Dossier on Wooden Deck Chair Design & Construction

By Yashvardhan Singh
15-03-2025

UPES SOD Batch one.

TABLE OF CONTENTS

Acknowledgements

I would like to express my gratitude to my university for its support in the design thinking process, helping shape the conceptual approach and problem-solving aspects of this project.

A special thanks to Mr. Lavendra, who led the wood material exploration module, providing valuable insights into working with wood. I am also grateful to Omvardhan for assisting with the 3D modeling of the chair, which helped refine the design before construction.

The construction and assembly of this project were carried out independently and I deeply appreciate the expertise of Mr. Chitrasen, whose carpentry skills turned the design into a functional reality.

Lastly, I extend my heartfelt appreciation to my family for their unwavering support and encouragement throughout this project.

1. Abstract

1.1 A Brief Summary of the project

The objective of this project was to design and construct a functional and sustainable wooden deck chair, focusing on ergonomics, durability, and upcycling. The project aimed to repurpose leftover wood from previous builds and reuse fabric from an old curtain, reducing material waste while maintaining structural integrity.

A preliminary study was conducted to define key design challenges and establish specifications. This phase included research on existing deck chair models, user comfort requirements, material properties, and construction techniques. The sustainability aspect was a central consideration, ensuring that the final design would not only be functional and durable but also contribute to responsible material use.

Once the design requirements were established, the concept development phase began. Various design approaches were explored, with an emphasis on structural integrity, material efficiency, and user-friendly adjustment mechanisms. A systematic evaluation of different concepts was carried out, ensuring they met functional, aesthetic, and sustainability criteria.

The final concept was refined in the detailed design phase, where aspects such as wood selection, joinery techniques, recline adjustability, and surface finishes were finalized. The decision to use shagoon (teak) wood was based on its strength and longevity, while the casement fabric was chosen for its durability and breathability. Instead of traditional notch-based recline adjustments, a separate wooden piece with notches was designed and fastened, preventing unnecessary modifications to the main frame.

A working prototype was built and tested to assess comfort, stability, and usability. The findings from this phase provided insights into potential improvements and refinements for future iterations, ensuring that the design remained practical while staying true to its upcycling philosophy.

1. Abstract

1.2 Purpose of the Deck Chair Design

The primary purpose of this deck chair was to explore woodworking and furniture design through a hands-on approach. Built as an independent project during my free time, the chair serves as both a functional seating solution and a learning experiment in material selection, joinery techniques, and ergonomic considerations. Additionally, sustainability was a key factor, with repurposed materials integrated into the design to reduce waste.

The chair is designed to offer adjustable comfort, making it suitable for both indoor and outdoor relaxation. Its collapsible X-frame ensures ease of storage and portability, while the use of solid teak wood provides durability and resistance to environmental factors.

1.3 Key Features

The chair incorporates a three-step adjustable reclining mechanism, allowing users to shift between angles of 30°, 35°, and 40° for varied seating preferences. It folds at the center, making it easy to store and transport when not in use. The frame is made of teak wood, chosen for its durability and weather resistance, while the seat is repurposed casement fabric, adding a sustainability aspect to the design. Instead of using staples or direct stitching, the fabric is looped around aluminum rods and slotted between two wooden planks, securing it in place without the need for adhesives. The frame is held together using mortise and tenon joinery, reinforced with hex bolts and washers, ensuring stability while allowing for movement.

2. Introduction

2.1 Background

Furniture design is not only about functionality but also about material efficiency and sustainability. With growing awareness around upcycling and responsible material use, repurposing leftover resources has become an essential approach in modern product design.This project focuses on the development of a wooden deck chair, designed with an emphasis on reclining comfort, adjustability, and sustainable material use.

This chair was built as a personal design experiment, carried out independently during my free time, before taking part in the wood material exploration module at university. The goal was to explore woodworking techniques, structural stability, and material reuse without external guidance. The chair was constructed using shagoon (teak) wood, known for its strength and durability, while the seating surface was made from casement fabric repurposed from an old curtain. This approach not only reduced material waste but also reinforced the principles of upcycling in furniture design.

2.2 Aims & Objectives

The primary objective of this project was to design and construct a functional, adjustable, and durable deck chair that balances ergonomics, stability, and material efficiency. Key design considerations included:

- Adjustable Recline Mechanism – Allowing multiple seating positions for enhanced comfort.
- Sustainable Material Use – Utilizing leftover wood and repurposed fabric to minimize waste.
- Structural Integrity – Implementing mortise and tenon joinery for durability.
- Ease of Fabric Replacement – Ensuring that the casement fabric seat could be easily removed or replaced.

Beyond these functional aspects, the project also aimed to explore practical woodworking techniques, improve design problem-solving skills, and apply fundamental ergonomic principles in seating design.

