UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2005/2006

November 2005

EBB 524/3 - Bahan Komposit

Masa : 3 jam

Sila pastikan bahawa kertas peperiksaan ini mengandungi DUA BELAS muka surat beserta SATU muka surat (Lampiran) dan SATU muka surat HELAIAN JAWAPAN yang bercetak sebelum anda memulakan peperiksaan.
Please ensure that this paper consists of TWELVE printed pages including ONE page (Appendix) and ONE page (ANSWER SHEET) before you proceed with the examination.

Kertas soalan ini mengandungi TUJUH soalan.
This paper contains SEVEN questions.

Jawab LIMA soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.
Answer FIVE questions. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.

SOALAN NO. 5 hendaklah dijawab dalam HELAIAN JAWAPAN yang disediakan di belakang helaian soalan ini dan tolong sertakan bersama-sama dengan buku jawapan.
QUESTION NO. 5 must be answered in ANSWER SHEET provided at the back of this question sheet and please attach with the answer script.

Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.
Answer to any question must start on a new page.

Soalan bolah dijawab samada dalam Bahasa Malaysia atau Bahasa Inggeris.
Question can be answered either in Bahasa Malaysia or English.

...2/-

1. [a] Dengan mempertimbangkan suatu komposit polimer yang diperkuat gentian selanjar yang disusun pada arah membujur dan arah melintang, tunjukkan modulus yang terhasil adalah :

By considering a polymer composite with uni-directional continuous aligned fibres at longitudinal and transerve direction, show that the resultant modulus is :

$$E_{CL} = E_f V_f + E_m V_m \quad \text{dan}$$
$$E_{cT} = E_f E_m / (V_f E_m + V_m E_f)$$

(50 markah)

[b] Di dalam komposit Kevlar/epoksi satu arah, nisbah modulus ialah 20 dan epoksi memenuhi 60% daripada isipadu. Kira modulus komposit dan tegasan di dalam gentian dan matrik apabila suatu tegasan 50 MN/m^2 dikenakan kepada komposit. Modulus bagi epoksi ialah 6 GN/m^2.

In a unidirections Kevlar/epoxy composite the modular ratio is 20 and the epoxy occupies 60% of the volume. Calculate the modulus of the composite and the stresses in the fibres and the matrix when a stress of 50 MN/m^2 is applied to the composite. The modulus of the epoxy is 6 GN/m^2.

(50 markah)

...3/-

2. Terdapat 4 jenis bahan polimer yang boleh digunakan di dalam bahan komposit iaitu :

(a) Getah
(b) Termoplastik
(c) Termoplastik elastomer
(d) Termoset

Dengan mengambil satu contoh setiap bahan polimer ini, terangkan bagaimana ianya boleh digunakan untuk menghasilkan komposit polimer.

There are 4 type of polymeric materials which can be used in polymer composite, i.e.:

(a) Rubber
(b) Thermoplastic
(c) Elastomer thermoplastic
(d) Thermoset

By selecting one example for each polymeric material, discuss how they can be used to produce polymer composite.

(100 markah)

...4/-

3. [a] Bincangkan pelbagai proses pembentukan yang boleh digunakan untuk menghasilkan komposit polimer.

Discuss various forming processes which can be used to manufacture polymer composite.

(50 markah)

[b] Satu ujian tegangan dijalankan ke atas tiga jenis sampel seramik: seramik monolitik, komposit gentian selanjar dan komposit diperkuat partikel. Plotkan keputusan yang dijangka dalam satu graf tegasan-tegangan dan bincangkan kelakuan pecah sampel-sampel tersebut.

A tensile test was conducted on three types of ceramic samples: monolithic ceramic, continuous fiber composite and particulate reinforced composite. Plot the expected results in a stress-strain curve and discuss the fracture manner of these samples.

(30 markah)

[c] Terangkan prinsip penguatan seramik berdasarkan mekanisme berikut:

(a) lenturan retak

(b) pesongan retak

Explain the principle of ceramic toughening based on the following mechanisms:

(a) crack bowing

(b) crack deflection

(20 markah)

...5/-

4. [a] Buktikan luas antaramuka bagi komposit diperkuat gentian berhubung secara songsang terhadap diameter gentian.

Prove the interfacial area of fiber reinforced composites is inversely dependence on the fiber diameter.

