SIIPU CHAIR
AN INVESTIGATION INTO THE APPLICATION OF LAMINATED BENDING VENEER
TECHNIQUE IN FURNITURE DESIGN FOR MUSEUM

MASTER THESIS
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In today’s rapidly evolving society, where trends often dictate the fleeting relevance of various phenomena, it is crucial to not only discover new materials and resources but also to delve deeper into the properties of existing materials, uncovering novel possibilities and applications. By thoroughly investigating the materiality and processes of these resources, we can reveal overlooked characteristics and inherent qualities. In this context, wood stands out as a primeval material that has coexisted with humans for millennia, consistently demonstrating its versatility and untapped potential.

In light of this, the present thesis conducts an in-depth investigation of a distinct type of wood—veneer—exploring its unique materiality that may not be readily apparent. By integrating the veneer with the ‘Molded Laminated Bending Technique,’ this research focuses on designing chairs for indoor spaces, primarily modern art museums. Utilizing CNC-Milling for mold fabrication and incorporating it into seat design, the study examines the behavior of bending veneer under various conditions and environmental factors. Throughout this process, the veneer’s bending capabilities are rigorously tested, revealing a multitude of material properties and potential applications in design.

This research aims to establish a comprehensive understanding of wood bending techniques applicable to various tree species, ranging from solid wood to veneer. By examining the works of renowned designers such as Alvar Aalto, Marcel Breuer, Arne Jacobsen, and Eames, the study identifies key bending veneer furniture pieces they have created. In doing so, the investigation seeks to elucidate how the advantageous properties of bending veneer have been employed in furniture design, particularly in chairs. Furthermore, the research delves into not only structural considerations but also the architectural and sculptural aspects of bending veneer chairs, exploring how their unique aesthetics have been influenced by the social phenomena of their respective eras.

This study further probes the potential for symbiosis between veneer and alternative materials, while concurrently, the research exhibits the physical attributes and innate allure of veneer by expressing it in a contemporary design vernacular through the fabrication of chairs. The study examines how these chairs engage with and enhance their encompassing environments.

The project comprises a total of three distinct chair designs: single chairs with veneer seats of varying thicknesses, a design that integrates a linkable system, and a beam-type bench. As prototypes, these chairs offer a range of design modifications and effectively showcase their potential as versatile indoor public seating options.
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In the realm of ecological inspiration, diverse sources contribute to the development of unique regional approaches to materiality and technique, with particular emphasis on the interplay between human life and the surrounding environment. One such material, wood, serves as a fundamental connector between tangible and intangible realms, providing both mental stimulation and physical benefits to humans as they adapt to their environment in harmony with nature. In this context, designers act as mediators between nature and humanity, rather than as exploiters of natural resources.

The essence of wood and its potential for innovative applications are central to the design process, wherein the successful integration of function and materiality gives rise to inherent aesthetic qualities. This paper explores the untapped potential of veneer, a derivative of solid wood, by examining its structural stability and aesthetic properties in the context of novel design applications.

Termed "Non-Human Person," wood and similar substances are acknowledged for their spiritual and inspirational value by intelligent beings such as humans. This study delves into the deeper structural possibilities of veneer, uncovering novel forms of beauty in the creation of chairs that evoke mental inspiration through their unfamiliar shapes. Furthermore, the chair, an object intimately connected to human life, serves as an exemplar of how veneer can be employed to create and inhabit an unseen space, demonstrating the transformative potential of this versatile material.
PURPOSE OF STUDY

The purpose of this project is twofold:

1. Design chairs using wooden veneer bending technique and local materials: Through this design process, the study aims to observe the synergy between local materials and the bending technique, demonstrating the potential of combining these elements in innovative furniture design.

2. Examine the interaction between the designed chairs and humans in indoor public spaces, particularly museums: The research seeks to understand how the chairs engage with users in these environments and proposes recommendations for how they can best be integrated into such spaces, enhancing the overall experience for visitors.

SCOPE OF STUDY

This research encompasses the following aspects:

1. Review and classification of typical wood bending techniques: The study investigates and categorizes various wood bending methods based on their processes, examining their history, development, and unique characteristics.

2. Focus on the molded plywood technique: Among the diverse techniques, the research places particular emphasis on the molded plywood technique, presenting an in-depth analysis of specific cases and incorporating personal insights.

3. Examination of prominent designers and cabinet makers: The study references various designers and cabinet makers, conducting a comparative analysis of their works and methodologies related to the molded laminated wood bending technique. This approach allows for a comprehensive understanding of the experiments and innovations they have contributed to the field.

METHODOLOGY

The research methodology consists of the following steps:

1. Visiting museums, primarily in Finland: Investigate and analyze data on furniture currently in use at various museums. During this process, the focus is on understanding how furniture interacts with people, spaces, and exhibits within the museum, as well as examining the role of furniture in shaping the identity and atmosphere of the museum.

2. Chair design using molded plywood: Based on the analysis, create chair designs that incorporate the molded plywood technique. The designs are broadly categorized into single chairs and linkable chairs, all sharing a common design context. These designs showcase a novel structure and aesthetic by combining molded plywood techniques with local materials, highlighting the unique characteristics of each model in relation to the space.

3. Integration of traditional techniques and IT technologies: Emphasize the potential for coexistence between traditional methods and modern IT technologies by synthesizing them in the design process, addressing design challenges within the context of contemporary language.

4. Suggesting the role of chairs in museum spaces: Propose how the designed chairs should function as distinct entities within museum environments, contributing to the overall experience for visitors.
The laminated bent wood technique enables the creation of various organic forms by harnessing the exceptional bending strength of wood, a material with more than twice the bending strength of steel and a lower carbon footprint. This technique presents a new approach to addressing specific needs in modern society. (Benson, 2009, p.10)

Veneer, a material that offers unique design possibilities not found in solid wood, retains the wood grain on its surface and can be mass-produced while still maintaining a handcrafted appearance. Veneer can be used to create both straight lines and arbitrary curves, showcasing its versatility as the primary material for furniture and objects. By layering thin veneers with different grain directions and using glue and heat to maintain a specific shape, the resulting laminated bent wood exhibits the same robustness as solid wood and the flexibility to naturally absorb force. (Benson, 2009, p.13)

This study investigates the various possibilities of the laminated bent wood method and implements the results to articulate the inner beauty and structural existence of veneer as a material.

Key aspects of this research include:

1. Exploring the unique properties of veneer that differentiate it from solid wood.
2. Investigating the versatility of veneer as a primary material for furniture and objects, capable of creating both straight lines and arbitrary curves.
3. Analyzing the laminated bent wood technique as an essential material for expressing the physical structure of furniture and the creator’s philosophy.
4. Implementing the findings to showcase the inner beauty and structural existence of veneer as a material.

By examining these aspects, the study aims to uncover the potential of veneer and the laminated bent wood technique in creating innovative and aesthetically pleasing furniture designs.
THE BEGINNING OF BENDING WOOD AND SOCIAL EFFECT

Michael Thonet (2 July 1796, Boppard – 3 March 1871, Vienna) is often considered a pioneer in wood bending techniques, with his iconic chair No. 14 serving as a symbol of bentwood furniture. Widely recognized and appreciated even by those not particularly interested in furniture, the No. 14 chair is the world’s best-selling bentwood chair and is remembered as the first mass-produced bentwood chair. Thonet invented bentwood furniture in his studio in the late 1830s. (Michael Schweer et al, 2006, p.10)

Thonet’s work is emblematic of bentwood furniture due to its demonstration of the infinite possibilities of wood and the various ways it can showcase its beauty as a bending wood structure. In ‘Figure 1’, a bending structure is used in the leg and backrest part of the chair, achieving a strong yet minimal structure and expressing aesthetic beauty through natural curves. His contributions to the field of bentwood furniture design have had a lasting impact, inspiring further exploration of wood bending techniques and the development of innovative furniture designs. His work serves as a testament to the versatility of wood as a material and the potential for creating beautiful, functional, and enduring pieces of furniture using bentwood techniques. (Michael Schweer et al, 2006, p.11)
Michael Thonet, a pioneer in wood bending techniques, designed his iconic No. 14 chair with mass production in mind, as illustrated in 'Figure 3'. He first created various molds by heating them with water vapor according to the desired shape of the model. Individual parts were then made and assembled using screws, resulting in a completed chair with only six parts. This method significantly reduced production time and lowered both production and distribution costs by minimizing the number of parts. If necessary, individual parts could be sent to stores for final assembly, further streamlining the process. (Michael Schweer et al, 2006, p.13)

By shipping parts for 36 chairs in a single flat-packed box, Thonet dramatically reduced logistics costs and stimulated consumer desire for his products. His technology-oriented pioneering spirit and ability to cater to the needs of a new social class, transitioning from the nobility to the general public, garnered significant attention for both him and his chair. Thonet’s work exemplifies the potential for creating beautiful, functional, and enduring pieces of furniture using bentwood techniques and efficient mass-production methods. (Michael Schweer et al, 2006, pp.12-13)
As can be seen from trees stretched by time, trees themselves have excellent elasticity, giving them the ability to adopt new forms momentarily before they return to their original state once the pressure has stopped.

**STEAMED BENT SOLID WOOD**

The technique of steam bending solid wood, first devised by Michael Thonet, involves altering the wood's characteristics through moisture and heat. This process entails placing the wood in a steam box for a specific duration, after which the shape is fixed and dried using a particular mold to achieve the desired form. Heat and moisture rearrange the fibrous tissue of the wood, altering its properties and enabling it to bend. The wood is then fixed in a specific form to prevent it from returning to its original shape upon cooling. (Peck, Edward, 1978, pp. 48-51)

The time required for the wood to become completely saturated varies depending on its hardness and the density of its fiber tissue. Once the wood has absorbed sufficient water, it can be easily bent and prevented from returning to its original form. Commonly used wood species for steam bending include beech, ash, birch, and oak, with English beech or ash being particularly well-suited for bending. (Peck, Edward, 1978, pp. 48-51)

**RESEARCH 2**

**TYPE AND FEATURE OF BENDING WOOD TECHNIQUE**

As can be seen from trees stretched by time, trees themselves have excellent elasticity, giving them the ability to adopt new forms momentarily before they return to their original state once the pressure has stopped.
WETTING HARD WOOD: RING & PORES

Trees with evenly distributed ring-porous or diffuse-porous timber pores are generally more amenable to bending. For instance, saplings can bend more naturally due to their high cellulose content, which imparts high tensile strength as a result of its high moisture content and long chain molecular structure. Pores, small circular holes found in the cross-section of hardwood, serve as conduits for sap transport throughout the tree. The size and distribution of these pores help identify the tree species, with certain species, such as white oak, being particularly suitable for shipbuilding due to the presence of tyloses that fill the pores and prevent water absorption. (Porter, Terry, 2004, pp. 16-20)

Hardwood features an array of three different pore types:
1. Ring-porous, primarily found in earlywood, where pores are evenly distributed in concentric rings.
2. Semi-ring-porous, characterized by a gradual transition of pore sizes from large to small diameters within the growth ring.
3. Diffuse-porous, distinguished by the size and arrangement of pores evenly distributed throughout the wood.

