POST-WAR HOUSE PANELLING MATERIALS

by

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INTRODUCTION

For years architects, contractors, and housing authorities have been searching for an ideal panelling material for use in house construction. Years of expenditure of effort and money in research has resulted in several products which approach in varying degrees the ideal construction material desired by the building profession.

The definition of the ideal panelling material is presented by the Temporary National Economic Committee in its Monograph No. 9. This monograph is accepted by building authorities as the most complete work to date on the subject of low cost house development. The following quotation is from the monograph:

"The ideal building material for greatest efficiency in the building of houses should possess the following qualities:

(1) It should be light in weight.
(2) It should be structurally strong.
(3) It should be durable.
(4) It should be fire-resistant.
(5) It should be moisture, weather, and sound proof, and should have a low rate of expansion.
(6) It should lend itself readily to molding in large panels or sections.
(7) It should be easily bonded together to present
either a smooth or broken finish.

(8) It should have permanent exterior and interior finishes in a variety of colors molded into the units as integral parts of the material.

(9) It should be adaptable to assembly in either traditional or modern design.

(10) It should be inexpensive to produce in large quantities, and available throughout the country.

It is the purpose of the author of this thesis to present the qualities of the wall products which have been developed by manufacturers, their relative advantages and disadvantages in the light of their use in the post-war era of building and reconstruction.

To obtain up-to-date information on products, letters were sent to 35 different building product manufacturers throughout the country requesting data on their respective products. The cooperation of these manufacturers was excellent and sufficient information was obtained to make this survey of their products and their methods of manufacture.

Both wood products and their competitors were considered in this survey in order to present a broad view of the field.
POST-WAR HOUSE PANELLING MATERIALS

PLYWOOD PRODUCTS

Although plywood has been used for several thousand years, it was only during the last decade that industrial chemists and engineers developed the synthetic resins and hot-plate presses which permit the manufacture of an unassailable product. Now, utilizing phenol formaldehyde resin and other superior adhesives for a bonding agent, the plywood industry manufactures large quantities of plywood for both the aircraft and ship-building industries as well as technical grades for applications which require resistance to unlimited soaking and a degree of heat up to a point at which the veneers themselves will char.

Douglas fir plywood is perhaps the most famous of all the various types of plywood now being produced in this country. It is an engineered wood board or panel and consists of an odd number of sheets of Douglas fir veneer placed crosswise and bonded together under hydraulic pressure with water-resistant glues which are stronger than the wood itself. The result is strong, serviceable panels generally ranging in size up to four feet wide and eight feet long, and even greater dimensions when desired.

The strength is obtained because the strength of wood along the grain is capitalized in both directions. Shrinkage is minimized to a negligible amount because, although
wood tends to shrink crosswise it has almost no shrinkage lengthwise. Thus we have in plywood a product that is strong, rigid, and split-proof, in large panels of practically and thickness from 1/8 inch to 1 3/16 inches in standard sizes; a product finished naturally, stained, or painted. It is easily worked, has considerable insulation value, and is economical to use, not only from the standpoint of initial cost and upkeep, but also, and perhaps principally because of the great labor savings effected in the ease of handling the large panels. (1)

Grademarks and Trademarks

As the Douglas fir region is the largest producing area of plywood in the United States, a description follows of the grades and trademarks which have been developed by the Douglas Fir Plywood Association. This association is a non-profit organization of United States manufacturers of Douglas fir plywood, founded to sponsor a continuing program of technical research, to promote the use of this material in construction and industry, and to help users employ it to the best advantage.

A grade and thickness of Douglas fir plywood suitable for virtually every purpose is now available and is made to conform with the moisture-resistance standards set forth in U. S. Commercial Standard 45-40.