3. Pre-Study & Research

3.1 User Needs & Considerations

A deck chair is primarily designed for casual seating and relaxation, making comfort a key factor in its usability. Since this chair was developed as a self-initiated experiment, there was no direct client or user requirement. Therefore, to ensure that the deck chair meets functional and ergonomic expectations, personas were created to simulate potential users. These personas helped define the key design requirements based on lifestyle, comfort preferences, and practical usability.

Persona 1: Aditi, 32 – Working Professional
- Enjoys relaxing on her balcony after work.
- Needs a comfortable recline with proper lumbar support.
- Prefers low-maintenance furniture that can withstand outdoor conditions.

Persona 2: Rajesh, 65 – Retired Individual
- Looks for a stable and supportive chair for extended seating.
- Needs an easy-to-use reclining mechanism without complex adjustments.
- Prefers traditional wooden furniture over plastic or metal alternatives.

Persona 3: Kabir, 27 – Minimalist Traveler
- Enjoys portable, space-saving furniture.
- Prefers a lightweight yet sturdy construction.
- Interested in sustainable products made from upcycled materials.

3.2 Key Design Considerations

Based on these personas, the following user-centered design requirements were established:

- **Adjustability** – The chair should provide multiple recline positions to accommodate different seating preferences.
- **Structural Stability** – A solid wood frame with mortise and tenon joinery ensures durability.
- **Ease of Use** – The reclining mechanism should be intuitive, utilizing a separate notched adjustment piece for reliability.
- **Sustainable Materials** – The use of leftover wood and repurposed fabric aligns with eco-conscious design trends.

3. Pre-Study & Research

3.3 Market Research

Deck chairs are a staple in outdoor and leisure furniture, commonly used in patios, gardens, and recreational spaces. However, the market offers a wide variety of options, each with distinct advantages and drawbacks based on material, construction, and usability. To better understand existing products, research was conducted on material trends, pricing, structural limitations, and user expectations.

Material Trends in Deck Chairs
The global outdoor furniture market has seen a shift towards durable and weather-resistant materials, with manufacturers opting for aluminum, resin, and engineered wood to reduce maintenance costs. However, natural wood remains a preferred material for premium deck chairs due to its strength and aesthetic appeal.

- **Teak wood** is one of the most durable choices due to its natural oils that protect it from moisture and decay. However, it is expensive, often driving up the price of wooden deck chairs.
- **Pine and other softwoods** are commonly used in budget-friendly wooden furniture, but they require chemical treatments to withstand outdoor conditions.
- **Plastic and resin-based** deck chairs are lightweight and low-cost but contribute significantly to environmental waste, as they degrade over time and are difficult to recycle.
- **Metal chairs (aluminum, steel, or iron)** are popular for their durability, but they tend to heat up under sunlight and may rust if not coated properly.

Since teak is naturally resistant to rot and insects, it was chosen for this project to ensure longevity without the need for additional chemical treatments. Additionally, upcycling leftover teak wood reduces material waste, making the design more sustainable.

Structural Issues in Existing Deck Chairs
Several design flaws are commonly reported in mass-produced deck chairs, particularly in low- to mid-range models:

- **Weak Folding Mechanisms** – Many deck chairs rely on metal hinges or plastic joints, which tend to loosen over time, affecting stability.
- **Limited Reclining Positions** – Some chairs have a fixed-angle backrest, offering little flexibility for different seating preferences.
- **Fragile Notched Recline Adjustments** – In wooden deck chairs, the notches cut directly into the frame often weaken with repeated use, leading to cracks or wear over time.
- **Uncomfortable Seating Materials** – Many deck chairs use synthetic fabric (e.g., polyester or vinyl mesh), which can trap heat and become uncomfortable after prolonged use.

3. Pre-Study & Research

3.3 Market Research

To address these issues, this project used a separate wooden adjustment piece for the recline mechanism rather than cutting notches into the main frame, ensuring better load distribution and long-term durability. Additionally, casement fabric, which is breathable, durable, and repurposed from an old curtain, was chosen to enhance comfort and sustainability.

Cost & Market Positioning
Deck chair pricing varies widely based on material and craftsmanship:

- **Budget plastic or metal** deck chairs are available for **₹1,500–₹4,000** but lack durability.
- **Mid-range wooden** deck chairs range from **₹6,000–₹15,000**, offering better quality but often using cheaper softwoods.
- **High-end solid teak** deck chairs cost **₹20,000 and above**, making them inaccessible to many buyers.

The deck chair developed in this project was positioned as a durable yet cost-effective alternative, utilizing high-quality teak wood but reducing costs through upcycling. This approach makes it competitive with mid-range chairs while offering the longevity of premium models.

