LAMPIRAN

Lampiran 1: Perhitungan Komposisi Komposit

Diketahui:

ρ Luffa cylindrica	= 0,85 gr/cm³
ρ PLA	= 1,25 gr/cm³
ρ MCC	= 0,31 gr/cm³

Asumsi :

Volume Cetakan	= 17 cm x 11 cm x 0,32 cm
	= 59,84 cm³
v10%	= 0,1
v20%	= 0,2
v30%	= 0,3
V MCC 4%	= 0,04 x 59,84 = 2,39 cm³
Vf 10%	= 0,1 x 59,84 = 5,984 cm³
Vf 20%	= 0,2 x 59,84 = 11,968 cm³
Vf 30%	= 0,3 x 59,84 = 17,952 cm³

Komposisi komposit fraksi volume 0% :

Massa serat Luffa cylindrica

-$m$serat	= ρserat x Vf 0%
	= 0,85 x 0 cm³ = 0 gr

Massa MCC

-mMCC	= ρ serat x V MCC 4%
	= 0,31 gr/cm³ x 59,84 cm³ x 0,04
	= 0,74 gr

Massa PLA

-mPLA	= ρ PLA x V PLA
	= 1,3 gr/cm³ x 0,96 x 59,84 cm³
	= gr

Komposisi komposit fraksi volume 10% :

Massa serat Luffa cylindrica

-$m$serat = ρserat x Vf 10%

= 0,85 x 59,84 cm³ x 0,1

= 5,09 gr

Massa MCC

-mMCC = ρ serat x V MCC 4%

= 0,31 gr/cm³ x 59,84 cm³ x 0,04

= 0,74 gr

Massa PLA

-mPLA = ρ PLA x V PLA

= 1,25 gr/cm³ x 0,86 x 59,84 cm³

= 66,9 gr

Lampiran 2 : Data Hasil Uji Densitas dan Porositas Komposit

1. Perhitungan Densitas Komposit Teoritis

- Fraksi Volume 0%

Diketahui :

Densitas PLA = 1,25 gr/cm³

Densitas Luffa cylindrica = 0,85 gr/cm³

Densitas MCC = 0,31 gr/cm³

Fraksi Volume Serat = 0

Perhitungan :

ρ_c $= (vMCC\ x\ \rho_{mcc}) + (vm\ x\ \rho_m) + (vf\ x\ \rho_f)$

= (0,04 x 0,31 gr/cm³) + (0,96 x 1,3 gr/cm³) + (0 x 0,85 gr/cm³)

= 1,2604 gr/cm³

- Fraksi Volume 10%

Diketahui :

Densitas PLA = 1,25 gr/cm³

Densitas Luffa cylindrica = 0,85 gr/cm³

Densitas MCC = 0,31 gr/cm³

Fraksi Volume Serat = 0,1

Perhitungan :

ρ_c $= (vMCC\ x\ \rho_{mcc}) + (vm\ x\ \rho_m) + (vf\ x\ \rho_f)$

= (0,04 x 0,31 gr/cm³) + (0,86 x 1,3 gr/cm³) + (0,1 x 0,85 gr/cm³)

= 1,2154 gr/cm³

2. Contoh Perhitungan Densitas Komposit Aktual

- Fraksi Volume 0%

Diketahui :

Densitas Fluid = 0,83 gr/cm³

Spesimen A10

- Massa diudara = 1,148 gr
- Massa difluida = 0,347 gr

Perhitungan :

$$\rho = \frac{m_u}{m_u - m_f} \times \rho_a$$

$$= \frac{1{,}148}{1{,}148-0{,}347} \times 0{,}83 \text{ gr/cm}^3$$

$$= 1{,}190 \text{ gr/cm}^3$$

3. Contoh Perhitungan Porositas

Diketahui :

Densitas Teoritis Komposit = 1,2154 gr/cm³

Densitas Spesimen A10 = 1,190 gr/cm³

Perhitungan :

$$Pt = \frac{\rho t - \rho c}{\rho t} \times 100\%$$

$$= \frac{1{,}2154 - 1{,}190}{1{,}2154} \times 100\%$$

$$= 2{,}126\%$$

Maka, Porositas komposit spesimen komposit A10 sebesar 2,126%

4. Data Hasil Pengujian Densitas Komposit PLA/MCC serat LC

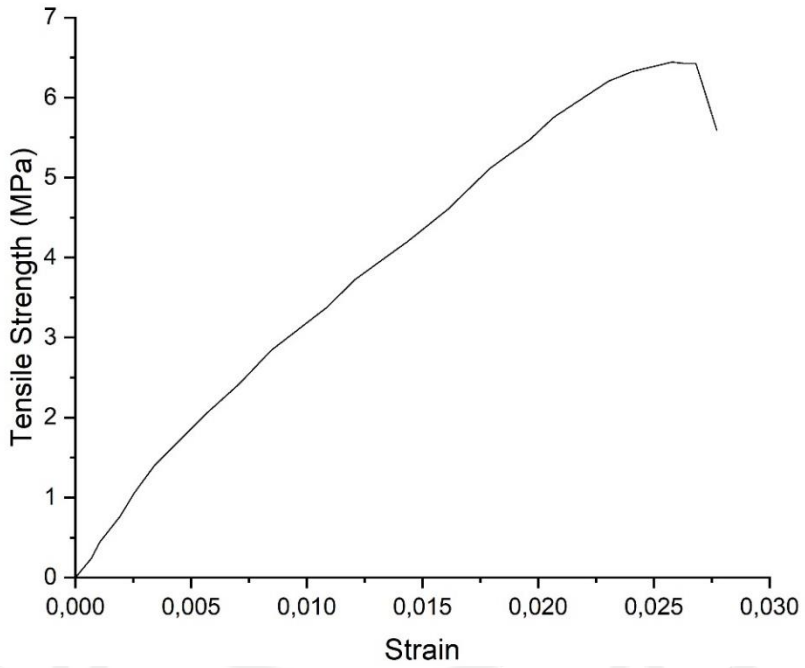
Specimens		Mass on air (gr)	Mass on fluid (gr)	Fluid Density (gr/cm³)	Composite Density	Porosity (%)
vf 0%	A	1,833	0,606	0,83	1,240	1,624
	B	1,633	0,551	0,83	1,253	0,613
	C	1,17	0,382	0,83	1,232	2,225
	D	1,205	0,403	0,83	1,247	1,058
	E	1,37	0,462	0,83	1,252	0,642
	F	1,451	0,473	0,83	1,231	2,299
	G	1,254	0,416	0,83	1,242	1,458
	H	1,531	0,501	0,83	1,234	2,117
	I	1,391	0,463	0,83	1,244	1,293
	J	1,132	0,371	0,83	1,235	2,044
	Average				1,241	1,537
	Standar Deviasi				0,008	0,600
vf 10%	A	1,148	0,347	0,83	1,190	2,126
	B	1,443	0,445	0,83	1,200	1,260
	C	1,337	0,402	0,83	1,187	2,349
	D	1,543	0,467	0,83	1,190	2,071
	E	1,354	0,413	0,83	1,194	1,737
	F	1,253	0,355	0,83	1,158	4,713
	G	1,521	0,454	0,83	1,183	2,653
	H	1,325	0,398	0,83	1,186	2,390
	I	1,472	0,443	0,83	1,187	2,310
	J	1,183	0,347	0,83	1,175	3,364
	Average				1,185	2,497
	Standar Deviasi				0,011	0,905
vf 20%	A	1,567	0,392	0,83	1,107	5,425
	B	1,308	0,346	0,83	1,129	3,578
	C	1,216	0,299	0,83	1,101	5,961
	D	1,223	0,313	0,83	1,115	4,692
	E	1,272	0,316	0,83	1,104	5,643
	F	1,341	0,351	0,83	1,124	3,941
	G	1,257	0,322	0,83	1,116	4,662
	H	1,472	0,377	0,83	1,116	4,668
	I	1,382	0,353	0,83	1,115	4,756
	J	1,418	0,352	0,83	1,104	5,667
	Average				1,113	4,899
	Standar Deviasi				0,009	0,734
vf 30%	A	1,43	0,321	0,83	1,070	4,901
	B	1,94	0,429	0,83	1,066	5,309
	C	1,84	0,412	0,83	1,069	4,970
	D	1,885	0,431	0,83	1,076	4,387
	E	1,12	0,264	0,83	1,086	3,503
	F	1,347	0,302	0,83	1,070	4,935
	G	1,482	0,332	0,83	1,070	4,957
	H	1,327	0,298	0,83	1,070	4,890
	I	1,271	0,271	0,83	1,055	6,262
	J	1,424	0,301	0,83	1,052	6,481
	Average				1,068	5,059
	Standar Deviasi				0,009	0,806

