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UNIVERSITI SAINS MALAYSIA

2<sup>nd</sup>. Semester Examination  
2002/2003 Academic Session  
*Peperiksaan Semester Kedua  
Sidang Akademik 2002/2003*

February / March 2003

**EAS 562/4 - Construction Materials and Repair Techniques**  
*(Bahan Binaan & Teknik Baikpulih)*

Time : 3 hours  
*Masa : 3 jam*

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**Instruction to candidates:**

1. Ensure that this paper contains **SIX (6)** printed pages.  
*1. Sila pastikan kertas peperiksaan ini mengandungi **ENAM (6)** muka surat bercetak sebelum anda memulakan peperiksaan ini.*
2. This paper contains **FOUR (4)** questions. Answer **ALL (4)** questions.  
*2. Kertas ini mengandungi **EMPAT (4)** soalan. Jawab **SEMUA (4)** soalan.*
3. All questions carry the same mark.  
*3. Setiap soalan mempunyai markah yang sama.*
4. Answer either in English or Bahasa Malaysia or combination of both languages.  
*4. Soalan boleh dijawab dalam Bahasa Inggeris atau Bahasa Malaysia ataupun kombinasi kedua-dua bahasa.*
5. Write answered question numbers on the cover sheet of the answer script.  
*5. Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.*

1. A masonry structure, which is made from clay bricks, has been reported to undergo deterioration approximately 6 years after the structure was built. Significant damage was observed on the mortar joints in particular at the exterior parts of the masonry walls and columns (parts that are exposed to weather). In the worst area, the mortar joint has turned into a loose material with minimal strength and cohesiveness.
- (a) Describe the procedure that you would adopt to try to identify the cause of the deterioration. (5 marks)
- (b) Explain in detail the mechanism or mechanisms that you think are the most likely cause of the deterioration. Your explanation should include how the problem is initial. (14 marks)
- (c) Describe recommendations that you would suggest to avoid or minimize similar problem occurring to any new clay bricks masonry structure to be built in the future. (6 marks)

1. *Sebuah struktur batu-bata yang dibina daripada bata tanah liat telah dilaporkan mengalami kemerosotan selepas 6 tahun ianya dibina. Kerosakan yang ketara telah berlaku kepada mortar pengikat terutamanya di tiang dan dinding yang terdedah (bahagian yang terdedah kepada cuaca). Di sesetengah tempat, mortar pengikat batu-bata telah bertukar menjadi bahan yang peroi (loose material) dengan kekuatan dan kejelekitan yang minima.*
- (a) *Jelaskan prosidur yang anda akan ikuti di dalam usaha untuk menentukan punca kemerosotan. (5 markah)*
- (b) *Terangkan secara mendalam mekanisma atau mekanisma-mekanisma yang anda fikir telah menjadi utama punca kepada kemerosotan. Penjelasan anda perlu merangkumi bagaimana masalah ini bermula. (14 markah)*
- (c) *Jelaskan cadangan-cadangan yang anda akan beri untuk mengelakkan atau mengurangkan risiko masalah yang sama daripada berlaku kepada struktur batu-bata yang akan dibina di masa akan datang. (6 markah)*

2. (a) Explain **FOUR (4)** modes of protection, which surface treatment/coating work. Use appropriate sketch for each mode of protection.

(6 marks)

- (b) A laboratory investigation has been performed to assess the effectiveness of two types of proprietary surface treatment, namely epoxy and silane under wetting and drying cycles. A concrete slab with a thickness 40 mm has been prepared and cured in water for 7 days. After curing, 50-mm diameter concrete core samples were extracted from the slab and oven dried at 105°C for a period of 24 hours before being surface treated with the epoxy and silane. Some specimens were also left untreated for comparison purposes. Then the specimens were exposed to wetting and drying cycles for up to a period of one year. The specimens were tested for total porosity after 1, 3, 6 and 12 months of exposure to wetting and drying cycles. Data for the total porosity test is given in Table 1.

**Table 1:** Data for total porosity test for treated and untreated concrete specimens

Test Period (months)	Controlled/Untreated			Epoxy treated			Silane treated		
	$W_w$	$W_{ssd}$	$W_{od}$	$W_w$	$W_{ssd}$	$W_{od}$	$W_w$	$W_{ssd}$	$W_{od}$
1	119.47	200.36	193.18	122.42	204.46	200.56	120.93	202.61	197.80
3	119.58	200.30	193.12	122.39	204.88	200.96	121.58	201.53	196.57
6	120.26	200.42	193.28	123.02	204.52	200.64	123.46	203.64	197.60
12	120.48	200.36	193.22	122.56	204.98	201.06	122.62	203.54	196.42

Note:

$W_w$  = weight of saturated specimen in water, gram

$W_{ssd}$  = weight of specimen under saturated and surface dry condition (ssd) in air, gram

$W_{od}$  = weight oven dry specimen in air, gram

Determine the total porosity of all specimens at all test periods and then determine the efficiency index of the surface treated specimens. Tabulate your results in a suitable format. Based on the efficiency index obtained, discuss the performance of the surface treatments used under wetting and drying cycles for the duration of the test period.

