

**PERBANDINGAN JUMLAH LAMINASI KOMPOSIT SERAT  
KARBON TERHADAP KEKUATAN TARIK DAN *IMPACT***

**PROYEK AKHIR**



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**PROGRAM STUDI DIPLOMA 3 TEKNIK PESAWAT UDARA  
POLITEKNIK PENERBANGAN SURABAYA  
2025**

**PERBANDINGAN JUMLAH LAMINASI KOMPOSIT SERAT KARBON  
EPOXY TERHADAP KEKUATAN TARIK DAN *IMPACT***

**PROYEK AKHIR**

Diajukan sebagai Salah Satu Syarat untuk Mendapatkan Gelar Ahli Madya  
(A.Md) pada Program Studi Diploma 3 Teknik Pesawat Udara



**PROGRAM STUDI DIPLOMA 3 TEKNIK PESAWAT UDARA  
POLITEKNIK PENERBANGAN SURABAYA  
2025**

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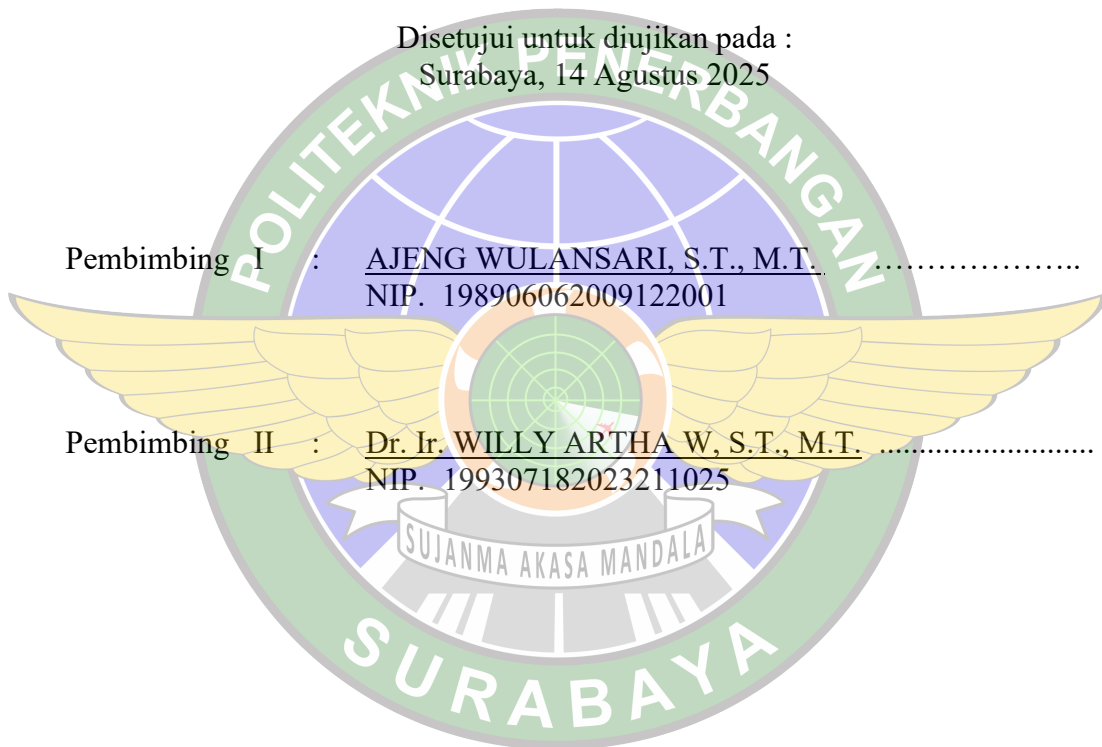
### PERBANDINGAN JUMLAH LAMINASI KOMPOSIT SERAT KARBON *EPOXY* TERHADAP KEKUATAN TARIK DAN *IMPACT*

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## ABSTRAK

### PERBANDINGAN JUMLAH LAMINASI KOMPOSIT SERAT KARBON *EPOXY* TERHADAP KEKUATAN TARIK DAN *IMPACT*

Oleh :  
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Tujuan penelitian ini adalah menganalisis jumlah laminasi dan orientasi serat karbon mempengaruhi kekuatan tarik dan ketangguhan benturan pada material komposit berbasis resin epoksi. Variasi yang digunakan meliputi jumlah lapisan 2, 4, 6, dan 8 dengan arah serat  $0^\circ/90^\circ$  serta  $45^\circ/45^\circ$ . Proses fabrikasi dilakukan menggunakan metode *vacuum bagging* untuk menghasilkan komposit yang homogen dan minim cacat. Pengujian sifat mekanis dilakukan berdasarkan standar ASTM D638-1 untuk pengujian tarik serta ASTM D6110 metode Charpy pada pengujian impak.

Pengujian tarik memberikan indikasi bahwa peningkatan jumlah lapisan berbanding lurus dengan kekuatan tarik yang dihasilkan. Orientasi serat  $0^\circ/90^\circ$  secara konsisten memberikan nilai kekuatan tarik lebih tinggi dibandingkan  $45^\circ/45^\circ$ , dengan nilai maksimum pada spesimen 8 lapis sebesar 13,241 N/mm<sup>2</sup>. Sebaliknya, hasil uji impak memperlihatkan bahwa orientasi  $45^\circ/45^\circ$  memiliki ketangguhan lebih baik, terutama pada jumlah lapisan 6, dengan nilai harga keuletan tertinggi mencapai 0,641 J/mm<sup>2</sup>. Perbedaan ini disebabkan oleh arah distribusi beban dan kemampuan serat dalam menahan retakan.

Kesimpulan dari penelitian ini adalah jumlah lapisan yang lebih banyak meningkatkan kekuatan mekanis komposit, namun pemilihan orientasi serat harus disesuaikan dengan kebutuhan aplikasi: orientasi  $0^\circ/90^\circ$  optimal untuk beban tarik, sedangkan  $45^\circ/45^\circ$  unggul dalam menahan beban kejut. Temuan ini diharapkan dapat dijadikan referensi oleh sektor kedirgantaraan maupun industri komposit saat menentukan konfigurasi laminasi yang tepat untuk mencapai kombinasi kekuatan dan ketangguhan sesuai kebutuhan operasional.

**Kata Kunci :** komposit, serat karbon, *vacuum bagging*, kekuatan tarik, *Impact Charpy*, laminasi.

## ABSTRACT

### PERBANDINGAN JUMLAH LAMINASI KOMPOSIT SERAT KARBON EPOXY TERHADAP KEKUATAN TARIK DAN *IMPACT*

Oleh :  
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*This study investigates the influence of laminate number and fiber orientation concerning the durability in tension and resistance of impact to epoxy resin-based carbon fiber composites. Laminates with 2, 4, 6, and 8 layers were produced through the vacuum bagging technique, employing two different fiber orientations ( $0^\circ/90^\circ$  and  $45^\circ/45^\circ$ ). Mechanical properties were evaluated according to ASTM D638-1 for tensile testing and ASTM D6110 Charpy method for impact testing.*

*Results indicate that the tensile strength increases proportionally with the number of layers, with the  $0^\circ/90^\circ$  orientation consistently outperforming the  $45^\circ/45^\circ$  configuration. The maximum tensile strength of  $13.241 \text{ N/mm}^2$  was obtained in the 8-layer  $0^\circ/90^\circ$  specimen. In contrast, the impact tests revealed that the  $45^\circ/45^\circ$  orientation exhibited superior toughness, particularly in the 6-layer configuration, achieving a maximum value of  $0.641 \text{ J/mm}^2$ . The observed differences are attributed to variations in load distribution and fiber resistance to crack propagation.*

