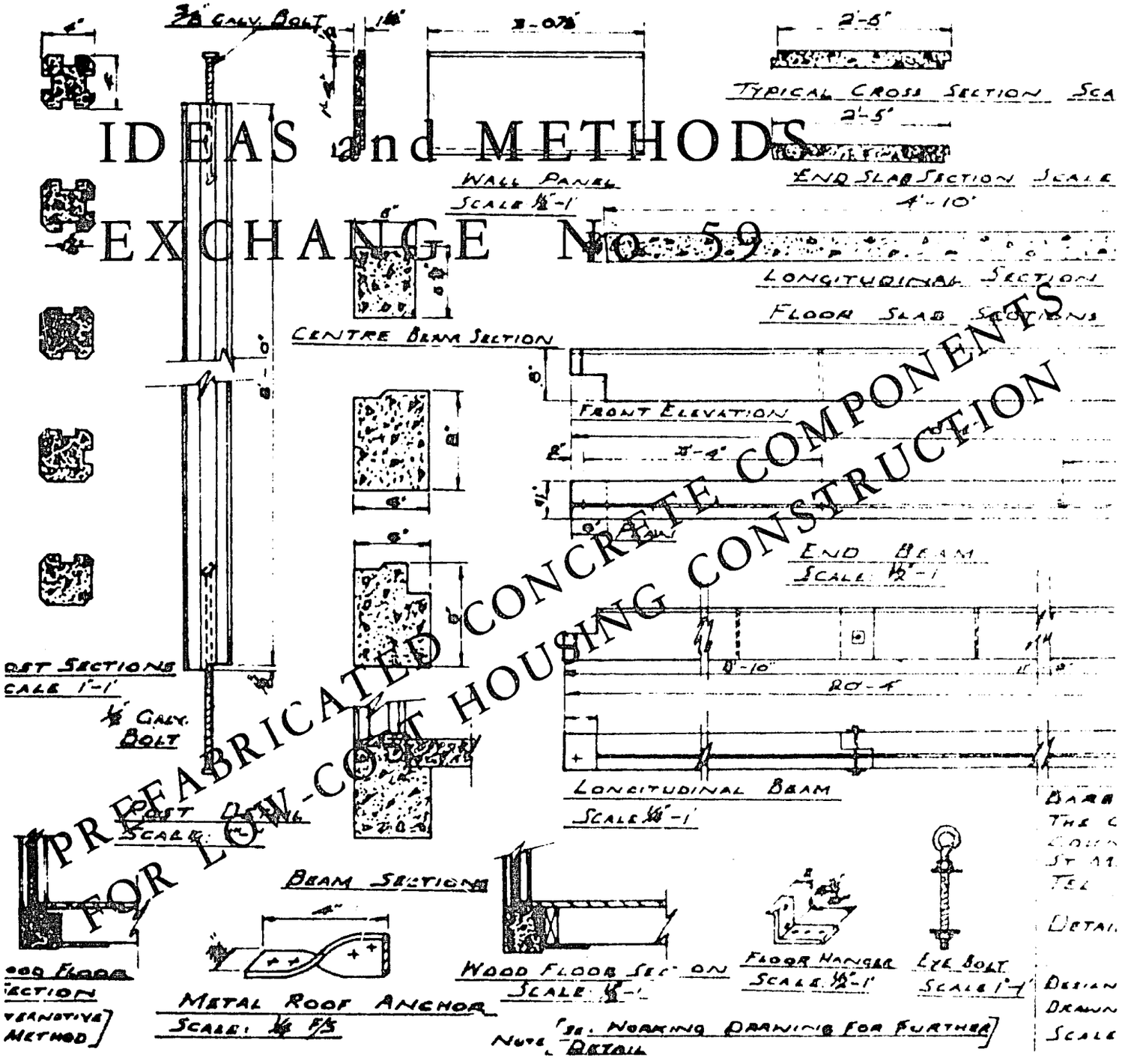

IDEAS and METHODS
EXCHANGE No. 59
PREFABRICATED CONCRETE COMPONENTS
FOR LOW-COST HOUSING CONSTRUCTION

Department of Housing and Urban Development
Office of International Affairs
Washington, D. C. 20410

IDEAS AND METHODS EXCHANGE No. 59

PREFABRICATED CONCRETE COMPONENTS FOR LOW-COST HOUSING CONSTRUCTION

407 Building Design and Construction,
Prefabrication

For the Use of
UNITED STATES A. I. D. MISSIONS

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
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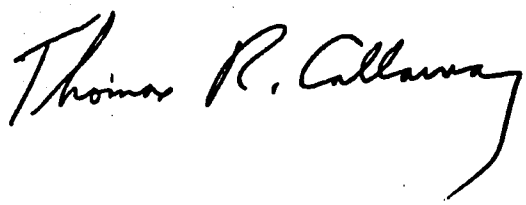
FOREWORD

The system of construction described in this publication was developed originally in Surinam by Mr. Joseph Coulam under the U. S. technical assistance program and later refined under the Agency for International Development program of technical cooperation with Barbados.

Although the publication deals in part with the adaptation of this system to the construction of small movable dwellings known in Barbados as "Chattel Houses", the system is just as useful in building low-cost, permanently located dwellings.

Because of its simplicity, durability, and low-cost and because it appears to be adaptable for use in aided self-help programs generally, it is believed that it will be of considerable interest to U. S. Agency for International Development housing advisors and others working in less industrialized countries.

Senior Housing and
Urban Development Advisor
Agency for International Development



Director,
Division of Technology & Documentation
Office of International Affairs
Department of Housing & Urban Development

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SUMMARY OF THE PRINCIPAL FEATURES OF THE PREFABRICATED CONCRETE HOUSE

Low-Cost

The two-room basic portable house including foundations, floor, walls, partitions, roof of corregated aluminum, windows, doors, louvers, two drop cord electrical fixtures with wall switches, but not including a ceiling, set in place and painted, has been built for US $589 (or US $2.80 per square foot) in Barbados in 1962.

The materials alone for this house (using either a concrete or wood floor) cost approximately US $300 in Barbados.

There is little difference in cost between a portable house and one of the permanent type using the same pre-cast wall units.

A four-room house can include running water in a kitchen sink for the same per square foot cost quoted for the two-room house; this is because of the saving of the cost of one wall.

A more elaborate house containing three bedrooms, a bath a kitchen, a dining room, a living room, a front porch, adequate closet space, kitchen cabinets which form the wall between the kitchen and dining room, wall service outlets, wall switches for ceiling lights, a ceiling throughout the house and with a septic tank sewage disposal has been built for US $3.53 square foot.