(14 marks)

- (c) Several columns of a reinforced concrete school building have been reported to undergo significant reinforcement corrosion as a result of carbonation. In many areas, the concrete cover has cracked and spalled. Giving reasons, list **FIVE (5)** important properties that you think a repair material should have to ensure effective and durable repair to the reinforcement corrosion problem.

(5 marks)

2. (a) *Jelaskan EMPAT (4) mod perlindungan di mana rawatan permulaan/salutan berfungsi. Lukiskan rajah yang sesuai bagi setiap mod perlindungan.*

(6 markah)

2. (b) Satu penyiasatan makmal telah dijalankan untuk menganggar keberkesanan dua jenis rawatan permukaan, iaitu epoksi dan "silane" di dalam keadaan kering dan basah yang berulang-ulang. Papak konkrit dengan ketebalan 40mm telah disediakan dan diawet di dalam air selama 7 hari. Selepas pengawetan, teras-teras konkrit dengan diameter 50mm telah diambil daripada papak konkrit dan dikeringkan di dalam oven pada 105°C selama 24 jam sebelum dirawat dengan epoksi dan silane. Beberapa sampel teras juga dibiarkan tanpa rawatan permukaan untuk tujuan perbandingan. Kemudiannya, semua sampel teras telah didedahkan kepada keadaan kering dan basah yang berulang-ulang untuk jangka masa satu tahun. Ujian keliangan total telah dijalankan kepada sampel-sampel teras yang berkenaan selepas 1,3,6 dan 12 bulan didedahkan kepada keadaan kering dan basah. Data-data untuk ujian keliangan total diberikan di dalam Jadual 1.

**Jadual 1:** Data for total porosity test for treated and untreated concrete specimens

Test Period (months)	Controlled/Untreated			Epoxy treated			Silane treated		
	$W_w$	$W_{ssd}$	$W_{od}$	$W_w$	$W_{ssd}$	$W_{od}$	$W_w$	$W_{ssd}$	$W_{od}$
1	119.47	200.36	193.18	122.42	204.46	200.56	120.93	202.61	197.80
3	119.58	200.30	193.12	122.39	204.88	200.96	121.58	201.53	196.57
6	120.26	200.42	193.28	123.02	204.52	200.64	123.46	203.64	197.60
12	120.48	200.36	193.22	122.56	204.98	201.06	122.62	203.54	196.42

*Nota:*

$W_w$  = weight of saturated specimen in water, gram

$W_{ssd}$  = weight of specimen under saturated and surface dry condition (ssd) in air, gram

$W_{od}$  = weight oven dry specimen in air, gram

Tentukan keliangan total bagi semua sampel untuk setiap waktu ujian. Seterusnya tentukan indeks keberkesanan bagi sampel-sampel/spesimen-sepsimen yang dirawat. Susun jawapan anda di dalam bentuk jadual yang sesuai. Berdasarkan kepada indeks keberkesanan yang diperolehi, bincangkan prestasi kedua-dua jenis rawatan permukaan di bawah keadaan kering dan basah untuk tempoh ujian yang telah dijalankan.

(14 markah)

- (c) Beberapa tiang bagi sebuah bangunan sekolah daripada konkrit bertetulang telah dilaporkan mengalami pengurangan tetulang yang berpunca daripada proses pengkarbonatan. Di beberapa tempat, konkrit penutup telah retak dan "spalled". Dengan memberikan justifikasi yang sesuai, senaraikan lima (5) sifat utama yang anda fikir perlu ada pada bahan baikpulih yang akan digunakan untuk membaiki masalah pengurangan tetulang yang berkenaan bagi memastikan kerja baikpulih yang akan dilakukan berfungsi dengan baik dan tahan lasak.

(5 markah)

3. (a) Giving reasons, suggest **FIVE (5)** main tests (non/semi-destructive, chemical, durability related or other suitable tests) that you think should be conducted in the appraisal/assessment of concrete structure facing corrosion problem.

