UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

EAS 662/4 – Structural Retrofitting Technology

Duration: 3 hours

Please check that this examination paper consists of **SIX (6)** pages of printed material before you begin the examination.

Instructions: This paper consists of **SIX (6)** questions. Answer **FOUR (4)** questions only. All questions carry the same marks.

You may answer the question either in Bahasa Malaysia or English.

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

Write the answered question numbers on the cover sheet of the answer script.

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

[6 marks]

(b) The recently reported carbon fiber debonding from the top of one of the strengthened piers of the MRR2 elevated highway is a case of strengthening failure. Explain **TWO (2)** probable reasons for the failure.

[4 marks]

(c) If the originally distressed piers of the MRR2 elevated highway in (b) were to be strengthened by "external post-tensioning", explain the strengthening technique with the help of suitable sketch.

[6 marks]

(d) Before any strengthening work can be carried out to concrete structure, any crack should be first repaired. Explain the process of crack repair using epoxy injection technique. Describe **TWO (2)** methods which can be used to check the effectiveness of crack repair.

[9 marks]

2. (a) Several piers of a reinforced concrete marine jetty have suffered some damages due to corrosion of reinforcement. The worst affected areas are those exposed to alternate wetting and drying cycles, i.e. those within the tidal zone. Explain **FIVE (5)** tests that should be conducted in the appraisal for the corrosion damaged piers of the marine jetty. For each test, give your justification as to why it is required.

[12.5 marks]

(b) List and describe **FIVE (5)** important properties of the repair material to be used in repairing the affected piers in (a) to ensure effective and lasting repair work.

[12.5 marks]

3. Several piers of a concrete bridge constructed 10 years ago crossing Sungai Linggi was reported to undergo deterioration. The outer surface of the affected piers exhibit extensive cracking in the form of random map cracking. In some areas, some gel appears to be oozing out from the cracks. Construction record given in Table 1 shows the materials used during the construction.

Table 1: Concrete Materials from Construction Record

Materials	Piers	Beams
Cement Type	OPC	OPC
Cement Content	400 kg/m^3	370 kg/m^3
Total Alkali Content (Na_2O equivalent)	2:1 %	0.5 %
C_3A Content of Cement	5 %	8 %
Coarse Aggregate	20 mm Rhyolite	20 mm Granite
Fine Aggregate	Quartzite, zone M	Quartzite, zone M
Workability	75 mm slump	60 mm slump
Free Water/Cement Ratio	185 kg/m^3	170 kg/m^3
Admixture	Water reducer	Water reducer

(a) State the most probable deterioration process at work. Give your justifications. Explain why the beams of the bridge did not undergo the same problem.

[6 marks]

(b) Explain the mechanism of the deterioration process in (a).

[10 marks]

(c) State the factors that could affect the progress of the above deterioration process.

[4 marks]

(d) Describe the measures that could be taken in the planning and construction stages to avoid or minimize the risk of the same problem occurring to other construction projects in the same area.

[5 marks]

4. (a) Figure 1 shows the relative compressive strength development of concretes containing silica fume (SF) in comparison to a control Ordinary Portland Cement (OPC) concrete. The SF was used as a partial cement replacement material at replacement levels of 5, 10, and 15 %. Discuss the different trend in relative strength development for the concretes containing SF in comparison to the OPC concrete.

[8 marks]

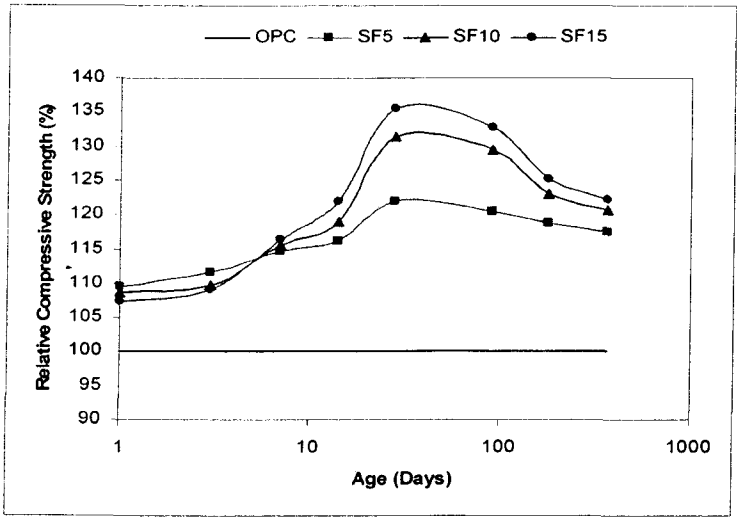

Figure 1

(b) With the aid of appropriate sketches, explain the principles how sacrificial anode and impressed current cathodic protection systems work.

[10 marks]

(c) Several columns of a fire damaged reinforced concrete building show some sign of distress a few months after being repaired. Up to about 40mm of concrete has been replaced with cementitious repair material using pressure grouting technique after the fire. The trend of the distress exhibits that the concrete and the interface crack, but the repair material seems to be intact. Assuming that all steel reinforcements are in good condition, discuss the probable causes of the observed distress.

[7 marks]

5. (a) In a reinforced concrete bridge, the pier has been damaged with severe cracks and internal steel reinforcement were also corroded due to the increase of age and adverse environmental condition. To improve the structural performance of the damaged piers, Fibre Reinforced Polymer (FRP) composites have been identified as an appropriate external strengthening material.

(i) Describe the preliminary steps that should be carried out to the damaged piers before repairing.

[4 Marks]

(ii) What are the different types of FRP? List any **FOUR (4)** advantages of FRP.

[6 Marks]

(iii) Suggest any **ONE (1)** type of FRP and give reason for choosing such type. Briefly explain the procedures involved for external strengthening technique using the suggested FRP.

[8 Marks]

(b) What is the purpose of using retarding admixtures. Describe the purpose of using retarding admixtures. List the active components in retarding admixtures. Describe the circumstance, where retarding admixtures are used.

[7 Marks]

6. (a) What is patch repair and state **TWO (2)** under water patch repair materials.

[3 Marks]

(b) What is sprayed concrete and highlight its main benefits. Why it is also known as Gunite. List the different methods of producing sprayed concrete and explain any **ONE (1)** type with appropriate sketch.

[12 Marks]

(c) What is the purpose of surface coatings. State the different types of surface coatings and briefly discuss any **ONE (1)** type.

[10 Marks]

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