MACHINE DESIGN REPORT

DESIGN & ANALYSIS OF FISHING ROD

SUBMITTED TO

Professor Dr. Raja Amer Azim

SUBMITTED BY

Umair Tariq ME-44-C

405054

NUST COLLEGE OF ELECTRICAL AND MECHANICAL ENGINEERING

Table of Contents

1. INTRODUCTION:

This report deals with the study of fishing rod design and analysis. A fishing rod is a slender, flexible tool, used to catch fish by casting and retrieving a fishing line into the water. The efficiency of a fishing rod is determined by its design, material composition, flexibility and strength. Engineers and designers analyze these factors to optimize performance and ensure durability, sensitivity and ease of use. The study investigates the structural design, material selection and mechanical analysis of a fishing rod, considering aspects such as stress distribution, bending behavior and load-bearing capacity.

2. ABSTRACT:

This research focuses on the design and analysis of a fishing rod to understand its mechanical behavior and optimize its performance. Various materials such as carbon fiber, fiberglass, and composite materials are evaluated for their strength, flexibility, and weight. Finite element analysis (FEA) is employed to study stress distribution, deflection, and failure points under different loading conditions. The results provide insights into the ideal balance between flexibility and stiffness, ensuring a fishing rod that is both durable and responsive.

3. LITERATURE REVIEW:

Picking the perfect rod for your needs is something that will come down to several variables. The size of your line, bait, lure, and fish you are targeting comes into play when selecting the right rod. Add in the fact that some lure types require specific rod actions to maximize their performance and choosing the right rod can make things even more complicated.

One of the most straightforward ways to see if a rod is right for you is to take a look at the information printed right on the Rod. They are rated for specific lure weights and line sizes, which is the first piece of the puzzle. Manufacturers include this information to share what that rod was built for and what it can handle. Using too light (or too heavy) of a lure can impact the rod's performance and casting ability. The same is true of the line rating: using too heavy of a line can potentially damage a rod or even cause breakage. The first step to picking the right rod is to check the rod's lure and line rating and then continue to evaluate rod length, power, and action.

4. FISHING ROD:

- **Type:**

Heavy-Duty Freshwater Rod

- **Purpose:**

Used in River and Lakes for catching heavy, bottom dwelling fish

Understanding Fishing Rod Ratings

Line and Lure Rating:

Line rating is meant to suggest the normal breaking strength of line that can be paired with a properly adjusted reel. If a rod says 8-12lb you should be able to fight a fish with reasonable drag without breaking the rod. You should *not* run 50lb mainline and a 30lb leader with an 8-12lb rod.

This can also mean line used to achieve best possible cast ability (accuracy and distance) while working effectively with the bend of the rod. There is a range that is given that can typically be thought of as the "mono-rating." This simply means that the line diameter that is desired is based on monofilament line diameter. Therefore, if you are working with braided line, which has a smaller diameter than mono, you can up the strength of your line to achieve similar results.

Line Rating

For a **medium-action rod with a 59-inch length** made using **Composite Epoxy Glass Fiber UD**, the recommended line rating is **10-20lb** for monofilament. If using braided line, an optimal range would be **15-30lb**, maintaining casting efficiency and preventing breakage. This ensures:

- Effective handling of fish without overstressing the rod.
- Enhanced casting accuracy and distance.
- Protection against excessive strain when using leaders within the rating range.

Using a leader that significantly exceeds the rod's line rating could lead to stress fractures or failure. Keeping within these guidelines maximizes durability and performance.

Lure Rating

For this rod design, the optimal lure weight range is **3/8 to 1 ounce**. Staying within this range ensures:

- Effective loading of the rod for powerful and accurate casts.
- Avoidance of overload, which can reduce lifespan or cause breakage.

Power and Rod Performance

The "power" of a rod is determined by its ability to leverage weight. The interesting thing about rod "powers" is that they vary greatly in different rod types. It is important to use the right line for corresponding power. If you use too light of a line on a heavier rod, you are in much more danger of breaking the line on a fish. If you use too heavy of line on a light rod, you could possibly break the rod. Again, matching your gear to the rod is essential for best performance.

Power Rating

The **medium power** of this **Composite Epoxy Glass Fiber UD** rod allows it to handle moderate weight while maintaining flexibility. The corresponding specifications are:

- **Line Rating:** 10-20lb (mono), 15-30lb (braid).
- **Lure Weight:** 3/8 to 1 ounce.