Sustainability in the Furniture Industry

According to industry reports, the furniture industry generates over 9 million tons of waste annually, with wooden furniture contributing significantly due to manufacturing cutoffs and discarded materials. Upcycling not only reduces waste but also lowers the demand for newly sourced timber, reducing deforestation impact.

This project aligns with sustainable design principles by repurposing leftover wood instead of sourcing new material. The fabric choice further supports this by reducing textile waste. By combining durability, ergonomic design, and sustainability, this deck chair offers a practical solution that addresses common market gaps.

3. Pre-Study & Research

3.4 Anthropometry & Ergonomics

To ensure comfort and usability, the chair was designed with three adjustable reclining angles: 30°, 35°, and 40°. These angles were selected to accommodate different levels of relaxation:

- **30°** – A more upright position suitable for reading or casual sitting.
- **35°** – A balanced recline that offers a mix of relaxation and support.
- **40°** – A deeper recline for lounging, designed for extended periods of rest.

Seat Height & Dimensions

- The seat height falls within the typical range of 30-45 cm depending on the set angle, ensuring accessibility for most users.
- A 40-50 cm seat depth allows proper thigh support without restricting circulation.
- The 40 cm seat width (excluding the frame) aligns with standard single-person seating dimensions, offering sufficient space without compromising stability.

Backrest & Support

- The fabric seat, secured with aluminum rods, evenly distributes weight, reducing pressure points and enhancing comfort over extended use.
- However, due to the frame's structure, the headrest area rests against the wooden frame, which may not be ideal for extended lounging. Adding a cushion or padded headrest could improve long-term comfort.

4. Specification sheet

4.1 Technical Specifications

The deck chair is designed with a balance of functionality, durability, and aesthetics. Below are its key technical specifications:

Overall Dimensions:
- **Width:** 46 cm (40 cm excluding 3 cm side supports)
- **Long Frame Length:** 130 cm
- **Short Frame Length:** 100 cm
- **Wood Thickness:** 3 cm
- **Wood Depth:** 6 cm
- **Adjustable Stand Length:** 40 cm
- **Backrest Angles:** 30°, 35°, and 40°

Structural Features:
- **Adjustability**: Reclining mechanism with multiple height adjustments.
- **Support**: Cross-braced frame for stability.
- **Portability**: Collapsible X-frame design for easy storage and transport.

4.2 Materials selection

Frame: Shagoon (Teak) wood, selected for its strength, weather resistance, and aesthetic appeal.
Seating Material: Upcycled casement fabric, repurposed from an old curtain, offering a soft yet durable surface.
Fasteners & Supports: Aluminum rods secure the fabric in place through a looped design. Nails fasten the adjustable stand piece. Hex bolts with washers connect the chair's moving parts, for better stability and controlled movement.

4. Specification sheet

4.3 Functional Requirements

To ensure the chair meets user expectations and practical usage scenarios, the following functional requirements were set:

Portability & Storage:
- The chair should be lightweight enough to be moved easily and compact enough for storage when not in use.

Adjustability & Comfort:
- The backrest must allow for three distinct reclining positions (30°, 35°, and 40°) to accommodate different seating preferences.

Structural Integrity & Durability:
- The mortise and tenon joinery ensures a sturdy construction, reducing the risk of loosening over time. the joints were also reinforced with wood adhesive.
- The wooden frame should withstand repeated use without significant wear or deformation.

Weather & Wear Resistance:
- The wood has been treated with protective paint to enhance resistance to moisture and environmental conditions.
- The seat fabric should withstand prolonged use without tearing or sagging.

Sustainability & Material Efficiency:
- The chair is constructed using upcycled materials, reducing environmental impact.
- The design optimizes material usage to minimize waste.

These specifications define the core parameters that guided the design and manufacturing process, ensuring a balance of usability, longevity, and sustainability.