The process of wetting wood for bending is based on the principle that the cells within the tree are softened by moisture, allowing for easier deformation. The uniform size and arrangement of pores within the wood facilitate the absorption and transportation of water, which is essential for bending. However, trees also contain lignin, a major component of the tree’s cell wall that plays a crucial role in solidifying its structure. Lignin acts like cement within the cells, preventing cell walls from collapsing and functioning as a glue between cells. Despite its significant presence in wood composition (22-29%), after cellulose (40-43%), lignin softens at the same temperature (100° C) as boiling water. When heated by steam, lignin allows for the compression and slight stretching of cells. (Hoadley, Bruce, 2000, pp. 64-66)

This condition is optimal for bending wood, with steam serving as an ideal medium for transferring heat to the deep tree cells and lignin. However, as the wood returns to its original temperature and moisture evaporates, the cells exhibit a tendency to remember the original shape of the tree and attempt to revert to it. This phenomenon, known as springback, can be mitigated by using a specific frame to fix and dry the movement of the tree. Consequently, a tree can change its shape and substrate through a combination of physical frameworks and chemical processes. (Hoadley, Bruce, 2000, pp. 64-66)
The ideal moisture content (M/C) for bending wood ranges from 13-20%, with final processing required after cooling[2]. Tree species vary in their bending properties, but in the case of oak, for example, the wood becomes 6-8% thicker after steaming. In general, heat and moisture can provide up to 10 times the bending strength of wood at room temperature. The required steaming time depends on the thickness of the timber; for typical thicknesses at an appropriate autoclave (20-54 mm), approximately 1 hour of steam per 25 mm thickness is needed. Once the wood is dried and its moisture content reaches equilibrium, a stable and fixed state can be achieved, resulting in successful bending. (Schleining, Lon, 2001, pp. 40-43)

After steaming, a soft steel strap of the same width as the wood being molded is useful for bending wood effectively. A G-cramp can be used to fix the steamed wood together with the mold to achieve the desired bending shape. After steaming and molding, the wood must be cramped for at least 24 hours. If not fixed for an appropriate time, the wood may exhibit a springback phenomenon, returning to its original shape. Thicker wood requires a longer time to return to equilibrium moisture content, increasing the time required for fixing. (Schleining, Lon, 2001, pp. 40-43)

**KERF-CUT BENT WOOD**

The kerf-cut bent wood technique is an alternative method for bending dry, thick wood by altering the physical properties of wood fibers through sawing. This technique has been employed in general construction for bending multiple wood curved cabins or solid wood round arched windows. Among these methods, kerf bending is the simplest and is primarily used on parts where edges are not visible. By sawing, the vertical fibers of the wood are damaged, making the timber more pliable. As the wood gains flexibility, its strength decreases, necessitating the use of a V-shaped router blade to increase the bonded surface area when bending the wood after sawing. (Schleining, Lon, 2001, pp. 12-14)

Kerf spacing is a significant factor in determining the minimum bending radius for a piece of stock. When the kerfs close on the inside, the piece can no longer bend. The narrower the gap, the smoother the curve and the more flexible the wood becomes. After sawing, the wood is fixed to a mold with the desired bending radius. A thin bending wooden plate is then attached to the surface of the cut wood to maintain its shape and provide reinforcement. The performance of the bent wood varies depending on the tree species used, with walnut, mahogany, and ash being characterized by their flexibility, and oak being the most commonly used wood. (Schleining, Lon, 2001, pp. 12-14)
An additional noteworthy wood bending approach is the utilization of molded bent laminated wood. This technique involves transforming the trunk into a veneer and subsequently bending it using a specialized mold, a process that is carried out in a series of stages.

MOLDED BENT LAMINATED WOOD

Depending on the tree species and geographical region, the techniques employed in the fabrication of laminated bent wood can exhibit variations. Nevertheless, a schematic representation of the typical process methods for chair production can be outlined as follows:

FROM TRUNK TO VENEER

Steaming Trunk / Peeling Trunk to Veneer / Optimizing of Veneer / Gluing of Veneer / Heating and Pressing
1. STEAM TREATMENT OF TREE TRUNKS

Initially, tree trunks are placed in storage and periodically moistened to preserve the wood’s quality. Subsequently, the trunks undergo a 48-hour steaming process to enhance their pliability for further processing. Following this treatment, each timber piece is categorized based on its intended use in chair components, such as the seat, backrest, or armrest. Finally, the trunks are cut to the appropriate length, debarked, and processed into sheet veneer. (Michael Schweer et al, 2006, p.58)

2. PEELING THE LOG

In the subsequent stage of timber processing, various peeling or slicing techniques may be employed to produce veneers of differing thicknesses and grain patterns, tailored to specific product applications. Within the bentwood industry, standard thicknesses include 0.8mm, 1.1mm, 1.5mm, and 2.3mm. These veneers may serve as intermediate layers in plywood or as decorative surface coverings. However, due to the inherent variability in the peeling process, veneers may exhibit natural features such as discoloration, tinting, and protruding grooves, necessitating production in accordance with specific requirements. These characteristics are intrinsic to the growth patterns of trees and are considered natural occurrences. During this phase, the tree remains in a dampened state as a result of steaming. (Michael Schweer et al, 2006, p.58)

'SLICED VENEER'

The term “sliced veneer” refers to an exceptionally thin, high-quality veneer primarily utilized for ornamental surface covering of products. This type of veneer is employed when the surface must be exposed due to specific demands. Additionally, the surface pattern of the veneer is contingent upon the cutting method and direction of the tree trunk, resulting in a diverse range of appearances. (Fine Woodworking, 1986, pp.29-30)
3. OPTIMIZING VENEER

Following the debarking process, each veneer sheet undergoes optimization in terms of dimensions and quality, with factors such as knot presence and grain alignment assessed using electronic image processing equipment. Automated systems facilitate the removal of defects, after which the wet veneers are subjected to a large roller dryer and heating chamber maintained at 180 degrees Celsius, effectively reducing the moisture content to a mere 3-5%. Subsequently, the veneers are transported to an electronic sorting system for further quality assessment and categorization. (Michael Schweer et al, 2006, p.59)

QUALIFICATION OF VENEER

Plywood quality classifications adhere to international standards and can be broadly categorized into five distinct levels. Quality E represents an impeccable standard, primarily utilized for product covers. Quality 1 serves as a top veneer, characterized by a bright, defect-free surface suitable for natural varnish or light stains. Quality 2, also employed as a top veneer, is compatible with darker stains or colored varnishes, devoid of wood joint points, and permits the presence of sessile knots, making it ideal for plywood middle layers. Quality 3, a top veneer for products with no specific appearance requirements, is primarily used for middle layers and may include minor imperfections such as sesame knots and ridges. Lastly, Quality 4 constitutes the lowest grade, primarily utilizing defective portions and is typically employed when no specific requirements are necessary, such as beneath upholstery. (Michael Schweer et al, 2006, p.60)

4. GLUING OF VENEER

In the process of preparing veneers for laminated molded shapes, they are adhered using paste rolls and watertight glue. Veneers are typically produced through circular cutting or knife-work techniques when sliced from timber, resulting in a “closed side” and an “open side” created by the blade. During this stage, the open side is also referred to as the broken side, which must always be glued. (Michael Schweer et al, 2006, p.60)
5. OVERLAPPING THE VENEER IN VARIOUS COMBINATION FOR SPECIFIC PURPOSE

The pressing process is a crucial step in transforming veneer into the final product, with its purpose contingent upon the manner in which each layer is overlapped. Specifically, the term 'plywood' refers to the assembly of three or more veneers bonded together, wherein each layer is interlocked such that the grain direction of adjacent veneers is oriented at 90 degrees. This grain alignment serves to prevent deformation, ensuring that individual veneers neither warp nor shrink, thereby providing enhanced stability and rigidity. This technique is predominantly employed in the fabrication of thin, lightweight, yet sturdy seat or backrest components. (Michael Schweer et al, 2006, p.66)

‘LAMINATED WOOD’

The laminated wood is characterized by the parallel grain orientation of all interlocking veneers, resulting in a substantial tensile force that effectively supports the load. This configuration is particularly advantageous for cantilever structures, as it possesses the inherent property of reverting to its original form due to the tensile force. In specific applications, up to 15% of the veneers may be oriented in a crosswise manner. Furthermore, by integrating these two approaches, an optimal configuration can be achieved, which combines crosswise grain orientation for enhanced stability on one side and a unidirectional grain orientation with tensile force on the other, thereby exhibiting dual characteristics. (Michael Schweer et al, 2006, p.66)

‘VENEER CROSS-PLYWOOD’

In the context of large-scale applications, the veneer cross-plywood technique is frequently employed to ensure structural stability. Technically speaking, this method entails the adhesion and overlapping of three or more layers of wood. The wood grains of each veneer are oriented perpendicularly, intersecting at 90-degree angles, which effectively mitigates the potential for swelling and shrinkage within the plywood structure. (Michael Schweer et al, 2006, p.67)

Laminated Wood

By aligning all layers in the same direction, the material exhibits a remarkable tensile strength, thereby enhancing its structural integrity and performance.

Veneer Cross-Plywood

The fiber orientations within the material are arranged perpendicularly, intersecting at 90-degree angles relative to one another, thereby contributing to the overall structural stability and performance.

Star Plywood

Comprised of a minimum of five plies, the grain directions within the structure are oriented perpendicularly, intersecting at 45-degree angles relative to one another. This configuration signifies a uniform materiality in all directions, thereby enhancing the overall stability and performance of the composite.
6. HEATING AND PRESSING

Subsequently, the adhesive-laden veneers undergo a molding process involving high pressure and heat. In the context of shape pressing, a diverse range of two-dimensional or three-dimensional forms can be generated by placing the bonded veneer within a purpose-designed mold and subjecting it to consistent pressure and heat, ensuring the maintenance of its specific shape. The pressing methodology may vary depending on the medium utilized for veneer compression. Notably, two prevalent approaches include conventional gluing with heat and high-frequency adhesion techniques. (Michael Schweer et al, 2006, pp.70-71)

**SHAPEd PRESSING TOOL IN DIFFERENT TYPES**

- Two-part shape pressing tool
- Multiple shape pressing tool
- Three-part shape pressing tool

6-1 CONVENTIONAL GLUING WITH HEAT

The heating of the pressing mold facilitates an effective adhesive bond between the layers of veneer. This process can be categorized based on the medium employed for heating the pressing mold, such as heating wires, hot water, or thermal oil. (Michael Schweer et al, 2006, p.72)

6-2 HIGH-FREQUENCY ADHESION

High-frequency adhesion represents a contemporary approach in which the shaped components to be bonded are selectively heated in the joint areas, facilitated by a connection to a high-frequency generator. This advanced technique results in a significantly accelerated hardening time for the adhesive. Owing to this characteristic, high-frequency adhesion is particularly well-suited for thicker and tolerance-insensitive components. (Michael Schweer et al, 2006, p.72)

The degree to which the adhesive penetrates the veneer varies depending on the way the glued veneer is heated, and when Conventional heated-press gluing (Fig.20. right) is used, it can be seen that the glue penetrates the tree more deeply than when High-frequency gluing (Fig.20. left) is applied. (Michael Schweer et al, 2006, p.72)
Furthermore, numerous factors, including the pressure and speed of the press and the precision-cut veneer, are essential for achieving superior quality. When these conditions are optimally satisfied, an exceptional shape and quality can be attained, particularly in the case of three-dimensional pressing, which compresses the veneer on three sides, fostering remarkable stability and a robust shell with innovative, unforeseen forms. Additionally, employing thinner veneers results in increased thickness due to the greater number of layers and adhesive content, ultimately yielding a more durable and resilient structure. (Michael Schweer et al, 2006, p.72)

**SHAPED PRESSING PISTON TOOL IN DIFFERENT TYPES**

- Single-piston press
- Triple-piston press
- Quadruple-piston press
POTENTIAL OF MOLDED LAMINATED FURNITURE

It can be asserted that the convergence of furniture and bent laminated wood, along with the exploration of its potential, was undeniably facilitated by Alvar Aalto. He reinterpreted bentwood within an entirely novel context, ultimately developing a unique chair design. Aalto’s initial exposure to Asplund’s Senna Chair (Fig.23.) at the Paris Fair piqued his interest, as it was an intricate and costly piece, meticulously crafted by skilled artisans. Inspired by this chair, Aalto reimagined it using bent laminated wood, giving rise to the Folk Senna Chair (Fig.24.). (Michael Schweer et al, 2006, pp.14-15)

The laminated shell of this chair is solely supported by its legs, while the backrest employs a cantilever design. Aalto’s pioneering creation aptly encapsulated the designer’s philosophy and Finland’s innovative materiality. Moreover, the transition from a labor-intensive, expensive chair to a more accessible design enabled a broader audience to appreciate Aalto’s work. Consistent with this approach, the cantilevered backrest reflects Aalto’s belief that only organic materials were suitable for human use, a conviction that guided him in realizing the potential of bent laminated wood. (Michael Schweer et al, 2006, pp.14-15)

ANALYSIS 1

MOLDED BENT LAMINATED WOOD FURNITURES

This analysis focuses on molded bent laminated wood furniture, investigating novel methodologies in the field and examining the public’s awareness and appreciation of furniture designs that draw inspiration from the esteemed works of Alvar Aalto.
THE DYNAMIC ERA OF MOLDED LAMINATED FURNITURE

The Paimio chair, crafted in 1931, exemplifies the potential of molded laminated birch to cater to discerning clientele. The one-piece seat seamlessly forms a natural angle with an elegant curve, providing comfort to the user while capitalizing on the inherent flexibility of the wood, which functions as a suspension system. Simultaneously serving as armrests and legs, the structure on either side of the seat securely anchors the central shell, exhibiting a fluid curvature that imparts warmth and coziness in conjunction with its material properties. (Michael Schweer et al., 2006, p.17)

