USN		CMRIT

Internal Assessment Test 1 – MAY 2022

Sub:	REHABILITATION AND RETROFITTING	Sub Code:	18CV824	Branch:	CIVIL
Date:	14.05.2022	Duration: 90 mins	Max Marks: 50	Sem / Sec: VIII A & B	OBE

Answer all questions. Provide neat sketches wherever necessary	MARKS	CO	RBT
1. Define and explain the following a) Repair b)Retrofitting c)Rehabilitation d)Deterioration e)Distress	10	CO1	L1
2. Explain the mechanism of chemical deterioration of concrete structures.	10	CO1	L1
3. Write short notes on freeze thaw in concrete and thermal movement in concrete.	10	CO1	L1
4. Explain the steps involved in the post evaluation of damage in concrete structures due to earthquake.	10	CO1	L2
5. Which one do you prefer- "strong column weak beam" or "weak column strong beam"? Under what conditions do we adopt them and support them with proper diagrams.	10	CO1	L3

ANSWER KEY: Internal Assessment Test 1 – MAY 2022

1) Define and explain the following

a) 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.

b)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.

c)Rehabilitation

It is an act that improves the strength of a structure or a member which is deteriorated or damaged due to various reasons or restoration of a building or a structure to its acceptable standard from its present.

d)Deterioration

After a particular age and due to lack of maintenance, defects in a structure develops. If these defects goes on increasing due to lack of maintenance, the compounds of mortar and concrete decomposes making the concrete weaker .

In maintenance engineering, the Deterioration is defined as "The continuous degeneration of structure and its components which render it unusable,"

e)Distress

Distress in concrete members occurs with age due to corrosion in reinforcement Jloading, settlement of foundations etc. This distress in building can be found byl| development of cracks in concrete members such as slabs, beams, columns etc. The cracking of concrete in building is developed in three stages:

Stage-1: Volume of rust formed due to corrosion of reinforcement is increased about 2.5 times the volume of steel. With the result of corroded reinforcement bar presses the concrete outwards. Since concrete is poor in tension, longitudinal cracks are developed along the reinforcement bar.

Stage - II: Longitudinal cracks in RCC provide wide access to oxygen, carbon dioxide, and moisture with result excessive carbonation starts and structural damages starts. Fear in the mind of users starts.

Stage - III: In this stage cover comes out and causes danger to the life of structure and structure becomes unserviceable.

2) Explain the mechanism of chemical deterioration of concrete structures.

Chemical attack is the reaction of chemical elements from exposure and moisture present in the concrete which results into deterioration of RCC Structure.

Ingress of dissolved substances from the external environment may cause various forms of chemically induced deterioration by reaction with the cement paste or aggregate constituents.

Chemical attack on concrete can be classified as

• Carbonation

• Acid attack

• Alkali attack

• Chloride attack

• Leaching

• Salt attack

• Sulphate attack

Ingress of dissolved substances from the external-enyironment may cause various forms of chemical induced deterioration by reaction with cement paste or aggregate constituents.

Resistance of concrete to-chemical attack is directly influenced by:

• Its porosity

• The cement composition used in the concrete.

• Conditions under which the cement paste hardened.

• Properties of concrete.

• Ability to resist various effects of fluids in the environment.

(1) Carbonation:

Carbonation of concrete is one of the reasons for corrosion of reinforcement. It is a process by which carbon dioxide from air penetrates irito_the concrete and reacts with calcium hydroxide to form calcium carbonates.

Mechanism

• The percentage of CO_2 prosent is ajo vary from place to place. In case of rural areas the concentration of CO_2 air may be about 0.03% by volume, where as in urban areas it may vary from 0.3% to 1.0% This-CO_2, in presence of moisture changes into dilute carbonic acid and attacks the concrete and reduces L alkalinity of concrete

Due to reduction of alkalinity of concrete, the pH value of pore water in the hardened cement paste reduces from 13 to 9.0. When all the $Ca(OH)_2$ has become carbonated, the pH value again reduces to about 8.3. And at this low pH value, the protective layer gets destroyed and the steel is exposed to corrosion

In good quality concrete, the carbonation process is slow. Lesser is the porosity lesser will be the penetration of CO_2.

(2) Sulphate attack on the concrete

Sulphate attack on concrete is a chemical breakdown mechanism where sulphate ions attack components of the cement paste.