(30 markah)

[b] Secara ringkas jelaskan prinsip bagi teknik sambungan komposit matrik seramik yang berikut:

(a) Ikatan kaca ke logam secara ikatan elektrostatik

(b) Kimpalan geseran seramik ke logam

(c) Ikatan resapan

Briefly describe the principle of the following ceramic matrix composites joining techniques:

(a) Glass to metal bonds by electrostatic bonding

(b) Friction welding of ceramic to metal

(c) Diffusion bonding

(30 markah)

[c] Dalam satu eksperimen, seorang pelajar dikehendaki memotong komposit matrik seramik kaca diperkuat gentian Nicalon yang disusun searah dengan menggunakan pemotong intan dan pemotong laser. Kemudian, beliau mengkaji topografi permukaan-permukaan yang dipotong dengan pemotong laser dan pemotong intan di bawah mikroskop imbasan elektron. Jangkakan topografi yang mungkin bagi kedua-dua permukaan. Jelaskan jawapan anda.

In an experiment, a student is required to cut a uniaxially aligned Nicalon fibers reinforced glass ceramic matrix composite by using diamond wheel and laser cutting. Afterward, he observed the topography of the laser cut surfaces and diamond sawn surfaces under scanning electron microscope. Predict the possible appearance for both cut surfaces. Justify your answer.

(40 markah)

...6/-

5. [a] Indicate whether statements 1 to 15 are true or false.

(1) The superconducting properties of a multifilamentary superconductor are determined by the Nb_3 Sn layer thickness and grain size.

(2) In the squeeze casting process molten metal is forced by mechanical pressing into perform.

(3) Powder metallurgy is commonly employed for the fabrication of MMCs but only if the reinforcement is continuous fiber.

(4) Although an MMC has higher room temperature strength than the matrix the converse is true at elevated temperatures.

(5) The electrical conductivity of an MMC is usually higher than that of the matrix.

(6) Materials property charts always have Young's modulus for one of the axes.

(7) The main objective in reinforcing a metal is to lower the Young's modulus.

(8) The properties of a composite are essentially isotropic when the reinforcement is randomly orientated, equiaxed particles.

(9) A laminate is an example of a particle reinforced composite.

(10) A hybrid has a mixed metal and ceramic matrix reinforced with polymer fibers.

(11) The performance indicator $E^{l/2}/p$ is applicable when considering the Possibility of buckling under the action of a compressive force.

(12) Usually the matrix has a lower Young's modulus than the reinforcement.

(13) The most widely used composites are metal matrix composites.

...7/-

(14) There are five basic ways of making honeycomb: adhesive bonding, resistance welding, brazing, diffusion bonding and thermal fusion.

(15) There are two basic techniques used to convert the sheet material into honeycomb: the bending process and the shearing process.

(45 markah)

[b] For each of the statements of questions 16 to 25, one or more of the completions given are correct. Mark the correct completions.

16. The matrix
    (A) is always fibrous,
    (B) transfers the load to the reinforcement,
    (C) separates and protects the surface of the reinforcement,
    (D) is usually stronger than the reinforcement,
    (E) is never a ceramic.

17. Compared with a ceramic, a polymer normally has a
    (A) greater strength
    (B) lower stiffness,
    (C) lower density,
    (D) setter high temperature performance,
    (E) lower hardness.

18. Metal matrix composites usually
    (A) have a heavy metal for the matrix,
    (B) have a poorer ductility than the matrix,
    (C) retain their strength to higher temperatures than the matrix,
    (D) have a lower Young's modulus than the matrix,
    (E) are reinforced by polymer fibers

...8/-

19. The creep curve of a metal reinforced with continuous ceramic fibers
    (A) asymptopically approaches a zero creep rate,
    (B) exhibits a marked monotonically increasing tertiary creep regime,
    (C) is a classical three-stage creep curve,
    (D) is identical to that of a continuous in situ composite,
    (E) is a consequence of significant creep of the ceramic fibers.

20. The transverse tensile strength of an aligned continuous fiber composite
    (A) is obtained when testing normal to the fiber axis,
    (B) is obtained when testing parallel to the fiber axis,
    (C) is the lowest tensile strength,
    (D) is the highest tensile strength,
    (E) depends mainly on the properties of the matrix and of the fiber matrix interface.

21. The Young's modulus of an aligned continuous fiber metal matrix composite
    (A) increases with increasing volume fraction of fiber,
    (B) is independent of volume fraction of fiber,
    (C) is the same in the longitudinal and transverse directions,
    (D) is greater in the longitudinal direction,
    (E) is greater in the transverse direction.

22. In situ MMCs
    (A) are produced by squeeze casting,
    (B) are produced by unidirectional solidification,
    (C) are produced by spray co-deposition,
    (D) have an aligned microstructure,
    (E) usually have a two-phase eutectic microstructure.

...9/-

23. Rheocasting

(A) a solid state technique,

(B) can only be employed for in situ composites,

(C) involves mixing the reinforcement with solid-liquid metal,

(D) is a modification of melt stirring,

(E) involves applying a mechanical pressure during casting.

24. In honeycomb composite facing failure may occur

(A) in either compression or tension face.

