

博士論文

**Observations on Plywood Development  
in Twentieth Century Japan:  
Between craftsmanship and industrialization**

(20世紀日本における合板の発展に関する考察：  
クラフツマンシップと工業化の視点から)

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## Introduction

*Architecture is posited as a craft, that is to say, as the practical application of established knowledge through rules of the different levels of intervention. Thus, no notion of architecture as problem-solving, as innovation, or as invention ex novo, is present in showing the permanent, the evident, and the given character of knowledge in the making of architecture.*<sup>1</sup>

### 1. Context and relevance

Changing conditions and variations in the domains of technologies, materials and organizations have transformed the context in which architecture is practiced and constructed over the course of history. While establishing distinctive regional cultures, these patterns of change have been continuous throughout, with increasing speed and complexity. Within this context, diversified processes have replaced the search for the absolute, or a prototypical process believed to have the capacity to address all issues at hand: Grand narratives, large-scale theories and philosophies including concepts of absolute freedom, revolution and the ability to know everything through science, that were accepted by the public as universal to the human conditions of the world, could no longer represent or contain us all.<sup>2</sup>

For the built environment, increasing alternatives in fabrication processes have challenged the preceding notions of architectural productions and processes, including possibilities in the latest methods of fabrications and customizations. Impacts of these changes have always reached beyond the process of making to that of designing. Increased level of control that these methods have granted to the architectural designer has led some to claim that what was once a seamless practice of designing and making, exemplified in the practice of a master craftsman, has come full circle today. Reinstated by the newly available technologies at the scale of individuals and small-scale operations, “crossovers between the crafts and digital technologies – a way of reuniting the crafts with manufacturing and with ‘industries of one.’”<sup>3</sup>

Processes that span both designing and making have been directly and profoundly

affected by, and have affected, changing conditions in technologies and materiality that are inevitably in negotiations with social, political, and cultural factors. These themes are explored in this thesis through the aspect of *craft*: A practice of the continuous, involved process developed from conception to physical implementation. While the nature and degree of engagement vary for each specific case, craft is simultaneously a way of physical realization through skills and knowledge, an approach for practice that places a certain value on the work process, their organizations within society, and the outputs themselves. Singularity of each process is often emphasized whenever craft approach is undertaken, although once the process is refined, it may be subsequently repeated for more efficient modes of production. The process also evolves significantly over time. For example, a typical operation of making a ceramic bowl has changed remarkably from coil-based additive construction to possibility of a more controlled, smoother, and faster production by throwing on a potter's wheel, even though some of their resultant variations of form and basic material may remain fundamentally unchanged.

If the modern movement is seen as a result of the ambition towards industrialization and standardization, or partly a cause of their prevalence, the aspect of craft often associated with hand-based work and one-off production seem contrary to this development. Yet a wide range of overlaps has existed, where craft processes influenced and informed industrial manufacturing, and where industrialization has nurtured its own craft practices and in turn affecting the course of crafts. Across cities, organized industries with highly sophisticated machinery in a factory setting, often coexisted with the hand-based productions through the most basic machinery, if any, in smaller workshops. This thesis positions the practice of craft as a starting point to explore its critical development relative to industry through the perspective of historical events, movements, and figures that have borne architectural consequences.

Craft, as it stands in contrast to other practices, manufacturing methods, social and economic issues, is a relatively modern concept. It is understood in conjunction with, or in contrast to, the industrial manufacturing systems and their larger impacts to society developed through much of eighteenth and nineteenth century. What might be called early

or ‘primitive’ crafts, before the advent of industry, cannot be discussed linearly to the notion of modern craft: While early crafts were borne out of the need for tools and objects, much of modern craft’s definition and position today have been cultivated through tensions with different disciplinary forces.

Long relegated to a peripheral status, craft as a perspective may seem restraining in the larger context of manufacture. However a number of contemporary post-industrial makers have chosen to model after craft practices, or at least adopting some of its concepts when given the choice to operate at small scale rather than a large one; conventional industry has required a substantial investment to launch it, thus considerably limiting its participants. With growing number of micro-narratives, the alternative and marginalized are displaying increased presence.

## **2. Aim and objective**

The aim of this thesis is to pursue the reciprocal development of craft and industry, through which the reshaping of both craft and industrial processes related to architecture can be observed. Aspects of architecture such as technologies, materials, and aesthetics, have led to refinement of the architectural process, or vice versa, as changes in processes encouraged the advancement of technologies, materials, and aesthetics. In the production of architecture, intertwined associations of these aspects are often ambiguous in a sense that clearly determinable or hierarchical relationships are absent.

Architecture has never been a strictly linear practice. From the conceptual to actual, or design to physical implementation, the process employed may vary from project to project dependent on scale, program, location, contract, or other factors with numerous reassessments and modifications. Roles of the profession according to the practice have been adopted, both before and since the distinction between designer and maker has been made.

Discussions and reevaluations of craft in the contemporary era are, in part, an attempt to establish a more tight-knit relationship between designing and making in the process, which is not necessarily dependent on factors such as the scale of production. Industry, which early modern craft advocates such as Morris criticized but nevertheless depended on,

has also been fostering its own kind of craft – different from the traditional one in the steps taken towards the outcome, perhaps, but with shared concerns and approaches. The definitions of craft, which distinctly reflect the sentiments of its time and of the purveyor's viewpoint, and the range of what falls under craft will be discussed in the subsequent chapter.

The objective is to address the relationship between craft and industry in the modern era, through their ideologies, strategies, practice models, aspirations, outcomes, and consequences. Konrad Wachsmann has stated in 1961: “As it no longer seems possible to get closer to the central problem of building, manifested in industrialization, by way of detailed improvements in materials, methods, and techniques, it will be necessary to run through the entire development of scientific technology to reveal the complexity of all the interrelated problems and the conclusions that they permit.”<sup>4</sup>

The relative simplicity of the processes in traditional crafts, dependent on tacit knowledge and time-consuming to master, have been largely replaced by the increasingly complex processes that are dependent on engineering and scientific understanding. Yet even the most sophisticated industrial processes have been rooted in the crafts in one aspect or another, including the borrowing of its stylistic language and approaches to material manipulation.

Maturing of industrialization from its beginnings in the mid-eighteenth century into the nineteenth century can be viewed as a transitional and relatively stagnant period from the perspective of ideologies. Changes in technological, social, and economical conditions occurred more rapidly and often seem to precede the theoretical framework of practice and labor, and that these discussions seem to have only taken place in the periphery of larger and economically expanding developments.

The research aims to understand what craft processes have conveyed through its development, and in parallel to the development of the material of plywood. The early production and implementation of plywood as an industrial material coincide with the emergence of early craft movements and ideologies. The objective is to follow both developments, in their processes and contextual circumstances that instigated the changes.

Specifically, aspects of production, distribution, consumption, and designs will be addressed through the case study.

### **3. Research questions**

The area of investigation concerns how the modes of knowledge and its context have shifted relative to production and design through processing of a material, through the advent of plywood. Technical change can be understood “as a process of trial and error, as a cumulative result of small and mostly random modifications,” rather than rational, goal-oriented activity.<sup>5</sup> Assuming the former approach, experimentations with materiality, industry, design and other factors through the development, or process of change, will be observed through the following question: If craft represents a continuum through accumulation of knowledge and techniques, can it be sustained through abrupt shift in manipulation of the material, such as in the transitions from hand to machine, one-off to mass production?

Further observations will be made on: 1. How the approaches of craft-informed processes translated to industrial productions of plywood and their effects on designs, while reviewing the relationship between craft and industry; 2. Understanding the reorganization of resources in terms of raw materials, labor and skills in the plywood industry; 3. Effects of the materiality of plywood on the roles of the designer, maker and other relevant participants in the process on the patterns of consumption and their consequences.

### **4. Research Methodology**

The relationship between society and technology is often discussed in terms of how technology affects society. With a closer view, the interplay between society and technology, both being human constructs, are sometimes coincidental and not necessarily logical nor premeditated. The first section of the thesis focuses on this framework of craft practice and technology relative to its social context through theories and definitions, by examining what craft meant and what it came to signify since the era of industrialization up to contemporary conditions.

The second section surveys the development of plywood both generally, as an international phenomenon, and in more detail, as it pertains to Japan. The intention here is to examine the understanding of technology related to plywood development, to cover the basic knowledge and related techniques, and the social, economic and political context. They are examined through the case of plywood as both a material and a product. Included are observations on production processes, analysis of the material manipulation, technological aspect, comparisons to preceding and subsequent designs, and their material and social contexts.

In addition to reviewing and analyzing material development, interviews to experts with the commonality of having been involved with plywood from their respective fields in design, material engineering, research, and fabrication will provide perspectives that will fill in the gaps between the more widely known technological achievements.

<b>Subject</b>	<b>Areas of investigation</b>
Craft / industrialization	Definitions and theories Labor and the social context Related movements in art, crafts, architecture
Plywood	Historical development Material derivatives Statistics: production, import/export, demand, use, etc. Related movements Regional developments
Plywood, design, craft	Interviews, categorized by general, industrial, design and regional perspectives

### **Case study review**

Based on the assumption that the “social construct of an artifact” is established through “the outcome of two combined processes, closure and stabilization,”<sup>6</sup> which are in fact the two aspects of the same process, the artifact – plywood – is followed from its early



experimentation to its height of production and consumption, to the current state and challenges. Along the way, its closure and stabilization process, and other key aspects in Wiebe Bijker's theory of sociotechnical change will be examined.

Target:	Plywood development seen from the craft perspective
Framework:	Technological (materials and tools), design (aesthetic)
Timeframe:	International (focus: 1872 - 1941); Japan (1907 - 1950s)
Disciplinary background:	Mechanical (partly chemical), design
Industrial context:	Factory (and laboratory, corresponding with above)
Intended market:	Industrial and consumer
Related fields:	Architecture, interior, furniture, products, industry, craft, art

In the development of plywood, international history in Europe and the US had made the earliest progress, starting from the early nineteenth century with the invention of rotary veneer lathe and experimentations with laminated veneer furniture. Japan's involvement took place decades later, successfully producing plywood for the first time in 1907. While the basic techniques that have endured are nearly identical, these developments occurred independently in different regions into the first half of the twentieth century.

Major developments in the history of plywood are linked to mechanical aspects, from the processing of veneers to the press, as a reflection on the history of traditional processing wood that preceded it. The development of adhesives is based in the chemical background. The product had been marketed to industries first, but the general public also gained direct access to it later through retailers of home improvement and construction products.

## **Precedents**

Preceding researches on the topic of plywood can be generally categorized into two types: Industry based and design based. The industry based perspective covers the material's technical, economic and distributional data as well as their historical developments. These are generally targeted to those operating within the industry and scientific researchers,

published via trade reports and journals. Examples of this would include comprehensive reports by the APA the Engineered Wood Association, Timber Trade Federation, the Japanese Plywood Manufacturer's Association, among many others.

Perspectives rooted in design consist of extensive accounts on the history of furniture designs and productions, notably from the body of the work of a particular designer or workshop, such as Thonet, of a specific era determined by style, such as Victorian, or by region, such as eighteenth century London. There are also manufacturer-based catalogues and publications, which cover design, manufacturing, material, structure, technology, and marketing strategies. Examples include publications on Tendo Mokko in Japan, Knoll and Herman Miller in the US. Design theories also fall under this category, written by the designer or retrospectively by a researcher on a particular designer or a group of designers.

This thesis will use both categories of sources related to the key developments in plywood, in an attempt to draw associations to craft in the wide spectrum of plywood's domain.

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<sup>1</sup> Frampton, Kenneth. *Studies in Tectonic Culture*. Cambridge, MA: MIT Press, 1996. First published in 1995. p 3. Quoting Ignasi de Sola Morales, from Giorgio Grassi, "Avant Garde and Continuity," *Oppositions* 21, 1980, pp 26-27.

<sup>2</sup> Lyotard, Jean-Francois. *La Condition Postmoderne*. Trans. Kobayashi, Yasuo. Tokyo: Suiseisha, 1986. pp 8-11.

<sup>3</sup> Frayling, Christopher. *On Craftsmanship: Towards a New Bauhaus*. London: Oberon Books, 2011. p 143.

<sup>4</sup> Wachsmann, Konrad. *The Turning Point of Building: Structure and Design*. Trans. Thomas E. Burton. New York: Reinhold Publishing Corporation, 1961. p 11.

<sup>5</sup> Bijker, Wiebe E. *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge, Mass. and London: The MIT Press, 1997. p 13, as proposed by Elster, 1983.

<sup>6</sup> Bijker, p 84.

## **Chapter 1**

### **Post-industrial revolution: Exploring new directions for craft-making**

#### **1.1 Framework for craft, definitions and theories**

The term *craft* has been used in a wide range of situations, under changing circumstances and contexts. The general perception of craft has also evolved considerably over time. Today it often reflects attitudes and idealisms relative to the process of making executed with utmost care. Such is a modern notion of craft, where the understanding of it lies in its implicit contrast to industrial manufacture, where mass production is enabled by greater capacity of the machines. An example of the negotiations and tensions between the hand and the machine, which may be interpreted by some as tradition versus innovation, can be contentious because of its ambiguous boundaries and definitions when observed closely.

From one perspective, it reflects a resistance to technical progress and a sense of security with the traditional and the familiar. Occasionally this argument is further fueled by the notion of the original versus the copy – based on the belief that crafts produced with substantial involvement of the hand, due to its slight variations between the output, can add to the value of the one-off, the original. For the identically mass-produced and machine-made products, the machine itself or a tool such as the mould would be the only original. Resulting products are essentially copies of the mould, and therefore of less value. As widespread or ingrained this impression might be, it has never been a given. The perspective of labor, value, and efficiency in the social context adds to the complexity in determining the qualifications for craft.

Craftspeople constituted less than ten percent of the medieval labor force,<sup>1</sup> contrary to a kind of idyllic notion that hand-based productions dominated the workforce in the pre-machine age. While some have argued that craft has been the practice from the ancient times and that making of utilitarian objects and tools are essentially what defines human civilization from its very beginnings, craft as we know it today is based on the relationships and contentions between it and the industry, after systematized industrialization has taken place.

Linguistically, terminology denoting the worker dates back to 1546 for the French *artisan* or to the fifteenth century for the Portuguese *artesão*. Yet it was three to four centuries later, in the nineteenth to twentieth century, that the term and abstracted concept of the produced work of handicraft that is equivalent to the French *artisanat* or Portuguese *artesanato*, emerged. It was around the same time the words craft and industry took on their modern meanings, since “prior to this time, industry usually meant skill, dexterity, diligence, assiduity.”<sup>2</sup> By today’s standards these qualities would be presumed for craft but not industry, and these underlying circumstances would shape the practices and products of craft into the contemporary era.

Craft can represent entirely different issues depending on the discipline it is perceived from. A sociologist may consider it as skilled manual labor or the aristocracy of labor; for an economist, it may be a stage preceding capitalism; for a trade unionist, a way of defending the way skilled workers perform their occupations and its conditions; for a policy-maker, a stimulus to local or regional economics; for an art critic, a distinction between intellectual or conceptual art versus manual craft; or for an educationalist, craft can stand for learning by doing, in other words, experiential learning.<sup>3</sup>

### **1.1.1 Material practice: Between industry and art**

The trajectory of knowledge for humans, according to Manzini, has diverged into two paths from the beginning: The philosophical, in which the forms of thought are linked to the ability to use language to produce symbols, and the technical, where a relationship between matter and those who work with it evolve over much longer periods of time and thus following a very different path to abstraction.<sup>4</sup> Belonging to the latter, the craftsman is defined as a figure whose ‘knowledge’ followed rules dictated by matter – “his actions, his thought were always linked and subalternate to the requirements of the material with which he worked” with profound familiarity in physical terms and in terms of perception, and for whom “innovation, when it arises, is the result of a fortuitous piece of happenstance – often the product of an error that has yielded positive results, rather than that of a deliberate design choice in the modern sense of the word.”<sup>5</sup> It is only enabled by extended exposure to

and continuous work with the chosen material.

From one of the most prevalent perspectives, craft is acknowledged as a material practice associated with the likes of ceramics, textiles, wood, metal, glass, or any other material the craftsman chooses to engage in and subsequently gets trained for. In architecture, materials are invariably aggregated to achieve its necessary scale. The idea of the tectonic has transitioned from the art of construction, a generic notion of making, then to the art of joining. Therefore the assemblage of the different materials in architecture and art has become one of the essential themes in the discourse, evolving into an idea capable of aesthetic judgement and not constricted to the technological.<sup>6</sup>

The origins of architecture is described through this frame by Gottfried Semper, who used a methodology of explaining the arts through its material, technology, and function. His book *The Four Elements of Architecture* published in 1851 refers to the basic understanding of earliest form of dwelling in four dominant traditional crafts: Stereotomy or masonry for mound or earthwork; ceramics for hearth; tectonics or carpentry for roof or framework; and textiles for wall or lightweight enclosure. Semper adds metal as the fifth element, as one that unites all properties of the raw materials of the previous four elements.<sup>7</sup> In observing the vernacular examples, he found the authority of these materials to provide order to its architecture, distancing himself from the historicism and aestheticism of his time. It is notable that Semper deliberately chose to categorize by the basic elements of architecture through motives and not exclusively by material classifications, although they are inherently linked in the vernacular architecture on which his four elements are based upon. This understanding was nurtured through his exposure and involvement with Henry Cole and the Great Exhibition in London. Ultimately it also contributed to Semper's recommendations on the structure of educational reform in England that included the industrial arts – *kunstindustrie*, following the concept that form is determined by the materials.

Categorizations within academic institutions and works reinforce this association even today, where disciplines are organized by material. Many craftspeople in training or in practice pursue one or few set of materials to master the material in its behavior, characteristics, and possible manipulations mostly on empirical level. It is not coincidental

that basically all of the material categories are so-called natural materials, or has its origins in the natural materials; synthetic materials such as plastics have been regarded to be lesser in the realm of quality production and artistic values for the most part. By doing so, craftspeople distanced themselves from the close associations between synthetic materials and industry, seeking a superior cultural and moral value. Yet they failed to surpass the ranks of fine arts since that boundary was established, and over time craft came to be wedged between industry and fine arts.

Craft has often been discussed in contrast to the fine arts, which is perceived to be conceptual and therefore non-material-based, or not subject to materiality. Also called practical arts or applied arts, craft has been seen as intellectually subordinate to that of fine arts since the Renaissance in the sixteenth century, and the divide between the two reached its height in mid nineteenth century, with the concept of art for art's sake, or *l'art pour l'art*.<sup>8</sup> The phrase is thought to have been first used in the magazine *Revue des Deux Mondes* in 1845 by Victor Cousin. It cemented the autonomous state of art, although its autonomy and its supposedly pure and uncontaminated status – achieved by being removed from the mode of its production – is also arguable under changing social conditions, from appropriation to non-space based relational art.

Through these frictions, the history of modern craft can be regarded as a mirror image of the history of modern art, supplementary to its narrative of progress and conceptual discovery.<sup>9</sup> Theodor Adorno, German philosopher and the author of *Aesthetic Theory* written in the 1960s has argued that because of its lack of self-doubt and rigorous internal analysis that art possesses, craft only functions as a supplement of the artwork. Craft, heavily dependent on the method of production, serves as a means and the decorative, as implied in the term supplement. Unlike art, craft could not be in a position to critique the culture industry, whose base can include commercial, political, social, economic, or religious relations. Meanwhile Adorno also believed the mastery of technique of the materials to be essential in creating the artist's autonomous work, stating that “the ends are certainly not independent of the means.”<sup>10</sup>

While Semper saw the potential of ‘technical crafts’ to bridge the gap between craft

and fine arts, there has always been a recognized divide that some attempted to reconnect. One of the consequences of this stigma has been a tendency to regard craft in more ‘artistic’ values with the rise of artist-craftspeople, in contrast to the virtues of other preceding craftworkers whose work tend to remain anonymous. Today both groups coexist within the spectrum of what craft might represent within their niches, not as adversaries.

Craft also can be described in contrast to another form of practice: Engineering. It is a field that, just like craft to fine arts, was seen as secondary to science. Sometimes called ‘applied science’ until questioned by scholars in the 1970s, engineering was always seen to apply the results and discoveries of science but never cultivating its own. Later it would be acknowledged that technology has a parallel framework to science, but nevertheless its own conceptual framework.<sup>11</sup> It is also analogous to the distinction between practice and theory, and their relationship that is often interdependent yet potentially adversarial, which comes up repeatedly in the discussion. With the rise of technological advancement and engineering closely tied to it, traditional forms of crafts were often left way behind. Summarized by Bill Addis, the characteristics that has differentiated craft from engineering are the following: “1. The use of calculations to establish suitable sizes of components; 2. The use of scientific knowledge and understanding to inform decisions and to generate or raise confidence in a certain design proposal before it is built; 3. The ability to deal with power, forces, and temperatures whose magnitude far in excess of what a human can experience directly; 4. The ability to learn (certain) engineering knowledge from books and in the classroom, rather than by direct personal experience.”<sup>12</sup> One of the main challenges that contemporary craft practices face today is often attributed to the fact that learning craft takes time, and mostly out of the academic environment.

### **1.1.2 Defining craft practice**

One of the historical references, *Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers* (Encyclopaedia or a Systematic Dictionary of the Sciences, Arts, and Crafts) published between 1751 and 1772 and edited by Diderot and D’Alembert, is from the context of aristocratic France where craft was taught and practiced by the relatively privileged, who

had their own educational systems. Its definition of craft follows:

*Craft. This name is given to any profession that requires the use of the hands, and is limited to a certain number of mechanical operations to produce the same piece of work, made over and over again. I do not know why people have a low opinion of what this word implies; for we depend on craft for all the necessary things of life. Anyone who has taken the trouble to visit casually the workshops will see in all places utility applied with the greatest evidence of intelligence: antiquity made gods of those who invented the crafts; the following centuries threw into the mud those who perfected the same work. I leave to those who have some principle of equity to judge if it is reason or prejudice that makes us look with such a disdainful eye on such indispensable men. The poet, the philosopher, the orator, the minister, the warrior, the hero would all be nude, and lack bread without this craftsman, the object of their cruel scorn.*"<sup>13</sup>

The passage shows that patronizing of those involved in the making, accompanied by frictions against the machine and mechanical operations, could be found by the early years of the industrial movement in the social order of mid-eighteenth century France. The tacit, non-verbal tradition of the work then and now can often leave the rest of the society have a sense of being removed from the workshop; whatever happening in the workshop is mystified, for better or for worse. Combined with a general perception that the work mainly consists of mechanical repetitions, it has countered efforts to elevate the status of craft.

After the effects of organized industry had disseminated, the framework for craft has changed significantly and further developed into our understanding of modern craft. The general notion of craft turned into a marginalized profession seen in contrast to industrialized productions, or, on the other hand, that craft was no longer limited to its traditional methods of productions.

David Pye, a furniture designer and maker with a background in architecture, is one such figure who contributed to bring the definition up to date. Most significantly, he has made a distinction between the two poles of workmanship, in what he calls a workmanship of risk versus workmanship of certainty: "The word craftsmanship [...] means simply workmanship using any kind of technique or apparatus, in which the quality of the result is



not predetermined, but depends on the judgement, dexterity and care which the maker exercises as he works. The essential idea is that the quality of the result is continually at risk during the process of the making; and so I shall call this kind of workmanship ‘The workmanship of risk.’”<sup>14</sup> It is then contrasted to the “workmanship of certainty,” in which, found in quantity production, the result is predetermined as are each operation conducted during production. Pye argues that while the workmanship of certainty in its pure state is found in full automation, it is not limited to mass-production. Neither can the workmanship of risk be called hand-made, because of the core issue asserted here is ingenuity.

The argument is steered away from the overly simplified hand versus the machine opposition, and expands his point by saying that the workmanship of risk “has no exclusive prerogative of quality. What it has exclusively is an immensely various range of qualities, without which command the art of design becomes arid and impoverished.”<sup>15</sup> From this perspective, he underscores the futility of categorization between fine art, craft, and manufacture.<sup>16</sup> Pye, in arguing his point, also makes a reference to the process in which modern techniques operate; any quantity production requires prototypes, tools, and jogs that must be made exclusively in its beginning, which will always necessitate a certain kind, or level, of craftsmanship. This is a realm that the Pye’s sense of workmanship may thrive within quantity productions, even if it is increasingly diminishing in proportion.

The non-verbal nature of craft has served to preserve its enigma, in its occasionally excessively idealistic and insular world, but also undermine its practice that is in competition with ever-increasing alternatives of productions which are more advantageous in economy, speed, and scale. The steady decline of the number of craftspeople engaged in the traditional practices, can be partially attributed to the long held ideals of their practices, such as the refinement of skills that have become obsolete in some fields. Like the alchemist who became the scientist and the researcher, Konrad Wachsmann wrote that a “comprehensive idea of technology gradually arose and began to replace that of craftsmanship.”<sup>17</sup> The shift in dominant modes of production from hand tools to machines to the expansion of industrialization has, in large part, eradicated practices that were replaceable by more economical and efficient means of productions.

Before moving further in time, the understanding of the craft tradition should also be clarified. Philip Steadman, a professor of architecture and urban studies, describes it from the the approach of the craftsperson to the work: “Since there are no radical departures from the repeated type, it is possible for artefacts to be made which are technically sophisticated, which exploit physical principles, chemical processes or the properties of materials in very subtle ways – but without any of their makers having any *theoretical* understanding of how these effects are achieved. The principles have been discovered empirically, and *are embodied in the inherited design*. [...] The craftspeople knows how to make the object, he follows the traditional procedure (the recipe); but in many respects he literally *does not know what he is doing*.”<sup>18</sup> The emphasis on technique and the knowledge of ‘how’ as opposed to knowledge of ‘why’ that is passed on to the next generation of craftspeople, have been central to their practice to some extent; aforementioned *Encyclopedie*, in its attempt to collect and organize all available knowledge, was basically a manual of how-to of practical information. This is painted as the main difference between craft and the scientific knowledge, and their potential cause of strife – with the increasing dominance of academia, tacit knowledge based on experiential learning became marginalized.

Sociologist Richard Sennet pursues this issue from the idea of antisocial craftsperson, citing an example of Stradivari Syndrome where the highly skilled violin craftsperson was not able to pass on his tacit knowledge to others and therefore his expertise in making was forever lost. In his definition, Sennet writes about the two issues that consummates craftsmanship: “The first is the craftsman’s desire to do good work; the second lies in the abilities required to do good work.”<sup>19</sup> Craft’s association with good work, or the equally subjective term, quality – whether determined by precision, strength, durability, aesthetics, coherence, or the combination of all of these characteristics – has been to its advantage and detriment. Industrialization brought on the decline of the amateur and his or her curiosity, replaced by professionals with specialized knowledge. Yet the professional’s obsession or perfectionism with work, for example, can have destructive effects on both the process and the result when it “degrades into a self-conscious demonstration.”<sup>20</sup> Sennet, comparable to Pye in this sense, also defines craft and craftsmanship in terms of values that is not

constricted to the ways of the past, or a specific point in history, but one that is evolving with the time and not limited by specific tools, methods or professions.

Additionally, the good craftsperson described by Sennet can also be compared to Ivan Illich's idea of shadow work, which is posed in contrast to subsistence work. Shadow work refers to the unpaid performance and self-discipline, which becomes increasingly important for wage labor for further economic growth. Illich argues that the unpaid performance, rather than unpaid wage labor, is one of the values denied by industrial society and what it simultaneously cherishes.<sup>21</sup> This notion represents contradictory values, which are not fully representable by the monetized economy. The dominant conditions of the industrialized society in setting the values have caused many traditionally minded craft practices to fall out of favor, except for a very narrow niche market that can afford to sustain and nurture the practice precisely for its rarity, such as the exclusivity of the handmade.

### **1.1.3 Extending boundaries**

The application of craft to information technology has increased in the discourse since 1990s with phrases such as digital craft or digital artisan. While the tools applied have changed drastically, the scale of production and the personal involvement with the work and its process can correspond to the more traditional craft definitions. Malcom McCullough describes the beginning of digital craft with the capability to directly manipulate the artifact, that is, by pointing the mouse at the work on the computer screen. The best measure of direct manipulation "as a basis for digital craft is its capacity for continuous actions."<sup>22</sup> The ability of the computer, namely its speed and capacity, to provide continuous feedback in realtime is essential as a useful tool for manipulation. The interaction between the user and the computer has evolved from the mouse, occurring without touch through the hands to simulate the sense of touch, toward more intuitiveness and directness. McCullough further poses that histories of technology reveal the increasing abstraction of work may or may not cause the decline of human hand skills, but that it can be practiced toward craftsmanship.

In the approach taken with craft-making, the information derived through the entire process – encompassing materials, tools, skills, and technologies – are inseparable and often

unfeasible to pinpoint which aspect preceded another. Craft is representative of both the process and the work, in which the design conception to realization is continuous and not necessarily linear nor hierarchical. The translation and mediation from conception to physical presence occur via lesser known and generally, although not limited to, anonymous makers and their tools. Some of refined techniques in crafts are highly specific to its material and purpose, but might also be versatile and applicable for multiple functions, most of which may be unanticipated initially. Even a very particular technique or knowledge can disseminate into different applications, in the same manner as scientific knowledge, but craft also implies more than pure technique.

#### **1.1.4 The social aspect**

Changes in social and economic climates stimulate changes in demands. The pursuit for quality over means for profit have sometimes been viewed as promoting traditional and local values or simply another facet of commercial capitalism, targeting the bourgeois. It is notable that the Arts and Crafts movement in England was based on the sense of romantic socialism, as did Buckminster Fuller's own social agenda in the United States. However Deucher Werkbund, whose rise was motivated by the Arts and Crafts movement, represented a politically opposing position. Both movements embraced the guild-idea as a platform for education and production, as an indication of their presence in the society.

The idealisms associated spanned from political idealism to social awareness. Rudofsky, in *Architecture Without Architects*, laments the architectural prejudice for works in underdeveloped countries as opposed to "the architectural blight in industrial countries."<sup>23</sup> Moving the focus from the individual architect to the communal enterprise, he quotes Pietro Belluschi's definition of communal architecture that it is "a communal art, not produced by a few intellectuals or specialists but by the spontaneous and continuing activity of a whole people with common heritage, acting under a community of experience."<sup>24</sup> This touches on the issues of amateurism and of bricolage, which are understood differently from the development of modern craft.

Nevertheless the development of craft reveals the nature of the engaged process of

making, typically informed by what preceded it, accumulated knowledge and techniques, and occasionally representing an unexpected shift or a kind of discontinuity. Its hidden orders and techniques have very limited ways to be transferred, symbolized by systems such as apprenticeship, that are increasingly difficult to be fostered in contemporary society. However it is also limiting as the process of making and materiality have developed substantially into the modern era. Changes in the perspective of crafts, which also evolved considerably over time, challenges the meaning of any practice related to making.

### **1.1.5 Hand and the machine: Sublimation of the handmade**

*To find the junior avant-garde admiring with equal fervour peasant houses on Santorin, and the chrome-work on Detroit cars; the Cutty Sark, Chiswick house, Camels cigarette packs, and Le Corbusier's chapel at Ronchamp; Pollock, Paolozzi and Volkswagens – all this sounds like the complete abandonment of standards. In fact it is nothing of that sort – it is the abandonment of stylistic prejudice, and its replacement by the concept of 'the style for the job'. This abandonment opens the way for a more viable integration of design with practicalities of machine age existence.<sup>25</sup>*

The term 'handmade' has never been unambiguous. Its recourse, 'substantially handmade' can then be defined as a condition that lies between simple hand tools and full automation.<sup>26</sup> It is also a typical practice in the arts today for someone else other than the artist to fabricate the object, for the artist's credit. Putting aside the accuracy of the term, the label handmade conjures a sense for the most traditional method of making of crafts.

In the crafts of the substantially handmade nature, there are hidden orders, personalized and unspoken, including a technique not obvious to an outsider, organization of the space a craftsperson occupies, or sequence of movements in time. These modest adaptations allow for the maker to adjust for minute differences in materials or conditions of that day. For instance, the dominance of soft wood for typical fabrication and preference for unvarnished wood in Japan, such as cedar and *hinoki* cypress, has yielded sharper bladed tools in comparison to the West and China; conifers whose grain can get fuzzy more easily than the deciduous species, steered the development of planes with two blades, or some

planes used in right and left-bladed pair.<sup>27</sup>

Beyond the technical aspect of the handmade, its domain in the contemporary society can be represented as “a relationship of power between the purchaser and the maker,” where the client expresses the financial and moral superiority by exercising the ability to buy unnecessary labor.<sup>28</sup> It can evoke a sense of superiority because the handmade objects are often tied to the maker whose labor is directly sustained by the purchaser, and are also beyond the means of the majority of consumers. On the other hand, objects of mass production that belong to the realm of popular culture were neither highly regarded in monetary value or cultural impact of the elite.

The concept of culture has never been neutral. Prevalent discussions of culture have leaned towards the elitist and unilinear perspective, or masculine and dominant. The action of acquiring a “cult object” indicates the social group of capitalistic nature that one chooses to belong to, which is contrasted to the sub-culture category that includes multilinear paths and mixtures.<sup>29</sup> Nevertheless, the relative rarity of the handmade and its ethical correctness, while debatable, can be seen as an inevitable result of the relationship between the handmade and the machine made over the course of industrialization.

Another perception is of the ability to work anonymously or in teams, putting the integrity of the collective work beyond self-expression. Generally observed in the realm of functional and industrial crafts, there is a clear contrast with the artist crafts category, in which the practice resembles the autographed work of an artist. The craftsperson works in service of the materials, and sometimes even tools. Teijiro Muramatsu observes that the fundamental difference between tools used in the hand-based craft society versus the machine-based society is expressed in the approach of who is in service of whom. In an idiosyncratic situation in Japan, the craftsperson was in the service of the tool; the plane box, far from being ergonomic, never changed its form to comply to the movements of the craftsperson, or the handle of a handsaw was a plane piece without any grip form. Being in the service of tools was directly tied to being in the service of beauty, and one would be scolded for stepping over the tools.<sup>30</sup>

Both cases concern the labor implied in the object perhaps more than the object itself,

and the economy of that activity within society. In this sense it is unlike the machine aesthetic, which will be discussed later in this section, where the mode of production is secondary to the expressive nature of the object. Craft as a product of hand-based labor generally occupies the fine line between affordability and exorbitance. “Contemporary craft is necessarily peripheral to all mainstream economic activity. If it comes too close to trade, then both the nature of the craftsman’s work and the nature of the artefact is compromised by the need to be priced competitive with trade.”<sup>31</sup> So today it has come to signify “a middle-class choice, as an expression of free will for an audience that has sufficient money – and perception – to afford useless objects of contemplation. What distinguishes craft from trade is a diminution in the amount of pain involved and a very considerable rise in the quotient of pleasure and self-fulfillment.”<sup>32</sup>

### **1.1.6 Seeking the machine aesthetic**

With faith in the power of the machine seeping into general consciousness, its effectiveness and logic began to gain greater momentum. Its beginnings were unsteady, however. The earliest machines for manufacture were made to mass produce objects modeled directly after the handmade, but with inferior quality. At the time, machine failed to satisfy anyone both in terms of labor and products.

Kaufmann observes that it was around 1850 when people began to demand standards of quality that was “suited to the new society that had taken shape, and that this called for design that would speak for the new values, not in the discredited accents of imitation tradition, but in a voice that carried conviction and promised to keep pace with life itself.”<sup>33</sup> Thus began the divergence of the handmade and machine made.

By the time of Dresser’s geometric tableware or Owen Jones’ wallpapers and his book *Grammar of Ornament* in 1856, architectural historian Hiroyuki Suzuki argues that the avoidance of the use of the machine became no longer feasible. Even Morris & Co.<sup>34</sup> had incorporated machinery in its productions, despite Morris’ strong aversion to the machine for dehumanizing its workers. Likewise, works of the Art Nouveau glass artist Emile Galle (1846-1904) were claimed handmade but were in fact made in an assembly line-like

condition with his signature added at the end. The preceding sense of truth was replaced by the truth of the machine, thus the emphasis was placed on the continuity of patterns created by the continuous mechanized production. The machine style was not the result of mechanical process; rather, it was a way to emphasize the style as a fact of mechanical production.<sup>35</sup>

These conditions subsequently prompted the rejection of the machine and the revival of handicraft on one hand, exemplified in the art, craft, and design-oriented movements, while industrialization advanced on in the larger domain. The following years of the first world war, during the twenties and thirties, marked the rise of the Machine Style<sup>36</sup> or the machine aesthetic and epitomized in the descriptions such as ‘a machine for living’ for a house, or ‘a machine for sitting’ for a chair.<sup>37</sup>

The idea of the machine aesthetic came along after a declaration for the Machine Age and the material of reinforced concrete serving as its symbol for the White Architecture in the 1930s, and which Banham called the “ill-drawn analogies between machinery and abstract art.”<sup>38</sup> The analogy of the machine was used in part to distinguish those who prescribed to the specific stylistic expression and not necessarily congruent with the mode of production or its symbolism.

While seeking the virtuous form of the all-encompassing aesthetic of the machine, it was also not possible to stop the proliferation of stylistic terms such as modern, modernistic, moderne, Manhattan Style, cubistic, jazz, streamlined, International Style, functionalist, organic, etc.<sup>39</sup> There were mixed reactions to what the machine aesthetic was considered to be, from complete rejection to praise. It could neither distance nor assimilate into any particular style, but four styles are said to have emerged from the machine aesthetics of the 1920s and 30s, successively: Moderne, the decorative expression of machine parts; machine purity, a celebration of the pristine geometries aiming toward a kind of universal order; streamlining, a minimization of parts and aerodynamic smoothness with the airplane as its representative; and lastly the biomorphic, or organic, a multi-contoured and natural forms originating from the attempt to humanize the machine in the late thirties.<sup>40</sup>

In his commentary to the 1925 *L'Exposition internationale des Arts décoratifs et industriels*



*modernes* in Paris, Le Corbusier likened handicraft to “the cult of ‘failures’” that are “Excuse for daubs. Slack hour of imprecision. Triumph of weak egoism. Delight of the free will, regard for the individual. Refusal of control,” all the while the mechanic was finding new order by his accomplishment from the stone age, the bronze age, the iron age up to the steel age.<sup>41</sup> Framing craft as the contrary and external activity of technological and societal progress is essentially the same technique of craft transitioning from the everyday to the privileged preoccupation, to preserve its status and demand.

Clearly, technological modernization that advanced on did not necessarily sterilize the living environments. Among the steel tube frame furniture, white plaster walls and long horizontal wall cabinets, coexisted oriental rugs and ceramics for Marcel Breuer or Le Corbusier’s wood, leather and tile used in large areas.<sup>42</sup> Eventually the machine aesthetic, or its attempts in purest terms, would be worn out by the forties and the assimilation of mechanized forms with more organic themes would begin to prevail. The bent wood chairs of Thonet, which will be discussed later, could be found in these contexts too, as were bent plywood chairs by Eames.

### **1.1.7 Organic and mechanical**

“The linkage between bodies and machines is even more explicit in the nineteenth century, tied not only to the repercussions of the factory assembly line, but to the history of gestures and postures of a first industrial age when the machine progressively took over the human *habitus*.”<sup>43</sup> From mechanized patent furniture seen in Sigfried Giedion’s *Mechanization Takes Command* to Eugene-Emmanuel Viollet-le-Duc’s analogies of anatomical joints to mechanical devices constructed in iron, the direction was toward what we may call the organic, where “now the kinetics of machinery are modeled on living beings because industrialization has to fully assume its role as the creator of second nature.”<sup>44</sup> The mechanized process that models after the organic system or aesthetic existed traces back to Ruskin, to whom the medieval represented the organic that manifested what he called vital beauty, whereas classicism was a type that represented the mechanical. He strived for a sense of familiarity lacking in mechanical production.

From another perspective, it was around the same time that the critical flow of analogy between technology and biology – or organic and mechanical – was reversed: “Structures and processes in living organisms were described and explained in mechanical terms” since the Renaissance, when the association was first made, yet in the mid-nineteenth century, “the development of technology was interpreted through organic analogies” for the first time.<sup>45</sup>

The infusion of technology and production on one hand seem to have made the separation between the hand and the machine clear, but exactly constitutes handmade or machine made raises even more questions. The boundary between tools and machinery is ambiguous – it is more dependent on perception of the general public than the actual actions of labor, each with specifically expected qualities. Over time, the values by which the hand-making processes and the machine-production processes are assessed shape and reflect the expectations of the collective, with the wide range from subtle to more expressive outputs of mechanization.

<b>HAND</b>	<b>MECHANICAL</b>	<b>COMPUTATIONAL</b>
<i>qualitative</i>	<i>quantitative</i>	<i>behavioral assessment</i>
<i>domestication</i>	<i>standardization</i>	<i>differentiation</i>
<i>skill, dexterity</i>	<i>automation</i>	<i>simulation</i>
<i>experience</i>	<i>efficiency</i>	<i>optimization</i>
<i>local</i>	<i>statistical</i>	<i>ubiquity</i>
<i>limited quantity</i>	<i>mass production</i>	<i>varied</i>
<i>shadow work</i>	<i>monetary reward</i>	<i>autonomy</i>

Fig. 1.1.7 The three technical ages and their perceived qualitative differences

## 1.2 Social context and the dissemination of industrialization

### 1.2.1 Social context after 1850 to the beginning of twentieth century

The period leading up to 1850, from the perspective of design and production, marks the time following the conclusion of the first Industrial Revolution which lasted approximately

from 1760 until 1840. Unlike the political disruption in France in the form of French Revolution to the rise and defeat of Napoleon, England succeeded in the capitalist system, with the weaving industry central to its success: More mills brought in more goods, wealth, machinery, infrastructure, trade, etc.<sup>46</sup> From the late 1820s railways began connecting towns, enabling the movement of raw materials and distribution of goods. Its architecture of monumental railway stations, along with similar scale programs such as exposition halls, were enabled by the large-quantity productions of wrought iron, followed by steel. By the 1860s, engineers were making calculations for the buildings' structural design, including foundations, columns, beams, floors, roof trusses, and heating and ventilation systems.<sup>47</sup>

The decade of 1850s was a time that celebrated the technology and science, where “a stodgy and complacent optimism was the [prevailing] frame of mind.”<sup>48</sup> The Great Exhibition of the Works of Industry of all Nations was held in London in 1851, housed in the iconic Crystal Palace by Joseph Paxton. For the first time, objects from machinery to decorative tableware from all over the world were exhibited: Half of the space was dedicated to showcase artifacts from France, Germany, Russia, and other European nations, along with exhibitors from Egypt, Brazil, Mexico, China, Arabia, and Persia. Attracting more than six million visitors, it was the largest event recorded to date. The end of this decade was capped by the seminal book by Charles Darwin, *Origin of Species*, on evolutionary biology through natural selection, published in November 1859.

Industrial development in the United States for the first half of the nineteenth century was similar to what took place in Europe: First the water mills and forges, followed by the automation of the textile industry, then the industrial plants built along waterways with its reliance on water power. The resemblance was not limited to technological but also social aspects, where workers' housing were set up close to production sites, forming towns and cities.<sup>49</sup> Industry, backed by engineering and scientific knowledge, began to shape the lives of people and their surroundings at vast scales.

### **1.2.2 Industrialization and the division of labor**

The birth of mid-eighteenth century industrialization in England propelled mass productions

and is generally understood to lead to a segmentation of work and operations. While division of labor and tasks, logically, has long preceded this phenomena – that even in entirely hand-based productions the larger and more precise outputs came from shops where workers specialized in one or few tasks for increased productivity – industrialization reinforced these divisions to significant and irreversible extent and manifested in their work environments such as factories.

Mathematician, engineer, philosopher, and the inventor of the concept of a computer in the 1820s with his differential machine, Charles Babbage observed in 1832 that division of labor was a natural occurrence that was not driven entirely by financial interest but mostly by observed benefits of specialization. Some of the cases included shortened training or apprenticeship period and increase in production, such as an ability to make upwards of 2300 nails per day by a specialized nailer, versus a smith who could make nails but whose trade was not limited to its production can make only 800 to 1000 per day.<sup>50</sup> Thus for Babbage it was reasonable to postulate that the improvement of a single occupation and its tool became the first step towards a machine, not vice versa. The accumulated knowledge in the forms of skill and science could then spread into other regions and be replicable. While his position was not necessarily endorsing the machine to dominate the artisans, his statements including “the economy of human time is the next advantage of machinery in manufactures,”<sup>51</sup> were interpreted as such by many. The idea of replacement or substitution of labor with machinery was highly contentious, and could be seen as undermining the value of human labor. The changing political economy and its development, combined with family values and morality, became part of the discussion from this period onward.

One of the outspoken figures was Peter Gaskell who, around 1833, took a position of mechanization as a threat that would lower the value of human labor and thus reduced the workman to “a mere watcher of, and waiter upon, automata,” in his text titled *Artisans and Machinery* with a loaded subtitle, *The moral and physical condition of the manufacturing population considered with reference to mechanical substitutes for human labour*.<sup>52</sup> The resentment also stemmed out of the uneven distribution of wealth enjoyed by the first successful manufacturers. They did not come from the privileged class, who were expected to have corresponding moral and

social character, but were previously independent farmers or workers. At the same time they were unlike the ‘master manufacturers’ who rose from the ranks of laborers. Gaskell further argued on the effects of urban work conditions on family values and envisioned that the effects of mechanical production would lower the value of human labor and destroy it, leaving machine making as the last resort in hand engagement until machines started to make machines.

The general acceptance of the nineteenth-century logic in Britain and subsequently elsewhere can be summarized as an industrial development that operates “through the mechanisms of competition, concentration and technical change,” which then “tends radically to reduce the demand for skilled labour and so to subvert the basis for craft organization, together with other sectional divisions within an increasingly homogeneous working class.”<sup>53</sup> Zeitlin challenges the assumption that widespread mechanization led to the erosion in the position of skilled workers and the effectiveness of craft regulation, noting that there are causes in specific circumstances of the industry whenever technical and organizational change result in the subversion of craft regulation. In the example of the printing industry in mid-nineteenth century Britain, increased demand imposed a threat to the hand compositor, who tried to protect their profession and professional status mainly by unionizing, but was unable to hold back the surge of partially trained cheap and casual labor.

It is further argued by Zeitlin that apprenticeship was perhaps the most crucial issue for the long-term effectiveness of craft regulation, and the most discussed theme at union delegate meetings and such. By 1850, the ratio of apprentices to journeymen, or skilled craftworkers, in the United Kingdom had reached 6000 to 8500, and in London where the situation was better the figures were at 1500 to 3000, respectively. “The decline of indentured apprenticeships, and still more their diminished technical content, meant that apprenticeship was becoming more a source of cheap labour than a means of imparting technical training. The multiplication of badly-trained apprentices threatened not only the long-term state of the labour-market, but also the immediate bargaining position of the journeymen.”<sup>54</sup>

### 1.2.3 Roots and trajectories

From the mid-nineteenth to twentieth century, from the perspective of the modes of production, marks the period following Industrial Revolution and preceding the surge of Digital Revolution while carrying over both ideologies as they shifted, overlapped and revived. Mario Carpo writes, “the age of mass-produced, standardized, mechanical, and identical copies should be seen as an interlude, and a relatively brief one – sandwiched between the age of hand-making, which preceded it, and the digital age that is now replacing it.”<sup>55</sup>

While dominated by the proliferation of industrial processes, the latter half of nineteenth century also marked by the anti-mechanical sentiments, namely the Arts and Crafts movement that originated in late nineteenth century England. It was later transplanted to the United States, where *Craftsman Magazine*<sup>56</sup> first published in October 1901 chronicled the ideologies of Morris, followed by John Ruskin and Medieval Guilds in the subsequent months.

In 1934, Lewis Mumford stated that industrialization, rather than arising abruptly in the eighteenth century, occurred over a much more extended period of time than commonly recognized. He describes how “the machine” swept over civilization in three successive waves: The first, beginning around the tenth century, marked the “early triumph of the machine [...] to achieve order and power by purely external means,”<sup>57</sup> while neglecting moral and social issues surrounding them. The Middle Ages represents the second wave, where – in universalizing the ideological premises of the machine – the moral, social, and political issues came back in urgency to integrate purposes in society, together with the efficiency of the machine. In the final third wave, both technics and civilization “manifest themselves in every department of activity, and which tend toward a new synthesis in thought and a fresh synergy in action.”<sup>58</sup> Success is no longer measured by the mechanization of life, Mumford states, but in terms of its approach to the organic and the living – a direction opposite to those of the past waves. The contemporary situation could be considered a continuation of the third wave, where the synergy is evaluated from the moral,

economical and cultural values of its time.

While a series of revolutionary gestures around 1910 connected with the Cubist and Futurist movements were the main point of departure for the development of Modern architecture, there were also a number of causes that helped to guide the mainstream developments that flowed in the twenties. These predisposing causes were all of nineteenth-century origin, and may be loosely grouped under three heads according to Rayner Banham: Firstly, the sense of an architect's responsibility to the society in which one finds oneself – an idea of largely English extraction, from Pugin, Ruskin, and Morris, which was summed up in the Deutscher Werkbund founded in 1907; secondly, the Rationalist, or structural approach to architecture, again of English extraction from Willis but elaborated in France by Viollet-le-Duc and codified in Auguste Choisy's magisterial *Histoire* at the very end of the century, though the parallel tradition in Germany has no major exponent after Gottfried Semper; and, thirdly, the tradition of academic instruction that was worldwide in distribution, but owing most of its energy and authority to the *École des Beaux-Arts* in Paris. From there emerged Julien Guadet's compendious summary of his course of professorial lectures, just after the turn of the century, though again no equivalent work appeared in Germany at that time.<sup>59</sup> These distinct currents would lead to a golden age of machine.

To address the question of what defines modernity, Edgar Kaufmann, then director of Industrial Design department at the MoMA, presented twelve precepts of modern design based on a hundred years of development:

1. *Modern design should fulfill the practical needs of modern life;*
2. *Express the spirit of our times;*
3. *Benefit by contemporary advances in the fine arts and pure sciences;*
4. *Take advantage of new materials and techniques and develop familiar ones;*
5. *Develop the forms, textures and colors that spring from the direct fulfillment of requirements in appropriate materials and techniques;*
6. *Express the purpose of an object, never making it seem to be what it is not;*
7. *Express the qualities and beauties of the materials used, never making the materials seem to be what they*

*are not;*

*8. Express the methods used to make an object, not disguising mass production as handicraft or simulating a technique not used;*

*9. Blend the expression of utility, materials and process into a visually satisfactory whole;*

*10. Be simple, its structure, evident in its appearance, avoiding extraneous enrichment;*

*11. Master the machine for the service of man;*

*12. Serve as wide a public as possible, considering modest needs and limited costs no less challenging than the requirements of pomp and luxury.*<sup>60</sup>

Handicraft is mentioned only in passing and given a value as a means of experimentation and of making preliminary models for the machine, although he does not discount its value of rarity and qualities that machine products were not able to sustain. Kaufmann's main emphasis relative to production, however, is a more democratic one of availability and affordability for the consumer, which modern craft often failed to address. These criteria for modernity, in large part, have spread internationally and served as a set of standards for design to this day.

The reorganization of resources, particularly in terms of materials and labor, in the nineteenth to twentieth century has had profound effects on society as a whole. Both craft and industry were in the process of reconfiguration for its roles, scales and implications; alone, neither could satisfy everyone.

#### **1.2.4 Skill and labor**

Changes in social and economic conditions, facilitated by technological developments, were closely tied to systematized labor and its associated educational and training aspects. It may seem as a given that almost any industrial production process would follow the process of planning and concept to design, development, then finally to manufacture and production. Up until the eighteenth century, however, these phases were neither clearly distinguished nor occurring in this order necessarily, and the labor within the system was equally difficult to classify. While the mode of mass production began to dominate, the sector of small scale



production also survived in areas that mass production could not address.

Such case of ‘industrial dualism’ took place across cultures. The case of silk-reeling industry in 1910 in Suwa district, Japan, is one of the many examples that small scale craft operations and industrial manufacture actually coexisted, both in competition with each other and other times smaller firms supplementing the mass production sector.<sup>61</sup> Another is a case of Charles Rohlf (1853-1936) who was an American industrial pattern maker who preferred to be known for his “artistic furniture.”<sup>62</sup> Patternmaking, the shaping of wood into forms which were then used to make sand moulds for metal casing, was a traditional skill applied to industry with traces of the hand and the wood erased altogether. The disparities of Rohlf’s authorship of his artistic practice versus the anonymity and dependence of factory production is more socially constructed perception than in actuality where his patternmaking is equally artisanal and not far from his furniture making.<sup>63</sup>

That craft or handwork yielded little income and therefore became leisure activity or hobby is only part of the story. It is generally understood that the American Arts and Crafts, also known as Craftsman or Mission Style, which developed after the British model “became associated with the individual working at home and with the societies formed as exhibitions and sales organizations rather than with manufacturers.”<sup>64</sup> The utopian ideal of the self-supporting communities of artists and craftsmen seemed entirely unfeasible by the early 1920s industrialized society, largely because the distancing from that society, along with the necessary customers of the output, could not be financially viable in most cases.

Historians have pointed out that the relationship between craft and industry is not simply dichotomous, as is the idea that industrialization replaced hand-based work with automated machines. The predominant story of the transition “from a world of decentralized handicraft production to a world of concentrated factories in which specialized machines turn out standard products,” is a typical misunderstanding of the history of mechanization, according to Sabel and Zeitlin.<sup>65</sup> They argue that there are two forms of mechanization: The standard kind and the other, which had more flexible machinery to manufacture much more diversified range of products. It is not a contemporary phenomenon but one that the economic actors in the past have also attempted to increase

efficiency without sacrificing, and in some cases even increasing, flexibility. Evidences throughout the history of industrial capitalism show that they have weighed the choices between mass production and flexible specialization, which seems sensible given that taking extreme positions is often a risky bet.<sup>66</sup>

The main argument of the nineteenth-century Britain in terms of the logic of industrial development can be summarized as “operating through the mechanisms of competition, concentration and technical change” reducing the demand for skilled labor and “so to subvert the basis for craft organization, together with other sectional divisions within an increasingly homogeneous working class.”<sup>67</sup> And yet the development of the division of labor has also had contradictory consequences, with the major technical innovations not aiding in the deskilling of the labor force but in fact conditioning worker organization, market structures and managerial strategies.<sup>68</sup> For example, the position of hand compositor belonged in the labor aristocracy, in which skilled workers and engineers were essential in making prints up to the mid-nineteenth century. Their work required both technical skill and intelligence to decipher and correct the handwritten copy, which for a long time was irreplaceable by technology.

The degradation of the working class, however, in the capitalistic development cannot be undermined, even though there were exceptions to this rule. In many instances, skill was removed systematically – through incorporation of science and technology and by managerial organization of the workers – and to the effect of more competitive capitalist mode of production. In what John Roberts calls for the awareness of *productive labor* vs. *artistic labor*, the hand becomes operative, rather than constructive, in the former type of labor that is subject to new intellect and technical base. In the latter, the ‘craft-less decadence of contemporary art’ is subject to general social technique, which does not devalue the autonomy of hand but limits the understanding of craft.<sup>69</sup> What it implies is that the engagement with craft processes was no longer necessary nor most effective in manufacturing as industrialization advanced through its engagement with technologies. In contrast, craft processes were associated with liberated form of labor while being marginalized simultaneously.

### **1.2.5 Training and education**

The changing demands in the workforce was reflected in the educational system, from the apprenticeship model to craft, art, and technical school model. The first of its kind was the École Polytechnique in Paris, founded in 1794 to train technocrats in science and engineering. It was also where graphic documentations of architecture took place under guidance of Jean-Nicolas-Louis Durand. Polytechnique was followed by the Mechanics Institutes several decades later in 1821, in Edinburgh, Scotland in 1821, which established branches in several large UK cities by 1835. Previously the educational system in England largely ignored the industrial aspects, but the school of the Institutes, instead of Greek and Latin, taught “geometry, mechanical drawing and drawing of ornament, the human figure and landscape” although they were not highly regarded.<sup>70</sup> In 1829, École Centrale des Arts et Manufactures was founded in Paris, and subsequently many other institutions were created around Europe.

In London, Henry Cole led the Government School of Design, established initially in 1837 and under Cole’s lead from 1852 for twenty-one years, seeking for alliances between art and industry. It was later rejected by Ruskin as misguided and materialist, including those who followed this development; values potentially at stake as seen by Ruskin included training and education, autonomy and anonymity, fulfillment and exploitation, and the individual and the collective. While they were never entirely contradictory, these values were weighed against each other by supporters and opponents. The induced anxiety relative to the reorganization of labor became a crucial platform for many of the modern craft movements.

## **1.3 Aims and ideologies of the movements in craft, art, and design:**

### **From mid-nineteenth to the twentieth century**

#### **1.3.1 Principles of the Arts and Crafts movement, 1860-1910**

Following the Industrial Revolution that first began in Britain in the mid-eighteenth century,

the modern society and what may be called ‘modern craft’ began to take shape. The rapidly changing conditions of economy and labor in the nineteenth century as mentioned in the preceding section prompted a range of responses and consequences to the conditions of learning and practicing crafts. Additionally the kinds of products and aesthetics produced through such practices, and how they were received and influenced by the public at large were in a state of flux. These conditions would drive the reevaluation of the triadic relationships of the maker, the object, and the user.

Design and the production of crafts for William Morris (1834-96), the founder of the Arts and Crafts movement beginning around 1880 was a process to socially reform the modern society, namely through improvements in the work environment to address the economy and labor related to the work of design and production. His beliefs largely stemmed from the ideas of Marx and John Ruskin (1819-1900) that industrialization had brought “the total destruction of purpose, sense and life,” triggering the destruction of human values that have led to “poverty, overcrowded slums, grim factories, a dying countryside and the apotheosis of the cheap and shoddy.”<sup>71</sup>

Ruskin’s book *Nature of Gothic* defined inherent or formal characteristics and the higher orders of human virtue, and emphasized the role of the workers by noting that the internal elements of the Gothic are “certain mental tendencies of the builders, legibly expressed in it.”<sup>72</sup> The character of the builder, or the freedom to express the personality of the individual workman, was notable. More importantly, however, Ruskin aimed to unify the personality with higher moral virtues, which would culminate in symbolical ornament. The execution of stonework was another key element of the Gothic, where the potential of masonry structure was explored to its limits.

Equally central as the aesthetics of the Gothic were the medieval working conditions, seen in contrast to that of industrial workers in nineteenth century England, that resonated with Ruskin; he saw the labor then to be democratic and pleasurable. Thus Morris “viewed art as a fundamental expression of human activity where material and form provided a more direct relation to what it meant to be human than did the abstraction of ornamental treatment,” and that, “material and form were tools of human labour and gained their value

through that labour and not through their own inherent qualities.”<sup>73</sup>

*Arts and Crafts Essays* published in 1893 opens with Walter Crane’s essay “On the Revival of Design and Handicraft: With Notes on the Work of the Arts and Crafts Exhibition Society.” His main theses can be summarized as follows: 1. The movement for a revival of arts, design and handicrafts led by William Morris has been going on for some time; 2. The true root and basis of all art lies in the handicrafts; 3. Every material has its own proper capacity and appropriate range of expression; 4. Plain materials and surfaces are preferable to inorganic and inappropriate ornament, but any article, even the simplest, is capable of receiving art; 5. The impersonal artist or craftsman, under the designation of a company, who produce things of beauty for an impersonal and unknown public, have led to the decline of art of design; 6. The movement represents a revolt against the hard mechanical conventional life and its insensibility to beauty, which is different from ornament; 7. The brotherhood of designer and craftsman, or the unity and interdependence of the arts, is essential.<sup>74</sup> These principles manifests the movement’s desire to affect taste governing all aspects of life, along with the underlying battle of the mechanical versus the organic. The latter, for the members, represented the harmonious and honest relationship between the object and the people, and the moral high ground.

### **1.3.2 Medieval ideals and guilds in the Arts and Crafts movement**

One of the ardent supporters of John Ruskin and William Morris was Charles Robert Ashbee (1863-1942), sharing the ideals of improving the conditions of the working class. Ashbee’s pursuit took form in the Guild and School of Handicraft, established formally in June of 1888, adapting the idea of the medieval guild and all that preceded them, and closer in time and place, by John Ruskin. Ruskin, in the 1850s, had advocated for the re-establishment of the guild system as a way to control unemployment and to maintain standards of craftsmanship. His utopian foray into establishing the guild in the form of The Guild of St George in the early 1870s was concerned more with applying his ideal of the just society more than extension of craft techniques. These ideas were taken on later by Macmurdo and Lethaby in addition to Ashbee.<sup>75</sup> Arthur Heygate Mackmurdo founded the

Century Guild in 1882, and William Richard Lethaby founded the Central School in 1896. Lethaby had been one of the initiators of the preceding Art-Workers' Guild in 1884, which was established to preserve the associations between art, architecture, and craftsmen, opposing their distinctions made by academies and placing craftsmanship as its central theme with an experimental inclination.<sup>76</sup>

Ashbee's The Guild and School of Handicraft was formally inaugurated in June 1888, and was unique because "it was based not just [...] on the medieval guilds of England and craft guilds of the Italian Renaissance, but also on its founder's dearest dreams and chief obsessions."<sup>77</sup> The Guild workshops and the School were run interdependently; the craftsmen of the Guild would teach in the school, while the pupils from the school graduated to the workshops as their skills matured. Great emphasis was put on the importance of developing the individuality, or the inherent creative talents, of each workmen. By the time Ashbee was 26 years old, he believed that "the craftsmen should set his own individual standard and the workshops should set a standard in society."<sup>78</sup> Acquiring the printing presses and majority of craftsmen from Morris' Kelmscott Press upon Morris' death in 1899, the Guild of Handicraft which had been founded as a private industrial partnership was reconstituted to become a limited company. "The perfectionist attitude to craftsmanship, the civilized environment, the leisure for discussion, the humanity of outlook"<sup>79</sup> contributed to its success and yet eventually its decline, with general decline in trade and increasing competition in the market. In addition, moving of the company away from East London to Chipping Campden proved costly with materials and products constantly transported between these cities, thus his practice failed to adapt to local rural situation.

Ashbee was particularly concerned with the standards of workmanship, perhaps more than that of design. He believed that machine tools such as circular saws, band saws, planing machines and lathes were acceptable aids as long as they were not used "on the score of cheapness, neatness or trade finish," as described in *Craftsmanship in Competitive Industry*.<sup>80</sup> The book, which was published in 1908 – the same year the Guild and School of Handicraft went into liquidation – also demonstrates that Ashbee had come to believe that machinery should be regulated by an external authority, that "the maintenance of Standard in modern

industry is not permanently possible within the workshops themselves.”<sup>81</sup> The shift from his idealism some twenty years earlier when the Guild was established, that such standards would develop from the workshop example, was a result of the Guild’s economic problems due to competitions from mechanical productions, and that such mode of production in the contemporary society was irreversible.<sup>82</sup>

### **1.3.3 Setbacks and dispersion of the movement**

One of the main issues with the praise of medieval model was that it did not resonate with the state of society more than three centuries later, especially in the glorified ‘harmoniousness’ of the people to object relationship highlighted by the movement. The meanings embedded in its objects and ornaments were lost and assimilated into the Victorian middle class, which Morris resented but also shared a likeness in terms of taste.<sup>83</sup> The Gothic Revival, from the end of eighteenth until nineteenth century, and other revivals in some ways also undermined the situation by further removing style and meaning from historic significance, as designs turned to nature – as something morally correct, and able to substitute preceding religious morality – to establish their new repertoire.

On the accounts of output quantity, economy, production systems, shared notion of meaning of design, the Arts and Crafts movement was defeated. The end of nineteenth century marked the end of the demise of the glorified medieval.<sup>84</sup>

### **1.3.4 The German Werkbund**

Much influenced by the Arts and Crafts movement from his days in the UK, Hermann Muthesius, one of the central members of the Deutscher Werkbund, set standardization as a principal objective for the Werkbund in 1914. It was founded in 1907 out of the applied arts movement *Kunstgewerbebewegung* from the turn of the century. Muthesius claimed that through standardization, a recovery of universal significance as characteristic of harmonious culture and “unfailing good taste” would be achieved towards creating preconditions for the export of its industrial arts.<sup>85</sup> His position was that modern industry and applied arts movement are comparable in spirit, that they both share “severe trend toward the subordination under

leading principles, the strict ordering of every individual element, the suppression of the inessential in favour of the essential.”<sup>86</sup> Muthesius’ exposure to the Arts and Crafts movement in England had taught him the futility of opposing industry, in addition to his perspective of holding a key post in the Prussian Ministry of Commerce and Trade.

Within the group were other opinions concerning its priority, although not entirely contradictory nor opposing. Henry van de Velde was one such figure, a victim of owning no copyright to his frequently copied Art Nouveau style designs under the German law that did not extend to applied arts at the time. In attempts to both protect and elevate the rights of industrial designers, the Werkbund advocated for non-anonymity of the designers by only allowing objects with individual signatures, not of the firms, in their exhibitions.

It is often misunderstood that the Deutscher Werkbund has its origins in the Arts and Crafts movement. The Werkbund promoted for intellectual and spiritual motivations rather than profit-oriented companies that Muthesius criticized in his lectures on applied arts, which is comparable to the ideals of labor advocated by Ruskin and Morris. However the Werkbund was much more successful in its integration to the modern society and its needs.

## **1.4 Aims and ideologies in Japan**

### **1.4.1 Introduction of the concept of art and design into Japan**

The idea of industrialization was introduced through the governmental policy of modernization of Japan in the Meiji period (1868-1912). The policy was intended in large part to reinforce the national military power, but also for the imperial family and the new central government to divorce themselves from the traditions of the feudal structure of *Bakuhatsu-taisei*. While a system of wholesalers dealing with very small scale productions preceded, usually at the scale of households, it was not until the early nineteenth century that the collective production systems with skilled artisans began to arise. Additionally the lack of distribution networks and market limitations under *sakoku*’s seclusion policy prevented such business models to flourish. As the nation took lead towards modernization, which was interchangeable with westernization almost unfailingly, technology and machinery were



actively imported and the industry was set forth.

A few centuries prior to the modernization, professions related to the term *shokunin*, or craftspeople, spanned from those involved in the making such as blacksmiths, paperer and plasterers, to other professions including doctors, *ama* female divers who collect seafood, boatmen, Shinto maiden, and even gamblers, as depicted in the *Tohokuin Shokunin Utaawase* scroll of poetry and paintings from the early thirteenth century Kamakura period.<sup>87</sup> Basically anyone who was employed could be considered a *shokunin* up to the early modern Edo period, when the accepted use of the term was understood to specifically point to those involved in the making of products for public consumption through mostly handwork. The context in which the transition of the definition of craftspeople occurred also saw the introduction of the idea of art, design, and industry to the country.

