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Component Residential Building Construction

Gary L. Trickey
University of Northern Iowa

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Abstract

To study residential component building as one of the first steps towards a more industrialized method of home construction.

DEPARTMENT OF
INDUSTRIAL TECHNOLOGY
University of Northern Iowa
Cedar Falls, Iowa 50614-0178

COMPONENT RESIDENTIAL BUILDING CONSTRUCTION

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by
Gary L. Trickey

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CHAPTER I

INTRODUCTION

Technology has a tremendous influence on our life styles. It has influenced nearly everything we buy and use from the plastic bags we use to contain our garbage to the colored television sets we have in our homes to entertain us. Some industries have been influenced more than others for various reasons.

The residential building business is one industry that has had some resistance to this technology. This resistance is due in part to: (1) the fact that home construction companies are usually small companies without the capitol to invest in technological change, (2) the size of the product; brings about many transportation problems, (3) regulations by small governmental agencies; city codes vary so widely that custom housing is required, (4) carpenters unions have generally resisted changes which they thought would threaten their jobs.

Industrialized housing has been represented in the residential building business for some years, but still today the conventional stick by stick method of building is the method used in over 50% of new housing starts. If this nation is going to meet its requirements for economical housing in the years to come, technology will have to have

a greater influence in the residential building business.

Our educational institutions will also have to place more emphasis on the technology that is available to the residential building business. Courses in home construction still place their greatest emphasis on the stick by stick method.

Statement of the Problem

To study residential component building as one of the first steps towards a more industrialized method of home construction.

Limitation of the Problem

Components in the residential building industry include a wide range of materials and parts of the finished product. This study will concentrate on the framing aspects of the component building industry.

Definition of Terms

The following is a list of terms and their definitions as they are used in the building industry.

Stick by stick---- In this age of voyages to the moon, the most common type of residential construction is also the oldest type of construction. Stick by stick construction is a process where almost all materials are selected, cut and fastened at the site to form the desired shape by the builder. Stick by stick construction requires more skilled labor at the site than other types of

construction. There are a number of prefabricated parts installed at the site. These include windows, stairs, pre-hung doors, cabinets and an increasing number of builders use truss roofs.

Pre-cut---- Pre-cut houses are built by the stick by stick method, but the building process is speeded up by having all members cut, ready for assembly. The house is sold as a package, including all materials necessary to build it for occupancy. Some components may be used as would be used for conventional houses such as pre-hung doors, windows and stairs.

Mobile---- Mobile home is a term used to describe a type of housing that is built on a trailer frame and is licensed as a vehicle rather than as a house. They are generally considered as temporary housing and do not have to meet building code requirements as other housing. Mobile homes do not meet the requirements for long term loans. Today a good portion of the mobile home market is in "double wides". These units are very similiar to sectionals. The basic difference is that sectionals are not built on a trailer frame and sectionals meet all local building codes.

Components---- A component, is a prefabricated part of the total building project. The component may be prefabricated to different stages of completion. Exterior wall components may come with just the framing members, or they may include windows, exterior sheating, exterior siding,

insulation, interior paneling, electrical wiring or prefinished woodwork. The builder determines how much prefabrication he wants in his components. In residential building, components are used in almost all phases of construction.

Modular---- Modular structures are built or erected from one or more three-dimensional box shaped units, which are completely factory-finished and require only to be connected together at the building site. There is a variety of modular units and they will be defined under their titles.

Sectional---- Sectionals are usually rectangular boxes which when fitted together at the building site form a completed modular unit. There may be two sectionals to form a single story house or they may be stacked to form an apartment building. Sectionals are not limited to residential construction, but are used for offices, motels and a mulitude of commercial buildings.

In residential house construction, sectionals are usually fabricated in half-house sectionals which may vary in width from 10 to 14 feet. Sectionals vary in length from 36 to 70 feet. These dimensions are dependent somewhat on state laws governing transportation. Sectionals when they leave the factory are completely finished inside and out. Construction required at the site before the sectionals arrive includes a permanent foundation, electrical access, water and sewer (Reidelbach, 1971, p.5).

Three Dimensional---- This term is used to describe a type of industrialized housing that falls between components and modular. It is classed under modular because it is a completely finished unit inside and out when it arrives at the site. Three dimensional units do arrive in panels and need to be erected at the site.

Mechanical Cores---- Mechanical cores are factory produced modular units which include all mechanical, electrical and related systems. These units generally contain the kitchen, one or more bathrooms, and the utility room complex. Smaller units may serve only one purpose such as a single bathroom. Mechanical cores are completely assembled units which only need to be connected to existing utilities at the site. Mechanical cores are being used by an increasing number of builders because they eliminate from the job site the most expensive portion of the entire construction process, the need for skilled craftsmen. The remainder of the house is then built around the mechanical core by either conventional, component or modular systems.