Lampiran 3 : Data Hasil Pengujian Tarik Komposit

1. Data Hasil Uji Tarik Komposit Variasi Fraksi Volume 0%

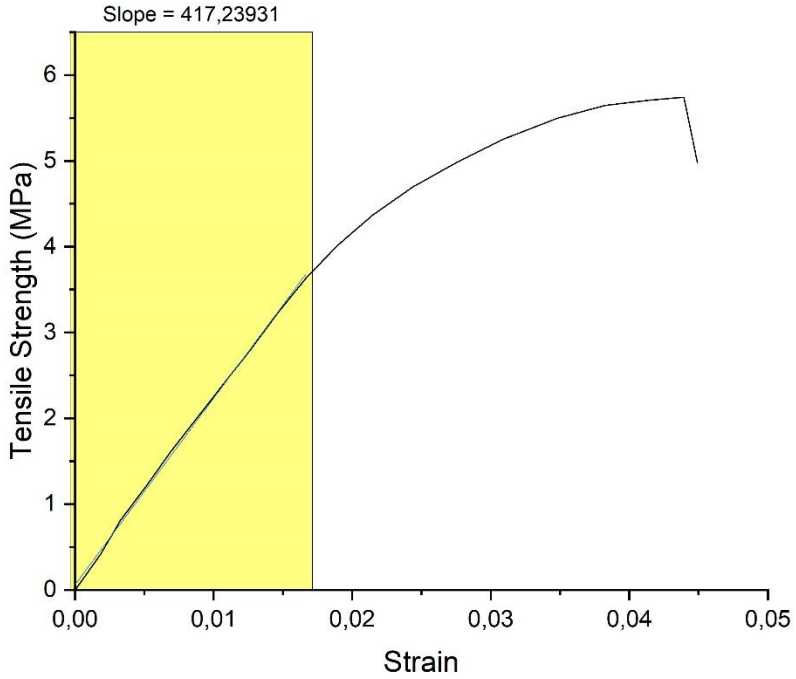
Specimens	Penampang			Beban Maksimal (N)	Tensile Strength (Mpa)	ΔL (mm)	L_o (mm)	Regangan	Modulus Elastisitas (Mpa)
	Lebar (mm)	Tebal (mm)	Luas (mm^2)						
0% A	12,8	2,8	35,84	205,770	5,741	2,197	50	0,0439	417,239
0% B	12,8	2,8	35,84	229,183	6,395	0,748	50	0,0150	705,333
0% C	12,8	2,8	35,84	278,722	7,777	1,382	50	0,0276	460,787
0% D	12,8	2,8	35,84	237,315	6,622	1,297	50	0,0259	570,565
0% E	12,8	2,8	35,84	194,862	5,437	0,999	50	0,0200	472,372
Average				229,170	6,394	1,324	50	0,0265	525,259
Standard Devitiation					0,813				103,054