#### 1.4.2 Terminology and concept of art and craft

The Japanese term *bijutsu* for art, typically indicating fine arts, did not exist prior to or during the Edo period (1603-1868). It is thought to have been invented several years into the Meiji period for the occasion of participating in the 1873 Wien Weltausstellung World Exposition held in Austria, which was the first world exposition for Japan to take part in. It was suggested as a translation for *shone kunst*, or fine arts. While the dichotomy between artist versus artisan is said to have emerged in the west sometime in the sixteenth century late Renaissance, the divide between the two have reached its height in mid nineteenth century, with the art for art's sake or *l'art pour l'art*.<sup>88</sup>

Concurrently the term *kogei* took off, also led by the government. *Kogei* most closely translates as craft or industrial arts, with implications of design and manufacture. It was chosen from an obsolete Japanese word as something equivalent to the western notion of applied arts. Today it is generally used to address both functional and ornamental objects, predominantly for works produced through *teshigoto*, or the work using the hands.<sup>89</sup>

Prior to *bijutsu* and *kogei*, the term *gigei* – a combination for the characters for technique and art – was used during Edo period which encompassed any skill-related productions and performances. Until early Meiji period in the 1870s, there had been no particular separation

between arts and crafts, since there was quite a number of indistinguishable characteristics. Both arts and crafts were seen as expressions through paintings on screens, Buddha sculptures, vases, incense burner, and woodcuts<sup>90</sup> – all of which required high technical skills and assessment of the aesthetic qualities at the same time.

Yet the confusion over terminology in this early phase led the German *Kunstgewerbe* (industrial arts) and *BildendeKunst* (formative arts) from the original text for the Vienna exposition to be both simply translated as *bijutsu* with a footnote, which stated that in the west *bijutsu* refers to music, painting, sculpture, and poetry.<sup>91</sup> On the side of craft terminology, there was also a confusion since craft, *kogei*, and industry, *kogyo*, were used interchangeably for any produces made using the hands – the previously mentioned *teshigoto*, or handiwork, until the late 1880s to 1890s. Large scale manufactures with machine tools were not yet established, and a major export sector depended on the handmade traditional craft objects, in addition to raw materials including silk, tea, and copper.

In Vienna, the exhibited Japanese products including ceramics, lacquerware, and copperware were received favorably. It initiated the promotion of systematized and increased productions of such crafts for trade purposes for Japan, and increase in demand due to the popularity of Japonism trend for Europe in the nineteenth century. Following the success at the Vienna exposition, the Japanese government began to host its own domestic and international industrial expositions starting in 1877 in Ueno, Tokyo, and expanded the products showcased to furniture, tapestry, machinery and agricultural products.

It was also around this time when the term *design* was first introduced to Japan.<sup>92</sup> The 1876 Centennial International Exhibition in Philadelphia, Pennsylvania, was the first occasion for Japan where crafts were produced after having being ‘designed’: Approximately ten artists were contacted to draft the designs, or *zuan*, which were then distributed to renowned craftsmen, who produced the designs according to their accustomed materials and techniques. However in this early phase of the concept of design, it typically remained at the ornamental level prescribed as flattened surface patterns, rather than taking functionality of the object into account.

It is also worth noting that the term *kenchiku*, architecture, only came to use in 1904.

*Fushin* and *sakuji* were early terms, both of which indicated building of a house. In Meiji, the term *zouka* came into use, again signalling the making and a house, but the professor Chuta Ito found it necessary to update the term to reflect a modern understanding of the discipline.<sup>93</sup> It would not be until around the 1920s to 30s when ‘design’ in terms of form would be recognized widely, and the distinctions between art, craft, and industry would become evident through its own social and economic changes.

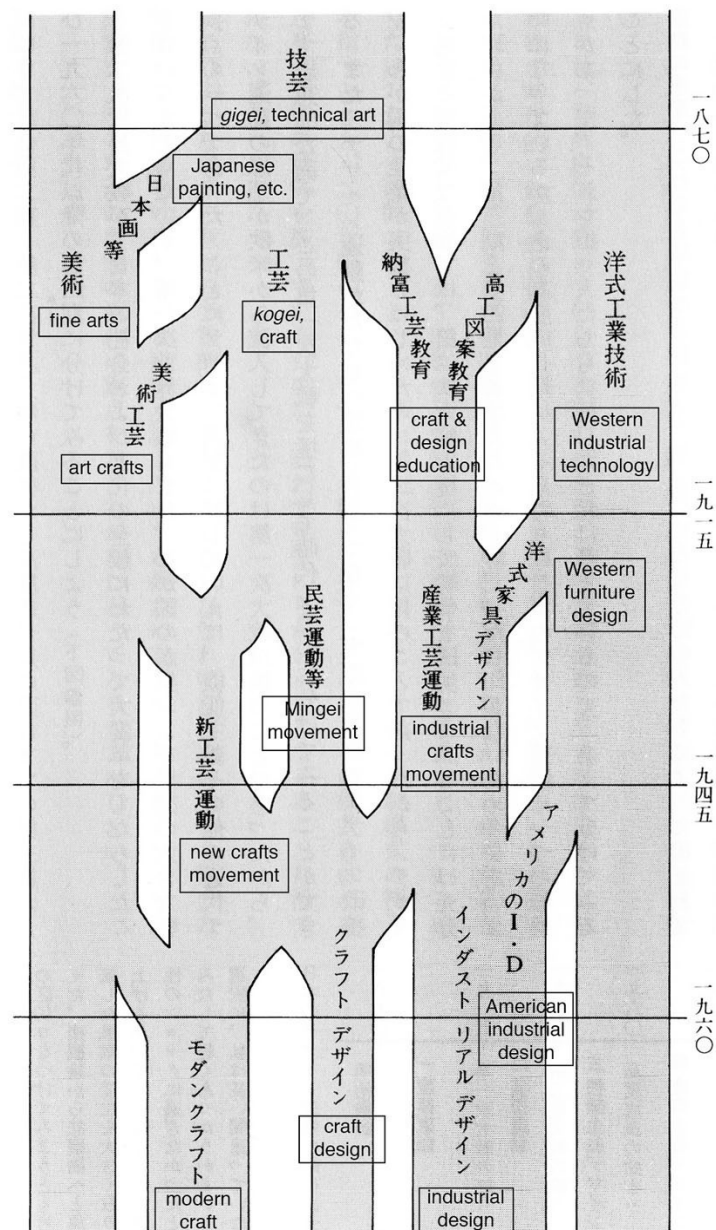


Fig. 1.4.2 Genealogy of modern design related movements in Japan (with captions in English by author)<sup>94</sup>

### 1.4.3 Efforts toward modernization

The social and cultural background to craft and art-related movements were spurred by the strong current towards modernization in Japan. While its effects were felt earlier, the efforts for modernization began around 1910 and continued further throughout the twenties and thirties. Mechanization, westernization, and industrial rationalization were common terms used interchangeably to describe the process of the government-led modernization, and these adaptations were referred to as improvement and reform. The significance of this process towards industrialization in Japan was that it was motivated initially by international trade, much more than for the sake of the nation's own artistic pursuit. In addition to the attempts in the private sector such as popularizing the 'Americanized' housing and housekeeping, one example in the public sector was the *Seikatsu Kaizen Domeikai*, the Alliance for Lifestyle Improvement, established in 1920 by the Ministry of Education, Science and Culture. Its mission was to promote improvement through westernization of all aspects of daily life, including clothing, housing, food, and social interactions.<sup>95</sup>

Specific proposals for the shift to westernization can be seen through *Jutaku kagu no kaizen*, or The Reform of Domestic Furniture. In its 1924 report by the Research Committee for Improved Housing, summarized its six main themes as follows: 1. Homes should incorporate chairs, rather than sitting on the floor; 2. Domestic floor plans and facilities should be based on the family, rather than around visitors as is currently the case; 3. Domestic structural facilities should shun decoration and place weight on hygiene and the prevention of accidents; 4. Gardens should not be for mere entertainment, as is currently the case, but should emphasize on its practical use in preventing accidents; 5. Furniture should be simple but strong in keeping with the reform of the house; 6. Public housing (apartment houses) and garden city facilities should be constructed in accordance with the circumstances of the megalopolis.<sup>96</sup>

An extensive cultural and social change as this one called for its citizens to adapt swiftly to the new sets of needs. Along with it came the unfamiliar forms in which craft techniques were applied to new industrial methods and systems, and profound effect on

social and economic systems. In some ways comparable to how the Arts and Crafts movement emerged out of their reaction to the widespread dominance of industrialized manufacture, some movements arose in Japan due to this transfer to westernization to reevaluate the traditional crafts and their lifestyle.

#### **1.4.4 Establishing own sense of craft: the Mingei movement, 1926 -**

William Morris' relatively affluent upbringing and his background in religious studies, philosophy, and literature echoes with circumstances of Soetsu Yanagi (1889-1961), one of the principal leaders of the Mingei movement in Japan from 1926. Yanagi subscribed to the fundamental principles of Ruskin, Morris, and the Arts and Crafts movement through his keen interest in Christianity, belief in the superiority of the Gothic with special weight on its moral superiority, idealization of the medieval craft practices, and devotion to the writings and art by William Blake. The common concern for the decline in the 'taste for beauty' was mainly attributed to industrialization, although Naylor argues that they had no clear understanding of the nature of their adversary – the industry.

One of the fundamental contrasts with the Arts and Crafts movement is that Mingei movement did not take any part in promoting new ventures, entrepreneurship, nor innovations in the craft-making. There was essentially one experiment, *Kamigamo Mingei Kyodan*, which was heavily influenced by the guild model and where young craftsmen lived and worked in a large residence set up in 1927 in Kamigamo area of Kyoto. Eventually financial troubles due of low sales of the produced crafts, as only one of the members Tatsuaki Kuroda was able to sell work, and personal grudges within the group led to its eventual demise in 1929. Most of the sales of subsequent craft products took place through *Takumi Kogei-ten* in Ginza and Japan Folk Crafts Museum, but they were in essence far from the production of the arts and crafts products. The infiltration of Mingei movement in certain regions, mostly rural, raised their profile, but also complicated the possibility of starting new craft practice in the same areas.<sup>97</sup>

#### **1.4.5 Defining the aesthetic**

The Mingei movement, which began in collaboration with Yanagi, ceramicists Kawai Kanjiro, Shoji Hamada, and several other prominent craftspeople, was much more concerned about discovering and preserving the existing regional folk crafts that were deemed valuable through their aesthetic lens. The sensibility for the aesthetic, Yanagi described, was rooted in the early Japanese tea crafts that embodied what he called the ‘internal truth’.

Similarly to the Arts and Crafts movement that looked back on the Gothic for their ideological model, Mingei movement drew direct inspirations from the Japanese tea ceremony culture of *cha-no-yu*, or way of tea: It is a prerequisite for tea practitioner to be able to evaluate and select the craft objects and consequently to cultivate the sense of beauty, since the viewing and appreciation of the craft objects plays a prominent role throughout the ceremony. This is true of early tea masters from the founder of *cha-no-yu*, Juko Murata (1423-1502) in Muromachi period, Soami (-1525), Jo-o Takeno (1502-1555), Sen no Rikyu (1522-1591) who is said to have refined and completed the form of *wabi-cha*, to Oribe Furuta and Enshu Kobori from Edo period.<sup>98</sup> Their humble aesthetic sensibilities, which valued imperfection, simplicity, and modesty, preceded the formalization and increasingly ornate branch of the tea practice which would thrive later. *The Book of Tea* by Okakura Tenshin, published in New York in 1906, was a seminal book in introducing the ideas of tea and associated aesthetics to the English speaking world.

The concept of *Yo-no-Bi*, the beauty of the function, is one of the dominant and enduring concepts from the Mingei movement. In the words of Yanagi, beauty is a utility coming into appearance. Fundamentally, however, Mingei did not take any part in prescribing any methodology for the design process. Its basis was farther removed from the ideas of functionalism in the modern sense, as the focus was primarily on the found beauty within the existing folk crafts in the purest forms.

Applying the Buddhist metaphor for salvation through benevolence, dependence on others and losing of self, it was suggested that the way of crafts might be such in the worship of beauty.<sup>99</sup> Yanagi believed that tradition, regionalism, and the involvement of the hand in the production to be the elements that could restore the state of crafts, by bringing the crafts

closer to the arts and reconnecting them. While not necessarily opposing the use of machine to supplement production processes, he disagreed with the aesthetics cultivated by dominant machine productions of his time with the belief that it deprives workers of their happiness. His proclamation that folk-crafts are the purest form, however, undermined artistic interventions in crafts and led to some of the members to leave the movement, since in practice most of them were well-established craftsmen in their own right, specializing in ceramics, woodworking, printmaking, dyeing, textiles, etc.

The state of industry in Japan and its perception of technology and beauty was in a very different condition compared to the West. For example, without the consequences of a mature industrialization, initial importation of technology and techniques for machine production into Japan was adapted without opposition. The move to link modern technology with the existing highly skilled handicrafts was generally received without objections. The simultaneous development of the idea of design and the imported technologies was antithetical to the European model of applying the arts to ‘beautify’ the industrial products of poorer quality or of their socially inclined craft movements.<sup>100</sup> Eventually, however, Japan would follow a similar course by the 1930s.

#### **1.4.6 Yanagi and Mingei**

Yanagi coined the term *mingei*, which is short for *minshuku-teki-kogei*, or craft for the people. It primarily referred to folk crafts. Perhaps one of the most important distinctions from the Arts and Crafts is that Morris was himself a designer, whereas Yanagi remained a philosopher and observer. Yanagi wrote that while beauty is definitive, there are two ways of achieving it: Either via fine arts or crafts.<sup>101</sup> He accused the popularity of individualistic expression of beauty that is common in the fine arts as being the cause for the crafts to become subordinate; similarly, the failure of the Arts and Crafts movement stemmed from its inclination towards the artistic – or the ‘art-ification’ of crafts – and the lack of understanding that craft itself could express beauty beyond such operation. Thus he strongly felt a disparity between Morris’ ideologies versus the works Morris’ company produced. His endeavors in folk crafts, therefore, purposefully left out industrial crafts and art crafts

produced by individual artists. These unaddressed forms of crafts would be taken up later by other movements, chiefly the *Jitsuzai Kogei Bijutsukai*, or Existing Crafts Art Society, and *Keiji Kobo*, also known as the Ideal Form Atelier.

#### **1.4.7 Social inclination and dissociation**

Yanagi also idealized the medieval guild system, believing that it was the latest form of socialism with an ordered society, what has been lost in the society of his day. He sympathized with the principles of Guild Socialism on the issue of economy, although criticized economist and theorist G. D. H. Cole for failing to point out the contradictions between the kind of free will upheld by the guilds versus the rigid and unforgiving nature of industrial systems based on machinery, and for not addressing the relationships between aesthetics and the machine.<sup>102</sup> The two possible perspectives of craft described – the first, approving the current social state and its future production of craft based on it; and the second, pioneering the future of craft through reform of the current system – are essentially the representative of the capitalistic versus socialistic approaches to craft production. Yanagi clearly supported the latter, following the footsteps of Ruskin and Morris, and proclaimed it as a requirement to guarantee the beauty of craft.

Capitalism was understood as a source of restriction without order, individualism as freedom without order, and the guild, or *kyodan*, as freedom with order, where craft became equivalent to communal art. Yanagi claimed that his rather neutral stance on the issues of economy is not meant to be an opposition to economic science; he had an optimistic outlook that socialism is inevitable and that a thorough argument for the aesthetic would align with the assertions of the ‘correct’ economy.<sup>103</sup> Yanagi seems to have consciously distanced himself from the economic and social issues related to craft-making and instead chose to examine problems of craft through aesthetics, based on the belief that such considerations were underdeveloped by those in earlier craft-related movements.

He argued that even Morris’ works were not satisfactory because of the lack of appreciation for anonymous crafts, that the works only cultivated a way for artist-crafts. For example, Yanagi regarded the publications from the Kelmscott Press established in 1890 as



the best work of Morris for its absence of individual taste and representation of faithful medieval traditions through its fonts, decorations, paper and leather selections. He criticized the illustrations in the publications, however, as falling for artistic romanticism represented by a fellow Pre-Raphaelite painter and poet, Dante Gabriel Rossetti – that such sentimentalism has no place in craft.<sup>104</sup>

In the instance of furniture design, Morris favored both categories of the simple “necessary workaday furniture” as well as the ornamental and elaborate “state-furniture”<sup>105</sup> and expressed an opinion that the “Japanese have no architectural, and therefore no decorative, instinct,” with their achievements were “mere wonderful toys, things quite outside the pale of the evolution of art.”<sup>106</sup> This fundamental difference is evident in the Arts and Crafts principle that “a work of utility might also be a work of art, if we cared to make it so,”<sup>107</sup> whereas Mingei and The Existing Crafts Art Society both strongly believed that utility was essential in producing their aesthetic.

#### 1.4.8 In praise of lesser arts and *getemono*

Yanagi categorized the types of craft as follows, elaborated in several of his publications.

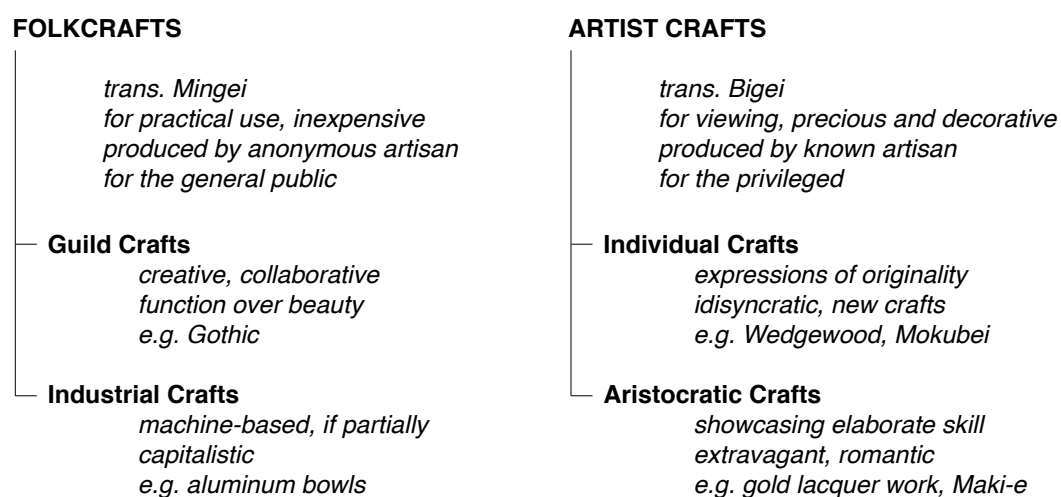


Fig. 1.4.8 Basic categorizations of crafts by Soetsu Yanagi<sup>108</sup>

Morris advocated for the lesser arts, or the so-called decorative arts. Yanagi similarly

advocated for *getemono*, a term that was used by merchants for inexpensive, abundant, common products for everyday use in contrast to the high-end *gyotemono* whose purpose is mainly for visual appreciation, reflecting corresponding perspective on what the movements promoted. Existing Crafts Art Society also addressed a similar category of products, calling them ‘small crafts’ and listing familiar objects such as tools and products in the kitchen, factories, and offices, from toys and bookbinding,<sup>109</sup> in an attempt to overcome the inferiority associated with crafts relative to fine arts.

All of these craft-related movements attempted, in theory or in practice, to define the quality of the everyday life of the general public. In Morris’ description, it was to replace luxury and vulgarity with qualities of simplicity, common sense, and honesty. He argued that the context in which preceded and promoted “the insensibility of the artist towards the beauty of pure shape, pure material, pure decorative pattern, is monstrous.”<sup>110</sup>

The concept of *getemono* originally arose from the early Japanese tea masters mentioned earlier. Their deliberate choice to unearth beauty in the common tea bowl and container was unique in that they noted certain beauty in flaws, cracks, and distortions – a concept previously unexplored in the realm of the aesthetic. As a movement, Mingei’s main characteristics were focused on utility over visual appreciation, anonymity as opposed to artist-craftsmen, efficiency of production through division of labor, requirement of skilled labor, affordability of the products, reflection of tradition, and regional specificity. To showcase Yanagi’s vast craft collections and his ideas for selection, Japanese Folk Crafts Museum was established in 1936.

Both Morris and Yanagi were concerned with defining the standard of aesthetics for the public to counteract with what they saw as a decay of taste and sense of beauty, which was mainly based on the handicraft aesthetics. In doing so, however, the machine was stigmatized and its potential remained unexplored in these two movements.

#### **1.4.9 Other explorations:**

##### **Ideal Form Atelier, Formless movement, and Existing Crafts Art Society**

*Keiji Kobo*, also known as the Ideal Form Atelier, was founded in 1928 under the leadership of

the architect Chikatada Kurata (1895-1966), together with several furniture and industrial designers including Noboru Kobayashi, Masao Matsumoto, and Katsuhei Toyoguchi. The group aspired to define what surrounds the day-to-day lives, including architecture and industrial products, through the awareness of the time, their zeitgeist. Kurata had spent time in Germany and was heavily influenced by Bauhaus and the Deutscher Werkbund, and set Keiji Kobo's goal to establish a design process through rationalization of production and standardization. The group contributed in disseminating the standards of western lifestyle through furniture, on the premise of mass production for the everyday life products, although their design activities did not directly result in industrial production of the pieces.<sup>111</sup> Nevertheless they worked toward the alliance of materials, structure and market, and published a journal *Raporto*, for three issues. Their activities lasted until around 1940.

*Jitsuzai Kogei Bijutsu Kai*, or The Existing Crafts Art Society, was founded in 1935 by former members of the avant-garde art-craft movement *Mukei*, or formless, that was active between 1926-33 which had been a collective of many craftsmen with varying directions. As its name *formless* suggests, the preceding group *Mukei* was concerned with promoting individuality amongst its members in terms of their creative actions. Their collective idea that the work would be an expression of each artist toward qualities of freshness, vividness, liveliness, progress, etc., rather than a more constrained central agenda or style. Despite *Mukei* being in the limelight for its edginess, the individuality eventually won over the collective mentality and the group disbanded in 1933.<sup>112</sup>

The subsequent Existing Crafts Art Society stood by a motto *Yo-soku-Bi*, which means function equals beauty. While the phrase is similar to Yanagi's concept of *Yo-no-bi*, the beauty of the function, they arose from differing backgrounds. Existing Crafts was strongly influenced by the practices at Bauhaus like Keiji-Kobo, and some of the members had studied there; Michiko and Iwao Yamawaki in Dessau, who studied with the likes of Joseph Albers, Wassily Kandinsky and Joost Schmidt; and Tamae Ono in Berlin, under the direction of Mies van der Rohe, although she was only able to stay for four months before the school's closure by the Nazis.<sup>113</sup> There were also those who came from the *Kogei-shidousho*, National Research Institute of Industrial Arts, founded in Sendai by the Ministry of

Trade and Industry. *Yō-soku-bi* sought seamlessness in two qualities of function and beauty, and seeing them as inseparable and indiscriminate whether the object was mass produced or a result of one-off production by a highly skilled artisan. The composition of the object's function would simultaneously produce its beauty, independent of the method of production. The fundamental difference lies in the somewhat passive act of finding beauty versus the active approach of cultivating a new product and aesthetics.

#### **1.4.10 The Industrial Arts Institute: *Kogei-shidousho* to *Sangyo-kogei-shikenjo***

Rising awareness in the potential of existing craft techniques to be applied and developed into an industry culminated in the founding of *Kogei-shidousho*, also known as the Industrial Arts Institute (IAI), in 1928. It was not a frictionless process, as crafts were synonymous with beautiful art crafts then and not in line with the interest of the Ministry of Commerce and Industry and its subsidiary Agency of Industrial Science and Technology, under which the IAI belonged. It also cultivated an interesting idea – industrial arts – that was positioned between industry and crafts leaning toward the arts; crafts would help inform the object's form and aesthetic while it will be manufactured through an industrial process. The selection of the location of IAI's headquarters in Sendai was a strategic move in that modernization of the relatively uncultivated Tohoku area had become a political issue, and thus was used to justify the institute's establishment.

The national research organization's aim and objective was to “aid and guide the manufacturers and the craftsmen in the improvement of design, in the application of new materials to the manufacturers and in the modernization of the traditional Japanese industrial arts, in order to promote the nation's export trade.”<sup>114</sup> The government wanted to gain more foreign currency to strengthen its economy, and one key approach was to promote exports. Funded by the government to train professionals in industrial crafts, the institute only received the operational fee of 70,000 yen during the first year, whereas the funding for the activities at *Tokyo Kogyo-shikenjo*, an industrial research institute that produced chemicals such as ammonia, that same year was 500,000 yen.<sup>115</sup>

The institute focused on what they called trial-manufacture to lead the manufacturing

of industrial arts and to give guidance to the manufacturers.

The first exhibition of their trial-products was held at Mitsukoshi department store in Tokyo, in 1933 to show the results to the general public.<sup>116</sup> The display included small objects such as containers, ink-stands and lamps, to furniture and screens; the applied materials ranged from traditional lacquerware and bamboo to aluminum and steel pipes.

In 1940 its headquarters was moved to Tokyo, while the Sendai facility was kept as an outpost. In April 1952, its official name was changed to *Sangyo-kogei-shikenjo*, the National Research Institute of Industrial Arts, but still commonly referred to as IAI.

Early on, conducted researches and corresponding departments were categorized by the topics and materials as follows:

General research	conditions of craft, elements of design
Design prototypes	furniture, objects, industrial design
Fabrication	bamboo, coloring and lacquering, adhesive, plastic wood: processing, moulded plywood, carving, structure metal: surface finishes, moulding, soldering, casting
Wrapping	containers, paper and cardboard, moisture and rust-proofing, special printing

#### 1.4.11 Bruno Taut and Charlotte Perriand

International designers were invited by the Ministry of Commerce and Industry to the IAI to improve the export products by providing suggestions and instructions to its employees.

Early prominent figures included Bruno Taut, who came in 1933 and Charlotte Perriand, who followed in 1940. Although Taut's tenure only lasted for 4 months, he had a profound influence with his denouncement of imitative garishly decorative products and encouragement for the strength of the clarity of material and function that he saw in the older crafts. During his visit to the exhibition of the trial-products of the IAI in 1933 at

Mitsukoshi, Taut was disappointed by the lack of regard for functionality and that the decorative patterns determined the value of the crafts, and encouraged the institute to engage with products that apply traditional craft skills but can be internationally acknowledged, rather than serving the niche collectors of Eastern art. He concludes the critique by stating that the Katsura villa, as opposed to Nikko, emanates a boundless and noble spirit of crafts.<sup>117</sup>

Toyoguchi and Kenmochi were among the group at the IAI profoundly influenced by Taut's approach of rationalization of design toward industrial manufacture, and dissociating from the artist-crafts. One of the areas that both of them later addressed was standardization of furniture, as in Kenmochi's book *Kikaku Kagu* published in 1943 and Toyoguchi, who entered the IAI the same year that Taut came and continued to work at Keiji Kobo, whose book *Hyojun Kagu* was published in 1935.

Charlotte Perriand arrived in 1940 by the recommendation of Junzo Sakakura, who had been her colleague at Le Corbusier's office in Paris. She held the position at the IAI for 7 months, whose work culminated in an exhibition at Takashimaya in Tokyo and Osaka in 1941, titled "Selection, Tradition, Creation."<sup>118</sup> Upon surveying factory productions and traditional crafts especially in Tohoku – including metals, straw, bamboo, wood, ceramics, handmade paper, and urushi lacquer – the skills and materials to realize the test designs at the institute were selected and adopted by Perriand. It was important for her to cultivate a sense of vernacular Japan in the craft making, and also to adopt these skills into new directions, as Perriand established a close friendship with Soetsu Yanagi. Like Taut, she also emphasized the importance of standardization of furniture and rationalization of its production and functions. For the exhibition, she also incorporated the design for free arrangement of structurally independent walls.

Transitions from crafts for viewing to crafts for using, art crafts to functional crafts, and hand crafts to industrial crafts, were manifested through modernization of material and process during the prewar era and again during the postwar. The role of the IAI in researches and experimentations relative to plywood's early development in Japan is further discussed in chapter 3.

While pre-modern, hand-based crafts developed throughout history somewhat gradually, the

context of industrialization in the eighteenth to nineteenth century rapidly changed the conditions surrounding craft. The meanings of labor and products, among the social, economical and political issues, were reevaluated during this period of transition.

Movements in nineteenth century Europe, including the Arts and Crafts movement, showcased the collision of craft versus industry in terms of ideologies, interests and objectives. The dichotomy between each of their spokespeople never seemed to reach an agreement as if there was no common ground. Human will, creativity, and independence did not have a place in the efficiency of scientific management; on the other hand, the preservation of certain skills or artifacts seemed archaic and insufficient in the fast growing economy.

Changes in general perceptions of craft (Fig. 1.5) over the years show the transition over the past two centuries, where those in tensions with craft – fine arts, industry, engineering, and academia – have well established themselves economically and socially, while craft was increasingly representative of the marginalized – individualism, skill, small-scale and the traditional. These have also been disputed through the varying definitions of craft, and in practice, the process of industrialization occurred in multiple phases where craft played a central role.



changes in general perception of craft

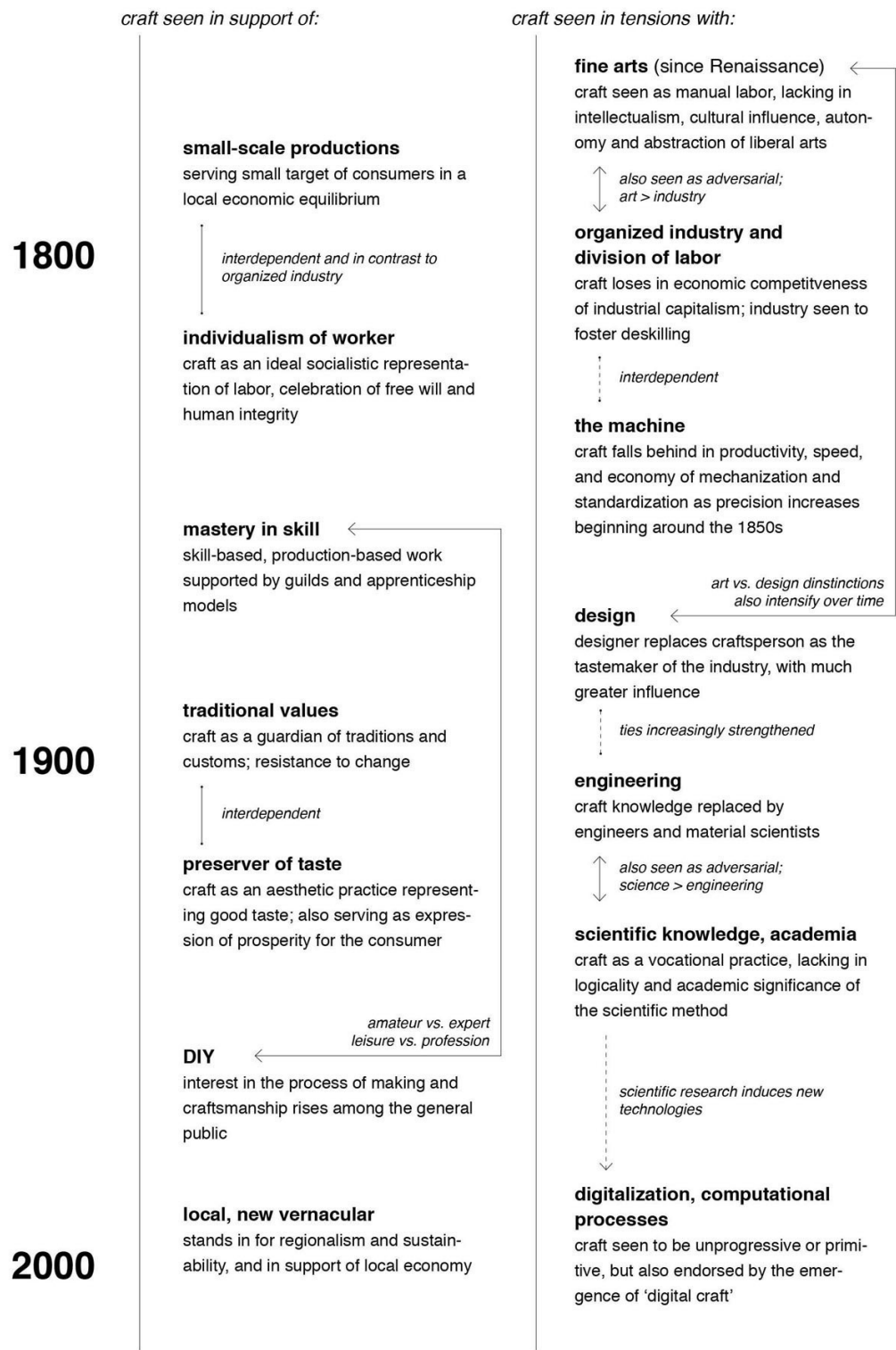


Fig. 1.5 Changes in the general perception of craft from nineteenth to twentieth century

By comparison, the situation manifested quite differently in Japan, where craft and industrialization were neither at odds nor contradictory in the early phase, from the macro perspective. With the Meiji Restoration beginning in the mid-nineteenth century, modernization became a central national agenda, which was synonymous with westernization and therefore naturally entailed industrialization. Progress towards a powerful and more technologically advanced nation, through organization of heavy industries, was an ambition that the public could collectively get behind.

Its potential threat to highly skilled traditional craftsmanship seems to have been put aside as a nonissue. On one hand, elaborate crafts had an audience who could be best described as patrons of the arts; it is important to note that the distinction between crafts and fine arts did not exist in Japan prior to the introduction of these concepts in the event of 1873 Vienna Exposition. Such valued crafts had minimal exposure to the general public except in special exhibitions. On the other hand, everyday products such as tools, kitchenware, containers, textiles, etc – areas that the Mingei movement had primarily focused on – were not the target of industrialization in Japan, at least initially. The preoccupation with strengthening the nation meant that the initial attention was mostly in the heavy industries of steel, shipbuilding, coal and military related areas; the other products were produced cheaply and locally by small operations that their shift to mass-production did not seem urgent nor necessary. An article in *Industrial Art News* in 1953 mentions that distinctions between “arts and crafts” and “industrial arts” had just begun to be recognized at last.<sup>120</sup>

Both craft and industrialization served as potential source of national pride: The traditional and vernacular qualities in the ‘discovered’ crafts of Mingei and the latest industrial developments could be celebrated at the same time, and doing so was not paradoxical. Nevertheless the discourse on craft had been greatly influenced by the ideologies of the western counterpart, and the positioning of craft almost always occurred relative to other disciplines.

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- <sup>1</sup> Frayling, Christopher. *On Craftsmanship: Towards a New Bauhaus*. London: Oberon Books, 2011, citing Robert Blauner, *Work Satisfaction and Industrial Trends in Modern Society*. University of California, 1960. pp 64-65.
- <sup>2</sup> Cardoso, Rafael. *Craft versus Design: Moving Beyond a Tired Dichotomy*, cited in Adamson, *The Craft Reader*. pp 322-23.
- <sup>3</sup> Frayling, pp 10-12.
- <sup>4</sup> Manzini, Ezio. *The Material of Invention: Materials and Design*. London: The Design Council, 1989. p 52.
- <sup>5</sup> Manzini, p 52.
- <sup>6</sup> Frampton, Kenneth. *Studies in Tectonic Culture*. Cambridge, MA: MIT Press, 1996. First published in 1995. pp 3-5.
- <sup>7</sup> Semper, Gottfried. Trans. Harry Francis Mallgrave. *Style in the Technical and Tectonic Arts; or, Practical Aesthetics*. Los Angeles, CA: Getty Publications, 2004. pp 109-111.
- <sup>8</sup> Izuhara, Eiichi. *Design Movement in Japan: History of Industrial Design*. Tokyo: Perikansha, 1989. Reprinted in 1996. pp 50-52.
- <sup>9</sup> Adamson, Glenn. *Thinking Through Craft*. London: Berg Publishers, 2007. p 14.
- <sup>10</sup> Adamson, *Thinking Through Craft*. pp 9-11.
- <sup>11</sup> Channell, David F. "The Harmony of Theory and Practice: The Engineering Science of W. J. M." *Technology and Culture*, Vol. 23, No. 1, Jan, 1982. pp 39-52. The Johns Hopkins University Press. Web. <http://www.jstor.org/stable/3104442>. 07 Feb. 2013.
- <sup>12</sup> Addis, Bill. *Building: 3000 Years of Design, Engineering and Construction*. London: Phaidon Press Limited, 2007. p 315.
- <sup>13</sup> Diderot, Denis. *Encyclopedie*, cited in Malcolm McCullough, *Abstracting Craft*. Cambridge: The MIT Press, 1996. pp 12-13. Its title in full was *Encyclopédie, ou Dictionnaire raisonné des sciences, des arts et des métiers, par une société de gens de lettres, mis en ordre par M. Diderot de l'Académie des Sciences et Belles-Lettres de Prusse, et quant à la partie mathématique, par M. d'Alembert de l'Académie royale des Sciences de Paris, de celle de Prusse et de la Société royale de Londres*, making a reference to crafts in its title (*métiers*).
- <sup>14</sup> Pye, David. *The Nature and Art of Workmanship*. Bethel, CT: Cambium Press, 1998. First published in 1968 by the Cambridge University Press. p 20. Pye was a furniture designer and maker, and taught furniture design at Royal College of Art from 1940s to 70s.
- <sup>15</sup> Pye, p 23.
- <sup>16</sup> Frayling, p 94. Pye in conversation with Frayling in the section "Things Men Have Made."
- <sup>17</sup> Wachsmann, Konrad. *The Turning Point of Building: Structure and Design*. Trans. Thomas E. Burton. New York: Reinhold Publishing Corporation, 1961. p 10.

- <sup>18</sup> Steadman, Philip. *The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts, Revised Edition*. Abingdon, England: Routledge, 2008 (first published by the Syndics of Cambridge University Press, 1979). p 225.
- <sup>19</sup> Sennet, Richard. *The Craftsman*. New Haven & London: Yale University Press, 2008. p 241.
- <sup>20</sup> Sennet, p 262. To illustrate his point, Sennet summarizes the good craftsman as someone who “understands the importance of the sketch – that is, not knowing what you are about when you begin [...]; places positive value on contingency and constraint [...]; needs to avoid pursuing a problem relentlessly to the point that it becomes perfectly self-contained [...]; avoids perfectionism that can degrade into a self-conscious demonstration – at this point the maker is bent on showing more what he or she can do than what the object does [...]; learns when it is time to stop. Further work is likely to degrade.”
- <sup>21</sup> Illich, Ivan. *Shadow Work*. Salem, NH and London: Marion Boyars Inc., 1981. p 100.
- <sup>22</sup> McCullough, Malcom. *Abstracting Craft: The Practiced Digital Hand*. Cambridge, Mass.: The MIT Press, 1998. p 24.
- <sup>23</sup> Rudofsky, Bernard. *Architecture Without Architects: A Short Introduction to Non-Pedigreed Architecture*. Albuquerque: University of New Mexico Press, 1987. First published in 1964. n. pag.
- <sup>24</sup> Rudofsky, n. pag.
- <sup>25</sup> Banham, p 28.
- <sup>26</sup> Shiner, Larry. “The Fate of Craft.” In Sandra Alfoldy, ed., *Neocraft*. Nova Scotia: The Press of the Nova Scotia College of Art and Design, 2007. pp 39-40.
- <sup>27</sup> Planes for right- or left-sided uses have blades set diagonally and placed at the edge of the plane box. It is also described in Muramatsu, Teijiro, et al. *Shokunin no Microcosmos – i.e. Microcosmos of the Artisans*. Tokyo: Inax Publishing, 1985. p 11.
- <sup>28</sup> Dormer, Peter. *The Meanings of Modern Design: Towards the Twenty-First Century*. London: Thames and Hudson, 1990. p 142.
- <sup>29</sup> Barnard, Malcolm. *Art, Design and Visual Culture*. Trans. Nagata, Takashi and Suga, Yasuko. Tokyo: Agne Shofu Publishing Inc., 2002. Originally published by Macmillan Press Ltd. in 1998. pp 18-30.
- <sup>30</sup> Muramatsu, Teijiro. *Dougu to Teshigoto* (Tools and Handiwork). Tokyo: Iwanami Shoten, 2014. pp 217-222.
- <sup>31</sup> Dormer, p 153.
- <sup>32</sup> Dormer, p 153.
- <sup>33</sup> Kaufmann, Edgar Jr. *Introductions to Modern Design*. New York: Arno Press, 1969. First published in 1950 by the Museum of Modern Art. pp 14.
- <sup>34</sup> Initially Morris, Marshall, Faulkner & Co. was established in 1861 but was disbanded in 1875, and subsequently Morris & Co. was founded.
- <sup>35</sup> Suzuki, Hiroyuki. *Kenchiku no Seikimatsu*. Tokyo: Shobunsha, 1977. pp 219-20.
- <sup>36</sup> Kaufmann, p 15.

- <sup>37</sup> Examples include Le Corbusier's Villa Savoye completed in 1931, and Josef Hoffmann's Sitzmaschine, 1905.
- <sup>38</sup> Banham, Mary, et al. *A Critic Writes: Essays by Reyner Banham*. Berkeley and Los Angeles, CA: University of California Press, 1999. First published in 1955. p 27.
- <sup>39</sup> Wilson, Richard Guy, et al. *The Machine Age in America, 1918-1941*. New York: Harry N. Abrams, 1986. pp 43-45.
- <sup>40</sup> Wilson, pp 45-63.
- <sup>41</sup> Le Corbusier. *The Decorative Art of Today*. Trans. Dunnett, James I. Cambridge, Mass.: The MIT Press, 1987. First published under the title *L'art décoratif d'aujourd'hui* in 1925. pp 61-64.
- <sup>42</sup> Kaufmann, p 18.
- <sup>43</sup> Bressani, Martin. "Prosthetic Fantasies of the First Machine Age." *AA Files*, Vol. 68, 2014. p 44.
- <sup>44</sup> Bressani, p 45.
- <sup>45</sup> Basalla, George. *The Evolution of Technology*. Cambridge, MA: Cambridge University Press, 1988. p 15.
- <sup>46</sup> Addis, Bill. *Building: 3000 Years of Design, Engineering and Construction*. London: Phaidon Press Limited, 2007. p 293.
- <sup>47</sup> Addis, p 369.
- <sup>48</sup> Pevsner, Nikolaus. *Pioneers of Modern Design: From William Morris to Walter Gropius*. Harmondsworth, England: Penguin Books, 1960. First published by Faber and Faber, 1936. p 40.
- <sup>49</sup> Bergeron, Louis and Maiullari-Pontois, Maria Teresa. *Industry, Architecture, and Engineering: American Ingenuity 1750-1950*. New York: Harry N. Abrams, Inc., 2000. p 29.
- <sup>50</sup> Babbage, Charles. *On the Economy of Machinery and Manufacturers*, cited in Glenn Adamson, *The Craft Reader*. Oxford: Berg, 2010. pp 51-53.
- <sup>51</sup> Babbage, p 49.
- <sup>52</sup> Gaskell, Peter. *Artisans and Machinery: The Moral and Physical Condition of the Manufacturing Population Considered with Reference to Mechanical Substitutes for Human Labour*, London: J. W. Parker, 1836, cited in Adamson, *The Craft Reader*. pp 58-60.
- <sup>53</sup> Zeitlin, Jonathan. "Engineers and Compositors: A Comparison." Harrison, Royden and Zeitlin, Jonathan, eds. *Divisions of Labour: Skilled Workers and Technological Change in Nineteenth Century England*. Sussex: The Harvester Press, 1985. p185.
- <sup>54</sup> Zeitlin, p 193.
- <sup>55</sup> Carpo, Mario. *The Alphabet and the Algorithm*. Cambridge, MA: MIT Press, 2011. p 10.
- <sup>56</sup> Published by The United Crafts at Eastwood, New York, the magazine expresses its motto under its title: "The lyf so short the craft so long to lerne." (The Life So Short, The Craft So Long to Learn).
- <sup>57</sup> Mumford, Lewis. *Technics and Civilization*. Chicago: The University of Chicago Press, 1934, edition 2010. pp 4-5.
- <sup>58</sup> Mumford, p 5.

- <sup>59</sup> Banham, Rayner. *Theory and Design in the First Machine Age*. London: Architectural Press, 1960. p 14.
- <sup>60</sup> Kaufmann, p 7.
- <sup>61</sup> Tanimoto, Masayuki. "The Role of Tradition in Japan's Industrialization: Another Path to Industrialization." Oxford Scholarship Online, 2013. Web, [www.oxfordscholarship.com](http://www.oxfordscholarship.com). 14 May 2013.
- <sup>62</sup> Scarlett, Sarah Fayen. "The Craft of Industrial Patternmaking." *The Journal of Modern Craft*, Volume 4 – Issue 1, March 2011: 27-48. Print.
- <sup>63</sup> Scarlett, pp 45-46.
- <sup>64</sup> Moss, Gillian. "Textiles of the American Arts and Crafts Movement," in Parry, Linda. *William Morris and the Arts and Crafts Movement*. London: Studio Editions, 1989. pp 17-18.
- <sup>65</sup> Sabel, Charles F. and Zeitlin, Johnathan, eds. *World of Possibilities: Flexibility and Mass Production in Western Industrialization*. Cambridge: Cambridge University Press. 2002. First published in 1997. p 4.
- <sup>66</sup> Sabel and Zeitlin, pp 3-5.
- <sup>67</sup> Zeitlin, p 185.
- <sup>68</sup> Zeitlin, p 186.
- <sup>69</sup> Roberts, John. *The Intangibilities of Form: Skill and Deskilling in Art After the Readymade*. London and New York: Verso, 2007. pp 82-89.
- <sup>70</sup> Naylor, Gillian. *Arts and Crafts Movement: a study of its sources, ideals and influence on design theory*. London: Studio Vista Publishers, 1971. p 17.
- <sup>71</sup> Naylor, p 8.
- <sup>72</sup> McLauchlan, Valerie. "Aestheticism in British Architecture: An analysis of the relation between idea and form in the late nineteenth century." Diss. The Architectural Association, 1992. Print, pp 227-28.
- <sup>73</sup> McLauchlan, p 238. In *The Nature of Gothic*, Ruskin described his attempt to unite formal criteria to moral virtue of the Gothic being, in the order of importance, "1. Savageness. 2. Changefulness. 3. Naturalism. 4. Grotesqueness. 5. Rigidity. 6. Redundance" which, belonging to the builder, are expressed to be "1. Savageness or Rudeness. 2. Love of Change. 3. Love of Nature. 4. Disturbed Imagination. 5. Obstinacy. 6. Generosity." p 228.
- <sup>74</sup> Suzuki, pp 202-3. Paraphrased from *Arts and Crafts Essays*, 1893.
- <sup>75</sup> Naylor, p 30.
- <sup>76</sup> Naylor, pp 178-180.
- <sup>77</sup> MacCarthy, Fiona. "C. R. Ashbee and the Guild Idea." Exhibition catalog, *C. R. Ashbee and the Guild of Handicraft*. Cheltenham: Cheltenham Art Gallery and Museum, 1981. n. pag.
- <sup>78</sup> MacCarthy.
- <sup>79</sup> MacCarthy.
- <sup>80</sup> Greensted, Mary. "Furniture." Exhibition catalog, *C. R. Ashbee and the Guild of Handicraft*. Cheltenham: Cheltenham Art Gallery and Museum, 1981.

<sup>81</sup> Truman, Catherine M. "C. R. Ashbee: An Examination of the Influences which Inspired The Guild and School of Handicraft." Diss. The Architectural Association, 1992. Print, p 81. Quoting *Craftsmanship in Competitive Industry*, p 110.

<sup>82</sup> Truman, p 82.

<sup>83</sup> Suzuki, pp 211-13.

<sup>84</sup> Suzuki, p 223.

<sup>85</sup> Conrad, Ulrich, ed. *Programs and Manifestoes on 20th-century Architecture*. Cambridge, Mass.: The MIT Press, 1995. p 28-29. First English edition published in 1970. Muthesius and van de Velde at the Werkbund conference in Cologne, 1914.

<sup>86</sup> Schwartz, Frederic J. "Hermann Muthesius and the Early Deutscher Werkbund." Exhibition catalogue, *Vom Sofakissen Zum Stadtebau: Hermann Muthesius und der Deutsche Werkbund*. Kyoto: The National Museum of Modern Art, Kyoto, 2002, and Tokyo: The National Museum of Modern Art, Tokyo, 2003. p 369.

<sup>87</sup> Ichikawa, Yuki. "The consideration about a historical change of the 'crafts' and 'craftsman' concept" in *Chiiki Seisaku Kenkyu*. The Society of Regional Policy, Takasaki City University of Economics. Vol. 10, No. 1, July 2007: 109-128. p 111.

<sup>88</sup> Izuhara, Eiichi. *Design Movement in Japan: History of Industrial Design*. Tokyo: Perikansha, 1989. Reprinted in 1996. pp 50-52.

<sup>89</sup> The Ministry of Trade, Economy and Industry of Japan defines "*Dento-teki Kogei-hin*" (traditional crafts) as follows: Functional objects to be used primarily for everyday life, and that: 1. Within the production process, the handwork is chiefly what grants the characteristic of the product; 2. With a continuous history of over 100 years, the traditional techniques have been used in its production; 3. The main material has been used continuously for over 100 years; and 4. A regional industry of a certain size has been maintained in the particular area, producing the concerned crafts.

<sup>90</sup> Izuhara, p 50.

<sup>91</sup> Ichikawa, p 112.

<sup>92</sup> Izuhara, p 27.

<sup>93</sup> Narita, Juichiro. *Nihon Mokko Gijutsushi no Kenkyu* (Research on the technological history of Japanese woodworking). Tokyo: Hosei University Press, 1990. p 373.

<sup>94</sup> Izuhara, p 20.

<sup>95</sup> Kashiwagi, Hiroshi. "On Rationalization and the National Lifestyle: Japanese Design of the 1920s and 1930s," in Tipton, Elise and Clark, John, ed. *Being Modern in Japan: culture and society from the 1910s to the 1930s*. Honolulu: University of Hawaii Press, 2000. pp 62-63.

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<sup>97</sup> Miyakawa, Yasuo. "Farmers Art Movement and Folk Art Movement in Japan: localization of cultural climate and evolution of industrial region." Kyushu University Institutional Repository. 20 Feb. 2005. Web,

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<sup>99</sup> Yanagi, n. pag.

<sup>100</sup> Izuhara, pp 82-85.

<sup>101</sup> Yanagi, n. pag.

<sup>102</sup> Yanagi, n. pag.

<sup>103</sup> Yanagi, n. pag.

<sup>104</sup> Yanagi, n. pag.

<sup>105</sup> Naylor, p 107.

<sup>106</sup> Naylor, p 117. Quoted from “Textiles,” *Arts and Crafts Essays 1893*, p 35.

<sup>107</sup> Naylor, p 110. Quoted from “Printing,” *Arts and Crafts Essays 1893*, p 133.

<sup>108</sup> Yanagi, n. pag.

<sup>109</sup> Kida, Takuya. “Existing Crafts Art Society (Jitsuzai Kogei Bijyutsu Kai), 1935-1940: the ‘Function equals Beauty (Yo soku Bi)’ of Crafts.” *Bulletin of the National Museum of Modern Art*. Tokyo (13), 37-64. 2009. Web, [http://www.momat.go.jp/research/kiyo/13/pp37\\_64.pdf](http://www.momat.go.jp/research/kiyo/13/pp37_64.pdf). 14 Apr. 2013. p 43.

<sup>110</sup> Pevsner, Nikolaus. *Pioneers of Modern Design: From William Morris to Walter Gropius*. London: Penguin Books, 1991. First published 1936. p 43.

<sup>111</sup> Kashiwagi, pp 64-65.

<sup>112</sup> Kida, pp 39-41.

<sup>113</sup> Kida, p 50.

<sup>114</sup> Kogyo Gijyutsu-in Sangyo Kogei Shikenjo (the Industrial Arts Institute). *Sangyo Kogei Shikenjo Shisakuhin-shu* (Trial Examples of the Industrial Arts Institute). Tokyo: The Industrial Arts Institute, March 1955. p 3.

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## **Chapter 2**

### **Development of the material: The industrialization of wood**

*Today we have a Scientist or Inventor in place of a Shakespeare or a Dante. Captains of Industry are modern substitutes, not only for Kings and Potentates, but, I am afraid, for great Artists as well. And yet – man-made environment is the truest, most characteristic of all human records.<sup>1</sup>*

#### **2.1 Material development and technology**

The realm of materials represents a parallel to the technological adoption, and is closely entwined in its outcome. The industrialized societies have all seen a tendency of materials towards an increase in the number, in diversity, and in complexity, with the invention of new materials and new combinations. The natural materials such as mineral, vegetable or animal based, were available to be foraged and extracted from the natural environment, thus making them adaptable for conventional crafts. The higher level of processing a material undergoes before assembly or manufacture into a product, the more demanding of the industrial processes in most cases. It has created a kind of hierarchy between different materials and practices from all sides, from the craftsman to the scientists and engineers.

The integration of science and engineering, accelerated by industrialization, has turned the materiality into a possible area for innovation, rather than the empirical response to the existing conditions of a certain material. This has led to material diversity, each of which were further developed to better suit the goal, whether specific or general. Mastering the material, which was essential in the traditional craft practices in dealing with the naturally found materials, became less consequential while specialization of knowledge to exploit the materiality, from the scientific understanding, proceeded on to develop synthetic and composite materials.

## general material categorizations

### natural materials

mineral (metals, metal oxides, clay, sand)	
vegetable (wood, natural fibers)	<i>conventional craft materials</i>
animal (leather, horn, ivory)	

### synthetic materials, categorized by the nature of their origin

mineral (coal, petroleum, silica)	
vegetable (cellulose, latex)	<i>industrial materials</i>
animal (milk)	

### composite materials

use both natural and synthetic materials	
binding matrix + strengthening properties	<i>typ. requires industrial processes</i>

Fig. 2.1 General material categorizations, summarized from Guidot's *Industrial Design Techniques and Materials*<sup>2</sup>

## 2.1.1 Consequences on production, labor and consumption

On the surge of technological adoption, Kevin Kelly has observed that, “Whereas it took electrification 75 years to reach 90 percent of the U.S. residents, it’s taken only 20 years for cell phones to reach the same penetration. The rate of diffusion is accelerating.”<sup>3</sup> He explains that in addition to the more obvious effects on manufactures, processes, and distributions, having more combined with ubiquity also leads to strange effects. In the example of a camera, it first began as a novelty, then a replacement for the painters as a way to capture the scene. That was followed by photojournalism, and eventually brought movies and alternative realities, while the emergence of cheap cameras has helped feed tourism, globalism, and international travel,<sup>4</sup> as completely unforeseen outcome of this invention.

On a more micro level of the material world, the case of a chemical company DuPont, which was first founded in 1802 as a gunpowder mill, shows that its number of products available rises from single digit throughout much of the nineteenth century to just over 10 products in 1910, to 50 products in 1970, then an abrupt increase to 200 products by the year 2000.<sup>5</sup> And while conventional materials generally have had a relatively low strength to density ratio, the later materials tend to invert this relationship. Lightness of structure has

been explored as it contributes to the reduction of impact on site and an advantage in transportability.

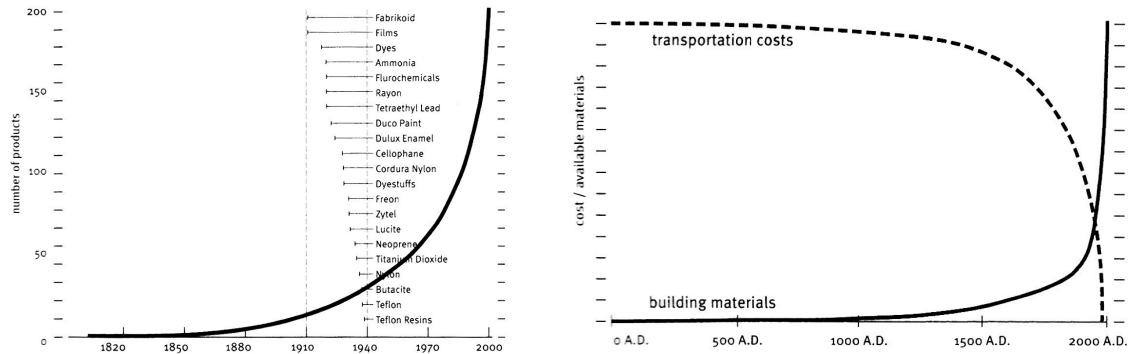


Fig. 2.1.1 (left) Explosion of new materials – number of DuPont products available through history;<sup>6</sup> and Fig. 2.1.1-2 (right) Rapid increase in materials and reduction in transportation costs, both due to technological developments in the mid-nineteenth century, increase choices<sup>7</sup>

The effects of the exponential increase of materials in our constructed environment has been profound. Often combined with the capacity to mass-produce, material diversity and its sheer quantity have proliferated the markets worldwide. One of the consequences to such change is the role of scientists and engineers, who have become the inventors of raw materials: Their part in the field have become increasingly crucial as new materials, their applications, and manufacturing processes are developed and refined. Conversely, the role of the hands-on craftsperson becomes marginalized and less consequential.

Prior to this shift, “For about two centuries theoretical knowledge and practical experience coexisted,” due to the number of available materials and the pace of their development, before mostly overtaken by the emergence of abstract and theoretical knowledge of the new engineer figure.<sup>8</sup> For craftspeople, “Innovation, when it arises, is the result of a fortuitous piece of happenstance – often the product of an error that has yielded positive results, rather than that of a deliberate design choice in the modern sense of the word.”<sup>9</sup> The mode of knowledge is fundamentally dissimilar in these two factions, as is the

scale of the production that each of the knowledge is applied to. The ability for communication between various disciplines with different technical worlds and languages was difficult to attain in the traditional craft context.

The aspect of time required for training and working was another consequence on the parallel between material and labor in the practice of traditional craft, as mentioned in the section on training and education of crafts that were transferred over time to increasingly systematized education. The history of the use of wood exemplifies this trajectory, which will be examined through its developments and applications.

## 2.2 Wood as a material

### 2.2.1 Overview

Wood is one of the earliest materials to be employed for functional use by humankind. As a material, it has been used by craftspeople and industries alike, from small practical objects to buildings, ships and airplanes. It has also enabled architectural applications from early construction types of logs, timber frame, light framing, and many variations arising from regional traditions.

The transformation of wood from a natural solid material to plywood, in other words from the conventional craft material to a composite that is a typical industrial material, first began with plywood. A material with long history, early iterations of veneer and plywood making was a hand based operation and far from what we know as modern plywood. Before the arrival of plywood, the processing of wood was rather limited – they could be cut, carved, smoothed, drilled, or treated on the surface (further elaborated in Table 2.2.1), but the veneer and plywood expanded the ways in which they could be utilized. The ability to produce thin sheets and strips, and combining them, was revolutionary.

Category	Subcategory	Tools or techniques used
Removal	Separate: cut, split, saw	Axe, saw, knife, hatchet
	Carve: perforate, hollow, gouge	Chisel, plane, knife

	Surface treatment: shave, sand, plane	Plane, file, whetstone, sand
Assembly	Attach: adhesive, glue	Plant or animal based protein, lacquer
	Fasten: tie, bind, screw, sew	Nail, screw, string, wire, bark
	Join, connect	Extension of length or width of wood
	Weave	Wickerwork, basketwork
Deformation	Bend, stretch	Boil, steam, heat
	Cure	Dry

Table. 2.2.1 Categorization of woodworking techniques since the ancient period;<sup>10</sup>  
contemporary developments are omitted for clarity

It was fundamentally different in nature from working with the material of solid mass, not only structurally but also embedded with cultural meanings and traditions.

For example, the Shakers in rural areas of northern New England and New York State were “celibate and their lives were dedicated to religious fervour and the making of fine, simple handcrafts and furniture.” For this particular group, their “love for structural expression in wood was also characteristic of the architecture and handcrafts of a mystic, religious sect, whose membership was in the thousands in the first half of the nineteenth century.”<sup>11</sup>

Similar phenomena can be observed in different regions around the world where wood, or certain species of wood, holds a special significance for the collective psyche, whether in religious settings or vernacular domestic domains. In a sense, the industrialization of wood into plywood liberated the material from these traditions and meanings, while popularizing and democratizing the use of this new wood material.

The making of architecture has been profoundly dependent on wood, and its development can be seen in direct correlation to how the wood has been processed and applied, especially in areas with abundance of this natural resource. The successive stages of building in wood over the past three centuries in the United States is observed as follows: “In the seventeenth century, wood was used naturally, in an unabashed manner, and structural utility was the dominant consideration. During the eighteenth and nineteenth centuries, wood was considered the handmaiden of more academic form and it served the purposes of

a number of revival styles. Wooden architecture has now come full circle and architects find that the usefulness of designing in wood is only surpassed by the sheer beauty of the resultant designs.”<sup>12</sup>

The material also gave rise to the purpose of the oldest method of prefabrication, through the pre-cut method. Sections of wood were prepared at the factory by being cut into specified lengths, notched, marked with the identification numbers indicated on the construction drawings, bundled into units and delivered to the building site<sup>13</sup> in different parts of the world. Essential to the prefabrication of wood, joinery was one of the areas that craftsmanship thrived. Carpenters of traditional Japanese architecture have been found to leave a kind of signature with a characteristic modifications to the basic joinery. Such skilled carpenters were expected to have the ability to assess the material quality and to execute the work accordingly, with the understanding of durability, appearance and efficient use of the material.

Other technological achievements, such as the production of mineral wool to provide thermal insulation after the second world war, further contributed to the proliferation of processed timber for applications such as prefabricated houses. Particularly at the residential scale, the use of wood in architecture had prevailed in vernacular buildings around the world, including northern Europe. It has been documented that even the Great Fire of London, in 1666, did not deter from the use of timber for construction or its prestige as a material.

### **2.2.2 Terminology**

Timber, or lumber, is a term used to indicate sawn wood, that are almost always harvested from the main stem. As a material timber is “a low-density, cellular, polymeric composite, and as such does not conveniently fall into any one class of material,” and that considering its high strength to the low cost, “timber remains the world’s most successful fibre composite.”<sup>14</sup>

More specifically, the term timber is used to designate “the material which was used for the construction and repair of the structural parts of a building, a bridge or ship,”<sup>15</sup> as

opposed to wood which is the raw material or one used for furniture, tools, fuel, etc. Timber covers building elements include posts, beams, roof members, joists, and floor boards.

Structurally, three main types of loads are considered: Superimposed loads, self-weight and wind loads, which then affect timber building mainly through bending, shear, and structural movement.

From the center of the log outwards, parts of the wood are roughly organized into heartwood, including the pith; sapwood, which includes earlywood and latewood; cambium; inner bark; and outer bark. The parts may be distinctly used with their characteristics in mind, or processed without differentiation, such as when treated down to finer state such as pulp.

The species of wood are most commonly categorized into two groups for use: Hardwoods, which are timber from deciduous or evergreen broad-leaved trees, and softwoods, which are timber from coniferous or needle-leaved, cone-bearing trees that are mostly evergreen. The uses for hardwood versus softwood are quite distinct, as hardwoods are typically considered finer in its appearance, and the most dense types of hardwood have the hardness and strength that many softwoods do not. With some exceptions, hardwoods are more often applied in decorative uses whereas softwoods are typically used for structural purposes.

Within each category there are further classifications by species. For example, an anecdote on the native timber in the UK describes that oak was the most versatile and desirable species, harvested in most of England and Wales, while elm was an alternative for floorboards, wheels, and machinery. Ash and chestnut were used for building members, although chestnut was said to be susceptible to damp. Beech was suitable for joinery but typically not used for buildings, and poplar was applied in ancillary purposes.<sup>16</sup>

Additional classification of wood incorporate traits inherent to the wood or according to the treatments applied. Temperate and tropical timbers, preservative treatment, moisture content, dimensional stability, availability, and finishes. Its technical attributes ranges from durability, treatability, density, moisture movement, workability and availability.<sup>17</sup>

### 2.2.3 Timber sourcing

The distribution of forest is uneven throughout the world. The greatest areas of closed forest, as opposed to the open or savanna type woodland of low stocking, are present in North America, South America, and Russia, each of which possesses almost a quarter of the world's total resource. Of the remaining sizable forests, 15 percent are located in Asia, 7 percent in Africa, and 5 percent in Europe.<sup>18</sup>

There is also a sharp contrast in the type of trees harvested in these different areas. Approximately 90 percent of the softwood forests are in developed countries with predominantly temperate climate, while about 70 percent of the hardwood forests are located in developing and predominantly tropical regions.<sup>19</sup> Almost all softwoods currently are harvested from planted forests, managed at around 60 to 80 year crop cycle.

The unevenness of resources have produced a vibrant trade for raw and processed woods around the world. One prominent example is in the UK, which had a large demand and capacity to process timber as the world's pioneer of industrialization, but owned little of the resource; 80 to 90 per cent of its timber requirement has been imported, mostly from Russia, Scandinavia, and Canada. Its international trade of timber began centuries ago with spruce and pine from Norway and the Baltic regions, and by late seventeenth century softwood was brought in from Sweden and Russia and white pine from America. In the first half of the nineteenth century, western North America entered international trade with spruces, pines and Douglas fir.<sup>20</sup> By 1913, 7 percent of the timber imported into the UK originated from the US, 8.9 percent from Canada, 16.2 percent from Sweden, 3.9 percent from Norway, and 48 percent from Russia and Finland.<sup>21</sup>

The Timber Trade Committee was formed in the UK in December 1891, in response to the raise in monopolistic railway rates – railways dominated the mode of transport for commodities and people in Britain, and the timber industry was hit hard especially for the distance the products had to travel along with to the product weights that determined the cost of transport. The method of charging for wood and the passage of the 1891 Railway Rates Act and the 1892 Rates Bill mostly affected imported softwoods. From January 1893, railways could calculate according to the traditional “measurement weight” or the



alternative of “machine weight,” both of which were very complicated as a system of classification depending on the type and shape of wood.<sup>22</sup> Nevertheless, this substantial and lucrative international trading of wood and associated industries became the norm, with local and global policies adopting to the changes brought on by these trades.

Another impact particular to this material as a natural resource is where it is harvested, whether in plantation or natural forest. The commercial productivity of a new plantation is approximately seven times higher than that of natural forest. Growing environmental concerns for the loss of old-growth forests has also encouraged the planted forests, which are economically feasible only at a large scale and with long term management programs.

#### **2.2.4 Mechanical processing of timber**

On the economy of timber conversion, the mid-seventeenth century notebook by Sir Roger Pratt describes the following detail on the economy of processing: “The trees having been bought as growing timber, the bark would more than pay for the felling, the lop and top i.e. the thinner and otherwise useless branches, when sold, would pay for their own removal and usually for carriage as far as twenty miles, the chips resulting from trimming would pay for the cost of trimming and, if the timber was to be squared, the slabs of rounded section would pay for the sawing.”<sup>23</sup>

Mechanical saws that were first powered by water and later by steam engines replaced the pitsaw, where a large saw operated by two people, one above and one in the pit below ground level, was moved manually to create sawn planks out of logs. Different kinds of axes were used by skilled workman to make a clean finish to the timber, including the adze which has a curved blade set perpendicularly to the handle. It was considered a precision tool when used by skilled workers to perform the task.

