The Five Ages of Wood

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Archeologists have long described civilizations by their technological achievements. Terms such as the Stone age, the Bronze age and the Iron age are used to characterize leading materials and associated technologies of civilizations.

Round log construction 1900, Marcell, Minn.

Considering the history of construction in North America, I divide the almost 400 years into five overlapping ages. *Shaping*, the minimal refinement of the tree; *Joining*, the moderate refinement of the tree into frames; *Commodity*, major refinement of the tree into small parts; *Transformation*, the disassembly and reassembly of the tree; and *Reconstitution*, the breaking down of the tree into particles no longer recognizable to the naked eye as wood, combining with other materials, and being cast, extruded, or molded into shaped forms and products.

Scribed, squared log construction, Embarrass, Minn 1910

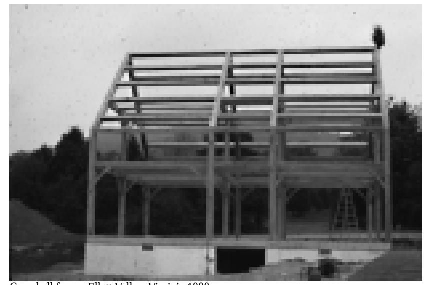
A unique characteristic in American wood technology is that the technology and methods of previous ages are never completely eliminated, simply decreasing in market presence.

The first age of wood, Shaping, was an age where the economy of labor outweighed concerns for economy of material. In North America, this age began in the early 1600's in the Delaware Valley,[1] persisted through the settlement of the Great Lakes forest in the early 1900's and survives today as a specialty market, primarily for vacation and second homes. In this age, the pieces refined from the tree were large (the bole) and the components used in building were large (the log). Building in this age was often seen as an expedient means of providing initial shelter, with more permanent structures to follow. The log cabin was the recognized building method of this age. Trees were felled near the construction site by the builders to minimize transportation.

Lock joint in squared log construction, Embarrass, Minn. 1913

The amount of effort invested in preparing the logs was proportional to the intended permanence of the structure, but was usually much less than required for timber frames[2]. Winter shelters for loggers often left the bark on the logs and relied on large areas of chinking to seal log joints, while Finnish settlers in Minnesota squared two sides of the logs with a broadaxe, adze or pitsaw, and scribed the fit from one log to another for a nearly airtight seal[3]. The exterior of these squared logs were often covered with bevel or drop siding over firring strips[4]. (the first ventilated exterior wall construction). Corner joints ranged from simple saddle notching to refined dovetail and lock joints. The exterior envelope in this age was almost monolithic wood, with no subsystems running in the walls, and no insulation beyond the logs themselves. Heat was provided by a wood burning fireplace made of wood and clay, a substitute for masonry...or was masonry the earliest wood substitute?

The age of Joining closely paralleled the age of shaping, overlapped the age of commodity, and was almost always perceived as a permanent way of building. During this age, the pieces of the tree used for building were smaller than the full bole of the tree and the bents these were assembled into were larger than one person could handle. This age began with the earliest settlements on the East Coast and persists today in the upscale home market. The builders in this age also felled trees themselves, usually near the site of construction, then sawed, or hewed them into square or rectangular sections. The squared members were assembled into skeleton frames traditional to European immigrants, and raised with the help of the community.



Campbell frame, Ellett Valley, Virginia 1988

Campbell frame detail, Ellett Valley, Virginia 1988

The members of the skeleton frames were joined together using variations of the mortise and tenon, dovetail, and scarf joints. These joints required a higher skill level and more precise tools than the simple joints of the log cabin[5].

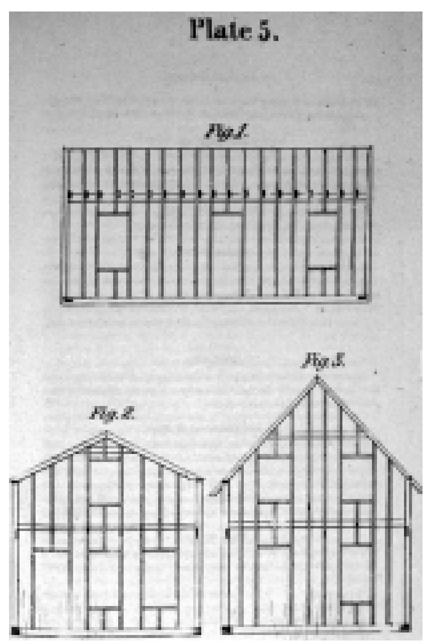
Between the vertical timbers of the skeleton, a secondary wall structure was constructed to form the exterior envelope. This envelope was constructed in a variety of ways including:

- brick and stone masonry,
- cordwood and mortar,
- wattle and daub,
- scantling, clapboards, lath and plaster.

The brittle materials infilled between timbers required constant maintenance to repair the opening of cracks, as both wood and masonry reacted to moisture and temperature differently[6]. Ultimately, the scantling infill proved most compatible with timber frame while the combination of masonry and timber reverted to masonry bearing walls with timber spanning members.