2. Grafik Tegangan-Regangan Komposit Variasi Fraksi Volume 0%

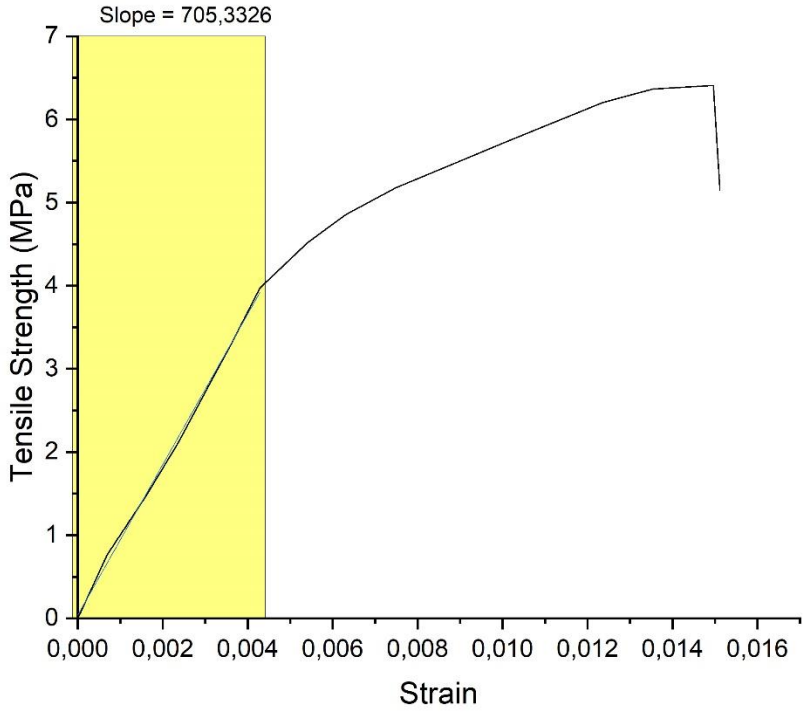


3. Penentuan Modulus Elastisitas Komposit Variasi Fraksi Volume 0%

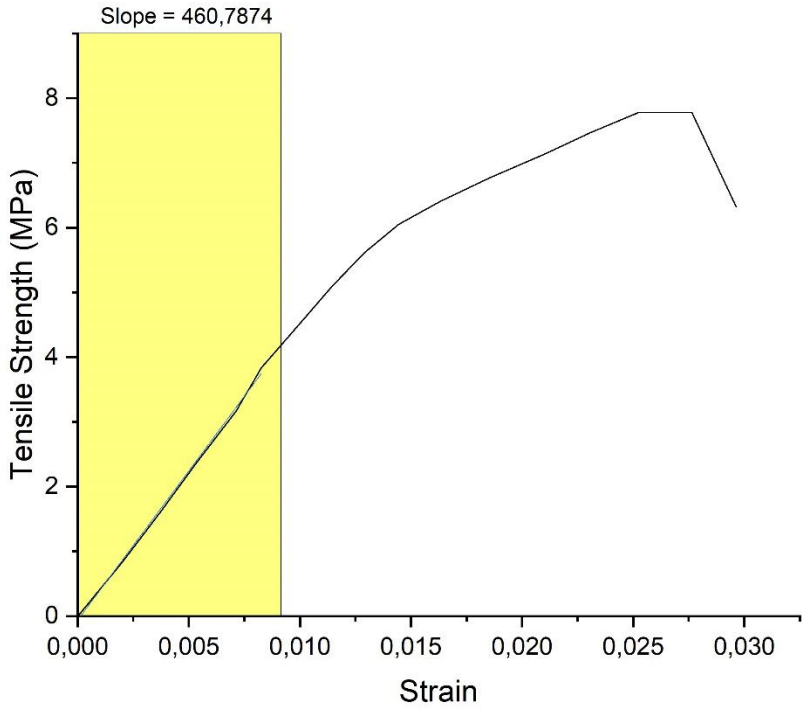
a. Spesimen A0



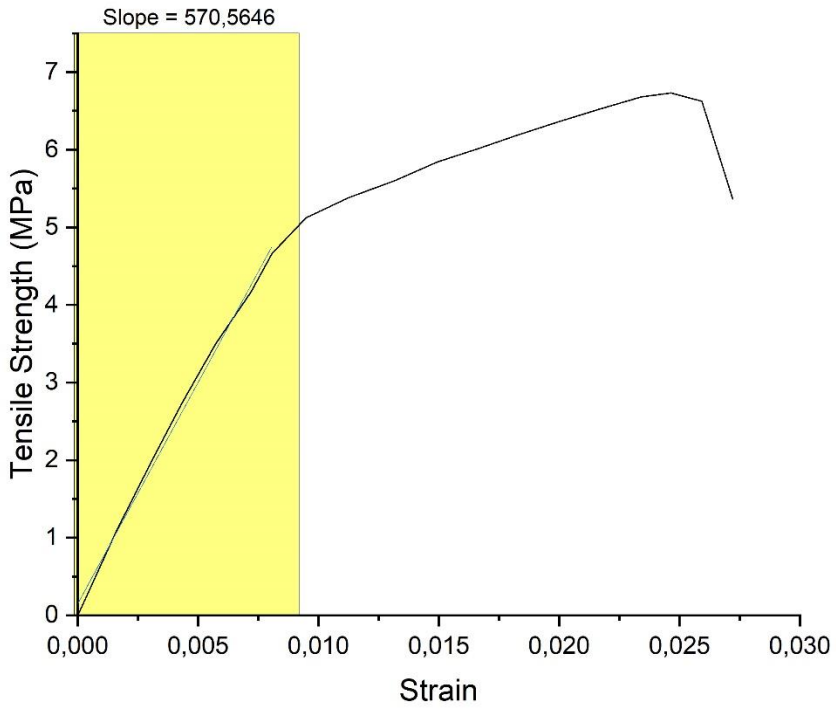
b. Spesimen B0



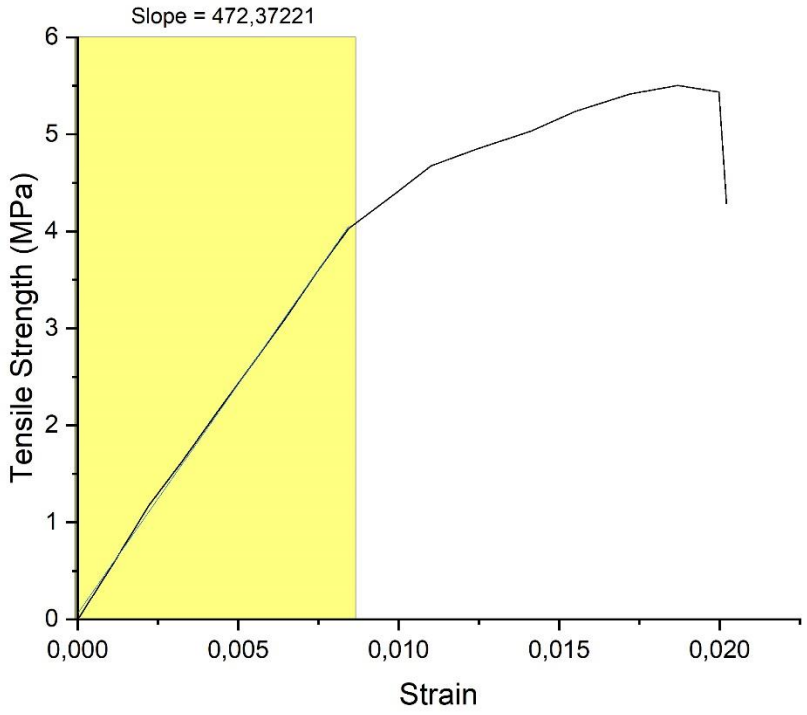
c. Spesimen C0



d. Spesimen D0



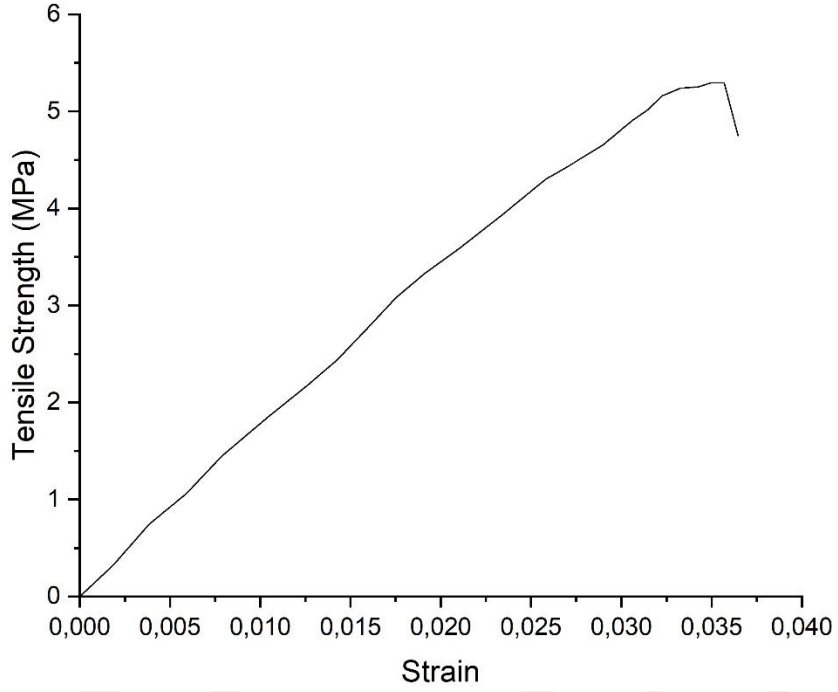
e. Spesimen E0



4. Data Hasil Uji Tarik Komposit Variasi Fraksi Volume 10%

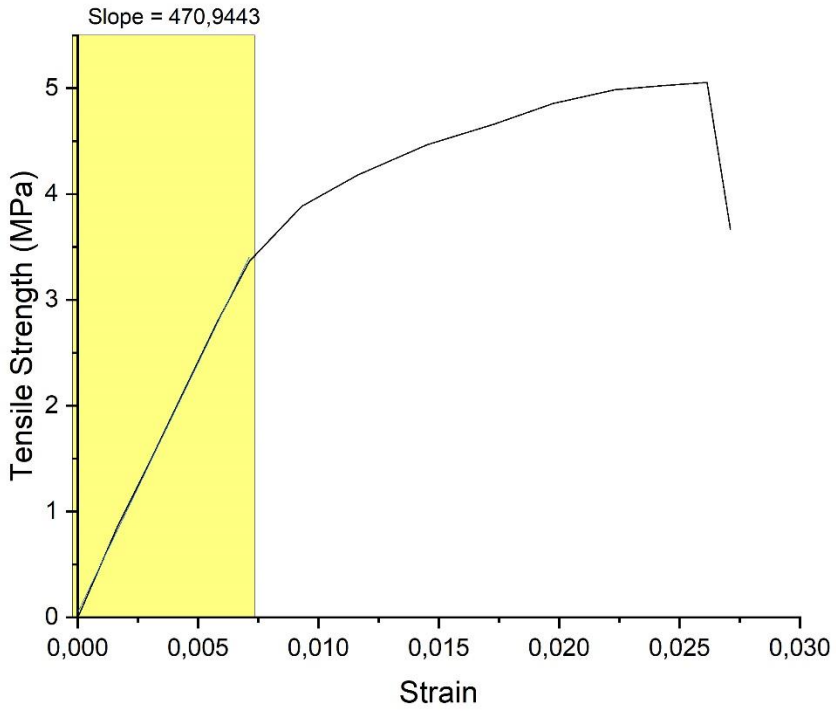
Specimens	Penampang			Beban Maksimal	Tensile Strength	ΔL (mm)	L_o (mm)	Regangan	Modulus Elastisitas (Mpa)
	Lebar (mm)	Tebal (mm)	Luas (mm^2)						
10% A	12,8	2,8	35,84	181,054	5,052	1,307	50	0,0261	470,944
10% B	12,8	2,8	35,84	192,211	5,363	1,261	50	0,0252	356,753
10% C	12,8	2,8	35,84	198,539	5,540	2,415	50	0,0483	231,726
10% D	12,8	2,8	35,84	187,381	5,228	2,659	50	0,0532	171,115
10% E	12,8	2,8	35,84	184,794	5,156	1,292	50	0,0258	374,126
Average				188,796	5,268	1,787	50	0,0357	320,933
Standard Devitiation					0,170				106,789