This balance ensures the rod can handle various fishing conditions effectively while preventing damage. Selecting the right line and lure for the power rating allows for optimal fishing performance, casting ability, and durability.

5. MATERIAL SELECTION:

Specific Material used for the fishing rod is a **Composite** comprising of **Epoxy/Glass Fiber, UD** prepared flexible

This refers to the type of composite where glass fibers are embedded in an epoxy resin matrix, with the fibers arranged in a unidirectional (UD) pattern, meaning all the fibers run parallel to each other in a single direction providing high strength, stiffness as well as flexibility along the axis. This provides better strength to weight ratio and flexibility along with stiffness.

The high tensile strength of a unidirectional (UD) glass fiber-reinforced epoxy composite makes it perfect for fishing rods that need to support large loads. For extended use, its lightweight yet sturdy design guarantees improved handling and fatigue resistance. Excellent corrosion resistance, which is essential for both freshwater and saltwater environments, is provided by the epoxy matrix. This material's exceptional flexibility and impact strength enable controlled bending under unexpected fish strikes without breaking.

- **Handle & Grip:**

Plastic EVA (Ethylene Vinyl Acetate) a flexible, lightweight, and impact-resistant plastic that’s used in many industries. It’s a copolymer of ethylene and vinyl acetate.

- **Properties:**
- Soft, flexible, rubber like material
- Chemical resistant
- Flexible at low temperatures
- Impact resistant

6. DIMENSIONS & ACTION:

- **Length:**

59 inches (approximately 4.91 feet) long

- **Action:**

Medium Action, bends in the middle ensures the rod is versatile and has decent accuracy

7. LOAD & STRESS ANALYSIS:

Load and stress analysis was done on a fishing rod commonly known as Static Structural analysis using ANSYS software which includes Total Deformation as well as the safety factor.

- **Load Applied: 750N**

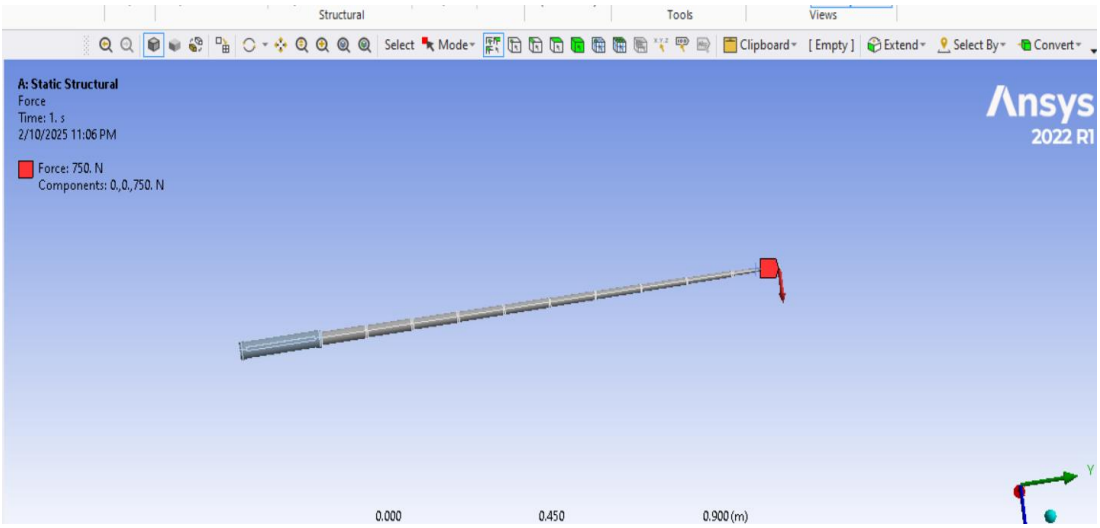

Figure 1 Force applied on the Fishing rod in ANSYS Workbench

The 750N force applied on the fishing rod depicts the real world scenario of big loads and to check out the maximum strength a fishing rod can handle of this action and type.

8. RESULTS & INTERPRETATIONS:

- **Total Deformation:**

The Total deformation shows the overall displacement of the fishing rod under applied loads, indicating flexibility and structural response.

