



Indian Institute of Technology, Madras

# **AS2070: COURSE PROJECT**

**Group D**

**Module: Composite Mechanics**



# **Experiment 1**

## **Experimental Analysis of**

## **Composite Laminate Failure**

# **HELLO!**

# **Experiment 2**

## **High Temperature Creep in**

## **Laminated Composites**

Divjot S Multani

Harsh Jena

Kusuma Priya

Mahesh Kumar

Nandan Surya

# OVERVIEW

01

AIM

02

APPARATUS

03

PROCEDURE

04

TENSILE TESTING

05

OBSERVATIONS

06

HIGH TEMPERATURE CREEP  
ANALYSIS

07

OBSERVATIONS

08

MISTAKES AND LEARNINGS



01

# AIM

## TENSILE TESTING OF LAMINATED COMPOSITES

In this experiment, we subject the laminated composites to tensile force and plot the stiffness curve.

02

## CREEP TESTING OF LAMINATED COMPOSITES

In this experiment, we subject the laminated composite to a constant tensile load which is below the yield strength at a certain temperature and plot the creep curve.

# APPARATUS

- Laminate sample (GFRP)
- Epoxy resin and hardener
- Waterjet Cutter
- Creep Testing Machine
- Universal Testing Machine (UTM)
- (Zwick Roell 7050)



# PROCEDURE

- Cut the specimen and tabs to the required size and shape using a water-jet cutter.
- Attach the tabs to the test specimen using epoxy resin and hardener.
- Can proceed with the experiments.



Dog-bone specimen used for  
creep testing



Specimen with tabs attached for  
tensile testing

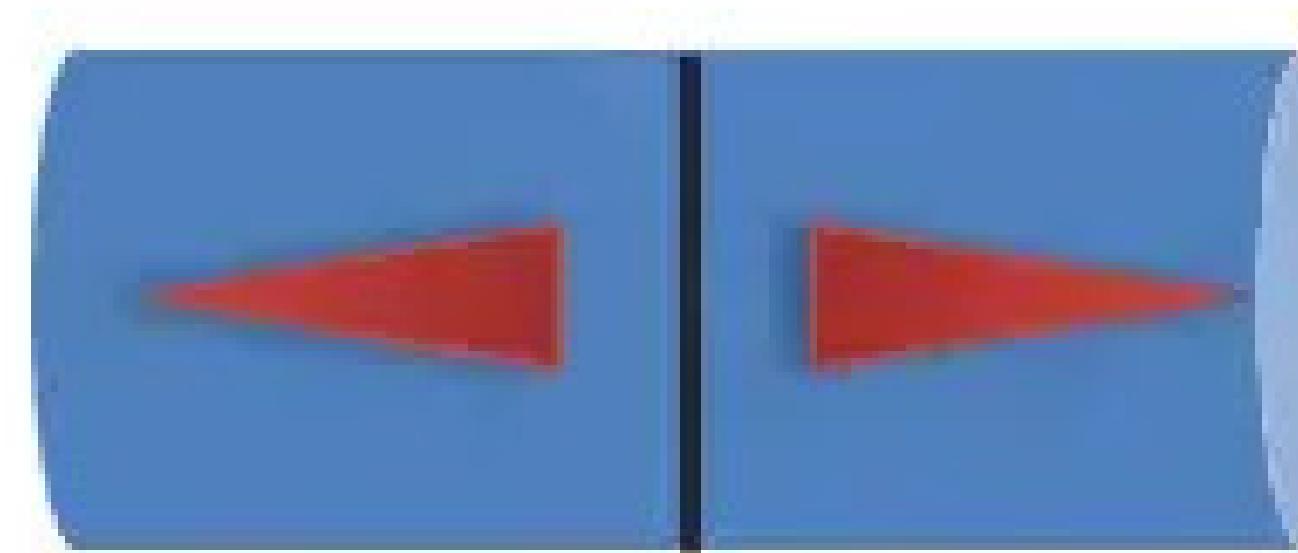
# WATER-JET CUTTER



# TENSILE TESTING

Tensile testing is a destructive mechanical test used to measure a material's strength and how much it can be stretched before breaking

Tensile



# **KINDS OF CONTROL**

## **FORCE CONTROL METHOD**

- Force-controlled tensile testing, the tensile testing machine applies a tensile force to a sample, and the test is controlled by the amount of force applied and the corresponding strain is measured.

