Home Construction
By Prefabrication

By

L. W. Anderson
Home Construction
By Prefabrication

by

L. W. Anderson

A Thesis
Presented to the Faculty
of the
School of Forestry
Oregon State College

In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science
June 1947

Approved:

Professor of Forestry
# Table of Contents

List of Illustrations ........................................ ii

Introduction ..................................................... 1

Chapter II Increasing the Efficiency of the Home Building Industry by Prefabrication ........................................ 5

Chapter II Problems confronting the Prefabricators ................ 13

Chapter III The More Important Methods of Prefabrication .......... 19

Chapter IV "Prenco Homes" -- Typical Example of Modern Prefabrication ........................................ 24

Bibliography ...................................................... 41

Appendix .......................................................... 42
LIST OF ILLUSTRATIONS

Figure I Specialization in Construction of Panels .......................... 8

Figure II Conveyor Belt used in Assembly Line Construction .... 9

Figure III Chain Type Overhead Conveyors ......................... 10

Figure IV Roughing in of Panel Wiring ............................. 21

Figure V Basic Selling Prices of Prenco Houses ...................... 26

Figure VI Section of Prenco Home Crated for Shipping ............. 27

Figure VII Loaded Truck Ready for Departure from Plant ........... 28

Figure VIII Prenco One-Bedroom Home Floor Plan .................. 29

Figure IX Prenco Three-Bedroom Home Floor Plan ................. 30

Figure X Prenco Two-Bedroom Home Floor Plan ...................... 31

Figure XI Exterior Wall Panel Showing Windows and Ventilators ... 33

Figure XII Kitchen-Bathroom Wall Section Containing Roughed-In Plumbing .... 35
Introduction

The purpose of this thesis is to familiarize the reader with the Prefabrication Industry and what it has to offer the public, why there is a need for the economy which prefabrication can bring to the Home Building Industry, and what problems confront the prefabricators.

As defined by Commercial Standard, C. S. 125-45, "a prefabricated home is one having floors, walls, ceilings, or roof composed of sections or panels of varying sizes which have been fabricated prior to erection on the building foundation. This is in contrast to the conventionally built home which is constructed piece by piece on the site."

According to a 1946 Fortune survey conducted by Elmo Roper, "Approximately 70% of the people admit to having heard of prefabricated houses. However, only slightly over 50% seem to know what they are, and only 16% say they would be interested in living in them. Advertising and public relations programs would therefore appear to be in order (among veterans, however, 27% are interested in prefabricated housing). 33% say that they would consider a prefabricated house only if they could get nothing else. People in this group were asked: What don't you like about a prefabricated house? Their answers were as follows:
Based on those answering question 67.4%  Based on total sample 22.2%

<table>
<thead>
<tr>
<th>Unsatisfactory constructions</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack individuality</td>
<td>13.4%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Too small</td>
<td>4.6%</td>
<td>1.5%</td>
</tr>
<tr>
<td>All other</td>
<td>18.4%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Don't know</td>
<td>9.6%</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

Some of the reasons given for this answer were (1) not substantial enough, (2) not strong enough, (3) not permanent, (4) not warm enough.

The exigencies of war forced vast changes upon the entire residential building industry, and more particularly upon the prefabricated home manufacturing industry. (1)

There were only approximately a dozen outfits regularly producing and marketing prefabricated houses before World War II, their output making up less than 2% of the entire residential construction production. From this fact, it can be seen that prefabricated housing before 1941 was not a very important factor in the Home Building Industry.

There is a tremendous shortage of adequate housing in the nation at the present time. The shortage has arisen due to many and varied factors. Perhaps the most important reason why we are facing a critical housing situation at this time is because of the "built up" deficit of homes which has been taking place since as far back as 1900. (2) This deficit has been brought to a head by the tremendous effect the war has had on the building program.
During the war, the government had to practice strict regulation and control over the construction of all types of structures. These wartime restrictions placed a complete ban on residential construction. There was a heavy governmental demand for building materials for military installations creating a critical shortage of even those building materials needed for upkeep and repair of existing residences. The accelerated marriage rate brought about by the war meant an abnormal increase in the number of families in the nation, bringing more pressure for available and livable dwellings. The "all-out" war effort brought thousands of families to industrial centers for employment. Many of them will never return to the place from which they came, creating an immediate need for more permanent residences in their places of immigration.