The age of joining overlapped with the early age of commodity when the incorporation of water, sewer, gas, electricity, and telephone systems into walls and floor was common. Heating was still provided by the fireplace, primarily masonry, with cast iron fireboxes in the latter portion of the age.

The third age of wood I call the age of commodity. In this age, the carpenter no longer begins the building process by felling trees. In this age the carpenter begins by ordering lumber, the tree having already been reduced to small standard sized pieces, light enough to be moved by one person. These small pieces of lumber are the end product of an industrial process extending back to the lumberjack in the forest[7]. Steam is the force behind this process driving railroads, sawmills and riverboats bringing trees out of the forest, through the mill, and delivering finished lumber to the growing prairie towns.



Balloon framing diagrams, *Carpentry made Easy*, William Bell, 1858

These small pieces of wood are assembled into a light structure described as being more like a basket than a skeleton by advocates and derided as being “light as a balloon” by critics[8]. Whatever the name, this light wood frame was rapidly adopted across the west by settlers, miners, and speculators who could build this frame with fewer people, simpler tools, and less skills than the timber frame required. This frame was very similar to the “scantling” infill used by timber framers but was controversial for the lack of large members and proven joinery.

The machine made nail, steadily increasing in availability as a building commodity since the late 1700’s, was the key to the simple family of end, face, and diagonally nailed joints making up the balloon frame. Timber hybrids (the combination frame) and derivative methods (western platform) began to emerge almost immediately and were slowed only by the publication of books and articles in widely read agricultural journals proposing "proper methods" of "ballooning." Sheathing, made of 1x6 boards fastened with two nails to each stud kept the basket stable under lateral loading. The resulting 112 nails in 32 square feet made an impressively rigid integrated frame and enclosure. The "Country Gentlemen" a popular serial of the time reported a balloon framed house rolling across the prairie during a tornado without sustaining appreciable damage[9].

Interior finishes were plaster on lath with wallpaper a popular fix for plaster cracks common in structures built of uncured or partially cured lumber. Structures of this age were heated by stoves or fireplaces initially and coal fired gravity and forced air furnaces in latter stages. Like the structures of the age of shaping, these balloon frames were virtually all wood. (structure, enclosure, roof, floors)

The combination of population explosion and resulting demand for forest products (and resulting shortages) would drive the development and introduction of many wood replacement materials. By the early 1900's all major producers of precut houses were offering a composition shingle option[10].

By 1929, asbestos was being heavily promoted as an alternative to the cedar shingle and composition roofing. Asbestos reinforced siding was promoted as the maintenance free alternative to painted wood siding[11].

The western platform derivative of the balloon frame, with integral firestopping provided by top and bottom plates of the wall assemblies, use of shorter lumber for studs, and floors as integral work platforms were easily observable advantages leading to its rapid diffusion. The platform frame came to be riddled with holes for doorbell circuits, power and lighting wires. Plumbers took their cut of the frame as well with galvanized steel pipe replacing lead for hot and cold water supply, cast iron waste lines, & black iron pipe for gas.

Prior to 1929, enhancement of the thermal performance of the stud wall was limited to the application of a layer of building paper between the sheathing and siding. Aside from a few experiments at insulating by placing brick (held more moisture, accelerated deterioration) or fire place ashes (burned down a few houses) between the studs or back plastering of the stud cavity, thermal performance hadn't improved much since the balloon frame's inception in the mid 1830's[12]. Reducing heating bills hadn't been much of an issue to early builders, as the occupants of these light frames regarded them as primarily being shelter, not the climate controlled environment expected today.

The 1930's brought a host of insulation products to market. Mineral wools, poured Gypsum, and eelgrass in paper quilts were all marketed to reduce coal bills[13]. Generally these insulation values were low enough that the furnace was still pumping heat through the walls, keeping stud cavities warm and dry.

The 1940's and 1950's generated little change to the construction of the structure and enclosure. Platform framing, which began appearing in western towns as early as 1850, now dominated homebuilding, and gypsum board held an established place in the market.

The age of transformation overlaps the age of commodity at about 1950. During this age, the tree is reduced to smaller parts, still identifiable as wood, but no longer a solid piece subtracted from the bole. Subcomponents were increasing in size to reduce labor costs and required skills. Up to this point in time the craftsman had to respect the dimensional limits of the tree when building. Plywood, became the first material to transform wood products beyond the tree's dimensional limits.

Plywood sheathed modular house, Blacksburg, Virginia 1989

Plywood, found in Egyptian tombs, had been around since the late 1800's in the furniture industry and had become an important material for the aviation industry in World War I and II[14]. It was proven as a building material in the early 1930's by the Forest Products Laboratories series of prototype houses featuring 1/4 inch plywood panels mounted to insulated 2x2 frames forming the early stressed skin panel. The series of prefabricated houses constructed in Madison, Wisconsin, Chicago, Illinois and Fort Wayne, Indiana proved the performance of plywood in extreme heating and cooling conditions of the Midwest[15].

