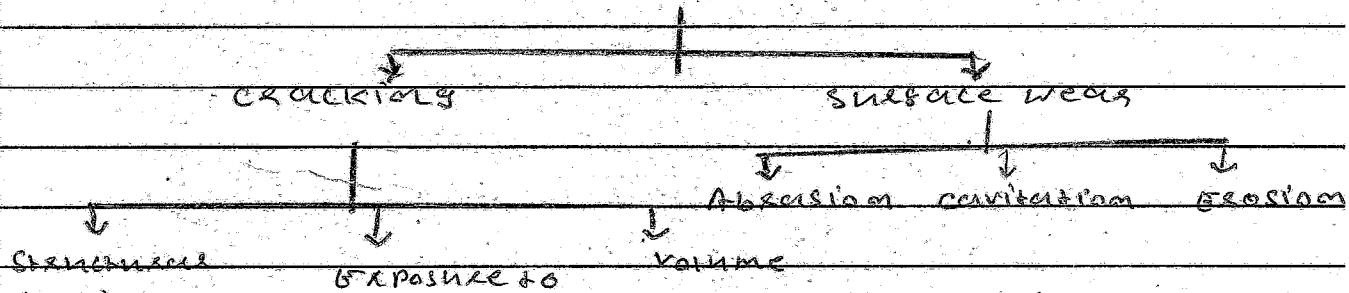
Durability of Portland cement is defined as its ability to resist weathering action, chemical attack, abrasion or any other process of deterioration

The factors affecting durability are broadly divided in two groups, namely external factors and internal factors



Environmental penetration into concrete

Physical causes of deterioration of concrete



Requirement for Durability

Requirement for durability under following heads

(1) Exposure conditions
(a) Ordinary environment
(b) Freezing and thawing
(c) Exposure to sulphate attack
(d) Acid attack
(e) Sea water attack
(f) Abrasion, erosion and cavitation
(g) Carbonation
(h) Fire resistance

(2) Requirements of Concrete cover

(3) Shape and Size of member

(4) Type and quality of constituent materials
(a) concrete mix proportions
(b) maximum cement content
(c) Chloride in concrete
(d) sulphate in Concrete
(e) Alkali aggregate reaction

Q.10 Explain the permeability of concrete and factor affecting on it.

There are three fluids principally relevant to durability which can enter concrete

1. Water
2. Carbon dioxide
3. Oxygen

The transport of fluid through concrete depend on the structure of the hardened cement paste. The flow of fluid through concrete is referred to as permeability.

The main factors affecting permeability are

1. Water/cement ratio
2. Properties of cement
3. Aggregate
4. Absorption and homogeneity of concrete
5. Curing
6. Use of admixtures
7. Age of Concrete

1. Water/cement ratio :- For the pastes hydrated to the same degree, the permeability is lower with lower water/cement ratio or higher cement content.

2. Properties of cement :- The permeability of concrete is affected also by the properties of cement. For the same water/cement ratio, coarse cement tends to produce a paste with a higher porosity than a finer cement. For instance, higher fineness of cement

paste, the lower will be the permeability.

(3) Aggregate :- The permeability of aggregate affects the behaviour of the concrete. For a given water/cement ratio, greater the maximum size of aggregate greater is the permeability.

(4) Absorption and homogeneity of Concrete :- The volume of pore space in concrete is measured by absorption. Absorption is a physical process by which concrete draws water into its pores and capillaries. The permeability can be reduced by working mix so that segregation is avoided.

(5) curing :- continued hydration of the cement paste results in the reduction in the size of the voids which decreases the permeability. Proper curing of concrete decreases the permeability of concrete.

(6) Use of Admixtures :- Use of water proofing admixtures reduces permeability of lean mixes. For general the use of extra cement will be more effective in reducing the permeability.

(7) Age of Concrete :- The permeability of cement paste also varies the age of concrete as with the degree of hydration. In a fresh paste the flow of water is controlled by size, shape and connectivity of the original cement grains.