"Between 1900 and 1940 there were 17,791,000 new homes produced. During the same period there was a net increase of 17,967,000 new families--leaving a deficit of 176,000 homes. Add to this all the homes destroyed by fire in those 40 years--those which depreciated to uselessness--those demolished or taken over to provide for the rapid commercial and industrial expansion of the business centers of our cities and you have the background for our present housing shortage."(2)

The National Housing Agency estimates that during the first post-war decade an average yearly construction
of 1,260,000 non-farm dwellings will be required. After that time, the yearly rate of production would have to be 800,000 units per year continuously to maintain the housing supply of the country. Construction during the period 1920-29 averaged 700,000 units annually. In the peak year, 1925, a total of 937,000 units were built.

This estimate of annual post-war need is based on a requirement of 410,000 units per year for increased families, 140,000 units per year for returned married veterans, 80,000 units a year for those families now jointly occupying homes, and to establish a normal vacancy reserve, and 630,000 units per year to replace substandard dwellings and those destroyed by fire storm and other disaster.

The question is -- Why haven't enough homes been produced to meet the current deficit? It is not because there weren't enough materials to build them with, or enough men to do the work, -- it is simply because a new home has been an unattainable luxury for such a large proportion of our families that the market for new homes at the necessary price could not be expanded.

Then the question is asked -- Why haven't housing costs been reduced in step with the reduction in cost of other articles. It is simply because mass production and distribution techniques have not been introduced into the Home Building Industry as they have in most other industries.
CHAPTER I
Increasing the Efficiency of the Home Building Industry
by Prefabrication

The real solution to the home building problems is to increase the efficiency of the Home Building Industry with incident lower costs. The Home Building Industry needs to be reorganized along the lines of our great mass production industries. Planning and action toward this goal of mass production housing is mandatory if the needed houses are going to be provided for the families of our nation. Prefabrication is the answer.

Lower Costs.

The whole American economy is based on mass production. It is an accepted fact that mass production increases efficiency. Increased efficiency brings about lower per unit costs. By increasing the efficiency of the Home Building Industry through mass production, the ultimate consumer cost of a home lessens.

In 1941, a new industry came of age. This industry, Prefabricated housing, embraces a rapidly increasing number of factories or shops in which house walls, partitions, ceiling and roof panels are prefabricated in completed units, shipped to the job, and erected in a short time.

Prefabrication leaped into prominence during the past few years because of the urgent demand for defense housing,
but it had already established itself on a sound, practical basis in various sections of the country.

Several factors had contributed to the development and acceptance of this new method of building houses. First was the national interest in better housing. Second was the phenomenal growth of the plywood industry. Third was the prefabricated house built by engineers of the U. S. Forest Products Laboratory of Madison, Wisconsin, in 1935. Many types of prefabricated houses had been tried already but with little progress toward the desired goal. When, however, these engineers actually built a practical prefabricated house, erecting it in a few hours, attention was immediately focused on the methods and the materials. This demonstration proved plywood to be almost the ideal material for which they had been waiting. Douglas-fir plywood over a skeleton frame has become the standard material with prefabricators from coast to coast.\(^{6}\)

Plywood's preeminence in this field is due to its unusual and well-established structural properties, its large panel size, and the ease with which attractive yet economical finishes may be applied.

Tests at the U. S. Forest Products Laboratory have proven the superior rigidity imparted to a frame or wall when it is covered with plywood. Gluing plywood to the framing is tremendously effective because it creates a "stress-covered" panel, famous in airplane construction. Such plywood units possess remarkable strength and stiffness
yet are so light as to be easily portable. Plywood is quickly applied at substantial savings in time.\(^{(6)}\)

Prefabricators boast of certain outstanding advantages of prefabrication over conventional house building. They are:

1. Shop work can be systematized and is much faster than field work, there being no delays for bad weather. Figures I, II, and III illustrate just how much systematization can be obtained in prefabrication shop work.

2. Greater speed minimizes overhead.

3. Greater accuracy and control are obtainable.

4. Glued construction far superior to nailing is made possible.

5. Foundation work can be carried on simultaneously with shop assembly

6. Field erection is accomplished in hours and days as contrasted with weeks and months.

7. The result is generally an overall economy in favor of the prefabricated house.

The extent of economical prefabrication depends upon several factors, the most important of which are the weight and strength of their parts and their ability to withstand handling.

