Bamboo Foldable Chair for Urban Gardens

Submitted in partial fulfillment of the requirement of the degree of

Masters of Design
by

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22M2232

Project Guide
Prof. Avinash Shende

IDC School of Design

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
(2024)

Approval Form

This is to certify that the Industrial Design Project entitled "Foldable chair for urban gardens" by Abhishek P. Kushwaha is approved for partial fulfillment for the Master of Design degree in Industrial Design.

Prof. Avinash Shende (Project guide):

Signature of chairperson:

Signature of internal examiner:

Signature of external examiner

Declaration Form

I solemnly declare that the content in this written report is a true representation of my own ideas, expressed in my own words. In instances where I have included the thoughts and words of others, I have duly cited and referenced the original sources of the same. I further attest that I have strictly adhered to the principles of academic integrity and honesty, and I have not engaged in any form of falsification, misrepresentation, or fabrication of ideas, data, facts, or sources in this submission.

I am fully aware that any breach of the above-stated principles may lead to disciplinary action by the educational institution and may also result in legal consequences if proper permissions have not been obtained or if sources have not been accurately cited.

Name of the student: Abhishek Purushottam Kushwaha

Roll No: 22M2232

Date: 28-06-2023

Abstract

This endeavor aims to breathe new life into the bamboo sector, fostering economic growth and environmental sustainability through collaborative efforts and awareness initiatives. This study investigates the difficulties that the bamboo product sector faces and explores the potential for its resurgence. Even if they are a more economical and environmentally responsible option than cane, artisans are hampered by issues including scarce resources, regulatory restrictions, and a lack of understanding about efficient manufacturing methods. These hurdles are compounded by the misconception that bamboo products aren’t cheap. The project emphasizes the importance of community backing, educational initiatives to improve manufacturing efficiency, and the endorsement of the affordability and sustainability of bamboo products to tackle these issues.

Acknowledgement

To my renowned mentor, Professor Avinash Shende, for his constant support and invaluable assistance throughout this endeavor, I would like to offer my profound gratitude. His knowledge and experience have played a crucial role in making this project successful.

In addition, I would want to express my gratitude for all of the help and collaboration I got from the brilliant instructors, hardworking staff, and other students at the Industrial Design Centre (IDC). Their helpful advice, priceless insights, and perceptive recommendations have substantially improved the caliber of this job.

Additionally, I would like to express my gratitude to Mr. Prayag P. Kushwaha, Mr. Palav A. Chahande, Mr. Nikhil S. Samant and Mr. Kailash sir for their unwavering technical support, which has inspired me to reach higher standards and provide the greatest results.

Finally, but just as importantly, I want to express my sincere gratitude to my family and friends for their unwavering support throughout this trip. Their encouragement and understanding have helped me stay motivated and resilient.

The successful completion of this project is greatly due to the cooperative efforts and assistance of these people and groups, and I sincerely appreciate what they have done.

Index

Index

Introduction

The bamboo product industry should address multiple challenges to achieve both environmental sustainability and commercial success. As bamboo is widely acknowledged for its cost-effective and environmentally sustainable alternative to traditional materials such as cane and jute, artisans faces difficulties such as limited supplies, complex regulations, and lack of knowledge of suitable manufacturing techniques.

The misconception about bamboo goods are expensive creates complexities in the industry's recovery. Understanding the importance of addressing these challenges, this project aims to explore potential solutions, innovations and opportunities for the bamboo sector.

This initiative aims to revive the bamboo industry by creating community support, improving educational initiatives, and emphasizing the affordability and sustainability of the same.

This project looks forward to promote economic growth while preserving the environment by design intervention.

Research

Secondary research

Chair model Butterfly Chair (BKF)	**Designer** Jorge Ferrari-Hardoy	**Country** Argentina	**Timeline** 1950s	
Material Iron frame, leather or canvas	**Manufacturing Process** Handcrafted, designed for a Buenos Aires apartment	**Notable Elements** Iconic pear-shaped seat, retro design		
Chair model Trienna Folding Chair	**Designer** Carl Hansen & Son	**Country** Denmark	**Timeline** 1957s	
Material Oak wood, canvas or leather	**Manufacturing Process** Handcrafted	**Notable Elements** Folding X-frame, simple elegance		

Credits: Google images

Chair model Magis Folding Air-Chair	**Designer** Jasper Morrison	**Country** Italy	**Timeline** 2005
Material Polypropylene	**Manufacturing Process** Injection-molded	**Notable Elements** Lightweight, versatile, contemporary	
Chair model Fermob Bistro Folding Chair	**Designer** Unknown	**Country** France	**Timeline** 19th-century
Material Steel or aluminum, optional cushions	**Manufacturing Process** Powder-coated, inspired by 19th-century French bistro	**Notable Elements** Classic bistro style, vibrant color options	

Credits: Google images

Chair model Skagerak Dania Folding Chair	**Designer** Designit	**Country** Denmark	**Timeline** 2016	
Material Teak wood	**Manufacturing Process** Cutting, bending, assembly	**Notable Elements** Scandinavian style, foldable		
Chair model IKEA TERJE	**Designer** IKEA	**Country** Romania	**Timeline** 2018	
Material Solid beech, Stain, Clear acrylic lacquer	**Manufacturing Process** Cutting, bending, molding, and assembly	**Notable Elements** Natural material, simple foldable structure		

Credits: Google images

Chair model Model no. S88 Folding chair	**Designer** Osvaldo Borsani	**Country** Italy	**Timeline** 1955	
Material Teak-faced plywood, Steel	**Manufacturing Process** Cutting, bending, assembly (conventional processes)	**Notable Elements** Single axis folding		
Chair model Tric folding chair	**Designer** Achille & Pier Giacomo Castiglioni	**Country** Ginevra	**Timeline** 1965	
Material Painted solid wood, Plywood, BBB Bonacina,Meda	**Manufacturing Process** Cutting, bending, assembly (conventional processes)	**Notable Elements** Armrest, innate functionality (rivets)		

Credits: Google images

Chair model Dafne folding chair	**Designer** Gastone Rinaldi	**Country** Italy	**Timeline** 1979	
Material Steel, wood laminated composite board	**Manufacturing Process** Cutting, bending, drilling manual assembly	**Notable Elements** Pin cylinders for pivot folding		
Chair model Snap chair	**Designer** Peter Costello	**Country** Australia	**Timeline** 1992	
Material Marine plywood, steel hardware cables	**Manufacturing Process** CNC cutting, lacquering	**Notable Elements** Structural stability by cable's tension		

Credits: Google images

Chair model Kermit Chair	**Designer** Christoffer Sørensen	**Country** Denmark	**Timeline** 2012
Material Oak wood, leather or canvas seat	**Manufacturing Process** Handcrafted, inspired by Scandinavian camping tradition	**Notable Elements** Portable,outdoor-friendly, classic design	
Chair model Muji Ash Wood Folding Chair	**Designer** Naoto Fukasawa	**Country** Japan	**Timeline** 1967
Material Ash wood	**Manufacturing Process** Cutting, bending, molding, laminating, and assembly	**Notable Elements** Simplicity, clean lines, natural materials	

Credits: Google images

Chair model Coleman Oversized Quad Chair	**Designer** Designit	**Country** Denmark	**Timeline** 2016	
Material Polyester, Steel tube	**Manufacturing Process** Cutting, bending, assembly	**Notable Elements** Cup holder, side pocket, sturdy frame		
Chair model Alessi chair	**Designer** David Chipperfield	**Country** United States	**Timeline** 1911	
Material Polypropylene	**Manufacturing Process** Injection moulding, CNC, assembly	**Notable Elements** minimalist, fiberglass		

Credits: Google images

Chair model Alite Designs Mayfly Chair	**Designer** Alite Designs	**Country** USA	**Timeline** 21st century	
Material Aluminum frame, ripstop fabric	**Manufacturing Process** Tube bending, injection moulding	**Notable Elements** Compact, portable, outdoor adventure style		
Chair model Plia Folding Chair	**Designer** Giancarlo Piretti	**Country** Italy	**Timeline** 1967	
Material Chrome-plated steel, acrylic	**Manufacturing Process** Injection-molded, iconic '70s design, transparent seat	**Notable Elements** Sleek, transparent, folding mechanism		

Credits: Google images

Chair model Mogens Koch Folding Chair	**Designer** Mogens Koch	**Country** Denmark	**Timeline** 1932	
Material Oak or mahogany wood	**Manufacturing Process** Handcrafted, for the Royal Danish Academy	**Notable Elements** Classic Danish design, simple and foldable		
Chair model Mogens Koch MK-16 Safari chair	**Designer** Mogens Koch	**Country** Denmark	**Timeline** 1930	
Material Tropical hardwood, black leather	**Manufacturing Process** Handcrafted	**Notable Elements** Combination of a safari chair and a director's chair		

Credits: Google images

Details

Hinges

Rivets

Height adjustment (inclination)

Locking

Credits: Google images

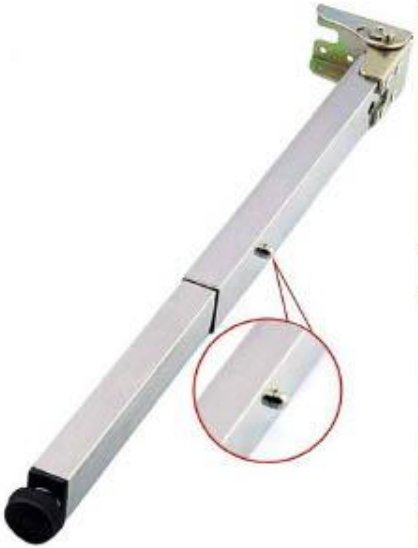
Reclining Mechanisms

Guides

Fabric

Credits: Google images

Height adjustment (linear)



Cables

Internal locking splice

Credits: Google images

Bracket

Overlapping

Conclusion

As material changes, the Details, physical properties, manufacturing processes and utilities also changes.

Credits: Pinterest

Market visit

Primary Research

Oshiwara & mahim, Jogeshwari:

Located in Mumbai, an endless stretch of furniture making and selling shop, prices starts around rs 800-1200/- onwards.

Station market at Bandra:

Located just outside bandra station, this market offers low cost furnitures which includes **bamboo** and **cane** made furnitures and mirrors.

Scenario

- In after corona timeline, bamboo artisans facing shortage of raw material, strict regulation and limited knowledge of efficient production / manufacturing methods.
- Amongst the artisans, it is found that there is a misconception that bamboo made products are more expensive than cane made products.
- To revive bamboo community, community support, introduction to efficient production, exposure to affordability and sustainability of bamboo products is needed.

Insight

Market Gap: Furniture makers in Mumbai makes traditional bamboo furniture, but there is a an evident market gap in foldable bamboo furniture.

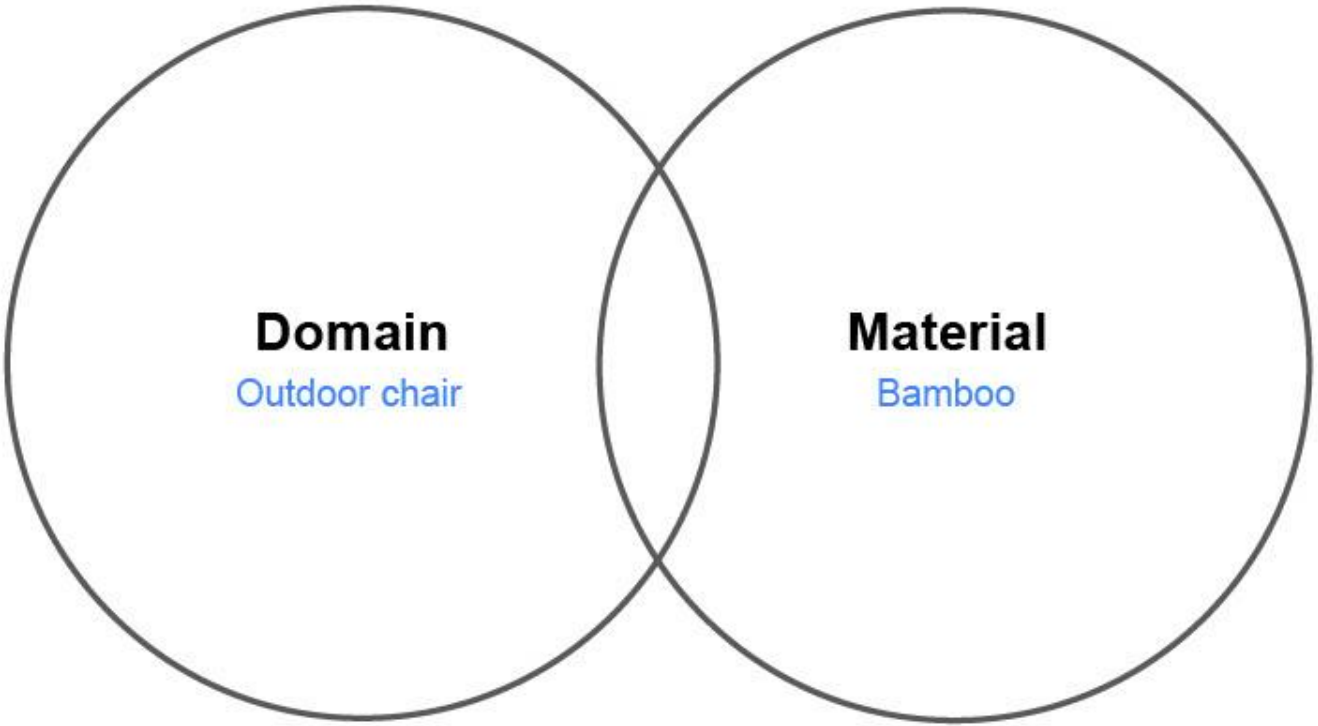
Consumer Demand: Foldable furnitures in mumbai bought by customers for various purpose, but unavailability of the bamboo made furnitures are still not meeting the customer’s demand.

Lack of Awareness: Consumers don’t know about the potential of bamboo-made foldable furniture, which leads to uncertainty towards its desirability.

Feedback from Makers: Local furniture makers of Mumbai shows their interest in creating bamboo made foldable furniture but lacks the available designs or formats for reproduction for sale.

Opportunity Identification: There is an opportunity of making bamboo made foldable furniture that can addresses the consumer’s demand in mumbai.

Emerging Outcomes



Persona

Neha, 32 yrs old, working for marketing and lives in the rushing city of Mumbai, finding peace in her small garden retreat. Despite the city's chaos, she enjoys the tranquility of the space. Recently relocated, for her, the garden serves like a sanctuary from the urban commotion.

At the break of the day, Neha starts her day with a sip of tea in the garden, finding peace in the middle of the busy schedule. It's her place to to return after a hectic day. No need to say, she feels that the garden space of her would be better if there were a better sitting aid and space to move around.

Indeed, Neha's garden is beautiful, but limited seating space restricts its use. She looks for a elegant solution that will complements the garden's beauty and offer both comfort and flexibility around.

Credits: Unsplash

The Indian Context

National bamboo mission (NBM) summary

Holistic industry support: Supporting the whole bamboo value chain to cater entrepreneurship and skills development of people connected with the same.

Market driven product development: Attention on product aligning to market requirement to profit small and medium enterprises and conducts market-oriented research and development.

Reducing import dependency: Working for reducing dependency on imported bamboo and boosting the production of locally available raw materials.

Madhya Pradesh
State Bamboo Mission

Credits: agriculture post, ebamboobazar, tbm.org

Inclusive assistance: Providing understandable assistive supports from government organizations, farmers, artisans, entrepreneurs, and others.

Self dependency and make in india: Promoting self-dependence and India-made production creates bamboo nurseries to foster automation with the made in India initiative.

Sustainable future material: Raising voice for sustainable materials support for bamboo as a sustainable resource of the future.

Environmental impact: Creating environmental impact for the cultivation of bamboo to increase the environment, promote biodiversity, and contribute to change in climate.

Economic growth and livelihood: Creating financial increment and income triggers economic development throughout in bamboo value chain, helps in ascending the progressive well being in accordance with socio economic objectives.

Uravu
Bamboo & Beyond

Uravu is known for being the top organizations in the country that gives training in bamboo processing skills. Established in 1996, Uravu has took part in teaching bamboo handicraft-making skills to over a thousand women in different regions of Kerala and neighbor states.

The skilled artisans of Uravu have been trained to be an instructors in prestigious institutions such as the National Institute of Design (NID), Cane and Bamboo Technology Centre (CBTC), and Bamboo Studio at **IIT-Bombay**.

