
UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2012/2013

January 2013

EBP 420/2 – Rubber Engineering [Kejuruteraan Getah]

Duration : 2 hours
[Masa : 2 jam]

Please ensure that this examination paper contains SEVEN printed pages and ONE page APPENDIX before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH muka surat beserta SATU muka surat LAMPIRAN yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of SEVEN questions.

[Kertas soalan ini mengandungi TUJUH soalan.]

Instruction: Answer **FOUR** questions. If a candidate answers more than four questions only the first four questions answered in the answer script would be examined.

[Arahan: Jawab **EMPAT** soalan. Jika calon menjawab lebih daripada empat soalan hanya empat soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]

The answers to all questions must start on a new page.

[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.

[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

1. [a] Based on Figure 1 below, explain the deviation of experimental with the statistical theory prediction of elastic behaviour of rubber. Suggest the suitable theory/theories to explain the stress-strain behaviour of rubber.

Berdasarkan Rajah 1 di bawah, jelaskan perbezaan antara eksperimen dan ramalan teori statistik bagi menerangkan kelakuan elastik untuk getah. Cadangkan teori/ teori-teori yang sesuai untuk menerangkan kelakuan tegasan-terikan getah.

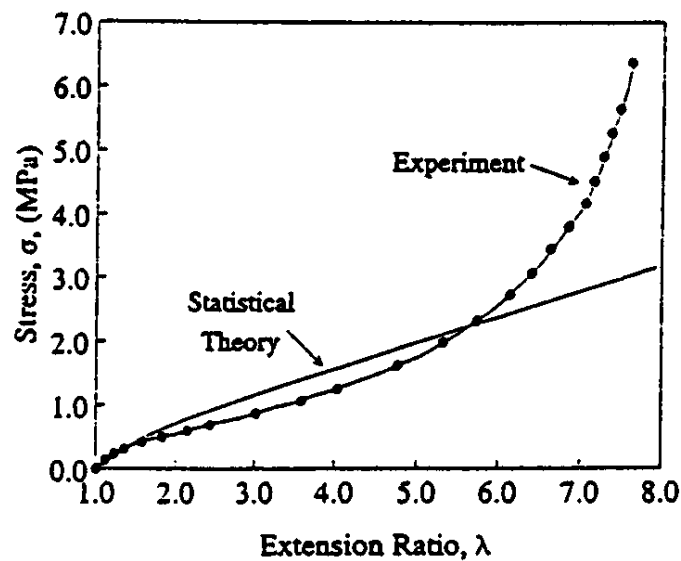


Figure 1: Comparison of force-deformation behavior for rubber based on statistical theory and experimental.

Rajah 1: Perbandingan kelakuan daya-canggaan getah berdasarkan teori statistik dan eksperimen.

(40 marks/markah)

- [b] Explain briefly with schematic illustrations the below:
- (i) Mullin's effect
 - (ii) Non linear behaviour
 - (iii) Payne's effect

Jelaskan secara ringkas dengan bantuan gambarajah skematik bagi perkara-perkara di bawah:

- (i) *Kesan Mullin (Mullin's effect)*
- (ii) *Kelakuan tak-linear*
- (iii) *Kesan Payne (Payne's effect)*

(60 marks/markah)

2. A circular disc with measuring diameter of 500 mm and thickness of 25 mm made with rubber of shear modulus, $G = 621$ kPa.

Satu cakera bulat dengan ukuran diameter 500 mm dan ketebalan 25 mm diperbuat daripada getah dengan modulus ricih, $G = 621$ kPa.

- (a) Using the classical approach, calculate the force required to compress it by 20%.

Menggunakan pendekatan klasik, kirakan daya yang diperlukan untuk memampatkannya sebanyak 20%.

(35 marks/markah)

- (b) If the statistical approach is used calculate the resulted force to compress it by 20%.

Jika pendekatan statistik digunakan, kirakan daya yang diperlukan untuk memampatkannya sebanyak 20%.

(35 marks/markah)

- (c) If the Lindley approach is used, what is the expected results and point out why it is expected to be more accurate?

Jika pendekatan Lindley digunakan, apakah keputusan yang dijangka dan jelaskan mengapa keputusan yang dijangka adalah lebih tepat?