CHAPTER II

HISTORICAL INFORMATION

It is impossible to document the first time a human being prefabricated building materials to build a shelter. One of the first examples of prefabrication would be the burnt clay bricks of the Mesopotamian civilization (Kelly, 1951, p.7).

In the United States, it is recorded that as early as 1624 the English brought with them to Cape Ann a panelized house of wood; it was used by the fishing fleet and this house was disassembled and moved several times. In 1727 two houses were cut and partially assembled in New Orleans for shipment to the West Indies. There are other recordings which indicate that prefabricated shelter was used during the next hundred years to provide settlers with immediate shelter in a new settlement. Significant production of prefabricated houses appears to have been brought about by the Gold Rush of 1848. In the New York area alone over 5,000 houses were prefabricated for shipment to California. These houses sold in the east for $400, but by the time they reached California they sold for over $5,000. This boom came to a end by 1850 when some Californians found more money in building houses than in digging for gold (Kelly, 1951, p.10).

New markets were looked for by the builders in the east after the California boom was over. They found a market in small buildings such as chicken houses, dog houses, children's houses and small houses for plantations. The civil war brought about a demand for portable hospitals and head-quarters buildings. The market remained somewhat stable until the invention of the automobile, which brought about a demand for "auto stables", and then later vacation cottages.(Kelly, 1951, p.12).

Pre-cut houses received their big start during the early 1900's. While pre-cut houses are not usually considered as prefabricated, they did build prefabricated doors and windows and standardized many other parts of the completed house. The pre-cut industry also put together for the first time a complete house for a base price.

World War I was not too important to the development of the prefabricated building business. The war was a foreign war and did not demand the buildings that the civil war demanded. Europe had always been ahead of the United States in the development of prefabricated buildings, so it was able to take care of this demand. After W.W.I there was a big demand for new housing, but since there was no government sponsorship for research as in Europe, the demand was satisfied by on site builders (Kelly, 1951, p.16).

The depression brought about a new search for jobs and a way to re-establish our capitolistic system. The nation needed housing and jobs; many felt that manufactured

housing could provide both. The amount of research increased and new materials were developed to experiment with, they included progress in the manufacture of plywood, plastics, wallboards, hardboards, materials made from gypsum, asbestos and the new steel products. For all the talk and research very little developed in the form of new housing. By 1940 there were only 30 firms manufacturing houses on a steady basis. The great bulk of the production was of a sort that involved comparatively little in the way of new materials or prefabrication. During the period of 1935 to 1940 only 1% of new housing was built by the factory method (Kelly, 1951, p.22).

World War II brought about another big demand for housing. The military needed new bases with housing and the private sector needed new housing around key industrialized areas. Prefabricators were given a good share of this demand because they were able to produce it faster than by the old conventional method. By 1945 prefabricated housing had 16% of the new housing starts, compared to 1% five years earlier (Kelly, 1951, p.32).

While prefabricated housing was able to flex its muscle and do its share for the war effort, it did not necessarily aid its movement. To meet the demands of the war effort, prefabricated housing quality during the war was not up to peace time standards. While this was true of all construction during the war, to most people this was their first contact with prefabricated housing. This brought

about an image that prefabricated housing was inferior to conventional housing. The housing boom that developed after the war was shared by the prefabricated builder, but this image of inferior quality has hindered its growth.

The prefabricated builder maintained his share of the market during the 40's and 50's. It was during the early 50's that components were being used by on site constructors. They had been using windows, doors and stairs, but at this time they were discovering the assets of the truss roof. This was more or less the beginning of the component framing business.

CHAPTER III

TECHNICAL INFORMATION

Truss Roof Components

Today many roofs are framed just as they were 40 or more years ago by the old rafter-ridgeboard method. A big drawback to the rafter-ridgeboard method is that it usually requires a load bearing wall in the center of the span. This load bearing wall not only raises costs in material, labor and time, but also interferes radically with the use of space inside the house. Members of the rafter-ridgeboard roof span a greater distance allowing more distortion in each member. The rafters do not receive verticle support and this places pressure on the outside walls.

