



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. A key transition took place during the period of wood to plywood development, from catering to the privileged to the masses, from patrons to consumers, from skilled craftspeople 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.

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.

The adaptability of plywood encouraged a wide range of scales and applications from furniture, architecture to civil engineering, serving both as a material and as a product. It could be expressive of its materiality, as in moulded furniture, or eliminate its expressivity entirely, such as in concrete formwork. The successful commodification of the plywood product has significantly affected the structure and building process toward overall architectural compositions through the impact of its standard sizes – 4 x 8 in the US or 3 x 6 in Japan – which has been exceptionally consequential in the construction industry from the scales of other materials, components, and buildings.

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. 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.

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.

In 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. 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* – interchangeable in its meaning as the mould, form, or original prototype – which determined the quality of repeated production, regardless of the scale of the production. 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.

Architecture today is reliant on premises of both industrialization and craftsmanship. 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. Another is the continued reduction in the scale of fiber and particles integrated with other materials to create a new composite, in development with the new combinations and tools to process them. 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. 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.