AS2070: AEROSPACE STRUCTURAL MECHANICS

Verification of Rule of Mixtures

Presented by:
Rishabh
Chitharth
Saran Raam S
Harshal J Patil
Niranjan B
P Siva Vardhan

Aim:

Validate the **Rule of Mixtures** for a composite laminate in Longitudinal Direction (E1)

Apparatus:

- Compression Moulding Machine to cure the laminate.
- Composite stacking station to make the laminate.
- UTM Machine for Sample Testing.
- Cutter: To cut out testing samples from laminate.
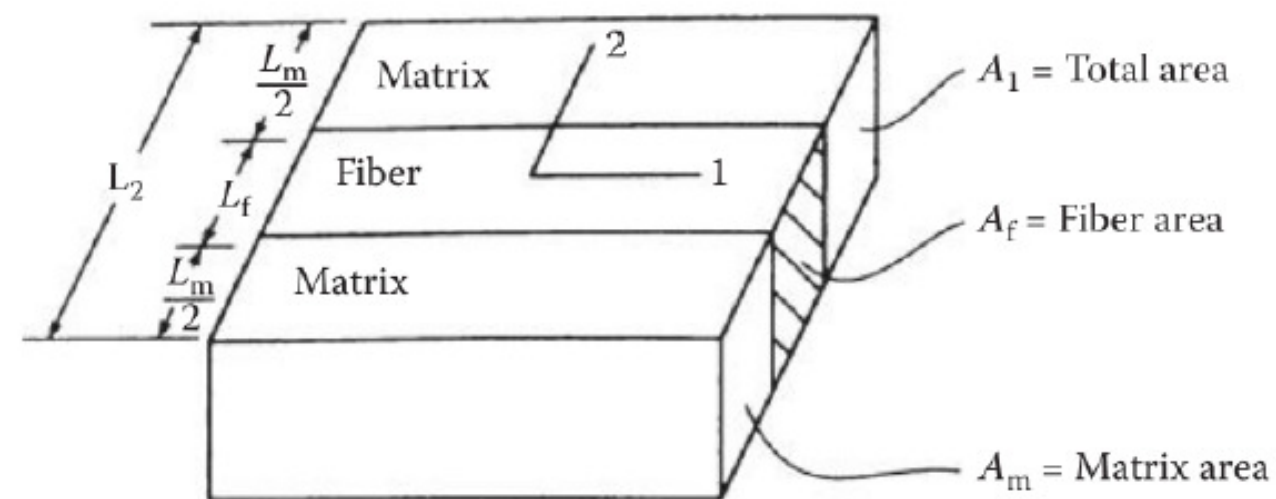

Compression Moulding Machine

Cutter

The Rule of Mixtures:

Volume Fraction $v_f = \frac{V_f}{V_c}, v_m = \frac{V_m}{V_c}, v_v = \frac{V_v}{V_c}$ such that $v_f + v_m + v_v = 1$
Note that composite density $\rho_c = \rho_f v_f + \rho_m v_m.$

Weight Fraction $w_f = \frac{\rho_f}{\rho_c} v_f$

$$E_1 = v_f E_f + v_m E_m$$

Procedure:

- Preparation of Matrix by mixing **epoxy** with a hardener (reaction catalyst)
- Stack the **fiber laminates**, ensuring thorough **impregnation** with the matrix

Dog bone shaped matrix

Stacking the laminates

- Place the laminate in a **compression moulding machine** and cure for 24 hours
- After curing, mark **dimensions** and **cut** samples using the cutter for burnout and UTM tests

Cutting of the laminates

- Prepare 2–3 samples per vf value to ensure experimental accuracy
- The Vf value is obtained by **burning** the square samples and getting the **remaining mass of matrix**