Shop prefabrication has certain advantages. It capitalizes on the time saving made possible by mass production and the use of power machinery. It uses the specialization
Note the proximity of all materials required at each table. Each worker does one specialized job on each panel and then it is sent on for more workers to each do their special job on the panel—no worker doing varied types of tasks. By continually doing the same job on each and every panel, every worker becomes more efficient, wastes less time in lost motion, and puts out workmanship of greater accuracy with greater speed.
A second type of assembly line technique in which a conveyor belt passes through the center of the working space, with tables of workers on each side, constructing panels.
At least one manufacturer (Gunnison Homes, Inc.) uses overhead conveyors to speed production. Similar type overhead conveyors are used in many of the automobile manufacturing plants.
of men and machines which made possible mass production in other industries. Houses may speedily be brought to an advanced state of construction within the shop while the site is being prepared and roads, sewers, water lines, and utilities are being brought to the location. Selection of stock is simplified, permitting the use of odds and ends of lumber which ordinarily would be scrapped. Also, factory fabrication, being independent of the weather, is capable of uninterrupted production. (7)

However, the results of these advantages have not always been evident on completed projects. Unsatisfactory joints between prefabricated section, failure to protect finished parts in transit to location, a general inflexibility, and the incapacity to easily make individual adjustments to the site conditions, have been some of the more noticeable failures.

Production.

The actual productive capacity of the established prefabricated home manufacturers is an unknown quantity. Estimates vary with degree of experience or optimism of the estimator. Established concerns with a producing record to guide them have a fairly accurate idea of what their plants can do -- given the materials and labor to do with. But there remains the unknown quantity of houses that will be turned out by newcomers to the field in addition to those whose only experience was limited to the production of war housing. This group grew up on prefabricating standardized
units and has yet to meet head on public reaction to its method of construction and architectural styles. (1)

An official effort (by the Federal Government) definitely is to be made to expand mass prefabrication of houses, an effort for 600,000 units for 1947. To get the industry on its feet, the Government is to subsidize production of materials needed and give them high priority on these materials. Then it will guarantee the market for the final product. Government analysts are estimating that the newcomers will be able to cut costs by 40% to 50% making home ownership available to the higher paid $1/2 of the nation's income earners rather than just the upper 15% to which home ownership has largely been limited now. Thus it could triple the market for home sales. (3)

Variation in Design.

Prospective buyers will have a wide range of floor plans and exterior elevations from which to make selections. Most of the older and larger manufacturers expect to produce more than one model. Several will have four or five, a few will reach as high as twenty, and at least two have announced that as many as fifty models will be available. Interesting is the fact that by far the majority of the prefabbers plan to produce houses of traditional design, leaving the experimentation with "Modern" types to the more venturesome of their contemporaries. (1)
CHAPTER II

PROBLEMS CONFRONTING THE PREFABRICATORS

The big hurdle confronting the prefabricators is the development of a sound and economical method of merchandising and distribution. This involves not only transportation to the site, but also erection at the site. Commenting on this particular obstacle, pioneer prefabricator, Foster Gunnison, president of Gunnison Homes, Inc., New Albany, Indiana, said. "The prefabricated home industry's success or failure in the post-war period will depend upon the soundness of the method of distribution it decides to follow. Before the war, the Industry was in the research and product development phase -- with the Government as its sole customer. After the war, the Industry will enter its distribution phase. If it chooses the right method of distribution it will succeed -- if it chooses the wrong method it will fail."

With unimportant exceptions, distribution up to this time has been limited to "economical trucking distance" from the manufacturer's plant. This has varied with different firms from less than 100 miles to as many as 350 miles in isolated instances. A definite pattern is being established, however, in the expansion programs of several of the larger established prefabricators. It is to "regionalize" production by building plants at strategic points across the nation.
in order to serve all areas where the potential market is sufficient to justify full time manufacture. The alternative solution to the distribution problem is to fabricate sections in panel form so that they can be readily shipped by any available means — truck, rail, or water.

Site erection, the last step in the distribution process, will be handled, in most cases, either by the prefabricator using his own specially trained crews, or by the "authorized dealer" using his own erection force. This latter method would make the entire merchandising and erection operation one purely local in character.

Most plan to sell to conventional or operative builders who will erect and sell the houses in the usual way. Others will try to sell through department stores, leaving erection and other problems to be handled by various means. Some will work through local lumber dealers, and a few may have the money and ability to set up independent sales organizations, operating in much the same way as automobile dealers.(8)

Building Code Problem.

There are about 2000 different state and local building codes in the United States to plague prefabricators. They tend in general to indicate how house parts shall be made, not what they shall accomplish.

