AN ASSESSMENT OF THE POTENTIAL OF THE UNITED STATES STICK-BUILT HOUSE FOR SELF-HELP CONSTRUCTION

by

YUTAKA TAKASE

M. Eng. in Arch., University of Tokyo, 1978
B. Eng. in Arch., University of Tokyo, 1976

SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF

MASTER OF SCIENCE IN ARCHITECTURE STUDIES

at the

Massachusetts Institute of Technology

September 1981

Signature of Author ______________________________
Department of Architecture
June 9, 1981

Certified by ______________________________
Eric Dluhosch, Associate Professor of Building Technology, Thesis Supervisor

Accepted by ______________________________
Julian Beinart, Professor of Architecture
Chairman, Departmental Committee on Graduate Students

AN ASSESSMENT OF THE POTENTIAL
OF THE UNITED STATES STICK-BUILT HOUSE
FOR SELF-HELP CONSTRUCTION

by

YUTAKA TAKASE

Submitted to the Department of Architecture on June 9, 1981 in partial fulfillment of the requirements for the degree of Master of Science in Architecture Studies

Abstract

This thesis initially focuses on the development of the U.S. stick-built house. The material and construction methods of the structure remain simple and unchanged, whereas the non-structural elements offer an enormous variety of choices in materials and components as a result of the improvements in technology.

In Chapter 2, a case study of the U.S. system suggests that the stick-built house has a great potential for self-help construction, with least subcontracting, rental of some special tools and equipment and the use of prefabricated materials.

A comparison of the U.S. and Japanese systems shows that the Japanese system offers lesser potential for self-help. On the average, higher skills would be required in on-site assembly. Difficulties would occur in using members of different sizes and joining methods. Also, there would be less flexibility in future change of housing design. The author recommends greater simplification of structural members for production and construction methods in Japan.

Thesis Supervisor: Eric Dluhosch
Title: Associate Professor of Building Technology

Acknowledgements

I would like to thank Eric for his guidance and patience. He did a tremendous job of organizing this thesis.

My appreciation goes also to John, who helped me with the theorectical aspect of this thesis. To Sandra, for introducing me into seeing things from a psychological viewpoint.

I owe much to Yamamoto-sensei, for providing me with his expertise in Japanese traditional houses, and to Albert and Edward, for instilling much insight into the American stick-built house.

Barbara also deserves my thanks for her willingness to edit much of my draft.

This thesis was only possible through the generous sponsorship of Ishisaka Foundation. In a sense, I have gained much from the exposure here in the United States to an absorbing and diversified culture. For that I owe them much gratitude.

I dedicate this thesis to Yumi for her gentle encouragement and understanding throughout and to Boon Chai, for making my stay here at M.I.T. an enjoyable experience.

Last but not least, my thanks go to Leigh for her efficient typing and retyping.

CONTENTS

CHAPTER 1
<u>Introduction</u>

1-1 Historical Introduction of the Stick-Built House

1-2 Development of the System

- 1-2-1 Customization and Standardization of Materials and Construction Methods
- 1-2-2 Introduction of Prefabrication: Preassembly and Prefinishing
- 1-2-3 Development of Wood Substitutes
- 1-2-4 Development of Power Hand Tools

1-3 Present System

- 1-3-1 Structural Frame
- 1-3-2 Variety of Surfaces

1-4 Potential for Self-Help

1-1 Historical Introduction of the Stick-Built House

In 1833 St. Mary's Catholic Church, the earliest authenticated balloon frame structure, was erected in Chicago.[1] Although the origin of the balloon frame is disputed, it seems likely that this building system developed from the seventeenth-century farmhouse construction of the early settlers in New England. However, it first appeared as a recognizable type in Chicago.

The balloon frame quickly became the dominant type of house construction in Chicago and surrounding areas.[2] Yet it did not remain in the Chicago area alone and spread with the frontier settlements to become the most common house type in the United States as well as in Canada.

The near miraculous success of the balloon frame system was due to certain advantages of this building system over other conventional ones. In addition the system resulted from

---

[1]Credit for the invention of the balloon frame is given by Seigfried Giedion to George Washington Snow, and by Walker Field to Augustine Deodat Taylor. It is interesting to note that both were born and bred in New England and mastered the skill of constructing early wooden frame houses in New England.

[2]In his book *The Builders* Martin Mayer notes: "The significance of the change was great. 'Early visitors to Chicago were astonished,' Daniel Boorstin writes, 'at the speed with which balloon frame-houses were built. In one week in April, 1834, seven new buildings appeared; by mid-June, there were seventy-five more. In early October, 1834, a writer noted that, although a year before there had been only fifty frame houses in the city, 'now I counted them last Sunday and there was six hundred and twenty eight, and there is from one to four or five a day and about two hundred and twelve of them stores and groceries."

According to A.L. Huxtable, "By contemporary reckoning, nearly all of the frame buildings in Chicago and in all the surrounding country, were of this construction by 1855. Most of these light, wood-framed houses in the Chicago area were to serve as tinder for the great fire of 1871."

and became possible because of the specific social needs, historical context, and vis-a-vis level of industrialization which existed in the United States at the time.

The advantage of the balloon frame system was its readily assembled structure with thin plates and studs which replaced the laborious, expensive mortised and tenoned joining of heavy wooden members in previous house construction. However, due to the nature of this construction, mass-produced nails and mechanically sawn lumber were prerequisites for the development of the balloon frame. In the 1930's United States industry had entered the early stages of mechanization. By means of the rapid improvement of machines for producing nails,[3] they became cheap and plentiful.[4]

From the eighteenth to nineteenth centuries, the method for sawing lumber was being more and more mechanized and steadily improved. Earlier, lumber was produced by a vertical saw run by a watermill. At the end of the nineteenth century the circular saw was invented, which could cut the lumber at less cost with greater speed and accuracy.

According to A. L. Huxtable who describes the success of the balloon frame:

> "It (the balloon frame) appeared at a fortunate moment in history, through an equally fortuitous

---

[3]Albert S. Bolles, in his book *Industrial History of the United States*, describes this change: "when the manufacture of cut nails was first undertaken, wrought nails cost 25¢ a pound. . .In 1828 the production was so brisk that the price was reduced to 8¢ a pound. . .In 1833, 5¢. . .In 1842, 3¢ a pound."

[4]According to *Time, Space and Architecture* by G. Giedion, "several machines for cutting and heading nails were developed in both England and the United States toward the end of the eighteenth century. Thomas Clifford patented such a device in 1790, and about the same time a similar machine was invented by Jacob Perkins of Newburyport. A machine which cut, shaped, and headed tacks in a single operation at the rate of sixty thousand a day was patented by Jesse Reed in 1807."

combination of circumstances. Population in frontier communities and the new cities was increasing at a rapid rate. The country was on the move. The invention of the balloon frame marked the initial industrialization of the building industry at the exact moment to help solve the problem of housing a growing, shifting population. Because its simplicity and durability were matched by its economy and ease of erection, it became a vital element of the country's westward growth. Flexible, inexpensive structures could be erected with a minimum of skilled labor, in the shortest possible time, for a maximum of convenience, profit, and popular use."[5]

Nowadays, the modern two-story wood house is not a balloon frame structure except in a few places like Detroit where traditions survive. In balloon frame construction, the studs run all the way from the sill, which rests on the foundation, to the plate, which supports the rafters. The second floor is nailed onto the vertical support. Thus all the weight rests on the full length of the exterior frame (Fig. 1-1).

Most modern American building uses instead a platform frame, in which the studs that support the roof rest on the floor of the second story, rather than running all the way down to the first floor sill (Fig. 1-2). The advantage of this frame over the balloon frame is that each floor forms a platform, so that the construction for the next floor can be prepared on it. However, the principle of the rigid frame of sticks has survived and, in America, homes are still built now as they were 150 years ago. In later sections of the chapter, platform frame houses are chiefly discussed, although most of the discussion is relevant to both the balloon frame and the platform frame. From now on, the general term "stick-built" house will be used to represent the conventional wood frame house in the United States, including the balloon frame and the platform frame.

As time passed, materials and construction methods became simpler and were standardized. The aim and result was the

---

[5] Huxtable, A.L., *Progressive Architecture in America: The Balloon Frame*

BALLOON FRAME

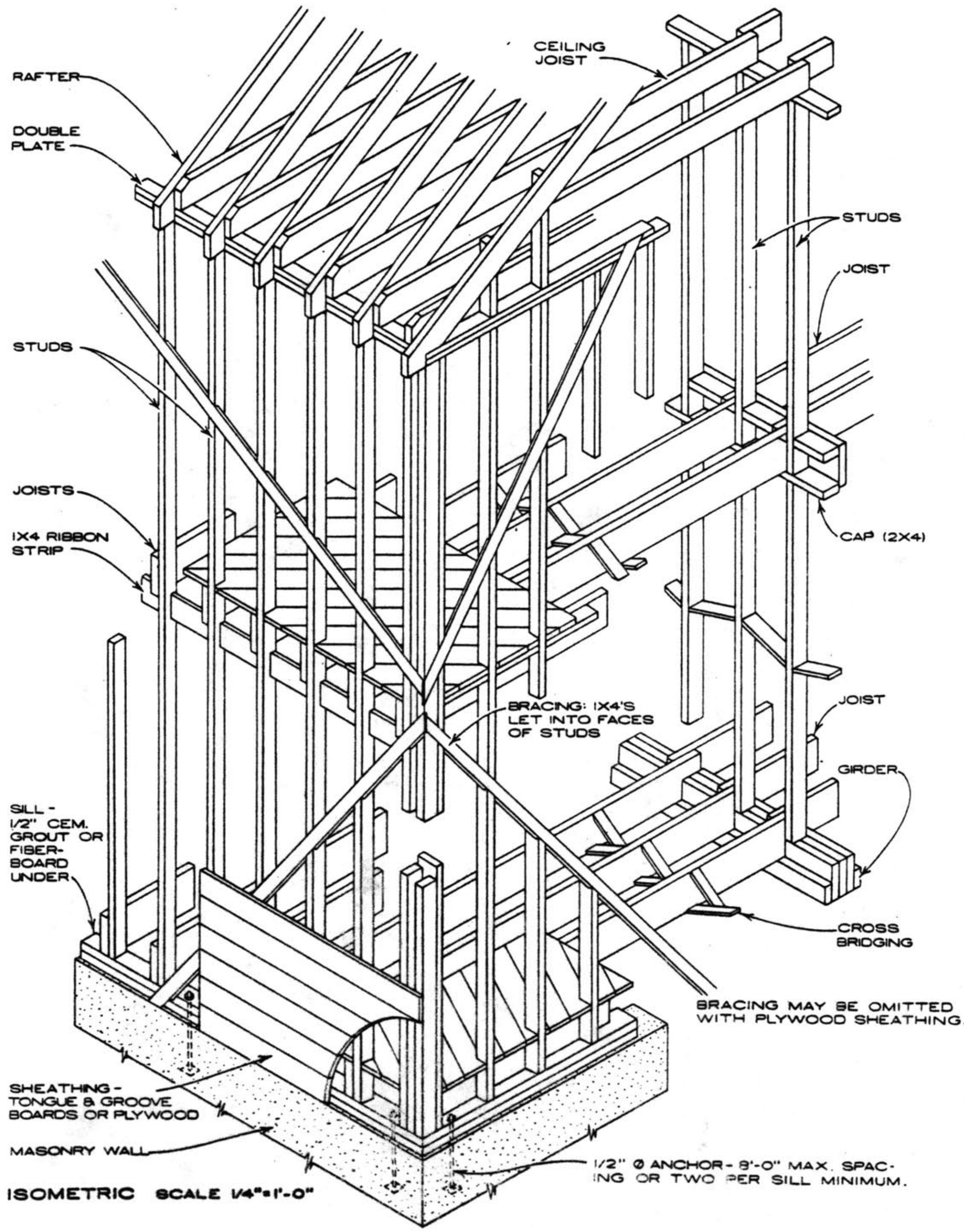


Figure 1-1 Source: Ramsey and Sleeper, Architectural Graphic Standards.

PLATFORM FRAME

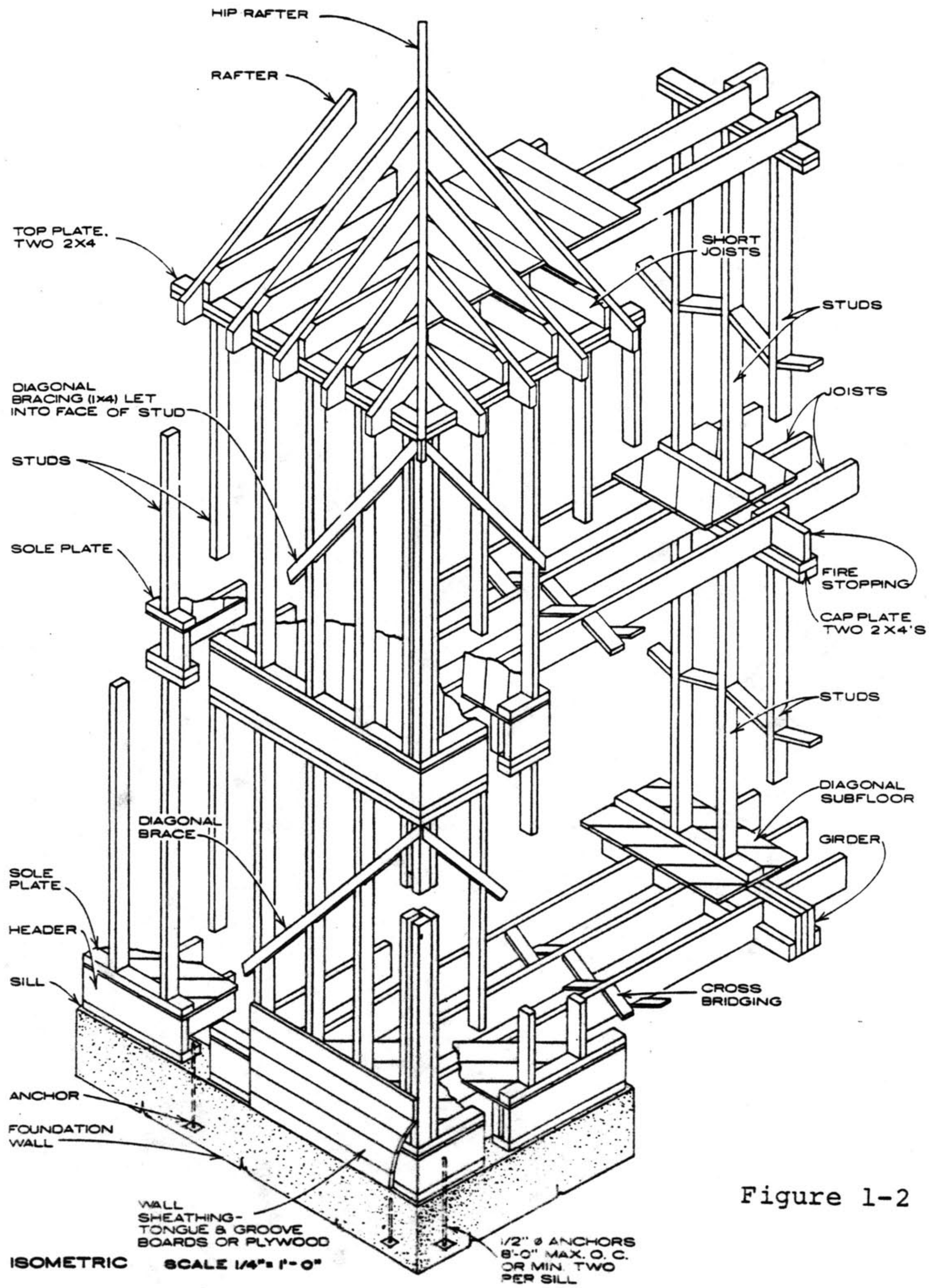


Figure 1-2

Source: Ramsey and Sleeper, Architectural Graphic Standards.

reduction of construction cost and time. The whole housing industry grew around this structural system, and produced and marketed a wide variety of finishing materials and components.

One of the triumphs of this construction is the adaptability of the American house to rapid changes in American life-styles, and especially the population's increasing needs for comfort and space. The wood frame wall provided a hollow space for the introduction of inside plumbing, electric wiring, insulation, and vapor seals. Because few of the interior walls are load-bearing, rooms can be enlarged, and house layouts changed to meet changing needs and preferences with relatively little expense.

The stick-built house remains the dominant construction method in America. It still costs less and is easier and cheaper to maintain and improve than other types of dwelling construction. A well built and maintained wood frame house is one of the most durable types of construction. Some of the oldest existing buildings, and many old houses of the United States are of this type.

To summarize the history of the stick-built house in the United States, the wood frame system has been successful from its invention through its development. Even today, the stick-built house, with its standardized structural materials, simple construction method, wide choice of finishing components and materials, and flexible adaptation to electrical and plumbing systems, is one of the best and most economical housing systems in the world.

1-2 Development of the System

When we look at the development of the stick-built house in the United States, we discover that the basic principles of this building system have remained unchanged until this day. Since the invention of the balloon frame, the idea of framing a simple wood cage by nailing together identical thin sticks which are subsequently covered with various surface materials, has persisted. Even the 16" spacing of the sticks has been used as a basic module throughout this history. This consistancy has allowed the standardization and customizations of other material sizes and components.

Within the framework of peresistent structural principles, the following significant changes in materials and construction methods may be observed in the development of the stick-built house:

1. Customization and standardization of materials and construction methods, in parallel with the development of mass-production.
2. Introduction of prefabrication, especially the pre-assembly of larger components and prefinishing.
3. Development of substitute materials and components for traditional materials and components.
4. Introduction of power driven hand tools on construction sites.
5. Development of a network of support industries with small to "marjor-market" type lumber yards, hardware stores, and do-it-yourself outlets.

1-2-1 Customization and Standardization of Materials and Construction Methods

In any country, when industrialization has not yet reached the point where housing production and market have been organized for industrialized materials and construction methods, houses are built in a traditional manner in terms of use of materials and construction methods and in accordance with implicitly agreed-upon rules. Standardization, or explicitly and officially agreed-upon rules, becomes significant only when nation-wide industrialization of housing is desired. Because traditional or conventional ways often include similar but varied alternatives in material size and joining methods, standardization, if not appropriately institutionalized, tends to result in a barrier against further development of the building industry. This is one of the greatest difficulties with standardization, when applied to conventional systems.

From the inception of the stick-built house, lumber sizes and their spacing became gradually standardized, either implicitly or explictly.

The standard section of joist or stud spacing goes back to the time when wood lath was cut from cordwood which was 4'-0" (48 inches) long, or some other multiple of 16 inches. The 24 inch spacing was too large and the 12 inch spacing was too small. Therefore, it has become universal practice to set studs and joists 16 inches in centers. There is no structural reason for this spacing.[6]

The 16 inch spacing determined the standard sizes of other underlayment materials such as plywood, gypsumboard, hardboard and fiberboard, which were introduced after World War I, with a standard size of 4 feet by 8 feet.

The 16 inch module is also strongly related to the four inch module which is actually the basic module for many

---

[6] Personal interview with Professor Albert G.H. Dietz at M.I.T., and in his book *Dwelling House Construction*, p. 110.

components designed in conventional construction practice in the United States. A multiple of four inches neatly matches bricks, concrete blocks, the spacing of studs and the sizes of plywood and wallboard. It is also small enough for doors and windows, yet large enough to eliminate unnecessary variety in component sizes. The 4 inch module serves mostly as a control, which enables or helps further development of design, rather than as a restriction which would prevent design freedom.

Apart from lumber, plywood, wallboard, and nails, most of the small parts, such as fastening devices, electrical accessories, basic hardware, and even larger items, such as doors, flooring, and to a lesser extent, window sashes, have been standardized on the basis of the above-mentioned modular order.

1-2-2 Introduction of Prefabrication: Preassembly and Prefinishing

Mass production and prefabrication are two major means of industrialization. Since the ultimate object of prefabrication is to reduce on-site work, parts and components tend to become larger and larger. However, if larger components are mass produced, diversity of housing design is restricted. This is the inevitable contradiction in the prefabrication and mass production of today. Generally speaking, it seems that smaller parts are more suitable for mass production and larger parts for smaller scale production, if diversity in house design is to be preserved.

One of the most significant changes in the development of the stick-built house is that more and more industrial methods of production, especially prefabrication, have been introduced. Two major aspects of these changes are: preassembly of increasingly larger structural components, and prefinishing of surface and joints.

The unexposed portions of the house, where quality of finishing is not important, have greater potential for the preassembly of larger components in parallel with mass production. The introduction of plywood is one of the most significant changes, where a larger sheathing component of 4 feet by 8 feet replaced smaller sheathing boards which had been used ever since the beginning of the balloon frame. After World War II, large structural components, such as prestressed-skin panels which consist of plywood facings glued and nailed on the two sides of an inner structural framework of lumber and trussed rafters, which are composed of truss-framed rafters, a ceiling joist and other members connected by gusset plates or steel connectors, have been developed and are commonly used in field constructions (Fig. 1-3). The application of these preassembled, large components has reduced greatly on-site work, when compared to the conventional construction methods.

Today, a variety of prefabricated (either preassembled or prefinished, or both) materials, components and space units are available on the U.S. market and are routinely employed in housing construction. For example, fireplaces, bathroom units, bay windows, dormers, cabinets, stairs, storage wall systems, heating and air conditioning packages are available in prefabricated form, or as kits. Trussed rafters, stressed-skin panels, box beams, pre-hung doors and windows are typical preassembled larger components. Most surface components have prefinished alternatives, which include windows, doors, interior wall coverings, siding, floorings, and ceiling systems (Table 1-1).

PRE-ASSEMBLY OF LARGER COMPONENTS

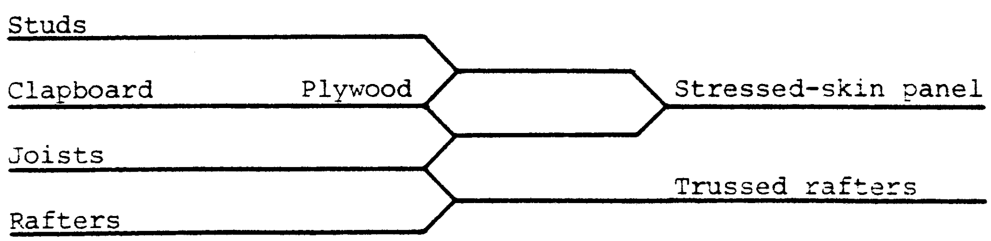


Figure 1-3

DEVELOPMENT OF THE U.S. STICK-BUILT HOUSE

		1833	W.W.I	W.W.II
Fastening hardware	Cut nails Wood pins	Wire nails		Synthetic adhesives
Tools	Hand tools		Electric hand saws	Electric hand drills & routers
Frame	Watermill-sawn lumber		Surfaces lumber	Trussed rafters Stressed-skin panels Plywood box beams Sandwich panels
Sheathing	Clapboards		Plywood Gypsumboards Fiberboards	Hardboards Particleboards Foamboards
Roof & ext. wall surfaces	Wood shingles Slate tiles	Corrugated steel Asphalt roofing & siding Corrugated asbestos	Asbestos panels Glass blocks	Aluminum roof. & siding Vinyl siding
Floor surfaces	Wood boards	Asphalt tiles Linoleum tiles		Vinyl tiles & sheet
Int. wall surfaces & ceiling	Lath & plaster		Gypsumboards	Plastic sheet Prefinished boards Suspended ceiling systems
Paints	Paints			New synthetic paints
Trim	Wood moldings			Prefinished plastic, metal and wood moldings
Openings	Wood windows & doors	Steel windows		Alunimum & stainless steel windows
Services				Plastic coated electric wire, switch boxes, plates & pipes

Table 1-1

1-2-3 Development of Wood Substitutes

In his book *The Evolving House,* Albert F. Bemis describes the typical suburban house in the United States which was found in the early 1930's:

> "It is ten to one of wood frame covered on the exterior either with clapboards, shingles, stucco, or a single layer of brick. . .On the interior there is lath or plaster. . .The chimney is of brick. The whole is built in accordance with law on a foundation of concrete or concrete block set below frost line. The roof framing is of wood, rafters, plank, and then wood, asbestos or asphalt shingles, clay tile or quarried slate. Windows are either double-hung or casement, the latter of wood or metal. Doors are of wood, floors of wood, furniture of wood, trim of wood."

Comparing the typical suburban house in the 1930's with today's houses, we are surprised by the variety of new materials and components that have replaced conventional materials. Nowadays, it is hard to find a traditional material which does not have a substitute made of plastic, aluminum or steel. They are used everywhere in house construction.

Plastic or aluminum siding is commonly used for exterior wall coverings, while stucco and brick veneer finish are rarely used now. Dry wall is now more common for interior finish material than lath and plaster. Floors are often finished with resilient tiles, and so forth. Thus, we can observe that most of the commonly used materials and components have changed in terms of material, when comparing the traditional house with today's houses. However, the "system" of the house has remained the same, including its principle structural elements, such as floors, walls, and roofs, as well as the separation between structure and finishes.

As a result of extensive research in the field of materials science since World War I, new materials such as plastics, aluminum and steel were developed and commercialized, especially in the automobile and aircraft industries. After World War II, many new materials were introduced into the building industry, which borrowed new technology from the more advanced industries. Some products have been successful, and other have not been.

As Richard Bender says in his book *A Crack in the Rear-View Mirror,* those materials which improved performance at lower cost without radically changing appearance have been more successful than those which conflict with traditional procedures of production, marketing and obtaining official acceptance." Early attempts at innovative housing systems were unsuccessful because of unexpected problems of financing, distribution, cost of production investment, inflexibility of design, or too radical a departure from traditional forms.

Light frame metal studs and joists are successful examples of substitutes for the wooden platform frame. Both aluminum and steel are used. They are entirely equivalent to the wooden platform frame system, although they require special tools and joints such as metal screws and drills for assembly.

The development of wood substitutes is summarized in Table 1-1.

1-2-4 Development of Power Hand Tools

Since World War I, many power hand tools have been developed, and their use has grown in parallel with the introduction of new materials. In the 1930's, the electric hand saw was introduced into house construction, and during World War II, carpenters started to use electric hand drills and routers on construction sites (Table 1-1).

Today a variety of power-operated hand tools, such as compressed air-operated staplers, nailers and adhesive guns, electric staplers, nailers, screwdrivers, saws (circular saws, jig saws, and band saws), drills, planes, routers and sanders (disc sanders and orbital sanders), and other power driven fasteners, are commonly used on construction sites.

These tools are widely used for cutting lumber, fastening playwood sheets and boards, installing doors and windows, setting hardware, and penetrating the wood structure to install pipes and wiring. To some extent, these power tools have resulted in lowering the skills required for construction, speeded up construction time, with greater and more uniform quality of the final product while at the same time maintaining the potential for broad diversity.

Characteristically, in the United States, power hand tools are available inexpensively for anyone, as a result of simple and direct mass marketing and distribution systems.

1-3 Present System

In viewing the history of conventional building systems of housing in industrialized countries, we can observe a persistent movement towards "open" systems, i.e., systems which are generally compatible with components of other "outside" systems in parallel with the development of technology and social systems towards greater adaptability, flexibility, and change.