*In conclusion, increasing the number of laminates enhances the overall mechanical performance of composites, while fiber orientation must be selected based on specific application requirements. The  $0^\circ/90^\circ$  orientation is more suitable for tensile load-bearing applications, whereas the  $45^\circ/45^\circ$  orientation is advantageous under impact loading. These findings provide valuable insights for the aerospace and composite manufacturing industries in optimizing laminate design to achieve a balance between strength and toughness.*

**Keywords :** Composite, Carbon Fiber, vacuum bagging, tensile strength, Impact Charpy, lamination.

## PERNYATAAN KEASLIAN HAK CIPTA

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|            |                                                     |
|------------|-----------------------------------------------------|
| Mpa        | : <i>Megapascal</i>                                 |
| $\sigma$   | : Tegangan (N/m <sup>2</sup> atau Pa)               |
| $\epsilon$ | : Regangan (%)                                      |
| $\Delta L$ | : Perubahan panjang (mm)                            |
| L0         | : Panjang awal spesimen (mm)                        |
| ASTM       | : <i>American Society for Testing and Materials</i> |
| g          | : Percepatan gravitasi (9,81 m/s <sup>2</sup> )     |
| $\theta_1$ | : Sudut awal sebelum tumbukan (° atau rad)          |
| $\theta_2$ | : Sudut akhir setelah tumbukan (° atau rad)         |
| °C         | : Derajat Celsius (suhu)                            |
| mm         | : <i>Milimeter</i>                                  |
| °          | : Derajat (sudut)                                   |



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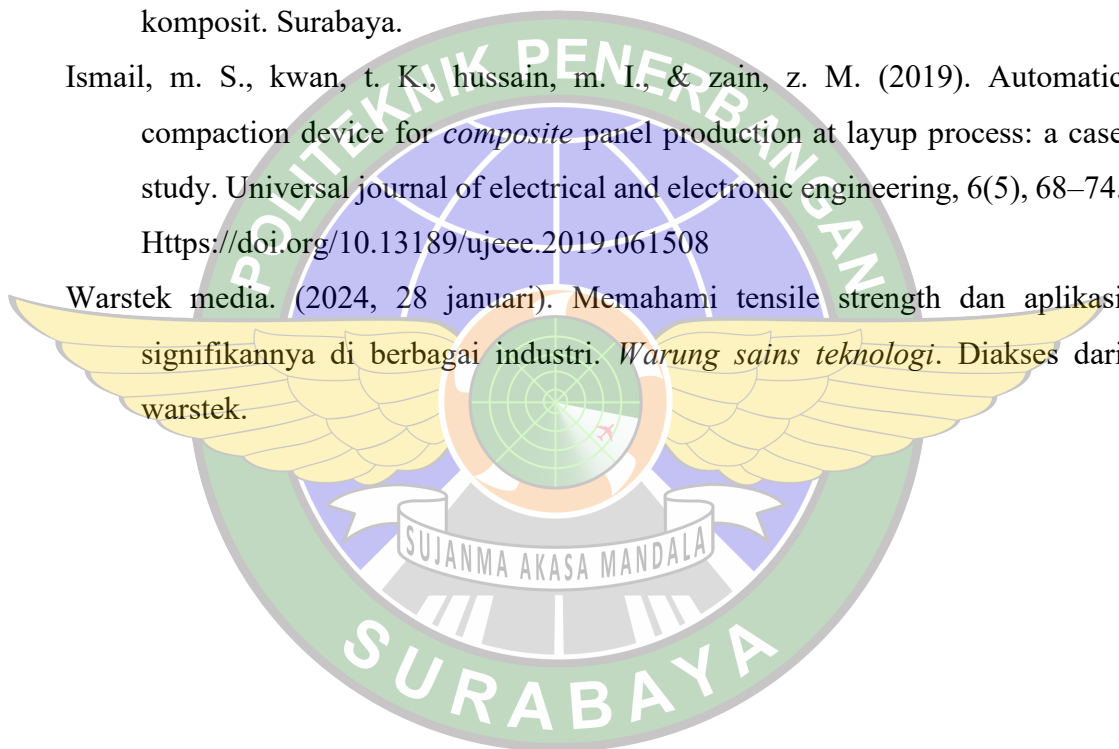
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**LAMPIRAN**  
Pembuatan Spesimen



### Proses Pengujian Spesimen



## Data Uji Tarik

## 1. Uji Tarik 2 layer

## a. hasil uji tarik dua layer arah serat 90/0 sample ke 1

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 51.012    | 15    | 63.5   | 0.27                     | 12.75                             | 4.000941       | 0.004252     |
| 2         | 121.644   | 15    | 63.5   | 0.45                     | 12.75                             | 9.540706       | 0.007087     |
| 3         | 168.732   | 15    | 63.5   | 0.66                     | 12.75                             | 13.23388       | 0.010394     |
| 4         | 198.162   | 15    | 63.5   | 0.98                     | 12.75                             | 15.54212       | 0.015433     |
| 5         | 380.628   | 15    | 63.5   | 1.12                     | 12.75                             | 29.85318       | 0.017638     |
| 6         | 561.132   | 15    | 63.5   | 1.34                     | 12.75                             | 44.01035       | 0.021102     |
| 7         | 661.194   | 15    | 63.5   | 1.49                     | 12.75                             | 51.85835       | 0.023465     |
| 8         | 796.572   | 15    | 63.5   | 1.78                     | 12.75                             | 62.47624       | 0.028031     |
| 9         | 933.912   | 15    | 63.5   | 2.02                     | 12.75                             | 73.248         | 0.031811     |
| 10        | 1081.062  | 15    | 63.5   | 2.23                     | 12.75                             | 84.78918       | 0.035118     |
| 11        | 1174.257  | 15    | 63.5   | 2.66                     | 12.75                             | 92.09859       | 0.04189      |
| 12        | 1269.414  | 15    | 63.5   | 3.03                     | 12.75                             | 99.56188       | 0.047717     |
| 13        | 2038.518  | 15    | 63.5   | 3.47                     | 12.75                             | 159.8838       | 0.054646     |
| 14        | 2263.167  | 15    | 63.5   | 3.88                     | 12.75                             | 177.5033       | 0.061102     |
| 15        | 2713.446  | 15    | 63.5   | 4.18                     | 12.75                             | 212.8193       | 0.065827     |
| 16        | 2964.582  | 15    | 63.5   | 4.32                     | 12.75                             | 232.5162       | 0.068031     |
| 17        | 3159.801  | 15    | 63.5   | 4.62                     | 12.75                             | 247.8275       | 0.072756     |
| 18        | 880.938   | 15    | 63.5   | 5.16                     | 12.75                             | 69.09318       | 0.08126      |
| 19        | 855.432   | 15    | 63.5   | 6.49                     | 12.75                             | 67.09271       | 0.102205     |
| 20        | 851.508   | 15    | 63.5   | 6.93                     | 12.75                             | 66.78494       | 0.109134     |