From the mid-nineteenth century the more economical and versatile circular saw dominated. The first patent of the circular saw seems to have been granted in 1777 to Samuel Miller in England, although this tool did not reach a point of utility until around 1805, shortly after the advent of the steam engine. It would take over half a century to come in to general use, which took place around 1840, with the art of inserted teeth opening up its

application to industry.<sup>24</sup>

The circular saw was followed by invention of band saw, which is first recorded in the English patent to William Newberry in 1808. As with the circular saw, the band saw also took several decades to come into general use, which occurred around 1870. Circular saws and frame saws, which were traditionally used in Scandinavia for softwood logs, have been replaced in most part by bandsaws; the advantages of the band saw are smaller kerf and higher feed speed, both of which enable greater output.

In converting a log into planks and timber, the emphasis is on maximizing financial output rather than volume. For example, a batten of a large cross-sectional area is worth considerably more than two battens each half the cross-sectional area of the large batten, and one long batten is worth more than two battens half as long.<sup>25</sup> Thus timber applications increasingly require large volumes of a few selected sizes, to maximize the length and cross-sectional area corresponding to market demand for particular sizes. Restrictions posed by the natural log that come into play during the processing include log taper especially for coniferous trees, bowed logs, knots, and growth stresses, which are longitudinal compressive stresses in the inner layers, the tensile stresses on the outer rings, and lateral stresses. Growth stresses can result in the development of shakes, which are star-shaped cracks in the core of the tree, the outer sapwood that is physiologically active and lighter in color, and its possible exclusion. All in all, it has been said that only about 35% of hardwood and 45% of softwood logs are converted into timber, due to the character of material irregularities such as hollow cores, with hardwood having more irregularities than softwood.

Different methods of processing timber produces different results: “Straight up and down sawing produced slabs or planks which were liable to warp; quartering gave timbers of better quality but still liable to distort whereas radially cut members were the most stable of all but involved much waste in the conversion.”<sup>26</sup> Tools such as the chipper canter and associated double or quad bandsaws, which reduce the log to a square cross-section, have partially eliminated the type of decision of how much to cross-cut to reduce waste and increase the volume of timber obtained from the lower log.<sup>27</sup>

As industrial processing of wood began to spread and mature, basic categorizations of

required machinery came to be known as the following: 1. saws; 2. planar and surfacer; 3. boring machine, including drill; 4. grooving, moulding, and shaping machines; 5. veneer slicer; 6. routing machine; 7. sanding machine; 8. saw teeth sharpener; 9. grinding and sharpening machine; and 10. the universal woodwork machine, shown below.

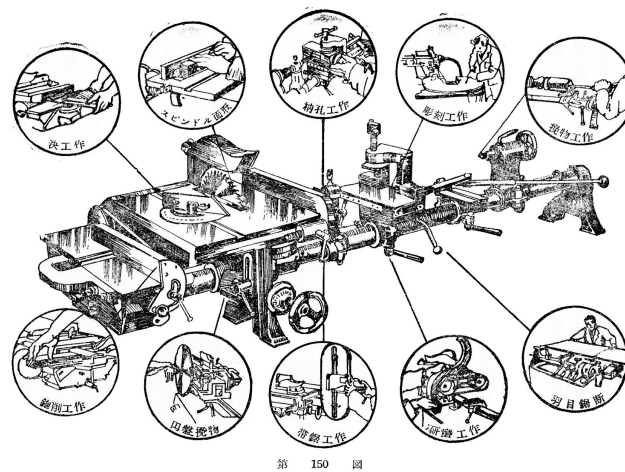


Fig. 2.2.4 An example of the universal woodwork machine in Japan, combining many different functions into one<sup>28</sup>

### 2.2.5 Grading timber

Since wood itself is not a manufactured, growing quantities of trade and consumption entailed a history of grading timber, especially structural softwood, which reveals the attempt to control and regulate the material for the expanding market. Prior to stress grading that came into practice in the mid 1970s, softwood grading was based on a defects system, where large defects in materials of large dimensions would receive the same grade as material of small dimensions with small defects. Defects taken into account included knots and ring width, resulting from structural variability, and wane, splits, twist, cup, and bow, arising from conversion and drying, and sap-stain or actual rot, resulting from fungal development; however, the assessment of these defects vary between countries.<sup>29</sup>

For the evaluation of structural size timber, knot sizes were specified through knot-area ratio, which is “the ratio of the sum of the areas of the projections of all knots at a cross-section, to the total area of the section.”<sup>30</sup> Through this assessment, visual stress grades of

general structural (GS), which is the lower grade of the two, and special structural (SS) were defined, both satisfying requirements relating to slope of grain, rate of growth, wane and distortion.<sup>31</sup>

Values of duration of load derived from small clear test pieces and the calculation of the basic stress, which took into account the variability of in strength of defect-free wood, was not adequate for structural timber and therefore led to derivation of grade stresses directly from actual structural-size timber.<sup>32</sup> As early as 1891 in the United States, test samples of 2 x 2 inches (approx. 50 mm) in cross-section were originally used, followed by the European test specimen f 20 x 20 mm also in cross-section.<sup>33</sup> Strength ratio were defined in four grades of 40, 50, 65 and 75, which represent the percentage of strength relative to the clear straight-grained timber.

Table 7.7 Changes in derivation of design stresses over the period before 1973 to about 2005

	UK			EUROPE		
→1973	1973–1995			1996 →		
Data from testing small clear test pieces	Structural timber			Structural timber		
↓	↓			↓		
Mean value less 2.33s	Grading		Tests°	Grading		Tests°
↓	↓	↓	BS 5820	↓	↓	EN 408
Divided by safety factor* to give <b>Basic stress</b>	Visual BS 4978 (1988) BS 5756 (1980)	Machine BS 4978 (1988)	↓ ↓ ↓ ↓	Visual BS 4978 (1996) BS 5756 (1997)	Machine EN 519	EN 384 ↓ ↓ ↓
↓	↓		↓	↓		↓
Multiplied by <i>strength ratio</i>	<b>Grade or Strength classes</b> BS 4978 (1988)		↓	<b>Strength classes and Characteristic values</b> EN 338		↓
↓	↓		↓	↓		↓
Derived <b>Grade stresses</b> in BS 5268 Part 2	Stresses in standard BS 5268 Pt. 2		↓	factored ↓ → <b>Grade stresses</b>		↓
↓	↓		↓	↓		↓
<b>Design code</b> BS 5268 Pt. 2	<b>Design code</b> BS 5268 Pt. 2			<b>Design code</b> BS 5268 Pt. 2		
				<b>Design code</b> ENV 1995–1–1		

s = standard deviation

\* = safety factor (1.4 for compression || to the grain; 2.25 for all other modes) to cover effects of specimen size and shape, rate of loading and duration of load

° = testing used only to derive values for inclusion in the standards

Fig. 2.2.5 Changes in derivation of design stresses over the period before 1973 to 2005 in the UK and Europe.<sup>34</sup>

## 2.2.6 Mechanical stress grading

Stress grading by machine is based on the relationship between the strength and stiffness of

timber, taking into account growth characteristics such as knots, wane and slope of grain. As each piece is fed through a series of rollers, the machine automatically loads and measures the deflection, in addition to a visual inspection by the operator who ensures that timber with unacceptable defects are not accepted by the machine.<sup>35</sup>

In the late 1950s, correlations between bending strength and modulus of elasticity –  $E$ , or deflection related to stiffness – were discovered that paved the way to more reliable ways of predicting the strength. There were also additional distinctions by use, such as general structural and special structural for softwood timber.

The quality control procedures help ensure the following: 1. proper operation of the machine used to make the non-destructive measurements; 2. appropriateness of the predictive parameter – bending strength relationship; and 3. appropriateness of properties assigned for tension and compression.

Developments in grading timber corresponds with the standardization of materials for improved quality control, guaranteeing that assigned properties are secured by the material, and the proper assignment of design properties based on strength prediction.<sup>36</sup>

Type	Wood element	Wood composite name	Example of use in structures
natural	natural composite	solid timber	structural framing: small, general carcassing, door panels, general joinery
laminated composite	sawn timber sections	glulam, mechlam	structural elements: small to large framing, window joinery

structural timber composites	veneers, flakes	laminated veneer lumber (LVL), parallel strand lumber (PSL), laminated strand lumber (LSL), oriented strand board (OSB), waferboard, flakeboard	structural elements: small to large framing, general carcassing, door panels, general joinery, furniture and boarding
particleboard	particles	chipboard, flaxboard, cement bonded particleboard	flooring, ceiling and panel infill
fiberboards	wood fibers	hardboard, softboard, medium density fiberboard (MDF)	moulding, internal joinery and panel infill

Fig. 2.2.6 Classification of wood products<sup>37</sup>

Each of these products have structural and aesthetic qualities associated with them, determining how they might be applied, whether visible or concealed, and for the necessary structural strength. Plywood products span the range of low to high on both structural and aesthetic scales, with a variety of products manufactured for different purposes. The aesthetic quality, which contributes to its economic value, is not absolute, and often changes over time; exposing the surface of structural plywood or wood fiber cement boards as a finishes have become more prevalent, while application of darker, conventionally prized decorative veneers have declined in the past few decades in Japan. It can also be postulated that higher the aesthetic quality, the closer to traditional craft material categorization.

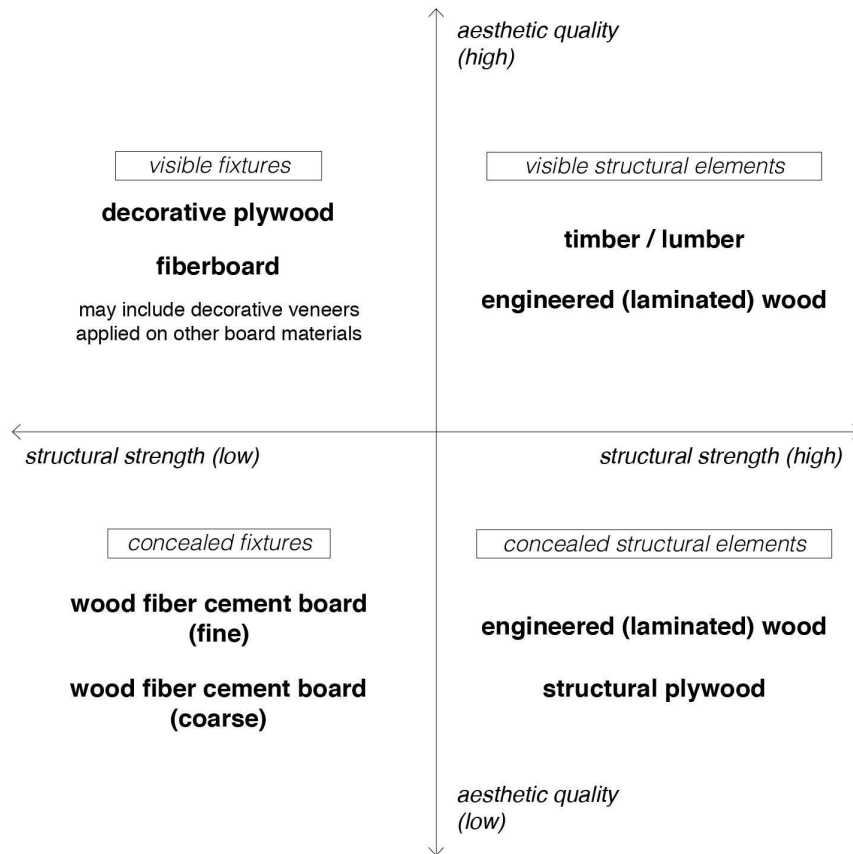


Fig. 2.2.6-2 General classification of wood products by their structural and aesthetic qualities<sup>38</sup>

## 2.3 Development of modern plywood

### 2.3.1 Overview of the board material as a modern development

*A lag between the invention and creative exploitation of a medium and its cultural assimilation is not unusual – with both cinema and television, critical thinking about their social and artistic implications developed well after the first rush of creative output.*<sup>39</sup>

The production of modern plywood has been dependent on the mechanized processing of veneers, and thus has always been an industrialized material. The capacity to be mass-produced led to wide range of applications for the standardized board material, from small objects to covering large surfaces in buildings and beyond. The objectification of wood-ness

through industrialized plywood also occurred at different degrees from being expressive in its design to erasing any trace of the it.

The arrival of wood products in panel form, which became one of the representative architectural materials after the Industrial Revolution and into the twentieth century, now seems inevitable. Their development in the trajectory of processing solid timber to forming a composite, or so-called engineered wood, addressed several issues that were then coming into focus: The necessity for panel products to fill between framing members as diaphragm in addition to other uses; the need to find uses for trees without much commercial value in the existing and established wood industries; and the increasing awareness of the abundance of wood fiber material discarded after the conversion of timber for other uses.<sup>40</sup> These concerns were coupled with the availability of power, beginning in the form of steam from the eighteenth century, machinery, and advancements in the quality of adhesives as byproduct of the expanding oil industry.

The nature of these products are compositionally comparable to the first example of plywood that had existed in Egypt dating back to 2500 BC, which is why plywood is said to be one of the earliest composite materials. The Egyptian plywood examples were found in chairs and other furniture surfaced with veneers of sycamore and acacia, or from ebony and inlaid with ivory,<sup>41</sup> to the six layers of glued wood applied on the side of a sarcophagus,<sup>42</sup> all of which were produced high level of skilled workers for the aristocracy. There were also cases of laminated wood excavated from ancient Chinese burial sites, where the technique was found to be applied to bows and chariot wheels. After a long absence during the middle ages, the Italian Renaissance revived it in marquetry, where “thin pieces of rare woods were tightly joined together and adhered to a structural substrate,” for decorative purposes.<sup>43</sup> All of these early plywoods, however, were limited in size by the width of the tree trunk and the means of cutting by hand-based tools, before the advent of the rotary cutter.

Egypt also had developed bent wood techniques for wheel making by 1330 to 1340 BC, displaying their knowledge in bending of solid wood, scarf joint, and mortise and tenon joint by this time. Around the world, the production of barrels, tubs or buckets entailed some technique of bending, carving, or tying the planks together by a more flexible branch



material.<sup>44</sup> The dominance of beech furniture in Europe can be accounted for the transfer of long developed techniques associated with barrel production in oak, which also belongs to the Fagaceae or beech family. Curiously the development of barrel making has led to reduced curvature of the body and larger bottom plate, into a more cylindrical, and structurally weaker, form. The traditional method employed planks with approximately 20 percent moisture content to avoid cracking in the wood, but it also required longer drying period than the artificially dried planks bent into the form. This shows a case where production efficiency is at odds with structural advantage as a result of greater curvature.<sup>45</sup> These negotiations can be seen throughout the technological history.

Since the 1970s, board materials have been the fastest growing area in the timber industry for construction, furniture, and as substitution for solid timber, largely due to the lowered deficiencies than in solid timber, such as high degree of variability, anisotropy in both strength and moisture movement, dimensional instability caused by humidity, and dimensional limitations especially in width. These characteristics that eliminated issues of solid timber guaranteed products of higher consistency, a common attribute in all engineered woods that followed.

### key influences on plywood development

	tools	materials	economy	applications
<b>1800</b>	circular saw (1805) early bandsaw (1808)	bent wood (since 14th century)	Industrial Revolution (1760-1840)	decorative veneers on furniture (since 2500 BC)
	rotary veneer cutter (1819 Europe, 1850 US, 1907 Japan)		railways (1820)	experimental furniture (1830s)
<b>1850</b>	solid wood bending machine (1850s)	mechanical veneer production; mechanical wood bending (1850-)	international expos and trade flourish (1851-)	furniture and piano industry (1860s)
<b>1900</b>	band saw (1870)		Long Depression (1873-96)	flush doors railroad cars, buses (1890s)
	hot-plate press (1896)	casein adhesive (1892) waterproof adhesive (1896)		
		softwood plywood (1905-)	WW1 (1914-18) financial panic (1918)	aeronautical (WW1)
		synthetic resins (1920) first 4x8 plywood, US (1928) Luan from Southeast Asia (1931)	Great Depression (1929-39)	automobiles (1920) building industry (1928)
<b>1950</b>		resin adhesive (WW2)	WW2 (1939-45) housing shortage and surge of prefab houses	moulded ply (WW2)
	numerical control, MIT (1952) nail gun (1956)			

Fig. 2.3.1 Key influences on plywood development

With these advantages of plywood, the employment of the material spread to various industries, with the representative uses today shown in the following table:

Type	Applications
Architectural	Exterior wall, interior panel, scaffolding, floor, roof substrate, concrete formwork, fence, structural shear wall
Fixtures	Screen, door, window frame
Furniture	Dresser, drawer, table, chair
Display	Signboard, ornament
Vehicles	Platform and floors for cars and trucks, baseboard
Ships	Deck, outer structural wall, floor, interior panel
Aircraft	Spar flange, wing, fuselage covering
Packaging and shipping	Pallet, shipping container, box
Other	Instrument, sports equipments such as skis, stationary, sewing machine

Fig. 2.3.1-2 Representative applications of plywood

### 2.3.2 The term *plywood*

One of the earliest references to the term plywood in an English standard dictionary is found in the Appendix of the 1913 Edition of *Chambers's Twentieth Century Dictionary*, “as: *n.*, a thin board made from three very thin layers of wood, the grain of the middle layer at right angles to the grain of the other two, cemented together under pressure.”<sup>46</sup> However an article from 1936 addresses the issue with the term plywood being a misnomer: “Whereas both the French and German equivalents, *Contreplaqué* and *Sperrholz*, stress its essential structural principle of cross-grained lamination, ‘plywood’ arbitrarily singles out a purely subsidiary characteristic of the material, implying the antithesis of rigidity to the layman, and ignores its intrinsic nature. [...] To ‘ply’ originally meant to curve, bend, or fold, as the French verb *plier*, from which it is derived.”<sup>47</sup>

Prior to the use of the term circulated during World War I, the products were called veneered or veneered stock, and the process was called veneering. A negative connotation associated with veneers was detrimental to the growth and promotion of a rapidly expanding industry.<sup>48</sup> To address this problem, association meetings were held at the Forest Products Laboratory at Madison, Wisconsin, the term plywood emerged and was adopted. By 1919, the Veneer Association was renamed the Plywood Manufacturers Association in Chicago and the industry made progress toward favorable recognition.<sup>49</sup>

### **2.3.3 Technological developments**

The first world war (1914-18) contributed to the development of plywood industry due to its demand for aeronautical purposes, chiefly in terms of the quantity produced and perfecting of waterproof glues by the chemists. The second world war (1939-45) saw further developments that would ensure uniform strength for structural uses, so much so that “the mid-twentieth century may well become known to woodworkers as the ‘plywood era.’”<sup>50</sup> One of the most iconic plywood objects from the second world war is the moulded plywood leg splints developed for the US Navy in 1941 by Charles and Ray Eames, an early examples of moulding plywood into double curvature.

### **2.3.4 Production of veneers**

Veneers are generally categorized into decorative and structural. The early cases of plywood, made by hand, all belonged to the decorative category. Decorative veneers, as the name suggests, are applied to enhance the aesthetic appearance of a product and are occasionally sliced, rather than rotary cut, to a thickness of 0.6 to 0.8 mm. Their values are determined by rarity, beauty and difficulty of conversion from the log.<sup>51</sup>

Initially the capability of cutting planks into very thin slices by a pit saw enabled the application of decorative wood, by sawing a board into two leaves and opening these up as a book-fashion to obtain a reasonably good match of the grain pattern by a technique currently known as ‘matching’.<sup>52</sup> In this sense, the sliced veneers were considered preferable to the solid planks in the past, and the process required skilled workers to achieve the effect.

Since decorative veneers are derived from high quality timber and wood grain pattern is crucial to their value, they are often sliced instead of rotary cut, depending on the species. Oak is a typical example of the sliced process. Resulting flitch would have a straight grain, although the width is limited to the radius of the trunk. Species such as oak, mahogany, red gum, also known as eucalyptus, are often processed by slicers to produce veneers for instruments and furniture. In Japan, flitch is also applied in Japanese oak and cedar ceiling boards displaying their straight grain.<sup>53</sup> Without the need for the veneers to be continuous and rolled up as in the rotary lathe, the thickness of the veneer can be as thin as 0.15 mm.

Approximately 95 percent of all veneers since the mid-twentieth century are processed through the rotary lathe, which has higher productivity than either sawing or the slicer in speed and scale. The length of the veneer is limited only by the thickness of the log as it is continuously peeled, and the width by the height of the log and the size of the lathe. For the purpose of building up laminates for strength, such as in typical plywood products, structural veneers are applied. Structural veneers are typically rotary cut into thickness between 0.6 to 4 mm.<sup>54</sup> The downside of this method is that the resulting cross grain is more prone to shrinkage and expansion, causing small cracks on the surface of the veneer. Also with certain species of wood the grain pattern is often not as expressive as the sliced decorative veneers.

Moisture content, presence of tension wood, mineral and resin content are characteristics of wood that can affect the quality of surface and finish, such as raised grain, which is the difference in height between early and late wood on a planed surface.<sup>55</sup> The machinery involved in processing board materials are smaller in comparison to log conversion, and include circular saws, narrow bandsaws, planers, routers, spindle molders,<sup>56</sup> and sanders as the basic tools. As the machineries are also adjusted in accordance to the characteristics of the wood. A few examples of the precautions to be noted for the use of the circular saw are that teeth must be higher for hardwoods than for softwoods; rip-sawing timber blades with a positive hook angle are used, while cross-cutting blades have negative hook angle and also more teeth; tungsten-carbide tipped (TCT) are recommended and polycrystalline diamond tipped (PDT) blades for long production runs.<sup>57</sup>

### 2.3.5 Tools for veneer production

The invention of the circular saw, as mentioned previously, dates back to the early nineteenth century with the first patent issued in the late eighteenth century. When it came into general use in the 1840s, the circular saw pioneered the way for the development of slicing or shaving machines for the purpose of “cutting thick shavings of wood that were used for boxes and or ornamental purposes,”<sup>58</sup> and the modern rotary lathe machines to follow. The first circular veneer saw in the UK, erected in Battersea in 1805, was able to produce veneer of approximately 1/16 inch (1.59 mm) thick until replaced by veneer slicers by 1935.<sup>59</sup>

Although sawing is better than slicing in that sawing distorts the wood fibers less than slicing or rotary-cutting, it is more costly since a thickness equal to or more than the resulting veneer was turned into sawdust and lost. The first mechanical slicer appeared in France in 1830, and it would later enable large scale of veneer to be obtained from the log. In the US, John Dressor received a patent in 1840 for the invention of the hand-crank veneer lathe.

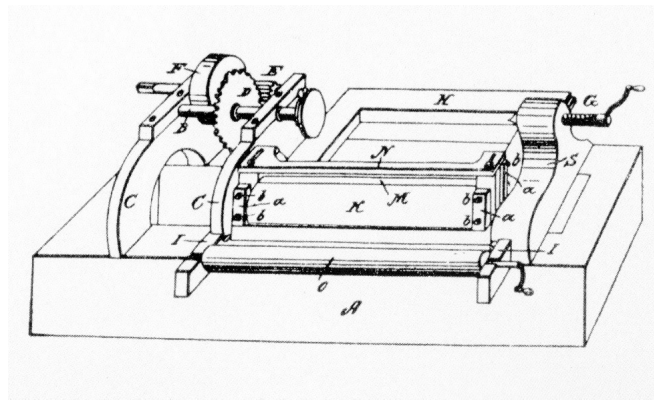


Fig. 2.3.5 A hand-cranked veneer lathe patented in the United States by John Dresser, in 1840.<sup>60</sup>

The introduction of the steam engine powered lathe in 1890 marked the shift from handmade and delicate craft of veneer making to mechanized production. The steam-powered rotary cutter, which was also called a veneer peeler, was a much larger version of Dresser's version that utilized the principle of turning a thick dowel of wood against a stationary blade to produce continuous veneer sheet, unprecedented in size, quality, and

consistency.<sup>61</sup>

Early plywood produced and imported into the UK beginning around 1890s up to 1906, had typical problems such as plies lifting and corrugating, uneven surfaces warpage. It was in 1912 when the quality of plywood became adequately reliable in terms of glue and flatness that furniture and joint manufacturers were able to apply them in place of thin lumber for such work as “carcass-backs, dust-boards and drawer-bottoms,” beyond the previously limited low-quality product “suitable only for box-making, backs of mirrors and picture frames.”<sup>62</sup> It is evident that early phase of plywood experienced its share of technical trials and errors, but most central aspects of the development of plywood in modernized industry corresponded with the development of the adhesives, rotary lathe and the press.

### **2.3.6 Adhesives: From organic to synthetic**

Adhesive is the other primary material in plywood aside from the veneers. Prior to 1939, plywood was categorized into three types: Dry-glued, semi-dry glued and wet-glued, although at the time the term ‘cemented’ was more commonly used in place of ‘glued’.<sup>63</sup> Referring to the state of the treatment of veneers, the dry-glued plywood employed veneers that had been dried to the predetermined moisture content, and therefore most reliable of the category and most expensive. The wet-glued type has fallen out of favor in most mills by 1960.

The unstable and inferior quality of the adhesives in the early stages of manufacturing plywood led to its undermined use and applications. The better options early on were casein glue, derived from milk protein, and blood-albumin glue, derived from animal blood such as cows. Both, separately or mixed, were in extensive use for decades, but in 1920s synthetic resins were developed from plastic technologies, which drastically advanced the material in terms of strength and durability.<sup>64</sup>

The first patented waterproof glue was introduced in 1896 by the furniture maker A. M. Luther Company. It was developed by the Luther brother’s cousin and chemical engineer Oscar Paulsen, who had joined the company three years prior.<sup>65</sup> The previous version introduced in 1892 and was also patented, was based on casein, water and slaked

lime, and was not waterproof. This earlier type was meant to be applied in the same way as joiners' glue, but cold. The waterproof version four years later was achieved "by introducing a chemical reaction to the glueing process, and this involved mixing an alkali with an albuminous substance [...] based on the balance of chemicals and the fact that '[a] mixture containing an excess of alkali, becomes after a time insoluble in water at an ordinary temperature.' [...] In addition to explaining the chemical reaction involved, this patent specification from 1896 also contained a description of how 'the surfaces to be united should be treated with mixture, allowed to dry, and then pressed together between hot iron surfaces.'"<sup>66</sup> The process enabled two significant outcomes: Pre-treated components could be stored and transported independently according to the need and the cycle of production, and the separation of glueing and pressing operations allowed for the divisions within the production cycle, with increased flexibility.

An article from 1939 notes the latest Forest Products Research Laboratory's investigation of four types of glue commonly in use: "(1) an animal glue of the Scotch blue type; (2) a Casein (cold water) glue; (3) a Blood Albumen (hot press) glue; (4) a synthetic resin of the film type."<sup>67</sup> Examining their qualities, it was concluded that, "Animal glue, Casein and Blood Albumen were all found to be unsuited for prolonged use in warm humid conditions. The first two were found to be insufficiently proof against moisture and lost adhesive power so that the material broke down into its separate laminae. [...] The synthetic resin emerged after one month apparently unaffected."<sup>68</sup>

### **2.3.7 The press**

Throughout history, there have been attempts to apply pressure for plywood production to ensure a reliable bond between veneers and adhesive and especially for bent-plywood forms. These efforts were seen in heated sand bags in ancient Egypt to manually-attached wood and metal clamps in the 1700s.<sup>69</sup>

In 1896, Luther helped transform the industry with the invention of the hot-plate press in addition to the development of adhesive. Using hydraulic pressure, Luther's press utilized steam-generated heat during the pressing to speed up the glue drying, reducing the 'press



time' from days to a matter of minutes.<sup>70</sup> The patent specification from that year describes how "the surfaces to be united should be treated with the mixture, allowed to dry, and then pressed together between hot iron surfaces."<sup>71</sup>

As a result, the nature of the construction of plywood makes the product very stable in comparison to solid wood, as movements, or the working of wood, are restricted by the stable axial direction of the veneers composing adjacent layers; the expansion or contraction of a plywood in 3-ply board that is 60 in. wide (1524 mm), for example, will not expand more than 1/20 in. (1.27 mm) even when exposed to damp.<sup>72</sup> Additionally its increased resistance to splitting and shear, and the symmetrical character in bending resistance due to its construction also contribute to its wider use.

### **2.3.8 Applications in furniture**

Furniture industry was most instrumental in the early development of plywood. Especially in the making of chairs, the desired curvature to conform to a person's seated position was painstakingly realized through carving of wood, sometimes with elaborate joints such as in the Ming dynasty Chinese chair with continuous arm and back piece. It would later inspire European designers including Hans Wegner. One of the answers for a more efficient process of realizing such curved forms was brought by steam, an emblematic force behind industrialization, that allowed ease in bending of wood.

Thomas Chippendale, an eighteenth century English furniture designer and craftsman, provides an example of the pre-modern laminated wood application. Pevsner writes that *Age of Satinwood* by Percy Macquoid was probably "the first to mention that Chippendale's dining room chairs for Osterley Park, designed by Robert Adam in or before 1773, have back splats 'composed of layers of mahogany in three plies.'"<sup>73</sup>

It was in the late 1870s in the United States and around 1885 in Reval, which is known today as Tallin, Estonia, that the knowledge of three pieces of wood glued together with the middle being laid with the grain across would be applied beyond the master cabinet-makers to the construction of chair seats.<sup>74</sup> The plywood furniture and chairs by George Gardner's Gardner & Company (1863 - 1887) based in New York, USA, were

developed “to offer a cheaper, stronger, and more durable alternative to the cane seat,” and involved a double-sided press, or caul, in which the glued veneers were steamed under pressure and then dried.<sup>75</sup> Their process involved bending of a finished plywood, and their products would have profound influence on the European manufacturers.

Christian Luther came across these Gardner seats in 1884 according to Pevsner.<sup>76</sup> That same year, Luther would develop their rotary cutter to aid its production. A. M. Luther’s early chairs were almost identical to those of Gardner in both technique and designs. It was due to Luther brothers’ limited experience in using plywood for structural purposes, and the range of products were simply labeled “American furniture.”<sup>77</sup> Their bent plywood production of continuous surface component forming the seat and back began in 1889.<sup>78</sup>

While plywood had remained basically unknown to many of the other furniture manufacturers in 1914, it had become an essential raw material for them by 1930, representing 15 per cent of the total costs of labor, materials and overheads.<sup>79</sup> In other industries, the American piano manufacturer Steinway & Sons Co. had already begun to produce own plywood in 1860, and door manufacturers started to use plywood in 1890. Around 1920, the material was also promoted to the automobile industry in the US. It expanded rapidly during the first world war and beyond.

### **2.3.9 Thonet’s experimentations with plywood**

Michael Thonet, a cabinet maker located in Boppard on the Rhine, Germany, began experiments in bending of veneers of wood, starting in 1830 with chair parts of laminated veneers. Prior to this experiment, veneers from special woods were only used as face veneers for fine surface layer of furniture in a traditional manner to hide imperfections of the lesser quality wood below. There were also some cases of working with laminated wood prior to this period, but not to the extent of techniques and ambitions of Thonet. He attempted to glue several layers of thin, less costly veneers in heated wooden forms, although these parts were not the structural elements of furniture yet.

Thonet soon moved on to making whole chairs with this technique, boiling the

wooden slats in glue to encourage the bending process. The widths and number of layers in different parts of the chairs varied, but “the main elements, such as the legs or side pieces, were made from five veneer strips measuring approximately 2.5 centimeters (1 inch wide) and .4 centimeters (5/32 inch) thick.”<sup>80</sup>

He relocated to Vienna in 1842 with the support of Prince Klemens von Metternich, first working for the Leistler firm, and later establishing his own firm in 1849. Gebrüder Thonet, or Thonet Brothers, of Vienna was founded in 1853, named for Michael Thonet’s five sons.<sup>81</sup> The opening of the Koritschan factory would mark the symbolic beginning of industrial mass production: No craftsmen or cabinetmakers were employed for the first time, and the facility was capable of producing 10,000 articles of furniture in the first year, which jumped to 50,000 by the year 1860. The significance of production methods and its structure at the factory was particularly based on the fact that the Thonets invented and built all the necessary machinery, “crudely made but nonetheless essential to the greatly increased growth in production,” from multiple-blade saw for cutting logs, circular and bandsaws for cutting planks, lathes for turning wood, some belt-type sanding machines, steam retorts, and iron molds used in treating and bending the wood.<sup>82</sup>

The experiments in laminated veneers turned out to more problematic due to the inadequate quality of adhesive at the time. First shipment of Thonet plywood furniture turned into a disaster when the adhesive could not withstand humidity, far beyond that of Germany and Australia. These setbacks would push Thonet towards working with bent solid wood pieces, which became an enormous success.

Stylistically, the early chairs dating around 1836 and 1840 emulated the late Biedermeier style, popular in Germany in the first half of the nineteenth century to the earliest recorded representations of moulded plywood chairs. A similarly shaped table legs that Thonet exhibited at the Great Exhibition of 1851 incorporated thin sheet metal sandwiched between the veneers, enabling tight curvature and fooling the eyes of the visitors that it the structure was entirely made of wood. Over time, especially after the advancement and utilitarian applications of plywood during the war, the forms and assembly began to reflect attributes specific to plywood. Thonet also began to develop his own, more

streamlined forms subsequently.



Fig. 2.3.9 Thonet's early experiments with laminated veneer furniture, from left to right: A chair dating between 1836-40 and its detail of the leg composed of glued bent veneers,<sup>83</sup> experimental chair from laminated veneers from 1880 and a scale model showing its construction.<sup>84</sup>

Thonet had targeted the international market from the very beginning, and the information for the customer was printed in at least four languages, typically German, French, Italian, and English. "The typical text was as follows: The wood for this furniture is first cut in the direction of the grain and then bent solid to the desired shape, thus combining strength, elegance, and elasticity. The separate parts are united by screws without using glue. A case with 3 dozen chairs, when they are taken to pieces, occupies a space of 36 cubic feet. These articles are manufactured of beechwood, and may be polished in their natural color or stained like rosewood, walnut, or mahogany."<sup>85</sup>

Thonet's most significant and widespread bent wood chair, No. 14, later came to be regarded to as 'the first consumer chair' with only six pieces of bent wood, ten screws, and two washers. As experimented in earlier models, the strength, light weight, and the affordability of the No. 14 led to it becoming the most popular commercial chair of the nineteenth century, and perhaps, of the last two centuries.<sup>86</sup> The manufacture of unassembled furniture was unheard of, and its popularity spread quickly as branch offices were opened in Budapest, Paris, London, Prague, Berlin, Hamburg, Rotterdam, and Brno from 1861 to 1866.

Pevsner, in comparing to the twelfth century technicians who invented and introduced the cross-rib vaulting to the architect in search of the new idiom which would later become Gothic: “so the modern designer soon began to realize that plywood was the very material for achieving those flush surfaces without which his aesthetic ideals could not be expressed.”<sup>87</sup>

### **2.3.10 The process**

Typical process of making of modern plywood:<sup>88</sup>

1. Logs transported to processing factory
2. Logs cut into suitable dimensions
3. Veneers peeled off
4. Veneers dried
5. Veneers cut into suitable dimensions
6. Narrow veneer sheets joined together
7. Adhesive spread on veneers
8. Pressurized and glued; initial bonding
9. Heated and pressurized; final bonding
10. Boards cut into suitable dimensions
11. Surfaces smoothed out and finished
12. Checked and packed for shipment

Between steps 2 and 3, after the logs are cut to size and before the peeling of veneers, where the moisture content of the log is raised to around 40 percent by soaking in water at 120 degrees Fahrenheit, or about 50 degrees Celsius. By comparison, kiln-dried timber has around 7 percent and live trees has around 20 percent moisture content. During this process, the cell structure of the wood is loosened, minimizing the tearing and breaking in the next step of peeling.<sup>89</sup>



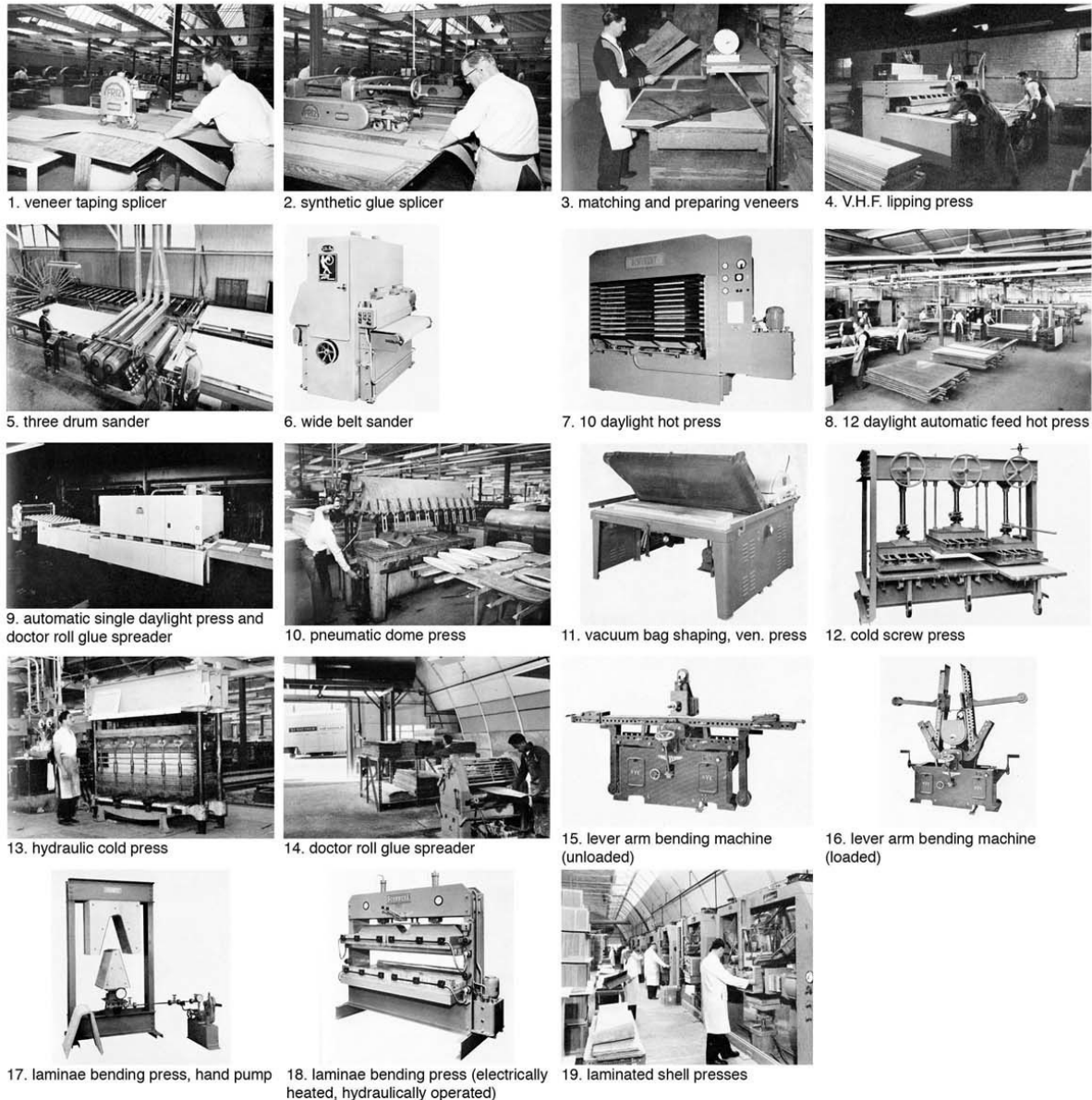
Fig. 2.3.10 Stills from an instructional film, “Plywood in the Making” published in the Architectural Review from 1936 shows the process of birch plywood production typical in northern Europe:<sup>90</sup> 1. Selection of trees; 2. Logs are sorted by size, quality, and ownership; 3. Logs transported to the manufacturer; 4-6. Logs being punted into the sawmill; 7-9. Sorted and cut into appropriate lengths; 10. Bark is roughly sliced off; 11. The wet log is peeled on the veneer lathe; 12-13. Gaboon (West African hardwood, also known as Okuome) logs provide a scale comparison to the birch; 14-15. Cutting by a slicer into required lengths, while smaller strips are connected with paper tape; 16. The wet sheets of veneer are placed onto the racks of drying kiln; 17-19. Veneers after kiln dried; 20. The “liquid cement” – a compound of blood albumen and casein – kept in the heated cauldron at the right consistency; 21. Veneers fed through cementing rollers; 22. Stacked veneers are subjected to regulated pressure and increasing heat; 23. Flat and rigid sheets of plywood

after emerging from the steam press; 24. Uneven edges are trimmed off by a slicer, the surface are fed through planing and sanding machines; 25. Checking by wooden mallet for loose knots or cavities; 26-28. Plywood boards are stacked for shipment.

### **2.3.11 Machinery in plywood production**

The basic process of manufacturing veneers into moulded plywood requires a number of industrial machines, which are highlighted below in a publication from 1965. In the types of factories where these photos were taken, it is more common to purchase the veneers, as that facility alone requires extensive space and machineries. The typical moulding process, just like ordinary plywood, requires the press that is heated either by electricity or steam. For small operations, vacuum method may be used alternatively, or hydraulically pressed without the addition of heat. While transportation methods, type of adhesive, machineries used and the manufacturing systems may have changed, the basic process remains very comparable to the one employed today.

### Veneering and Wood Bending: Process and machinery (1965)



Plywood process images from: Clark, W. *Veneering and Wood Bending in the Furniture Industry*. Oxford: Pergamon Press, 1965.

credits:

1, 2, 3, 4, 8, 10, 13: by courtesy of Harris Lebus Limited  
 5, 9, 11, 14, 19: by courtesy of Interwood Limited  
 6: by courtesy of Thos. White & Sons Limited  
 7, 12, 17, 18: by courtesy of H. Schubert Limited  
 15, 16: by courtesy of Rye Engineering Limited

Fig. 2.3.11 Process and machinery for veneering and wood bending from 1965<sup>91</sup>

### 2.3.12 History of moulded plywood

Moulded plywood not only shares the same early history and ambitions of plywood, and it can be said that moulded plywood pioneered the way for plywood in a substantial way. The first forms of ancient plywood, such as the ones in Egypt, were decorative with sheets of



veneer sawn by hand applied on the surface. The capability of modern plywood's cutting of logs by mechanical means, first by the circular saw, then the band saw and the rotary veneer cutter, meant that the thin, pliable sheets of wood can be manipulated in ways that were previously impossible except through labor intensive techniques such as carving, slicing thin sheets by hand tools. Bending of solid pieces, historically, had also been laborious before the advent of steam from the industrial revolution. From the invention of the tools necessary to manufacture thin veneers in large quantities, there were experimentations in smaller furniture factories, testing the material characteristics and suitable forms, prior to the large scale plywood factories.

Initially, in these smaller scale factories, the designs emulated the popular styles of the time that was not fully taking advantage of how moulded plywood is understood today. An example is the case of Thonet applying the then-popular late Biedermeier style in Germany in the first half of the nineteenth century, as discussed earlier. Over time, especially after the advancement and utilitarian applications of plywood during the war, the forms and assembly began to reflect attributes specific to plywood.

The composition and process of moulded plywood also correspond with that of plywood. Composed of veneers which can vary from 0.2 to 2.5 mm thick, but more typically between 1 to 2.5 mm for moulded plywood, most of which are rotary cut. Standard plywood employ 0.6 to 0.8 mm thick veneers in comparison, although it is dependent on the species. Naturally, the thinner veneers under 0.8 mm can be bent at tighter curvature. Each of the veneers are laid cross-grain to the one below and above it, for a total of odd numbered layers. Depending on the structure the direction of the grain may be the same for all of the stacked layers, meaning that they are parallel for all layers – technically these are called laminated wood, instead of plywood.

After each of the veneers are coated with adhesive, typically polyvinyl acetate or urea formaldehyde, they are stacked and placed in the mould while wet. One of the two most common moulds is made of wood, which is sheathed in a high-conductor metal, for the dielectric process with high-frequency radio waves to produce heat. The other type of mould is made from cast aluminum, which uses high pressure instead of electricity. The process can

take between 5 to 20 minutes, depending on the thickness of the total layers and the moulding process used.<sup>92</sup> Since time equals cost in manufacturing, it has been critical to minimize processing time through design engineering.

Dominant species of wood employed for the veneers vary by region. Maple and oak have been the standard in the United States, whereas beech and birch are much more common in Europe. In Japan, beech is the one of the first materials used since they could be harvested in most places throughout the country, from Hokkaido to Kagoshima, and also due to their characteristic pliability that is suitable for bending.

Reduction of time and of material loss were significant appeal of the moulded plywood and laminated veneer bending fabrication, compared to the conventional carving process. The commodification of manufactured products in the general market would affect the pattern of consumption, especially in the furniture industry early on; the choices, affordability and marketing of products were unprecedented. Technically, the use of plywood in aircrafts during the two world wars, which succeeded in achieving lightness, structural integrity and durability, enhanced the prospects for further applications.

## **2.4 Timeline**

The following timeline was organized in order to highlight events associated with the development of modern plywood alongside events associated with craft, art, design and other major technological breakthroughs. By showing the events adjacently it is possible to compare, for example, that the early decades of experimentation and commercialization of bent wood and plywood techniques in Europe and the US occur simultaneously as the early trends of international expositions, craft movements, and rapidly growing industrial capacities. The expositions were important opportunities to display manufacturing techniques and new or exotic products from around the world, in order to promote trade and industry. The process of closure and stabilization can be gleaned through plywood's technical changes.

### Key technical changes

1830 - 1875	Earliest experimental iterations in plywood furniture
1850	Successful mechanical veneer production
1875 - 1920	Quantity plywood furniture production
1890	Use in other industries spread
1892	Significant improvements in adhesive
1902	Derivatives of engineered wood begin to emerge
1920 - 1970	New plywood furniture designs, combination with other materials
1928	Standardization of panels (4 x 8)

## MODERN PLYWOOD TIMELINE

### craft, art, design, technological events

- 1794 École Polytechnique founded in Paris, the first Grandes Écoles to train technocrats in science and engineering.
- 1800 Modern conventions for drawings of buildings established – Jean-Nicolas-Louis Durand at École Polytechnique publishes graphic documentations of buildings in the *Recueil*.  
Polytechnic schools founded throughout German-speaking Europe, - 1855. (BA)
- 1805 Gas lighting in mills. (BA)
- 1811 **Luddite movement** in the UK, where textile artisans protest against and destroy machinery – first movement against industrialization, - 1817.
- 1818 Institution of Civil Engineers founded in the UK.

1800

### plywood-related events

- 1779 British naval engineer, Samuel Bentham, applies for patent with the concept of gluing layers of veneer to form a thicker piece, essentially the idea of plywood.

- 1805 Invention of the **circular saw** – the first patent had been granted in 1777 to Samuel Miller in England, but did not reach the point of utility until 1805, when a circular veneer saw was erected in Battersea, producing veneers around 1/16 in thick. (AW)



One of the earliest bent solid wood chair dated 1805, by Belgian chairmaker Jean-Joseph Chapuis, who also experimented with veneers (DO)



Another early bent solid wood chair between 1805-08, by Boston furniture maker Samuel Gragg, who received a patent for an "elastic chair" in 1807 (GZ)

- 1808 **Invention of band saw**, patented by William Newberry in England. (TP)
- 1819 **Rotary veneer cutter** invented in Reval, Russia (currently Tallinn, Estonia), as

- 1820s **Mathematical analysis** of structural elastic behavior (stress and strain) by Navier. (BA)
- 1821 **First Mechanics' Institutes** founded in Edinburgh, Scotland.
- 1823 Mechanics' Institutes in UK, teaching "geometry, mechanical drawing and drawing of ornament, the human figure and landscape." (GN)
- 1824 **Portland cement** manufacture patented by Joseph Aspdin.
- 1825 **Aluminum** first produced.
- 1829 **École Centrale des Arts et Manufactures** founded in Paris.
- 1830 End of first Industrial Revolution, 1760-1830.  
**JP** - Beginning of commercialization of craft-making and hand-based manufacture with wholesaler.  
**Swing Riots** in the UK, where agricultural workers destroyed threshing machines as a protest against the system and rich tenant farmers who profited from lowered wages and use of agricultural machinery.  
**I-beam** developed.  
**First passenger trains.**

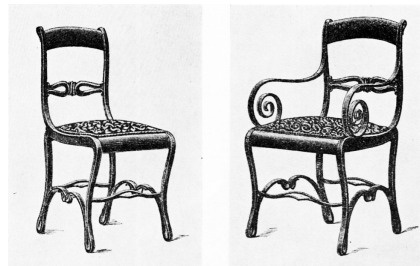
## 1820

- 1820- Rotary veneer cutter introduced to Western Europe, between 1820-50. (JK)

recorded in the *Great Soviet Encyclopedia* of 1934. (JK)

## 1830

- 1830 Initial experimentations by **Michael Thonet** with thick veneers bent under heat and glued together, as an alternative to carving. (CW)



Thonet chairs made of bent plywood between 1836 - 40 (NP)

**US** - Earliest application of plywood in the **piano industry**, the first North

1837 **The Government School of Design**  
founded in Somerset House, London.  
Later renamed the Royal College of Art.

1840s First **artificially cooled buildings**.  
First **rolled wrought iron** sections.  
US - fireproof cast iron construction.  
(BA)

1844 **French Industrial Exposition.**

1847 **Exhibition of Art Manufactures**,  
organized by the Royal Society of Arts  
(officially known as the Royal Society for  
the encouragement of Arts,  
Manufactures and Commerce), UK.

1848 **Pre-Raphaelite Brotherhood** founded  
by D. G. Rossetti, J. E. Millais, W. H.  
Hunt.

1849 **The Journal of Design and  
Manufactures**, H. Cole and R.  
Redgrave. Last issue, 1852.  
**Exposition Nationale des produits de  
l'industrie agricole et manufacturière**,  
Paris.

1850s **Reinforced concrete** first used and  
patented by W.B. Wilkinson and Joseph-  
Louis Lambot.  
**'Factor of safety'** by William Rankine.  
**Blueprint reproduction** from original  
drawing. (BA)

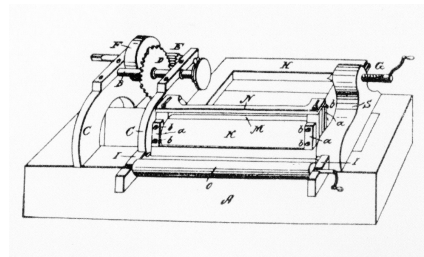
## 1840

1840 **Circular saw** comes into general use.  
(TP)

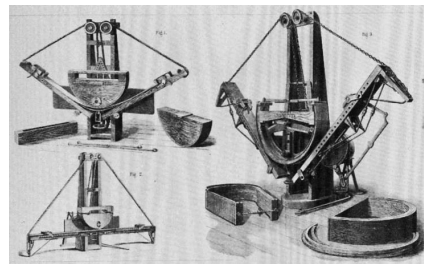
**Timber formwork for concrete**

developed for reuse without full  
disassembly.

**US** - John Dresser patents the **hand-  
crank veneer lathe**. (DN)



Hand-crank veneer lathe drawing for patent,  
by John Dresser in 1840 (DN)



Wood bending machine from Ohio, mid-19th  
century (CW)

## 1850

1850- Immanuel Nobel invents the **rotary  
lathe** used in plywood manufacturing,  
mid-1800s, in Stockholm. (PP)  
Method of **bending solid wood**  
**developed by Thonet**, mostly  
abandons experiments with plywood.  
(CW)

1851 ***The Great Exhibition of the Works of Industry of All Nations*** at the Crystal Palace in London, organized by H. Cole and Prince Albert, under four categories: raw materials, machinery, manufacturers, and fine arts.

***The Four Elements of Architecture*** by Gottfried Semper.

1852 *Science, Industry, and Art* by Gottfried Semper.

1854 **JP - Sakoku ends.**

1855 **Mass production of steel** begins.

***Exposition Universelle*** in Paris, held at the Palais de l'Industrie. Held again in 1867, 1878, 1889, and 1900.

1856 ***The Grammar of Ornament*** by Owen Jones.

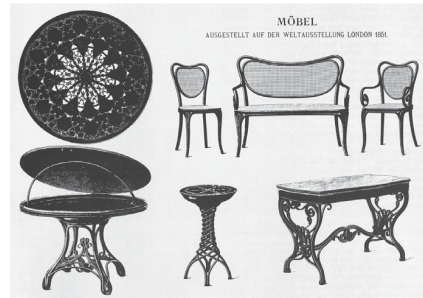


Example of the Egyptian patterns depicted in the *Grammar of Ornament* (OJ)

1859 William Morris' **Red House** designed by Philip Webb.

***On the Origin of Species*** by Charles Darwin.

1851 Thonet furniture shown at the Great Exhibition, London. (CW)



Thonet and sons, furniture for the Great Exhibition, 1951 (CW)

1856 **Thonet patents solid wood bending technique.** (CW)

1857 **Gebrüder Thonet/ Thonet Brothers'** Koritschan factory opened to enable industrial mass production (no craftsmen or cabinet makers were employed for the first time; 10,000 articles of furniture produced in 1857, and 50,000 by 1860). (CW)



"The first consumer chair" No. 14 from bent wood by Thonet, 1859 (CW)

# I 1860

- 1860 **Arts and Crafts movement**, UK.  
**Aestheticism/ Aesthetic Movement.**  
**Lightbulb** by Sir Joseph Wilson Swan.  
Use of bending moment and shear force diagrams by Karl Culmann.
- 1861 **Morris, Marshall, Faulkner & Co.**, Fine Workman in Painting, Carving, Furniture and the Metals founded in London.  
**US - American Civil War**, - 1865.
- 1862 ***The Art of Decorative Design*** by Christopher Dresser.
- 1865 Second Industrial, or **Technological Revolution**, - 1900.

- 1860 **US** - Piano factory of **Steinway & Sons Co.** uses 8 to 12 layers of sawn veneer glued and bent with the grain direction of all layers parallel, forming laminated wood. (TP)
- 1863 **US** - Plywood furniture manufacturer **Gardner and Co.** active in New York, until around 1887.
- 1865 **US** - **First American patent issued for plywood**, then called scale board, to John K. Mayo. Re-issued in 1868. (NP)
- 1867 **US** - The Sewing Machine Cabinet Company, Indianapolis, was started by the Wheeler & Wilson Sewing Machine Company to make plywood parts for various sewing-machine cabinets. (TP)



Thonet bentwood exhibition chair by solid wood bending, late 1860s (CW)

- 1869 Thonet Brothers' patent for the manufacture of bentwood furniture expires; production by other companies and competitions begins, including **Jacob & Josef Kohn**, Vienna.

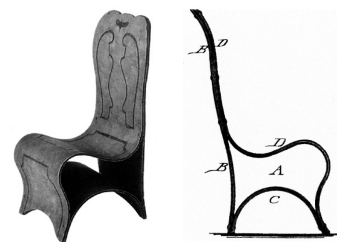


- 1870 **Hydraulic power** used for various applications.
- The Elementary Education Act** by William Forster, UK.
- 1871 **US - Chicago fire.**
- The Guild of St George, by John Ruskin.
- 1872 **JP - Elementary school education** becomes compulsory; marking the end of apprenticeship model.
- 1873 **Vienna International Exposition,** Weltausstellung 1873 Wien, with theme of culture and education. First time for Japan to participate in an international expo.
- JP - Imperial College of Engineering** founded.
- 1875 **Meter Convention,** the Treaty of the Meter, signed by representatives of 17 countries in Paris.
- Finnish Society of Crafts and Design** established as design-industry organization.
- 1876 **US - Centennial International Exhibition** in Philadelphia.
- 1877 **JP - The first Domestic Industrial Exhibition** in Japan, in Ueno, Tokyo.

## 1870

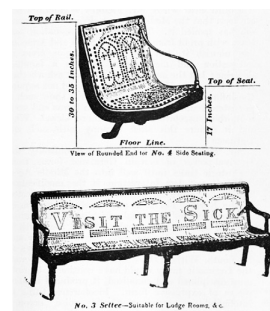
- 1870 Use of **band saws** spread. (TP)

- 1872 **US - American patent** granted to George Gardner, **Gardner & Co.**, New York, for a three-ply veneer chair seat; reissued in 1876; production for bent perforated sheets for chair seats and backs begins. (NP)



Issac Cole, one piece plywood chair, 1873 left (VT); right (DN) for which he received a patent in the US

- 1875 **US - First recorded use of cross-ply curved plywood by Gardner & Co.**, New York, to form seating for stations, where the layers were bent in the forms while the glue was still wet. (TP)



Bent and perforated benches for railway stations and hospital waiting rooms, in Gardner and Co. catalogue published in 1875 (NP)

1880s **Iron and steel frame construction** of high-rise buildings. (BA)

**1880**

1882 **Century guild** established by A. H. Mackmurdo to preserve craft artistry, - 1892.

1883 Paris Convention for the Protection of Industrial Property, signed initially by 11 countries.

1884 UK adopts meter convention.  
**Art-Workers' Guild** established by W. R. Lethaby in opposition to the systems of the Royal Academy and RIBA.

1885 **JP** - Japan adopts meter convention.



Gardner and Co. chair from mid 1870s to early 1880s, costing \$3.25 in 1875. (JK)

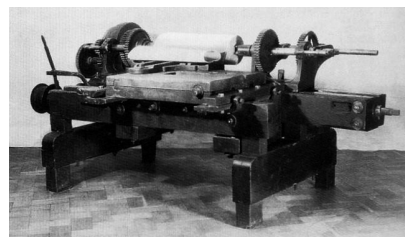


Thonet chair from 1880. (VT)



Thonet experimental chair from laminated veneers, process shown on right, 1880 (CW)

1883 **US** - Plywood desk top with **lumber cores** developed in the plant of the Indianapolis Cabinet Company; a number of other manufacturers producing it by 1890. (TP)

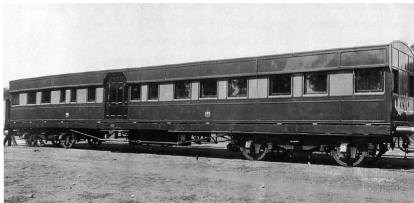


A. M. Luther's first rotary veneer cutting machine, 1884. (JK)

1885 **Plywood production** begins at the

- 1886 **JP** - German architect **Hermann Muthesius** in Japan until 1890, bringing ideas of Arts and Crafts and what would later become Bauhaus.
- 1887 **The Arts and Crafts Exhibition Society** established by Walter Crane, promoting the exhibition of decorative arts and fine arts.  
**JP** - **First craft-design kogeï school** opens in Kanazawa, **Tokyo School of Fine Arts** founded, headed by Tenshin Okakura, current Tokyo Univ of the Arts.
- 1888 **The Guild and School of Handicraft** by C. R. Ashbee.  
*The Revival of Architecture* by William Morris.
- 1889 **Eiffel Tower** and **Paris Exposition**.  
First use of wind bracing in tall buildings.
- 1890 **Art Nouveau**, aka Jugendstil.  
First reinforced concrete frame buildings.  
Many **university-based research** institutes founded, - 1920s.  
Gaudi's masonry structure models.  
*News from Nowhere* by William Morris.
- 1892 **Reinforced concrete system** patented by François Hennebique. (BA)  
*The Claims of Decorative Art* by Walter Crane.

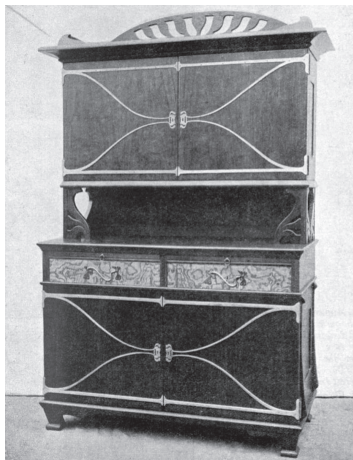
## 1890

- Christian Luther's factory – **A. M. Luther Company** for Mechanical Woodworking was founded in 1877 in Reval (Tallinn); selling 48,000 three-ply veneer sheets by the end of same year, and 135,000 seats in the following year. (JK)
- 1889 A. M. Luther Co. begins to bend plywood shells forming backs and seats in one component. (NP)
- 1890 **Increased variety** in plywood seat shapes and surface treatments.  
Use of plywood begins in **door panel construction**, producing flush door. (TP)
- 
- 1890 "Benares Saloon" and railway industry widely applied plywood boards by Luther (JK)
- 1892 **Introduction of casein glue** from milk

*Architecture, Mysticism and Myth* by  
Lethaby.

1893 **US - World's Columbian Exposition,**  
or Chicago World's Fair.

1897 **US - The Society of Arts and Crafts**  
formed in Boston, following the UK  
model and organizing the first American  
crafts exhibition in the same year.  
**Fiberglass insulation** invented by  
Russell Games Slayter.



One of the first plywood cabinetry according to N. Pevsner, a dining room sideboard by J.V. Cissarz and Karl Schmidt in Germany, 1898 (NP)

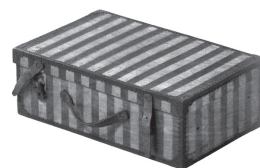
1899 Glasgow School of Art by Charles  
Rennie Mackintosh.

protein, applied cold, by A. M. Luther  
Company. (JK)

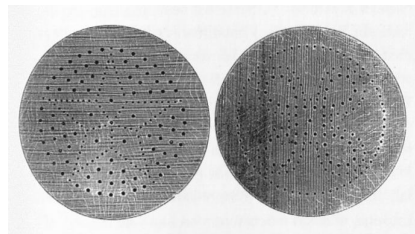
1894 **JP - Introduction of plywood** into  
Japan, brought back from World's  
Columbian Exposition by Shikazo Suwa;  
6 plywood pieces were exhibited.  
(JPMA)

1896 **Introduction of waterproof glue** by  
A. M. Luther Company. (JK)  
**Invention of the hot-plate press** by  
Christian Luther, using hydraulic  
pressure and steam-generated heat  
during pressing to speed up glue drying.  
(DN)  
Plywood made primarily for **tea-chests**  
was evolved in Reval (Tallinn), followed  
by the **commercial 3-ply board**. (AW)

1890's In the late 1890s, plywood becomes  
increasingly affordable.



1900  
plywood suit-  
case with fluted  
boards (JK)



Luther factory first plywood seats, 1900 (JK)

1900 **Electric motors** replace steam and hydraulic power.

***Exposition Universelle of 1900*** in Paris, showcasing Art Nouveau style.

**Standard design codes** for steel and concrete adopted in most countries, - 1910.

First use of **air-conditioning** in large buildings. (BA)

## 1900

1900 **JP** - President of Nihon Gakki Seizou, currently Yamaha, returns from US for research on piano manufacturing techniques, with plywood made by a veneer saw. (JPMA)



Luther office chair with plywood seat and bentwood back, 1900 (JK)

1902 Sheet glass drawing machine patented by Irving W Colburn, beginning the **mass production of glass**.

1903 **JP** - **The first International Exhibition** in Japan, held in Osaka.

1905 **US** - World's Fair in Portland, Oregon, also known as the **Lewis and Clark Centennial Exhibition**.

1902 First industrially produced **blockboard plywood** (plywood with an interior composed of strips of solid timber) by Kummel's at Rehfelde, near Berlin, Germany; later incorporated into Bruning's. (NP)

1905 **US** - Gustav Carlson from Portland Manufacturing Co. begins producing '**3-ply veneer work**' marking the **beginning of the industry in the US**. (APA)

**US** - First examples of softwood plywood, **douglas fir panels**. (TP)

**JP** - Research on plywood begins, triggered by a tea chest imported from United Kingdom obtained by Kichijiro Asano in Nagoya. (JPMA)

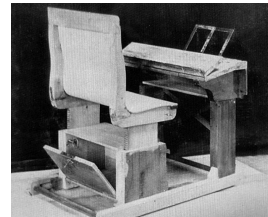
**First bent wood factory** for furniture in Tokyo. (HM)

1907 **Deutscher Werkbund**, organized by

1907 **JP** - **Industrial production of plywood**

**Bakelite plastic invented.**

1908 Luterma (A. M. Luther Mechanical  
Woodworking Factory) established  
**Venesta Plywood Company** in London.  
(JK)



First ribbed thin concrete shells.

- 1912 **Stainless steel** invented and industrialized by Harry Brearley in England.
- 1914 **World War I (1914-18)**
- 1915 The concept of **ready-mades**, or found object, established in art by Picasso and Duchamp.
- 1916 US Gypsum Co. develops **drywall**.
- 1917 ***On Growth and Form*** by D'Arcy Thompson.
- 1918 **Financial panic post WWI.**
- 1919 **Staatliches Bauhaus** founded in Weimar, Germany, by Walter Gropius.  
**JP - Farmers Art movement** led by Kanae Yamamoto, after Russian farmers' art movement.



Asano plywood variations (above) and plywood products (below), from their promotional postcards

- 1913 First Canadian plywood produced at Fraser Mills in New Westminster, British Columbia.
- 1914- World War I causes rapid advancements in **aeronautical industry** with the use of thin plywood with improved waterproof glue quality. (AW)
- 1918 **JP - Mokuzai Kogei Gakkai** (Wood Crafts Society), research group focused on wood-based interior objects, founded.
- 1919 **US - The term 'plywood' adopted** by the Veneer Manufacturers Association, which changed its name to Plywood Manufacturers Association the same year.  
**JP - First plywood factory** capable of the entire manufacturing process, founded in Hokkaido.

1920 **Art Deco** in France.  
**JP - First industrial movement.**  
Westernization of lifestyle is promoted.  
**JP - *Bunri-ha Kenchiku-kai***, or  
Secessionist Architectural Society, the  
first modern architectural movement in  
Japan with Sutemi Horiguchi and 5  
others from the Tokyo Imperial Univ.,  
- 1928.

1922 'Comfort zone' chart developed.

1923 **JP - Great Kanto Earthquake.**

1925 **Paris Exposition**, *Exposition  
Internationale des Arts Décoratifs et  
Industriels Modernes.*  
**Welding of structural steel.**

1926 **JP - Mingei movement.**  
***Mukei*** 'free form' group, - 1933.  
**National Crafts Organization**  
established.

1928 **CIAM** International Congresses of  
Modern Architecture founded, - 1959.  
**JP - *Keiji Kobo***, inspired by Deutcher  
Werkbund / Bauhaus, works toward

1920 **Development of synthetic resins** from  
plastic industries contribute to strength  
and durability of plywood. (DN)  
**US -** The primary softwood plywood  
industry begins to market to **automobile  
industry**, prior to which relied  
primarily on door panels market only,  
through Gus Bartells of Elliot Bay  
Plywood in Seattle. (APA)

1923 **JP -** Plywood demand increases post  
Great Kanto Earthquake on Jan. 09.

