

#### SNS COLLEGE OF TECHNOLOGY



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#### DEPARTMENT OF AEROSPACE ENGINEERING

Faculty Name	:	Dr.P.GOPI KRISHNAN, ASP/ AERO	Academic Year	:	2024-2025 (EVEN)
Year & Branch	:	III AERO	Semester	:	VI
Course	:	<b>19ASE310 FATIGUE AND FRACTURE MECHANICS</b>			

#### LECTURE NOTES

### **TOPIC: Fatigue of Composite Materials**

## 1. Introduction

Composite materials are widely used in aerospace, automotive, marine, and structural applications due to their high strength-to-weight ratio, corrosion resistance, and tailored mechanical properties. However, when subjected to cyclic loading, composite materials exhibit unique fatigue behavior that differs significantly from metallic materials. Understanding fatigue in composites is essential for ensuring structural reliability and durability.

## 2. Definition

**Fatigue of composite materials** refers to the progressive and irreversible damage accumulation that occurs when these materials are subjected to repeated cyclic loading, eventually leading to failure. Unlike metals, which fail due to crack propagation, composite materials degrade through multiple damage mechanisms such as matrix cracking, fiber breakage, delamination, and interfacial debonding.

## **3. Importance of Studying Fatigue in Composites**

- **Structural Safety:** Ensures the reliability of composite structures under cyclic loads.
- **Material Selection:** Helps engineers choose appropriate fiber-matrix combinations for fatigue resistance.
- **Design Optimization:** Enables the development of fatigue-resistant composite structures for critical applications.
- **Predictive Maintenance:** Aids in establishing maintenance schedules and lifecycle assessments for composite components.

#### 4. Fatigue Behavior of Composite Materials

Unlike metals, where fatigue life is mainly governed by stress amplitude, composites exhibit complex fatigue behavior influenced by multiple factors:

- **Stress Ratio:** The ratio of minimum to maximum stress in the cycle affects fatigue life.
- **Fiber Orientation:** The alignment of fibers plays a crucial role in fatigue strength.
- Loading Type: Axial, bending, and shear loads result in different fatigue failure modes.
- Environmental Factors: Temperature, humidity, and exposure to chemicals can accelerate fatigue degradation.

# 5. Advantages of Composite Materials in Fatigue Performance

- High Specific Strength: Lightweight yet strong, reducing weight in structures.
- **Resistance to Corrosion and Wear:** Unlike metals, composites do not suffer from oxidation-related fatigue.
- **Tailorable Properties:** Engineers can modify fiber orientation and layup to enhance fatigue resistance.
- **Damage Tolerance:** Some composite systems exhibit damage progression without sudden failure.

### 6. Limitations of Composite Materials Under Fatigue

- **Complex Failure Mechanisms:** Matrix cracking, fiber breakage, and delamination can occur simultaneously.
- **Difficult Damage Detection:** Internal defects and fatigue damage are not easily visible.
- **Manufacturing Variability:** Small defects during fabrication can significantly affect fatigue life.
- **Environmental Sensitivity:** Exposure to moisture and extreme temperatures can degrade fatigue resistance.

# 7. Applications of Composite Materials in Fatigue-Prone Environments

- Aerospace Industry: Fatigue analysis is critical for aircraft wings, fuselage panels, and rotor blades.
- **Automotive Sector:** Composite components in electric vehicles and performance cars require fatigue-resistant designs.
- **Wind Energy:** Turbine blades experience cyclic wind loads, requiring fatigueresistant composites.
- **Marine Structures:** Ship hulls and offshore platforms benefit from fatigueresistant composite materials.
- **Sports Equipment:** Bicycles, tennis rackets, and golf clubs use composites for enhanced durability.

Fatigue behavior in composite materials is a complex phenomenon influenced by multiple factors, requiring detailed analysis for effective engineering applications. While composites offer excellent fatigue resistance compared to metals, their failure mechanisms differ significantly, necessitating specialized testing and predictive modeling. Understanding these aspects is essential for designing durable and reliable composite structures across various industries.