Registered grade-marks and trade-marks for all standard panels have been adopted by the DFPA mills. The grademarks
have been trade-marked and are as follows:

1. The word "Plywall" appears in a square stamp on the back of every panel of Douglas fir plywood wallboard grade.

2. The word "Plypanel-DFPA" appears on the edge of every panel grade of Douglas fir plywood.

3. The word "Plyscord" appears in a circular stamp on the face of every panel of Douglas fir plywood sheathing grade.

4. The word "Plyform" appears in a diamond-shaped stamp on one face of every panel of Douglas fir plywood concrete form grade. The edges of the panels are sealed with a silver-green paint for ready identification.

5. The word "Ext-DFPA" appears on the edge of every panel of exterior type plywood, suitable for permanent exterior service.

These grade-marks and trade-marks are designed to protect the purchaser of plywood and to assure him that he will always receive the exact grade he specifies.

**Wallboard and Panel Interiors**

Douglas fir plywood has a "sound" face and a "utility" back. The face is suitable for natural or stained finishes and, of course, for painting or papering. All the face blemishes are cut out in the manufacturing process and replaced with perfectly fitted patches that blend with the
grain of the panel so as to be obscure and generally unnoticeable, even in clear, natural finishes. This type of finishing makes the panel of high quality suitable for any interior whether it be mansion or cottage.

Plywood is air-tight and consequently produces true dead-air spaces within the walls it covers, adding materially to the insulation value of the walls and to the comfort of the home's occupants.

With two coats of asphalt paint on the back, plywood becomes one of the most effective vapor barriers known.

Some of the uses of plywood in house construction includes wall and ceiling panels, partitions, cabinets, built-ins, cupboard doors; base for wallpaper and felt; and as an underlayer for resilient flooring.

Joints may be butted flush, V-grooved, covered with a molding, or have a moulding inserted. A smooth flush joint may be formed by nailing strips to the framework, covering these with a casein glue, and then butting the panels over these glued strips, using nails 6 inches apart to exert required pressure on the glue.

Panel Sheathing

Plywood when used as sheathing has proved to be very effective with its superior rigidity and strength; quick, economical application; air-tightness, and large size. Panels 5/16" thick, applied either horizontally or vertically
have been proved to provide 40% greater wall rigidity than diagonal bracing or sheathing.

The ability to hold nails is another quality that plywood has to a high degree. Nail bearing is the vital property on which the effectiveness of any sheathing or diaphragm depends. Tests at the University of Washington after two years exposure of panels to the weather showed that a force of 85 lbs. minimum was required to pull an 8" cedar shingle (one of a panel group) from its 5/16" plywood sheathing base. Other panels of shingles nailed to 5/16" plywood, after three years weather exposure, were subjected to an 85 mph. wind with no trace of damage or loosening of nails.

Plywood sub-floors result in a smooth, level working platform, and act as insulation in the protection against drafts from below. These sub-floors also provide a horizontal diaphragm to resist earthquakes and high winds. Over the plywood subfloor, linoleum, hardwood, carpeting or any finish floor can be laid to form a serviceably perfect platform.

**Exterior Plywood**

A relatively recent development of plywood research is a plywood panel which is suitable for permanent exterior use. This new panel combines the structural superiority of standard moisture-resistant plywood with a strictly waterproof bond between the plies (guaranteed by the manufacturer)
that renders it suitable for permanent exposure to weather or water. This bond of synthetic resin, hot-pressed, is similar to Bakelite in its action.

Most severe of all its uses occurs in the thousands of Douglas fir plywood boats, dinghys, skiffs, sail-boats, and cruisers, built during the past five years. It is now conservatively estimated that 100,000 exterior plywood boats are now in service in the United States. The demand for exterior plywood in boat construction is increasing continually, a sound testimonial to the adequacy and permanency of this waterproof material.

Exterior Douglas fir plywood was specified by the Army Air Corps in the emergency barracks building program undertaken at eleven air fields in August 1939. Economy, speed of erection, and permanency constituted the basic reason for its selection.

The 1940 National Defense program brought about many additional similar uses for exterior plywood and millions of square feet have now gone into barracks, attack and pontoon boats, fences, and even crates and cases.