Q.3 Ch 2 — Write short note "polymer Concrete" pg. 162
4/12/13

polymer Concrete is a mixture of aggregates with a polymer as the sole binder. There is no other bonding material present i.e portland cement is not used.

It is a manufactured in a manner similar to that of cement concrete. monomers or pre-polymers are added to the graded aggregate and the mixture is thoroughly mixed by hand or machine. the thoroughly mixed polymer concrete material is cast in moulds of wood, steel or aluminium etc.

To minimize the amount of the expensive binder it is very important to achieve the maximum possible dry packed density of the aggregate ~~is~~ For example, using two different size fractions of 20 mm maximum coarse aggregate and five different size fractions of sand, higher densities can be achieved.

The polymer concrete material cast in the mould is then polymerized either at room temperature or at an elevated temperature. The polymer phase binds the aggregate to give a strong composite polymerization can be achieve by any of the following methods

① Thermal - catalytic reaction
② Catalyst - promotes reaction
③ Radiation

for the thermal - catalytic reaction method catalyst is added to the monomer and polymerization

is initiated by decomposing the catalyst by the application of elevated temperature upto 90°c various catalysts used are, benzoyl peroxide, methyl-ethyl ketone peroxide etc.

The polymer systems used for polymer concrete are

- methyl - methacrylate
- Polyester - Styrene
- Epoxy Styrene
- Styrene
- furfuryl acetone etc.

The applications of polymer concrete are repairs for overlayers, air field pavements and industrial structures, it is also used for repairs of sluiceways and stilling basin of the dam. It is also used in rock bolting. Polymer concrete possess good electrical properties, and it can be used for manufacturing of electrical poles.

most of the cement mortars proportion for polymer modification used in the range of 1:2 to 1:3 (cement - fine aggregate ratio), the polymer latex (solid contents) : cement ratio by ranges from 5 to 20% by weight whereas W/C ratio is of the order of 0.30 to 0.60 depending upon the required workability.

Q. How the corrosion takes place? Explain the various techniques to avoid or decay the corrosion.

The damage to the concrete due to corrosion of reinforcement is considered to be one of the most serious problems. The corrosion take places due to following reasons

(1) Formation of white patches :- CO_2 reacts with $Ca(OH)_2$ in the cement paste to form $CaCO_3$. The free movement of water carries the unstable $CaCO_3$ towards the surface and forms white patches. It indicates the occurrences of carbonation.

(2) Brown patches along reinforcement :- When reinforcement starts corroding, a layer of ferric oxide is formed. This brown product resulting from corrosion may permeate along with moisture to the concrete surface without cracking of the concrete.

(3) Occurrence of cracks :-

The increase in volume exerts considerable bursting pressure on the surrounding concrete resulting in cracking. The hair line crack in the concrete surface lying directly above the reinforcement and running parallel to it is the positive visible indication that reinforcement is corroding. These cracks indicate the expanding rust has grown enough to split the concrete.

(4) Formation of multiple cracks

As corrosion progresses, formation of multiple layers of rust on the reinforcement which in turn exert considerable pressure on the surrounding concrete resulting in widening of hair cracks.

In addition, a number of new hair cracks are also formed. The bond between concrete and the reinforcement is considerably reduced. There will be hollow sound when the concrete is tapped at the surface with a light hammer.

(5) Snapping of bars :-

The continued reduction in the size of bars results in snapping of the bars. This will occur in ties/stirrup first. At this stage, size of main bars is reduced.

(6) Buckling of bars and bulging of concrete

The spalling of the cover concrete and snapping of ties causes the main bars to buckle. This results in bulging of concrete in that region. This follows collapse of the structure. When corrosion of reinforcement starts, the deterioration is usually slow but advances in geometrical progression. Corrosion can also cause structure failure due to reduced cross section and hence reduced load carrying capacity. It is possible to arrest the process of corrosion at any stage by altering the corrosive environment in the vicinity of the reinforcement.