Plywood did not effectively replace solid sawn boards for sheathing and subfloor until the 1960's. The adoption of plywood was a vote for simplification by the building industry. Replacing 16 – 1x6's with one sheet of plywood requiring half the nails was a significant advantage to builders who readily adopted it. The plate truss for roofs was a similar innovation – where one component replaced multiple parts – which was rapidly adopted in the 1970's .

The oil embargo and subsequent energy crisis of the early 1970's complicated the age of transformation. The exterior wall was now asked to have so much thermal resistance that the condensation point could occur within the wall assembly itself.

This was the beginning of "solve a problem – make two more problems" in light wood construction which affected issues from air quality and material durability to structural integrity.

To solve the condensation problem and reduce air infiltration, vapor barriers were introduced which sealed up the interior keeping warm air and water vapor out of the stud cavities (except at electrical outlets.) That solved the condensate problem - except in moist air conditioned climates… but now the inside of the house, made of a broad array of transformed materials - fiber, flake and particle boards, along with the adhesives used in the flooring, and VOC's in lead-replacement paints made indoor air quality a problem – an issue to be addressed.

Polystyrene vent chute on OSB over fiberglass batts at eave. Allegheny St. Houses 1999

So the oil embargo caused the energy crisis, which led to higher insulation values, which led to condensation, which led to vapor barriers, which exposed air quality problems with the materials of this age of transformation. Adhesives in the board materials were reformulated, as was paint (which brought mercury to the painted interior) and a ventilation system was added to the house. To save energy, the ventilation system used a heat exchanger to warm incoming air, which condensed the moisture out of the exhaust air causing freeze-ups of the exchanger, and making a habitat for mold and mildew growth. This often meant one more duct system and set of control wires to be drilled into the frame.

Housewrap, taped window joint over OSB. Allegheny St. Houses 1999

All this insulation, air exchange, and better windows was driving up the cost of housing and simultaneously people were becoming less interested in scraping, sanding, and painting their house every five years. Asbestos had already been ruled out as an acceptable material – the perceived need for its removal as shingles and siding created a new industry in itself. Transformed wood materials – hardboard, chip and flake board appeared as lower cost alternatives to plywood or solid sawn siding and trim. These materials were less tolerant of exposure to moisture than those they replaced, exposing weaknesses in design and execution which had crept into practice. Their premature deterioration is raising awareness of the relationship between design, execution and durability, especially where water protection from overhangs, flashing and grade termination is required and increasingly in the development of drying mechanisms for exterior wood walls.

The seemingly unforgiving state of materials in the age of transformation seldom applied to traditionally designed houses having solid sawn members making up the framing. These members had changed little in the 140 years since their introduction and siding or trim failures were seldom severe enough to compromise the integrity of the frame. This changed in the late 1980's and early 1990's. The movement away from maintenance that began in the 1930's with the introduction of asbestos roofing and siding, had been slowly gathering steam. By 1990, vinyl siding, vinyl clad or PVC windows were all positioned to sweep wood from the exterior of the house. In areas of Southeastern Virginia and North Carolina, EIFS systems, commercially successful for decades, were marketed as an upgrade from vinyl siding, costing less than brick. These Exterior Insulation and Finish Systems – acrylic stucco over expanded polystyrene insulation, combined with vapor barriers on the interior face of the stud meant trapped moisture. In this warm climate, the biological agents of deterioration flourished, and as the wall had no way to release water condensing or passing into it, and framing rotted, compromising the structural integrity of the house in remarkably little time.

The age of reconstitution seems to be just beginning. Trees are being reduced to their constituent parts, individual fibers and cells, perhaps ultimately as molecules. These parts, small enough that their origins in trees are not apparent to the naked eye are recombined with plastics in extruded, molded, and cast components. These materials may ultimately make it possible to extrude no maintenance, self draining, highly insulating, structurally continuous walls having integral conductors for power, telephone, network, and home automation systems. Perhaps the process will simultaneously extrude circuits of heating and cooling conduits.

The trends in products since 1604 are towards reducing the tree into smaller and smaller parts. First the log, then the timber, then the stud, then the flitch, then the flake, then fiber, then cell, headed towards molecule.

The trends in building since 1604 is bigger components, taking more horsepower, but less skill to be erected by more and more specialists – subcontractors, each having discretely evaluated their own process and product with proclamations of superiority.

The trends in design since 1604 is bigger, thinner, lighter, with more windows, more control of indoor climate, and less responsibility to anything outside. No maintenance, no porch, no neighborhood. Materials are engineered closer to their performance limits, design and labor practices have been pared to near minimums affording little or no tolerance – no forgiveness in the system - for a mis-step by a subcontractor, a wood scientist, or an architect. It's not a grim present or hopeless future. But each of us has to become an advocate for tolerance, and prepare for error, or failure of the subsystem or material next to ours. Our wood centered homebuilding industry has to come to some agreements on how new materials, subsystems, practices, even designs should be tested for performance and compatibility in assemblies, across a wide spectrum of thermal, moisture, and structural loading over time before they come to market.

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