During that period, contemporary designers such as Marcel Breuer, Lasar Lissitzky, Gerald Summers, and Bruno Mathsson did not achieve a three-dimensional wood bending form. However, Aalto innovatively developed a three-dimensional laminated bent wood leg, commencing with the Spaghetti-wood structure. He achieved this by cutting laminated bent wood at specific angles and connecting them to heated molds, resulting in the creation of the so-called X-leg. While this joinery technique is still regarded as one of the most aesthetically pleasing to this day, it necessitates considerable attention to detail and labor. Furthermore, it was not an ideal method due to the substantial waste of wood materials involved. (Schmidt, Goran, 1984, pp.32-33)
ANALYSIS 2

CONVERGING OBJECTIVES FROM DISTINCT MATERIALS

This study examines the possibilities surrounding bent laminated wood by contrasting the works of Alvar Aalto and Marcel Breuer, two renowned designers who pursued similar goals while employing distinct materials in their respective creations.
LAMINATED BENT WOOD AND ALUMINUM IN CHAISE LOUNGE CHAIRS

Contemporaneously with Aalto, designer Marcel Breuer experimented with plywood and laminated wood, albeit with a focus on the potential of metal tubing. Interestingly, a connection can be observed between the works of these two designers. In 1936, Breuer constructed the Chaise Lounge chair, which was inspired by the form of his aluminum Lounge chair 313, completed in 1934. (Wilk, C., 1981, p.123)

The Chaise Lounge’s seat is supported by two laminated birch structures. A year later, in 1937, Aalto unveiled a similar piece—an organically shaped lounge chair that leveraged the flexibility and materiality of laminated wood to provide optimal elasticity for the user. Both designers explored the limits of their chosen materials, interpreting them in their own unique ways, ultimately sharing the common goal of creating an organically shaped, warm, safe, and resilient lounge chair. This perspective elucidates the purpose and motivation behind the use of laminated bent wood in furniture, demonstrating its potential and validity. (Wilk, C., 1981, p.125)

In Breuer’s Isokon long chair (Fig.29.), he reinterprets his aluminum Lounge chair 313 using plywood, resulting in an organic or biomorphic form that was absent in the original aluminum design. The use of wood during this period conveyed a visually warmer and tactility more comfortable aesthetic, in contrast to the austere appearance of aluminum.

Furthermore, as the 1936 British market emphasized comfort, the choice of plywood can be viewed as an inevitable decision, aligning with the prevailing trends and lounge chair preferences of the time. (Wilk, C., 1981, p.127)
LAMINATED BENT WOOD AND ALUMINUM IN LOUNGE CHAIRS

In contrast to the aluminum chair (Fig.33.), the plywood version (Fig.31.) of the frame is not a single continuous structure but consists of twice the number of components. The parts forming the armrests and legs on both sides are composed of two plywood pieces, a process more complex and costly than that of aluminum. The outer section, which serves as both the leg support and armrest while simultaneously supporting the backrest, is connected to the part that supports the lower portion of the seat, forming the chair’s base through mortise and glue joints. However, in the case of the aluminum chair, stability is achieved by adding two support bars (beneath the seat) that connect both frames. Aluminum chairs appear as independent entities supporting the chair itself, while the leg and armrest components in the plywood version originate from a single piece, emphasizing their continuity. (Wilk, C. 1981, p.128)

Additionally, unlike aluminum chairs, the plywood versions exhibit varying thicknesses depending on their function, resulting in a greater level of detail and elements. When plywood chairs were first introduced, Breuer did not adopt the conventional method of plywood construction for the seat section (comprising layers of veneer glued with the grain of adjoining plies at right angles). Instead, he posited that the grain of the wood should overlap in a single direction. This approach was intended to provide greater resilience to the seat, although it may not have been sufficient to withstand the load. The plywood chair was introduced in 1936, and its weaknesses were addressed until 1950, with the addition of an invisible support to the backrest and a fin inside the armrest. While these changes improved the chair’s structure, the visual impact of the original aluminum chair was diminished. (Wilk, C. 1981, p.129)

Breuer explored over 10 different designs, seeking to maximize the characteristics of plywood. Through this process, he concluded that plywood was sufficiently strong and exhibited excellent resilience. This work highlights the performance of other materials in the same structure, their potential, and the distinctly different visual atmosphere they create. It serves as a reminder that a deep exploration and experimental spirit are necessary for all materials, not just the relationship between steel tubing and plywood. (Wilk, C. 1981, p.130)
Breuer subsequently adapted his established steel tube model to develop plywood versions of furniture. One such example is the nesting table, where the motif transcends mere imitation of the original model with different materials, instead expressing the overall furniture concept in plywood. (Wilk, C., 1981, p. 132)

The steel tube version (Fig. 36.) is conceived by bending a single tube to form the entire frame. This concept was further evolved when applied to the plywood version. As plywood can be bent and cut simultaneously, the leg and seat are formed in one cohesive piece. In essence, by constructing all structures with a single laminated bent plywood component, Breuer achieved an economical and compact design for the time. Notably, the leg shape, which minimized decorative detail and reflected the structure as it was, utilized the physical properties of plywood and became a prevalent design form in plywood furniture during the 1940s. This innovative leg design, tailored to the table’s structure, was not found in Breuer’s previous works. (Wilk, C., 1981, p. 133)

**VARIATIONS ON ISOKON LOUNGE CHAIRS**
ANALYSIS 3

LIMITATION OF BENT PLYWOOD AND SYNERGY WITH CUTOUT PLYWOOD
LIMITATION OF BENT PLYWOOD

The subsequent plywood side chair (Fig.40.) adopts a design akin to the nesting table (Fig.37.), utilizing only two plywood pieces: one forming the leg and seat, and the second reinforcing the backrest. While this minimal design and process yield a lightweight and stackable chair, the backrest lacks sufficient sturdiness to support weight, resulting in stability issues throughout the chair. (Wilk, C., 1981, p.135)

Typically, plywood chairs featuring compact, sophisticated thickness, shape, and lines were often compromised in terms of safety. Ultimately, by the end of 1936, seven additional plywood pieces were incorporated for structural reinforcement, culminating in a chair composed of nine plywood pieces, albeit with less morphological structural continuity than the initial model. To enhance resilience, the final model attempted to exploit the material’s properties by employing unusually thin plywood. However, the initial objective of creating a lightweight and safe chair with minimal plywood components was not fully realized. (Wilk, C., 1981, p.137)

The Isokon plywood side chair and nesting table serve as exemplary illustrations of the properties of bent laminated wood materials. While the elegant form, lightness, and robust structure of these plywood pieces were anticipated, their practical implementation necessitated several intricate details and additional supporting structures. The grain direction and glue visible in the plywood cross-section appear more complex than solid wood when different plywood components are combined, complicating the achievement of a unified continuity. (Wilk, C., 1981, p.138)

Nonetheless, the utilization of parts and their flexiblity allows for the relatively straightforward and unrestricted creation of ergonomic forms. Plywood chairs, developed through these experimental endeavors, consistently suggest the appropriate thickness, grain direction, and the need for a junction between structural form and physical properties. (Wilk, C., 1981, p.139)
CUTOUT PLYWOOD IN CONJUNCTION WITH LAMINATED WOOD

Capitalizing on the inherent characteristics of plywood—its thin yet vertically strong features, flexibility, and formability—Breuer devised a novel design that explored a new direction for the material.

Cutout plywood employs a jigsaw to carve the entire frame from a single sheet of plywood, subsequently integrating bent laminated wood with the appropriate sections. This type of furniture proposes a new principle for utilizing plywood, a form uniquely achievable with this material. Unlike solid wood, which exhibits varying qualities depending on the condition of the trunk or tree, plywood can be freely cut and transformed into the desired shape. Leveraging this advantage, Breuer altered the design direction, merging the seat frame and back components of the chair—its fundamental skeleton—into a single plywood piece. This approach reduced numerous details and joints, resulting in a significantly simpler and more compact chair. (Wilk, C., 1981, p.156)

Plywood effectively supplanted the minimal joints and details typically required by structural components, thereby reducing the quantity of parts and eliminating the need for intricate processes and machinery. The fusion of cutout plywood and bent laminated plywood facilitated the emergence of a novel chair design, revealing an alternative potential for plywood utilization. This innovative approach stemmed from an in-depth exploration of materials, and the adoption of a simplified thought process yielded a significant impact on the final product. (Wilk, C., 1981, p.157)
Breuer acknowledged that, despite his various experiments with plywood furniture, the material did not provide a perfect solution from both aesthetic and structural perspectives. However, more importantly, he sought to achieve resilience within the structure itself, rather than relying on additional elements such as springs or heavy upholstery. While he demonstrated this ideal solution through steel tubular materials, the public exhibited a preference for wood over cold, rigid, and shiny alternatives. (Wilk, C., 1981, pp.158-160)

Plywood furniture, introduced to the world by Aalto and Breuer, also faced several challenges, including less competitive pricing. Although the material itself may have been inexpensive, the initial investment costs were substantial due to mold manufacturing and pressure machines required for production. Furthermore, even with an established production environment, adapting the design or production method to suit market conditions and consumer preferences proved exceedingly difficult. (Wilk, C., 1981, pp.158-160)

Breuer’s nesting stool serves as an example of well-designed and produced laminated bent wood furniture. Its simplicity reduced costs across various aspects of the product. However, as a stool, it had relatively little consideration for comfort, resilience, and stress. Additionally, it did not address the inherent reliance on heavier supporting frames that structurally impacted laminated wood design effects. These factors primarily contributed to increased prices and compromised aesthetics and proportions. Moreover, once the mold was manufactured, the all-in-one furniture could not be altered in shape. Consequently, during that period, there was a need for lower initial production costs and a more adaptable approach to the process and design. (Wilk, C., 1981, pp.161-164)

Several years later, it was demonstrated that when plywood was combined with another material, creating synergy and fulfilling its structural role, the most optimized use of plywood emerged. Suitable examples of furniture, such as Charles Eames’ 1946 side chair or Arne Jacobsen’s 1952 stacking chair, incorporated steel supports and revealed that plywood was not ideal as a load-bearing member. (Michael Schweer et al, 2006, pp.26-27)

However, when plywood serves as the shell component of a chair, capitalizing on its resilience, elasticity, and deformability, and when legs and joints are composed of strong yet lightweight steel tubes, the resulting product satisfies users’ needs and reduces production costs. Although bent plywood is not a flawless material for chairs, it contributes to a sensuous structure. This fully open materiality and non-self-assertiveness enable plywood to synergize with various materials, exploring the potential advantages of each material in combination. (Michael Schweer et al, 2006, pp.26-27)

Breuer identified three essential criteria for a successful plywood chair:

1. A resilient and durable wood species capable of bending, which does not incur significant initial processing costs.
2. The number of connected parts should be minimized, ensuring that they do not weaken other components.
3. Ideally, the joints should be both elastic and comfortable, while the overall appearance should convey visual lightness in comparison to its actual weight.
Drawing upon his theorem, Breuer designed a side chair that incorporated several key features:

1. He reduced the overall thickness and employed one-inch Bakelite-glued plywood with hardwood cross-laminations, resulting in an indestructible structure.

2. The plywood elements of connections were linked using rubber pieces of varying widths and screws. These parts were fixed in place, acting as cement, and adhered between components through rubber pressure and heat. The rubber joints provided elasticity to the connection, preventing breakage between parts.

3. The 1948 side chair, while utilizing multiple components, exhibited improved continuity, thinner thickness, and a more delicate design.

Consequently, plywood demonstrated a stronger and more stable structure when employing double thin pieces connected, rather than a single thick form. Additionally, the physical properties of the joints connected between plywood were crucial, showcasing the optimal synergy of elastic materials such as rubber. In particular, when considering leg structures, cutout plywood outperformed bent laminated wood, as it could be thinner yet stronger, requiring less cost and labor. (Wilk, C., 1981, pp. 168-169)

Moreover, when observed from the front, the cutout plywood leg appears thin and delicate, contrasting with the horizontal seat and backrest, and displays an elegant shape with its side cut lines. The side view, which appears relatively thicker than the front view, imparts stability to the chair. As demonstrated in Figures 47 and 48, cutout plywood is well-suited as an overall frame structure, while laminated bent wood excels in providing appropriate tension for the seat and backrest. (Wilk, C., 1981, pp. 168-169)

Plywood effectively supplanted the minimal joints and details typically required by structural components, thereby reducing the quantity of parts and eliminating the need for intricate processes and machinery. The fusion of cut plywood and bent laminated plywood facilitated the emergence of a novel chair design, revealing an alternative potential for plywood utilization. (Wilk, C., 1981, pp. 168-169)
ANALYSIS 4

NEW WAVE OF BENT LAMINATED WOOD: DOUBLE-CURVED BENT PLYWOOD
In 1940, Charles Eames and Eero Saarinen achieved recognition by designing an organically shaped chair (Fig.51.) for the Museum of Modern Art in New York, under the theme of organic design in home furnishings. This groundbreaking design featured a double-curved plywood shell, a novel technology borrowed from the aircraft industry, which showcased new possibilities not only for chairs but also for bent plywood materiality.