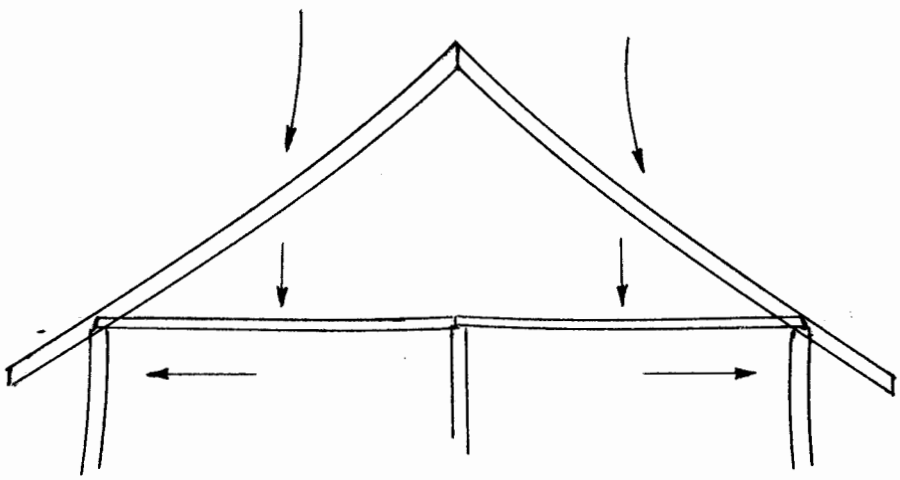

Figure 1

Forces in the Rafter-Ridgeboard Roof

The truss roof is the most widely used framing component in residential construction today. Its basic principle of design is based on the rigidity of the triangle. There are many sizes and designs, but triangular shapes are built into the frame in such a way that the stresses of the various parts are transfered to the exterior walls of the structure (Wagner, 1973, p.177).

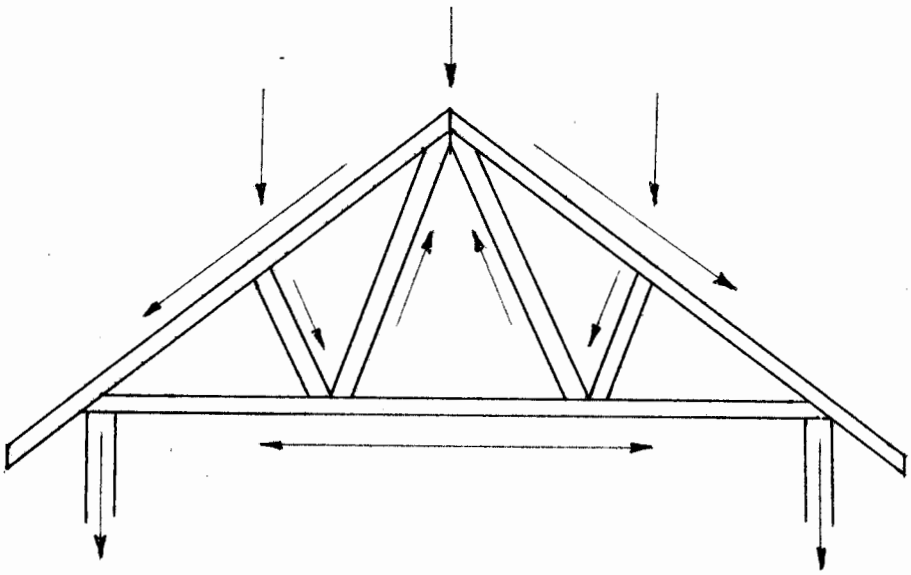

Figure 2

Forces in the Truss Roof

Load bearing interior walls are not needed with trusses; this allows complete flexibility with the use of the interior space. Ceilings are more uniform with fewer popping nails. Materials for the roof frame are about the same with the rafter-ridgeboard roof or the truss roof. Labor cost is lower with the truss roof because of the mass production used and with the need of less skilled labor.

Some builders claim savings up to 30% using the truss roof. (Automated Building Components, 1973, p.5).

Roof trusses entail a considerable amount of engineering and only approved types and designs should be used by the builder. Several sources will give the builder all needed information as to type, configuration, kind of lumber and exact dimensions of the various members.

Truss members are joined together by gusset plates made of plywood or metal. The design of the plates is determined somewhat by the method in which they are attached to the truss members. Plywood gusset plates are used by small builders who do not have the needed automated equipment. Most fabricators use metal plates that may be rolled on, pressed on or fastened by automatic nailers.

Exterior Wall Components

The number of builders using exterior wall components is increasing rapidly. There is a desire by builders to enclose their structures as soon as possible. An enclosed structure allows; the subcontractors to perform their work, storage for materials for later installation, and a reduction in the amount of vandalism to the structure and materials.

Builders also use exterior wall components because they are assured of better quality control. On site construction subjects the materials to adverse weather conditions which can affect the quality of the building

materials. Layout accuracy is also more accurate using factory jigs and fixtures rather than having it done at the site by the carpenters. Factory fastening methods have far greater holding ability than the common nailing method performed at the site.