5. Grafik Tegangan-Regangan Komposit Variasi Fraksi Volume 10%

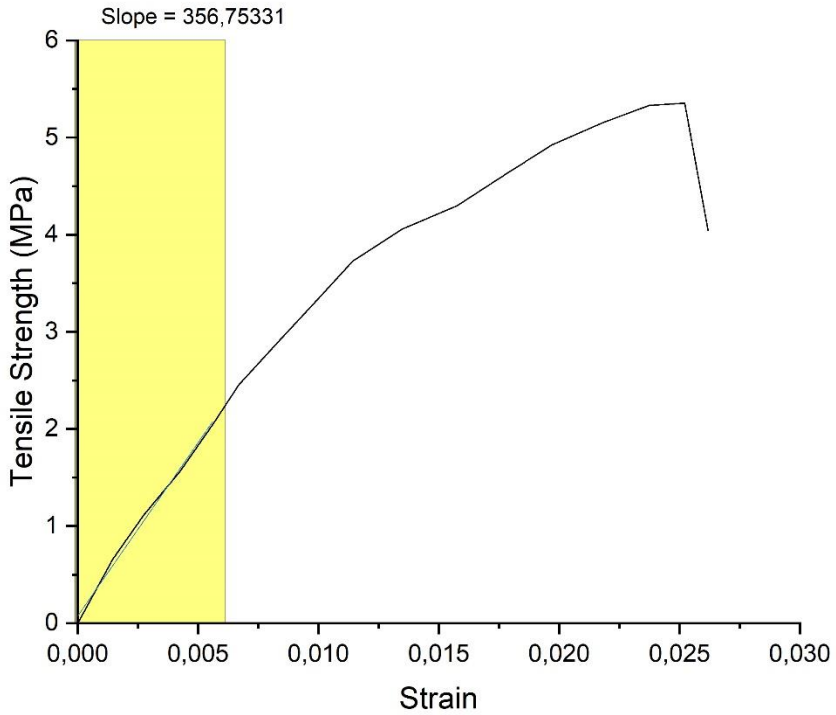


6. Penentuan Modulus Elastisitas Komposit Variasi Fraksi Volume 10%

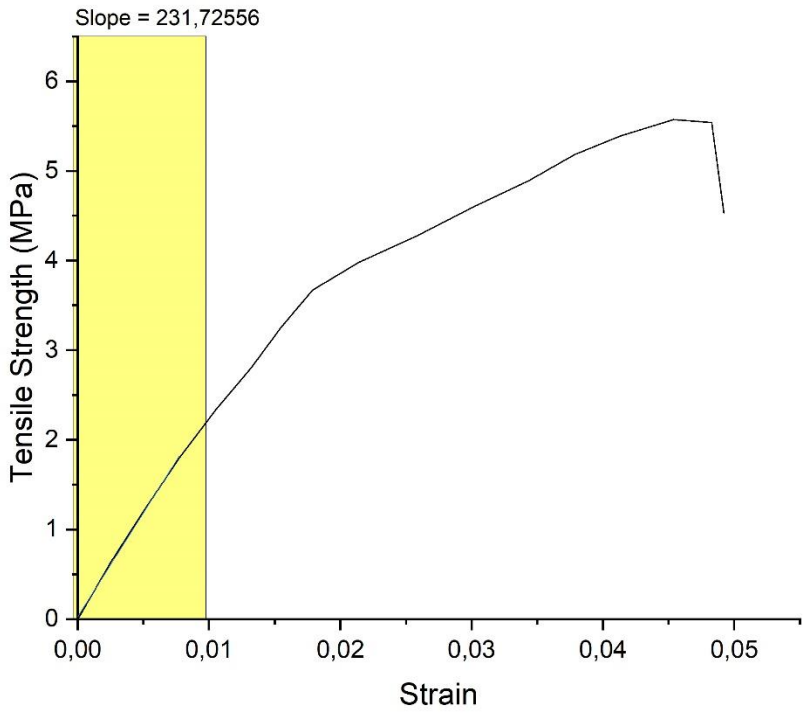
a. Spesimen A10



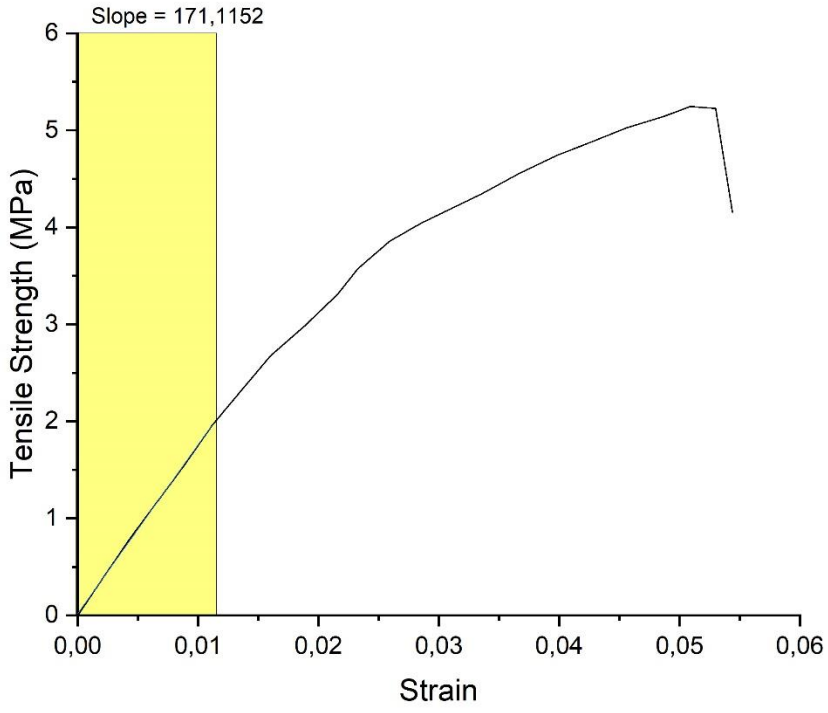
b. Spesimen B10



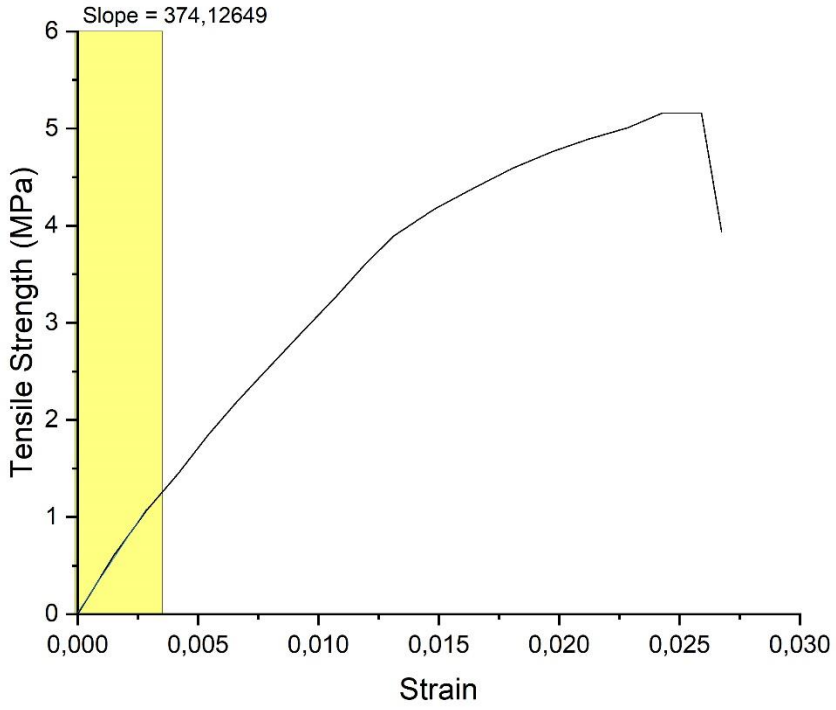
c. Spesimen C10



d. Spesimen D10



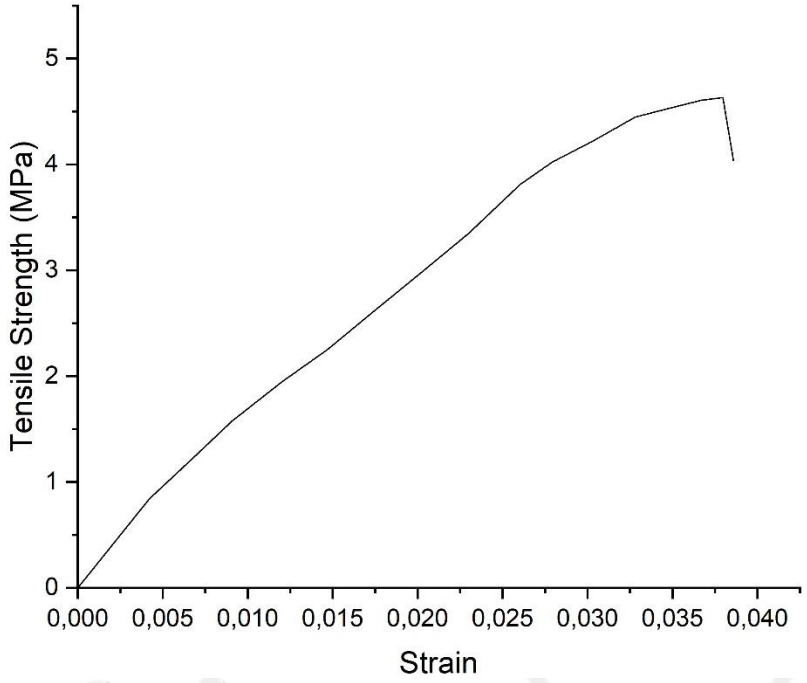
e. Spesimen E10



7. Data Hasil Uji Tarik Komposit Variasi Fraksi Volume 20%

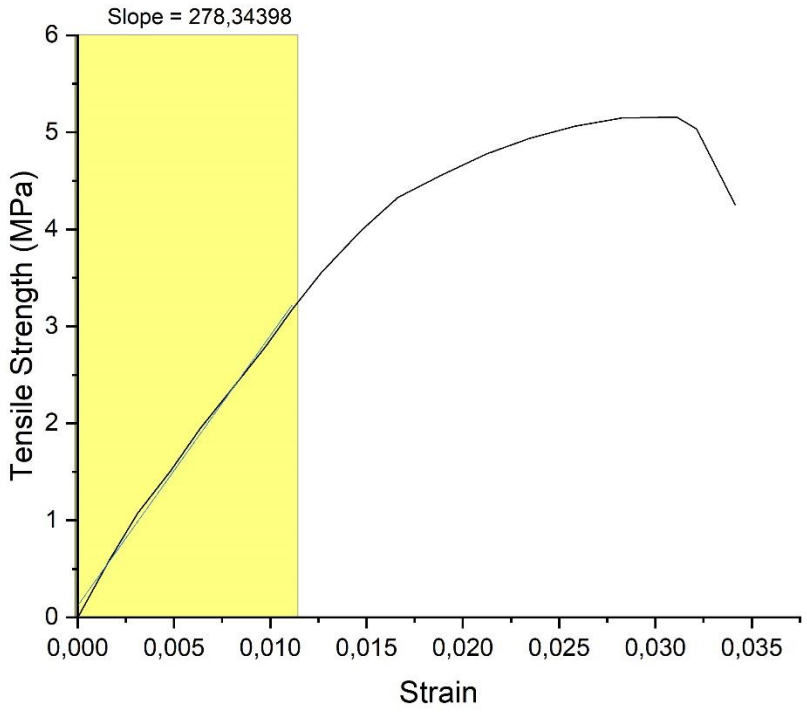
Specimens	Penampang			Beban Maksimal	Tensile Strength	ΔL (mm)	L_o (mm)	Regangan	Modulus Elastisitas (Mpa)
	Lebar (mm)	Tebal (mm)	Luas (mm^2)						
20% A	12,8	2,8	35,84	180,367	5,033	1,606	50	0,0321	278,344
20% B	12,8	2,8	35,84	181,336	5,060	1,884	50	0,0377	236,450
20% C	12,8	2,8	35,84	145,004	4,046	2,090	50	0,0418	191,067
20% D	12,8	2,8	35,84	174,597	4,872	1,771	50	0,0354	265,695
20% E	12,8	2,8	35,84	143,926	4,016	2,127	50	0,0425	152,600
Average				165,046	4,605	1,896	50	0,0379	224,831
Standard Devitiation					0,473				46,959