However, the shell was not a single continuous piece; instead, several steamed bent wooden strips were connected to achieve the desired angle and curvature, with the front of the seams necessitating an upholstered form. This double-bending plywood technology holds significant value as a new approach that satisfies the inherent characteristics of wood, the biomorphic meaning, the sculptural design method in line with contemporary trends, and the organic shape required for ergonomics. (Michael Schweer et al, 2006, pp.24-25)

NEW WAVE OF DESIGN

In the 1940s, the global atmosphere of the Cold War undermined progress and faith in the community, leading to an era in which existentialism emphasized individual responsibility. This shift contributed to the rise of Abstract Expressionism, and European artists such as Hans Arp and Henry Moore, as well as American sculptor Alexander Calder, began to create abstract works influenced by Surrealism, incorporating biomorphic shapes. As modernism's confidence in the social dimension waned, individual freedom found expression in painting, sculpture, and architecture, supplanting objective representation with subjective expression. (Michael Schweer et al, 2006, pp.24-25)

This societal trend influenced chair design as a sculptural expression: the integration of individual elements into a cohesive entity, or, taken to an extreme, their amalgamation into a single continuous form, often characterized by biomorphic or non-geometric curves. This design perspective fostered the creation of three-dimensional shapes that embodied the expressive essence of the chair. (Michael Schweer et al, 2006, pp.24-25)
SYNERGY OF LAMINATED WOOD WITH STEEL TUBULAR STRUCTURE:
ARNE JACOBSEN

In the 1950s, chair designs incorporated a diverse range of forms utilizing the double-curved bending technique. The three-dimensional shaping of the chair's shell resulted in a more sophisticated and thinner appearance. These designs embraced organic and biomorphic elements, while the structure itself was ergonomically designed, achieving a balance between practicality and aesthetics. Each chair possessed its own distinct character, and the combination of steel and rubber generated considerable synergy. A prime example of this fusion is Arne Jacobsen's iconic 'Ant Chair.' (Erick and Vindum, 1996, p.48)

The Ant chair, designed for the Novo pharmaceutical company's cafe, featured a double-curved seat and backrest created from a single molded plywood piece. To compress the double-curved structure of the plywood at that time, a small space between the seat and backrest—the waist shell—had to be maintained. Consequently, the chair's unique characteristics aligned with its name, the Ant chair. By incorporating a thin waist through an incision and utilizing three steel tubes for the legs, the chair minimized the required materials. Notably, the single continuous seat, backrest, and stackable structure introduced a novel chair shape and performance that had not been seen before. (Erick and Vindum, 1996, p.48)
Indeed, the integration of the seat and backrest into a single piece is not an unprecedented concept. For instance, Aalto’s hybrid chair featured steel tubular, stackable components, while Carlo Mollino’s Waist Chair also incorporated a curved shell. However, both models exhibited curvature in only one direction. Charles and Ray Eames designed the DCW chair during this period, but no other model maintained a double-curved shell as a single connected piece, akin to the Ant Chair. (Erick and Vindum, 1996, p.49)

The outermost layers, namely the top and bottom veneers, consist of perfectly cut lengthwise veneers without any flaws. Due to the single form of the shell, the chair is composed of only two parts: the shell and the leg. Three steel tubular legs are connected to the seat through a joint beneath the seat’s center, with a rubber medium buffering the gap between the two components. The combination of rubber and steel tubes with plywood stabilizes and comforts the chair itself through a spring effect. These three distinct elements optimize the chair’s shape, with each material fulfilling its necessary role. (Erick and Vindum, 1996, pp. 48-53)

The Ant chair embodies a user-friendly design that is easily manageable for both users and administrators, featuring the thinnest possible steel tube and bent plywood structure. Its lightweight and stackable nature, along with the organic design achieved through the double-curved shell, contribute to its practicality and aesthetic appeal. (Erick and Vindum, 1996, pp. 48-53)

A slit was made in the part connecting the seat and back, allowing the component to be twisted for conformity. However, the Ant chair distinguishes itself by cutting off the shell from the outside and creating a contour at the waist, thereby eliminating the warped section and maintaining a thin profile. To enhance durability, two layers of linen were glued between the plywood veneer layers. The shell comprises a total of nine layers, with five of the inner seven layers featuring a lengthwise grain direction and two layers overlapping crosswise. (Erick and Vindum, 1996, pp. 48-53)
EXISTENTIAL VALUE OF THE CHAIR IN SPACE

The Ant chair also serves an ornamental role when arranged or stacked in a space. This approach appears to address the fundamental question of a chair’s function as furniture within a space or as decoration through form. By minimizing its elements, the chair maintains a specific regular form that does not appear complicated when gathered. Originally designed for a cafe, the Ant chair exemplifies the sculptural and decorative beauty of a collective arrangement, transcending its function as merely stackable seating. As public goods, chairs are often gathered, and the Ant chair capitalizes on this characteristic. (Erick and Vindum, 1996, p.48)

Within the same space, users are not significantly disrupted by the chair’s form, experiencing both functional satisfaction and mental abundance from the materiality and formative shape. The human body, one of the most beautiful forms on Earth, is echoed in the Ant chair’s aesthetic form and organic lines, which resonated with people as a new type of familiar furniture, reflecting the fashion of the time. This chair serves as an exemplary representation of the ideal relationship between humans and the objects that accompany their lives, particularly in the context of furniture. (Erick and Vindum, 1996, p.48)
Following the success of the Ant chair, Jacobsen designed The Tongue, Series 7 chair, and Model 3103 and 4130 in 1955. These chairs featured thin yet elegant shells, incorporating resilience, compactness, and a simple steel tubular leg design. After the Ant chair, Jacobsen’s seat and backrest designs became curvier, with an increasing radius that accommodated users’ various postures in an ergonomic manner. During this period, market expectations leaned towards bent wood veneer with a clean, lightweight shape and flexibility, suitable for mass production while retaining a handcrafted atmosphere. (Erick and Vindum, 1996, p.52)

Moreover, the designs showcased a diverse range of connections with steel, emphasizing its flexibility as a material. As an architect, Jacobsen consistently contemplated the interrelationship between furniture, space, and human interaction, proposing numerous color palettes to enhance the manner in which these elements coexist within a given environment. (Erick and Vindum, 1996, p.52)
SITE ANALYSIS

INVESTIGATION OF MUSEUM FURNITURES
DESIGNMUSEUM – MUSEUM OF FINNISH DESIGN

Korkeavuorenkatu 24
00130, Helsinki

Design Museum Helsinki is a National Special Museum in Finland that focuses on selecting and maintaining a design collection. The museum’s responsibilities include:

1. Conducting research and documentation in the field of design.
2. Holding exhibitions on design history and contemporary design.
3. Organizing international touring exhibitions on Finnish art and design.

Design Museum Helsinki was founded in 1873 as a study collection for the arts and crafts school. It has been operating on its current premises since 1978. The museum building was designed in 1894 by Architect Gustaf Nyström. In 1989, the Foundation of the Museum of Art and Design was established to support the activities of the Design Museum.

The history of Finnish design is presented in the museum’s collection exhibition through living narratives, using today’s technology and digital applications. This remarkable facility aims to preserve the history of Finnish and international design. The museum is located in the Helsinki Design District, making it an integral part of the city’s vibrant design culture (designmuseum.fi)

Various exhibitions take place within the museum, and the design of the bench depicted in Figure 9 demonstrates several noteworthy characteristics:

1. The bench maintains a subtle and composed presence within the exhibition space, allowing it to blend seamlessly into the environment without detracting from the displayed artwork.
2. It effectively fulfills its function as a seating option, providing visitors with a comfortable and practical place to rest.
3. The bench’s warm materials and unobtrusive design contribute to a sense of refuge within the potentially austere atmosphere of the exhibition space.
4. By offering both comfort and a visually appealing design, the bench successfully fulfills its role as a museum seating solution that complements the surrounding artwork and enhances the visitor experience.

The reception area of the museum serves as an inviting space that encapsulates the institution’s identity and offers an immediate visual representation to its visitors. In this context, the design museum appears to convey artistic and design elements through contemporary language, utilizing modern household aesthetics while preserving the sophisticated and classical interior architecture.
5. They offer a brief respite through a design that strikes a balance between comfort and discomfort, ensuring that visitors can rest without becoming too relaxed or disengaged from the exhibits.

6. The benches provide visual warmth and contribute to mental relaxation, as visitors may experience cognitive fatigue from processing a large volume of information in a short period.

7. By utilizing materials that evoke a sense of familiarity and stability, the benches fulfill an essential role as museum furniture in promoting a sense of psychological well-being for visitors.

In summary, the design of museum benches plays a significant role in enhancing the visitor experience by offering physical and mental respite, while also contributing to the overall aesthetic and atmosphere of the exhibition space.
EMMA – ESPOO MUSEUM OF MODERN ART

Ahertajantie 5, Tapiola
Espoo

EMMA is an art museum that believes in the power of art to inspire and evoke a unique visual and spatial experience. The museum’s core values and objectives include fostering creativity and boundary-pushing in art and design, being bold ground-breakers and inviting open exchange with audiences, and presenting a varied calendar of exhibitions showcasing contemporary and modern art, design, and experimental pieces. EMMA offers an immersive experience that excites all the senses and caters to all types of visitors.

The museum’s exhibitions and programs aim to stimulate intellectual, aesthetic, and scientific growth; challenge pre-existing narratives and promote new visions for the future; and create a space for encounter and debate, symbolizing an intriguing fusion of intellect and emotions. By providing a platform for innovative and thought-provoking art, EMMA contributes to the ongoing discourse on the role of museums in society and their ability to shape and influence cultural understanding. (emmamuseum.fi)

The Emma Museum, known for hosting diverse and experimental exhibitions, presents a distinct atmosphere. The exhibition space showcases a wide range of artistic expressions, from small objects to large-scale architectural sculptures. In this context, the museum furniture serves specific purposes:

1. There is minimal emphasis on specialized museum furniture due to the diverse nature of the exhibits.
2. The furniture prioritizes functionality and spatial harmony over bold colors or designs, ensuring that it complements the exhibited artwork without detracting from it.
3. By focusing on these aspects, the furniture contributes to the overall aesthetic and atmosphere of the museum, allowing visitors to fully engage with the diverse range of artistic expressions on display.

In summary, the Emma Museum’s unique atmosphere and diverse exhibitions necessitate a careful consideration of furniture design, emphasizing functionality and harmony with the surrounding space to enhance the visitor experience.
The museum’s fundamental furniture exhibits a sense of cohesion through its black color scheme, indicating its function as a resting area.

Key aspects of the furniture design include:

1. Minimal decorative elements to ensure that visitors’ attention remains focused on the exhibited works.

2. A harmonious integration with the interior’s texture and color, which is predominantly characterized by concrete, further emphasizing the museum’s design intent.

3. The absence of any structural interference allows visitors to capture photographs of various artworks without obstruction, enabling the artwork to stand out against the backdrop of the interior and the furniture’s subtle decorative elements.

In conclusion, the Emma Museum emphasizes the importance of cultivating interactions between visitors and artworks, with the fundamental furniture design aligning with this aim.

A strictly functional approach, ensuring that the furniture serves its intended purpose without detracting from the exhibited works and the furniture’s role as an object that facilitates the relationship between visitors and artworks, occupying the space in a manner that encourages engagement and interaction can be key profound elements of furniture design in the Emma Museum.

Contrarily, Emma devised a distinct area utilizing furniture, establishing a comfortable environment for individuals to engage in discourse regarding their work. This furniture arrangement generates an unobservable boundary, segregating the space from the exhibition area while simultaneously cultivating a unique atmosphere. Within this setting, furniture showcases its distinct attributes, diverging from traditional exhibition spaces, and can be fashioned to evoke mental stimulation in visitors.