## b. hasil uji tarik dua layer arah serat 90/0 sample ke 2

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 51.012    | 15    | 63.5   | 0.17                     | 13.5                              | 3.778667       | 0.002677     |
| 2         | 92.214    | 15    | 63.5   | 0.97                     | 13.5                              | 6.830667       | 0.015276     |
| 3         | 133.416   | 15    | 63.5   | 1.24                     | 13.5                              | 9.882667       | 0.019528     |
| 4         | 241.326   | 15    | 63.5   | 1.86                     | 13.5                              | 17.876         | 0.029291     |
| 5         | 406.134   | 15    | 63.5   | 2.1                      | 13.5                              | 30.084         | 0.033071     |
| 6         | 671.004   | 15    | 63.5   | 2.75                     | 13.5                              | 49.704         | 0.043307     |
| 7         | 757.332   | 15    | 63.5   | 3.02                     | 13.5                              | 56.09867       | 0.047559     |
| 8         | 935.874   | 15    | 63.5   | 3.28                     | 13.5                              | 69.324         | 0.051654     |
| 9         | 1114.416  | 15    | 63.5   | 3.6                      | 13.5                              | 82.54933       | 0.056693     |
| 10        | 1297.863  | 15    | 63.5   | 4.08                     | 13.5                              | 96.138         | 0.064252     |
| 11        | 1679.472  | 15    | 63.5   | 4.43                     | 13.5                              | 124.4053       | 0.069764     |

|    |          |    |      |      |      |          |          |
|----|----------|----|------|------|------|----------|----------|
| 12 | 2009.088 | 15 | 63.5 | 4.71 | 13.5 | 148.8213 | 0.074173 |
| 13 | 2323.008 | 15 | 63.5 | 5.11 | 13.5 | 172.0747 | 0.080472 |
| 14 | 2827.242 | 15 | 63.5 | 5.51 | 13.5 | 209.4253 | 0.086772 |
| 15 | 3054.834 | 15 | 63.5 | 5.82 | 13.5 | 226.284  | 0.091654 |
| 16 | 3356.982 | 15 | 63.5 | 6.02 | 13.5 | 248.6653 | 0.094803 |
| 17 | 3473.721 | 15 | 63.5 | 6.47 | 13.5 | 257.3127 | 0.10189  |
| 18 | 629.802  | 15 | 63.5 | 7.73 | 13.5 | 46.652   | 0.121732 |
| 19 | 612.144  | 15 | 63.5 | 8.08 | 13.5 | 45.344   | 0.127244 |
| 20 | 606.258  | 15 | 63.5 | 8.35 | 13.5 | 44.908   | 0.131496 |

c. hasil uji tarik dua layer arah serat 45/45 sample ke 1

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 51.012    | 15    | 63.5   | 1.15                     | 12                                | 4.251          | 0.01811      |
| 2         | 121.644   | 15    | 63.5   | 2.55                     | 12                                | 10.137         | 0.04016      |
| 3         | 168.732   | 15    | 63.5   | 3.12                     | 12                                | 14.061         | 0.04913      |
| 4         | 198.162   | 15    | 63.5   | 5.12                     | 12                                | 16.5135        | 0.08063      |
| 5         | 380.628   | 15    | 63.5   | 5.96                     | 12                                | 31.719         | 0.09386      |
| 6         | 561.132   | 15    | 63.5   | 6.62                     | 12                                | 46.761         | 0.10425      |
| 7         | 952.551   | 15    | 63.5   | 7.11                     | 12                                | 79.3793        | 0.11197      |
| 8         | 1272.36   | 15    | 63.5   | 8.2                      | 12                                | 106.03         | 0.12913      |
| 9         | 2037.54   | 15    | 63.5   | 9.1                      | 12                                | 169.795        | 0.14331      |
| 10        | 2650.66   | 15    | 63.5   | 9.64                     | 12                                | 220.889        | 0.15181      |
| 11        | 2602.59   | 15    | 63.5   | 10.52                    | 12                                | 216.883        | 0.16567      |
| 12        | 2555.51   | 15    | 63.5   | 12.22                    | 12                                | 212.959        | 0.19244      |
| 13        | 2492.72   | 15    | 63.5   | 13.52                    | 12                                | 207.727        | 0.21291      |
| 14        | 2399.53   | 15    | 63.5   | 14.11                    | 12                                | 199.961        | 0.2222       |
| 15        | 2336.74   | 15    | 63.5   | 14.65                    | 12                                | 194.729        | 0.23071      |
| 16        | 2263.17   | 15    | 63.5   | 15.21                    | 12                                | 188.597        | 0.23953      |
| 17        | 2161.14   | 15    | 63.5   | 15.6                     | 12                                | 180.095        | 0.24567      |
| 18        | 1970.83   | 15    | 63.5   | 16.01                    | 12                                | 164.236        | 0.25213      |
| 19        | 973.152   | 15    | 63.5   | 18.1                     | 12                                | 81.096         | 0.28504      |
| 20        | 206.991   | 15    | 63.5   | 20.31                    | 12                                | 17.2493        | 0.31984      |

d. hasil uji tarik dua layer arah serat 45/45 sample ke 2

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 51.012    | 15    | 63.5   | 1.21                     | 12.75                             | 4.000941       | 0.019055     |
| 2         | 121.644   | 15    | 63.5   | 2.55                     | 12.75                             | 9.540706       | 0.040157     |
| 3         | 158.922   | 15    | 63.5   | 3.42                     | 12.75                             | 12.46447       | 0.053858     |
| 4         | 192.276   | 15    | 63.5   | 5.71                     | 12.75                             | 15.08047       | 0.089921     |
| 5         | 351.198   | 15    | 63.5   | 5.96                     | 12.75                             | 27.54494       | 0.093858     |
| 6         | 793.629   | 15    | 63.5   | 6.34                     | 12.75                             | 62.24541       | 0.099843     |
| 7         | 1182.105  | 15    | 63.5   | 7.21                     | 12.75                             | 92.71412       | 0.113543     |
| 8         | 1937.475  | 15    | 63.5   | 8.53                     | 12.75                             | 151.9588       | 0.134331     |
| 9         | 2355.381  | 15    | 63.5   | 9.41                     | 12.75                             | 184.7358       | 0.148189     |
| 10        | 2768.382  | 15    | 63.5   | 10.1                     | 12.75                             | 217.128        | 0.159055     |
| 11        | 2696.769  | 15    | 63.5   | 10.6                     | 12.75                             | 211.5113       | 0.166929     |
| 12        | 2631.042  | 15    | 63.5   | 11.31                    | 12.75                             | 206.3562       | 0.17811      |
| 13        | 2461.329  | 15    | 63.5   | 12.61                    | 12.75                             | 193.0454       | 0.198583     |
| 14        | 2441.709  | 15    | 63.5   | 13.1                     | 12.75                             | 191.5066       | 0.206299     |
| 15        | 2385.792  | 15    | 63.5   | 14.11                    | 12.75                             | 187.1209       | 0.222205     |
| 16        | 2359.305  | 15    | 63.5   | 15.1                     | 12.75                             | 185.0435       | 0.237795     |
| 17        | 2284.749  | 15    | 63.5   | 15.65                    | 12.75                             | 179.196        | 0.246457     |
| 18        | 1081.062  | 15    | 63.5   | 16.23                    | 12.75                             | 84.78918       | 0.255591     |
| 19        | 883.881   | 15    | 63.5   | 18.6                     | 12.75                             | 69.324         | 0.292913     |
| 20        | 398.286   | 15    | 63.5   | 20.65                    | 12.75                             | 31.23812       | 0.325197     |