Credits:https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQF703FKH74ZM2nyQ3vR_ZQzD28-G9DjpCxAg&s

Bamboo and Cane

	Bamboo	Cane
Processing	Requires cutting, curing, and sometimes splitting or flattening.	Involves peeling and treating for flexibility.
Cost (Raw material)	Cheap	Expensive
Cost (Product)	Cheap	Expensive
labour	Labour intensive (manual work) Easy by machines	Easy (complete handicraft)
Craftsmanship	Easy	Difficult
Mass production	Yes	No

	Bamboo	Cane
Versatility	Used in furniture frames, supports, and as a woven material	Used for weaving chair seats, backs, and decorative element
Sustainability	Textured surface, natural patterns contribute to visual appeal.	Smooth surface,contributing to a comfortable finish.
Strength	Bamboo has a high strength-to-weight ratio surpasses that of low-carbon steel	Less strength than bamboo
Weight	Lighter and more durable	Heavy
Appearance	Smooth, yellow-brown surface	Rough and have a reddish-brown hue

Mat Ply

Mat ply is made up from thin strips into, woven together to form a mat, then multiple mats are soaked into adhesive resin to form a ply.

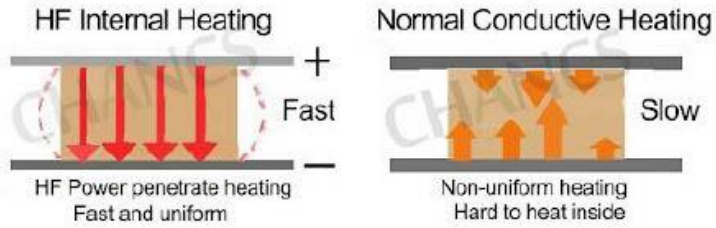
- Environmentally sustainable.
- Tensile strength of mat ply is 28,000 per square inch.
- Bending strength is equal to 8-10 times of that wood & 4-5 times of plywood.
- Used to make kitchen countertops, false ceiling and cabinets.
- Material of future.

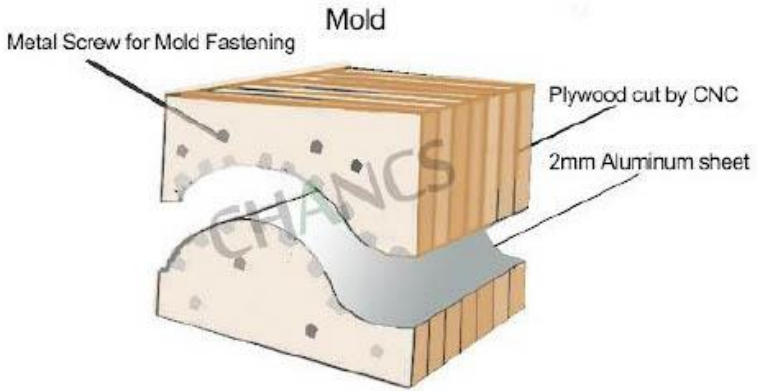
Credits: exportersindia.com

Hot Press

(Manufacturing process)

Hot pressing is used while making wood based composites, which involves physical deformation and chemical reaction, which works with each other to shape the wood based composite.





Credits: ecplaza.com

Credits: alicdn.com, Pinterest

Why Bamboo?

- India grows plenty of bamboo.
- World's second-largest producer of bamboo is India.
- usually referred to as "poor man's timber."
- Holds a deep-rooted history in Asian culture and is commonly used in place of wood because of its form, toughness, light weight, flexibility, manufacturability, high tensile strength, and cost effectiveness in comparison of steel.
- Known for its suitability in construction works and its resistance to earthquakes.
- Also, offers great potential for designing and making furnitures, specifically chairs.
- No one has done it in real sense before.

Problem Statement

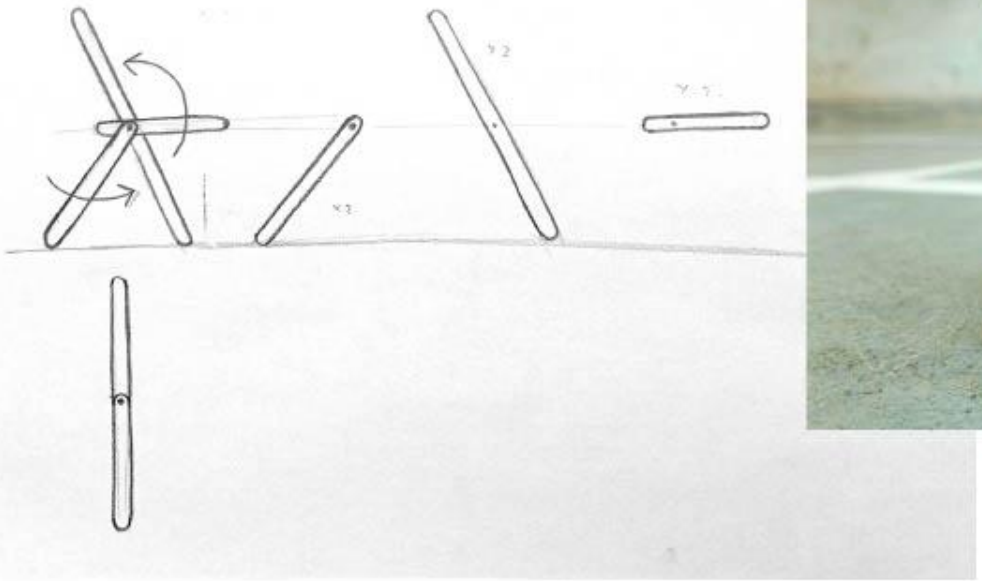
- In urban areas, where living spaces are constrained, compromises has to be made while enjoying the personal gardens.
- The limited knowledge in design and lack of awareness hinders the bamboo furniture success.
- Local makers are interested in making bamboo based furniture, but lack of knowledge about the methods, design and processes suppresses the opportunity of the introduction of space-efficient solutions in urban living spaces.

Brief

Design a garden chair for an urban living space using bamboo as a potential material

Ideation & Prototyping

Multiple scale down models are made to check the feasibility of the folding mechanisms.

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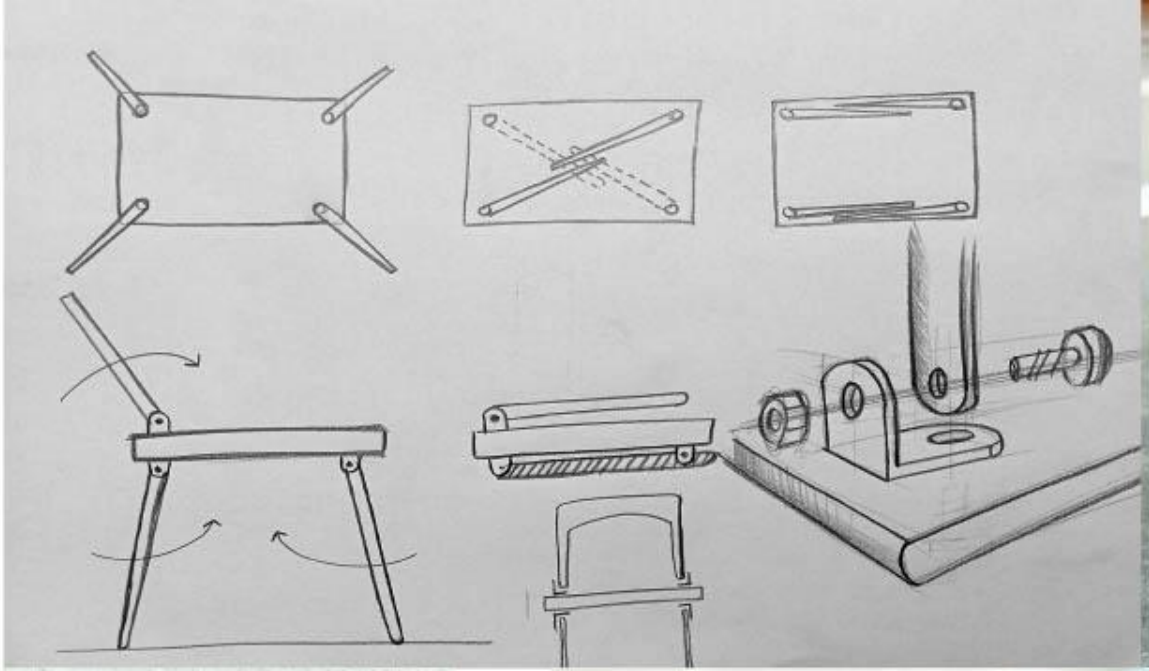
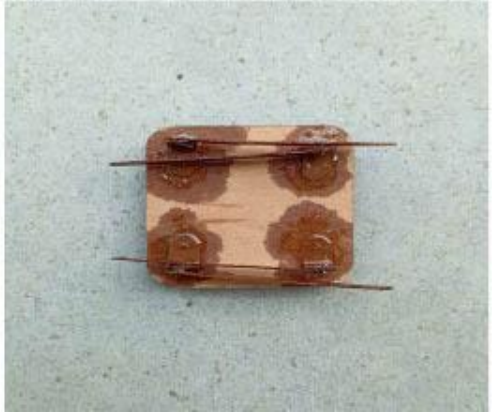
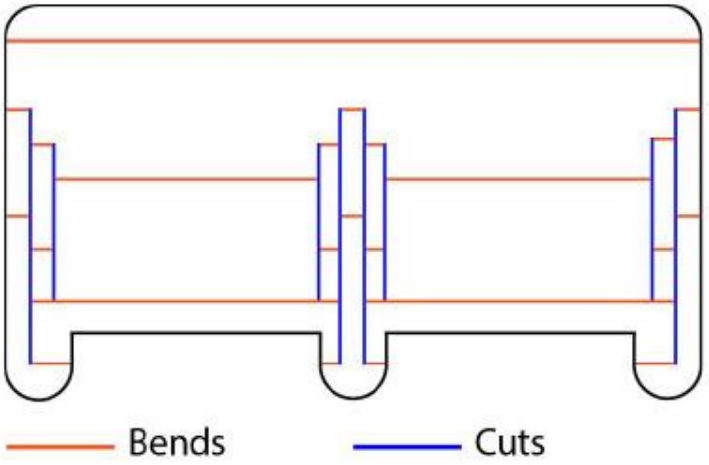
1
3