(B) by sufficient thickness

(C) by insufficient thickness panel

(D) by sufficient facing strength

(E) by sufficient facing thickness

25. In honeycomb composite, intracell buckling (dimpling)

(A) Applicable to cellular cores only

(B) Occurs with a thick facing

(C) Occurs with small core cell

(D) Failure may propagate across adjacent cells

(E) Inducing face wrinkling.

(55 markah)

...10/-

6. [a] (i) Determine the working stress at 600°C and 800°C for MMC if the design criterion is a creep strength based on 3.6% extension in 1000hr use factor of safety of 2.5. Use the following stress Vs. minimum Creep rate for this composite, as shown in figure bellow.

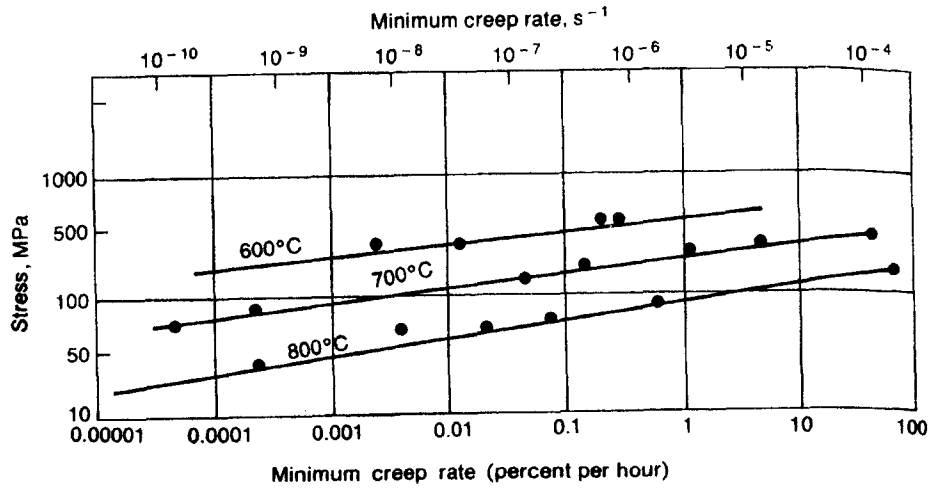


Figure 6 [a]

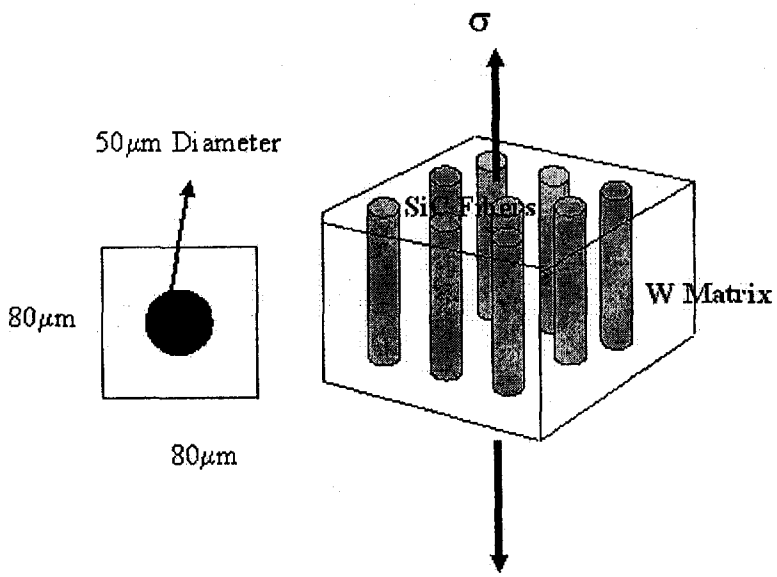
(ii) Determine the activation energy for the creep at a stress of 500MPa. (Gas constant R = 8.3 J /mol.k)

(50 markah)

...11/-

[b] A hard brittle metal matrix composite is made with continuous; SiC fibbers embedded in a tungsten matrix. (i) Calculate the tensile elastic modulus of the composite under isostrain conditions and (ii) calculate the stress at which the cracks start to grow. Data are as bellow:

Tungsten matrix:	**SiC fibers:**
E = 94 GPa	**E= 350GPa**
K_{1C} = 2.4MPam$^{1/2}$	**K_{1C}=4.8MPam$^{1/2}$**
largest preexisting flaw is 10μm in diameter	**largest surface notchs are 5μm deep**



(50 markah)

7. [a] Perihalkan fabrikasi komposit kaca diperkuat gentian selanjar melalui kaedah penusukan buburan.

Describe the fabrication of continuous fiber reinforced glass composite via slurry infiltration method.

(30 markah)

...12/-

[b] Senaraikan kelebihan dan kekurangan pemprosesan komposit matrik seramik melalui teknik-teknik pengoksidaan langsung dan penusukan wap kimia.

