First Semester Examination
2024/2025 Academic Session

February 2025

EBP 420 – Rubber Engineering
[Kejuruteraan Getah]

Duration : 2 hours
[Masa : 2 jam]

Please ensure that this examination paper contains TEN (10) printed pages before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEPULUH (10) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instruction: Answer **FOUR (4)** questions. Answer **ALL** questions from PART A, **ONE (1)** question from PART B and **ONE (1)** question from PART C. All questions carry the same marks.

*[**Arahan**: Jawab **EMPAT (4)** soalan. Jawab **SEMUA** soalan dari BAHAGIAN A, **SATU (1)** soalan dari BAHAGIAN B dan **SATU (1)** soalan dari BAHAGIAN C. Semua soalan membawa jumlah markah yang sama.]*

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

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

PART A / *BAHAGIAN A*

(1). The R&D team at Best Bearing Sdn. Bhd. is required to predict the crack growth behavior of a new design of bridge bearing. The rubber materials used in the design have the following properties:

Pasukan R&D di Best Bearing Sdn Bhd dikehendaki meramalkan kelakuan perambatan retakan bagi reka bentuk baharu galas jambatan. Bahan getah yang digunakan dalam reka bentuk mempunyai ciri-ciri berikut:

Young Modulus, E = 2.4 MN/m^2
Modulus Young, E = 2.4 MN/m^2
Natural occurring flaws c = 0.04 mm
Kecacatan semulajadi, c = 0.04 mm
Threshold energy for ozone crack growth, T_z = 40 Jm^{-2}
Perambatan retakan akibat ozon, T_z = 40 Jm^{-2}
Threshold energy for mechanical oxidative crack growth, T_o= 10 kJm^{-2}
Perambatan retakan akibat oksidatif mekanikal, T_o = 10 kJm^{-2}
Crack growth constant, B = 5.0 x10^{-8} $mcycle^{-1}/kJm^{-2}$
Perambatan retakan konstan, B = 5.0 x10^{-8} $mcycle^{-1}/kJm^{-2}$
Constant b = 4
Konstan b = 4

(i) Estimate the threshold cyclic strain for the bridge bearing in simple extension for each type of cracking [K is taken as 2 and $U = 0.5\ Ee^2$]

Kirakan kitaran terikan ambang bagi galas jambatan dalam pemanjangan mudah untuk setiap jenis retakan. [K diambil sebagai 2 dan $U = 0.5\ Ee^2$]

(8 marks/*markah*)

(ii) Predict the crack growth per year if the maximum cyclic strain of 20% is applied 10^6 times per year.

Ramalkan pembentukan perambatan carikan setahun jika kitaran terikan maksimum sebanyak 20% dikenakan 10^6 kali dalam masa setahun.

(9 marks*/markah*)

(iii). Assess the importance of fatigue life and crack growth behavior of rubber in predicting the lifetime of rubber bridge bearing based on the S-N curve.

Nilaikan kepentingan kelakuan hayat fatig dan perambatan retakan getah dalam meramalkan jangka hayat bagi product galas jambatan berdasarkan lekuk S-N.

(8 marks/*markah*)

(2). (a). Metal components are delivered by conveyor to a metal storage bin. The components are guided into the bin via a metal chute, as shown in Figure 1. Noise is produced by the metal components hitting the metal wall of the chute, as well as the metal base and walls of the storage bin. Identify the key issues in the system and propose a method to reduce the noise produced when the metal components struck the wall of the chute and bin.

Komponen logam dihantar melalui penghantar ke tong simpanan logam. Komponen tersebut dipandu ke tong melalui pelongsor logam, seperti yang ditunjukkan pada Rajah 1. Kebisingan dihasilkan oleh komponen logam yang menyentuh dinding logam pelongsor, serta dasar logam dan dinding tong simpanan. Kenal pasti masalah utama dalam sistem dan cadangkan kaedah untuk mengurangkan kebisingan yang dihasilkan semasa komponen logam menghentam dinding pelongsor dan tong sampah.