The compounds responsible for sulphate attack on concrete are water-soluble sulphate-containing salts, such as alkali-earth (calcium, magnesium) and alkali (sodium, potassium) sulphates that are capable of chemically reacting with components of concrete

Sulphate sources:

• Internal Sources

• External Sources

Mechanism

The effect of sulphate on concrete can be mainly chemical and physical and they are closely related. The sulphate attack or reaction is indicated by the characteristic whitish appearance on the surface. The chemical reaction between sulphate and hydration products results in changes in the microstructure and pore size distribution of the cement paste.

The second hydration product, tricalcium aluminates hydrate reacts with sulphate solution to form sulpho-aluminates hydrate Extrignate), which has a greater volume Han that of tile-original compound. Due to this, the resultant internal expansive stress may be great enough to cause deformation, cracking and eventually loss of cohesion. When concrete cracks, its permeability increases and the aggressive water penetrates more easily in to the interior, thus accelerating the process of deterioration.

Physical Mechanism

• In addition to the two chemical reactions, there is a purely physical phenomenon in which the growth of crystals of sulphate salt disrupts the concrete.

• The damage is usually starts at ends and corners and is followed by progressive cracking and spalling

• The rate of sulphate attack increases with an increase in the strength of the solution concentration of sulphide.

• The rate of sulphate attack can be reduced by using the cement having low tricalcium aluminate content and by the addition of pozzolanic materials.

(3) Acid attack on concrete

• Portland cement is a highly alkaline material and is not very resistant to attack by acids.

• Reaction between the acid and the calcium hydroxide of the hydrated Portland cement results in water soluble calcium compounds, which are leached away.

• When limestone or dolomite aggregates are used then the acid dissolves them.

• Dolomite is a carbonate mineral composed of calcium magnesium carbonate.

• If the acid is able to reach the reinforcing steel through cracks or pores of concrete, corrosion of the reinforcing steel will result and will cause further deterioration of the concrete.

Mechanism of acid attack

Concrete is susceptible to acid attack because of its alkaline nature. The components of the cement paste break down during contact with acids.

The severity of the attack depends on the type of acid and the porosity of the cement paste.

The action of acid on the concrete is to dissolve away the cement, and in case of limestone aggregate, the aggregate also gets dissolved.

This results in the formation of water soluble calcium compounds which are then leached away by the aqueous solutions, the same leads to increase in porosity and the permeability of the system.

Acids such as nitric acid, hydrochloric acid and acetic acid are very aggressive as their calcium salts are readily soluble and removed from the attack front.

Other acids such as phosphoric acid and oxalic acid are less harmful as their calcium salt, due to their low solubility, inhibits the attack by blocking the pathways within the concrete such as interconnected cracks, voids and porosity.

Sulphuric acid is very damaging to concrete as it combines an acid attack and a sulphate attack.

Alkali aggregate reaction

Aggregates in most of the Concrete are chemically inert. However, certain types of sand and aggregate such as opal, chert or volcanic aggregate with high silica content are reactive with the alkalies like calcium, sodium and potassium hydroxide present in Portland cement concrete. This phenomenon of chemical reaction is referred as alkali aggregate reaction. This reaction can cause expansion of the altered aggregate, leading to spalling and loss of strength of the concrete.

The alkali-aggregate reaction is a general, but relatively vague expression.

• Alkali-silica reaction (ASR) • Alkali-silicate reaction and • Alkali-carbonate reaction

Mechanism

The mechanism of ASR causing the deterioration of concrete can be described in four steps as follows:

• The alkaline solution attacks the siliceous aggregate, converting it to viscous alkali silicate gel.

• Consumption of alkali by the reaction induces the dissolution of $Ca2+$ ions into the cement pore water. Calcium ions then react with the gel to convert it to hard C-S-H.

• The penetrated alkaline solution converts the remaining siliceous minerals into bulky alkali silicate gel. The resultant expansive pressure is stored in the aggregate.

• The accumulated pressure cracks the aggregate and the surrounding cement paste when the pressure exceeds the tolerance of the aggregate.

The alkali-aggregate reaction may go unrecognized for some period of time, possibly years, before associate severe distress develops.

3) Write short notes on freeze thaw in concrete and thermal movement in concrete.