2. Uji Tarik 4 layer

a. hasil uji tarik empat layer arah serat 90/0 sample ke 1

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 51.012    | 15    | 63.5   | 0.27                     | 18.75                             | 2.72064        | 0.00425      |
| 2         | 121.644   | 15    | 63.5   | 0.54                     | 18.75                             | 6.48768        | 0.0085       |
| 3         | 168.732   | 15    | 63.5   | 1.32                     | 18.75                             | 8.99904        | 0.02079      |
| 4         | 198.162   | 15    | 63.5   | 1.99                     | 18.75                             | 10.5686        | 0.03134      |
| 5         | 380.628   | 15    | 63.5   | 2.23                     | 18.75                             | 20.3002        | 0.03512      |
| 6         | 561.132   | 15    | 63.5   | 2.64                     | 18.75                             | 29.927         | 0.04157      |
| 7         | 949.608   | 15    | 63.5   | 2.89                     | 18.75                             | 50.6458        | 0.04551      |
| 8         | 1331.22   | 15    | 63.5   | 3.04                     | 18.75                             | 70.9982        | 0.04787      |
| 9         | 1593.14   | 15    | 63.5   | 3.76                     | 18.75                             | 84.9677        | 0.05921      |

|    |         |    |      |       |       |         |         |
|----|---------|----|------|-------|-------|---------|---------|
| 10 | 1949.25 | 15 | 63.5 | 4.21  | 18.75 | 103.96  | 0.0663  |
| 11 | 2263.17 | 15 | 63.5 | 4.97  | 18.75 | 120.702 | 0.07827 |
| 12 | 2736.01 | 15 | 63.5 | 5.7   | 18.75 | 145.92  | 0.08976 |
| 13 | 2898.86 | 15 | 63.5 | 6.21  | 18.75 | 154.606 | 0.0978  |
| 14 | 3152.93 | 15 | 63.5 | 6.72  | 18.75 | 168.156 | 0.10583 |
| 15 | 3381.51 | 15 | 63.5 | 7.01  | 18.75 | 180.347 | 0.11039 |
| 16 | 3680.71 | 15 | 63.5 | 7.41  | 18.75 | 196.305 | 0.11669 |
| 17 | 4012.29 | 15 | 63.5 | 7.82  | 18.75 | 213.989 | 0.12315 |
| 18 | 816.192 | 15 | 63.5 | 9.21  | 18.75 | 43.5302 | 0.14504 |
| 19 | 790.686 | 15 | 63.5 | 10.04 | 18.75 | 42.1699 | 0.15811 |
| 20 | 780.876 | 15 | 63.5 | 10.63 | 18.75 | 41.6467 | 0.1674  |

b. hasil uji Tarik empat layer arah serat 90/0 sample ke 2

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 51.012    | 15    | 63.5   | 0.17                     | 18                                | 2.834          | 0.00268      |
| 2         | 92.214    | 15    | 63.5   | 0.97                     | 18                                | 5.123          | 0.01528      |
| 3         | 133.416   | 15    | 63.5   | 1.24                     | 18                                | 7.412          | 0.01953      |
| 4         | 241.326   | 15    | 63.5   | 1.86                     | 18                                | 13.407         | 0.02929      |
| 5         | 406.134   | 15    | 63.5   | 2.1                      | 18                                | 22.563         | 0.03307      |
| 6         | 671.004   | 15    | 63.5   | 2.75                     | 18                                | 37.278         | 0.04331      |
| 7         | 925.083   | 15    | 63.5   | 3.02                     | 18                                | 51.3935        | 0.04756      |
| 8         | 1418.53   | 15    | 63.5   | 3.28                     | 18                                | 78.807         | 0.05165      |
| 9         | 1583.33   | 15    | 63.5   | 3.6                      | 18                                | 87.963         | 0.05669      |
| 10        | 1959.06   | 15    | 63.5   | 4.08                     | 18                                | 108.837        | 0.06425      |
| 11        | 2476.04   | 15    | 63.5   | 4.43                     | 18                                | 137.558        | 0.06976      |
| 12        | 2995.97   | 15    | 63.5   | 4.71                     | 18                                | 166.443        | 0.07417      |
| 13        | 3208.85   | 15    | 63.5   | 5.11                     | 18                                | 178.27         | 0.08047      |
| 14        | 3359.93   | 15    | 63.5   | 5.51                     | 18                                | 186.663        | 0.08677      |
| 15        | 3553.18   | 15    | 63.5   | 5.82                     | 18                                | 197.399        | 0.09165      |
| 16        | 3777.83   | 15    | 63.5   | 6.02                     | 18                                | 209.88         | 0.0948       |
| 17        | 3933.81   | 15    | 63.5   | 7.68                     | 18                                | 218.545        | 0.12094      |
| 18        | 893.691   | 15    | 63.5   | 7.81                     | 18                                | 49.6495        | 0.12299      |
| 19        | 869.166   | 15    | 63.5   | 8.11                     | 18                                | 48.287         | 0.12772      |
| 20        | 845.622   | 15    | 63.5   | 8.42                     | 18                                | 46.979         | 0.1326       |

c. hasil uji tarik empat layer arah serat 45/45 sample ke 1

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|

|    |         |    |      |       |    |         |         |
|----|---------|----|------|-------|----|---------|---------|
| 1  | 51.012  | 15 | 63.5 | 0.5   | 18 | 2.834   | 0.00787 |
| 2  | 131.454 | 15 | 63.5 | 2.55  | 18 | 7.303   | 0.04016 |
| 3  | 317.844 | 15 | 63.5 | 5.1   | 18 | 17.658  | 0.08031 |
| 4  | 545.436 | 15 | 63.5 | 9.34  | 18 | 30.302  | 0.14709 |
| 5  | 957.456 | 15 | 63.5 | 12.65 | 18 | 53.192  | 0.19921 |
| 6  | 1279.22 | 15 | 63.5 | 15.15 | 18 | 71.068  | 0.23858 |
| 7  | 1715.77 | 15 | 63.5 | 17.52 | 18 | 95.3205 | 0.27591 |
| 8  | 2044.4  | 15 | 63.5 | 18.22 | 18 | 113.578 | 0.28693 |
| 9  | 2816.45 | 15 | 63.5 | 19.52 | 18 | 156.47  | 0.3074  |
| 10 | 3080.34 | 15 | 63.5 | 20.88 | 18 | 171.13  | 0.32882 |
| 11 | 3023.44 | 15 | 63.5 | 22.09 | 18 | 167.969 | 0.34787 |
| 12 | 2953.79 | 15 | 63.5 | 23.02 | 18 | 164.1   | 0.36252 |
| 13 | 2909.65 | 15 | 63.5 | 24.26 | 18 | 161.647 | 0.38205 |
| 14 | 2845.88 | 15 | 63.5 | 25.68 | 18 | 158.105 | 0.40441 |
| 15 | 2770.34 | 15 | 63.5 | 26.57 | 18 | 153.908 | 0.41843 |
| 16 | 2736.01 | 15 | 63.5 | 27.1  | 18 | 152.001 | 0.42677 |
| 17 | 1767.76 | 15 | 63.5 | 28.79 | 18 | 98.209  | 0.45339 |
| 18 | 806.382 | 15 | 63.5 | 30.1  | 18 | 44.799  | 0.47402 |
| 19 | 789.705 | 15 | 63.5 | 32.21 | 18 | 43.8725 | 0.50724 |
| 20 | 775.971 | 15 | 63.5 | 32.82 | 18 | 43.1095 | 0.51685 |