Square samples

- Test samples on the UTM to obtain **maximum stress and calculate stiffness modulus (Ex)** from the slope of the stress-strain curve
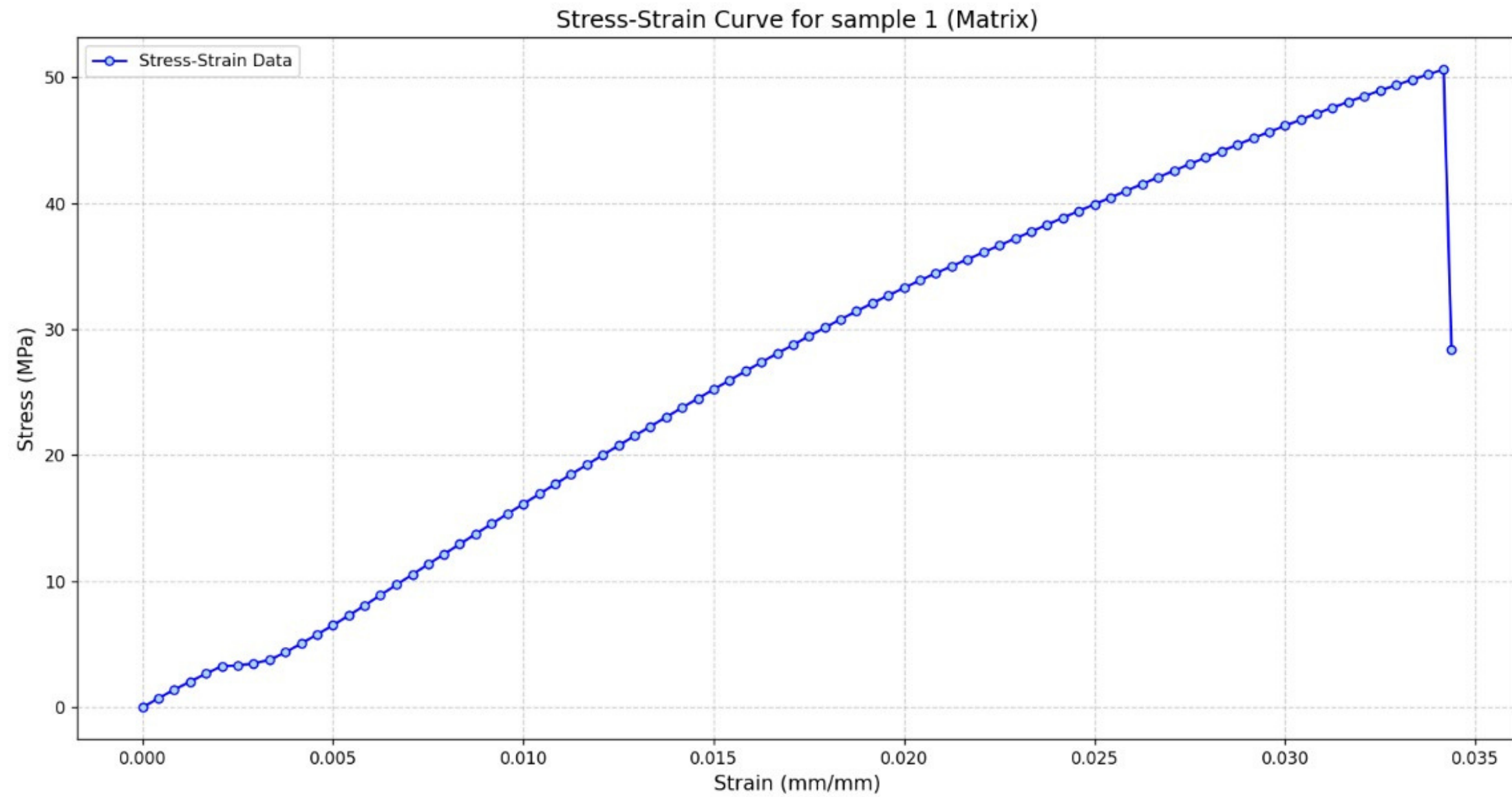