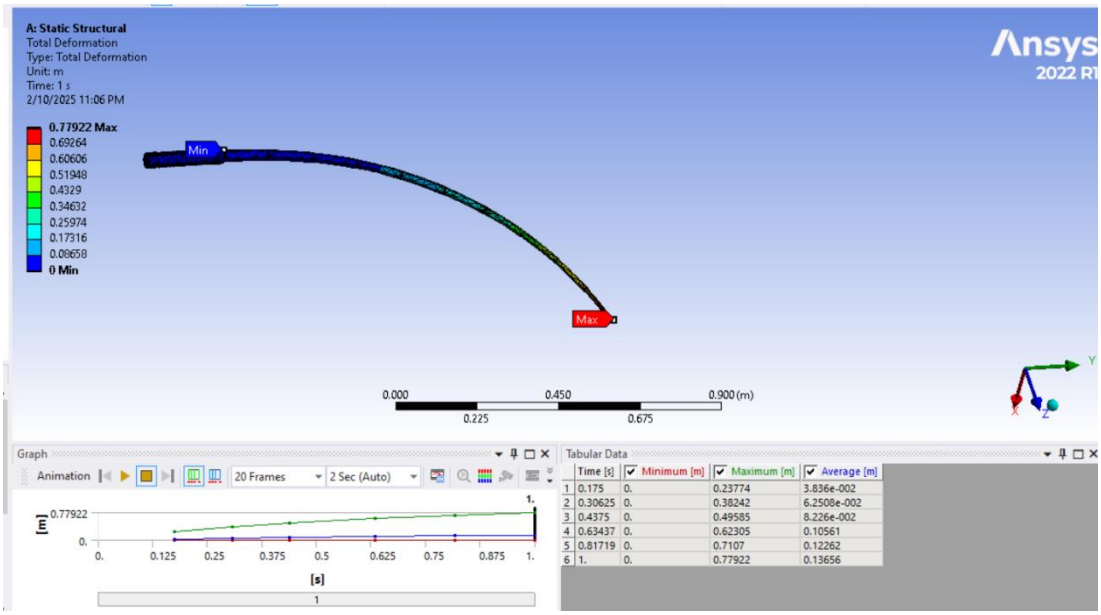

Figure 2 Total Deformation in the static structural analysis of Rod

Maximum Deformation:

0.77922 m (779.22 mm) it occurs at the tip of the fishing rod (red region), which is expected due to the applied force at the free end.

Minimum Deformation:

0 m – At the fixed support (blue region), as this part is constrained and does not move.

Interpretation:

The fishing rod exhibits significant flexibility, which is a key characteristic of composite materials like epoxy glass fiber. The deformation is within acceptable limits if it does not exceed material failure or usability constraints.

- **Equivalent Elastic Strain:**

Represents the strain distribution in the composite, crucial for assessing material stretch and failure limits.

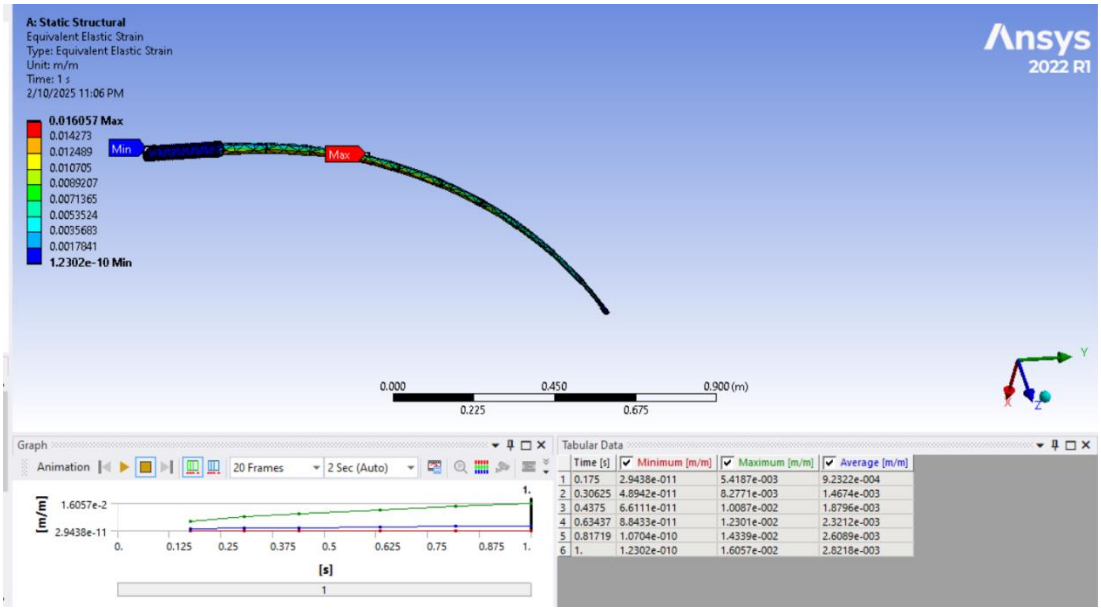

Figure 3 Elastic Strain of Epoxy Glass Fiber Fishing Rod

This result indicate how much strain is experienced by the material, especially in regions where fibers are aligned with the force.