These codes embody a rich diversity of obstacles to the new type of house and to better methods of putting together the conventional house.
For instance, they may assume that walls are necessarily framed with 2 x 4 lumber, sixteen inches on center, with lath and plaster on the interior, sheathing and siding on the exterior. Such walls have been tested in comparison with prefabricated panels and found to be weaker in some cases, but to build a house where such a code exists, the prefabricator must persuade code officials to adjust their codes, and, failing that, take the case through a series of courts. Many of the most flagrantly uneconomic provisions of the codes can be traced to pressure from the labor unions or from producers of building materials; others are still on the books only because nobody has bothered to check up on them.

For example, the last time the City of Chicago Council tried to revamp the code it took them eight years to accomplish nothing, as the rewritten draft was shuffled through the legislative processes of the council, it was crumpled all out of shape by pressure from labor unions, contractors, materials dealers, and other proponents of the status quo. Finally in 1941, a so-called new code was passed -- a document of some 600 pages of fine legal print that might just as well have been published in 1908.

The restrictions which have stirred up most criticisms are concerned mainly with protection against fire and disease. Fire restrictions for example make it impossible to build an ordinary wooden dwelling in the protected area --
some 9/10 of the city. Therein, all houses must be of masonry or reinforced concrete, which is obviously one protection not only against fires, but also against the economic decline of people who make bricks and lay them. Another equally protective measure prevents a house-owner from using his fireplace for any such house-warming gadget as a gas or electric heater, unless, of course, the fireplace has a brick, stone, or concrete chimney. Likewise, in the name of fire security, the code demands that walls and ceilings, even in basements must have a lath or gypsum base plus three coats of plaster of exact thickness. Chicago's plasterer's have been well considered.

Still more consideration comes under the guise of a code health regulation that, in effect, prohibits the use of any kind of wall boards. For example, gypsum board, certainly as fire resistant as plaster, are forbidden because the cracks between the boards can harbor germs. Hence, wall surfaces in Chicago must be seamless, a natural characteristic of plaster -- until it cracks. In another health provision, the code calls for a plumbing pipe one inch larger (and more expensive) than that recommended by the National Bureau of Standards.

Thus, the manipulators of the code have regularly stressed material rather than performance. Brick, lath, plaster, etc., are old fangled, the code's critics say. They require slow construction methods that cannot fling up
houses as fast as Chicago needs them. Totaling the costs of all the restrictions, the critics figure an increase in building expense of at least 15 per cent. A sizeable item for the special interest, it is bigger yet for the man who builds a house.

Fewer than 40% of the country's building codes have undergone a thorough revision in the last ten years. (8)

**Trade Union Problem.**

The AFL building trades union offers another obstacle or obstruction. In 1939 a Gunnison (prefab) home under construction in East St. Louis became a scene of violence and indictments were handed down against union leaders, city officials, and others. The case never came to anything, but prefabricators learned a lesson: to avoid communities where labor trouble can be expected. Ultimately, however, the problem must be solved if prefabrication is to succeed. National officials of the AFL have stated that they will offer no resistance in view of the housing emergency. But resistance by the more or less autonomous local unions is to be expected.

**Public Acceptance Problem**

Large sections of the public have been misled badly by both the proponents and the antagonists of prefabricated housing. The prefabricators seem optimistic about this problem, however, as is indicated by a statement of Harry Steidle, manager of the Prefabricated Home
Manufacturers Institute, who said, "The past year (1945) has been an eventful one. It has seen factory-built homes suddenly emerge from the haze of doubt and public cynicism to full stature as a new and promising industry." Some of the advocates have continually made claims of a widely exaggerated nature as to the flexibility and much lower cost of prefabricated homes as compared with those conventionally built. These statements too frequently have been loosely expanded upon until many now regard prefabrication as a totally new and miraculous short cut to the immediate production of great quantities of low-cost housing.