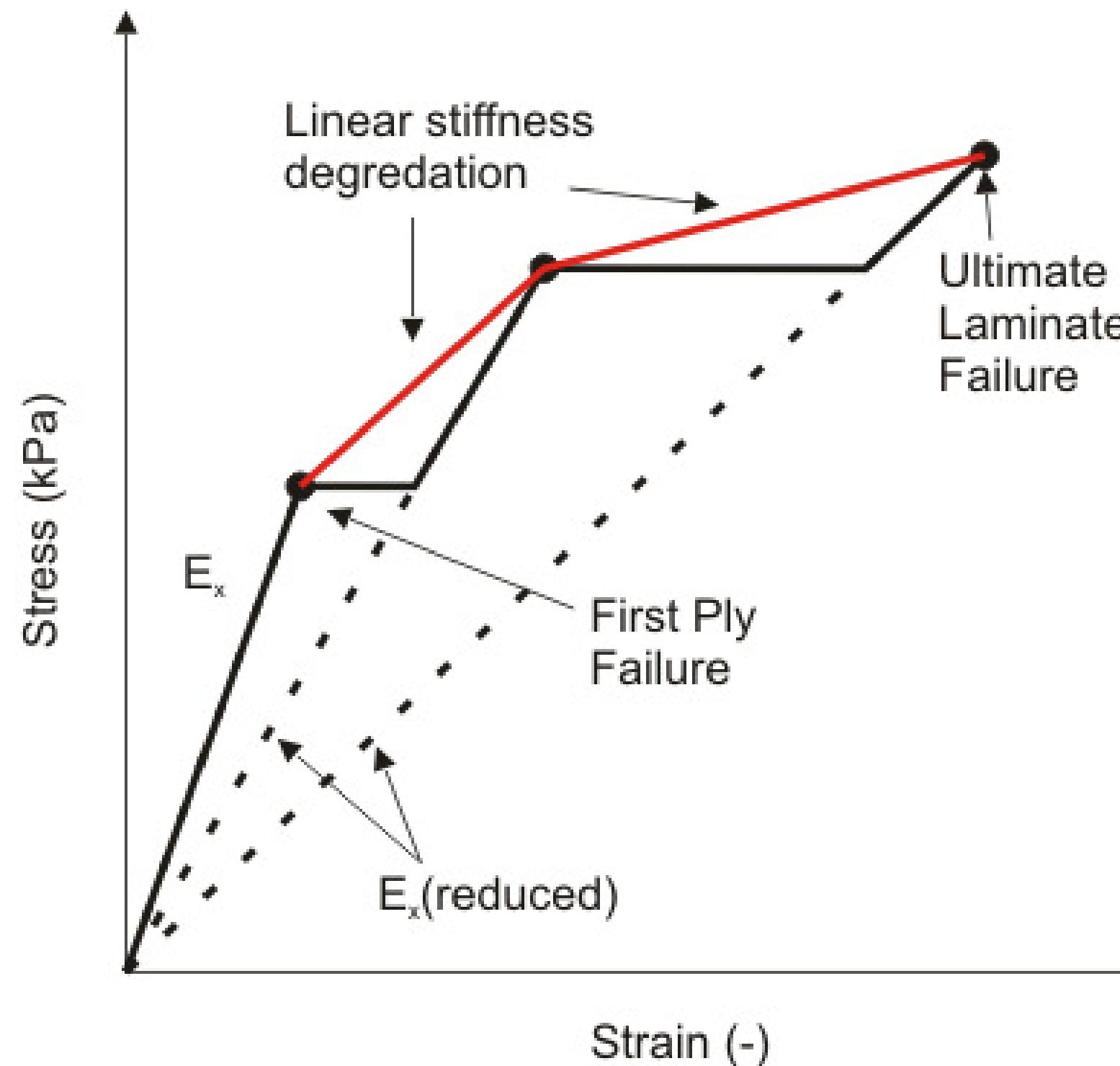
## **DISPLACEMENT CONTROL METHOD**

- In tensile testing with displacement control, the machine applies a specific displacement to the specimen, and the load required to maintain that displacement is measured
- We want this when we want to look into the plastic deformation of materials.

- The testing machine moves the specimen at a specified rate, and the load is measured as the specimen responds to that movement.
- The displacement is the independent variable, and the load reaction is the dependent variable.



# EXPECTED GRAPH



# PROGRESSION OF FAILURE

## 1. Matrix Cracking

- Occurs first in plies oriented transverse to the loading direction.
- As strain increases, the matrix experiences transverse tension and begins to crack perpendicular to the fibers.
- This reduces the local load-carrying ability of the affected plies and stiffness starts reducing.