The development towards "open" system has been supported by the rationalized evolution of compatible sub-systems and elements, including a clear definition of the physical boundaries between structural and non-structural elements, i.e., so called "by-passing" systems.

The stick-built house of the United States may be seen as a "total" system which consists of a structural frame (made of highly standardized lumber) and non-structural coverings. Interestingly, it has been enhanced by the addition of intermediate rough coverings, such as sheathing and subfloor, which have become part and parcel of the structural integrity of the frame, by providing additional bracing, or by acting as diaphragm.

Figure 1-4 shows the characteristics of the stick-built house in a simplified way. Characteristically, most of the joints between the structural members, bewteen the diaphragm and the surface, opening or survice materials, and between surface materials and trims, allow simple forms of nailing or adhersion. The solid diaphragm and simple joining methods enabled the independent development of a great variety of interchangeable materials for surfaces, opeings and service fixtures, from conventional to newly developed industrialized elements.

THE SYSTEM CHARACTERISTICS OF THE STICK-BUILT HOUSE

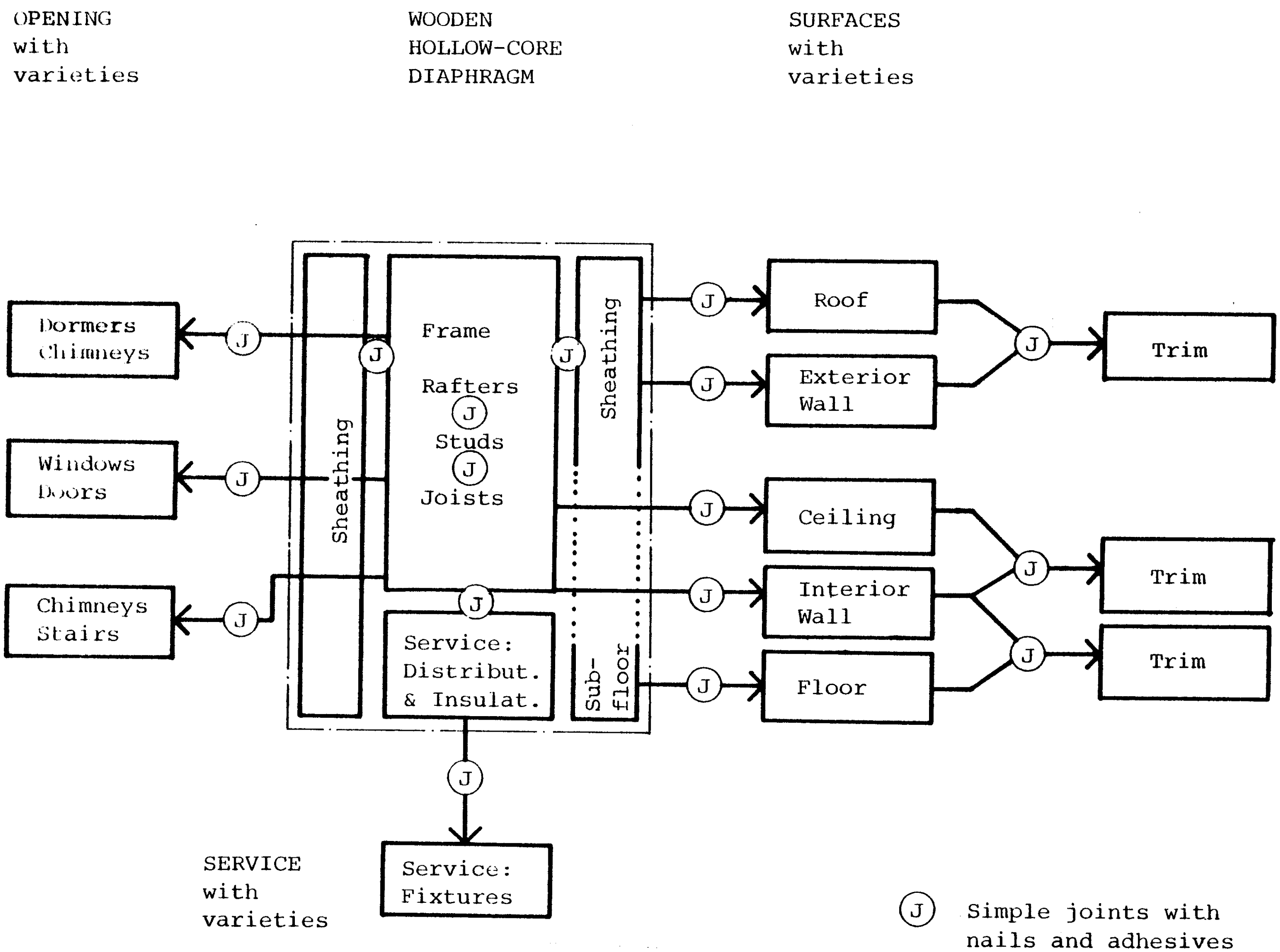


Figure 1-4

1-3-1 Structural Frame[7]

1. Simple Rule of Framing

Framing materials have been standardized to strictly limited sizes. Lumber dimensions for ordinary use in framing consist of 2" x 3", 2" x 8", 2" x 10" and 2" x 12". For every building element and in every construction phase, the method of construction is standardized in a very simple way, including spacing of lumber, allowable spans, and size of the nails, as well as the ways of nailing.[8]

For example, when the first floor joists are formed, 2" x 12" structural lumbers will be fastened to the sill and girder by toe-nailing three 8d nails at each meeting face, and spaced 16 inches on centers (Table 1-3). If the modulus of elasticity of the lumber is 1.4, with a required 40 lb./sq. ft. of loading, the allowable span of the joist is 19' 1" (Table 1-4). If 5/8" thick plywood is employed for the subfloor, the allowable maximum span of the joists will increase to 21' 9" (Table 1-5).

---

[7] Sources for this part of the thesis are the following books: Dietz, Albert G.H., *Dwelling House Construction*, Anderson, L.O., *Wood-Framing House Construction*, and Ramsey and Sleeper, *Architectural Graphic Standards*. Most rules of framing have been abstracted from the first two books, while the drawings are from all three.

[8] NAILING
Three ways of nailing are used: face nailing, toe-nailing and end-nailing (Figures 1-5). Wood members are joined by standard size nails, spaced according to desired strength and function (Table 1-2). Nails are the almost-universal means of fastening the wood members of a house together, or were until recently. They have now been largely replaced by staplers, nailing plates and glues. Although screws and bolts have some use, and some adhesives are employed, nails are the most important means of fastening. Common nails are available from 2d to 6d that is, 1 inch to 6 inches in length. They are used when the appearance of the work is unimportant, e.g., in the framing-in of houses and the building of concrete forms.

RECOMMENDED NAILING SCHEDULE FOR TYPICAL FRANING AND SHEATHING USING COMMON NAILS

Phases of Framing	Way of nailing	Number and size of nails
Joist to sill or girder	toenail	3-8d
Top plate to stud	end-nail	2-16d
Stud to sole plate	toenail	4-8d
Rafter to plate	toenail	3-8d
Ceiling joists to parallel rafters	face-nail	3-16d
32/12 plywood (1/2, 5/8" thick), subflooring, joists 16" O.C.	face-nail	8d, 6" O.C. for panel edges, 10" O.C. for intermediate

Table 1-2

THREE WAYS OF NAILING

Face-nailing: perpendicular to load

Toenailing

End-nailing: parallel to load

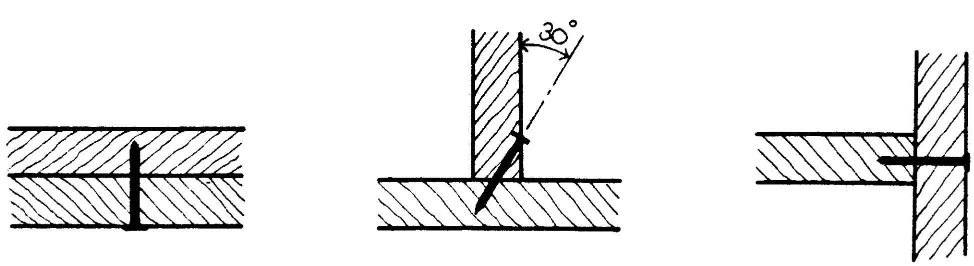


Figure 1-5

TYPICAL FRAMING OF PLATFORM FRAME

Building Element	Typical Framing		Grade of Lumber
Studs, bearing walls	2" X 4"	16" O.C.	"Stud" grade
Studs, non-bearing partitions	2" X 3"	16" O.C.	"Stud" grade
Floor joists, 1st. floor	2" X 12"	16" O.C.	#2 and better grade
Floor joists, 2nd. floor	2" X 10" 2" X 8"	16" O.C.	#2 and better grade
Rafters	2" X 8"	16" O.C.	#2 and better grade

Table 1-3

ALLOWABLE MAXIMUM SPAN OR FLOOR JOISTS

(Example: 16" O.C., 40lb./sq.ft. required, Modulus of Elasticity in 1,000,000 psi, E = 1.4, Douglas Fir)

Joist Size	Allowable maximum span
2" X 8"	12'-3"
2" X 10"	15'-8"
2" X 12"	19'-1"

Table 1-4

RECOMMENDED MAXIMUM SPAN WITH PLYWOOD SHEATHING

(Example: 5/8" plywood, joists" Douglas Fir, Larch, No.1)

Joist Size	Recommended maximum span
2" X 8"	14'-4"
2" X 10"	18'-1"
2" X 12"	21'-9"

Table 1-5

2. Rules for Framing partitions, Openings and Wall Projections

The rules for framing partitions, openings, and wall projections are equally simple.

A. Rules for Floor Framing under Partitions:

Non-bearing partitions, resting on the floor and running perpendicular to the direction of the joists need no extra support. If bearing partitions are situated close to the centers of joist spans, the joist should be doubled where the partition is located directly over it, or short pieces of block (solid bridging) are spiked across between the two joists. If bearing partitions run parallel to the joists, the joist framing should be engineered to be stronger than in the case of non-bearing partitions. (Table 1-6 and Figure 1-6)

FLOOR FRAMING UNDER PARTITIONS

PARTITIONS	RUNNING PERPENDICULAR TO JOISTS		RUNNING PARALLEL TO JOISTS	
	AROUND ENDS OF SPANS	AROUND CENTERS OF SPANS	ON A JOIST	BETWEEN JOISTS
NON-BEARING	No extra support		Doubling the joists	Solid bridging
BEARING	No extra support	Doubling the joists	Not appropriate, but can be engineered	

Table 1-6

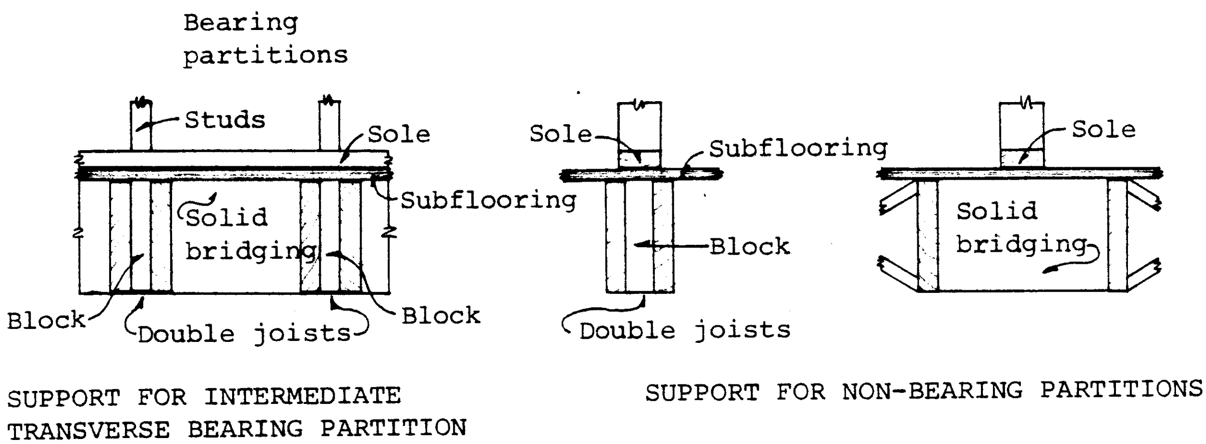


Figure 1-6

B. Rules for Framing Openings:

Whenever openings are necessary, for doors and windows in walls, for stairs, chimneys and fireplaces in floors or for dormers and chimneys in roofs, they are all framed in essentially the same way. That is, doubled headers and trimmers are framed around the opening, although different considerations are made for different structural reasons (Figures 1-7,1-8,1-9).

For openings in walls using double headers and cripples, a range of allowable spans based on header sizes are recommended as shown in Table 1-7 and Figure 1-7a.

For larger wall openings, requiring heavy framing to carry loads and to prevent excessive deflection, several methods are used, such as braces, heavy single or two-piece girders, steel I-beams or a pair of steel channels, or box girders with plywood webs (Figure 1-7b, c).

MAXIMUM SPAN OF OPENING WITH DOUBLE HEADER

Header Size	Maximum span of openings
2" X 6"	3'-6"
2" X 8"	5'-0"
2" X 10"	6'-6"
2" X 12"	8'-0"

Table 1-7

WALL OPENING

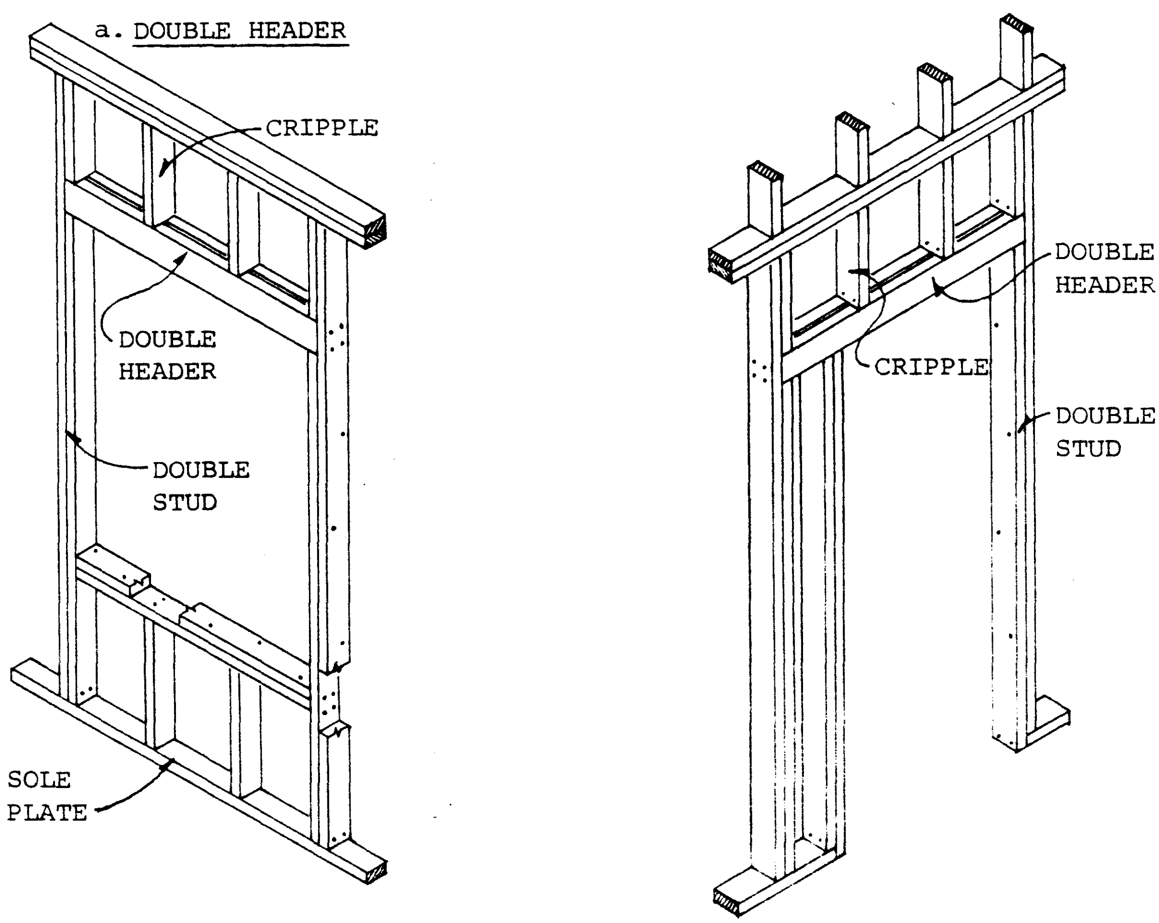


Figure 1-7

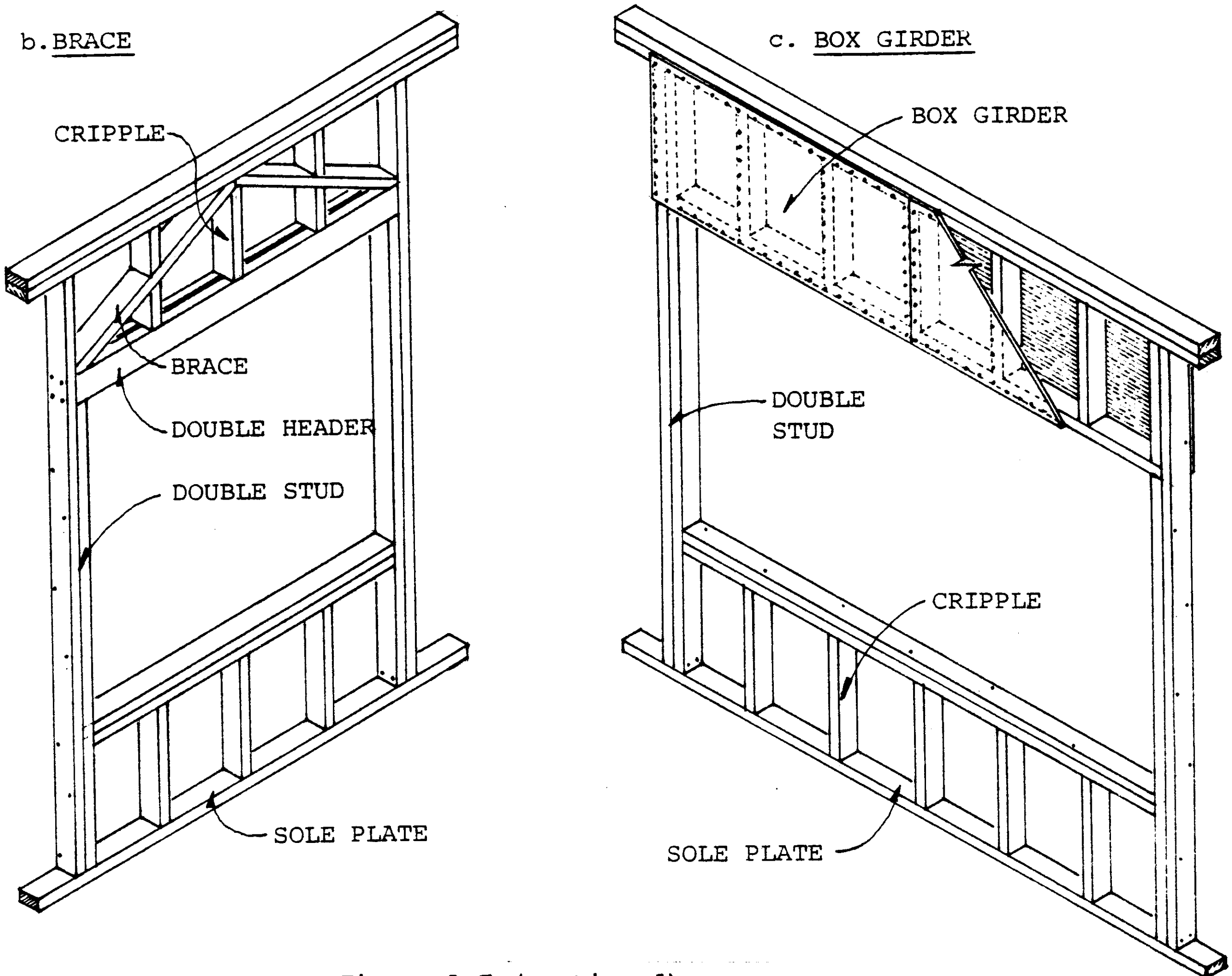


Figure 1-7 (continued)

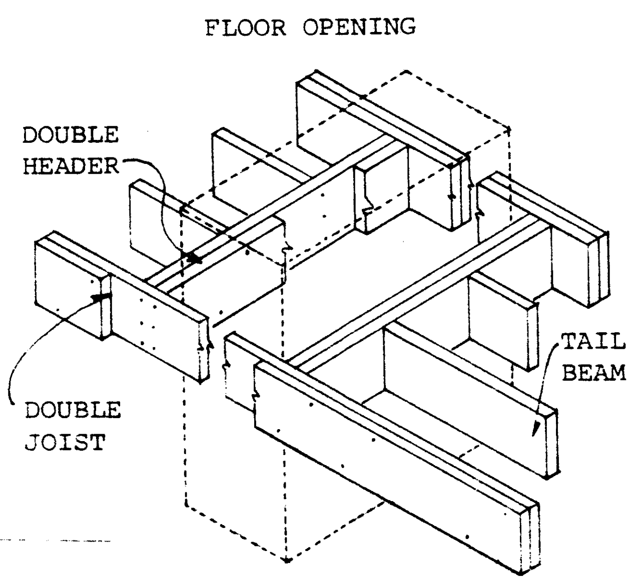
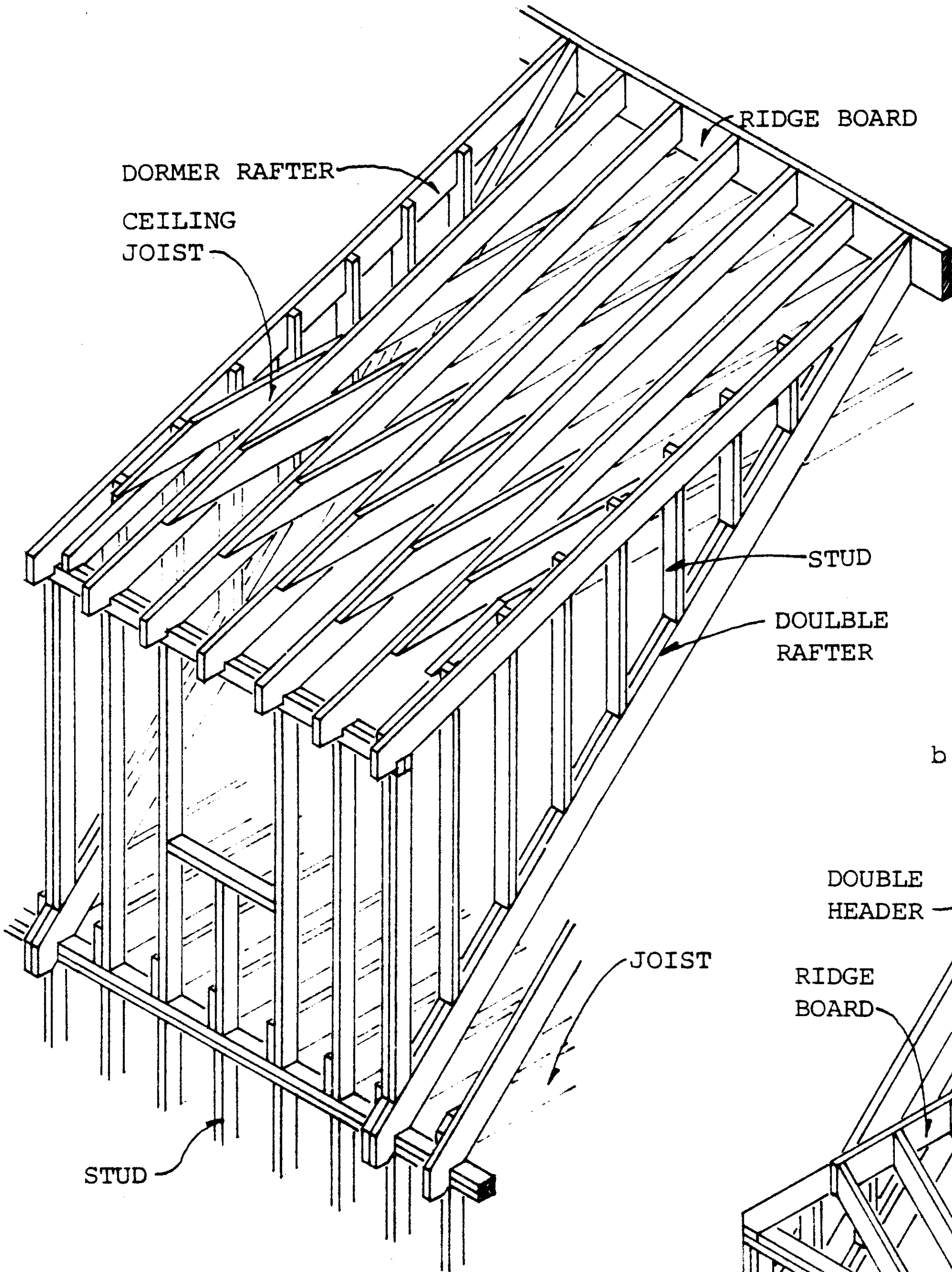