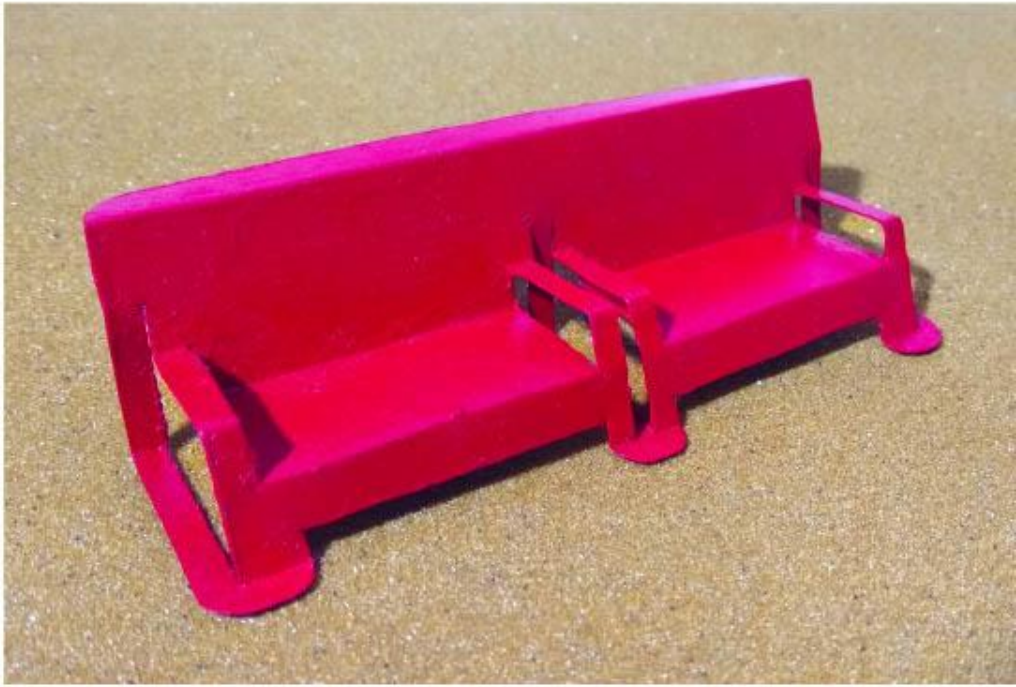
2
1
3

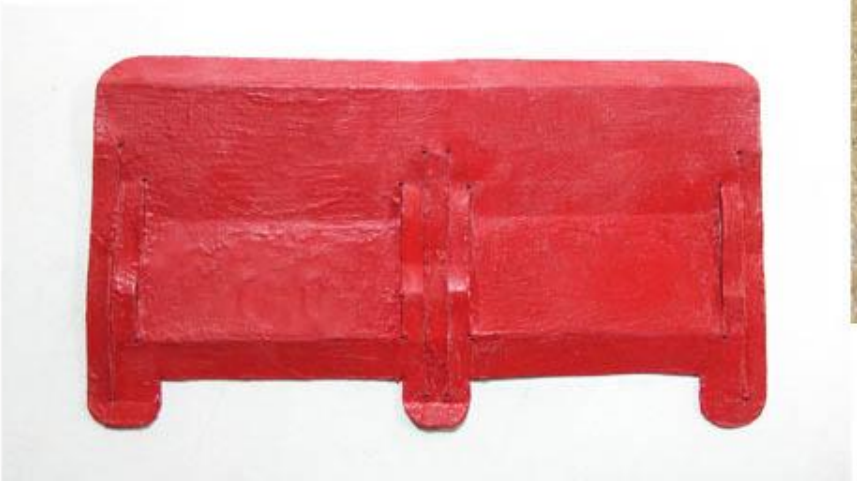


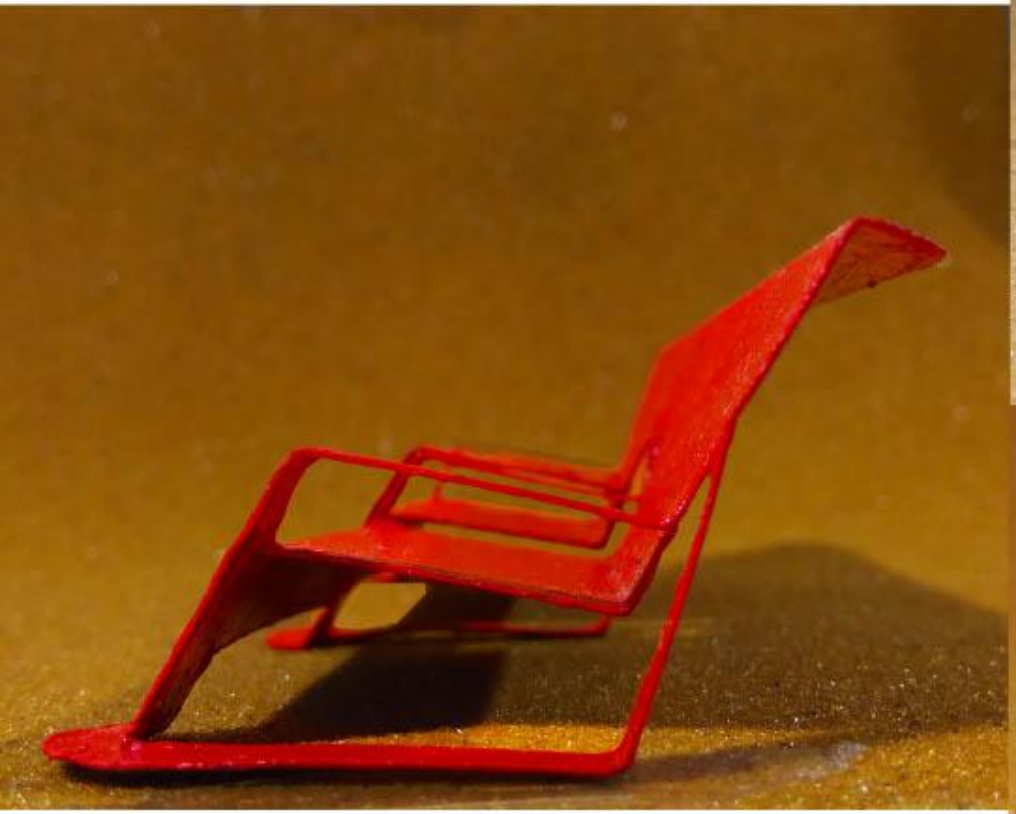


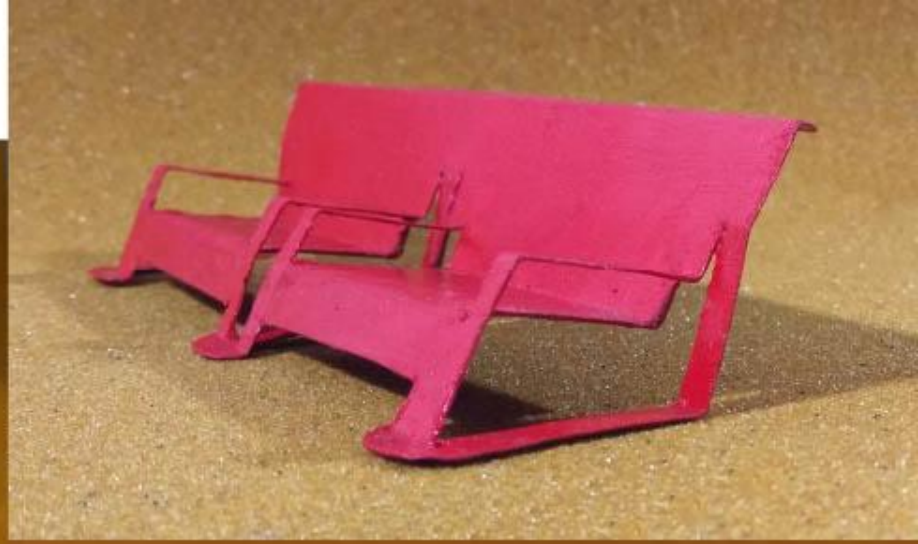


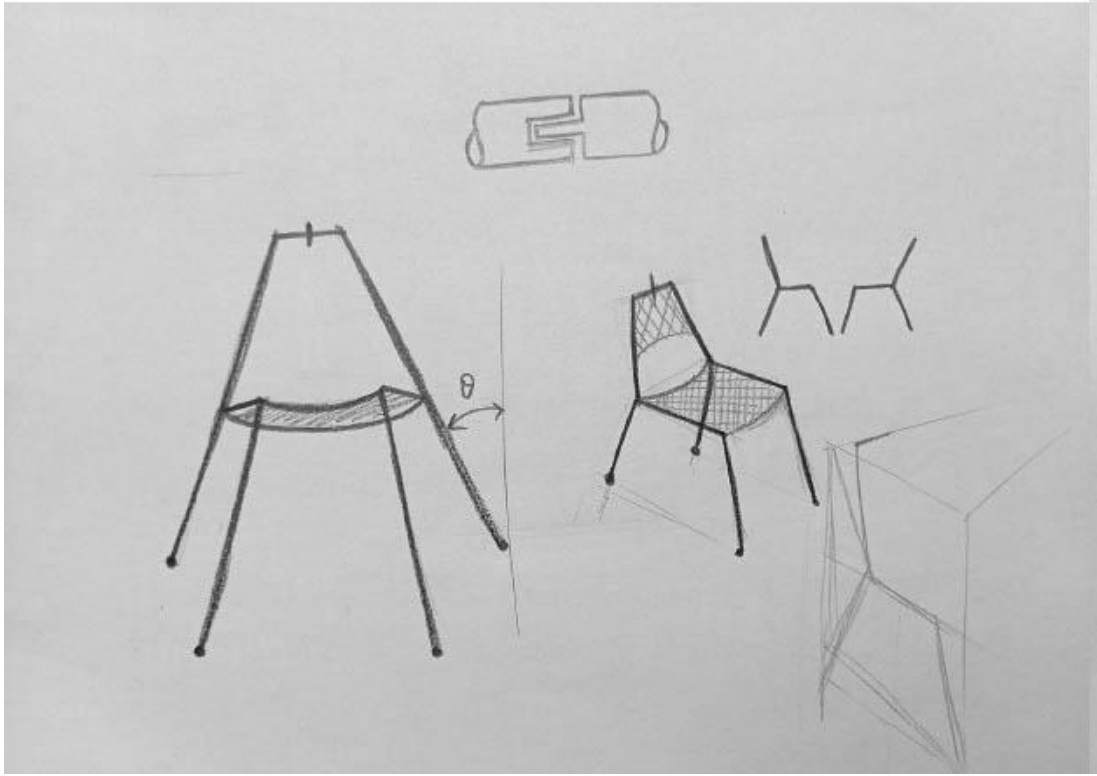
Various cuts have been made on the single piece material to create a pop-up members for the chair.







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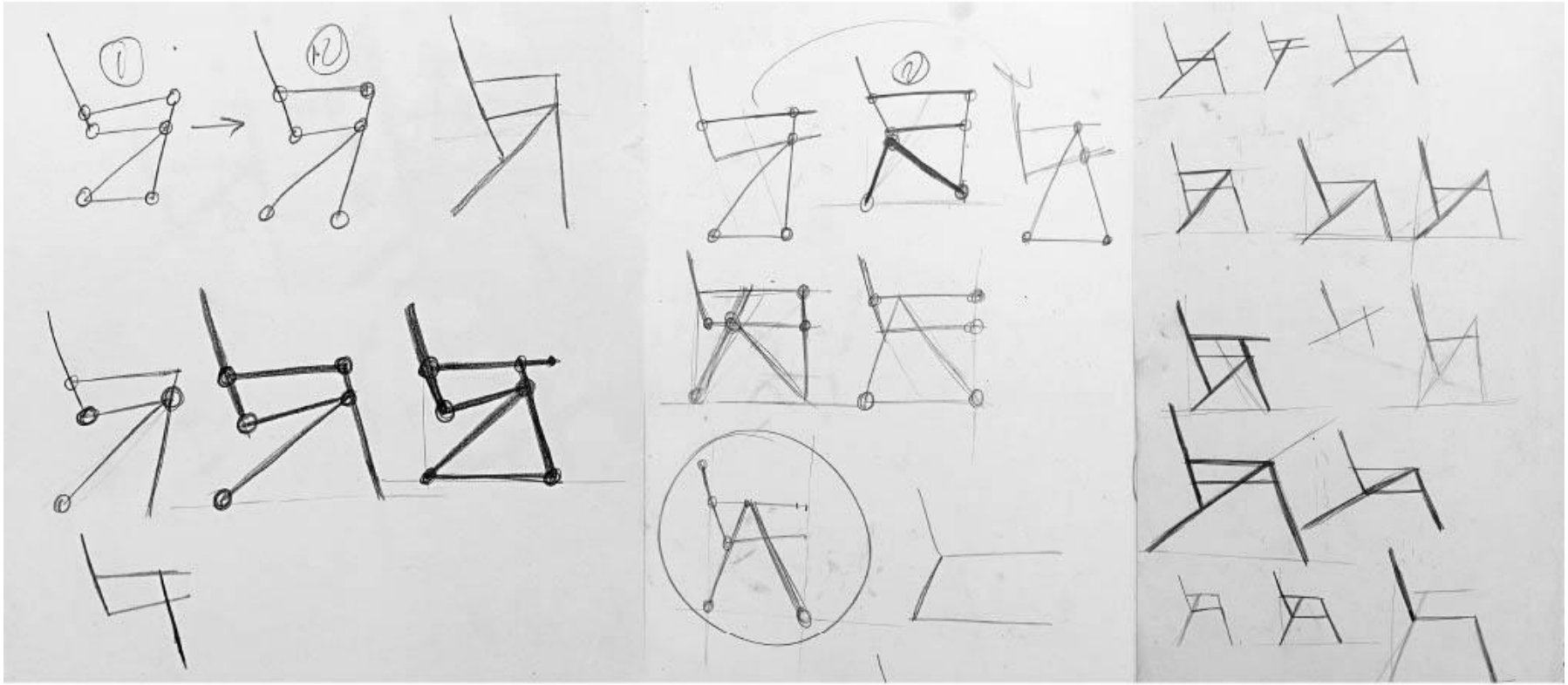
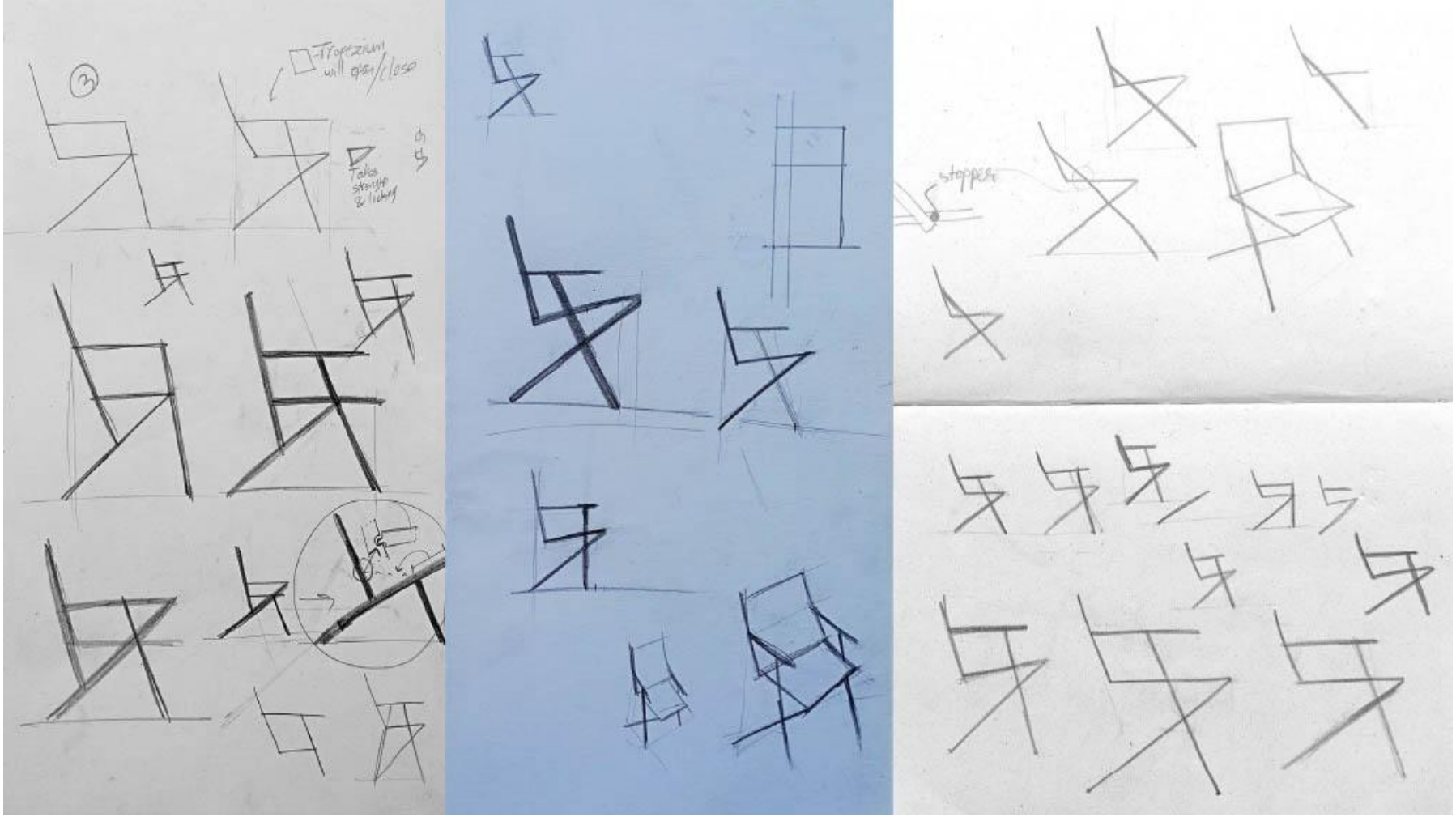
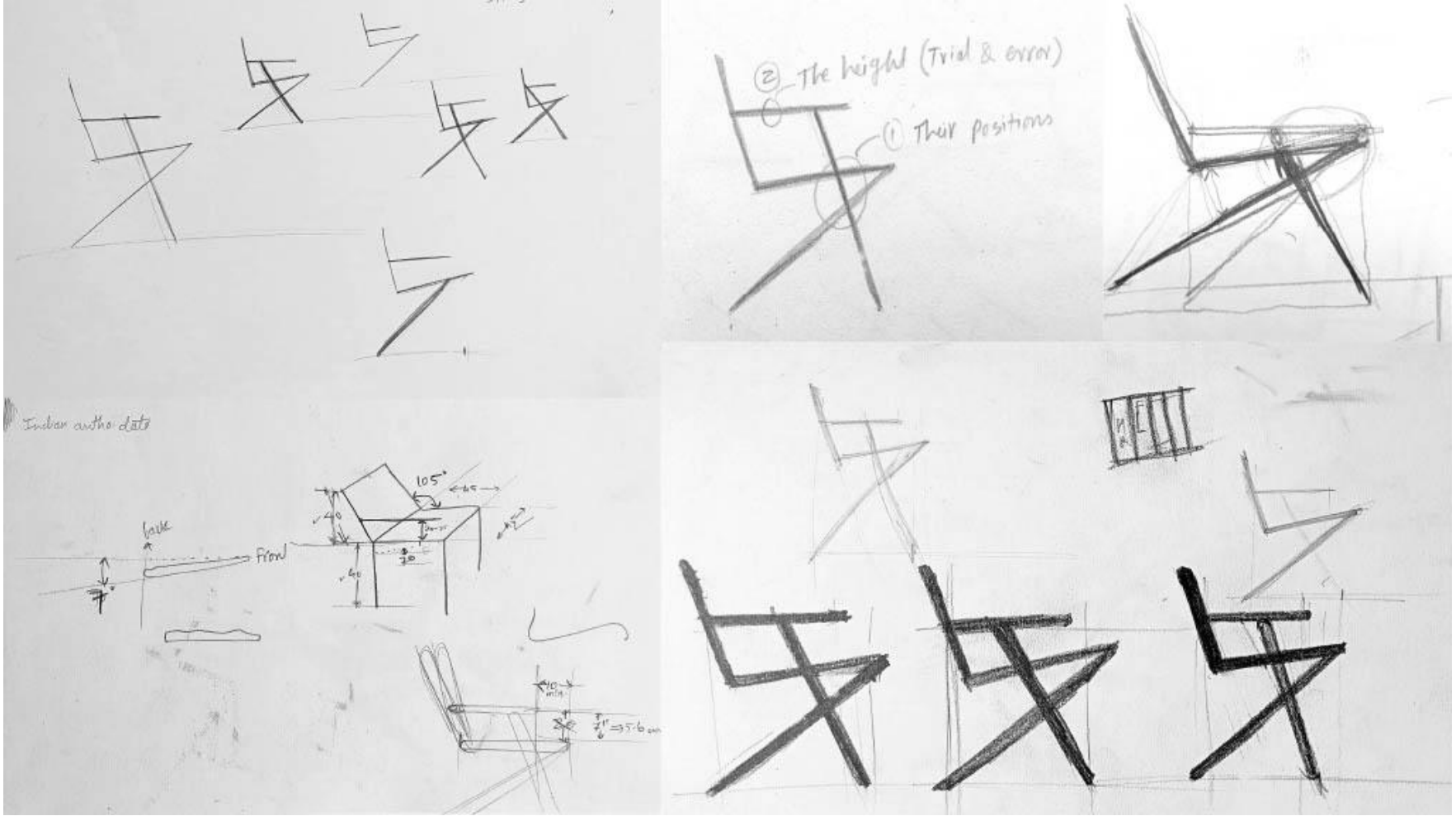
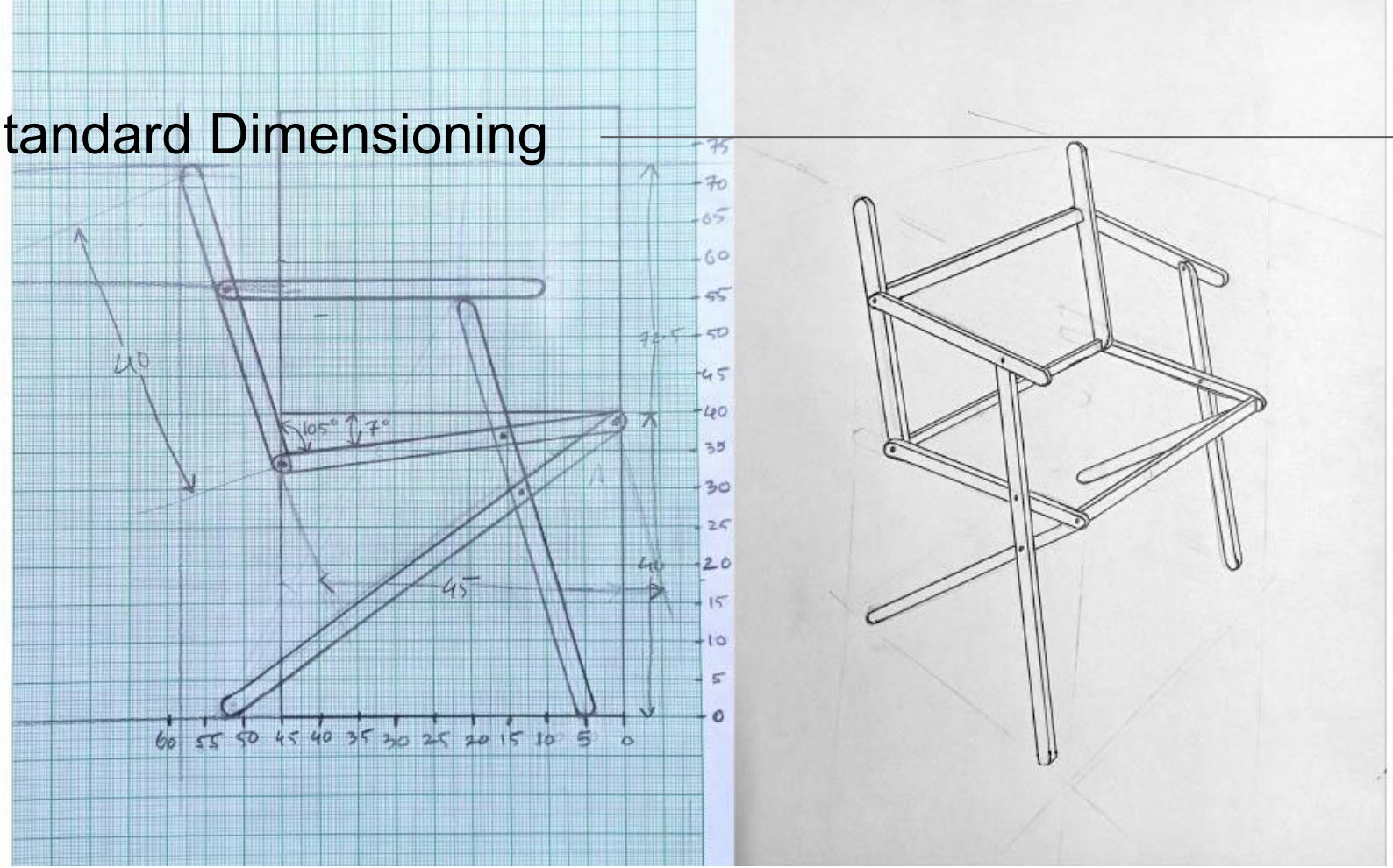
Members & Joinery ideation (side view)