d. hasil uji tarik empat layer arah serat 45/45 sample ke 2

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 51.012    | 15    | 63.5   | 0.5                      | 18.75                             | 2.72064        | 0.00787      |
| 2         | 129.492   | 15    | 63.5   | 2.87                     | 18.75                             | 6.90624        | 0.0452       |
| 3         | 286.452   | 15    | 63.5   | 5.88                     | 18.75                             | 15.2774        | 0.0926       |
| 4         | 458.127   | 15    | 63.5   | 9.42                     | 18.75                             | 24.4334        | 0.14835      |
| 5         | 796.572   | 15    | 63.5   | 12.89                    | 18.75                             | 42.4838        | 0.20299      |
| 6         | 1231.16   | 15    | 63.5   | 15.44                    | 18.75                             | 65.6616        | 0.24315      |
| 7         | 1666.72   | 15    | 63.5   | 17.87                    | 18.75                             | 88.8917        | 0.28142      |
| 8         | 2018.9    | 15    | 63.5   | 19.28                    | 18.75                             | 107.675        | 0.30362      |
| 9         | 2673.23   | 15    | 63.5   | 21.72                    | 18.75                             | 142.572        | 0.34205      |
| 10        | 3090.15   | 15    | 63.5   | 23.11                    | 18.75                             | 164.808        | 0.36394      |
| 11        | 3033.25   | 15    | 63.5   | 24.2                     | 18.75                             | 161.773        | 0.3811       |
| 12        | 2966.54   | 15    | 63.5   | 24.68                    | 18.75                             | 158.216        | 0.38866      |
| 13        | 2925.34   | 15    | 63.5   | 25.57                    | 18.75                             | 156.018        | 0.40268      |
| 14        | 2849.81   | 15    | 63.5   | 26.1                     | 18.75                             | 151.99         | 0.41102      |
| 15        | 2765.44   | 15    | 63.5   | 27.79                    | 18.75                             | 147.49         | 0.43764      |
| 16        | 2719.33   | 15    | 63.5   | 28.1                     | 18.75                             | 145.031        | 0.44252      |
| 17        | 1820.74   | 15    | 63.5   | 30.32                    | 18.75                             | 97.1059        | 0.47748      |
| 18        | 803.439   | 15    | 63.5   | 32.82                    | 18.75                             | 42.8501        | 0.51685      |

|    |         |    |      |       |       |         |         |
|----|---------|----|------|-------|-------|---------|---------|
| 19 | 795.591 | 15 | 63.5 | 34.2  | 18.75 | 42.4315 | 0.53858 |
| 20 | 760.275 | 15 | 63.5 | 36.11 | 18.75 | 40.548  | 0.56866 |

### 3. Uji Tarik 6 layer

#### a. hasil uji tarik enam layer arah serat 90/0 sample ke 1

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 174.618   | 15    | 63.5   | 0.37                     | 29.25                             | 5.969846       | 0.005827     |
| 2         | 345.312   | 15    | 63.5   | 0.77                     | 29.25                             | 11.80554       | 0.012126     |
| 3         | 631.764   | 15    | 63.5   | 1.21                     | 29.25                             | 21.59877       | 0.019055     |
| 4         | 742.617   | 15    | 63.5   | 1.78                     | 29.25                             | 25.38862       | 0.028031     |
| 5         | 981.981   | 15    | 63.5   | 2.33                     | 29.25                             | 33.572         | 0.036693     |
| 6         | 1436.184  | 15    | 63.5   | 2.87                     | 29.25                             | 49.10031       | 0.045197     |
| 7         | 1966.905  | 15    | 63.5   | 3.31                     | 29.25                             | 67.24462       | 0.052126     |
| 8         | 2429.937  | 15    | 63.5   | 3.91                     | 29.25                             | 83.07477       | 0.061575     |
| 9         | 3042.081  | 15    | 63.5   | 4.78                     | 29.25                             | 104.0028       | 0.075276     |
| 10        | 3441.348  | 15    | 63.5   | 5.01                     | 29.25                             | 117.6529       | 0.078898     |
| 11        | 3879.855  | 15    | 63.5   | 5.77                     | 29.25                             | 132.6446       | 0.090866     |
| 12        | 4391.937  | 15    | 63.5   | 6.12                     | 29.25                             | 150.1517       | 0.096378     |
| 13        | 4694.085  | 15    | 63.5   | 6.91                     | 29.25                             | 160.4815       | 0.108819     |
| 14        | 5208.129  | 15    | 63.5   | 7.47                     | 29.25                             | 178.0557       | 0.117638     |
| 15        | 5841.855  | 15    | 63.5   | 8.52                     | 29.25                             | 199.7215       | 0.134173     |
| 16        | 6426.531  | 15    | 63.5   | 9.92                     | 29.25                             | 219.7105       | 0.15622      |
| 17        | 6739.47   | 15    | 63.5   | 10.48                    | 29.25                             | 230.4092       | 0.165039     |
| 18        | 880.938   | 15    | 63.5   | 12.75                    | 29.25                             | 30.11754       | 0.200787     |
| 19        | 855.432   | 15    | 63.5   | 13.43                    | 29.25                             | 29.24554       | 0.211496     |
| 20        | 851.508   | 15    | 63.5   | 14.44                    | 29.25                             | 29.11138       | 0.227402     |

#### b. hasil uji tarik enam layer arah serat 90/0 sample ke 2

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 174.618   | 15    | 63.5   | 0.37                     | 30.75                             | 5.678634       | 0.005827     |
| 2         | 374.742   | 15    | 63.5   | 0.77                     | 30.75                             | 12.18673       | 0.012126     |
| 3         | 653.346   | 15    | 63.5   | 1.21                     | 30.75                             | 21.24702       | 0.019055     |
| 4         | 776.952   | 15    | 63.5   | 1.78                     | 30.75                             | 25.26673       | 0.028031     |
| 5         | 1001.601  | 15    | 63.5   | 2.33                     | 30.75                             | 32.57239       | 0.036693     |
| 6         | 1468.557  | 15    | 63.5   | 2.87                     | 30.75                             | 47.75795       | 0.045197     |
| 7         | 2003.202  | 15    | 63.5   | 3.31                     | 30.75                             | 65.14478       | 0.052126     |
| 8         | 2451.519  | 15    | 63.5   | 3.91                     | 30.75                             | 79.7242        | 0.061575     |
| 9         | 3067.587  | 15    | 63.5   | 4.78                     | 30.75                             | 99.75893       | 0.075276     |
| 10        | 3455.082  | 15    | 63.5   | 5.01                     | 30.75                             | 112.3604       | 0.078898     |

