Data Article

Load-displacement experimental data from axial tensile loading of CFRP-SPCC hybrid laminates

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ARTICLE INFO

Article history:
Received 9 December 2019
Received in revised form 10 January 2020
Accepted 10 February 2020
Available online 19 February 2020

Keywords:
Tensile loading
Hybrid laminate
CFRP
SPCC
Load-displacement

ABSTRACT

The current paper shows a data set of load-displacement output from axial tensile loading of CFRP-SPCC hybrid laminates. The specimen geometries are cut based on standard procedure from ASTM D-3039. At least 3 positions in each specimen, we measured its width and thickness. Data of the load and displacement were repeated at least 3 samples in each combination of hybrid laminates. Tensile test was conducted with a 1 mm/min of loading rate. The data were recorded from unloading until failure of specimens. The data gives information about the highest load and the behavior of load-displacement in axial tensile loading. By using width and thickness, normalized data can be obtained, the load can be calculated into stress (MPa) unit. The data are useful for researchers and structural engineers that deals with CFRP, SPCC, and hybrid CFRP-SPCC laminates.

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1. Data description

Comprehensive raw data of load-displacement values are available in the appendix. The data consist of specimens with several CFRPs and SPCCs can be seen in Table 1. Detailed dimension of all specimens can be seen in Table 2. Load-displacement of SPCC plate is shown in Fig. 1. Load-displacement of CFRP

| Table 1 |
|---|---|---|
| No. | Layups | Number of layers |
| 1 | SPCC | 0 |
| 2 | [0] | 4 |
| 3 | [0] | 2 |
| 4 | [90] | 4 |
| 5 | [±45]S | 4 |
| 6 | [SPCC/0]S | 2 |
| 7 | [SPCC/0/0]S | 4 |
| 8 | [0/0/SPCC/0/0] | 4 |
| 9 | [±45/0]S | 6 |
| 10 | [0/0/90/90] | S |
| 11 | [SPCC/±45/0]S | 6 |
| 12 | [SPCC/0/±45]S | 6 |

M.A. Muflihun, A.Y. Chua / Data in brief 29 (2020) 105306
Table 2
Dimension of all specimens.

