University of Technology
Building and ConstructionEngineering Department
Final Exam, 1st Attempt/ 4th Year

Subject: Structural Defects & Remedies.
Division: Building Engineering & Project management.
Examiner: Prof. Dr. S. A.Salih.
Asst. Lect. Mahmoud Hafidh

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Answer all the branches but one of each question(اترك فرع من كل سؤال)

Q1: What is meant by: (20%)

A-Oxidation cracks?

B- Periodical Maintenance?

C-Semi– direct transmission UPV test?

D-Dimensions standardization (تقييس الابعاد)?

E-Grouting?

Q2: Describe the various causes of: (20%)

A-Hardened concrete cracks.

B-Common defects in reinforced concrete beams.

C- Defects in reinforced concrete shallow foundations resting on clayey soil.

Q3: What are the main defects or structural damages which could be found in: (20%)

A- A reinforced concrete column due to fire?

B- A reinforced concrete beam due to overloading?

C- A reinforced concrete slab due to poor construction?

Q4: Suggest 2 methods for strengthening of: (20%)

A- A rectangular reinforced concrete column.

B-A reinforced concrete beam by shortening span.

C- A two–way reinforced concrete slab.

Q5: Explain the: (20%)

A- Repair of cracks by Drilling and Plugging.

B- Importance of using UPV tests in assessment of defected R.C. structures.

C- Effect of inspection team on maintenance cost of a building.

Ideal answers:

Q1: A. they are often caused by volume increment due to corrosion, corrosion products volume is as much as 2 or 3 time the original volume. Then, longitudinal cracks appear parallel to steel reinforcement. This type of cracks appears in a period of some months or years. (page 32)

Q1: B. It's wrong to postponed defects maintenance after they take place. The problem will escalate. And this leads to increase maintenance cost. In other words, building cost increases with time. The following Fig. represents the relationship between cost and time with and without periodical monitoring system. (page 4)

Q1: C. figure (page 41)

Q1: D. Generally each of structural materials especially finishing materials and fittings has its life cycle according to its type and the way it is used. For this reason the companies produce standard dimension materials.

A good design must deal by high accuracy with this matter that it has a significant effect on the maintenance in the future. The designer must take the materials standard dimensions in his consideration during design process, this will participate in simplifying the materials getting process in future to substitute them in maintenance work and defects' treatment.

The interest in standardize the dimensions and the use of the available materials will undoubtedly; effect the inhabitation cost in the building and on maintenance simplicity and cost. (page 9)

Q1: E. In structures such as dams and large foundations, wide and deep cracks may take place and extend deep in soil for long distances. The case is impossible to be solved by epoxy injection. Here, injection of cheap material is used, such as cement mortar or mud. (page 50)

Q2: A. There are many reasons for hardened concrete cracks, among which:

1. The late drying shrinkage cracks. The mechanism of these cracks is similar to that of drying shrinkage but they are deeper and appear after weeks or months.

2. Cracks due to chemical reasons such as the reaction of cement with carbon dioxide existed in the air (carbonation) or with aggregate particles or may be resulted from steel corrosion; accordingly, they can be classified as follow:

a. Carbonation: cracks result from chemical reaction between cement compounds and carbon dioxide from the atmosphere. They are so thin cracks and distributed irregularly on the concrete surface.

b. The aggregate alkali reaction: this type of cracks result from the reaction between active silica (non–crystalline silica which existed in some aggregate types) and cement alkalis, the result of this reaction is alkali silica gel which has the ability of unlimited swelling with the existence of external moisture, this leads to internal stresses and then cracks and concrete deterioration. These cracks are similar to carbonation cracks in appearance.

c. Oxidation cracks (corrosion): they are often caused by volume increment due to corrosion, corrosion products volume is as much as 2 or 3 time the original volume.

Then, longitudinal cracks appear parallel to steel reinforcement. This type of cracks appears in a period of some months or years.

d. Salts attack cracks: the essential salts compounds are sulfates, chlorides and calcium or potassium or magnesium carbonate. Salts attack concrete through two ways; 1. External salts attack (soil and water contain salts). 2. Internal attack (salts in concrete constituents).

- External attack tacks place by:
    - Sulfate salts in soil react with aqueous calcium aluminate in concrete. This reaction causes swelling. In case of magnesium sulfate, it attacks calcium hydroxide in cement paste.
    - Salt crystallization in the pores between cement and aggregate. This causes expansive forces which weaken the bonding between concrete and steel reinforcement, in addition to steel corrosion.
- Internal attack tacks place by the reaction between salt existed in concrete constituents and cement during setting or in the succeeding stages.

3. Thermal Cracks, there are four types:

A) Cracks due to cement hydration. Cement hydration is an exothermal reaction which emits heat, causes stresses during setting and solidification periods. The differentiation in temperature between concrete surface and inner concrete layers is the cracks cause. This differentiation increases when ambient temperature increases during casting days. Concrete surface cools faster than inside concrete. This increases the thermal differentiation and leads to tensile stresses in concrete surface. Those stresses may cause cracks in early days. Cracks depth does not exceed a few cms. However, these cracks are self–closed when the temperature inside concrete equals concrete surface temperature.