Figure 1-8

ROOF OPENING

a. SHED DORMER



b. GABLE DORMER

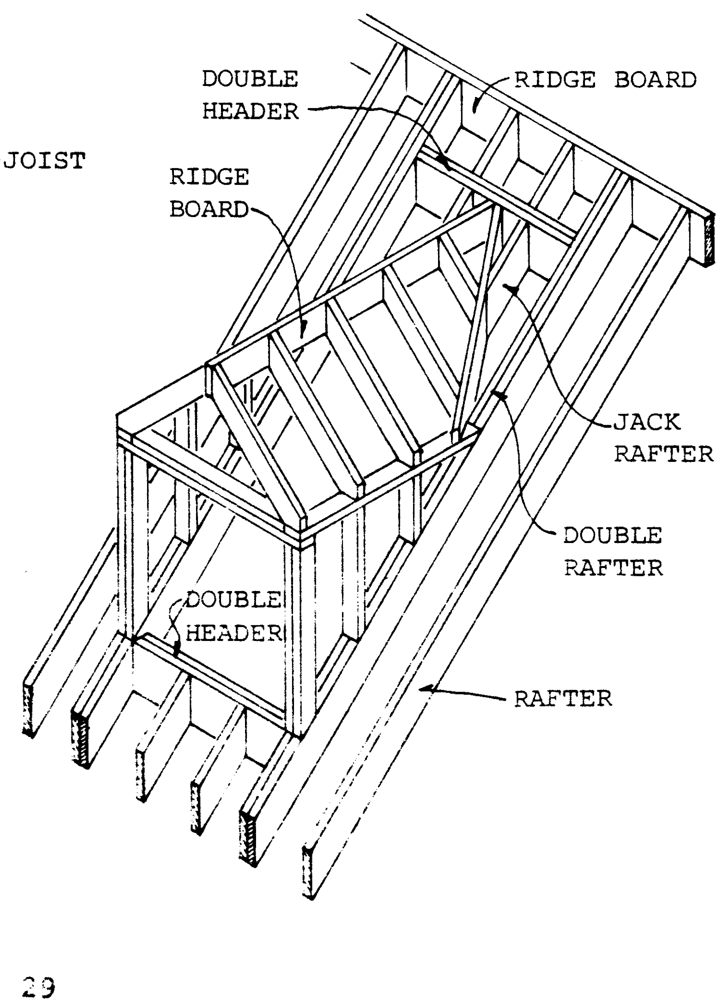
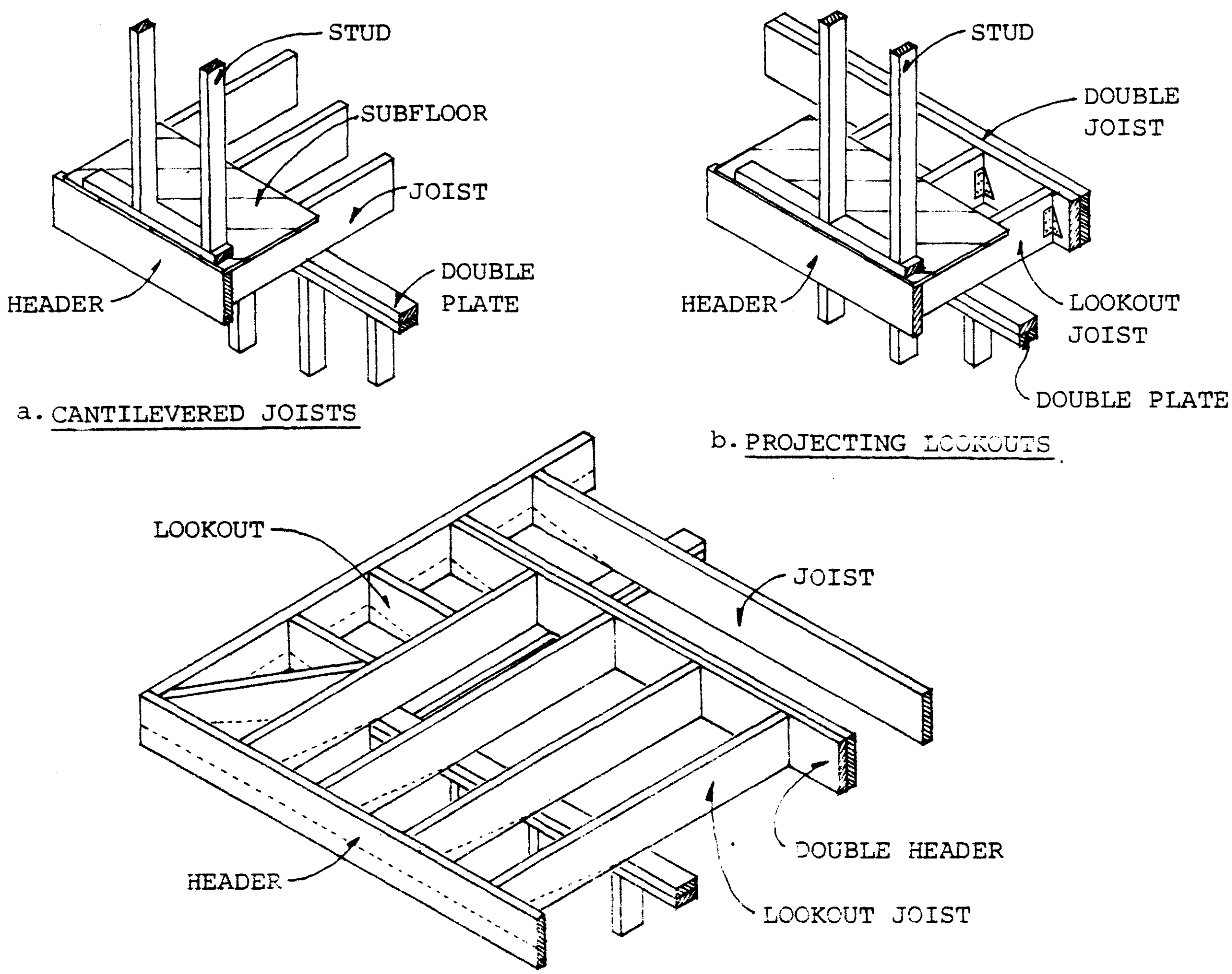


Figure 1-9

C. Rules for Framing Wall Projections:

The framing for wall projections such as a bay window, and first or second floor extensions beyond the lower wall, is generally accomplished by projecting the floor joists. Normally, this extension should not exceed 24 inches, unless designed specifically for greater projection. If joists run at right angles to the wall, they are simply extended as cantilevers (Figure 1-10a). If joists are parallel to the wall, the joist back is doubled, and lookout joists are framed (Figure 1-10b). This type of projection should be limited to small areas.

WALL PROJECTIONS



a. CANTILEVERED JOISTS

b. PROJECTING LOOKOUTS

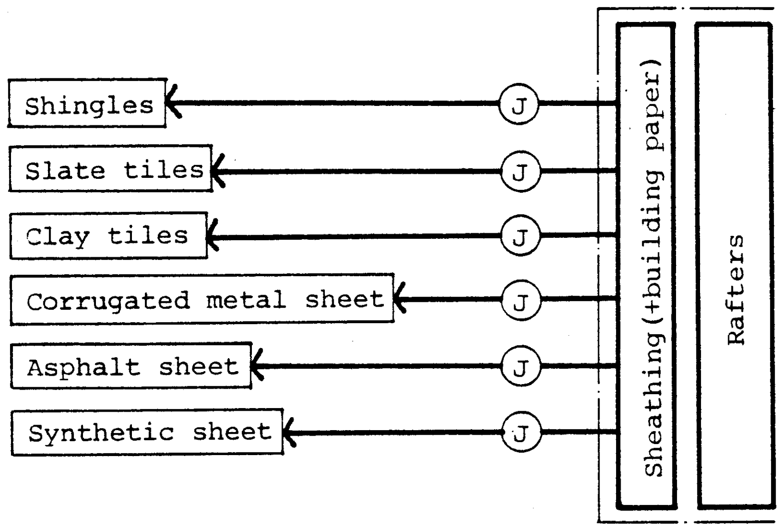
Figure 1-10 c. FRAMING FOR LARGE OVERHANG

As seen above, surprisingly simple, clear and comprehensive "rules" have been widely agreed upon, for very standardized lumber and nails, and standardized methods of assembly, as well, based on continuous experience and testing, ever since the system was first used.

1-3-2 Variety of Surfaces

The standardized methods of framing are used without regard to the type of floor, wall, or roof. As a result, the structure of the stick-built house consists of a generalized and standardized wood diaphragm, which permits a great variety of finishing materials to be attached to it. Since the method of joining is primarily nailing, which is extremely simple and universal for the wood frame, most of these finishing materials become interchangeable (Figures 1-11 and 1-12) and show the varieties of interchangeable surface finishes.

ROOF SURFACES



EXTERIOR WALL SURFACES

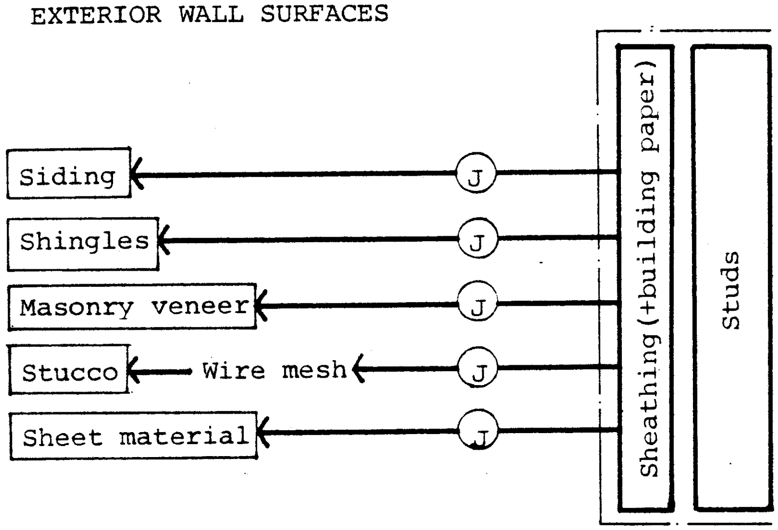
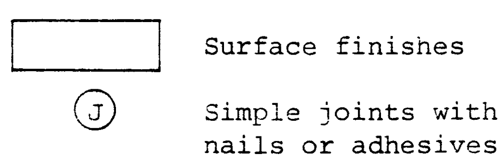
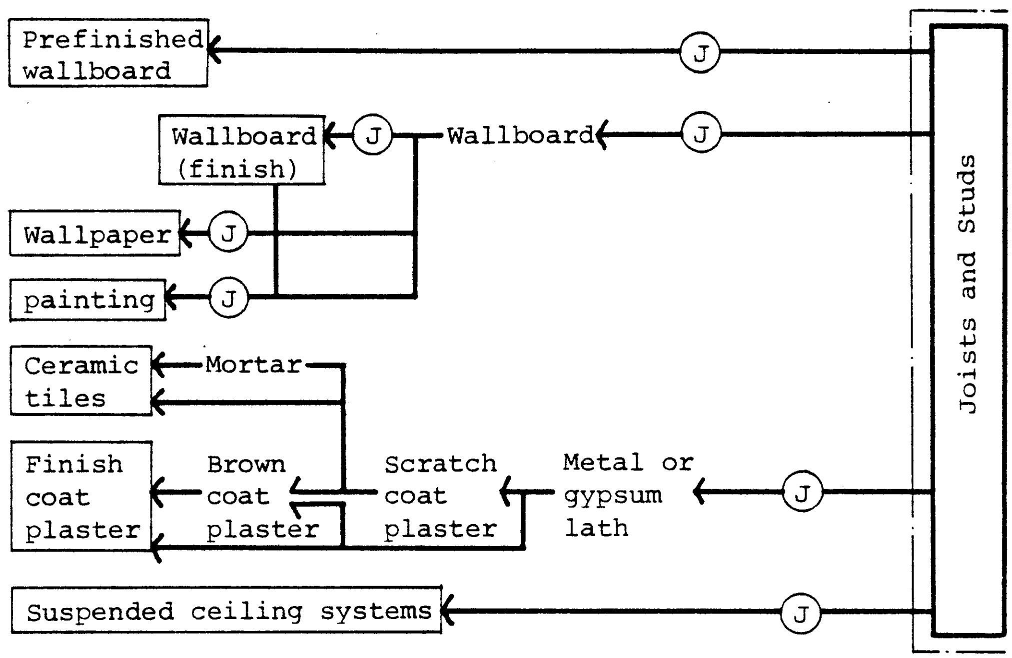


Figure 1-11

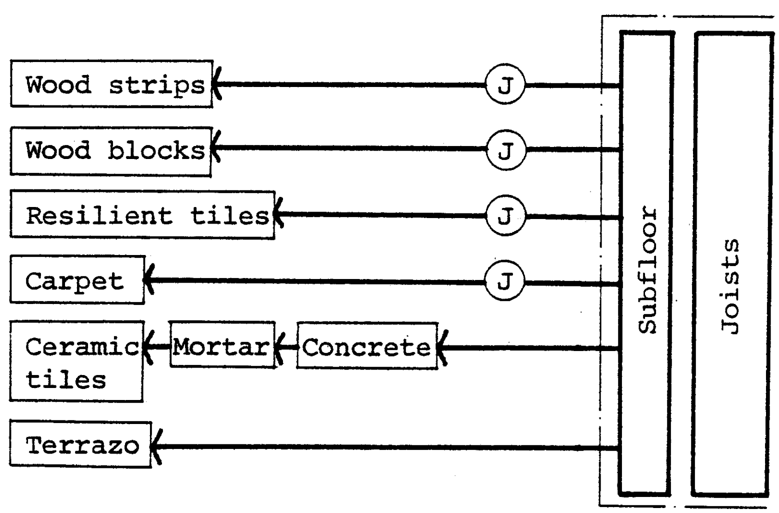
EXTERIOR SURFACES



INTERIOR WALL SURFACES
& CEILING SURFACES



FLOOR SURFACES



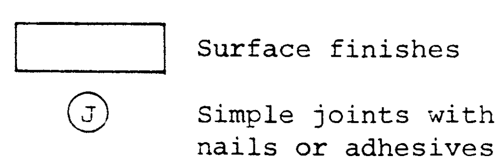


Figure 1-12

INTERIOR SURFACES

1-4 Potential for Self-Help

As the previous sections in the first chapter show, the American stick-built house is one of the most successfully industrialized house systems in the world today. Contributing to this success have been the characteristics of the technical system: the clearly distinguished structure and non-structure, simply standardized structural materials and construction methods, and the wide variety of alternative surface openings and surface materials.

At the same time, the whole structure of the marketing systems has supported the effective development of the stick-built house. The most significant characteristic of the United States housing market is that it provides direct short-cut market distribution of materials and tools. This direct relationship between producers of materials and individual users has brought great advantages in terms of cost and construction time over other systems. Because these characteristics of the stick-built house have provided individual users with access to multi-sourced information and resources fof housing, users may more easily understand the whole process of housing, including the design, construction, and maintenance of the stick-built house.

Those conditions for the success of the stick-built house which have been abstracted from the previous sections and shown above, are also the preconditions for self-help construction. The simple system of the stick-built house requires no highly skilled labor or special-purpose equipment. The direct distribution system provides the users easy access to information[9]

[9] An enormous variety and quantity of information is available to the user: magazines of house design, plans and modifications; catalogues of materials and tools; "do-it-yourself" books and so forth.

and to materials and tools.[10] Because the housing process is readily understood by the individual user, the self-help activity becomes much easier.

In fact, nearly 20% of the new single-family houses in the U.S. are constructed by the self-help builder each year (Table 1-8). In addition, the portion of stick-built houses should be a very great percentage of the total number of owner-built houses.

From a broader viewpoint, the thesis is based on the idea that housing should provide greater control or decision-making on the part of the individual user.[11] In that sense, the author believes that there is "much to learn" from the conventional building systems which have survived for a long period and are still effectively at work.

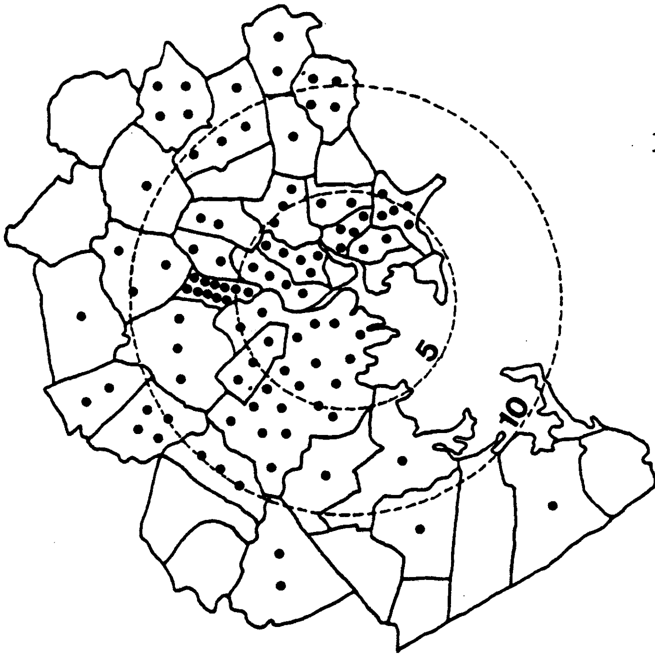
In the next chapter, a case study has been conducted in order to assess the potential of the American stick-built house for self-help construction. The case study is based on the analysis of the house system in the first chapter.

---

[10] In urban and suburban areas, material and tool/equipment stores are common, making their use common. Also the automobile culture of the U.S. gives easy access to them for the average user. Here the distribution of lumber-yards and rental equipment stores in the Boston area is shown in the next page.

[11] I agree with N.J. Habraken who persistently advocates the importance of increasing the decisive role of the individual user in housing; and also J.F.C. Turner who states in his book *Freedom to Build* the primary assumption for housing:

> "When dwellers control the major decisions and are free to make their own contribution to the design, construction, or management of their housing, both the process and the environment produced stimulate individual and social well-being. When people have no control over, nor responsibility for key decisions in the housing process, on the other hand, dwelling environments may instead become a barrier to personal fulfillment and a burden on the economy."



DISTRIBUTION OF "CONTRACTORS EQUIPMENT, SUPPLIES-RENTING & LEASING" COMPANIES IN GREATER BOSTON AREA

Figure 1-14

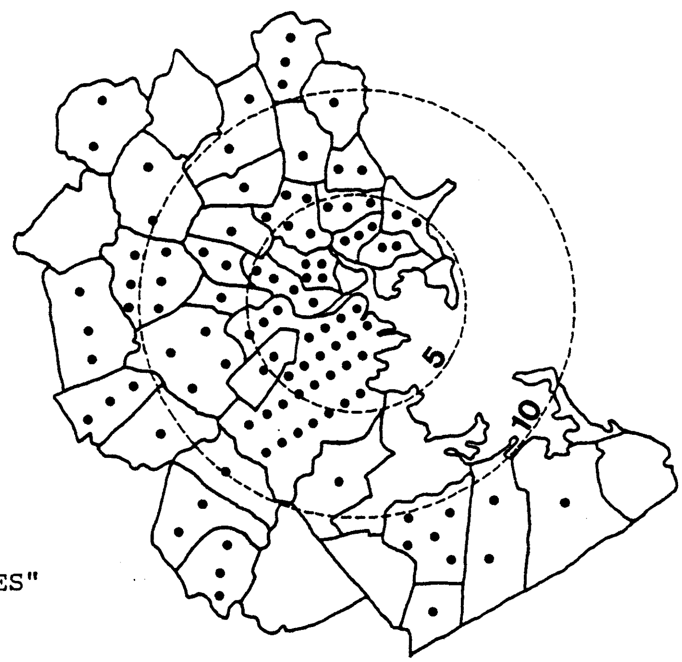


Figure 1-13

DISTRIBUTION OF "LUMBER-RETAIL" STORES" IN GREATER BOSTON AREA

Source: Bell System Yellow Pages, Boston Area
New England Telephone, 1981.

Note: The circumferential lines show 5 and 10 mile distances from Boston Center.

NUMBER OF OWNER-BUILT SINGLE-FAMILY DWELLINGS: 1968 AND 1979

Year	Owner-Built	Contractor-Built	Developer-Built
1968	158,000 (18%)	178,000 (20%)	536,000 (62%)
1979	244,000 (19%)	231,000 (18%)	799,000 (63%)

Source: Beaurau of the Census, Department of Commerce.

Table 1-8

CHAPTER 2
Case Study

2-1 Criteria for Self-Help

Ease or difficulty of performing self-help projects depends on the properties of the technology used for the project, that is, properties of material, tools, and labor. Therefore, the ease or difficulty of a self-help activity can be seen as a function of these factors. In the present thesis, after scanning a wide range of candidates, those factors which seem to be most important in determining the potential for self-help activities were selected from properties of the tools and labor.

The criteria are:

1. Required skill level
2. Required tools
3. Required physical strength of manpower units.

Because the study deals with a conventional building system, the choice of materials and assembly methods are customized or standardized for each subsystem, such as framing, sheathing, interior and exterior coverings, openings and services, usually with a variety of alternatives, each of which has advantages and disadvantages. The choice of materials and methods, which in themselves are strong determinants of potential in self-help construction, will be shown as alternatives chosen by the self-help builder.

In addition to these technological criteria, economic or psychological incentives or benefits of self-help construction are also significant in decision-making by the self-help builder, although most of them are hardly quantifiable. In the present thesis, actual savings by the self-help builder has been employed to determine the economic incentive or benefit.

2-2 Method of Analysis

2-2-1 Method of Assessment

For the assessment of the potential of the system for self-help construction, it seems to be appropriate to break down the whole process of building a house into a conventional unit of task with typical materials and construction methods. Therefore, evaluations have been made on these typical tasks in terms of the criteria stated in the previous section.

The results of evaluation have been shown in the form of evaluation matrices, which appear in pages 49 to 60 .

The intention of the development of the evaluation matrices is to show the potential of each task, subsystem, and the total system for self-help construction, and at the same time, to help understand characteristics of each task, subsystem and the total system.

In addition, characteristics of materials used for each task such as expected life cycle, assembly method, and finishing method, have been added in the lower half of the matrix. The intention has been to help understand characteristics of each task, subsytem and the total system of the present, and to help to further the discussion of relationships between the characteristics of material-method packages and their potential for self-help construction.

2-2-2 Definition of Criteria Entries of the Evaluation Matrix

In the upper half of the evaluation matrix, four criteria for self-help construction of each task have been entered. These criteria are: skill level, tool requirement, physical strength requirement and savings by the self-help builder.

1. Skill Level

The quality of construction is influenced by certain factors such as dexterity and experience of the laborer, as well as the tools used and instruction provided. Some tasks require little dexterity and experience, and can be accomplished with simple instructions, using simple and universal tools. For example, roof covering with wood or asphalt shingles can be achieved by a person with little dexterity and experience using a hammer, and provided with simple instructions on selection of materials, nailing and the spacing of shingles.

However, those tasks which involve intricate joining of materials and/or high positional accuracy necessitating measurement on site, require labor having qualities of dexterity, considerable experience, and good instruction. Examples of these tasks are installing windows and doors, laying ceramic tiles, plastering, and so forth.

In addition, such tasks as electrical wiring and plumbing are often not allowed to be performed by the self-helper by local building codes.

Assuming the provision of proper tools and instructions, each task has been categorized into three groups, according to required skill (dexterity and experience) level.

UNSKILLED: This task can be performed by any person with ordinary dexterity, with no or little experience, being provided with good instruction, and resulting in satisfactory quality.

SEMI-SKILLED: To be performed satisfactorily, this task requires a person with great dexterity, or considerable experience, who is provided with good instruction.

SKILLED: This task requires licensed labor, or so high an expertise to attain satisfactory quality that it can be achieved only by professional laborers.

2. Tool Requirements

The entry "Tool Requirement" has been sub-categorized into three groups, according to different characteristics of the tool requirement of the tasks, such as likelihood of self-help builders' investment on purchasing tools and availability of such tools in the market.

GENERAL TOOLS: The task can be performed by using tools which an ordinary unskilled person can operate easily by hand, whose functions and uses are basic and universal. In addition, the purchasing of these tools is regarded as an indispensable investment by most families not only for their self-help building activity but also for other everyday activities such as repairing a car or anything else. Therefore this category consists of hand tools with a variety of universal functions such as saws, chisels and knives for cutting; drills, planes, files and rasps for haping and smoothing; hammers, wrenches and screw-drivers for fastening; pliers for holding; rules, squares and levels for measuring; goggles, aprons and gloves for safety; brushes, pans and rollers for painting; laders for climbing, and so on. Also, there are inexpensive power hand tools for universal functions such as: electric hand-saws, electric jigsaws and electric routers with blades for cutting; electric drills with bits for drilling; electric sanders and electric planers for shaping and smoothing; and electric staplers for fastening. These power tools can save an enormous amount of time and can accomplish the task far more easily than would be possible by ordinary hand tools.

These hand tools and power hand tools are available at most department stores and lumberyards at relatively low cost.

Those tasks which can be accomplished using these general hand tools have been included in the category of GENERAL TOOLS, assuming that most families are likely to invest in them for self-help construction as well as for everyday, general use.

SPECIAL TOOLS: Certain tasks require tools with functions that are so specific, or that are so expensive that few self-help builders are likely to be equipped with them.

For example, the refinishing of a wood floor requires an upright drum sander for open spaces, and a disk-type edger for cutting in along base boards. For mixing and pouring quantities of concrete for a slab, the self-help builder must use a concrete mixer, a wheel barrow, and a full float. Few self-help builders own power nailers for framing, although they make tasks much easier. These hand tools, power tools, and equipment may be rented at equipment rental shops, which are distributed conveniently over urban and suburban areas.

Those tasks which should be done with rented or borrowed special tools and equipment have been included in the category of SPECIAL TOOLS.

HEAVY MACHINES: Any task which needs to be performed by special, heavy machinery with a qualified operator, such as a crane for lifting roof trusses, a back hoe for digging trenches, or machines for installing foam or loose-fill insulation material, will be considered as not appropriate for self-help activities, and assumed to be sub-contracted.

3. Physical Strength Requirement

This criteria is related to the physical strength required for lifting, holding, or carrying materials for performing the task. Therefore, weights and sizes of the components used in the task have a great influence on this criteria. For example, most of those finishing materials which are relatively light and small, such as shingles, sidings, moldings, tiles, and boards, can be handled by one person. Although most phases of framing can be accomplished by one person except for roof/ceiling framing, existence of one helper is preferable. Such tasks as roof/ceiling framing, lifting and holding a plywood sheet, and installing prehung windows, require two persons. It is difficult to find tasks in the stick-built house construction which require more than two persons. However, a few tasks, such as connecting end rafters to a ridge board and ceiling joists, are preferably done by three persons; while two persons fasten rafter ends to top plates, joists and a ridge board, the last person holds them in the center.

The definitions of entries of physical strength requirement are as follows:

ONE: The task requires one person for all phases to be completed.

TWO: The task requires two persons in a portion or in all of the phases.

MORE THAN TWO: The task requires more than two persons in portion or all of the phases.

4. Savings by the Self-Help Builder: Breakeven Wage Rate

Besides assessing the technological aspects, such as requirements of skills, tools, and physical strength, considerations of incentives and benefits of self-help construction are also significant. Why do self-help builders make decisions to build or change their own houses? And what will they get from self-help?

There seem to be economic incentives and benefits of self-help construction. People may do self-help because they wish to, or must, save money on the construction of their houses, to increase habitability, or to increase the market value of thier houses through upgrading them.

In addition, some people may want to build or change their own houses because such direct action in fulfilling housing needs seems to contribute to their psychological well-being, such as their sense of achievement or competence, their satisfaction at learning skills, or their sense of controlling space and time, as well as building's recreational effect. These psychological incentives and benefits of self-help activities are not easily quantifiable, but they are often as important as the physical improvement, or the economic advantage.

While psychological aspects of self-help are not to be quantified here, it seems appropriate to develop a criteria of economic aspects of self-help. As the fourth entry of the assessment matrix, therefore, an indicator of the actual savings by the self-help builder "breakeven wage rate" has been developed and employed. This value eventually shows the hourly savings in doing the task by the self-help builder compared to the cost for the same task done by the contractor.

Based on "Means Building Construction Cost Data 1981," and the table of "self-help efficiency factors" which shows ratios of self-help construction time to contractor's construction time that appeared in Large-Scale Self-Help Housing Methods by Building Systems Development (1970), the breakeven wage rate is obtained through calculation using the following formula:

$$\text{Breakeven Wage Rate (\$/man-hour)} = \frac{Oc \times (Cc - Csh)}{e}$$

Here, Oc: Contractor's hourly output per person (unit/man-hour)

Cc: Contractor's cost per unit ($/unit)

Csh: Self-help builder's cost per unit ($/unit)

e: Efficiency factor for self-help

The derivation of the formula and obtained values of the breakeven rate are shown in the Appendix.