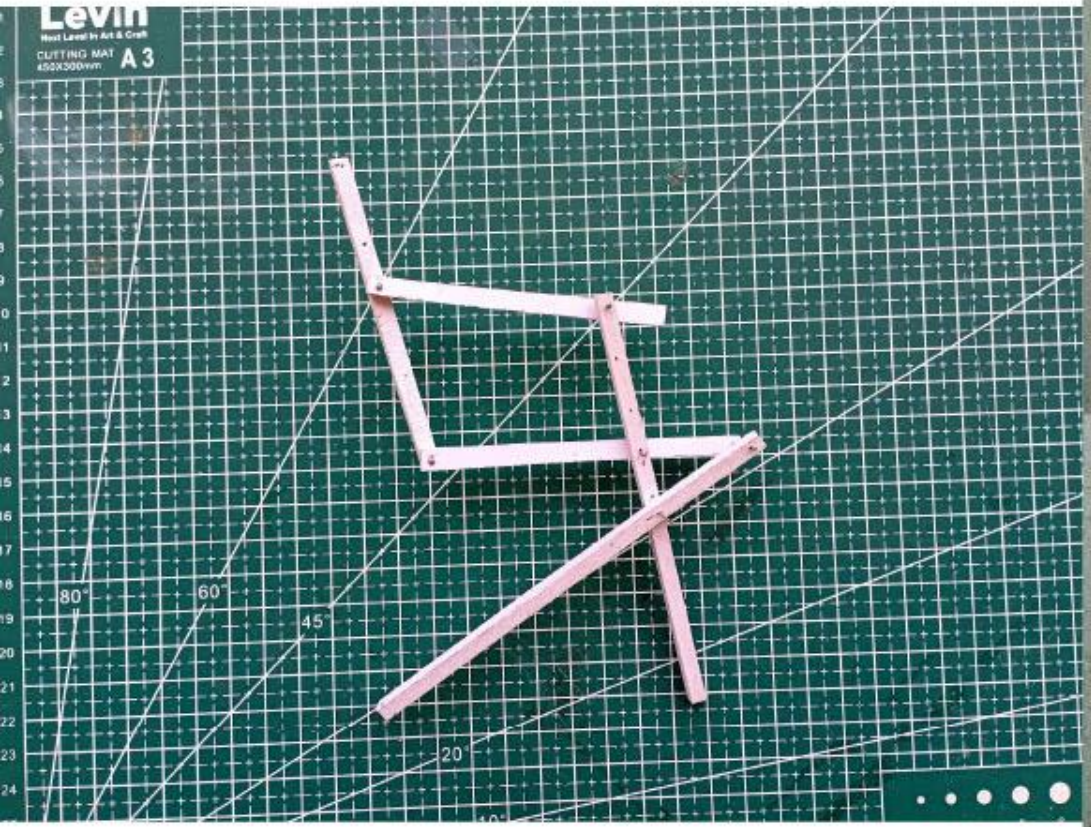


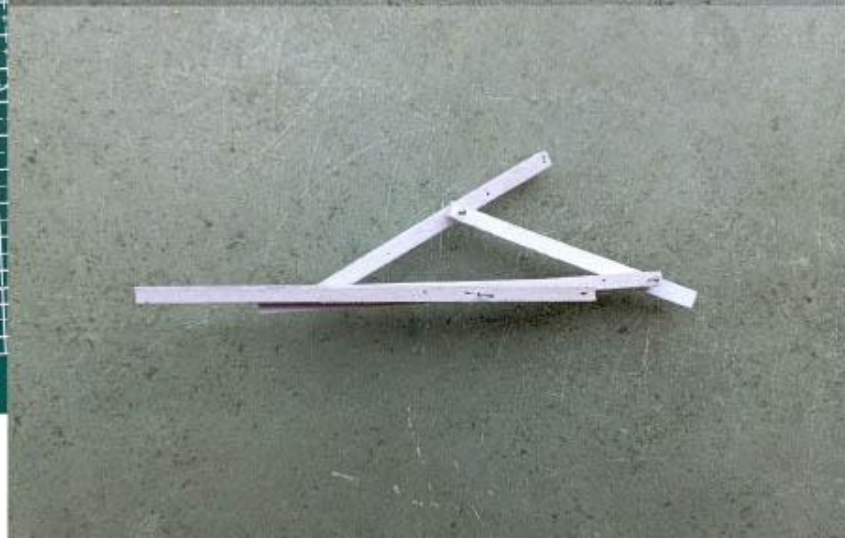

stopper


② The height (Trial & error)
① Their positions
Indian anthro. data
105°
back
front

Standard Dimensioning

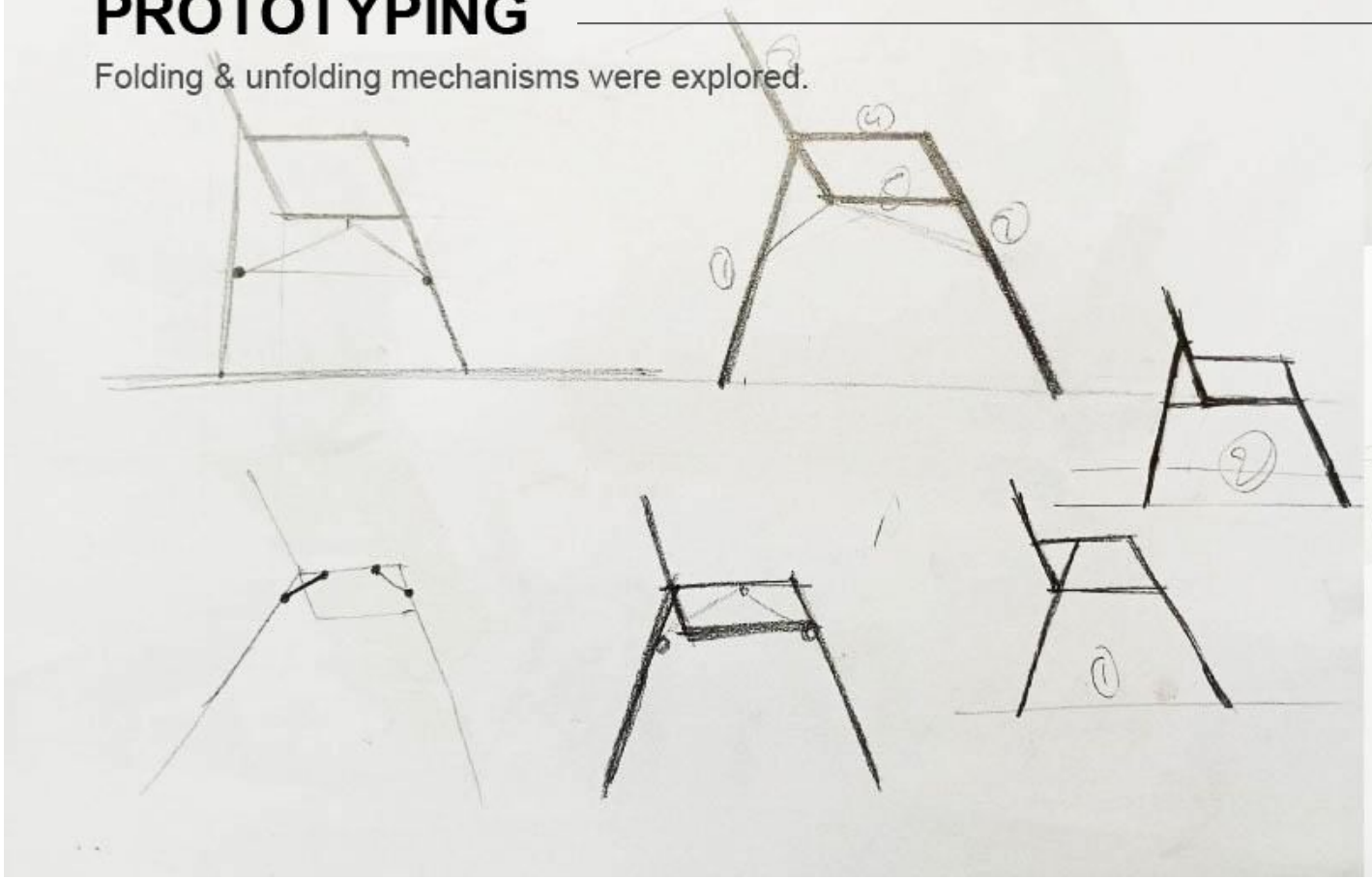



Levin
CUTTING MAT
A3
80°
60°
45°
20°



PROTOTYPING

Folding & unfolding mechanisms were explored.