1925 **Laminated board** (interior composed of  
strips of solid timber, narrower than  
those used for blockboard), also known  
as laminboard, invented by Moralt's of  
Tölz, Bavaria, Germany. (NP)  
**Hardboard**, or hard density fiberboard  
(HDF), developed.

1927 **US -** Georgia-Pacific founded in  
Augusta, Georgia as the Georgia  
Hardwood Lumber Co.  
**JP -** Plywood production employing  
douglas fir and red cedar, imported from  
the US, begins.



hat-box factory products, 1895-1930 (JK)



standardization of furniture dimensions, structural and material logic, etc., led by Katsuhei Toyoguchi, - 1940.

**JP - Kogeshidousho**, National Research Institute of Industrial Arts, (NRIIA) or **Industrial Arts Institute (IAI)** founded in Sendai.

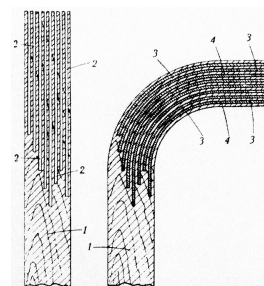
The antibiotic, **penicillin**, discovered by Alexander Fleming in London.

- 1929 **The Great Depression**, lasting throughout 1930s.
- US - The Museum of Modern Art (MoMA)** opens in New York.
- 1930 **Neoprene** invented.
- Model tests for **wide-span concrete structures** by E. Torroja and P. L. Nervi.
- 1931 The **Mukden (Manchurian) Incident**
- 1932 **US - International Style exhibition** at the Museum of Modern Art, New York.
- JP - Kogei (Craft) News** publication begins, by NRIIA, -1974.
- 1933 **Mid-century style**, - 1965.
- JP - Bruno Taut in Japan** as an adviser to IAI, - 1936.



Rietveld armchair with steel rod, 1927, left and 1927 lounge chair by Heinz and Bodo Rasch, Germany (DO)

- 1928 **US** - Introduction of the first standard sized **4 x 8 ft (1.2 x 2.4 m) sheet of plywood**, application in **building industry** begins.
- 1929 **US** - 17 plywood mills in the Pacific Northwest producing 258 million sq ft, measured based on 3/8-inch basis. (APA)
- 1930 **Particleboard**, or chipboard, developed.
- 1931 **JP - Lauan use begins at full scale**, drastically increasing the quantity of plywood production.



Alvar Aalto's 'bent knee' patent drawing, where partial grooves were sawn into a solid piece of birch along the grain, 1932. (DN)



one-piece plywood chair by Gerald Summers, 1933. (DN)

## 1930

1935 **Nylon** production begins.  
**Fiberglass** introduced by Owens Corning.  
**JP - Jitsuzai Kogei Bijutsukai**, Existing Craft Arts Society 'function equals beauty' established, - 1940.  
**First exhibition of industrial arts and crafts** to enhance industrial products, organized by the Osaka Prefectural Crafts Industry Promotion Department.

1938 **PTFE**, or Teflon, discovered.  
Deutscher Werkbund dissolved by the Nazis.

1939- **World War II (1939-45)**

1934 **US - Fully waterproof adhesive** developed by Dr. James Nevin, a chemist at Harbor Plywood Corporation in Aberdeen, Washington. (APA)



Eames FSW folding screen wood, 1935 (CE)

1937 **US - As part of stress skinned panel** research, a small stress-skin house built in Madison, Wisconsin.

1938 Nikolaus **Pevsner's** article "*The History of Plywood*" appears in The Architectural Review.

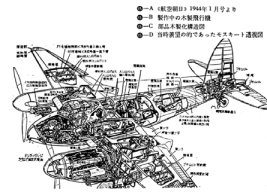
**US - Douglas Fir Plywood Association** established, later renamed American Plywood Association, then APA – The Engineered Wood Association, for furthering the use of plywood. (TP)

**Commercial standard** established; product promoted as standardized commodity rather than by individual brand names.

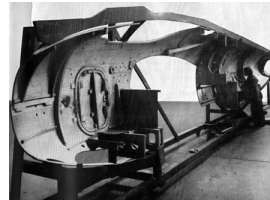
1939- World War II and the advent of **resin adhesives** and **molding of compound curves** in plywood by the flexible-bag process contributed to plywood's application to **aircrafts** as an alternative to **thin metal**, before greater availability of aluminum alloys. (TP)

## JP - Beginning of moulded plywood.

(IE)



plywood aircraft *Mosquito* used by the British Royal Air Force. (TM)



One half of the fuselage of a *Mosquito*, with stressed skin plywood with balsa core. (GL)

1940 **JP - Charlotte Perriand** in Japan as an adviser to IAI, - 1942.



*Organic Design Competition* drawing of the armchair submitted by Saarinen and Eames, with plywood shell, rubber-weld joint, and aluminum legs (EN)

1940

1940

**Glued laminated timber**, or Glulam, developed. Commercially available from 1950s. (BA)

British aircraft, **de Havilland DH.98**

**Mosquito**, made from plywood.

**US** - Softwood plywood use in subfloors, wall / roof sheathing, paneling and other building construction applications.

80% of production in Washington state.

**JP - Industrial Arts Institute**

headquarters move from Sendai to Tokyo, with Kenmochi and Toyoguchi.

**Tendo Mokko** founded in Yamagata.

1941 **US - Organic Design Competition** at the MoMA.

1941

Plywood industry contributes to WW2 efforts: boats, assault ships, airplanes, barracks, military buildings, shipping crates, footlockers, etc.

**US - Plywood shell chair** designed by Saarinen and Eames wins the MoMA Organic Design competition. (EN)

**US - 'Packaged House'** with General Panel System prefabricated house by K.

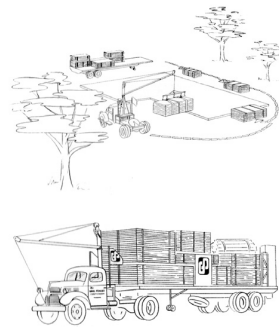
1942     **Duct tape** invented by Johnson & Johnson for the US government's request for waterproof cloth-based tape.

1944     **US - Good Design movement**, with Charles and Ray Eames, Hans Wegner, Maholy- Nagy, M. Breuer, E. Saarinen, etc.

1945     Development of **glass-reinforced polymers**.  
Post-war baby and housing boom.

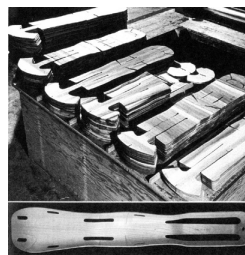
1947     **US - Postwar baby and housing boom**.

Wachsmann and W. Gropius, patented in 1942.



'Packaged House' illustrations of construction process and trucking system (HD)

1942     **US** - Charles and Ray Eames produce **leg splint** from moulded plywood for the U.S. Navy.



Eames leg splint, for the US Navy (DN)

1943     **US** - 'Plas-2 Point' prefabricated house with plywood substructure coated in liquid plastic, by Marcel Breuer. (HD)  
**JP** - Research on moulded ply for aircraft applications begins, both for actual and decoy planes, - 45. (HM)

1945     **US - The Plywood Research Foundation** established, sponsored by members of the Douglas Fir Plywood Association. (TP)

1947     Development of **structural insulated panels, SIPs** begins, initially with plywood, hardboard and paperboard.

1950s **Brutalism**, - 1970s.  
**JP - Good Design movement.**  
 Major structural use of aluminum.

1952 Use of glass for structural elements.  
**JP - Japan Industrial Designers' Association, JIDA, founded.**  
**JP - GK Design Group established.**

1955 **JP - Konrad Wachsmann** seminars at the University of Tokyo in November.  
**JP - Kenmochi Design established.**



Butterfly stool by Sori Yanagi, 1956 (DN)

1960 **JP - Metabolism**, - 1970.

## 1950

**JP - Tendo Mokko** acquires high-frequency oscillator, begins experiments with moulded plywood.



Adjustable plywood chair by H. V. Thaden, 1947, never mass produced for the market (VT)

1950 Plywood Manufacturers Association of British Columbia founded, today's Canadian Plywood Association.



Jean Prouve, 1950, and Andre Bloc, 1951, both incorporating steel with plywood (DN)

1953 **JP - JAS** (Japanese Agricultural Standards) established for veneers and plywood; reaches 3rd in plywood production quantity and 2nd in plywood export worldwide.

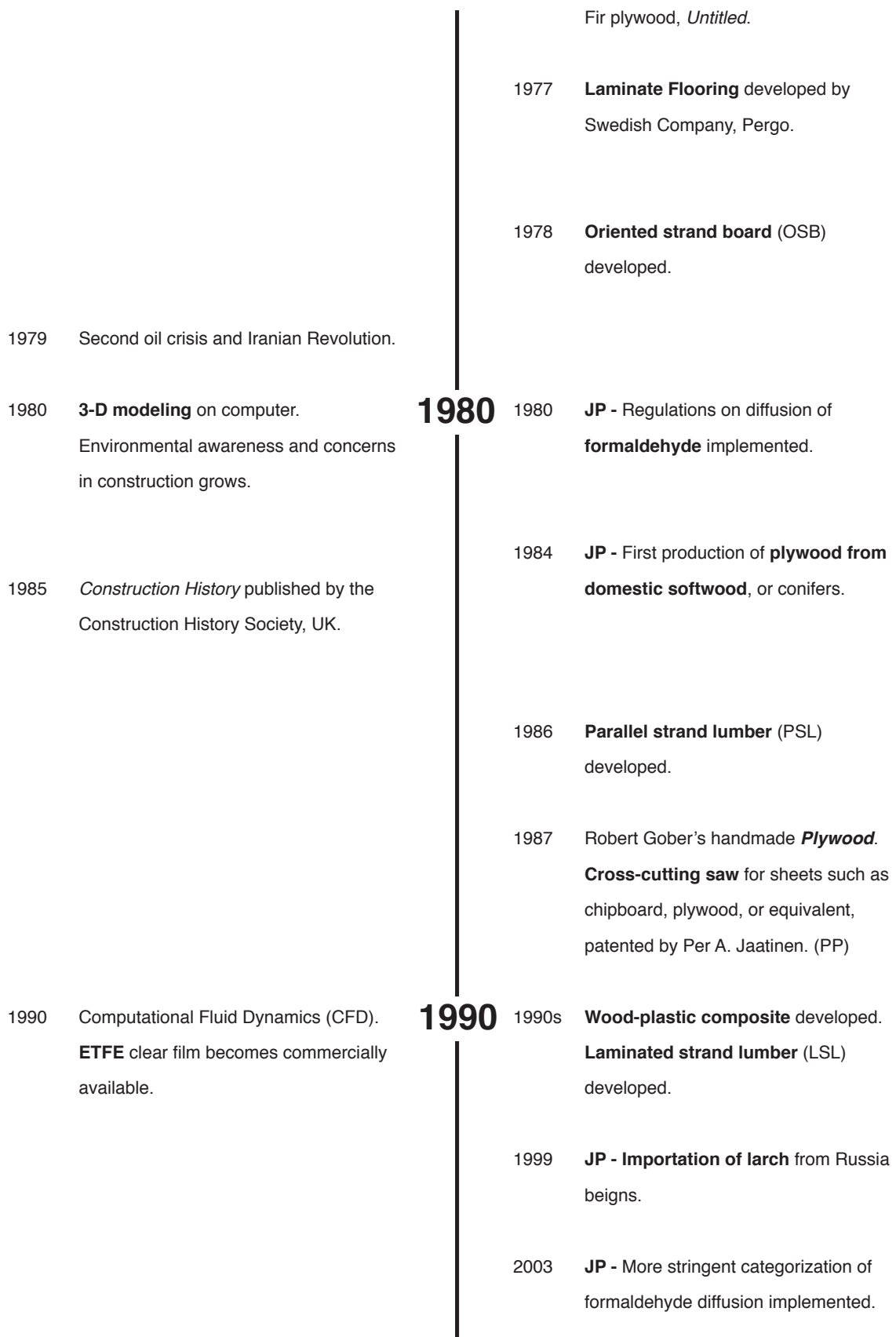
1955 **JP - First successful domestic production of urea melamine formaldehyde resin.**

1956 **Nail gun** patented by John Ollig, Reuben Miller and Marvin Hirsch.

## 1960

1960 **Medium density fiberboard (MDF)**

	<p><b>JP - World Design Conference</b> in Tokyo with K. Tange, N. Kawazoe, I. Kenmochi, S. Junzo, H. Bayer, J. Prouve, K. Kikutake, L. Kahn, B. Munari, K. Kurokawa, S. Yanagi, Y. Ashihara, P. Smithson, etc.; publication of the Metabolist manifesto.</p> <p>Wet photocopier developed.</p>		developed.
1964	<b>Tokyo Olympics.</b>		
1965	<b>Dry photocopier</b> developed.		
1968	Publication of <i><b>Whole Earth Catalog: Access to tools</b></i> begins.		
1969	First manned lunar landing, <b>Apollo 11</b> .	1969	<b>Laminated veneer lumber (LVL)</b> , a type of structural composite lumber, developed.
1970	<p><b>US - DIY (Do-It-Yourself) movement</b> spreads in North America.</p> <p><b>JP - Expo '70</b>, first World's Fair held in Japan, also known as <i>Osaka Banpaku</i>, with masterplan by Kenzo Tange.</p> <p><b>JP - Sekisui Heim M1</b> prefabricated 'unit construction system' house introduced, designed by Katsuhiko Ono.</p> <p><b>Computer-generated drawings.</b></p>	<b>1970</b>	<b>JP - First successful larch plywood</b> production by a manufacturer in Hokkaido.
1972	First hand-held scientific calculator, HP-35.		
1973	First <b>oil crisis</b> and stock market crash.	1973	<b>JP - Highest production, demand and raw material importation</b> in history. Price of plywood also skyrockets due to increase in oil prices.
1976	<i>History of Technology</i> published.	1976	Donald Judd's 15 boxes from Douglas



## 2.5 Derivatives of plywood

### 2.5.1 Chronology of engineered wood products

Wood products have evolved from processing solid wood into timber, to thin veneers which were laminated into plywood, then to finer fiber based products. Various combinations have emerged since the beginning of the twentieth century, such as the blockboard that combines veneers on the exterior and strips of timber inside that first appeared in 1902. All of these products are now under the categorization of engineered wood, basically a composite of wood based material and adhesive, in various sizes, strengths and applications.

Early derivatives stem directly from plywood, which is said to be the oldest engineered wood. Different surfaces, combination with solid timber and addition of metal or bakelite plastic, can be observed from an Architectural Review article from 1939.

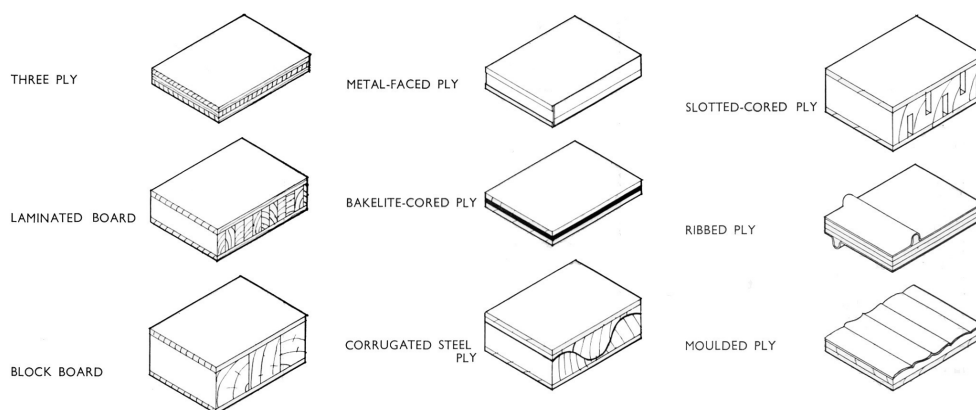


Fig. 2.5.1 “The varieties of plywood” published in 1939 issue of the Architectural Review<sup>93</sup>

These combinations of surfaces and inner materials have increased the areas in which plywoods can be applied. Some increase strength, rigidity, or resistance to heat and moisture to the basic plywood. Later, structural insulated panel, known as SIP, will come to provide insulation together with structural properties; early forms of these stress skin panels utilized plywood or tempered hardboard as the skin material, though OSB is much more common today. A slotted-core ply could enable tighter curvature, and was applied in areas such as column casings. Ribbed ply is noted as a French invention, giving rigidity to large sheets



with only a slight increase in weight. With a variety of moulded patterns used for the surfaces, moulded ply could be used as a finish decoratively.

The sandwiched layer could be changed to for specific application, and lead was used previously to shield the X-ray room or balsa core blockboard applied to airplane floors.

Other materials mentioned that had been used with plywood up to 1939 includes asbestos, linoleum, cork and even marble.<sup>94</sup>

## chronology of engineered wood products

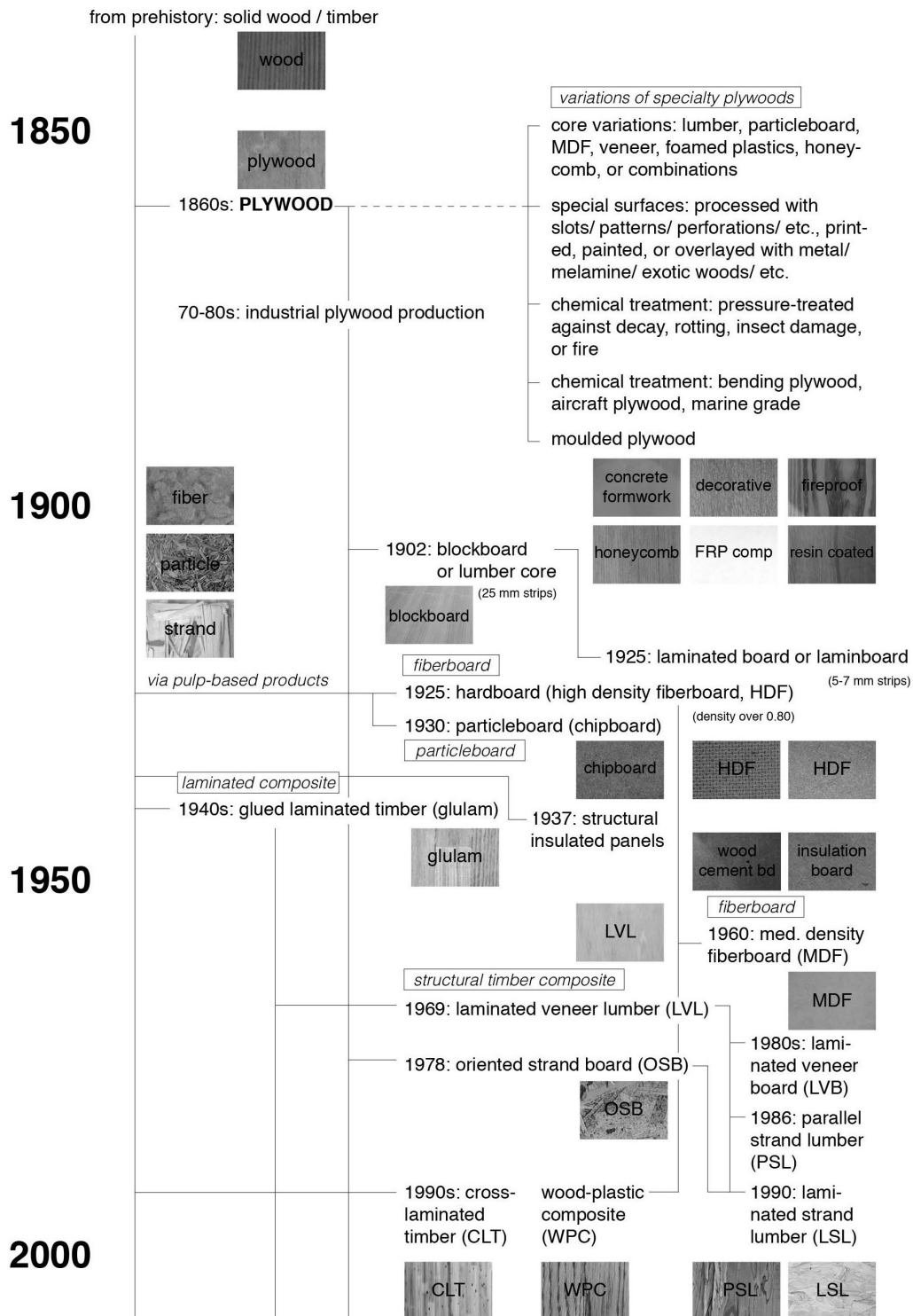


Fig. 2.5.1-2 Chronology of engineered wood products

### 2.5.2 Variations and terminology

The pliable nature of veneers has been exploited in moulded plywood, but there are products that have been created with the idea to sell board products that are bendable, sold flat but easily bent by the consumer. Bendyply, a trademarked product name, employs *Ceiba Pentandra* species from West Africa with its naturally flexible characteristic. Another trademarked product, multi-ply, uses high quality core and face veneers glued to solid core without any joints to allow for movement. A different method is kerfing, which is essentially cutting slots into wood on one side to make the board material, plywood or MDF, flexible.<sup>95</sup> It allows for dry-bending a thick section of wood, with the width of the cuts directly relating to the tightness of the final bend. These options enable the end user to achieve forms with lightness without the heavy industrial tools.

Alternative material, bamboo, has seen a rise in consumption as it grows more than 30 percent faster than any other tree on earth.<sup>96</sup> While it is technically in the grass family, its fibrous and lightweight nature has been beneficial in structural or decorative applications. In the last few decades, the market has seen products of bamboo plywood, often for flooring, and less commonly the bamboo fiber reinforced plastic, used rather experimentally.

The ability to process fibrous material into fine powder, such as wood or bagasse, the residue of sugar cane, has increased material efficiency as their use spread into different product types. Plastic wood, or wood plastic composite, uses between 30 to 50 percent of recycled wood flour combined with polymer resin. It is still relatively new in the group of engineered wood, and used for areas such as decks and cladding as they are fairly resistant to decay and moisture.

Other variations include veneers with adhesive backing, which can be used in the manner of wallpaper, a preassembled wood based block resembling a concrete masonry unit called Steko block that can be joined by slotting each other without additional fixings, and Paralam, also known as shredded wood, which is an engineered construction material made from strands of timber 6 to 8 inches long, reconstituted and glued together. Glulam, which became commercially available from 1950s, is timber of different thicknesses glued together with 2 layers or more; it applies solid wood of similar strength and weight, rather than

veneer, resulting in reduced flexibility and movement than sawn wood. Due to this method, Glulam can be made up to any size and is only restricted by transportation rather than production, facilitating the use of wood for large scale buildings with long spans.<sup>97</sup>

Structural composite lumber (SCL) is a type of engineered wood products used as an alternative to sawn lumber, and commonly used for the same structural applications. Its first iteration came in the form of LVL whose production began in 1969. Because the outermost layers of fiber, which are strongest in the log, are used for structural applications by distributing the natural log defects to minimize their effects. Among the most widely used are laminated veneer lumber (LVL), parallel strand lumber (PSL), and laminated strand lumber (LSL).<sup>98</sup> Oriented strand lumber (OSL) also belongs to this category. Materials not suitable for timber due to the small diameter, flaws or other deficiencies can be employed by structural composite lumber.

Laminated veneer lumber (LVL), which was developed in 1969 by Trus Joist Corporation, incorporates thin sheets of veneer that are laminated in parallel alignment. It is the most widely consumed structural lumber composite product. These are also used as flange material for I-joists today. Typically produced in 1.75 in (44.45 mm) members. Species such as douglas fir, larch, pine, and poplar are typically used in the manufacture of LVL.

Parallel strand lumber (PSL) can incorporate more of the outer layers which are less uniform for producing veneers, and therefore not suitable for LVL, but have higher strength. They have darker visible strands, which are glued under pressure. Strands of 2 - 8 feet long (about 600 - 2400 mm) long are used. It is the strongest of the three and can resist heavier loads and longer spans, the length of which are limited by transportation constraints, such as 20 m, rather than manufacturing constraints.

Laminated strand lumber (LSL), introduced in 1990, uses up to 75% of each log, making it one of the most efficient structural composite lumber. 12 inch (300 mm) long strands are bonded with resin and steam injection pressed. This one is also the most economical compared to the previous three, but also the least stiff and with lower strength. Its appearance resembles that of OSB, with long strands derived from fast growing species

such as aspen or poplar, although the strands are arranged in parallel and not cross-oriented. Oriented strand lumber (OSL) employs shorter flaked strands than LSL.

### **2.5.3 Sandwich-structured composite panels**

In addition to the structural composite lumber and reconstituted wood, which includes chipboard, MDF and particleboard, another category of the derivative is sandwich-structured composite panels. The idea for a composite with outer layers and a different inner core had been understood for over a thousand years.

In the early nineteenth century, a British engineer I. K. Brunel developed structural system with stressed skin, applied in bridges and steel ship constructions. As steel became increasingly available and applications of I-beam and H-beams spread widely, first patented in mid-nineteenth century and dominating high-rise structures into the twentieth century. These beams essentially incorporate the same structure as composite sheet material: For the most part, flanges resists bending moment, and the web resists shear forces. For a composite panel, the surface sheet material stands in for the flanges and the core material stands in for the web. If the material characteristic of the web, or core material, is not lighter, cheaper, or stronger than the sheet material, it is more efficient to use only the sheet material on its own.

In 1919, composite panel was employed for the construction of Sunstead aircraft, then increasing during World War II, with aircrafts such as de Havilland's Albatross and the better-known Mosquito in 1940. These examples used balsa sheets as the core material and birch plywood as the surface material, marking an early use of plywood as part of the primary sandwich-structured composite.

First architectural application of the composite panel was in the 1930s, with the product Cemesto boards developed by the company Celotex – the surfaces were composed of asbestos and cement, with a core of sugar cane fiber. Low cost, waterproof and fire resistant, the material was used extensively in the building industry throughout the war and in the following years.<sup>99</sup>

Around 1938, Dr. Hurry C. Engel began developing honeycomb core material in a research sponsored by an American company Glenn L. Martin Company. Engel first

experimented with sheet metal with drinking straws in between, then moved on to the hexagonal clusters of honeycomb. Patent was filed for the honeycomb panel with impregnated resin strips granted in 1952, along with the method of manufacturing them.<sup>100</sup> In 1966, “Method and apparatus for forming honeycomb”<sup>101</sup> was patented, and these techniques were again applied in aircraft construction.

In the mid 1940s Forest Products Laboratory, the national research laboratory of the United States Forest Service, had begun to assess the basic design, fabrication, and construction of structural sandwich materials in architectural applications. Testing of the material as the building component for a house started in 1947 to tackle the housing shortage problem, with an experimental unit built at the laboratory. Durability under long term exposure was observed over the following years, evaluated for various lengths of time up to 21 years when the unit was dismantled and moved to another location.<sup>102</sup>

## **2.6 Plywood statistics: International**

The following data on plywood production, imports, comparisons with other woods and costs show changes in economy, demands and sourcing over time. Both regional and international trends affect the types of wood used or products manufactured. For instance, widespread use of oriented strand board in the United States, surpassing plywood, can be attributed to the availability of poplar in the southern regions. Poplar’s small log diameters and proneness to decay had made the material less suitable for lumber or plywood, but appropriate for oriented strand board, parallel strand board, etc. Likewise the availability of beech and birch particularly in northern Europe has been strongly tied to its Scandinavian furniture traditions, while popularity of particleboards and fiberboards can also be seen throughout European nations.

Environmental concerns also have had a profound influence the engineered wood industry in the last few decades, with perhaps the most prominent case being luan harvested from southeast Asian tropical forests; many of the luan family are now considered endangered species due to over-harvesting. Luan plywood industry soared from mid-

twentieth century through much of the eighties, encouraged by luan's large log diameter, affordability, and highly consistent grains suitable for veneer productions. Increasing awareness and effort to preserve both the forests and industries by establishing appropriate plant and harvest cycles have begun to be implemented.

Most data in these areas of research are not available prior to the twentieth century, or even the mid-century in some cases. Units of measure vary by country and by time; in Japan, panel products were measured by area (square meters) until 1996, after which the products were measured by volume (cubic meters). When the quantity is converted from area to volume, plywoods are assumed the typical 4 mm thickness, a little over 1/8 inches. In fact measurement by surface area had been the case throughout the world, although the conversion to volume occurred at different times according to region and country.

### **2.6.1 Major plywood producers**

Over the first decade of the twenty-first century, five largest producers of plywoods have been China, United States, Indonesia, Malaysia, and Japan. Wood species used obviously vary by region. For example, from its early phase the American industry was based on the abundance of Douglas fir in the Northwest, and its softwood plywood production had already begun in 1905. Southeast Asia had a great availability of trees that belong to the family of Dipterocarpaceae (often referred to as luan, meranti, or seraya), which the plywood industries in Asia was largely dependent on.

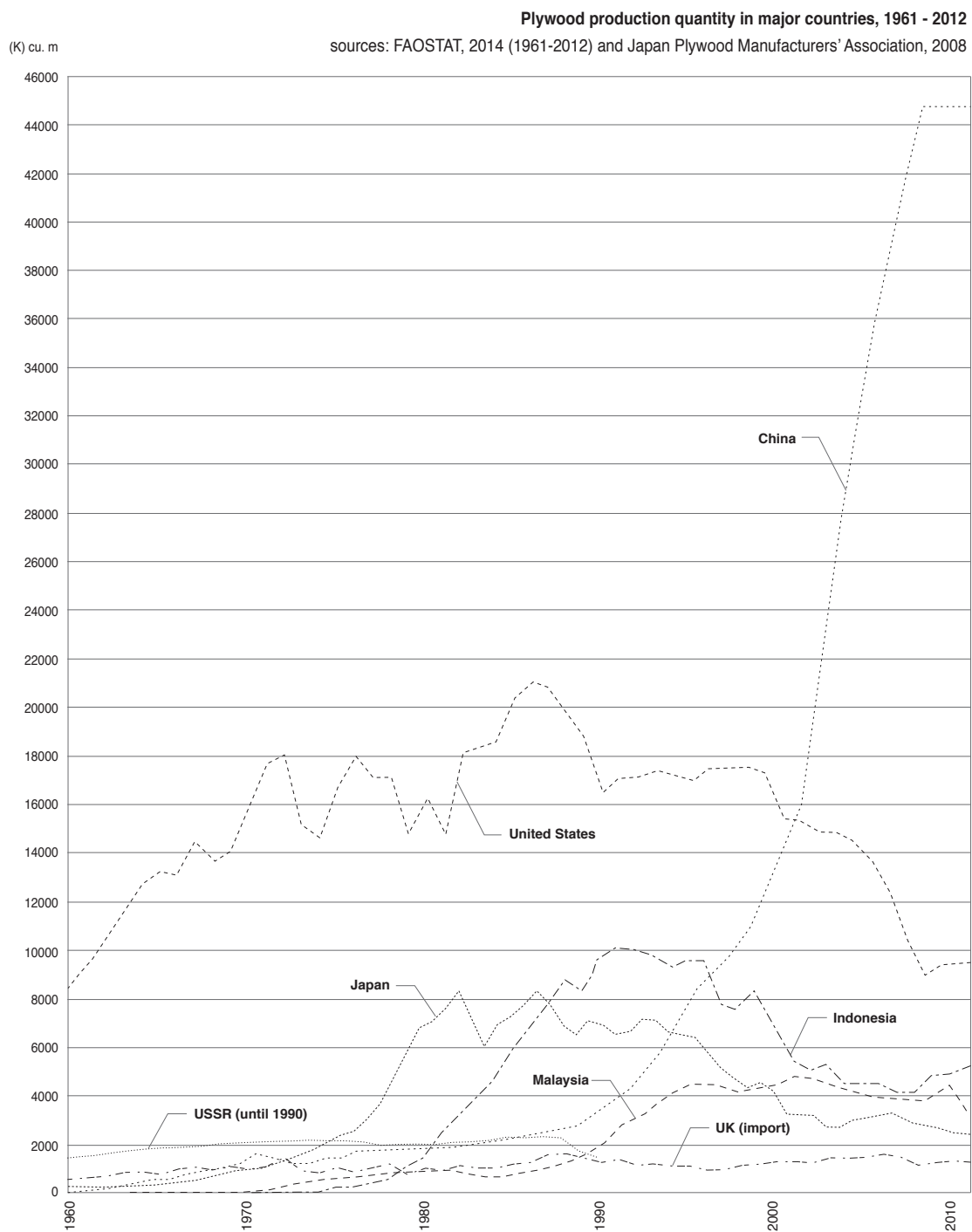


Fig. 2.6.1 Plywood production quantity in major countries, 1961-2012<sup>103</sup> (UK data is for imports mostly sourced from other European nations, as the nation had substantial manufacture using imported plywood).

Much of northern European birch forests had been under the ownership of the USSR



for decades during the twentieth century, and reflected in the production data as such. Finland, which maintained its independence, lost four of its plywood mills with a total output of 44,000 cubic meters in 1940, and 20 percent of good quality birch timber was transferred to Russia with the peace settlement in 1945.<sup>104</sup> Nevertheless Finnish plywood has retained a high international reputation for its quality and labor conditions relative to neighboring countries, most of which was consumed by the furniture trade. It may be argued that the development of mass-produced furniture in England saved the Finnish birch plywood industry.<sup>105</sup>

## **2.6.2 Production of industrial wood products in the US**

The nature of industrially produced wood products have also changed in the past century. Softwood lumber, which had been the dominant wood-based building material since sawing had begun – and also considered the first prefabricated element of building – was, and still is, one of the principal wood products. Its production and demand, while experiencing fluctuations, have not changed too dramatically, while the largest area of growth by far is in the pulp, paper, and board industry; this category refers to paper and paperboard, and not included in this category are plywood, oriented strand board, particleboard, hardboard, medium density fiberboard, and insulating board, all which are calculated in separate categories. In the industry, insulating board, MDF, and hardboard are the same product with different range of density, from low (0.02-0.40 g/cu. cm), medium (0.40-0.80 g/cu. cm) to high (0.80-1.20, special density up to 1.45 g/cu. cm).<sup>106</sup>

Between 1900 and 1998, industrial wood productivity in the United States rose by 39 percent, a figure calculated by the quantity of product output per unit of industrial roundwood input. The most rapid growth around 1950 is attributed to the gains in the use of wood residues and recycled wood fiber, with more products being produced from the same volume of harvested timber<sup>107</sup>; in 1950s industrial wood product output constituted around 70 percent, in comparison to around 95 percent in 2000. This is also reflected in the pulp, paper and board category, with more recycled paper applied in the manufacture of paper and paperboards especially with greater efficiency after the mid-1980s.

## Production of US industrial wood products, 1900 - 1998

source: USDA forest service

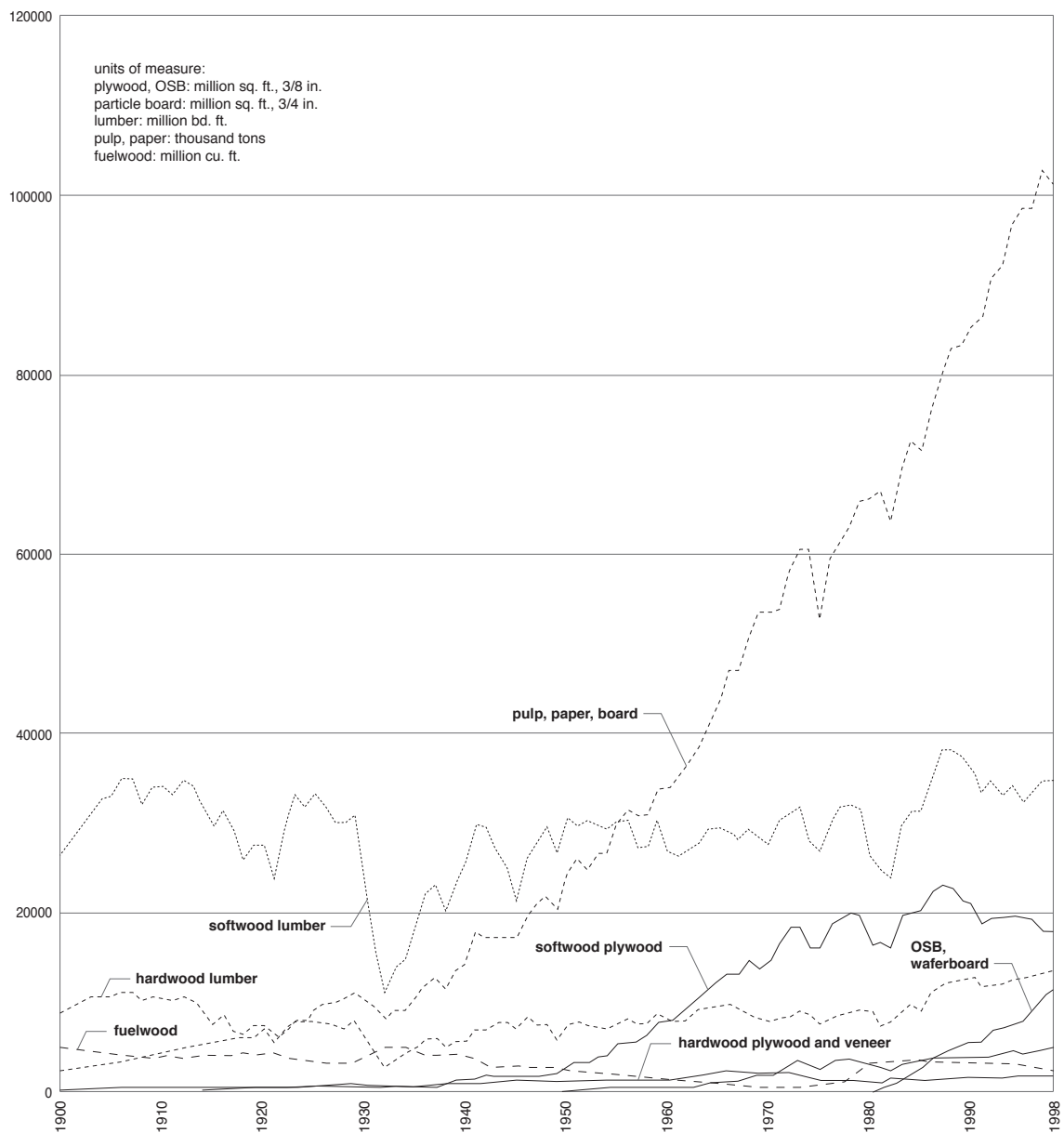
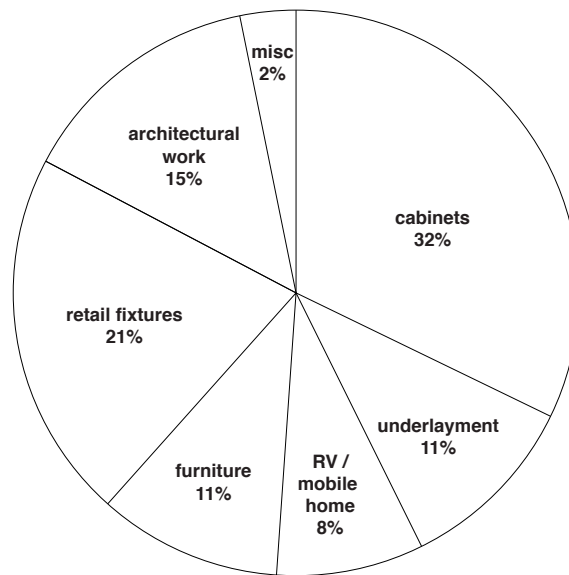


Fig. 2.6.2 Production of US industrial wood products, 1900-1998.<sup>108</sup>

### 2.6.3 Applications of hardwood plywood

Softwood plywood applications in the building industry are almost entirely structural, applied as sheathing, floors and ceilings, and formwork. Hardwood plywood is more often used in more visible applications; according to a recent survey conducted in the US, the use

of hardwood plywood on cabinetry, furniture, retail fixtures, architectural and mobile home applications comprise approximately 90 percent of the supply, whereas only 11 percent are for underlayment.<sup>109</sup>



hardwood plywood applications in US, 2013

Fig. 2.6.3 Applications of hardwood plywood in the United States, 2013, calculated as an average from both domestically produced and imported hardwood plywood usage.<sup>110</sup>

## 2.7 DIY, digital fabrication, art and plywood

Do-it-yourself, known as the DIY movement, came into the general public's consciousness in the late 1960s to early 70s in the United States. Its original roots have been credited to several precedents, such as one in the 1950s postwar Britain where shortage of materials and products was pervasive, to the punk movement and beyond. The movement, spanning fields of fashion, music, publications, objects and buildings, demonstrated an alternative way of living that was ignited by social awareness and critique of consumerism. Its seeds were planted by influential publications such as an American magazine the *Whole Earth Catalog* with the subtitle *Access to Tools*, which was first published by Stewart Brand in 1968. With a cult following, the publication focused on self-sufficiency, ecology and do it yourself ethos,

through reviews of functional products. It has come to be known as an alternative publication to the mainstream consumption, opening the discussion on how individual ingenuity can challenge the roles of passive consumers.

More recently the Make magazine, whose first issue was published in January 2005, has helped promote DIY projects to appeal to the wider range of audience than the stereotypical targets previously drawn to ‘crafts’, by expanding the notion of the handicraft to include computers, electronics, robotics, metalworking, woodworking and other disciplines. Its website claims that as the “first magazine devoted entirely to DIY technology projects, MAKE Magazine unites, inspires and informs a growing community of resourceful people who undertake amazing projects in their backyards, basements, and garages.”<sup>111</sup>

Charles Jencks had labeled it “Adhocism,” where “approximate craftsmanship” of the DIY builders, whom he called “woodbutchers,” has cultivated a new attitude and aesthetic that could only result from being unskilled.<sup>112</sup> Taking pride in the lack of craftsmanship marked this phase of the DIY movement, an inclination that propagated to sculptors and professional architects. The borrowing of the idea of bricolage – the act of working with whatever at hand, as opposed to having been designed or engineered in advance – which is an anthropologically based perspective of the vernacular and open-ended, also underlined the democratic nature of this movement in an unheroic and basic act of making things suitable in that context to satisfy the individual.

The system enabling the one-stop purchase of necessary materials to make things was essential in the expansion of individuals engaged in DIY. Retailers of construction products and home improvement, targeted to general consumers, began to open businesses in the United States in the late 1960s. The largest retailer, the Home Depot, was founded in 1978, and provided broad access to building materials for any individual, from one screw to a myriad of building materials and components. Its expansion of products from the neighborhood hardware store into the what we know today typified by Home Depot, averaging 105,000 sq. ft or 9,755 sq. m, is comparable to the emergence of supermarkets in the 1910s taking the place of vendors or merchants selling vegetables, meat, and other specialty trades. Japan quickly followed with the opening of large scale ‘home centers’ with

the first one in 1972; after 1975, between 100 to 200 retailers opened every year until slowing down at the turn of the twenty-first century. The stores, for the first time, prompted manufactures of tools and materials to consider nonprofessional users in their product development. Currently, over 4,500 retailers are in operation throughout the country.<sup>113</sup>

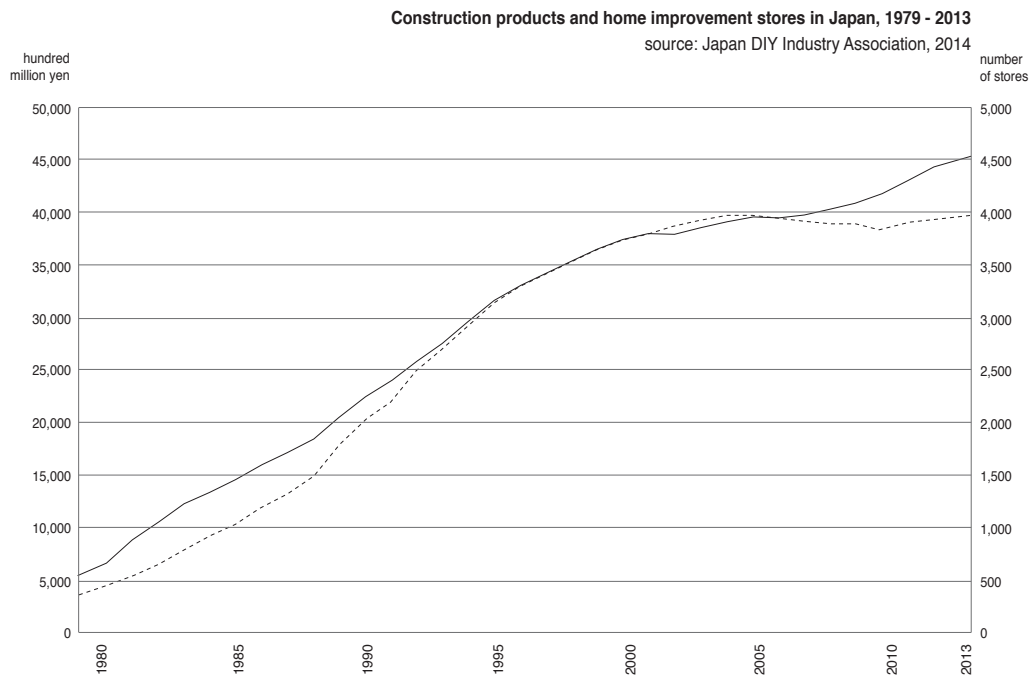


Fig. 2.7 Construction products and home improvement retailers in Japan, 1979-2013<sup>114</sup>

Affordability, workability, and the relative finished quality of plywood has encouraged its use by the public, particularly the amateurs to whom these materials were previously difficult to obtain in small quantities. These attributes also expanded the use of plywood in unexpected ways, and it has become clear that plywood is also conducive to new tools such as the computer numeric controlled machines, including routers, milling machines and laser cutters.

### 2.7.1 Digital fabrication

On the digital or computational modes of production, Branko Kolarevic has noted that, “The close relationship that existed between architecture and construction (what was once

the very nature of architectural practice) could potentially reemerge as an unintended but fortunate outcome of the new digital processes of production. In the future, being an architect will also mean being a builder, not literally, of course, but by digitally generating the information to manufacture and construct buildings in ways that render present inefficient hierarchies of intermediation unnecessary.”<sup>115</sup> This outlook is the basis for proponents of digital craft, that especially given the loss of skill in construction, it is a viable way for new craftsmanship to emerge. With this premise, software replaces hand-based material manipulation skill as the principal design tool.

Of the five types of digital fabrication techniques – sectioning, tessellating, folding, contouring, and forming – presented by Lisa Iwamoto as having emerged in the past fifteen years since the mid 1990s, all but one, forming, show cases made of plywood.<sup>116</sup> The material has been critical in the making of mockups, prototypes, to final constructions and not restricted to experimental or conventional aesthetics. Particularly for the flat bed fabrication, it has been an ideal option given its availability, strength compared to paper-based boards such as cardboard, and affordability compared to metals or other materials. The impact of the standard scale of the material sold at retailers, most typically 4 x 8 (1219 x 2438 mm), or 3 x 6 (914 x 1829 mm) in Japan, is significant. Since the 4 x 8 size was implemented in the US in 1928, other material and spatial dimensions have adopted to the scale for efficiency, although they can also be easily manipulated and adjusted with simple tools.

### **2.7.2 Modern art**

While the discipline of late modern art only serves as a commentary to the context discussed surrounding plywood, it is also a sign of the level of ubiquity and commodification that the material has reached. Some artists have directly appropriated its materiality as a product of industrial and commercial significance.

American artist Robert Gober’s has presented in 1987 the work *Plywood*, an ordinary sheet of 5/8” thick plywood stood against a wall. This seemingly readymade panel is in fact a handmade piece of veneer wrapped around a chipboard core, with the illusion of an

industrially produced one. Of this “fake” plywood, Gober has commented that it is a realistic portrait of an abstract object. Another American artist Donald Judd created the work *Untitled*, consisting of fifteen Douglas fir plywood boxes in 1976, and continued to make iterations of it through the eighties. Known for his penchant for industrial materials, Judd’s work highlighted the nature of plywood that is devoid of historical weight and meaning, while being conducive to his precise assembly to achieve extremely simple volumes.

Between 1985 and 1988, three tea rooms were completed by Ando Tadao by renovating an old existing timber *nagaya*-style house in Oyodo, Osaka.<sup>117</sup> Each of the rooms was assigned a characteristic material that it was named after: Veneer tea room, block tea room with concrete masonry units, and tent tea room, a lightweight structure perched above the roof. Between the existing readymade materials and the entirely designed space, the industrial nature of the materials is foregrounded for their simple effect.

All of these examples show unfinished plywoods in their plain state to highlight their materiality, challenging the viewers’ perceptive response. Other casual uses of plywood have

## **2.8 Chapter conclusion**

The primary contrast between wood and modern plywood is plywood’s reliance on industrial processes as a method of manufacture. Based on mechanical means of processing, the anisotropic character of wood as a natural material could be reduced significantly as a result of this process, ushering the traditionally craft-based wood material closer to other uniform, industrially manufactured materials such as plastics. Other consequential features brought by the arrival of plywood included the ability to cover large surfaces as demand for board materials increased, finding uses for wood unsuitable for application as solid timber, and to lessen the waste material from timber conversion.

The preceding technologies in mechanical processing of timber, in addition to the spread from its visual to mechanical grading, paved the way for plywood and subsequent derivatives of engineered wood products, such as medium density fiberboard, laminated veneer lumber, oriented strand board, and cross-laminated timber. The supply of standard

member sizes was also significant in simplifying and systematizing the market for the material, whether domestically or internationally.

Meanwhile, sourcing of timber has always been regionally varied, from available quantity to species. New transportation method of the railway system in the UK that came about in 1820, for instance, was essential in kicking off a vigorous international timber trade. The suppliers of raw material, industrial processing, and manufacturing of the end-use products could be located at a great distance, as long as there was a method of distributing the material and goods from one place to another.

The development of modern plywood, which is distinguished from the ancient materials that employed the same strategy as plywood but were laboriously produced by highly skilled artisans, grew out of the furniture industry as an alternative to carving of solid wood, which was also laborious. From the onset, moulded plywood was conceived as a way to express curvature for furniture parts that would be faster and cheaper to produce. The mechanical processing of veneers enabled by the rotary lathe, in the first half of the nineteenth century, and the chemical development of the waterproof adhesive during the last decade of the century, prepared the ground for plywood's ascent as the material in the twentieth century.

Michael Thonet, first based in Vienna and relocated to Austria, was one of its earliest pioneers starting around 1830, before his attention was diverted to developing solid wood bending techniques due to poor quality of veneers and adhesives at the time. American furniture company Gardner and Co., based in New York and active between 1860s to 80s, had begun to mass produce simple, bent and perforated plywood chairs and benches for public buildings such as hospitals and railway stations. Demands for furniture for the mass market was fueled by the rising economic power of the general public as well as the establishment of new social functions, in the form of large public buildings.

Industries that began utilizing plywood other than furniture included piano, doors, shipping boxes, automobile, railway, aircrafts, and architectural, in approximate chronological order. Rapid refinement of the material took place during the two world wars but especially in the second, which saw the emblematic Mosquito, a British plywood aircraft



which symbolized the advancement in thin veneer productions and reliable, waterproof adhesive, in addition to the realization of stress skin structure.

All of the technological achievements culminated in the mid-twentieth century as the expression of moulded plywood, simultaneously for structure and design, produced iconic modernist furniture and objects by the likes of Eames, Aalto, and many others. Mostly unseen, standard plywood panels spread even more extensively to be used in structural sheathing, or as concrete formwork in construction and civil engineering industries. With increased output, the material became ubiquitous in the twentieth century in many parts of the world.

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<sup>1</sup> Wright, Frank Lloyd. *Modern Architecture: Being the Kahn Lectures for 1930*. Carbondale and Edwardsville: Southern Illinois University Press, 1987. First published in 1931 by Princeton University Press. p 8.

<sup>2</sup> Guidot, Raymond. *Industrial Design Techniques and Materials*. Paris: Flammarion, 2006. p 92.

<sup>3</sup> Kelly, Kevin. *What Technology Wants*. New York: Viking, 2010. p 299.

<sup>4</sup> Kelly, p 299.

<sup>5</sup> Kieran, Stephen and Timberlake, James. *Refabricating Architecture*. New York: McGraw-Hill Companies, Inc., 2004. pp 119-121.

<sup>6</sup> Kieran and Timberlake, p 120.

<sup>7</sup> Kieran and Timberlake, p 32.

<sup>8</sup> Manzini, Ezio. *The Material of Invention: Materials and Design*. London: The Design Council, 1989. p 53.

<sup>9</sup> Manzini, p 52.

<sup>10</sup> Simplified from Narita, Juichiro. *Nihon Mokko Gijyutsushi no Kenkyu*. Tokyo: Hosei University Press, 1990. p 9.

<sup>11</sup> Hanse, Hans Jurgen. Trans. Seligman, Janet. *Architecture in Wood: A History of Wood Building and Its Techniques in Europe and North America*. London: Faber and Faber Limited, 1971. p 261.

<sup>12</sup> Hanse, p 262.

<sup>13</sup> United Nations Industrial Development Organization, Vienna. *Production of Prefabricated Wooden Houses*. New York: United Nations, 1971. p 9.

<sup>14</sup> Dinwoodie, J. M. *Timber: Its nature and behaviour*. London and New York: E & FN Spon, 2000. First edition published in 1981 by Van Nostrand Reinhold Co. Ltd. p 2.

<sup>15</sup> Brunskill, R. W. *Timber Building in Britain*. London: Cassell, 2004. First published in 1985. p 13.

<sup>16</sup> Brunskill, p 27-28.

- <sup>17</sup> Lefteri, Chris. *Wood: Materials for Inspirational Design*. Mies, Switzerland: Roto Vision SA, 2003.
- <sup>18</sup> Johnston, David. *Wood Handbook for Craftsmen*. London: B.T. Batsford Ltd, 1983. p 53.
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- <sup>20</sup> Johnston, p 55.
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- <sup>33</sup> Dinwoodie, p 148. In the UK, BS 373 *Methods of Testing Small Clear Specimens of Timber* in 1986 outlines the 20 x 20 mm small clear testing methods. For 50 x 50 mm testing, see ASTM D143-52 *Standard Test Methods for Small Clear Specimens of Timber*, in the USA and some of South American countries, as set by the American Society for Testing and Materials.
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- <sup>50</sup> Wood, p 5.
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- <sup>54</sup> Clark, pp 5-6.
- <sup>55</sup> Desch and Dinwoodie, p 159.
- <sup>56</sup> Typically called wood shaper or shaper in the United States.
- <sup>57</sup> Desch and Dinwoodie, pp 160-61.
- <sup>58</sup> Knight and Wulpi, pp 146-7.
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- <sup>60</sup> Ngo and Pfeiffer, p 18.
- <sup>61</sup> Ngo and Pfeiffer, p 19.
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## Chapter 3

### Development of plywood in Japan

*A lag between the invention and creative exploitation of a medium and its cultural assimilation is not unusual – with both cinema and television, critical thinking about their social and artistic implications developed well after the first rush of creative output.<sup>1</sup>*

#### 3.1 Overview of plywood history in Japan

Before following the development of plywood in Japan, it is important to note that many of the craft and design related concepts discussed earlier have had close ties with wood in the Japanese language and in practice. It also shows how material has been the premise for practice historically, where materials are cultivated to construct artifacts rather than search for materials that suit a preconceived idea. *Takumi*, a term for skill or craftsmanship, can be inscribed in three different characters: 工, 巧, or 匠; the first Chinese character is derived from a carpenter's square used for woodworking; the second character is from the skill to bend or correct the distortion of timber; and the third character is perhaps for the most skilled, indicating a box-like container with an axe inside – signifying a person who makes a house out of wood.<sup>2</sup> Another concerns with the characters for material, 材. The character is composed of wood, on the left, and inherent attributes, on the right. It is not inconceivable to claim that wood has been the basis of the idea of crafts in Japan, supported by skill and materiality, most likely affected by ancient China's longer history with woodworking.

The discovery of plywood in Japan occurred as a result of a competition for tea chest manufacture exported to Colombo, the largest city and former political capital of Sri Lanka. The tea chests from fir harvested around Nagoya area were manufactured for export beginning in 1899 or 1900, and sent to the regions of British Empire in India for 300,000 chests annually through the company Mitsui Bussan. The unanticipated decline of orders in 1905 prompted inquiry to Mitsui's Colombo branch for the cause; it turned out that their competition was a company in Britain called Venesta, associated with A. M. Luther company. Their chests were out to be made of glued veneers and could be produced more

cheaply. Further investigations revealed that Venesta had imported these plywood boards from Riga, Latvia.<sup>3</sup> Another important detail to note is that the tax on tea back then was based on its total weight, including the chest, and lighter chests proved advantageous.

A sample of Venesta product was shipped from Colombo to Japan, inducing the attempt to create its imitation. To recreate the thinness of layered veneers, 106 cm wide rotary lathe was developed by Kichijiro Asano by fixing a large, traditional carpentry plane, *ookanna*, on a roller in 1907.

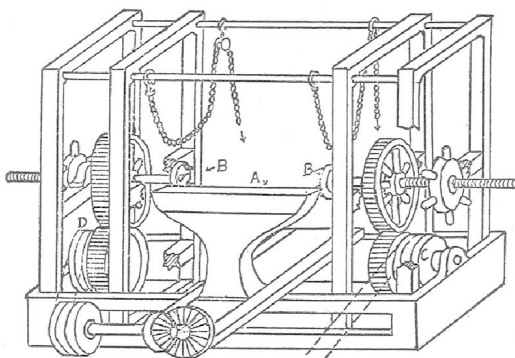


Fig. 3.1 Asano's draft for the first rotary lathe<sup>4</sup>

Asano had been born into a family business wooden barrels and tubs, which he eventually developed into a larger wood fabrication business and expanding into productions of fir tea chests and other products. By comparison, it has been recorded that there were 370 plywood factories over 30 states in the United States by the year 1907, and the first softwood plywood factory had already been built in Portland, Oregon, in 1905 under the name Portland Manufacturing Company.<sup>5</sup>

Obstacles encountered during the process of drying the veneers and gluing initially prevented Asano's factory from being able to meet satisfactory quality, as workers tried to recreate plywood through trial and error. Following Asano's steps in plywood production were several figures including Torakusu Yamaha of Nihon Gakki Co., who aimed to apply plywood in piano manufacture, Yasusaburo Mori who was previously involved in the matchstick manufacture in Amagasaki, Hyogo, and another former matchstick producer Hiroki Suzuki in Hokkaido, who had received technical support from Asano and later also supplied veneers to his factory.<sup>6</sup> Throughout Meiji period, the first three had been the only

manufacturers of plywood in Japan, but a large demand from the allied forces during the first world war pushed the industry to expand quickly from the early Taisho era, in the 1910s.

It is also worth noting that machinery imported from the United States and Germany had entered Japan by 1918, although only one machinery was imported from each country and the other 24 machines had been domestically built by then. The use of these machinery required training and repair work, as in other manufacturing fields that were increasingly reliant upon industrialized facilities.

During the first world war, Asano plywood was applied to floats, about 4 m long, that were fixed on seaplanes, which implies that waterproof adhesive had been developed by then. Asano had also obtained a patent for his plywood in 1910 for *Asano-shiki awase ita*, or Asano-style plywood.<sup>7</sup> Before waterproof adhesive was fully developed, however, plywood, which were formerly called *beniya-ita*, or veneer-boards, was a synonym for poor quality goods. While Asano had developed plywood with waterproof adhesive, other factories had been manufacturing with lesser quality adhesives.

### **3.1.1 Architectural applications**

The use of plywood architecturally has had significant effects on architectural design, from finishes to structural perspective. Decades preceding plywood, Richard Henry Brunton, a Scottish engineer who was hired by the Meiji government, recorded his observations of Japanese houses in his writing dated 1874. Brunton noted the precision of the joints and the lack of paint, and that the center of attention seems to be concentrated on the unfinished timber surface.<sup>8</sup> In addition, there were problems including the lack of bracing and heavy ceramic tiled roof, both of which made structures highly vulnerable in case of earthquakes. The smooth, fine grain of the wood has been treasured in the culture aesthetically, and carpenters and craftspeople had developed tools and techniques to achieve the softness of the surface.

Plywood helped introduce the bearing wall structural system, where thin pieces of timber with plywood nailed onto its frame formed the first case of stressed-skin panel in



Japan. Prior to this option, residential buildings were constructed with post and beam structure. The first wooden prefabricated building system was approved in 1962 for the application of Misawa Home, followed by Eidai House in 1964 and 65; these two companies dominated the prefabricated housing market at the outset.<sup>9</sup>

The North American systems of platform framing, or in very rare cases balloon or braced framing, constructions began to be adopted in Japan in 1965, commonly referred to as 2 x 4 construction system to this day. The existing types of wood based construction in Japan are shown in Fig. 3.1.1, the conventional post-and-beam structural systems, sometimes with infill of clay, earth or stone, having dominated the construction methods before bearing wall systems.

Type of construction	Primary functions	Structural system	Fabrication	Workload on site
<b>Conventional</b> Traditional	Shrines Temples Suki-ya Tea houses	Post and beam	Precut	High
<b>Conventional</b> Post and beam	Residential offices Schools	Post and beam (+ wall)	Precut	High
<b>Conventional</b> Half-timber masonry or half-timber with clay infill	Warehouse	Post and beam and wall	Precut	High
<b>Light framing</b> (2 x 4) Platform, balloon	Residential	Bearing wall (+ framework), or Bearing wall only	Unfinished Prefab	High Rel. low
<b>Prefab</b> Post and beam	Residential	Post and beam	Prefab	Relatively low
<b>Prefab</b> Panel	Residential	Bearing wall	Prefab	Low

<b>Prefab</b> Modular	Residential	Bearing wall	Prefab	Very low
<b>Prefab</b> Log construction	Residential	Bearing wall	Prefab	High
<b>Prefab</b> Laminated wood	Residential Gymnasium Church	Rigid frame, arch, three-dimensional truss	Prefab	Relatively low

Fig. 3.1.1 Classification of timber-based structures in Japan<sup>10</sup>

### 3.1.2 The spread of plywood use

Vast destruction of buildings and infrastructure due to Kanto Earthquake on Sept.1, 1923 created an urgent and boundless demand for building materials, as 580,000 houses had burned down or collapsed in addition to other building types such as factories, companies and banks. In Kiba, the largest distributing center of wood in the country, only 2 of the 420 recorded wholesalers escaped the damages, and most of the timber there had burned down.<sup>11</sup> Such circumstances led to the first widespread consumption of plywood, and any wood related products were sold as soon as they were produced, since nearly all built structures were made of timber. Importation of timber from North America had begun to rapidly increase from 1920, with species such as pine, fir and cedar. These were widely used in the aftermath of the earthquake since domestic products alone could not meet the demand.

The surge of luan importation from southeast Asia starting around 1931 was another occasion that fostered plywood production in Japan; it had first begun in early Meiji period, but in negligible quantities before 1919. The import quantity of raw material increased by sevenfold between 1931 and 1937. Starting around 1932, export of manufactured plywood also grew rapidly until the beginning of second world war. Initially the main importing countries were the UK and Australia, but quickly spread to include China, Belgium, and other countries.

Increased specialization of plywood was enabled by sophistication and variety of

adhesives, especially their waterproof quality. The labels included plywood for roof and floor substrate, scaffolding boards and concrete formwork. Notably from around 1952, plywood in concrete formwork began to replace the less efficient wooden formwork. The extensive research and development of plywood formwork application through the 1960s culminated in improved strength, durability, surface quality suitable for cement and concrete, and assembly considerations. Supported by and also backing the inflation of building demand during the high-growth economy, production of plywood formwork quadrupled in just five years, between 1968 and 1973.<sup>12</sup>

Likewise, with thicker plywood starting to grow in production, the approval of plywood application for structural use in 1969 brought changes to construction, especially after recognition for its functionality as applied to shear wall in timber frame construction.

Plywood factories, which were initially located in only a few major cities – Tokyo, Shizuoka, Nagoya and Osaka – spread to other cities, due to the combination of improved ports in rural areas and the rise in personnel expenses in metropolitan areas. As a result, the number of factories surged from the 1950s to early 70s. However, plywood being dependent on a naturally sourced material, the rising environmental concerns for over harvesting of luan in southeast Asia combined with the sourcing countries growing their own industrial capacities prompted a decline, then a shift to domestically sourced softwoods in the past two decades. Transition from hardwood to domestic softwood as the raw material required new techniques and adjustments, as Japan was slow in adopting its softwoods for veneer productions despite their abundance; another consequence of this has been that the location of factories are increasingly more advantageous near domestic forests rather than ports.

### **3.2 Plywood statistics: Japan**

Similarly to a 66 year gap between the beginnings of Arts and Crafts movement in 1860 and the Mingei movement in 1926, which took place six years after the first industrial movement in Japan, there was a comparable delay in the industrial plywood production: The first rotary lathe was in use by the mid-nineteenth century in northern Europe and the US,

compared to Japan, in 1907, about 60 years later. Nonetheless, production of plywood in Japan rose steadily and Japan until the 1980s, becoming second after the US in the worldwide production volume for more than a decade, from early 1970s.

### 3.2.1 Adhesive grades

Most of plywood in Japan today are manufactured under Japan Agriculture Standards, which categorizes the products as follows.

Category	Type	Adhesive	Typical applications	Sizes
<b>General plywood</b>		1, 2	Typical plywood for general use; mostly made of hardwoods and often called by the wood species used, such as luan plywood or linden plywood (does not include concrete formwork, structural, decorative, or specialty plywood)	T= 2.3-24 mm W= 910-1220 mm L= 1820-2430 mm
<b>Concrete formwork plywood</b>	Not coated	1	For the purpose of formwork; typically luan and softwood species are used; certain strength is guaranteed; applied in architectural and civil engineering projects.	T= 12, 15 mm W= 600, 900 mm L= 1800 mm
Same as above	coated	1	Same as above, except the surface is coated, painted or laminated; typically used for exposed concrete surfaces.	Same as above
<b>Structural plywood</b>	Grade 1	Special grade, 1	Used in timber structures where structural strength is required; some are fabricated with grooves on edges.	T= 7.5-30 mm+ W= 910, 1220 mm L= 1820, 2430 mm

Same as above	Grade 2	Special grade, 1	Essentially for the same applications as structural plywood type 1; typically used for floor, roof and wall substrate.	T= 5.5-30 mm+ W= 900, 910, 1220 mm L= 1800, 1820-3010 mm
<b>Decorative plywood</b>		1, 2	General plywood surfaced with decorative veneers, such as teak, rosewood, walnut, spruce, oak, etc., many of which are sliced rather than rotary cut; used in interiors and furniture.	
<b>Special plywood</b>			General plywood surfaced with something other than natural veneer material, such as painted, or laminated with melamine, polyester resin, metal foil, fabric, or PVC; also includes printed plywood, in which paper printed with wood pattern is applied onto the surface; classified by performance of the surface material.	

Fig. 3.2.1 Plywood categorization under Japan Agriculture Standards

Special grade adhesive is specified for use in conditions where prolonged exposure to moisture is expected, including outdoors. Structural plywood applied in exterior walls must use special grade. Most often, phenol formaldehyde resin is used.