Prefabricated Units.

A crew of one carpenter, one mason and six common laborers make up a working team. The carpenter is responsible for any needed repairs to the forms and is also in charge of assembly and removal of forms. The mason is in charge of casting and any necessary finishing. Such a team should be able to cast the concrete parts including the concrete floor for a two-room house in two days, or for a four-room house with bath in four days. If the house is of the permanent type, only the wall units are pre-cast. The above team should cast two four-room houses with baths per week. The estimate of time is

based on experience with well trained crews. A beginning team will need more time.

A mechanical vibrator simplifies the casting operation considerably. The table kind is the most convenient. It must be strong enough to handle whatever load is to be imposed.

A vertical type gang-form can be used with some of the heavier aggregates in casting the wall slabs, but in Barbados, the sand tends to float in such a form, since most of this material available for concrete is chiefly coral; so a flat type form has to be used. This has a tendency to slow-up the operation of the wall slabs slightly and requires more floor space for curing. Shelves are used for storage in Barbados.

Ease of Erection

All labor with the exception of the foreman can be unskilled.

No specialized or heavy equipment is required.

If units have been properly cast and sufficient play is allowed in bolt holes, the parts can be assembled without adjustment.

When all parts including concrete units, door and window frames, doors and windows, top plates, roof members, etc., have been prefabricated in the shop, a crew of six men consisting of a foreman and five unskilled workers can erect a two-room movable type house in less than eight hours. A four-room portable house will require from two to three days.

If a permanent type house of four rooms with bath is built, using pre-cast units for walls and a permanent foundation and floor slab, the structure, including the roof, can be set in place on the slab ready for painting, wiring, etc., within two days. This will depend mostly on the work involved in the type of roof chosen. A portable type house of this dimension will require three days.

Mobility

Parts for the pre-cast houses can be readily transported to the site and can be carried by manpower.

The movable type houses can be readily assembled, dismantled, and re-erected on a new site.

Adaptability

The basic design can be easily expanded within the limits of one story.

The use of a basic module makes for flexibility in choice of floor plans or placement of wall openings.

Treatment of timber members is recommended to rend the house more vermin resistant. Where metal window frames are available, they should be introduced in place of untreated lumber.

The principle used does not exclude a different module[1/] and can be adapted to numerous ideas.

1/ Unit measurement used in planning basic buildings.

DEVELOPMENT OF A DESIGN FOR A BASIC TWO-ROOM PREFABRICATED CONCRETE HOUSE

The House Plan

A floor area of approximately 180 square feet is commonly used in typical local two-room lumber homes and a wall height of eight feet is quite normal. The plan developed for the basic prefabricated concrete house has a floor area of 210 square feet and the posts for the walls are 8 feet long. The building is divided into two rooms by a movable cabinet partition giving flexibility in the choice of comparative room sizes. (See figures 1 and 2 for typical plan drawings.) The choice of design for floors and windows will depend upon locale but it will be noted that the intention is to have sufficient louvre or other type of ventilation. A wire mesh soffit is recommended for the cornice to provide adequate ventilation for the roof.

The Design

The following were chosen as major objectives to be met:

1. parts should be easily assembled and disassembled,
2. sufficient strength to resist any anticipated stresses,
3. reasonable flexibility in the use of standard parts,
4. ease in expanding the building in the future,
5. several men should be able to handle parts without needing heavy or expensive machinery.

Reinforced concrete "base" beams are designed to carry wall and floor units. Slotted reinforced concrete posts together with thin reinforced concrete slabs are used for the walls, and the design is suitable for either a reinforced concrete slab or lumber type floor depending upon owner's choice.

The length of the wall panel slab determines the module to be used. In the case of the "model" house (2-rooms) described in this report the span between wall posts is 36 inches which places the posts at 40 inch centres; thus, by using three wall panels in width and six in length, the over-all dimensions of the house are 10'-4" x 40'4".

Specifications for all pre-cast units call for a minimum of 3,000 pound concrete. Types and designs for reinforcing vary with the different units. Bar steel is used in the beams, B.R.C.[2/] is used in the floor slabs, 2" x 2" No. 18 gauge poultry netting provides the reinforcing for the wall slabs, and either four 1/4" bars properly tied or 4" x 12" B.R.C. bent to the same cross section shape as employed for the 1/4" bars can be used in the posts.

[2/] B.R.C. is an electrically cross-welded steel wire fabric manufactured by the British Reinforced Concrete Engineering Company, Limited. It is available in mesh opening sizes and in a wide range of wire gauges.

BILL OF MATERIALS
FOR
A TWO-ROOM MOVABLE TYPE PREFABRICATED CONCRETE HOUSE
(10'-4" X 20'-4")

Concrete materials including concrete slab floor:

27 bags cement
2 cubic yard sand
4 cubic yard broken stone (includes estimated waste)
160 linear feet 1/2" reinforcing rod
220 linear feet 1/4" reinforcing rod
144 square feet 3" x 12" welded mesh - 8 gauge x 12 gauge - of posts
200 square feet same specification welded wire mesh or substitute
34 square yard - 18 gauge - 2" mesh chicken wire
18 - 1/2" x 18" galvanized bolts with nuts and washers
18 - 3/8" x 14" galvanized bolts with nuts and washers
1 piece flat steel - 1/8" x 1/4" x 24" - roof ties
2 eye bolts 1/2" x 9" - complete with 2 - 2" x 2" x 1/2" washers and 2 nuts
1 - 1/2" x 10" steel rod to form center cross-tie for foundation beams
4 - 1/4" x 4-1/2" bolts for tying roof sections together
3 - 2" x 4" x 22' - roof purlins and ridge member
2 - 1-1/4" x 6" x 22' forming combination eaves purlin and facia
3 - 3" x 4" x 22' - for top plates
8 - 2" x 4" x 12' - rafters
2 - 1" x 4" x 12' - "A" frame cross ties
2 - 1" x 4" x 10' - miscellaneous roof bracing
20 Feet Board Measure[3/] siding for gable ends
10 sheets embossed corregated aluminum roofing - 26 - gauge - 32" x 14' bent at center to fit roof angle

---

3/ Feet Board Measure - 1 board foot is equivalent to a piece of lumber 12 inches wide 12 inches long and 1 inch thick (nominal dimensions).