Exterior walls are fabricated in various stages of completion. Most frequently, the wall is rough framed with sheating installed, and rough openings cut for windows and doors. The builder may have the windows and doors installed so that the structure will be enclosed as soon as it is erected. To completely finish the exterior wall as a component requires considerable more planning and equipment. Equipment is needed at the factory to handle the heavier panels, special loading and carrying equipment to protect the finished surfaces during shipment, and a crane at the site to unload the panels.

Interior Wall Components

Interior partitions are almost always rough-framed with no skins applied and with doors not installed. The principle reason for this is that most building jurisdictions require open inspection of these walls, both structurally and for the mechanical installations; such as plumbing, heating and wiring before finish materials are applied. When interior walls are complete, the fabricator usually tries to have a mechanical wall that houses the main mechanical systems. This may be a double wall or a

small mechanical core about the size of a closet.

Floor Framing Components

Floor components are not nearly as popular as roof trusses and wall components. The size and weight of a panel floor component requires the assistance of a crane. Their bulk size also may require an additional truck for delivery.

The standard floor panel component consists of 2" by 6" or 8" floor joist with plywood on both surfaces. This type of floor has the advantage that the basement ceiling is provided with the floor.

Floor trusses are gaining in popularity with builders. Floor trusses require less lumber than the traditional floor joist. Considerable time is also saved at the site with the plumbers and electricans because these trusses allow ready access for water pipes, electrical wires and heating ducts. The floor trusses are delivered with the same amount of prefabrication as the roof trusses.

Prehung Windows

Windows are one of the oldest and most used components in house construction. About the only decision a builder has to make about windows is the type to be used, and if they are to be installed in the wall components or installed at the building site.

Prehung Doors

Exterior and interior doors for many years have been

pre-cut for installation. The door frame was installed in the rough opening and the door was then fitted to the door frame. The prehung door needs only to be installed as a unit at the building site.

Stairways

Stairs are another difficult item to cut and fabricate at the building site. Stairs, have been available for many years pre-cut for assembly at the building site. The complete prefabrication allows the builder to do away with another fabrication at the building site.

Component Builders and What They Build

Information on component building and its part in the building business is difficult to obtain. Magazine articles and other available information indicates that it is a rapidly growing business. The writer did not find any information giving a complete breakdown on the percentage of components used in new housing starts. Table 1 does give information on what components builders do build.

Table 1

Type and Number of Manufactured Building Components

Type of component	Per cent plants manufacturing	Average units per plant	Total units manufactured
Trusses	54.6%	4086	4,355,786
Exterior walls	36.3%	1480	1,483,321
Interior partitions	32.9%	752	413,280
Prehung doors	46.8%	7472	6,831,632
Prehung windows	31.2%	3836	2,336,276
Cabinets	20.4%	2090	831,998
Stairways	21.9%	1116	476,634
Floor assemblies	15.2%	1013	300,987
Fascia & soffit	28.2%	756	416,688
Interior trim	32.1%	1470	921,890
Exterior trim	27.8%	1226	664,506
Complete mill-work package	24.1%	1071	503,401

(Automation In Housing, December, 1972, p.4)

CHAPTER IV

RELATED INFORMATION

Industrial-Geographical Information

Home building is almost in direct proportion to population increases of a given area. This would mean that most of the new housing starts are being built in the suburbs of our larger cities. Industrialized housing is not equally represented in these growth areas, but fluctuates with the labor market, variation of building codes and the transporation laws of a given area or state.

Iowa does not have a big demand for new housing because its population is quite stable. There is a constant population shift from the rural areas to our towns and cities, so that is where you will find most of our new housing starts.

Table 2 is a partial list of industrialized home builders in Iowa. Many material dealers also provide some type of prefabrication for their customers, but building materials is their main business. It is also difficult to list just component builders because many of these builders do build more than one type of industrialized housing.

Career Information

Total housing demand, including mobile homes, is projected to rise between 24.3 and 26.8 million housing

units in the 1970-1980 decade. This is substantially above the 17 million units produced in the 1960's and the 16 million units produced in the 1950's (Marcin, 1972, p.21).

A marked increase in the demand for houses will be equaled by a demand for skilled labor. Both conventional and industrialized methods of construction will need competent, skillful people to build the needed houses.

The carpenter is an important craftsman in the broad field of construction. He needs a very wide variety of skills to be able to perform all the jobs his title bestows upon him.

