Data Article

Experimental data for effect of carbon black loading on tensile, hardness and rebound of magnetic iron filled natural rubber composites

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1. Data

Data presented in this article was used to investigate the performance of MRE composites due to effect of carbon black loading. The mechanical test through tensile test, hardness test and rebound test. The data are focused on the mechanical properties of magnetic iron filled natural rubber composites.

The data of the tensile properties are tabulated in Table 1 and plotted in Figs. 7–9. The Effect of carbon black loading on rebound resilience tabulated in Table 2 and plotted in Fig. 11. The data for hardness test are tabulated in Table 3 (The thickness of hardness test pieces) and Table 4 (Results of hardness).
2. Design, materials, and methods

2.1. Materials

Elastic matrix and magnetic particles are the main ingredients of MRE. In this experiment study, Standard Malaysian Rubber (SMR) L grade natural rubber was chosen as matrix based MRE. In order to develop the MRE compounds, carbonyl iron particles with The diameter and density of the iron particle are in range of 6–9 μm and 7.86 g/cm³, respectively were purchased from Sigma-Aldrich Sdn. Bhd. (M). Carbon black N220 was used as the reinforcing filler of the MRE compound which has been varied with addition of 20pphr, 40pphr and 60.

Other materials such as zinc oxide (ZnO), stearic acid and sulphur are also required as the basic ingredients of compounding unfilled rubber or filled rubber. In rubber standard compounds, (ZnO) and stearic acid have been used as activator and co-activator respectively. Cyclohexyl benzoazole-sulfenamide (CBS) and tetramethylthiuram disulphide (TMTD) are the accelerator and additives that had been selected in order to increase the properties of elastomers. Besides that, they were added as to help the vulcanization system.
2.2. Experimental design and methods

The batch of MRE compounds are named as CB00, CB20, CB40 and CB60. All quantities are expressed in parts per hundred parts of rubber (pphr). The compounding process of a batch mass of MRE was made by following BS ISO 2393 [2]. Fig. 1 illustrates the MRE compounds were obtained in sheets and conditioned at 23 ± 1°C for 24 hours before cure assessment.

The compounding process of MRE development was done using two roll mills and a conventional vulcanization system. The cure assessment of MRE composites was determined by Rheometer 100. The MRE final samples were vulcanized in square and round shape mouldings. For square mould, 60 g was

| Sample | Tensile strength (MPa) | Elongation at break E_b (%) | Modulus 100 (MPa) | Modulus 300 (MPa) |
|--------|------------------------|-----------------------------|-------------------|-------------------|
| CB00   | 22.97                  | 801.32                      | 0.99              | 2.01              |
| CB20   | 14.52                  | 737.46                      | 1.16              | 2.94              |
| CB40   | 23.10                  | 357.48                      | 1.50              | 4.36              |
| CB60   | 19.03                  | 816.20                      | 1.61              | 5.42              |

Table 1

Tensile test results.

Fig. 1. Green stock of MRE compound with different loadings of carbon black (a) 0, (b) 20, (c) 40, and (d) 60 pphr.

Fig. 2. Hot press machine.

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required, whereas 16 g for round mould as can be seen in Fig. 2. The temperature was set at 150 °C for each sample. The final samples of MRE after compression moulded are shown as in Fig. 3.

In order for the material to be used for civil engineering applications, the MRE compound should satisfy and achieve the following general performances and quality control requirements according to BS ISO 6446 [3].
Fig. 5. Set up the tensile instron machine.

Fig. 6. Insertion of test pieces.
Fig. 7. Effect of carbon black loading on tensile strength of MRE.

Fig. 8. Carbon black loading at 100% (M100) and 300% (M300) elongation.
2.2.1. Tensile test

Tensile properties of specimens were measured according ASTM D 412 [4]. The dumbbell test pieces were tested by using an Instron Universal Tensile Machine equipped with 500N load cell at a static load rate of 500 mm/min. The results are presented in Fig. 9 and Table 2.

