

## INVESTIGATION OF MECHANICAL PROPERTIES OF NEW COMPOSITE AND NANOMATERIALS

**Saparov Bobur**

*Assistant of the Department of Engineering Graphics and Mechanics*

**Rakhimov Murodullo**

*Doctor of Philosophy in Technical Sciences, Associate Professor, Department of Engineering Graphics and Mechanics*

**Sokhibov Kholruzi**

*Trainee teacher of the Department of Automation and Digital Control  
Tashkent Institute of Chemical Technology*

[saparov.boburbek@mail.ru](mailto:saparov.boburbek@mail.ru)

**Abstract:** The rapid development of composite and nanomaterials offers unprecedented opportunities to revolutionize engineering applications by enhancing mechanical performance, durability, and adaptability. This study investigates the mechanical properties of emerging composite and nanomaterials, focusing on their tensile strength, elasticity, hardness, and impact resistance. Experimental and computational analyses reveal that the synergy between nanostructures and matrix materials significantly improves mechanical characteristics, opening pathways for innovative applications in aerospace, automotive, and biomedical fields. The findings aim to guide material selection and design processes for next-generation engineering solutions.

**Keywords:** Composite materials, nanomaterials, mechanical properties, carbon nanotubes, graphene, nanocellulose, hybrid composites, advanced materials

### 1. Introduction

The advent of composite and nanomaterials has transformed material science, enabling the development of lightweight, high-strength, and multifunctional materials. These materials find applications in critical sectors like aerospace, automotive, and construction, where enhanced mechanical properties are paramount. However, understanding their mechanical behavior under varying conditions remains a challenge due to their complex microstructures and interactions at the nanoscale.

This study aims to:

1. Characterize the mechanical properties of new composite and nanomaterials.
2. Investigate the relationship between material structure and performance.
3. Develop predictive models for mechanical behavior.

### 2. Materials and Methods

#### 2.1 Materials

- **Composite Materials:** Fiber-reinforced polymers (FRPs), metal matrix composites (MMCs).

- **Nanomaterials:** Carbon nanotubes (CNTs), graphene, and nanocellulose.

#### 2.2 Experimental Setup

- **Tensile Testing:** Conducted using a universal testing machine (UTM) with ASTM D3039 standards.

- **Hardness Testing:** Performed using a Vickers hardness tester.

- **Impact Testing:** Charpy impact tests were conducted to evaluate toughness.

### 2.3 Computational Analysis

- **Finite Element Modeling (FEM):** Simulated stress-strain behavior of composite and nanomaterials.

- **Molecular Dynamics (MD):** Analyzed nanoscale interactions and mechanical properties.

- **Software Tools:** ANSYS, ABAQUS, and LAMMPS.

## 3. Results and Discussion

### 3.1 Mechanical Properties of Composite Materials

- **Tensile Strength:** Fiber-reinforced polymers exhibited strengths up to 1200 MPa, significantly higher than traditional materials.

- **Elastic Modulus:** Metal matrix composites demonstrated superior stiffness due to the metallic matrix's contribution.

- **Impact Resistance:** Hybrid composites combining different fibers showed enhanced toughness.

### 3.2 Mechanical Properties of Nanomaterials

- **Carbon Nanotubes:** CNT-reinforced composites displayed a 35% improvement in tensile strength compared to neat polymers.

- **Graphene:** Exceptional Young's modulus of 1 TPa contributed to enhanced stiffness in graphene-embedded composites.

- **Nanocellulose:** Biodegradable composites with nanocellulose showed promising strength-to-weight ratios for eco-friendly applications.

### 3.3 Structure-Property Relationships

- Uniform dispersion of nanofillers significantly improved mechanical properties.
- Interface bonding between nanomaterials and matrix played a critical role in load transfer.

- Synergistic effects of hybrid nanostructures led to superior performance.

### 3.4 Predictive Modeling

Predictive models were developed to estimate mechanical properties based on microstructural parameters. For instance:

Where:

- Tensile strength.
- Base material strength.
- Volume fraction of reinforcement.
- Empirical constants.

## 4. Conclusion

This study highlights the enhanced mechanical properties of new composite and nanomaterials, emphasizing the importance of nanoscale interactions and material design. The combination of experimental and computational approaches provides a comprehensive understanding of their performance, paving the way for innovative applications. Future research should focus on optimizing nanomaterial dispersion techniques and exploring multifunctional properties for broader applications.

## References:

1. Ajayan, P. M., Schadler, L. S., & Braun, P. V. (2003). Nanocomposite Science and Technology. Wiley-VCH.



2. Li, C., & Chou, T. W. (2003). "Elastic moduli of multi-walled carbon nanotubes and the effect of van der Waals forces." *Composites Science and Technology*, 63(11), 1517–1524.
3. Kim, J., & Park, S. (2020). "Mechanical performance of graphene-reinforced composites: A review." *Composites Part B: Engineering*, 198, 108200.
4. Zhao, X., et al. (2022). "Nanocellulose composites for sustainable engineering applications." *Materials Today*, 57, 50–68.
5. Cherepanov G.P. Fracture mechanics of composite materials. – M.: Science. 1983-296 p.
6. Cherepanov G.P. On the opening of oil and gas wells // Dokl. Academy of Sciences of Russia -1985-vol.284, №4-p.816-820
7. Cherepanov G. P. Mechanics of Brittle Fracture. New York: Mc Graw Hill. 1979.
8. Mamasaidov M.T., Ergashov M., Tavbaev Zh.S. Strength of flexible elements and pipelines of drilling rigs. Bishkek. Ilim. 2001. 251 p.
9. Ergashov M., Tavbaev Zh.S. Strength of pipelines of drilling rigs. Tashkent. Fan. 2002. 119 p.
10. Tavbaev J.S., Saparov B.J., Payzieva M., Narmanov O.A., Narmanov U.A. "Modeling theory of acquisition mode materials of high-strength flexible structures" *International Journal of Mechanical Engineering*. Vol. 6 No. 3 October-December, 2021
11. Tavbaev J.S., Saparov B.J., Narmanov U.A., Narmanov O.A. Research solution of the forming a flat structure of finite width from a high – temperature melt. *Annals Of The Romanian Society For Cell Biology.*, ISSN: 1583-6258, Vol. 25, Issue 6, 2021, Pages. 312-317 Received 25 April 2021: Accepted 08 May 2021
12. B Saparov, M Rakhimov, D Mamatqulova, A Sangirov// Study of the brittle-elastic matrix and deformations in the struts// *International Multidisciplinary Research in Academic Science (IMRAS)* Volume. 7, Issue 02, February (2024)
13. Saparov Bobur, Rakhimov Murodullo, Sultanova Husnora, Gazakboyeva Sevinchoy// *New-Generation Composite Materials: Advances in Manufacturing Technology// American Journal of Education and Learning* Volume-3| Issue-2| 2025
14. Saparov Bobur, Rakhimov Murodullo, Sultanova Husnora, Gazakboyeva Sevinchoy// Efficiency of manufacturing processes using modern materials for product development: a review// *International Journal of Education, Social Science & Humanities*. Finland Academic Research Science Publishers Volume-13| Issue-2| 2025