The "anti-prefabers" argue that all prefabrication is glorified "chicken coop" construction and refuse to acknowledge that it can produce attractive, permanent, efficient homes that may well be brought within the ownership range of vast numbers of prospective home owners through industrialization of production. The qualified prefabricators have a major problem therefore, of overcoming both their irrational friends and illogical foes at one and the same time.(1)
CHAPTER III
The More Important Methods of Prefabrication

Framing

A great many types of methods are found to exist for framing -- different prefabricators using different sizes of studs for walls and partitions, depending upon panel construction. If plywood or composition board is nailed to the framing, studs are customarily 2" x 4", spaced 16 inches on centers. When panels are glued on, smaller studs are often used -- down to 1" x 3", spaced 12 inches on centers. This size reduction is a natural sequel to the adoption of stress-covered construction, since the plywood helps to carry any load and acts as a compensating factor for the use of lesser dimensions. Another quite common practice is to use headers or horizontal "nailing" strips between studs. Frequently two or even three rows are inserted in the 8' panel height.(1)

Insulation and vapor-barrier installation is made on all required panels before the last plywood surface is positioned. All plumbing and wiring is roughed in and all heating ducts run, while the panel is still on the jig table. Figure IV shows a typical wall panel with insulation and vapor barrier installed and the wiring being roughed in.

Exterior Wall Panels

The prefabrication methods of constructing exterior wall panels vary from manufacturer to manufacturer, however,
in general, there are three types used by the majority of prefabricators. These are (a) the Full Wall Size Unit, (b) the 4' x 8' unit, and (c) The Variable Size Unit.

Usually the panels of each type consist of a lumber frame with panels of plywood glued and/or nailed to each side, forming a structural framework which is virtually a box girder. These outside wall panels usually have the outer face of 3/8" or 1/2" exterior plywood applied directly to the studs, or else have 5/16" plywood sheathing on the studs to be covered later with exterior plywood, siding, asbestos shingles, or other suitable exterior siding. Suitable insulation and vapor barrier is also usually inserted. The inside face of the panel is generally covered with plywood or composition board to be finished as desired.

Exterior wall and interior partition units are fabricated by assembling pre-cut studs, plates, and headers in table jigs. Then the covering is glued or nailed to one side and the unit is turned over to receive the covering on the opposite face. (1)

**Full Wall Size Units**

This type of wall unit contains the door and window openings. One panel being constructed to extend the full length of the house. Several different methods are used when fabricating units of this type, to join the several 4' x 8' panels required. One method is to scarf-joint the adjoining edges. Another method is to use a long strip of plywood or other material, nailed lightly to the stud under
Figure IV

Worker Roughing-in Panel Wiring
the joint and to glue the contiguous panels to the strip. Some prefabricators use simple butted joints, machining the panel edges in order to produce a perfect fit.

4' x 8' Units

Units of this type include stock units for plain wall, door, and window panels, and also filler panels to fit the particular dimension required, all panels being 4' x 8' with the exception of the filler panels which vary in width in accordance with the particular dimension specifications of the house.

Variable Size Units

These are plain wall units extending fully between openings, and from edge of opening to house corner -- door and window frames being inserted between these solid wall units.

Floor Panels

Prefabricated floor panels are an item of a great number of manufacturers. One type of construction is to apply plywood to conventionally laid joists, the plywood being covered with a layer of two ply water proof building paper over which a pre-finished hardwood floor is laid. Another method is the prefabrication of hollow-core and stressed skin panels, either with or without self-contained insulation, vapor sealed and covered with prefinished hardwood flooring or plywood.(1)
Ceiling Panels

Ceiling panels are usually prefabricated by nailing or gluing the material being used for interior wall or partition units to parallel 1" x 2" ribs, 16" on centers. The panels are constructed to full room size so that the center line of the partition will fall directly below the joint between two such panels.

Interior Partitions

Interior partitions are constructed similarly to the exterior wall units except that both faces are lined with the interior finish material.

Roof Panels

Hipped Roofs

Hipped Roof panels usually are of plywood sheathing nailed to top of roof rafters, roof shingles being applied to the panels in the shop in some instances. The joint between panels is made weather tight by inserting shingles over the joint.

Flat Roofs

Panels for flat roofs are generally of stress-covered panels on top and plywood or composition board on the bottom to serve as the ceiling.
"Prenco Homes" -- Typical Example of Modern Prefabrication

The Prenco Home is a product of the Prefabrication Engineering Company, a veteran in the home prefabrication field. The Prefabrication Engineering Company is a wholly-owned branch of the C. D. Johnson Lumber Company of Toledo, Oregon, one of the Pacific Northwest's largest lumber producers.

During the war, the Prefabrication Engineering Company, known as "Prenco", mass produced 1810 prefabricated homes under TVA specifications for erection at the Hanford, Washington, atom bomb plant. Within 36 hours after they came off the line at Toledo, the houses were at Hanford ready for occupancy. On their truck trip north, they had been halted in Portland long enough for furniture to be put in place, and then "high-balled" on to Hanford.