|    |          |    |      |       |       |          |          |
|----|----------|----|------|-------|-------|----------|----------|
| 11 | 3924.981 | 15 | 63.5 | 5.77  | 30.75 | 127.6417 | 0.090866 |
| 12 | 4406.652 | 15 | 63.5 | 6.12  | 30.75 | 143.3058 | 0.096378 |
| 13 | 4716.648 | 15 | 63.5 | 6.91  | 30.75 | 153.3869 | 0.108819 |
| 14 | 5220.882 | 15 | 63.5 | 7.47  | 30.75 | 169.7848 | 0.117638 |
| 15 | 5894.829 | 15 | 63.5 | 8.52  | 30.75 | 191.7018 | 0.134173 |
| 16 | 6466.752 | 15 | 63.5 | 9.92  | 30.75 | 210.3009 | 0.15622  |
| 17 | 6994.53  | 15 | 63.5 | 12.2  | 30.75 | 227.4644 | 0.192126 |
| 18 | 806.382  | 15 | 63.5 | 14.73 | 30.75 | 26.2238  | 0.231969 |
| 19 | 800.496  | 15 | 63.5 | 15.55 | 30.75 | 26.03239 | 0.244882 |
| 20 | 792.648  | 15 | 63.5 | 16.21 | 30.75 | 25.77717 | 0.255276 |

c. hasil uji tarik enam layer arah serat 45/45 sample ke 1

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 125.568   | 15    | 63.5   | 0.27                     | 29.25                             | 4.292923       | 0.004252     |
| 2         | 201.105   | 15    | 63.5   | 1.11                     | 29.25                             | 6.875385       | 0.01748      |
| 3         | 426.9312  | 15    | 63.5   | 1.92                     | 29.25                             | 14.59594       | 0.030236     |
| 4         | 674.928   | 15    | 63.5   | 3.41                     | 29.25                             | 23.07446       | 0.053701     |
| 5         | 1012.392  | 15    | 63.5   | 5.21                     | 29.25                             | 34.61169       | 0.082047     |
| 6         | 1281.186  | 15    | 63.5   | 7.92                     | 29.25                             | 43.80123       | 0.124724     |
| 7         | 1625.517  | 15    | 63.5   | 9.81                     | 29.25                             | 55.57323       | 0.154488     |
| 8         | 1963.962  | 15    | 63.5   | 11.71                    | 29.25                             | 67.144         | 0.184409     |
| 9         | 2356.362  | 15    | 63.5   | 13.43                    | 29.25                             | 80.55938       | 0.211496     |
| 10        | 2751.705  | 15    | 63.5   | 17.45                    | 29.25                             | 94.07538       | 0.274803     |
| 11        | 2956.734  | 15    | 63.5   | 19.64                    | 29.25                             | 101.0849       | 0.309291     |
| 12        | 3533.562  | 15    | 63.5   | 21.22                    | 29.25                             | 120.8055       | 0.334173     |
| 13        | 3727.8    | 15    | 63.5   | 36.79                    | 29.25                             | 127.4462       | 0.57937      |
| 14        | 3630.681  | 15    | 63.5   | 37.63                    | 29.25                             | 124.1258       | 0.592598     |
| 15        | 3535.524  | 15    | 63.5   | 38.34                    | 29.25                             | 120.8726       | 0.60378      |
| 16        | 3445.272  | 15    | 63.5   | 39.92                    | 29.25                             | 117.7871       | 0.628661     |
| 17        | 3344.229  | 15    | 63.5   | 40.11                    | 29.25                             | 114.3326       | 0.631654     |
| 18        | 883.881   | 15    | 63.5   | 42.32                    | 29.25                             | 30.21815       | 0.666457     |
| 19        | 880.938   | 15    | 63.5   | 43.52                    | 29.25                             | 30.11754       | 0.685354     |
| 20        | 869.166   | 15    | 63.5   | 44.71                    | 29.25                             | 29.71508       | 0.704094     |

d. hasil uji tarik enam layer arah serat 45/45 sample ke 2

| Waktu (s) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 125.568   | 15    | 63.5   | 0.27                     | 30.75                             | 4.083512       | 0.004252     |
| 2         | 210.915   | 15    | 63.5   | 1.24                     | 30.75                             | 6.859024       | 0.019528     |
| 3         | 433.602   | 15    | 63.5   | 2.1                      | 30.75                             | 14.10088       | 0.033071     |
| 4         | 689.643   | 15    | 63.5   | 4.44                     | 30.75                             | 22.42741       | 0.069921     |

|    |          |    |      |       |       |          |          |
|----|----------|----|------|-------|-------|----------|----------|
| 5  | 1033.974 | 15 | 63.5 | 6.35  | 30.75 | 33.62517 | 0.1      |
| 6  | 1296.882 | 15 | 63.5 | 8.9   | 30.75 | 42.17502 | 0.140157 |
| 7  | 1652.985 | 15 | 63.5 | 10.88 | 30.75 | 53.75561 | 0.171339 |
| 8  | 2007.126 | 15 | 63.5 | 12.62 | 30.75 | 65.27239 | 0.19874  |
| 9  | 2379.906 | 15 | 63.5 | 14.71 | 30.75 | 77.39532 | 0.231654 |
| 10 | 2797.812 | 15 | 63.5 | 18.55 | 30.75 | 90.98576 | 0.292126 |
| 11 | 3046.005 | 15 | 63.5 | 20.82 | 30.75 | 99.05707 | 0.327874 |
| 12 | 3454.101 | 15 | 63.5 | 22.62 | 30.75 | 112.3285 | 0.35622  |
| 13 | 3767.04  | 15 | 63.5 | 37.92 | 30.75 | 122.5054 | 0.597165 |
| 14 | 3729.762 | 15 | 63.5 | 38.82 | 30.75 | 121.2931 | 0.611339 |
| 15 | 3684.636 | 15 | 63.5 | 39.51 | 30.75 | 119.8256 | 0.622205 |
| 16 | 3635.586 | 15 | 63.5 | 40.41 | 30.75 | 118.2304 | 0.636378 |
| 17 | 3617.928 | 15 | 63.5 | 41.11 | 30.75 | 117.6562 | 0.647402 |
| 18 | 869.166  | 15 | 63.5 | 43.32 | 30.75 | 28.26556 | 0.682205 |
| 19 | 859.356  | 15 | 63.5 | 44.52 | 30.75 | 27.94654 | 0.701102 |
| 20 | 848.565  | 15 | 63.5 | 45.73 | 30.75 | 27.59561 | 0.720157 |

4. Uji Tarik 8 layer

a. hasil uji tarik delapan layer arah serat 90/0 sample ke 1

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 185.409   | 15    | 63.5   | 0.65                     | 36.75                             | 5.045143       | 0.010236     |
| 2         | 743.598   | 15    | 63.5   | 1.64                     | 36.75                             | 20.23396       | 0.025827     |
| 3         | 1262.547  | 15    | 63.5   | 2.11                     | 36.75                             | 34.35502       | 0.033228     |
| 4         | 2006.145  | 15    | 63.5   | 2.75                     | 36.75                             | 54.58898       | 0.043307     |
| 5         | 2631.042  | 15    | 63.5   | 3.88                     | 36.75                             | 71.59298       | 0.061102     |
| 6         | 3618.909  | 15    | 63.5   | 4.85                     | 36.75                             | 98.47371       | 0.076378     |
| 7         | 4319.343  | 15    | 63.5   | 5.32                     | 36.75                             | 117.5331       | 0.08378      |
| 8         | 4511.619  | 15    | 63.5   | 6.79                     | 36.75                             | 122.7651       | 0.106929     |
| 9         | 4924.62   | 15    | 63.5   | 7.88                     | 36.75                             | 134.0033       | 0.124094     |
| 10        | 6183.243  | 15    | 63.5   | 8.31                     | 36.75                             | 168.2515       | 0.130866     |
| 11        | 7021.998  | 15    | 63.5   | 10.97                    | 36.75                             | 191.0748       | 0.172756     |
| 12        | 7676.325  | 15    | 63.5   | 12.54                    | 36.75                             | 208.8796       | 0.19748      |
| 13        | 8183.502  | 15    | 63.5   | 14.34                    | 36.75                             | 222.6803       | 0.225827     |
| 14        | 8896.689  | 15    | 63.5   | 15.53                    | 36.75                             | 242.0868       | 0.244567     |
| 15        | 9341.082  | 15    | 63.5   | 16.62                    | 36.75                             | 254.1791       | 0.261732     |
| 16        | 9910.062  | 15    | 63.5   | 17.1                     | 36.75                             | 269.6616       | 0.269291     |
| 17        | 11664.09  | 15    | 63.5   | 18.66                    | 36.75                             | 317.3902       | 0.293858     |
| 18        | 884.862   | 15    | 63.5   | 20.29                    | 36.75                             | 24.07788       | 0.319528     |
| 19        | 880.0551  | 15    | 63.5   | 21.62                    | 36.75                             | 23.94708       | 0.340472     |
| 20        | 862.4952  | 15    | 63.5   | 23.61                    | 36.75                             | 23.46926       | 0.371811     |