This form of inspiration serves as a catalyst for visitors to experience diverse artistic influences. In essence, the space cultivates a novel, personalized environment through strategic furniture design, fostering alternative connections between the audience and the artwork.
THE OULU MUSEUM OF ART (OMA)

Kasarmintie 9, 90130 Oulu

Oulu has a long tradition of visual arts, with numerous professional artists working in the city, including many of international renown. Many of the surrounding towns, such as Liminka, Hailuoto, Ii, Tyrnävä, and Pudasjärvi, are active in various arts, thanks to the artists and other individuals and organizations working in the field of art. The Oulu Museum of Art is distinct from other Luuppi destinations because, in addition to its recording and researching role, it has an identity as an art body. The museum collaborates closely with the artists of the region. The exhibitions of the Oulu Museum of Art provide:

1. A thorough cross-section of the visual arts of the region.
2. Exploration of different themes and collections.
3. Showcases of highlights from Finnish and international art

Museums, as public institutions and producers and transmitters of culture and knowledge, play a crucial role in representing the past and present. They are responsible for collecting, organizing, and displaying the immaterial and material traces of past and present to create and promote new visions for the future. By providing a space for encounter and debate, museums stimulate intellectual, aesthetic, and scientific growth, while also challenging pre-existing narratives. As a result, museums symbolize an intriguing fusion of intellect and emotions. (© City of Oulu | www.oulunluuppi.fi)

As a space dedicated to showcasing historical and traditional works of art, the museum possesses a distinct spatial character. The furniture, bearing traces of time and traditional designs, often exudes a more intense personality than the artworks themselves. However, the furniture does not flaunt its unique design; instead, it strongly embodies the passage of time and the humility it carries. Visitors experience this through:

1. Visual perception, as they sit on the furniture and observe the traces intermingling with the displayed works, akin to embarking on a time machine journey.
2. The provision of visual and atmospheric elements, enabling visitors to immerse themselves directly into the artworks.

Furthermore, the museum’s approach to highlighting its historical characteristics through furniture representation imbues the space with a novel character. This strategy effectively enhances the visitor experience, emphasizing the importance of furniture in conveying the museum’s identity and fostering a deeper connection with the displayed art.
DESIGN PROCESS

TECHNICAL AND FUNCTIONAL CONCEPT
TECHNICAL CONCEPT: MOLDED BENDING VENEER

The molded veneer bending technique is a skill that created a sensation when first applied to furniture, giving rise to a new type of design that had never been possible before. This innovation allowed for further expansion of the design realm through the use of wood. The technique preserves the original wooden aesthetic features and inherent lines, serving as a structural component rather than merely contributing to visual beauty. It demonstrates the true meaning of materiality by employing traditional techniques with local materials and reinterpreting them in a modern language.

This approach straddles the boundary between craftsmanship and industrial methods, offering a suitable skill for mass production while simultaneously conveying a handcrafted atmosphere. By maintaining the beauty of grain patterns and wood textures, and minimizing the required components for design and ergonomic structure, the technique reduces weight and processing requirements. The flexibility of this method, in which structure becomes both a function and an aesthetic element, aligns with 21st-century IT technology and unleashes its potential. Through these characteristics, the technique conserves traditional skills while simultaneously presenting a new atmosphere as a contemporary phenomenon.

FUNCTIONAL CONCEPT IN THE TARGET SPACE

The museum is a space where complex cultural elements must create maximum synergy, and everything from nature surrounding it, architecture, interior design, furniture, programs, and even visitors come together to create a single atmosphere of museum. It is not just a space for collecting artworks, it’s a place where people gather to share their views on modern cultural trends, value of arts and it’s a leader in preserving local culture and presenting future directions. For this purpose, furniture would be one of the answers to make identity of museum and makes people to be reminded it as memorable place for gleaning various inspiration.

Spatial Aim 1

A space like museum has various variable situations and exhibition forms. It is also visited by an unspecified number of people to get inspiration. Furniture is object and tool that provides people with comfortable and inspires them at the same time but should not affect the viewing or artwork. In the museum, furniture perform space for conversation and appreciation of arts. Sometimes, furniture forms invisible boundaries, providing a natural space in the museum for each purpose.

Spatial Aim 2

A chair can be the smallest unit of space that human can have. From chair to bench, each chair has a different degree of private and public character. For example, in the case of a stool, the space it occupies is small but has the most public character. Anyone can sit down and leave easily. In addition, when multiple stools are connected, they have a larger public character and can be used in public viewing-type exhibitions. However, the personal space that a person has is reduced, and the private personality is significantly lowered. In the case of a lounge chair, it occupies the wider amount of space, and you can see that the area of the human body that touches it is larger. This means increasing the amount of space an individual can occupy in the public space and provides more private to the user. This can be seen as providing a more private space for certain exhibition.
The natural ecosystem, encompassing humans, has evolved to adapt to the surrounding environment in which they exist. In essence, the structure of these living organisms serves a purpose, representing an optimized form for their lives. This configuration embodies beauty not only in its structural composition but also in its capacity for reproduction.
CONCEPTUAL APPROACH

Among the various creatures within the ecosystem, birds exhibit a particularly intriguing body structure, significantly influenced by nature. Birds possess streamlined wings and bodies for lift, and their bones are filled with air rather than bone marrow. In essence, the majority of the bone’s interior is hollow, with specific sections connected by bridge-like structures. This configuration results in an extremely lightweight yet strong structure. Birds’ bodies and wings are designed to withstand wind and are optimized to take advantage of airflow, displaying sophisticated and elegant lines that form naturally.

This form can also be observed in airplanes and boats, which share the common characteristic of reduced weight while maintaining structural robustness. Drawing inspiration from this structure, experiments with bending veneer can be applied to chair design. The streamlined shape provides users with an optimal seating experience and is sturdy enough to support their weight.
CONCEPTUAL APPROACH

As a structure capable of withstanding immense pressure, the wings of birds and airplanes exhibit both strength and flexibility. The wing, connected to the fuselage, maintains its structure through three vertices. By properly utilizing this force structure, it is anticipated that maximum synergy can be achieved through minimal structure and material. In this context, the streamlined shape of wings offers an intriguing structure that can be expressed through veneers.

Key aspects of this design include:
1. The ability to withstand enormous pressure while maintaining flexibility, as seen in bird and airplane wings.
2. The potential for creating maximum synergy with minimal structure and material by effectively utilizing the force structure.

By examining these characteristics, the streamlined shape of wings presents an interesting structure that can be further explored and applied in various fields, such as veneer design, to achieve optimal performance and efficiency.

In this respect, veneer, a versatile material, possesses distinct properties that enable it to exhibit both flexibility and robustness. As a log, it exemplifies solidity and durability, whereas its transformation into veneer unveils an entirely new character. Consequently, the primary objective of this project is to subtly alter the material’s inherent characteristics without contravening its natural essence, thereby unveiling its potential as a structural element that simultaneously serves as an aesthetically inspiring object.
MATERIAL EXPERIMENTS
CONCEPTUAL SKETCH – STRUCTURE

The concept sketch began by examining how the bent part supports weight under force, starting with the location where the veneer is bent. Additionally, the maximum angle of veneer bending was considered through the creation of prototypes. Simultaneously, the wood fiber is deformed by heat, moisture, and glue during the bending process, resulting in a more solid structure. Three bent points were established as a starting point to form a truss structure, and experiments were conducted to assess its weight-bearing strength.

BENDING EXPERIMENT 1

To establish three bending points, a molded laminated veneer with varying radii was initially designed, setting the innermost radius at 6 mm and the outermost at 12 mm. The 1 mm veneer layers were overlapped in different vertical directions to facilitate banding, and smaller radii, such as 6 mm, were successfully formed without any cracking.
**BENDING EXPERIMENT 2**

The initial concept involved connecting bent plywood at different angles with auxiliary materials, such as birch solid wood and urethane foam. The combination of materials aimed to compensate for the shortcomings of each structure and highlight their advantages within a sandwich structure. In particular, the urethane foam itself forms a honeycomb structure, which is lightweight and solid simultaneously, assuming a free shape before hardening. This material demonstrated suitable performance for bonding two bent laminated plywood pieces. However, by employing these two auxiliary materials, the full potential of the bending structure could not be realized.

When the bent part is connected to a wall or another structure, it exhibits the characteristics of rigidity, but the structure could not be fully deployed to support the weight. The bent plywood was significantly influenced by the other two materials, with most of its weight being supported by the auxiliary materials rather than the bent plywood itself.
Consequently, the strategy to integrate two distinct bending veneer plywood structures into a single form was pursued, as illustrated in the subsequent sketches. The design of two different bending plywood structures, encompassing three bending elements within a single form, began with a structure that could consist of a seat and backrest. The priority was given to a form that could utilize both elasticity and solidity.

Sketches were created to optimally leverage the structural advantages of the bending form and its aesthetics, resulting in a diverse array of variations. The seat structure of the bending veneer should be able to fulfill its function as a chair while simultaneously providing an ergonomic structure and an aesthetic shape that highlights the beauty of the veneer. From this perspective, consideration was given not only to the seat portion but also to the connection with the chair’s legs, as the seat part with three bending structures already incorporates numerous elements due to its curves and layers.

Moreover, the significance of using bending laminated veneer lies in its ability to faithfully and simply perform the required role of a chair as a structure. In this regard, the chair’s legs are also reliable in their role as a bridge, rather than involving any additional structural components.
Various bending structures were explored through sketches, but the most critical parts to be bent were identified as the backrest and the front part of the chair. Taking into account that the middle part of the chair seat can be connected to the leg, the design aimed to manage the load and flexibility solely with the backrest and front part of the chair in a bending structure.

The basic A-shape form was initially considered to minimize intervention from the chair’s legs. To achieve a balance between the leg structure, the overall chair, and the weight it can support, a predominant focus was placed on determining the number of layers of the bending veneer, the type of wood, and the radius. Subsequent experiments were conducted in accordance with these considerations.
MATERIAL EXPERIMENTS – METHODOLOGY

Under the same conditions, the common method of laminating veneers yields various results depending on the materials and elements involved in the process.

Mold Making / Gluing / Pressing / Heating / Drying

PROCESS OF LAMINATION

The lamination process can be broadly categorized into five stages, and the experiments conducted in this study adhere to this established process. By following these stages, the research aims to ensure a systematic and comprehensive exploration of the lamination technique and its potential applications.

1. Mold Making
2. Optimizing / Gluing
3. Pressing / Clamping
4. Heating
5. Drying
EVALUATION

The outcomes of the experiments are assessed based on the following predefined criteria, ensuring a structured and objective evaluation of the results in relation to the study's objectives and research questions:

1. The value of the radius, the number of layers with respect to the radius of the mold, and the correlation between the two.

2. The overlapping directions of the veneer grains and the moisture content of the veneer.

The sturdiness of the structure can be assessed on a scale from 1 to 5:

5- Firmness
3- Flexibility
1- Instability

The quality of the bending performance can be evaluated on a scale from 1 to 5:

5- Bending without defects
3- Some defects
1- Completely cracked

The wetness of the veneer can be rated on a scale from 1 to 5:

5- Completely wet
3- Semi-wet
1- Completely dry

GOALS AND DIRECTIVES

The study aims to achieve two primary objectives. First, it seeks to understand the various performance characteristics of bending veneers and their limitations. Under identical conditions, the focus will be on the results derived from different combinations of veneer and mold. Furthermore, when issues arise, new variables will be introduced under the same conditions, and the resulting changes will be observed.

Second, the research aims to explore the structural possibilities and aesthetic diversity of bending veneers. By examining various combinations of radii and the number of layers, the study will endeavor to identify structurally and dimensionally optimal methods for creating bent plywood furniture.
The subsequent material experiment focused on a tighter bending radius (10mm), as the previous experiment confirmed a smooth bend with a 12mm radius. The types of wood tested included birch, elm, and oak.

All experiments were defined according to the type of wood used, the number of layers, and the values of different radii, ensuring that the temperature of the glue, water, and oven used in the experiment remained constant.

1. Elm: Comprising seven layers with each layer measuring 0.6mm in thickness, resulting in a total thickness of 5mm. The bending process went smoothly, but the elm exhibited slightly lower robustness compared to oak and birch.

2. Oak: Consisting of nine layers with each layer measuring 0.6mm in thickness, yielding a total thickness of 7mm. The bending was also gently executed, but it was observed that the spring-back phenomenon was relatively strong.