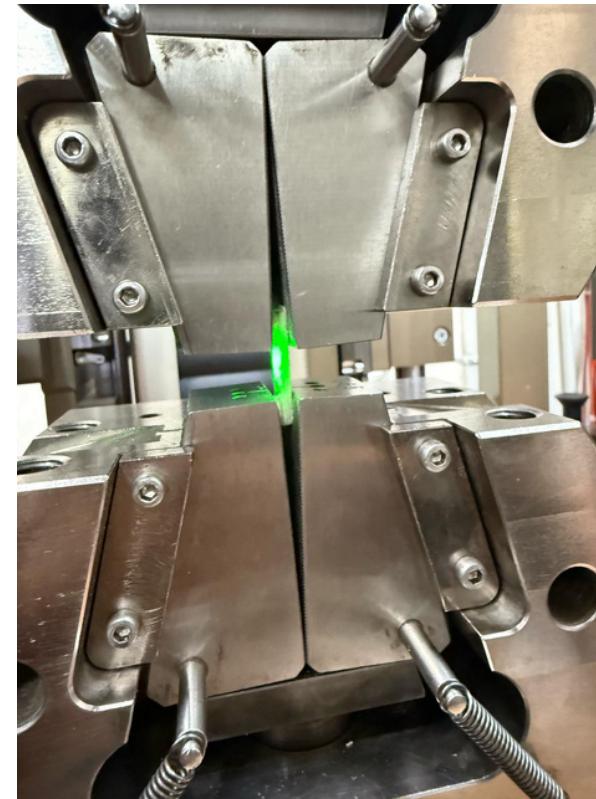
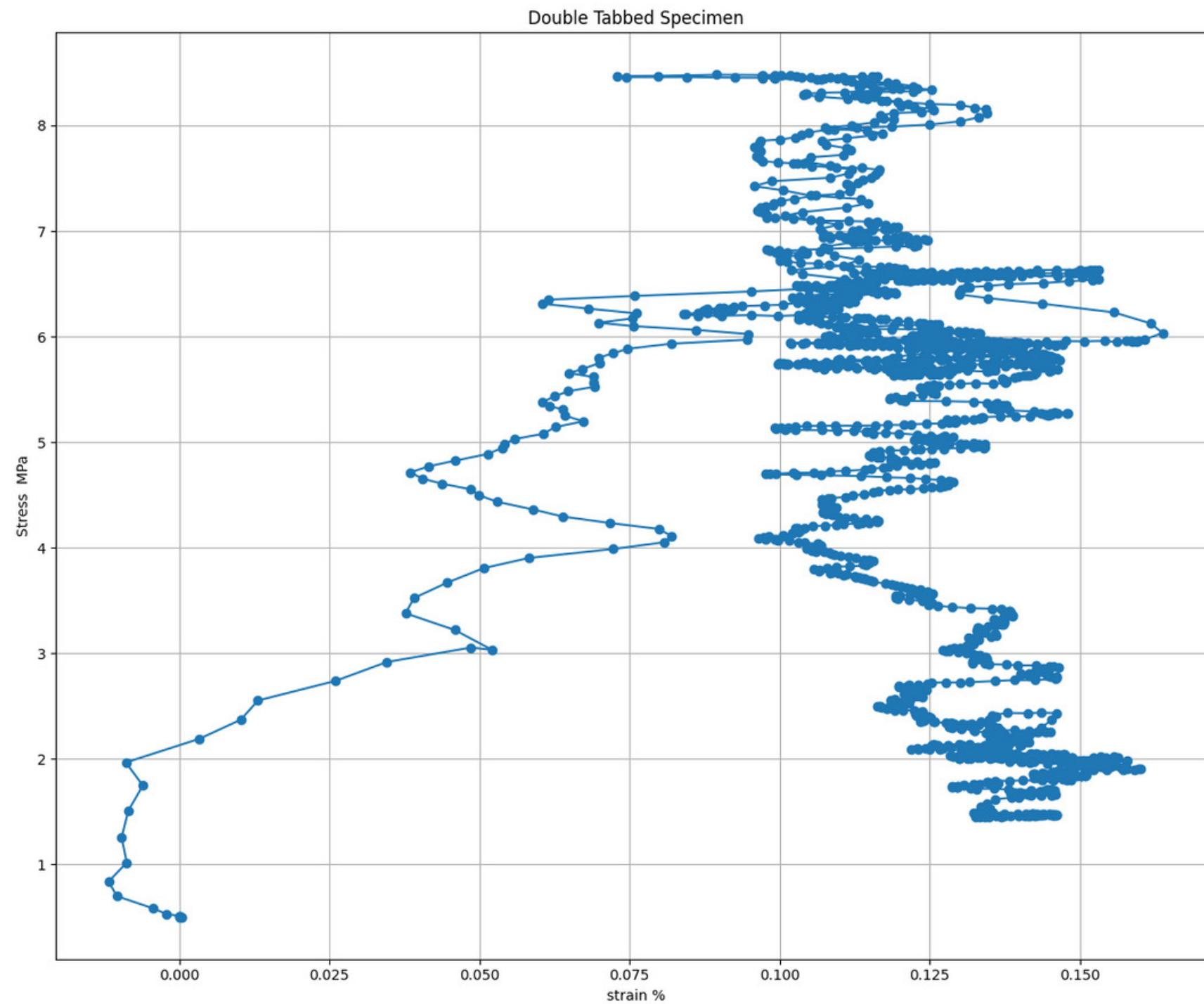
## 2. Ply failure

- As straining continues, more plies begin to fail based on their orientation and loading direction.
- Cracks accumulate in other off-axis plies and the fibres perpendicular too start breaking.
- This further weakens the laminate and stiffness gradually decreases with each ply failure.