More than three million feet were used in the huge plane and curved wall areas of the Treasure Island Fair buildings at San Francisco, while at New York in 1940 the 610-ft. Trylon received a new 50,000 square foot coat of \( \frac{1}{2} \)" exterior plywood to replace the old covering of magnesite stucco on gypsum board backing which was ripped off by wind.
WOOD-FIBRE PRODUCTS

In recent years men have been working on the perplexing problem of how to reduce the tremendous amount of lumber waste which goes to the trash-burner in the modern sawmill. Mr. W. H. Mason, a man who for seventeen years had been associated with Thomas A. Edison was trying to cheat the burner of its lavish feast. If he could discover a way to reduce that waste to fibre, without destroying the "Lignins" which nature uses to hold fibres together, he could make them into a strong, tough paper or, failing in that, into an efficient insulating board. In 1924 he finally discovered a satisfactory and efficient method of accomplishing this purpose, and the following paragraphs describe the interesting process of manufacture which Mr. Mason developed. (4)

Wood-fibre Board Manufacture

Trees which are selected for pulpwood purposes are felled, peeled, and cut into five foot lengths. These lengths are allowed to dry for a period of time and are then delivered to the mill, where they are run through large machines called chippers which cut the wood diagonally across the grain into $\frac{3}{4}$" lengths. These are screened and conveyed to storage bins from which they are run into the guns to be exploded into fibre.

The guns, which are approximately six and two-thirds feet long by twenty inches inside diameter, are filled with chips, the top filling valve is closed and steam is
introduced into the bottom of the gun from a central shooting station, until the pressure in the gun registers about six hundred pounds. The pressure is then quickly raised to from one thousand to twelve hundred pounds and held at this value for about two seconds after which the bottom valve is opened and the gun is discharged into a "cyclone" where the steam and fibres are separated. Less than one minute elapses from the time the gun is loaded with wood chips until the resulting wood fibres are discharged. The fibre is dropped out of the bottom of the cyclone into a stock chest where it is mixed with water and constantly agitated.

The mixture of gun fibre and water from the stock chest is now pumped through refiners. The material from the refiners is screened and such portions as are too coarse are rejected and returned through the refining operation. The accepted stock is pumped into a forming machine stock chest.

As this pulpy mixture is run over the board forming machine, water is gradually withdrawn either by suction or eliminated by pressure rolls. The result is a "wet lap" or blanket which is cut into twelve foot lengths and sent to the presses to be pressed to varying thicknesses and dried.

The pressure used in forming can be varied resulting in boards of varying thicknesses and densities. The thicker
boards formed from a section of "wet lap" have enclosed air spaces, as heavy pressure has not been applied. These enclosed air spaces in the board makes it an excellent insulating material, both for heat and sound insulation. If heavier pressure is applied to the "wet lap", the resulting board is thinner, denser, and has less insulating value. This is the product which is used extensively as wallboard and sheathing.

Other methods of producing fibre-boards have been developed by various companies throughout the country, but their processes of manufacture do not differ to any great extent from the process just described.

Qualities of Fibre-board

Fibre-boards are made of wood and possess many of the better characteristics of wood but are without grain and many of the defects of wood. The following is a list of the characteristics of softwood fibre-boards:

(1) Can be bent easily-- fibreboard can be easily bent or curved in one direction, but compound or "orange peel" curves or moulded shapes should never be attempted.

(2) Workability-- as fibreboard is made from wood, it can be cut and worked with all woodworking tools. Special tools for beveling and fluting have been developed.

(3) Nail-holding ability-- Fibreboard should never be
used as a nailing base as it has very poor nail-holding ability. When installing fibreboard with nails, all nails should be driven perpendicular to the surface of the board and into wood or some similar nailing base. Never toenail into the edges of the board.

(4) **Finish**-- the surface and color of natural fibreboard makes it particularly suitable for use as interior finish. It is smooth, with just enough texture and mottling to provide an interesting surface. It may be left in its natural state, or may be given many types of finishes.

