First Semester Examination
2017/2018 Academic Session

January 2018

EAS662 – Structural Retrofitting Technology

Duration : 2 hours

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

Instructions: This paper contains **FIVE (5)** questions. Answer **FOUR (4)** questions.

All questions must be answered in English.

1. (a) Several piers of a highway bridge situated in a swampy area have been reported to undergo deterioration. The deterioration focuses on the piers that are exposed to the swamp water. Analyses performed on several samples taken from the piers indicate the co-existence of magnesium silicate hydrates and magnesium hydroxide together with gypsum, ettringite, calcium hydroxide and calcium silicate hydrate in the affected parts of the piers. Nonetheless, representative samples obtained from a few sound parts of the piers exhibit predominant existence of calcium silicate hydrate and calcium hydroxide.

(i) With justification, explain the most probable deterioration mechanism that has affected the piers which has resulted in the observed deterioration.

[9 marks]

(ii) If the affected piers are to be rehabilitated, suggest and explain the measures that can be taken to avoid or reduce the risk of the same deterioration problem from occurring.

[6 marks]

(b) Describe **TWO (2)** major causes of the breakdown of passivity of steel in concrete. Explain the consequences of corrosion of reinforcement.

[6 marks]

(c) Explain how chloride binding ability of concrete can influence the chloride resistance of steel in concrete.

[4 marks]

2. (a) The use of admixtures has been recognized by engineers and concrete technologists to be able to improve the engineering properties and durability performance of concrete particulary in aggressive environmental exposures. Normally, chemical and mineral admixtures are utilized together in order to obtain the intended properties and durability performance. Referring specifically to superplasticizer (high range water reducer) and silica fume which are commonly used together, explain how their use could enhance:-

(i) Strength of concrete and
(ii) Corrosion resistance of concrete structure in chloride containing environment.

[17 marks]

(b) Explain the problem that may arise in mass concrete construction. In order to reduce the probability of the said problem occurring, suggest and explain a suitable mineral admixture that is advantageous to be use in mass concrete.

[8 marks]

3. (a) Several reinforced concrete piers of a 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. If the affected piers are going to be repaired by pre-placed aggregate pressure grouting technique, explain the repair processes with the aid of sketches.

[15 marks]

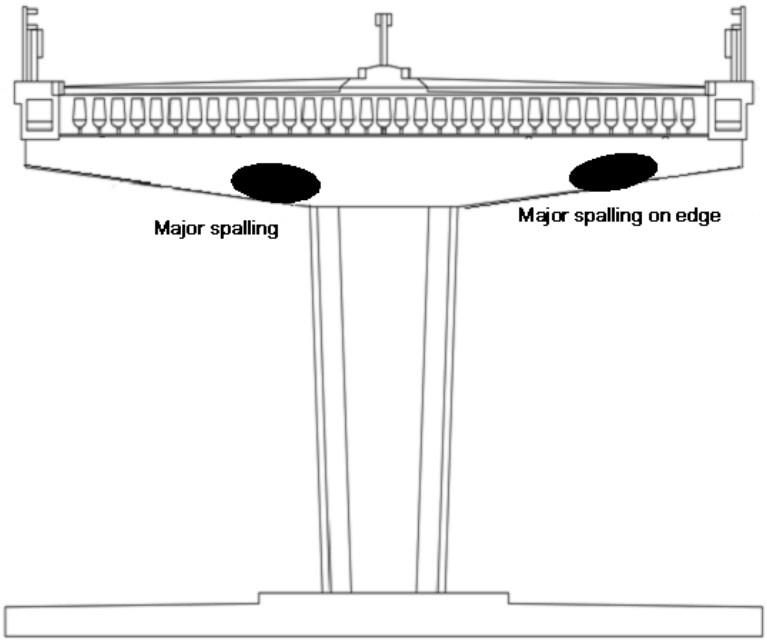
(b) The piers of a corrosion damaged deep water wharf have been repaired by patching. Several months after the repair was performed, some new corrosion problems have been observed at several places surrounding the previously repaired areas. Discuss how this phenomenon could have occurred and explain a suitable electrochemical technique to reduce the risk of it occurring. Use appropriate sketches to aid your explanation.

[10 marks]

4. (a) Acoustic Emission (AE) technology is used to safeguard against catastrophic failures, to assess structural integrity and to enhance safety in a wide range of structures. Define AE and discuss the phenomena that take place as AE wave propagates along the structure.

[10 marks]

(b) FOUR (4) concrete crossheads of an Elevated Viaduct near Perak have shown the presence of surface breaking cracks and advanced corrosion damage. The current condition of all the crossheads can be seen in **Figure 1**. Propose the 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.



CONCRETE CROSSHEAD

Figure 1

[15 marks]

5. (a) Penang Ferry began its operations in 1920, making it the oldest ferry service in Malaysia. Most of the piers of the Penang Ferry Jetty have been deteriorating (severe damage) and need to be repaired. The damage concentrates on parts of the piers located in the tidal zone **(Figure 2)**. The retrofitting technique suggested was using Carbon Fibre Reinforced Polymer (CFRP) Jacketing.

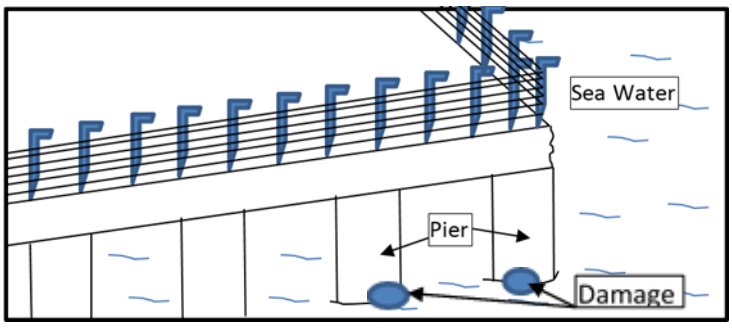


Figure 2: Illustration of Penang Ferry Jetty

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(i) Explain the installation process of Carbon Fibre Reinforced Polymer (CFRP) Jacketing technique on the damaged pier. Use a suitable sketch to explain your answer.

[13 marks]

(b) Strengthening of the MRR2 flyover **(Figure 3)** in 2006 was completed using the post-tensioning method on the horizontal and vertical directions. Explain the post-tension installation process to strengthen the flyover crossheads. Use a suitable sketch to explain your answer.

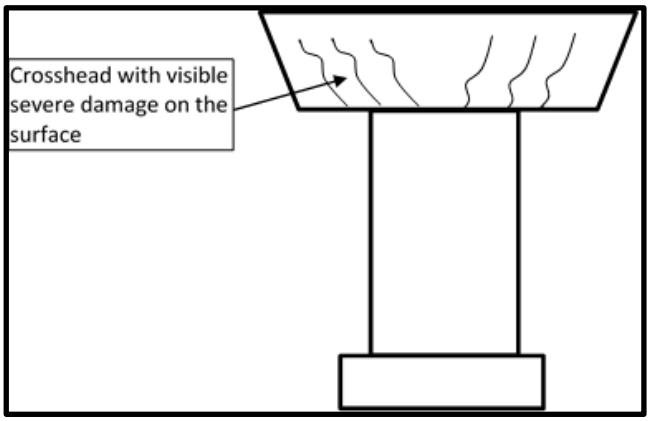

Figure 3: Flyover crosshead

[12 marks]

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