Thermal movement in concrete

Thermal movement takes place due to the considerable amount heat liberated during hydration, and heat due atmosphere temperature and may also due to external fire. Because of thermal movement, the concrete undergoes changes in shape and volume and the same results in cracking of concrete structure. The extent of temperature rise depends on the properties of concrete and shape and size of the component. The heat of hydration may not be significant in mass concrete works it is an important factor to be contented with the control of heat and avoidance of cracks to maintain the integrity

Preventive Measures

• Use of pozzolana

• Use of low heat cement.

• Pre cooling of aggregates and mixing water

• Post cooling of concrete by circulating refrigerated water through pipes embedded in the body of concrete

• Provide joints to relieve the restraints in the structure.

• Providing adequate reinforcement to distribute the stresses.

• Providing suitable insulation cover.

Freeze and Thaw in Concrete

Freezing: Freezing is a phase transition in which a liquid turns into a solid when its temperature is lowered below its freezing point.

Thawing: Make something) warm enough to become liquid or soft.

Freeze & Thaw cycle: When water freezes, it expands about 9 percent. As the water in moist concrete freezes it produces pressure in the pores of the concrete. The accumulative effect of successive freeze-thaw cycles and disruption of paste and aggregate can eventually cause expansion and cracking, scaling, and crumbling of the concrete.

Concrete is porous, so if water gets in and freezes it breaks off small fakes from the surface. This is typically called scaling and it can occur during the first winter and get worse over time. When severe, it can lead to complete destruction of the concrete.

Freeze-thaw disintegration or deterioration takes place when the following conditions are present.

• Freezing and thawing temperature cycles within the concrete.

• Porous concrete that absorbs water.

Mechanism:

The freezing water contained in the pore structure expands as it converts to ice. The expansion causes local tension forces that fracture the surrounding concrete matrix. The fracturing occurs in small pieces, working from outer surfaces inward. Deterioration of concrete from freeze thaw actions may occur when the concrete is critically saturated, which is when approximately 91% of its pores are filled with water. When water freezes to ice it occupies 9% more volume than that of water. If there is no space for this volume expansion in a porous, water containing material like concrete, freezing may cause distress in the concrete. Distress to critically saturated concrete from freezing and thawing will commence with the first freeze-thaw cycle and will continue throughout successive winter seasons resulting in repeated loss of concrete surface.

Preventive measures

• Use of lowest practical water cement ratio

• Usage of durable aggregate.

• Adequate curing of concrete prior to exposure to freezing and thawing

Rate of freeze-thaw deterioration

• Porosity (increases rate)

• Moisture saturation (increases rate)

• Number of froze-thaw cycles (increases rate)

• Air entrainment (reduces rate)

• Horizontal surfaces that trap standing water(increases rate)

• Aggregate with stall capillary structure and high absorption (increases rate)

4) Explain the steps involved in the post evaluation of damage in concrete structures due to earthquake.

When evaluating a slab or performing a crack survey, always measure the crack widths and determine if steel reinforcement passes through it and whether the crack is active or dormant.

Assessment of Cracks in Concrete Structures

For the assessment of the cracks following information will be useful:

1. Pattern of cracks

2. Type of crack, whether it is active or dormant.

3. Whether the crack is old or new

4. Whether it appears on the opposite face of the member

5. Type of foundation used, soil condition, sign of movement of ground, if any

6. Observations on the similar structures in the vicinity

7. Study of method of construction, test results of the site, specifications etc.

8. Weather in which the structure has been constructed.

The first step of Investigation is to make a diagnosis of the defect or the failure.

It is basically an inductive procedure and it requires abundant caution.

- Visual inspection
- Study of available documentation
- Estimation of actual loads and Environmental effects
- Diagnosis

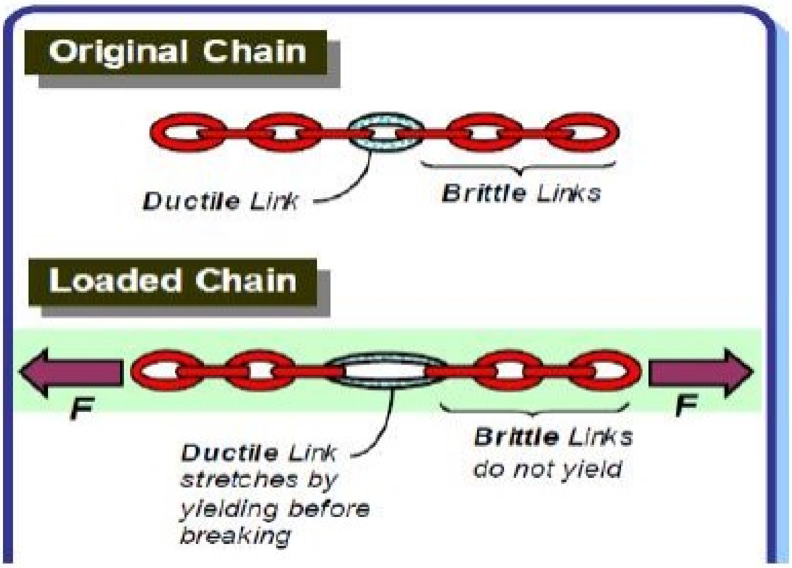
The following steps are necessary to highlight the problem and to take appropriate remedial action