1 piece 1/4" mesh wire - 24" x 22' to form vent type soffit
1 - 2" x 4" x 6' door frames
3 - 2" x 4" x 16' - door and window frames
5 - 2" x 4" x 14' - window frames
7 - 1/2" x 5" x 16' - louvers
5 - 1/2" x 1-1/4" x 12' - for window frames
2 - 1/2" x 1-1/4" x 16' - for door frames
1 - 2" x 6" x 16' - window sills
60 Feet Board Measure 1" x 12" for cabinet partition
2 - 48" x 96" sheets wall board - for cabinet partition
2 - 1-1/4" x 6' hardwood for threshholds
1 dozen aluminum screws with weather seal washers for roof joints
2 pound aluminum nails with weather seal washer - for aluminum roof
2 - 2'-8" x 6'-8" x 1-1/4" doors
5 pair casement sash or substitute to fit window frames
2 pair 3" x 3" butts - loose pin
10 pair 2" x 3" light loose pin butts
2 door locks
10 - 8" hooks and eyes for sash
5 window locks (can be used if sash are rabbeted)
5 pounds miscellaneous nails
5 dozen miscellaneous screws
1-1/2 gallon oil paint
2-1/2 gallon waterproof water solvent concrete wall paint

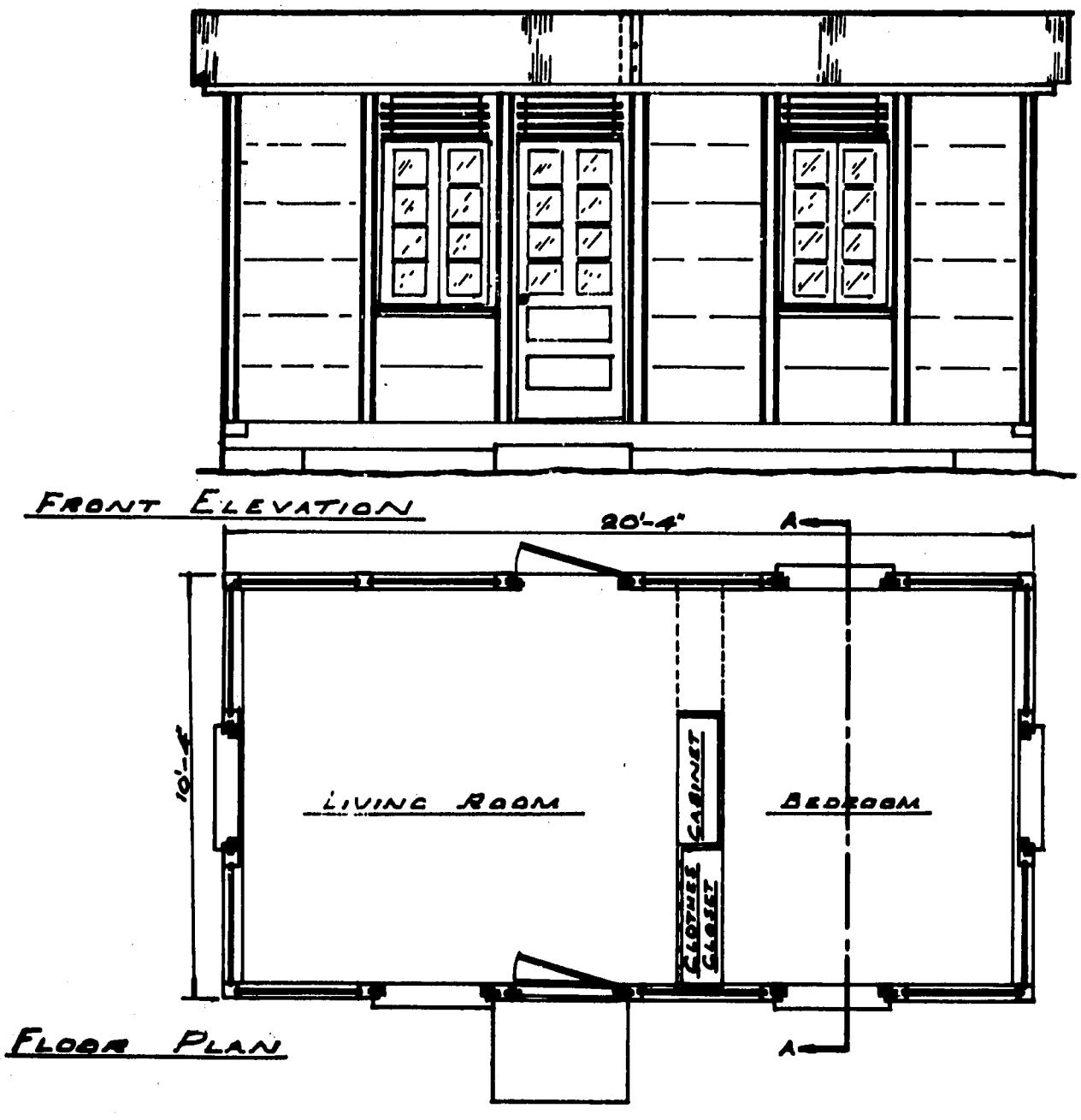

Figure 1. Basic 10'-4" x 20'-4" hou

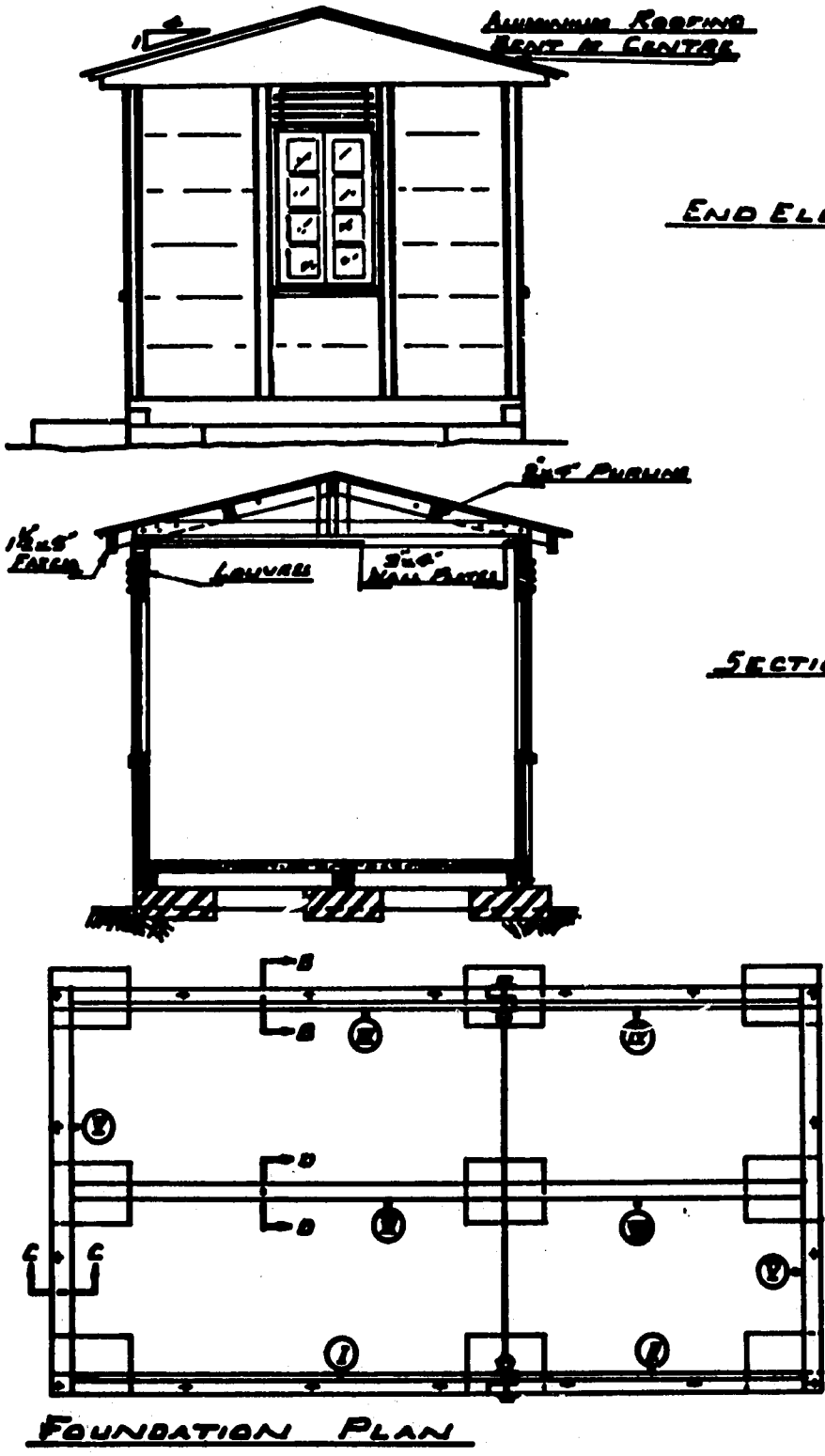

Figure 2. Basic house.

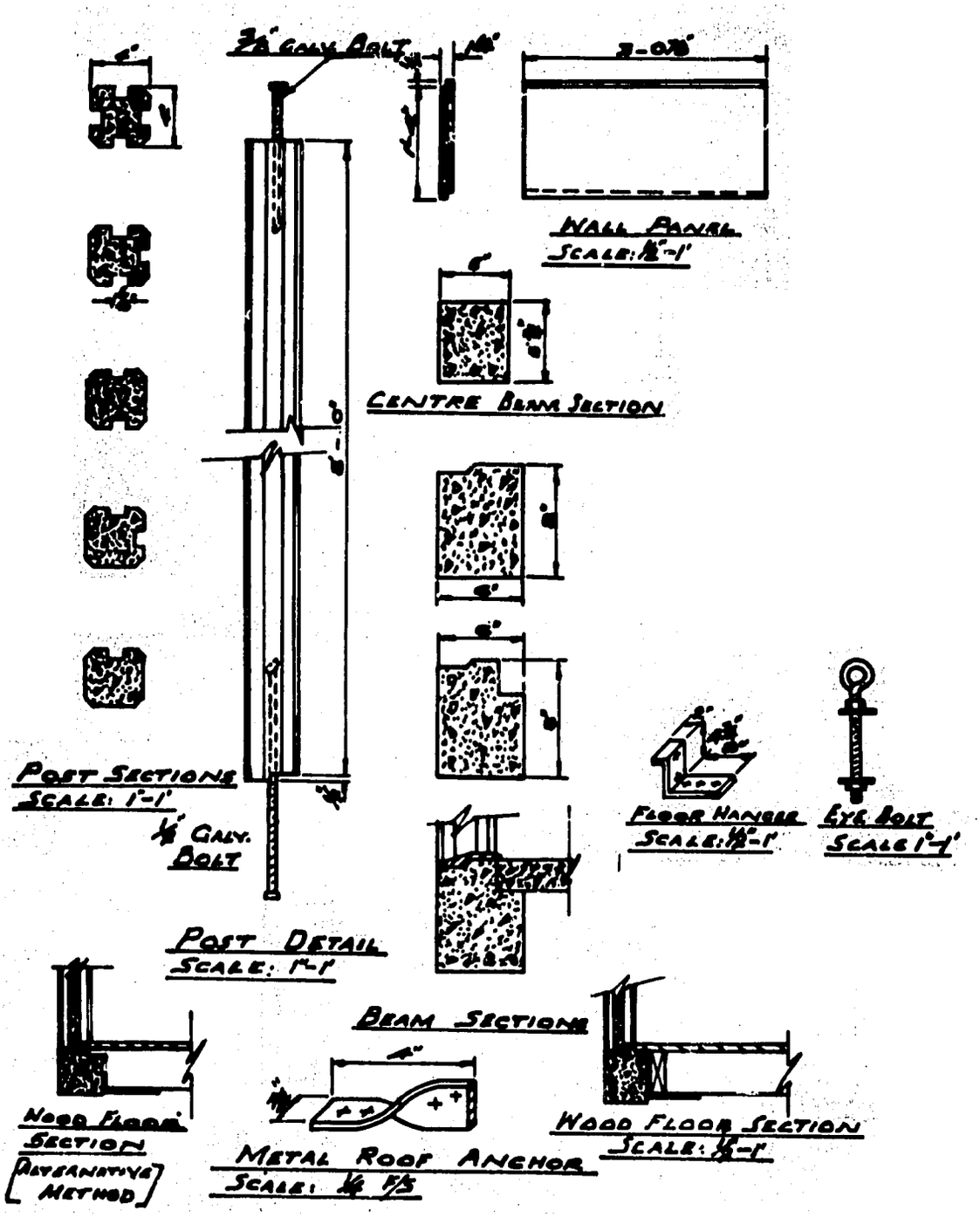

Figure 3a. Precast components—columns, beam sections, wall slabs.

