UNIVERSITI SAINS MALAYSIA

First Semester Examination
2012/2013 Academic Session

January 2013

EAS 662/4 – Structural Retrofitting Technology

Duration : 3 hours

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

Instructions : This paper contains **SIX (6)** questions. Answer **FOUR (4)** questions.

All questions must be answered in English.

Each question **MUST BE** answered on a new page.

1. (a) Acoustic Emission (AE) technology is considered unique in camparison to other non-destructive testing (NDT) methods. In contrast to other NDT methods, AE is usually applied during loading while most others are applied before or after loading of a structure. Before starting the test, a full AE structural calibration tests have to be carried out. Identify the calibration tests and with the aid of sketches discuss briefly the typical AE apparatus.

[10 marks]

(b) **TWO (2)** concrete crossheads of an Elevated Viaduct near Johor has shown the presence of surface breaking cracks and advanced corrosion damage. Propose an appraisal scheme for the scenario of damages and/or deterioration of the concrete crossheads. The proposal should EXCLUDE the recommendation of the repair/retrofitting technique.

[15 marks]

2. (a) Discuss how the appropriate use of superplasticiser in combination with suitable pozzolanic mineral admixture such as silica fume could improve the properties and durability performance of concrete, in particular for concrete exposed to marine environment.

[12 marks]

(b) The performance of blended cement concretes containing pozzolanic mineral admixtures such as fly ash, silica fume and ground granulated blast-furnace slag has generally been reported to improve the sulphate resistance in sodium sulphate exposure condition. Nonetheless, in the case of exposure to magnesium sulphate ($MgSO_4$), the blended cement concrete tends to exhibit inferior performance. Discuss the probable mechanisms contributing to the different performance. Propose a suitable measure to be taken to ensure adequate sulphate resistance for blended cement concrete exposed to $MgSO_4$.

[13 marks]

3. (a) Describe the four components of an electrochemical corrosion cell.

[4 marks]

(b) Discuss the principle of cathodic protection for arresting corrosion of steel reinforcement in concrete. Explain how the corrosion protection is achieved.

[6 marks]

(c) Several piers and girders of a bridge have suffered severe corrosion damages and in need of appropriate rehabilitation work. In the worst affected areas exposed to marine tide and splash, the concrete covers have delaminated, exposing the badly corroded steel reinforcements. Propose a repair scheme utilizing a preplaced aggregate pressure grouting technique to retrofit the affected piers and girders. The proposed plan should include the detailed procedures of the complete repair process as well as the relevant sketches to elucidate the explanation.

[15 marks]

4. (a) Several piers of a highway bridge were damaged due to fire resulting from highly flammable chemical spillage from accidental vehicular collision.

i. Suggest and discuss the appropriate testing techniques to assess the extent of the damage prior to rehabilitating the affected piers.

[10 marks]

ii. Prioritize and discuss the important properties of the repair material to be used in the rehabilitation of the affected piers to ensure efficient repair performance.

[10 marks]

(b) With the help of a suitable sketch, explain the process of crack repair by epoxy injection onto vertical cracks on reinforced concrete column.

[5 marks]

5. (a) Explain the differences between “method based specifications” and “performance based specifications” for concrete work. Discuss how the “performance based specifications” could ensure better durability performance of in-situ concrete exposed to aggressive marine environment.

[9 marks]

(b) Discuss the formation of “incipient anode” effect in patch repair of corrosion damaged reinforced concrete structure in chloride environment. Suggest a suitable technique to reduce the probability of incipient anode occurrence. Use appropriate sketches to aid your explanation.

[9 marks]

(c) Several reinforced concrete bridge girders have shown some structural cracks due to overstressed, resulting from excessively high vehicular loads. Thus, an immediate action of the Public Works Department is to limit the traffic load passing through the bridge by closing one of the dual carriageway bridge, to avoid exacerbating the problem and to ensure the safety of the bridge users. Suggest and explain a suitable active strengthening technique to strengthen the overstressed bridge girders. Provide a suitable sketch to aid your explanation.

[7 marks]

6. The durability of structural member against the aggressive environment always had been a concern to civil engineers. Bridge structure such as piers can be damaged due to the increase of age and aggressive environmental conditions. You have been assigned to do an assessment to bridge pier. Corrosion of pier steel reinforcement has been detected. Some severe cracks are also observed with crack width of 0.2 mm. To improve the structural performance of the damaged piers, Carbon Fiber Reinforced Polymer (CFRP) has been identified as an appropriate external strengthening material.

(a) Explain the role of CFRP in rehabilitation.

[5 marks]

(b) Discuss the characteristic of CFRP to be used in strengthening the piers.

[8 marks]

(c) Explain the procedures involve in the external CFRP strengthening technique.

[12 marks]

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