| No. | Specimen   | Width (mm) | Mean Width (mm) | Thickness (mm) | Mean Thickness (mm) |
|-----|------------|------------|-----------------|----------------|---------------------|
| 1   | SPCC-01    | 13.95      | 13.967          | 0.804          | 0.8013              |
|     |            | 13.95      |                 | 0.802          |                     |
|     |            | 14         |                 | 0.798          |                     |
| 2   | SPCC-02    | 14.15      | 14.2000         | 0.8            | 0.7990              |
|     |            | 14.25      |                 | 0.798          |                     |
|     |            | 14.2        |                 | 0.799          |                     |
| 3   | SPCC-03    | 14.1       | 14.2167         | 0.802          | 0.8010              |
|     |            | 14.25      |                 | 0.801          |                     |
|     |            | 14.3        |                 | 0.8            |                     |
| 4   | SPCC-04    | 14.2       | 14.0333         | 0.805          | 0.8043              |
|     |            | 14          |                 | 0.804          |                     |
|     |            | 13.9        |                 | 0.804          |                     |
| 5   | SPCC-05    | 13.5       | 13.5333         | 0.802          | 0.8017              |
|     |            | 13.5       |                 | 0.802          |                     |
|     |            | 13.6        |                 | 0.801          |                     |
| 6   | SPCC-06    | 15.1       | 15.1000         | 0.801          | 0.8023              |
|     |            | 15.1       |                 | 0.805          |                     |
|     |            | 15.1        |                 | 0.801          |                     |
| 7   | [0]_{14}-01| 14.3       | 14.4500         | 0.667          | 0.6723              |
|     |            | 14.35      |                 | 0.679          |                     |
|     |            | 14.7        |                 | 0.671          |                     |
| 8   | [0]_{14}-02| 13.85      | 13.9667         | 0.648          | 0.6467              |
|     |            | 13.95      |                 | 0.65           |                     |
|     |            | 14.1        |                 | 0.642          |                     |
| 9   | [0]_{14}-03| 14.35      | 14.5000         | 0.664          | 0.6643              |
|     |            | 14.5       |                 | 0.673          |                     |
|     |            | 14.65       |                 | 0.656          |                     |
| 10  | [0]_{14}-04| 14.4       | 14.3500         | 0.66           | 0.6697              |
|     |            | 14.35      |                 | 0.698          |                     |
|     |            | 14.3        |                 | 0.651          |                     |
| 11  | [0]_{2}-01 | 14.9       | 15.0000         | 0.32           | 0.3447              |
|     |            | 15          |                 | 0.378          |                     |
|     |            | 15.1        |                 | 0.336          |                     |
| 12  | [0]_{2}-02 | 13.4       | 13.4167         | 0.354          | 0.3563              |
|     |            | 13.55      |                 | 0.345          |                     |
|     |            | 13.3        |                 | 0.37           |                     |
| 13  | [0]_{2}-03 | 14.55      | 14.8667         | 0.34           | 0.3537              |
|     |            | 14.9       |                 | 0.363          |                     |
|     |            | 15.15       |                 | 0.358          |                     |
| 14  | [90]_{14}-01| 15.25      | 15.2500         | 0.653          | 0.6623              |
|     |            | 15.4       |                 | 0.676          |                     |
|     |            | 15.1        |                 | 0.658          |                     |
| 15  | [90]_{14}-02| 15.55      | 15.6667         | 0.657          | 0.6583              |
|     |            | 15.7       |                 | 0.662          |                     |
| 16  | [90]_{14}-03| 15.05      | 15.1167         | 0.669          | 0.6670              |
|     |            | 15.1        |                 | 0.663          |                     |
|     |            | 15.2        |                 | 0.669          |                     |
| 17  | [±45]_{15}-01| 14.1       | 14.1833         | 0.695          | 0.6850              |
|     |            | 14.2       |                 | 0.687          |                     |
|     |            | 14.25       |                 | 0.673          |                     |
| 18  | [±45]_{15}-02| 15.5       | 15.4833         | 0.645          | 0.6320              |
|     |            | 15.5       |                 | 0.642          |                     |
|     |            | 15.45       |                 | 0.609          |                     |
| 19  | [±45]_{15}-03| 15.65      | 15.9333         | 0.615          | 0.6230              |
|     |            | 16.6       |                 | 0.625          |                     |
|     |            | 15.55       |                 | 0.629          |                     |
| 20  | [SPCC/0]_{15}-01| 15.2 | 15.0000         | 1.893          | 1.8933              |
|     |            | 15          |                 | 1.9            |                     |
|     |            | 14.8        |                 | 1.887          |                     |

(continued on next page)
### Table 2 (continued)