Proposed structure

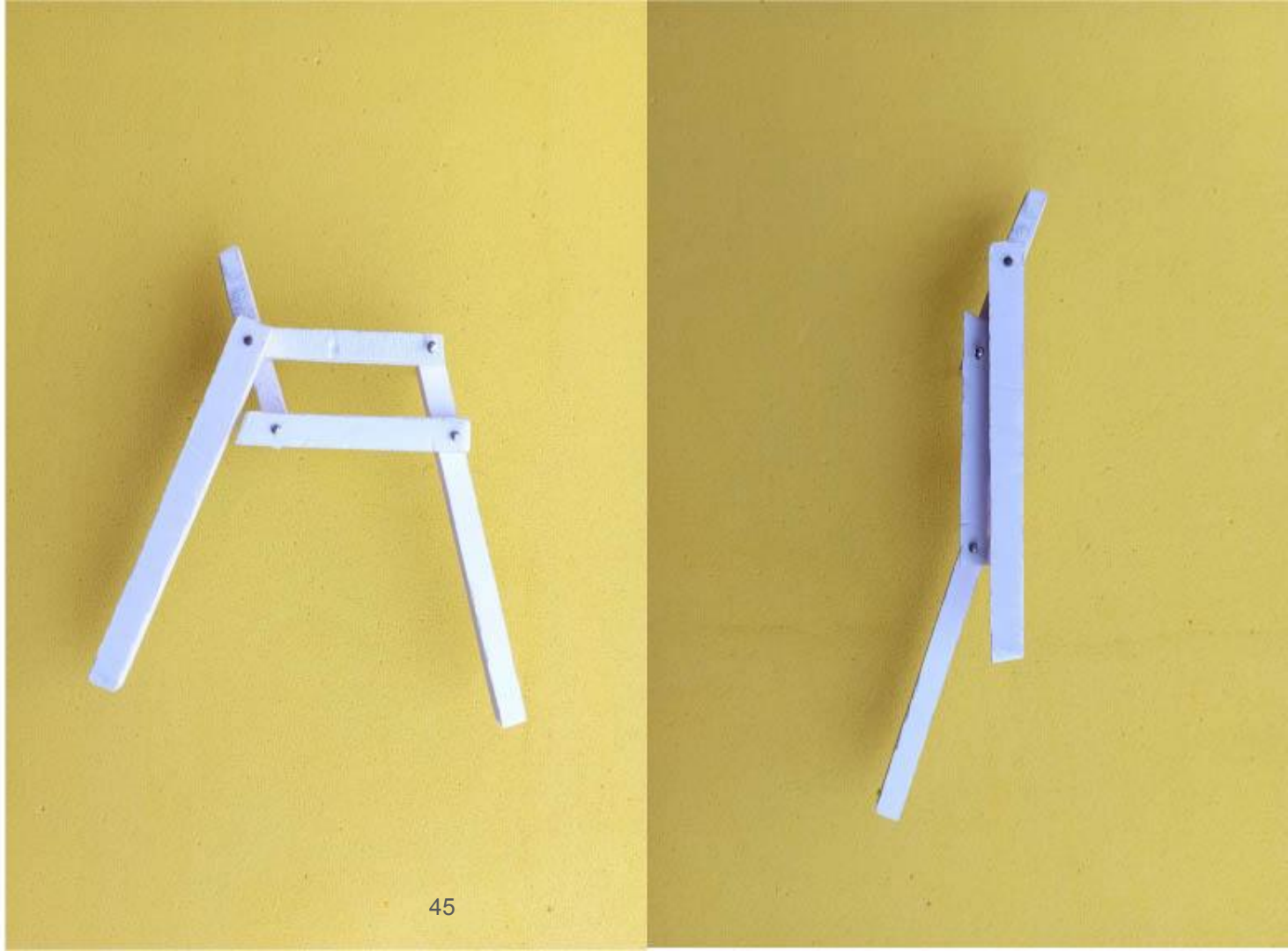
Not stable

Collapses during loading

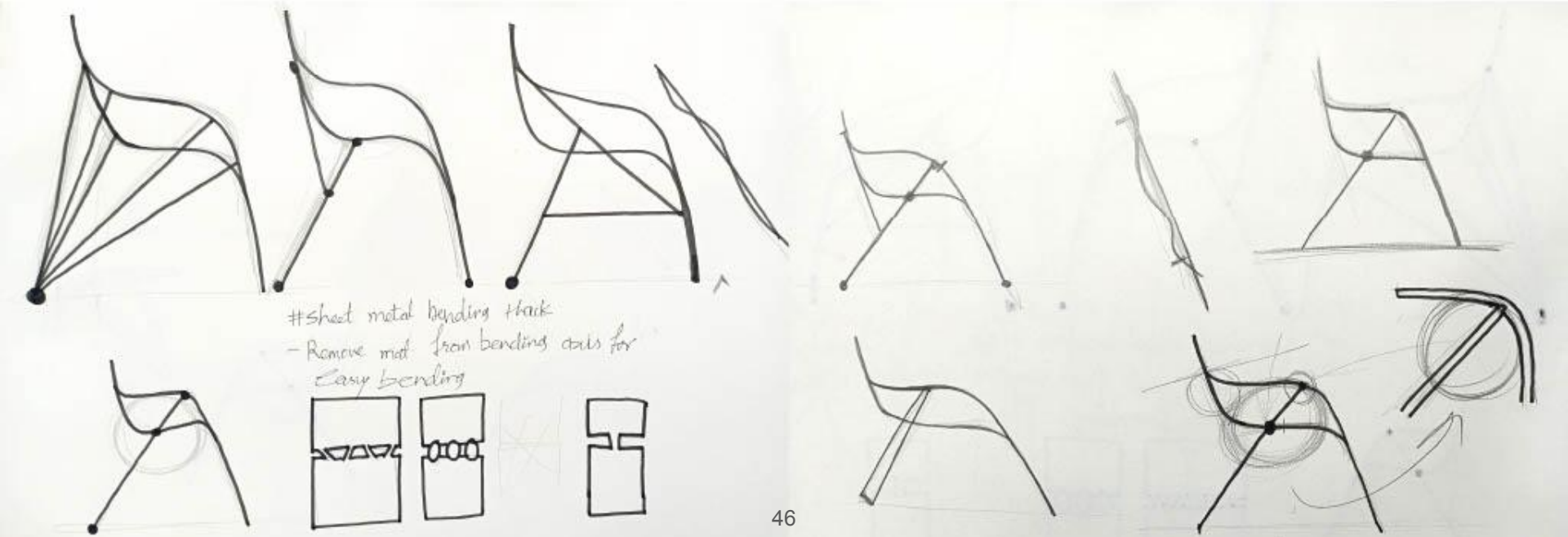
Skews either side

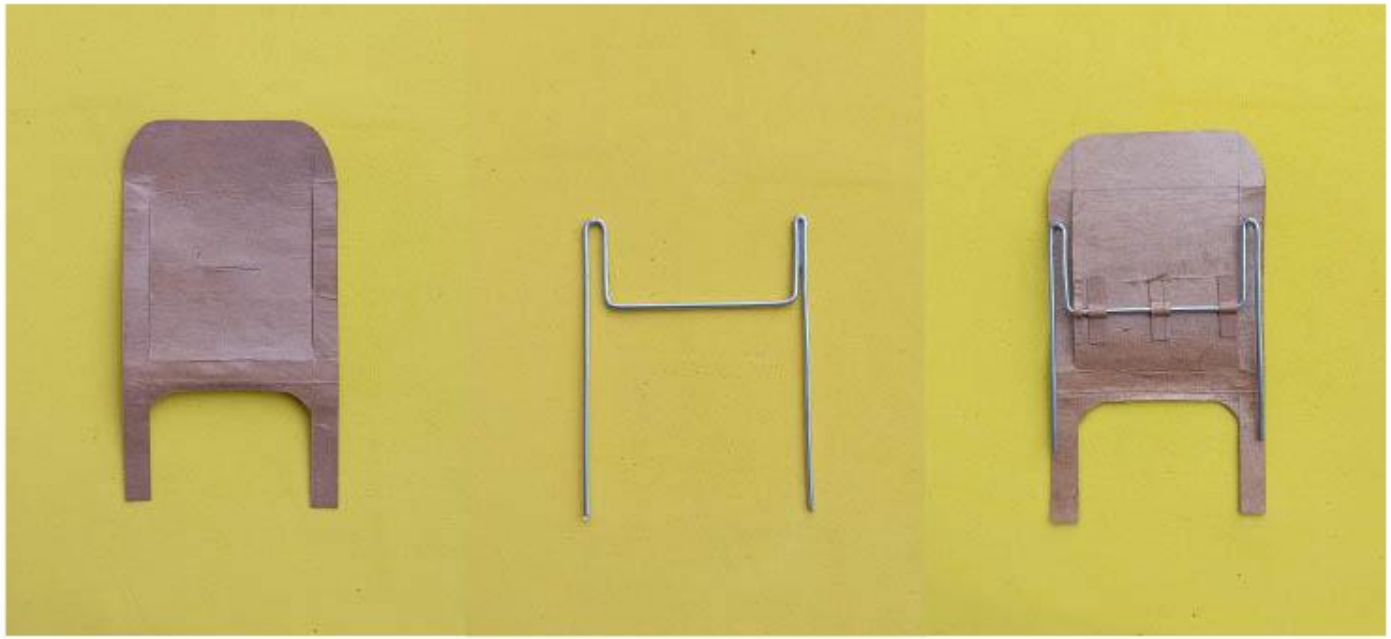
Stable & foldable

Looks like 1940's- 1950's chairs



New form mechanism developed.

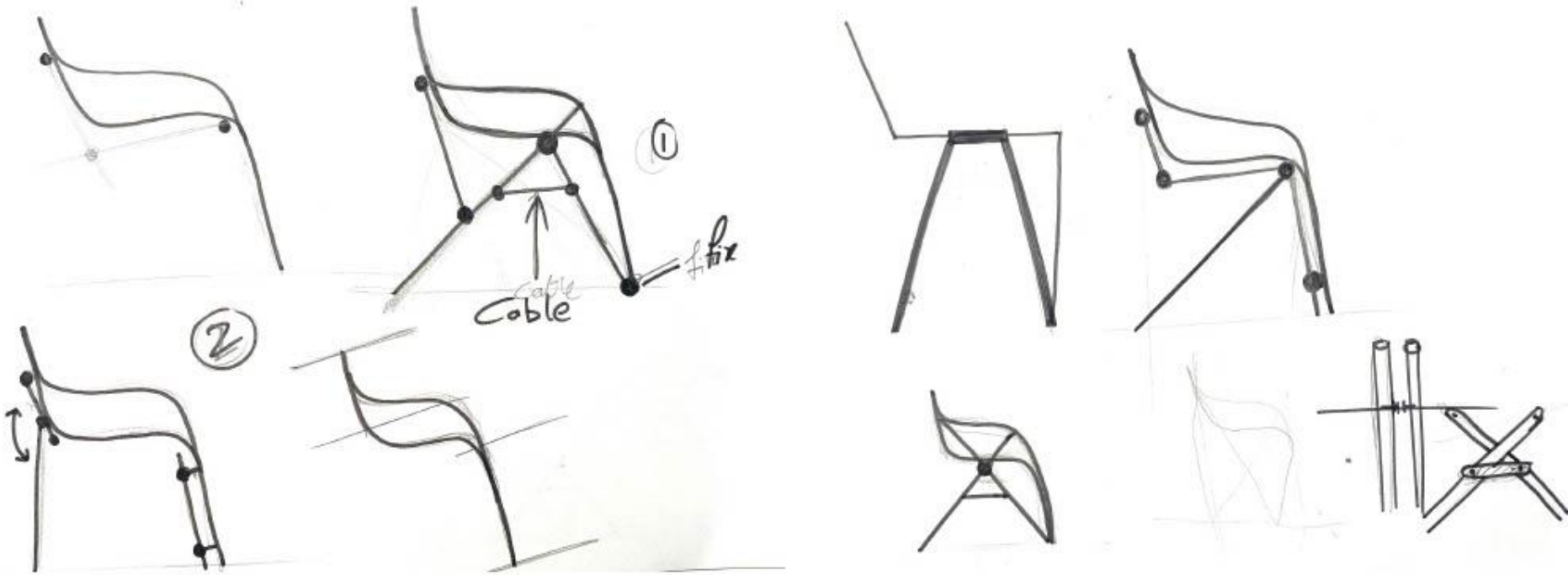


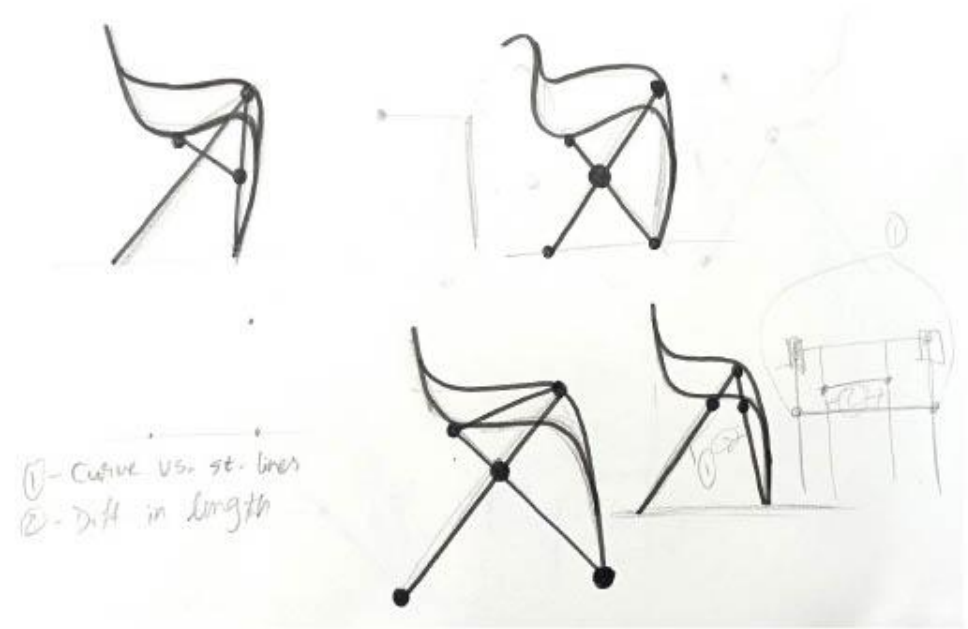


Front Legs (back) Back

Form itself was unable to provide structural strength and integrity.

Form strengthening reinforcements have been assessed.