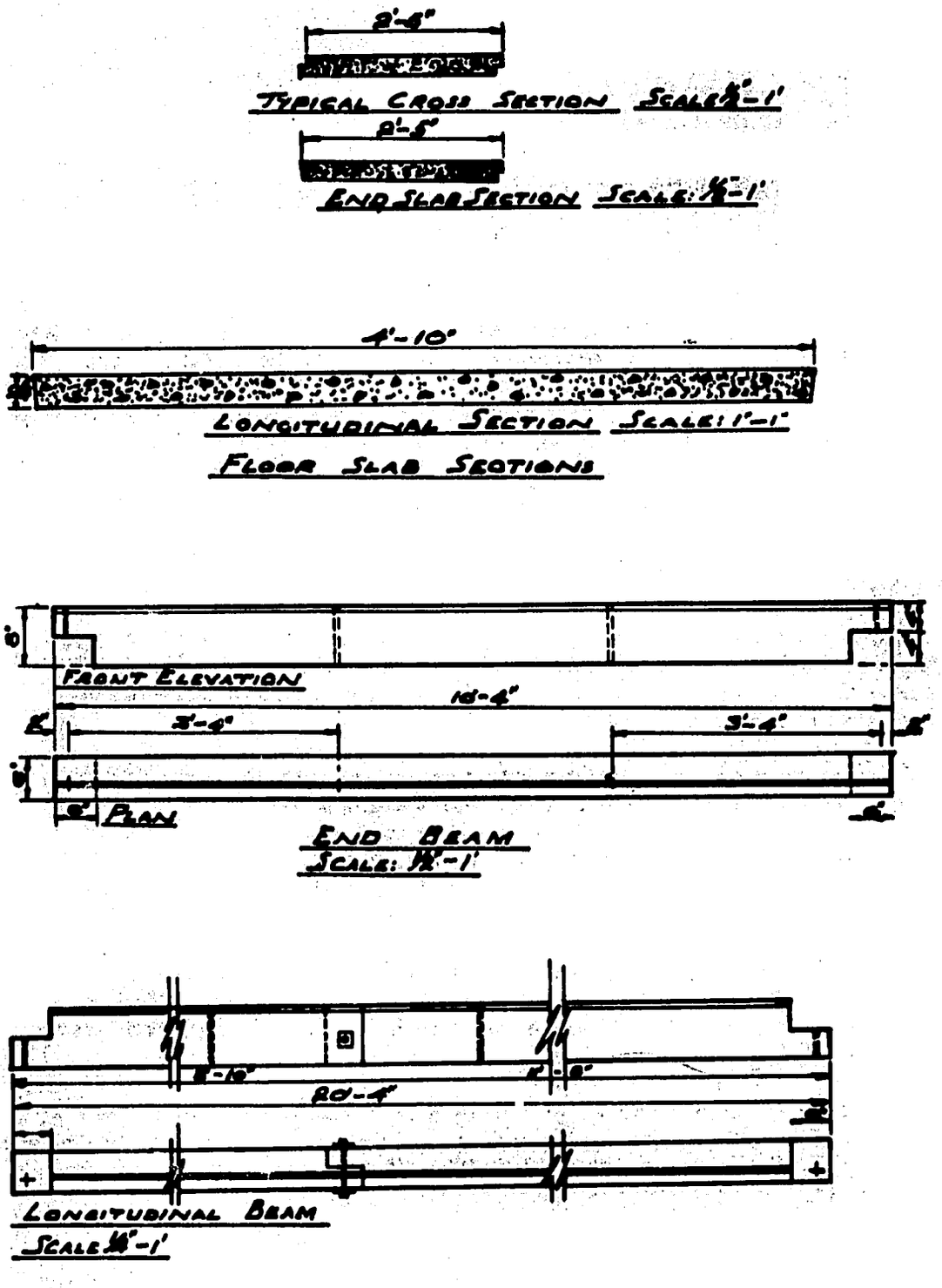

Figure 3b. Precast components—floor slabs and peripheral beams.

DESCRIPTION OF PARTS USED IN THE HOUSE

Beams

Concrete beams carrying the external walls (see figures 1, 2, and 3) all have certain common features. As noted in the detail sheet, figure 3, the top of the beam is designed to prevent water from passing under the rabbeted lip of the bottom wall slab. This lip fits the top of the beam outside the raised section. Five-eighth inch diameter bolt holes are pre-cast at 40" centers along the beams and at 2" centers from the ends and outside faces for receiving the 1/2" anchor bolts in the bottom ends of the wall posts. The bolt holes are cast 1/8" larger than the diameter of the bolts in order to provide flexibility and ease in assembling the house.

The end beams are cast in one piece. Note that the ends of these beams are half-lapped over a half-lap formed at the ends of the longitudinal side beams. To simplify casting there is no notch in the end beams for receiving the floor.

The longitudinal side beams are cast in two lengths for three reasons: first, the aim was to keep the weight within the limits of handling by manpower; second, by having two lengths as shown on the typical plans and detail sheet (figures 1, 2, and 3) greater flexibility is provided in the length of house obtainable, and, third, such dimensions avoid placing a post over the beam splice.

The estimated weight of the longest beam as noted in table of estimated weights (page 18) is 500 pounds, which can be loaded on a truck by manpower and is short enough to be handled on an ordinary two-ton truck bed.

It will be seen that the 20'-4" length of building uses one "short" member and one "long" one. By using two "short" members, the house becomes 17'-0" long or by using two "long" ones, the house can be made 28'-8".

There is a rabbet formed in the top inside edge of the longitudinal beams, forming a shelf to receive either a concrete slab floor or one made of lumber.

The two lengths of longitudinal beam sections are fastened through a splice by means of a fully threaded eye bolt as shown on the typical detail sheet (figure 3).

The center beam is used only if the floor is made of concrete slabs. This beam is cast in two lengths for ease of handling and to also match with lengths of the longitudinal exterior beams used in the house. Allowance is made in the lengths of the two beam sections for the tie-rod to pass between them. This is used to keep the exterior beams from spreading.

Floors

The floor can be made of either lumber or of concrete slab construction. (See figure 3.)

The concrete slab shown in the details was designed to fit the "model" house of 20'-4" length. So far, this size has proved to be the popular one, and the only length of "movable" type concrete house built. The slabs are 2'-5" wide, 4'-10" long and 2-1/4" thick, reinforced with 8 gauge B. R. C. They are easily handled for placing by four men.