B) Cracks due to temperature fluctuation between day and night. In night time, concrete surface is colder than inside concrete, concrete surface shrinks more than the concrete beneath layers. This leads to stresses try to bend up concrete mass, concrete weight resists these stresses. This causes tensile stresses in upper concrete surface and compressive stresses in concrete lower surface. In day time the same mechanism takes place but in opposite direction.

C) Freezing cracks; when water inside concrete freezes before initial setting, no setting will be. When freezing happens after initial setting, the result is ice crystals. Ice crystals cause friable concrete due to water volume increment when freezes. Accordingly, concrete volume increases by 9%. When ice thaws, empty voids will be in concrete of volume equals to volume increment due to freezing. When water fills these voids and freezes, further volume increment takes place. This volume increment leads to tensile stresses, then concrete deterioration within time. (page 32)

Q2: B. 1:-Cracks at the surface of the beam specially in the tension zones and concrete cover.

2:-Deflection higher than the accepted limit.

3:-Falling the concrete cover at different places.

4:-Diagonal deep cracks toward the depth of the beam near the supports.
5:-Different defects due to bad execution and quality control.
6:-Some defects due to bad use of the building.

Q2: C. as long as clay soil shrinks by drying and swells by moistening, this affects the shallow foundations.

The shrinkage in clayey soil is measured in summer with trees existence which absorbs the water from about 5 meters depth…..the shrinkage reaches 100 mm (very high shrinkage which negatively affects the structure).

The highest effect will be on foundation corners and edges.

The foundation must be far from the huge trees by a distance at least equal to the tree height if there is one tree but the distance must be equal 1.5 times the tree height if there is a group of trees.

When removing trees from clayey soil, sometime is to be given to the soil to let it takes its final shape then work can be started.

Generally, shrinkage of clayey soil under foundation may cause foundation deviation as a result of differential settlement or fractured foundation due to heterogeneous support under foundation. (page 20)

Q3: A. *Different types of surface cracks.
*Deep cracks in different locations.
*Falling some parts of the concrete cover.
*Cracking the concrete along the main reinforcements of the columns.
*Buckling of reinforcement and falling some parts of the adjacent concrete.
*Crushing some parts of concrete in compression zone.
*Others which depend on location of columns and type reasons. (page 54)

The very high temperature (due to fire) affects the concrete and the steel reinforcement significantly. The concrete starts to deteriorate at exposure temperature 300 Degree Celsius and higher. The strength of concrete reduces with the increase of temperature (from 300 to 800 Degree Celsius) . For temperature higher than 800 Degree Celsius the normal concrete loses all its mechanical properties due to de-hydration phenomena.

At 550 Degree Celsius and higher the steel reinforcement starts to lose its mechanical properties. So that the defects of a R. C. slab exposed to fire depend on many factors such as; degree of exposure, duration of exposure, location of exposure, …..etc. However all slab defects should be diagnosed during the preliminary and detailed inspections. (page 80)

Q3: B. 1:-Cracks at the surface of the beam specially in the tension zones and concrete cover.
2:-Deflection higher than the accepted limit.
3:-Falling the concrete cover at different places.
4:-Diagonal deep cracks toward the depth of the beam near the supports. (page 67)

Q3: C.

1- Cracks distributed randomly throughout the slab .

2- Cracking of the concrete cover, mainly along the steel reinforcements.

3- Deep cracks could be occurred in the tension zone of the slab.

4- Falling parts of concrete fragments from the slab.

5- Problems in thickness, level, alignment, dimensions and others. (page 78)

Q4: A.

a- Increasing the cross section of the column.

b- Using structural steel sections.

c- Adding additional steel reinforcement for longitudinal and or stirrups.

d- Using new concrete materials:

*fiber concrete

*epoxy

*carbon strips

*Ferro cement

*other composite or hybrid materials

e- Adding new additional columns to reduce spans leading to reduce loading.

f- Others. (page 58)

Q4: B. figures (page 73)

Q4: C. figures (page 82 and 83)

Q5: A. This method is used where water is in touch with structure parts to prevent water from passing through cracks, for example, in swimming pools, fountains and reservoirs.

When cracks run in reasonable straight lines and are accessible at one end, drilling down through the length of the crack and grouting it to repair them, as it is the case in retaining walls. Drilling a hole should be wider a little bit than crack width (diameter of 50 to 75 mm) and with crack depth. Repair steps are:

- Crack is to be cleaned and filled with grout (grouting material must be of low modulus of elasticity).
- Place reinforcement bars (of predetermined sizes and lengths) in them to stitch across the cracks (see fig.4).

A Hole is to be drilledin the wall,centeredon anddown through the crack.Sizeof holedependson the widthof the crack.Use2"to 2-1/2"minimumdiameter. (page 46)

Q5: B. The methodology of UPV is based at time monitoring of pulses in a section of the object. The UPV will depend on the density and the elastic properties of the material in study. The quality of many materials of construction is related with its rigidity, the measure of the UPV can be used to measure the concrete structures quality, estimate the mechanical properties, the compressive strength and the modulus of elasticity. (page 40)

Q5: C. figure relationship between cost and time(page 4)