Testing the laminates

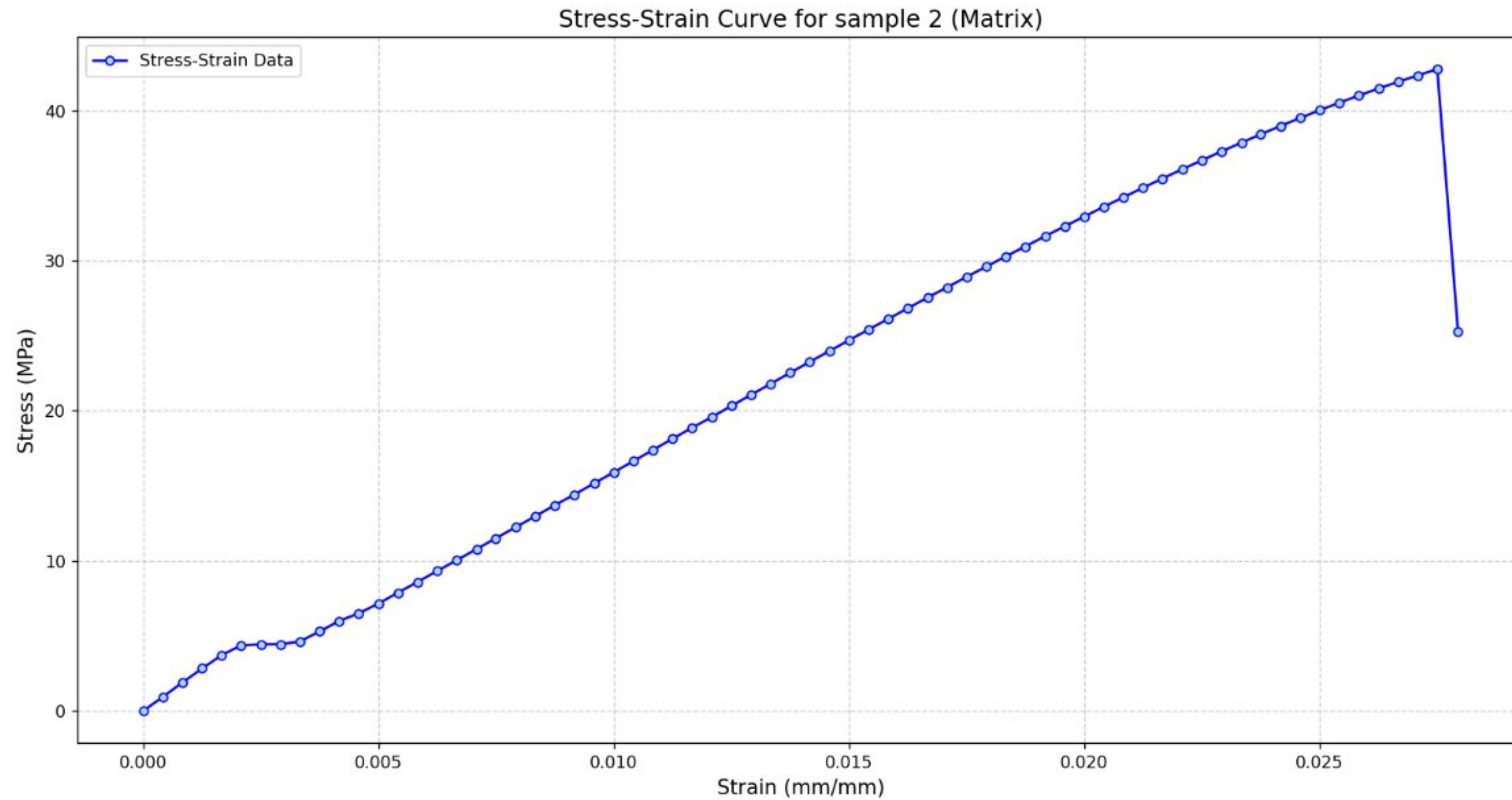