8. Grafik Tegangan-Regangan Komposit Variasi Fraksi Volume 20%

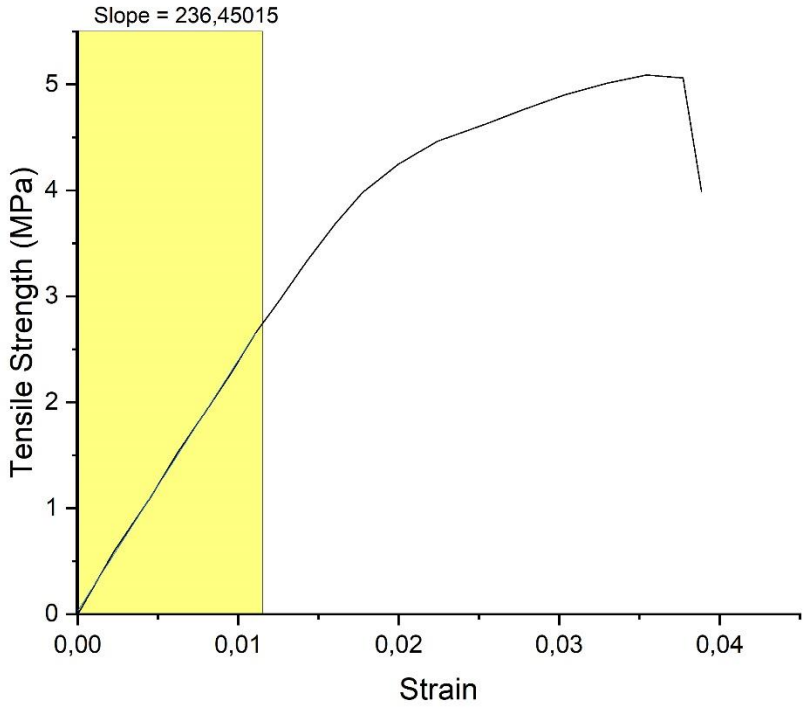


9. Penentuan Modulus Elastisitas Komposit Variasi Fraksi Volume 20%

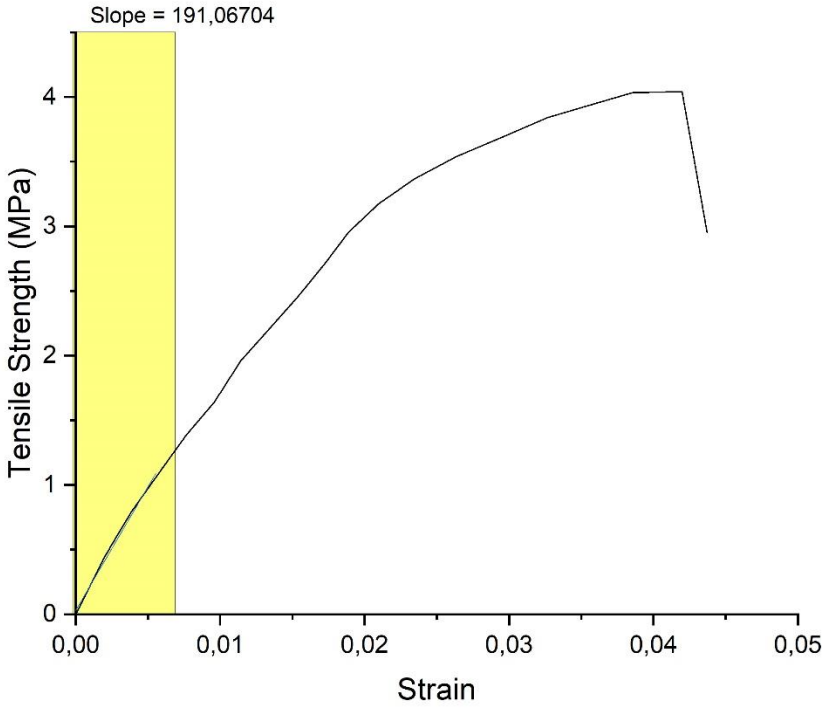
a. Spesimen A20



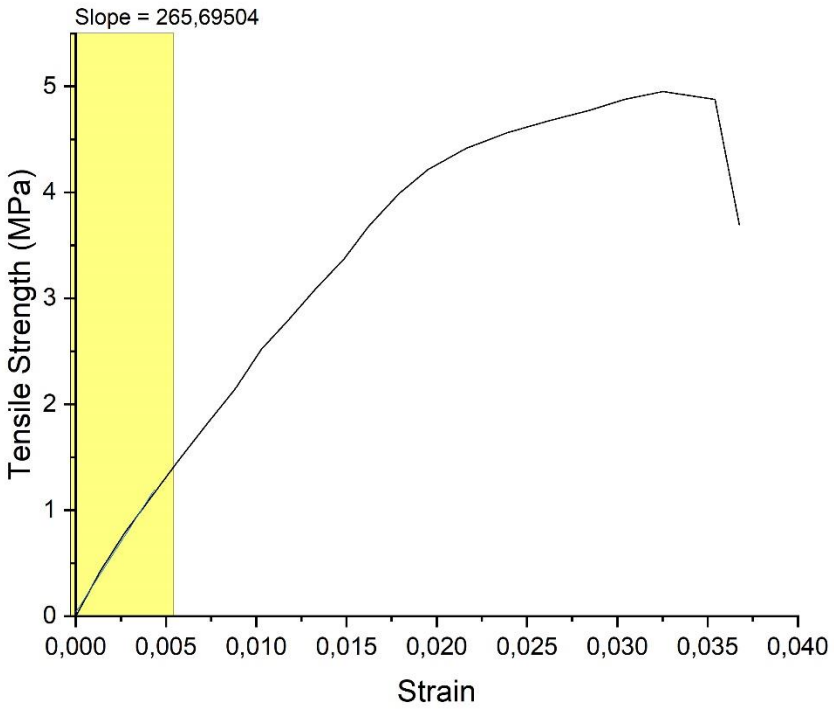
b. Spesimen B20



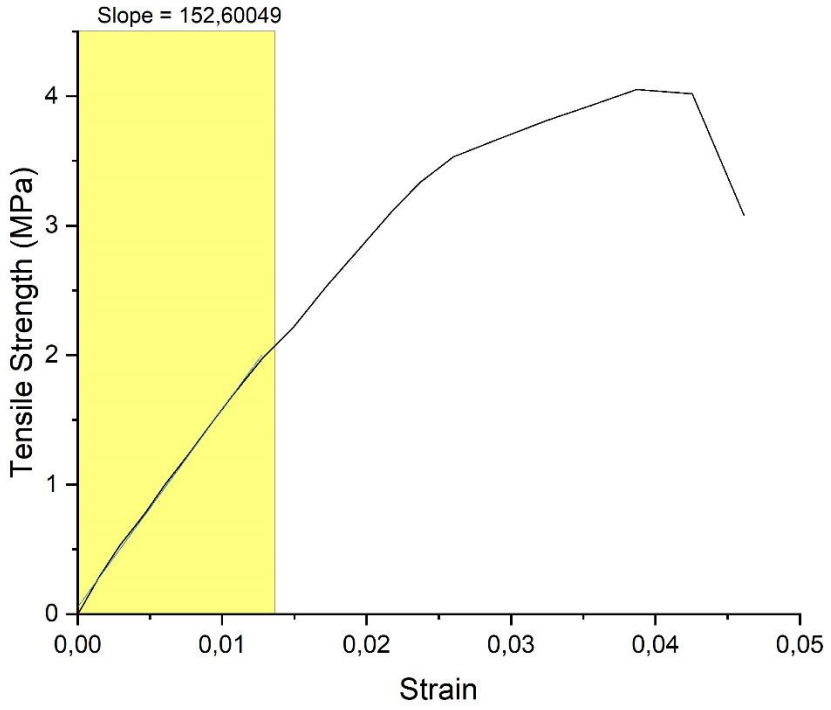
c. Spesimen C20



d. Spesimen D20



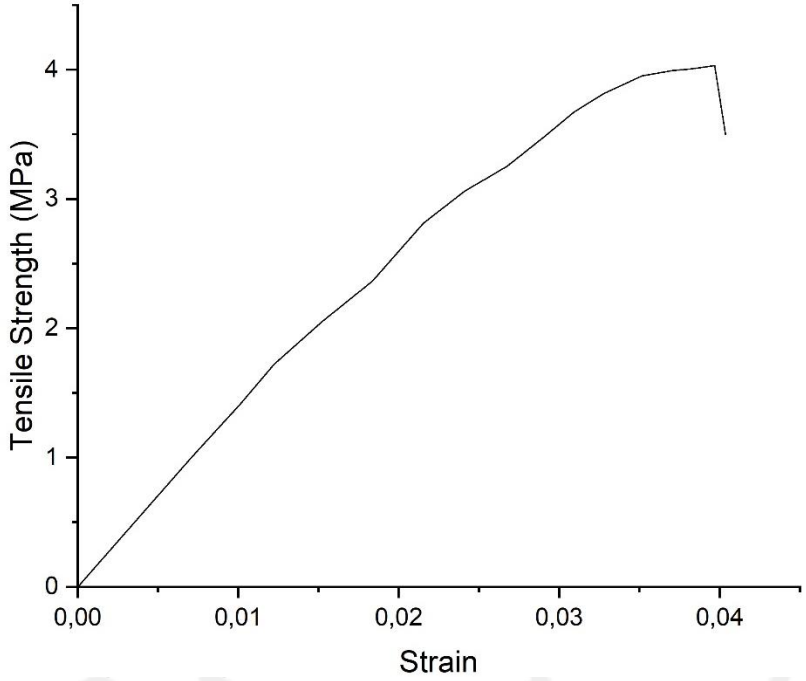
e. Spesimen E20



10. Data Hasil Uji Tarik Komposit Variasi Fraksi Volume 30%

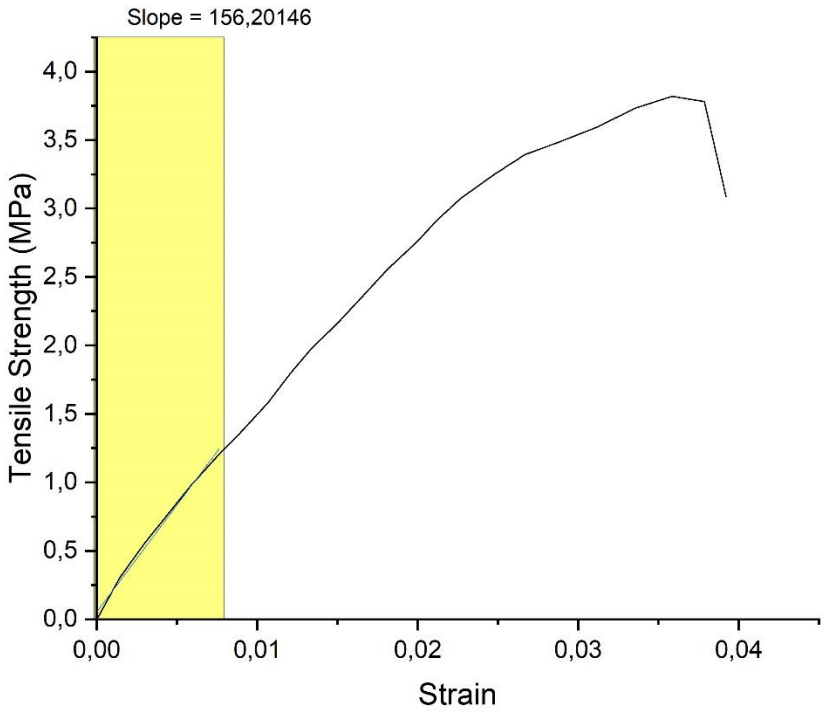
Specimens	Penampang			Beban Maksimal	Tensile Strength	ΔL (mm)	L_o (mm)	Regangan	Modulus Elastisitas (Mpa)
	Lebar (mm)	Tebal (mm)	Luas (mm^2)						
30% A	12,8	2,8	35,84	135,816	3,790	1,894	50	0,0379	156,201
30% B	12,8	2,8	35,84	145,146	4,050	2,366	50	0,0473	137,315
30% C	12,8	2,8	35,84	145,950	4,072	2,622	50	0,0524	130,535
30% D	12,8	2,8	35,84	166,257	4,639	1,150	50	0,0230	348,027
30% E	12,8	2,8	35,84	128,781	3,593	1,878	50	0,0376	157,833
Average				144,390	4,029	1,982	50	0,0396	185,982
Standard Devitiation					0,353				81,708

