UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2009/2010

November 2009

EAS 662/4 – Structural Retrofitting Technology

Duration : 3 hours

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

Instructions: This paper consist of **SIX (6)** questions. Answer **FOUR (4)** questions only.

All question should be answered in English.

Each question carry equal marks.

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

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

1. Explain the term “Durability of Concrete”. Discuss in detail the fundamental properties of concrete that affect durability paying particular attention to such aspects as:

   mix proportions
   construction practices
   environmental conditions

   (*Note: Your answer should relate to general aspects of durability and not to any particular mechanism*).

   (25 marks)

2. (a) A five storey reinforced concrete building has suffered some damages due to fire. Propose an appraisal plan to assess the fire damaged building. Justify the relevant testing techniques that you would include in your proposal.

   (13 marks)

   (b) Propose a retrofitting scheme to salvage the fire damaged building in (a). Select and justify the important properties of repair material that you would include in the proposed retrofitting scheme to ensure effective and lasting performance.

   (12 marks)

3. (a) A **FIVE (5)** storey reinforced concrete building is being constructed as part of the Universiti Sains Malaysia, Engineering Campus expansion plan. Due to some unknown reasons, some of the concrete cubes prepared to verify concrete compliance were lost. Propose a testing strategy to confirm the acceptability of the in-situ concrete with respect to strength and durability.

   (7 marks)

(b) You are required to evaluate the potential chloride resistant performance of several surface treatments as a mandatory measure prior to selecting the most suitable surface treatment for marine repair application. Propose and discuss how the evaluation could be carried out by using a simple laboratory test.

(6 marks)

(c) The piers of a corrosion damaged marine jetty 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 propose a suitable electrochemical technique to reduce the risk of it occurring. Use appropriate sketches to aid your explanation.

(12 marks)

4. (a) There are various methods in NDT, which are used mainly to estimate strength, and to evaluate conditions other than strength, such as the integrity of the structure. Please provide a list of at least five methods for each application.

(10 marks)

(b) Problems : The assessment of grouted prestressed cable ducts in post-tensioned concrete bridge decks

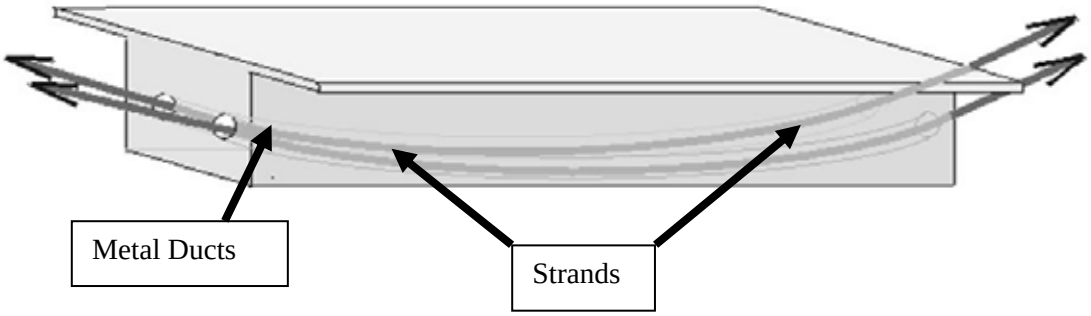
Objectives : To measure the loss in cross-sectional area of the steel strands through NDT

Description of Structure

- Post-tensioned bridge deck
- Ducts are made of metal
- Grout-encased pre-stressing tendons

Methodology

- Studying state-of-the-art NDT methods
- Selection of the most promising NDT techniques
- Evaluation of samples of post-tensioned concrete elements on a laboratory scale
- Assessment of selected post-tensioned bridge decks in the field



Explain the NDT methods that can be applied to measure the loss in cross-sectional area of steel strands caused by structural ageing and deterioration in grout-encased pre-stressing tendon in post-tensioned bridge decks. Justify your answer.

(10 marks)

(c) Due to various deterioration factors, the surface of a concrete structure is showing map-cracks, erosion and scaling. Why should you use Optical Imaging Methods to assess the damage, rather than visual inspection methods?

(5 marks)

5. A reinforced concrete beam in a bridge has been seriously damaged with flexural cracks and the internal longitudinal tensile steel reinforcement were also corroded due to the increase of age and adverse environmental effects. A group of experts investigated and recommended to use Carbon Fibre Reinforced Polymer Composites (CFRP) as external flexural reinforcement (i.e. CFRP plate bonding technique). Prior to the application of external CFRP plate bonding technique, the flexure cracks are required to be repaired. To improve the flexural capacity, the beam was bonded externally using CFRP reinforcement along the whole span. The CFRP reinforcement was applied using epoxy resin without any mechanical anchorages at the ends of the beam.

(a) What are the necessary preliminary steps that should be carried out before repairing the beam?

(4 marks)

(b) Explain the mechanism to repair the flexural cracks using epoxy injection technique.

(7 marks)

(c) Briefly explain the procedure of the external strengthening technique.

(7 marks)

(d) A CFRP strengthened beam (i.e flexural reinforcement along the soffit of the beam) is tested in the laboratory environment under four point bending system. What are the possible modes of failure that could occur in the CFRP strengthened beam. Sketch any **THREE (3)** modes of failures.

(7 marks)

6. (a) What is the function and constituents of retarding admixture. Under which situation this retarding admixture can be used.

(5 marks)

(b) The lining of the old highway tunnel in Ipoh has been damaged and it is now required to improve the lining in the tunnel using wet process of sprayed concrete method. Explain the mechanism of producing wet process of sprayed concrete with appropriate sketch. Also state the merits of using wet process of sprayed concrete.

(10 marks)

(c) Explain why surface coatings are required. Explain how the solvent based coating can be used.

(10 marks)

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