**SETUP**

<table>
<thead>
<tr>
<th>Radius</th>
<th>Species</th>
<th>Thickness of veneer</th>
<th>Number of layers</th>
<th>Total thickness including glue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elm / Oak Veneer</td>
<td>0.6 mm</td>
<td>7 of layers for elm / 9 of layers of oak</td>
<td>5.0 mm of elm / 7.0 mm of oak</td>
</tr>
</tbody>
</table>

**Combination of veneer**

- 0.6 mm Elm
- 0.6 mm Oak
- 0.6 mm Oak
Experiments using birch were conducted, as birch is readily available in the region, traditional, and available in various veneer standards. The aim was to explore the potential of birch in bent plywood furniture.

In the first part of the experiment, a 1mm thick birch veneer, manufactured according to local industrialization standards, was used. The bending was expected to be relatively less flexible due to the thickness being nearly twice that of the materials used earlier.

Experiments began with an extreme bending of radius 4 using three layers of 1mm birch veneer. The veneer bent without difficulty, but the combined thickness of the three layers was insufficient to maintain the bent shape. Additionally, the grain direction of the layers, featuring two horizontal wood grains and one vertical grain, had a significant impact on the bending performance.

**TABLE 4.1**

<table>
<thead>
<tr>
<th>SETUP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius</td>
<td>4</td>
</tr>
<tr>
<td>Species</td>
<td>Birch</td>
</tr>
<tr>
<td>Thickness of veneer</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>Number of layers</td>
<td>3 of layers</td>
</tr>
<tr>
<td>Total thickness including glue</td>
<td>4.0 mm</td>
</tr>
</tbody>
</table>
MATERIAL EXPERIMENT 3

The subsequent experiment aims to assess the bending performance under the influence of high-temperature water, while maintaining the same conditions as previous tests. This investigation will provide insights into the effects of water temperature on the bending process.

SETUP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius</td>
<td>6</td>
</tr>
<tr>
<td>Species</td>
<td>Birch</td>
</tr>
<tr>
<td>Thickness of veneer</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>Number of layers</td>
<td>5 of layers</td>
</tr>
<tr>
<td>Total thickness including glue</td>
<td>6.0 mm</td>
</tr>
</tbody>
</table>

Following the initial experiments, a bendability test was conducted using five 1mm birch veneers with a radius value of 6. For this test, three lengthwise grain veneers and two widthwise grain veneers were used. In the first experiment, all layers from the first to the fifth cracked, indicating that the bending part had a pointed shape. It was observed that the veneer fibers were severed from the beginning of the bending process, necessitating additional steps to increase flexibility.

In the second experiment, the combination of grain directions in the layers was altered, using three widthwise layers and two lengthwise layers. Additionally, when applying glue to each layer, high-temperature water (70 degrees Celsius) was sprayed only on the part where bending was to be applied, altering the properties of the wood fibers to a more pliable state.

As a result, the bending proceeded smoothly without defects, and the shape was well maintained. Furthermore, as the number of lengthwise veneer grain layers decreased, the laminated plywood exhibited slightly more flexible properties. Consequently, it was determined that the following four main factors affect the quality of the bending:

1. Number of veneer layers
2. Bending radius
3. Combination of lengthwise and widthwise veneer grain
4. The degree of wetness of a veneer with high-temperature water
MATERIAL EXPERIMENT 4

In the subsequent round, a bending experiment with a radius of 8 was conducted using nine 1mm birch veneers under the same conditions as before. In this experiment, the layers were combined with five lengthwise grain veneers and four widthwise grain veneers, with the lengthwise grain veneers positioned as the first and last layers. The result exhibited the same type of crack as in the previous experiment, with similar cracked veneer shapes and break lines. This observation suggests that the vertically grained veneer is consistently subjected to greater stress from the bending structure, particularly in the first and last layers, rendering it unable to withstand the bending process on its own.

Under the same conditions but with a different combination of veneer grain, the subsequent experiment was completed without difficulty when bending was performed with high-temperature water. Therefore, it appears that in any radius case, the grain combination of veneers is of utmost importance, and the method and amount of overlap determine the quality and shape of the veneer to be bent. Furthermore, the process of making the veneer more pliable using high-temperature water is also identified as an essential factor for achieving perfect bending.

**SETUP**

| Radius   | 8               |
| Species  | Birch           |
| Thickness of veneer | 1.0 mm         |
| Number of layers | 7 of layers    |
| Total thickness including glue | 9.0 mm         |

Consequently, the results obtained from the two different experiments highlight the differences in flexibility and changes in strength according to the combination method of the veneer grain, which in turn affects the appearance of the laminated plywood. Furthermore, the impact of chemically treating the veneer with high-temperature water on its properties and bending performance was demonstrated, necessitating an extended drying time.
MATERIAL EXPERIMENT 4

In the following experiments, the varying structural performances are assessed through the combination of 1.0 mm thick veneers and 0.6 mm thick veneers.

In the following experiments, the structural performance was evaluated through a combination of 1.0 mm thick veneers and 0.6 mm thick veneers. The bending test with a radius of 10 and nine layers was conducted again, comprising six longitudinal grains and three transverse grains. However, two of the six longitudinal grains, the first and last layers, were combined with 0.6 mm thick birch. The layers maintained a good bending shape with the glue.

The 0.6 mm thick birch veneer, despite having longitudinal grains, exhibited greater flexibility than the 1 mm veneer and performed well with high-temperature water, withstanding the most stretching in the first layer and the least radius in the last layer. It was verified that thinner veneers performed better than thicker veneers for the first and last layers. Applying the same methodology with nine layers, the first, third, and last layers were placed at 0.6 mm, reducing the overall thickness and weight of the structure and demonstrating more resilient properties. Subsequently, experiments using seven layers were conducted, with only the first and last layers applied at a thickness of 0.6 mm, proving to be the safest way to maintain their shape.

Ultimately, these experiments ascertained that the thinnest 0.6 mm veneer, with its flexibility and elasticity, is most appropriate for the first and last layers, while the intermediate layers can serve as the backbone of the structure based on their robustness.

SETUP

<table>
<thead>
<tr>
<th>Setup</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius</td>
<td>10</td>
</tr>
<tr>
<td>Species</td>
<td>Birch</td>
</tr>
<tr>
<td>Thickness of veneer</td>
<td>1.0 mm &amp; 0.6 mm (Top and bottom layers)</td>
</tr>
<tr>
<td>Number of layers</td>
<td>9 of layers</td>
</tr>
<tr>
<td>Total thickness including glue</td>
<td>11.0 mm</td>
</tr>
</tbody>
</table>
MATERIAL EXPERIMENT 5

The study aims to determine the potential of the structure by examining its performance and adaptability through an extended shape.

SETUP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius</td>
<td>10</td>
</tr>
<tr>
<td>Species</td>
<td>Birch</td>
</tr>
<tr>
<td>Thickness of veneer</td>
<td>1.0 mm / 0.6 mm</td>
</tr>
<tr>
<td>Number of layers</td>
<td>9</td>
</tr>
<tr>
<td>Total thickness including glue</td>
<td>11.0 mm</td>
</tr>
</tbody>
</table>

Combination of veneer

![Diagram of veneer combinations]

Fig.113. Radius 10mm, 1mm & 0.6mm Birch veneer, 9 Layers
MATERIAL EXPERIMENT 6

SETUP

Radius - 10
Species - Birch
Thickness of veneer - 1.0 mm / 0.6 mm
Number of layers - 7 layers
Total thickness including glue - 9.0 mm

Combination of veneer

Fig. 114: Radius 10mm, 1mm & 0.6mm Birch veneer, 7 Layers
**DERIVED RESULTS**

The experimental results were assessed based on the following three factors, ensuring a comprehensive and objective evaluation of the outcomes in relation to the study’s objectives and research questions:

### 3 layers of birch (1 of lengthwise / 2 of widthwise 1 mm) - Mold radius 4

<table>
<thead>
<tr>
<th>Firmness</th>
<th>Bending quality</th>
<th>Wetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable</td>
<td>Cracked</td>
<td>Completely dry</td>
</tr>
</tbody>
</table>

### 5 layers of birch (3 of lengthwise / 2 of widthwise 1 mm) - Mold radius 6

<table>
<thead>
<tr>
<th>Firmness</th>
<th>Bending quality</th>
<th>Wetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable</td>
<td>Cracked</td>
<td>Completely dry</td>
</tr>
</tbody>
</table>

### 5 layers of birch (2 of lengthwise / 3 of widthwise 1 mm) - Mold radius 6

<table>
<thead>
<tr>
<th>Firmness</th>
<th>Bending quality</th>
<th>Wetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable</td>
<td>Cracked</td>
<td>Completely dry</td>
</tr>
</tbody>
</table>

### 7 layers of birch (4 of lengthwise / 3 of widthwise 1 mm) - Mold radius 8

<table>
<thead>
<tr>
<th>Firmness</th>
<th>Bending quality</th>
<th>Wetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable</td>
<td>Cracked</td>
<td>Completely dry</td>
</tr>
</tbody>
</table>

### 7 layers of birch (3 of lengthwise / 4 of widthwise 1 mm) - Mold radius 8

<table>
<thead>
<tr>
<th>Firmness</th>
<th>Bending quality</th>
<th>Wetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable</td>
<td>Cracked</td>
<td>Completely dry</td>
</tr>
</tbody>
</table>

### 9 layers of birch (6 of lengthwise / 3 of widthwise 1 mm, 0.6 mm) - Mold radius 10

<table>
<thead>
<tr>
<th>Firmness</th>
<th>Bending quality</th>
<th>Wetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable</td>
<td>Cracked</td>
<td>Completely dry</td>
</tr>
</tbody>
</table>

### 7 layers of birch (5 of lengthwise / 2 of widthwise 1 mm, 0.6 mm) - Mold radius 10

<table>
<thead>
<tr>
<th>Firmness</th>
<th>Bending quality</th>
<th>Wetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable</td>
<td>Cracked</td>
<td>Completely dry</td>
</tr>
</tbody>
</table>
MOCK UP
MOCK UP 1

A mock-up experiment was conducted to investigate the feasibility of incorporating three sections of banding into a single veneer while maintaining its form. Two bending veneers were fabricated using CNC milling-processed plywood molds, with a front bending radius of 10 mm. This experimental approach demonstrated the potential for various veneer modifications, which informed the development of subsequent designs.

A hypothetical leg structure was established, and a conceptual seat shape was outlined. Among the four proposed designs, alternative 2 and 4 were selected to maximize the flexibility and rigidity of the bending veneer with minimal structural intervention in the leg framework. In contrast to the other two designs, the leg in alternative 2 and 4 serves as a supportive structure for the veneer, emphasizing the interrelationship between the seat and the leg.

![Fig. 116. From left: Alt 1, Alt 2, Alt 3, Alt 4](image1)

![Fig. 117.](image2)
In the accompanying illustration, the color denotes the direction and magnitude of the force exerted on the veneer independently. Consequently, as the leg structure widens and the connecting components increase, the structural support derived from the leg framework surpasses that of the veneer itself.

Alternative 2 and 4, among the four proposed sketches, serve as suitable examples for exploring the limits of the veneer’s capabilities while maintaining a natural connection with the chair’s leg and effectively dispersing the load through a three-part bending process. Specifically, if the lower structure of the seat extends further back than the front leg, the leg will protrude as depicted in the subsequent illustration. However, if the legs are positioned within the seat’s width, as demonstrated in alternative 4, and the veneer is connected to the front leg, a more streamlined and compact bridge design can be achieved without protrusion.

Furthermore, when loads are concentrated at the front, the force can be distributed with the front leg, while the rear leg disperses the force in conjunction with the middle seat section. Nevertheless, a significant portion of the load is still directed to the bending section of the backrest, presenting a challenge in which the veneer must solely bear the weight.
Drawing upon the previously presented sketches, a 1/1 scale mock-up was constructed, incorporating 0.5 mm elm layers on the top and bottom, with a 1 mm birch veneer filling the middle layer. Upon verifying the radius of the bending section, it was observed that the innermost and outer sides experienced the greatest stress. Consequently, the thinnest veneer and pliable elm were employed in both positions to facilitate bending.

The mock-up consisted of seven layers, including two 0.5 mm elm and five 1 mm birch veneers, resulting in a total thickness of 7 mm. Layers were arranged vertically, overlapping according to wood grain, and a powder glue to water ratio of 3.2:2 was utilized.

A three-part plywood mold was designed for the experiment, which comprised two trials. The first trial utilized a consistent 1 mm birch thickness, while the second incorporated a mixture of 0.5 mm elm. When the thinner veneer was combined and laminated, all bending sections proceeded seamlessly without cracking. However, the second trial revealed that the tightest bending section could not withstand the radius, causing fiber breakage during bending. Despite maintaining consistent oven temperature (90 degrees), glue, water, and clamp positions, disparate results were obtained. Although veneer quality influences outcomes, it was determined that a 1 mm thickness for all layers is untenable for achieving a 10 mm radius.