(5) **Combustion rate**-- fibreboard has a much slower combustion rate than wood, due to the removal of the pine oil, turpentine, and other inflammable ingredients usually found in wood. Continuous temperatures up to 350°F for four hours does not have any detrimental effect on the board.

(6) **Odor absorption**-- food odors are not readily absorbed by fibreboard, consequently it meets with ready acceptance for use in shops where foodstuffs are handled and sold.

(7) **Moisture-resistance**-- exceptionally resistant to moisture absorption and is recommended for use as a vapor barrier in walls. It is not, however, recommended for use where exposed to weather.

(8) **Insulation values**-- the thermal conductivities of fibreboard products have been determined by
Professor J. C. Peebles of Armour Institute of Technology, using the hot plate method of test, expressing the results in Btu. per inch of thickness, per square foot, per degree Fahrenheit difference, per hour. It was found that insulation type fibreboard had a thermal conductivity of about .328 Btu.

**Wallboard use of Fibreboard**

As interior wallboard the different types of fibreboard make a good substitute for plywood panels. It may be applied to the walls either by nails and screws or by adhesive application.

The framing of the studs, joists, or furring should be made as in ordinary frame construction, spaced accurately on 12 or 16 inch centers. In the nailing application, all nails should be driven perpendicular to the surface, and toe-nailing is not recommended.

Fibreboard may be applied with adhesive to any solid backing, such as plaster or cement. The adhesive should be applied to the entire back of the board, using a sawtooth trowel having notches approximately 1/8" in depth. The boards should be cut and fitted prior to the application of any adhesive and overnight bracing is required to insure solid bond of the adhesive to the backing. The boards should be brought into moderate contact at the joints, but should never be sprung or forced into place.
Sheathing

For use as exterior sheathing, fibreboard should have a coat of waterproof asphalt on at least one side and the edges, but preferably over the entire board. This coating of asphalt not only provides an efficient moisture barrier but also increases the effectiveness of thermal insulation.

Application should start at the corner of the building with full size boards working toward the center of the wall. Any narrow widths required should be located in or near the middle of the wall. Again, do not force any of the boards into place. The sheathing should be cut to fit snugly around rafters that project beyond the face of studs.

Wood siding can be applied directly over the sheathing and nailed to the studs. Shingles should be secured to furring strips in accordance with shingle manufacturer's specifications.

Preparatory to application of stucco, the sheathing should first be covered with asphalt saturated waterproof paper. Then an approved steel stucco base should be applied, nailing through to studs. Next, flash overhead casings of all doors and windows with metal. No stucco should be applied direct to the sheathing on exterior surfaces, but should be applied in accordance with stucco manufacturer's specifications.

In the application of brick or stone veneer exteriors to fibreboard sheathing, shelf angles for the support of
lintels, etc. and metal wall ties should be nailed through the sheathing into studs or plates. The brick or stone should be set out at least $\frac{1}{2}$" from the face of the sheathing.

Other Fibre-board Uses

Softwood fibreboard has several other allied uses in housing besides its use as wallboard and exterior sheathing. It makes an excellent backing for plaster and is a good substitute and improvement over wood lath. Much less plaster is required to efficiently cover a given wall area.

The hardest grades of fibreboard are sometimes used as flooring, either nailed or glued with adhesive to a level subfloor.

The sheathing grade is sometimes used as a base for shingles in roofing. The result has been more efficient insulation and savings in heating costs.
CANE-FIBRE PRODUCTS

Over a ten-year period of intensive research, improvement, and practical experimentation an efficient new wall-board material has been developed. The product consists of a cane fibre insulation board core, sealed with a special bitustatic compound between two layers of a weather-, fire-, and wear-resistant combination of asbestos and cement. The finished material is light in weight, easy to handle and work, and meets all the basic requirements for a unit thickness wall material.