11. Grafik Tegangan-Regangan Komposit Variasi Fraksi Volume 30%

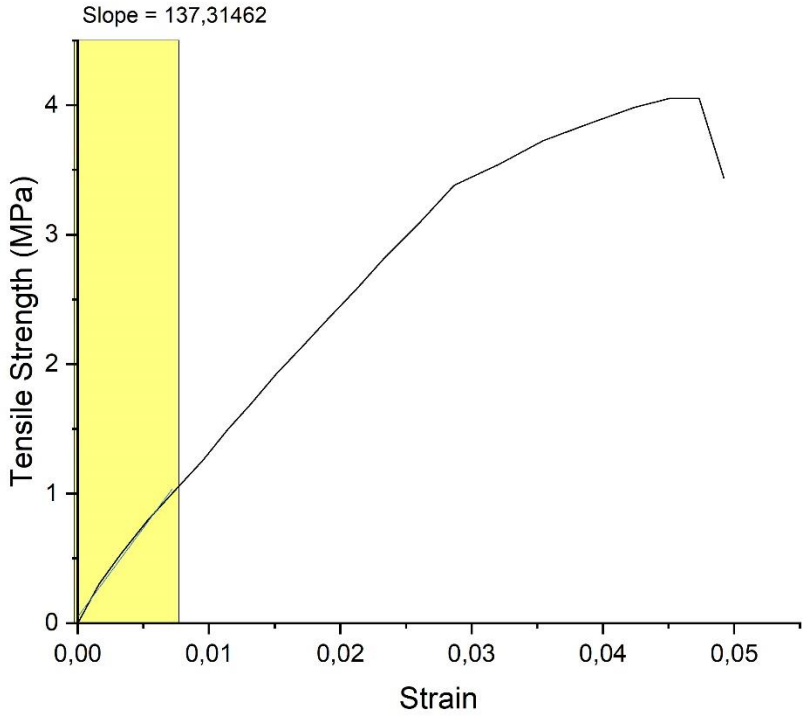


12. Penentuan Modulus Elastisitas Komposit Variasi Fraksi Volume 30%

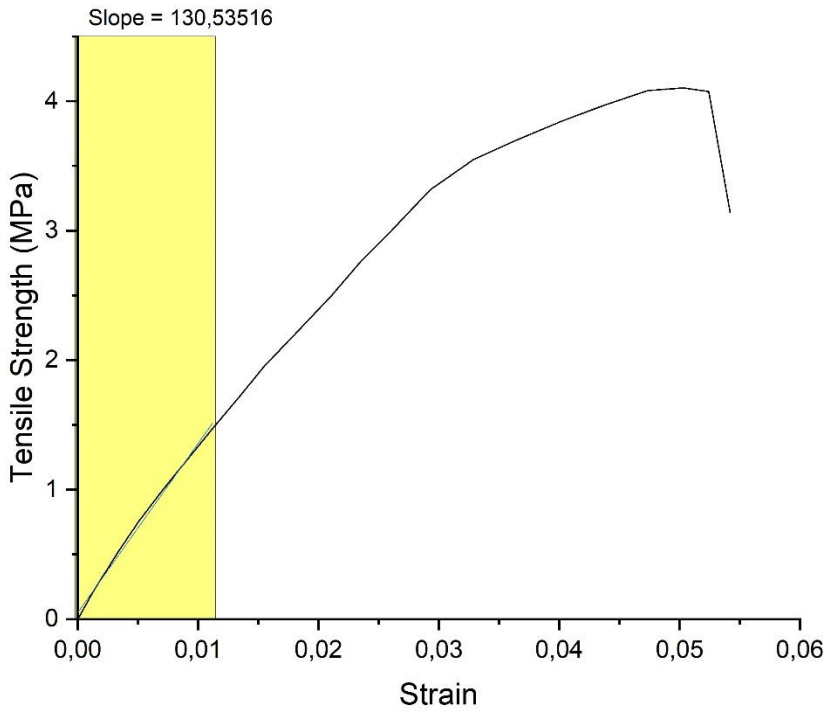
a. Spesimen A30



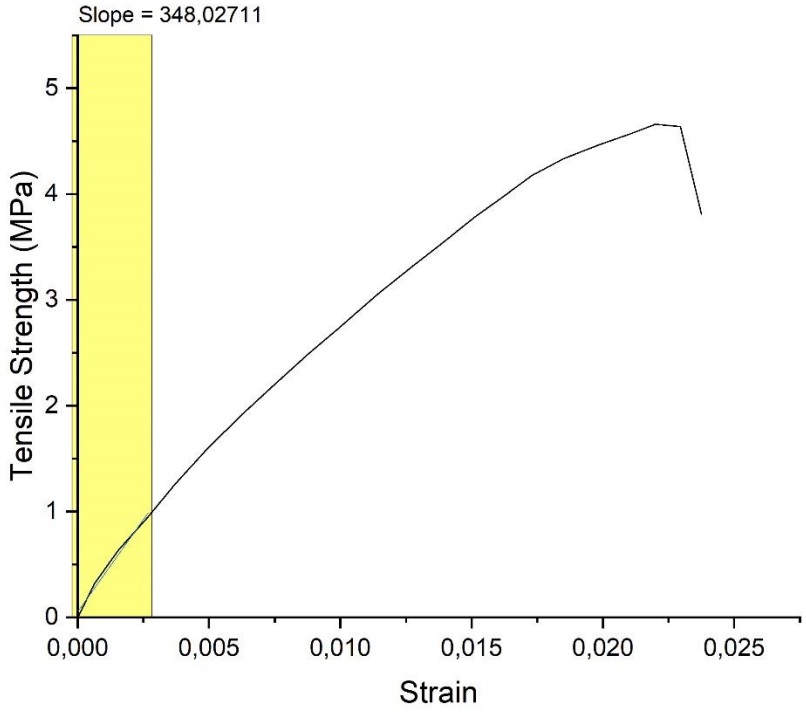
b. Spesimen B30



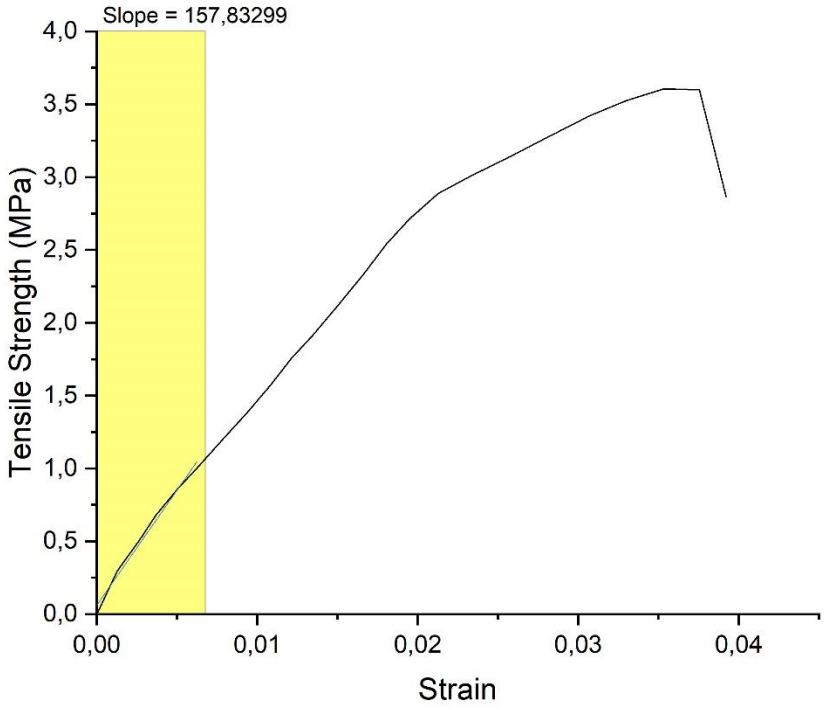
c. Spesimen C30



d. Spesimen D30



e. Spesimen E30



Lampiran 4 : Data Hasil Pengujian Impak Komposit

1. Data Hasil Uji Impak Komposit Fraksi Volume 0%

Spesimen	Berat Pendulum (N)	Panjang Lengan (m)	Sudut Awal (°)	Sudut Akhir (°)	Energi Total (J)	Tebal (m)	Lebar (m)	*Impact (J/m2)*
A0%	17,452	0,357	135	130,00	0,401	0,004	0,01	10018,3
B0%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
C0%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
D0%	17,452	0,357	135	130,00	0,401	0,004	0,01	10018,3
E0%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
Rata-rata				**131,20**	**0,302**			**7556,4**
Standar Deviasi				**0,980**				**2,010**

2. Data Hasil Uji Impak Komposit Fraksi Volume 10%

Spesimen	Berat Pendulum (N)	Panjang Lengan (m)	Sudut Awal (°)	Sudut Akhir (°)	Energi Total (J)	Tebal (m)	Lebar (m)	*Impact (J/m2)*