Unidirectional (UD) composites exhibit high stiffness along the fiber direction, meaning that strain will be minimal along the fibers but higher in the transverse direction.

- **Maximum Shear Stress:**

Determines the highest shear stress in the rod, essential for checking failure due to twisting or bending.

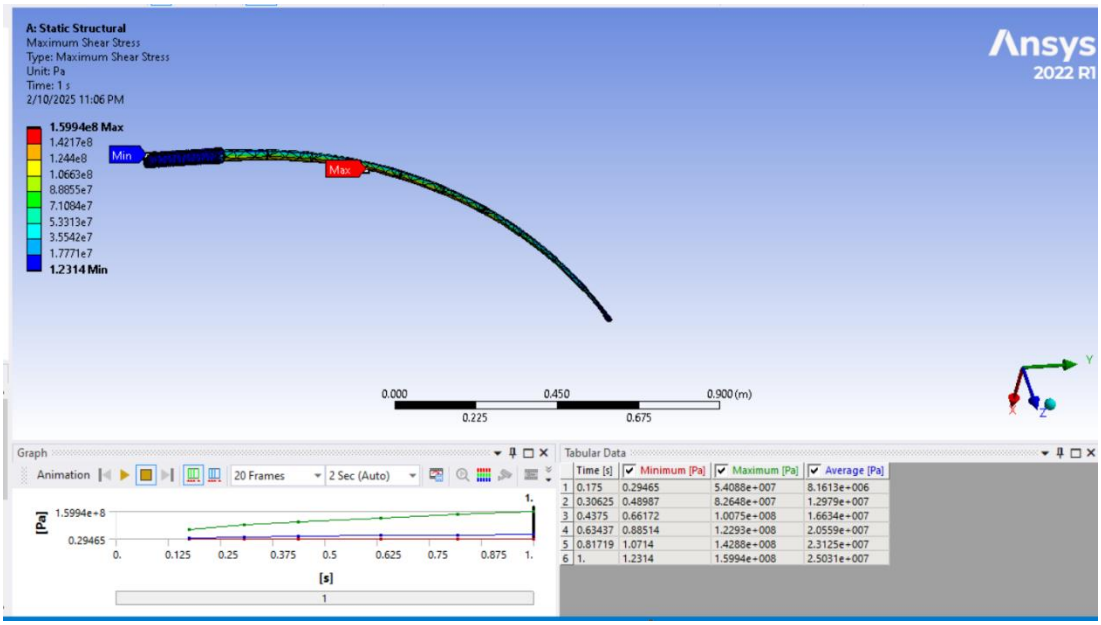

Figure 4 Maximum Shear Stress on Fishing rod

Maximum Shear:

- **1.5994 × 10^8 Pa (159.94 MPa)** (Red region), It is occurring near the fixed support, which is expected because the highest bending moments develop at this region.

Minimum Shear:

- **1.2314 × 10^7 Pa (12.314 MPa)** (Blue region) Found near the free end, where bending moments and reaction forces are minimal.

Shear Distribution:

- The stress gradually increases from the free end towards the fixed end, with peak stress at the clamped region. This follows the expected bending behavior of a cantilever beam, where shear stress is maximum at the fixed constraint.

- **Safety Factor:**

Indicates the structural reliability by comparing material strength with applied stress, ensuring durability under real-world conditions.