Delamination
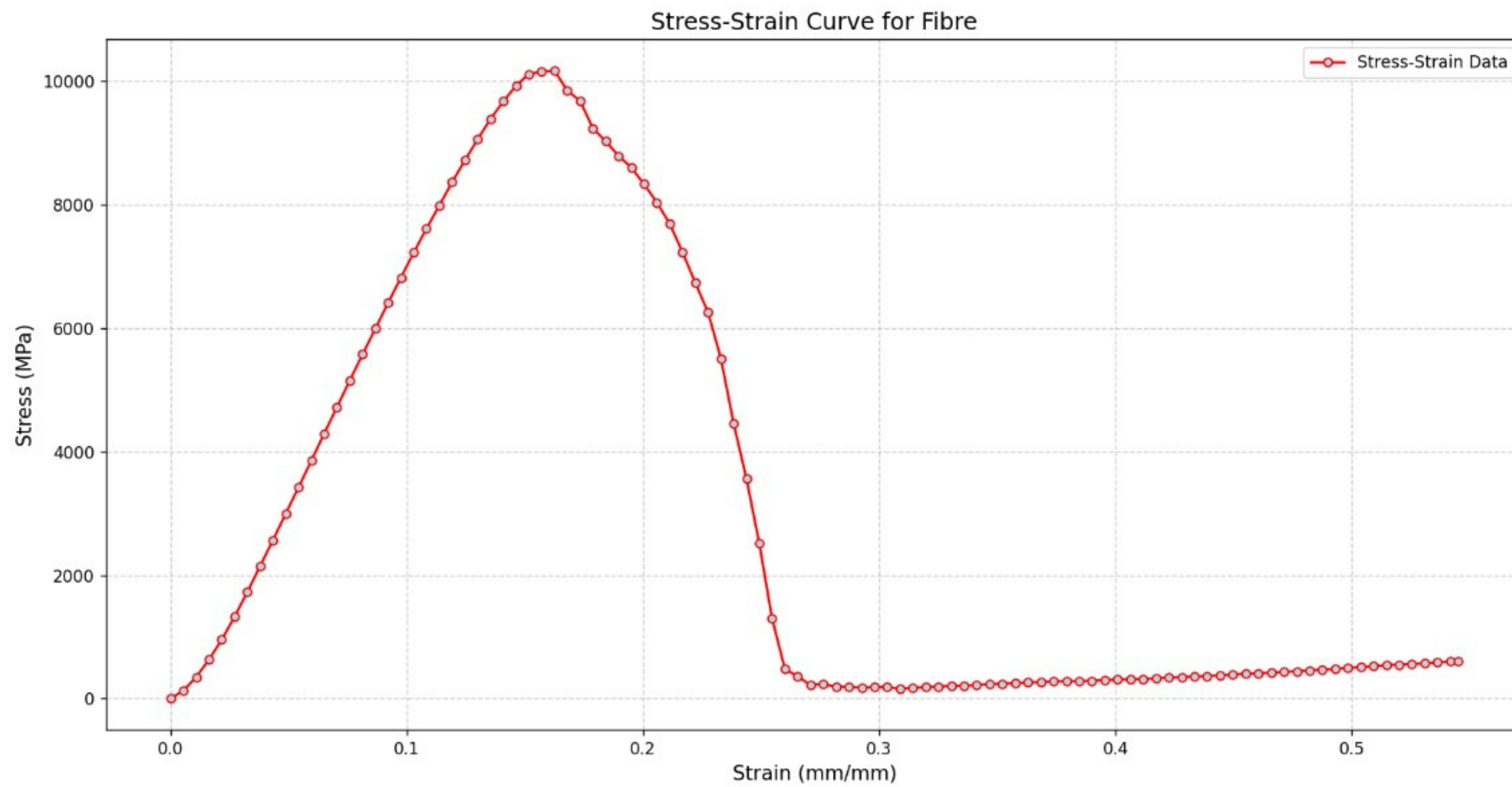