Considering that the average wage rate for ordinary construction laborers is a little more than $10 per hour, (Table 2-1) , and the minimum wage is about 5 dollars per hour. in 1981, the breakeven wage rates for tasks have been categorized into three groups:

HIGH: More than $10 per hour

MEDIUM: More than $5 and less than $10 per hour

LOW: Not more than $5 per hour

Because an assumption for the calculation is that the self-help builder owns all tools necessary for the tasks, the calculation has been applied for only those tasks which require GENERAL TOOLS for accomplishing the job.

WAGE RATES OF THE CONSTRUCTION INDUSTORY IN THE UNITED STATES

(National hourly averages as of January, 1981)

Carpenters	$14.88
Dry wall	15.47
Electrician, inside	16.75
Laborers	11.83
Painters	14.41
Pipe fitters	16.87
Plumbers	16.78
All crafts weighted average	14.94

Source: Depertment of Labor

Table 2-1

2-2-3 Definition of Entries Pertaining to the Characteristics of the System

In the lower half of the evaluation matrix, principal materials employed in each task have been categorized. Evaluation of the principally used material for the task in terms of expected life cycle, assembly method, and finish of the material or components is supposed to reflect the characteristics of total system and subsystems of today's stick-built house, such as the different considerations of life cycle, or different varities and ranges of alternative materials and methods.

The definitions of the categories are as follows:

1. Expected Life Cycle

LONG TERM: Elements or principal materials give adequate performance for 20 to 40 years, or equivalent, in the life of the house.
Examples: framing and sheathing (floors, walls and roofs), service distribution (piping and wiring), etc.

MEDIUM TERM: Satisfactory performance for 10 to 20 years.
Examples: relatively durable finishes such as siding, roof covering, floor covering, etc.

SHORT TERM: Satisfactory performance for 0 to 10 years.
Examples: appliances (ranges, dishwashers, heaters), fragile surfaces (paint, carpet, wallpaper), etc.

2. Material

RAW: Undefined shape. Need to be formed or shaped on site.
Examples: sand, cement, paint, etc.

SEMI-PROCESSED: Defined in one or two dimensions. Need to be cut on site.
Examples: lumber, wood panels, sheet materials, steel sections, extruded aluminum, moldings, etc.

PROCESSED: Defined shape; not necessary to use tools to define, simply attach on site.
Examples: shingles, tiles, plywood sheets, etc.

KIT: All parts are functionally defined to be assembled on site.
Examples: doors, windows, cabinets, etc.

PRE-ASSEMBLED: Partially assembled off-site, while some assembly task on site is left.

FULLY-ASSEMBLED: All or most of the parts are assembled off-site. Just necessary to be fixed and installed.
Examples: appliances, fixtures, etc.

3. Finish

NOT FINISHED: Surface of the parts is not finished. Exposed parts should be finished on site.
Examples: framing and sheathing materials, wood floor panel, unfinished doors and windows, etc.

PRE-FINISHED: Exposed surfaces are finished off-site. Not necessary to be finished on site.
Examples: most of the materials of surface finishes, doors and windows, appliances, fixtures, etc.

2-2-4 Process of Evaluation

The evaluation criteria of the various matrix entries, such as skill level, tool requirement, physical strength requirement and expected life cycle, are based on interviews with Professor Albert G. H. Dietz, Professor Edward B. Allen and Professor Eric J. Dluhosch at M.I.T., as well as other people, experienced in self-help construction. In the interviews definitions of the entries were presented to these individuals before requesting to define their own choice of criteria.

In addition, a great number of published material on "do-it-yourself" or self-help construction were consulted. These are listed in the bibliography at the end of this thesis.

EVALUATION MATRIX 1.

FOUNDATION

● Required

○ Preferable

• Expected life cycle, material, and finish

		Excavation, trench by hand	Footing, concrete in place, forms	Concrete block	Gravel fill	Compaction, by hand	Waterproofing	Slab, concrete in place	Mixing quantities of concrete	Sub-drainage	Base.wall, concrete in place, forms	Backfill, by hand				
SKILL LEVEL	UNSKILLED	●	●	●	●	●	●		●	●		●				
	SEMI-SKILLED		○	○			○	●		○	●					
	SKILLED							○								
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●		●	●		●	●	●				
	SPECIAL TOOLS					●			●							
	HEAVY MACHINES								○							
PHYSICAL STRENGTH REQUIREMENT	ONE	●		●	●	●	●		●	●		●				
	TWO		●	○	○			●	○		●					
	MORE THAN TWO															
SAVINGS BY SELF-HELPER	HIGH	●				/			/			●				
	MEDIUM				●	/	●		/							
	LOW		●	●		/		●	/	●	●					
EXPECTED LIFE CYCLE	LONG TERM	•	•	•	•	•	•	•	•	•	•	•				
	MEDIUM TERM															
	SHORT TERM															
MATERIAL	RAW	•	•		•	•		•	•		•	•				
	SEMI-PROCESSED						•									
	PROCESSED UNIT			•						•						
	KIT															
	PRE-ASSEMBLED															
	FULLY ASSEMBLED															
FINISH	NOT FINISHED	•	•	•	•	•	•	•	•	•	•	•				
	PRE-FINISHED															

EVALUATION MATRIX 2

FLOOR FRAMING

● Required

○ Preferable

• Expected life cycle, material, and finish

		Sills, 2"x6"	Girders, 4"x10"	Joists, 2"x10", 16'o.c.	Bridging, 2"x3"	Stressed skin panel, 4'x8'	Subfloor, 5/8" plywood
SKILL LEVEL	UNSKILLED	●	●	●	●	●	●
	SEMI-SKILLED	○	○	○	○		○
	SKILLED						
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●
	SPECIAL TOOLS	○	○	○	○		
	HEAVY MACHINES						
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●	●	●		●
	TWO		○	○		●	○
	MORE THAN TWO						
SAVINGS BY SELF-HELPER	HIGH						
	MEDIUM				●		●
	LOW	●	●	●		●	
EXPECTED LIFE CYCLE	LONG TERM	•	•	•	•	•	•
	MEDIUM TERM						
	SHORT TERM						
MATERIAL	RAW						
	SEMI-PROCESSED	•	•	•	•		
	PROCESSED UNIT						•
	KIT						
	PRE-ASSEMBLED					•	
	FULLY ASSEMBLED						
FINISH	NOT FINISHED	•	•	•	•	•	•
	PRE-FINISHED						

EVALUATION MATRIX 3

WALL FRAMING

● Required

○ Preferable

• Expected life cycle, material, and finish

		Studs, 2"x4", 16"o.c.	Top plates	Sheathing, 3/8" plywood
SKILL LEVEL	UNSKILLED	●	●	●
	SEMI-SKILLED	○	○	○
	SKILLED			
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●
	SPECIAL TOOLS	○	○	○
	HEAVY MACHINES			
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●	
	TWO	○	○	●
	MORE THAN TWO			
SAVINGS BY SELF-HELPER	HIGH			
	MEDIUM	●		
	LOW		●	●
EXPECTED LIFE CYCLE	LONG TERM	•	•	•
	MEDIUM TERM			
	SHORT TERM			
MATERIAL	RAW			
	SEMI-PROCESSED	•	•	
	PROCESSED UNIT			•
	KIT			
	PRE-ASSEMBLED			
	FULLY ASSEMBLED			
FINISH	NOT FINISHED	•	•	•
	PRE-FINISHED			

EVALUATION MATRIX 4

ROOF/CEILING FRAMING		Joists, 2"x6"	End studs, 2"x4"	Rafters, 2"x6"	Ridges, 2"x8"	Collar beams, 1"x6", 4'o.c.	Trussed rafters	Stressed skin panels, 4'x8'	Sheathing, 1/2" plywood
● Required ○ Preferable • Expected life cycle, material, and finish									
SKILL LEVEL	UNSKILLED	●				●	●	●	●
	SEMI-SKILLED	○	●	●	●	○			
	SKILLED		○	○	○				
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●
	SPECIAL TOOLS	○	○	○	○	○			○
	HEAVY MACHINES								
PHYSICAL STRENGTH REQUIREMENT	ONE					●			
	TWO	●	●	●	●	○	●	●	●
	MORE THAN TWO			○	○		○		○
SAVINGS BY SELF-HELPER	HIGH								
	MEDIUM		●			●			
	LOW	●		●	●		●	●	●
EXPECTED LIFE CYCLE	LONG TERM	•	•	•	•	•	•	•	•
	MEDIUM TERM								
	SHORT TERM								
MATERIAL	RAW								
	SEMI-PROCESSED	•	•	•	•	•			
	PROCESSED UNIT								•
	KIT								
	PRE-ASSEMBLED						•	•	
	FULLY ASSEMBLED								
FINISH	NOT FINISHED	•	•	•	•	•	•	•	•
	PRE-FINISHED								

EVALUATION MATRIX 5

ROOF SURFACE

● Required

○ Preferable

• Expected life cycle, material, and finish

		Shingles, wood	Shingles, asphalt	Shingles, asbestos	Slate, incl. felt underlay	Clay tile	Corrugated aluminum	Corrugated steel	Asphalt roll	Rubberized asphalt sheet
SKILL LEVEL	UNSKILLED	●	●	●	●	●	●	●	●	●
	SEMI-SKILLED			○	○	○				
	SKILLED									
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●	●
	SPECIAL TOOLS									
	HEAVY MACHINES									
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●	●	●	●	●	●	●	●
	TWO						○	○		○
	MORE THAN TWO									
SAVINGS BY SELF-HELPER	HIGH									
	MEDIUM	●	●	●			●	●	●	●
	LOW				●	●				
EXPECTED LIFE CYCLE	LONG TERM				•	•				
	MEDIUM TERM	•	•	•			•	•	•	•
	SHORT TERM									
MATERIAL	RAW									
	SEMI-PROCESSED						•	•	•	•
	PROCESSED UNIT	•	•	•	•	•				
	KIT									
	PRE-ASSEMBLED									
	FULLY ASSEMBLED									
FINISH	NOT FINISHED									
	PRE-FINISHED	•	•	•	•	•	•	•	•	•

EVALUATION MATRIX 6

EXTERIOR WALL SURFACE

● Required

○ Preferable

• Expected life cycle, material, and finish

		Siding, wood	Siding, aluminum, painted	Siding, plastic, prefinished	Hardboard, pre-painted	Shingles, wood	Shingles, asbestos	Shingles, asphalt	Masonry veneer, brick	Painting
SKILL LEVEL	UNSKILLED		●	●	●	●	●	●		●
	SEMI-SKILLED	●	○	○	○	○	○	○	●	
	SKILLED	○							○	
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●	●
	SPECIAL TOOLS									
	HEAVY MACHINES									
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●	●	●	●	●	●	●	●
	TWO				○				○	
	MORE THAN TWO									
SAVINGS BY SELF-HELPER	HIGH		●							●
	MEDIUM					●	●	●		
	LOW	●		●	●				●	
EXPECTED LIFE CYCLE	LONG TERM								•	
	MEDIUM TERM	•	•	•	•	•	•	•		
	SHORT TERM									•
MATERIAL	RAW									•
	SEMI-PROCESSED	•	•	•						
	PROCESSED UNIT				•	•	•	•	•	
	KIT									
	PRE-ASSEMBLED									
	FULLY ASSEMBLED									
FINISH	NOT FINISHED									•
	PRE-FINISHED	•	•	•	•	•	•	•	•	

EVALUATION MATRIX 7

CEILING

● Required

○ Preferable

• Expected life cycle, material, and finish

		Drywall, gypsumboard, incl. taping	Veneer plaster, incl. taping	Wood fiber tile, cemented	Wood fiber tile, suspension systm.	Metal lath and plaster	Painting
SKILL LEVEL	UNSKILLED	●		●	●		●
	SEMI-SKILLED	○	●	○	○	●	
	SKILLED		○			○	
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●
	SPECIAL TOOLS	○	○				
	HEAVY MACHINES						
PHYSICAL STRENGTH REQUIREMENT	ONE			●	●		●
	TWO	●	●			●	
	MORE THAN TWO						
SAVINGS BY SELF-HELPER	HIGH	●	●				●
	MEDIUM			●			
	LOW				●	●	
EXPECTED LIFE CYCLE	LONG TERM	•	•			•	
	MEDIUM TERM			•	•		
	SHORT TERM						•
MATERIAL	RAW					•	•
	SEMI-PROCESSED						
	PROCESSED UNIT	•	•	•			
	KIT				•		
	PRE-ASSEMBLED						
	FULLY ASSEMBLED						
FINISH	NOT FINISHED	•	•			•	•
	PRE-FINISHED			•	•		

EVALUATION MATRIX 8

INTERIOR WALL SURFACE

● Required
○ Preferable
• Expected life cycle, material, and finish

		Metal lath and plaster	Ceramic tile, pregrouted sheets	Plywood, prefinished	Gypsumboard, incl. taping	Veneer plaster, incl. taping	Wallpaper	Painting
SKILL LEVEL	UNSKILLED		●	●	●		●	●
	SEMI-SKILLED	●	○	○	○	●	○	
	SKILLED	○				○		
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●
	SPECIAL TOOLS		○					
	HEAVY MACHINES							
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●				●	●
	TWO	○		●	●	●		
	MORE THAN TWO							
SAVINGS BY SELF-HELPER	HIGH				●	●		●
	MEDIUM		●	●			●	
	LOW	●						
EXPECTED LIFE CYCLE	LONG TERM	•	•		•	•		
	MEDIUM TERM			•				
	SHORT TERM						•	•
MATERIAL	RAW	•						•
	SEMI-PROCESSED		•				•	
	PROCESSED UNIT			•	•	•		
	KIT							
	PRE-ASSEMBLED							
	FULLY ASSEMBLED							
FINISH	NOT FINISHED	•			•	•		•
	PRE-FINISHED		•	•			•	

EVALUATION MATRIX 9

FLOOR SURFACE

● Required

○ Preferable

• Expected life cycle, material, and finish

		Resilient floor, asbestos tile	Carpet	Wood panel, unfinished	Wood panel, prefinished	Wood block, unfinished	Wood block, prefinished	Ceramic tile
SKILL LEVEL	UNSKILLED	●			●		●	
	SEMI-SKILLED	○	●	●		●		●
	SKILLED		○					○
TOOL REQUIREMENT	GENERAL TOOLS	●	●		●		●	●
	SPECIAL TOOLS			●		●		○
	HEAVY MACHINES							
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●	●	●	●	●	●
	TWO							
	MORE THAN TWO							
SAVINGS BY SELF-HELPER	HIGH			/		/		
	MEDIUM	●	●	/		/		
	LOW			/	●	/	●	●
EXPECTED LIFE CYCLE	LONG TERM							•
	MEDIUM TERM			•	•	•	•	
	SHORT TERM	•	•					
MATERIAL	RAW							
	SEMI-PROCESSED		•	•	•			
	PROCESSED UNIT	•				•	•	•
	KIT							
	PRE-ASSEMBLED							
	FULLY ASSEMBLED							
FINISH	NOT FINISHED			•		•		
	PRE-FINISHED	•	•		•		•	•

EVALUATION MATRIX 10

EXT.& INT. TRIM

- ● Required
- ○ Preferable
- • Expected life cycle, material, and finish

		Soffit, 1/2" plywood	Facia, 1"x6"	Frieze, 1"x4"	Base moldings	Ceiling moldings, crown
SKILL LEVEL	UNSKILLED				●	●
	SEMI-SKILLED	●	●	●	○	○
	SKILLED					
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●
	SPECIAL TOOLS					
	HEAVY MACHINES					
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●	●	●	●
	TWO	○	○	○		
	MORE THAN TWO					
SAVINGS BY SELF-HELPER	HIGH					
	MEDIUM			●		
	LOW	●	●		●	●
EXPECTED LIFE CYCLE	LONG TERM					
	MEDIUM TERM	•	•	•	•	•
	SHORT TERM					
MATERIAL	RAW					
	SEMI-PROCESSED					
	PROCESSED UNIT	•	•	•	•	•
	KIT					
	PRE-ASSEMBLED					
	FULLY ASSEMBLED					
FINISH	NOT FINISHED	•	•	•		
	PRE-FINISHED				•	•

EVALUATION MATRIX 11

OPENINGS

● Required
○ Preferable
• Expected life cycle, material, and finish

		Wood door & frame, interior	Wood door, prehung, interior	Wood window,w/frame,trim,glazing	Aluminum window,w/frame,trim,glz.	Stairs, prefabricated, oak	Skylight, plastic dome	Fireplace, prefab. wall hung	Chimney, brick, two flues
SKILL LEVEL	UNSKILLED				●	●	●	●	●
	SEMI-SKILLED	●	●	●	○				○
	SKILLED								
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●
	SPECIAL TOOLS								
	HEAVY MACHINES								
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●		●		●	●	●
	TWO	○	○	●		●	○	○	○
	MORE THAN TWO								
SAVINGS BY SELF-HELPER	HIGH								
	MEDIUM	●							
	LOW		●	●	●	●	●	●	●
EXPECTED LIFE CYCLE	LONG TERM				•	•		•	•
	MEDIUM TERM	•	•	•			•		
	SHORT TERM								
MATERIAL	RAW								
	SEMI-PROCESSED								
	PROCESSED UNIT								•
	KIT	•		•		•			
	PRE-ASSEMBLED		•				•		
	FULLY ASSEMBLED				•			•	
FINISH	NOT FINISHED								
	PRE-FINISHED	•	•	•	•	•	•	•	•

EVALUATION MATRIX 12

SERVICES

● Required

○ Preferable

• Expected life cycle, material, and finish

		Plumbing, pipe	Bathtub, incl. trim & fitting	Kitchen sink faucets	Electric wiring	Receptacle, duplex	Fluorescent lamps, pendent	Ductwork, incl. fittings & joints	Insulation, batt	Insulation, cellulose fiber	Fan, roof exhauster					
SKILL LEVEL	UNSKILLED			●		●	●		●	●	●					
	SEMI-SKILLED					○	○	●			○					
	SKILLED	●	●		●											
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●		●					
	SPECIAL TOOLS															
	HEAVY MACHINES									●						
PHYSICAL STRENGTH REQUIREMENT	ONE	●		●	●	●	●	●	●		●					
	TWO		●					○		●	○					
	MORE THAN TWO															
SAVINGS BY SELF-HELPER	HIGH							●		/						
	MEDIUM	●			●	●			●	/						
	LOW		●	●			●			/	●					
EXPECTED LIFE CYCLE	LONG TERM	•	•	•	•	•		•	•	•						
	MEDIUM TERM						•				•					
	SHORT TERM															
MATERIAL	RAW									•						
	SEMI-PROCESSED	•			•			•	•							
	PROCESSED UNIT		•													
	KIT															
	PRE-ASSEMBLED															
	FULLY ASSEMBLED			•		•	•				•					
FINISH	NOT FINISHED	•						•	•	•						
	PRE-FINISHED		•	•	•	•	•				•					

2-3 Assessment of Self-Help Projects

In this section possible self-help projects are categorized in terms of the scale of the project and in terms of interior-exterior, starting from a typical and relatively small stick-built house in a suburban area. The standard house of 24' by 48', which includes three bedrooms, one bathroom, one laundry, one kitchen, one living room and one dining room, has been designed based on Plan No. A81054 in *House and Garden Plans Guide 1981* (Figure 2-1).

After categorizing expected self-help projects of different scales, examples of these projects have been assessed in terms of the potential for self-help construction based on the task evaluation described in the previous section.

STANDARD HOUSE

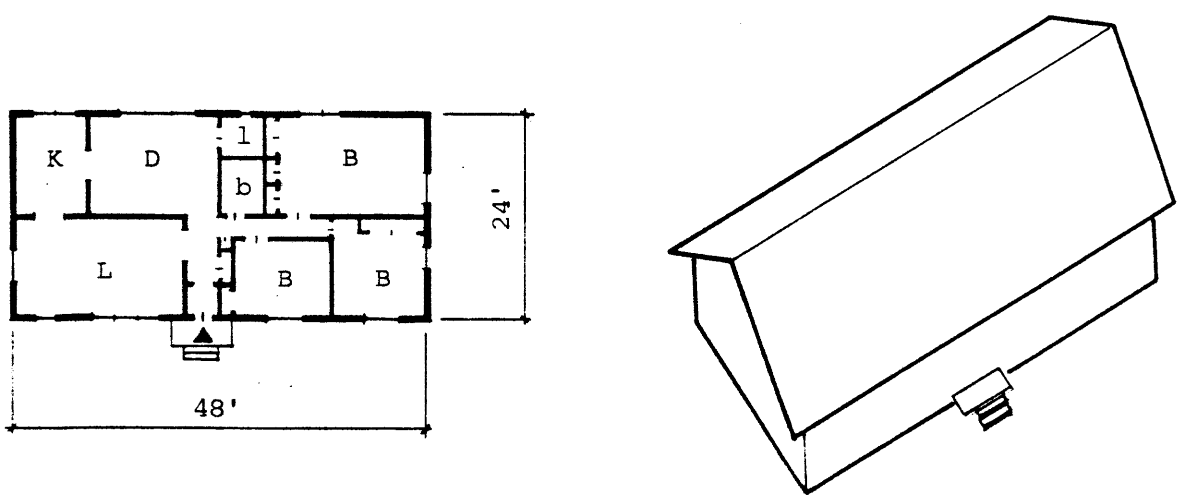


Figure 2-1

2-3-1 Evaluation of Potential for Self-Help

When the task requires either skilled labor or professional quality, or heavy machinery of special use, the task is considered difficult to be performed by the self-help builder. Therefore, tasks with the evaluation of required skill level as SKILLED, or with the evaluation of tool requirement as HEAVY MACHINES have been rated as having LOW potential for self-help (Fig. 2-2).

When the task can be accomplished by two unskilled laborers with general tools (or preferably by a semi-skilled laborer with special tools), the task is considered as easily performed by the self-help builder. Those tasks have been rated HIGH in potential for self-help.

Those tasks whose evaluations of the criteria are intermediate, between two categories of LOW potential tasks and HIGH potential tasks, have been rated as MEDIUM potential.

In assessing those projects which include tasks of different potentials, the evaluated potentials of the most critical tasks have been used.

EVALUATION OF POTENTIAL
FOR SELF-HELP

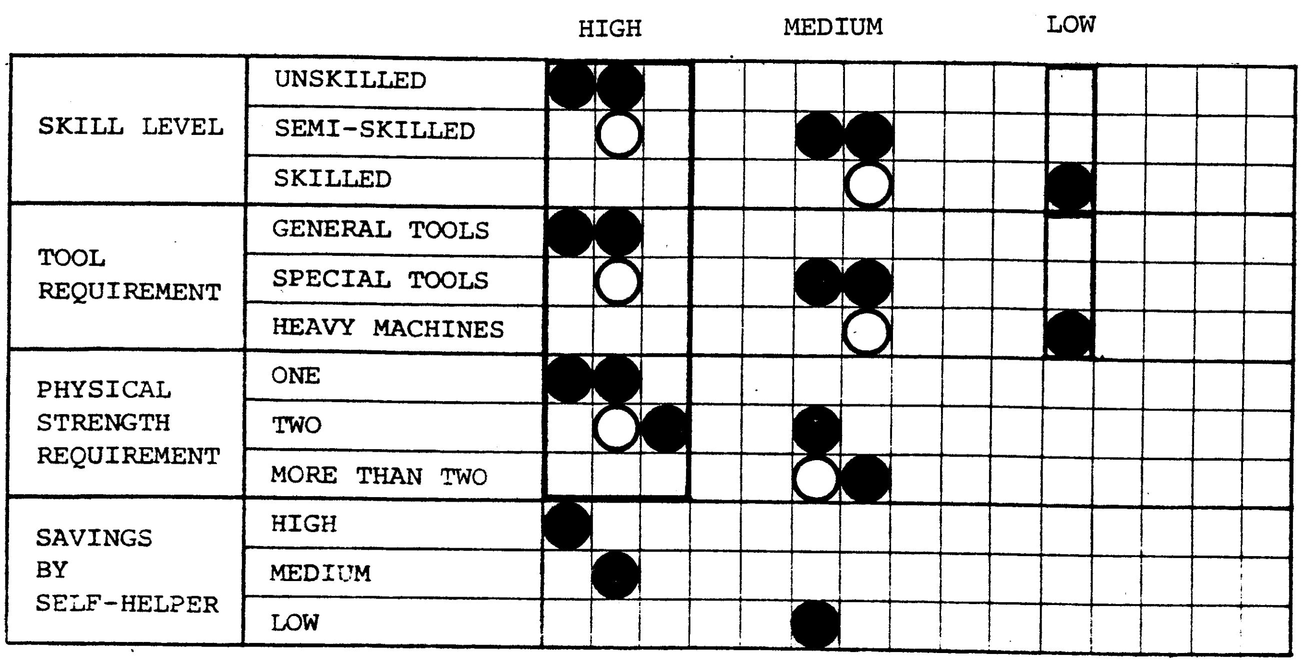


Figure 2-2

2-3-2 Self-Help Categories and Assessment

Self-help projects have been categorized according to the scale of the project, such as space, surface and service.

These categories are:

1. Adding exterior spaces
2. Changing interior spaces
3. Changing surfaces
4. Changing services

1. Adding Exterior Spaces

The house can be extended to its side, front, back, upward and downward, or a separate building can be added. Project scales of these of these changes are relatively great, and include structural changes. Examples of adding exterior spaces are:

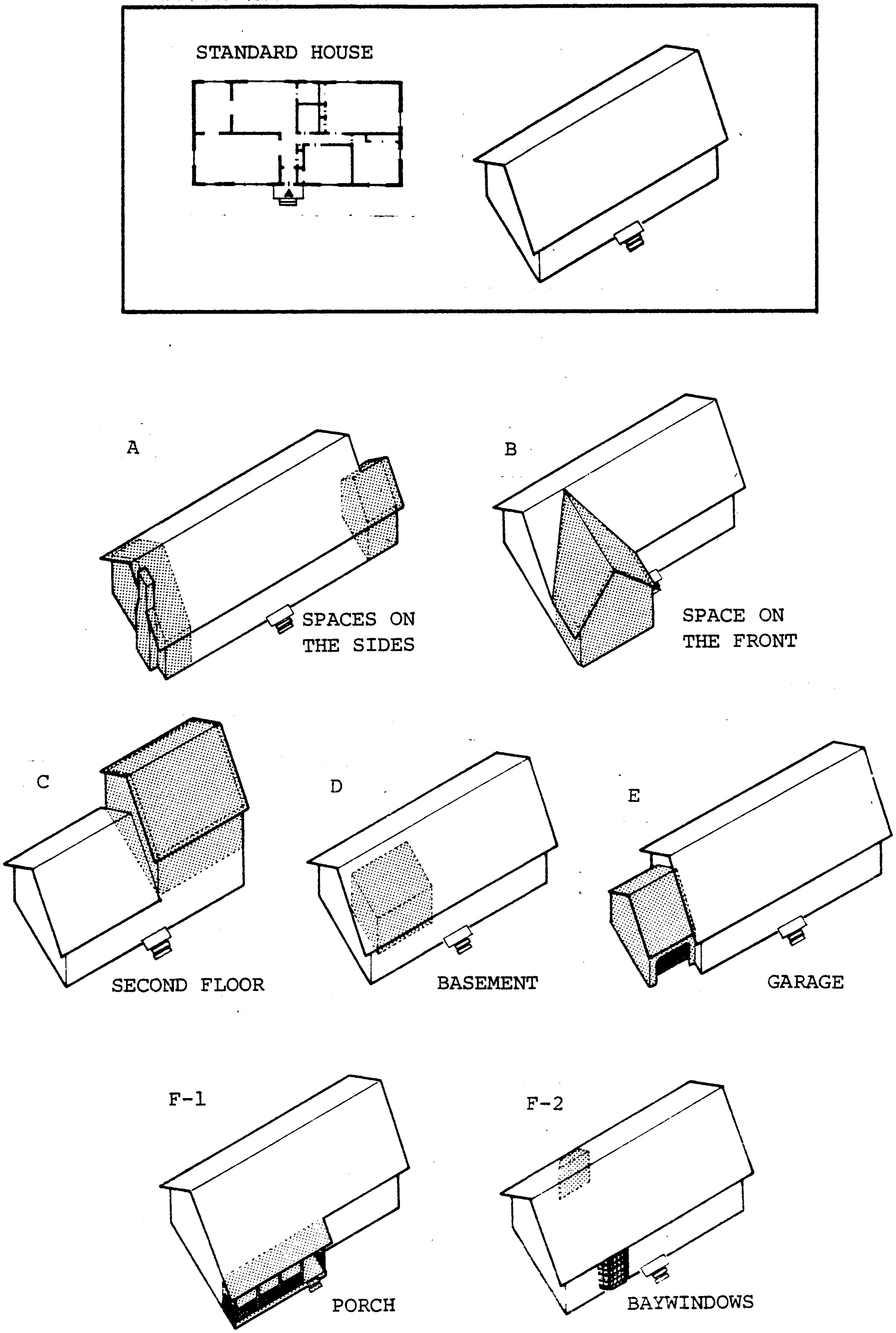
a. adding spaces at the sides of house
b. adding spaces at the front or back of house
c. adding a second floor
d. adding a basement
e. adding a garage
f. adding porches, bay windows, etc.