Type 1 adhesive is specified for conditions where intermittent exposure to moisture is expected, such as concrete formwork. Melamine formaldehyde resin is typically used.

Type 2 adhesive is specified for conditions where occasional exposure to moisture is expected, usually for interiors, furniture and cabinetry. Urea formaldehyde resin is a typical adhesive used for these purposes.

Other categorizations under JAS include low formaldehyde plywood, in which the 4 ranks are determined by the amount of formaldehyde in the adhesives, fire and insect proof plywood, and wood flooring, in which the decorative veneers are applied on general plywood.

Plywood not certified by JAS include panels used for scaffolding, which has to meet the Industrial Safety and Health Act, moulded plywood, anti-bacterial plywood, etc. In addition, lumber core, board core with particle board or MDF, and honeycomb core ‘plywoods’ are also categorized separately.

### **3.2.2 Production and demand**

The plywood industry took off in Japan after the war and the subsequent reconstructive efforts of the postwar period (1945-1954), and expanded during the rapid economic growth that followed (1954-1973); the country reached the second largest economy by the total GNP in the world after the United States and surpassing West Germany in 1968. Until 1986 the economy continued to grow steadily, at which point the country entered the bubble economy from 1986 to 1991, followed by the long recession that would last for over two decades.

During the postwar growth there were extensive construction projects throughout the nation, including public engineering works. The use of plywood in building of houses had not been typical with the traditional construction methods, and the surge in plywood use seems to correlate with the consumption of concrete, as they were applied for the purpose of formwork.

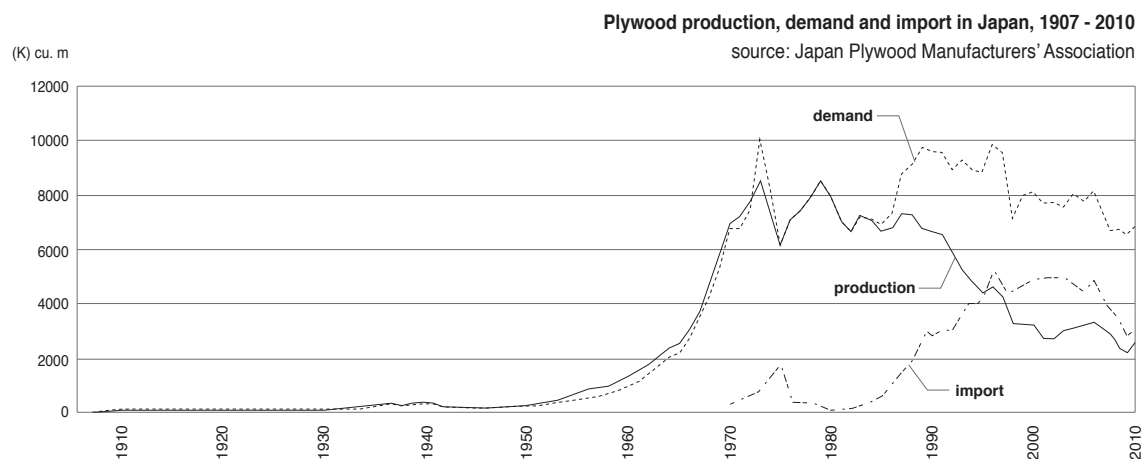


Fig. 3.2.2 Plywood production, demand and import in Japan, 1907-2010<sup>13</sup>

Production of concrete reached its peak in 1990, at 198 million cubic meters.<sup>14</sup> The category of formwork plywood was established by the Japanese Agricultural Standard in June 1967, known as *kon-pane*, which is short for concrete panels. These are graded from A to D according to the quality of the surface, including those with one or both surfaces coated or laminated with another material such as melamine.

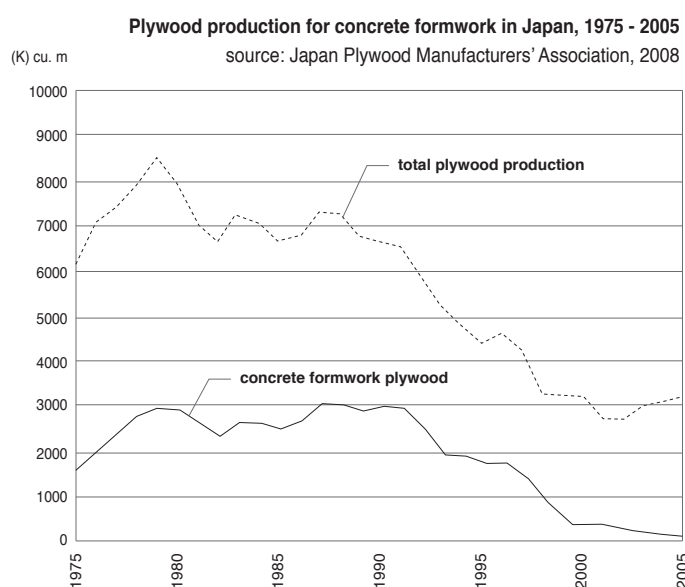


Fig. 3.2.2-2 Plywood production for concrete formwork in Japan, 1975-2005<sup>15</sup>

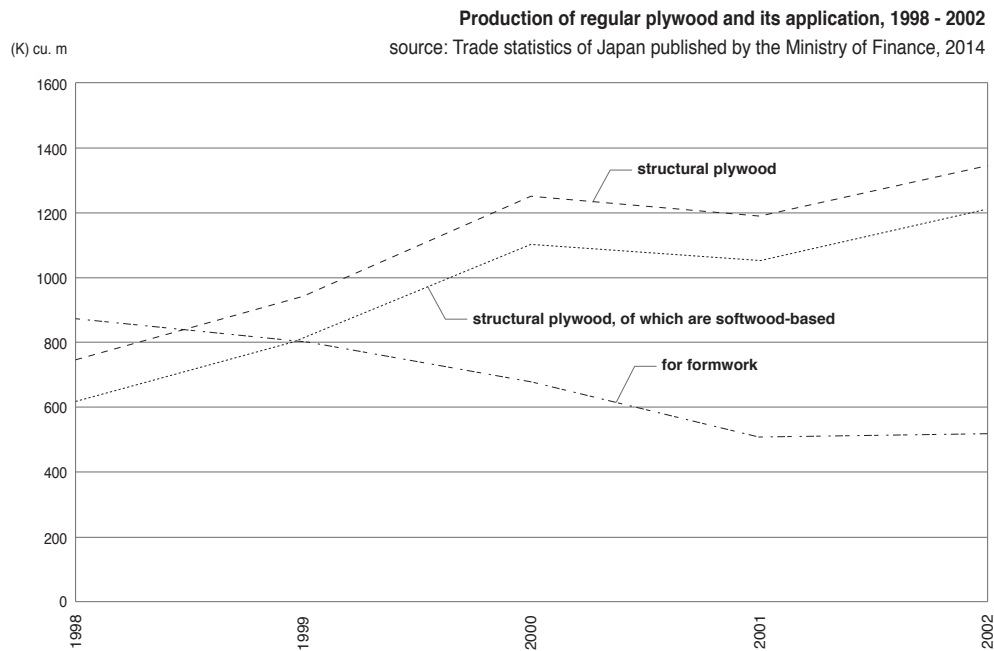


Fig. 3.2.2-3 Production of regular plywood and its application, 1998-2002<sup>16</sup>

The type of concrete formwork plywood were used for general structural purposes, however, changes in the building standard laws in 2003 prohibited the use of this type of plywood for anything other than formwork to address the sick building syndrome, for the adhesive used. Since then the quantity of formwork plywood used have dropped, combined with the economic stagnation.

While earlier data is not available, in 1975 the category for formwork plywood constituted 24.9 percent of the entire plywood production in Japan, and rose to its peak of 44.1 percent in 1991. By 2003, the ratio declined to 10.6 percent, and as the regulation amendment took effect, continues to drop to 0.9 percent in 2013.<sup>17</sup> There is no specific data on the raw materials for formwork plywood, but it seems that most – around 70 percent – were produced with imported luan until recently. Another change currently taking place is the expansion of steel formwork substituting plywood formwork; where coated or laminated plywood formwork can be used up to 5 times, the steel formwork can be used almost limitlessly thus making steel option more economically viable today.

It is generally assumed that for the purpose of furniture and cabinetry, plywood with



thickness of 6 mm or less are used in most cases. For concrete formwork, plywood 12 mm thick or more is typically utilized. The relative stability in the production of 12 mm plywood amidst the general decline can be accounted for the relatively small ratio of other Asian regions producing thicker plywood – many of which had concentrated on the production of plywood around 6 mm.

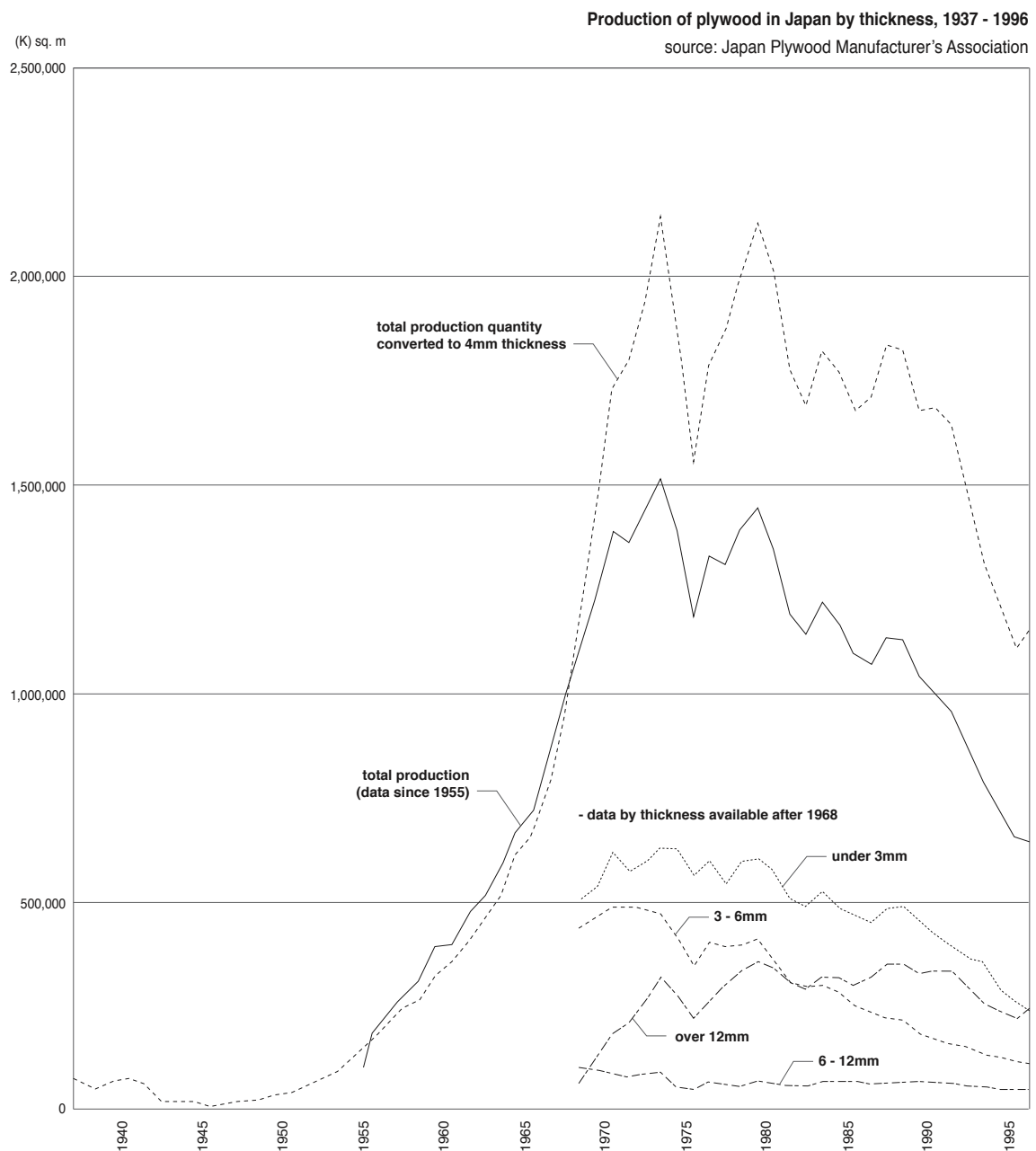


Fig. 3.2.2-4 Production of plywood in Japan by thickness, 1936-2006<sup>18</sup>

### 3.2.3 Cost of wood by species

The pricing of wood as raw material is another indication of the economical shifts and the changes in availability, whether domestically harvested or imported. Environmental concerns related to over-harvesting have also influenced the sourcing of certain species.

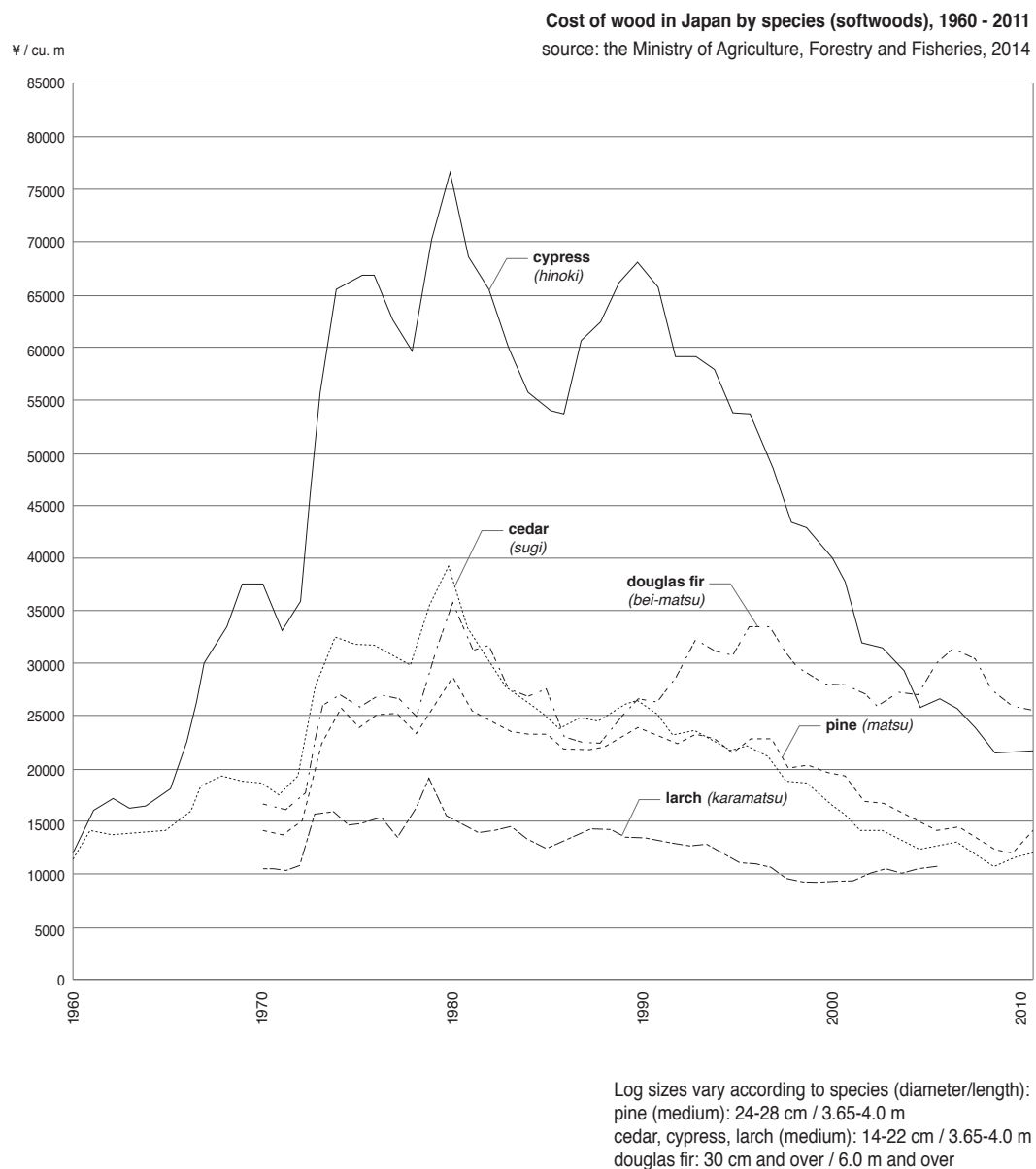


Fig. 3.2.3 Cost of wood in Japan by species (softwoods), 1960-2011<sup>19</sup>

*Hinoki*, Japanese cypress, has been the most valuable species of wood for most of the

last five decades, with Japanese oak and luan surpassing in value intermittently in the 80s and 90s. Luan was imported first from the Philippines, then Indonesia, followed by Malaysia, as the over harvesting of this species increasingly became an issue in the Southeast Asian region.<sup>20</sup> During the late 1960s to 70s, Japanese companies began to invest in logging in Kalimantan region of Indonesia with its support in technology, funds, and advice for large scale logging operations. Japan, mostly through *sogo shosha* also known as general trading company, imported over 40 percent of total log production in Indonesia through the 70s, which prompted a boom in logging that grew rapidly from 5.5 million cubic meters in 1968, and over 26 million cubic meters in 1973, to average of 23.7 million cubic meters annually from 1973 to 1980.<sup>21</sup> Current importation of luan as raw material has declined significantly as more processed products – in the form of plywood that are inexpensive but high-grade – are exported by these countries.

The establishment of the National Land Afforestation Promotion Organization in 1950 attempted to reverse the negative effects from the large-scale deforestation during the war, when resources were diverted to timber, charcoal, firewood, etc. Many of the forests that were previously dominated by hardwood were then planted with Japanese cedar and cypress, due to their faster growth cycle and value as building materials. These two species consisted about 70 percent of the entire afforestation efforts, while the remaining included larch and red pine, and the planting continued into the 1970s.

In 1964, however, import liberalization of timber greatly shifted the market conditions. Combined with the appreciation of the yen, the rate of self-sufficiency for timber has dropped from over 94 percent in 1955 to approximately 18 percent by the year 2000. It led to the sharp drop in value of domestic cedar and cypress, especially as they have matured after several decades. These species mature in approximately 50 years, and the unmanaged state of these planted forests have become a crucial issue.

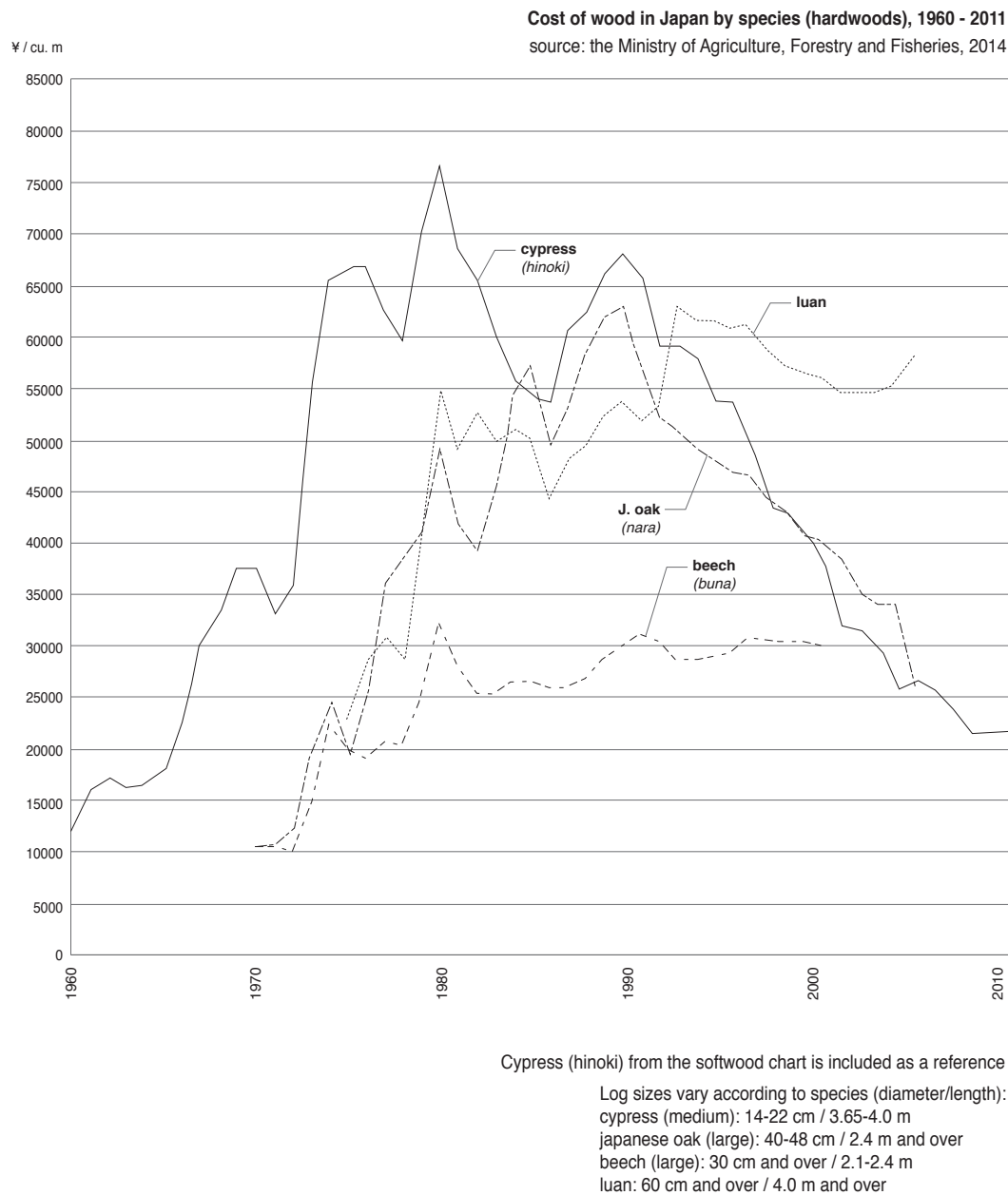


Fig. 3.2.3-2 Cost of wood in Japan by species (hardwoods), 1960-2011<sup>22</sup>

A clear advantage to the plywood and pulp industries is the relative low cost of the material compared to their timber counterpart; especially the pulp industry that can utilize scraps and chips from other wood processing and even recycled materials, and increased applications of these products such as in fixtures and fittings. There are differences with each of the products, for example, particle board production tends to utilize more recycled materials than MDF production, but it is also dependent on the available quantity of recycled

materials and the pricing of raw timber at any given time. Further refinement of wood into powder form has also led to wood-plastic composite products.

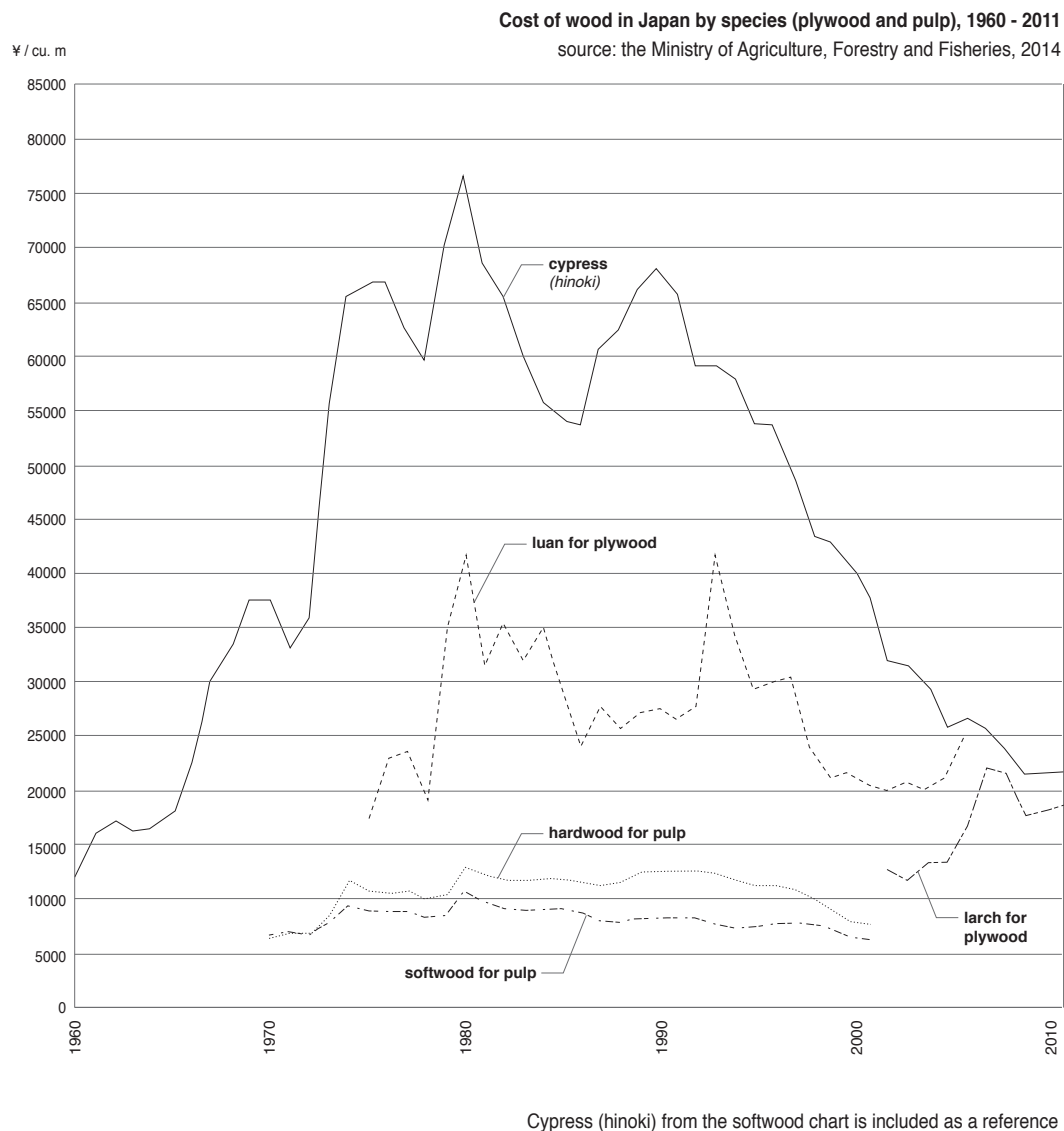


Fig. 3.2.3-3 Cost of wood in Japan by species (plywood and pulp), 1960-2011<sup>23</sup>

### 3.2.4 Industrial wood products

Timber had been the most prominent material of all the products derived from wood throughout much of history, but increasing quantity and variations of industrial wood products have steadily replaced some of its implementations. The data shows the biggest growth in the pulp and chip-based products in Japan, as was the case in the US, however,

the overall growth has declined after 1990s due to economic stagnation. Sources of wood pulp and chips are from four sources: Raw timber, unused remains from other factories, remains from forests, and scraps from demolished buildings.

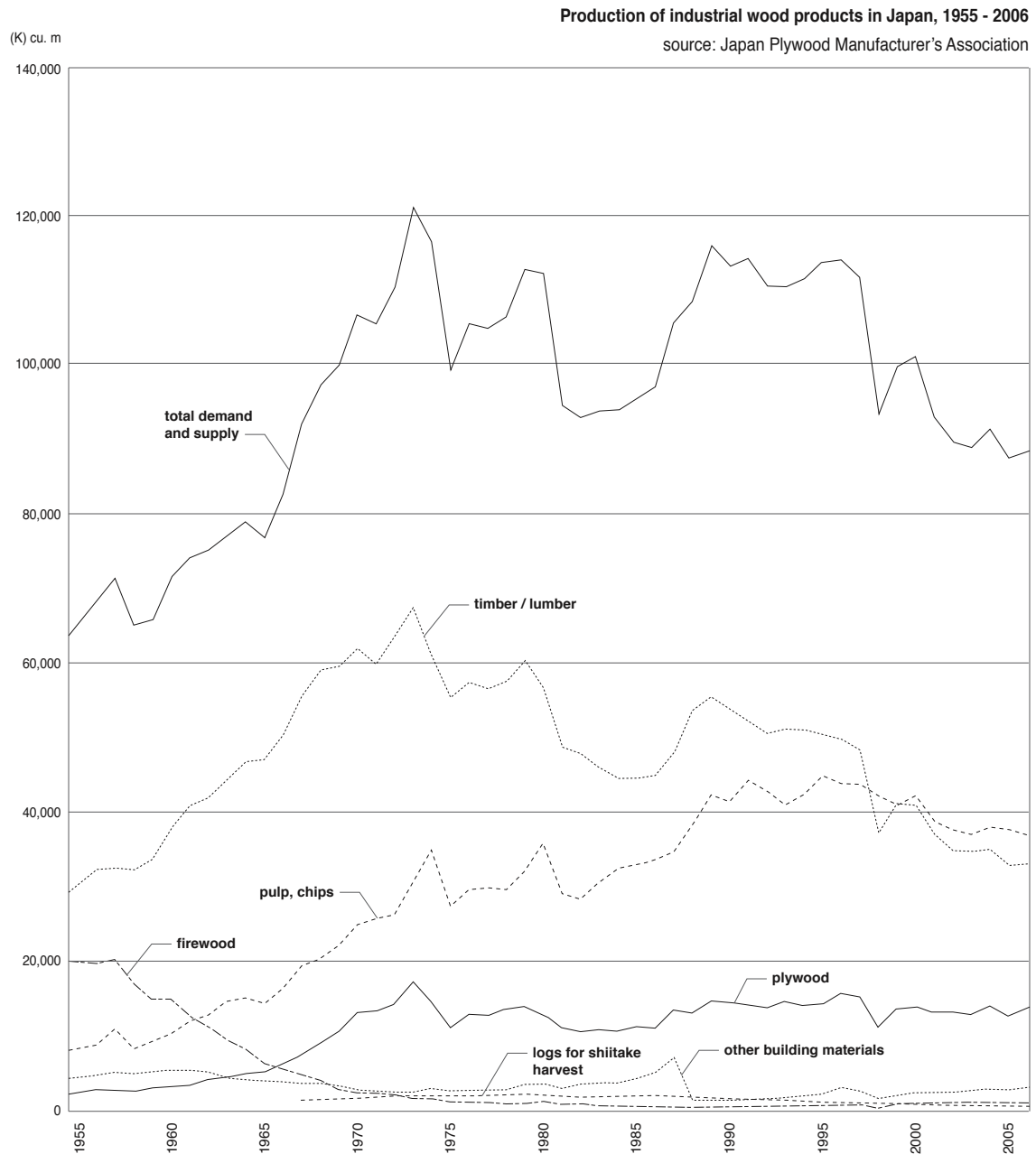


Fig. 3.2.4 Production of industrial wood products and firewood in Japan, 1955-2006<sup>24</sup>

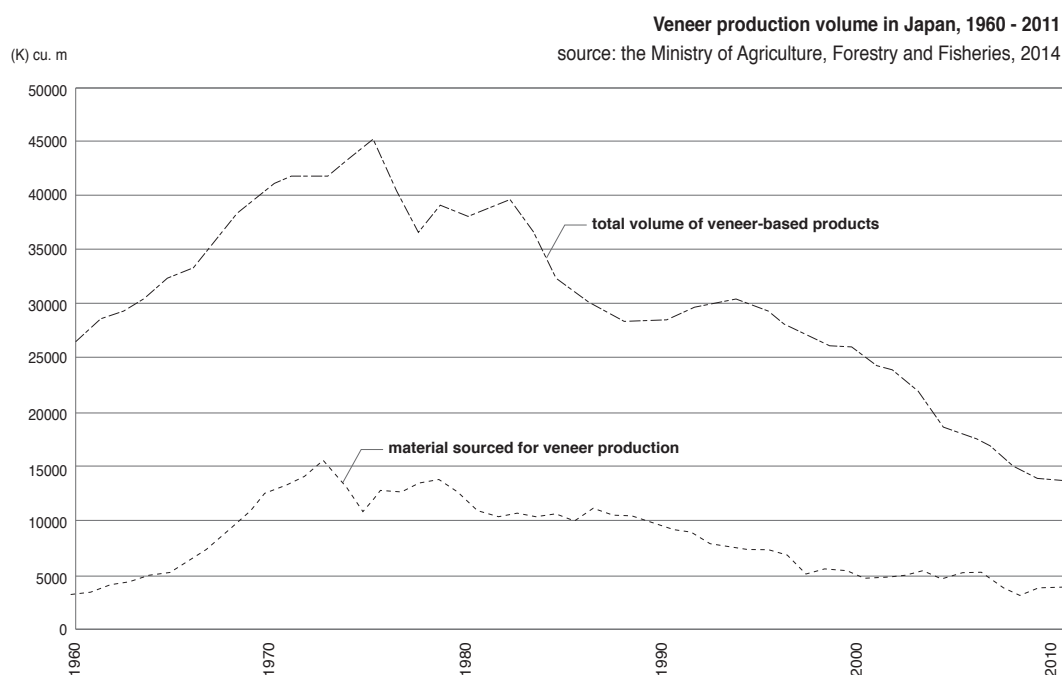


Fig. 3.2.4-2 Veneer production volume in Japan, 1960-2011<sup>25</sup>

The gradual decline in the volume of veneer-based products also underscores their replacement with finer, pulp and fiber-based products; what had been exclusively served by veneer, plywood and other board products have increased options in other materials such as MDF, especially for non-structural purposes.

Southeast Asia remains the top exporters of plywood for Japan between 1998 to 2002, led by Indonesia and Malaysia as Japan's production of plywood dwindled. Industrialization brought capacity for the countries to produce plywood and other products, rather than exporting the raw material of logs that yield smaller profit margins.

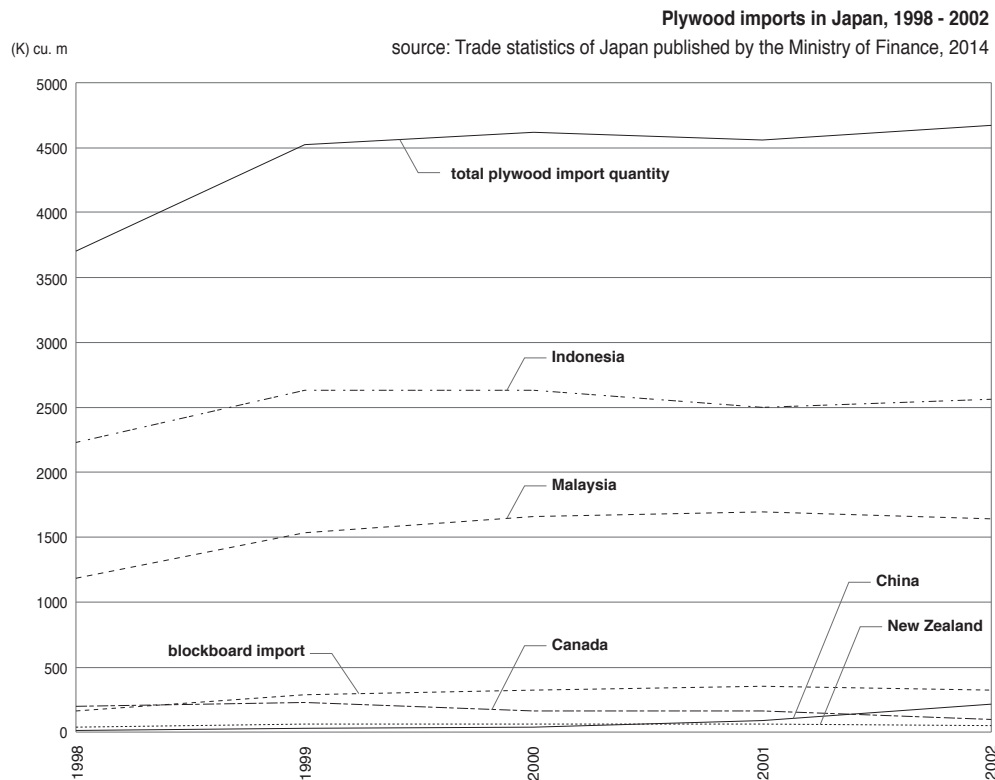


Fig. 3.2.4-3 Plywood imports in Japan, 1998-2002<sup>26</sup>

### 3.2.5 Specialty plywood

Specialty plywoods are applied in interior finishes, cabinetry and furniture. Print-applied plywood, including both direct print applied on the surface and laminate, which is a layer fixed to the surface afterwards, is the most produced specialty plywood. They are often printed with wood patterns to imitate real wood and are used for cabinetry, surfaces in the kitchen, and some interior finishes. They are in competition with MDF which, as a pulp-based product, takes ink better than the uneven veneer surface that is also prone to cracking. The advancement of print technologies through adhesives and paper materials in the first half of 1960s seem to have popularized the laminate method over direct print. The repetitive pattern of the wood grain in prints have also improved in recent years with more accurate depiction of real wood with variable textures, but there is also a negative association with cheaper products.



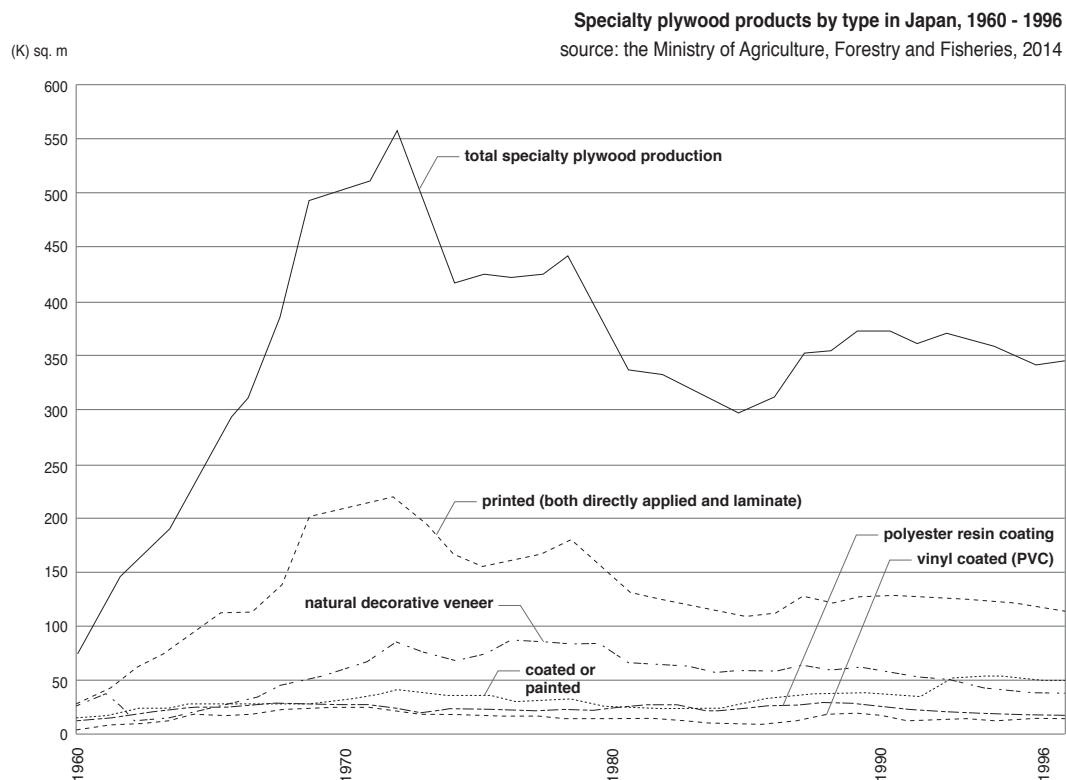


Fig. 3.2.5 Specialty plywood products by type in Japan, 1960-1996<sup>27</sup>

Natural decorative veneers are applied on plywood for moderately higher-end furniture and interior finishes. Common species used as surface veneer include zelkova, oak, birch, paulownia, and cypress for domestically sourced wood, and teak, walnut, ebony, and rosewood for imported species. Species applied are heavily dependent on the popularity of the time. With species such as oak, zelkova or cypress, sliced veneers are often used instead of the typical rotary cut type to showcase the grains for a more aesthetically desirable effect. Sliced veneers range in the way they are sliced: from lengthwise, plain which is also known as crown cut, half-round, or quarter sliced.

Both polyester resin coated plywood and vinyl (PVC) coated plywood belong to the basic category of synthetic coating such as melamine, diallyl phthalate resin and benzoguanamine resin. These can add qualities of heat, abrasion, and weather resistance to plywood, and applied for furniture and interior surfaces, including wainscot and ceiling.

### 3.2.6 Production efficiency

It is not a specific phenomenon to the plywood industry that with advancements and expansion in industrialized processes comes increase in efficiency of productions. While the number of plywood factories has dropped considerably since the mid 1970s, the output per factory has grown significantly. The same situation can be seen in the timber industry. Of the timber factories that closed down between 2009 and 2010, 80 percent were small scale factories with output scale of 75kW or less, whereas larger factories of 300kW or more, consisting of only 7 percent of the factories, processed 60 percent of total timber production.<sup>28</sup> With the surge domestic softwood applied to the plywood manufacture in the last decade, there is also a shift in trend that plywood factories are better advantaged to be situated in or around forests and no longer near ports when imported logs were the dominant source.

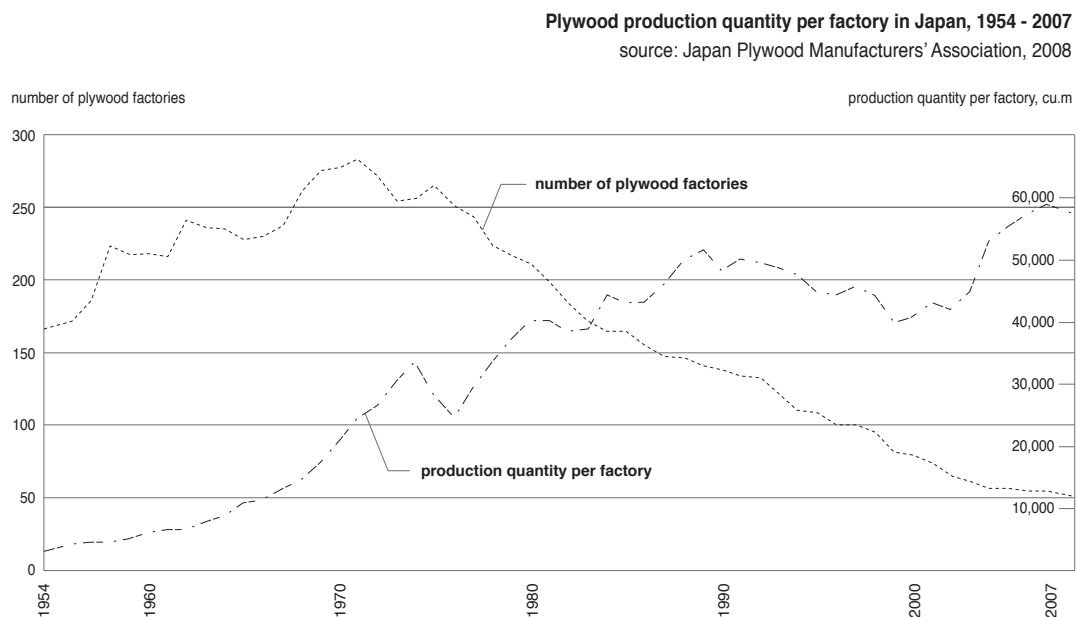


Fig. 3.2.6 Plywood production quantity per factory in Japan, 1954-2007<sup>29</sup>

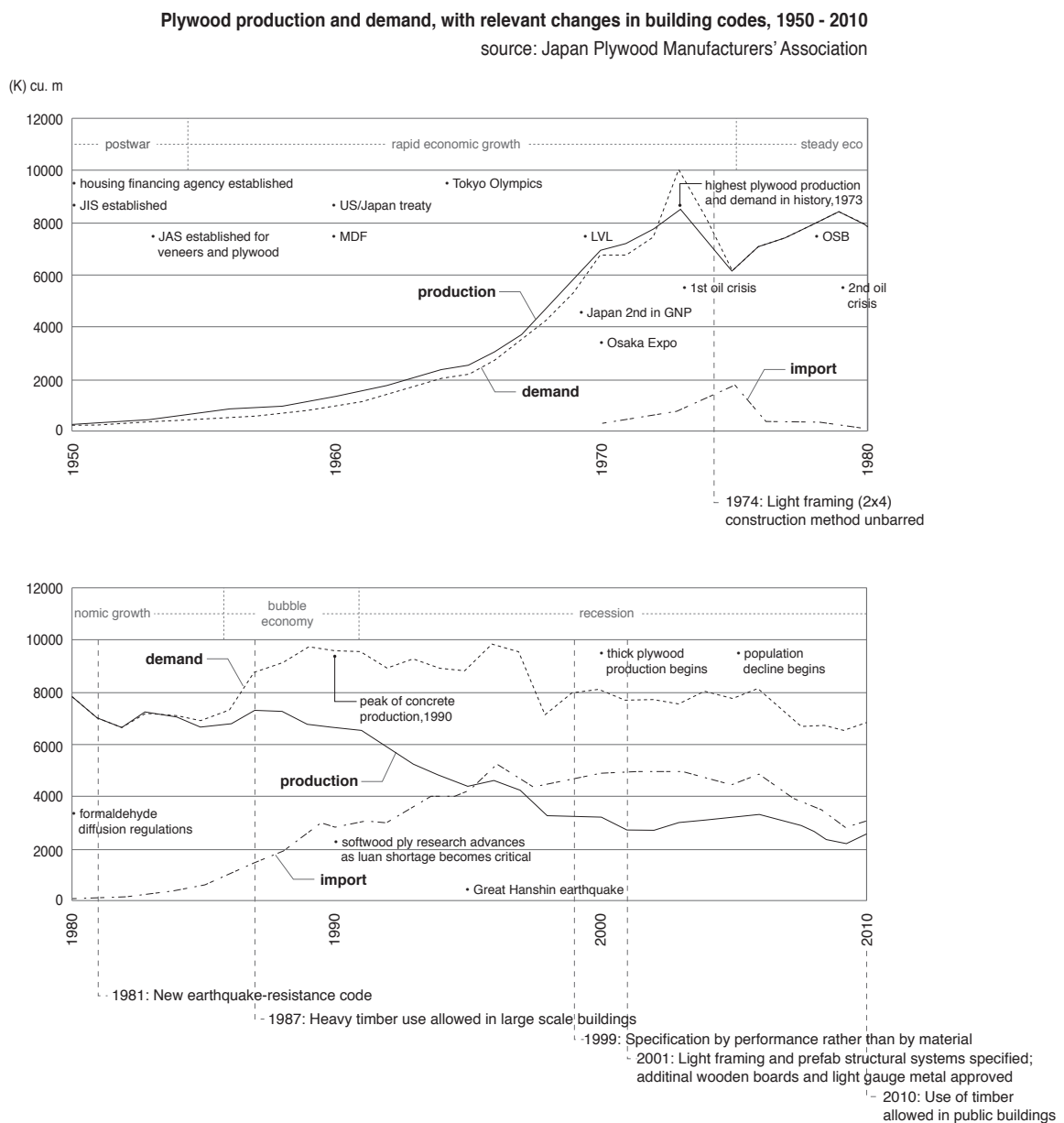


Fig. 3.2.6-2 Plywood production and demand in Japan and relevant changes in building codes, 1950-2010<sup>30</sup>

Plywood industry has clearly been subject to factors such as economic development, subsequent recession, increasing concerns for natural resources and changes in the building codes related to wood, among others.

Domestic production growth seen in the twenty-first century is almost entirely due to

softwood veneer applications that began earnestly for the first time around 1990, in combination with the marketing of thick structural plywood and its production since 2000. The abundance of Japanese cedar that require harvesting to maintain a healthy forest and the over harvesting of luan in southeast Asia have been a large factor in the transition from hardwood to softwood plywood. In the US, however, the production of softwood plywood had begun as early as 1905 with douglas fir, at the same time the industrial production of plywood began there.

There have been a number of factors that have influenced the plywood industry: Environmental, in terms of sourcing and the use of formaldehyde in the adhesives; structural, in terms of newly approved construction systems, seismic requirements and fire-resistance, which are also related to legislative regulations; and its relationship with other industries, such as concrete.

### **3.3 Moulded plywood in Japan: The case of Industrial Arts Institute**

#### **3.3.1 Prewar and the birth of plywood**

When the Industrial Arts Institute invited Charlotte Perriand from France in 1940, the subsequent 1941 Takashimaya exhibition *Selection, Tradition, Creation*, showcased examples of the transfer of design to available materials and techniques in Tohoku. Plywood, along with standardized steel sections and plastic, had been starting to dominate European markets at the time, but not yet readily available in the region of Tohoku.

The exhibition catalogue of Takashimaya mistakenly noted Alvar Aalto's armchair as the first model of plywood chair. Moulded plywood technique had not yet been developed in Japan, and the logical replacement seemed to be bamboo. The attempt to make a variation of it in bamboo first resulted in a rigid structure that did not take advantage of bamboo's elasticity; Perriand made structural revisions to enhance and also to streamline the form (Fig. 3.3.1, right). Variations on supports were also tested, with the arm and leg made from laminated bamboo plywood to solid wood (Fig. 3.3.1-2). The thinness of the bamboo strips and using its elasticity to the comfort of seating was comparable to plywood chairs to some

extent.

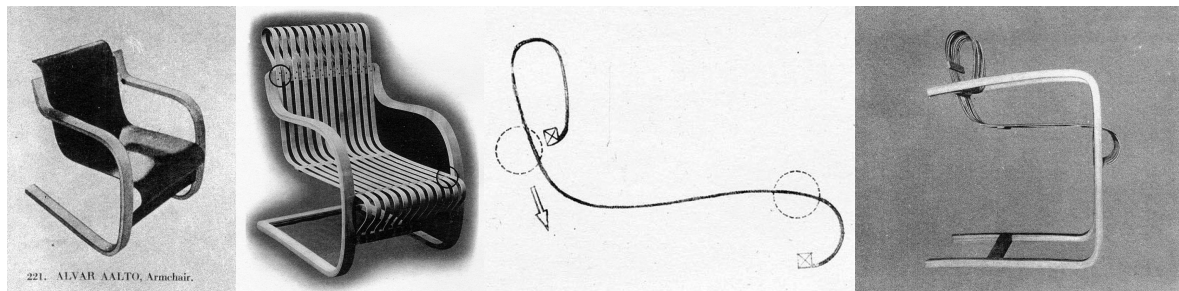


Fig. 3.3.1 Remaking of Aalto's plywood armchair in bamboo<sup>31</sup>, from left to right: The original armchair, first iteration, analysis of the material and chair structure's elasticity, and the revised model in bamboo.

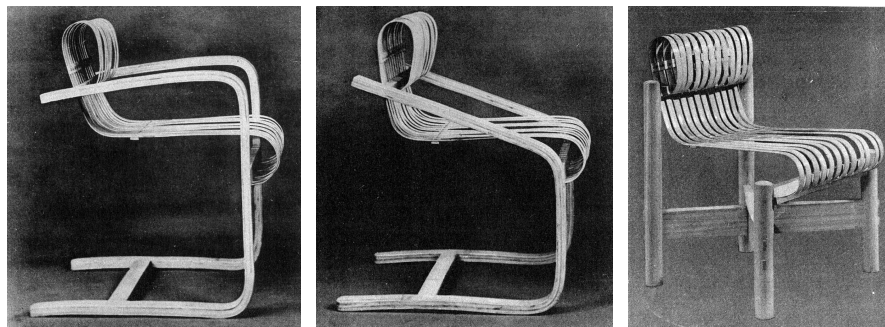


Fig. 3.3.1-2 Variations of the bamboo chairs with exactly the same seat and back supported in different ways; supports in laminated bamboo plywood (left and center) and in wood (right)<sup>32</sup>

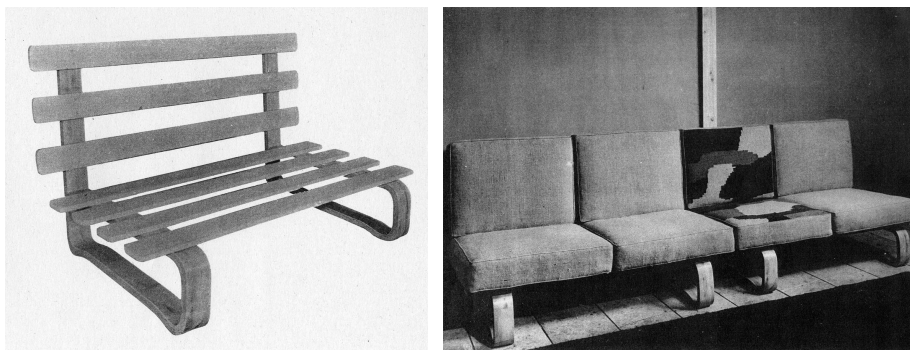


Fig. 3.3.1-3 The frame constructed by laminated bamboo plywood and Japanese cypress boards (left), finished with cushions (right)<sup>33</sup>

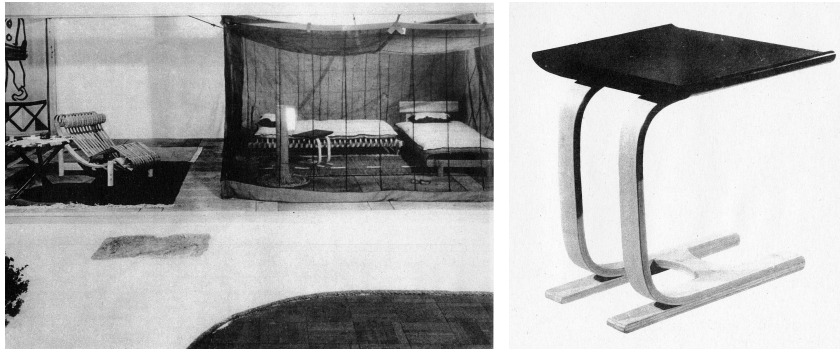


Fig. 3.3.1-4 Example of the interior space organization (left) and a side table with support made of laminated bamboo plywood, with tabletop in black lacquerware (right)<sup>34</sup>

### 3.3.2 1938 to the birth of moulded plywood

As the second world war was looming, limitations on the use of metals and other materials were gradually being imposed around 1937-1938 to direct them for military use. All kinds of metals, leather, rubber, wool, cotton, and linen were to be applied exclusively for military use; the products for civilians were to be restricted to wood, bamboo, hard paper as a form of galvanized fiber, synthetic resin, and marine leather,<sup>35</sup> which was an attempt to take fish skin as an alternative leather for shoes and other objects. Such conditions prompted researches at the Industrial Arts Institute to divert their focus to substitute materials.

In the fall of 1938, professor Kajita specializing in wood applications at Kyoto University visited the IAI in Sendai with a tego-film – an adhesive sheet to be sandwiched between the veneers that hardens in the hot-press to become waterproof. Previously, animal glue from the gelatin and casein from milk protein were the standard for gluing wood. Synthetic resins were not yet available except for imports from Germany, and casein, with its limited in its waterproof quality, had been their best option. The new world of adhesives paved the way for the techniques of moulded plywood to flourish.

It might be said that the birth year of moulded plywood in Japan is 1939. By then, there were increased alternatives for adhesives, including phenol resin for the hot-press, entailing metal moulds for the press, and urea resin, which could be used at room temperature and thus wooden mould was sufficient.<sup>36</sup>

### 3.3.3 Moulded plywood in wartime: Decoy plywood aircraft

By the end of 1943 the IAI was in danger of being closed down, as the government perceived their nonmilitary endeavors too leisurely and unfit in the wartime. Isamu Kenmochi, who was one of the designers there and a strong advocate for the new potentials of plywood both structurally and aesthetically, pitched the idea of applying moulded plywood to the production of airplanes to the army.<sup>37</sup> Kenmochi had been studying the techniques of moulded plywood for a while, and he believed that plywood can be applied to the production of airplanes. The head of the department of aerial weaponry who saw the idea thought it could be useful, and thus the IAI was sustained. Kenmochi ended up concurrently holding the posts in the Ministry of Commerce and Industry, and in the Ministry of War, which was in operation from 1872 to 1845.<sup>38</sup>

It was in 1945 that the research and training of constructing fuselage, propellers, and special weaponry from wood began at the IAI. The plan to transfer the IAI to the Ministry of War from the Ministry of Agriculture and Commerce was approved, but it disappeared along with the end of the war. Both of these ministries were discontinued, and the Ministry of Commerce and Industry, which was abolished in 1943, was established once again.<sup>39</sup>

When the president Oyama and factory chief Kato from Tendo visited the IAI to inquire about potential work beyond the production of basic ammunition boxes, Kenmochi requested them to fabricate the decoy aircraft. Modeled after the GI-type aircraft, the decoy was never intended for actual capacity to fly. Ten decoy aircrafts were manufactured and delivered to the Imperial Japanese Navy in Tsuchiura, Ibaraki.



Fig. 3.3.3 Decoy plywood aircraft, around 1945<sup>40</sup>

There were several predecessors of aircrafts made in plywood, though these earlier versions were structured to fly like any other planes. One is the prominent de Havilland DH. 98 Mosquito, which experienced its first flight in 1940 and was in use by the British Royal Air Force by the following year. The Soviet Union had also constructed plywood aircrafts that were in flight by 1940, known as LaGG. One of the Soviet sergeants crash landed this type of aircraft in the State of Manchuria in 1942, instigating the research into this application by Japan which obtained the plane and conducted analysis on the construction of the plywood.

Tendo Mokko was not the only factory undertaking the task of wooden aircraft production; Hida Mokko, known today as Hida Sangyo based in Gifu prefecture and specializing in wood furniture, had also been involved earlier. They had begun with the production of moulded plywood fuel tank in 1942, before embarking on the first wooden aircraft production in Japan in 1943 under the guidance of Tachikawa airplane company. Other furniture manufacturers were also drawn into this endeavor, by producing things such as aircraft seats from woven wisteria vines and military steel products by Kosuga and ladders, fuel tanks, submarine depth bomb and wooden tailplane by Maruni.<sup>41</sup> At the time, refusal to cooperate with national policy regarding the war resulted in imprisonment, and many of the companies with furniture manufacturing capabilities were pulled into the military related productions. However neither Tendo Mokko nor other companies reached full-scale operations for either flight or decoy airplane manufacture before the end of the war.

### **3.3.4 Proliferation in the furniture industry: Products for domesticity**

In addition to a direct involvement with military industry, one of the scopes dealt at the IAI was to replace domestic metal products into wood in order to direct all metals for the war effort. That included the household utensils, for which its necessary resistance for heat, water and chemicals prompted research on plywood-aluminum bond for a durable surface. The main obstacle for that research was the difference in the expansion rates of these two materials. Researchers Matsuzaki, Ooba, and Nakamura succeeded in developing the



intermediary layer from a combination of phthalic acid resin, lacquer and wood powder, to relieve the difference. In the following year, they also succeeded in the steel-plywood bond which was later applied in the construction of fire-resistant safety storage units.<sup>42</sup>

The manufacture of residential products increased even more immediately after the war, with whatever material was available, as all military related productions were terminated. For typical families, collapsible low dining tables, kitchen sinks and cupboards, which were produced from leftover cedar, proved to be in high demand.

Newly constructed residences for the occupation forces and their families raised the demand for western-style furniture, which were still very much unfamiliar in Japanese households. Chairs were especially new for the manufacturer, and there were many problems noted by a British lieutenant who came to inspect the factories that produced furniture for their new residences: Wood were not adequately dried before use, screws were hammered into the wood to save time, and glue was not applied evenly, among others, attributed to poor workmanship.<sup>43</sup>



Fig. 3.3.4 Interiors of the dependents house for the occupation forces: Living room from type A-2 (left), and from type B-2 (right).<sup>44</sup>

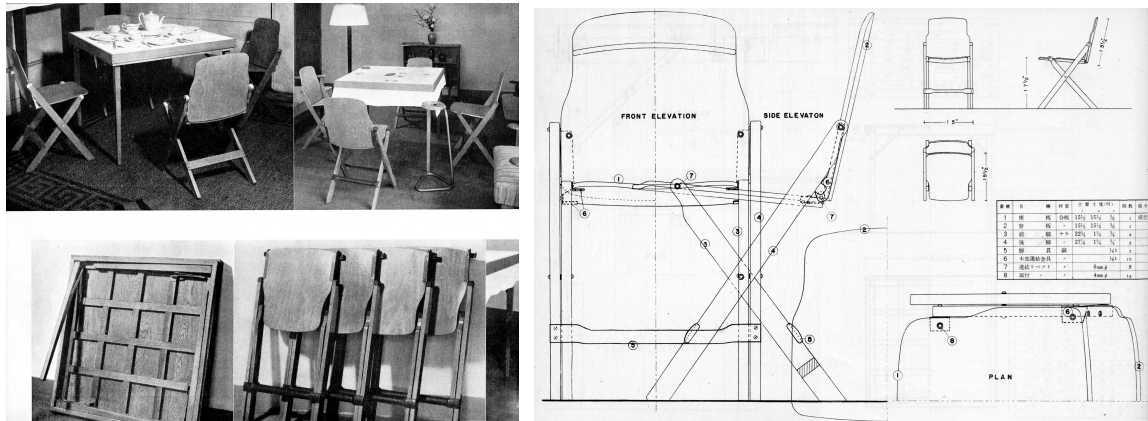


Fig. 3.3.4-2 The card room in the dependents house (left) and drawings of its plywood collapsible chair (right).<sup>45</sup>

### 3.3.5 Variations of moulded plywood techniques

Applications of moulded plywood can be generally categorized into either a surface or a narrower linear piece. The latter often functions as structural supports, such as legs of a chair. In experimenting with techniques early on, IAI was not only concerned with the efficiency of mass production, but also how the aesthetic of the technique might be expressed, even if the work required a laborious process.

#### Variation 1: Constant thickness with different curvatures

After the basic moulding plywood techniques had been established, attempts for more complex curve forms followed. Moulding as a single continuous piece that bends in multiple directions requires a larger mould to accommodate, as well as a method of sectioning the mould to remove the finished piece.

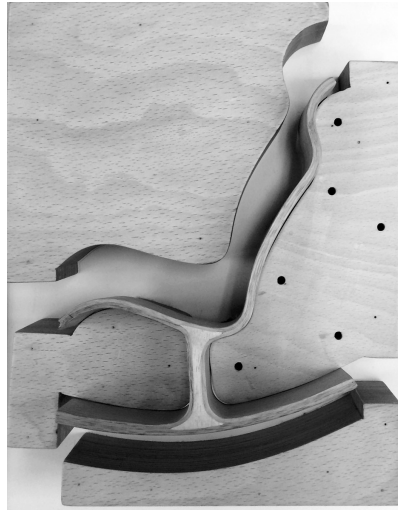


Fig. 3.3.5-1 Four-part mould for Heron rocking chair by Mitsumasa Sugasawa; the wide piece is moulded first as shown and is later sliced into multiple side frames.

### Variation 2: Irregular thickness

Research on ways to vary the thickness of continuous piece of moulded plywood arose mainly from design considerations, but also trying to meet aspects of economizing of material and simplification of the production process to achieve the desired result. The example of this technique is Monroe Chair by Arata Isozaki, produced in 1973, in which the tall, continuous back to leg piece. The curvature of the line narrows at both ends, at the top and the bottom, to make the undulations visually delicate and elegant.

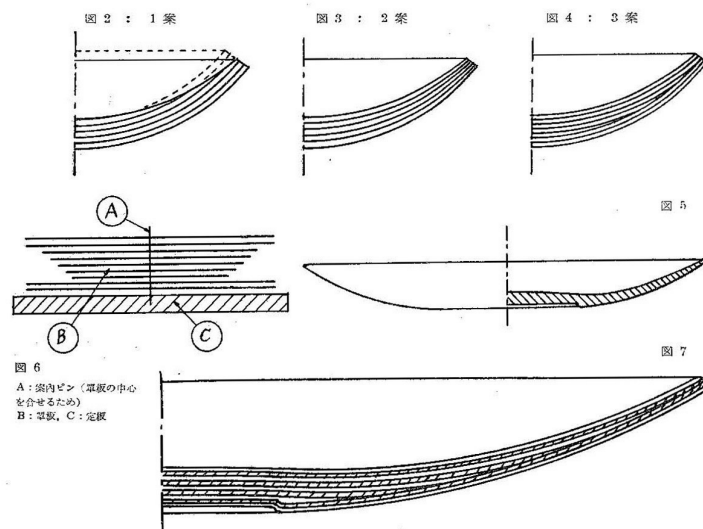


Fig. 3.3.5-2 Variations on the study of how moulded plywood with irregular thickness can be achieved: From top left, labeled as image 2. Equal thickness plywood is formed, then the unused part is carved out; 3. Each of the veneers are equally thinned out before moulding; 4. The veneers are cut into different lengths initially then combined; 5-7. Method shown on image 4 was developed with inner layers with softer wood that is more easily compressible and easier to finish as a completed piece.<sup>46</sup> The selected process uses continuous outer layers, with only the interior layers manipulated to account for the change in thickness.



Fig. 3.3.5-3 Example of the irregular thickness moulded plywood by Tendo Mokko today, used in some designs of chair legs

### **Variation 3: Solid *koma* piece embedded between veneers**

Another approach similar to the irregular thickness moulded plywood is the addition of a solid piece, which was called *koma*. Its first use was in tennis rackets when they were produced in wood, and it was quickly developed into furniture applications. The precise forming of the solid piece is a technique that had to be acquired, and the press also had to be designed to be taken apart into several parts.

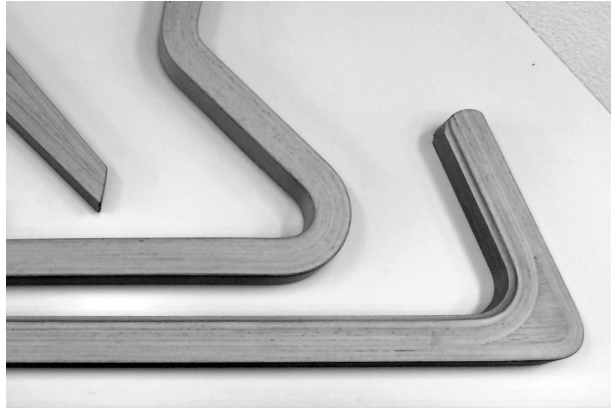


Fig. 3.3.5-4 Example of the solid wood piece, *koma*, embedded to strengthen the lower right corner of the moulded plywood

For the production of experimental projects, which they had called trial examples, trial-manufacture, or trial products, there were private manufacturers that contributed to the actual production. In the case of plywood, Yamagata Mokuzai Kogyo assisted with the irregular thickness moulded plywood between 1958-1965. Others included Kosuga, a furniture company, for the production of small chairs, tables, and furniture for the study, and Akita Mokko, for bent wood furniture.

### 3.3.6 *Kogei News*

*Kogei News* (Industrial Art News) was a journal edited by the Industrial Art Institute and published between 1932 and 1974. It was published by multiple publishers over the years, starting from Kouseikai Publishing (predecessor of the Union of Japanese Scientists and Engineers), Kogyo Chousa Kyokai, Takayama Shoin, Gijutsu Shiryou Kankoukai, and finally Maruzen Co., Ltd.