## 3. Fibre Breakage

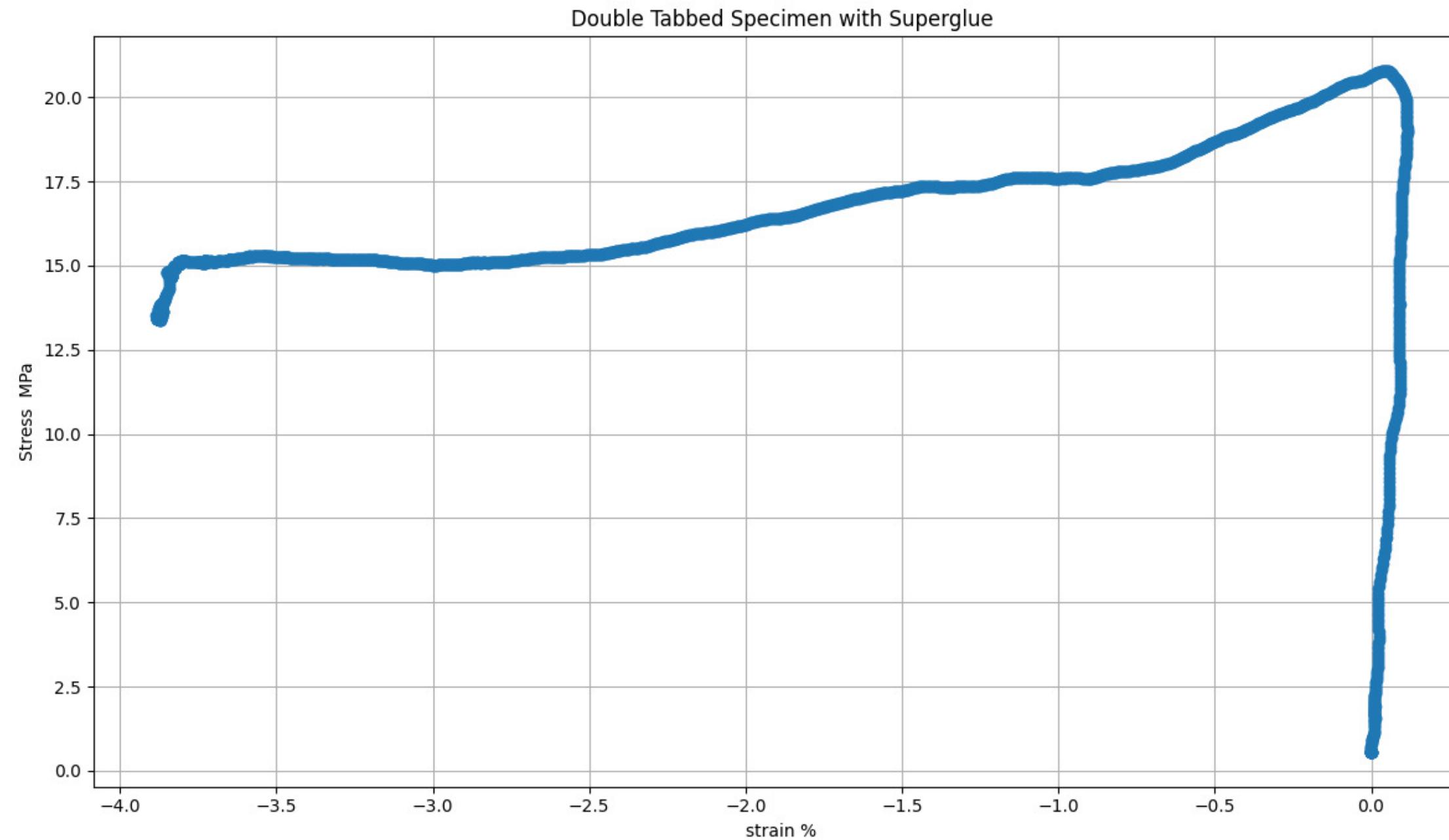
- At higher strains, fibres aligned with the load direction eventually reach their fracture point.
- These fibres bear most of the load, so their failure causes a sharp stress drop while strain continues. Once they fail, the structure can no longer bear load leading to sudden drop in the stiffness curve.
- This marks the complete failure of the laminate under tensile loading.