A various techniques to cure or deal corrosion are as below.

(1) Removal and replacement method
(2) Installing the barrier system of surface coatings
(3) Electrochemical corrosion protection
(4) Electrochemical chloride extraction
(5) Electrochemical realkalization

(4) cathodic corrosion protection methods

(a) Impressed current cathodic protection

(b) Sacrificial anodes & galvanic current cathodic protections

(1) Removal and replacement method

In this method involves the removal of the chloride or carbonated contaminated concrete surface. It is also not feasible from a cost point of view and is impractical.

(2) Installing the barrier system or surface coatings

⇒ The use of membrane coatings, surface painting, overlays, sealers etc. have been used quite often for mitigation of any future corrosion activity.

(1) Surface coatings to steel:- In many cases, some specialized coatings are applied to the reinforcement to prevent the corrosion. There are two type of coatings (1) Anodic coatings (2) hot dipped galvanizing

(2) Epoxy coated reinforcing bars

(3) Electrochemical corrosion protection

Electrochemical corrosion mitigating system intends to subsequent reinforced concrete structures against corrosion for long term by way of modifying environment around the reinforcing steel.

8.1 List out various Non Destructive Test (NDT) used to determine strength of existing structure. Explain any one of them.

=> The various non-destructive test used to determine strength of existing structure is given as below.

1. Surface hardness test
2. Rebound hammer test
3. Ultrasonic pulse velocity test
4. Radioactive methods
5. Nuclear methods
6. Magnetic methods
7. Electrical methods

In most of the NDT tests, the strength evaluation is based on direct measurement of concrete strength. Hence accuracy is not very high in case of NDT test results.

1. Rebound Hammer test

The SCHMIDT rebound hammer, developed by a Swiss Engineer, Ernst Schmidt, in 1948 is one of the most frequently used method worldwide for non-destructive testing (NDT) of concrete structural elements.

The test is based on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. The hammer consists of a plunger connected with a spring driven metal mass. The plunger is held against at 90° to the smooth concrete surface. Firmly supported and pressed - this will

impact a fixed amount of energy. Upon release, the metal mass rebounds, the plunger being still in contact with concrete.

The rebound hammer test is sensitive to local variations in the concrete; for instance, the presence of a large piece of aggregate immediately underneath the plunger would result in an abnormally high rebound number. Conversely, the presence of a void immediately underneath the plunger would lead to a very low result. For this reason, it is desirable to take 10 to 12 readings spread over the area to be tested, and their average value must be taken.

The test can be conducted horizontally, vertically - upwards or downwards or at any intermediate angle. At each angle the rebound number will be different for the same concrete and will require separate calibration or correction chart.

Q.7 Explain the significance of quality control. What are the recommendations given in IS 456-2000 to produce good quality concrete.

Quality control is a system of inspection, analysis and action applied to manufacturing process so that, by inspecting a small portion of the product currently produced, an analysis of its quality can be made to determine what action is required on the operation in order to achive and maintain the desired level of quality.

A concrete is said to be of good quality, if it is strongest, densest, most workable and most economical for the job for which it is prepared. Amount of cement used in concrete should be low and that of aggregate should be high. If the following general requirements are fulfilled, then we can produce the most economical concrete with highest possible density.

Requirements to be fulfilled

(1) The air bubbles should be eliminated from the mass of concrete.

(2) The cement particles should be of the smallest size.

(3) The concrete must be compacted fully so as to remove voids.

(4) The concrete should be cured sufficiently and adequately, say for 28 days.

(5) Wherever possible cubical particles of the aggregates should be used so that good interlocking is gained.

(6) The water-cement ratio should be kept low.