A career as a carpenter requires as a minimun a high school education. After graduation from high school, one may enter directly into an apprenticeship training program. The term of apprenticeship for the field of carpentry is normally four years. The time period may be adjusted for applicants with significant experience or those who have completed certain advanced courses in vocational-technical schools.

The apprentice receives instruction on the job, but in addition to this he is required to attend classes in subjects related to the trade. The classes cover technical information about tools, machines, methods and processes; and provide practice in mathmatical calculations, blueprint reading, sketching, layout work, and similar activities (Wagner, 1973, p.452).

During the apprenticeship period the apprentice is paid a portion of a journeymans wages; this ranges from 50 to 90 percent. Upon completion of his apprenticeship, the apprentice receives his journeyman certificate which is recognized throughout the United States.

Financial Information

In Iowa new housing starts are usually fairly well scattered throughout the state. The competition among builders is usually quite competitive. This market has been dominated in the past by small builders using the stick by stick method. The success of such a business usually depended upon the manager's use of his labor force and the ability to satisfy his customers. Today this market is being challenged by various forms of industrialized housing. They have the ability to reach a larger market area and to provide the finished product in a shorter period of time.

The financial success of either type of builder is still quite dependent upon efficient management. The invester would have to investigate each company independently, to determine if it is capable of providing a good return on his investment.

There are very few residential home builders who are large enough to have their stocks traded on the stock exchange in this country. The following five companies are some of the largest builders in this country. Residential house construction is not their only business. To invest in such a company requires examining the entire company.

National Homes. National Homes is the nation's largest manufacturer of prefabricated single family homes and multi-family housing. Output in 1971: 31,049 living units, which comprised 1.5% of total housing starts.

Sales were up 10% in 1972, but profits dropped 42% because of Phase 2 profit margin ceiling restrictions. The price of plywood and lumber increased while the selling price was frozen. The outlook in 1973 for the margin of profit is better because of Phase 3. Prices will increase if competition allows it.

The moratorium on subsidized housing could limit the earnings recovery. Production of subsidized housing accounted for about 40% of prefabricated home sales in 1972. Sales will have to be shifted to the more expensive, conventionally financed housing.

Earnings will be down in 1973, but this only to be expected with the decline in housing (The Value Line Investment Survey, Feb. 1973, p.798).

Ryan Homes. Ryan Homes is engaged in the construction of single and multiple-family residences, with operations in the eastern states.

Unit sales in 1972 totaled 5,706, up from 4,908 in 1971. Projection of sales in 1973 is over 7,000 units. Government subsidized Section 235 houses were to make up 10% of the 1973 sales, but the moratorium on this housing will have very little effect on total sales. Emphasis has been

placed on town houses which show the largest increase in new starts. Many of the prospective buyers for Section 235 houses will be able to finance the town houses of which Ryan Homes has its share of the market (Standard and Poor's, Feb., 1973, p.9096).

Kaufman and Broad, Inc. Kaufman and Broad, is primarily engaged in on-site housing. Underway are 72 major developments in the metropolitan areas of 7 U.S. cities. Home Systems subsidiary produces mobile homes at 10 plants. Output in 1971 included 5,700 on site houses and 9,285 mobile homes.

Record sales and profits were attained in 1972 with on site homes up 26% and mobile homes up 25%. Sales and profits will continue in 1973 because management foresaw the coming moratorium on government subsidized housing so phased out all such activity last year (The Value Line Investment Survey, Feb. 1973, p.787).

Boise Cascade. Boise Cascade is a leader in the building industry group. Products include newsprint, corrugated containers, lumber, plywood, veneer, single and multi-family homes (13% of sales). The company sustained an $85 million deficit in 1971 and has reported a $200 million special charge thus far in 1972 related to its withdrawal from unprofitable real estate operations and as provision for possible additional losses in Latin America. Various

non-real estate assets are also being sold, and debt is being restructured. Although the basic building materials and paper products business should improve in the next few years, the various uncertainties impart a significant degree of risk to the speculative shares (The Value Line Investment Survey, Feb. 1973, p.761).

Evans Products Co. Evans Products Company manufactures and distributes building materials, pre-cut and component homes (13% of sales), transportation equipment, and operates retail stores selling a broad range of building materials. Prospects are excellent for another record year in 1973. Expansion in Evans' homes and retail groups will more than offset any slowdown in the building materials business resulting from an estimated 15% contraction in housing starts this year. Home sales could expand 50% this year after a similar gain in 1972. Aggressive marketing is part of the reason. Evans has increased its emphasis on low-cost, factory built houses and has established a subsidiary to finance its homes sales. Look for a relatively strong stock price performance during the next 12 months (The Value Line Investment Survey, Feb., 1973, p.770).