①
Cable
fix
②

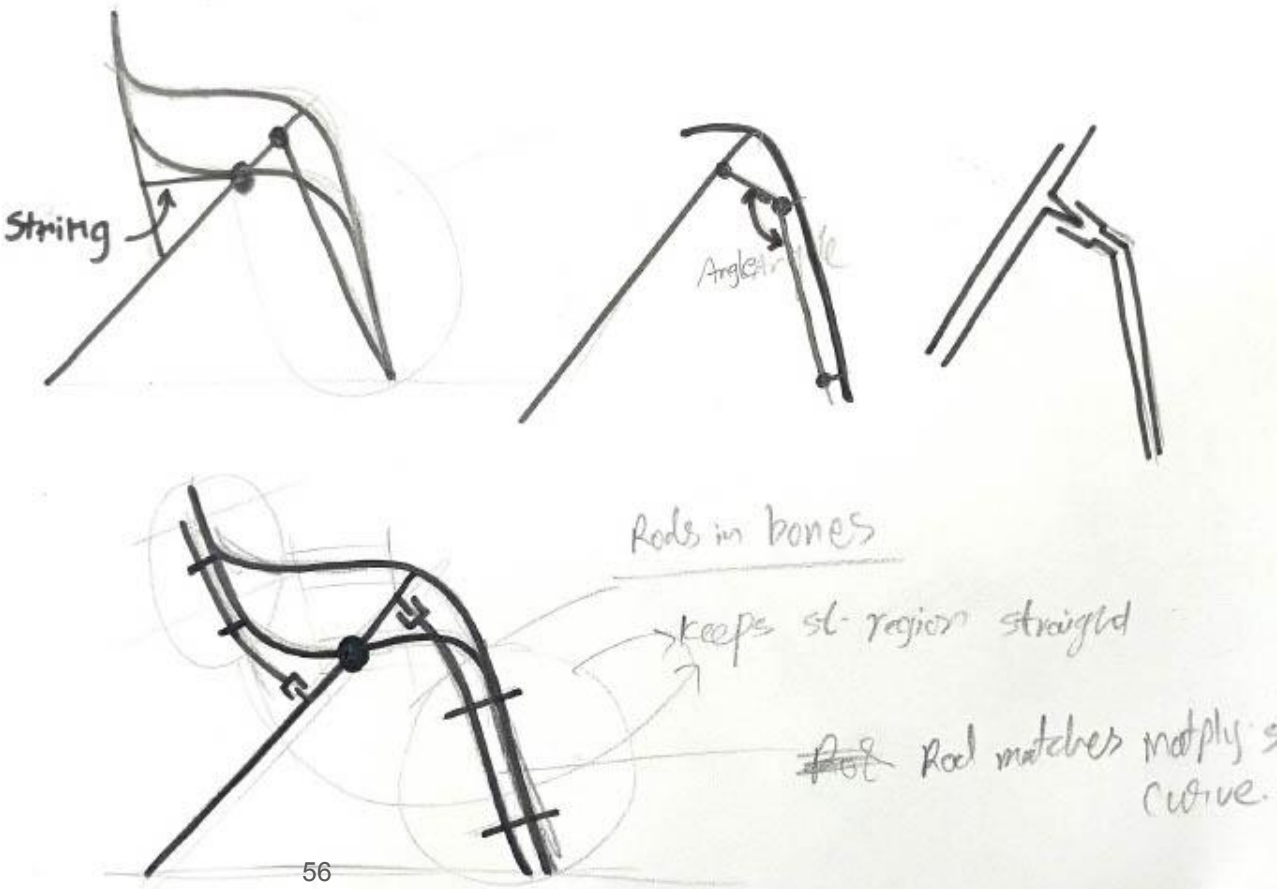

① - Curve vs. st. lines
② - Diff in length


lock
fix
fix

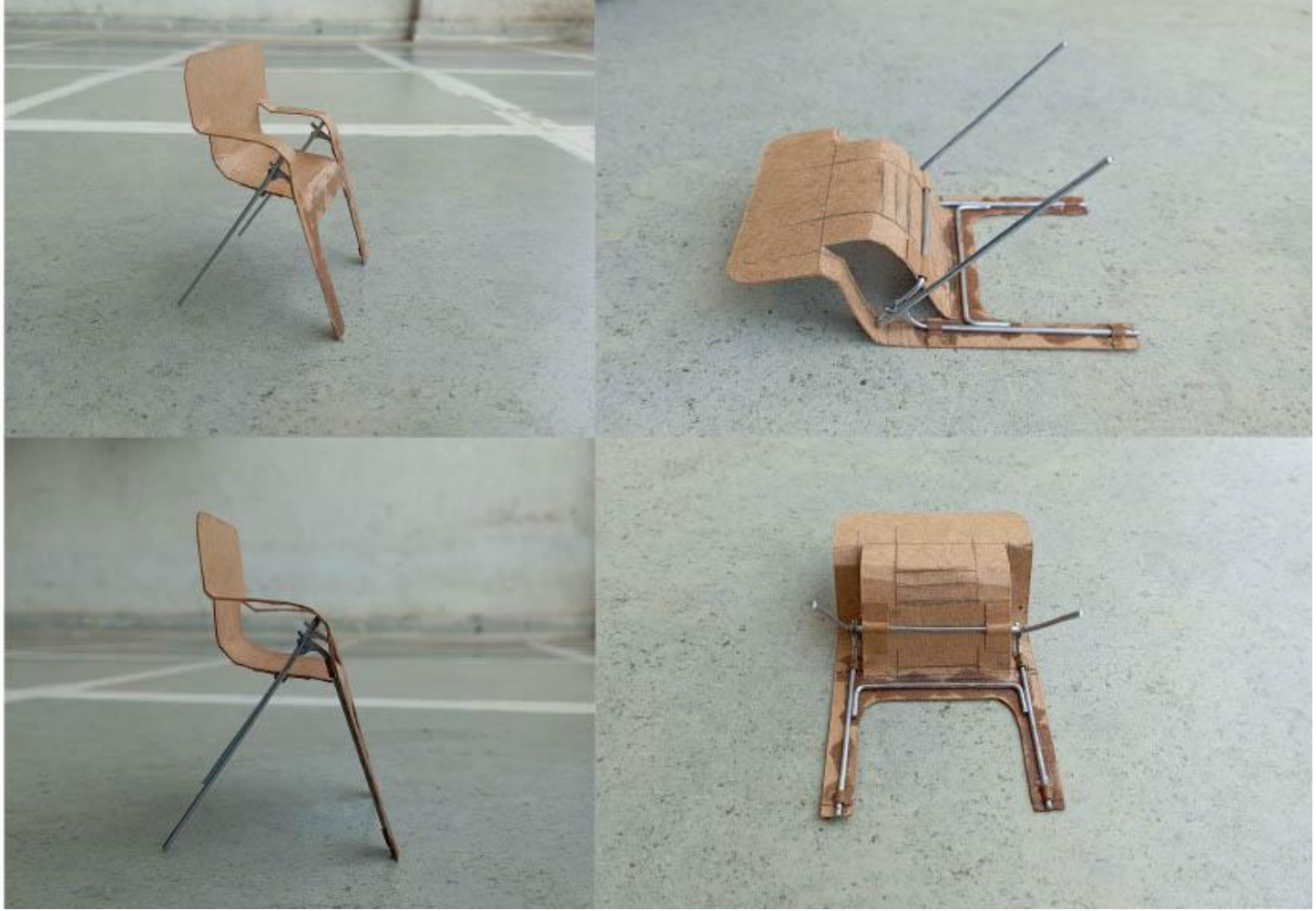
Inspiration

Bone fracture reinforced by medical rod implant

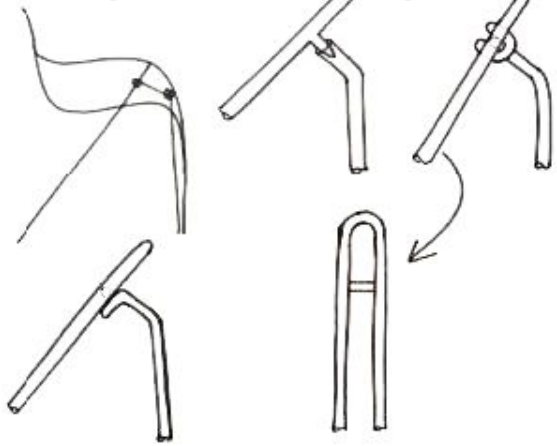
Credits: orthoinfo.aaos.org

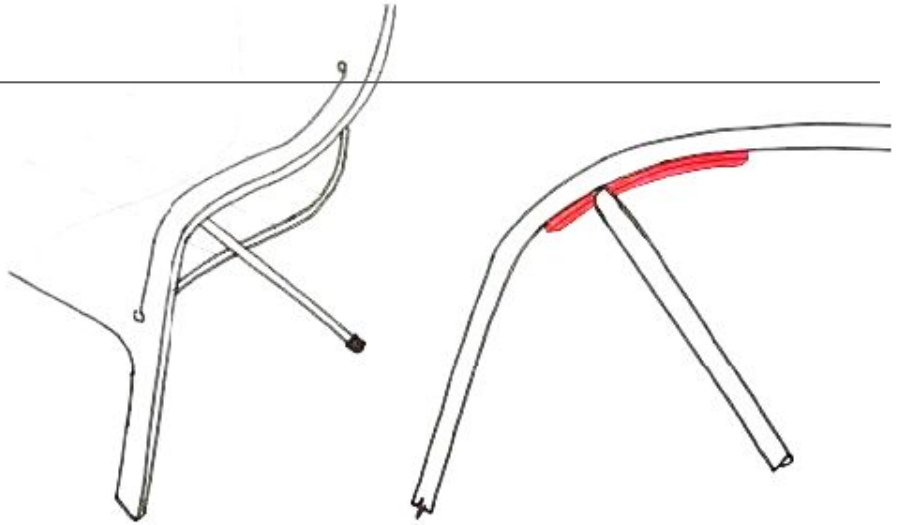


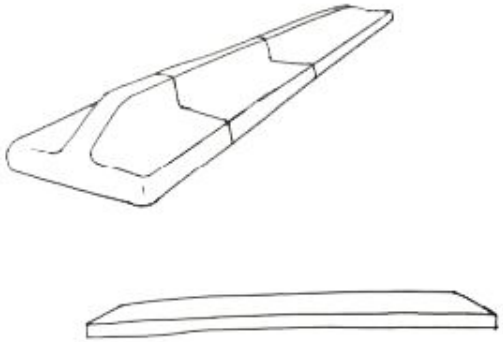
New modified form

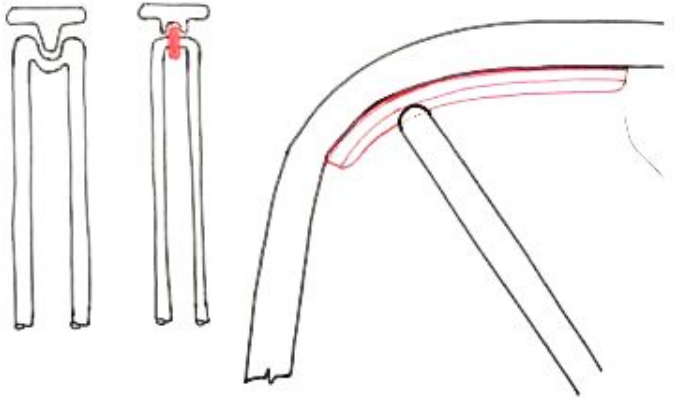


Details (Expected)



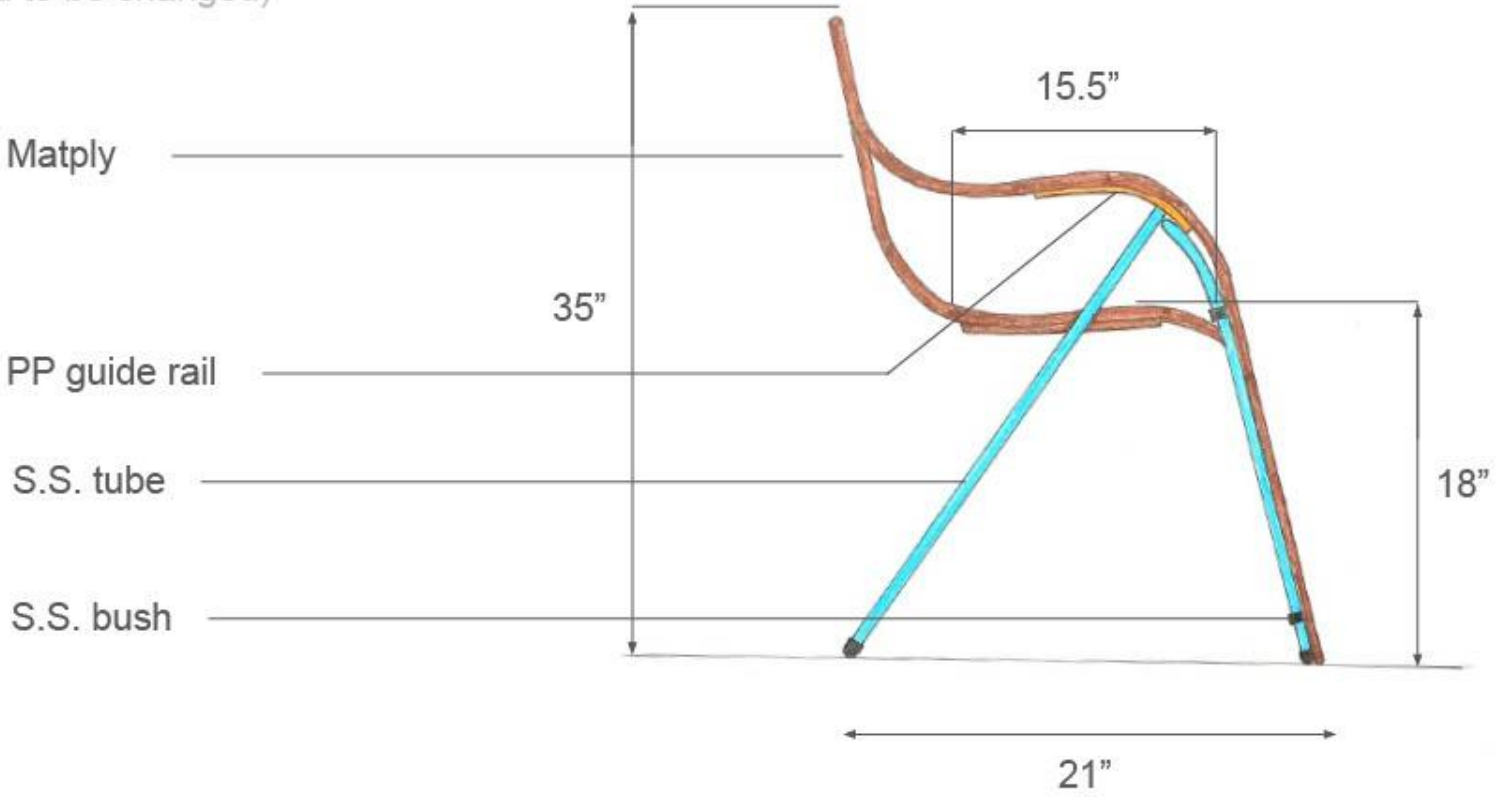






Dimensions

(Subjected to be changed)



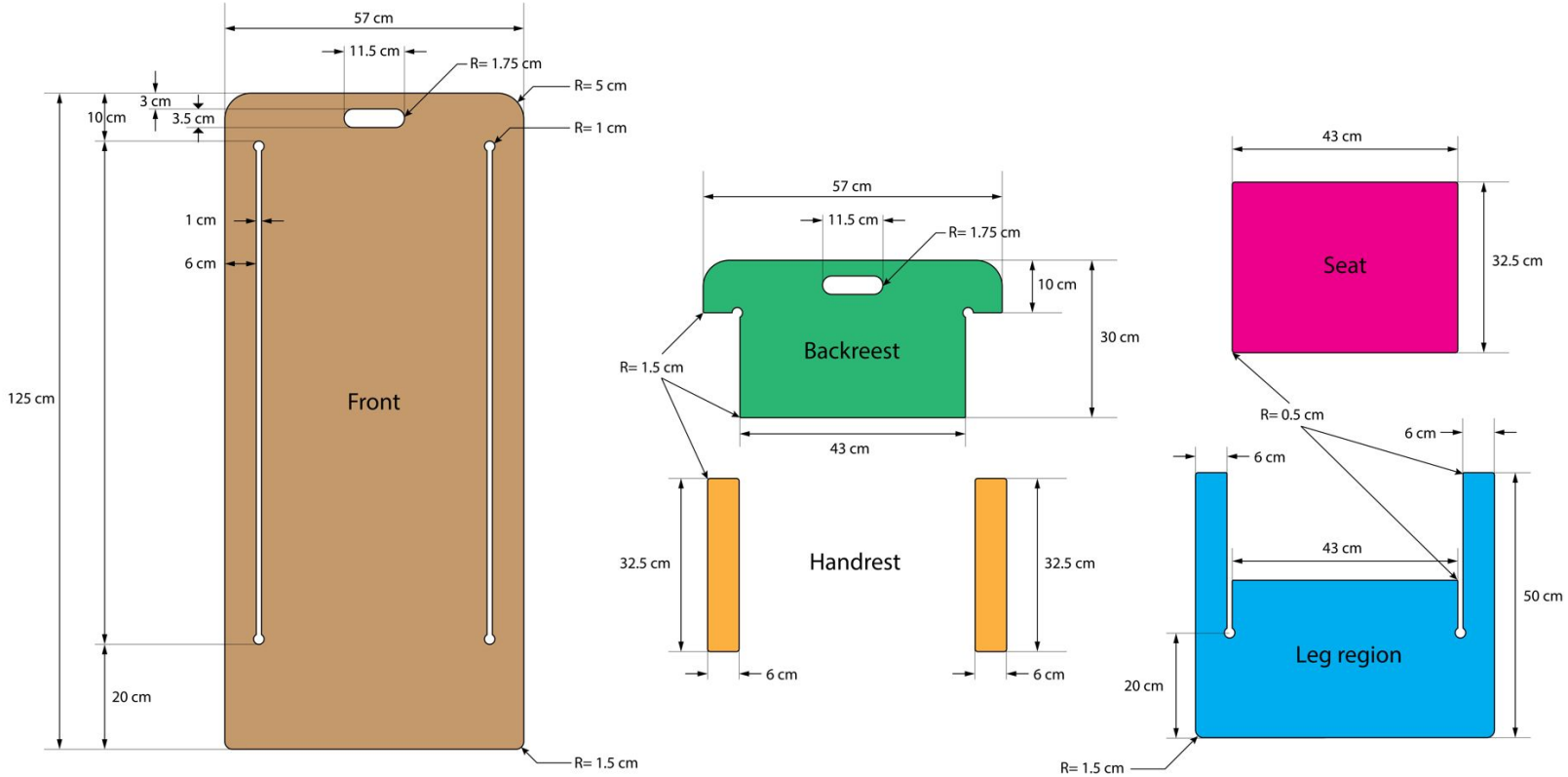
Testing Rig

To test the form and dimensions

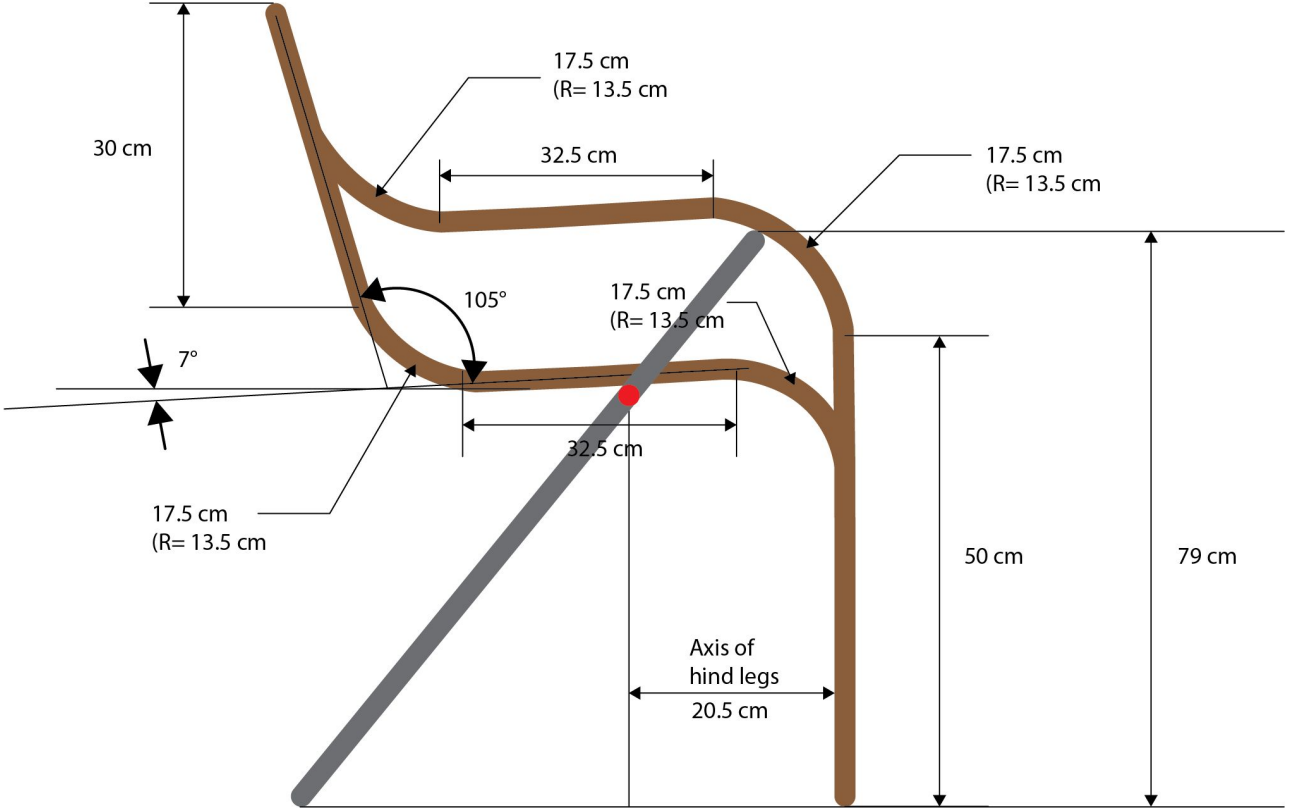
The test rig has been made and checked the ergonomics and dimensions.
Materials: Flexply and plywood.