Q. Explain Concrete repairing by grouting?

Based on grouting materials used, there are three methods

1. Portland cement grouting
2. Chemical grouting
3. Epoxy grouting

1. Portland cement grouting

Wide cracks, particularly in gravity dams and thick concrete walls may be repaired by filling with Portland cement grout. This method is effective in preventing water leakage, but will not strengthen honeycombed sections. The procedure consists of cleaning the concrete along the crack by air jetting or water jetting, installing grout nipples at suitable intervals, sealing the crack between the seats with sealant, flushing the crack to clean it and test the seal and then grouting the whole area. Grout mixtures may contain cement and water or cement plus sand and water, depending upon the width of the crack. Water reducers or admixtures may be used to improve the properties of the grout. For large volumes, a pump is used and for small volumes, a manual injection gun may be used. After the crack is filled, the pressure should be maintained to ensure proper penetration of grout.

Q. Explain Temperature effect on concrete?

With change in temperature the volume of concrete changes. Basically, there are three temperature change phenomena that may cause change to concrete.

First :- Temperature changes generated internally by the heat of hydration of cement in large placements.

Second :- Temperature changes generated externally by variations in climatic conditions.

Third :- Temperature changes due to Fire.

(a) Internally generated temperature changes :-

The reaction of cement with water is exothermic. The reaction liberates a considerable quantity of heat. For large volume placements (mass concrete) significant amounts of heat may be generated and temperature of the concrete may be raised by more than 35°C, over the concrete temperature at placement.

Usually, this temperature rise is not uniform throughout the mass of the concrete, and steep temperature gradients may develop. These temperature gradients give rise to a situation known as internal restraint. The outer portions of the concrete may be losing heat while the inner portions are gaining.

If the differential is great, cracking may occur in concrete, simultaneously as the

Concrete mass begains to cool, a reduction in volume takes place. If the reduction in volume is prevented by external constraints such as chemical bonding, by mechanical interlock, or by piles or bowels extending into the concrete), the concrete is externally restrained. If the stresses induced by external restraints are great enough, cracking may occur.

Q. What do you understand by sulphate attack on concrete? Discuss the factors responsible for it. How does it affect RCC elements? pg. 118

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Soluable sulphates like sodium, potassium, magnesium and calcium are sometimes present in soil, ground waters or clay bricks, react with tricalcium aluminate - $3CaO, Al_2O_3$ (C_3A) content of cement and hydrated lime in the presence of moisture and form products which occupy much bigger volume than that of original constituents. This, expansive reaction results in weakening of concrete, masonary and plaster and formation of cracks as well as corrosion of reinforcement.

Severity of sulphate attack depends upon amount of soluable sulpate present in soil, water or clay bricks, permeability of concrete, amount of C_3A content in cement and the duration for which concrete remains damp. To ensure safety against sulphate attacks following factors should be taken care of:

1. Concrete of grade 1:1:3:3 or richer is to be used.
2. Sulphate resisting Portland cement with C_3A content less than 3-5%. Should be used or super sulphated cement may be preferred.
3. Maximum cement content and minimum W/C ratio to be ensured.
4. Continuous dampness in superstructure due to leakage from water supply or drainage system or due to long spells of rain to be avoided.
5. Gypsum (Calcium Sulphate - $CaSO_4$) plaster should

not be used for locations where walls are likely to get damp, in particular for external walls, because sulphate content of gypsum reacts with Portland cement in presence of moisture resulting in cracking of concrete and corrosion of reinforcement.

(3) As per IS 456-2000 sulphate content (as SO_3) of mixing and curing water should not exceed 500 ml/liter.

Q.7 Elaborate on condition assessment of RC structures and distress - diagnostic techniques. 9-F & 4&6

Condition assessment or condition survey is an examination of concrete for the purpose of identifying and defining areas of distress. It is generally carried out under any of the given circumstances.

(1) Whenever change in the resistance of the structure due to deterioration owing to time-depending process such as corrosion or fatigue.

(2) Structural damage due to accidental conditions like earthquake, tsunami, fire, blasts etc.

(3) Structures subjected to change in use, operational changes or increased load, where it is necessary to check the adequacy of the structure to resist additional loads.