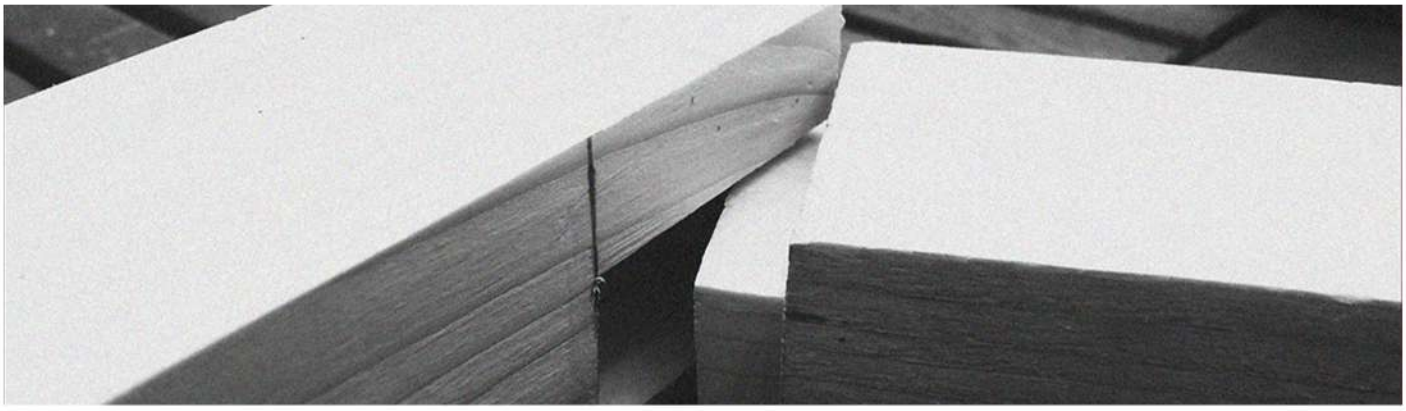
5. Design & Manufacturing Process

The construction of this deck chair was guided by a balance of structural integrity, material efficiency, and ease of assembly. Since this was an independent project built at home, the approach was hands-on, relying on available tools and materials while ensuring a sturdy final product.

5.1 Joinery & Construction

To maintain strength and durability, the frame was assembled using mortise and tenon joinery, a time-tested technique known for its resistance to shear and lateral forces. This ensures that the structure remains stable under weight without excessive reliance on metal fasteners. Additionally, hex bolts with washers were used at critical pivot points, allowing the chair to fold and adjust while keeping the moving parts secure.

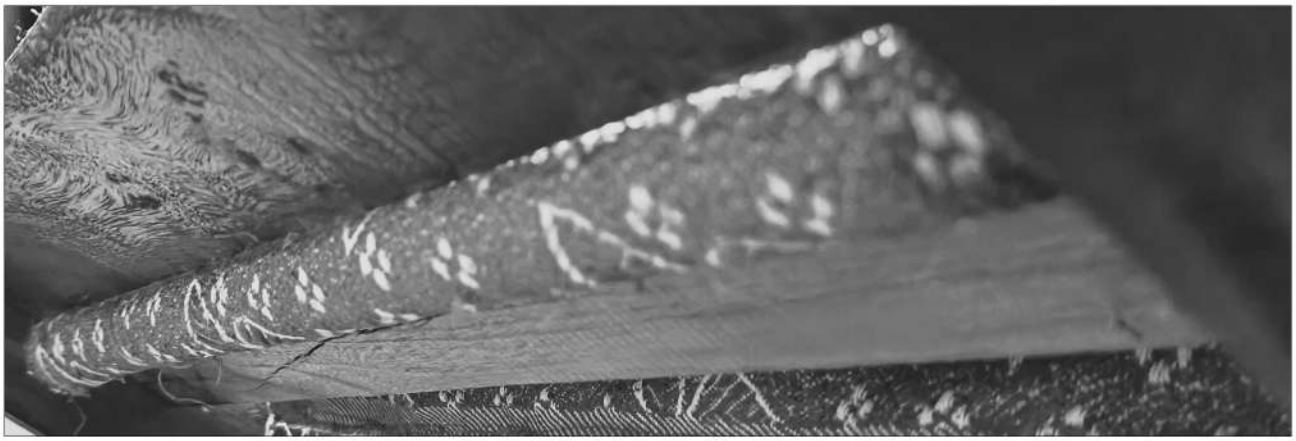
Instead of carving notches into the main frame for the reclining adjustments, a separate wooden support piece was added. This piece, fitted with notches, was nailed to the main structure, offering a simpler yet effective mechanism for adjusting the backrest angle.