Production

For its peacetime operation, Prenco, headed by Robert F. Johnson, has readied a plant in Portland -- the former Columbia Steel Casting plant at 734 N. E. 55th Avenue, Production started in mid January of 1947 at the initial rate of three or four a day, with a goal of thirty to forty per day if expansion plans materialize.(4)
Prices

The quoted prices of each class of Prenco Homes are tabulated in Figure V.

Distribution

Prenco has solved its distribution problem by crating the house parts in separate bundles that may be handled by ship, rail, or truck.

A crate ready to be shipped is shown in Figure VI. Three crates of this size contain one complete one-bedroom house. It requires four crates of this size to ship the complete two-bedroom home, and the three-bedroom home is contained in five crates. Figure VII shows a loaded truck ready for departure.(4)

Models

The different models featured by Prenco are four in number — a one bedroom home, two types of two-bedroom homes and a three-bedroom home. Structurally, all four models are identical — the only difference is in floor area, room number, and room arrangement. A study of Figures VIII, IX, and X will reveal these differences. All models are flat roofed.

The Prenco Home consists of several plant manufactured three dimensional sections, each approximately 8'-0" in width, 9'-0" in height, and 26'-8" in length. When field assembled in groups, these sections combine to form homes varying in size and living accommodation. Porches, storage rooms and other appurtenances are added in the form of plant manufactured panels, field erected.
Basic selling prices, F. O. B. factory, of Prenco assembled and crated houses.
## BASIC SELLING PRICES, F.O.B., FACTORY - ASSEMBLED HOUSES.

<table>
<thead>
<tr>
<th></th>
<th>Plant No. 1</th>
<th>Plant No. 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials &amp; Labor</td>
<td>1955.63</td>
<td>1024.06</td>
<td>2979.69</td>
</tr>
<tr>
<td></td>
<td>2339.68</td>
<td>1101.59</td>
<td>3441.27</td>
</tr>
<tr>
<td></td>
<td>3162.56</td>
<td>1315.25</td>
<td>4477.63</td>
</tr>
<tr>
<td></td>
<td>3691.36</td>
<td>1406.75</td>
<td>5098.14</td>
</tr>
<tr>
<td></td>
<td>247.78</td>
<td>589.47</td>
<td>837.25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2979.69</strong></td>
<td><strong>3441.27</strong></td>
<td><strong>5098.14</strong></td>
</tr>
<tr>
<td>House Area (Sq. Ft.)</td>
<td>480</td>
<td>680</td>
<td>912</td>
</tr>
<tr>
<td>House Wt. (lbs.)</td>
<td></td>
<td>912</td>
<td>1126</td>
</tr>
<tr>
<td>House Cubic (Cu. Ft.)</td>
<td>3840</td>
<td>5440</td>
<td>7286</td>
</tr>
<tr>
<td>No. of Bedrooms</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

## BASIC SELLING PRICES, F.O.B. FACTORY - CRATED HOUSES.

<table>
<thead>
<tr>
<th></th>
<th>Plant No. 1</th>
<th>Plant No. 2</th>
<th>Crating</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials &amp; Labor</td>
<td>1955.63</td>
<td>1024.06</td>
<td>217.21</td>
<td>2172.84</td>
</tr>
<tr>
<td></td>
<td>2339.68</td>
<td>1101.59</td>
<td>275.47</td>
<td>2615.15</td>
</tr>
<tr>
<td></td>
<td>3162.56</td>
<td>1315.25</td>
<td>282.90</td>
<td>3445.28</td>
</tr>
<tr>
<td></td>
<td>3691.36</td>
<td>1406.75</td>
<td>357.31</td>
<td>4048.67</td>
</tr>
<tr>
<td></td>
<td>247.78</td>
<td>589.47</td>
<td>240.85</td>
<td>240.85</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2172.84</strong></td>
<td><strong>2615.15</strong></td>
<td><strong>3445.28</strong></td>
<td><strong>4048.67</strong></td>
</tr>
<tr>
<td>House Area (Sq. Ft.)</td>
<td>480</td>
<td>680</td>
<td>912</td>
<td></td>
</tr>
<tr>
<td>No. of Crates</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Shipping Weight</td>
<td>13,500</td>
<td>17,000</td>
<td>24,000#</td>
<td></td>
</tr>
<tr>
<td>No. of Crates Per 48’ Cor</td>
<td>9</td>
<td>8</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Volume of Crates (Cu.Ft.)</td>
<td>2100</td>
<td>2500</td>
<td>3702</td>
<td></td>
</tr>
<tr>
<td>No. of Bedrooms</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Structure.