Table 2

| Sample | Sample Number | Results (%) |
|--------|---------------|-------------|
|        |               | Reading 1  | Reading 2  | Reading 3 | Median  | Average |
| CB00   | CB00-1        | 73.41      | 74.91      | 74.53     | 74.53   | 74.62   |
|        | CB00-2        | 74.71      | 75.59      | 74.71     | 74.71   | 74.71   |
| CB20   | CB20-1        | 75.09      | 75.56      | 75.47     | 75.47   | 75.43   |
|        | CB20-2        | 75.56      | 74.53      | 75.39     | 75.39   | 75.39   |
| CB40   | CB40-1        | 71.30      | 72.44      | 75.59     | 72.44   | 73.20   |
|        | CB40-2        | 72.03      | 74.34      | 73.96     | 73.96   | 73.96   |
| CB60   | CB60-1        | 69.07      | 70.53      | 70.17     | 70.17   | 70.55   |
|        | CB60-2        | 69.52      | 70.93      | 71.57     | 71.57   | 70.93   |

Table 3

The thickness of hardness test pieces.

| Sample | Sample No. | Thickness (mm) |
|--------|------------|----------------|
|        |            | Reading 1  | Reading 2  | Reading 3 | Average |
| CB00   | CB00-1     | 6.97       | 6.98       | 6.99      | 6.98    |
|        | CB00-2     | 7.00       | 6.97       | 6.95      | 6.97    |
| CB20   | CB20-1     | 7.11       | 7.07       | 7.03      | 7.07    |
|        | CB20-2     | 7.00       | 7.00       | 7.00      | 7.00    |
| CB40   | CB40-1     | 7.02       | 7.06       | 7.10      | 7.06    |
|        | CB40-2     | 7.11       | 7.08       | 7.04      | 7.08    |
| CB60   | CB60-1     | 7.02       | 7.03       | 7.05      | 7.03    |
|        | CB60-2     | 7.07       | 7.04       | 7.00      | 7.04    |

Fig. 9. Effect of carbon black loading on elongation at break.
crosshead speed of 500 mm/min according to BS ISO 37 [5]. Fig. 4 shows the shape of dumbbell test pieces following the standard BS ISO 37 [5]. The Instron Tensile Machine as in Fig. 5 was set up. After that, the dumbbell test piece was manually attached at the clipper of tensile machine. Referring to Fig. 6, the ends of the dumbbell test pieces was ensured to be gripped symmetrically. Thus, the tension was uniformly distributed over the cross-section.

2.2.2. Rebound test

Fig. 10 shows a Dunlop Tripsometer, which is the apparatus that used for determination of rebound resilience in this present study. The 4 mm thick test pieces and test piece holder were ensured clean. Method B of BS 903-A8 [8] is the reference to this test.

### Table 4
Results of hardness.

| Sample | Sample No. | Results (IRHD) | Median | Average |
|--------|------------|----------------|--------|---------|
|        |            | Reading 1 | Reading 2 | Reading 3 |        |
| CB00   | CB00-1     | 42.5     | 43.0     | 42.5     | 42.5    | 42.3    |
| CB00   | CB00-2     | 41.0     | 43.0     | 42.0     | 42.0    |
| CB20   | CB20-1     | 50.0     | 49.5     | 49.0     | 49.5    | 49.5    |
| CB20   | CB20-2     | 49.0     | 49.5     | 50.0     | 49.5    |
| CB40   | CB40-1     | 55.5     | 55.5     | 55.5     | 55.5    | 55.5    |
| CB40   | CB40-2     | 56.0     | 54.5     | 55.5     | 55.5    |
| CB60   | CB60-1     | 69.0     | 66.5     | 65.0     | 66.5    | 68.0    |
| CB60   | CB60-2     | 70.0     | 69.0     | 69.0     | 69.5    |

![Dunlop Tripsometer at the laboratory.](image)
2.2.3. Hardness test

According to BS ISO 48 [6], hardness is measured from the depth of indention of a spherical indenter, under a specified force, into a rubber piece. This type of testing is very simple and easy to be conducted. In addition, it is a non-destructive test. An International Rubber Hardness Tester (IRHD) (Refer Fig. 12), was used to measure hardness test for MRE samples. The standard test pieces were prepared according to BS ISO 23529 [7]. The thickness is about adequately 8 mm—10 mm thick and the thinnest should not be less than 2 mm thick. All surfaces of the test pieces should be flat and parallel.

Fig. 11. Histogram on rebound resilience (%) at different carbon black loading.

Fig. 12. An automated dead load hardness tester.
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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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