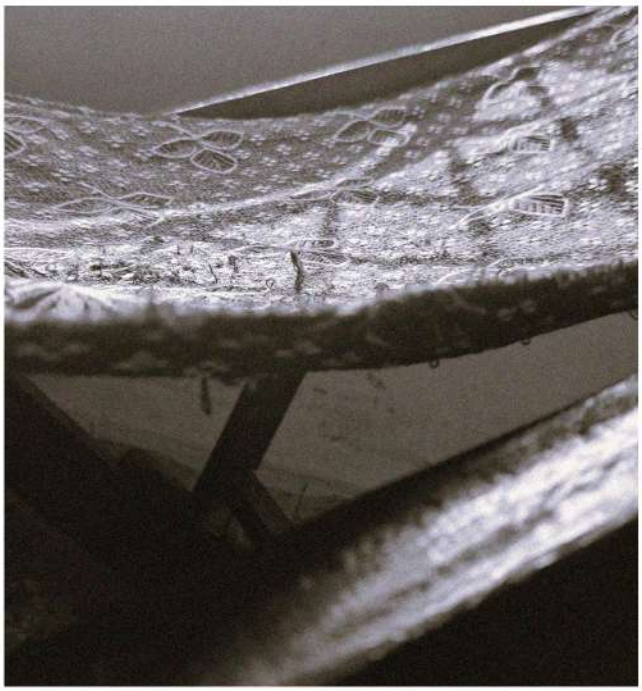


5. Design & Manufacturing Process

5.2 Fabric Attachment Method

The seat is made from repurposed casement fabric, which was originally an old curtain. Instead of stapling or tying it to the frame, the fabric was designed to be removable and replaceable. This was achieved by folding the fabric into a loop and inserting aluminum rods at both ends. These rods were then slotted into narrow gaps left between two layers of wood on each side of the chair's frame. This method ensures that the fabric remains securely in place while allowing for easy removal if it needs to be washed or replaced.





6. Testing & Evaluation

To assess the structural integrity of the deck chair, I conducted theoretical calculations for load-bearing capacity, reclining mechanism strength, and impact resistance. These evaluations provide insights into how the chair would perform under real-world conditions.

6.1 Load-Bearing Capacity

The deck chair's frame is made from solid teak wood, which has a bending strength of 10–15 MPa. To estimate how much weight the chair can support, we used the following formula for beam bending:

$$\sigma = S/M$$

Where:
σ = Stress (should not exceed teak's strength of ~12 MPa)
M = Bending moment (M=F×d)
S = Section modulus (S= bh^2/6)

Given the main planks' dimensions (130 cm x 6 cm x 3 cm) and considering two planks sharing the load, the theoretical weight capacity before significant structural stress is **~135.5 kg.**

Conclusion: The chair can safely support an average user of **80–100 kg** with a safety margin, though excessive prolonged loads may lead to wear over time.

6.2 Reclining Mechanism Strength

The backrest adjustment relies on a notched wooden piece that supports the user's weight. The key factors in its durability are:

- **Shear Strength of the Notches** – Determines how much force they can handle before breaking.
- **Hex Bolt Load Capacity** – Ensures the bolts won't bend or shear under stress.
  Shear Strength of the Notches.

The maximum force the 1 cm deep notches can withstand before failure is calculated as:

$$F=\tau \times A$$

6. Testing & Evaluation

Where:
- **τ** = Shear strength of teak (10 MPa)
- **A** = Shear area (6 cm x 3 cm = 18 cm^2)

F=(10×10×6)×(0.06×0.03)=1835N

Conclusion: The notches can theoretically support ~**1835 N (~1,835 kg)** before shearing, far beyond normal use conditions.

Strength of the 8mm Hex Bolts
The bolts experience tensile forces and need to resist shearing under weight. Their failure load is:

$$F=\sigma \times A$$

Where:
σ = Tensile strength of mild steel (400 MPa)
A = Bolt cross-sectional area (A=πr 2 for an 8 mm diameter bolt)

Conclusion: Each bolt can support **~2050 kg**, meaning failure is extremely unlikely under normal use.

6.3 Impact Load Resistance

A person dropping into the chair applies a sudden force greater than their actual weight. This impact force was estimated using the impulse-momentum equation:

$$F= t/mv$$

Where:
m = User weight (88 kg)
v = Velocity just before impact (0.5 m/s, assuming a relaxed drop)
t = Time taken for impact absorption (0.2 sec)

$$F= (88\times0.5)/0.2 =220N$$

Converting this force into an equivalent weight:

$$W= 220/9.81 \approx 22.4 \text{ kg}$$

6. Testing & Evaluation

6.3 Impact Load Resistance

Conclusion: A sudden drop increases the total load to ~110 kg (88 kg user + 22 kg impact force equivalent). Since the chair's max capacity is ~135.5 kg, it remains within safe limits.

Final Observations:

- Minor creaking is expected due to normal wood flexing and joint friction.
- Long-term concerns: Repeated sudden impacts may compress the notches slightly over time, requiring refinishing or reinforcement.
- Theoretical testing confirms that the chair can handle standard use, with a margin for occasional heavy loads.

7. Results & Conclusion

7.1 Meeting Design Goals

The deck chair successfully meets its intended design goals by balancing functionality, durability, and adjustability while incorporating a simple yet effective reclining mechanism. The three-position backrest provides a comfortable range of reclining angles, making it suitable for different seating preferences. The solid teak frame ensures stability, and the bolt pivot system allows smooth movement without excessive play.

In terms of structural integrity, the chair performs well under theoretical testing, with a maximum load capacity of around 135 kg. The reclining mechanism, supported by a separate notched adjustment piece, is strong enough to withstand user weight without failing. The fabric attachment system using aluminum rods and slotted wooden inserts proves to be both secure and easily replaceable, adding to the chair's longevity.