The top "lip" of the floor slab should be slightly longer than the lower one to insure a tight fitting at the floor surface. Note that the edge of the last slab which fits against the end beam does not have a rabbet. A small bevel is formed around the top edges of the slabs to avoid chipping during handling.

If the wood floor is used, the number of floor sections will be determined by the weight of the lumber and the method of transporting. In any case, where more than one section is employed, adjoining sections should be bolted together. When a wood floor is used, the "center" concrete beam can be eliminated.

Posts

There are five cross section types of 4" x 4" wall posts used in the prefabricated concrete houses. (See figure 3.) The channels cast in the posts to receive either the wall slabs or cleats attached to the backs of the door and window frames are 1/2" deep by 1-5/16" wide.

Note that the corners of the posts are beveled to prevent damage by chipping. (See figure 4.) A half-inch galvanized bolt is cast in the bottom end of the post for anchoring of the beams and a 3/8" galvanized bolt is cast in the top end for anchoring the top plates.

Figure 4. Supply of posts ready for use.

Galvanized bolts are used to avoid rusting. The bolts are slightly bent at the ends embedded in the cement to prevent them from turning when the nuts are tightened. Washers should be used on all bolts.

Note that if concrete posts are used for inside partitions, the 1/2" lip formed at the bottom of the post to fit the top of the exterior beams is eliminated.

Wall Slabs

The distance between wall posts when set in place is 36" and the slots in the posts are 1/2" deep x 1-5/16" wide; therefore, the wall slabs are made 36-7/8" long by 1-1/4" thick to allow for "play" in assembling the house. The slabs are 16" requiring six in the height of the wall. It is recommended that the lip be eliminated from the upper rabbet of the top slab. This slab can be made 1/4" wider than the others (i. e., 16-1/4") and a groove made in the top plate to receive the slab in order to prevent a crack between the top slab and the wall plate.

Where prefabricated interior concrete walls are used in a building, the lip on the bottom of the first wall slab is also eliminated.

Two types of slabs were tried: one with tongue-and-groove edges and one with rabbeted edges. The rabbeted type proved simpler to cast and easier to place.

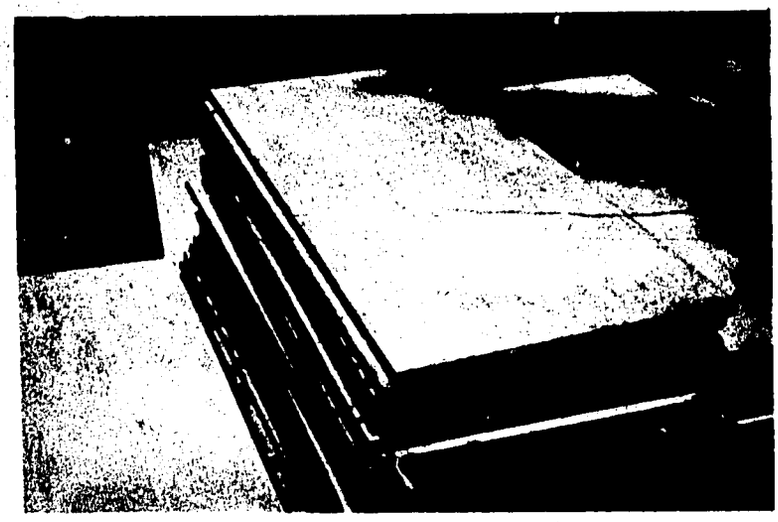

Figure 5. Pre-cast wall slabs ready for use.

The slabs being 1-1/4" thick, the lips on the rabbeted edges are 9/16" thick to allow a 1/8" air space between lips in place; thus preventing capillary action in the joints between slabs.

Slabs cast without reinforcing proved adequate in the wall, but suffered some breakage when dropped onto uneven hard surfaces during handling. Experience showed that the cost of 18 gauge poultry netting reinforcing was about the same as that for replacing non-reinforced broken slabs, and the results were of considerable advantage.

Top Plates

The plates used at the top of the walls of the pre-cast concrete house are of 3" x 4" timber bolted to the top ends of the posts. The end plate is half-lapped at the corners and the side wall plates are notched over them and extended for about 6" beyond the end of the building to provide an end "overhang" of the roof. This overhang allows roof ventilation at the ends of the building as well as at the eaves.

Doors and Windows

Designs for doors and windows may vary with location. Specially treated lumber has been used for the frames as well as for the doors and windows in the houses built to date.

The door frame is made to fit the opening between two posts. A louver at the top end of the frame aids in bracing it against the posts. A cleat to fit into the groove on the post is screwed to the back of the frame in order to hold it in place. A hardwood threshold at the bottom end of the frame fits over the "storm shoulder" of the beam, covers the joints between the beam and the floor and holds the bottom ends of the frame solidly in position against the posts.

The jambs for the door frames should be selected from 2" x 4"s which are slightly "bowed", with the convex sides towards the concrete posts so they will be under compression against the posts when in place. A "bowed" threshold should be used also, with the convex side down in order to hold it in place without fastening to either the beam or the floor.

If the above precautions are taken, there is no need for fastenings other than the cleat on the back of the frame which fits into the slot in the post for holding it in place.

The window frames are also made to fit between two wall posts and cleats screwed on the back of the jambs provide anchors for holding them in place. A 16" louver at the top part of the frame and a sill at the bottom provide sufficient side support under normal conditions. If a long window is to be used, the side jambs should be selected from "bowed" material to provide pressure for holding the timber tightly against the concrete posts without the use of fasteners.

The window sill should be grooved to fit over the concrete wall slab upon which it rests. The number of wall slabs used below a window will be determined by the desired height of the window.

Metal frames for the use of glass louver type windows can be easily set into the grooves in the wall posts.

The louvers over the top of the doors and windows are made to match the wall slabs in size.

Roof

The roof for the small house is made in two sections for ease in handling. The framing consists of an "A" frame at each end of each section with a 2" x 4" ridge, a 1-1/2" x 5" facia nailed to the lower end of the "A" frame rafters and a 2" x 4" purlin spaced midway between the ridge and the facia. (See section A-A, figure 2.) As will be seen in figure 6, the pitch of the roof is approximately 15° and aluminum sheets, bent to fit the roof slope, extend in one length from eave to eave, thus eliminating a ridge cap and increasing resistance to wind lift.