Patent Information

Technology has developed in the United States to a very high degree, partially because of the patent system. Without patents, industry would be even more concentrated

than it is. Large firms would exploit the ideas of individuals and smaller firms because they would have the capitol and marketing ability to make their ideas successful. The patent system allows anyone with a new idea, a chance to profit from his creative thinking. This process allows new blood into the industrial world.

The patent system allows the inventor to: (1) claim the invention as his; this prevents others from making, using, and selling the invention, (2) have for seventeen years in the United States the exclusive control of the invention, (3) claim his mental creations as ownership, (4) have his mental ability, in the form of a patent, as non-taxable property (Dorl, 1967, p.5).

The patent system will protect your rights as an inventor, but as with other "rights" you must be willing and able to protect them. Patents are only worth securing if: (1) you are financially able to protect them in the legal process from those who may try to enfringe upon them, (2) you are financially able to prove through an exhaustive search of all previous patents that your idea is new, (3) willing to search all publized material to verify that your idea has not been published.

The person who has a worthy idea, but is not financially able to persue it, may find it best to find a development firm to help sponsor his idea. A development firm will research, design, develop, and market your idea for you. This service will usually cost a part of all

royalties received, but they are capable of doing a service that you may not be capable of performing.

In our economic system all industries do not use the patent system equally. Dependence upon the patent system by an industry may depend on the degree of technology used by that industry. For instance, there would be fewer patents in the furniture building industry than in the electronics industry. The residential building industry is an industry where reliance upon patents is not great. There are only a few builders who use other than conventional materials and methods that would require patents.

Patents will become increasingly important in the residential building industry as new materials and methods are needed to replace our dependence on wood products and their conventional uses.

Field Trips

Four field trips were taken to gain information for writing this report. Each trip was very helpful in understanding industrial housing because three types of industrial housing were represented.

My visit to Paxton Prestige Homes was an opportunity to see and study a company that specializes in framing components. They build truss roofs, exterior and interior walls and usually sell them as a complete package. They can build for any builder and from any house plan.

Evanway Homes of Des Moines is a company that builds

three dimensional modules. All components necessary to build the house are completed at the factory including all finishing work. Each house is loaded onto two semi-trucks for delivery to Alabama or Minnesota.

Sandler-Bilt-Homes in Boone builds modulars in two sectionals. The sectionals are completely built in the factory including all finishing work. Units are started at one end of the factory with floor framing and progress to the other end for final finishing. The sectionals are loaded aboard trailers and delivered to the building site.

The fourth field trip was to Ames, to watch the Sheltered Construction Co., erect their first component framed home from Paxton Prestige Homes. The components consisted of all walls truss roof, windows, doors and insulation. This was the only field trip in which the writer was permitted to take pictures.

CHAPTER V

UNIT OF INSTRUCTION - COMPONENT HOUSE FRAMING

Unit Rationale

This unit is to be used as part of the 8th grade course, "The World of Construction". This course studies all phases of light and heavy building construction. Light construction is studied in part by the construction of a module. The construction of the module is by the conventional stick by stick method. Students also need to have some knowledge of the more industrialized building construction methods.

Component framing can best be illustrated through the use of model equipment and construction. Model construction will also allow the student to follow through with the complete framing process of a house.

Unit Objectives (Behavioral)

1. Name the terminology of floor, wall and roof members.
2. Given a house blueprint, the student shall take one exterior wall and divide it into wall components. The student will layout the top and bottom plate of each wall component.
3. With the use of references, the student will

describe the following types of industrialized building:

a. Component framing

b. 3-D modular

c. Sectionals

d. Mechanical cores

e. Mobile

4. With reference, the student will compare materials used for a house by the stick by stick method, and by one of the industrialized methods.

Unit Outline

I. Historical development of industrialized housing

II. Types of industrialized housing used today

IIII. Planning and building with framing components

IV. Framing a model using framing components

V. Evaluating industrialized methods of residential building

Textbooks

Wagner, Willis H. Modern Carpentry. Second Edition. South Holland, Illinois: The Goodheart-Willcox Co. Inc., 1973. List price $7.95.

Merritt, Frederick, Building Construction Handbook. McGraw-Hill Book Co., New York, New York.

Reference Materials

Building Supply News. (monthly), 5 South Wabash Avenue, Chicago, Illinois, $5.50 per year.

Automation in Housing. (monthly), Vance Publishing Corp., 300 West Adams St., Chicago, Illinois, $5.00 per year.

Professional Builder. (monthly), 5 South Wabash Avenue, Chicago, Illinois, $8.00 per year.

Films

In correspondence with people connected with the component building business, the writer would always inquire as to the availability of films. The film lists that were received listed films dealing with only wood products in general.