Final Dimension



Side view


17.5 cm
(R= 13.5 cm
30 cm
32.5 cm
17.5 cm
(R= 13.5 cm
105°
17.5 cm
(R= 13.5 cm
7°
32.5 cm
17.5 cm
(R= 13.5 cm
50 cm
79 cm
Axis of
hind legs
20.5 cm

T-nut

Material: 4.8 grade carbon steel

Nut size: M4 thread

Round base diameter 15 mm,

The thickness of circular base is 1.1 mm,

Overall height 7.5 mm

U-clamp

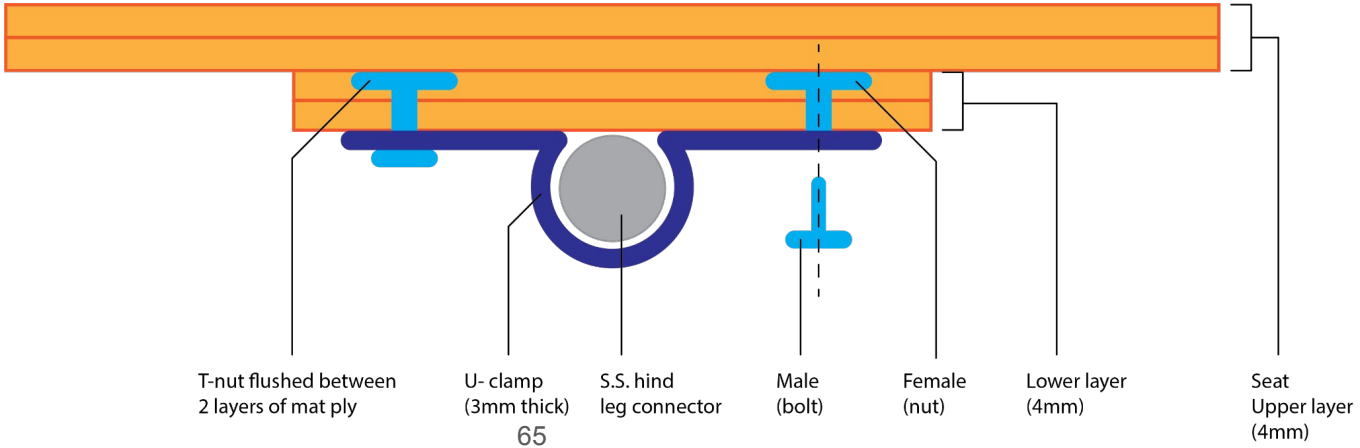
Clamp with cushion

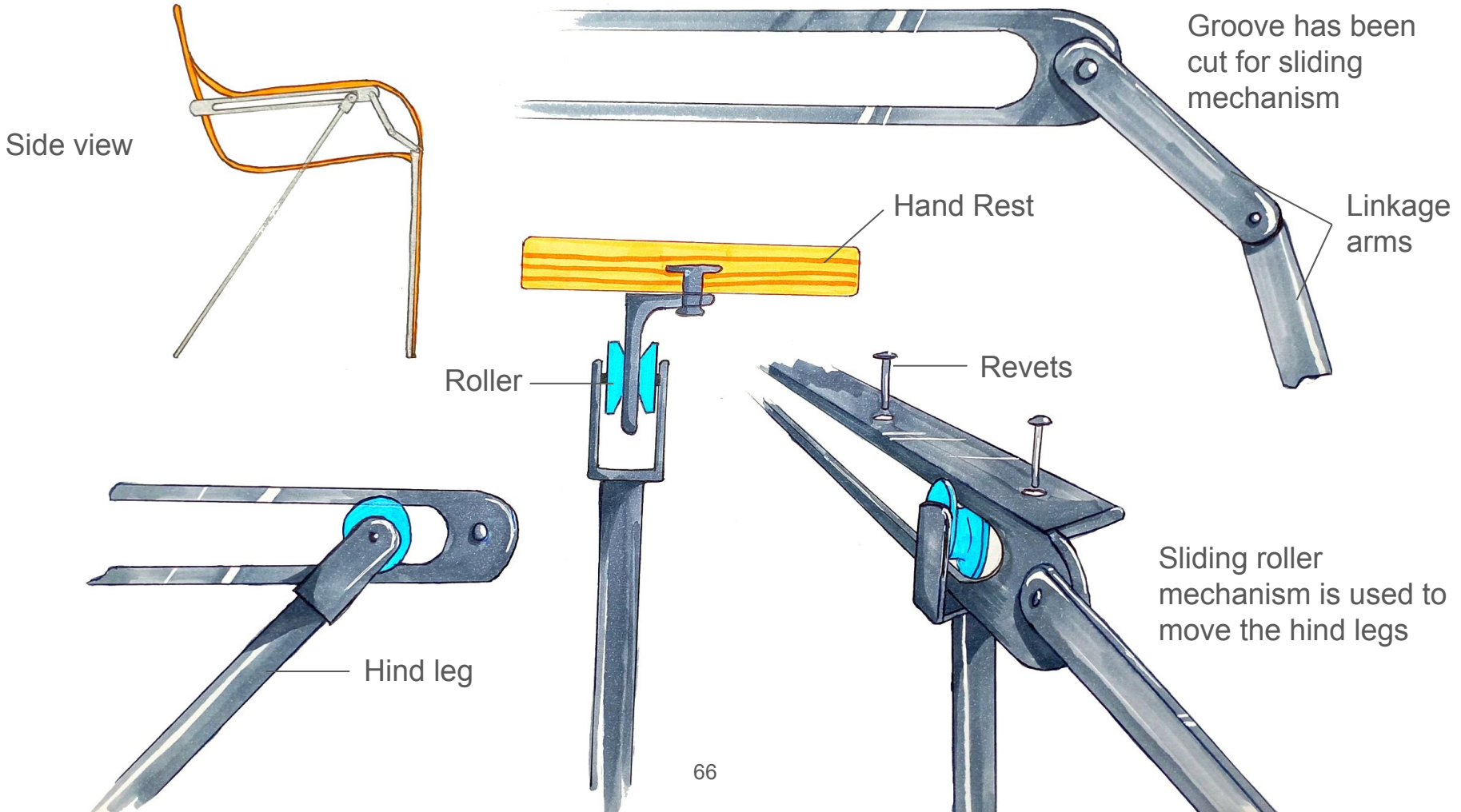
Internal dia= 16mm

Image credits: Amazon.com

Assembly

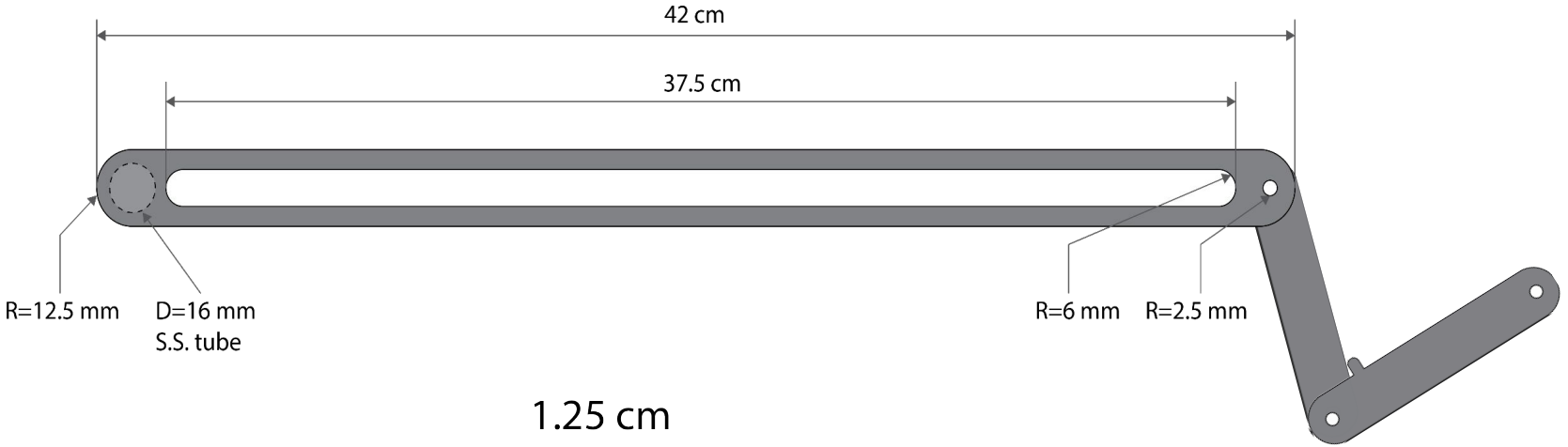
Side view



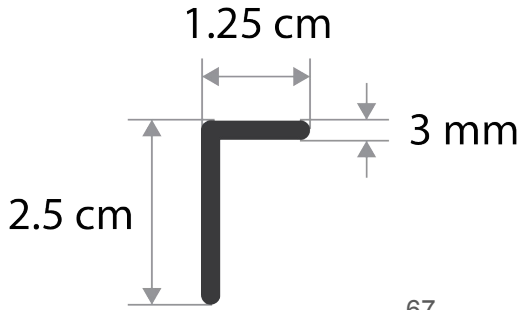

Side view
Groove has been cut for sliding mechanism
Hand Rest
Linkage arms
Roller
Revets
Hind leg
Sliding roller mechanism is used to move the hind legs

Dimensions

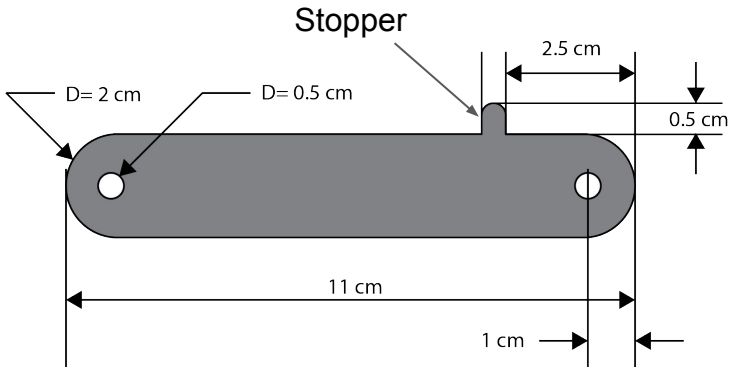
Slider (side view)



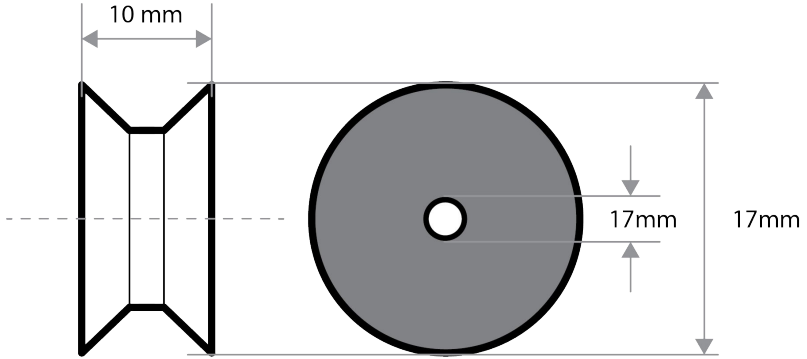
Slider (front view)



Linkage

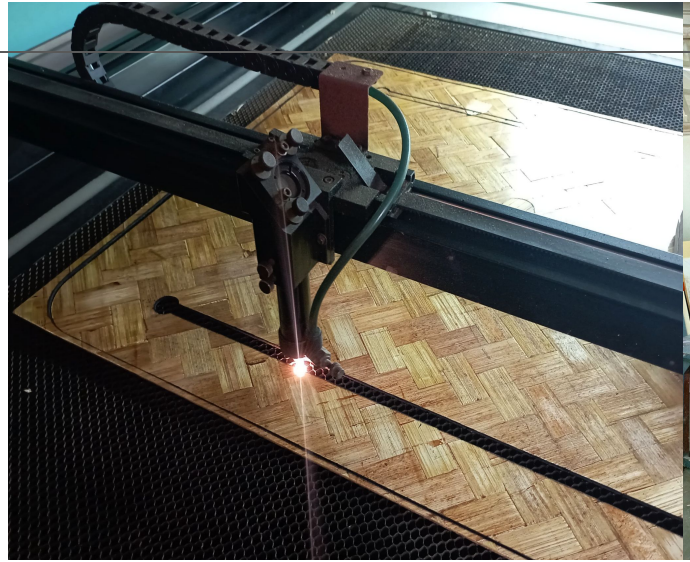


Slider roller



Process

Mat ply has been Laser cut based on finalised dimensions.

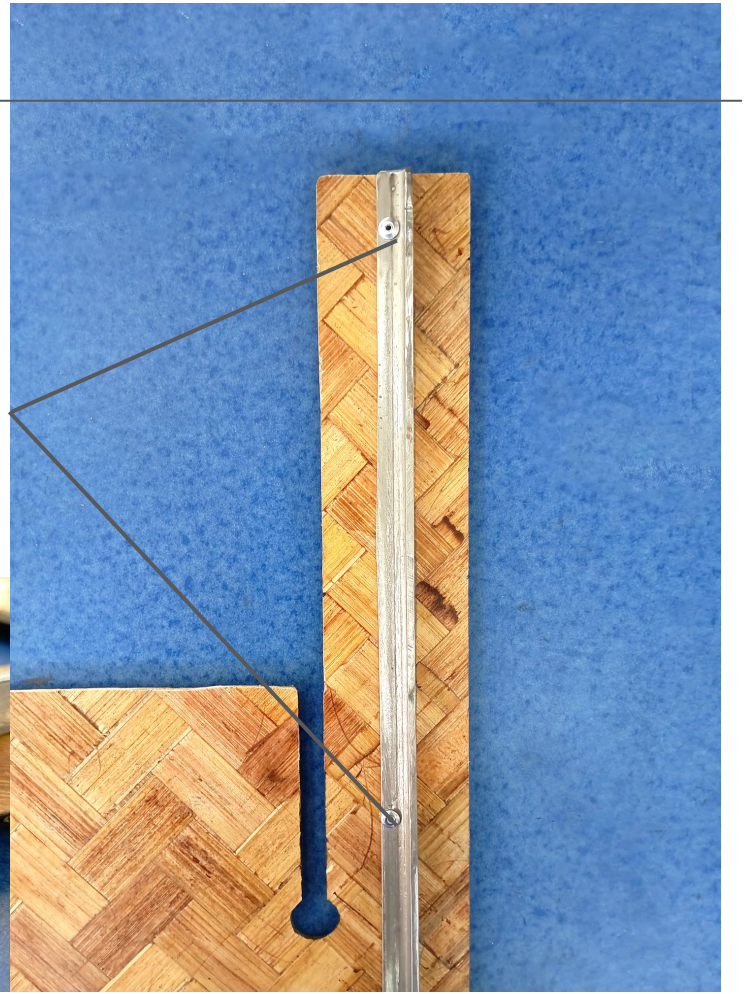


Different pieces of mat ply has been glued together.

Form and strength has been assessed.

Assembly

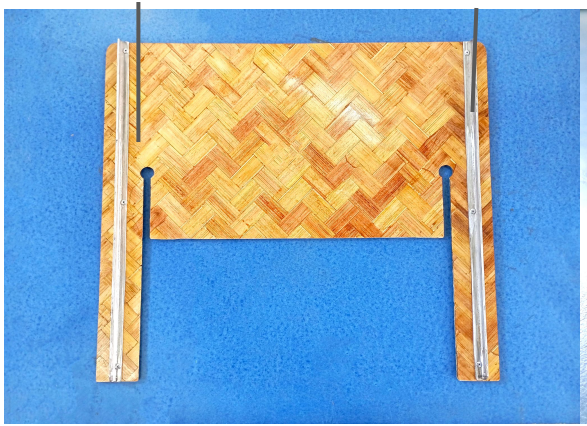
- For strength, stainless steel tube and angle is used in mat ply.
- Mat ply and the S.S. members are joined together by revetting.

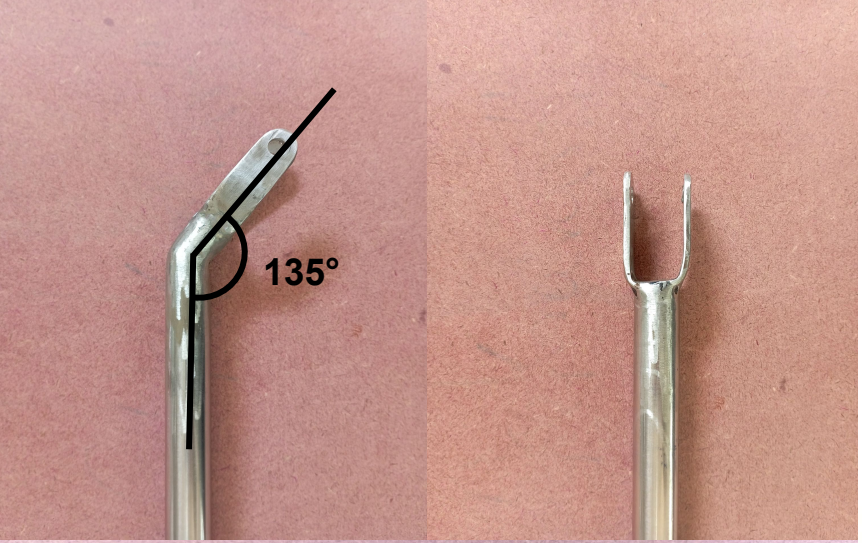


Mat ply

S.S. Members

Holes for arm linkages




135°

Testing

- The strength and functionality of the chair has been tested.
- With 18kg of loading on it, the failure appeared.
- As a natural material, mat ply's consistency and physical properties are not uniform throughout.

Observation

- For 2mm thick mat ply, the maximum bending radius is 13.5mm; beyond this, it starts to break and chip.
- Repairing of material is also difficult.

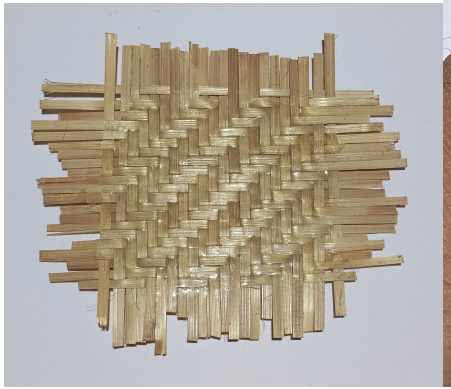
- Reinforcement is needed in bending areas using polypropylene and stainless steel, matching mat ply properties.

- Hooks are used as solution tends to revert into flat sheet.

- Unseen splinters hurt out of nowhere.