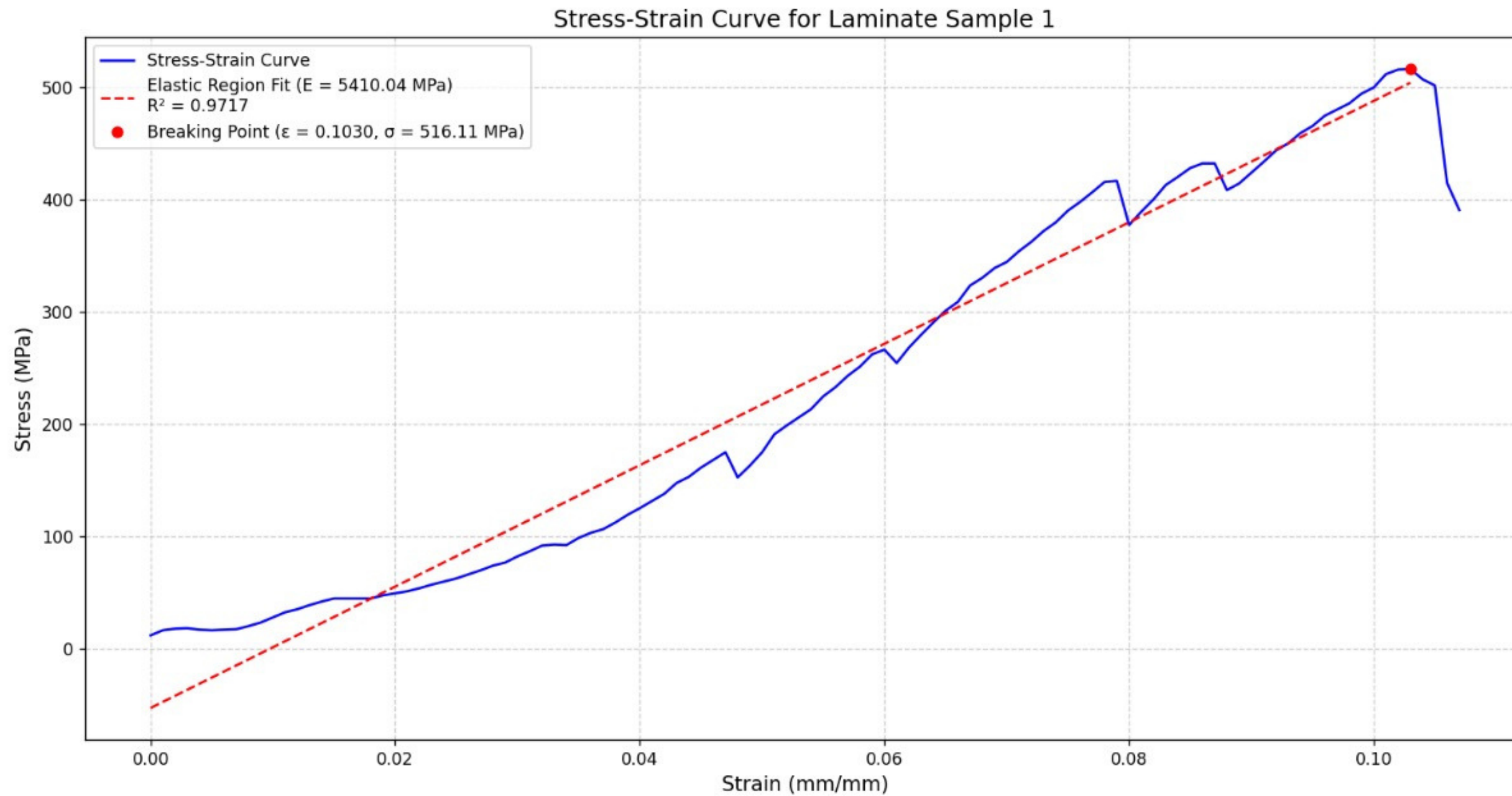
Plots:

Stress-Strain Curve for sample 1 (Matrix)

Plots:

Stress-Strain Curve for sample 2 (Matrix)

Plots:

Stress-Strain Curve for Fibre

Plots:

Stress-Strain Curve for Laminate Sample 1

— Stress-Strain Curve
--- Elastic Region Fit (E = 5410.04 MPa)
R² = 0.9717
● Breaking Point (ε = 0.1030, σ = 516.11 MPa)

Plots:

Stress-Strain Curve for Laminate Sample 2
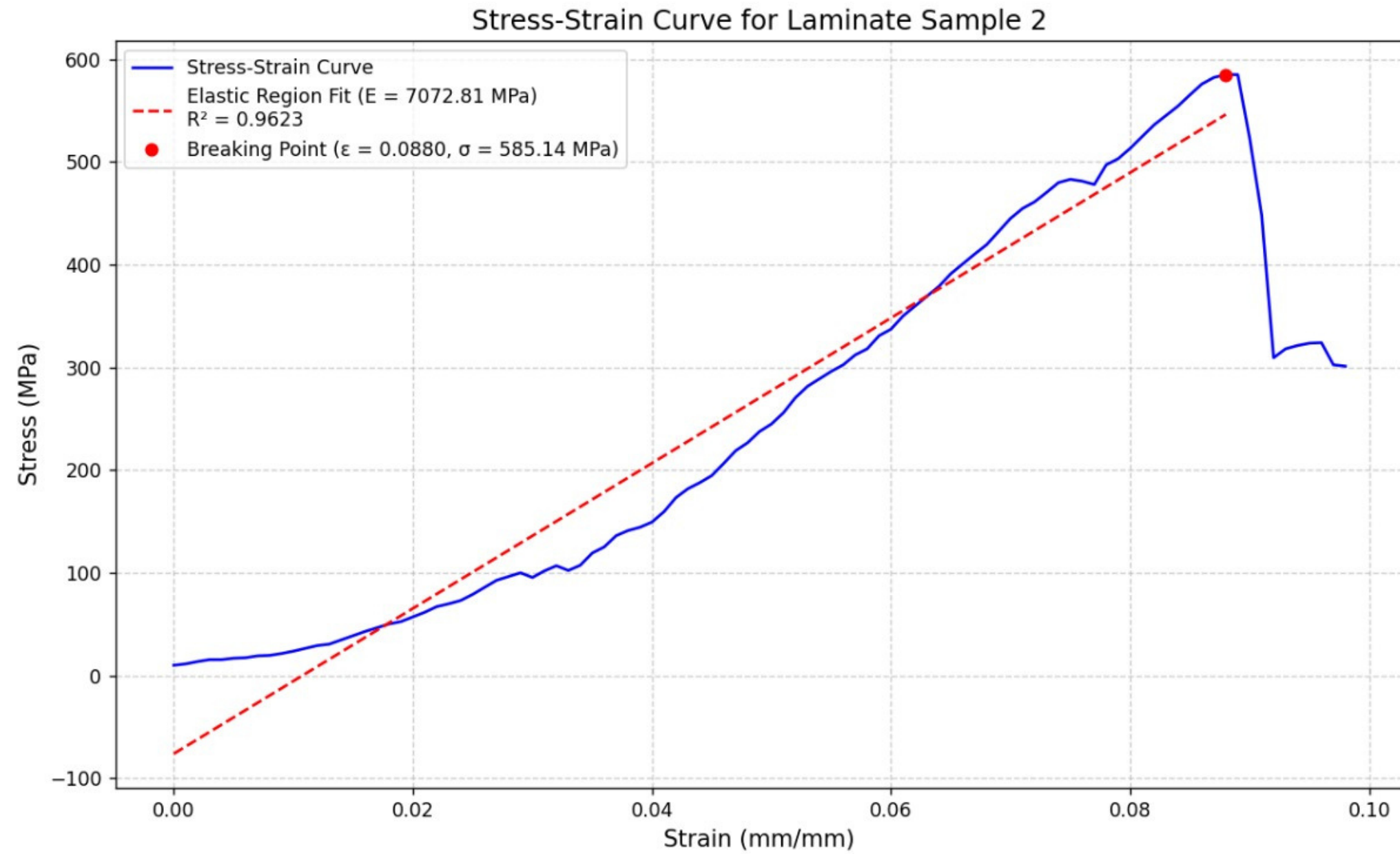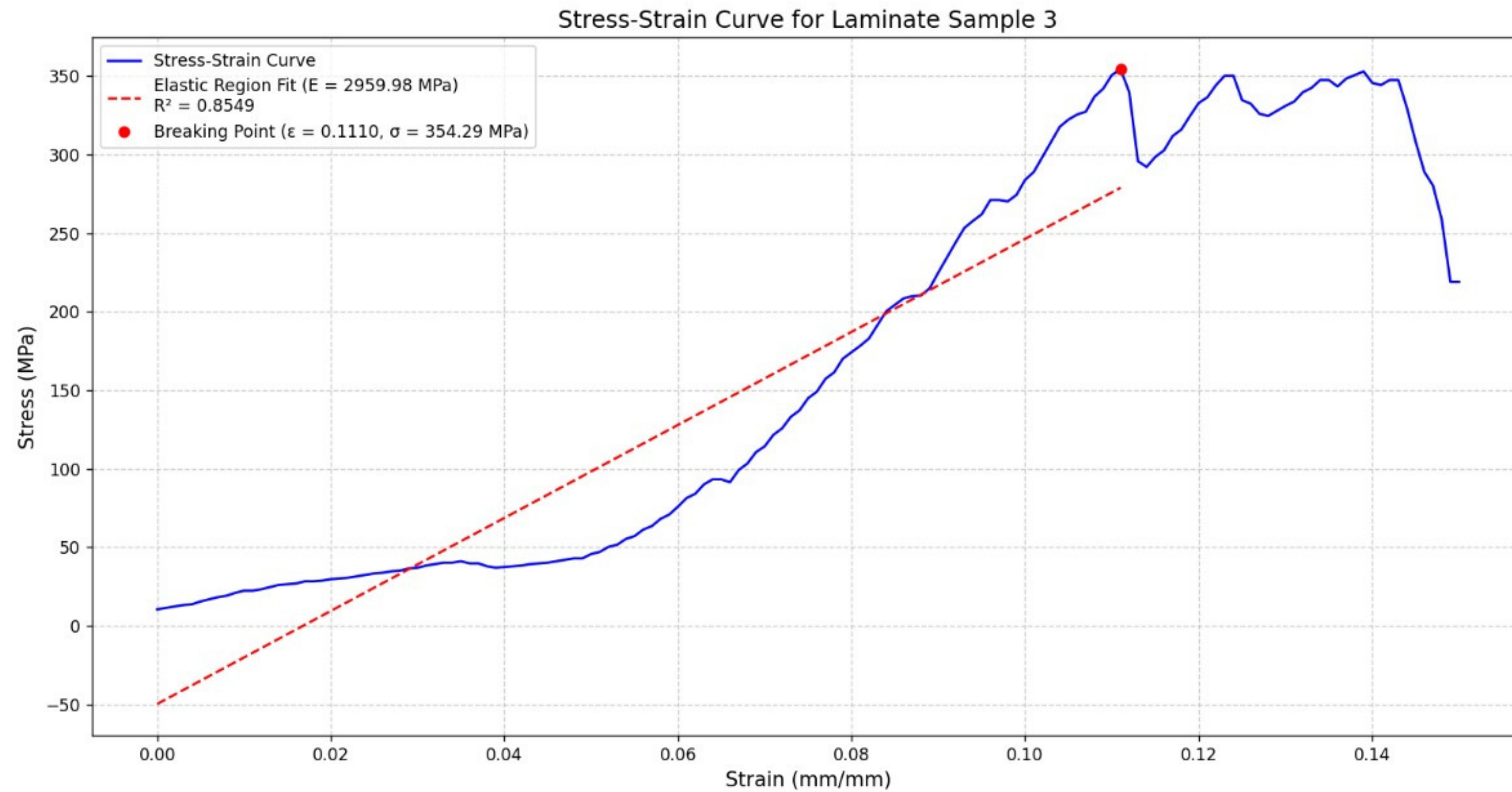
Plots:

Delamination

Plots:
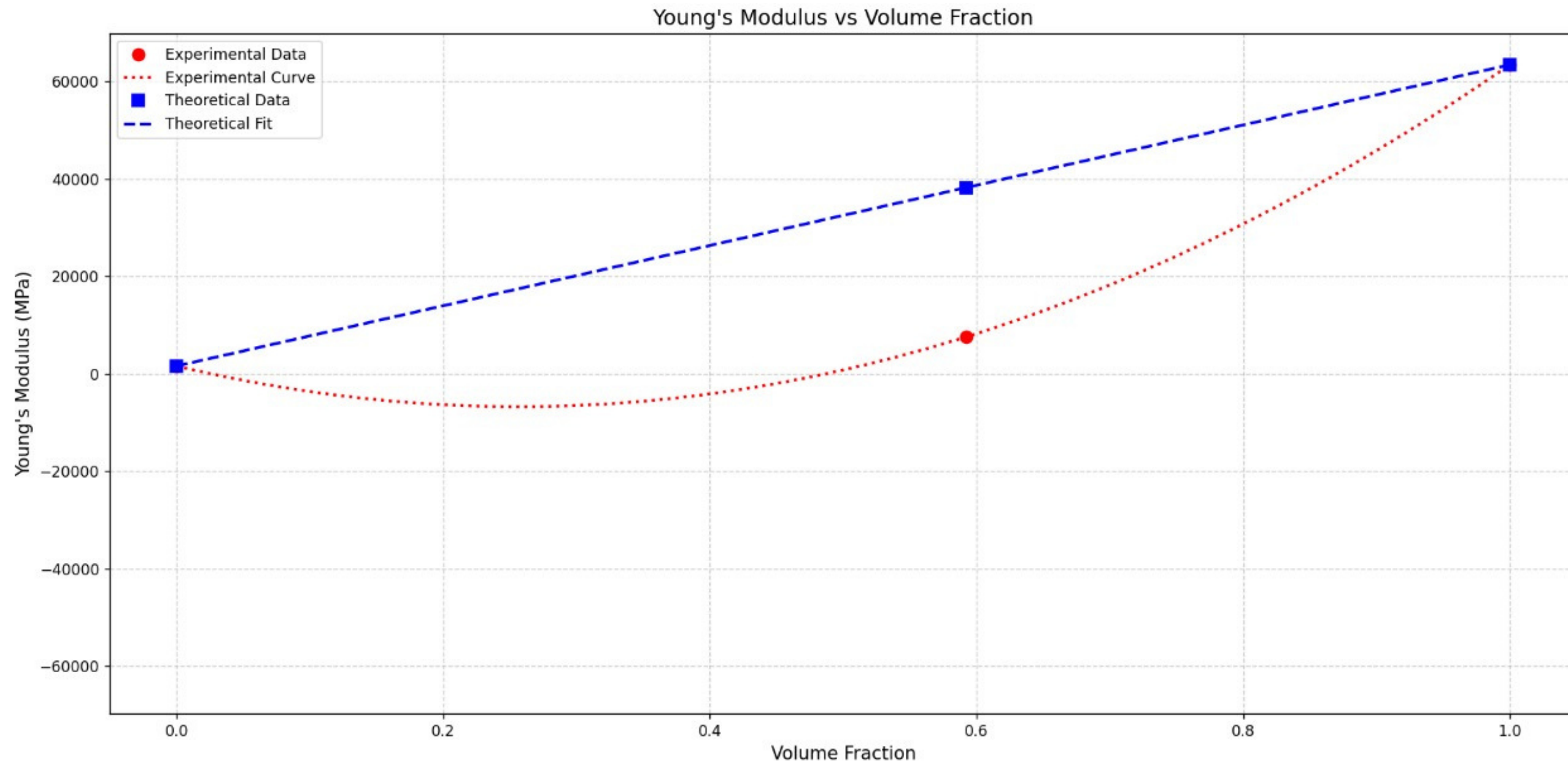
Ef vs vf

Results:

Vf = 0

E_m: 1584.52 Mpa

Vf = 0.592

$E_{theoretical}$: 38192 Mpa
$E_{experimental}$: 7543.93 Mpa

Vf = 1

E_f: 63423 Mpa

Sources of Error:

- Improper alignment of fibers
- Improper mixing of matrix and fibers
- Fabrication Defects

Conclusions:

- **Significant deviation** observed between theoretical and experimental Young's modulus values.
- **Improper fabrication techniques** could have introduced defects affecting material performance.
- Possible **delamination** between layers reduced effective load transfer, **impacting modulus**.

Acknowledgments

- Thanks to Professor Nidish sir for giving us an hands on opportunity to learn about structural mechanics
- Thanks to Teaching Assistant Senthil sir for helping us with this experiment
- Thanks to Professor David sir for giving us permission to use his Lab.
- Thanks to PHD student Sunil sir for helping us in manufacturing of composites
- Thanks to Vasanthi maam for giving us permission to use her lab for UTM testing

THANK YOU!