UNIVERSITI SAINS MALAYSIA

1st Semester Examination
2010/2011 Academic Session

November 2010

EAS 662/4 – Structural Retrofitting Technology

Duration : 3 hours

Please check that this examination paper consists of **FIVE (5)** printed pages before you begin the examination.

[Instructions: This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions only.

You must answer the questions in English.

All question **MUST BE** answered on a new sheet.

1. a) A reinforced concrete T-beam in a bridge has been severely damaged with shear cracks due to the increase of load and lack of shear reinforcement. The width of the observed shear crack is about 0.3mm. These shear cracks are required to be repaired using epoxy injection technique. Subsequently, the beam is externally strengthened using Carbon Fibre Reinforced Polymer (CFRP) composites. In order to improve the shear performance of the reinforced concrete T-beam, the external CFRP reinforcement is applied in form of U-wraps along the shear spans of the beam. The CFRP fabric reinforcement is applied using epoxy without any anchorages.

   i. Explain the processes to repair the shear cracks using epoxy injection technique.

   [7 marks]

   ii. Briefly explain the procedures of the external strengthening technique. State the merits of using FRP as external reinforcement.

   [12 marks]

   iii. If the CFRP strengthened beam in shear is tested in the laboratory environment under four point bending system, explain the possible modes of failure that could occur in the CFRP shear-strengthened beam with the aids of suitable sketches.

   [9 marks]

2. a) Discuss how the water reducing admixtures/plasticizers works?

   [5 marks]

   b) The lining of an old highway tunnel in Perak has been seriously damaged due to increase of age and adverse environmental condition. To improve the lining in the tunnel, the expert proposed to use dry process of sprayed concrete method. With the aid of appropriate diagram, explain the mechanism of producing dry process of sprayed concrete. State the pros and cons of using dry process of sprayed concrete.

   [11 marks]

c) Briefly discuss the functions of surface coatings for concrete surfaces. List out the different types of surface coatings and explain any **ONE** type.

[9 marks]

3. a) Explain the mechanisms of action of superplasticiser. Discuss how the use of superplasticiser contributes to superior durability performance of concrete.

[11 marks]

b) Figure 1 exhibits the influence of cement type and contents of ground granulated blast-furnace slag (GGBS) on chloride diffusion of concrete exposed to chloride solution. Discuss the probable reasons contributing to the difference in the observed chloride diffusion.

[12 marks]

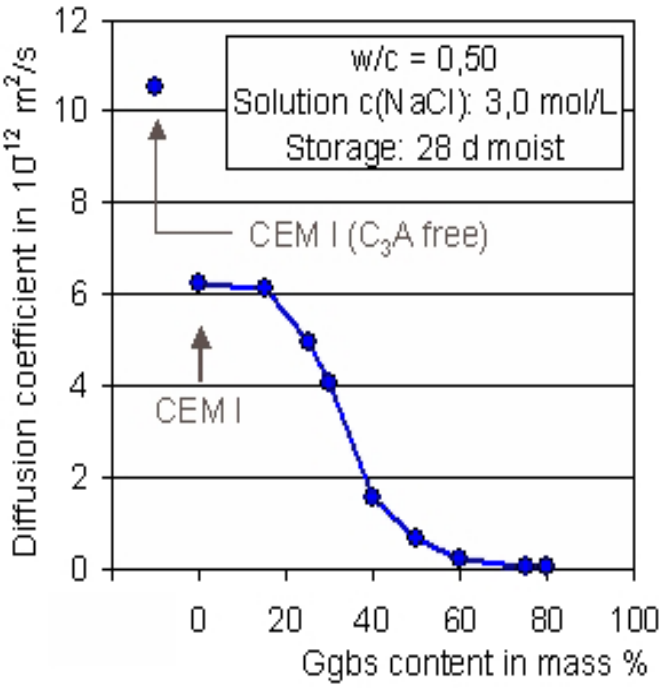

Figure 1: Influence of cement type and GGBS content on chloride diffusion of concrete

c) Describe the term pozzolan.

[2 marks]

4. a) Mineral admixtures are becoming increasingly utilized to enhance the durability performance of concrete. When pozzolans are included to cement or concrete, they react with the calcium hydroxide, in the presence of moisture to produce secondary calcium silicate hydrate (C-S-H). Explain the probable beneficial impacts of the pozzolanic reaction on sulphate resistant performance of concrete.

[8 marks]

b) Explain the necessary elements required for corrosion of steel in concrete to occur.

[5 marks]

c) Most deterioration mechanisms of concrete structure associated with chemical attack involved the development of expansive forces in the concrete, causing the concrete to crack. State three such deterioration mechanisms and for each one, explain the mechanism involved leading to deterioration of concrete.

[12 marks]

5. a) Explain what is meant by passive and active strengthening of a structure or structural member. For each case, provide appropriate example and sketch.

[5 marks]

b) Several piers of a reinforced concrete marine jetty have been observed to undergo corrosion of reinforcement and require immediate rehabilitation work. The worst affected areas are those located in the tidal zone; where they are submerged during high tide and exposed during low tide. Assuming that the main reinforcements in the affected areas have to be supplemented due to severe corrosion problem, explain the whole retrofitting processes involving preplaced aggregate pressure grouting technique. Use appropriate sketches to aid your explanation.

[15 marks]

c) Explain the principle of *"Cathodic Protection"* in electrochemical prevention of reinforcement corrosion.

[5 marks]

6. a) Lists and discuss **FIVE (5)** the important of in-situ non and semi-destructive tests.

[10 marks]

b) **FOUR (4)** concrete crossheads of the M4 Elevated Viaduct near London has shown the presence of surface breaking cracks and advanced corrosion damage. The four crossheads namely Crosshead number 66, Crosshead number 68, Crosshead number 74 and Crosshead number 82. The current condition of all the crossheads can be seen in the figure below. Propose the appraisal scheme for the scenario of damages and/or deterioration of the concrete crossheads. The proposal should EXCLUDING the recommendation of the repair/retrofitting technique.

[15 marks]

Figure 1

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