A10%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
B10%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
C10%	17,452	0,357	135	133,00	0,156	0,004	0,01	3910,87
D10%	17,452	0,357	135	132,50	0,196	0,004	0,01	4908,99
E10%	17,452	0,357	135	132,50	0,196	0,004	0,01	4908,99
Rata-rata				**132,40**	**0,204**			**5111,82**
Standar Deviasi				**0,374**				**0,750**

3. Data Hasil Uji Impak Komposit Fraksi Volume 20%

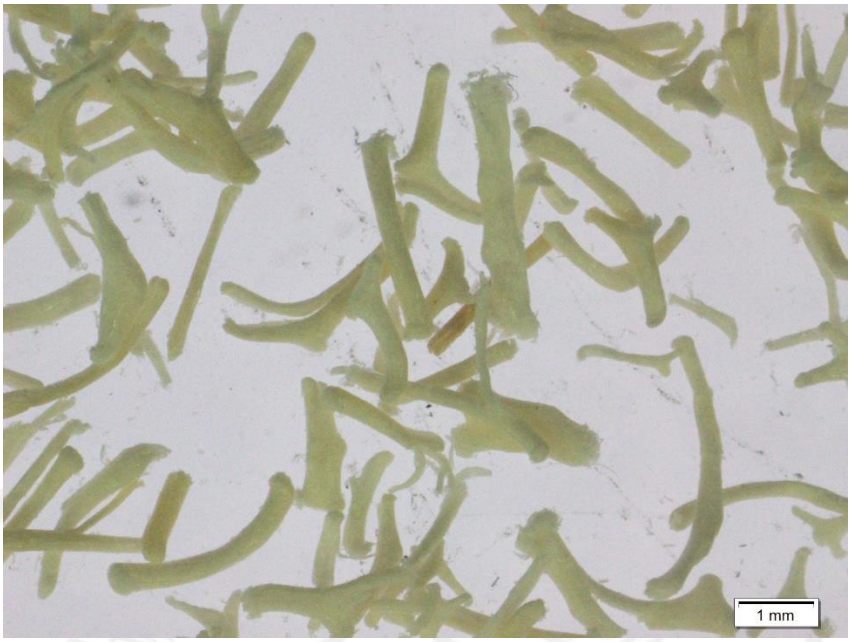
Spesimen	Berat Pendulum (N)	Panjang Lengan (m)	Sudut Awal (°)	Sudut Akhir (°)	Energi Total (J)	Tebal (m)	Lebar (m)	*Impact (J/m2)*
A20%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
B20%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
C20%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
D20%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
E20%	17,452	0,357	135	133,00	0,156	0,004	0,01	3910,87
Rata-rata				**132,20**	**0,221**			**5514,28**
Standar Deviasi				**0,400**				**0,802**

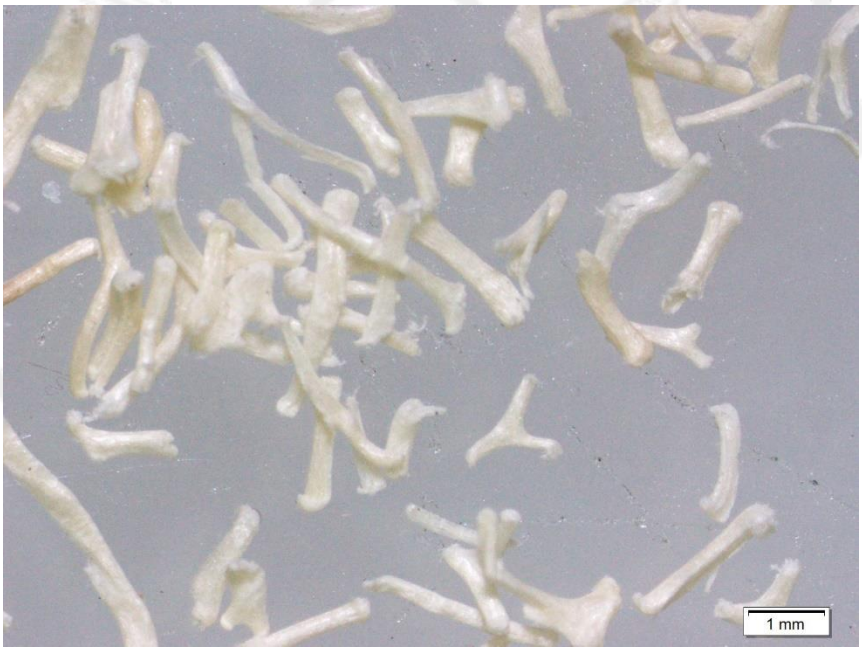
4. Data Hasil Uji Impak Komposit Fraksi Volume 30%