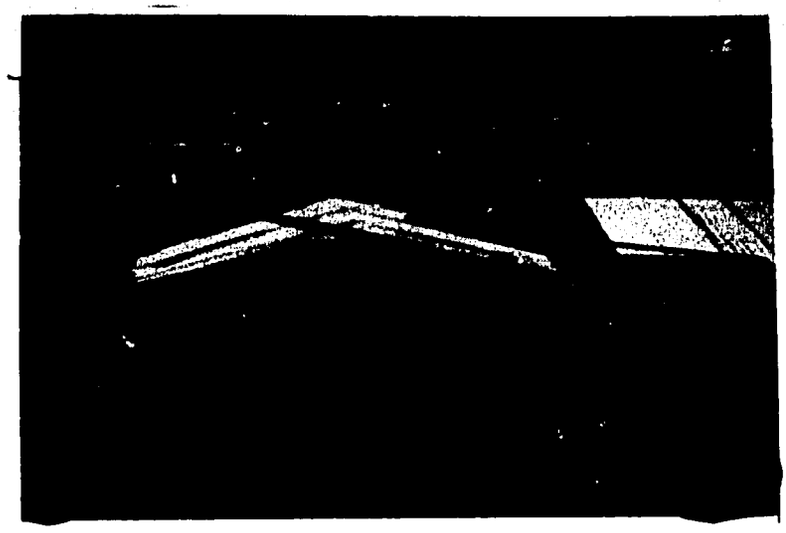

Figure 6. A typical section of roof.

The two sections are made so that the aluminum roofing on one section laps over the roofing on the other section. The two roof sections are bolted together and the roofing lap is fastened down by use of aluminum screws.

The roof is tied to the wall plates by means of 6 metal roof anchors. (See figure 3a.) A screened soffit provides roof ventilation and at the same time keeps out bats, etc., at night.

Weights of Parts

One important point in the project is to be able to handle the precast concrete units and prefabricated floor and roof sections by "man power." The following table gives estimated weights of the concrete units used in the "model" prefabricated concrete house:

TABLE OF ESTIMATED WEIGHTS OF PRE-CAST UNITS USED IN A MODEL PREFABRICATED CONCRETE HOUSE

UNITS		ESTIMATED WEIGHT POUNDS
Longitudinal side Beam	8'-10" long	390
Longitudinal side Beam	12'- 2" long	500
End Beam	10'- 4" long	430
Center Beam	8'- 4" long	220
Center Beam	11'- 8" long	300
Floor Slab	2'-5" x 4'-10"	300
Post	8'- 0" long	100
Wall Slab	16" x 36"	50

Note: The plans and details (figures 1, 2, and 3) are representative of the more complete working drawings used for casting the parts and constructing the houses.

PREFABRICATING OPERATIONS

Concrete Forms

Forms which can be knocked apart and reused are used for casting the construction units for the prefabricated concrete house. An attempt was made to use "gang" forms for casting the wall slabs, but too much "honey-combing" resulted so casting has been done in single flat forms. Flat forms are also used for casting concrete floor slabs.

Doors, Windows and Frames

The doors, windows and frames are normally prefabricated in carpentry shops. The roof sections can also be built at the shops and transported intact to the site.

Special Equipment

A vibrating table or other means of vibrating the concrete into place is essential for casting operations. Measuring containers for sand, gravel and water are also a necessity if consistent results are to be obtained. The vibrating table (figure 7) was locally built by Mr. St. Clair Prout, Superintendent of Farm Machinery at St. Lucia. In large operations it would be best to have larger equipment.

Figure 7. A locally constructed vibrator table in use.

Special tools were made locally for forming levels on the upper edges of the floor slabs and also for the two edges of the posts exposed when cast in the forms. (See figure 8.)

The beveling tool used on the posts is a combination bevel and trowel. The other two beveled edges of the posts are made by strips fastened to the bottom of the form. The tool shown at the right in the picture is used for making bevels on the corners of the posts and the others are two types used for beveling the top edges of the floor slabs.

Figure 8. Beveling tools made in local machine shops.

Curing

It is essential that all castings be laid on level, unwarped surfaces during hardening and curing to avoid warping or twisting of these pre-cast units.

TRANSPORTING TO THE SITE

The same care should be exercised in handling and transporting the pre-cast concrete house units to the site as would be expected in the transport of clay, bricks or tiles.

STEPS IN ASSEMBLING THE PREFABRICATED CONCRETE TWO-ROOM "CHATTEL" HOUSE

1. Set the Temporary Foundation

Temporary pier-type supports are set in place, firm and level, to receive the beams. The exterior supports at the rear of the house should extend sufficiently to receive beams which may be used in building a later addition. (See Section A-A, figure 2.)

2. Place the Beams

First, set the outside longitudinal beams and insert the "eye" bolt through the splice. Now set the end beams in place and pin the corners with temporary steel dowels. (See figure 9.)

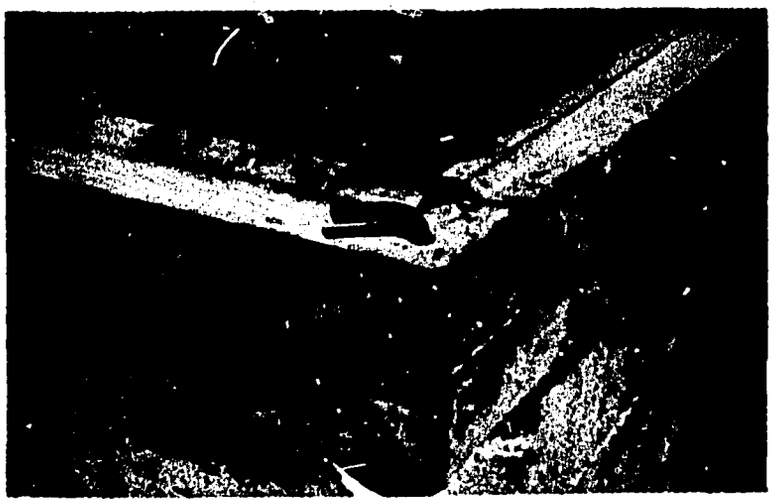

Figure 9. A temporary steel dowel is used to hold the beams together until the corner posts are placed.

3. Place the Tie-Rod

A tie-rod is used to keep the longitudinal beams from spreading. The "eye" bolt through the splice in the beam serves as a clamp for the splice and also provides an "eye" into which the tie-rod fastens. Adjust the tie bolt tension and tighten the eye bolt after the floor is placed. (See figure 10.)

Figure 10. Placing a tie-rod for a 4-room house.