(4) Extension of the design working life on structure on the grounds of sustainability and economic constraints.

This type of assessment generally leads to two major findings

(1) Condition of the structure is satisfactory and requires no further intervention.

(2) Structures requiring either of the following

(1) Preservation
(2) Rehabilitation
(3) Repairs
(4) Restoration
(5) Strengthening
(6) Retrofitting

Condition assessment of the structures is the systematic and logical examination of the structure to identify the area and cause of distress. The examination could include a number of activities like visual inspection, checking of designs, drawings, construction records, previous investigation records, sampling, field and laboratory testing, documentation and report preparation.

Objective of conditional assessment

(1) To provide current condition of structure
(2) To assess the extent and development of the deterioration.
(3) To assess the influence of deterioration on the safety and life expectancy of the structure
(4) To accurately assess the scenario of concrete in structure in term of its physical, chemical and electro-chemical properties.
(5) To prioritise the repair of distressed elements in order of the seriousness of the deterioration.
(6) To suggest out an effective and economically feasible concrete repair program.

Shoste note

Rust Eliminators

Cement paste normally provides a highly alkaline environment that protects embedded steel against corrosion, Concrete with low water/cement ratio, well compacted and well cured, has a low permeability and hence minimizes the penetration of atmospheric moisture as well as other components such as oxygen, chloride ion, carbon dioxide and water, which encourage corrosion of steel bar.

In very aggressive environments, the bars may be coated with special materials developed for this purpose coating on reinforcing steel, therefore, serves as a means of isolating the steel from the surrounding environment, common metallic coatings contain galvanizing zinc, High chloride concentration around the embeded steel corrodes the zinc coating Followed by corrosion of steel.

Hence, this treatment used for moderately aggressive environments For high corrosive atmospheres caused by chloride ions from the de-icing salts applied to protect against sodium chloride and calcium chloride.

Q. Enlist common design and construction errors. (Pg-4 /B)

common design & construction errors given as below.

(a) Construction Errors

Poor construction practices and negligence can cause defects that leads to the cracking and deterioration of concrete.

The common construction errors are

(1) Use of inferior quality construction materials i.e cement, sand, aggregate, reinforcement etc.

(2) Use of waste waters or saline waters in construction.

(3) Adding more water to concrete to improve its workability. Addition of water increases W/C ratio resulting in shrinkage cracks and reduction in strength.

(4) Poor proportion (or) batching of concrete ingredients.

(5) Poor mixing of concrete

(6) Batching of concrete by volume using measure pans.

(7) Insufficient compaction of concrete, resulting in honeycombing and porosity.

(8) Dropping concrete from height resulting in segregation.

(9) Insufficient reinforcement in slab, beam, column etc using spaced bars.

(10) Improper location of reinforcing steel.

(11) Hooks, bends, overlap, concrete cover to reinforcement are not proper.

(12) Formwork props not resting on hard base may settle down resulting in settlement of the structural member.

Manoj

Teacher's Signature :

13 Premature removal of formwork props.

14 Using props of insufficient strength.

15 Construction joints, expansion joints, contraction joints, etc. are not properly provided.

16 Improper curing of concrete, brickwork etc. resulting in shrinkage cracks.

17 Segregation of concrete during transportation

18 Settlement of foundation constructed on soil of low bearing capacity

19 After concreting in hot weather or direct sun, if concrete surface is not covered.

20 In case of brick masonary

→ Bricks are not soaked in water before using in masonary.

→ In the masonary, if brick layers are laid with face on downside

→ Joints of masonary are not properly filled with mortar

→ Excess quantity of brick bats are used.

→ Compressive strength of bricks is less than 7 N/mm^2 and water absorption is more than 25%.

(b) **Design Deficiencies**

Design deficiencies can be broadly categorised into two types

1 Inadequate structural design

2 Poor design detailing

(1) Inadequate structural design

The common errors of structural design are

→ Errors in load calculations

→ For the design of foundation, SBC of soil is assumed without conducting plate load test or other tests.