Equipment and Supply Sources

The materials used to build the model houses were cut from #2 white pine. A model house 24 inches by 36 inches will cost approximately $4.00 for materials. A regular paper stapler was used to fasten building materials together.

Fixtures were built to scale from maple and plywood. The cost of materials for the truss roof fixture and the wall framing fixture was approximately $12.00. Details of these two fixtures are given in Figure 3, page 36 and Figure 4, page 38.

CHAPTER VI

SUMMARY

This study was undertaken to determine the extent component building construction is utilized in meeting our society's demand for housing.

Mankind at various times in history has had a need for some form of prefabricated housing. War time demands especially have contributed to the growth of prefabricated housing.

The availability of skilled labor has been a consistent factor in the growth of prefabricated housing. Complex items such as windows were one of the first items to be made available as a prefabricated component. The truss roof developed because of superior engineering features and the labor savings in utilizing mass production techniques.

Component framing developed after the acceptance by builders of prefabricated units such as windows and the truss roof. Component framing is quite flexible as to the degree of completion of the components, as desired by the builder. Component framing allows complete flexibility in the design of a home, this flexibility is gradually lost with further efforts to industrialize the building process.

Conclusion

The success of component framing in a construction business depends upon many variables within the construction company. Each year more construction companies do find it desirable to use more framing components. Builders generally credit speed of erection, the need for a smaller labor force, less dependence on skilled labor and better quality control for their acceptance of component framing. It is estimated that framing components will soon be utilized in over 50% of all new residential construction.

Recommendations

The trend to use more component framing in residential building construction needs to be reflected in building construction courses in our public schools. Full scale laboratory work representing industrilized building methods is quite difficult because of the needed machinery and space. Component framing can be taught quite effectively by using model construction. The machines that are required in the industry can be made to scale and be incorporated into the production line flow of scale units. The small amount of space required of model construction allows the student to follow the complete construction process.

Scale production of framing components should only be a part of the overall construction course. The major part of the construction course should continue to use full size materials and equipment to give the student the needed laboratory experience.

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APPENDIX

Table 2

Industrialized Home Builders in Iowa

Builder	Type of industrialized building	Units built in 1972	Predicted units for 1973
Benton Construction Co. 3324 50th Street Des Moines, Iowa 50310	N.A.	N.A.	N.A.
Cardinal-Craft 675-44th Street Marion, Iowa 52302	Mobile	200	N.A.
Capp Homes Hwy. 69 N. Des Moines, Iowa	Pre-Cut	1000	N.A.
Citation Homes 1100 Lake Street Spirit Lake, Iowa 51360	N.A.	N.A.	N.A.
Component Homes, Inc. P.O. Box 192 Iowa City, Iowa 52240	N.A.	N.A.	N.A.
Design Homes, Inc. Humboldt, Iowa	Modular	71	71
Engineered Components Clarinda, Iowa 51632	N.A.	N.A.	N.A.
General Homes, Inc. 3115 Douglas Avenue Des Moines, Iowa 50310	N.A.	N.A.	N.A.
Kalonial Industries, Inc. P.O. Drawer V Kalona, Iowa 52247	Mobile Modular	186	240
Midwest Component Homes P.O. Box 7 West Burlington, Iowa	N.A.	N.A.	N.A.

Table 2 (continued)

Builder	Type of industrialized building	Units built in 1972	Predicted units for 1973
Modcomp Homes, Inc. 12th Street N.E. Independence, Iowa 50644	Modular	42	60
Sandler-bilt Homes Old Highway 30 East Boone, Iowa	Modular	200	240
Solar Homes Co. 702 Second Avenue Des Moines, Iowa 50301	Modular	134	250
Stewart Building Systems 501 South 1st. Street Marshalltown, Iowa 50158	Framing components	N.A.	N.A.
Timbercraft Homes, Inc. R.R. #1, Box 60 West Burlington, Iowa 52655	N.A.	N.A.	N.A.
U.S. Homes, Inc. 5390 Second Avenue Des Moines, Iowa 50313	Pre-cut	800	N.A.
Wausau Homes, Inc. Ottumwa Airport Ottumwa, Iowa 52501	3-D Modular	2117	3176