It had started as a monthly publication and was suspended in the final year of the war, 1945, then restarted with irregular publications of varying number of issues per year. Between issues 12-8 (October 1943) and 13-9 (November 1944), *Kogei News* changed its name to *Kogei Shidou*, with more emphasis on the instructional aspect of the journal. The first publication after the war came in June 1946 with issue 14-1, which reverted its name to *Kogei News*. The journal covered international design trends, researches at the IAI, exhibitions,

and designers. Other publications came in the form of reports on what they called trial manufacture, examples, or products, and exhibitions showcasing their results.

Following is a list of articles related to plywood, its techniques, designs, and accompanying commentaries, published in *Kogei News* (\* denotes articles with only the titles available in the archives):

Year	Issue - No.	Title (author, when noted)
1935	4-9	Comparative testing on the strength of adhesives (Suzuki, Takeshi) Material, technique, application: Bubbling of adhesive on veneers
	4-10	Research on standard work chair in wood Plywood chairs by Alvar Aalto and Kem Weber Material section: Veneers
1936	5-3	Sliced veneer adhesives and bleaching (Ueda, Jisaku)
1938	7-8	Trial furniture from laminated veneers
	7-10	Substitute products from plywood*
1939	8-7	Research on specialty plywood*
	8-8	Comprehensive plywood research*
1940	9-10	Specialty plywood: Fire-resistance tests for the safe
1941	10-8	Fire resistance of plywood portable safe (Ooba, Kichisaburo)
1942	11-11	Proposal for portable furniture in the field (Kenmochi, Nakai, Kaneko)
1943	12-10	Wood and bamboo aircraft components (Kenmochi, Isamu and Yamawaki, Iwao)
1944	13-3	Report on the technical workshop on wooden aircraft components
	13-5,6	Special issue on wooden aircraft components (various authors)
	13-7	Plywood seating for pilots
	13-8	Special issue on adhesive variations for wood
	13-9	Plywood and adhesives (Izumi, Iwata) Moulded plywood and adhesives (Sasou, Keiya, Fuji airplane corp.)
1946	14-2	Furniture and dependents housing for the occupation army (Saito, Nobuharu) Furniture design for dependents housing (Toyoguchi, Katsuhei) Furniture specifications for dependents housing Making American furniture in Japan (Kaneko, Tokujiro)
1947	15-3	Research on mass-produced furniture
		Proposal for residential furniture set for reconstruction (Toyoguchi, Katsuhei) Moulded plywood adhesion with high frequency-heating (Ogawa, Shigeru)
	15-9	Prevention of checks in finished veneer surfaces
1948	16-1	Furniture that do not fail – for dependents housing (Kaneko, Tokujiro) Marcel Breuer's latest furniture (Kenmochi, Isamu)
	16-5	Organic design, puc-cm design (Toyoguchi, Katsuhei and Kouchi, Makoto)

	16-8	Dream of industrial arts: The world of plastics (Katsumie, Masaru) Tubular steel furniture of B.C.O.F (Kaneko, Tokujiro)
	16-11	Industrial artists of the world – Alvar Aalto (Katsumie, Masaru and Koike, Shinji)
	16-12	Outline of wood processing techniques (Miyoshi, Touichi) Wood drying by high frequency method (Shinohara, Ukichi) Utilization of high frequency heating in the industrial arts (Kenmochi, Isamu) High Frequency Moulding and Welding (Shiozawa, Eifu) Moulding jigs in high frequency heating
1949	17-1	Chair (Toyoguchi, Katsuhei)
	17-5	Techniques on trial-manufacture (Kenmochi, Isamu)
	17-6	Thoughts on machine-processing (Kosugi, Jiro) Design and techniques (Yanagi, Sori)
1950	18-2	New wood products enabled by high frequency - trial manufacture (Kenmochi, Isamu and Shiozawa, Eifu)
	18-6	Moulded plywood furniture for mass-production (Shiozawa, Eifu and Kenmochi) Moulded plywood furniture for mass-production (IAI Tohoku branch)
	18-10	Recent works of Isamu Noguchi at Mitsukoshi, Tokyo (Usui, Masao) Modern trends in interior furnishings (Noguchi, Isamu) Isamu Noguchi at the IAI (Kenmochi, Isamu)
1951	19-1	Wood and Plastic (Fukuoka, Kazuo)
	19-2	Furniture since the War (I) Furniture since the War (I) – on H.M. Dannet's Thesis (Kenmochi, Isamu)
	19-3	Kitchen Space to Kitchen Function (Ikebe, Kiyoshi)
	19-4	Laminated wood (IAI technical section) Plywood furniture suitable for mass-production (IAI Tohoku branch)
	19-5	Veneers of wood and metal (Kenmochi, Isamu)
	19-6	Furniture production by high frequency process (IAI Tohoku branch)
1952	20-11	Charles Eames, the modern Proteus (Katsumie, Masaru) Furniture by Taichi Nakai - introduction of industrial designers
1953	21-6	Study on moulding method with laminated veneers of irregular thickness (IAI technical section)
	21-10	Furniture for the Ministry of Agriculture and Forestry (IAI design section)
1954	22-6	New wood-binding agent (IAI technical section)
	22-7	Recent trend in furniture design - tables and desks (Toyoguchi, Katsuhei) Walter Gropius at the IAI
	22-10	Re-design of piano by GK group
1955	23-2	Neutra's furniture, Neutra's thoughts on design (Katsumie, Masaru) Relationship between the form of saw tooth and artificial wood (IAI technical section)
	23-11	Characteristics of binder for wood through various testing (IAI technical section)

1956	24-5	Manufacturing of plywood and laminated wood (IAI technical section)
	24-6	Design: unit shelving (IAI design section)
1957	25-8	Technics: wood sanding (IAI technical section)
	25-9	Technics: wood sanding (IAI technical section)
	25-10	Technics: wood cutting (IAI technical section)
	25-11	Technics: wood cutting (IAI technical section)

Fig. 3.3.6 Articles in *Kogei News* on plywood techniques, designs, and commentaries

The articles indicate that plywood was considered to be a promising material for industrial mass production from the beginning. In order to achieve quality and efficiency, however, researches conducted spanned between craft, industry and design. National interest of the government also played into the aims of the research and productions at the publicly operated institute, from goods for export to war efforts in the forties. Initially, prior to the war, the journal articles focused on basic technical information in the areas of chemical research of adhesives, manufacturing processes and understanding of plywood application in designs from abroad, most of which were represented in furniture. New design proposals observed by *Kogei News* on western plywood designs include ‘open composition’ of Aalto’s chair in 1935, in which the seat and legs are joined to the frame in realizing a continuous lightweight structure. The following observation on Kim Weber’s streamlined Airline Chair regards the general structure positively, including the use of hickory veneer which is resistant to tension, but skeptical of the chair’s resolution of joints in relationship to angled back and seat surfaces.

In addition to the standard techniques related to plywood development, there were unique attempts that occurred as a result of the war: Diversion of all metals for military use meant that plywood, bamboo and other natural materials were put forward to replace metal objects in civilian lives, ranging from practical to obscure. Toward more direct war efforts, aircraft components and pilot seats were produced with the support of private aircraft and furniture manufacturers, as discussed in the section on decoy plywood aircraft.

An article from November 1940 (9-10) discusses the second experiment for fire-proof quality of plywood when combined with thin steel plate, for the purpose of making a simple



safe; an earlier experiment had used aluminum. The safe was constructed with 10 mm thick exterior wood panel and 13 mm interior panel, both of which were treated, with rust-proofed 0.6 mm thick steel sandwiched in between. Phthalic acid resin was applied onto the steel in advance, and casein glue was used to adhere the wood and the steel plate. This construction was categorized as a specialty plywood, and the result seems to have been satisfactory in protecting the content even though the safe itself was no longer unusable.

To meet both qualitative and quantitative demands of plywood fabrication, high frequency heating became crucial in the postwar processes of the drying and gluing, the latter being critical especially for moulded plywood. The artificial drying of timber was necessitated by the rising demands that naturally dried stock was failing to meet. In 1948 article “Utilization of high frequency heating in the industrial arts,” Kenmochi laments the unambitious experimentations in moulded plywood products that were limited to “radio case, suitcase, bag, wardrobe and a few furniture pieces” up to that point.<sup>47</sup> He also makes an observation on American products utilizing the high frequency heating process for moulded plywood adhesion, such as a 5-ply moulded desk by Plymold Corporation of Lawrence, Mass., as representative of the practical, efficient and daring approaches of American designers compared to the rather stylistic functionality that many European designers embodied. Members of the institute including Eifu Shiozawa, Ukichi Shinohara, and Mitsuo Yamagata contributed to the technical aspects of this technique and collecting data on the systems employed in the US.

By 1950 the critical processes in plywood production, especially of drying of veneers and gluing, had reached a satisfactory level and the Japanese Industrial Standards established for five types of plywood according to degrees of waterproofness and durability. Other experiments and researches at the institute dealt with how to successfully mass produce furniture from plywood at reduced cost, which had been the material’s strong suit combined with modern expressions across the world. In Japan, from postwar into the rapid economic growth period, the demand for furniture both for public and domestic environments – the latter instigated by the occupation army’s dependents house, as previously mentioned – drove the production quantity of moulded plywood furniture.

Yet the optimism surrounding the prospective utilization of plywood in the 1930s lost momentum around 1950s as well, after which reference to plywood in the journal declines promptly. On plywood associated designs, an article from 1961 mentions the visit by Borge Jensen from Denmark visits and his seminar on wood-working techniques (29-2), and other articles on Charles and Ray Eames (29-5) on their designs and office environment, which includes their experiments with the material. Generally speaking, however, the institute moved on to newer materials in terms of technical and design researches as their knowledge in general and moulded plywood was transferred to private companies, such as Tendo Mokko.

The focus of the institute increasingly shifted to resins and metals. Although research on these materials had been underway for decades, including research on aluminum which had begun around 1932, these fields had increased potential for development in the postwar period with material availability for civilian use. While many prominent designs in plywood by industrial designers and architects continued to emerge into the sixties, it can be said that plywood was established in terms of processing and techniques by the 1950s. In the sense of closure and stabilization, the process spanned over approximately 15 years in the case of Japan.

### **3.4 Moulded plywood in Japan: The case of Tendo Mokko**

#### **3.4.1 Background**

The predecessor to the furniture maker Tendo Mokko originated in 1940 as an industrial cooperative, *Tendo Mokko Kagu Tategu Kogyo Kumiai*,<sup>48</sup> for the town of Tendo and ten other surrounding towns. The trades of carpentry, fixtures, traditional furniture with wood joinery, buddhist alter fittings, and pails were encompassed in the cooperative, as remedy for the material shortage during the intensifying wartime. Manufacturing military supplies such as boxes for ammunition accounted for majority of the their initial output.



Fig. 3.4.1 Original ammunition boxes produced during the war

By 1942, Tendo Mokko founded its own company and factory. Until the end of the war, they also aided in the production of decoy airplanes in moulded plywood at the request of Kenmochi from the Industrial Arts Institute. The relationship between Tendo Mokko and the IAI was a relatively close one; they are located about 60 km apart in a straight line. In addition, guidance on the manufacturing process were given by members of the IAI, most notably by Saburo Inui who was knowledgeable in high-frequency radio waves for heat bonding and had worked closely with Isamu Kenmochi on the design and production of plywood furniture. Eventually Tendo Mokko began to take on some experimental design by Kenmochi for the annual exhibition at the IAI.<sup>49</sup>

The purchase of high-frequency oscillator in 1947 marked the beginning of a full-scale manufacture of moulded plywood furniture. It was a considerable investment, costing 250,000 yen, especially at the time when the base fare for a train cost 0.5 yen and many were struggling to meet basic necessities.<sup>50</sup> The oscillator would signify the company's industrial standing, an investment based on the anticipation of quantity productions to follow.

### 3.4.2 Aspects of design

From 1950s onwards, furniture production increased rapidly. It was fostered by a modernization of production and lifestyle – a combination of technological developments in productions and increase in demands for furniture, in both public facilities and domestic contexts.

The largest commission for Tendo Mokko came in 1953 for the Imabari City Hall

auditorium in Ehime, designed by Kenzo Tange, with the order of 1400 seats for the audience. Tange wanted the structure for the seats to be thin; Tendo Mokko was one of the few, if not the only back then, manufacturers able to produce one-piece moulded plywood shell without any joints. This collaboration was followed by another commission of 3000 seats for the Shizuoka Gymnasium in 1958.

As a product, a significant one in the history of the company is the iconic Butterfly Stool by Sori Yanagi. He brought a prototype to Tendo in 1954 following Inui's suggestion at the IAI, and through trial and error, realized the form with 7 mm thick plywood. It did not turn out to be a commercial success initially, but the international reception promoted its value from design accolades. The stool was slightly enlarged, about 10 percent, for the international market, for which Yanagi adjusted the sections and the balance of the form accordingly.<sup>51</sup>

Before branching out to domestic furniture, the company had mostly focused on commercial furniture called 'contract furniture' that were intended for governmental, public and commercial facilities. They were designed for functions such as reception, office, meeting room, library, restaurant, cafe and tearooms, lobby and lounge, hotel, welfare facility, and medical centers; these functions were noted on their product catalogue after 1968.<sup>52</sup> Due to the nature of these furniture, the target customers for their furniture were architects, interior designers, and the purchase departments of government and municipal offices or companies. There were multiple collaborations with product designers and architects outside of Tendo Mokko, which ultimately helped the company establish its reputation.

The same year the Tokyo Olympic was held, in 1964, the company opened a branch office in Hamamatsu-cho, Tokyo, designed by Junzo Sakakura, which was followed by opening of more branches in Sapporo and Fukuoka. It was a strategy to appeal to a larger market, to overcome the disadvantage of being located far from the metropolis.

Some of the notable designers who have collaborated with the company include the following:<sup>53</sup>

1950-60s	Tadao Mizunoe for Kunio Maekawa, Tokukichi Kato, Saburo Inui, Mitsumasa Sugawara, Sori Yanagi, Isamu Kenmochi, Daisaku Cho for Junzo Sakakura, Reiko Tanabe (nee Murai), Yamanaka Group, Kenzo Tarumi, Kenji Fujmori, F&F Design, Katsuhei Toyoguchi, Nikken Sekkei, Katsuo Matsumura, Riki Watanabe, Yoshiteru Hara, Tadashi Minohara, Takenaka Corp., Matsuzakaya design team, Charlotte Perriand, Arata Isozaki
1970s	Isamu Kenmochi, Tadao Mizunoe, Daisaku Cho, Katsuo Matsumura, Form International, Shuji Izumi, Makoto Shimazaki, Nobuchika Moriya, Bruno Mathsson
1980-90s	The Design Studio, Toshimitsu Sasaki, Komplot Design (based in Denmark), Kawakami Design Room, Kunihide Oshinomi, Arata Isozaki, Masanori Umeda (Umeda Design Studio), Yoshiyuki Kita, Kozo Abe, Kazuko Fujie, Fumio Okura, Tadao Shimizu (TAD), Noboru Inoue, GK Design Group, Sunaga Design Office, Arata Isozaki, Kisho Kurokawa, Kiyonori Kikutake, Oscar Niemeyer (whose furniture were manufactured in their factory in Taubate, Brazil that was in operation from 1975 until 1985), Kazuhiro Ishii, Toyo Ito, Tomohiko Shibata, Norihiko Dan, Makoto Watanabe, Taro Ashihara, Osamu Ishiyama, Atsushi Kitagawara, Shin Takamatsu, Yoh Shoen, Peter Wilson
2000s	Tomoyuki Matsuoka, Tomoko Koike, Kiyoyuki Okuyama, Alex Macdonald

Most of the furniture designed by architects in the list above, especially in the 1980s, have been rather experimental and were not developed for larger market, with the exception of Monroe Chair by Arata Isozaki in 1984. They were used in the corresponding architects' buildings at times, but never mass produced as readymade furniture for the general public.

### 3.5 The case of furniture city Okawa

#### 3.5.1 Background: Wood industry and Okawa

Okawa is a city known for its furniture and interior-related industries, and was selected to observe how the context surrounding plywood has influenced regional conditions and the industry in contemporary Japan. Okawa is located in southeastern part of Fukuoka prefecture, neighboring with Saga and Yanagawa cities, and where Chikugo River meets Ariake Sea estuary. Its current population is approximately 35,600 as of 2014. Historically the city thrived as a base for transportation of goods along the Chikugo River, as logs from the upper stream were assembled into rafts in Hita, Oita, and amassed further down stream in Okawa. This practice began in 1680s and flourished especially between 1910s to early 1950s. The rafts measured 28-30 m long and 4 m wide, gathering between 80 to 130 logs. Downstream, four of these rafts were linked into one piece. In early Showa period, 90 percent of timber were transported to Okawa using this method.<sup>54</sup>

It is said that the furniture making in Okawa began when ship building techniques were applied to *sashimono*, indicating furniture that employ wood in board form, usually without the use of nails or other fasteners. Typically forms of *sashimono* include containers, desks, cabinetry and *hibachi*, a Japanese charcoal heating appliance. Kumenosuke Enokizu (1485-1582) is credited for initiating furniture production in 1536, during the late Muromachi period. The furniture was called *Enokizu shashimono*, and the workers were additionally involved in making waterwheels, cabinetry, *shoji* doors, and chests.<sup>55</sup> It gradually matured into a city-wide collective industry around 1877, having refined the techniques in the four key fields with increased specializations of trade: Wood processing from raw material into timber, woodworking, metal joinery productions, and lacquering.<sup>56</sup> Also around this time, nationally owned railroads began to replace cargo boats as the main mode of distribution.

Toward the end of Meiji period, around the 1910s, marked the democratization of furniture when the general public began to purchase box-like furniture. Furniture then primarily meant lightweight cabinetry for kimono, which was an important property for the

people, that could be carried out of the house quickly in case of fire. Furniture began to take on more value as a semi-permanent object and possibly with decorative value, after management of fire protection policies were set in Taisho period.

### **3.5.2 Scales of production**

Even with the expansion of productions with mechanization and more efficient distribution via railways and new roads for trucking, 85 percent of the factories and companies in Okawa employed less than 10 workers in the mid-1960s to 70s. To this day, most of the businesses are family owned and work as small scale operations in contrast to other cities and their furniture industries.

Production reached its peak during Japan's stable economic growth period and into the bubble economy, especially during the decade between 1980 to 1990 when total furniture sales in Okawa marked 111.96 billion yen and 191.41 billion yen, respectively. As a comparison, the total sales were 27.2 billion yen in 1972 before the rapid economic growth and dropped again in the post-bubble economy to 65.0 billion yen in 2004.<sup>57</sup> During the postwar era, Okawa accounted for approximately 10 percent of all furniture production in the country.

The furniture of Okawa has been known for its inexpensiveness relative to other furniture producing districts, and sometimes associated with inferior quality. It had been declared in the policy of the city, around 1921 or slightly earlier, that it Okawa advocates the production of a large number of products for the masses, rather than making of high-end products to be praised by a few wealthy customers. The furniture types produced also catered to the functionality required by the general public. The circumstances of keeping costs low have been attributed to their custom of involving many apprentices, women and children in the production, and concentrating the production to single model of furniture, per type, that would be produced repeatedly in large quantities – a quintessential advantage of industrialization.

### **3.5.3 The apprenticeship model**

The traditional system of training skilled successors had a clear hierarchical structure consisting of the master craftsman, craftsman, and apprentice. In Okawa, the duration of apprenticeship was dependent on the trade and determined by the trade union: 5 to less than 6 years for furniture making, 3 to less than 4 years for wooden fixtures such as doors and windows, and less than 3 months for lacquering.

Conventionally the second or third son of a farmer would take on the apprenticeship, which meant living with the master's family and working without pay except for a small allowance. In addition to the work, an apprentice would also help with house chores such as cleaning and babysitting. On average, work day began at 5 am and last until evening; night time was dedicated to school during the summer months, and additional work from early autumn to March, until midnight. When one had completed the apprenticeship, the master would gift him with ceremonial clothing and a set of tools necessary to start working as a full-fledged craftsman.

The work during the first year consisted of cutting boards out of wood that the master had marked, setting the teeth of a saw, sharpening the tools, making bamboo nails, and learning how to glue properly. After the basic training, making of a dustpan followed, before more advanced training.<sup>58</sup>

### **3.5.4 Educational model**

Due to the poor reputation for the quality of Okawa furniture, a school was established with a funding from Fukuoka prefectural assembly in 1911. Its two-year program was divided into woodworking and lacquering departments; woodworking department mostly drafted designs for desks, bookshelves and small cabinetry, whereas lacquering department were more hands-on and applied lacquer on small objects to cabinetry.

Despite the notable advancement of techniques through education, the cut in funding forced the closing of the school in 1913. However the effects of the school model was felt even after its closure, as new applications of lacquer in metal fittings or new living room furniture were proposed.

Around the 1970s, a plan for *Mokko Daigaku* (university for woodworking) was proposed



for the purpose of training highly skilled professionals in furniture. The shift from the “craftspeople” based (*shokunin-gata*) to the “machine” (*kikai-gata*) based business was central to their objective, and to secure workers proficient in design and development of new furniture. Unfortunately the plan has stalled to this day.

Other attempts have sprouted, especially as the sales have decreased due to post-bubble recession, increase in the demand for more variety, and a surge in imported furniture market. A “revival plan” of Okawa was suggested in 2004 with a focus on professional training, development of a new brand, and cultivating a new market, in order to target these issues. More specifically, Okawa Interior-juku (school) was set up to address advanced training of administrators, interior designers, salespeople, highly skilled technicians, and craftspeople. Development of a brand attempts to strengthen the traditional techniques to create a kind of Japanese modern aesthetic through the use of lacquer, Japanese handmade paper, dye, and woven rush, etc., with both the domestic and international markets in mind. Promotions toward international market also will address the currently limited sales, to small retailers and wholesalers that the region have mostly depended on, to directly distribute to larger markets, including domestic department stores.<sup>59</sup>

### **3.5.5 Postwar developments**

Gradual transition to mechanization had initially begun in 1920 under the guidance of Kyoto University professor Takeda, by acquiring basic woodworking machinery.<sup>60</sup> Log splitter machine, router, planer, and drill press imported from Britain are some of the machinery archived in Murakami Machinery Co.<sup>61</sup> The gradual transition to mechanization proliferated in the 1960s, in many ways epitomized by the spread of veneers and plywood industry, coinciding with the predominance of imported timber.

Around the same time that the veneer factory was established in the city, Okawa received the national designation of *Juuyo Mokko Shudan*, meaning significant woodworkers group in 1949, along with cities of Asahikawa (Hokkaido), Takasaki (Gumma), Arakawa (Tokyo), Kamo (Niigata), and Wakayama (Wakayama). The designation pushed the city to further industrialize, in terms of moving from heavily hand-based productions to a more

mechanized manufacture where machineries for drying and processing wood were either imported or constructed. This postwar period saw a great demand for the woodworking industries, as war recovery efforts and housing construction surged.

In 1952, a craft-designer Makoto Kouchi moved to Okawa from Kumamoto, where he was the head of Research Institute of Industries. Kouchi was especially instrumental in modernizing the designs of cabinetry and storage products, *hakomono*, and the Japanese-style chest of drawers of his design won the grand prize at the 1955 West Japan Product Exhibition in Osaka. It was revolutionary for its simplicity and completely eliminating the pulls, which were often made of metal and attached on the face of each drawer in a decorative manner, so the surface was entirely finished in wood. Okawa furniture became a household name with this particular furniture, and it was so successful that the style was copied elsewhere. Kouchi also helped expand the market to the rest of Japan from 1955, through connections he had in his hometown of Tokyo.

The main challenge for the industry then was how to improve the quality and design. Kouchi advocated for the transformation from what he called the ‘regional sensibility’ to ‘central sensibility’ – refined designs that catered more to urban residents – and instructed them on the importance of proper drying of timber and improved lacquering. Meanwhile, he also recognized the advantage of the small businesses to be able to work beyond the rationalized mechanical process of production, to adjust and modify by hand when needed, while the collection of such businesses in the same city were able to support each other’s specific trades.<sup>62</sup>

### **3.5.6 Technical developments**

The system of furniture production by category was established, from high to low in ratio: Japanese chests, western-style wardrobes, cupboards, office desks, low tables for the living room, bedding storage, shoe cabinets, and chairs. The technological evolution, modernization and mechanization of production, have fostered the industries that are now being confronted by outsourcing and changes in trends.

Okawa veneer application process (from *Okawa Tanpan Sangyo*)



exterior view of the factory



CNC router prepares MDF forms



checking and finishing MDF substrate



gluing veneers



roller machine applies glue onto veneers



hydraulic heated veneer press



small strips of veneers (0.25 - 1.0mm), with industrial *washi* paper backing applied



applied veneers, with unfinished edges



preparing MDF for veneer application



prepared MDF



edge of veneer



ironing the veneer edges



example of applied veneer

Fig. 3.5.6 Decorative veneer application process at Okawa Tanpan Sangyo: Due to the small scale of the operation and the nature of their work, which are mostly custom pieces in relatively small quantities, there is a substantial involvement of the hand for the application of decorative veneers.

### **3.6 Reactions to international moulded plywood designs**

Up until the first half of the twentieth century, moulded plywood was much more advanced in Europe and the United States, where there was a longer history with related technologies, industries, and designing of furniture. Early on, information on works on Alvar Aalto, Marcel Breuer, Charles and Ray Eames, and the like, were introduced via magazine articles and imitated for export purposes. Furniture-making began to spread for export as well as domestic use after the war, because prior to that there was no such industry in Japan with the exception of cabinetry, the so-called box shaped *hakomono* furniture, and the low table.

As in the West, techniques of bent wood preceded the successful iterations of moulded plywood furniture. During the development from wood, straight timber, bent wood, to plywoods and other veneer based board materials, the capacity for mass production multiplied.

#### **3.6.1 Plywood and steel**

Like plywood, early steel furniture imitated the form of wood furniture. Steel and plywood in furniture share several common characteristics in their furniture application: Relative lightness, durability, elasticity, potential for simple assembly, economy and the ease in bending of the material. However there is a fundamental difference in how they were perceived. Whereas steel was an ideal vehicle in communicating the separation from the past into the modern society, plywood still held a strong association with the material of the past, represented by wood.

Tubular steel furniture, called pipe furniture in Japan, was the prototypical interior device essential in the new and modern architecture. Because steel was not initially selected for its aesthetic quality per se, it was a better representative of the new and the modern, with the combination of plywood and steel falling somewhere in between. Marcel Breuer who graduated from Bauhaus is known to be one of the pioneers in the field of tubular steel furniture.



Fig. 3.6.1 Early examples of the combination of plywood and tubular steel, from left to right: Heinz and Bodo Rasch's lounge chair, 1927, manufactured by L. & C. Arnold GmbH, Schorndorf, Germany;<sup>63</sup> Gerrit Rietveld's armchair from 1927-28;<sup>64</sup> Aalto's first widely recognized stacking side chair, 1930;<sup>65</sup> Hans and Wassili Luckhardt, 1931, manufactured by Desta Deutsche Stahlmobel in Berlin, Germany<sup>66</sup>

Heinz and Bodo Rasch, brothers who were architect and cabinetmaker, respectively, constructed a lounge chair where a piece of bent plywood was directly screwed onto the tubular steel. So did Rietveld in 1927, in joining the one-piece plywood seat and back to the steel structure. Aalto's early furniture from 1930 proved to be unsuccessful, but is said to be the cause for him to give up tubular steel and pursue subsequent designs in plywood. ST 14 by Hans and Wassili Luckhardt, who were also brothers and both of whom were architects, had a rare streamlined and organic design in comparison to the more geometric forms of the other Bauhaus designers. Chrome-plated steel aligns with the curvature of the moulded plywood back to form "a cantilever within a cantilever."<sup>67</sup> It was to be covered by large cushions, but the skeletal combination of the plywood and steel is expressive of the simplicity of form and assembly.

By the time the two important exhibitions were held in Stuttgart, Germany in the late twenties, information of the designs and productions in Europe were being transmitted to Japan relatively quickly – magazines such as a German design magazine *Die Form* was sent by surface mail and arrived 2 months after publication. Both of these exhibitions were sponsored by the German Werkbund: *Die Wohnung* (the Dwelling) in 1927 and *Der Stuhl* (the Chair) in 1928. The exhibited products were structurally and formally analyzed by figures

such as Toyoguchi, as a way to propagate designs that were efficient for manufacture and advocating a new lifestyle as a direct result of the systematized production. Metal furniture was sold in department stores and depicted in posters during the 1930s as a representation of urban and modern culture.

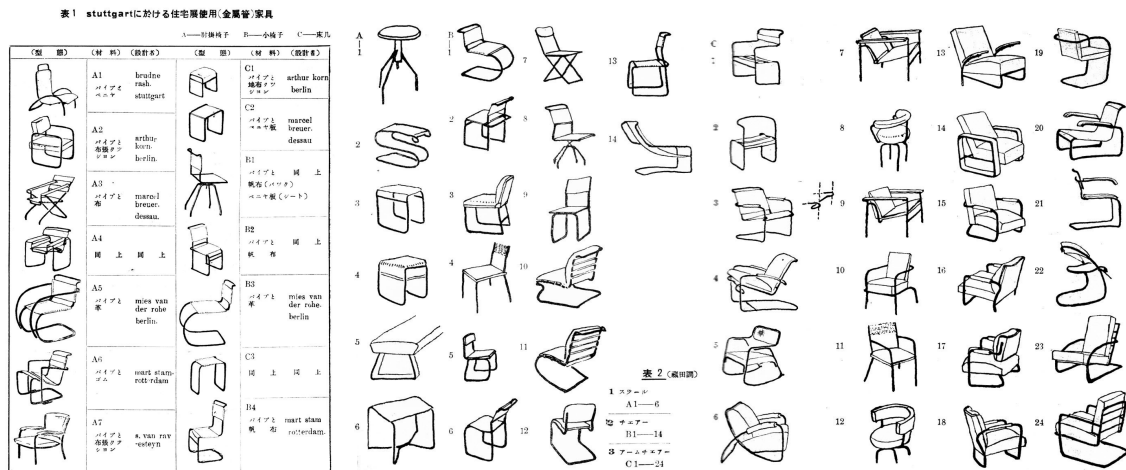


Fig. 3.6.1-2 Domestic tubular steel-based furniture from Stuttgart, shown in Keiji-Kobo's first Raporto journal (left);<sup>68</sup> and a study of existing chair designs by type: stools A1-6, chairs B1-14, and armchairs C1-24 (right)<sup>69</sup>

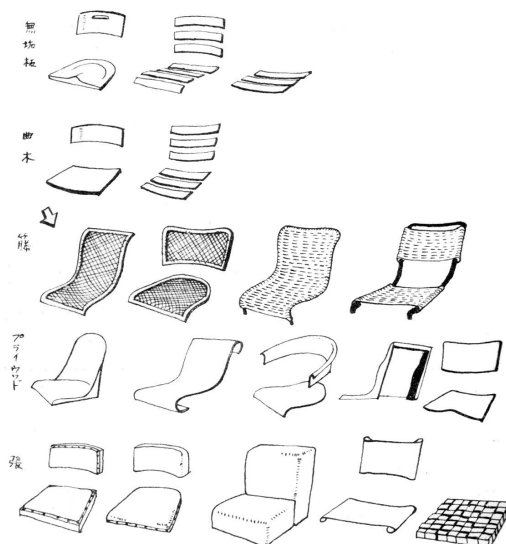


Fig. 3.6.1-3 A study of seating surfaces by material from Toyoguchi's "Standard Furniture"<sup>70</sup> from top row: Solid wood; bent wood, wicker, plywood, and fabric and other coverings

### 3.7 Chapter conclusion

The history of plywood in Japan in its early phase resembles a very compressed version of that in the western history, except that the initial attempt for Japanese engineers was the production of panel form plywood rather than bent plywood for furniture. The industry lagged behind Europe and the United States by about 60 years, just as Mingei movement occurred 66 years after the Arts and Crafts movement. Yet, since the inception of plywood in Japan in 1907 as a way to mimic plywood tea chest assembled in Britain with plywood made in Latvia, the industry steadily grew and became the second largest producing nation for about a decade, between 1970s and 80s. The year 1973 marked the highest plywood production and demand in its history.

Plywood turned into a substantial industry and phenomenon in Japan after World War II. Immediately before and during the war, there were efforts to replicate western style objects and furniture to promote export. To this end, the Ministry of Commerce and Industry, with its subsidiary Agency of Industrial Science and Technology, founded *Kogei Shidousho* in 1928 that was later renamed *Sangyo-kogei Shikenjo*. Also known as the Industrial Arts Institute (IAI), it took on the role of research center, industry advisor, a kind of design studio and workshop all at once. Prominent designers Bruno Taut and Charlotte Perriand were also invited to provide guidance regarding designs to be produced by the local craftspeople in 1933 and 1941, respectively.

During the war, shortage of metal fueled the sometimes obscure research for ‘substitute’ materials. Naturally derived materials such as wood and bamboo served as the main target in the substitute productions of kitchenware to furniture, while their material resistance to moisture or fire were tested. Plywood, although still in its infancy at the time, was becoming increasingly important: For one, the material of plywood was used to persuade the government to save the IAI from being closed down during the war, because of its potential application in military purposes, namely, building the aircraft. It was applied partially in the decoy aircrafts, but for the most part, militaristic aspirations never came to fruition for plywood before the end of the war.

Instead the material achieved refinement during the postwar to the rapid economic growth period. Improvement in adhesives and processing factories helped stabilize the quality of plywood, which was then certified by the Japanese Agriculture Standards, although there was an abundance of uncertified plywoods on the market. Meanwhile, the occupation by the allied powers after the war until 1952 created demands for domestic western furniture with expectations for design and product quality that the residents were accustomed to in their homeland.

With the technical and design knowledge for moulded plywood passed on from the IAI to Tendo Mokko, along with the refinement in furniture design over time, distinctive techniques such as irregular thickness and solid *koma* piece embedded between veneers were realized and adopted. While still in the spirit of mass production, with one mould repeatedly used, these two techniques required much more labor intensive processes and were aesthetically driven.

The monthly journal that chronicled the researches at the IAI came in the form of *Kogei News*, which covered themes from international design trends to their own ‘trial-manufactures’, and technical data to material experimentations in efforts to support industries and businesses, both local and national.

Just as Gardner and Co. in the US had expanded by supplying to public buildings in the latter nineteenth century, the mass-produceable chairs of Tendo Mokko produced in collaborations with prominent architects and designers spread together with the building of public architecture. Before modern design found its way into the domestic landscape, city halls and other public buildings became the ground to showcase light and thin structures of moulded plywood. Efforts to standardize furniture suitable for domestic conditions, exemplified by figures like Keiji-Kobo’s Katsuhei Toyoguchi, relied upon industrial materials such as plywood, steel, fabric, and bent wood.

Application of softwood for plywood production in Japan did not take off until after 1990, when rapid decline of imported luan from Southeast Asia turned critical mostly due to environmental concerns. Standard structural plywoods have had its own share of vicissitudes, rising and falling with the economy while affected by changes in building codes,



material sourcing, quality regulations, and import quantities.

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<sup>1</sup> Forty, Adrian. *Concrete and Culture: A Material History*. London: Reaktion Books Ltd., 2013. First published in 2012. p 79.

<sup>2</sup> Narita, Juichiro. *Nihon Mokko Gijutsushi no Kenkyu*. Tokyo: Hosei University Press, 1990. pp 14-15.

<sup>3</sup> Japan Plywood Manufacturers' Association, ed. *Gouhan Hyakunenshi* (Centennial history of plywood). Tokyo: Japan Plywood Manufacturers' Association, 2008. pp 46-49.

<sup>4</sup> Forestry Agency, Ministry of Agriculture, Forestry and Fisheries. [http://www.rinya.maff.go.jp/j/kikaku/hakusyo/24hakusyo\\_h/all/a60\\_01.html](http://www.rinya.maff.go.jp/j/kikaku/hakusyo/24hakusyo_h/all/a60_01.html). 02 Jan. 2015.

<sup>5</sup> "Milestones in the History of Plywood." APA–The Engineered Wood Association. Web, [http://www.apawood.org/level\\_b.cfm?content=srv\\_med\\_new\\_bkgd\\_plycen](http://www.apawood.org/level_b.cfm?content=srv_med_new_bkgd_plycen). 12 Nov. 2013.

<sup>6</sup> Japan Plywood Manufacturers' Association, pp 56-7.

<sup>7</sup> Takeshi Okano, interview by Kaon Ko, Tokyo, Japan, July 2, 2014.

<sup>8</sup> Mokushitsu Kouzou Kenkyukai, ed. *Shin-Mokushitsu Kouzou Kenchiku Dokuhon* (New timber based architectural structure reader). Tokyo: Ki-mirai, 2012. p 13.

<sup>9</sup> Mokushitsu Kouzou Kenkyukai, pp 8-10.

<sup>10</sup> Mokushitsu Kouzou Kenkyukai, p 14.

<sup>11</sup> Japan Plywood Manufacturers' Association, pp 75-77.

<sup>12</sup> Japan Plywood Manufacturers' Association, pp 223-28.

<sup>13</sup> Japan Plywood Manufacturers' Association.

<sup>14</sup> Ministry of Economy, Trade and Industry.

<sup>15</sup> Japan Plywood Manufacturers' Association.

<sup>16</sup> The Ministry of Finance. Trade Statistics of Japan. Web, <http://www.customs.go.jp/toukei/info/tsdl.htm>. 20 Sept. 2014.

<sup>17</sup> Japan Plywood Manufacturers' Association.

<sup>18</sup> Japan Plywood Manufacturers' Association.

<sup>19</sup> The Ministry of Agriculture, Forestry and Fisheries. Web, <http://www.e-stat.go.jp>. 01 Sept. 2014.

<sup>20</sup> Takeshi Okano interview by Kaon Ko, Tokyo, Japan, July 2, 2014.

<sup>21</sup> Dauvergne, Peter. *Shadows in the Forest: Japan and the Politics of Timber in Southeast Asia*. Cambridge, Mass.: The MIT Press, 1997. p 174.

<sup>22</sup> The Ministry of Agriculture, Forestry and Fisheries.

<sup>23</sup> The Ministry of Agriculture, Forestry and Fisheries.

- <sup>24</sup> Japan Plywood Manufacturers' Association.
- <sup>25</sup> The Ministry of Agriculture, Forestry and Fisheries.
- <sup>26</sup> The Ministry of Finance. Trade Statistics of Japan. Web, <http://www.customs.go.jp/toukei/info/tsdl.htm>. 20 Sept. 2014.
- <sup>27</sup> The Ministry of Agriculture, Forestry and Fisheries.
- <sup>28</sup> The Ministry of Agriculture, Forestry and Fisheries.
- <sup>29</sup> Japan Plywood Manufacturers' Association.
- <sup>30</sup> Japan Plywood Manufacturers' Association.
- <sup>31</sup> Exhibition catalogue, *Sentaku, Dentou, Souzou (Selection, Tradition, Creation)*. Edited by Perriand, Charlotte and Sakakura, Junzo. Tokyo: Oyama Shoten, 1941. p 32.
- <sup>32</sup> Exhibition catalogue, *Sentaku, Dentou, Souzou (Selection, Tradition, Creation)*. p 34.
- <sup>33</sup> Exhibition catalogue, *Sentaku, Dentou, Souzou (Selection, Tradition, Creation)*. p 43.
- <sup>34</sup> Exhibition catalogue, *Sentaku, Dentou, Souzou (Selection, Tradition, Creation)*. p 47.
- <sup>35</sup> Izuhara, Eiichi, ed. *Kenmochi Isamu no Sekai, Vol. 2: Sono Tankyuu no Kiseki* (The World of Isamu Kenmochi, Vol. 2: Traces of its Explorations). Tokyo: Kawade Shobo Shinsha, 1975. pp 49-51.
- <sup>36</sup> Izuhara, pp 51-52.
- <sup>37</sup> Tetsuo Matsumoto, interview by Kaon Ko, Tokyo, Japan, April 1, 2014.
- <sup>38</sup> Matsumoto, interview.
- <sup>39</sup> Mori, Hitoshi, ed. *Sangyo Kogei Shikenjo 30-nenshi* (30-year history of the National Crafts Organization). Tokyo: Yumani Shobo, Publisher Inc., 2010. pp 46-47.
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- <sup>41</sup> Arai, Ryuji. "Sengo Nihon ni Okeru Shuyou Mokusei Kagu Maker no Rekishi-teki Kenkyu." (Historical survey of principle wood furniture manufacturers in postwar Japan) Diss. The University of Tokyo, 2012. p 37.
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- <sup>44</sup> Industrial Arts Institute - Ministry of Commerce and Industry, GHQ Design Branch, ed. *Dependents Housing*. Tokyo: Gijutsu Shiryo Kankokai, 1948. pp 141 and 143.
- <sup>45</sup> Industrial Arts Institute - Ministry of Commerce and Industry, pp 150 and 178.
- <sup>46</sup> IAI Technical Section. "Futouatsu Seikei Gouhan" (Study on moulding method with laminated veneers of irregular thickness). *Kogei News*, Issue 21, No.6, 1953: 31-32.
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- <sup>49</sup> Sugasawa, Mitsumasa. *Tendo Mokko*. Tokyo: Bijutsu Shuppan-sha, 2008. pp 42-45.

- <sup>50</sup> Sugasawa, pp 11-12.
- <sup>51</sup> Sugasawa, p 92.
- <sup>52</sup> Arai, p 183.
- <sup>53</sup> Arai, pp 184-194, and additional pamphlets of Tendo Mokko.
- <sup>54</sup> Okawashishi Henshu Inkai. *Okawashishi* (Record of Okawa City). Okawa: Okawa City Hall, 1977. p 780.
- <sup>55</sup> Okawashishi Henshu Inkai, p 587.
- <sup>56</sup> Moto, Akiko. "Okawa Furniture" in *Japanese Society for the Science of Design*, special issue, vol. 15-2 no. 58, 2007: 44-47.
- <sup>57</sup> Moto, p 46.
- <sup>58</sup> Okawashishi Henshu Inkai. pp 605-6.
- <sup>59</sup> Moto, p 46.
- <sup>60</sup> Okawashishi Henshu Inkai. p 600.
- <sup>61</sup> *Okawa Mokko Kōgyō Sangyō Shiryōkan* where the archived machinery are displayed is located within the company building of Murakami Machinery Co., at 1540 Mukaijima, Okawa, Fukuoka.
- <sup>62</sup> Okawashishi Henshu Inkai. pp 784-7.
- <sup>63</sup> Ostergard, Derek E., ed. *Bent Wood and Metal Furniture: 1850-1946*. New York: The American Federation of Arts, 1987. p 147.
- <sup>64</sup> Ostergard, p 148.
- <sup>65</sup> Ostergard, p 150.
- <sup>66</sup> Exhibition catalogue, *100 Masterpieces from the Vitra Design Museum Collection*. Japanese edition. Weil am Rhein: Vitra Design Museum, 1996. p 109.
- <sup>67</sup> Ostergard, p 134.
- <sup>68</sup> Tezuka, Keizo and Matsumoto, Masao. *Keiji-Kobo – Raporto: 1 Paipu Kagu* (Pipe Furniture). Tokyo: Yumani Shobou, Publisher Inc., 2012. First published by Keiji-Kobo/Kokusai Kenchiku Kyokai around 1930. p 11.
- <sup>69</sup> Tezuka and Matsumoto, pp 18-19.
- <sup>70</sup> Toyoguchi, Katsuhei. *Hyojun Kagu* (Standard Furniture). Tokyo: Yumani Shobou, Publisher Inc., 2012. First published by Tokyo: Tougakusha, 1936. p 226.

## Chapter 4

### Perspectives in Japan: From design to industry

This chapter examines the different perspectives and approaches to plywood by professionals on the forefront of plywood. Subjects covered range from the early days of industrial design in Japan and its relationship to modernity, developments related to industrial manufacture, economical and other factors affecting the plywood industry, and a regional case study.

Despite their affiliation, none of the interviewees were particularly wedded to plywood as a material and were keenly aware of its shortcomings, at least not in the popularly idealized way of the craftsman to one's disciplinary material. It was chosen to promote the consumption of domestic timber from the environmental preservation perspective, a new material in the postwar period to experiment with, a part of structurally advantageous systems to enhance its earthquake resistance, replacement for other materials, or economy and availability, the material was selected for its specific characteristic rather than for its own sake from the wide range of choices available.

Section	Interviewee	Subject
		<b>General perspective</b>
4.1	Takeshi Okano	Material development, historical
		<b>Industrial perspective</b>
4.2	Fumio Kamiya	Material development, technical and industrial
4.3	Tendo Mokko Co.	Fabrication of moulded plywood
4.4	Mitsumasa Sugasawa	Design and materiality of moulded plywood
		<b>Design perspective</b>
4.5	Kenji Ekuan	Beginnings of industrial design and craft movement
4.6	Tetsuo Matsumoto	Industrial to furniture design
4.7	Noboru Inoue	Furniture design
		<b>Regional perspective</b>

4.8	Okawa Interior Promotion Center	Regional industry and its challenges
4.9	Okawa Coated Plywood Industrial Cooperative	Regional industries and challenges

#### 4.1 Interview with Takeshi Okano

##### Director of Wood & Plywood Museum, Tokyo

02 July 2014 at Wood & Plywood Museum NPO, 1-7-22 Shinkiba, Koto-ku, Tokyo

Excerpts from the interview, translation and text in parentheses by author

#### Furniture and plywood

There are basically two categories of furniture: *Ashimono* are those with legs (*ashi*) such as tables and chairs, whereas *hakomono* are box-furniture including chests and storage items made of board material. Plywood is often applied in the making of *hakomono* but only because it is economical and lightweight, not for the sake of plywood itself.

For bent plywood furniture, it can be said that the furniture is made at the same time plywood is made, which is different from describing furniture as being made from plywood. Veneers are layered over a mould, adhesive applied, then pressed together and heat-cured at high frequency. This is a method used by makers such as Tendo Mokko in Yamagata. Traditionally chairs were comprised of separate parts like seat and back, so making curved surfaces in the process of making plywood could be an advantage.

There are several cities in Japan known as hubs for furniture productions: Kariya in Aichi prefecture, Fuchu in Hiroshima, Okawa in Fukuoka, and Asahikawa in Hokkaido. Their products range from high quality to mass produced furniture that are more affordable and manufactured in larger factories. Mass produced furniture tend to use large amounts of plywood, such as for cafeteria chairs. I would say that the biggest advantage of plywood is its low cost.

Then there are the more artistic renditions by well-known designers, produced one by one. Within the industry they make up a very small market. Processing with thin veneers like bass plywood<sup>1</sup> in the bent plywood process (mentioned earlier) can be quite costly. There is an alternative method of making bent plywood, by making cuts in a thicker board (up to 30 mm available in the market, 28 mm are typically sold in stores) in order to enable curvature. Those grooves are later filled with *pâte*.

## Beginnings of plywood in Japan

It is said that Immanuel Nobel from Sweden is the father of plywood, who achieved industrial success in the United States.<sup>2</sup> There the plywood industry began approximately 50 years before the birth of Japanese industry in 1907; Nov. 3 of that year has been recorded as the day the first plywood was produced. Japan's export of fir tea chests to India had substantially declined in a competition with British tea chests, which were made out of plywood. This prompted Kichijiro Asano, who had been manufacturing and exporting these fir chests, to construct a machinery enabling the production of veneers.<sup>3</sup> From early on, Asano had already claimed that any kind of wood can be turned into plywood. He was a visionary.

Hardwoods can be grouped into *kankou-zai* (ring-porous) where the xylem cells are found along the annual rings due to faster growth in the spring, and *sankou-zai* (diffuse-porous), in which xylem cells are diffused throughout. We associate ring-porous wood to be higher in aesthetic quality; tabletops usually incorporate this type – zelkova, chestnut, oak, ash, etc. Diffuse-porous species offer relatively even pattern, less contrast and more reserved in appearance – beech, birch, luan, *katsura*. When the veneers are peeled off the log concentrically, large xylem cells of the ring-porous trees can be problematic, where they produce areas that are basically translucent. So diffuse-porous wood are better suited for plywood productions. Asano said both types would be possible for plywood production, which shows that his techniques were quite advanced.

Asano encountered a problem with the lack of appropriate adhesives. Bows for archery had used glue derived from starch, but it cannot be easily applied to large areas (like boards). Only naturally derived adhesives were available initially, such as blood-derived serum or milk protein-derived casein, in addition to starch. But none of them were waterproof, so the veneers would peel off. Waterproof adhesives only came after the advancement of processing petroleum; phenol and melamine are prime examples. Asano had to develop appropriate adhesive and blended a kind of coal tar, a by-product of petroleum that we call *rekisei*, with some natural elements like lacquer and gelatinous glue to increase its viscosity. Thus he came up with his original adhesive for the plywood.

During World War I, Asano plywood was applied to floats, about 4 m long, that were fixed on seaplanes. This means he had developed waterproof adhesive by then. He had also obtained a patent for his plywood (in 1910) for *Asano-shiki awase ita* (Asano-style plywood). Although his plywood company was not succeeded by the following generation, Asano was very innovative; he is also credited for inventing things like the sawing machine and the rice-polishing machine. However Asano's company only lasted for one generation.

Before waterproof adhesive was fully developed, however, plywood (formerly called *beniya-ita*, or veneer-boards) was a synonym for poor quality goods. We even used to curse some people *beniya-ita*, meaning that he is good for nothing. People of my age and above still tend to have a negative impression, and one of the reasons for establishing the Plywood Museum was to dispel such a reputation. And while Asano had developed plywood with waterproof adhesive, other factories had been manufacturing with lesser quality adhesives.

Even prior to that, when plywood was still rare, they were showcased in exhibitions to display the capability of manufacturing such large boards. Plywood then was not for practical use, and applications in airplanes, for example, were rare exceptions. There was no sense of plywood being a cheap thing back then; there are some superb examples and even some applied in the Diet Building.<sup>4</sup>

### **Importation of raw materials**

The plywood industry began in Japan in the Meiji year 40 (1907), and developed through the Taisho era, and Showa era saw the widespread availability of waterproof adhesive after World War II. This is the form of plywood as we know today.

What we are most familiar with today as the raw material for plywood are not domestic trees but those imported from Southeast Asia, which was dominant until quite recently. The family of Dipterocarpaceae (*Futabagaki-ka*) is most common, and they are diffuse-porous species since there is no spring in the tropics. This family of trees make up about 80 percent of the forests. It is widely known under the name Luan, which in fact is a group name – four groups of the Dipterocarpaceae family are together called luan. Rising environmental concerns and awareness of the exhaustion of resources in the 1980s,



combined with the governmental policy changes, influenced the manufacturing conditions in Japan. We had first mainly imported luan from Philippines, then Indonesia, and finally Malaysia.

Luan (or lauan), is a name in Tagalog from the Philippines. The over harvesting of luan in Philippines caused the shift in sourcing of the material to Indonesia, where it is called Meranti. It is also a group name, exactly the same as luan. Partly because Indonesia is a prosperous nation with oil supply, the government shifted its policy to ban the exportation of logs, the raw material, to processed wood products. Japan then turned to Malaysia, whose wood is mainly harvested not from the Peninsular Malaysia but from East Malaysia, in Sabah and Sarawak states, and Borneo island's Kalimantan area. There the same group of trees is called Seraya. Eventually Malaysia also faced the shortage of resources. So Japan's plywood industry had been dependent on the resources of these Southeast Asian nations but conditions have changed, mainly due to lack of resources in Philippines and Malaysia, and national policy change in the case of Indonesia.

### **Applications of plywood**

United States had been importing its raw material for hardwood plywood mostly from Africa. Domestically they have large quantities of softwood, Douglas Fir, called American pine in Japanese, although it does not belong to the pine species. They are abundant particularly in Washington, Oregon and California. Douglas fir is a conifer – softwood – and softwood plywood has become very commonplace in that region, including Canada.

The main difference between US and Japan is the way that residences are built there, employing frame construction with dimensional lumber. The structural panel is composed by nailing the plywood onto lumber, in the box-like structure.

Quite recently, most of the trees in artificially planted forests in Japan from decades ago have matured.<sup>5</sup> Japanese cedar consists of about 40 percent of these total planted forests, and together with Japanese cypress, these two species make up 70 percent of the planted forests in the country. Thus the application of softwood in plywood production began. But they are almost strictly used for structural panels, not furniture.

Plywood made from softwood is not used for concrete formwork either, due to a rather strange expectation that formwork panels must be completely flat. Wood grains inherent in the softwood are typically avoided for the concrete surface, with a few exceptions of people appreciating the expression of the pattern.

In fact, plywood for concrete formwork has generally disappeared. Steel panels have overtaken the market, which can be used over and over. In the past, scaffolding was made from cedar logs and planks. Solid planks were also used for concrete formwork into the postwar era, which were eventually replaced by plywood. Today it is said that wood for concrete formwork can be used only up to 5 times, which is not economically viable compared to steel. The exception to this rule is the melamine-coated boards. The transition to steel panel formwork is relatively recent.<sup>6</sup>

### **Issues surrounding the furniture industry**

In preparation for marriage, brides used to take pieces of furniture that included Japanese-style chest of drawers to store kimonos, western-style wardrobe, and a regular chest of drawers; these would consist a 3-piece set that the parents would purchase for the newlyweds. Most houses today are not built for these kinds of furniture, and the houses have built-in closets. The industry for *hakomono* are therefore suffering. The demand for *ashimono*, for tables, etc. are doing fine by comparison.

The issue of interiors should be addressed, as it is failing currently from the perspective of wood. So far we have failed to bring wood into the interiors; in all the commercial and office buildings that you see around here, its walls, floors, and furniture can, and should, employ more wood.

### **Areas that plywood have helped advance**

I would say perhaps the biggest impact that plywood had is on frame construction. This method developed in the United States and spread to Europe, Korea and China, and has become quite mainstream in many regions. In Japan this construction type never caught on, because of the sound issue. The wall structures of the house act like a drum, and both

echoing and leaking of sounds are problematic. In large plots and houses where privacy can be achieved even without hedges, it would not be a problem. In Japan, the houses are in close proximity from one another. The sound travels sideways, vertically and outside. In terms of insulation, draft and comfort throughout the seasons, however, this construction is very functional.

### **Issues concerning the use of plywood**

Tough fire protection laws here have made it challenging for wood to be applied in construction. In Japan, high density cities have developed near the sea and the mouth of rivers, which is clearly visible when you fly over the country. Whenever there was a fire, it would often spread over large areas, fanned by strong winds and fueled by the density. There was even a saying in Tokyo: Fires and quarrels are the flowers of Edo. Local firefighters, *hikeshi*, were organized all over the country. City scale fires are very different from one house burning down. We called it *taika*, big fire. These conditions led to the ban of combustible materials for construction in cities, and in due course the regulations made wood disappear from homes.

However I think it is unnatural for living organisms to not have wood and trees around us. All organisms oxidate, but only plants and some fungi can have redox reactions. The balance is lost right now. We need to have more plants and trees, and allow them to mature. The issue then is that we don't have space to plant them. The solution, although it might sound strange, is to cut down the grown trees and plant new ones. It would be wasteful to use the cut wood for fuel, but to make use of it in ways that oxidization is prevented. I would urge everyone to use more wood, avoiding applications where it can burn easily and coming up with something more long-term.

For centuries wood had been very close to our lives from fuel to everyday objects. And having experienced the over harvesting and its result in *hage-yama*, bald mountains, we learned to plant trees, keep the mountains green and allow the trees to mature.

Some new building codes have passed recently to allow the use of wood in public buildings, just 2 or 3 years ago. In this neighborhood, for example, recent construction of 4-

story elementary school used reinforced concrete structure for the ground level and wood structures from the second floor up.

### **Implications of plywood on structure of houses**

The typical structure of houses in Japan are what we call *zairai-jikugumi-kohou*, or conventional post-and-beam structure. Columns and *ma-bashira* puncheons make up the wall structure to support the weight of *koya-gumi* roof truss structure. This construction method is still employed, but plywood has changed some of its conditions.

Now we have structural plywood, 9 mm and up, with phenol-based adhesive that is highly waterproof and strong, which can be applied in residential construction. The veneers would be torn if one tries to take the layers apart, not the adhesive layers. Researches after the Great Hanshin earthquake in Kobe (1995) and offshore Miyagi earthquake swarm (occurring multiple times from 1793 - present) have shown that the failed residential structures did not have adequate stiffness in the floors – the floors lacked shear strength. Plywood proved to be a solution for this problem.

Traditionally the carpenter would lay out the foundation, then place *oobiki* sleepers, then *neda* joists (45 x 60 mm is common) spanning in between, with 12 mm thick plywood nailed on top as substrate. Instead of having these rectangular *neda* members bridging the foundation and sleepers, fixing 24 - 28 mm structural plywood directly onto the sleepers was found to increase the stiffness of the floor structure. Thus the earthquake resistance is greatly improved. It is a landmark for residential structures.

Currently there are products such as *Neda-non*, structural plywood specifically sold to be used for floor structure, eliminating the need for joists. Some of them use the Japanese cedar for interior veneers, this one with larch veneers outside. The artificial forests planted in this country between the mid-1950s to 70s consist mostly of cedar, and are in serious need of thinning out. That means we need to use more wood. But the number of built houses already exceeds the number of households. We can use wood to increase performance in terms of earthquake-resistance for existing houses, or use thick plywood when rebuilding. Among the Great Hanshin earthquake's approximately 6000 victims, the main cause was

from being trapped by the structure. When the fire broke out after the quake, they couldn't escape. It's tragic. These plywood products like *Nedanon*, I think, can help save lives.

Structural plywood is based on performance specification today, not by product specifications as it used to be. So the type of adhesive used is not necessarily specified. You can check the color of the adhesive layers with the naked eye – this black type is phenol-based; the clear one is aqueous vinyl-polymer solution-isocyanate adhesive, used for non-structural purposes.

Another thing to note about the typical construction we use in Japan, using the method called *tatema*, is that just after the columns are set up the roof is built first. I wonder if it is to avoid getting wet? It is different from the platform construction of the framing method typical in the United States, where the ground floor is prepared, then the walls of that floor are put up, then the upper floor, then its walls, and so forth.

Most plywood are manufactured from softwood in Japan currently. We still get some seraya, or luan, from Malaysia, but the quantity is almost negligible compared to how much we used to import. The use for these are concrete formwork mostly, and floor substrate. When calculating the amount of plywood, we convert to 12 mm thick panels, and count the number of sheets. It is the most standard thickness.

### **Into other derivative materials**

In Japan, houses are built and demolished in about 30 years. This cycle produces lots of scrap wood and plywood from these sites. Scrap plywoods are turned into what we simply call boards, which are particle boards. These are one of the cheapest products. If the contractor trashes the construction waste, it would cost around ¥15,000 per cubic meter just to get rid of the material. So they are reused for making particle boards.

Just this year JAS (Japanese Agricultural Standard) for LVL (laminated veneer lumber) was changed, and the inner layers beyond 3 exterior layers from either side can now include veneers laid crosswise, and up to 30% of the total layers. It would help ensure dimensional stability, and shows that LVLs are becoming increasingly similar to plywood. However the main difference is that plywood is a board that resist forces in X and Y directions. LVL is

designed to resist one-directional force, for example as a beam where the upper in compression and lower section in tension. So the use is fundamentally different. Although there was an attempt to make LVB (laminated veneer board), plywood is functionally better in this case. There are a few examples of LVB nonetheless, and they are made to order.

Then there are fiberboards. There are basically two ways to make them; wet or dry. Dry method uses adhesive to attach the fibers to each other. Wet method does not require adhesive, as in trees where fibers are already stuck together. Fibers are loosened, suspended in water, formed into boards, and compressed with heat, to result in a product with density above 0.85 (0.80 by JIS), which we call hardboard. If the boards are not compressed with heat and just allowed to dry, resulting in less density (typically under 0.35g/ cu. cm), they are categorized as insulation boards, or insulation fiber boards.

In the dry method, pulp is mixed in with adhesives, then pressed. When pressing between two steel panels, there is a distance bar that is adjustable. This is how the density can be controlled, for thicker panel with less density or thinner panel with higher density. Since several years ago, if the boards are made using this dry process, they are called MDF (medium density fiberboard) regardless of the actual density. This one is determined under JIS (Japan Industrial Standard) specification, rather than JAS.

The market for MDF is growing rapidly, mainly for architectural fixtures and fittings. It is more resistant to warping than plywood. Another advantage is that, because it is more like paper, the surface takes ink and prints very well. It can even register embossed patterns. MDF is pulp-based, so the raw material is not limited to wood – bagasse, which is sugarcane pulp residue, or tree branches are often mixed in. The yield from the sawing industry (to produce lumber) remains around 50% and the rest are sawdust and *seita* bent boards not appropriate for lumber. Those can be used for MDF too.

In regard to wood-plastic composite, WPC, there are different methods of producing them. The common method employed in Japan is quite different from the rest of the world. Basically the wood fibers are soaked with monomer, then allowed to polymerize in the cells. These are used for things like buttons and knife handles.

In a more typical process outside of Japan, wood is crushed into fine powder down to

micron level (also called wood flour), combined with thermoplastic, and extruded into required form. A product called M-Wood by Misawa Homes is one of these types. I think the ratio is something like 60% wood and 40% plastic, and they also incorporate recycled plastic from PET bottles and other discarded products. The product is used for exterior applications such as decks, and around kitchens and bathrooms as well, for its high resistance to water.

The polymerization process seems to be particular to Japan. The advantage of this product is that it can be recycled, though it has not gone through these cycles yet at this point. It is a different approach from the solid wood being recycled to boards. By crushing the wood-plastic composite, it is said that the WPC can be recycled almost endlessly.

I would say that wood should not be treated as something precious. We should avoid wasting, burning, or letting it oxidize, but I hope that more wood will be used for reasons mentioned earlier. Otherwise the plants and animal kingdom would not function.

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<sup>1</sup> Typically basswood veneers are applied on the outer layers, with interior layers composed of luan veneers.

<sup>2</sup> Luther, based in Estonia, precedes Nobel who is regarded as the father of plywood in the United States.

<sup>3</sup> Further discussed in chapter 2: Overview of plywood history in Japan.

<sup>4</sup> The current Diet building in Tokyo was built in 1936.

<sup>5</sup> Large areas of artificially planted forests in Japan occurred between Showa 30s to 40s, which span from mid-1950s to 70s.

<sup>6</sup> According to data from the Japan Plywood Manufacturing Association, production of plywood specifically designated for concrete formwork is available since 1967. Between 1977 and 1992, the annual production of concrete formwork plywood has been over 2.3 million cubic meters, reaching its peak of 3 million cu. m in 1987. In those years, this type of plywood constituted between 34 - 44 percent of the total production of plywood in Japan. Its steady decline began from 1993 onwards, reaching below 1 million cu. m by 1998 and in 2007, the numbers has been down to 61,000 cu. m.

## **4.2 Interview with Fumio Kamiya**

**Fellow at Forestry and Forest Products Research Institute and chief technical officer at Seihoku Corporation**

14 October 2014 at Seihoku Corporation

1-25-5 Hongo, Bunkyo-ku, Tokyo 113-0033

Excerpts from the interview, translation and text in parentheses by author

### **Industries of plywood**

Plywood has a long history: The first form of plywood originated in Egypt, then later its mass production was enabled by the advancement of adhesive and the rotary lathe. First country to mass produce plywood, I think, was the United States. Japan experienced its own development, with Asano Kichijiro being the initiator. Back then, plywood was made to be applied for tea chests, with advantage being its resistance to splitting or warping. Developments for many other products followed.

The structural application of plywood – which is my speciality – is a relatively recent development in Japan. Most of its use was in furniture, fixtures, interior finishes and substrates, which are not structural. The subsequent industrial applications to grow were for wall and floor surfaces: Printed (laminated) plywood, or decorative veneers, and flooring. This is no longer the case, as plasterboard (or gypsum board) with wallpaper is the mainstream finish for walls today. For wood flooring, plywood made from Southeast Asian timber, imported from Malaysia and Indonesia, used to be dominant substrate material. There are still a few manufactures in Japan producing them, but the latest research and development today is being conducted for the softwood plywood in wood flooring applications.

Predominant plywood application for structural purpose is in the North American light-frame construction, based on dimensional lumber (typically called 2x4 construction method in Japan). Solid boards originally used in this method were replaced by plywood almost instantaneously. Seeing this, companies in Japan began to incorporate plywood for panelized walls, floors, and roof in prefabricated construction of houses, such as Eidai House



(founded in 1946 as a manufacturer of plywood; entered the prefabricated house market in 1960) and Misawa Home (founded in 1962). The very first wood panel application was probably the Mizetto house (1959)<sup>1</sup> manufactured by Daiwa House (founded in 1947), but for full-sized house manufacture, Eidai and Misawa were the pioneers. This development was taking place from early to mid 1960s onward.

### **Residential construction: light-framing versus post-and-beam**

In 1974, the light-frame construction became unbarred (Notification No. 1019: “*2x4 kohou open-ka*”) and opened the way for the adoption of this construction method in residential buildings. It is exactly modeled after the American system, in which plywood has always been very central. However the traditional Japanese post-and-beam construction was not adopting plywood at all. I always wondered why this was. I graduated university around this time, in the early 70s, and had engaged in research and experiments on the qualities of plywood – it was a wonderful material, and I thought it should be used in a wide variety of applications, but in reality this wasn’t the case.

I was largely concerned with earthquake-resistant structural designs, and so I thought shear walls would be a great utilization of plywood, after conducting tests on shear walls. It comes down to economy. The combination of lath and plaster (called mortar) was the cheaper option then, compared to finishing with plywood.

The floor is another advantageous area for structural enhancement. According to the building code, *hiuchi-bari* – an angle brace at the corners spanning between the beams – was considered sufficient. In fact, they are not so solid. It is more structurally sound to lay the plywood directly on the beams, so I tried to convince them that the post-and-beam construction should be as rigid as light-frame or prefabricated houses. What I didn’t know, working on my experiments in the lab, was what went on in the building site: In the traditional post-and-beam method, the columns are erected first, and the floors are laid out afterwards. If they were to directly place the plywood on top of the beams, the columns are in the way, which would mean the plywood has to be notched wherever it interferes with the column. That is just way too laborious. Eventually, the application of plywood as floor

substrates spread as a replacement of some timber elements, but there was still a problem. Joists were favored for preventing squeaking of the floor and the ease of construction. On top of the beams, joists (45 x 60 mm) were placed at 303 mm on center, and then plywood was nailed on top of joists in a single row. Structurally this is not an ideal solution, because the connection between the beam and joists is still vulnerable and it is where failure occurs. It would be far better to fix the plywood directly onto the beams for shear strength.