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.

5) Which one do you prefer- “strong column weak beam” or “weak column strong beam”? Under what conditions do we adopt them and support them with proper diagrams.

Capacity Design: The idea behind this is to make the structural beams ductile compared to columns

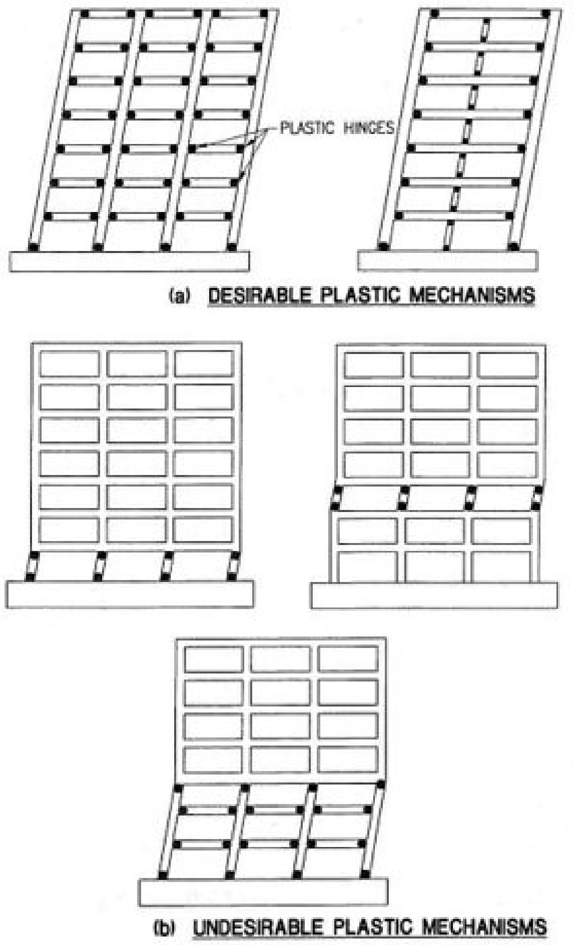
To explain this let’s take a chain having several links, out of which one link **(A) is ductile** andthe other links are brittle. Now for the chain to undergo ductile failure, it is enough to make sure that the ductile link has lesser strength than the brittle elements. So when load is being applied, since A link has **lesser strength** it starts to fail first when compared to other links. These forces the chain to ductile failure.



Comparing this concept to a lane frame, we want our structure to have ductile failure so

that the structure would be able to take large deformations in its inelastic zone. For this to be applicable, we need to make one structural element to behave relatively ductile to the others. We chose beams to behave relatively ductile compared to columns. (If we chose columns to be ductile then whole building would collapse as shown).

So, during an earthquake beams tend to fail first which imparts a ductile failure to the structure. So the term “Weak Beam Strong Column” came into effect. The Idea of Strong column-weak beam concept is to prevent total collapse of the building while resisting the lateral loads (especially the seismic loads/EQ). Having a strong column with more stiffness as compared to the beams resting on it as such, in case of failure or collapse the weak beam i.e upper portion will fail thereby resulting in partial collapse. Thus a column with greater stiffness than beam is provided is ensuring strong column and weak beam analogy.



In building design we follow the philosophy of strong column and weak beam .that is so because in case of excessive load like in earthquake we want our beams to yield i. e., that is to fail but want our columns to be intact so that the whole structure stays even with some damage to beam so that the human cost can be minimized.

However in case of bridges we follow opposite of above i. e., strong beam and weak column. Which means in case of excessive loading we want the bridge deck to be intact as vehicles are there on it and want the piers to yield .For the same reason that human life can be saved and a safe and ductile failure can be allowed with economy in design.