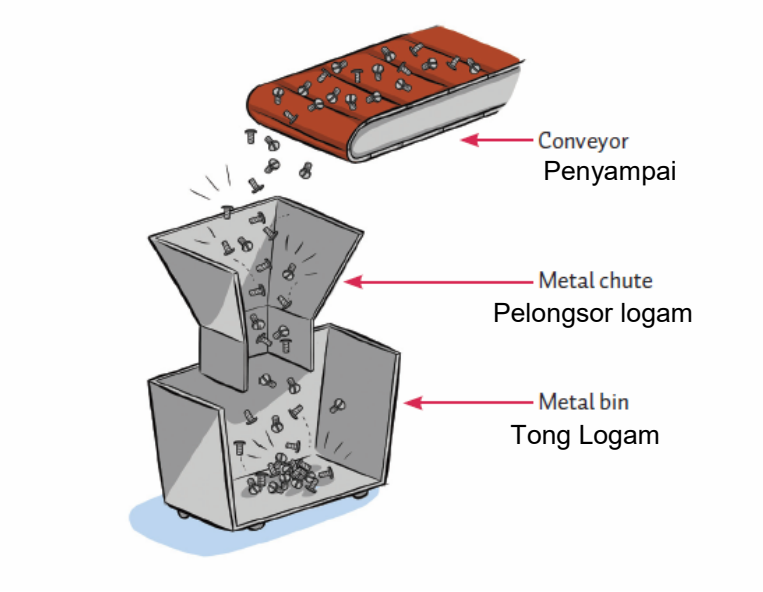

Figure 1 : Metal component conveyor system

Rajah 1: Sistem penghantaran komponen logam

(10 marks/*markah)*

(b). Vibration in industrial equipment can be both a sign and a source of trouble. With the aid of a suitable diagram, discuss the most effective mounting options of anti-vibration rubber mounts to reduce the vibration and increase the stability of the equipment.

Getaran dalam peralatan industri boleh menjadi tanda dan punca masalah. Dengan bantuan gambarajah yang sesuai, bincangkan pemilihan pemasangan peredam getah anti getaran yang paling berkesan untuk mengurangkan getaran dan meningkatkan kestabilan peralatan.

(9 marks/*markah)*

(c). Explain functions of tire as a part of automobile and discuss three different frictional forces generated during driving on smooth, rough and sharpened road surface.

Terangkan fungsi tayar sebagai sebahagian daripada bahagian kereta dan bincangkan tiga daya geseran berbeza yang dijana semasa memandu di permukaan jalan yang licin, kasar dan tajam.

(6 marks/*markah)*

…5/-

PART B / *BAHAGIAN B*

(3). A rectangular rubber block bearing, measuring of 150 mm x 75 mm x 16 mm (length x width x thickness), has the following rubber properties:

Satu segiempat tepat blok galas getah dengan ukuran 150 mm x 75 mm x 16 mm (panjang x lebar x tebal), mempunyai sifat-sifat getah seperti berikut:

Young's modulus = 3.25 MN/m^2
Modulus Young = 3.25 MN/m^2
Shear modulus = 0.81 MN/m^2
Modulus ricih = 0.81 MN/m^2
Bulk modulus = 1090 MN/m^2
Modulus pukal = 1090 MN/m^2
Correction factor = 0.72
Faktor pembetulan = 0.72

(a). Calculate the deformation force of the rubber bearing under 15% compression using a classical and statistical approach.

Kira daya ubah bentuk galas getah dibawah mampatan 15% menggunakan pendekatan klasik dan statistik.

(10 marks/*markah*)

(b). Proposed suitable approach in calculation of force deformation behavior of rubber bearing.

Cadangkan pendekatan yang sesuai untuk mengira kelakuan ubah bentuk daya bagi galas getah.

(5 marks/*markah*)

(c). Based on the concept of a laminated rubber unit, correlate the application of British requirements with bridge design. Include the influence of instability in your design considerations based on the given rubber bearing.

Berdasarkan konsep unit getah berlamina, hubungkaitkan aplikasi keperluan British dengan reka bentuk jambatan. Sertakan pengaruh ketidakstabilan dalam pertimbangan reka bentuk anda berdasarkan galas getah yang diberikan.

(10 marks/*markah*)

(4). As a Design Engineer, your task is to design a rubber bearing for a machine component subjected to torsional loading. The rubber bearing should be capable of absorbing and resisting the applied torque while maintaining its structural integrity and performance under cyclical loading conditions. The key design requirements are as follows:

Sebagai Jurutera Reka Bentuk, tugas anda adalah untuk merekabentuk galas getah untuk komponen mesin yang tertakluk kepada beban kilasan. Galas getah harus mampu menyerap dan menahan tork yang digunakan sementara mengekalkan integriti dan prestasi strukturnya di bawah keadaan pemuatan kitaran. Keperluan reka bentuk utama adalah seperti berikut:

Maximum torque = 100 Nm
Tork maksimum = 100 Nm
Maximum torsional angle of rotation = 5^o
Sudut kilasan maksimum putaran = 5^o
Shear modulus, G = 1.2 MN/m^2
Modulus ricih G = 1.2 MN/m^2
Bearing Length, L = 50 mm
Panjang Galas, L = 50 mm

(a). Calculate the required torsional spring rate (K_{tor}) of the rubber bearing.
Kira kadar spring kilasan (K_{tor}) yang diperlukan bagi galas getah.