Also around the same time – in the late 80s, I would say – plywood was also beginning to be applied for roof sheathing. However the dominant type used were the plywood produced for concrete formwork,<sup>2</sup> not structural plywood; the building codes did not dictate what had to be used, so it could be just boards, battens, steel panels, or anything else, as they don't fall down. There was no concept that plywood would increase earthquake resistance structurally then.

Plywood for the use of concrete formwork can be categorized into two types: JAS (Japanese Agricultural Standards) certified and not JAS certified (called non-JAS). The difference between these two was the strength of the adhesive, and its waterproof quality. In civil engineering, for example, the plywood formwork won't be used over and over again anyway. The consensus is that if the plywood can be used a couple of times without the veneers peeling apart, that's good enough. With lower quality of adhesive, the price goes down too, so quite a lot of non-JAS plywoods were in the market. When hundreds of thousands of plywood panels are purchased for a large-scale public engineering work, even if it's just a 10 yen difference – with 100,000 panels, that difference would come to a million yen. It may not be a big difference, the purchasing department of the company would choose the cheaper option, even 1 or 10 yen. The funny thing about the companies is that the technical department is the one to use plywood structurally, but the purchasing department is responsible for making the call for what to buy even though they had nothing to do with the decision to use plywood in the first place.

It was the machine precut technology (such as the CNC) that brought a big change. The post-and-beam construction had traditionally engaged in the precut method: The carpenters would fabricate all the timber members in the shop in advance, so it would only

take about 2 to 3 days to assemble the posts and beams on site, even back in the day. Then the roof is laid out, basically to protect the wood members from being exposed to the rain, before proceeding on to the rest (such as walls).

What this suggests is that the number of carpenters determined the production quantity throughout Japan. If there were a *koumuten*<sup>3</sup> that wanted to double its output of houses from 10 per year to 20, then it meant that they need to hire double the number of carpenters too. Around the time prefabrication and light-framing came into popularity, the idea of processing each timber member by machine began to take shape, which we call machine pre-cut. This predates the numerically controlled machines today that can directly translate from the drawings. With increased rationalization in the production, *koumuten* that incorporated new technologies began to grow. Ichijo Koumuten is a typical example of this case. When *koumuten* wanted to grow in size, they no longer had to hire more carpenters; as these companies have grown in size with more capital, they began to engage in technological developments and innovations. The more technologically advanced, the bigger the company grew.

Meanwhile, voices advocating the use of plywood began to be heard, because now plywood could be precut as well. It allowed the application, usually of 12 mm plywood, application directly onto the beams to be less troublesome. The term *gousho-kohou* (translates to stiff floor construction method) came to be used for promotion purposes.

### **Plywood and earthquake-resistant structure**

It first appeared around 1990, before the Great Hanshin earthquake in 1995. After Hanshin, the discussion of how to make the structure more earthquake resistant became more critical. Then I got a call from Japan Plywood Manufacturers' Association, and was asked why 12 mm plywood was being used, and if it wouldn't it be stronger to apply 24 or 28 mm thick plywood. From structural standpoint, of course I said yes, thicker plywood would be better. And the manufacturers prefer to market thicker plywood, it would double their sales. Today, as a result, 24 and 28 mm thick plywoods have become the standard in post-and-beam construction. This is one of the most significant development of structural plywood in this

country.

This was a great progress, but more could be done from my point of view. The wall and roof elements can also be improved structurally, which prompts the question of why plywood was not used for wall construction.

Plywood shear wall is listed in the a notification (*kokujō*) of the building codes, but it basically only addresses the exterior wall and not in *majikiri*, interior partitions. Therefore we applied to multiple authorizations by the minister (*daijīn-nintei*): It is a system of approval by the Minister of Land, Infrastructure and Transport (*kokudō kōtsu-shō*) when you want to employ a method that is not listed in the building codes. We take the material to the specified testing agencies where tests are conducted, then the analyzed results and the values are sent to the ministry for approval. We got about 11 of these approvals.

For example, here is a case of 24 mm plywood sandwiched panel acting as a shear wall. We also got an approval for 12 mm plywood shear wall, where 24 mm is too much or unnecessary. Here are the options for this type: *Okabe*, where the columns and studs are hidden behind the panel, which is plywood in this case, and *shinkabe*, where the panels are nailed to the studs but are set between the columns that are exposed. In both cases of *okabe* and *shinkabe*, we provide further specifications depending on whether the floors are laid out before the walls or after. Unless we provide these clear-cut options and specifications for each condition, the carpenters are not easily compelled to use this construction method. Needless to say, there is also an option to have the exterior walls acting as shear wall, and using diagonal bracing (*sujikai*) in the interior.

We've also made the specifications for nails to be used which are generally longer and thicker than previously used, and also determined the spacing of the nails. Here you can see the chart, in the first case CN65 nails are specified for spacing under 50 mm on the outer edges and under 200 mm on the inside face along the backing timber. By providing several options in terms of strength and material thickness, people can pick the specification suited for their purpose, like choosing from a menu.

The roof is one of the areas we are focusing on. There is a ceiling in a typical house, which creates an unused, wasted space above where small structural elements are

crisscrossing throughout. Our basic approach for the roof is the same as the floor. We can eliminate the rafters and directly attach the plywood onto the beams. The resulting appearance is very uncomplicated, with only the thick beam members and thick plywood, and space with bigger volume or additional room can be achieved.

Results of these construction methods are realized by the designers, some of which we did not anticipate at all. We just provided the construction method, which is very simple and something that any structural engineer can come up with. We conducted the tests, made guidelines for construction methods, provided values for its performance. For example, thick insulation can sometimes cause condensation in the interior side of the wall, so here we've shown some ways to avoid it by providing vents, after testing these conditions in an environmental testing laboratory.

### **Non-residential applications of structural plywood**

The examples I've shown you are so far are all residential applications, but plywood has the strength beyond the residential. Here are some very large storage or factory facilities in the US, with concrete walls spanning 30 or even up to 100 meters. Plywood roof, fixed on laminated timber beams serves as the diaphragm. People are often concerned with vertical structural elements when we discuss shear forces, but the horizontal elements are just as important, if not more, in an earthquake. We call it *suihei-goumen* (horizontal stiff plane).

So we've recently began to incorporate plywood in medium to large scale buildings in Japan. The nails used are even thicker, and arranged very densely. Here (a hall) both the floor and the walls use these panels – well, the difference between the floors and the roof are basically if the plane is slanted or not. We have proven that plywood can compose a large, structurally sound building and is not only limited to residential application.

### **On visible application of plywood**

The way I see it, it is interesting because Japanese people are seemingly conservative but are aesthetically quite progressive. When luan plywood first appeared in the market, the carpenters thought it was beautiful and used it directly as finishes.

Before that, cedar battens were used as the wall finish. Their surfaces would darken, get dull and nicked. Compared to that, the clean, light colored, smooth surface of the luan plywood was really appreciated.

The same could be said for particleboard. Its first incarnation was a product called Homogenholz, which was composed of larger sized wood chips, kind of resembling the current day OSB. The carpenters were quick to apply this material as a finish too, and considered these boards aesthetically pleasing.

When I was in middle school, my family's house was partially renovated. This material (Homogenholz) was used there, I remember. I was about 15 years old, so it must have been around 1960. Hardboard was another relatively new material then. The kitchen area was finished in hardboard, and the rest were in Homogen-board. We didn't know the properties very well, and eventually the hardboard began to warp because it was in the kitchen. For Homogenholz, lines from the saw were notched on the surface, to break up the flatness. It looked pretty good.

Japanese tend to embrace new materials and are quite open minded and enthusiastic in using them, but when everyone else starts to follow suit, it gradually came to be considered cheap and boring.

### **Changes in trends**

Softwoods are usually full of knots. Until around the time I graduated from the university, the use of timber with knots in residential buildings was unthinkable, as they were considered vulgar. Interestingly, what seems to have changed this is the laminated plywood (with printed material applied on the surface) with imitation of pine, with lots of knots. It's a kind of a reversal of idea, in the way of thinking. Initially pine entered the homes via bunk beds, for children. As these bunk beds became popular, people began to accept knotty woods too.

Having a ceiling can be beneficial in terms of soundproofing and aesthetic purposes, hiding a large number of structural members such as joists or rafters. Replacing these elements in conventional structures with plywood led to a neater appearance, so the ceilings could then be eliminated. Again, it's the designers who started this trend.

Designers can't do what everyone else is doing as a nature of their job, like using wallpaper on plasterboard as a finish. And the tendency is to show the material close to its original state, like exposed concrete. Sometimes we are shocked by the kind of material that designers choose to use, the kind that we consider are not very good – with dark red hue or wood with so many knots. They are often treated with color, so they look fine in the end. The standard for plywood is very general.

After the 24 mm plywood shear wall structure was approved by the minister, no one used the system for a while. So I decided to construct a villa in Futtsu, Chiba. As you can see, I had the plywood coated in white urethane lacquer on the interior. From the traditional sense in Japan, it is unthinkable to paint wood, but it is very common in the United States. People here say that once you paint it, it is no longer wood. But I think that even with paint, texture of the wood surface is still unique, and especially works well when a kind of sandy surface like plywood gets coated. On the ground floor, I left all the surfaces unfinished. Wood aids in absorption and desorption of moisture in the air, if unfinished, so I am just trying it out.

Because large surfaces of plywood can be quite monotonous, I thought of cutting the plywood in strips and stacking them to break up the dullness. One plywood manufacturer told me that it's not necessary; they told me that if I just add some saw marks by notching the surface, that should do the trick. Human eye is funny in that way, it feels very different and abstracted with a simple maneuver like that. Another thing was to have 5 to 10 mm gaps between the boards, in the manner of *mesukashi-bari* (a technique in which gaps between panels are provided instead of butt joint, often used for ceilings in Japan). Actually I was anticipating some knots on the plywood, but none of the delivered plywood had any knots whatsoever. I was a bit disappointed. Anyway, there are lots of applications with exposed plywood these days.

When I entered this industry was at its peak in terms of production. There is Japan Plywood Manufacturers' Association, under which regional associations like Tokyo Plywood Manufacturers' Association and others operate. Back then, there were well over than 300 companies were affiliated with JPMA; it is now down to 30. The remaining 300 or so

companies have closed down or gone out of business. There are some, like Eidai or Daiken, that began with plywood manufacturing but shifted to fabrication, so they are able to process imported plywood from Indonesia, Malaysia, etc.

The manufacturing companies left are ones who have been focused on plywood only, the unfinished kind. They were able to streamline the production process, and in a sense, the best manufacturers have survived.

Today's plywood supply is roughly 55 percent imported and 45 percent domestically manufactured. Most of the domestically produced type now are softwood structural plywood, which in the past used to be minimal in ratio but we've shifted almost completely to structural plywood.

Our aim is to supply more plywood again in the market of concrete formwork. The plywood used for formwork has been dominated by imported luan, but its quality has dropped and price has gone up. It was difficult to apply softwood plywood for formwork – it tends to absorb moisture due to its growth pattern, and increased moisture content causes warping – but we've overcome the issues and trying to transition into softwood plywood for formwork use (12 and 15 mm thick, 600 or 900 mm x 1800 mm are available now).<sup>4</sup> They are also used as substrate for wood flooring, and we are encouraged to expand the uses for softwood plywood.

The use metal formwork has largely replaced plywood for residential or buildings where the form is relatively straightforward. There are still some areas that metal formwork is not useable, such as foundation on sloped site, diagonal planes or if the form is even slightly complex. But there is still a lot of plywood used as concrete formwork today.

### **Changes in material sourcing to the introduction of thick plywood**

In the past, there were just a few materials, like the beautiful basswood from Hokkaido, that was used for the production of plywood. The ratio of domestically sourced wood was not zero percent but in the lower single digits. Currently the raw material used for domestic plywood manufacture is about 70 percent domestically sourced Japanese cedar, larch and Japanese cypress; roughly 2/3 of the total is cedar. The use of cedar is revolutionary.



When the plywood industry was thriving, a Japanese professor concluded that it would be impossible to make plywood out of cedar. If you look at the annual rings of a cedar, there are some dense sections and a lot of soft sections. The transition from the dense to soft is very abrupt. This means that processing of the veneers causes a constant and frequent impact on the blade, resulting the blade to be worn down quickly as well as a poor surface quality of the veneer. Additionally, the strength of cedar is quite low – to be precise, cedar has a low Young's modulus compared to other woods. In fact the flexural, or bending, strength is not too bad, but overall the strength is relatively low.

What changed its fate is the emergence of *atsumono-gouhan*, thick plywood (for 24 and 28 mm thickness). The bending strength is mostly determined by the two outermost veneers; using strong wood veneers on the inside doesn't affect the bending strength of that plywood. So the cedar veneers were used as inner layers, with, say, larch on the outside. In the case of the very thick 28 mm plywood, all layers be composed of cedar veneers for adequate strength. The reason why cedar use is low in thinner plywood is because a 9 mm plywood, for example, is either composed of 3-ply or 5-ply; in 3-ply, cedar would only constitute 1/3 of the total veneers. In thick plywood with more layers, the ratio of the cedar in the entire plywood becomes much higher.

Just before the *atsumono-gouhan* appeared on the market was the year of the lowest plywood production in Japan. The number depends on the statistics, but it was somewhere around 16 million cubic meters per year. In the past it was 60, 70 million cubic meters (the highest recorded production was in 1973, at almost 86 million) and the numbers kept declining. *Rinya-cho*, Forestry Agency (within the Ministry of Agriculture, Forestry and Fisheries) was under pressure to close down, and had to cut back considerably. When it ultimately seemed like it can no longer go on, the agency successfully transformed its position from production focused to an environmentally focused one. They became the allies of the conservation groups, with whom they used to fight with all the time.

Plywood has been central to the rising use of domestic raw material. The Plywood Association receives funding for research from the Forestry Agency and the Ministry of Land, Infrastructure and Transport, because the association has made some achievements

for the industry. The aim now is to raise the ratio of domestically sourced wood to 50 percent, for the overall use. This policy was set not by the Forestry Agency but the cabinet; it is one of the 12 main national policies instituted by the national government, to promote the use of domestically sourced wood and of timber in general.

Of the 50 percent goal, plywood production is aimed at 5 million cubic meters (for domestically sourced softwood plywood). This means we need to increase production by another 2 million cubic meters from today's numbers, but in my opinion, the fact that we even got to 3 million today is already quite significant.

### Increased applications

Since the effort to use more domestically sourced wood, there has been more outlets for applying softwood plywood. On a small scale, the election notice boards (where each of the candidate's posters are attached before election) had been using imported luan plywood, and have been switched to domestic softwood. In civil engineering works, the steel boards that are laid out for trucks to drive on have been switched to plywood. Another application is for noise barriers; I was involved in its development. For a case in Gifu, we used 24 mm so it was strong enough to withstand typhoons (The noise barrier product is available in 12, 15, 18, 24 and 28 mm thick, 910 - 1220 mm x 1820 - 3030 mm).

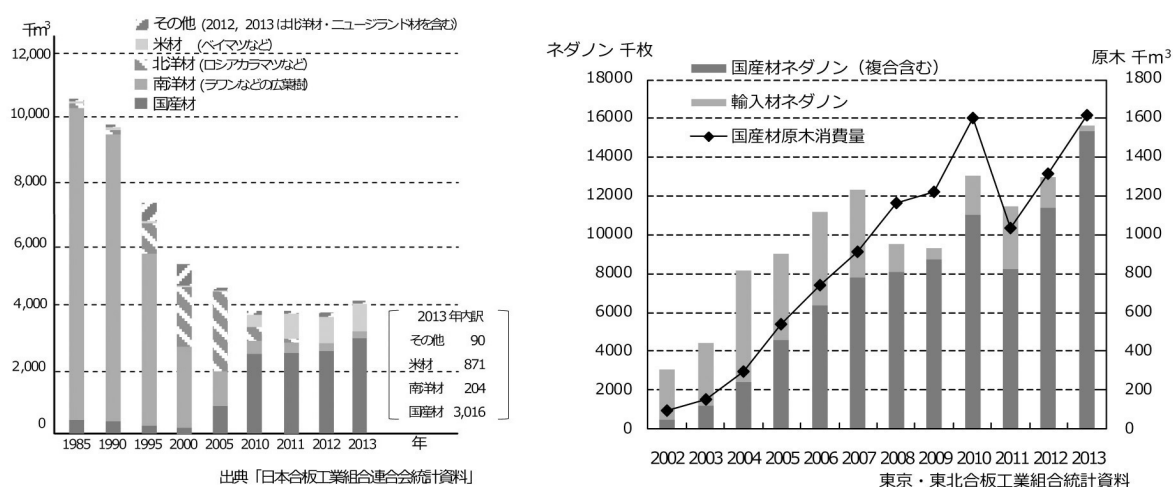


Fig. 4.2.1 Consumption of logs for plywood manufacture (left), where the lowest dark grey

bar area indicates the domestically harvested wood that has been increasing after 2001 and reaching 72 percent of overall use in 2013; production of thick plywood product *Nedanon* (right), with the dark bar area indicating the quantity of thick plywood produced using domestic timber, and the overall consumption of domestically harvested wood in the line chart.<sup>5</sup>

## **Personal background**

My major was in forestry resources and products in the university. There were several assistant professors then who had graduated from architecture department with focus on structural engineering – at that time, timber engineering was considered over, and they were brought in to revive the department. That’s how I leaned towards architectural applications, while very few people were experimenting on how wood can be used structurally. Lab tests conducted on shear walls and floor structures did not prompt anyone to use it, so I got increasingly involved in structural engineering and architecture. Of all the engineered woods on the chart (by author: the chronology of engineered wood products), I have conducted tests on most materials directly or indirectly except perhaps the WPC, wood-plastic composite.

This year the Japanese Agricultural Standard was established for CLT. My recommendation for the testing criteria for its strength is used. Unlike European CLT product, the Japanese standard allows the infill of the CLT to be of much inferior material, as long as they are filled. There is also category for the product with all high quality timber inside, but we’ve made a choice to allow the use of cedar with low Young’s modulus too, so they can be used for appropriate applications.

Interestingly, I am also involved in the Chinese building codes too, so I visit about 6 times a year. Every 5 years, the building codes are reviewed and revised. In the previous revision, the North American and European timber light-framing construction method was included. This time around, they want to include the post-and-beam construction.

What triggered it was that the Japanese Forestry Agency wanted to promote the use of cedar, larch and cypress in China too, so I was sent there. China is very open – it doesn’t

matter where you are from to make these suggestions and guidelines. I became close to a Chinese professor, who asked me why I wasn't introducing the construction methods, instead of just the material. So I did.

### **Popularization of the material**

For plywood, distribution is central, whether through general trading company, building material supplier, etc.; they influence the daily fluctuations in the price of plywood. When the thick 24 and 28 mm plywood began to be produced and entered the market, they were stocked in the DIY-stores too. That opens the door for the consumers to think about how the material can be used. What began for me as encouraging people to replace 12 mm plywood floor with 24 and 28 mm for better performance, led to other people coming up with a variety of unanticipated uses. It made me realize that the distribution of product causes people to think and be creative.

For example, I've heard a case that during the repair work when people need to walk over the railway tracks, that a temporary platform was built with this thick plywood. I think 12 mm plywood would have been too difficult to work with, because it's too flimsy. Another case is a lecture theater, to create the steps. Or for the sculptural object, or boutique interiors. We receive many inquiries on their uses.

A house can be constructed entirely out of the thick plywood too with something like kit-of-parts, structurally speaking, although it is not approved by building codes yet. I think it was utilized for temporary shelter after the tsunami disaster in Tohoku.

### **OSB vs. plywood**

Oriented strand board is considered the biggest trade rival of plywood. When the full scale production of OSB began and expanded in the 1980s, it took over a big share of the plywood market. After it grew, the market reached a sort of equilibrium: OSB at 60 percent and plywood at 40 percent.

In the United States, the uses are very distinctive. Many of the houses that are built and sold, or apartments employ OSB. Most houses that are built to order use plywood. The

separation is very clear. The situation is quite similar in Japan, where most apartment buildings use OSB, but the single family homes that are built and sold typically use plywood.

I have nothing against OSB, but the material doesn't react well to water. Because the wood chips are glued together on points, the water gets trapped easily and the board expands. For my own house, I'd say that plywood is more reliable in this sense, but OSB is slightly cheaper than plywood.

Someone said that you can tell the quality of a project by how it is called: From the highest quality, a *sakuhin* (work of art), with a lot of budget; then *shouhin* (a product), constructed by a regular builder; *bukken* (a property), something like an apartment building for landlord's investment purposes – considered good enough if it lasts 30 years, by the end of which the landlord would've made a profit; then the lowest of the bunch is *uwamono* – this was a term used when land prices kept going up, not used much anymore. In real estate, higher taxes are imposed for the resale of the land by itself, as opposed to if there was a building on it. So these are the basic four categories, and as you can see, not all houses are built with the same interest in mind.

OSB is not a bad material, I was also involved in testing of the material. As long as they are used correctly and appropriately, they are not bad at all. Strength-wise, OSB and plywood are also comparable. The only issue is its weakness to water.

There is a reason why carpenters do not like to use particleboard or OSB or MDF, which is too expensive anyway. When they are working on site and it starts raining, which you just can't avoid sometimes, plywood is fine even if they get wet. That's not the case with the other board materials. When I worked at the research institute, we used to tell everyone not to get plywood wet at all times. Now that I know what happens in reality, on the building site, carpenters use plywood because they are fine even getting wet.

These days many of the inquiries made to the Plywood Manufacturer's Association come through to me. I especially get a lot of calls during the rainy season, like this one: The rain got on the plywood on site and black liquid is seeping out of the surface, do I need to replace them? I say that's not necessary, if your client is doubtful then have the client call me. The black liquid is just a result of a chemical reaction with natural elements like metals

in the wood; the elements you see on the periodic table exist inside the wood in very minute amounts, to begin with. When they react to water it becomes visible. Sometimes black mold develops on the surface too, but I tell them, they are everywhere and they die when the board gets dried out. There is no need to worry about either case, because their strength is not compromised.

### **Building codes affecting the use of plywood**

The building code for plywood shear wall existed for a while, but its application didn't catch on because it was written up by lawmakers and technical experts. By applying and qualifying for special minister's approval, as I described before, variations of its application increased. The use is just recently beginning to grow steadily, which was confirmed by *kinyu shien kikou*, Japan Housing Finance Agency's research too. This is the current situation with the walls.

Regarding the floor and roof, the building code does not specify the use of plywood. The use of *hiuchi-bari*, the diagonal brace, is enough to meet the minimum standard. In 2000, *hinkaku-hou* in which the performance is classified into grade 1, 2, or 3 for criteria such as earthquake resistance (The law was passed in June 1999, with the purpose to clearly indicate and set evaluation criteria for the performance of houses). It indicated the significant structural improvement when plywood is applied, and its use for floor and roof is slowly beginning to spread.

Structural analysis (including seismic analysis) is required by law for any building with 3 stories or more, or if the floor area exceeds 500 square meters, whereas smaller buildings just need to meet the specifications established for construction methods. Using plywood can also be beneficial for the structural analysis, and as a result the consumption of it has been rising.

Building codes are really the minimum requirement; it doesn't guarantee any high-quality house. It doesn't promote the use of any particular material, but of course it prefers reliable structure that can last longer. Some contractors are also selectively using domestically sourced materials, out of environmental concerns, such as Daito Kentaku. The company specializes in building of apartments, but they are trying to use better materials

and be considerate environmentally.

Another one, as you may already know, is the law on the promotion of the use of timber in public buildings (passed in May 2010). It specifies “public buildings, etc.,” whereas the “etc” indicates noise barriers and guardrails. I was involved in the testing of cars and trucks colliding into them, because these need to withstand the impact.

### **Wood as a fireproof material**

Wood was thought to be a highly combustible material for a long time. Currently there are researches on how to make wood more fireproof, with chemicals or other techniques. The Fireproofing Association of Urban Disaster Prevention was also founded recently (in 2012).

Because timber buildings were thought to be combustible, the building code did not allow timber construction for large buildings. It was first amended in 1987 to allow for *daidanmen-mokuzou* (construction with heavy timber, with large sections, was allowed for buildings higher than 13 m or the height of eaves over 9 m). Suddenly the understanding of timber structure had changed – it burns, but doesn’t keep burning. If the building is required to not fail for one hour, it could now be designed that way. The concept of *moeshiro-sekkei* appeared (based on the understanding that after fire penetrates a certain thickness from the surface of wood the flame stops internally, the structural element is sized to account for the burnt thickness to still function structurally).

Fire related codes can be quite complicated. *Jun-taika* signifies the safety of the building under fire, so if the fire engine can arrive before the building fails structurally, certain damages to the building is accepted. *Taika* category was previously limited to concrete and steel structure, and timber was out of question. What changed was the amendment in 2000 for *seinou-kitei*. Previously the *shiyou-kitei* had specified materials and dimensions, but *seinou-kitei* took over, which is a performance-based specification. As long as timber can meet the specified performance, its use was allowed.

Under the *taika* category, there are 1, 2- and 3-hour types. It is dictated by the number of floors in the building and its site. Different rules apply for residential buildings, so I’ll just explain generally here. If you wanted to build a 3-story building in a dense urban condition

like Tokyo, it has to be a *taika* building; if it's a 1-hour *taika* building, the structure must be standing semi-permanently after being exposed to 1 hour of fire and heat from the outside as determined by ISO fire curve. One-hour *taika* building can be built up to 4 stories, 2-hour up to 14 stories, etc. The number of stories are counted from the top floor level, so if the lower floors are constructed from steel up to 30 stories and the upper 14 stories are in timber, that would be fine.

For *jun-taika* category, the assumption is that the fire occurs within that building and that the firefighters will get there. *Taika* has to do with the spread of fire collectively in the region, it's called *shudan-kitei*. For example, in a situation of a fire after an earthquake, the fire engines are not expected to get there. A 2-hour *taika* building has to either stop burning or structurally withstand after being exposed to fire on its exterior walls for 2 hours. The building cannot collapse, because that would spread the fire.

We got the minister's approval for the material based specification for fireproof performance, and there are several 1-hour *taika* buildings throughout Japan. This year, for the first time, a 2-hour *taika* building was approved for a timber structure 14-story building. The columns are made up of steel H-beam with chemically fireproofed LVL around it. Even if it starts to burn, the flame stops after 2 hours, by design. We expect to see more developments, with governmental promotion to employ more timber and with these techniques used in public buildings.

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<sup>1</sup> Models of 7.4 sq m (108,000 yen, in 1959) and 10 sq m (118,000 yen) were sold through unconventional outlets like department stores. The walls were composed of light gauge steel (available from the mid to late 1950s), and wood based panels. Its name derived from 'midget'.

<sup>2</sup> Concrete *katawaku-you gouhan*.

<sup>3</sup> A construction and/or engineering company, often working on the design as well.

<sup>4</sup> From promotional pamphlet by Tokyo and Tohoku Plywood Manufacturers' Association.

<sup>5</sup> Tanikawa, Nobue, Kamiya, Fumio, et al. "Kouzo-yo Gouhan no koudo-riyou ni kansuru gijutsu-kaihatsu (Technological developments on the use of structural plywood)." Article given by F. Kamiya.



#### **4.3 Interview with Takayoshi Okuyama (section manager) and Jun Yuuki (manager; both at product planning department) at Tendo Mokko, Yamagata headquarters**

11 September 2014 at Tendo Mokko showroom

1-3-10 Midaregawa, Tendo, Yamagata 994-8601

Excerpts from the interview, translation and text in parentheses by author

#### **Tools**

The jig – or the mould – is key in our manufacture of moulded plywood furniture. CNC router enabled the making of jigs that are more accurate and more symmetrical, in addition to aiding the production of furniture itself. In the past the moulds were made by hand from drawings, and were not quite uniform or symmetrical. With this tool, the quality is much easier to control now.

Another aspect is the reduction of cost, as cost equals time. It is a huge leap from a heavily hand-based work to more machinery-based work. Of course, it has been offset by the increased cost of material and labor; something that cost 1,100 yen have risen to 40,000 yen now, and so our products are priced accordingly.

#### **The moulding process**

We currently have just over twenty moulds, some of which have been in use since the 1940s or 50s. There are two types of moulds – metal and wood. Most of the moulds we use are wood, surfaced with a metal plate, which we can produce ourselves. There are currently only 3 metal moulds: For the Butterfly Stool, Za-isu and Za-taku. Metal moulds, with its steam process, allow for speed in large quantity of productions and the higher level of accuracy, which determines which product should be produced this way. A certain quantity of a specific product has to be guaranteed to have a metal mould produced.

For wood moulds, we layer the white beech veneers of 1.5 mm or thicker, and carve them afterwards. If luan veneers are used, the moulds start to degrade over the years, and it would require a lot of repair or some parts might get damaged beyond repair. As the veneers

of white beech, which we usually apply pressure to compress, are setting, we apply Duralumin plate and the entire mould is formed together. For a typical chair, the wood mould would cost around 500,000 to 600,000, and up to 1 million for larger or more complex moulds. For a metal mould, even for a small piece like the Butterfly Stool, it can cost around 2 million yen.

When the veneers are fixed into the form for bending process, we have to account for the edges, especially when the piece is bent from one sheet of plywood with little tolerance. Under the applied pressure of the moulding process, the veneers begin to slide off of each other due to the difference in curvature from the top to bottom veneers, and the excessive adhesive gets squeezed out. If adjacent surfaces within one sheet are bent in different directions, and if the distance between them is too tight, there is no room to finish the edges even if we can bend the planes accurately. It is very difficult, like the Perriand chair (Ombre, designed in 1954). It would be good to have about 1 cm gap to work with, and up to 2 cm depending on the design.

### **Working conditions at the company**

All products are manufactured after the order is placed. So our operation is somewhere between made-to-order and regular manufacturing. We also receive fully custom orders.

In the first factory (there are total of 4 factory buildings on site), where furniture is produced, there are about 140 workers including administrative staff. There are also 5 designers here. Currently there are a little over 300 workers total in the company.

For furniture production, areas are designated for fabric application, woodworking, moulding, and painting, in addition to administrative offices. It is important to improve working conditions, and workers are encouraged to make proposals for changes to increase safety and efficiency, or anything they notice on the floor. There is a system to reward good proposals by bonus.

### **Environmental concerns**

Underneath the wood flooring of the woodworking area is what is basically a dumpster,

where all the sawdust and scraps of wood are collected. Each of the machinery's ducts are directly connected to this area below.

They are used to fuel the boiler, and that steam is used for heating the buildings and also for moulding (for the metal moulds). Scrap lumber is also purchased from surrounding lumberyards. This system was implemented in the mid 1960s. All the wood that has entered our building since then have either been consumed for furniture and products or fuel.

In the painting department, we have installed 4 stands with constantly running, large oil surfaces. The air flow is subtly directed toward the oil surface; any particles from the spray paint or coatings adhere to the oil. I think it is quite rare for a furniture maker to have this kind of equipment, which is more common in larger industrial settings like the car industry. They have greatly improved the working conditions, as the smell and fumes level have decreased significantly. We also use non-toxic paint.

### **Skills of workers**

Only 2% of the workers here come from outside the prefecture; most are local residents. We have a very low turnover, and many stay in the company for decades. When there is a temporary increase in the work, we contact the alumni – former employees who have retired, who still live in the neighborhood – to come in for short periods of time. These are people in their 70s or over, and are so skilled that it also becomes a great opportunity for younger workers to learn how to do things better.

There are no manuals on how to do things. Almost all new workers have no previous experience with the fabrication procedures, so they learn as they make. Sometimes we get people who are interested in furniture designs that did not expect the work on the factory floor to be so demanding. Also many are surprised to find that so many of the tasks are hand-based work, and that the factories are far from automated manufacture.

### **Eames and Tendo Mokko**

In the 1960s, when Subaru 360 (a 2-door car manufactured and sold between 1958-1971) had cost about 300,000 yen (it was released in 1958 for 356,000 yen), the Eames lounge

chair was priced at 500,000 yen. It was so pricey, nobody could afford it. The solution was to make one here for the Japanese market, rather than importing the lounge chair manufactured by Herman Miller. That is how Tendo Mokko came to acquire the license to produce the lounge chair. I've been told that the rubber gasket posed some difficulties; the workers melted the surface of the rubber with sulfuric acid and quickly attached to the plywood.

When the lounge chair by Tendo Mokko was sent to the United States, Eames saw it and asked who had made it because it was better in quality than the American version. After learning that we had, he requested that the technicians to come to the US and train the workers at Herman Miller. So several of the employees went there. The lounge chair was in production at Tendo Mokko for about 10 years, but there are no documents for how many were made. I have seen a very old one made in Japanese oak, and its light color is quite unique because all the lounge chairs produced in the US back then were limited to dark colored wood such as walnut or rosewood.

### **Products for the car industry**

Tendo Mokko also manufactures steering wheels and dashboards (also known as instrumental panel or fascia) for high-end cars, for Honda, Toyota, Nissan, Isuzu, etc., applying the moulded plywood technique. One of the most coveted is the walnut root, which has a pattern that is non-directional and thus suitable for these applications.

The company visits California to bid on the mature walnut roots, at which point the trees begin to produce less edible walnuts. There are four companies at the bidding: Tendo Mokko and three automobile companies.<sup>1</sup> The roots stand about 1.2 m tall, and cost around 6 million yen per piece. After they are shipped to Japan, the roots sit in storage for five years to dry. The inner conditions of the roots are only revealed after this five year period, and depending on the patterns and potential holes made by woodworm, large parts of the piece may end up not being used. They are cut to about 0.2 mm thickness to be applied onto the surfaces.

## Material sourcing

Most of our materials come from Germany, Croatia and Denmark. They are imported about twice a year, in shipping containers. We purchase veneers of 1 mm and 1.5 mm mostly, and white beech is the most prominent species. White beech has been dependable as a supply over the years, whereas some other species have become difficult to source.

In the past, it was quite typical to apply the same species of wood for all the veneers. Today, in almost all cases, the inner veneers and the outer visible veneers are of different species. We use white beech for the inner layers, and can apply other species on the outside. Or the surfaces are stained or painted.

A few people can tell that the Japanese oak has been used for the inner layers as well, which, of course, raises the value. It is more expensive than beech. However most people are not able to tell the difference, and mainly for cost reasons we have decided to apply white beech for most of our products. Other aspects are influenced by the ease of sourcing and its suitability for bending.

## Japanese cedar

In the past 3 years, we have been researching on the use of Japanese cedar (there is a national incentive to use Japanese cedar in order to maintain the artificially planted forests, also mentioned in the interview with Takeshi Okano). It is one of the most thriving species in Japan; it can grow up to 50 m tall, and 2000 - 3000 years old. Japanese cedar is very soft and the curvature for bending is limited, for its lack of strength, and so had not been a material we used in the past.

In case of cedar, we purchase solid wood. We've developed a technique to slice the wood, for example to 2 mm, then compress to increase its density down to 1 mm.<sup>2</sup> That is how we could begin to apply them for the moulding process with added strength. Then these veneers can be used for inner layers, and outer ones too, for some designs.

The same applies to *hinoki* cypress and pine that have also been traditionally considered unsuitable for bending. The awareness to use locally sourced materials have also pushed for the use of these materials.

There is an advantage to these softwoods too; they don't require years of drying before use unlike hardwoods. We feel that it is important to incorporate more of them into our designs. Next month we will officially start the sales of the cedar products.

After the wood is turned into lumber, they are boiled, cut into appropriate sizes, sliced, and then compressed. The imported white beech veneers do not require this process, so the company had to make room for new facility and machinery for this additional process. This added cost is offset by the material cost of cedar which is very low.

The problem is we cannot keep up with the orders received, especially for the process leading up to compression of veneers. We have to make the material when we receive the order, because we do not store the cedar in veneer form. Also white beech is generally used only for moulded plywood, but cedar is used in flat applications such as tabletops. When a facility like an assembly hall places an order, we have to start making the veneers from scratch and extends the delivery time.



Fig. 4.3.1 Examples of cedar moulded plywood applications at Tendo Mokko

### **Trial and error, new materials**

We may be one of the pioneers in moulded plywood, but basically the process is the same everywhere. Other manufacturers employ the same techniques. We are probably best known for our collaborations with designers and architects over our history. Some of the more economical furniture producers, such as Nitori, do not have the same accuracy in their productions as we do, but the process is not unique to us.

There are new materials we test with. We have tried a material called 3D veneer that we imported from abroad, which is a veneer with many slits (the standard veneer is essentially cut into tiny strips on one side). It is flexible in multiple directions, and achieves

curvature that was unthinkable before. In the end, however, we decided not to since the end product is not as strong, structurally. The cost is about 3 times more than the regular veneer, and it would have been fine if we can justify the use, but the strength is very important to us. The fact that it can be bent in different directions means that there are gaps that need to be filled, which means more labor.

We actually tried making 3D veneer here in our factory, and it was not too difficult to make them. But due to the weakness, to make a product of the same strength that we offer now, it would have to be thicker. It would not be good from design perspective. There are international companies that have incorporated these 3D veneers for their furniture productions, like benches and chairs. I think there is another structural support underneath because I don't think it is possible for the thin ply to hold up the weight.

Urethane foam is another material we have tried to use. One reason is they are not easy to work with, and the other is from an environmental concern since it is not a green material. In the past, urethane foam used to produce cleaner curvature than moulded plywood, which was an incentive for us to try the material initially. But over time we used it less and less, and decided not to use it anymore.

We also experimented with acrylic, and even made a Butterfly Stool out of it. We tried again just a few years ago, bending acrylic sheet with veneer fixed on its surface. The problem was that most of our design has to do with curvature, but the warping always happens with acrylic panels due to its material property. That requires an additional process to restore it to the correct curvature. There were also issues with strength and static electricity.

There are other new materials that we are in discussion, though I don't know what will happen yet. Some companies have approached us with proposals of interesting materials, but I think our foundation is still in the moulded plywood. Furniture companies like Herman Miller's ergonomic chairs are so well made and designed, and we have no intention of competing with them. Some people just prefer wood, even though the adjustments are limited to basic movements like up and down. The least we do is to try to provide as much comfort as possible with simple structure.

## Changes in demands

Species of wood and functions have changed according to the lifestyle. Some spaces have gotten larger. Less occasions to entertain people eliminated the need for the Japanese room, *washitsu*, and furniture for that room. The productions of Za-isu and Za-taku have dropped dramatically. We have kept the production line, because we still get orders for them from inns and hotels once in a while.

Functions and designs of furniture depend on the changing trends of the space: The preference for a larger one-room arrangement over smaller rooms divided by walls and partitions, the color of interior walls, and so on. Dark woods such as Brazilian rosewood and teak used to be sought after for a kind of dignified look. These days lighter colored woods are preferred, such as maple, white beech, and white ash. Oak has been popular throughout. This transition of the dominance of dark to light woods happened in the 1990s, but walnut has been regaining popularity recently as an exception. There is also a technique to bleach the wood, which we tried with steering wheels and the automobile interior panels; it accentuates the grains with an overall light appearance.

We can be experimental with smaller objects. It's a more recent development to sell these objects such as hangers, racks, notebooks, etc. that customers can purchase as souvenirs when they visit our showroom. They are made in the downtime when the production line is slow with furniture production, and to make use of the leftover materials. Sometimes companies approach us to produce something for their products, such as Softbank for iPhone cases, or Panasonic for camera cases or television stands.

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<sup>1</sup> Mercedes, BMW, and GM were mentioned.

<sup>2</sup> The process is called “atsumitsu” in the company.



#### **4.4 Interview with Mitsumasa Sugasawa (former technical chief and director, 1963-2005) at Tendo Mokko** from 1963 - 2005, for 42 years

25 November 2014: Nasu-shiobara city, Tochigi prefecture

17 December 2014: Tendo Mokko showroom, 1-19-2 Hamamatsu-cho, Minato-ku, Tokyo (designed by Junzo Sakakura, project manager Daisaku Cho, in 1964)

Excerpts from the interview, translation and text in parentheses by author

#### **Relationships with other companies**

While I was working for Tendo Mokko, I tried to research a bit about the history of plywood too. I found that, in Japan, the president of the musical instrument company Yamaha was one of the early pioneers of plywood. At one point Yamaha also manufactured plywood furniture, such as folding chairs.

I've helped reproduce a plywood chair by Andre Bloc (1951, see 2.4 Timeline), at the request of Mr. Kurosaki, who was the president at IDEE. He came to Tendo and asked us to reproduce the Bloc chair. He initially started up the company by importing antique furniture from the UK (in 1975) and became successful, but wanted to branch out to modern furniture as well, to early modern pieces. He collected photographs of these plywood furniture.

We even manufactured the Herman Miller's Eames plywood lounge chair as a licensed product for a few years. Back then, the company was under a different name (the Michigan Star Furniture Inc.) and I also visited their factory in Zeeland, Michigan. In the Herman Miller factory back then, it seemed like the workers were making things in the corner of the factory rather than in a large scale operation. I am not sure if the company had outsourced to other manufacturers too, but when I visited, there were only a few employees working in the small corner.

There are some offshoots of Tendo, such as Tada Mokko, which is headed by a former employee of Tendo and located in the southern region of Tendo City. There is another, called Asahi Soufu, in Asahi town located in the mountains. Both companies have applied their knowledge of moulded plywood furniture in the new companies. Asahi Sofu has been

gaining track lately, and their business model is to entirely focus on production as OEM (original equipment manufacturer). So instead of spending time on product development, they concentrate on the manufacture of ordered products.

### **Industrial furniture production and public buildings**

Applying plywood in furniture production is a result of the development of the same technique during the war, including bending. The techniques were transferred to furniture in the postwar period. Another condition was that Tendo, back then, was a small town with a population less than 10,000 – they sought for a new industry for this very rural town. This is when furniture production using plywood began with the support and guidance from *Kogei Shidousho* (Industrial Arts Institute), which had conducted a number of researches on moulded plywood from wartime onwards.

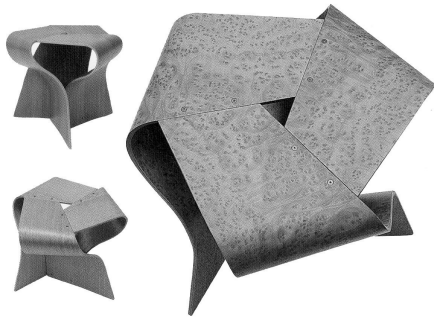
After the war there was a boom of public buildings, and that was when we teamed up with architects for industrial production of furniture (this line of furniture was called ‘contract use’ and distinguished from the domestic ‘home use’ line). Moulded plywood was a technologically advanced method back then. Compared to the traditional method of production, from carving of wood, moulded plywood enabled furniture making as an industry. With public buildings, the ability to mass produce repetitively with the same mould was very appealing. This capability led to a close liaison of moulded plywood furniture with public architecture, especially in the 30s of Showa era (1955-64), in city halls, government offices, etc.

Directors of Tendo Mokko were keenly aware of the necessity for the furniture industry to create new designs and new techniques, to meet new needs. Designers outside the company, particularly Kenmochi, gave valuable advice in setting the direction for the company; the company is deeply indebted to Kenmochi.

When I began working for the company (in 1963), 90 percent of the work was for public buildings. The rest consisted of traditional furniture, like *tansu* cabinets for residential use, produced for retailers. Many of the residential furniture were outsourced to local manufacturers, too. The general public wasn’t at all familiar with the light plywood

structure, and preferred the heavy appearance of traditional styles. The image of plywood was associated with low-quality veneer panels in the beginning, and so it wasn't very positive. However, the fact that Japan didn't exactly have a tradition of furniture, perhaps, enabled modern designs to seep into our environment gradually.

The making of *kata*, the mould, is key in moulded plywood. Something like the Mushroom Stool requires a complex *kata* that can be realized rather easily with the NC router these days, but it used to be made entirely by hand. The process of making the *kata* has several steps, and some difficult steps require machinery, although many of the simpler steps are still conducted by hand.



Group<sup>1</sup>

Fig. 4.4.1 Mushroom Stool designed by Yamanaka

Typically it takes minimum of 2 months, to manufacture new moulded plywood furniture after a given design has been adjusted – from designing and making of the mould to the finished product, not including the time for the design revision and adaptation.

### Changing trends in design and wood

When I entered the company, Scandinavian design was popular. Its simplicity and functionality suited Tendo well, and I think Scandinavian design profoundly influenced all the designers in Japan since. After that, in the 70s, Italian design was in vogue: Round fluffy cushions, bright colors, etc. Then Japanese designers began to develop their own designs, just a selected few in the 60s but increasingly more in the 70s: Before that time, the profession of furniture designer or interior designer was not widely known. Training in schools was lacking, and mostly limited to woodworking courses.

For moulded plywood, the inner layers are almost always beech. The changes in trends influence the surface veneers. Walnut and rosewood were favored when I started working. Back then rosewood was imported from Southeast Asia, which are now scarce and difficult to obtain. The material for Herman Miller's Eames Lounge chair, for example, has changed too. Brazilian wood Pau Ferro is now being used, but originally, rosewoods that we called Palisander or Jacaranda were applied. These woods were very fragrant and had a fine, beautiful wood grain pattern. The quality of wood has declined considerably these days. Scandinavian designers such as Finn Juhl and Hans Wegner were early ones to apply Jacaranda rosewood to furniture.

Social conditions have affected the use of wood greatly throughout history. Early in my career we used mostly domestic beech, processed into veneers. They are very rare now. Shimokita, in Aomori prefecture, had high quality beech and a veneer factory located there, but they have closed down. Now we have no choice but to import from Europe, mostly from Germany. Beech has some reddish hue. If you go to a beech forest in Europe, the trees are lined up (in their planted forests), and each of them straight like utility poles. In contrast, Japanese beech usually grow into a crooked shape; the quality isn't as good as the European type, and the hue is darker and more red too. Here, in Japan, we never got into planting and managing forests of beech, oak, or basically any other hardwoods – only softwoods.

Regional conditions and availability of the wood in each country greatly influences the materials applied to production. In Finland, for example, there is a greater quantity of birch than beech, and so birch is used in the inner plywood layers. In the US, the available material was poplar. The inner layers do not matter so much in the sense of strength, although beech is probably the best structurally.

Moulded plywood can be discussed through aspects of materiality, techniques, and machinery. World War II is also crucial in the historical background of plywood, in the countries that employed this material for military purposes. In the decoy aircrafts (called *otori* aircrafts in Japan, produced near the end of the war; see Fig. 3.3.3), moulded plywood technique was not used. The frame was made of solid timber, and plywood was applied to cover large curved surfaces. I've never seen the actual one, however.

When I visited London, I tried to find more information on this theme too. I saw the aircraft Mosquito, which I believe is the largest realized wooden fuselage. At the time, research on plywood was being conducted everywhere – in the US, Europe, and in Japan, which you can see in the articles of *Kogei News*. Some hobbyists in the US still make airplanes out of plywood, with 1.5 mm 3-ply that is very strong and lightweight. The ease in making large curved surfaces was especially advantageous in the making of aircrafts. In Hokkaido, there is a factory that manufactures this type of plywood from birch, with 3 layers of 5 mm veneers. Techniques developed to make very thin veneers and a slightly more flexible type of adhesive, compared to the rigid urea-based type used in regular plywood, have made this kind of aircraft plywood possible.

### **Microwave heating process**

As you have said, design and techniques related to the manufacture plywood furniture had mostly matured by the 1950s. Production techniques stayed pretty much the same since then. A big achievement after that time, at Tendo Mokko, would be the microwave heating machine developed in 1975 by Saburo Inui. The technical development related to microwave was conducted together with the company Toshiba.



Fig. 4.4.2 Microwave machine by Saburo Inui, 1975<sup>2</sup>

The required equipment had to be larger in scale because the moulds had to be entirely enclosed inside for the microwave – just like you can't operate the microwave oven with its door open. This process was particularly effective for designs with the solid *koma* piece inserted between the veneers, which you can sometimes see in the legs of the chair (due to the longer duration of time required to heat multiple moulds required for *koma*). The

electric heating process could then be achieved in one of two ways: High frequency or microwave. The basic difference between these two are in the frequency. In the case of high frequency, there are positive and negative electrodes. If a form is triangular in shape, it is difficult to arrange the electrode distribution. In case of microwave, the entire form gets heated. It is possible to cover some parts in metal, so that the microwave does not penetrate that section. The mould is made of wood in both cases (for the steam process, metal mould is required).

The machinery was a huge investment for the company, as the cost was remarkably high. Tendo's investment in their equipments has begun to decline since then. After all, there is still only one microwave machine being used there. However this is just one of the production technologies, so it had no effect on the design. Making of the mould and the methods of laminating remained the same as they used to be. This technique was used simply to increase production efficiency.

### **Explorations in plastic**

I was in charge of the attempt to make acrylic furniture at Tendo, and the first one was the Butterfly Stool. Plastic furniture became very popular in Italy, in early 1970s, and turned into one of the emblematic products of Italy's modern design. The popularity came into Japan, and I experimented with several types of resin, including ABS and acrylic. Acrylic panels become pliable when heated. It was relatively easy to form small objects into desired shapes, but difficult for larger pieces, because parts of the piece cools down and becomes rigid while we were still trying to form the entire piece. We decided it would be best to ask a specialist, so we called the expert of acrylic signboards in Sendai and asked him to shape two types: Butterfly Stool and also the Ply Chair. He was able to do it.

Within 2 to 3 years of this experimentation, however, we received too many complaints from the customers concerning the strength. Eventually we stopped making plastic furniture, and besides, they were also quite expensive. There is a difference in strength, if you compare plywood to acrylic panels. Butterfly Stool is made from 7.5 mm plywood, but 7 mm acrylic would be too pliable, so we had to use 10 mm thick acrylic

version from the standard stock. With that, we made a larger model of the Butterfly Stool. If we were to make a regular size stool with the thicker 10 mm panel, the result would be unsightly. Yanagi was also involved in this process.

Other than that, we also experimented with styrofoam, and before that with rigid urethane foam – the kind that is used for insulation. I was also put in charge of these tests, since the president of the company back then was very supportive in trying out new things. So I visited several chemical companies, looking at the materials they were working with that might be suitable for furniture. It is common these days to use urethane foam, but it was very unusual then. The Swan Chair from Denmark (by Arne Jacobsen) used to be made with styrofoam, but now uses polyurethane. Styrofoam isn't used much these days due to environmental concerns and were replaced, for the most part, by rigid urethane foam.

Rigid urethane foam allows free curved surfaces and volumes. I have also designed a chair using this material, which received a G-mark (Good Design Award). I visited many designers with this material and showed its potential, and received quite a few orders. The round lounge chair in Kyoto International Conference Center (by Yukio Otani, 1966, who won the competition in 1963) designed by Kenmochi, is one example. The mould for it was made in fiber reinforced plastic, then styrofoam was poured into it. You could say that they were really hand-made, one by one. It was possible because of the limited number, around 200 to 300. For Keio Plaza Hotel chair, another one designed by Kenmochi, was made entirely with FRP shell that is hollow inside.

### **Relationship with retailers**

Tendo is quite unique compared to other furniture manufacturers and retailers, almost all of whom began as cabinetmakers. Typically they used to make wedding furniture sets, which we sometimes outsourced. These retailers are scattered around the country. Having relationship with them helped us in knowing when something like a government office is going to be built in their region, and other local demands. So there was also a strategic interest for Tendo as well.

Retailers don't only sell to customers in their stores, they also supply in large quantities

to public buildings. There are several companies in each prefecture of Japan that Tendo is connected to, so we have a sizable network. In bidding for public buildings, the local businesses are often favored, especially in recent years. Tendo supplies to the local business in such cases, and the furniture are invariably selected from the catalogue (rather than custom designed and manufactured). Most of the time, bidding for public buildings is only concerned about cost. Whatever they can sit on is good enough, and design is not really a consideration. Only when there is someone who understands design in the government office is the situation is different.

### **Manufacturer and designer**

Tendo Mokko, as a manufacturer, was willing to try new processes with new materials. Another important aspect of the company is the sales department. Even today, about half of our production is for custom orders; we have a thick catalogue of products, but in addition to these, the made-to-order furniture constitute about half of the total production. These include countertops, tables, library shelves, etc. for specific buildings, which are designed from scratch and manufactured. Typically, in an assembly-line operation, custom orders are disliked because they tend to disrupt the flow. For Tendo Mokko, making of custom products was the norm so related tasks were never considered bothersome.

The relationship with designers was very important to the company, since that contributed to developing new products before other companies did. Designers are always enthusiastic to create new designs with new materials. When there was a new building going up, we would go to the designer and inquire if he or she would like to make something for the building with new materials. I often accompanied the salesperson to provide technical information in such occasions, and we went to Osaka frequently.

Kenmochi is one of these designers. We also worked with large construction firms such as Takenaka and Kajima, with their design department. The interior department of Takenaka in Osaka, for example, was eager to design their original furniture so we worked with them quite often. Tendo would produce the furniture as OEM, while Takenaka is pleased to have their own designed furniture in their buildings. Tendo was successful with



this approach: Receiving custom orders, which requires new techniques and new designs. The process would be repeated again and again. If there is a suitable product for the market, we could include it in our catalogue, in which case it does not require product development. Designers also receive royalties on their design when the product sells, so everyone benefits from this system.

### **New developments in plywood**

What is considered relatively new in the technique of plywood is the 3-D plywood (also called 3-D veneer; discussed in 4.3 Tendo Mokko interview in more detail). Typically, in wood, the bending occurs in a 2-D plane, but with 3-D plywood the surface can be formed like a plate, just like metal spinning. The technique was developed in Germany, and is applied mainly in Europe. The inner veneers are machine processed to increase flexibility (there are very small slits cut into the veneers), which allows for tighter curvature, but from the outside it is identical to regular plywood. The material was even successful in replicating Eames' plastic shell chair entirely in plywood. Gubi chair, from Danish design unit Komplot and manufactured in Germany, is probably the earliest one to employ this technique. I believe it was included in the MoMA collection too.

Other than that, there aren't new techniques I can think of. The furniture market in Japan has been stagnant, and imports from China now dominate our market. So the companies are no longer willing to invest in their machinery or other equipments.

### **Wood and hand**

The important feature of any wood product is that somewhere in its process, the hand gets involved. It is what distinguishes wood products from something like metal parts for automobiles, which can be manufactured entirely by the machine and placed into the car's mechanism. There are steps for wood, such as finishing, where handwork is required. That is a significant aspect of the industry that works with the materiality of wood.

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<sup>1</sup> From Tendo Mokko product catalogue, *For Home Edition 14*.

<sup>2</sup> Sugasawa, Mitsumasa. *Tendo Mokko*. Tokyo: Bijutsu Shuppan-sha, 2008. p 25.

#### 4.5 Interview with Kenji Ekuan, chairman of GK (Group of Koike) Design Group

09 April, 2014 at GK office, 3-3-5 Shimo-ochiai, Shinjuku-ku, Tokyo

Born in 1929, Tokyo

Excerpts from the interview, translation and text in parentheses by author

##### On crafts and Mingei theory

Crafts have been in existence from the ancient times, such as this bowl, and millions of bowls that have been made since.

Soetsu Yanagi founded the *Mingei-kan* (The Japan Folk Crafts Museum) and mingei theory. A simple white plate is formed on a potter's wheel, then the hand of the ceramicist flicks in a circular motion with a brush dipped in glaze: Quickly, and without thinking, and repeated a million, two million times. Mingei theory asserted that the height of artistry can be found in the movement of the hand and the pattern that reflects it. The subconsciousness of the action is what gave it substantial meaning. Without thought, the action turns into a drawing. What might it be? That was mingei.

Until then, there were crafts like traditional dolls and bowls for tea ceremony. Those were made entirely by hand, formed and painted, one by one. Each piece is unique; if there were three pieces, those were three distinctive pieces. The method of making that allows for one person to make a million pieces, which are then appreciated by a million people, marks the beginning of democratization.

Soetsu Yanagi was a scholar of religious studies, and preached that democracy and equality would save the people. The circular brush stroke on a white plate drawn subconsciously was the premise for democracy and a cutting edge idea of the time. And that, they decided to call mingei – Yanagi, Shiko Munakata (woodblock printmaker), Kanjiro Kawai (ceramicist), and others, while chatting in a pub or someplace like that. They also insisted that mingei be viewed as a new category, and it was thus detached from 'craft'. They chose not to associate with it, to break off from it. By developing the mingei idea as a new category, what craft was and what emerged out of craft were clarified. That was a very good

cause, in my opinion.

### **Machine and hand productions**

Basically I see it (the Arts and Crafts movement) and Mingei movement to be the same, because their productions were ultimately mechanized. They began with the hand, but eventually relied on mechanical processes to enable mass production. The constructive aspect is the exploration of the limitations of the machine and of the craftspeople, in seeking for the arbitration between the possibilities of both the machine and hand techniques.

### **On whiteness**

I once asked Isamu Kenmochi: If it's white, then is it modern? He said that white has the capacity to accept, to receive anything it is applied with. White was all the rage in the post-war period. Everything was white. Before the war, white for us (culturally) was the color of funerals. It was a difficult color to work with, but as the nation that lost the war, we followed what was popular in the United States and Europe.

### **Subconsciousness of the hand vs. unconsciousness of the machine**

When an object is made by hand, the thought passes on directly to the other person. The unconscious making by the machine may need a hand to operate, but is thoughtless.

Super-subconscious is a state of mind when one is sitting for Zen meditation, and the legs go numb: First, the mind is preoccupied with the numbness, but after a while it transcends any thoughts and something else begins to float in the mind. We call it super-numbness. We call that *satori* (enlightenment). If the action is repeated a million times, as a monk would, one can reach that state.

You can take a million breaths confronting the city of Tokyo without any thought. It would drive you mad. If you can grasp something within that madness, you would know who you are. Everything disappears, and a different world emerges. There are many forms of that different world, but some of them borrow the form of craft to emerge.

In an industrial production, there is *kata* (a form, or prototype, that serves as the

original to subsequent productions). Craft can result from a *kata*, but it is distinct from the *tewaza*, hand technique. There is a sense of familiarity and intimacy with the handmade. *Kata* belongs to a different realm.

### ***Kata*, the hand, and the machine**

The hand is so convenient. When you knead a piece of clay, it is possible to make something that no machine can. Something useful, something that fits the hand, can be made. In that sense, that hand technique is familiar and intimate.

There is a clear difference between a handmade doll using the technique of *tsumami* and the machine-made doll. Before the war there was an exchange of dolls between Japan and the United States (also known as the Japanese friendship dolls in the 1920s). There were American blue-eyed celluloid dolls, made in the tens of thousands, from the US. The technology was so advanced. It was wonderful. For the first time, Japanese dolls came in contact with celluloid, a material suitable for mass production.

Hand-making built the bridge to mass production, it is continuous. It happened around the time I was born, eighty, eighty five years ago. The technique of the hand can be transferred through *kata*. It is like the prototype, especially if it is good. But there are obstacles for making the appropriate *kata* – if the object can be taken out of the formwork, things like that. If one understands and is experienced, so many things are possible.

### **Mass production to distribution**

Mass production and the hand need to be coordinated. The equation – how to make use of the capacity of the hand in mass production – needs to be solved. Any manufacturer in the automobile, electronics or any other industry, is working on it, regardless of the era. They know what can be made by hand that can't be made by machine.

Take robotics, for example. In laboratories, like the ones at University of Tsukuba, they are made by hand. Some are within the range of *kata*, some must be made entirely by hand if *kata* cannot realize it. Robotics is very complex, but it is a good opportunity to employ craft into the more practical world. Perhaps Japan is one of the most advanced in

transforming the complexity of the hand into the machine *kata*.

To make the *kata* presumes mass production, since making it is very expensive. It would only make sense financially to produce hundreds or more if a *kata* is made.

Then there is the issue of distribution, a powerful force behind Japanese economic development. *Kuroneko Yamato*,<sup>1</sup> is a good example. They are always on time, even in a traffic jam. I suppose their analysis functions well; congestion is never evenly dispersed, so it is possible to analyze where there is flow of traffic or not.

During the Osaka Expo '70,<sup>2</sup> thousands of visitors came through everyday. Because overcrowding is a major risk, sets of data were collected for where crowding was predicted to occur, whether it would take place in the afternoon or evening, etc., and analyzed under supervision of Tange Kenzo. Armed with that data, there were no accidents for the 6-month duration of the Expo.

Distribution is essential, and the analysis of the given conditions made it happen. And the Japanese economy gained its power by increasing the speed of distribution. But it also triggers the not-so-good intensions, like making cheap things that would break down easily. It forces consumption, and is a wrong kind of take on distribution.

There were a lot of those (cheap and poorly made things), and those have ultimately led to supermarkets and convenience stores. Without the small stores, taking a stroll is no longer enjoyable. Roadside has become dull, for the most part. Only small parts of Asakusa or Ginza has interesting street-scape.

### **On craft and its evolution**

When the ways of making *kata* increases, it can get closer to making by hand, or handicraft. For example, Japan was an expert in making metal moulds. When these moulds were sold to China and Southeast Asia, they began to copy. We cannot complain, because Japan did the same thing earlier. If one is good at copying, it is possible to make many *kata*.

This teacup (a standard ceramic cup), for example, would be typically made with the handle attached to the body later. Instead, by casting all of it at once, the production cost would be much lower.

Medical apparatus is a good example. Because human bodies are complex, in order to perform an operation or to stop the blood vessels, many forms are required. Mass production seems difficult in that case, whereas handmade crafts can adopt to each item. If a *kata* is made to adopt in this field, it would be a great contribution to humankind.

### **Postwar democratization and industrial design**

The way for democracy was being paved. The United States Army Jeep was praised for contribution in advancing the nation.<sup>3</sup> Its four-wheel-drive allowed it to be driven in the war-scorched fields, on rough earth, carrying four to five people at once. And it was so open, that the soldier could hand out chocolates to children without getting off the car. We did not have anything like it in Japan. Chocolates were given to children, and (Japanese) ex-soldiers received Lucky Strike (cigarettes) lit by Zippo. The soldiers would have their feet up on the fender, riding around carefree.

Looking at the soldiers more closely, they carried rifles that were shorter than what we used. The longer ones would bump into trees when fighting in the jungles. Another thing they owned was a water bottle suspended at the hip that would not flap. I was in the Navy, but when we ran, the bottles would flap up and down. Then we would have to hold the bottle down with our left hand, while carrying the long rifle in our right hand. That's not a way to fight a war.

In that sense, the U.S. Army – under their righteous cause to free the people – employed its citizens to make their products. That was the shift from munitions to private, civilian demand. Democratization occurred at once. An empire, where anybody can buy as long as they have money, was established.

Postwar Japan, defeated, was told not to do certain things. Horikoshi (Jiro), who engineered the Zero fighter planes, was my senior in middle school. The (Mitsubishi A6M) Zero fighter was matched equally to the American Grumman aircrafts, but after the war (American general Douglas) MacArthur ordered us not to manufacture any more aircrafts. So the people involved moved to the black market. The leftover duralumin<sup>4</sup> was appropriated to make cooking pots. The underside was stamped with Mitsubishi mark. All

those skilled people, with MacArthur's word, lost their traditions and trade.

### **The economy and politics of making**

All the talk about traditional cultures and traditional crafts have gained traction in the last few years. Previously, the topic was never discussed. Through mass-production, everyone could own a refrigerator for the same price. All households became much the same.

So Japan became a leading democratic nation: By the way things were made. Producing things meant economic growth, and the country developed into the second largest economy following the United States. This, I think, is because Japan had the capacity to make *kata*. We were skilled with the hands, producing the preliminary models and prototypes. Drawing the ability to make prototypes and the ability to make *kata* closer to each other, things was made.

China is now bigger economically in Japan, through the force of mass production. In that sense it is repeating what Japan went through, but the population is about ten times more,<sup>5</sup> so if 10 per cent of the population is wealthy, it equals the entire population of Japan.

One-party rule always hides a pistol behind its back. Its peak was during the Tiananmen Square protests (1989), when a student stood in front of a tank. Mass production can be successful under one-party rule, during calm and peaceful times. It usually does not work out, though, with corruption and such getting in the way.

You could say that Japan is a nation of *kata*. It is a small island nation, but looked up to the United States as its teacher after the war. The citizens assumed it would be better to follow the American model from the way things are made, how we think, to the final products. There were housings for GIs, usually named something-Heights. The neighboring residents would gather outside the fence, watching the stacked white boxes being moved into the Heights and wondering what they were. One of them knew, and told the others: That is a refrigerator, that is a washing machine. Those entered the Japanese homes later.

But this is not a just story about Japan as the imitator. There is one thing that impressed me: Making something smaller means the whole mechanism and materials need to be changed. Moving an American refrigerator into a Japanese home would puncture and



fall through the floor. So they had to be smaller, and companies like Matsushita worked on Japanizing the appliances. That was incredibly inventive, to reduce the size of something by half, along with the weight, without compromising the cooling capacity. They reconstructed the entire system from materials to mechanism.

As a result, we also got into automobiles, because U.S. was a major automobile country. Toyota made cars about half the size, and they became popular even in the U.S. People say that it ultimately destroyed the industry in Detroit. I saw articles and photos of the enraged workers smashing Japanese cars with axes. When there is an economic failure, it should be reciprocated through economic means, not emotionally.

### **The future of the industry in Japan**

Japan was good at making small scale objects from the *kata*, and achieved a realm of smallness. Company such as Sony, which made portable calculators and personal computers, announced to the world that smallness is good. However that was the end of growth for Japan, around twenty years ago.

Our country may collapse before the Olympics (Tokyo, 2020). The Olympics is a good incentive for reconstruction. It is a question of whether we can clean up the disaster in Tohoku in the next six years, and a question of technology and our ability to cooperate. The news has been reporting on the slow progress of decontamination (of radioactive materials), which is mostly due to internal conflicts. It boils down to Fukushima nuclear power plant: If it is fixed, Japanese technology would be considered one of the best, if it fails, it is over. We are on the verge right now.

We should pride ourselves in the strength of mass production and hand skills. We have developed techniques to apply hand skills to mass production, and it can recover our confidence. It is a matter of if a country can be saved; if its population of 130 million can survive or not. What would we choose to do?

### **Thoughts on plywood**

There are various possible applications. For example, the processing of plywood has

developed into the design of airplane seats, where thinner structure of the seat equals more leg space.

Charles Eames was one of the central figures to apply plywood to mass production. What worked in his favor was the development of leg splint during the war, and his furniture as its extension. After helping with the war efforts, even though it was to aid the soldiers, furniture for the general public was born out of that collaboration.

Veneers developed in Japan as surface material typical in domestic conditions. There are not so many interesting applications that took advantage of the plywood material. Just a few, like Tendo Mokko and Butterfly stool by Sori Yanagi. Akita Mokko made some wheelchairs.

Perhaps too much of the material was consumed by architectural uses. The raw material was imported from China, former Soviet Union, and Russia. There is also a limit to the allowable curvature in plywood, and large metal moulds are required. The necessary cost becomes prohibitive for the furniture industry, which does not have too much authority, then and now. That is because the chairs was only used by urban residents, while the others sat on the *zashiki* (on tatami mats) in the traditional way with *zabuton* (flat square cushions) and sleeping on *futon*. The industry that is based on a lifestyle of beds and chairs is limited, and can not invest much on the *kata*.