## b. hasil uji tarik delapan layer arah serat 90/0 sample ke 2

| Waktu (s) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 198.162   | 15    | 63.5   | 0.65                     | 39                                | 5.081077       | 0.010236     |
| 2         | 773.028   | 15    | 63.5   | 1.52                     | 39                                | 19.82123       | 0.023937     |
| 3         | 1301.787  | 15    | 63.5   | 2.31                     | 39                                | 33.37915       | 0.036378     |
| 4         | 2012.031  | 15    | 63.5   | 2.77                     | 39                                | 51.59054       | 0.043622     |
| 5         | 2674.206  | 15    | 63.5   | 3.62                     | 39                                | 68.56938       | 0.057008     |
| 6         | 3567.897  | 15    | 63.5   | 4.44                     | 39                                | 91.48454       | 0.069921     |
| 7         | 4372.317  | 15    | 63.5   | 5.72                     | 39                                | 112.1107       | 0.090079     |
| 8         | 4912.848  | 15    | 63.5   | 6.83                     | 39                                | 125.9705       | 0.107559     |
| 9         | 5617.206  | 15    | 63.5   | 7.22                     | 39                                | 144.0309       | 0.113701     |
| 10        | 6280.362  | 15    | 63.5   | 8.02                     | 39                                | 161.0349       | 0.126299     |
| 11        | 7072.029  | 15    | 63.5   | 10.62                    | 39                                | 181.3341       | 0.167244     |
| 12        | 7676.325  | 15    | 63.5   | 12.62                    | 39                                | 196.8288       | 0.19874      |
| 13        | 8183.502  | 15    | 63.5   | 14.72                    | 39                                | 209.8334       | 0.231811     |
| 14        | 8922.195  | 15    | 63.5   | 15.75                    | 39                                | 228.7742       | 0.248031     |
| 15        | 9405.828  | 15    | 63.5   | 17.1                     | 39                                | 241.1751       | 0.269291     |
| 16        | 10016.99  | 15    | 63.5   | 18.1                     | 39                                | 256.8459       | 0.285039     |
| 17        | 12409.65  | 15    | 63.5   | 19.24                    | 39                                | 318.1962       | 0.302992     |
| 18        | 850.527   | 15    | 63.5   | 21.66                    | 39                                | 21.80838       | 0.341102     |
| 19        | 834.831   | 15    | 63.5   | 22.52                    | 39                                | 21.40592       | 0.354646     |
| 20        | 821.097   | 15    | 63.5   | 23.01                    | 39                                | 21.05377       | 0.362362     |

## c. hasil uji tarik delapan layer arah serat 45/45 sample ke 1

| Waktu (S) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 197.181   | 15    | 63.5   | 0.55                     | 36.75                             | 5.365469       | 0.008661     |
| 2         | 417.906   | 15    | 63.5   | 1.42                     | 36.75                             | 11.37159       | 0.022362     |
| 3         | 687.681   | 15    | 63.5   | 2.1                      | 36.75                             | 18.71241       | 0.033071     |
| 4         | 1100.682  | 15    | 63.5   | 4.23                     | 36.75                             | 29.95053       | 0.066614     |
| 5         | 1757.952  | 15    | 63.5   | 6.44                     | 36.75                             | 47.83543       | 0.101417     |
| 6         | 2067.948  | 15    | 63.5   | 8.92                     | 36.75                             | 56.27069       | 0.140472     |
| 7         | 2572.182  | 15    | 63.5   | 12.55                    | 36.75                             | 69.99135       | 0.197638     |
| 8         | 3123.504  | 15    | 63.5   | 16.41                    | 36.75                             | 84.99331       | 0.258425     |
| 9         | 3607.137  | 15    | 63.5   | 20.82                    | 36.75                             | 98.15339       | 0.327874     |
| 10        | 4129.029  | 15    | 63.5   | 24.2                     | 36.75                             | 112.3545       | 0.381102     |
| 11        | 4730.382  | 15    | 63.5   | 28.78                    | 36.75                             | 128.7179       | 0.453228     |
| 12        | 5223.825  | 15    | 63.5   | 32.62                    | 36.75                             | 142.1449       | 0.513701     |
| 13        | 5875.209  | 15    | 63.5   | 36.72                    | 36.75                             | 159.8696       | 0.578268     |
| 14        | 6394.158  | 15    | 63.5   | 40.12                    | 36.75                             | 173.9907       | 0.631811     |

|    |         |    |      |       |       |          |          |
|----|---------|----|------|-------|-------|----------|----------|
| 15 | 6955.29 | 15 | 63.5 | 42.66 | 36.75 | 189.2596 | 0.671811 |
| 16 | 6768.9  | 15 | 63.5 | 43.92 | 36.75 | 184.1878 | 0.691654 |
| 17 | 6592.32 | 15 | 63.5 | 45.23 | 36.75 | 179.3829 | 0.712283 |
| 18 | 6288.21 | 15 | 63.5 | 46.72 | 36.75 | 171.1078 | 0.735748 |
| 19 | 6170.49 | 15 | 63.5 | 48.92 | 36.75 | 167.9045 | 0.770394 |
| 20 | 851.508 | 15 | 63.5 | 49.91 | 36.75 | 23.17029 | 0.785984 |