→ design not conforming IS: 456-2000 and IS 1893-1984 guidelines.

→ Load transfer path in the structure is not properly understood by the designer.

→ Design with many cantilevers and projected balconies.

→ Shear wall is not designed in the multi-storey framed structure

→ In the ground floor storey for parking only columns are provided without walls, resulting in 'soft storey'

→ stiffness of the structures in both directions is different, resulting in torsion during earthquake

→ In one storey, if some of the columns become shorter columns, they attract larger lateral load.

→ Lack of knowledge of using design softwares like STADD PRO, ETABS, STRUDL etc.

(2) Poor design detailing

Detailing of reinforcements is equally important as structural design. Something or structure may fail due to poor detailing, though the design is proper.

Some of the detailing errors are

→ Abrupt changes in section

→ Insufficient reinforcement at re-entrant corners and openings

→ Inadequate provision for deflection
→ Inadequate provision for drainage
→ Inadequate expansion joints
→ masonry incompatible
→ Error in showing oneway/two way slab in the drawing
→ Bent up bars are not properly shown.
→ In beams, spacing of vertical stirrups is wrongly shown, i.e shown 250 mm c/c instead of 150mm c/c.
→ similarly, in columns spacing of lateral ties is wrongly shown.
→ Hooks for lateral ties and vertical stirrups are shown 90° instead of 135°
→ Ductile detailing is not done as per IS: 13920

Q. Differentiate between the following

Rehabilitation	Retrofitting
The process of repairing or modifying structure to a desired useful condition	The process of strengthening structure along with structure system with all relevant local provision
Porosity	**Permeability**
Porosity is a measure of how much of a rock is open space. This space can be between grains or within cracks or cavities of rock.	permeability is measure of ease with a fluid can move through a porous rock
micro-cracking	**macro-cracking**
→ The cracks present in the interfacial transition zone of cement matrix and aggregates are called micro-cracks. microcracks combining with continuous porosity are responsible for ingress of aggressive chemicals in R.C.C.	→ Any crack width that allows aggressive chemicals to travel freely into the concrete is termed as macro-crack width. codes of practice of RCC defines the threshold limit of this crack width which varies from 0.1 mm to 0.3 mm.

Plastic Shrinkage	Drying Shrinkage
It is the structure shrinkage that happens at a very early age of concrete, when the concrete mass beneath is still in the plastic state.	Drying shrinkage" refers to long-term volumetric change in concrete effected by the loss of moisture.

Q What is the importance of the field and laboratory testing for damage assessment of the structure? (P.61, 8)

⇒ The various importance of the field and laboratory testing for damage assessment of the structure

1. Verification / identification of current geometry / member sizes
2. Estimation of the in-situ Compressive Strength of concrete
3. Detection of hidden flaws and defects, Presence of cracks, voids and other imperfections.
4. Location and spacing of embedded items like reinforcement, conduits etc.
5. Identification of the reinforcement profile, measure of cover and bar diameter etc.
6. Assessing the extent of damage i.e corrosion, chemical attack (chlorides, sulfate, alkali content and degree of carbonation.
7. Determining the material properties i.e concrete and reinforcing steel properties.
8. mapping of the cracks -
9. Installation of instruments to monitor the changes in structure of concrete over time, movements of cracks.

Q. Which are the distinct stages to be recognized while taking up any repair work. (Dec 92, 93, DHE)

The following stages to be recognized while taking up any repair work

(1) Determination of the cause of damage
(2) Evaluation of the extent of damage
(3) Evaluation of the need to repair
(4) Selection of the repair materials and repair method
(5) Preparation of the old concrete for repair
(6) Application ~~and~~ cost of the repair materials and curing method

(1) Determination of the cause of damage:-

The first step for the selection of effective concrete repair is diagnosing the cause of failure or distress. However, if the repaired area is not resistant to the original cause of failure, the repair will fail or damage will be extended to the adjacent parts of the structure. Also if an incorrect determination of the cause is made, then, whatever final, whether caused damage to the original concrete will also damage the repaired concrete.