# OBSERVATIONS



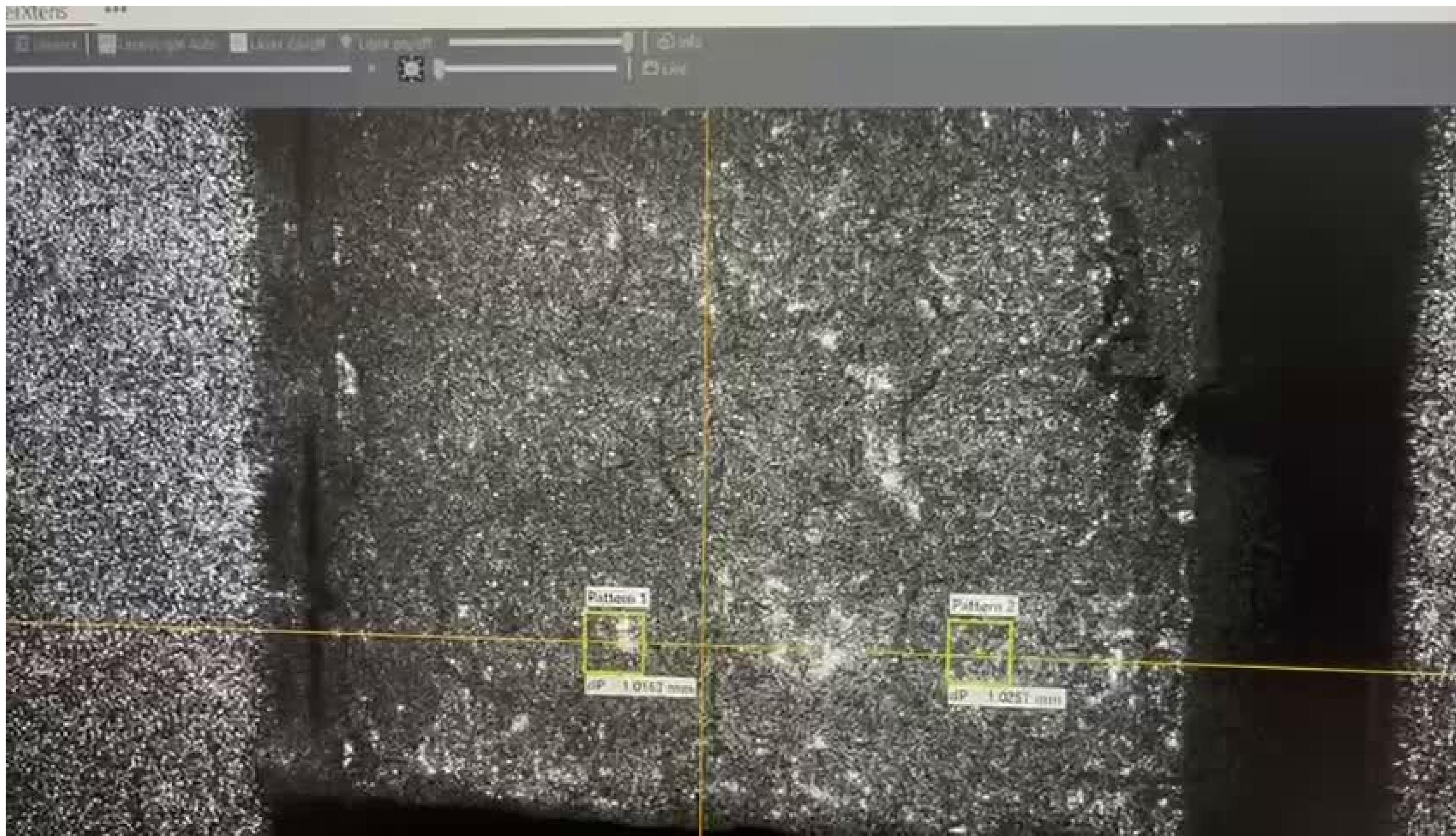
Specimen with tabs on both sides

# OBSERVATIONS



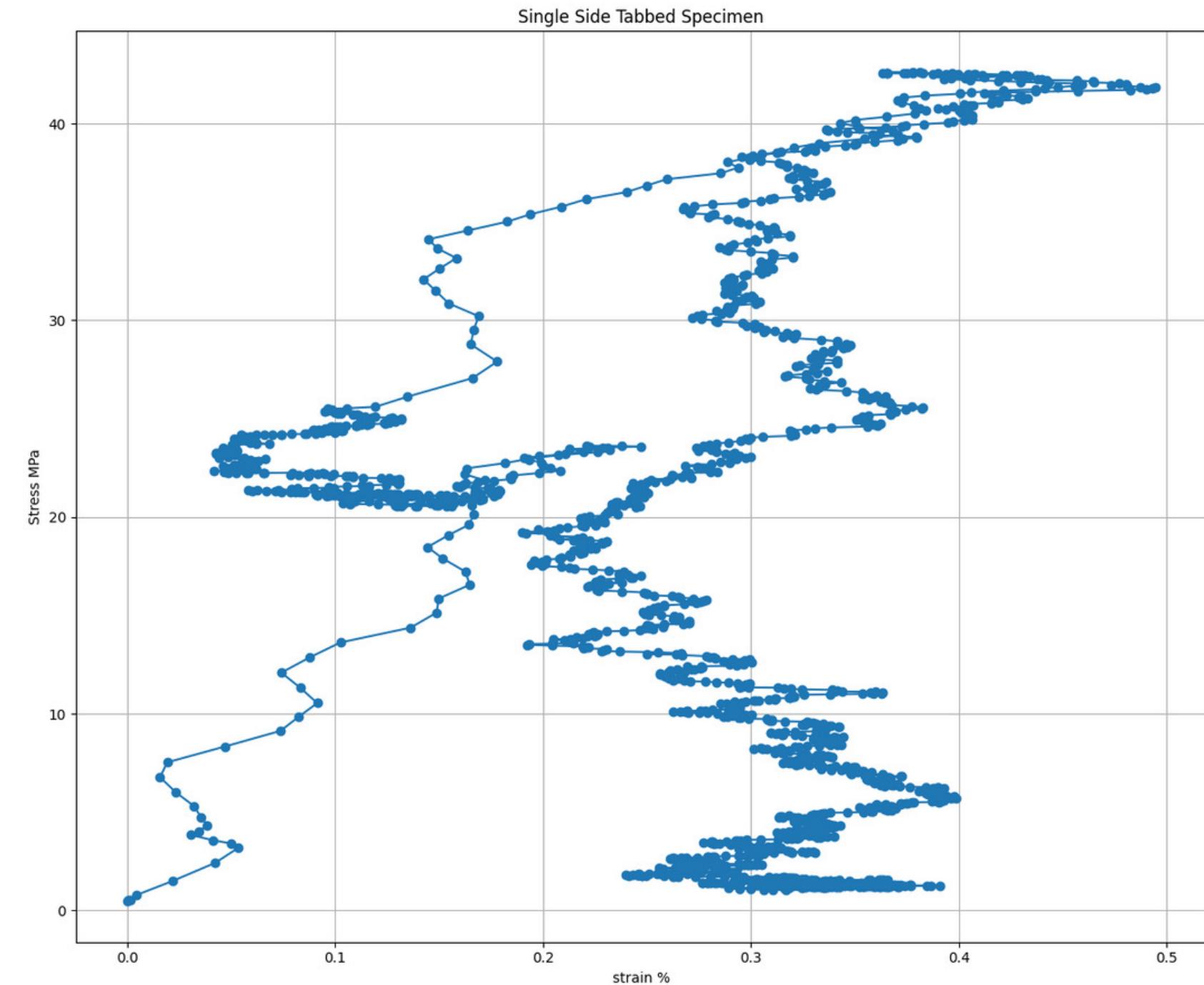
Specimen with tabs on both sides, enhanced using superglue