On the next page, examples are illustrated with potential for self-help of the project. These changes are independnet of each other, and can be, and actually are expected to be made on the same house.

Abbreviations for functional spaces used in the illustrations are:

B: bedroom	l: laundry
K: kitchen	S: storage
D: dining room	P: playroom
L: living room	G: garage
b: bathroom	

Figure 2-3 EXTERIOR SPACE PROJECTS



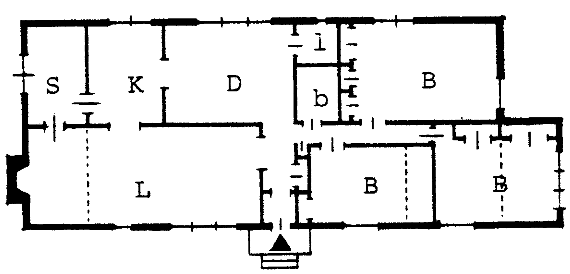
EXTERIOR SPACE PROJECT: A

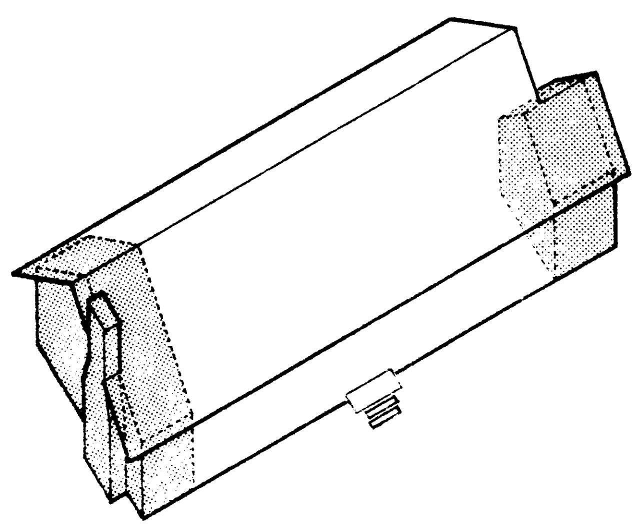
ADDING SPACES
ON THE SIDES
OF THE HOUSE

POTENTIAL
FOR SELF-HELP: LOW

● Required
○ Preferable

		Replace wall	Foundation	Floor framing	wall framing	Trussed rafters & sheathing	Roof surface, wood shingles	Opening, doors & windows	Service, distribut. & insulat.	Ext. wall surface, wood shingles	Ext. trim	Ceiling, gypsumboard	Int. wall surface, gypsumboard	Floor surface, resilient floor	Int. trim	Service, fixtures & appliances
SKILL LEVEL	UNSKILLED	●		●	●	●	●			●		●	●	●	●	●
	SEMI-SKILLED	○	●	○	○		○	●		○	●	○	○	○	○	○
	SKILLED		○						●							
TOOL REQUIREMENT	GENERAL TOOLS	●		●	●	●	●	●	●	●	●	●	●	●	●	●
	SPECIAL TOOLS		●	○	○							○				
	HEAVY MACHINES		○													
PHYSICAL STRENGTH REQUIREMENT	ONE	●					●		●	●	●			●	●	●
	TWO	○	●	●	●	●	○	●	○		○	●	●			
	MORE THAN TWO					○										





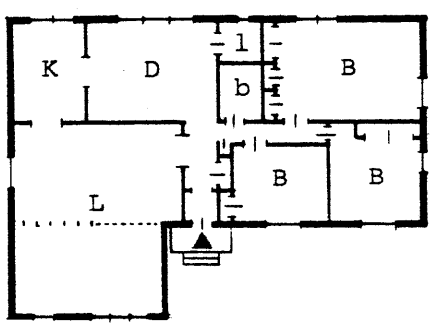
EXTERIOR SPACE PROJECT: B

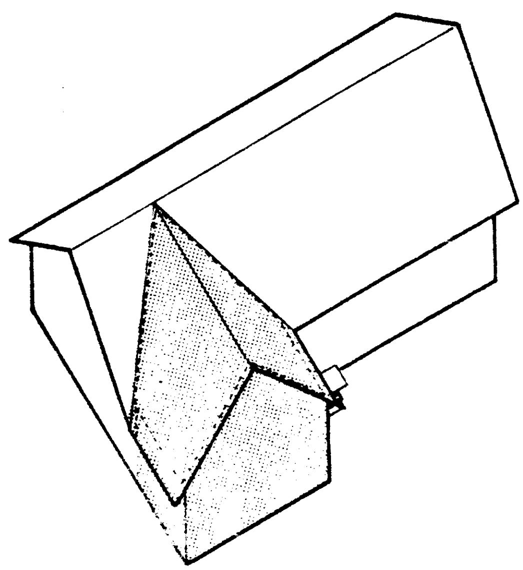
ADDING SPACES ON THE FRONT OR THE BACK OF THE HOUSE

POTENTIAL FOR SELF-HELP: LOW

● Required
○ Preferable

		Replc. wall, roof surf. & sheath	Foundation	Floor framing & subfloor	Wall framing	Trussed rafters & sheathing	Roof Surface, wood shingles	Openings, doors & windows	Service, distribut. & insulat.	Ext. wall surface, wood shingles	Ext. trim	Ceiling, gypsumboard	Int. wall surface, gypsumboard	Floor surface, resilient floor	Int trim	Service, fixtures & appliances
SKILL LEVEL	UNSKILLED	●		●	●	●	●			●		●	●	●	●	●
	SEMI-SKILLED	○	●	○	○		○	●		○	●	○	○	○	○	○
	SKILLED		○						●							
TOOL REQUIREMENT	GENERAL TOOLS	●		●	●	●	●	●	●	●	●	●	●	●	●	●
	SPECIAL TOOLS		●	○	○							○				
	HEAVY MACHINES		○													
PHYSICAL STRENGTH REQUIREMENT	ONE	●					●		●	●	●			●	●	●
	TWO	○	●	●	●	●	○	●	○		○	●	●			
	MORE THAN TWO					○										





EXTERIOR SPACE PROJECT: C

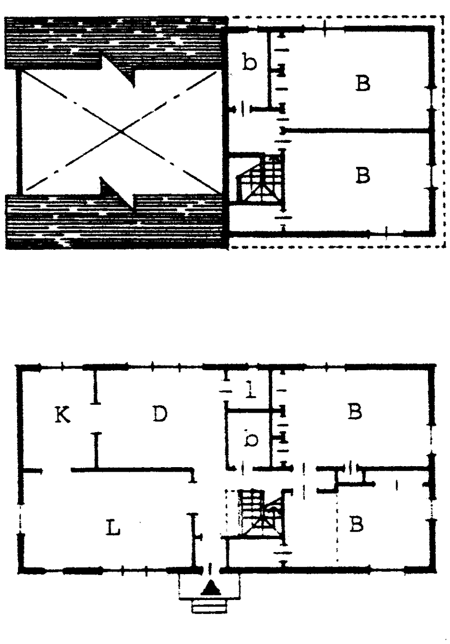
ADDING THE SECOND FLOOR

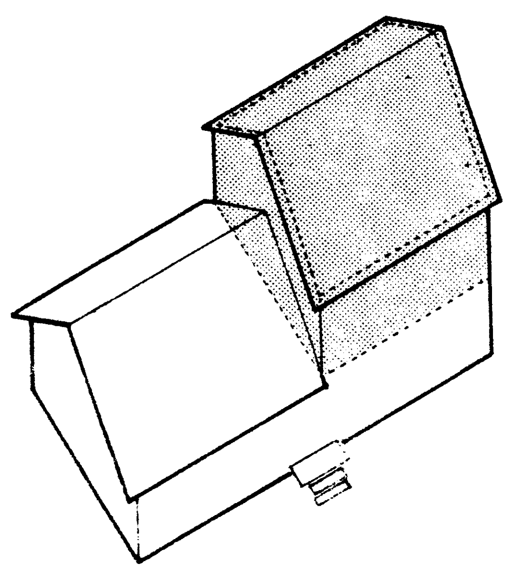
POTENTIAL
FOR SELF-HELP: LOW

● Required

○ Preferable

		Replace roof, surface & rafters	Subfloor	Wall framing	Trussed rafters	Sheathing, roof & ext. walls	Roof surface, wood shingles	Openings, door, window & stairs	Service, distribut. & insulat.	Ext. wall surface, wood shingle	Ext. trim	Ceiling, gypsumboard	Int. wall surface, gypsumboard	Floor surface, resilient floor	Int. trim	Service, fixtures & appliances
SKILL LEVEL	UNSKILLED	●	●	●	●	●	●			●		●	●	●	●	●
	SEMI-SKILLED	○	○	○			○	●			●	○	○	○	○	○
	SKILLED								●							
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	SPECIAL TOOLS			○		○						○				
	HEAVY MACHINES															
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●				●		●	●	●			●	●	●
	TWO	○	○	●	●	●	○	●	○		○	●	●			
	MORE THAN TWO				○	○										





EXTERIOR SPACE PROJECT: D

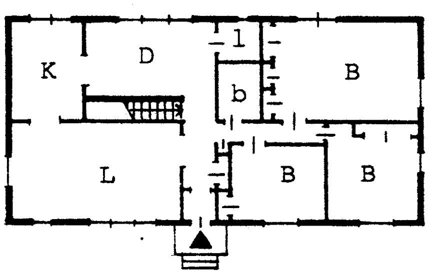
ADDING A BASEMENT

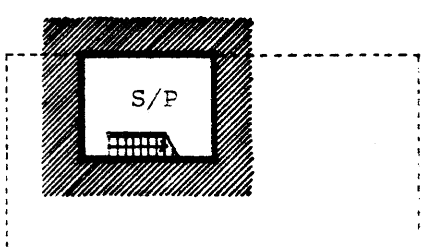
POTENTIAL
FOR SELF-HELP: LOW

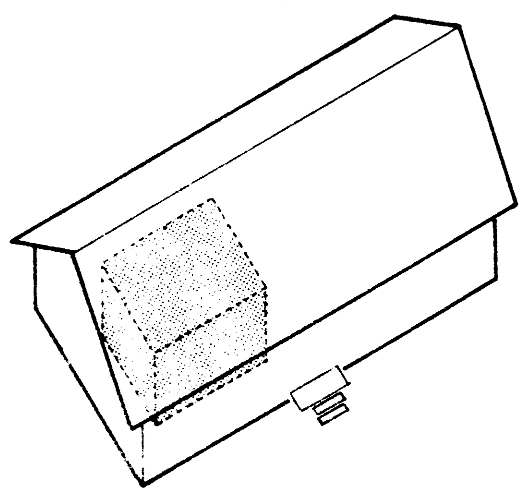
● Required

○ Preferable

		Replace floor surface & subfloor	Excavation & supporting	Foundation, slab, wall & subflr.	Stairs, prefabricated	Service, distribut. & insulat.	Ceiling, gypsumboard	Wall surf. plywood, prefinished	Floor surface, resilient floor	Int. trim	Service, fixtures & appliances
SKILL LEVEL	UNSKILLED	●	●		●		●	●	●	●	●
	SEMI-SKILLED	○		●			○	○	○	○	○
	SKILLED			○		●					
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●	●	●
	SPECIAL TOOLS						○				
	HEAVY MACHINES										
PHYSICAL STRENGTH REQUIREMENT	ONE	●				●			●	●	●
	TWO	○	●	●	●	○	●	●			
	MORE THAN TWO										







EXTERIOR SPACE PROJECT: E

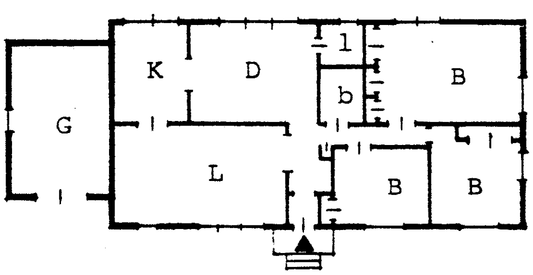
ADDING A GARAGE

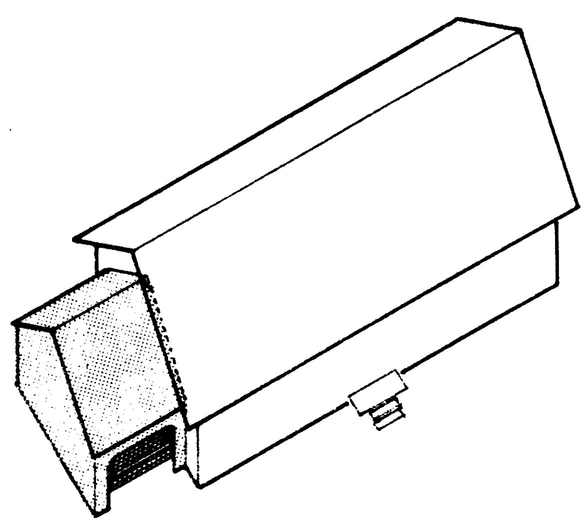
POTENTIAL FOR SELF-HELP: LOW

● Required

○ Preferable

		Replace wall surface & sheath.	Foundation	Wall framing	Trussed rafters	Sheathing, roof & ext. walls	Roof surface, asphalt shingles	Opening, doors & windows	Service, wiring & piping	Ext. wall surface, plastic siding	Service, fixtures & appliances
SKILL LEVEL	UNSKILLED	●		●	●	●	●			●	●
	SEMI-SKILLED	○	●	○				●		○	○
	SKILLED		○						●		
TOOL REQUIREMENT	GENERAL TOOLS	●		●	●	●	●	●	●	●	●
	SPECIAL TOOLS		●	○		○					
	HEAVY MACHINES		○								
PHYSICAL STRENGTH REQUIREMENT	ONE	●					●		●	●	●
	TWO	○	●	●	●	●		●			
	MORE THAN TWO				○	○					





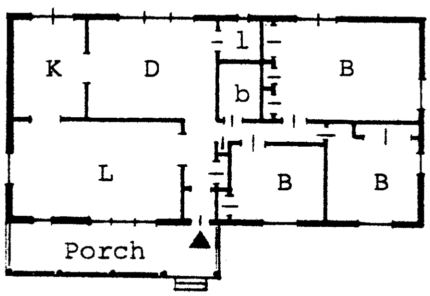
EXTERIOR SPACE PROJECT: F-1

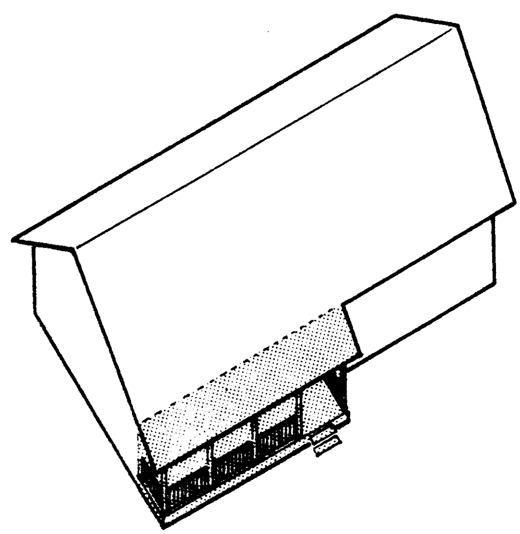
ADDING A PORCH

POTENTIAL
FOR SELF-HELP: <u>HIGH</u>

● Required
○ Preferable

		Footing & anchoring	Posts 4" X 4", & beams	Floor joists & decking	Stairs	Rafters & sheathing	Roof surface, asphalt shingles	Railings, 2" X 4" & 1" X 3"
SKILL LEVEL	UNSKILLED	●	●	●	●	●	●	●
	SEMI-SKILLED	○	○					
	SKILLED							
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●
	SPECIAL TOOLS							
	HEAVY MACHINES							
PHYSICAL STRENGTH REQUIREMENT	ONE	●	●	●	●	●	●	●
	TWO		○			○		
	MORE THAN TWO							





EXTERIOR SPACE PROJECT: F-2

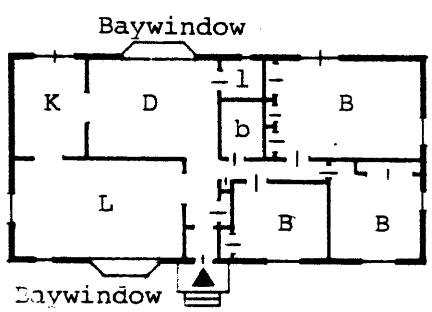
ADDING BAYWINDOWS

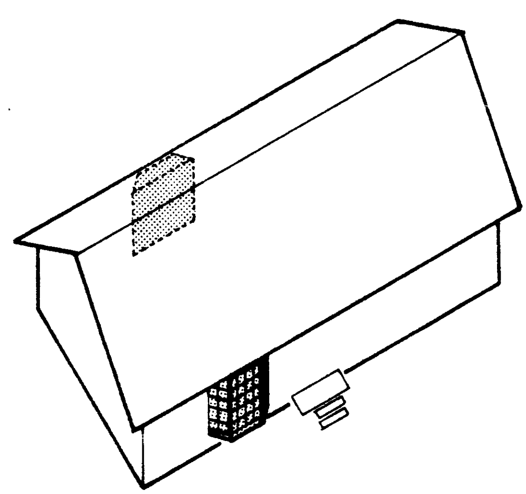
POTENTIAL
FOR SELF-HELP: HIGH

● Required

○ Preferable

		Replace wall for windows	Install prefab. baywindows
SKILL LEVEL	UNSKILLED	●	●
	SEMI-SKILLED		
	SKILLED		
TOOL REQUIREMENT	GENERAL TOOLS	●	●
	SPECIAL TOOLS		
	HEAVY MACHINES		
PHYSICAL STRENGTH REQUIREMENT	ONE	●	
	TWO		●
	MORE THAN TWO		○





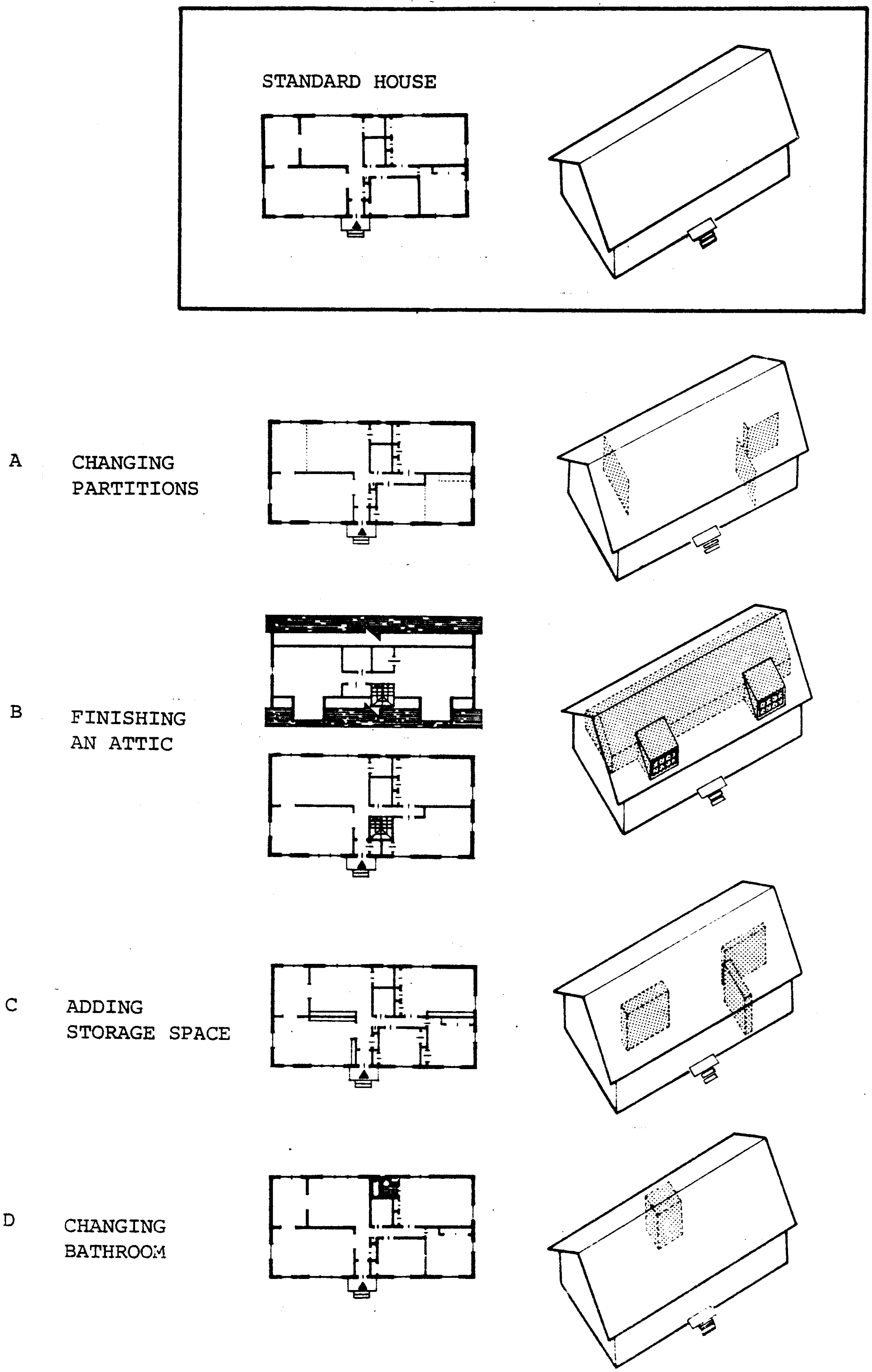
2. Changing Interior Spaces

Examples of changing interior spaces are:

a. changing partitions; adding or replacing partitions
b. finishing an attic
c. adding storage space
d. changing bathroom

On the next page, examples which are commonly observed are illustrated with the assessed potential for self-help of the project.