(7 marks/*markah*)

(b). Propose suitable inner and outer diameters for the rubber bearing, based on the shear modulus and the calculated torsional spring rate.

Cadangkan diameter dalam dan luar yang sesuai untuk galas, berdasarkan modulus ricih dan kadar kilasan spring yang yang dikira.

(8 marks/*markah*)

(c). Assess the effect of the rubber bearing design on the lamination layers, wall thickness, and materials selection to enhance the rubber bearing performance.

Menilai kesan reka bentuk galas getah pada lapisan laminasi, ketebalan dinding, dan pemilihan bahan untuk meningkatkan prestasi galas getah.

(10 marks/*markah*)

PART C / *BAHAGIAN C*

(5). (a). Describe the importance of viscoelasticity in the field of rubber engineering.

Perihalkan kepentingan viskoelastik dalam bidang kejuruteraan getah.

(5 marks/*markah)*

(b). A number of rubber engineering applications involve deformation of the product in a cyclic loading. Sketch idealized cyclic stress-strain curve of a vibration mounting on an engine moves repeatedly through a sinusoidal cyclic deformation. Identify the phase angle, δ and derive the complex modulus E* and tangent of the phase angle δ (tan δ).

*Beberapa aplikasi kejuruteraan getah melibatkan ubah bentuk produk semasa beban kitaran. Lakarkan kitaran lengkung tegasan-terikan ideal untuk aci pemancu enjin yang bergerak melalui ubah bentuk kitaran gelombang sinus. Kenal pasti sudut fasa, δ dan terbitkan modulus kompleks E * dan tangen daripada sudut fasa δ (tan δ).*

(12 marks/*markah*)

(c). Explain **TWO (2)** methods for assessing damping of a material under cyclic loading.

Terangkan DUA (2) kaedah untuk menilai redaman bahan di bawah beban kitaran.

(8 marks/*markah)*

(6). (a). Figure 2 illustrates the relationship between vibration transmissibility and vibration frequency ratio for various types of rubber. Suggest rubbers with high and low damping characteristics, and explain how the properties of the chosen rubbers influence the amplification and isolation regions in the transmissibility behavior of the vibrating system

Rajah 2 menunjukkan hubungan antara transmisibiliti getaran dan nisbah frekuensi getaran bagi pelbagai jenis getah. Cadangkan getah dengan ciri-ciri redaman tinggi dan rendah, serta terangkan bagaimana sifat-sifat getah yang dipilih mempengaruhi kawasan penguatan dan pengasingan dalam tingkah laku transmisibiliti sistem getaran.

(13 marks/*markah)*

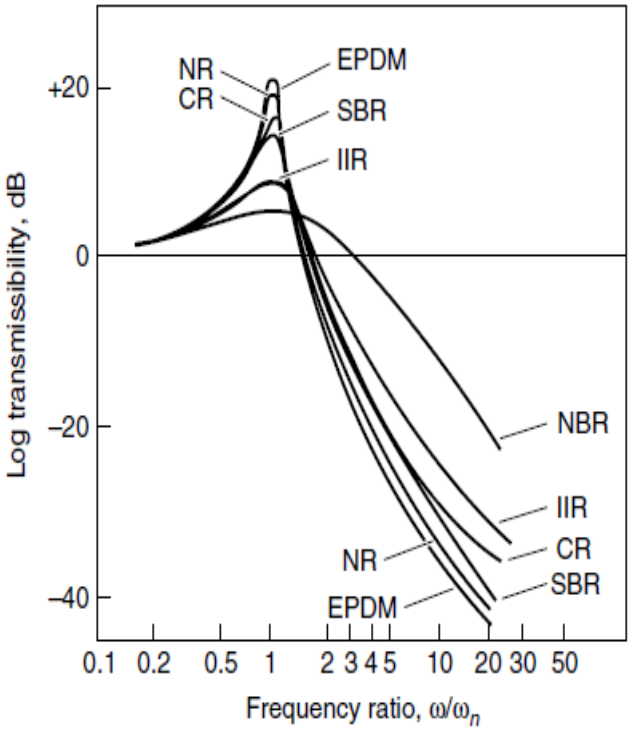

Figure 2: Effect of Types of Rubber on Transmissibility

Rajah 2: Kesan Pelbagai Jenis Getah terhadap Transmisibiliti

(b). Using appropriate damping models explain viscous damping and interfacial damping mechanisms of a bridge bearing under shear deformation and suggest how to obtain total damping capacity of the materials.

Dengan menggunakan model redaman yang sesuai, terangkan mekanisma redaman likat dan redaman antaramuka untuk galas jambatan di bawah ubah bentuk ricih dan cadangkan bagaimana untuk mendapatkan jumlah keseluruhan kapasiti redaman bahan tersebut.

(12 marks/*markah)*

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