# OBSERVATIONS



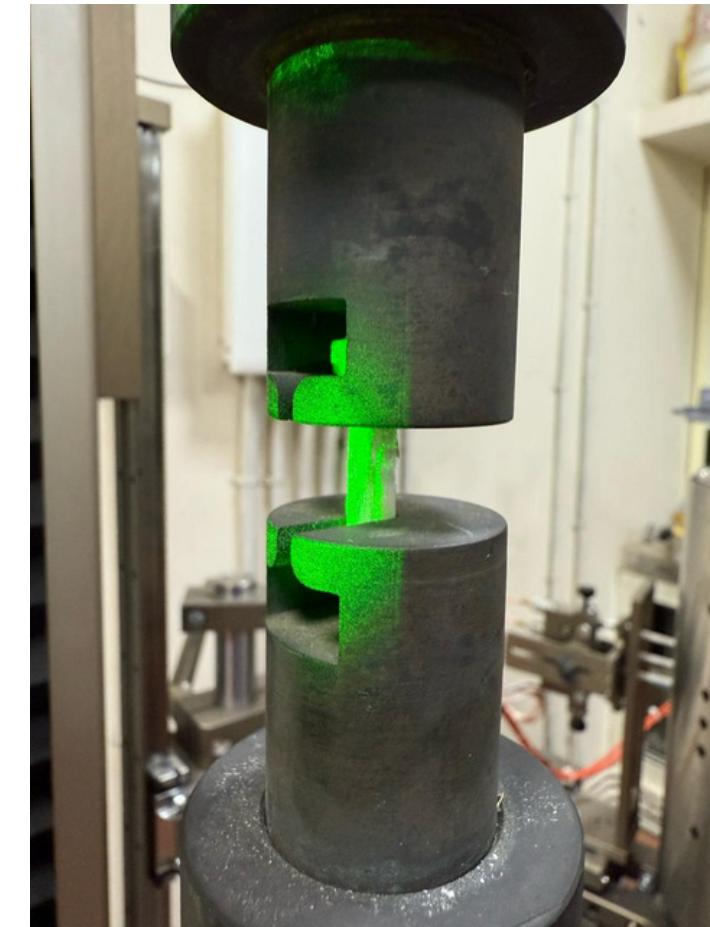
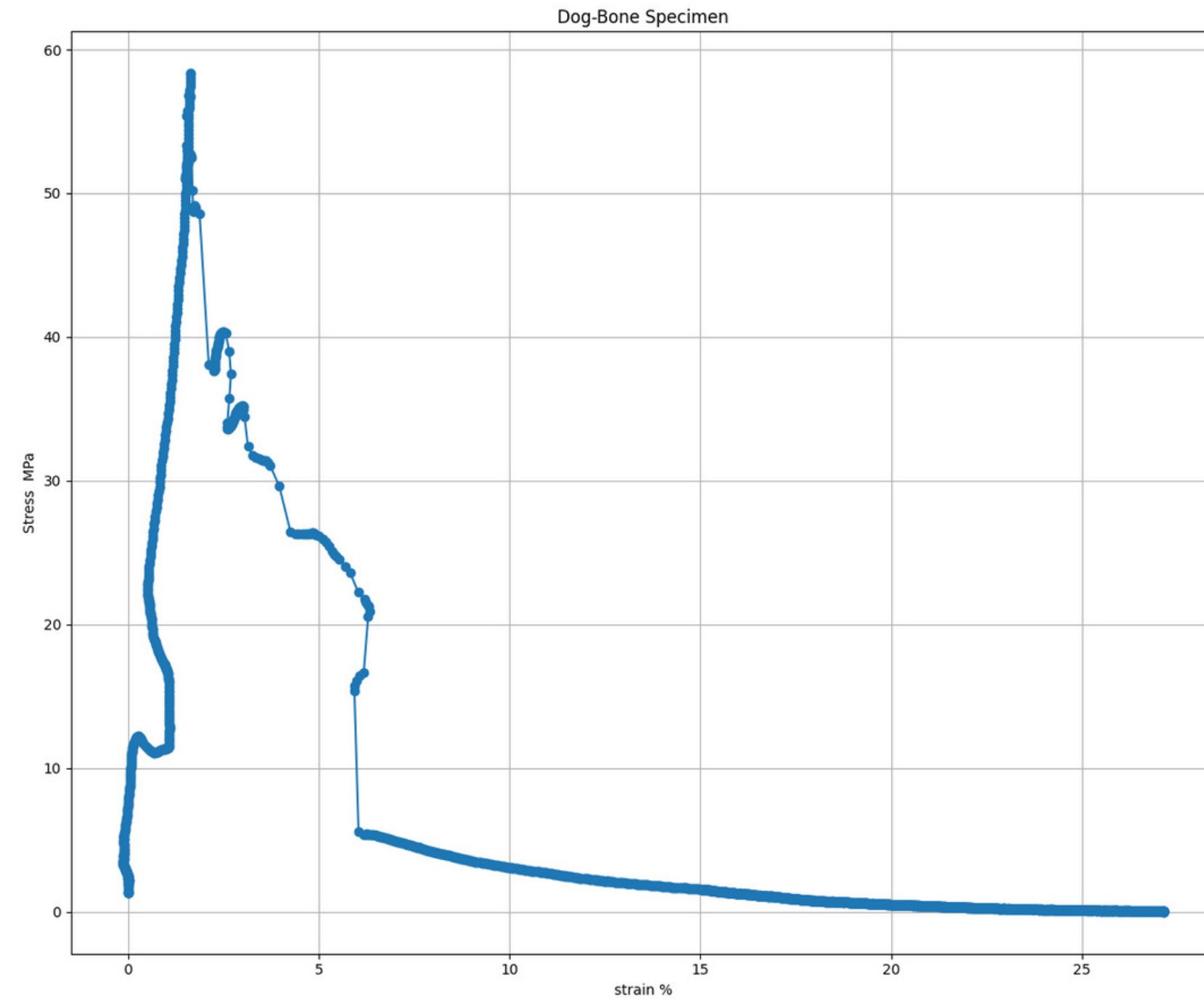
Visualising the Slipping of tabs