Figure 2-4 INTERIOR SPACE PROJECTS



INTERIOR SPACE PROJECT: A

CHANGING PARTITIONS

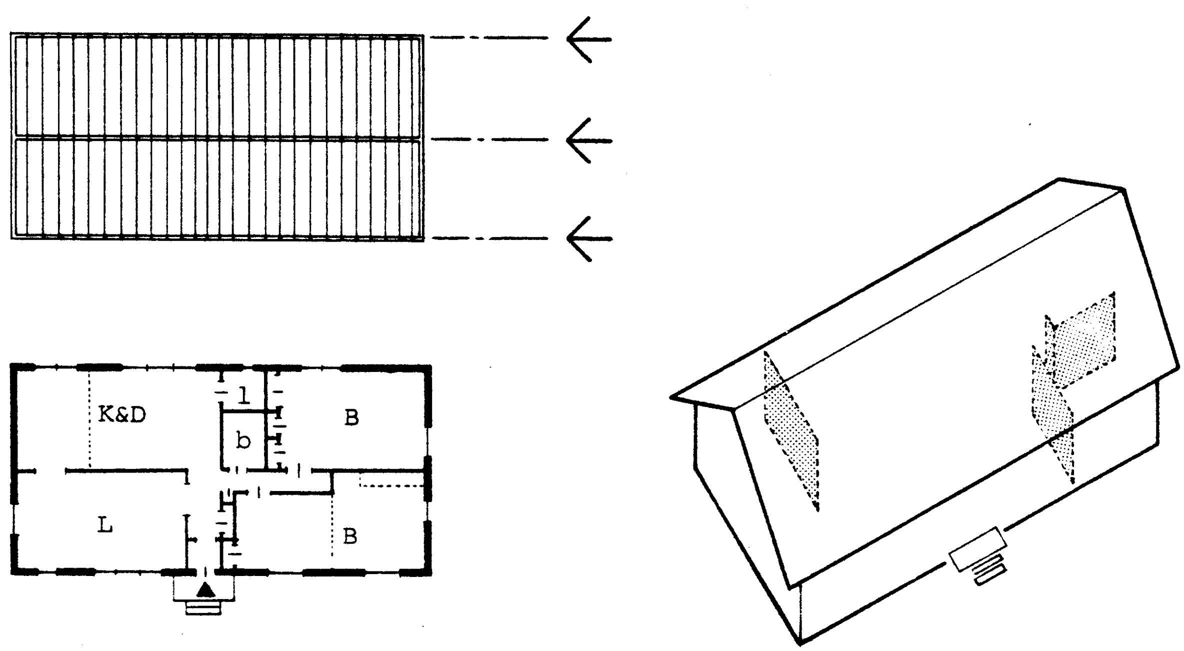
POTENTIAL
FOR SELF-HELP:

<u>HIGH</u> for replacing
<u>MEDIUM</u> for adding

● Required

○ Preferable

		REPLACING PARTITIONS:	Replace partitions	Finish surfaces (ordinary finish)		ADDING PARTITIONS W/OPENINGS:	Replace finish surfaces	Wall framing	Door	Wall framing	Trim
SKILL LEVEL	UNSKILLED		●	●			●	●		●	●
	SEMI-SKILLED		○	○			○	○	●	○	○
	SKILLED										
TOOL REQUIREMENT	GENERAL TOOLS		●	●			●	●	●	●	●
	SPECIAL TOOLS							○			
	HEAVY MACHINES										
PHYSICAL STRENGTH REQUIREMENT	ONE		●	●			●		●		●
	TWO							●	○	●	
	MORE THAN TWO										



INTERIOR SPACE PROJECT: B

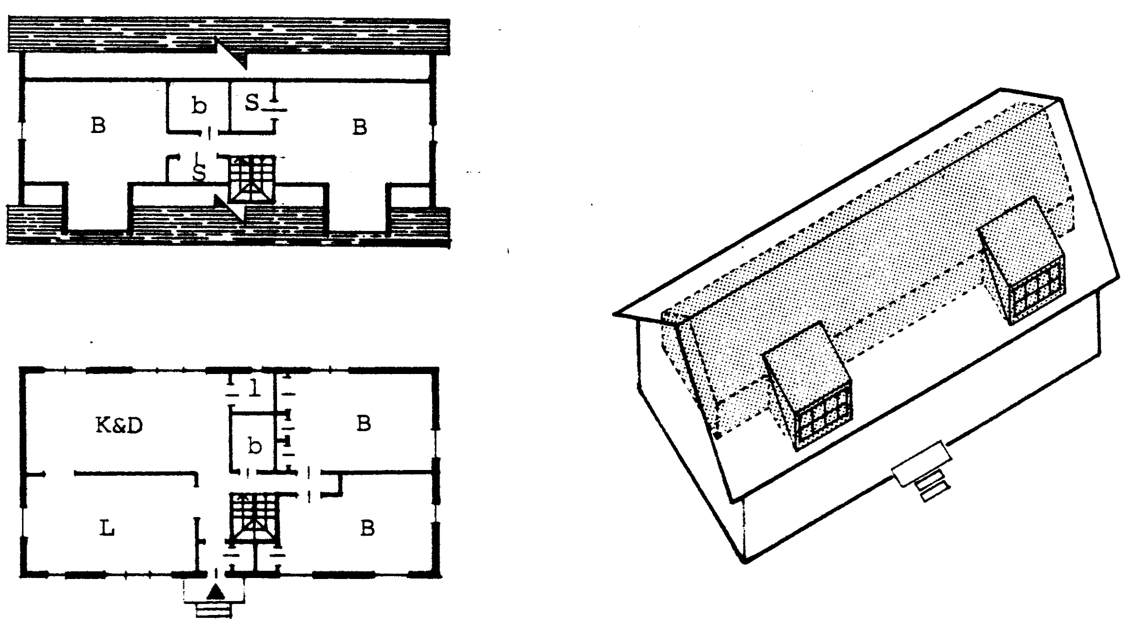
FINISHING AN ATTIC

POTENTIAL
FOR SELF-HELP: HIGH

● Required

○ Preferable

		Replac. ceiling/ roof for opening	Framing opening	Stairs, prefabricated	Service, distribut. & insulat.	Subfloor	Windows, dormers & doors	Ceiling, gypsumboard	Int. wall surface, gypsumboard	Floor surface, resilient tile	Int. trim	Service, fixtures & appliances				
SKILL LEVEL	UNSKILLED	●	●	●		●		●	●	●	●	●				
	SEMI-SKILLED	○	○			○	●	○	○	○	○	○				
	SKILLED				●											
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●	●	●	●				
	SPECIAL TOOLS		○					○								
	HEAVY MACHINES															
PHYSICAL STRENGTH REQUIREMENT	ONE	●			●	●				●	●	●				
	TWO	○	●	●	○	○	●	●	●							
	MORE THAN TWO															



INTERIOR SPACE PROJECT: C

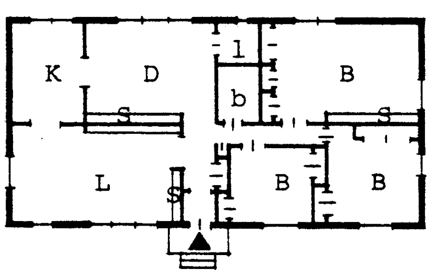
ADDING STORAGE SPACES

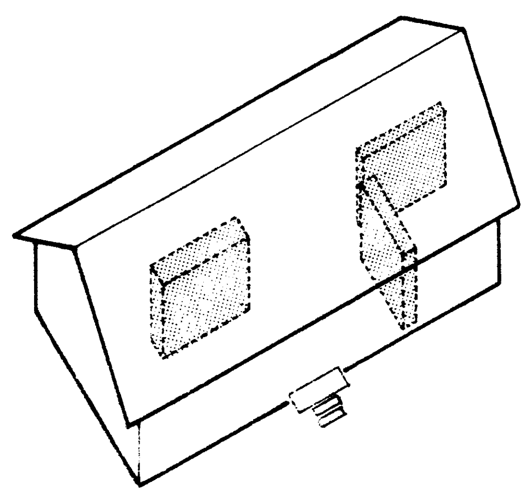
POTENTIAL
FOR SELF-HELP: HIGH

● Required

○ Preferable

		INSTALLING PREFAB. CABINETS:		SHELVING:		BUILDING A CLOSET:	Framing	Surface, gypsumboard
SKILL LEVEL	UNSKILLED	●		●			●	●
	SEMI-SKILLED			○			○	○
	SKILLED							
TOOL REQUIREMENT	GENERAL TOOLS	●		●			●	●
	SPECIAL TOOLS							
	HEAVY MACHINES							
PHYSICAL STRENGTH REQUIREMENT	ONE			●			●	
	TWO	●						●
	MORE THAN TWO							





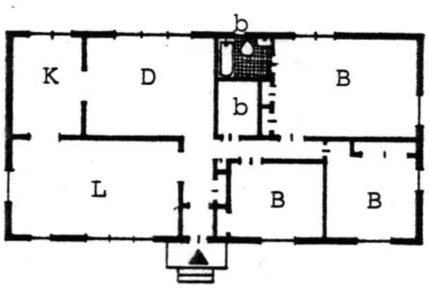
INTERIOR SPACE PROJECT: D

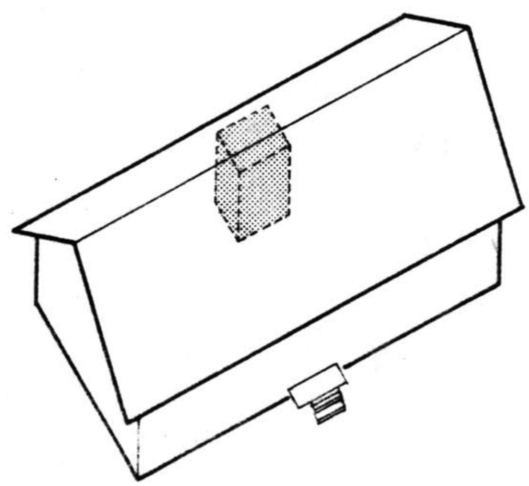
CHANGING BATHROOM

POTENTIAL
FOR SELF-HELP: <u>LOW</u>

● Required
○ Preferable

		Replace partitions & subfloor	Wall framing	Service, wiring & piping	Floor concrete	Doors	Ceiling, gypsumboard	Bathtub & other fixtures	Floor & wall surf. ceramic tiles
SKILL LEVEL	UNSKILLED	●	●				●		
	SEMI-SKILLED	○	○		●	●	○		●
	SKILLED			●	○			●	○
TOOL REQUIREMENT	GENERAL TOOLS	●	●	●	●	●	●	●	●
	SPECIAL TOOLS						○		○
	HEAVY MACHINES								
PHYSICAL STRENGTH REQUIREMENT	ONE	●		●	●	●		●	●
	TWO	○	●	○		○	●		
	MORE THAN TWO								





3. Changing Surfaces

As the previous analysis of the system shows, a wide variety of surface materials and methods have been available and customarily employed. The potential for self-help projects of changing exterior surfaces which are employed in functional spaces commonly or occasionally has been assessed and shown in Table 2-2. Also the potential for self-help projects of changing interior surfaces has been assessed and shown in Table 2-3.

PROJECT EXAMPLES: CHANGING EXTERIOR SURFACES

EXTERIOR SURFACES	POTENTIAL FOR SELF-HELP*	FREQUENCY OF USE**
Roof Surfaces:		
Shingles, wood	H	C
Shingles, asphalt	H	C
Slate tiles	H	o
Clay tiles	H	o
Corrugated metal sheet	H	o
Asphalt sheet	H	C
Exterior Wall Surfaces:		
Shingles, wood	H	C
Shingles, asphalt	H	C
Slate tiles	H	o
Siding, wood	M	o
Siding, aluminum	H	o
Siding, plastics	H	o
Masonry veneer	M	o

* H:high, M:medium, L:low.

** C:commonly employed, o:occasionally employed.

Table 2-2

PROJECT EXAMPLES: CHANGING INTERIOR SURFACES

INTERIOR SURFACES	POTENTIAL FOR SELF-HELP*	USE-FREQUENCY IN** FUNCTIONAL SPACES					
		BEDROOM	KITCHEN	DINING ROOM	LIVING ROOM	BATHROOM	GARAGE
Ceilings:							
Ceiling tiles on drywalls	H	C	C	C	C	C	
Paint or wallpaper on drywalls	H	C	C	C	C	C	
Veneer plaster	M	C	C	C	C	C	
Prefinished wallboards	H	C	C	C	C	C	
Lath and plaster	M	o	o	o	o	o	
Suspended ceiling systems	H	o	o	o	o	o	
Interior Wall Surfaces:							
Paint or wallpaper on drywalls	H	C	C	C	C	C	
Veneer plaster	M	C	C	C	C	C	
Prefinished wallboards	H	C	C	C	C	C	
Lath and plaster	M	o	o	o	o	o	
Ceramic tiles	M					C	
Floor Surfaces:							
Resilient floor, vinyl sheet or tiles	H	C	C	C	C	C	
Resilient floor, asphalt tiles	H	C	C	C	C	C	
Rubber or cork tiles	H	o	o	o	o	o	
Wood strips or blocks, unfinished	M	C	C	C	C	o	
Wood strips or blocks,prefinished	H	C	C	C	C	o	
Ceramic tiles	M					C	
Concrete	M						C

* H:high, M:medium, L:low.
** C:commonly employed, o:occasionally employed.

Table 2-3

4. Changing Services

Self-help projects for changing services vary greatly, from repairing fixtures, to installing appllances, to changing piping or wiring. Although some communities prohibit most electrical and plumbing work to be done by non-professionals, this category has, nevertheless, been assessed as if it were free from local building codes the same way as other projects, which are permitted legally. The results are shown in Table 2-4.

Table 2-4

PROJECT EXAMPLES: SERVICES

SERVICES	POTENTIAL FOR SELF-HELP*
<u>Electrical</u>:	
Changing fixtures and appliances, including refrigerator, dishwasher, washer/dryer, air conditioner, receptacles, light fixtures and bulbs, plugs, cords, sockets, televisions, fuses, and switches.	H
Extending circuits	M
Installing hardwares, including wall boxes, ceiling boxes, and receptacles.	H
<u>Plumbing</u>:	
Repairing fixtures, including sinks, drains, traps, faucets.	H
Connecting fixtures to piping, including tubs, sinks, labatories, toilets, water heater and washers.	H
Changing piping, including pipes and fittings	M
<u>Gas</u>:	
Installing appliances, including gas range, gas dryer.	L
<u>Heating and Air Conditioning</u>:	
Maintaining appliances, including furnaces, radiators, boilers, and room air conditioners.	H
Installing appliances, including power humidifier, radiation units, high-wall return, new radiator, space heaters, electric heater, wood-burning heater, timed thermostat.	L
Ductwork	L
<u>Insulation</u>:	
Adding insulation, in attic floor, heated attic, crawl space walls, floors, sucts and pipes, basement walls, and exterior walls.	H
<u>Ventilation</u>:	
Installing fans, in roof, attic floor, range hood, bathroom.	M
Changing vents	M

2-4 Result of the Analysis

The whole set of Task Evaluation Matrices in the section 2-2 shows the fact that most tasks in the stick-built house construction have"high"to"medium"potential for self-help, that is they can generally achieved by two people and with general hand tools.

All the tasks which were evaluated "low" potential for self-help belong to service subsystems, or more specifically, to service distribution systems such as wiring and plumbing, which are subjected to restrictions in many areas by local building codes. As shown, these restricted tasks become critical in exterior addition or house expansion projects which by necessity include these tasks. If and when such service distribution have to be subcontracted, the related self-help project has been evaluated as "medium" in terms of self-help potentials.

Those tasks which were evaluated as "medium" are actually less frequent than those evaluated as "high." Furthermore most of them are usually part of the foundation sub-system (especially, concrete work), or contained in the framing openings and/or exterior trim. Some of them have been evaluated as "medium", because they require semi-skilled labor, including those which require special tools or equipment for the job. This means that the self-help builder can increase the potential for self-help of a given project to "high" by hiring a subcontractor, or renting special tools or equipment and, if necessary, even operators of such equipment, while finishing related tasks himself.

Prefabricated components can help to reduce the difficulties of self-help in certain tasks. For example, when trussed rafters are used in roof/ceiling framing instead of assemblying ceiling joists, rafters, end studs and the ridge board, the required skill level is lessened by purchasing a preassembled standard or custom-made component. The use of prefinised wood panels, instead of unfinished wood panels, decreases not only required skill level but also special tool requirements.

Thus, preassembled. larger components usually tend to reduce required skill levèl. However, when those companents become very heavy or large, they may require more than two persons for handling and/or installation.

In summary, the stick-built house has great potential for self-help constraction, especially when combined with partial subcontracting, rental tools/equipments, and the use of prefinished or preassembled materials and elements. It is actually a nighly industrialized building system which has the greatest potential for self-help construction.

In the next chapter, a comparative study of the stick-built house in the United States and the traditional wooden post-and-beam frame in Japan will be shown, and the potential of the two systems for self-help will be compared.

CHAPTER 3

Self-Help Potential of the Japanese Traditional House

3-1 Comparative Analysis of Two Structures: The U.S. Stick-Built Frame and the Japanese Traditional Frame

3-2 Implication of the Analysis: Self-Help Potential of the Japanese System

3-1 Comparative Analysis of Two Structures: the U.S. Stick-Built Frame and the Japanese Traditional Frame

This chapter compares the stick-built house in the United States with the Japanese traditional house in terms of the self-help potential.

The first section of the chapter deals with the comparison between the structures of the stick-built house and Japanese traditional house. The "standard house," which was used in the third section of the second chapter as the starting point for self-help projects, is here employed again. Then, the structural elements of the standard house, such as the foundation and the frames of the floor, walls, ceiling, and roof, were designed using the U.S. system. At the same time, each element was designed with the Japanese system. In addition, a typical example of a window was designed using both the U.S. system and the Japanese system, because the opening shows effectively the different characteristics of the two systems. Following, differences discovered between the two structural systems, related to the self-help potential, are described in itemized form for comparison. Then, the designed structural element is shown to explain these descriptions.

1. Foundation

U.S.A.

a. Foundation walls are built in correspondence with exterior walls, and are independent of partitions. Therefore, the position of partitions can be easily changed in accordance with the user's needs.

b. The design principle and construction of post footings is very simple, and the number of post footings is very small. Because the span of the floor joists is usually quite long, large girders are required.

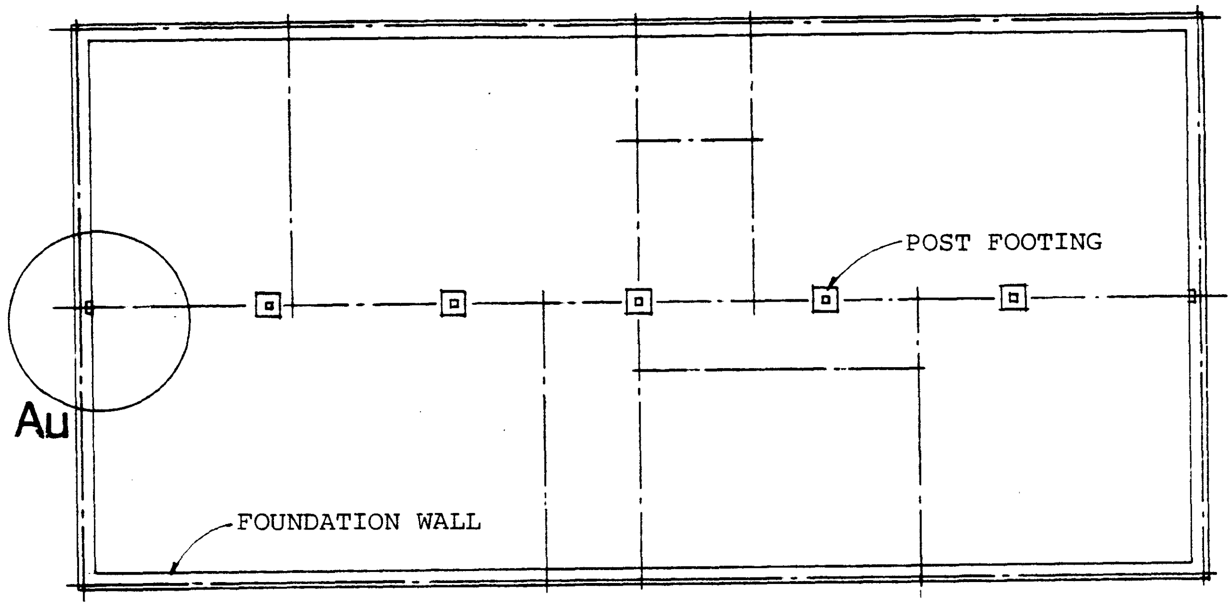
JAPAN

a. The foundation walls are positioned under partitions as well as under exterior walls. Therefore, it is usually difficult to change the positions of the partitions later.

b. The frame is supported by a good number of posts. Therefore the construction of the foundation is more complicated than that of the stick-built frame. Because the spans of the floor joists are short, thinner joists are used.

Figure 3-1

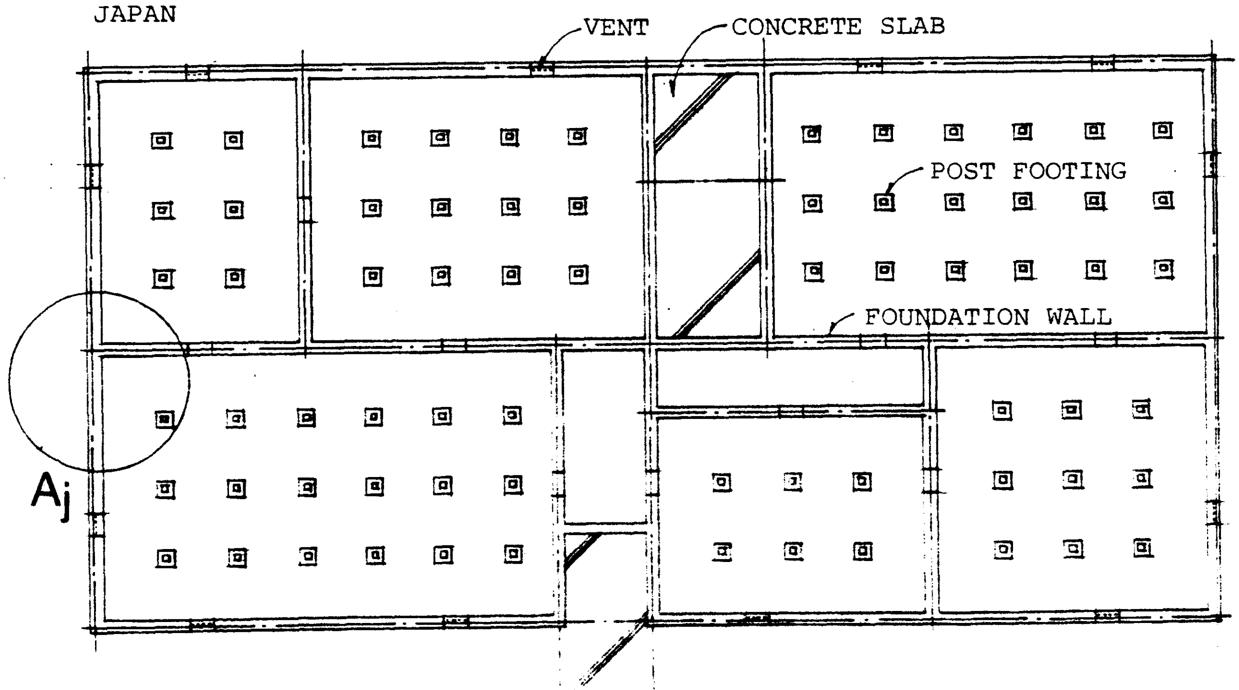
FOUNDATION



U.S.A.

——·—— Position of walls

JAPAN



2. Floor

U.S.A.

a. The principle of positioning floor joists is relativity independent of the positions of partitions. Therefore, the replacement or addition of partitions is easy.

b. The spans of the floor joists are long, and the joist size is large (about 50mm X 300mm).

c. The subfloor imparts a high degree of stiffness to the floor.

d. Jointing method in floor framing is extremely simple.

JAPAN

a. Usually sills are necessary under partitions, which makes future changes of the position of partitions difficult.

b. The spans of the floor joists are short (commonly 910mm), and the joist size is thin (commonly 90mm X 90mm for the girder, and 45mm X 45mm for joists).

c. The stiffness of the floor is provided by horizontal braces.

d. Sills, girders and horizontal braces are connected by using complicated skilled carpentry methods such as precisely shaped mortises and tennons.

Figure 3-2

FLOOR FRAMING

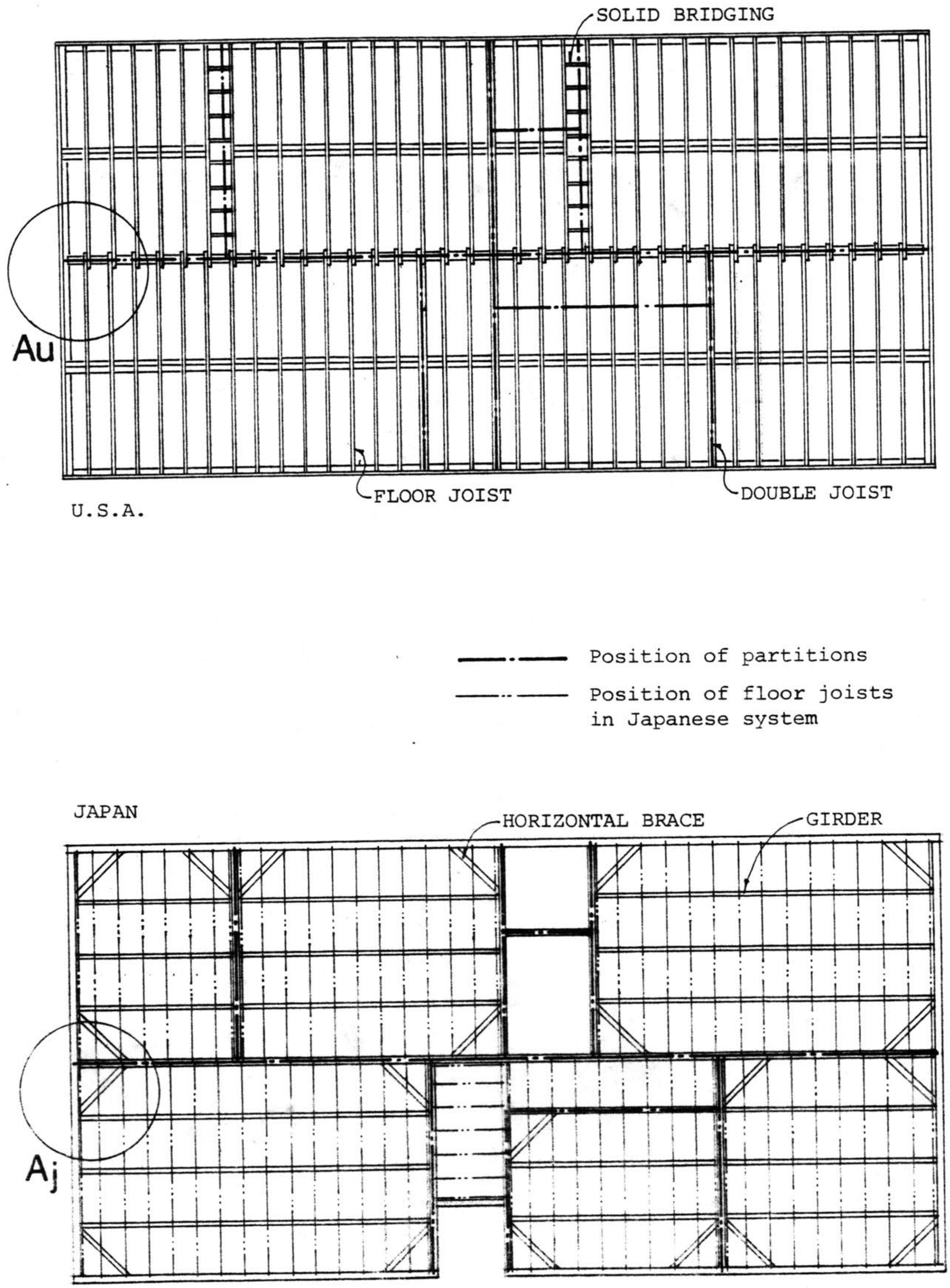
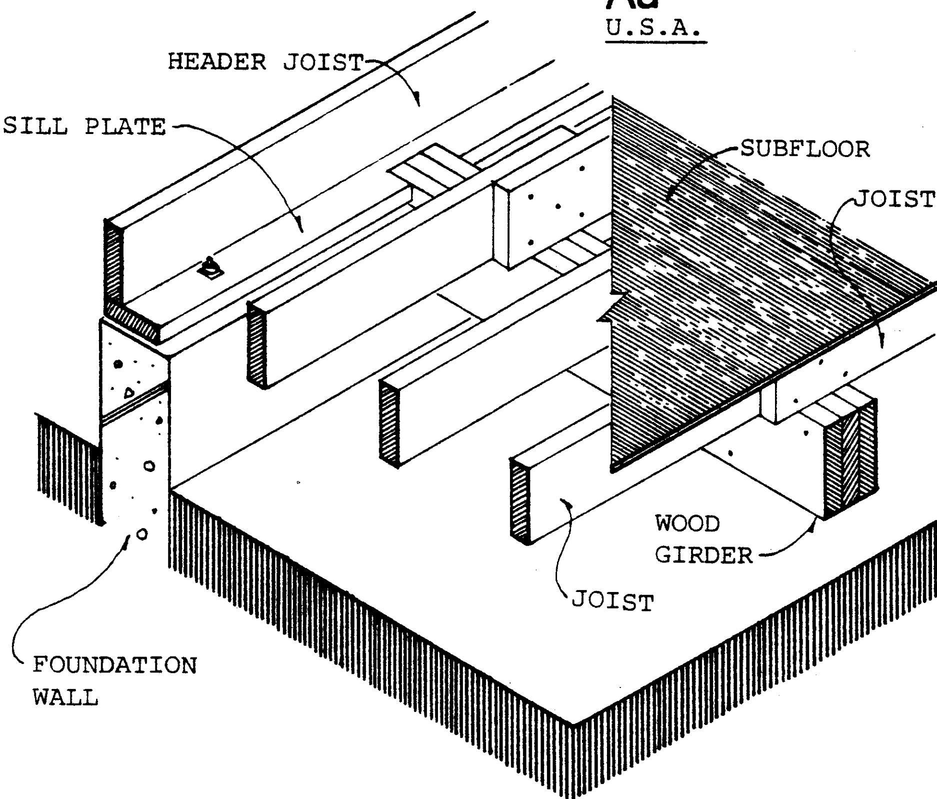


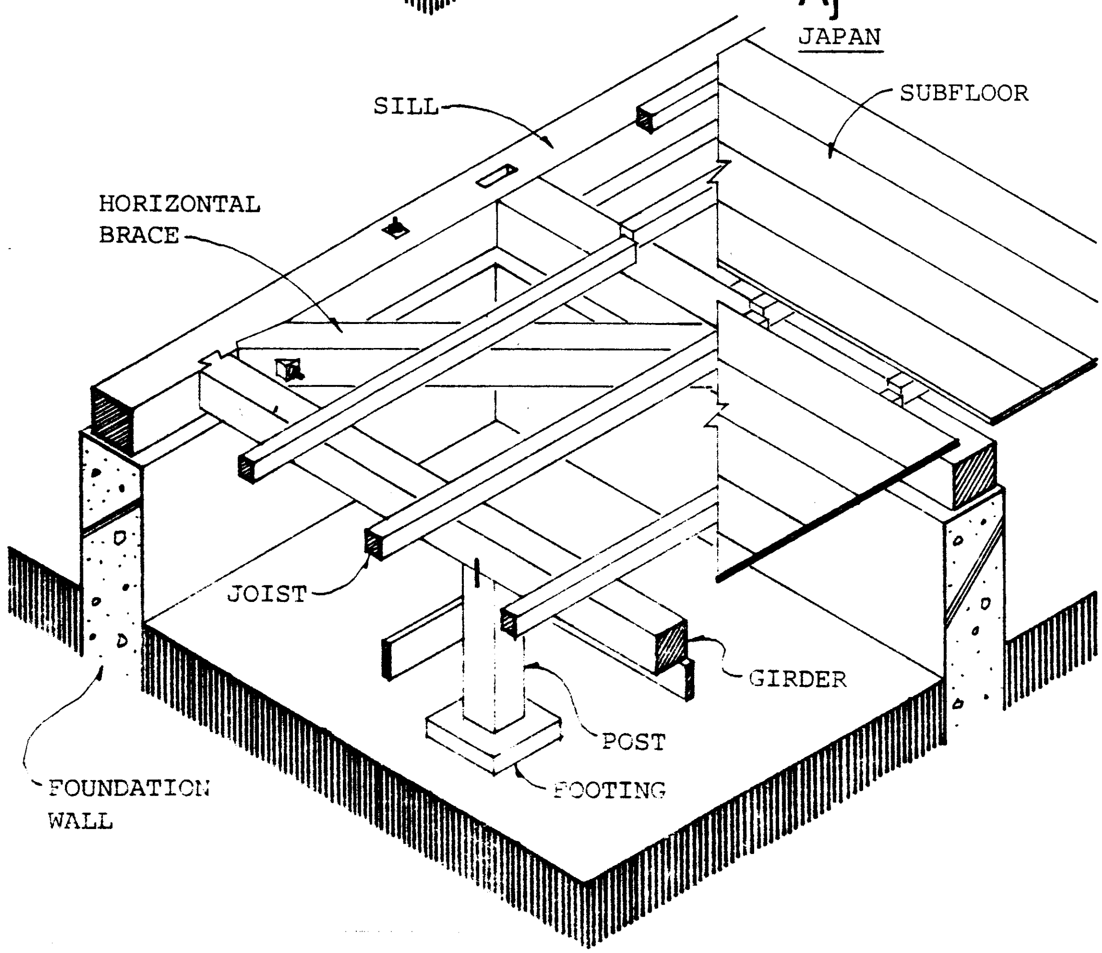
Figure 3-3

FOUNDATION & FLOOR

Au
U.S.A.