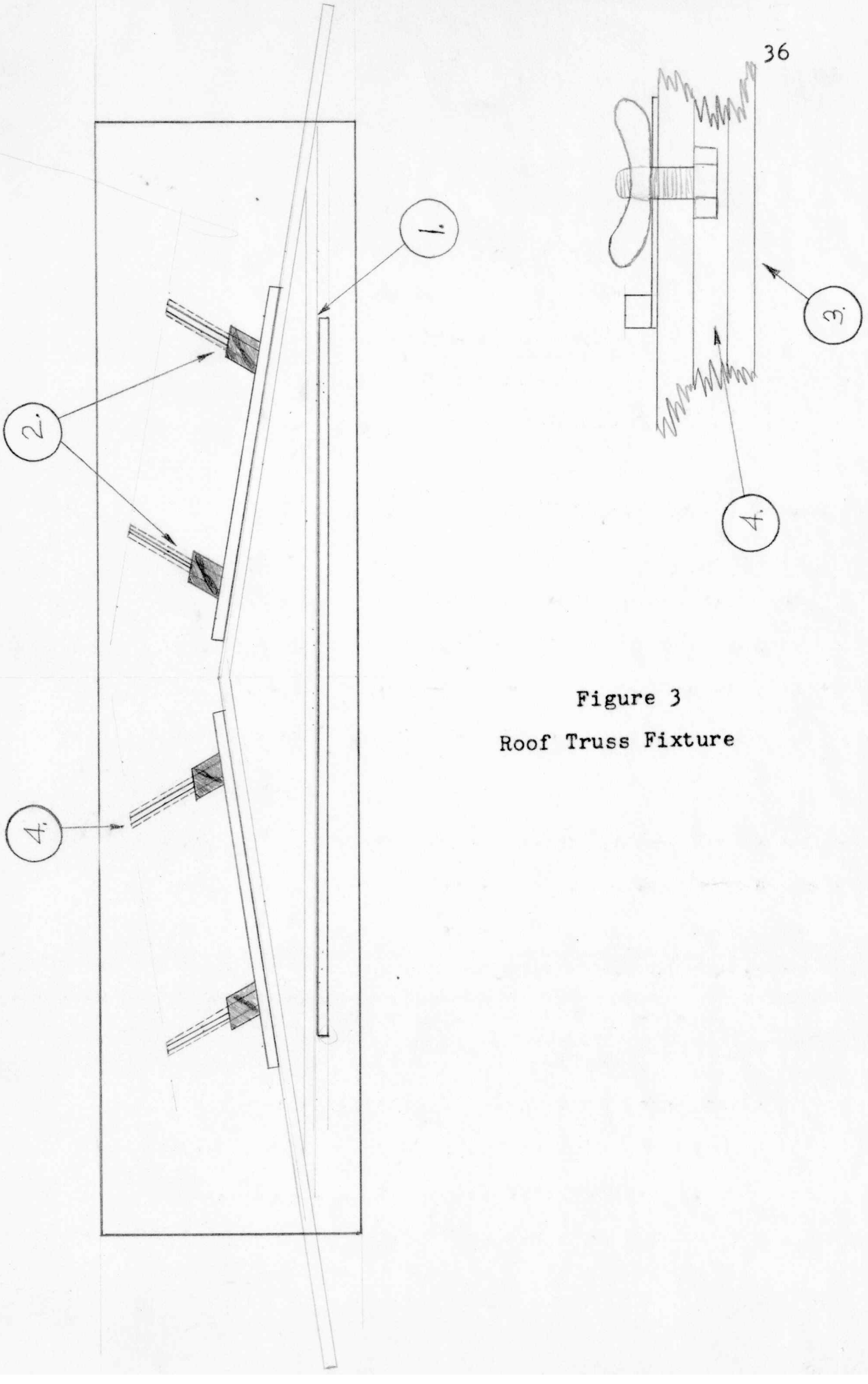

Figure 3

Roof Truss Fixture

ROOF TRUSS FIXTURE — Figure 3

Roof Truss Fixture, Figure 3

1. The bottom chord is positioned against a permanent 1/4 inch steel wquare.
2. The pitch of the roof is adjustable by changing the position of the guides for the top chords.
3. Guides for the top chords consist of 1/4 inch steel squares pivoted on 18 gauge sheet metal and a attached to the plywood by 1/4 inch carriage bolts and wing nuts.
4. The plywood has been slotted to accept the carriage bolt head.
5. Gusset plates are made of 26 gauge sheet metal and attached to the wood members with a hot glue gun.
6. The scale selected for model construction will determine the size of the fixture.

Wall Framing Fixture, Figure 4

1. Sash window pins provide pressure while the panel is being fabricated. They may be purchased at hardware stores for about 30 cents.
2. Lift bars assist in lifting out the fabricated panels.
3. A standard paper stapler is used to attach the full studs to the top and bottom plates.
4. The fixture is made with a plywood base, maple is used for the rest of the fixture.
5. The scale selected for model construction will determine the size of the fixture.

Figure 4

Wall Framing Fixture