(5 marks)

3. (b) Described the steps that are normally followed in conventional repair of reinforced concrete structure undergoing corrosion problem. (10 marks)
- (c) Explain how patch accelerated corrosion could occur and describe a suitable technique to overcome or reduce the risk of patch accelerated corrosion. Use appropriate sketches to elucidate your explanation. (10 marks)
3. (a) Dengan memberikan justifikasi/sebab-sebab yang munasabah, cadangkan **LIMA** (5) ujian utama yang anda fikir perlu dijalankan di dalam penyiasatan/appraisal ke atas struktur konkrit yang mengalami pengaratn tetulang. (5 markah)
- (b) Jelaskan langkah-langkah yang selalunya diikuti di dalam kerja baikpulih secara konvensional ke atas struktur konkrit bertetulang. (10 markah)
- (c) Terangkan bagaimana "patch accelerated corrosion" berlaku dan jelaskan satu teknik yang sesuai untuk mengatasi atau mengurangkan risiko "patch accelerated corrosion" daripada berlaku. Gunakan rajah-rajah yang sesuai untuk membantu penjelasan anda. (10 markah)
4. (a) Assuming concrete to be represented by the two-phase composite model as shown in Figure 1, derive the relationship between the elastic modulus of concrete and the elastic modulus of aggregate and hardened cement paste. (5 marks)

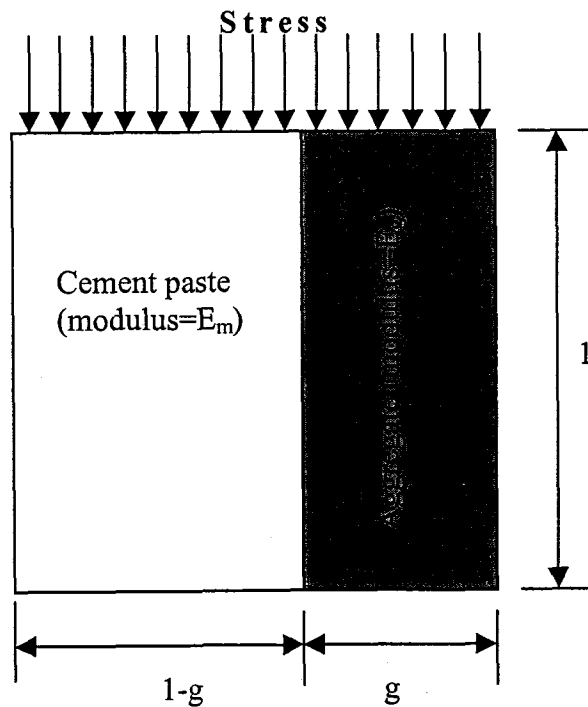
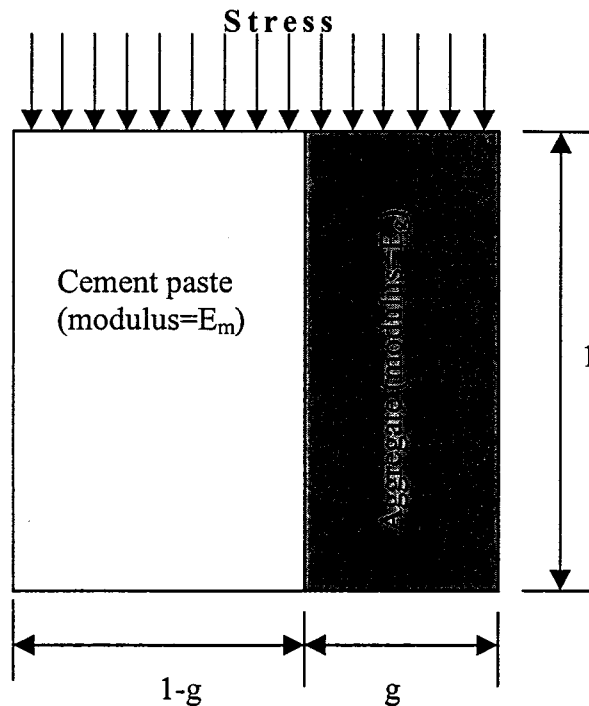


Figure 1

4. (b) Provide/write an appropriate expression for the creep strain of concrete under the following conditions:
- (i) Concrete is sealed
  - (ii) Concrete is allowed to dry from the time of loading
  - (iii) Concrete is stored continuously in water
  - (iv) Concrete is subjected to rise in temperature
- (4 marks)
- (c) Explain **SIX (6)** factors that could affect creep of concrete. (12 marks)
- (d) Describe the effects of creep on concrete structures. (4 marks)
4. (a) Dengan menganggap konkrit diwakili oleh model dua-fasa seperti di Rajah 1, dapatkan hubungan di antara modulus keanjalan konkrit dengan modulus keanjalan agregat dan adunan simen terkeras. (5 markah)



Rajah 1

- (b) Berikan/tuliskan ungkapan (expression) yang sesuai bagi terikan rayapan untuk konkrit di bawah keadaan-keadaan berikut:
- (i) Konkrit yang disalut.
  - (ii) Konkrit yang dibiarkan kering selepas dibebankan.
  - (iii) Konkrit yang sentiasa direndam di dalam air.
  - (iv) Konkrit yang didedahkan pada suhu tinggi selepas dibebankan.
- (4 markah)
- (c) Terangkan **ENAM (6)** faktor yang boleh mempengaruhi rayapan konkrit. (12 markah)
- (d) Jelaskan kesan-kesan rayapan kepada struktur konkrit. (4 markah)