(30 marks/markah)

3. [a] An unprotected vulcanizate with the following properties:

Threshold energy for ozone crack growth $G_z = 0.08 \text{ Jm}^{-2}$

Mechanico oxidative crack growth $G_o = 40 \text{ Jm}^{-2}$,

Young's modulus = 4 MPa

crack length = 0.04mm

- (i) Estimate the threshold strain in simple extension for each type of cracking. [K taken as 2 and U is $0.5 Ee^2$]
- (ii) Predict the threshold energy for ozone crack growth if the natural occurring flaws increased to 0.08 mm

Satu vulkanizat getah yang tidak dilindungi dengan sifat-sifat berikut:

Tenaga ambang untuk perambatan carikan akibat ozon $G_z = 0.08 \text{ Jm}^{-2}$

Perambatan carikan akibat oksidatif mekanikal $G_o = 35 \text{ Jm}^{-2}$,

Young modulus = 4 MPa

panjang retak = 0.04 mm

- (i) *Anggarkan terikan ambang dalam pemanjangan mudah untuk setiap jenis perambatan carikan. [K diambil sebagai 2 dan U ialah $0.5 Ee^2$]*
- (ii) *Ramalkan Tenaga ambang untuk perambatan carikan akibat ozon jika kecacatan semulajadi meningkat kepada 0.08 mm*

(70 marks/markah)

- [b] Illustrate the mechanical fatigue of rubber in terms of fatigue crack growth behaviour

Gambarkan kelakuan fatig mekanikal untuk getah dalam konteks kelakuan perambatan retak fatig.

(30 marks/markah)

4. [a] Based on the concept of laminated rubber unit, correlate the application of British requirements in bridge bearing design. (Include the appropriate equations and/or sketches).

Berdasarkan konsep unit getah terlaminat, berikan hubung kait penggunaan keperluan British dalam merekabentuk galas jambatan. (Sertakan persamaan dan/atau lakaran yang sesuai).

(60 marks/markah)

- [b] For Raykin dock fender, illustrate the force-deformation behaviour of a mounting based on shear load, compression load, and total load.

Untuk Fender dok Raykin, sila gambarkan kelakuan daya-canggaannya berdasarkan beban ricihan, beban mampatan dan beban keseluruhan.

(40 marks/markah)

5. A rectangular rubber block bearing, measuring 50 mm x 75 mm x 10 mm (length x width x thickness), made with rubber of shear modulus $G = 524$ kPa.

Satu segiempat tepat blok galas getah yang berukuran 50 mm x 75 mm x 10 mm (panjang x lebar x tebal), diperbuat daripada getah dengan modulus ricih, $G = 524$ kPa.

- (a) Assume bulk compressibility effects to be negligible, calculate compression and shear spring rates and the ratio K_c/K_s .

Andaikan kesan mampatan pukal boleh diabaikan, kirakan kadar mampatan spring dan kadar ricihan spring serta nisbah K_c/K_s

(40 marks/markah)

- (b) If the rubber bearing is divided into 5 equal thickness sections by rigid shims, estimate the new compression spring rates and the ratio K_c/K_s .

Jika galas getah dibahagikan kepada 5 bahagian yang mempunyai ketebalan yang sama oleh kepipis tegar, anggarkan kadar mampatan spring yang baru dan nisbah K_c/K_s

(60 marks/markah)

6. [a] Explain the importance of transmissibility parameter in earthquake rubber mount and differentiate how the types of rubber will influence the transmissibility.

Jelaskan kepentingan parameter transmisibiliti dalam pengasingan getaran bagi cagak getah gempa bumi dan bezakan bagaimanakah jenis getah yang berbeza akan mempengaruhi transmisibiliti.

(60 marks/markah)

- [b] Compare three different frictional forces and their relations with the skid resistance of tire.

Bezakan tiga tenaga geseran ini dan perkaitan daya-daya tersebut dengan rintangan gelinciran bagi tayar.

(40 marks/markah)

APPENDIX / LAMPIRAN**Table: Material Properties**

Shear Modulus, G (kPa)	Young's Modulus, E_o (kPa)	Bulk Modulus, E_B (kPa)	Material correction factor
296	896	979	0.93
365	1158	979	0.89
441	1469	979	0.85
524	1765	979	0.80
621	2137	1007	0.73
793	3172	1062	0.64
1034	4344	1124	0.57
1344	5723	1179	0.54
1689	7170	1241	0.53
2186	9239	1303	0.52

Given Equations

$$\sigma = \frac{E_c}{3} \left(\frac{1}{\lambda^2} - \lambda \right)$$

$$S = \frac{LB}{2t(L+B)}$$

$$S = \frac{a}{2t}$$

$$E_c = E_o \left(1 + 2kS^2 \right)$$

$$E_c = E_o \left(1 + 2S^2 \right)$$

$$\frac{\partial}{E} = \ln \frac{1}{\lambda} + kS^2 \left(\frac{1}{\lambda^2} - 1 \right)$$

$$K_s = \frac{AG}{t}$$

$$K_c = \frac{AEC}{t}$$

$$\frac{1}{1 + \frac{E_o}{E_B}}$$

$$G = 2KUc$$

$$\frac{dc}{dn} = BG^\beta$$

$$T^2 = \frac{1 + \tan^2 \delta}{\left[1 - \left(\frac{W}{W^n} \right)^2 \frac{G_o^1}{G^1} \right]^2 + \tan^2 \delta}$$

$$\frac{F}{x} = 2 \left(k_c \cos^2 \partial + k_s \sin^2 \partial \right)$$

$$T_t = T_q + T_b$$

$$T_q = 6Se_c$$