7.2 Potential Improvements

While the chair is structurally sound, a few areas could be refined:

- **Headrest Comfort** – Since the frame extends behind the head, adding a small cushion or padding could improve long-term comfort.
- **Notch Wear Over Time** – The wooden adjustment notches may compress slightly with repeated use. Reinforcing them with a metal plate or hardwood insert could extend their durability.
- **Weight Reduction** – At ~20 kg, the chair is quite heavy. Using slightly thinner planks or an alternative hardwood could make it easier to transport without compromising strength.

7.3 Final Thoughts

This project served as a practical experiment in woodworking, joinery techniques, and product design thinking. Building the chair outside a workshop setting provided valuable insights into working with available materials and problem-solving in a real-world scenario. Despite being an independent build, the final product is sturdy, functional, and aesthetically balanced.

With minor refinements, this design could be further developed into a long-lasting, upcycled seating solution. The experience gained through this process will inform future furniture projects, reinforcing the importance of material efficiency, ergonomics, and hands-on experimentation in product design.

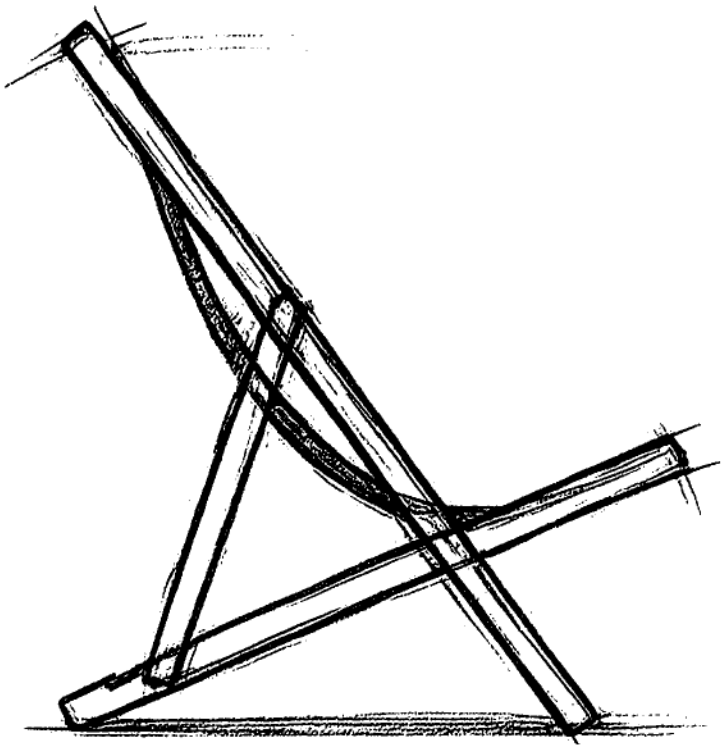
8. References & Appendices

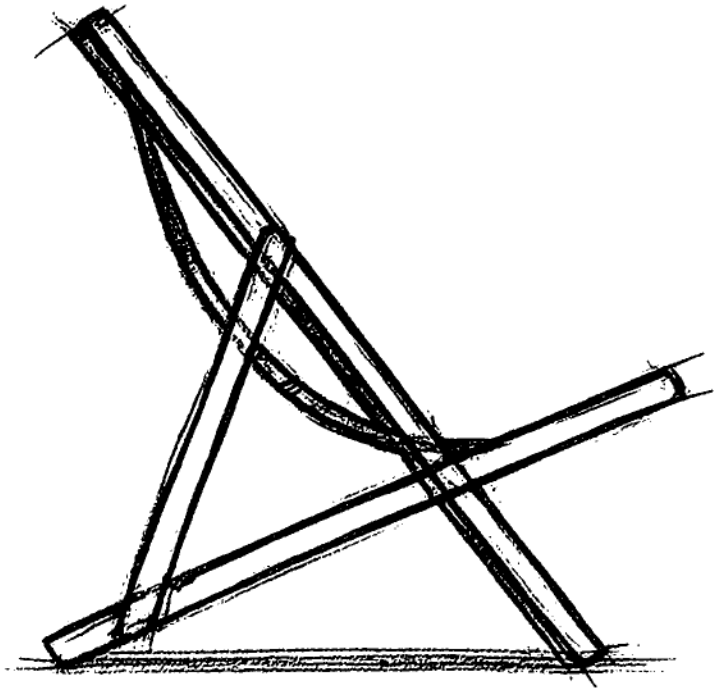
8.1 References and citations

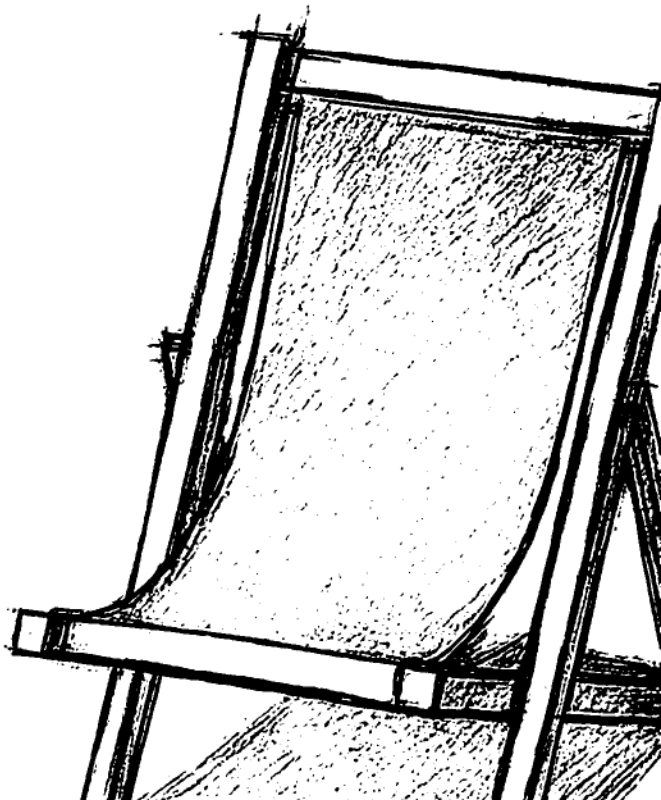