Spesimen	Berat Pendulum (N)	Panjang Lengan (m)	Sudut Awal (°)	Sudut Akhir (°)	Energi Total (J)	Tebal (m)	Lebar (m)	*Impact (J/m2)*
A30%	17,452	0,357	135	133,50	0,117	0,004	0,01	2920,83
B30%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
C30%	17,452	0,357	135	132,00	0,237	0,004	0,01	5915,13
D30%	17,452	0,357	135	132,50	0,196	0,004	0,01	4908,99
E30%	17,452	0,357	135	132,50	0,196	0,004	0,01	4908,99
Rata - rata				**132,50**	**0,197**			**4913,82**
Standar Deviasi				**0,548**				**1,093**

Lampiran 5 : Perhitungan Panjang dan Diameter Serat

1. Foto Makro Serat *Luffa cylindrica*





2. Perhitungan Panjang dan Diameter Serat *Luffa cylindrica*

Pengukuran menggunakan *software* ImageJ dengan cara kerja membandingan serat dengan skala yang terhitung.

a. Panjang Serat

Capture	No	Area	Mean	Min	Max	Angle	Length (mm)
capture 1	1	0.009	162.257	144.648	212.250	-8.383	1.340
	2	0.012	136.337	121.249	175.667	-25.153	1.773
	3	0.010	159.923	129.918	194.333	74.208	1.436
	4	0.009	129.189	116.299	146.667	70.346	1.245
	5	0.017	142.633	125.410	165.000	70.324	2.445
	6	0.012	139.482	121.224	173.605	-27.378	1.760
	7	0.012	145.032	131.874	206.000	90.470	1.702
	8	0.012	143.794	133.317	160.333	-36.597	1.755
	9	0.009	149.052	123.560	166.706	-65.501	1.211
	10	0.016	131.815	116.147	150.332	10.465	2.228
	11	0.013	141.355	127.095	153.667	-53.383	1.895
	12	0.010	151.318	114.898	207.899	2.302	1.389
	13	0.012	134.556	111.435	163.333	-30.881	1.658
	14	0.013	135.428	114.940	158.170	-69.419	1.885
capture 2	1	0.015	215.684	175.667	238.023	39.591	2.146
	2	0.011	210.963	177.625	246.791	-96.572	1.524
	3	0.012	199.375	159.226	226.555	-97.323	1.751
	4	0.011	208.688	187.667	231.298	60.286	1.591
	5	0.010	176.568	157.720	225.040	-3.434	1.398
	6	0.012	206.655	146.898	243.405	61.274	1.655
	7	0.012	193.259	152.453	236.607	123.288	1.653
	8	0.009	209.202	185.333	243.545	-56.226	1.318
	9	0.012	205.463	188.153	223.086	-162.135	1.774
	10	0.012	207.945	176.000	242.633	-101.399	1.765
	11	0.009	207.705	145.283	252.290	75.964	1.237
	12	0.011	211.111	163.000	228.297	76.729	1.520
Average							1.656

b. Diameter Serat

Capture	No	Area	Mean	Min	Max	Angle	Length (µm)
capture 1	1	0.002	142.151	129.827	189.000	10.176	276
	2	0.002	149.741	131.333	199.667	-86.309	217
	3	0.001	156.105	148.476	189.333	-14.534	195
	4	0.002	152.333	142.454	200.333	-30.651	219
	5	0.002	149.541	139.387	173.000	38.089	328
	6	0.002	127.036	114.848	147.667	43.919	262
	7	0.002	151.143	137.888	204.000	-16.991	263
	8	0.002	144.361	130.730	190.333	-25.710	209
	9	0.002	151.138	141.690	186.333	-13.325	272
	10	0.002	143.146	128.292	197.667	-52.651	334
	11	0.001	141.560	131.333	160.000	-90.000	167
	12	0.002	138.861	125.338	187.333	-34.077	286
	13	0.002	140.640	126.333	196.667	-12.804	315
	14	0.002	147.263	132.931	200.333	50.906	288
	15	0.002	136.904	124.893	163.333	12.653	350
	16	9,74E-01	143.296	130.895	178.333	-3.013	133
	17	0.002	160.389	145.333	191.167	36.870	244
	18	0.001	162.849	147.433	193.667	29.604	177
	19	0.001	157.179	139.444	190.333	-19.799	185
	20	0.001	144.192	137.817	180.000	-38.660	179
	21	0.002	138.183	120.694	193.333	-41.496	242
capture 2	1	0.002	205.045	176.333	214.759	-140.042	337
	2	0.002	185.745	162.014	198.833	28.706	334
	3	0.003	214.089	197.000	228.034	0.988	405
	4	0.002	217.225	176.000	246.267	33.341	317
	5	0.002	201.758	176.667	216.833	-4.764	252
	6	0.002	200.588	174.333	212.496	-54.866	230
	7	0.002	197.850	177.333	211.381	-2.726	293
	8	0.002	199.468	183.667	223.259	16.260	349
	9	0.002	195.663	167.667	211.990	19.983	327
	10	0.002	213.946	167.037	244.041	-63.435	250
	11	0.002	206.270	175.000	226.991	-110.556	238
	12	0.001	203.116	180.000	215.000	-112.166	203
	13	0.002	191.402	153.970	219.503	-60.642	256
Average							262,706

Lampiran 6 : Perhitungan Panjang Kritis dan *Aspect Ratio*

1. Perhitungan Panjang Kritis Serat *Luffa cylindrica*

Diketahui :

d = 0,262 mm

S_{f1} = 367 MPa

τ_y = 2,92 MPa

Panjang Kritis:

$L_c = dS_{f1} / 2\tau_y$

$L_c = (0{,}262)(367) / 2(2{,}92)$

$L_c = 16{,}46$ mm

2. Perhitungan *Aspect Ratio* Serat *Luffa cylindrica*

Diketahui :

Panjang Serat (L_f) = 1,656 mm

Diameter Serat (d) = 0,262 mm

Aspect Ratio Fiber :

$$Aspect\ Ratio = \frac{Lf}{d}$$

$$= \frac{1{,}656\ mm}{0{,}262\ mm}$$

$$= 6{,}303334596$$

3. Perbandingan Panjang Kritis Dengan Panjang Serat *Luffa cylindrca*

Diketahui :

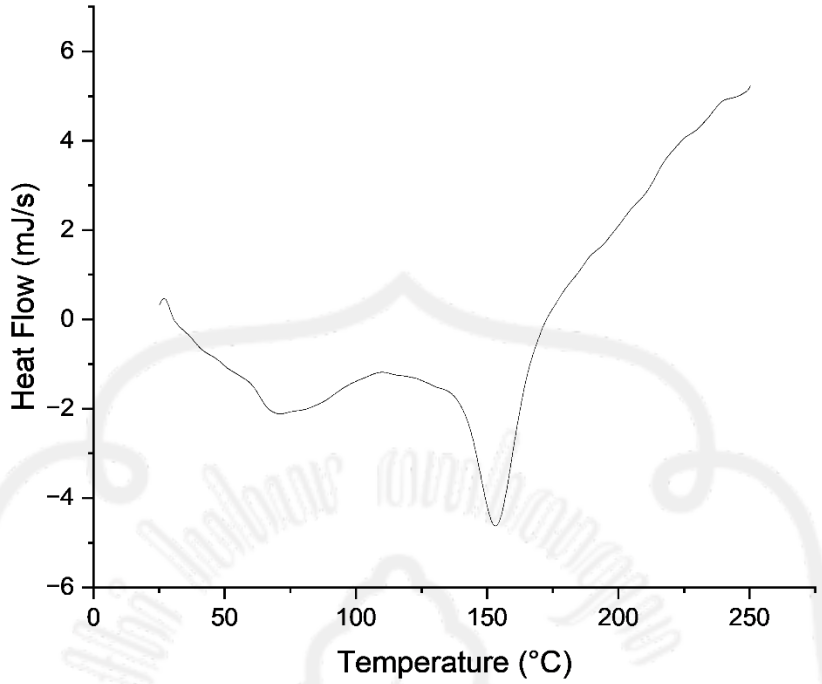
Panjang Kritis Serat (L_c) = 16,46 mm

Panjang Serat (L_f) = 1,656 mm

L_c / L_f = 9,939

Lampiran 7 : Grafik DSC dan TGA Poly Lactid Acid (PLA)

1. Grafik DSC PLA



2. Grafik TGA PLA