**Exterior Wall Panels**

The framing members of nominal 2" x 3" stock are fabricated and placed in jig tables (prepared according to the various wall panel designs) and assembled by nailing. The insulating vapor barrier foil, -- genuine sheets of aluminum foil laminated to one or both sides of tough kraft paper -- is then placed over the entire panel and secured to the framing members with staples. The interior surface plywood sheets (\(\frac{4}{16}\)" moisture resistant fir plywood) are then installed by nailing. The panel is then turned over and the exterior surface plywood sheets (\(\frac{1}{2}\)" Exterior Waterproof type fir plywood) are applied. The exterior plywood surface sheets are solid glued to the framing members along the edges of each sheet and spot glued 6" on center to all of the other framing members, and nailed. The window frames, sash, and screens are then installed. A typical Prenco window section panel is shown in Figure XI.

**Interior Wall Panels**

The framing members of interior partitions, cut from 2" x 2" stock lumber, are placed in jig tables (prepared to the design of the panels) and assembled by nailing. Plywood surface sheets (\(\frac{4}{16}\)" moisture resistant fir plywood) are then applied to either side, following the procedure as outlined previously concerning exterior wall panel construction. Interior partition panels in which doors occur have the door installed with hardware applied. For all walls
Prenco Home exterior wall panel containing windows and ventilators.
which accommodate rough plumbing, wiring, or heating ducts, the panels are constructed with required leads before both wall coverings are placed. A typical interior wall panel is presented in Figure XII.

Floor Panels

Assembly is similar to that for exterior wall panels, except: (1) the bottom and top surface plywood sheets (top surface of 3/8" moisture resistant fir plywood, and bottom surface of 3/8" exterior waterproof type fir plywood) are secured by solid gluing and nailing to all framing members, (2) protective metal edging is installed at the edges of the panel, except those edges forming house joints. The bottom surface is then coated with a heavy asphalt paint for protection from moisture.

Roof Panels

Structural framing members, 2" x 6", running the length of the panel, tapered to allow a pitch of 1/4" to 1' are used. The headers, solid blocking members, and plywood bridging members are fabricated with these, and then the bottom and top surface sheet plywood members, and insulation-vapor-barrier-foil are placed in the aforementioned manner. The top surface plywood sheets are of 5/16" unsanded moisture resistant fir plywood and ceiling surface sheets are of 1/4" moisture resistant fir plywood.
A Prenco Home kitchen-bathroom wall section showing roughed-in plumbing
Connectors

Floor, wall, and roof connections are designed so as to have adequate strength and stiffness to transfer the applied test loads from one connected part to another. Floor to sill or foundation connections are designed to resist shear, uplift, and overturning when subjected to lateral live load.

Details of the panel joints at all connected sections are shown in the appendix.

Design Loads and Strength Tests

Prenco homes have been designed to sustain live loads per square foot of area in excess of 40 pounds for floors, 40 pounds for roofs and 20 pounds for wind.

According to the FHA accepted Prenco Homes specifications, all elements of the house will sustain, without failure, for a period of 24 hours, a super-imposed load equal to \( \frac{3}{2} \) times the above listed design live loads, with a recovery within 24 hours after removal of the full test load, of at least 75\% of the measured deflection.

Insulation

Each Prenco home is provided with sufficient resistance to heat loss by insulation or by double wall construction, so that the heat loss in B. T. U. per hour in the completed home does not exceed sixty times the floor area in square feet. Insulating material in the floors,
walls, and roofs is of a metal foil reflective type. This metal foil also serves another very important service — that of being a vapor barrier.

In recent years, more moisture has been introduced into homes due to the use of humidifying apparatus. The more general use of insulation within walls and roofs, weatherstripping and storm sash have tended to make the houses tighter. In such houses, the moisture laden air is not easily carried away as it is in loosely constructed houses, but when it reaches the cooler areas within the wall it may condense. Over long periods of time, there may be a considerable accumulation of moisture, the insulation may become wet, thus greatly reducing its efficiency. Even with the arrival of warm weather, moisture is slow to disappear and may make favorable conditions for rust, mold, and decay. Many paint problems, such as the peeling of outside paint, also arise from the accumulation of moisture within walls. Obviously it is most important to prevent these conditions. To accomplish this, moisture barriers are put in outside walls of houses.(5)

**Heating**

Each Frenco Home is equipped with a circulating filtered hot air heating system complete with furnace, fresh air intake, ducts, grills, and controls.
Plumbing and Sanitation

The plumbing work consists of bath tub with shower over, lavatory, water closet, automatic storage type hot water heater, double compartment sink, cabineted laundry tray, supplies and waste for clothes washer with all trim, fittings, and rough-in-piping required.