| No. | Specimen       | Width (mm) | Mean Width (mm) | Thickness (mm) | Mean Thickness (mm) |
|-----|----------------|------------|-----------------|----------------|---------------------|
| 21  | [SPCC/0] S-02  | 14.8       | 14.5500         | 1.92           | 1.9010              |
|     |                | 14.6       |                 | 1.899          |                     |
|     |                | 14.25      |                 | 1.884          |                     |
| 22  | [SPCC/0] S-03  | 14.55      | 14.6333         | 1.902          | 1.8850              |
|     |                | 14.65      |                 | 1.881          |                     |
|     |                | 14.7       |                 | 1.872          |                     |
| 23  | [SPCC/0/0] S-01| 15         | 14.8667         | 2.208          | 2.1810              |
|     |                | 14.9       |                 | 2.168          |                     |
|     |                | 14.7       |                 | 2.167          |                     |
| 24  | [SPCC/0/0] S-02| 15.05      | 14.8167         | 2.169          | 2.1823              |
|     |                | 14.85      |                 | 2.176          |                     |
|     |                | 14.55      |                 | 2.202          |                     |
| 25  | [SPCC/0/0] S-03| 15.5       | 15.2833         | 2.19           | 2.1973              |
|     |                | 15.35      |                 | 2.197          |                     |
|     |                | 15          |                 | 2.205          |                     |
| 26  | [0/0/SPCC/0/0] | 14.65      | 14.7500         | 1.442          | 1.4420              |
|     | S-01           |            |                 | 1.44           |                     |
|     |                | 14.75      |                 | 1.444          |                     |
|     |                | 14.85      |                 | 1.44           |                     |
| 27  | [0/0/SPCC/0/0] | 14.8       | 14.9667         | 1.444          | 1.4473              |
|     | S-02           |            |                 | 1.457          |                     |
|     |                | 14.95      |                 | 1.441          |                     |
|     |                | 15.15      |                 |                |                     |
| 28  | [0/0/SPCC/0/0] | 14.2       | 14.2500         | 1.443          | 1.4573              |
|     | S-03           |            |                 | 1.467          |                     |
|     |                | 14.2       |                 | 1.462          |                     |
|     |                | 14.35      |                 |                |                     |
| 29  | [±45/0] S-01   | 14         | 13.9167         | 0.957          | 0.9553              |
|     |                |            |                 | 0.967          |                     |
|     |                | 13.9       |                 | 0.942          |                     |
|     |                | 13.85      |                 |                |                     |
| 30  | [±45/0] S-02   | 14.2       | 14.1833         | 0.943          | 0.9540              |
|     |                |            |                 | 0.951          |                     |
|     |                | 14.1       |                 | 0.968          |                     |
|     |                | 14.25      |                 |                |                     |
| 31  | [±45/0] S-03   | 14         | 14.0000         | 0.957          | 0.9697              |
|     |                |            |                 | 0.969          |                     |
|     |                | 14         |                 | 0.983          |                     |
|     |                | 14         |                 |                |                     |
| 32  | [±45/0] S-04   | 12.35      | 12.2833         | 0.975          | 0.9810              |
|     |                | 12.3       |                 | 0.99           |                     |
|     |                | 12.2       |                 | 0.978          |                     |
| 33  | [0/0/90/90] S-01| 14.2      | 14.2500         | 1.302          | 1.2990              |
|     |                |            |                 | 1.303          |                     |
|     |                | 14.25      |                 | 1.292          |                     |
| 34  | [0/0/90/90] S-02| 14.3      | 14.3167         | 1.308          | 1.3127              |
|     |                |            |                 | 1.308          |                     |
|     |                | 14.35      |                 | 1.322          |                     |
|     |                | 14.3       |                 |                |                     |
| 35  | [0/0/90/90] S-03| 14.35     | 14.3500         | 1.306          | 1.3097              |
|     |                |            |                 | 1.315          |                     |
|     |                | 14.35      |                 | 1.308          |                     |
|     |                | 14.35      |                 |                |                     |
| 36  | [SPCC/±45/0] S-01| 15.55     | 15.4500         | 2.59           | 2.5750              |
|     |                | 15.4       |                 | 2.567          |                     |
|     |                | 15.4       |                 | 2.568          |                     |
| 37  | [SPCC/±45/0] S-02| 13.65     | 13.5667         | 2.566          | 2.5813              |
|     |                | 13.55      |                 | 2.597          |                     |
|     |                | 13.5       |                 | 2.581          |                     |
| 38  | [SPCC/±45/0] S-03| 14.5      | 14.5000         | 2.557          | 2.5647              |
|     |                | 14.5       |                 | 2.598          |                     |
|     |                | 14.5       |                 | 2.539          |                     |
| 39  | [SPCC/±45/0] S-04| 14.05     | 14.5667         | 2.51           | 2.5033              |
|     |                | 14.65      |                 | 2.501          |                     |
|     |                | 14.7       |                 | 2.499          |                     |
| 40  | [SPCC/0/±45] S-01| 14.7      | 14.6667         | 2.583          | 2.5937              |
|     |                | 14.55      |                 | 2.597          |                     |
|     |                | 14.75      |                 | 2.598          |                     |
| 41  | [SPCC/0/±45] S-02| 12.75     | 12.7833         | 2.589          | 2.5940              |
|     |                | 12.85      |                 | 2.593          |                     |
laminates with sequences of $[0]_4$ can be seen in Fig. 2. Furthermore, for $[0]_2$ CFRP laminate, load-displacement curves are illustrated in Fig. 3. The load-displacement performance of $[90]_4$ and $[\pm 45]_s$ CFRP laminates are displayed in Figs. 4 and 5, respectively.

For hybrid laminates that consist of SPCC and $0^\circ$-layer of CFRP laminate are presented in Figs. 6-8 with the sequences of [SPCC/0]_S, [SPCC/0/0]_S, and [0/0/SPCC/0/0]. Moreover, for combination of $0^\circ$-layer and non $0^\circ$-layer of CFRP, Fig. 9 with 4 specimens, shows load-displacement curves of $[\pm 45/0]_S$. Fig. 10 shows the load-displacement performance of $[0/0/90/90]_S$. For the last two different combinations, load-displacement curves can be seen in Figs. 11 and 12 with [SPCC/$\pm 45/0]_S$, and [SPCC/$0/\pm 45]_S$ hybrid CFRP-SPCC laminates.