The bending laminated veneer was baked at 90 degrees for one hour, then allowed to rest for two days at room temperature with molds and clamps. After removing the clamps, the veneer was air-dried for an additional two days. During this process, the top veneer layer dried considerably, while the inner layer remained relatively moist. Subsequently, all molds were removed, and the veneer was left to dry for approximately two more days.
During the drying process, various cracking or distortion phenomena may arise. Such distortions are attributed to the spring back phenomenon, wherein the moisture within the veneer dries and alters the wood’s properties. To mitigate this issue, the plywood is reattached to the mold to maintain its shape.

In the initial prototype, it was demonstrated that a straight line with a straight backrest was more susceptible to twisting. Furthermore, premature mold removal or insufficient clamp tightening may result in gaps between the veneer and mold, leading to uneven glue application and an irregular shape.

It was also established that, even when laminated with glue, the veneer’s shape consistently changed slightly in response to ambient moisture levels. Consequently, the most effective method for preventing twisting and cracking is to maintain the completed plywood shell with the mold until it is connected to other structures, such as the chair’s legs.

In the initial experiment, a 1 mm birch veneer was employed, and insufficient water was applied to the bending section prior to oven baking, resulting in cracks during the bending process. Consequently, the first and second layers exhibited the most significant cracking, particularly in the first layer with vertically aligned wood grain.

Additionally, the drying period was less than two days, leading to the lower structure’s angle narrowing and subsequent deformation of the shape. The backrest section was also severely distorted, with its angle and form completely altered.
In light of the findings from the initial experiment, modifications were implemented for the second trial to enhance the process. Firstly, thinner and more flexible materials were chosen for the outermost and inner layers. Following the layering process, 70-degree water was applied to the outermost and inner banding areas, as illustrated in the figure, to soften the material prior to bending. It is essential to avoid excessive water application, as this may induce further cracking and twisting during the drying process. Instead, sufficient water should be applied to moisten the first and second layers.

As a consequence, all bending points were successfully bent without cracking and conformed to the mold’s shape. However, a gap emerged due to inadequate glue adhesion between layers, suggesting that the force was not evenly dispersed during the clamping process.
Upon testing the structure with a 65 kg adult woman, it was observed that the weight was supported without stress, and the shape was well-maintained. However, the backrest section exhibited instability, and when the user leaned against it, the response was overly flexible, causing significant tilting. Additionally, a crackling sound was produced when the user applied maximum weight, indicating that the 7 mm final thickness of the backrest was insufficient to support the human weight.

Furthermore, although the chair initially maintained its original shape, it gradually bent in the direction of the weight as usage increased. These findings suggest that further refinements to the backrest design and thickness are necessary to ensure stability and durability under various weight conditions.

Mock up 3

Subsequently, a new shell was designed, incorporating a total of seven Birch layers and two Elm layers, with the addition of two 1 mm Birch layers, resulting in a total thickness of 9 mm—2 mm thicker than the initial prototype. Despite maintaining identical environmental conditions and processes, the backrest warp was more pronounced than in the first prototype. However, the bending section proceeded smoothly without issues, and the revised design demonstrated greater strength than its predecessor, providing stable weight support. These findings indicate that the increased thickness and modified layer composition contributed to the enhanced performance of the second prototype.
During the back-bending process, an area with insufficient adhesive bonding to the layer was identified, which was attributed to a clamping issue. Furthermore, the extended duration between adhesive application and oven insertion led to premature drying of the adhesive. To address this, increasing the water content in the adhesive mixture could provide additional time for the material to maintain its shape before drying. Moreover, the backrest angle exhibited a distortion exceeding 20 degrees, likely due to the increased drying time as a result of the augmented layer, adhesive, and water quantities.

Additionally, this experiment revealed that laminated veneer with a straight configuration was more prone to distortion. This finding contradicts conventional design principles that aim to minimize design elements and maintain simplicity and compactness. Consequently, it is worth considering the incorporation of subtle radii in the backrest design for both ergonomic and aesthetic purposes.
MOCK UP 4

Before developing mock-up 2, several issues were identified in mock-up 1, prompting the exploration of solutions and the investigation of diverse approaches to achieve the desired bending radius. The initial challenge to address involves the leg design and the seamless integration between the seat and the leg structure, ensuring that both components adequately support the user’s weight and various postures. Subsequently, a novel methodology is required for the layering technique, veneer type and thickness, optimal adhesive and water ratios, mold and clamp utilization, and veneer manipulation.

From an aesthetic perspective, it is essential to design a harmonious proportion between the shell and leg shapes, particularly focusing on the shell as a chair component. Additionally, determining the angle and form that best accentuates the natural beauty of the veneer and its inner lines is crucial. One of the project’s ultimate objectives is to uncover the untapped potential of veneer and showcase its elegance as an object, furniture piece, and structural element, thereby delivering not only tactile satisfaction but also visual inspiration to the user.

MOCK UP 4 / SKETCHES

The accompanying sketch illustrates the front leg’s angle, designed in accordance with the seat shell’s bending angle and radius, particularly the section associated with the chair’s feet. The rear leg’s angle is determined accordingly. Consequently, various sketch forms were generated, with the bending radius serving as a crucial factor in establishing the chair’s balance and proportion.

Based on these sketches, 1/5 scale models were fabricated, employing 3D printing for the seat structure. Multiple leg material alternatives were proposed, including molded plywood, cut plywood, metal tubing, and solid wood. Among these options, cut plywood and metal, previously discussed in the case study, were deemed the most suitable materials.

This rationale can be attributed to the seat’s form. Firstly, from a structural standpoint, the lower section of the third bending part, i.e., the leg-connected portion, should comprise a stable structure and material capable of supporting the seat and withstanding forward-leaning loads. Simultaneously, it appears necessary for the area slightly behind the seat’s center to bear weight by distributing the front leg structure and load appropriately. Secondly, the use of veneer for chair design aligns with its intended purpose, as one of the many reasons for employing veneer is to showcase wood’s flexibility, which is not evident in solid wood materials, and to explore its novel structural possibilities and inherent beauty.
In this context, metal tubing represents an innovative approach to reducing the material’s weight by adopting a tubular shape, thereby enhancing its productivity and efficiency.

Both materials share a commonality as instances where new structural possibilities have been uncovered, deviating from their inherent material forms. Veneer and metal tubing are the outcomes of human investigations into optimizing material properties, presenting novel design, structural, and inspirational possibilities to humanity.

From an aesthetic standpoint, the seat’s shape encompasses numerous design elements, including three bending instances. As a result, it is deemed essential for the leg structure to remain as simplistic as possible; incorporating additional elements in the leg design may detract from the sophisticated curvature inherent in the veneer.

The leg serves as the fundamental structure, necessitating materiality and structural properties that further emphasize the veneer’s aesthetic form. In this regard, the metal’s color, structural stability, and lightness are anticipated to yield suitable performance in conjunction with the molded veneer.

Concurrent with the seat design, three distinct leg types were developed and incorporated into the 1/5 scale model, serving as the foundation for a more detailed leg design process. The following aspects were considered:

1. Leg impedance: The resistance of the leg structure to deformation, which influences the stability and performance of the chair.
2. Geometry: The shape and dimensions of the leg components, which contribute to the overall aesthetic and functionality of the chair.
3. Foot curvature: The contour of the chair’s feet, affecting its contact with the ground and overall stability.
4. Inertial properties: The distribution of mass within the leg structure, impacting the chair’s balance and weight-bearing capacity.
The two structural designs employ a trilaminar configuration, in which a single shell is subjected to triple bending, thereby enhancing load-bearing capacity. This thin shell evolves into a bilayer to counteract the anterior load exerted on the chair. A triad of joints, encompassing the posterior aspect of the seat, the midpoint, and the curved segment directed towards the legs, form a triangular arrangement that stabilizes the overall structure.

In alternative 1, the leg structure adopts a cantilevered design, offering simplicity and flexibility in accommodating the seat’s curvature. Although plywood serves as a supportive intermediary between the legs, it is anticipated that supplementary structures may be required between the base and the distal extremities of the legs. In contrast, alternative 2 employs a bridge-like structure, which demonstrates superior stability and fundamentality among various models. This design is distinguished by its potential for stackability, contingent upon the angle. Nevertheless, it is evident that the chair itself may lack distinctive features to establish a unique character.

Alternative 3 exhibits a more pronounced character through its A-shaped leg configuration, which provides a stable foundation. Moreover, the rear leg adopts an inward orientation, resulting in a more compact spatial footprint compared to other designs. However, this model may necessitate the incorporation of additional structures between the legs.

In contrast to alternatives 1 through 3, alternative 4 employs rectangular tubing for the legs, maximizing the utilization of the veneer’s form and structural properties. The juxtaposition of the straight legs with the sinuous design of the bent veneer seat accentuates the seat’s aesthetic, while the planar legs convey a sense of stability to the user. Additionally, the angle of the bent veneer connecting the seat and leg has been modified, yielding a more efficient structure that mitigates stress on the bending components and supports the weight through a linear leg and seamless junction. Ultimately, alternative 4 was deemed the most suitable option among alternatives 1 through 6, leading to the development of a scale model with a broader range of dimensions.
**PROCESS OF SCALE MODEL BASED ON THE ALTERNATIVE 4**

Four distinct seat dimensions are devised, with variations in seat length and angular values. Alternative 4-1 features the shortest seat length of 375mm and the largest opening angle, resulting in a compact design and a relatively simplified manufacturing process as the angle increases. This alternative is characterized by a visually awkward horizontal display and a center of gravity shift in the leg, with a shorter front foot and a longer rear foot. While the front seat remains stable, the rear seat exhibits a relatively unbalanced structure with more floating space. The front side's double-layered form, created by the veneer's bending, offers greater stability than the back side, which lacks structure and relies solely on the veneer for weight support.

Alternative 4-2 addresses the issues of alternative 4-1 by shifting the leg's center backward, extending the overall seat length to 396mm, and narrowing the angle. The upper seat layer and lower part layer lengths are reduced from 72mm to 60mm, rendering the chair's seat portion longer and sharper in appearance. The backrest appears relatively stable, and the overall balance is more harmonious than in alternative 4-1.

Alternative 4-3 reduces the seat length by approximately 7mm and the angle by 5mm, resulting in a more compact form than alternative 4-2 while still providing a sense of stability for the user. The front seat and back side are divided into appropriate lengths, appearing suitable for equal weight distribution. The narrower angle imparts a sophisticated ambiance and cleanly accentuates the curve. This alternative also effectively utilizes the veneer's structure and naturally connects with the leg structure.

Alternative 4-4 mirrors alternative 4-3 in all aspects except for an 11mm longer seat length. While no significant difference from Alternative 4-3 is apparent, the anterior veneer may experience increased stress due to the added weight. Additionally, the veneer may potentially warp as the weight it bears increases.
1/5 SCALE MODEL CONCERNING ALT 4

[Images of chair models from different angles, labeled from left to right as alt 4-1, alt 4-2, alt 4-3, alt 4-4]
Utilizing the 1/5 scale model of alternative 4-3 as a foundation, a full-scale 1/1 model was constructed to facilitate a comprehensive understanding of the overall proportions and structural components. This model was developed using cardboard, enabling the determination of the leg’s approximate structure, its relationship with the seat, and the weight distribution direction.
LEG DESIGN PROCESS

RECTANGULAR METAL TUBING

The potential materiality inherent in this design approach is highlighted by the utilization of rectangular metal tubing in a structurally appropriate direction, and synergy is built with bending veneer in a similar language of structural deformation of material.
Firstly, the leg's regular shape facilitates a natural connection with the veneer. The flat surface of rectangular tubing, as opposed to rounded tubing, provides an increased attachment area for the veneer, yielding a simple, compact, and secure structure that instills confidence in the viewer.

Secondly, the visible screw connection demonstrates the leg's flexible attachment without the need for specialized mechanisms, allowing the viewer to easily grasp the structure and focus on the materiality. Thirdly, the tubular structure offers the advantage of significantly reducing the chair's weight while maintaining its rigidity. Tubular steel sections inherently exhibit strength against longitudinal stress, with steel pipes demonstrating considerable resistance to compression and bending forces compared to flat steel sheets. Additionally, tubular structures possess enhanced resistance to corrosion, vibrations, shocks, and pressure, with the added benefit of bending rather than breaking under extreme stress.