Electric Work

The electric system consists of service equipment for metering, service switch, ground, fuse panels, branch circuit wiring to all outlets, switches, convenience outlets, electric lighting fixtures, and bathroom space heater.

Utilities

Water service, sewer (or septic tank), gas service, and overhead electric service is completely installed and connected.

Special Fittings

Special fittings include bathroom soap dishes, towel bars, paper holder, robe hook, tooth brush and tumbler holder, bathroom mirror, coat hooks, and door or call bell.

Inclusions

The Prenco assembled home comes complete and ready for occupancy by the consumer -- all details of construction and erection taken care of by the company. All earth and rock excavating for all footings, under parts of building, driveway, terraces, walks, etc., is taken care
of. Trees are removed as directed in the area of construction. Back filling is done. Porch floors, entrance steps, sidewalks, driveway, and garage floor are concrete with cement finish.
CONCLUSIONS

In order to gain and keep public favor, prefabricators must turn out good quality houses. This can be done and must be done without sacrificing any of the speed of construction and money saving factors connected with prefabrication. Perhaps this type of construction will gain greater public favor as more and more are built and prove their worth in competition with other type structures.

The abnormal conditions existing at the present time tend to lessen the gap in cost between a prefabricated structure and a conventionally built structure, but as prices level off and settle down, the differences in cost should become more apparent and the industry will undoubtedly introduce many more efficiencies and money saving methods which will bring the costs down more in line with other mass produced items.

More and stronger organizations such as the Prefabricated Home Manufacturer's Institute (PHMI) will be formed to coordinate the activities of the prefabricators, to provide law and economic services, publicity, and merchandising and trade promotions.

As public acceptance changes to public demand, pressure will be brought on labor unions to include this industry in the realm of other mass production industries, and building codes will be changed to admit structures of this type on a merit rather than a material basis.
BIBLIOGRAPHY

5. Forest Products Laboratory, Madison, Wisconsin.
7. Federal Public Housing Authority.
APPENDIX

CEILING
3/2 x 11/2

4d GALV NAILS, 6" O.C.

15/8 x 15/8 CLEAT
GLUE & SCREW NAIL TO FLOOR.

FLOOR

VERTICAL SECTION
INTERIOR PARTITION
APPENDIX

INTERIOR CORNER.
APPENDIX

**HOUSE JOINT AT FLOOR**

NAILING NOTES: ALL 1/4" INTERIOR PLYWOOD NAILING TO BE.
4d. GALV. FIN. NAILS - 6" O.C.
ALL NAILS IN 3/8" & 1/2" EXTERIOR PLYWOOD TO BE 6d. GALV. FIN. 6" O.C.
APPENDIX

HOUSE JOINT AT ROOF

3-Ply Built Up Roof

3/4 Plywood Rib

Metal Cap 1/2 GA B.W.
Set in Plastic Cement

1/3" Tolerance
(1/16" each side of house joint)

Nail & Glue

3/4" Insulation Bailer

Tight Butt Joint

Batten Only as Necessary
APPENDIX

3 METAL STRAPS AT 4" APART, 6" ON EACH SIDE OF CENTER.

GLUE & SCREW NAIL TO FLOOR, SECTION.

CRACKING - 4 1/4"
FIELD APPLIED SKATEBOARD

26 4" CONTINUOUS METAL STRIP.
COVER MOULD AT STEPS, PORCHES, ETC.
SKIRT BOARD CUT UP AT STEPS, PORCHES, ETC.

2x4 PLATE (IN-SITE WORK), ANCHOR TO CONCRETE, COUNTERSINK, BOLT HEADS, BOLTS 1/2" x 10" - 6 O.C.

1/2" x 1/2" x 1/4" CLIP ANGLES.

2 PER SECTION - ENDS
5 PER SECTION - SIDES

PLYWOOD
ASPHALT PAINT

FOUNDATION WALL IN-SITE WORK

EXTERIOR WALL SECTION RAKE ENDS.