There are just a few: Tendo Mokko in Yamagata, Akita Mokko, Miyauchi Industrial Complex in Hatsukaichi City, Hiroshima,<sup>6</sup> and several places in Kyushu. Small-scale businesses. Even if they consolidate their efforts, it is not much of a force.

The postwar democratization is an American term, but I think Japan had been a nation that prescribed to that belief formerly. Coming out of that process, technology was freed by that democratization, distribution was changed, and production systems were also changed.

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<sup>1</sup> The largest door-to-door delivery service company in Japan, originally founded in 1919.

<sup>2</sup> World's Fair held in Osaka between March - September, 1970.

<sup>3</sup> The Army Jeep manufactured by the Willys-Overland Motor Company was included in the “Eight Automobiles” exhibition at the MoMA in 1951 of great car designs, along with Mercedes, British MG, Bentley, etc. and organised by Philip C. Johnson, then Director of the Department of Architecture and Design. The Good Design exhibition was held the same year at the MoMA.

<sup>4</sup> Lightweight alloy of aluminum with copper and other elements.

<sup>5</sup> Current population of China: 1.35 billion, Japan: 127 million, as of 2014.

<sup>6</sup> The city of Hatsukaichi, Hiroshima, is historically known for timber processing and woodworking in the southwest region of Japan. Currently the industrial complex is thriving in the production of building materials and furniture industries, and there is a port dedicated specifically to timber.

#### **4.6 Tetsuo Matsumoto, director of Kenmochi Design Associates**

01 April, 2014 at KDA office, 2-19-19 Shimo-ochiai, Shinjuku-ku, Tokyo

Born in 1929, Tokyo

Excerpts from the interview, translation and text in parentheses by author

##### **Childhood to teaching at the university**

When I taught at the University of Tokyo, I gave the students a piece of hard wood and told them to think about what they can make out of it and how. I showed a sample of a paper knife, and most students submitted something similar to it. The best one was not by an architecture student. I believe he majored in mechanical engineering – he said that the wood had split, so he had carved a chain out of one piece of wood. Architecture students in general were not very earnest, and some of them made worthless things, probably with just a utility knife.

I taught at the university until retirement, which was sixty, so I encountered professors Ashihara and Maki, successively. On Saturdays I would take some of the students out to lunch, and Kuma would always be there. We would visit Kanda Myojin festival, or walk through Ueno park and to the back side of Nippori station. We'd visit places like Asakura Choso-kan (Asakura museum of Sculpture). Isn't the garden wonderful? It extends underneath the floors of the Japanese rooms too. The water of the lake is natural spring water, so even when it rains the water level stays constant. Apparently there is a passage for water underground, invisible from the front side. The rooftop with the forest is also great, it takes you by surprise.

My elementary school art teacher used to take us to that neighborhood. The school was closed down, but it was located by the only crossing of the Yamanote line, between Komagome and Tabata. And our art teacher would take us to the museum in Ueno, which is now Maekawa's building. Back then it had a wide vestibule with stairs and columns with entasis. After reaching the top of the steps, you could look down onto a large sculpture room that was on the ground level. I still remember vividly. The kids who liked art were taken there, and after one or two visits, we learned the way to get there on our own. We would

hang around Hie Shrine, and before coming back home.

### **Kenmochi in the United States**

Isamu Kenmochi was in the US sometime around 1951 to 52. Isamu Noguchi was visiting Japan in 1950, and introduced Kenmochi to Eames and some others. Since there was no money back then, he travelled on a ship, arriving in San Francisco and then heading to Los Angeles from there. Even though it was his first time there, he stayed at the Eames house for two nights. After that he had to travel around the country on the Greyhound bus because there was not enough money to fly. I think it was good for him, making many stops like an old style stagecoach rather than flying over the vast land. And so Kenmochi met Mies, Breuer, George Nelson, and many others.

The budget was only enough for a 3-month stay, so he sold his Nikon camera – even though it was a national property, since he traveled as a government official. It caused much trouble later on. As a kind of payoff, he wrote very detailed reports daily and sent them via mail. Upon his return, he took his photo slides all over Japan, traveling to regional design-related institutions and such, which lasted about half a year.

Kenmochi tried to promote design by calling it ‘Japanese Modern’. He told me that he was not responsible for coming up with the term, that he just borrowed it from the department store buyers in the US who would advertise furniture by calling it Swedish Modern, Danish Modern, and so forth. Classically designed items constituted most of the sales in department stores, but modern design appealed to the intelligentsia. The market, though relatively small, did just fine. So Kenmochi thought we could export Japanese Modern to the US.

Hida Sangyo (furniture manufacturer founded in 1920, located in Hida Takayama), for example, was manufacturing Windsor chairs for export per request by the American market. It had absolutely nothing to do with design. Some considered it was quite wasteful, since Japan had advanced woodworking techniques. That is where the idea to design and produce something under the phrase Japanese Modern came about, to target the contemporary American market. There is a discussion by Kenmochi included in his book,

discussing whether it constitutes Japonism or Japanese Modern.

### **On moulded plywood and the Research Institute of Industrial Arts**

As far as I know, Thonet's bent chairs are made by forcing the steamed wood into the form made with steel angles, and clamping into the final form. This method requires one form for every piece. Then they are dried in the kiln.

Akita Mokko employed the same process. They used to fit something like a steel pipe on either ends of the wood, and by great amount of strength, bent the wood as another guy clamped the piece. It's a lot of work and inefficient. But because it was more difficult to bend steel pipes, it was a significant invention.

Toward the end of 19<sup>th</sup> century, Akita Mokko hadn't been founded yet but the man who would become its first president was sent to Vienna, Austria. I believe Thonet was located there then. It was the first time the Japanese government funded such a trip, and he stayed there for a year. They had used mostly beech, and Akita had quite a bit of beech too. When he returned with newly acquired techniques, the factory was built for him with the support of local bank and other businessmen in Akita Yuzawa. This is the beginning of the company, Akita Mokko. So the techniques had entered into Japan relatively early, and the government was also involved in training people. The Ministry of Commerce and Industry (which is now known as the Ministry of Economy, Trade and Industry) had established *Kogei Shidousho*, which had changed its name to *Sangyo Kogei Shikenjo* by the time I joined (the Research Institute of Industrial Arts, or more commonly known as the Industrial Arts Institute, IAI, was founded in 1928; the former name literally translates as 'craft training center', whereas the latter indicates that the focus has changed as the 'research center for industrialized arts and crafts').

Yes, there were quite a lot of craftsmen when I joined. One of the research areas was bamboo handicrafts. There was also woodworking, though it was more focused on the mechanical process.

Moulded plywood made a leap during World War II, although the technique preceded it. We were also aware of it, because we had a lot of research data that were sent

from abroad. It was around the time the Institute was founded in Sendai. Kenmochi joined them in 1929, the year I was born.

Barcelona Chair was also made then (in the same year). Its original construction is different from what it is now, where the base (legs) crosses. There was no stainless steel, so steel had to be tempered to maintain its strength. Welding would not work. There are several methods for making the flat bars create springiness, such as cooling down the heated metal rapidly. The suspension supporting the axis for the railway cars have layers of spring, reducing the vibrations carried to the car floors. This kind of structure has been in use from long ago. However, when the flat bars were crossed over with halved joint, initially they were riveted with extra plates. If they were welded, this part would heat up and the elasticity would be lost. Besides if you grind the surface to remove the bulge from the weld, it typically reduces the strength. There are some drawings left (of this joint). Eventually steel was replaced by stainless steel, which already has some elasticity by nature, but it seems to have taken a substantial time and effort to reach that point. I think that when Mies first tried to realize the chair, it was not in the perfect state as we know it now. In fact the first attempt to process steel in this way was the father of Hans Knoll, who started the Knoll furniture company.<sup>1</sup> The chair reached its ideal form after the World War II after the advanced technologies could be applied.

He was the first husband of Florence Knoll. She remarried to a very wealthy man (banker Harry Hood Bassett, in 1958; Hans Knoll had died in an automobile accident in 1955). She is more of an interior designer than a furniture designer. She worked Saarinen's interiors and many layouts of offices with the understanding of architecture, using chairs from different sources including Herman Miller's. But she did design a sofa too – it is very simple but also refined.

### **Adaptation of new technologies**

The book *Mechanization Takes Command*<sup>2</sup> shows steam locomotives that have a horse carriage-like attachment on either side of the car. The central section is the locomotive, but it gives you the sense of riding in a carriage. Sometimes the engine itself took on the shape of a

horse. There was a sense of incongruity, of strangeness, when something that was part of the everyday life seemed to mechanical. There were no photographs, so some illustrations remaining. I suppose these illustrations were published on the newspapers to enlighten people of the new means of transportation. Perhaps these were included in another book? Anyway, I would show these slides at the university to students like Kuma.

Sewing machine is another case. In the beginning they had to be turned by hand, so a large pulley was attached. Quickly they turned into something like the Singer Company's sewing machine, but even their domestic models retained the gold arabesque decorative patterns. In the earlier phase of transition, as the rotational movement was transferred to a vertical movement, there was also a model of a horse attached on the outside that would bounce up and down with the movement.

Such residues have endured. How could new technologies, which create new functions, could be adopted and familiarized into our lives? I assume these were the questions that the craftspeople, the people who made the machinery, and their organizations, have contemplated.

The so-called industrial design, the term, originated in the United States. As industrialization advanced, objects with the same function are put in competition with one another. That's where industrial design came about. The content is the same, but the package – how something like a radio would exist inside the home, whether a square shape with sharp corners or rounded edges are preferred – made a difference. In part they are influenced by the efficiency of production, such as bakelite that were better suited to produce round forms. There were new technologies springing up constantly, and variety was required through styling.

Europeans took industrial design as something of an American culture, an American concept. France and Germany, for example, tried to use some other wording, but Japan accepted the term 'industrial design' in *katakana*<sup>3</sup> without any hesitation. I think this is an essential point: The style determined the value, despite the same function. I believe that the Europeans would have been convinced if the function could be better represented on the exterior.



For some reason, the Czech Republic was pursuing designs of medical equipments such as surgical knives. The design reflected how the knife would be held or used, and for which organ. To us it was such a fresh idea. The function, to cut, remained the same but the form and design changed. Anyway, they did not use the term industrial design.

### **The industrial arts and education of Japan**

We used the term *sangyo-kogei* (industrial crafts), connecting craft and industry. What we called *kogei* (crafts) and *bijutsu-kogei* (art-crafts) had preceded, but industrial crafts were something else. How the necessary craftsmanship could be linked to industry was the issue.

At the time, the Ministry of Economy had a board of industrial technologies, with subsidiary research institutes: Electrical, which dealt with everything from electricity to appliances; industrial, which concerned mostly with chemistry-based research; machinery such as vehicles but not railways, and so on. I know this because when I joined the Industrial Arts Institute, we were sent to visit different research institutes each week, and had to write a report on it. We also visited other places like a shipyard owned by Nihon Koukan Co., Iwata Glass, and Okura Touen ceramics, who were making teacups with golden handles. We watched how steel pipes are made, too. Now there is a housing development where the factory of Tokyo Kisha Seizo (manufacturer of train cars), which we visited in Fukagawa area. In the end, I belonged to the Institute of Industrial Arts for only 4 years.

I was in the first generation in the new university system, which meant 6, 3, 3, 4 for elementary, middle school, high school, and university, respectively. The old system was 6, 5, 2, 3. The total number of years remained the same, but it was changed due to the American occupation. Under the old system, middle school taught foundations and during high school one would decide to go into either humanities or science. The decision of the area of study could be discovered gradually, but with the new system the objective had to be clear upon entrance.

I was always interested in design. With poor eyesight – I wore glasses from fourth grade – I couldn't have become a soldier. So as an alternative I considered designing airplanes, but then the war ended. By that I mean we lost the war. All of a sudden, every

university course related to weaponry vanished. Because I enjoyed technical drawings, I went to visit my friend, an upperclassman from elementary school who worked in the firm of Hiroshi Oe.<sup>4</sup> He didn't have his own office yet, and had a space within Mitsubishi's brick office building called Ginkgo London. As my friend was explaining the work, Oe came out from the back. He was very stylish, and I decided to give architecture a try.

### **Getting into university**

My friend applied to the Tokyo University of the Arts the same year I applied (to Chiba University). He told me that for the entrance exam, they were given a plan and were told to draw a perspective of it. They had to color the perspective too.

The exam for Chiba University was less intense. We were given a poem, and told to draw in pencil whatever image that arose in our mind. It could be a landscape or anything. The other exercise was to draw forms using a triangle and a compass. We didn't have to color the forms, but we would shade them if they were supposed to be three-dimensional. They were not actual objects, just an image that measured the skill for expression. So the exam included these two drawings and a regular subject-based exams like calculus. It was quite boring.

### **Kenmochi's office**

We had a staff whose wife had studied textiles at Cranbrook with Kenmochi's introduction. She had previously studied at Tama Art University. It was right after the war and she might have been the first female student to study abroad postwar. She studied the structure of textiles, how to potentially receive royalties on the new fabric structure. It might be possible now, but I've heard that it is still difficult. There must have been someone who came up with the structure for Issey Miyake's wrinkled fabric, designed specifically for Miyake. The fabric might have existed in Miyake's mind but he didn't know how to realize it. Ideas don't just come into fruition without technology.

I met Charles Eames twice. He is very frank but doesn't speak much, and my impression of him is that he's like a farmer. George Nelson, on the other hand, talks a lot; he

is a New Yorker. Ray Eames always wore a dark colored long dress or a long skirt; I think she didn't like to show her legs.

### **Development of moulded plywood from IAI to Tendo Mokko**

Alvar Aalto's bent joint (the "bent knee" joint, patented in 1932) is very solid, but the process is laborious: The wood is sawn in multiple grooves, and the sawn parts are filled with adhesive, and inserted to the other grooved piece of wood. Sori Yanagi's Butterfly Stool (1956) also was not easy to produce. It requires just one mould but the structure of it is actually not logical, including the rod connecting the two parts. Initially a wooden mould was used, which was later replaced by a metal one. And the leg splint by Eames for the U. S. Navy (1942) paved the way for the technology of moulded plywood.

During the war, the Industrial Arts Institute faced a critical point of being terminated, because the activities there were considered too leisurely in contrast to the urgency of the war. Kenmochi had been studying the techniques of moulded plywood for a while then, so he claimed that plywood can be applied to the production of airplanes. He went to pitch the idea to the army himself. The head of the department of aerial weaponry who saw the idea thought it could be useful. That is how the Industrial Arts Institute survived, and Kenmochi ended up concurrently holding the posts in the Ministry of Commerce and Industry, and in the Ministry of War (which was in operation from 1872 - 1845).

In the Nomonhan Incident (also known as Battles of Khalkhin Gol, 1939), where Japan fought with Soviet Union and lost, there was a Soviet plane that had crashed. Through analysis, Kenmochi and others had found the use of coal, type 30C. They were looking into what kind of adhesive was used, since that is really the central question in plywood. Typically working with thermosetting resin speeds up the process, but the resulting product is not necessarily stronger.

After the war, the technical information that the IAI had was pretty much transferred to Tendo Mokko, and Kenmochi also gave guidance. One of the technical engineers at the IAI (presumably Saburo Inui) became the technical manager, then a senior director, at Tendo. Then further developments in moulded plywood ensued. For example there was an

attempt to add a solid piece between the veneers, the same technique used for the part in tennis racket where it diverges, to form the leg of a chair. Some were techniques that Kenmochi had helped develop.

They were able to take in and develop these techniques in the period immediately following the war, even though the machineries are quite expensive, partly because of subsidy from the government. It worked to their benefit to be affiliated with the IAI. Then it allowed them to create new things, or in multiple quantities of 2 or 3 at once. It led to their miscellaneous ventures afterwards.

### **War and moulded plywood**

Moulded plywood really developed from the war – although the war was regrettable – like the Eames' techniques that led the chairs in the postwar, Kenmochi's researches prewar that grew into the capability of producing aircrafts imitating the Russian aircraft.

Iwao Yamawaki was also at the IAI the same time Kenmochi was there. Yamawaki had studied architecture at the Bauhaus. Together they published an article in *Kouku Asahi* (a representative aviation magazine) on wooden aircraft.<sup>5</sup> Fumio Matsumoto (another co-author) later founded the industrial design office with Jiro Kosugi (1915-1981).

They entered design from what the rationale taught by Taut, like studying the section of human body when sitting. These analysis were published in the magazines like *Kouku Asahi*, with a broad readership. It means that the British fighter Mosquite, flying over Burma, has a close connection to moulded plywood furniture developed postwar.

During the war, manufacturers in the wood industry couldn't be producing things like the pieces for *shogi* (a chess-like board game). They would be reprimanded. So there were many carpenters, cabinetmakers and the like, skilled in woodwork, who formed a woodworkers' cooperative and made things like ammunition boxes.

Ultimately, there were talks on making wooden aircrafts, but Japan no longer had the ability to produce a functioning aircraft. So instead they developed the fake ones. Every time there was an air raid, all aircrafts in the airfield had to evacuate because they would be destroyed otherwise. The fake ones could serve as the target for the raids. It would not be

feasible to carve out the wood, so moulded plywood was used for the body. But these planes would never fly, they neither had engines nor gasoline. These techniques spread toward the very end of the war.

Tendo Mokko was able to link these techniques successfully into the postwar period. They weren't making furniture originally. Manufacturers of chairs, including bent wood, after the war did so to export them to the US, to earn more dollars. Design had nothing to do with it. If Windsor is popular, then just make copies of Windsor. American dealers would come and buy them. In the case of carpet, if red carpet were in demand, the manufacturer would make thousands and tens of thousands of meters of red carpet as needed. But wool was quite scarce then, and no synthetic fiber was available either, so it must have been a challenge. Although I saw a huge stock of Australian wool, even after losing the war, which had been intended for military use. I assume it was used to make other products later.

There was a muslin factory near Ise, producing winter clothes for military officers. I used to work there, walking around the machineries with an oilcan. I was curious to know the mechanism. It wasn't automated so each machine had a female worker. All the men, except a few students and old men, were in the military. There were 100 weaving machines, and there wasn't enough oil to go around all of them, so I had to stagger the order. One day I made a mistake, and the motor of the machine that did not get the oil for 2 days burnt out. I was chastised, but I asked the factory manager to tell me how the machines worked. Then he lent me a book. That's how I learned: The oil from the wool, imported from Australia, was removed with caustic soda, then are washed and dried, sent to the next processing factory through a vacuum tube. After the war this factory became part of Dainihon Bouseki (Japan spinning co., now under the name Unitika Limited).

I never expected to be working on architectural or interior design; I always thought I'd design airplanes. My interest in these mechanisms helped me later on, about materials and how things are made.

<sup>1</sup> Originally founded in 1938 in New York as a furniture manufacturing company, it changed the name to Knoll Associates in 1946 with his marriage to Florence Schust.

<sup>2</sup> Sigfried Giedion, 1948.

<sup>3</sup> A Japanese syllabary often used to transcribe foreign words.

<sup>4</sup> Hiroshi Oe (1913-1989) is an architect known for combining modernism and traditional Japanese styles. He had worked for Mitsubishi Estate Company for 5 years, before establishing his own architectural firm with his brothers.

<sup>5</sup> Included in *Kenmochi Isamu no Sekai, Vol. 4: Sono Shiteki Haikai*, pp 92-93.

#### 4.7 Interview with Noboru Inoue, head of Inoue Associates, Inc. and Isu-juku

18 April, 2014 at Inoue Associates office in Minami-Azabu, Tokyo

Excerpts from the interview, translation and text in parentheses by author

##### On the state of Japanese furniture industry

Sugi, Japanese cedar, has been widely used lately, due to the current government policy and subsidies.<sup>1</sup> In fact you can profit a lot (from subsidies) by using cedar for architectural projects.

For us in the furniture industry, we see cedar as a poor quality material. It was a mistake for the government to plant so much cedar, in the first place. *Mage-wappa*<sup>2</sup> or *oke*<sup>3</sup> have traditionally used cedar. Not furniture. There were more beech, from Tohoku to Hokkaido areas, and Japanese oak too, in the past. Although I've heard that there are beech in the government-owned forests in some regions. There are several companies like *Hida Sangyo*, which uses compressed cedar for their furniture – but I don't think that they are so successful in the sales.

Plywood is great for its strength (relative to weight), inexpensiveness, and stability of form. Also the manufacturing process of furniture can be speedier; the high-frequency plywood moulding device speeds up the hardening process, whereas solid wood need more time to rest until the form can be stabilized.

The furniture industry regards plywood as something cheap as well these days; it was quite popular among consumers some decades ago, but not so much anymore. Compared to MDF (medium density fiberboard) which is essentially a paper material and one that companies like *Nitori*<sup>4</sup> or *Asku*<sup>5</sup> would most commonly use these days, plywood is much better, of course. If you poke a hole in that furniture and put a drop of water, the board would expand almost immediately. Plywood is more resistant – it is somewhere between the cheapest board material and the luxury of solid wood. It is never high-end.

While I was working at Itoki Corporation<sup>6</sup>, we did not have the kind of research and development budget like Herman Miller did. They could afford to spend five to ten million

(dollars) for the development of one chair. Which means that their Aeron chair, for example, could never have been born from a Japanese company. The mesh fabric, structure, etc. have been patented and, although other manufacturers try to copy, it cannot be quite replicated by others. It is still one of the best in ergonomics. They used to sell more than 10 million chairs annually, I heard. Less today, but still popular. The capacity for initial investment makes a huge difference for the resulting design and production.

For the Japanese furniture industry, 1980s to 90s was the peak of production and sales. The sales of most companies have dropped significantly. For one, let's say their annual sales that was 18 billion yen then, and is now 4 billion yen. Number of employees went down from 800 to 300. Still a large enough company, but nothing compared to what it was. Just a few decades ago there were designers who could live comfortably from royalties, perhaps a million per year just in royalties. Those would include Kenmochi Associates, Nikken Sekkei, Yoshiteru Hara. Tendo-mokko also produced designs by Bruno Mathsson, from Sweden; these lines and tight curvature would not be possible with solid wood; they are enabled by the use of plywood.

Currently, domestically produced furniture accounts for about forty per cent of the furniture market. The rest are imported, most of which are the cheap ones but also some of the high-end designs. You could say that the furniture industry is suffering, but also gave birth to smaller designers and fabricators, such as Time and Style, Truck, which is based in Osaka, Oak Village, Standard Trade.

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<sup>1</sup> Government-led large scale afforestation especially in the post-war period concentrated on cedar, followed by *hinoki* cypress, for its relative straightness of the trunk and characteristic fast growth, maturing in just over 50 years. However, decline in the number of workers in forestry and cheaper imported timber have resulted in unmaintained forests. To combat this issue, the Japanese government has been pushing the use of cedar.

<sup>2</sup> A technique of boiling and bending of thinly sawn planks, commonly used for tableware and bento boxes.

<sup>3</sup> Tubs of varying sizes, from washtubs to barrels, where slightly curving vertical planks are assembled and tightened by bamboo.

<sup>4</sup> Nitori specializes in economical furniture mostly for the home, Japanese version of Ikea.



<sup>5</sup> Askul is Japanese version of Office Depot.

<sup>6</sup> Itoki specializes in office furniture and supplies.

#### **4.9 Interview with Hidenori Takeda (production area coordinator) and Katsuya Ryu (matching coordinator) at Okawa Interior Promotion Center, Okawa**

24 July 2014 at Okawa Interior Promotion Center

483-8 Goubaru, Okawa, Fukuoka 831-0028

Excerpts from the interview, translation and text in parentheses by author

#### **Origins of Okawa furniture industry**

The beginning of the furniture industry in Okawa was initiated by Kumenosuke Enokizu (1485-1582) in 1536, when he thought of getting his 100 or so shipbuilders to apply their techniques to carpentry. The most known representation is the *Enokizu sashimono*, cabinetry constructed without the use of nails.

In the 1800s, Kasaku Tanoue (1812-) contributed to improving the design of *sashimono* in late Edo period by incorporating new techniques and designs from abroad (from China and the Netherlands, which he came into contact with in Nagasaki). It was quite revolutionary at the time. Around the same period, there was a sculptor named Muraishi (Shigetaro, 1832-) who contributed to the advancement in that area, which was also applied to *ranma chokoku* (decorative wooden transoms typically above sliding doors and walls that aided in air circulation).

Transitioning from Meiji to Showa period, from around 1945 on, designer Makoto Kouchi proposed new designs for furniture, whose impact has continued up to the present.

Fukuoka prefecture has designated four trades to be its specialty traditional crafts: *Kumiko* (decorative wooden lattice-work), *chokoku* (sculptural objects, most famously the *ranma*), *kakegawa-ori* (woven textile using the grass-like plant rush, typically applied for making mats), and *kiri-tansu* (paulownia wood cabinetry).

Hita city (in Oita) along the upper stream of Chikugo River had been known its production of Japanese cedar and cypress. Hita, now known as a tourist site, was originally a Tenryo (one of the bakufu lands, or shogun's demesne) so it had flourished in many sectors, including forestry. Until the dam (*Yoake* dam) was completed in 1952, log rafts were floated

down the river from Hita to Enokizu, Okawa. The logs were applied to shipbuilding and also to making of barrels. The Chikugo Plains are also known for rice production, so there was a demand for sake barrels. Then they were applied to *sashimono* eventually. Before the concept of furniture, the box-shaped furniture were all traditionally called *sashimono*. Within Okawa, Enokizu is the area best known for it.

### **Transitions in materials related to plywood**

Building of the dam caused changes in materials. The material had to come from elsewhere. When the embargo on timber was lifted, more imported wood came in and replaced a lot of domestic wood. (With the opening of the market to imported materials in 1964, the supply of imported timber exceeded the domestic timber for the first time in 1969 and has continued to this day.)

Okawa never had its own plywood factory, and neither did Fukuoka prefecture. The closest factory that is still in operation is located in Minamata, Kumamoto, called Shin-ei Plywood Co., Ltd. They are the biggest manufacturer of plywood in the Kyushu area. From there Okawa bought veneers and plywood, most of which were made of timber from the South Seas (luan) and sold to furniture manufacturers. So Okawa's introduction to veneers and plywood coincided with the importation of timber into the country. There is no machinery or facilities for producing plywood in Okawa. What is done here is applying the purchased veneers as decorative finish, on plywoods and boards that are also purchased.

Shin-ei Plywood Co. had been selling their products to Okawa until 14 or 15 years ago. Until about twenty years ago, our city was one of their biggest customers. However environmental concerns caused a decline in the importation of logs from the South Seas area (nationally). Shin-ei then switched to using more locally sourced Japanese cedar from Kumamoto, Miyazaki and Kagoshima areas, manufacturing domestic softwood plywood. These are better suited for architectural applications, less for furniture. So with the transition from imported to domestic timber, business with Okawa began to decline.

Plywoods are both cheap and easy to fabricate, less prone to warping or twisting. There are also what we call "flush material" that are veneers applied to the core material

(which can be lumber, lumber core, LVL, plywood, particle board or MDF). It spread with the shortage of wedding furniture *konrei-tansu* made of solid wood, when they were at its peak. Okawa area, which includes some of its neighboring cities, produced at one point about 120 billion yen worth of furniture, which is now down to 20 to 30 billion yen.

The ease of fabrication and low cost led to larger productions using plywood that influenced the designs, although I wouldn't say that plywood really elevated the design in any way here. It's more that the use of solid wood has deteriorated along with its techniques. The kind of connoisseurship required to evaluate solid wood, which differ from piece to piece that need to be properly dried, is difficult to achieve. We still have a few craftspeople working with traditional hand techniques, but the mainstream is more plywood and 'flush material' based mass-produced kinds of furniture. The wholesaler's demand for cheap furniture, I think, determines the cost of materials.

One could say that it is because of plywood that the perception of Okawa as a domestic producer of cheap furniture took root, rather than being associated with high-quality stuff. In fact, we supply to Nitori and Nafco (stores for interiors and home goods known for low prices) today as original equipment manufacturer. It supported an industry that met the demands at a certain point in history, and acquiring necessary technologies along the way.

Originally *Enokizu-tansu* is modeled after the paulownia chest of drawers. During the prewar, the drawers made from cedar and exterior from zelkova. The locally sourced material of cedar was incorporated in this way. This is before the availability of plywood. Currently 4 to 5 companies in Okawa are specializing in handmade paulownia chests, and perhaps only 2 of them have a market for their products. The market is completely different from the plywood furniture manufacturers, with different policy of their business model.

For example there is a company dealing with *Yaku-sugi* (old-growth cedar from Yakushima, Kagoshima) using both solid wood and veneers. In their case it is hard to secure the material, as it is said that *Yaku-sugi* would run out in a few years.

Plywood, especially when combined with fine veneers, is a very efficient use of material for furniture. For one panel of solid wood, if it is turned into veneer, it can satisfy a hundred

customers. Transition to plywood from solid wood was inevitable, when they had to meet high demand of furniture in a short time.

Other regions have passed on traditional techniques and trained people in order to keep their industry alive. In comparison, the skill to operate machinery is good enough in Okawa, for the most part.

### **Issues related to crafts and industries**

Okawa businesses are quite small. With 20 employees, the business would be considered medium scale here. So the businesses often are unable to meet the needs of large construction companies, but the low-cost, flexible, and wide range of productions here are advantageous for subcontractors.

The Japanese National Railway opened the Saga line in 1936, connecting from Setaka to Saga (running east-west). It was in operation until around 1977. The railway network increased distribution to the rest of Japan, and combined with the mechanization of the manufacturing process, the scale of production in Okawa greatly increased.

We are behind on training of the successors for traditional crafts such as *kumiko* or *tategu* wooden fixtures. Often the children of family *tategu* business are working in a different field, for example. And the number of companies associated with the trade unions has dropped from 200 to about 50 right now. Some cooperatives such as the Coated Plywood Industrial Cooperative are doing relatively fine in terms of numbers, by comparison.

Okawa has many cooperatives in the specialties of furniture, wood, fixtures, plywood, metal fittings, coatings, edged tools (for machinery), construction, trucking, etc. Until 2 years ago we also had a float glass cooperative, but when the number of its members went down to 8 companies, the cooperative closed down. The companies are still in operation though. There are also a lot more cooperatives that are not associated to us.

### **Divisions of labor and particularities**

Division of labor (between the businesses) is quite significant here. There isn't one company that does everything on its own. In terms of veneers, for example, there are companies who

only apply the veneers, those that only slice the veneers, and those only involved in sales. In furniture, there are companies that specialize in bending of the wood, and others who would assemble the bent wood and finished plywoods into furniture.

In this method of working, companies here don't keep much of an inventory. It is easy to get whatever they need, by just making a phone call the necessary materials can be delivered right away. So the city, as a whole, supports the productions – like a convoy. This is the advantage of being able to sustain several hundreds of small businesses in the city. On the downside, if one companies goes out of business, it could drag 10 other companies into the chain-reacting bankruptcy. Because the businesses support each other, if a fabricator that one is dependent on is no longer available or if the receivables cannot be collected, a small business can easily fall into bankruptcy. This model is very susceptible to recessions.

Increase in the importation of low-priced products from China and southeast Asia have also become a real threat to our economy. The mutually supported regional model of Okawa to keep the cost of production low cannot compete with them.

Other regions such as Asahikawa (Hokkaido) or Hida-Takayama (Gifu) have transitioned into producing higher-end furniture, employing well known designers. They have established the brand. And because their companies are larger, after they purchase the material, they are able to manufacture everything from chair seats, backs, to legs within the company. They even have a collection of leather imported from leather for seats, with a room dedicated to them. From ordering to manufacturing to shipping, everything is controlled and managed by the company. Materials can be purchased anywhere. The business model is very stable in that sense.

In Okawa there are too many varieties of businesses, which makes it difficult to share the same goal collectively. There are some companies that specialize in cheap furniture. There are some that purchase all the necessary parts, assemble them, and claim that the their products are made in Japan. The definition of domestic furniture is very ambiguous. The source of materials do not have to be disclosed, unlike food ingredients. There are businesses searching for ways to survive and ways to establish their brand. It is ultimately up to the policy of the owner, if the company wants to differentiate from others with unique

products or look for stability by satisfying the needs of the wholesaler.

### **Challenges in Okawa's business model**

Marketing, or sales, is the what is lacking here. It is not typical for Okawa's manufactures to have a representative in sales; often the owner does the negotiations as well. So if a large company, like Nitori, Nafco, or Otsuka Kagu, wants to place an order type of furniture at 100, 200, or 300, then most likely the company would choose to do so at the offered price. Going to Tokyo and visiting company to company is another option, but only a few do that. This is not new – the dominant business model had been this way, of meeting the needs of the wholesalers, since the wedding-furniture industry was the mainstream.

One can suggest pulling out of the current situation and attempt something new, but often there are too many risks and the business can potentially go bankrupt. Then, even if they have to scrape by, they would choose to manage within the existing market. They need to pay their employees, at the end of the day. It is necessary.

A large company can choose to operate *daini-sogyo* (launching of a new type of business, establish new cooperation, etc. in order to diversify and keep the company up to date) to cultivate a new market, for example. It is financially difficult for small family-owned businesses to follow suit, let alone expanding their businesses abroad.

Larger companies in other regions that were able to pull through the recession have transitioned into a more resilient business model. Only the very capable ones have remained, and these businesses are solid now.

As a contrast, in Okawa, larger companies have gone bankrupt, the ones with 80 or more employees. Smaller businesses have had a better chance of surviving here. This is the major difference from the other regions. Having 80 employees means they need to handle all tasks within the company, from sales to manufacture, and the employees receive better pay than in the small companies. These conditions mean higher cost for the employer. Division of tasks among many small businesses here have kept the costs down.

In the past, these jobs were conducted by farmers during the off-season on the farm. Most workers were part-time employees, looking to make some extra cash in the winter.

Now the scale of industry has gotten too big for such operation, too big to be organized.

Asahikawa only has about 30 companies, and Hida-Takayama also has less than 50 companies associated with the cooperative, but scale of each of the companies is large. The largest companies employ about 300 workers. Fuchu, Hiroshima, has around 20 to 30 companies, including ones dealing with veneers, furniture, and other related trades.

Okawa's scale is very atypical. Although there is a sense here that we should do something about the current situation, it is difficult to organize the businesses to turn to the same direction toward the same target.

For example, there is a company here that owns a factory in Vietnam. The company imports the furniture and does retail here. The business is doing very well financially, much better than the businesses struggling to manufacture things here.

### **Possible adaptations and challenges**

One of the ideas proposed was to make Okawa the base for distribution, for trucking. We have a trade union for the trucking industry. With so many businesses having closed, there are lots of empty warehouses, and there is an international port Miike-Kou nearby, in addition to the ports in Imari (Saga) and Hakata. It is easy for us to receive imported goods. Should we then switch to a model of importing products, stock them here, and sell them? That would be much more lucrative, but we would lose the local industry.

If we shift our focus to domestically produced furniture, then companies that have relocated their factories abroad would object. If we create a kind of "Okawa stamp" for the products made here to create a brand, the same companies with imported products would be left out. As a strategy for branding, it would make sense. Asahikawa does that, but we have too many varieties of businesses, heading in opposing directions.

We are aware of what the problems are and what we should do. Typically, and ideally, the locality should address the issues, but we cannot be so organized with a shared goal. Supporting one means being hostile to another, if we shore up one the other, then another would oppose to it. We need to abandon someone. If we support medium-sized companies with 20 to 30 employees, then we would crush family businesses. In theory, if we help elevate



the businesses of medium to larger companies, the number of production would increase, statistically speaking. But the number of manufacturers would be reduced, and it would be like giving priority to the numbers than to the popular appeal of this place. It can also be detrimental to the human relationships.

### **Recent developments**

There is a group organized by relatively young, mostly in their 40s, called *Okawa Ishin-no-Kai* (Okawa restoration group). Their businesses range from timber, furniture, plywood, to fittings, but they are collaborating with each other and also with other designers. They have organized an exhibition in Tokyo.

Until the present, the mutual support system in the city has been positive for businesses. However as the market starts to operate more at international scale, we may start to receive more high quality products from other countries like Vietnam, Laos, China, etc. We probably are importing some already.

With the small scale businesses with division of labor in fabrication, research and development doesn't really exist. From the very beginning, Okawa was known for *hakomono*, the box-furniture like cabinetry and other storage. Plywood was very well-suited for that purpose. The changes in lifestyle decreased the demand for these kinds of furniture, whose function is satisfied by built-in closets and such. When it comes to *ashimono* furniture – tables, chairs, TV stands, etc. – plywood is not necessarily suitable. Some companies in Asahikawa produced bent seat backs, using the moulded plywood techniques, as does Tendo Mokko. Okawa never really developed this technique, mostly fabricating with just linear applications. A few places, like one in Yanagawa, specializes in bent wood (solid), but the scale is so small and incomparable to the others.

The transition from *hakomono* to *ashimono* in Okawa has been very slow. We are especially poor in manufacturing chairs. Only about 5 companies here specialize in chair production. Many companies can make tables, which are simpler, but chairs are much more complex, including design and specific expertise.

The changes in market and the productions here did not mesh well. There are a few

exceptions, where companies have been outlining how to remake themselves. The planning process can last for over 10 or 20 years and these businesses have been steadily working on the transition, such as acquiring new machinery. It is a huge undertaking. I'm not saying all companies are complacent, and every business has its own vision. As a city, I think that 50 to 60, maybe even 100 companies will make it eventually.

Not too far from here is the JR Shinkansen Chikugo-Funagoya station, and next to it is a new facility Kyushu Geibun-kan (Kyushu arts and cultural center, opened in 2013), which was designed by Kengo Kuma. The moulded plywood tables and chairs in that building are made by Tendo Mokko (in Yamagata), although we are located just next door as one of the main furniture manufacturing areas of Japan. In fact, locally sourced wood for the furniture was supplied by a timber company in Okawa, which were then shipped to Tendo Mokko for fabrication. In the end, the fact that the furniture was supplied by a large company from another region is a bit upsetting for us. We are only 10 minute drive away and can produce at lower cost. I suppose we are really inadequate in getting information out there, or getting large contracts.

#### **4.10 Interview with Okawa Coated Plywood Industrial Cooperative members:**

**Kazumi Ikesue** (chair of OCPIC / president, Tomato Co. Ltd), **Nobuhiko Morimatsu** (vice chief director of OCPIC / president, Okawa Tanpan Sangyo Co. Ltd), **Hiroomi Imayama** (president, Imayama Co. Ltd), **Toshihiro Osajima** (president, Osajima Co. Ltd), **Yoshihiro Ogata** (president, Kansai Tsuki-ita Shokai Co. Ltd), **Taketomo Hiromatsu** (president, Hiromatsu Tsuki-ita Co. Ltd)

24 July 2014 at Okawa Coated Plywood Industrial Cooperative office

1370-3 Mukaijima, Okawa, Fukuoka 831-0005

Excerpts from the interview, translation and text in parentheses by author

Background: Okawa Coated Plywood Industrial Cooperative, also known as Okawa Veneer and Fancy Plywood Association, was founded on May 15, 1972. Currently 34 companies are members of the cooperative, whose products range from architectural applications to toys.

#### **Issues of the industry in Okawa**

Sales and cost of distribution is one of the biggest issue for a regional industry like this one. The question is how we can sell to larger markets. Distance to major cities is also problematic for our presence to be visible in other areas. Production and purchasing of materials are not the issue for us.

As smaller manufacturers, we are unable to directly deal with major construction companies, because we are not capable of providing services after sales. We can only manufacture and ship the products, which will have to be installed by someone else. So our businesses are mostly with subcontractors and supply materials to them. We cannot compete with the production volume of large-scale veneer factories such as Hoxan, in Shin-kiba. Or Aikawa-Kogyo for decorative boards utilizing plastic imitation veneers. Each business is small, and usually at family scale, but the city of Okawa is collectively known for its furniture industry.

#### **Craft and mechanization**

When you say traditional craft techniques, there is something like Okawa-style *kumiko* (a kind of lattice-work with thin pieces of wood between 2 to 10 mm, often creating decorative patterns within screens, transoms and small objects). But *kumiko* belongs to *Tategu Kumiai* (union of wooden fixtures, which covers doors, windows and partitions).

Recently, the *Nanatsu-Boshi* ('Seven Stars' cruise train in Kyushu) utilized walnut veneered ceiling that we have supplied. Plywood production in Okawa really began after the war. The city was already known for *tansu* wardrobe furniture productions with solid boards.

The main transition in technique is the difference between gluing by hand, one by one, or using the hot press. The speed and scale of manufacture greatly changed.

Plywood replaced a lot of solid wood use in interior, like wall finishes. In the past the furniture were created entirely out of solid boards, or entirely out of plywood. Even the baseplates for drawers were made of solid wood. Today a lot of these have been replaced by veneer and plywood materials.

In terms of mechanization, rollers replaced the hand in the gluing process, for example. It is a very basic form of automation. We don't have robotics. For us, the production is still heavily reliant on hand-based work. It is the reason why we can still survive within the industry; otherwise, the large-scale factories would have replaced us all by now.

### **Natural vs. Imitation**

The shift from solid wood boards to boards with applied veneers, most importantly, allowed for mass production and efficient use of material. The traditional 3-piece or 5-piece wedding furniture set, usually made from solid paulownia wood, can cost anywhere in the range of 300,000 to 10,000,000 yen with the average falling somewhere between 500,000 to 600,000 yen. This is not necessarily affordable for everyone, and requires a lot of solid timber. Combined with low birthrate, aging society and changing lifestyles, demand for this type of furniture have diminished.

They are now replaced by furniture with applied veneers or printed PVC sheets, which can appear to be high-end with improved quality. Furniture industry in general is in big

problem, because closets and shelves are often built into the prefab houses and people do not need to purchase furniture, except for a table and a sofa.

One might say that applied veneer is a form of imitation, because the inner composite is often not wood. There is also a distinction between natural veneer and a sheet of PVC (polyvinyl chloride) printed with wood grain. I'd say 80 to 90% of the veneers used are PVC compared to real veneers.

Recently preference for visible wood grains have increased. For a while solid colors, like black or red, were more popular – perhaps consumers got sick of the monochromatic furniture. And solid white furniture was in favor too, for a while. But manufacturers have begun to incorporate unique patterns too, such as an extremely straight wood grain pattern that does not look like wood anymore. So each manufacturer began to adopt their own distinctive style, as consumers began to look for specific styles among abundant choices.

### **Changes in material and production**

These days we get materials imported from Russia, walnut and white oak from the US, and (Manchurian) ash from China. The use of Japanese cedar has also increased, as well as wood-plastic composites and strengthened wood. Increasingly, the inner material for furniture have switched to MDF. There is only one factory in Niigata prefecture that produces luan plywood today.

Also the scale of products have changed. The maximum length we can produce these days are 8 *shaku* (2.42 m), although we used to produce 9 (2.72 m) or even 10 *shaku* (3 m) panels, which you see on the wall panels here. It is dependent on the size of the produced veneers, including imported ones.

We jokingly say that the price of a sheet of plywood and the price of ramen have been known to correlate, although the case may apply only to Okawa. That is a typical 2.5 mm thick sheet, 3-ply, 900 x 1800 mm (called 3x6 board). When a bowl of ramen cost 50 to 60 yen, the veneer was the same too, perhaps give or take 5 or 10 yen. Except for the time of oil crisis, when the cost went up abruptly. The price of plywood has not changed for a while since; it has been around 500 yen for a long time now.

Compared to the peak in production, beginning from around 1980, we produce approximately a third or quarter of that quantity. The total shipment of furniture in 1989 was about 180 billion yen, whereas today it is down to around 45 billion yen. (Okawa city furniture production constitutes about 1.7% of the national market share<sup>1)</sup>) We are dependent on the furniture industry, since they are the buyers of our products, so it affects us profoundly.

### **Specialization**

All of us work with interiors and furniture, none of us do exterior materials. Some of us specialize in sales only, vacuum laminated veneers, or special prints on the veneer surface. We recognize different strengths within the specialization, but from the outside it probably would seem more or less the same, as we belong to the same trade.

### **Additional information from the cooperative administrator**

Most of the businesses that belong to the cooperative operate as family business, from 2 to 10 employees. I think the biggest one has 30 employees. If the business only deals with sales, 2 people are enough to operate. In the factories, there are quite a few women. Two of them would make a team, applying veneers by hand before putting them through the press. There are some detailed work involved. Men typically do more of the heavy work.

Almost all of the business owners are also second generation, passed down from their fathers. The companies in which the predecessors expanded to larger business have now mostly gone bankrupt, and only the small ones have survived. When the number of orders declined, the larger businesses were unable to pay so many employees. A lot of the owners I've seen are short-lived, living to their 60s or 70s. Closing a business is a very difficult process, so it's very rare; in that situation they would choose to go bankrupt.

In good times, there were about 63 or 64 veneer related companies associated with the cooperative (currently there are 34), and over 100 including those that did not belong to the cooperative.

Due to the small scale of their businesses, the cooperative works to support all of them

in getting certification, for example. It is a demanding process to meet the JAS (Japan Agricultural Standards), and a business would have to hire a full-time staff for the task. It is not feasible at the family business scale. By working on it collectively, we can split the time and cost among the cooperative members; one application can take a full year and cost 2 million yen. That is how we got the non-combustible material certification.

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<sup>1</sup> According to the 2013 Statistics of the interior industry in Okawa, compiled by Okawa Interior Promotion Center.

#### **4.10 Chapter conclusion**

Modern plywood was a material that held diverse potentials for experts in different fields, with equally varied motives, while trying to overcome the negative associations with poor quality veneer-boards of the past. One of the motives was environmentally driven and marketed as such, especially given the currently pressing issues with afforested and unmaintained softwood forests throughout Japan that require thinning out. While this problem is not limited to plywood or engineered wood, governmental programs have promoted the use of domestic wood-based products with subsidies.

One noticeably growing market since the steady decline in production from 1990 onward has been the thick, 24 and 28 mm structural plywood boards that were developed, in part, to utilize the domestically sourced yet structurally inferior softwoods. Structural plywoods over 9 mm thick have provided in conventional post-and-beam or frame constructions to strengthen the building's structural integrity. Given its advantage in earthquake resistance, the structural application of plywood took off in the last three decades, after years of being underutilized and losing in competition with lath and plaster walls. Simultaneously, higher efficiency in general plywood's material production, with fine fibers and powders being integrated into fiber or particle-based boards, can be seen as supporting similar concerns.

Another motive, although on a much smaller scale in terms of its market, was of moulded plywood as a vehicle to propagate modern design. Moulded plywood was one of the first methods to mass produce furniture, and was directly influenced by precedents from the West; early on, mimicking their styles helped advance the techniques in manufacturing furniture and moulded plywood at the same time. In other words, moulded plywood as an industry and furniture as an industry emerged simultaneously in Japan.

Furniture prior to that was something entirely foreign until the twentieth century in a typical domestic context, with the exception of cabinets to store clothing and a low table around which residents sat on the floor. Introduction of international designs in plywood, sophistication of the process of moulded plywood, and rapid growth of furniture demands in public buildings all contributed to the rise and success of Japanese moulded plywood



furniture. From inception to maturity of moulded plywood, the process occurred mostly in about a decade, and has remained more or less the same to this day.

In bridging between architecture and furniture, the involvement of the architectural designer in the furniture industry seems to have been informed of material capacities through designing and working with furniture manufacturer; architectural details have borrowed ideas from furniture making. While this is not limited to plywood, it was a material that successfully spanned both realms.

Other applications between the two disparate areas of structural and moulded plywood were fixtures, substrates, interior finishes, and concrete formwork. In its sheer volume, the construction boom during the bubble period escalated plywood's use for concrete formwork, which peaked in 1990. Plywood supported many industries rather quietly in this way, some of which were then replaced by other materials later.

The city of Okawa, whose industry is the production of furniture, manufactures products to be supplied to the wholesalers in large part. There the issue was not concerned with design implications per se, but more purely on cost, demand and distribution. As such, the city's manufacturers have been subject to slight shifts in the market. Yet with its vulnerability, the city that functions like a large factory – the division of labor occurring at the scale of each of the several hundred small business – has retained the potential to produce a variety of products in a flexible way.

## Conclusion

### 1. Craft and industrialization

*The mechanization of various practices across the full spectrum of production, processing, and eventually dissemination and consumption is open to migration rather than fixed in supercession. [...] Craft, therefore, does comprise a natural response to material necessity, be it the organic moments in mechanized process, the rapid prototyping of mass-produced components that takes place in auto production, or the customized, one-off at Lockheed's SkunkWorks program. Rejection of craft [...] cannot be justified by an ideological platform that purports to reinvent production without recognizing the distribution of craft practices.<sup>1</sup>*

In the rapid transition during the nineteenth century from the pre-industrial society into the modern society, which was prompted by large-scale industrialized manufacture, the notions and processes of craft were transferred and transformed. In the meantime, it seemed on the surface that industrialization had prevailed over the crafts through its sheer power in economy, quantity and organizations.

Ideologically, advocates for craft as their idealized representative versus those who regarded craft as anti-progressive seemed to occupy divergent contexts, until the argument turned somewhat irrelevant by the first half of twentieth century. Evolving ideas surrounding craft during this transitional period help underline the current discussions on diversifying productions away from the dominantly large-scale industries, and how the changing definitions explored areas where craftsmanship still thrived.

Negotiations between what represented craft as opposed to industries were regionally distinctive, as the attitude in Japan in contrast with the UK, but the resulting dominance of industrialization was an internationally shared phenomenon. Industrial processes that were replacing craft practices also absorbed them into the industrial system, especially during the early development. Meanwhile traditional craft knowledge and techniques were sustained within the industrial productions to a certain extent, perhaps most clearly in the process of working with new materials and in the making of prototypes. Industrialization had the potential to accelerate and expand craft-like approaches and techniques with one of its main

strengths: Liberation from the restricted labor-based speed and scales.

The interpretation of craft was repeatedly revised to accommodate for the changes over time, including what constitutes 'hand-made'. Unlike fine arts, craft did not engaged with the realm of the representational, both to its benefit and detriment. It has been rooted in the process that is primarily dependent on labor, materiality and in the physicality of the produced object. Its marginal position in modern to contemporary productions was where modern craft originated, constantly in tension with practices from fine art, industry, science and engineering. Its values have been subject to the conditions of more consequential mediators such as economy.

Craft, which is neither an isolated condition nor an abstract concept, is a process towards physical manifestation that continuously evolved over time. Inherent in its practice are conditions of materials, tools, skill and labor; the context immediately bordering the practice include economy, design, art and industry. Craft has represented a continuum through accumulation of knowledge and techniques, but also has shown aspects of malleability – an imperative for its subsistence, if not success.

Its role as a definer of quality, process, or the object, contingent upon the maker's intentions and disciplines, became increasingly important and helped position itself within the evolution of production methods. Thus the drastic shift in the manipulation of the material is removed farther away from the traditionalist sense of handicraft but has accommodated the modern interpretations of craft by catering to designers and makers, which has also extended to the general public in the latter half of the twentieth century. Malleability of craft practice also allowed multiple interpretations: Ideologies surrounding craft changed according to the agenda of its advocate and adversary. One of the commonly accepted perception today is that craft is not limited to a particular method or material, but rather it an engaged process capable of incorporating the latest technologies and different modes of productions.

Nonetheless the critique of being at the service of machinery in the factory versus the autonomy of the maker in the workshop has lingered into the contemporary society, with a central critique that the spirit of experimentation and of risk-taking has been lost in major

industries. It cannot be negated that the larger an industry grows, so does the mitigation of risk and the incentive for high efficiency. Researches on materials conducted by scientists and engineers has become much more consequential than experimentations conducted by individual makers and builders.

A key transition took place during the period of plywood development, from catering to the privileged to the masses, from patrons to consumers, from skilled craftsman to the less skilled. Wood, which had been a prominent craft material for centuries in diverse cultures and required expertise in assessment and manipulation, became a homogeneous, easily manipulatable and accessible material through plywood. It opened the door to amateurs and professionals alike, and as a result, plywood has been widely present in prototyping and DIY movement.

## **2. Implications of plywood**

Modern craft had been selective with the materials used, which typically fell in the range of natural materials, since the practice was heavily dependent on the selected materiality as much as skill and technique in establishing its practice in the industrialized context. For the use of wood, craft knowledge was applied from selection, evaluation and application, where the understanding of the characteristics of behavior and appropriate forms were acknowledged over the centuries. On one hand, simplification of the entire process through industrialization of wood rendered many preceding skills unnecessary. The material could be mechanically graded and sorted according to its use by the mid-twentieth century, and having them processed into standard sizes in factories meant that components could be produced with fewer workers in the shop or in the field.

Traditional value system associated with wood continued to thrive in a relatively niche market that esteemed the natural characteristics of the prized solid wood. Synthetic and composite materials, in contrast, were associated with industrial processes and therefore deemed lesser or unsuitable from the perspective of traditional wood crafts. However, there was no strong incentive to completely eliminate the hand from industrial processing of wood either. Partly because wood is easily manipulatable by hand tools or the machine, interesting

overlaps have occurred with varied degrees of mechanization, dependent on the type of industry.

The birth and development of plywood corresponded with the time when mechanization and new technologies became the source of faith and replaced the former stylistically based traditions, making it a truly modern industrial material. Its main technological developments covered the timespan of late nineteenth to mid-twentieth century, the period in which the process of industrialization had reached a level of maturity and was becoming an integral part of urban conditions in some parts of the world, as the rest followed suit. The house became a machine, and so did the furniture inside it, in their own right. Objects and furniture often proved to be the superior vehicle in conveying the modernist matrimony of technology and function than architecture, since the entire process of furniture production is uncontaminated by the particularities of site or other factors. Thus moulded plywood came to represent an era of modern design, particularly in the 1940s and 50s, before the advent of steel and plastic in the furniture industry.

With lingering affiliation to tradition through wood, however, the machine aesthetic was never directly or fully embraced through the material of plywood as it did in steel or plastic despite the fact that plywood was one of the most successful early modern industrial materials. This perception sometimes worked to plywood's favor through the identifiable familiarity of being not quite being old nor entirely new and foreign.

The adaptability of plywood encouraged a wide range of scales and applications from furniture, architecture to civil engineering. It could be expressive of its materiality, such as in moulded furniture, or eliminate its expressivity entirely, such as in concrete formwork. The contrast is also apparent the process. Moulded plywood might be considered closer to the craft end of the spectrum, with the potential risk taking in the simultaneous process of making the object and the plywood itself. On the other end are the standard plywood used for structural sheathing and concrete formwork applications, produced and consumed at incomparably substantial scale. Although they tend to remain invisible and aesthetically trivial from the design perspective, the successful commodification of the plywood product has significantly affected the structure and building process toward overall architectural

compositions. The impact of plywood's standard sizes – 4 x 8 in the US or 3 x 6 in Japan, for example, with the assortment of typical thicknesses – have not been scrutinized in this research, but has been exceptionally consequential in the construction industry from the scales of other materials, components, and buildings.

Large scale productions enabled by industrialization presented plywood as a product, with succeeding derivative products, which came to be known for their consistency and uniformity. In the industrial and mechanized productions, the creative energy is poured into the means of production and the organization of its facilities. These conditions are then assumed to improve the quality of the output, and the outputs become more economical through streamlined production. This system, idealistically, was believed to lead to democratization where the general public could afford the products, instead of only serving the wealthy. Simultaneously, countering this argument was the concern for deterioration of labor conditions and deskilling of the workers, as well as the loss of 'taste' argued by some of the craft movement advocates.

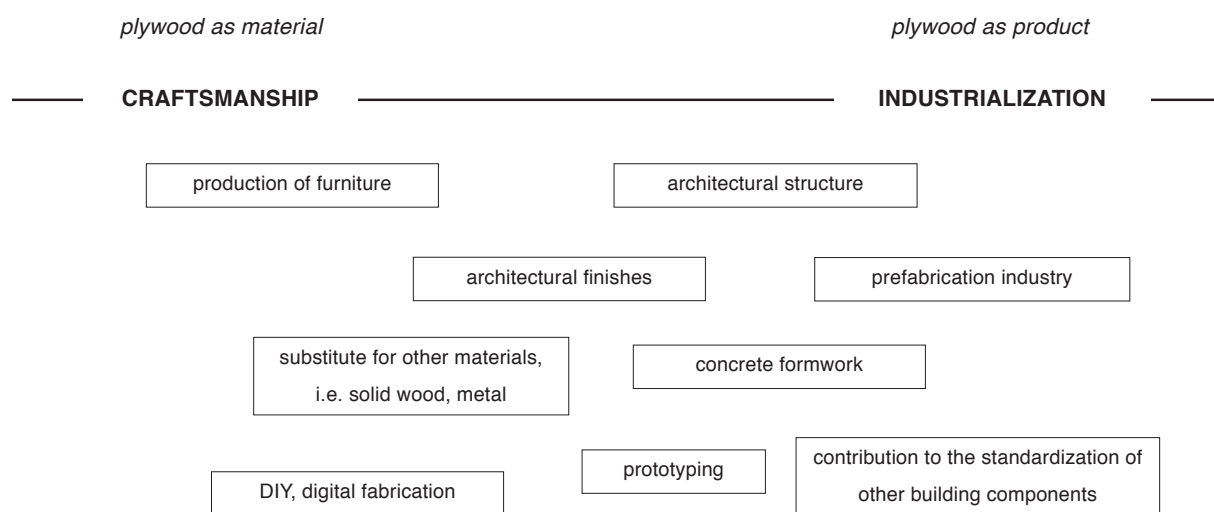
The elimination of craftspeople and skilled cabinetmakers from the factory of Thonet in the mid-nineteenth century was emblematic of the shift from craft skill being a requisite to an optional one. In this context, the value of traditionally produced crafts became dependent on its exclusivity rather than its ability to engage with the larger public.

In parallel to the categorization of craft, plywood underwent a trajectory from art, craft, to a fully industrialized material. The rarity and high value of veneer before the invention of machine cutting or slicing made it an extremely valuable material, limited to singular decorative purposes such as the sarcophagus. Transformation into modern plywood required a number of tool-making and experimentations, namely the developments in adhesive, rotary lathe and slicer, and the press.

As a modern material, plywood manufacture has depended on the machinery and industrial process, and in that sense, is distanced from the handicrafts. Yet the early plywood's experimental, trial-and-error craft-processes, from bending of wood efficiently applied toward large-scale industrial productions, show that the material has always been open to transformation and manipulation by experts and amateurs alike, yielding numerous

results. The knowledge of material scientists, product engineers, designers, with craftspeople's 'truth to the material' and the general public's do-it-yourself attitude were merged into what turned into a populist material, in the same vein that 'craft' pursued proliferation amongst the general public but failed. Plywood represented a break from tradition, with a sense of liberation from the dominant traditions of wood and associated styles, but was also replaced by metals, plastics and fiber composites subsequently.

At the same time, plywood as industrial material did not suffer the shortfall of craft in its promotion and marketing. Closure and stabilization of plywood as a standard board material occurred over many decades, covering almost an entire century up to the 1950s. During that time the product of plywood was celebrated for technical performance, utilized in a wide range of scales and fields, served the purposes of industry to amateurs, and became increasingly ubiquitous.



### 3. Plywood as material, plywood as product

Technical change, with its process of trial and error and “a cumulative result of small and mostly random modifications”<sup>2</sup> without necessarily being a goal-oriented activity, also applies to the development of plywood. The question – if craft represents a continuum

through accumulation of knowledge and techniques, can it be sustained through abrupt shift in manipulation of the material, such as in the transitions from hand to machine, one-off to mass production? – could be addressed from several positions regarding plywood.

One is that the shift in approach to the materiality of wood, which is the change from wood as solid material to wood as veneers and composite. Plywood, serving both as a board material that could cover large surfaces and a pliable material that could be bent and moulded, offered completely different possibilities from what traditional carpentry and wood crafts allowed. Unlike many of the heavy adaptation of conventional approach that dealt with the mass of solid wood, which developed techniques such as carving, plywood made the working process quickly repeatable and the output substantially lightweight.

As a result, the commodification of wood was accelerated internationally, in conjunction with the democratization of the material. The industrially manufactured plywood, in its inception – in the experimental European furniture workshops and in the Japanese carpentry plane attached to a roller to make a rotary lathe – could not have taken place without the accumulated knowledge from previously working with the wood material. The succeeding history of plywood is a reflection of international trade policies, distribution networks, degrees of industrialization in a given country relative to another, design trends, material sourcing and environmental issues, and the technological, mechanical and chemical advancements, among others.

Accumulated knowledge and techniques of wood over centuries, once they transitioned into the realm of plywood, took on a different course. As industrial processes developed further and were refined, experimentations entailed more financial investments and therefore bigger risks. Early adaptations of technology in industrialized processes relied upon prior techniques as well as designs. Familiarity to the stylistic expression had been a significant feature in the shift to mechanization, before the mutual relationship between technology and design began to be established. In plywood, the attempt to recreate the popular Biedermeier style chairs had initially set off the quest for laminated and bent plywood, followed by the much simpler bent plywood surface seats for public buildings produced in large quantities some forty-five years later. Another fifty years would pass before



modern designers fully embraced the potential for plywood furniture. Around the same time, plywood panels as a product on the market were standardized and finally began to be applied in the building industry. The success of plywood, especially visible in interior designs, made it one of the representative materials of the mid-century and defined the aesthetic of its time.

#### **4. Plywood and Japan**

There were several factors in play from early trial phase to the dissemination and ultimate success of plywood in Japan. One was the successful craft knowledge transfer of the wood material in producing veneers and plywood, and the other was the abundant supply of raw material from Southeast Asia suitable for veneer production. Continuous experimentations and improvement of adhesives also contributed to the maturity of plywood industries, as it did in other nations as well. Within the general evolution from natural, notably casein glue, to synthetic glues worldwide, Japan has also been distinctive with the development and widespread application of aqueous vinyl urethane adhesive in wood processing.

In its approach to manufacture, Japan had already been equipped with a strong tradition in carpentry and in wood-related crafts long before modern design of Western background was imported. First it entered through invited advisors and publications from abroad, impacting the educational systems for art and design, and later more directly through products after the war. When mechanical processes, industrial materials and modern designs were introduced into Japan, more or less simultaneously, the response was to embrace them all and to try to foster required techniques toward realization.

The invention and production of modern plywood coincided with the intensification of industrialization and its friction with craft practices, particularly in the West. In case of Japan, the production was deeply tied to postwar democratization with minimal resistance. In the history of moulded plywood furniture in Japan, it is evident that this new material and technique thrust the furniture making shops into an industry – an industry that was assisted by, and helped support, the modernist public architecture from the mid-1950s and altering the lifestyles, domestically and publicly.

Particularly in objects and furniture, the key to successful transition and development of the material and design was, in essence, the sophistication of *kata*. Both designers and manufacturers alike understood that the *kata* – interchangeable in its meaning as the mould, form, or original prototype – determined the quality of repeated production, regardless of the scale of the production. It could be made by hand, with the use of machinery, or a combination of both, and the possible adjustments gave a level of freedom to its maker. One of the industrial design pioneers Kenji Ekuan referred to the distinctive realms that each *kata* and the hand technique *tewaza* occupy, in discussing the relationship of craft and industrial productions. As the handmade paved the way into the mechanical, *kata* was perhaps the most critical element in bridging that transfer from hand to machine: It embodied quality, complexity, and efficiency in the process of making, and facilitated the reconstruction of the nation after the second world war.

Japan's encounter with the concept of craft and design concurrently brought the discovery of the sense of regionalism and its associated cultural heritage, perhaps for the first time in its history. Plywood and moulded plywood ushered in modern production methods and aesthetics, but also began to take on its own design approaches and techniques rather quickly beyond the reproduction of the Western import.

## **5. Craft and design trajectories**

Jean-Francois Lyotard, in 1979, had anticipated a condition in which “anything in the constituted body of knowledge that is not translatable into digital language will be abandoned and the direction of new research will be dictated by the possibility of its eventual results being translated into computer language.”<sup>3</sup> Craft epitomizes a continuity – of skills and knowledge, interfaced by new materials and new forms. While many craft knowledge has undoubtedly been lost, craft practice and craftsmanship have also transformed and incorporated the digital realm in ways unanticipated a century ago.

Architecture today is reliant on premises of both industrialization and craftsmanship. Each processes is subject to change. The future trajectory of plywood and its subsequent materials will be influenced by many of the factors reviewed in this thesis: Changing

resources, economy, technologies, advancements in other disciplines, networks and required labor, etc. Wood has been one of the most suitable materials for manipulation by the most basic tools to sophisticated machinery, and an interesting one since it continues to thrive in various scales and modes of practice.

The novelty of plywood does not necessarily lie in its formal technical inventiveness but more in its wide adoptions and effects on building, furniture, engineering and other manufacturing related industries. The non-hierarchical and democratic approach of craft and plywood embodied, in its essence, the attitude of the twentieth century, with a sense of optimism. With its success both in covering flat surfaces and in creating curved planes, plywood came to be known as an efficient material for its thin, lightweight, and durable quality. These characteristics were central to the modern world in the sense of aesthetics and practicality: A stylistic break from the past, while facilitating workability from early industrial manufacture to transportability around the world.

The current landscape returns the potential for wood to be used once again as a sizable mass, not necessarily as a naturally grown solid timber but one that is achievable from the process of aggregation and lamination. In addition to widening the domains of possible applications that are contingent on changes in building codes, it has produced unprecedented scales in wood-based architecture and increased visibility of large scale wooden structures. Another is the continued reduction in the scale of fiber and particles integrated with other materials to create a new composite, which may develop further with the advent of new combinations and tools to process them. This category tends to further advance the homogeneity of engineered wood material. Supplementary attributes to make wood more resistant to external stress such as fire, moisture, insects or decay, are steadily refined. On a more experimental level, there are approaches to use wood's inherent behavior to an advantage: From a dimensional stability that was first typified by the plywood material, there are researches on how to use shrinkage and expansion of wood to amplify such changes into design and structural means. Attempts like this stem out of predictive parameters of behavior, a growing set of data that, in the case of wood, has been accumulated from craft practices to industries.

Through cycles of nature dependent on the growth of forests, advancements in associated fields, technologies and sophistication of techniques, the descendants of plywood will continue to expand in their variations, as the decades of engineered wood product derivatives indicate. Although plywoods and the like rely on the industrial context for their production both as a material and a product, they have also granted anyone from individuals, artists, researchers, artisans to factories, to modify and to adopt the material for miscellaneous purposes with additional access to tools. In the process, reversal of preconceived ideas and breaking of aesthetic rules have taken place, in of how wood should be used or how they should be expressed. These transformations will likely keep the wood industry and crafts robust in the choices of ever diverse domain of materials.

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<sup>1</sup> Reiser and Umemoto. *Atlas of Novel Tectonics*. New York: Princeton Architectural Press, 2006. p 236.

<sup>2</sup> Bijker, Wiebe E. *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge, Mass. and London: The MIT Press, 1997. p 13.

<sup>3</sup> Lyotard, Jean-Francois. *The Postmodern Condition: A report on knowledge*. Manchester: Manchester University Press, 1979.

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