# OBSERVATIONS



Specimen with tabs on one side only

# OBSERVATIONS



2 Dog-Bone Shaped specimens stuck together

# OBSERVATIONS



Slipped/Detached Tabs

Failed Dog-bone Specimen  
under Tensile Testing



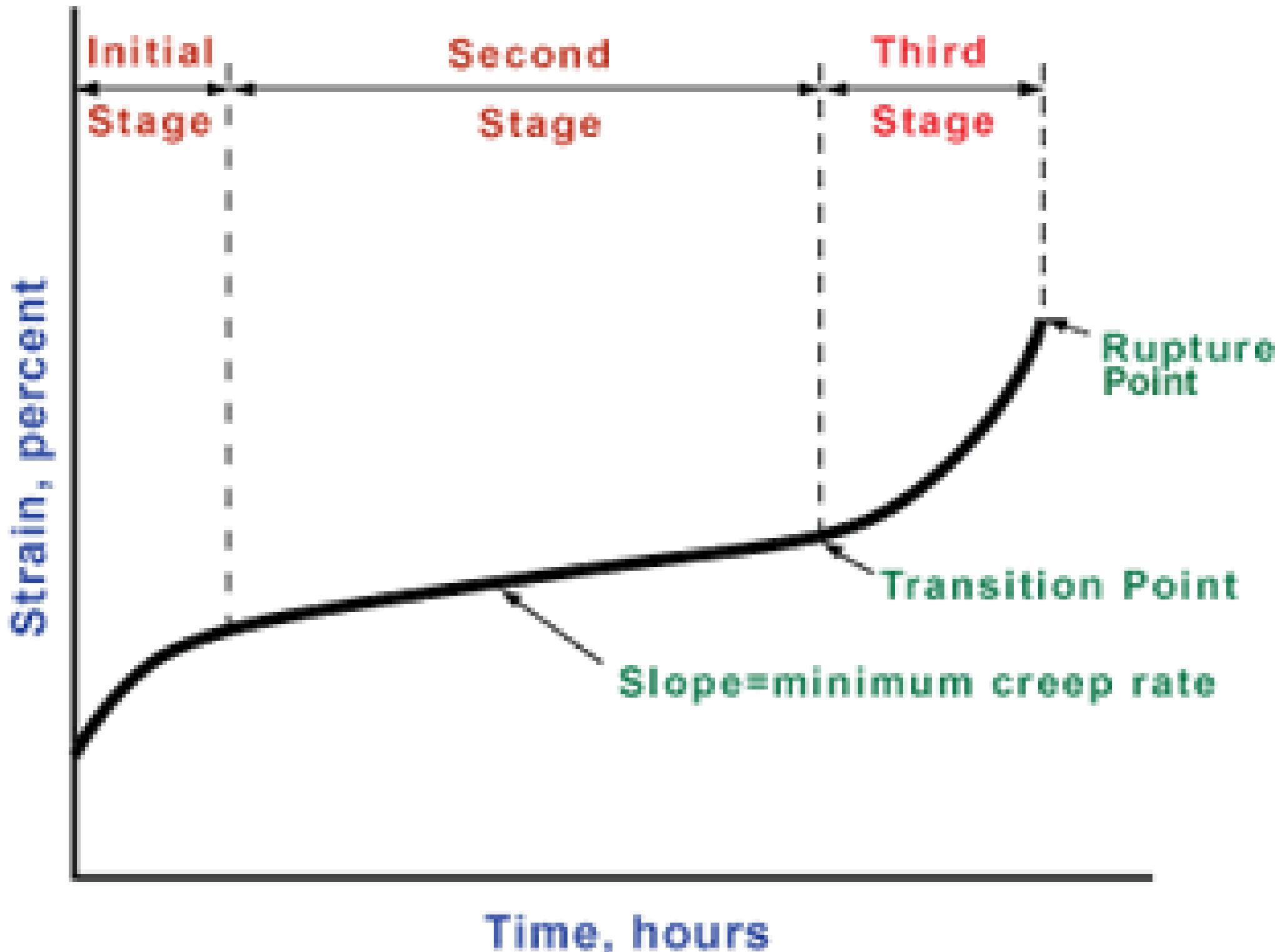
# **HIGH TEMPERATURE CREEP ANALYSIS**

# WHAT IS CREEP ?

- A small load applied for a long period of time
- The material initially has defects and small holes.
- The random motion of particles and these holes makes them club together to make larger defects.
- When these defects become large enough the material fails



# The Expectation



## Three Stages of Creep

### Primary Creep:

- Decreasing strain rate.
- Material work-hardens.
- Initial adjustment to stress.

### Secondary Creep:

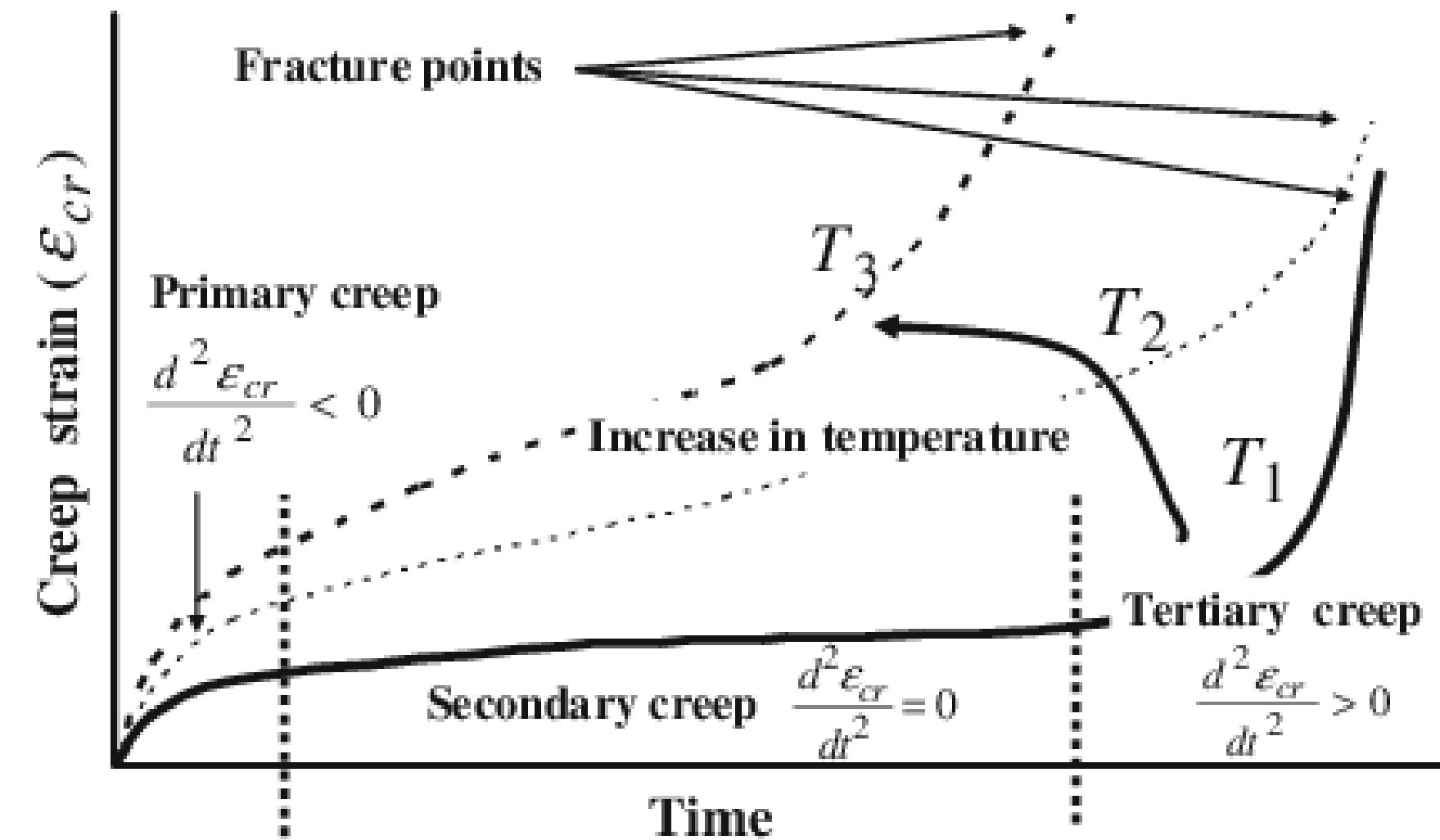
- Constant strain rate.
- Balance between hardening and recovery.
- Longest and most important stage for design.