(2) Evaluation of the Extent of Damage

This step helps to determine the extent and severity of the damage in terms of length, width, depth, position of structure damaged. This helps in calculating the volume of the concrete to be repaired, which finally helps in preparation of repair specifications.

(3) Evaluation of the need to Repair

All the damaged Concrete does not require immediate repairs. Repairs are generally required, if the damage has reached a state or it is progressing at a rate, that can affect the serviceability of the structure. In some cases, the timely detection of deterioration can be arrested using proper maintenance. Even if repair is required, the early detection will help in curtailing the final cost of repair works.

(4) Selection of the Repair material and Repair method

This step is very important to make a proper, economical and successful selection of repair material and repair procedure. The repair of Concrete structure may vary from cosmetic patching or restoring concrete to a more pleasing appearance to serviceability repairs or restoring structures to a satisfactory operational standards.

The selection of appropriate repair materials and procedure is based on properties of repair material, compatibility between the repair material and substrate concrete and stability under service conditions. The selection of the repair method/ procedure is based on the objective of the repair which could be one of the following

→ Increasing strength or restoring the load carrying capacity.

→ Improving functional performance
→ Restoring or increasing stiffness
→ Providing water tightness
→ Improving appearance of concrete surface
→ Improving durability
→ Preventing corrosion.

Q. What is meant by Jacketing? Discuss repair and strengthening of columns by Jacketing. [Pg.232]

Jacketing of RCC members increases its size significantly. This has advantage of increasing the members stiffness and is useful where deformations are to be controlled. Jacketing of slender RCC columns in a building provides a better solution for avoiding buckling problems.

Design for strengthening is based on composite action between the old and new work. Strain compatibility calculations may have to be carried out carefully giving due account to factors such as creep. As the new jacket is to behave compositely with the parent members cold concrete, the new jacket can take additional loads only with the increase in the stresses and strains in the old concrete.

It is also necessary to ensure perfect bond between the old and new concrete by providing shear keys and effective bond coat with the use of epoxy or polymer modified cement slurry.

Column Jacketing is done to improve the load carrying capacity of the column.

The procedure followed is

→ open the Footing of the column by excavating soil around it.

→ Remove the plaster from the surface of the column.

→ make the surface of column concrete rough by sand blasting.

→ Remove the corroded bars by cutting them. Add new bars from footing to the slab as per the instruction of engineer.

→ Apply bonding agent on the old concrete for proper bonding between old and new concrete.

→ Erect necessary shuttering around the column.

→ Pour minimum M-25 grade of concrete, vibrate and cure it.

Q. Explain about concrete jacketing and its usefulness?

Jacketing of RCC members increases its size significantly. This has advantage of increasing the member stiffness and its useful where deformations are to be controlled. Jacketing of slender RCC columns in a building provides a better solution for avoiding buckling problems.

Design for strengthening is based on composite action between the old and new work, the new jacket can take additional load only with the increase in the stresses and strains in the old concrete.

It is also necessary to ensure perfect bond between the old and new concrete by providing shear keys and effective bond coat with the use of epoxy or polymer modified cement slurry.

The need for jacketing of many buildings can be attributed to various reasons like existing weak and unsafe buildings, building not designed as per code provisions. It can be summarized as follows

→ Increase the internal strength & stiffness of the building

→ Increasing the ductility in order to avoid the brittle mode of failure and to enhance the energy dissipation capacity

→ Improving the interface action and continuity to the structure

→ Eliminating the source of weakness, for instance the irregular geometry that can result in to

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concentration of stress

→ increasing the number of lateral load resisting elements - to enhance redundance and eliminate progressive collapse

→ Achieving the target building performance level in the event of an anticipated earthquake hazard level