Aj
JAPAN



3. Wall

U.S.A

a. All the studs are 2" X 4" (50mm X 100mm) in size. The intersection of walls whose shape is "L", "T" or "+" is implemented by using different but standard combinations of stud arrangements.

b. Because all the studs are eventually covered with finishing materials, the requirement for accuracy in rough assembly is not very high.

c. Bearing walls and non-bearing walls are clearly differentiated.

JAPAN

a. As a rule, a post (90mm X 90mm to 120mm X 120mm) is necessary on the intersection of walls whose shape is "L", "T" or "+".

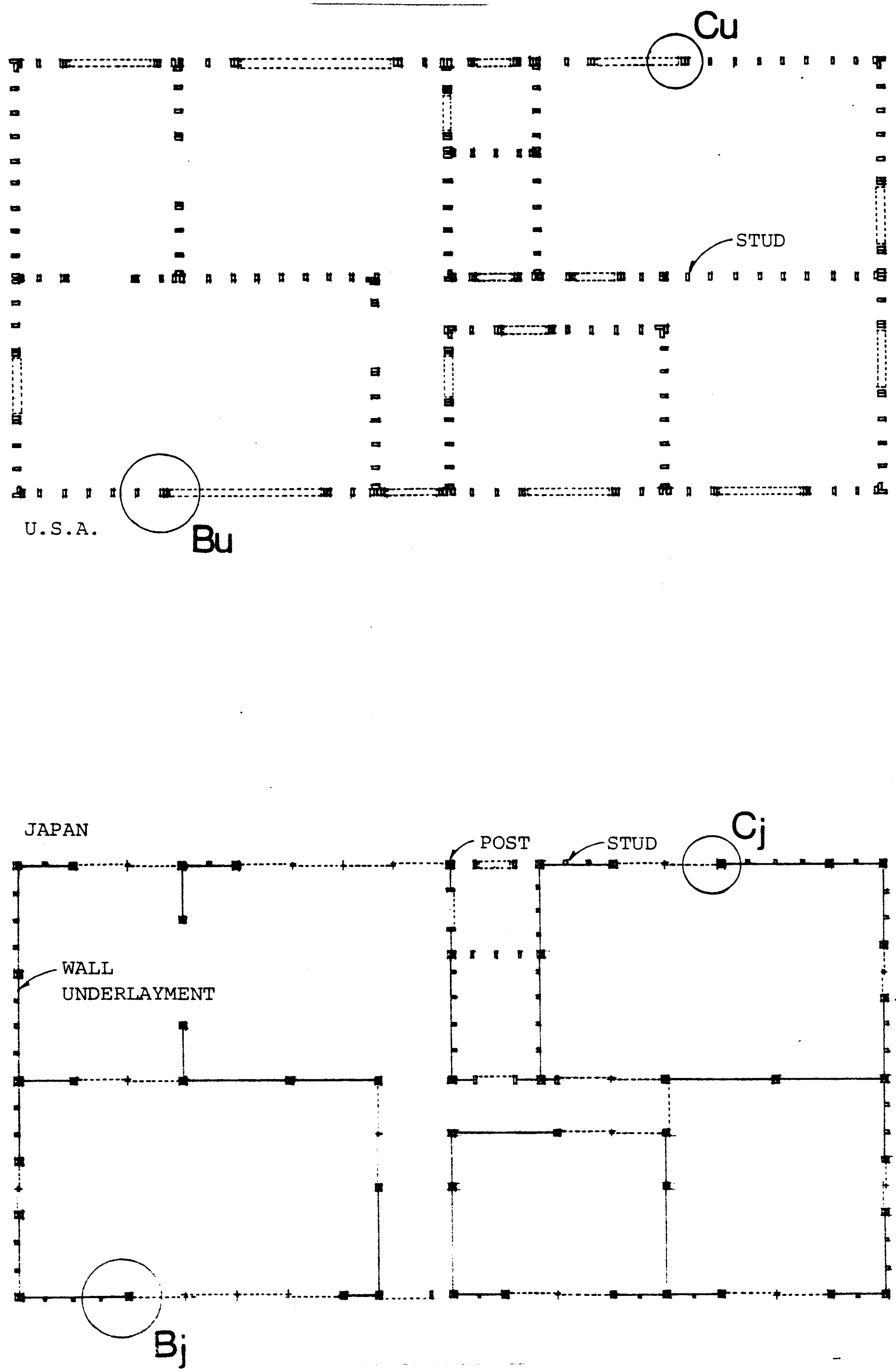
b. As a rule, the post is exposed to the interior, as an important design factor. Therefore, the accurcy requirement of assembly is very high.

c. As a rule, the post is a structural member, but the stud is non-structural.

d. Studs (45mm X 45mm) are employed only for the "ohkabe" (the wall with covered post), while "nuki" (horizontal member) is employed in the "shinkabe" (the wall with exposed post).

WALL FRAMING

Figure 3-4



4. Ceiling

U.S.A

a. The principle of positioning ceiling joists is relatively independent of the positions of partitions. Therefore, the replacement or addition of partitions is easy.

b. The space between the ceiling and a pitched roof can be utilized as an attic.

c. Jointing method in framing ceiling joists is extremely simple.

d. Section of ceiling joists is uniform.

JAPAN

a. The jointing method of beams and posts varies depending on the relative position of the partitions. Therefore, it is difficult to change the position of the partitions later.

b. Utilization of an attic is close to impossible because the roof frame is supported by a great number of roof posts.

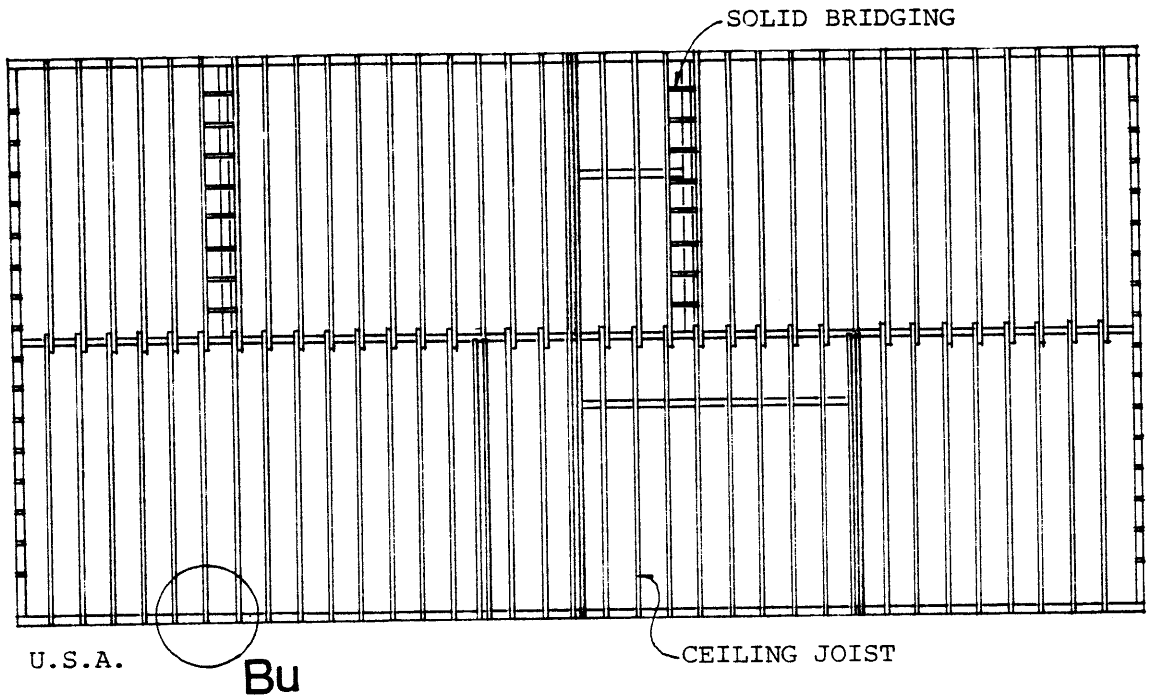
c. A large log is employed where a long span is necessary. A great expertise is required for assuring high demensional precision

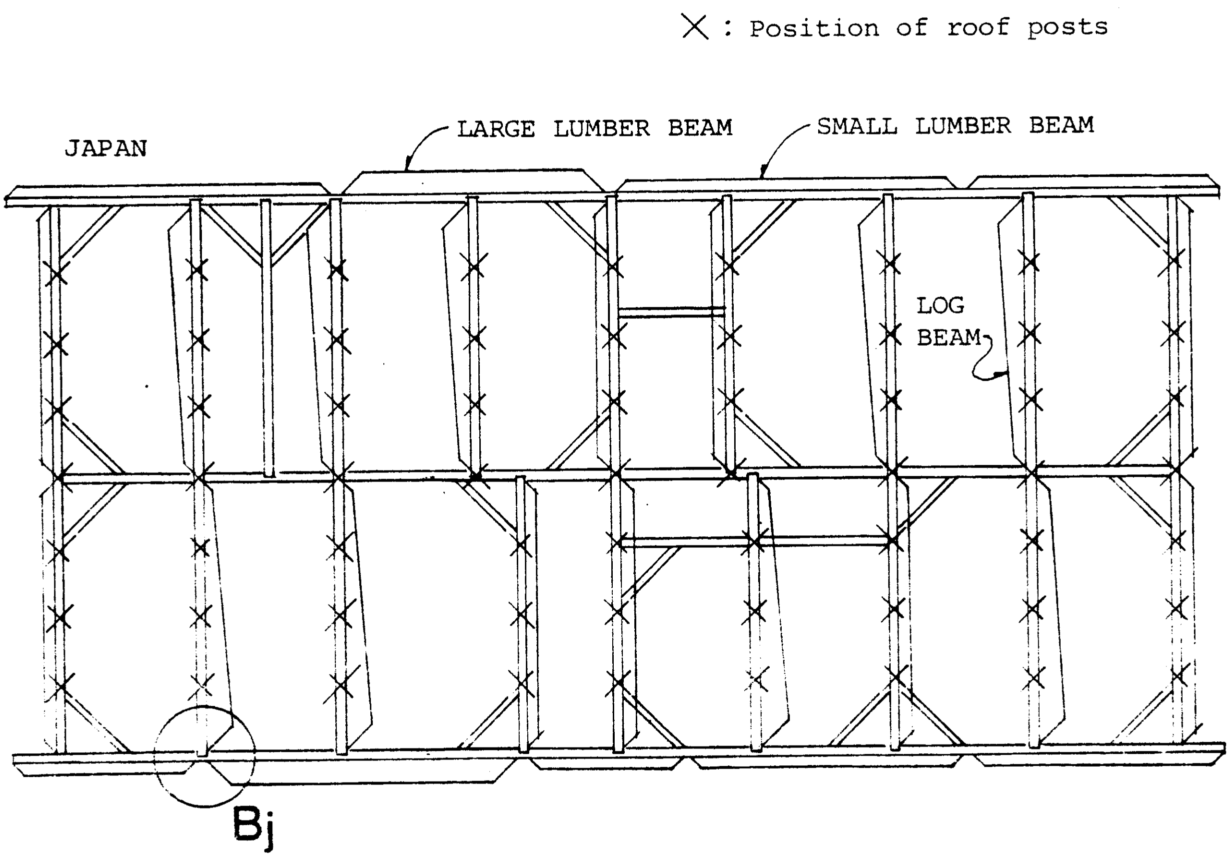
d. The stiffness of the ceiling frame is provided by horizontal braces.

e. Different sizes of beams are employed in responce to different lengths of spans.

CEILING FRAMING

Figure 3-5





5. Roof

U.S.A

a. The size of the rafter is large (about 50mm X 200mm).

b. Without additional engineering, it is difficult to make a deep overhang on the gable side of the roof.

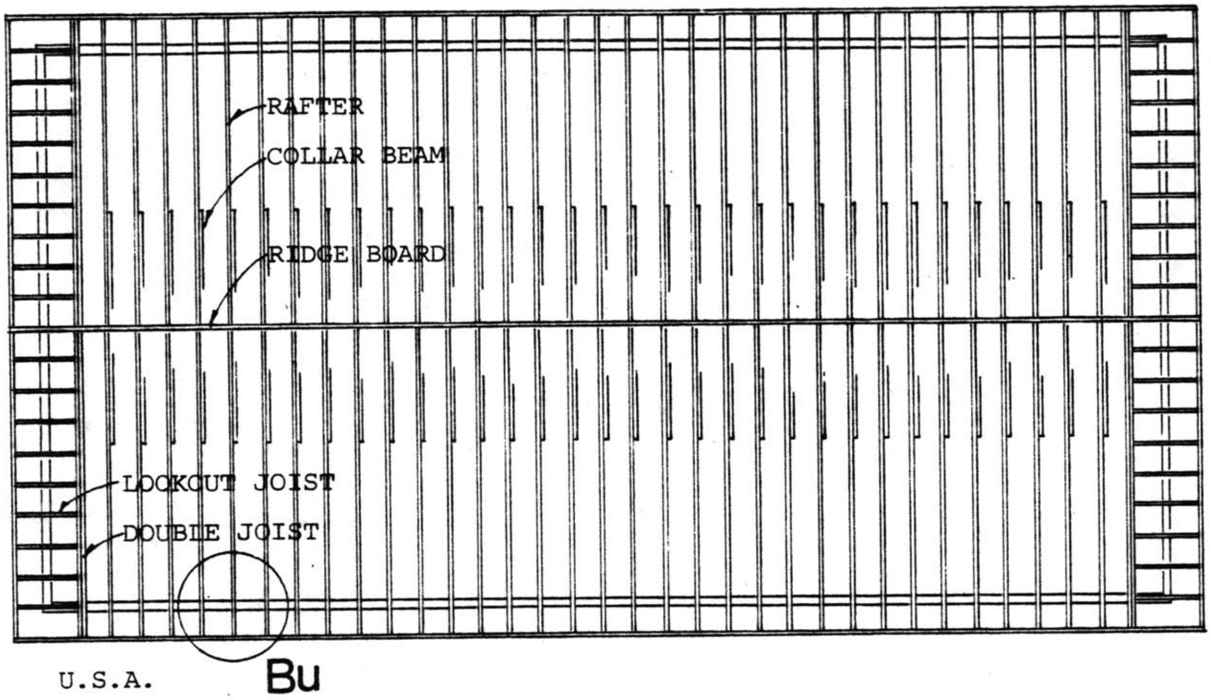
JAPAN

a. The "moya" (the purlin) which supports the rafters is commonly employed.

b. The sizes of the members are small (commonly, 90mm X 90mm for the purlin, and 45mm X 40mm for the rafter).

c. It is easy to make a deep overhang on the gable side as well as the eave side of the roof.

Figure 3-6



U.S.A.

Position of rafters

JAPAN

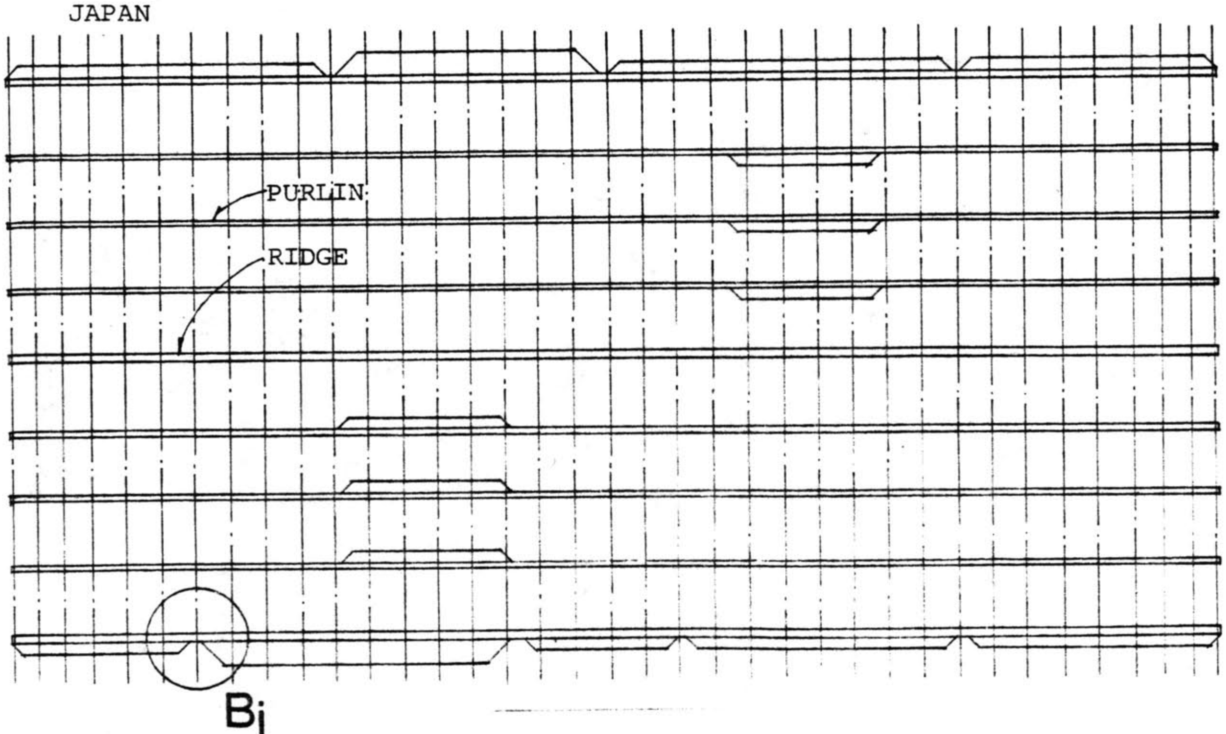
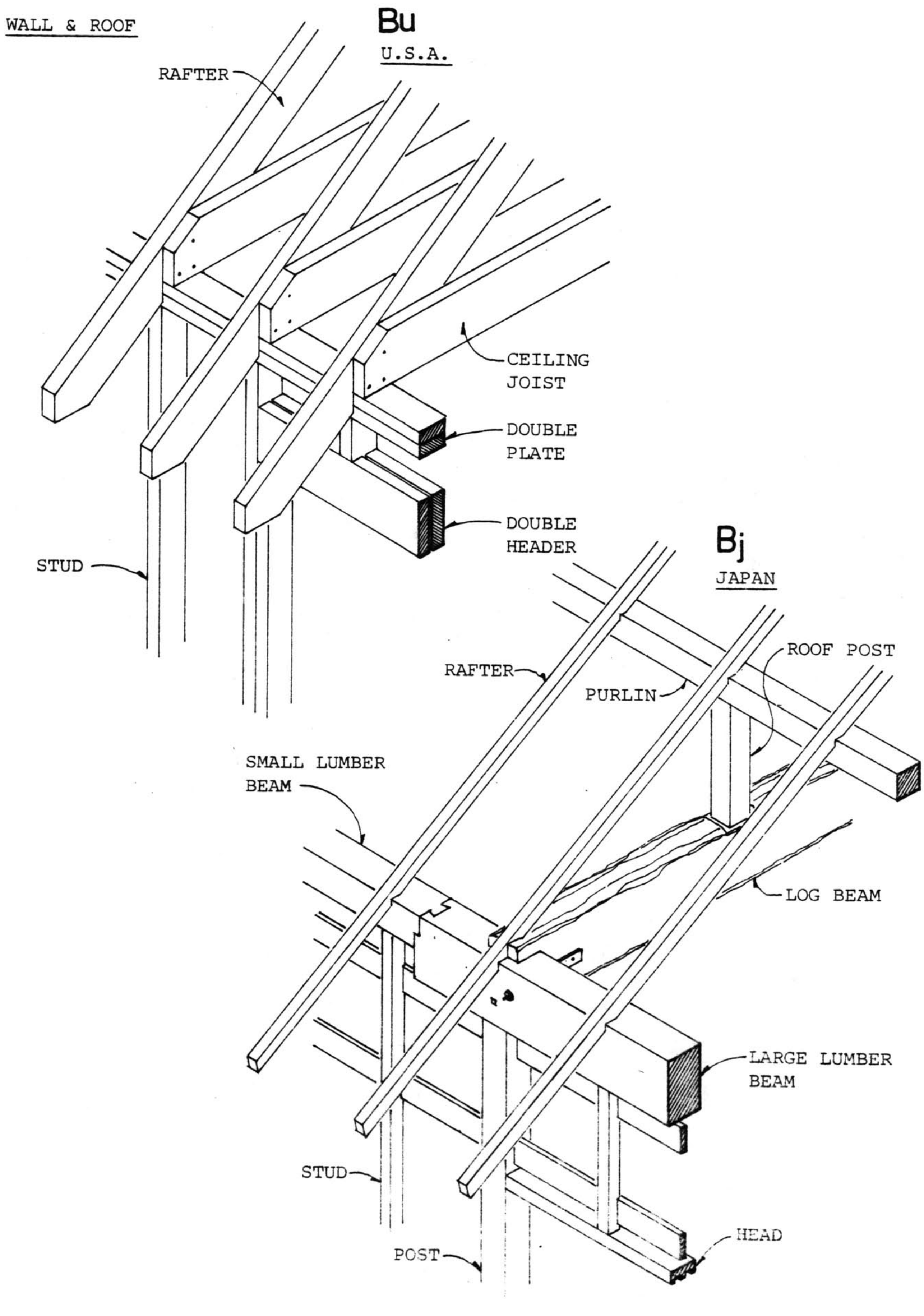


Figure 3-7


WALL & ROOF
Bu
U.S.A.
RAFTER
CEILING
JOIST
DOUBLE
PLATE
DOUBLE
HEADER
STUD
Bj
JAPAN
ROOF POST
RAFTER
PURLIN
SMALL LUMBER
BEAM
LOG BEAM
LARGE LUMBER
BEAM
STUD
HEAD
POST

6. Openings

U.S.A

a. For openings, preassembled and prefinished components including frames are usually employed. All work which requires accuracy is done off site.

b. The chief work on site is the trim work.

c. Because all the structural members of the openings will be covered with finishing materials, requirements for accuracy in the assembly of these members is not very high.

JAPAN

a. Only movable parts are assembled and finished off site. Preassembled opening components, including frames, are inconvenient for transportation, because the size of opening is usually very large.