From the sugar cane country of Louisiana comes bagasse, the basic material of all cane board products. After the sugar has been extracted from the cane, this tough fibred bagasse pulp is processed to separate and sterilize the long, resilient fibres and make them ready for the board forming machines. Here they are firmly felted and woven together in long, continuous board sheets. Color and texture are then added and the units cut and fabricated to their final form.

The fibres of cane are especially suitable for structural insulating units because of their length, strength, and air sealed cellular formation. The insulating efficiency of cane-fibre boards is remarkable—a one-inch layer of cane-fibre board has a heat stop value equal to 3 one-inch layers of plasters board, a 15-inch thickness of common
brick, or 36 inches of concrete.

Some manufacturers treat their products with a chemical treatment which protects it from destruction from termites, fungus growth, and dry rot.

The sturdiness and weather protection provided by cane-fibre board wall construction is illustrated by the standard rain test, using the same type of machine with which the Bureau of Standards makes the test. This machine will usually force moisture through an ordinary brick wall in from eight to ten minutes. After five days of the test, the cane-fibre board wall was penetrated to a depth of only 1/8"--to the asphalt line which cements the asbestos surface to the cane-fibre core, no moisture penetrating the core.

Product Uses and Developments

The utility of cane-fibre boards covers the same field of uses as has already been described for wood-fibre boards. It is used for interior wallboard, ceiling, insulating lath, sheathing, siding, sub-floors, insulation, etc.

In addition to these conventional uses of panelling material in house construction, one manufacturer of cane-fibre board has developed a single unit wall for use in prefabricated housing. Low cost is achieved by the new method of construction which conserves materials, increases labor efficiency, and which utilizes a single thickness wall material in place of the eight or ten separately applied
layers, such as sheathing, building paper, insulation, lath, multiple coats of plaster, wallpaper, and paint employed in traditional wall construction.

The efficiency of the construction method is demonstrated by the fact that the entire exterior structure of the prefabricated house—foundation, walls, doors, windows, and roof—can be erected on a schedule of approximately thirty-five man-hours, or less than one day with a crew of five men. This is a modern combination of methods, labor and materials which alone makes possible the many war housing projects throughout the country.
GYPSUM PRODUCTS

Gypsum rock is a mineral particularly endowed by Nature to fight fire. Regardless of raging flame, the temperature of gypsum will not exceed 212° F. This feature is the outstanding attribute of gypsum building products and a characteristic which cannot be claimed by any wood product.

Tests show that 3/8" gypsum wallboard will withstand flame and intense heat of a normal house fire up to 23 minutes before the framework back is charred. This protection helps to confine fire to its source of origin and allow the fire department to do the rest.

Of special interest to contractors in this period of shortages of building materials--gypsum wallboard is a non-critical material and is available in almost any quantity desired. Also, since gypsum is a rock material it is unaffected by dampness and climatic changes. There is no danger of warpage, expansion, or contraction.

The wall panel itself is made up of a core of processed gypsum rock of varying thickness--1/4", 3/8", 1/2", or 1". The core is enclosed by an exterior layer of heavy kraft paper or other surfaces with special designs such as imitation wood-grain, tile, marble, and limitless color combinations. The surface will also take enamels, eggshell stipple, and paints.
One manufacturer of gypsum products has developed a system of movable wall partitions, sturdy enough to last for the life of the building, yet so simple in construction that they can be quickly dismantled and the materials salvaged. Briefly, the system consists of a framework of 2x4's spaced 4 feet apart to permit the 4 feet wide panels of gypsum to be inserted—the latter units held permanently in place by wood mouldings. The work is fast and the walls go up rapidly—from 6 to 10 feet high and as long as desired.

Gypsum wall panels also have the same uses as wood-fibre and cane-fibre boards in interior walls, ceilings, exterior sheathing, siding, as a base for roofing, and as insulation. It is not suitable for subfloors, however, and cannot be used as a nailing base.
ASBESTOS-CEMENT PRODUCTS

Gypsum and asbestos-cement products have a great deal in common—both are fire-resistant, rot- and vermin-proof, and are unaffected by dampness.