d. hasil uji tarik delapan layer arah serat 45/45 sample ke 2

| Waktu (s) | Beban (N) | Lebar | Tinggi | Pertambahan Panjang (mm) | Luas Penampang (mm <sup>2</sup> ) | Tegangan (MPa) | Regangan (%) |
|-----------|-----------|-------|--------|--------------------------|-----------------------------------|----------------|--------------|
| 1         | 185.409   | 15    | 63.5   | 0.55                     | 39                                | 4.754077       | 0.008661     |
| 2         | 413.982   | 15    | 63.5   | 1.55                     | 39                                | 10.61492       | 0.024409     |
| 3         | 685.719   | 15    | 63.5   | 2.42                     | 39                                | 17.58254       | 0.03811      |
| 4         | 1141.884  | 15    | 63.5   | 3.1                      | 39                                | 29.27908       | 0.048819     |
| 5         | 1744.218  | 15    | 63.5   | 5.23                     | 39                                | 44.72354       | 0.082362     |
| 6         | 2018.898  | 15    | 63.5   | 7.44                     | 39                                | 51.76662       | 0.117165     |
| 7         | 2516.265  | 15    | 63.5   | 11.92                    | 39                                | 64.51962       | 0.187717     |
| 8         | 3054.834  | 15    | 63.5   | 15.55                    | 39                                | 78.32908       | 0.244882     |
| 9         | 3487.455  | 15    | 63.5   | 19.41                    | 39                                | 89.42192       | 0.305669     |
| 10        | 4099.599  | 15    | 63.5   | 23.64                    | 39                                | 105.1179       | 0.372283     |
| 11        | 4796.109  | 15    | 63.5   | 27.52                    | 39                                | 122.9772       | 0.433386     |
| 12        | 5201.262  | 15    | 63.5   | 31.21                    | 39                                | 133.3657       | 0.491496     |
| 13        | 5812.425  | 15    | 63.5   | 35.44                    | 39                                | 149.0365       | 0.55811      |
| 14        | 6088.086  | 15    | 63.5   | 39.22                    | 39                                | 156.1048       | 0.617638     |
| 15        | 6454.98   | 15    | 63.5   | 40.26                    | 39                                | 165.5123       | 0.634016     |
| 16        | 6235.236  | 15    | 63.5   | 41.33                    | 39                                | 159.8778       | 0.650866     |
| 17        | 6060.618  | 15    | 63.5   | 42.21                    | 39                                | 155.4005       | 0.664724     |
| 18        | 5901.696  | 15    | 63.5   | 42.92                    | 39                                | 151.3255       | 0.675906     |
| 19        | 5713.344  | 15    | 63.5   | 43.5                     | 39                                | 146.496        | 0.685039     |
| 20        | 731.826   | 15    | 63.5   | 45.92                    | 39                                | 18.76477       | 0.72315      |

Data uji impact

1. Uji impact 2 layer

a. Arah 0/90

| Sampel    | m (Kg) | R (m) | g    | $\theta_1$ | $\theta_2$ | impact energy (Joule) |
|-----------|--------|-------|------|------------|------------|-----------------------|
| A         | 8.3    | 0.62  | 9.18 | 90         | 89.3       | 0.57713454            |
| B         | 8.3    | 0.62  | 9.18 | 90         | 89.8       | 0.16489935            |
| Rata-rata |        |       |      |            |            | 0.37101695            |

## b. Arah 45/45

| Sampel    | m (Kg) | R (m) | g    | $\theta_1$ | $\theta_2$ | impact energy (Joule) |
|-----------|--------|-------|------|------------|------------|-----------------------|
| A         | 8.3    | 0.62  | 9.18 | 90         | 88.8       | 0.98932578            |
| B         | 8.3    | 0.62  | 9.18 | 90         | 88.4       | 1.31902603            |
| Rata-rata |        |       |      |            |            | 1.15417591            |

## 2. Uji impact 4 layer

## a. Arah 0/90

| Sampel    | m(Kg) | R (m) | g    | $\theta_1$ | $\theta_2$ | impact energy (Joule) |
|-----------|-------|-------|------|------------|------------|-----------------------|
| A         | 8.3   | 0.62  | 9.18 | 90         | 86.8       | 2.63702353            |
| B         | 8.3   | 0.62  | 9.18 | 90         | 87.1       | 2.39002466            |
| Rata-rata |       |       |      |            |            | 2.51352409            |

## b. Arah 45/45

| Sampel    | m (Kg) | R (m) | g    | $\theta_1$ | $\theta_2$ | impact energy (Joule) |
|-----------|--------|-------|------|------------|------------|-----------------------|
| A         | 8.3    | 0.62  | 9.18 | 90         | 87         | 2.47236523            |
| B         | 8.3    | 0.62  | 9.18 | 90         | 86.4       | 2.96624172            |
| Rata-rata |        |       |      |            |            | 2.71930348            |

## 3. Uji impact 6 layer

## a. Arah 0/90

| Sampel    | W (Kg) | R (m) | g    | $\theta_1$ | $\theta_2$ | impact energy (Joule) |
|-----------|--------|-------|------|------------|------------|-----------------------|
| A         | 8.3    | 0.62  | 9.18 | 90         | 80.7       | 7.63420976            |
| B         | 8.3    | 0.62  | 9.18 | 90         | 79.9       | 8.28437324            |
| Rata-rata |        |       |      |            |            | 7.9592915             |

## b. Arah 45/45

| Sampel    | m (Kg) | R (m) | g    | $\theta_1$ | $\theta_2$ | impact energy (Joule) |
|-----------|--------|-------|------|------------|------------|-----------------------|
| A         | 8.3    | 0.62  | 9.18 | 90         | 77.8       | 9.98304256            |
| B         | 8.3    | 0.62  | 9.18 | 90         | 77         | 10.6267508            |
| Rata-rata |        |       |      |            |            | 10.3048967            |

## 4. Uji impact 8 layer

## a. Arah 0/90

| Sampel    | m (Kg) | R (m) | g    | $\theta_1$ | $\theta_2$ | impact energy (Joule) |
|-----------|--------|-------|------|------------|------------|-----------------------|
| A         | 8.3    | 0.62  | 9.18 | 90         | 72.7       | 14.0480723            |
| B         | 8.3    | 0.62  | 9.18 | 90         | 73.1       | 13.732853             |
| Rata-rata |        |       |      |            |            | 13.8904627            |

## b. Arah 45/45

| Sampel    | m (Kg) | R (m) | g    | $\theta_1$ | $\theta_2$ | impact energy (Joule) |
|-----------|--------|-------|------|------------|------------|-----------------------|
| A         | 8.3    | 0.62  | 9.18 | 90         | 71         | 15.3799308            |
| B         | 8.3    | 0.62  | 9.18 | 90         | 70.6       | 15.6913849            |
| Rata-rata |        |       |      |            |            | 15.5356578            |

## DAFTAR RIWAYAT HIDUP



Nama Raditya Nabilah, yang akrab dipanggil Radit, lahir di Surabaya, 18 September 2004. Penulis merupakan anak pertama dari Bapak Machmud ST dan Ibu Hartati. Pendidikan dasar ditempuh di SD Kyai Ibrahim Surabaya pada tahun 2010 hingga lulu pada 2016. Selanjutnya, penulis melanjutkan ke SMPN 13 Surabaya dan tamat pada tahun 2019, penulis melanjutkan ke SMK Penerbangan Dharma Wirawan Sidoarjo hingga lulus pada 2022. Pada tahun yang sama penulis melanjutkan

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Hobi penulis adalah bersepeda dan bermain badminton. Berbekal ketekunan serta motivasi tinggi, penulis berhasil menyelesaikan Proyek Akhir. Diharapkan hasil dari proyek akhir ini dapat memberikan kontribusi bagi dunia pendidikan. Penulis mengucapkan syukur yang mendalam atas terselesaikannya Proyek Akhir yang berjudul “PERBANDINGAN JUMLAH LAMINASI KOMPOSIT SERAT KARBON TERHADAP KEKUATAN TARIK DAN *IMPACT*”. Kritik dan saran yang membangun sangat penulis harapkan mengenai Proyek Akhir ini, yang dapat di samapaikan kepada penulis di alamat email [radityanabilah18@gmail.com](mailto:radityanabilah18@gmail.com), atau No. HP: 087846090536.