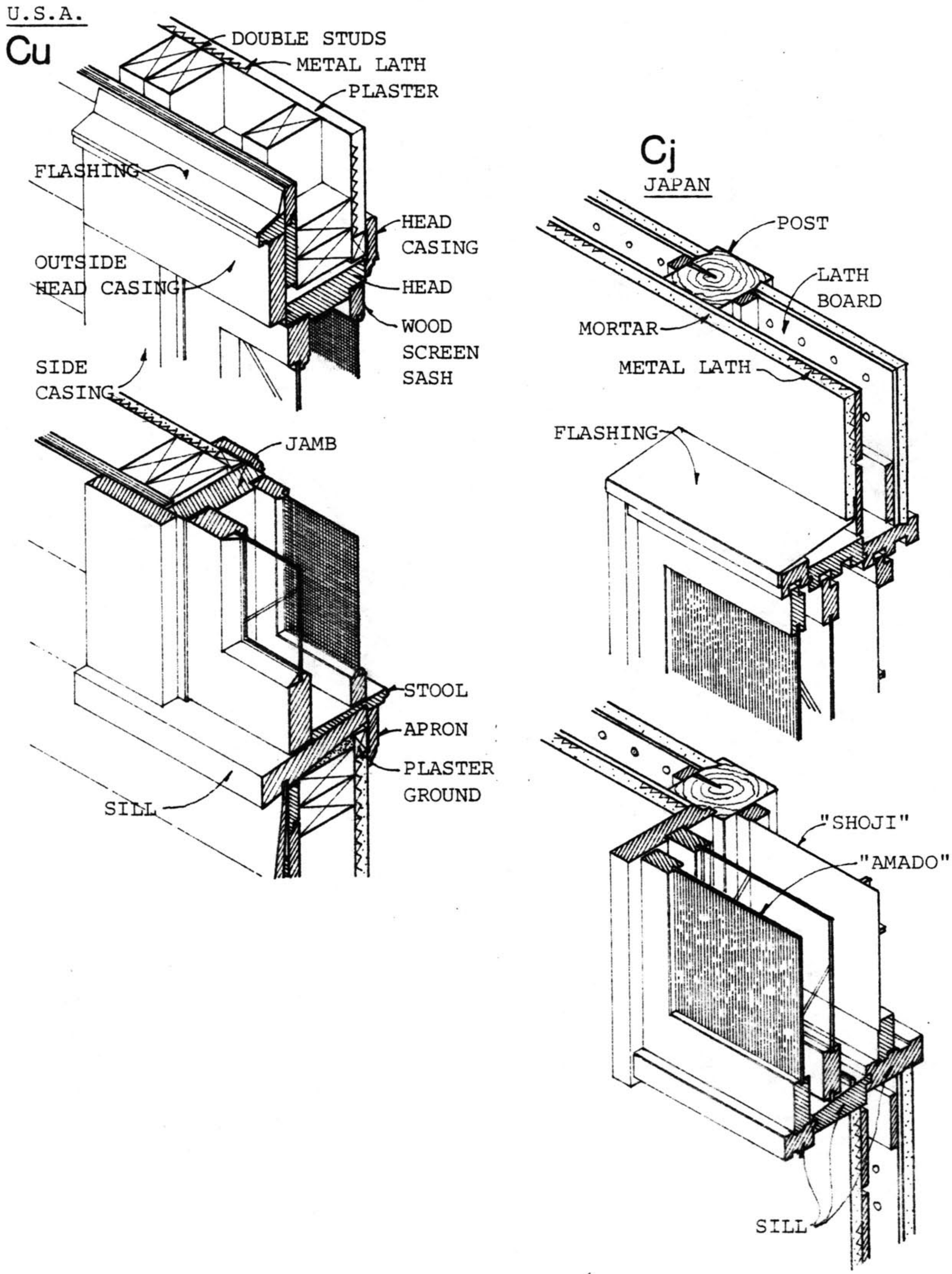
b. The post plays a role of the vertical frame, and horizontal frames are attached to the wall on site. Therefore, high accuracy and expertise in assembly is required on site. Furthermore, a precise adjustment is required when the movable part is installed.

c. Because the post is usually exposed to the interior as an important design factor, high accuracy is required for its finishing. At the same time, very precise methods such as making an artificial crack in the post ("chiri-jakuri" and "sewari") in order to provide a delicate finish or to prevent cracks caused by drying.

d. Trim work is seldom seen. Even if there is any, trim is supposed to be least expressive.

Figure 3-8

WINDOWS



3-2 Implications of the Analysis: Self-Help POtential of the Japanese System

In the comparative analysis of the two structural systems in the previous section, the different characteristics of the two systems were pointed out.

First, the construction of the structure of the Japanese house includes many tasks which require high skill and expertise. The task of joining structural members requires great precision in the on-site assembly, because precise mortise and tenon joints are often used.

The task of finishing the post also requires great skill, because most posts are left exposed in the interior space as an important design factor.

Secondly, in the Japanese system, different sized members are used in varying positions. The section of the member varies depending on the span. The joining method also differs according to the combinations of members. If the stick-built house is considered as the system whose general rules are exactly applied and realized in each specific house, the Japanese system can only provide a real house as a specific solutions, while general rules of framing, such as spacing and sizes of members are still applied.

To summarize these two characteristics, the Japanese system has been oriented towards maximizing the saving of materials, while the U.S. system is strongly oriented to saving on time and skilled labor.

The third characteristic of the Japanese system is that it has less flexibility in use than the U.S. system. As the analysis shows, it is very difficult to change the positions of partitions because all the frame is originally designed in accordance with the house plan. Also the later utilization of the attic is close to impossible because of structural members crowding the attic space.

All these characteristics of the Japanese system point to the difficulty of self-help construction. Furthermore, the distribution system of lumber is highly complicated because there are several hundred kinds and grades of lumber. A long chain of wholesale and retail lumber stores make access difficult for ordinary people. Due to these varied reasons, the structural system of the Japanese house has a very limited potential for self-help.

In contrast to the structural system, non-structural elements such as surfaces and opening partitions have a high potential for self-help. "Fusuma" (sliding partitions), "shoji" (half-transparent sliding partitions) and "amado" (sliding exterior walls) have been standardized according to traditional module, and are available as ready-made components on the market. This is also true for "tatami" (prefinished floor mats).

The surfaces, especially interior surfaces, have as much variety of interchangeable finishing materials as the U.S. system (Tables 3-1 and 3-2). Recently a variety of new materials and prefinished materials have been introduced, and have become commonly employed in Western-style rooms. In most tasks, these surface finishes have a high potential for self-help.

In conclusion, the structural system is the critical barrier at present, not only for the industrialization of Japanese houses but also for the self-help construction. Considering rapidly rising material and labor costs in Japanese housing, a drastic change in the production of the traditional frame seems to be inevitable, including the simplification of materials and construction methods. This change may even include the use of attached posts, instead of the structural exposed posts, which would sacrifice a part of the conventional Japanese aesthetic.

In 1974 the stick-built house became legally allowed in the Architecture Standard Law of Japan, strongly supported by the Japanese government. By the end of 1979, 30,000 units had been constructed. The introduction of the stick-built

EXTERIOR SURFACE FINISHES OF JAPANESE HOUSE

EXTERIOR SURFACE FINISHES	FREQUENCY OF USE *
Roof Surfaces:	
Kawara (ceramic tiles)	C
Slate tiles	o
Corrugated steel sheet	o
Exterior Wall Surfaces:	
Mortar	C
Wood panel	o
Wood siding	o
Metal siding	o

* C:commonly employed, o:occasionally employed.

Table 3-1

house is expected to play a role in promoting the rationalization of the housing industry, especially the traditional Japanese system.

It may appear unrealistic to advocate the significance of self-help in Japanese housing. People work very hard, and seem to have little time to spend changing their homes. However, I believe people are gradually getting more and more free time, and they will want more control over their houses. I hope that this study may help improve understanding of both the U.S. stick-built house and the Japanese traditional house, encouraging people to self-help construction as a means of control over their own homes, and improving the house systems in both countries.

INTERIOR SURFACE FINISHES OF JAPANESE HOUSE *

INTERIOR SURFACE FINISHES	MAIN BEDROOM	BEDROOM	KITCHEN	DINING ROOM	LIVING ROOM	BATHROOM	TOILET	GUEST ROOM
Ceilings:								
Wood board	C	C	o	C	C			C
Fiberboard			o	o	o			
Asbestos board		C	o	o	o	o		
Gypsumboard, prefinished		o	C	o		o		
Asbestos & cement board		o	o			o		
Cloth	o		o	C	C			o
Vinyl sheet		o	o	o		o		
Paint			o	o		o		
Interior Wall Surfaces:								
Mud & sand	C	o			C			C
Vegetable fiber	C	o			o			o
Lath and plaster	o	o	C	o	o	C	C	
Plywood, prefinished	o	C	C	C	C			o
Cloth	C	C		C	C			C
Vinyl sheet		o	o	o				
Ceramic tiles			o			C	C	
Floor Surfaces:								
Tatami	C	C			C			C
Wood blocks		o	o	o	o			
Plywood, prefinished	o	C	C	C	C			o
Vinyl tiles			o	o				
Vinyl sheet			C	C				
Carpet	o	C		C	C			
Ceramic tiles						C	C	

* C:commonly employed, o:occasionally employed.

Table 3-2

APPENDIX

The Derivation of the Formula for the Calculation of the Breakeven Wage Rate

The Derivation of the Formula for the Calculation of the Breakeven Wage Rate

The factors in the formula have been obtained with a certain set of assumptions. The contractor's cost per unit (Cc) has been obtained simply through identifying the values in Means Building Construction Cost Data 1981. The constractor's hourly output per person (Oc) has also been obtained by referring to Means Building Construction Cost Data. The efficiency factor (e) has also been simply identified in the table of these factors in p.106,107.

The assumptions for the calculation of the self-help builder's cost per unit (Csh) are as follows:

a. 10% higher material cost than the contractor

b. 10% for overhead, 10% for profit, and 5% for contingency on the self-help builder's material cost (a), therefore, 25% increase.

All the values of items obtained are shown in the tables, pp.108 to 119.

TABLE OF EFFICIENCY FACTORS

BY TASK

TASKS	EFFICIENCY FACTORS
Backfill	1.4
Trenching (hand)	1.4
Insulation (batt)	1.4
Pour Footings	1.7
Foam Ext. Wall Panel	2.3
Panel Joists	2.3
Panel Studs	2.3
Paint Walls & Ceiling	1.4
Panel Sheathing	2.3
External Wall Sheath	2.3
Foam: Floor-Ceiling & Roof Ceiling	2.3
Plywood & Spacers (foam Panels)	1.9
Cut & Set Tubes (foam Panels)	2.3
Setting Membranes	1.9
Roofing	2.3
Resilient Flooring	1.9
Furr blk Walls	1.9
Earth Wall	3.0
Install Gyp Bd	4.0
Install roof Trusses	4.0
Mortarless Masonery	3.0
Conv. Joists: Floor or Ceiling	3.8
Floor - 2.4.1 w/BMS	3.8
External Panel - Install	3.8
Frame internal & external Walls	3.8
Sheath Wall or Floor/Ceiling	3.8
Install Doors & Windows	3.8
Install Fosts & BMS	5.0
Rough Plumbing	3.8
Finish Plumbing	3.8
Install HVC	3.8
Install Ductwork	3.8
Rough Electrical	3.8
Post & BM Modular unit	6.3

TASKS	EFFICIENCY FACTORS
Install Floor Panel	6.0
Install Trim & Ceiling	3.8
Electrical Finish & Hookup	3.8
Concrete Block Wall Surface Bond	4.5
Install Plocking & Fescla	6.0
Install Rubber Base	3.8
Pour Concrete Slab	6.0
Install Roof Sheath	6.0
Install Casework	4.5
Finish Slab	8.0
Plaster on Block	6.0
Install Roof/Ceiling panels	8.0
Tape GYP BD	6.25
Concrete Formwork	10.0
Concrete Block	10.0
Unit Building	10.0

Breakeven Wage Rate of the Self-Help Builder:

Task Packages	Contractor's Crew Size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Foundation & Basement							
Excavating, trench by hand	1	1	CY	17.45	0	1.4	12.46
Footing, concrete in place incl. forms and reinforcing	10	.27	CY	155	81	10	2.15
Concrete blook, foundation walls	5.25	10.2	SF	3.16	1.46	10	1.73
Gravel fill, compacted under floor slabs 6" deep(gravel at $3.75/ton)	6	187.5	SF	.24	.15	1.7	9.93
Waterproofing polyethylene 1/4" thick	2	35.7	SF	1.39	1.01	1.9	7.13
Slab, concrete in place incl. forming and reinforcing	10	.25	CY	175	91	8	2.63

Breakeven Wage Rate of the Self-Help Builder:

Task Packages	Contractior's Crew Size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-helper ($/man/hr)
Sub drainage perforated pipe ø4"	2	16.7	LF	2.95	1.93	3.8	4.48
Wall concrete in place incl. formwork	10	.12	CY	310	128	10	2.18
Backfill by hand light soil	1	1.8	CY	9.95	0	1.4	12.79
Floor Framing							
Sills, 2" X 6"	2	.05	MFBM	1400	1183	3.8	2.86
Girders, 4" X 10"	2	.065	MFBM	950	743	3.8	3.54
Joists, 2" X 10" @16"	2	.095	MFBM	655	523	3.8	3.30
Cross bridging, 2" X 3"	1	.16	CPr	210	88	3.8	5.14
Stressed skin panels plywood 4" X 8"	4	54	S.F.Flr	2.89	2.96	2.3	-3.99

Breakeven Wage Rate of the Self-Help Builder:

Task Packages	Costractor's Crew Size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Subfloor, 5/8" plywood, 4' X 8'	2	84.5	SF	.68	.58	1.9	6.67
Wall Framing							
Studs, 8' high, 2" X 4"	2	.045	MFBM	865	440	3.8	5.03
Top plates, 2" X 4"	2	.046	MFBM	945	584	3.8	4.28
Sheathing, 3/8" plywood, 4' X 8'	2	87.5	SF	.62	.45	6.0	2.48
Roof/Ceiling Framing							
Ceiling joints, 2" X 6"	2	.065	MFBM	710	461	3.8	4.26
End studs, 2" X 4"	2	.045	MFBM	865	440	3.8	5.03
Rafters, 2" X 6"	2	.055	MFBM	785	454	3.8	4.79
Ridges, 2" X 8"	2	.055	MFBM	770	468	3.8	4.37
Collar beames @4' 1" X 6"	2	.04	MFBM	950	440	3.8	5.37

Breakeven Wage Rate of the Self- Help Builder:

Task Packages	Contractor's Crew Size	Contractor's Hourly Output	Unit	Contractor's Cost/Unit	Self-Helper's Cost/Unit	Efficiency Factor	Breakeven Wage Rate of Self-Helper
	n (men)	Oc (unit/man/hr)		Cc ($/unit)	Csh ($/unit)	e	($/man/hr)
Trussed rafters	4	94	S.F.Flr	1.17	1.00	4.0	4.00
Stressed skin panels, plywood, 4' X 8'	4	54	S.F.Roof	2.75	2.78	3.8	-.41
Roof Sheathing 1/2 plywood	2	87.5	SF	.62	.45	6.0	2.48
Roof Surface							
Wood shingles	1	.31	Sq	160	111	2.3	6.60
Asphalt shingles	1	.69	Sq	61	36	2.3	7.50
Asbestos shingles	1	.50	Sq	125	102	2.3	5.00
Slate, incl. felt underlay, 3/16" thick	1	.22	Sq	470	461	2.3	.86
Clay tile, Americana	1	.21	Sq	340	289	2.3	4.66
Corrugated aluminum .0125" thick painted	4	144	SF	1.00	.58	8.0	7.56
Corrugated steel	4	144	SF	1.03	.63	8.0	7.20

Breakeven Wage Rate of the Self-Help Builder:

Task Packages	Contractor's Crew Size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Asphalt roll roofing	1	1.9	SF	24	15.46	1.9	8.60
Polyethylene & rubberized asphalt sheets 1/8"	2	35.5	SF	1.02	.51	2.3	7.87
Exterior Wall Surface							
Wood siding Bgrade, cedar, 1/2" X 6"	1	31	SF	1.72	1.29	3.8	3.51
Aluminum siding painted	4	87.5	SF	1.00	.45	3.8	12.66
Vinyl siding, solid PVC panels, 8" wide, plain	1						
Hard board, 7/16" prime painted, lap	2	46.5	SF	.83	.44	3.8	4.77
Wood shingles	1	.26	Sq	145	76	2.3	7.80
Asphalt Shingles	1	.31	Sq	160	111	2.3	6.60
Asbestos Shingles	1	.50	Sq	125	102	2.3	5.00

Breakeven Wage Rate of the Self-Help Builders;

Task Packages	Contractor's Crew Size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Masonry Veneer brick	5.5	.035	M	805	282	10.0	1.83
Painting	1	58	SF	.44	.11	1.4	13.70
Ceiling							
Drywall, gypsumboard,	2	113	SF	.95	.34	4.0	17.23
Taping & finishing	2	125	SF	.18	.01	6.25	3.40
Texture spray	2	91	SF	.31	.10	1.4	13.65
Furring, 1" X 3" furring strips 12" o.c.	1	60	SF	.47	.14	1.9	10.42
Wood fiber tile 1/2" thick cemented	1	50	SF	.85	.65	1.9	5.25
Wood-fiber tile T bar suspention system, 2' X 2' grid	1	81	SF	.55	.36	3.8	4.05
Gypsum plaster, 3 coats incl. painted metal lath, on wood studs, on ceilings	6	1.6	SY	16.95	5.14	6.0	3.23

Breakeven Wage Rate of the Self-Help Builder:

Task Packages	Contractor's Crew Size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Gypsum plaster, 3 coats no lath incl. on ceilings	5	1.96	SY	12.75	2.85	6.0	3.23
Painting, interior, brushwork, primer + 3 coats	1	45	SF	.53	.10	1.4	13.82
Interia Wall Surface							
Gypsum plaster, 3 coats, no lath incl.	5	2.2	SY	11.65	2.83	6.0	3.23
Ceramic tile pregrouted shuts, 4 1/4" X 4-1/4", 4 Sf Sheets silicone grout	2	15	SF	2.83	1.98	1.9	6.71
Plywood prefinished 1/4" thick 4' X 8' sheets Birchfaced	2	26.5	SF	1.64	.99	2.3	7.49
Drywall, gypsumboard incl. taping & spray	2	113	SF	.87	.34	4.0	14.97

Breakeven Wage Rate of the Self-Help Builder:

Task Packages	Contractor's Crew Size n (men)	contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Wallpaper at $12 per double roll, average workmanship	1	67	SF	.61	.38	1.9	8.11
Painting interior, primer + 3 coats	1	45	SF	.53	.10	1.4	13.82
Remove existing paint & refinish with 2 coats of paint	1	25	SF	.92	.14	1.4	13.93
Floor surface							
Resilient flooring, 1/8" asphalt tile on wood subfloor with felt underlayment	1	58	SF	.44	.11	2.3	7.04
Carpet, nylon with antistatic 22 oz. medium traffic	1	5	SY	12.20	10.11	1.9	5.50
Wood panel, prefinished white oak, prime grade, 2-1/4" thick	1	21	SF	2.97	2.45	6.0	1.84

Breakeven Wage Rate of the Self-Help Builder:

Task Packages	Contractor's Crew size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Wood Block natural finish, end grain, 2" thick, incl. finish	1	9.4	SF	4.39	2.61	6.0	2.73
Ceramic tile, porcelain type, 2" X 2"	2	12	SF	3.16	1.91	8.0	1.88
In. & Ex. Trim & Millwork							
Soffit 1/2" plywood	2	26.5	SF	1.47	.76	3.8	4.95
Facia 1" X 6"	1	31	LF	1.07	.48	3.8	4.81
Facia & trim 1" X 8"	1	28	LF	1.28	.65	3.8	4.64
Frieze & trim 1" X 4"	1	25	LF	1.12	.31	3.8	5.33
Base moldigs	1	30	LF	1.54	1.03	3.8	4.03
Ceiling moldings	1	31	LF	1.54	1.06	3.8	3.92
Openings							
In wood door & frame, passageway flush, birch 3'-o" X 6'-8", hollow core	2	.63	Ea	105	82	3.8	3.81

Breakeven Wage-Rate of the Self-Help Builder:

Task Packages	Contractor's Crew Size n (Men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Ex. wood door, 3' X 6'-8" X 1-3/4", flush, birch	2	.57	Ea	115	96	3.8	2.85
In. wood door, pre-hung hollow core,birch, 3-0" X 6'-8" solid jams	2	1.25	Ea	102	106	3.8	-1.32
Ex. wood door, pre-hung, incl.frame, still, hardware, and weatherstripping	2	.57	Ea	240	264	3.8	-3.60
Wood window with frame, trim & glazing	2	.40	Ea	130	98	3.8	3.37
Aluminum window with frame, trim & glazing	2	.50	Ea	165	138	4.5	3.00
Stairs, prefabricated, 3'-6" wide, oak, 8 ft. high	2	.19	Flight	490	468	3.8	1.10
Skylight, plastic done, single	2	14.5	SF	12.20	13.41	3.8	-4.62

Breakeven Wage Rate of the Self-Help Builders:

Task Packages	Contractor's Crew Size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Fireplace, prefabricated, free standing or wall hung, with hood & screen, average	1	.13	Ea	1125	1169	3.8	-1.51
Chimney, brick, 16" X 24", with two 8" X 8" flues	2	.88	VLF	37	18	10	1.67
Services							
Pipe, copper, 3/4" diameter	1	5.5	LF	6.25	2.15	3.8	5.93
Bath tub, 72" X 36", incl. trim, fitting	2	.19	Ea	770	811	3.8	-2.05
Bath tub with rough-in supply, waste & vent	2	.14	Ea	1030	931	3.8	3.65
Kitchen sink faucets, top mount, cast spout	1	1.25	Ea	44	30	3.8	4.61
Wiring #14	1	1.63	CLF	19.70	5.5	3.8	6.09

Breakeven Wage Rate of the Self-Help Builder:

Task Packages	Contractor's Crew Size n (men)	Contractor's Hourly Output Oc (unit/man/hr)	Unit	Contractor's Cost/Unit Cc ($/unit)	Self-Helper's Cost/Unit Csh ($/unit)	Efficiency Factor e	Breakeven Wage Rate of Self-Helper ($/man/hr)
Receptacle, duplex, 120 V, 5 Amp.	1	5	Ea	7.55	3.23	3.8	5.68
Flourescent C.W. lamps, pendant, 4' with 2-40 W	1	.71	Ea	83	61	3.8	4.11
Fan, roof exhauster	3	.25	Ea	360	358	3.8	.13
Ductwork, incl. fittings, joints & supports, galvanized steel	3	26.7	lb	3.10	1.05	3.8	14.40
Wall or Ceiling insulation, batt, R 19	1	150	SF	.42	.35	1.4	7.50

Abbreviations Used in the Tables

CLF	Hundred Linear Foot
CPr	Hundred Pair
CY	Cubic Yard
Ea	Each
lb	Pound
LF	Linear Foot
M	Thousand
MFBM	Thousand Feet Board Measure
SF	Square Foot
S.F.Flr	Square Foot of Floor
S.F.Roof	Square Foot of Roof
Sq	Square 100 sq. ft.
SY	Square Yard
VLF	Vertical Linear Foot

BIBLIOGRAPHY

BIBLIOGRAPHY

Allen, Edward B., *How Buildings Work*, Oxford University Press, Inc., New York, 1980

Anderson, L.O., *Wood-Frame House Construction*, Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Agriculture Handbook No. 73, 1970

Architectural Forum, *Building's Post-War Pattern, No.2: Standardization*, Nov. 1941, pp. 353-364; *No. 3: An Integrated Industry*, Architectural Forum, Oct. 1942, pp. 70-81.

Autry, James A., *Complete Guide to Home Repair, Maintenance & Improvement*, Meredith Corporation, Des Moines, Iowa, 1980

Bemis, Albert F., *The Evolving House: Vol. 1, A History of the Home* and *Vol. 3, Rational Design*, The Technology Press, Cambridge, MA, 1933 and 1936.

Better Homes and Gardens, *Complete Guide to Home Repair, Maintenance, and Improvement*, Meredith Co., Des Moines, IA, 1980

Building Construction Cost Data 1981, R.S. Means Co., Kingston, MA, 1980

Building Systems Development, *Large Scale Self-Help Housing Methods*, Report #2 and #4, 1970

Bureau of the Census, Department of Commerce with the Department of Housing and Urban Development, *Construction Reports C-25 Series*, Washington D.C., U.S. Government Printing Office, 1963-69 and 1975-79

Bureau of the Census, Department of Commerce with the Department of Housing and Urban Development, *Annual Housing Survey 1978, Part A: Housing Characteristics*

Clark, Stephen and Lyman, Daniel, ed., *The Incredible Illustrated Tool Book*, Pathfinder Publications Inc., 1974

Dietz, Albert G. H., *Dwelling House Construction*, MIT Press, Cambridge, MA 1974

Durbahn, Walter E., *Fundamentals of Carpentry*, American Technical Society, Chicago, 1977

Falcon, Joseph E., *How to Design, Build, Remodel and Maintain Your Home*, John Wiley and Sons, Inc., 1978

Fischman, Walter I., *Carpentry*, Grosset and Dunlap, New York, 1975

Grant, Donald, *Small Scale Master Builder*

Habraken, Nikolaas J., *Support Structure and Detachable Unit*, Toshijutaku, Sept., 1972

Halpin, Daniel W. and Woodhead, Ronald W., *Construction Management*, John Wiley & Sons, Inc., New York, 1970

Hauf, Harold D., chairman, and Boab, Joseph N., editor, *Architectural Graphic Standards*, John Wiley & Sons, Inc., New York, 1970

Hornbostel, Caleb, *Materials for Architecture: An Encyclopedic Guide*, Reinhold Publishing Co., New York, 1961

House and Garden, *House and Garden Plans Guide 1981*

Japan External Trade Organization (JETRO), *Japanese Home in Transition*, Feb. 1979, No. 28

Japan Two by Four Association, *Two by Four* (monthly) No. 1-21, Tokyo, March 1977 - Dec. 1980

Jutaku-kinyukoko Kensetsu-Shido-bu, *Wakugumi-kabe-koho Jutaku Koji Kyotsu-Shiyosho*, (Specification Standards of Platform Frame Construction) 1974 edition, Jutaku-Kinyu Fukyu-Kyokai, Tokyo, 1974

Kader, Nasamat A. and Dluhosch, Eric, *Housing Construction Systems and Design: Prefabrication, The Housing and Construction Industry in Eygpt*, Interim Report Working Papers 1978

Kogyo-jiji Tsushinsha, *Wakugumi-kabe-koho no Zenyoto Shorai (Applicability of the Platform Frame Construction in Japan)*, 24th Lecture Series on Housing Industry, Tokyo, 1973.

Lamb, Felton, Jr., *Self-Help: When is it Viable?*, submitted to a class at MIT, Dec. 1980

Mayer, Martin, *The Builders*, W. W. Norton & Company, Inc., New York, 1978

McGraw-Hill, Inc., *1981 Dodge Manual for Building Construction Pricing and Scheduling*, 1980

McGuiness, William J. and Stein, Benjamin, *Mechanical and Electrical Equipment for Buildings*, John Wiley and Sons, Inc., 1971

Modi, John, *The Best Kitchen Remodeling Workbook*, Comtemporary Books, Inc., 1978

Neal, Charles D., *Do-It-Yourself Housebuilding*, Macmillan Publishing Co., Inc., New York, 1973

New England Telephone, *Bell System Yellow Pages: Boston Area*, 1981

The Nihon Keizai News Corp., *Two by Four no Subete (All about the Platform Frame Construction)*, the Nihon News Corp., Tokyo, 1977

Philbin, Tom, *The Encyclopedia of Hardware*, Hawthorn Books, Inc., 1978

Reidelbach, John A., Jr., P.E., *Modular Housing 1971: Facts and Concepts*, Cohners Books, Boston, MA 1971

Sears, Roebuck & Co., *1981 Sears Catalogue*

Shokokusha, *Mokuzu no Shosai (Details of the Japanese Wooden House)*, Vol. 1-4, Tokyo

Sloane, Eric, *A Reverence for Wood*, Funk & Wagnalls, New York, 1964

Sweet's Catalogue File

Turner, John F.C., *Freedom to Build*, MacMillan Company, 1972

Turner, John F.C., *Housing by People*, Pantheon Books, New York, 1976

Yeck, Fred, *Building Your Own Home*, Arco Publishing Co., Inc., New York, 1975

Yoshichica Uchida, *Open System in Building Production*, Shokokusha, Tokyo, 1977.