In the asbestos-cement manufacturing process, tough fibers of asbestos are criss-crossed, interwoven, merged together, and imbedded in a selected grade of portland cement. This mixture is placed on carrier trays, sent through a large press, and permanently combined under heavy pressure. Made from these two durable and fire-resistant minerals, asbestos-cement board is a permanent material, possessing natural properties that enable it to resist the action of the elements and the many and varied destructive influences existing in most industrial plants.

It is available as corrugated material for roofing and exterior siding, and as flat wall material for interior uses.
The use of light-gage steel for covering purposes has been growing slowly and not always steadily during the past few years, but is actually still in the experimental stage. At the present time a considerable research program is under way which, when completed, will provide a technical basis for the economical design of thinner and lighter sections formed from steel. It will be apparent, of course, that greater structural efficiency will also result in lower cost.

There are several important factors which determine the present and future practicability of light-gage steel for covering purposes, either interior or exterior. These are as follows:

Stiffness-- Panels should not sound tinny when tapped, neither should they be dented easily when struck by accidental blows. To be satisfactory, they must convey to the observer an appearance of substantial construction associated with the strength of steel. Panels have been made of light-gage steel used either plain, reinforced by stiffeners, crimped, or stiffened by a backing of solid insulating material.

Insulation-- It is well recognized that steel, because of its inherent characteristics, is a poor insulator against transmission of heat and sound. As a result, the use of steel for wall or ceiling panels is always attended by the
requirement of special insulation. Both loose and board-type insulation of many kinds have been used successfully.

**Jointage** -- This feature seems to be a most critical one where light-gage steel is used for exterior wall panels. A wall, no matter how impenetrable the material of which it is made, is no better than its joints. For this reason, many systems of wall construction, otherwise satisfactory, have been abandoned because the detail at the joints did not provide resistance to infiltration of moisture, nor insulation against heat or cold. Many ingenious solutions, more or less satisfactory, have been attempted.

**Durability** -- The question of light-gage steel panels involves primarily their resistance to corrosion. Studies indicate that if steel is kept dry, it will not corrode. Therefore, one of the main problems in steel wall construction is to avoid a metal-to-metal contact through the wall so as to prevent condensation caused by warm, moist air contacting cold surfaces.

**Surface finish** -- Paint, vitreous enamel, and the newer plastic paints and lacquer finishes have all been applied to steel panel surfaces. One method of overcoming the tendency of large flat steel surfaces to accentuate the visibility of very slight waves, is by breaking up the surface into curved or crimped contours.

**Economy** -- A thickness of steel that is sufficient to fulfill the required characteristics of a wall panel has so far been found to cost much more than non-metallic materials.
SUMMARY

None of the various types of panelling materials just considered completely fulfill the qualifications of the ideal construction material as put forth by the Temporary National Economic Committee in its Monograph No. 8. All of the described materials fail in one or more of the requirements:

(a) Plywood is not sufficiently fire-resistant and could be more durable. It does, however, have a great nail-holding capacity which none of the other materials has.

(b) Wood fibre-board is not weather-proof or structurally very strong under compression or tension.

(c) Cane fibre-board is not as yet available at a low cost and in large quantities throughout the country.

(d) Gypsum wallboard is not structurally strong under compression, tension, and bending stress. It is, however, very fire-resistant.

(e) Asbestos-cement board is not sufficiently durable against shock impulses and should be lighter in weight. It is very weather- and fire-resistant.

(f) Steel panelling is still in the experimental stage. At present it is too expensive to produce, rusts easily, and is too heavy and hard to handle and work.

Research programs now being carried forward by the government and private industry should soon improve and
perfect the basic building materials of the future—the past ten years alone have produced remarkable new developments in the building profession. It is not saying too much to predict that in the near future we will be able to select an attractive house from a catalog as we now do our automobiles—and these houses will be prefabricated, movable and made of steel, aluminum, or even glass. Nothing is impossible.
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