### Tertiary Creep:

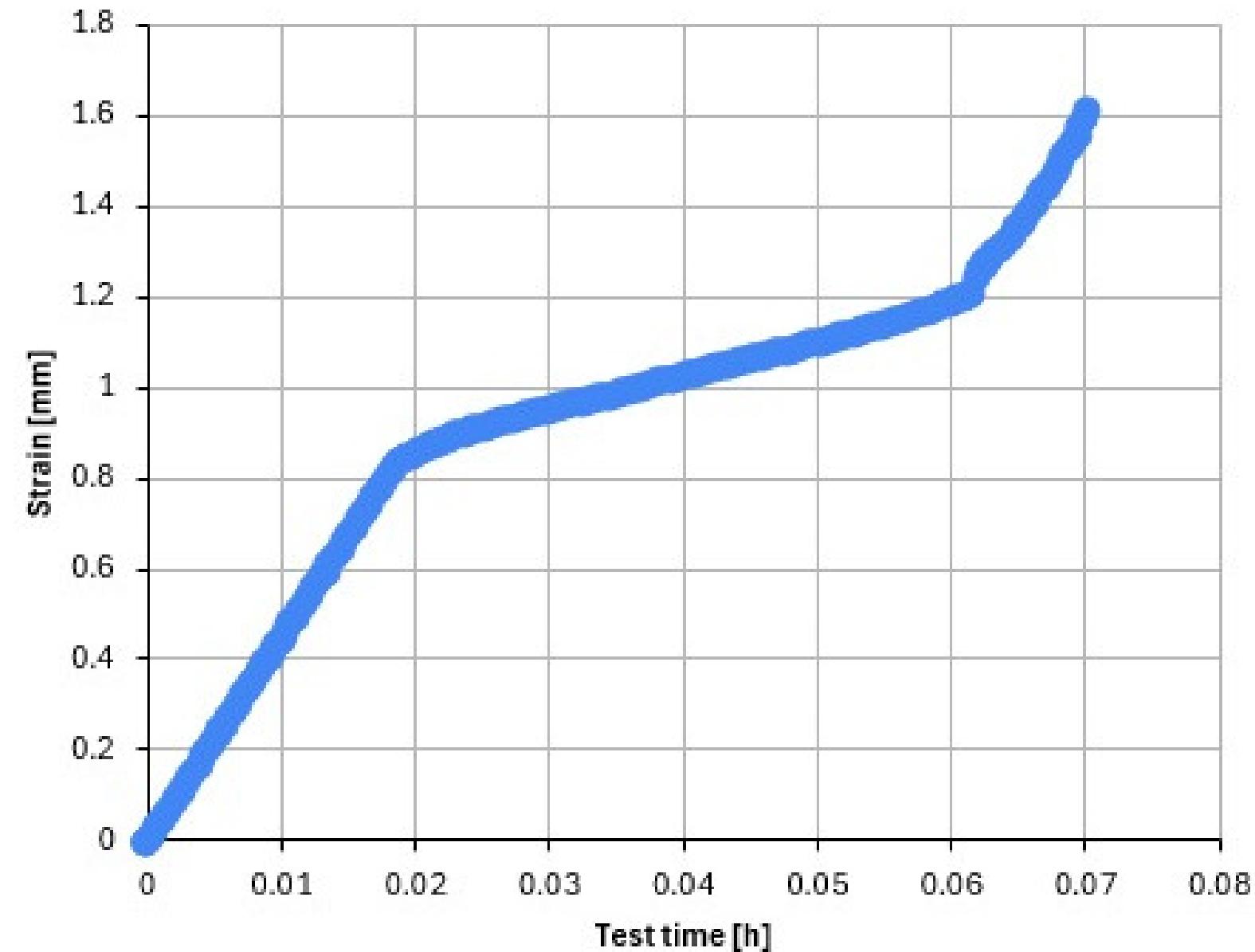
- Accelerating strain rate.
- Damage accumulation (voids, cracks).
- Leads to failure.

# The Effect of Temperature

Higher temperatures accelerate creep by increasing atomic diffusion and dislocation movement. This leads to faster deformation under constant stress. As a result, material life is reduced in high-temperature environments.



# OBSERVATIONS



High Temperature Creep Analysis

# MISTAKES & LEARNINGS

Listing down the mistakes we made during the Project and points to remember before performing an experiment

01

## ASTM Standards

We didn't follow the ASTM Standards for our Experiments Which is necessary to produce a result to compare with others

02

## Preparing Specimens

We didn't give cutting allowance for Specimen (When given for cut using Waterjet Cutter)  
Thus we couldn't meet accurate dimensions required

03

## Extra Specimens

We didn't make Extra specimens for our Experiments, which was essential when we made mistakes along the way

# MISTAKES & LEARNINGS

Listing down the mistakes we made during the Project and points to remember before performing an experiment

## 04

### Misinterpretation

#### Tensile Test Specimen

We made a specimen of similar dimensions used for creep test for Tensile Testing: Which resulted in lesser gripping area

#### Sticking Creep Specimens

We stuck two creep specimens together which wasn't required and added increased complexity and irregularities to our experiment

# Special Thanks To:

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**THANK YOU**