Fourthly, from a manufacturing perspective, tubular structures are easily recyclable industrial materials available in various sizes and designs. This versatility presents numerous possibilities and advantages for chair designs, particularly when considering mass production. Lastly, the connection between tubes is exceptionally robust, and the tubular structure effectively conceals welding points, ensuring a seamless and aesthetically pleasing connection.

STEEL LEG DESIGN MAKING PROCESS

For the prototype, rectangular steel tubing measuring 40x20/25x15 was employed; however, larger dimensions were deemed unsuitable for maintaining an appropriate ratio with the veneer. The fundamental objective of the chair leg structure is to achieve a robust design through a linear steel tubing configuration, a veneer connection method, and minimal components. Two steel tubing welding methods were explored, with a particular focus on alternatives 1 and 2.

The T-shaped leg structure experiences the greatest stress at the junction of the vertical and horizontal steel tubing when subjected to weight, as this point serves as the convergence of all forces.
WELDING METHOD OF ALT 2

As depicted in the accompanying sketch, when an individual shifts their seating position, the leg joint indicated by the arrow experiences movement and force. Consequently, joints such as those in alternatives 1 and 2 necessitate robust welding to ensure stability.

As a solution, alternative 2 entails drilling a hole in the horizontal steel tubing that contacts the floor, maintaining its integrity as a single object. The horizontal structure supports the vertical steel structure in resisting force through the hole, resulting in a relatively sturdy and cohesive design. Additionally, the 2mm clearance on both ends of the hole conceals the welded portion due to shadowing, with only the horizontal part appearing welded as in sketch 2. The double welding technique further strengthens the joint, eliminating the need for supplementary materials or structures.
PROTOTYPE OF LEG DESIGN

The leg structure components were joined exclusively through welding, without the need for additional screws. As demonstrated in the accompanying image, the welding seam is minimized while simultaneously strengthening the leg structure. The vertical and horizontal metal tubing appears as a singular structure, contrasting with the seat shell’s aesthetic through the straight structure’s visual elements. This juxtaposition enables the user to focus more on the materiality and inherent beauty of each component.
MOLD DESIGN

CNC MILLING
MOLD PROCESS

A mold, comprising a total of three lumps, is designed with consideration for the bending direction of the veneer, resulting in the veneer being pressed in all directions. The weight of potentially massive molds is minimized, and the optimal pressing method is provided by the manufacturing process using CNC milling.

From the perspective of hand clamping, all structures for molds must be carefully calculated, ensuring even distribution of appropriate forces. The mold should be easy to move, and the shape of the veneer should be secured through appropriate weight. Additionally, the maintenance of the bent veneer’s shape is required of the mold even during the drying process.
Lamination Experiments of Shell

A series of veneer experiments were conducted using the mold, with factors such as veneer wetting, moisture content, glue-to-water ratio, and final drying period significantly influencing the outcomes. A key observation from these experiments is that a curved backrest exhibits enhanced strength and relatively less distortion compared to a straight form.
PROTOTYPES AND TECHNICAL DRAWING

SIIPi CHAIR SINGLE / ARMCHAIR / LINKABLE / BEAM TYPE
SIIP CHAIR - SINGLE CHAIR TYPE

ELEVATION
SIIP CHAIR - SINGLE TYPE
1:10 SCALE
DAEIN KANG

SIDE VIEW

TOP VIEW

BACK VIEW

FRONT VIEW

SIIP CHAIR - SINGLE TYPE
SHELL DETAIL
NON SCALE

R1576

SIDE VIEW

TOP VIEW
SIIPCI CHAIR
SINGLE CHAIR TYPE

MEASUREMENTS

Width : 400 mm
Height : 850 mm
Layers : 11mm / 9 layers
SIIPi CHAIR
Single chair type

MEASUREMENTS

Width : 400 mm
Height : 850 mm
Layers : 9mm / 7 layers
SIIPPI CHAIR
PAIR OF CHAIR
SIIPi CHAIR
PAIR OF CHAIR
PERFORMANCE TEST OF CHAIR
SINGLE CHAIR TYPE
TECHNICAL DRAWING
SIIPI CHAIR – LINKABLE TYPE

SIDE VIEW

TOP VIEW

BACK VIEW

FRONT VIEW

SIIPI CHAIR – LINKABLE TYPE
JOINT DETAIL
NON SCALE

JOINT DETAIL

LINKABLE SYSTEM
VARIATION OF LINKABLE SYSTEM
1:10 SCALE DRAWING

2 SEAT TYPE

3 SEAT TYPE

PERSPECTIVE DRAWING - NON SCALE
SIIPi CHAIR
Linkable type

MEASUREMENTS

Width : 460 mm
Height : 900 mm
Layers : 9mm T / 7 layers
Fig. 183.
A preliminary sketch of armchair type 1 illustrates the integration of the armrest as a component of the chair. By connecting the vacant space within the shell of the seat to the armrest, details are simultaneously concealed and minimized, resulting in enhanced stability for the backrest.
TECHNICAL DRAWING
SIIPI CHAIR - ARMCHAIR TYPE 2
1:10 SCALE
DAEIN KANG

ELEVATION
SIIPI CHAIR - ARMCHAIR TYPE 2

SIDE VIEW - NON SCALE

SIDE VIEW
BACK VIEW

TOP VIEW
FRONT VIEW
A preliminary sketch of armchair type 2 presents a streamlined approach to armrest design. The armrest is connected to the leg structure, capitalizing on the metal tube's properties to achieve a compact assembly.
ELEVATION
SIPI CHAIR - ARMCHAIR TYPE 3
1:10 SCALE
DAEIN KANG

SIDE VIEW

BACK VIEW

TOP VIEW

FRONT VIEW

SIDE VIEW - NON SCALE
A preliminary sketch of armchair type 3 depicts an extended leg length that seamlessly connects to the armrest. The leg and armrest appear as a unified structure, exhibiting a compact form.
CONCEPTUAL DRAWING

BEAM TYPE

The beam-type configuration offers a more efficient public seating solution for accommodating unexpected visitors, presenting diverse variations. This design adapts suitably to the spatial layout and caters to the audience’s needs. Based on the beam profile, the seat shell is tailored to the specific intervals, with options for both a standard chair type and an armchair type.

MEASUREMENTS

WIDTH : 2000 mm (3 SEATS)
HEIGHT : 900 mm
The beam type is anticipated to be employed in a multitude of forms within public spaces. As an object, its presence signifies a relatively broader demarcation of public space, enhancing the area’s overall functionality and appeal.
TECHNICAL DRAWING
SIIPI CHAIR - BEAM TYPE

ELEVATION
VARIATION OF BEAM TYPES
1:10 SCALE
DAEIN KANG

VARIATION OF BEAM TYPES
1:20 SCALE
FRONT VIEW

460 x 3 / 2000

460 x 4 / 2200

460 x 5 / 2800

460 x 5T / 2735
PROTOTYPES IN THE TARGET SPACE

EMMA – ESPONN MODERNIN TAITEEN MUSEO
RESEARCH PROCESS

The comprehensive investigation of veneer as a material for furniture design, particularly in the context of chairs, has revealed its potential for expanding design possibilities and enhancing the relationship between materials, people, objects, and space. This study has focused on exploring the material limits of veneer through various bending radius experiments, acknowledging its longstanding use and established production methods. The research has demonstrated that veneer transcends its material definition, enabling the creation of diverse structures and designs from a single material source.

Within the scope of target environments, the study has scrutinized the positioning of veneer-centric furnishings, particularly chairs, and their subsequent influence on the comprehensive spatial experience. Despite its ostensibly trivial nature, this subject bears the potential to effectuate considerable alterations in the perception and engagement of spaces. The research has yielded invaluable revelations concerning the function of furniture in public domains, the interplay between materials and users, and the nexus between veneer and spatial design.

Moreover, the inquiry has delved into the adaptability of chair designs predicated on their designated functions, encompassing stools, armchairs, and lounge chairs. The research underscored the facility of fabrication and the potential for mass production via mold design, accentuating the diverse manners in which chairs can inhabit a space and engage with users. This examination of the manifold aspects of veneer-based chair designs has culminated in an enriched comprehension of material attributes and their impact on design and spatial encounters.

Although this endeavor has engendered numerous research findings, it is manifest that additional experimentation and refinement are requisite. Specifically, the veneer experimentation procedure calls for further investigation, as the employment of distinct veneer types and overlapping methodologies may unveil novel possibilities. Furthermore, the reliance on manual production techniques, barring CNC milling for mold fabrication, has presented several challenges.

These encompass:
1. Designating ample time for adhesive curing during the veneer clamping process
2. Guaranteeing precise alignment and pressure application on the mold.
3. Contending with the intrinsic variability in capricious veneer conditions, which may result in inconsistent outcomes.

From the standpoint of furniture design, the chair prototypes necessitate additional refinement to attain optimal stability and functionality. Elements such as veneer thickness and overlapping techniques can be fine-tuned to bolster stability and incorporate flexibility as required. Through the modification of veneer layering, the chair’s structural robustness can be preserved while customizing its thickness to cater to particular demands. This methodology elucidates the chair’s purpose and accentuates the material attributes of veneer.

The present investigation employed a solitary mold for the ultimate design; nevertheless, the utilization of distinct molds for various chair categories, encompassing stools, armchairs, and lounge chairs, might unveil a broader spectrum of design possibilities through nuanced structural modifications. Supplementary refinements, such as stackable chair leg configurations and upholstery collaborations with fabric, are also envisaged. Although the museum context functioned as a singular exemplar for chair positioning, the adaptable character of the chair design intimates potential applicability in an array of indoor public spaces (transition spaces), comprising airports, bus terminals, and lounges.

REFLECTION

PROCESS AND CONSEQUENCE
In the context of modern society, chairs epitomize multifaceted and functionally impeccable entities that maintain an intimate connection with human beings, potentially evolving their existential significance in myriad ways in the future. The relevance of furniture is contingent upon its recognition within intellectual spheres, and it is postulated that it may serve as an apt substitute for fulfilling both cognitive and corporeal inspirations as an object possessing functional attributes. From this vantage point, wood engenders novel inspirations by manifesting diverse potentials through the employment of veneers derived from familiar materials. Trees, which have been utilized since the inception of human existence, persist in synergizing with innovative technologies, such as pressing machines, 3D printing, and CNC milling, signifying their limitless possibilities.

In the realm of design, the juxtaposition of structural integrity and aesthetic appeal frequently presents challenges, and veneers have emerged as a versatile material adept at addressing both facets. This observation transcends the domain of wood and encompasses the vast array of contemporary materials, which seemingly possess boundless potential. It is postulated that the onus lies on designers to discern and judiciously utilize these materials in fitting contexts and approaches. Consequently, veneers epitomize an exemplary and advantageous perspective that humans ought to adopt in relation to nature, serving as a laudable paradigm.

CONCLUSION
SCULPTURAL PRINCIPLE

Adopting an architectural perspective, the object significantly incorporates and accentuates the space it occupies. Rather than exhibiting a concentrated form, the chair dissolves into transparent elements that seemingly necessitate continuation or repetition. The chair’s shape, characterized by the arrangement of elements and the void between two lines, generates a distinct visual impression in the side view, allowing the observer’s gaze to seamlessly transition to the next chair and extend further towards the room’s boundaries. Consequently, the entire architectural space is activated through expansive and tranquil movements.

Ultimately, the object transcends traditional constraints to establish cohesion not only in the technical and aesthetic aspects of furniture design but also in the focused presentation of artworks. This distinctive form serves as a prominent component in understanding how the chosen material and technique systematically exploit the tension between sculptural and architectural facets, with increasing deliberation in a specific spatial context.

ARCHITECTURAL PRINCIPLE

As a sculptural concept, this structure exhibits both suppleness and flexibility, accommodating a diverse range of visitors. Its presence within the space exudes a natural dignity, often causing observers to overlook the original conception and experience of this furniture. The underlying principle is intimately connected to the sculptural approach, necessitating movement within the space surrounding the object, which stands autonomously, emanating a concentrated force. As an integral component of the museum’s collection, the object should possess a concise form characterized by exquisite angles, nonparallel lines, and a relaxed structure that simultaneously fosters comfort and a subtle tension, directing attention towards the displayed artworks.

Conversely, the form actively engages with and expands the surrounding space, resulting in a concentrated effect accentuated by its distinct shape. Exhibiting rhythmic vitality, the chair endeavors to extend outward from its center while simultaneously consolidating its inherent directionality. This dynamic interplay may serve to guide the audience towards the artwork or welcome the user as a sculpture, distinguished by its unassuming yet intuitive form.
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