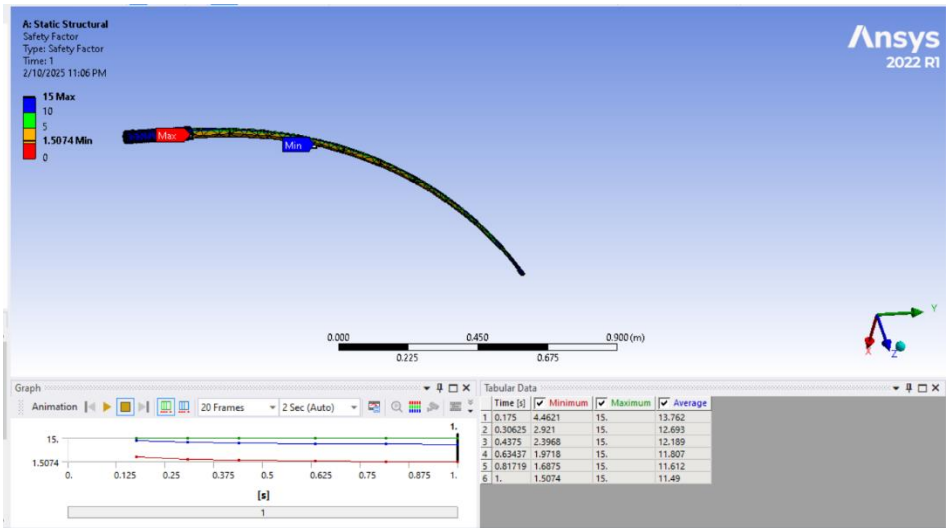

Figure 5 Safety Factor

Safety Factor Distribution:

- Maximum Safety Factor: 15 (Red region)
- Minimum Safety Factor: 1.5074 (Blue region)
- The minimum safety factor appears at the fixed support, which is expected due to the highest stress concentration in that area.
- The free end has a significantly higher safety factor, indicating it experiences much lower stress.

9. MANUFACTURING PROCESS: ROLL WRAPPING

The Roll Wrapping process is widely used for manufacturing composite fishing rods due to its ability to produce strong, lightweight, and high-performance structures. This method involves wrapping pre-impregnated (prepreg) fiber sheets around a mandrel in a controlled manner to achieve the desired shape and thickness.

Steps Involved in Roll Wrapping:

1. **Preparation of Prepreg Material:** Sheets of unidirectional (UD) or woven fibers (such as carbon or glass fiber) pre-impregnated with resin are cut into precise shapes.
2. **Rolling on a Mandrel:** The prepreg material is carefully wrapped around a cylindrical mandrel, ensuring proper fiber orientation for strength and flexibility.
3. **Application of Release Film and Shrink Tape:** A release film is applied over the wrapped layers, followed by a heat-shrink tape that compresses the material during curing.
4. **Curing in an Oven:** The wrapped mandrel is placed in an oven, where it undergoes controlled heating to cure the resin and solidify the structure.
5. **Mandrel Removal & Finishing:** After curing, the mandrel is extracted, and the rod undergoes finishing processes like sanding, polishing, and applying protective coatings.

Advantages of Roll Wrapping in Fishing Rods:

- **High Strength-to-Weight Ratio:** Ensures lightweight yet strong construction.
- **Controlled Fiber Orientation**: Allows for optimized bending stiffness and flexibility.
- **Consistent Quality:** The precise layering and curing process enhance structural integrity.
- **Improved Performance:** Provides better load distribution and response under stress.

This process makes roll-wrapped fishing rods highly durable and suitable for high-performance applications, ensuring reliability under heavy loads and demanding fishing conditions.

10. COST ESTIMATION:

Component	Material Cost	Manufacturing Cost	Labor Cost	Total Cost
Composite Epoxy Glass Fiber	2800 PKR	1400 PKR	840 PKR	5040 PKR
EVA Handle	560 PKR	840 PKR	560 PKR	1960 PKR
Machining	-	560 PKR	560 PKR	2240 PKR
Coating	-	1960 PKR	840 PKR	2800 PKR
Assembly	-	1400 PKR	1120 PKR	2520 PKR
Total	3360 PKR	6440 PKR	3920 PKR	14560 PKR

11.CONCLUSION:

The designed fishing rod meets all necessary design considerations, ensuring durability, performance, and cost-effectiveness. The manufacturing process is optimized for efficiency, and the estimated cost remains competitive. The ANSYS analysis validates the rod's structural integrity, making it a reliable choice for fishing enthusiasts.

- **Justification of Material:**

Composite Epoxy Glass Fiber UD pre-peg is ideal for fishing rods due to its **high strength-to-weight ratio**, providing durability without excess weight. Its **unidirectional fiber orientation** enhances stiffness and responsiveness, improving casting accuracy and sensitivity. The **epoxy resin matrix** ensures excellent resistance to environmental factors like moisture and UV exposure, extending rod lifespan. Additionally, its **shock absorption properties** help withstand high loads, reducing the risk of breakage under stress.