2. Experimental design, materials, and methods

2.1. Specimen preparation and test

The steel used in the research is called Steel Plate Cold Commercial (SPCC), or equivalent to JIS G 3141 with 0.8 mm of thickness. SPCC commonly used in structures applications and automobile parts [1]. Prepreg CFRP T800 from Toray Industries Inc. were manufactured alongside with SPCC directly by using hand lay-up technique. Curing process were used hot press machine with 130 °C for 3 h in room temperature condition (25 °C) to ensure all resin completely cured. The specimen then cut based on ASTM D3039 by using cutting machine. Fig. 13 shows materials used in the study, hot press machine for curing process, and cutting machine to cut the specimens.

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Table 2 (continued)

| No. | Specimen | Width (mm) | Mean Width (mm) | Thickness (mm) | Mean Thickness (mm) |
|-----|----------|------------|-----------------|----------------|---------------------|
| 42  | [SPCC/0/$\pm 45]_S$-03 | 12.75 | 12.85 | 12.9 | 2.6 | 2.617 | 2.5940 | 2.615 |

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Fig. 1. Load-displacement of SPCC plates.
using hand lay-up technique. Curing process was done by using hot-press machine with 130 °C for 3 h to ensure all resin completely cured. After curing, cutting process, sample preparations and testing were done in the room temperature (25 °C). The specimens were then cut based on ASTM D3039 by using cutting machine. Fig. 13 show materials used in the study, hot press machine for curing process, and cutting machine to cut the specimens.

**Fig. 2.** Load-displacement of [0]₄ CFRP laminates.

**Fig. 3.** Load-displacement of [0]₂ CFRP laminates.
Before testing specimens, they were attached to 0.5 mm of aluminium tab with 40–50 mm length at both ends. The detailed specimen’s dimension can be seen in Fig. 14 where \( t \) is the specimen thickness (mm), \( w \) is specimen width (mm), \( c \) is tab length (45 mm), \( l \) is total specimen length (200 mm). Data of specimen thickness and width are shown in Table 2. At least 3 different positions were required to measure specimen thickness and width. The detailed measurement method is illustrated in Fig. 15.
Tensile test was conducted by using an Instron servo-hydraulic Universal Testing Machine (UTM) 8802. During tensile loading, load-displacement were recorded automatically until the failure of specimens. To investigate the condition of side surface of laminates during tensile loading, a Dino-Lite optical microscope was used. Detailed experimental setup is shown in Fig. 16.

![Fig. 6. Load-displacement of [SPCC/0] S CFRP-SPCC hybrid laminates.](image1)

![Fig. 7. Load-displacement of [SPCC/0/0] S CFRP-SPCC hybrid laminates.](image2)
2.2. Note from the experiment

- To increase the bonding strength between CFRP and SPCC, sandpaper P120 can be used to increase SPCC surface roughness.

Fig. 8. Load-displacement of [0/0/SPCC/0/0] CFRP-SPCC hybrid laminates.

Fig. 9. Load-displacement of [±45/0] CFRP laminates.
After sandpaper applied, ethanol was used with a clean tissue to remove all debris and SPCC tiny residual object from the SPCC surface. Make sure to clean all the surface and remove all the pollutants.

- Fig. 10. Load-displacement of [0/0/90/90] S CFRP laminates.

- Fig. 11. Load-displacement of [SPCC/±45/0] S CFRP-SPCC hybrid laminates.
Fig. 12. Load-displacement of [SPCC/0/±45]_S CFRP-SPCC hybrid laminates.

Fig. 13. (a) SPCC plate, (b) Prepreg CFRP, (c) Hot press machine, and (d) Cutting machine.

Fig. 14. Specimen dimension [2].
To avoid pollutant attached on the material surface and hands, lab gloves can be used.

Placed specimen in the hot press machine before the machine is started.

Use heat resistance gloves to remove the specimen from hot press machine.

Do not directly cut the sample while the sample is not properly cool and still in cooling process. At least wait 4 h to make sure the sample is properly cured and cool.

Carefully to use cutting machine. Make sure to use gloves and lab glasses to protect the eyes.

Keep distance during tensile loading is in progress since the delamination of CFRP may cause injury since it usually forms as sharp debris.

**Acknowledgments**

The authors would like to thank Prof. Takahira Aoki, and Prof. Tomohiro Yokozeki for the chance to conduct research in their lab and Ms. Kobayashi for helping and assist author during experimental
process. Authors also thank Siwat Manomaisantiphap for reviewing manuscript and AUN SEED NET JICA scholarship for the funding.

**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.

**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2020.105306.

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