List down the advantages and disadvantages of ceramic matrix composite processing via directed oxidation and chemical vapor infiltration techniques.

(20 markah)

[c] Uniformly loaded, simply supported beam is shown in Figure 7 [c]. Using appendix provided to make comparisons between approximate and exact solutions in term of

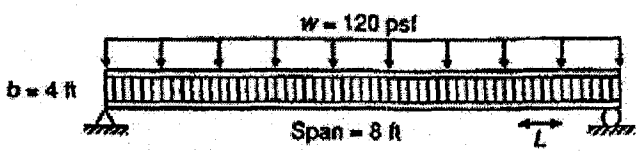
(a) shear stress,

(b) Top facing stress,

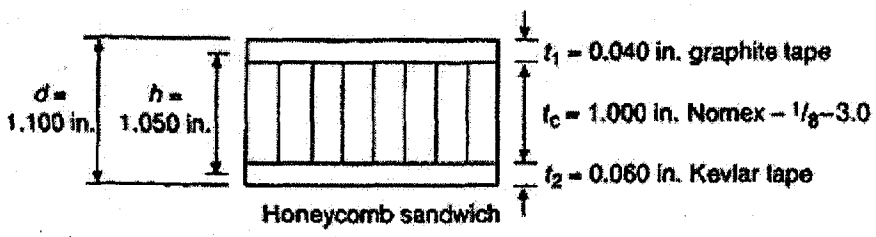
(C) Bottom facing stress,

(d) Panel deflection.

(50 markah)



Core L orientation is in the span direction



Material properties

Carbon tape $F_t = 187$ ksi, $E_t = 18.3$ Msi, $\lambda = 0.99$, $\rho = 106$ pcf.
Kevlar tape $F_t = 156$ ksi, $E_t = 9.5$ Msi, $\lambda = 1.00$, $\rho = 86$ pcf.
Nomex-1/8-3.0 honeycomb:
minimum values $\sigma_c = 245$ psi, $\tau_L = 150$ psi, $\tau_W = 75$ psi.
typical values $E_c = 20$ ksi, $G_L = 6.5$ ksi, $G_W = 3.5$ ksi.

Figure 7 [c]

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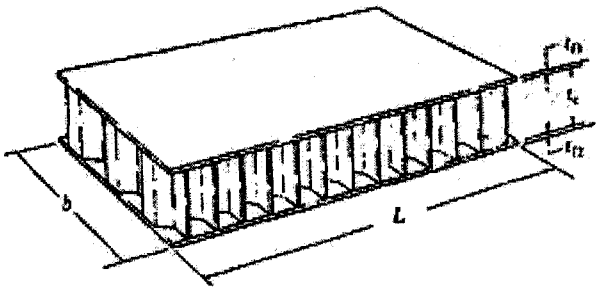
APPENDIX

LAMPIRAN



$$h = \frac{t_{f1}}{2} + \frac{t_{f2}}{2} + t_c$$

Bending stress in facings

$$\sigma_{fi} = \frac{M}{t_{fi} h b}$$

$i = 1$ or 2

Core shear stress

$$\tau_c = \frac{V}{hb}$$

Deflection K_b and K_s

$$\Delta = \frac{K_b P L^2}{D} + \frac{K_s P L}{h G_c b}$$

$$D = \frac{E_{f1} t_1 E_{f2} t_2 h^2 b}{E_{f1} t_1 \lambda_2 + E_{f2} t_2 \lambda_1}$$

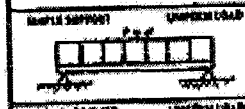
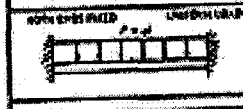
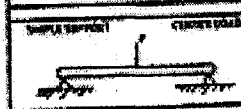
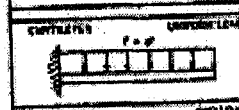
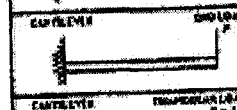
Face dimpling

$$\sigma_{cr} = \frac{2E_f}{\lambda}\left[\frac{t_f}{S}\right]^2$$

Face wrinkling

$$\sigma_{cr} = 0.82\, E_f \left[\frac{E_c E_f}{E_f t_c}\right]^{1/3}$$

Beam Chart

BEAM TYPE	MAXIMUM SHEAR FORCE V	MAXIMUM BENDING MOMENT M	BENDING DEFLECTION CONSTANT K_b	SHEAR DEFLECTION CONSTANT K_s
	0.5P	0.125PL	0.01302	0.125
	0.5P	.08333PL	.013604	0.125
	0.5P	0.25PL	0.02083	0.25
	0.5P	0.125PL	.00521	0.25
	P	0.5PL	0.125	0.5
	P	PL	0.3333	1
	P	0.3333PL	0.06666	0.3333