- Ashby, M. F. (2010). Materials Selection in Mechanical Design (4th ed.). Butterworth-Heinemann.
- Booth, J. (2001). Furniture Design. Laurence King Publishing.
- Gere, J. M., & Goodno, B. J. (2012). Mechanics of Materials (8th ed.). Cengage Learning.
- Pheasant, S., & Haslegrave, C. M. (2006). Bodyspace: Anthropometry, Ergonomics and the Design of Work (3rd ed.). Taylor & Francis.
- Teak Wood Mechanical Properties. (n.d.). Wood Database. Retrieved from https://www.wood-database.com/teak/
- Load-Bearing Capacity of Wooden Beams. (n.d.). Journal of Wood Science. Retrieved from https://link.springer.com/journal/10086
- Mortise and Tenon Joints in Wooden Structures. (n.d.). Wood Science and Technology. Retrieved from https://link.springer.com/journal/226
- Optimal Backrest Angles for Comfort. (n.d.). International Journal of Industrial Ergonomics. Retrieved from https://www.sciencedirect.com/journal/international-journal-of-industrial-ergonomics
- The Impact of Furniture Waste on the Environment. (2022). Environmental Research Letters. Retrieved from https://iopscience.iop.org/journal/1748-9326
- Upcycling in Furniture Design: Sustainable Approaches to Material Reuse. (n.d.). Sustainable Design Journal. Retrieved from https://www.sciencedirect.com/journal/journal-of-cleaner-production
- U.S. Environmental Protection Agency (EPA). (2018). Advancing Sustainable Materials Management: 2018 Fact Sheet. Retrieved from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling

8. References & Appendices

8.2 Technical Drawings





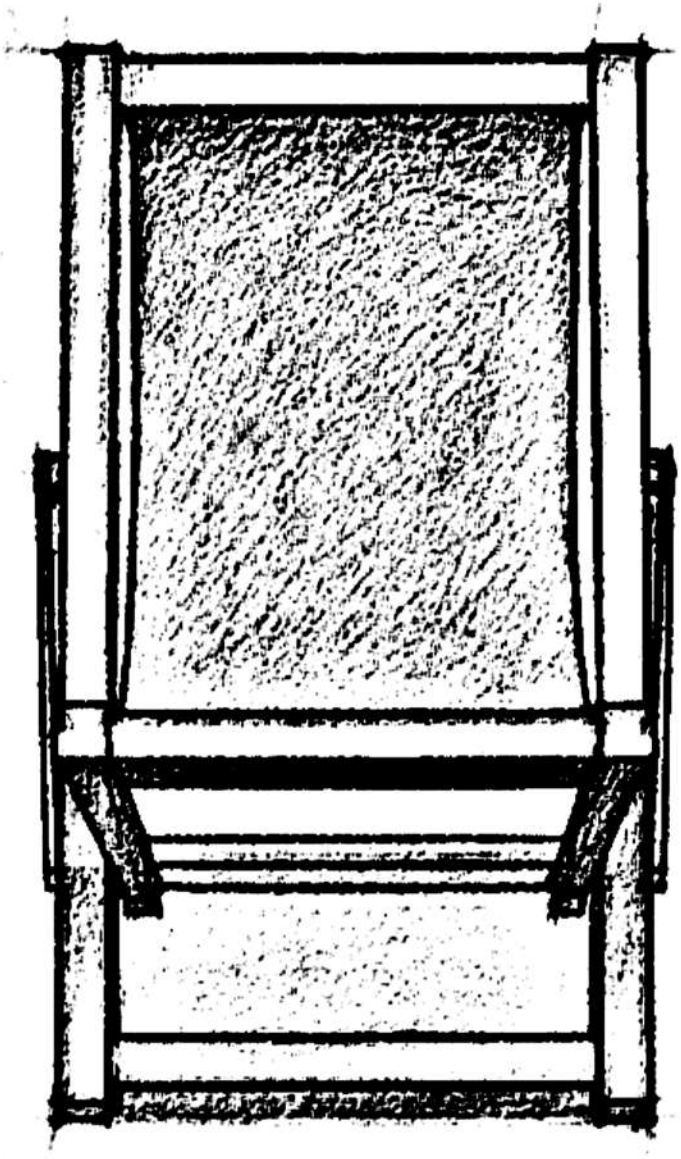


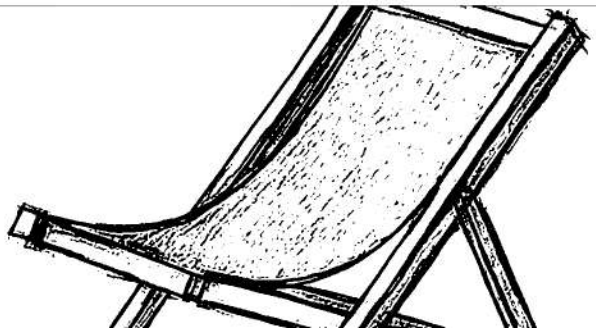
8. References & Appendices

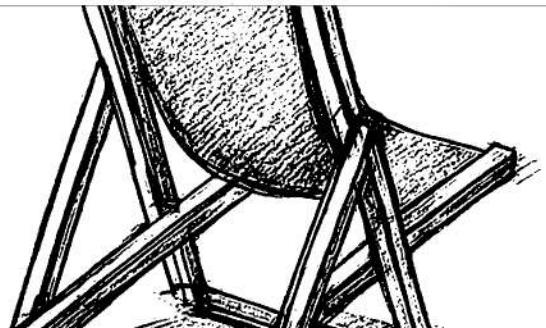
8.2 Technical Drawings

8. References & Appendices

8.2 Technical Drawings







8. References & Appendices

8.3 Material Data Sheet

1. Wood (Shagoon/Teak Wood)

Properties:
- **Density**: 650-700 kg/m³
- **Bending Strength**: 10-15 MPa
- **Durability**: Highly resistant to moisture and decay

Wood Used in Chair:
- **Main planks (2x)** – 130 cm x 6 cm x 3 cm
- **Shorter planks (2x)** – 100 cm x 6 cm x 3 cm
- **Joining planks (4x)** – 40 cm x 6 cm x 3 cm
- **Notched adjustment piece (1x)** – 40 cm x 6 cm x 3 cm
- **Total Wood Required** – ~0.00864 m³ (8.64 liters of teak wood)

2. Fabric (Casement Fabric, Repurposed Curtain)

Properties:
Medium-weight, durable weave
Breathable and flexible

Fabric Used in Chair:
Seat Fabric (1x): ~50 cm x 100 cm
Total Fabric Required: ~0.5 m²

3. Fasteners & Hardware

Hex Bolts with Washers (8mm) – 4x (for moving parts)
Aluminum Rods (~1 cm thick) – 2x (for fabric attachment)
Nails (for notched adjustment piece) – 6x

8. References & Appendices

8.3 Material Data Sheet

Bill of Materials (Estimated)

The following materials were used in the construction of the deck chair, along with their approximate costs:

Teak Wood (Shagoon) – ₹4,500–₹6,500
Main planks: 130 cm x 6 cm x 3 cm (2 pieces)
Shorter planks: 100 cm x 6 cm x 3 cm (2 pieces)
Joining planks: 40 cm x 6 cm x 3 cm (4 pieces)
Notched adjustment piece: 30 cm x 6 cm x 3 cm (2 piece)

Casement Fabric (Repurposed curtain) – ₹0 (Upcycled)
If purchased new: ₹300-500 per meter
Required size: ~50 cm x 100 cm

Fasteners & Hardware
Hex Bolts (8mm) + Washers– 4 pieces (₹200-400)
Aluminum Rods (~50 cm long, 1 cm thick) – 2 pieces (₹400-600)
Nails (for notched adjustment piece) – 6 pieces ₹50-100)

Wood Paint / Finish – ₹300-8,000

Total Estimated Cost: ₹6,000–₹9,000 (excluding labor and tool costs).

9. Gallery

9. Gallery