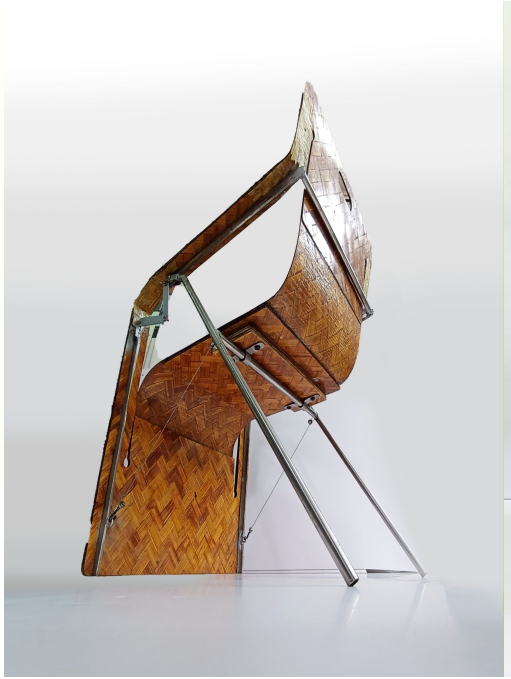
Altered Material

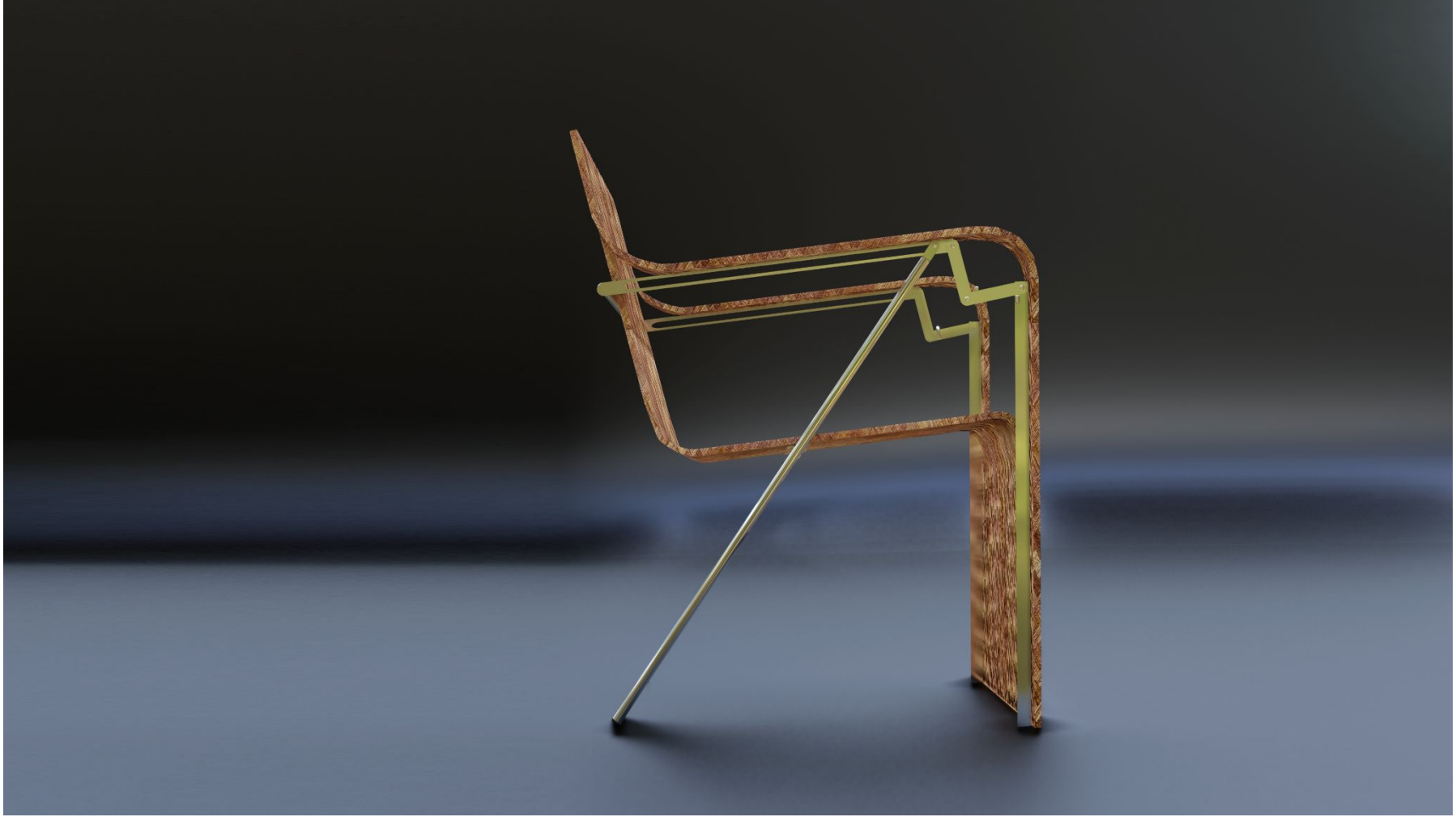
- As bamboo strip’s width is reduced, the strength and flexibility is improved.
- To mimic the desired properties, a new mat ply sample has been made using bamboo strips of less width and cyanoacrylate based glue.
- It is found that the flexibility and the strength has been improved.
- Amount of moisture in mat ply also plays an important role in bending.

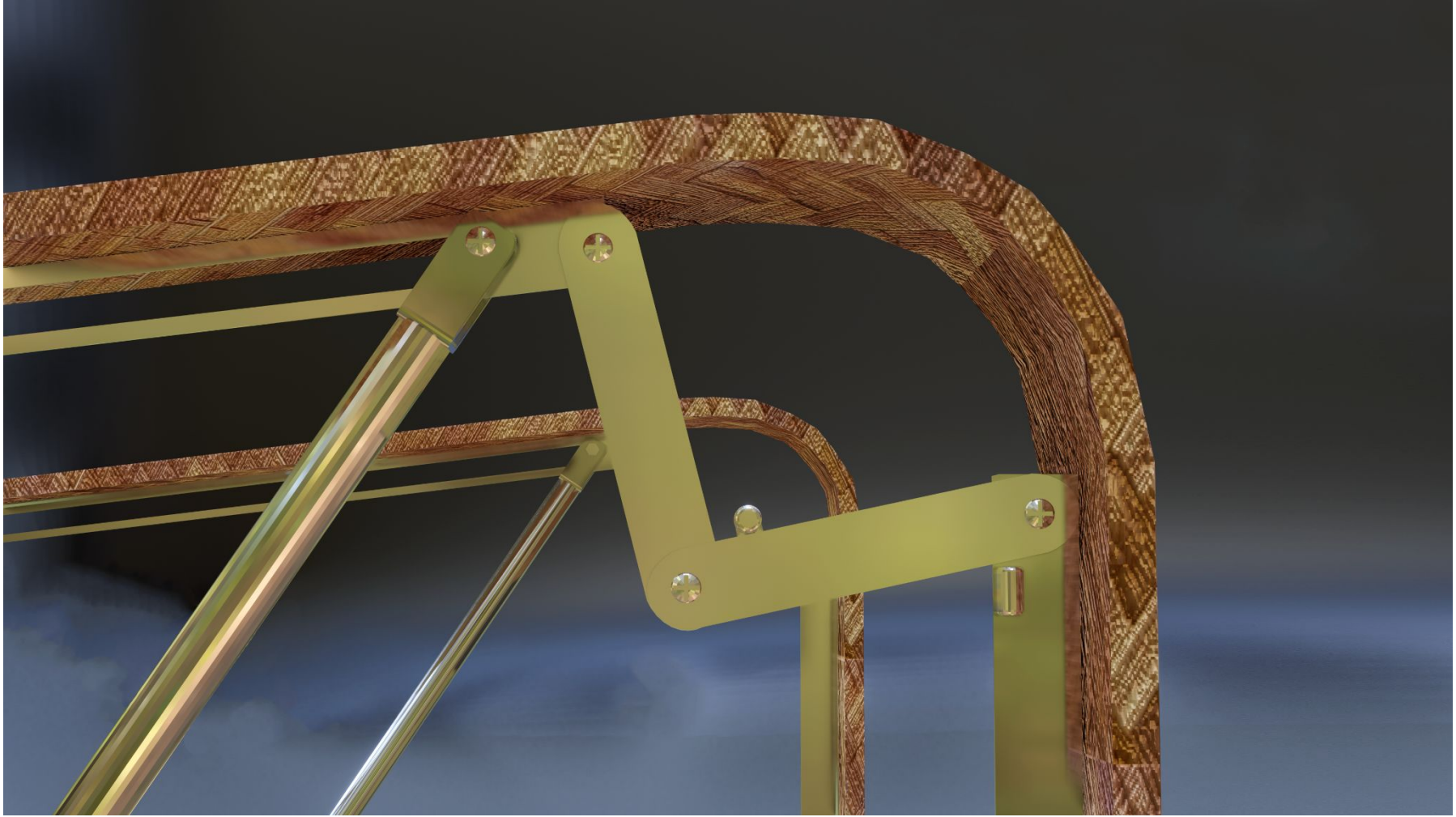


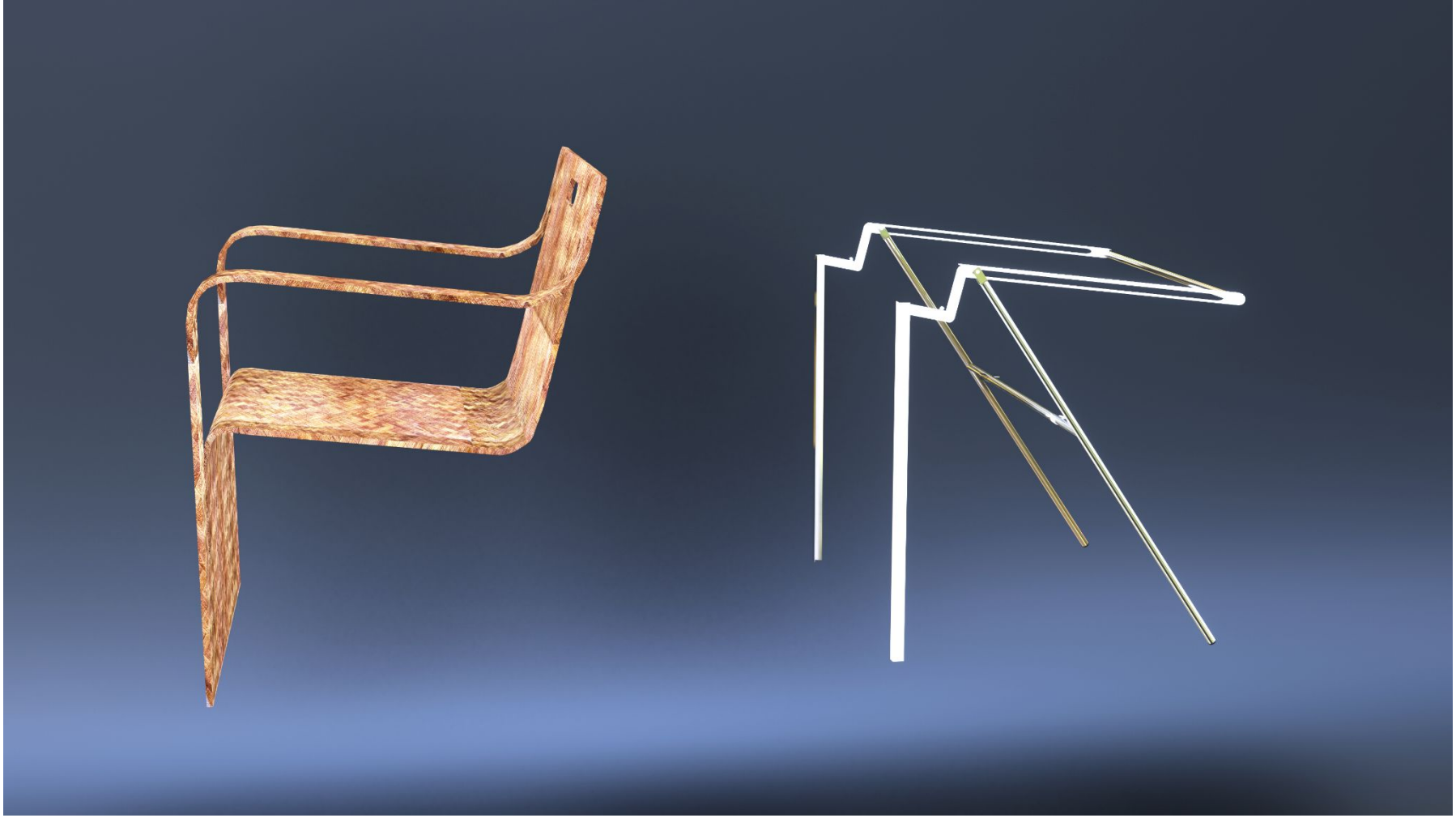
- Altered width of mat ply bamboo strips: 5mm.
- Existing width of mat ply:25mm.

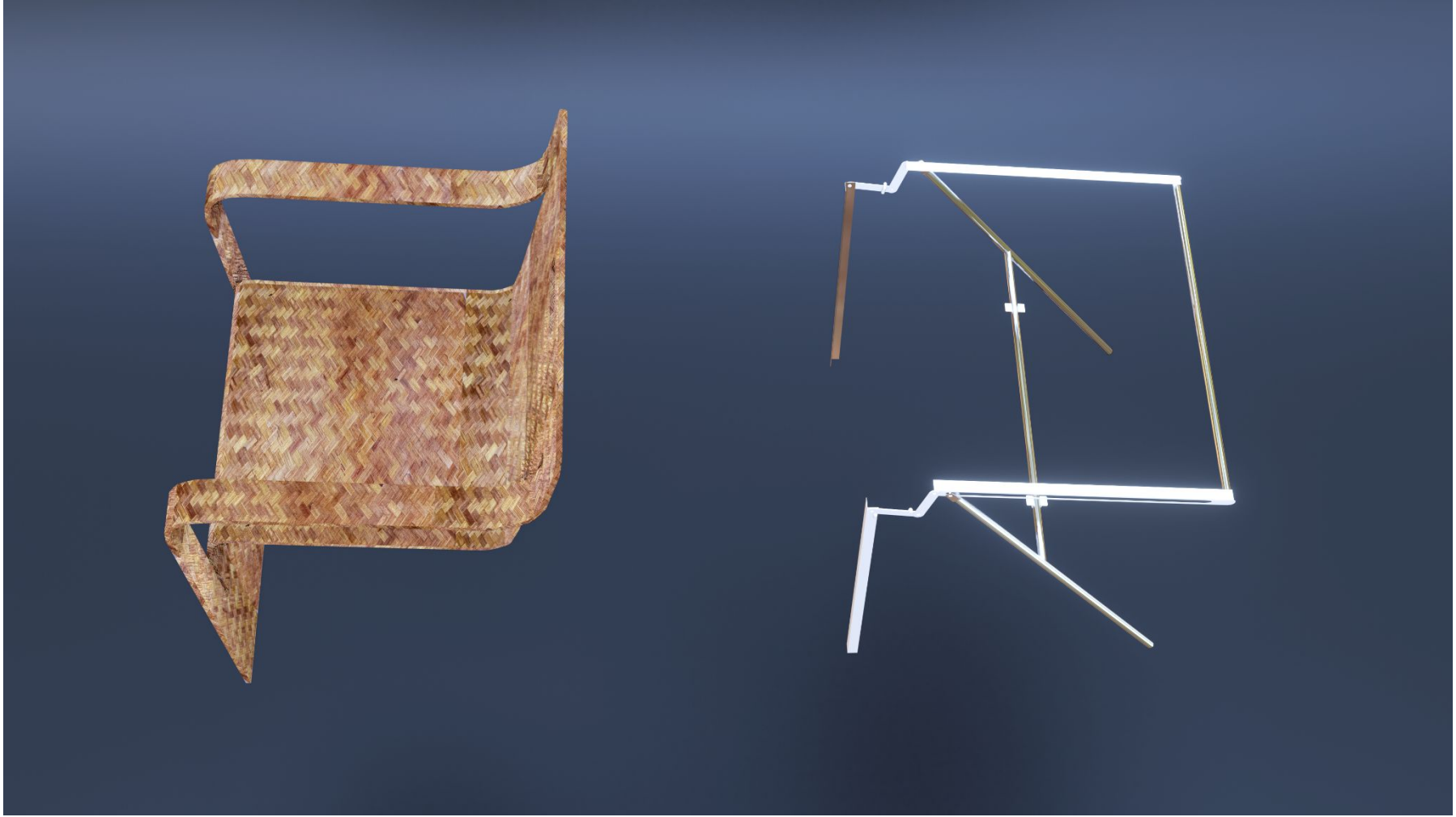
Assembled Chair











Conclusion

Bamboo, not a new concept in a furniture design, still requires a special attention for its development.

Utilizing bamboo's true potential demands advanced material synthesis, manufacturing processes for desired properties and innovation.

Such improvements will help to overcome the hindrances that kept bamboo from being a viable material in furniture market, will also help its acceptance amongst the customers.

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