4. Place the Floor

The next step is to lay the floor in place. If a wood floor is used, it sets on the floor shelves provided in the exterior longitudinal beams and no center beam is necessary. The concrete slab floor is laid with two slabs in width and eight slabs in the length of the floor. (Note the slab shown in place in figure 11.) When the floor is laid, tighten the tie-rod and eye bolts.

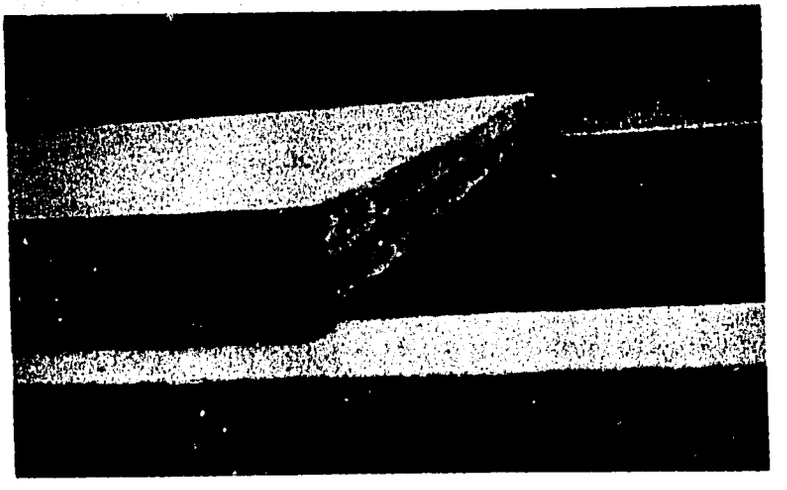

Figure 11. Concrete floor-slab in place.

5. Set a Corner Post

Remove the temporary dowel from one of the corners of the foundation beam and set a front corner post in place. Brace the post plumb and true, apply the washer and nut on the bottom end of the anchor bolt and tighten to secure the post in position.

6. Place Wall Slabs

If only a small crew of men is used for erecting the walls, complete one end before starting the sides. With a larger crew, erection may proceed in both directions from the corners.

The procedure here assumes going from the starting corner in one direction only.

Slide the bottom wall slab into the channel in the post and set four more in place on top before setting the next post. The top slab can be dropped into place afterwards from the top of the wall. Place the second post to secure the first wall panel slabs and anchor loosely. (See figure 12.)

Note: Leave the nuts loose on the bottom anchor bolts of all but the first corner post until the panels are placed.

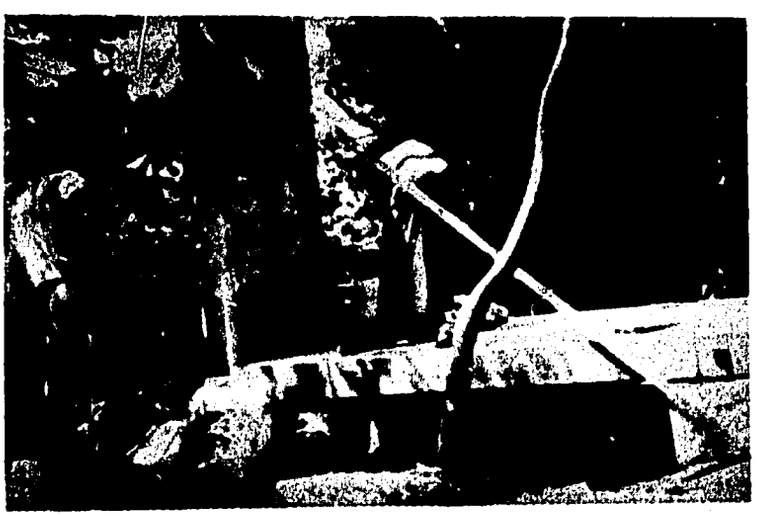

Figure 12. Starting the wall.

7. Set Windows and Door

For windows, slide the required number of wall slabs into the groove of the adjacent post and set the window frame into position on top of the slabs. The cleat on the back of the frame jamb fits into the groove of the post to hold it in the wall. Now set the next post. (See figure 13.)

Figure 13. Setting a window.

For doors, slide the cleat on the back of the door frame jamb into the groove on the adjacent post and then set the next post into position. The jamb cleats hold the frame securely in place in the wall. (See figure 14.)

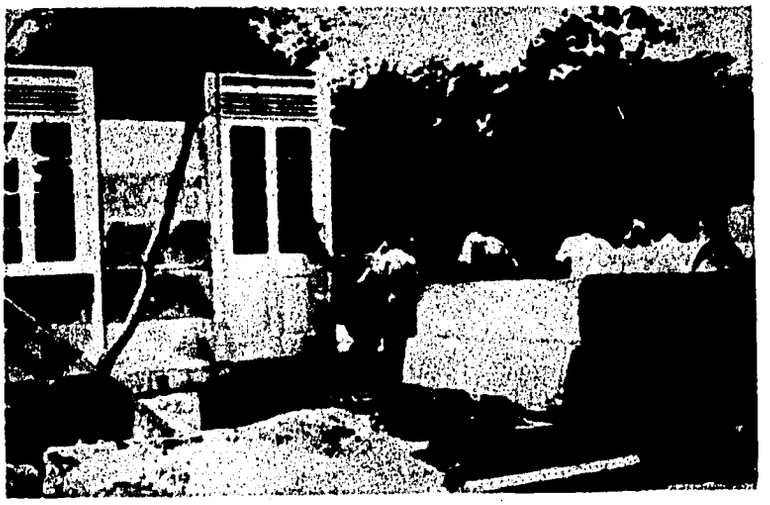

Figure 14. Setting a door.

Arrange exterior door positions to avoid coming over the splice in the longitudinal beam.

8. Complete End Wall and Fasten Wall Plate

Complete the first end wall and then bolt the wall plate on top before proceeding with the side walls.

Note: Rear Posts and Windows.

It is normally expected that an addition may be desired later for the two-room house; therefore, the corner posts at the rear of the house should have at least one exposed groove for future connections. Other posts at the rear should also have three grooves if another wall or interior door is anticipated later. (See suggested "shed" addition plan, figure 17.)

If an addition is anticipated for the house within the near future, use wall slabs in place of windows in the rear.

9. Place the Cabinet Wall Partition

Before completing the exterior walls, set prefabricated movable cabinet wall partition inside the house.

10. Complete the Walls

The procedure for completing the walls is a repetion of the steps 5 - 8. After the walls are erected, the nuts on all the anchor bolts should be tightened. (See figure 15.)

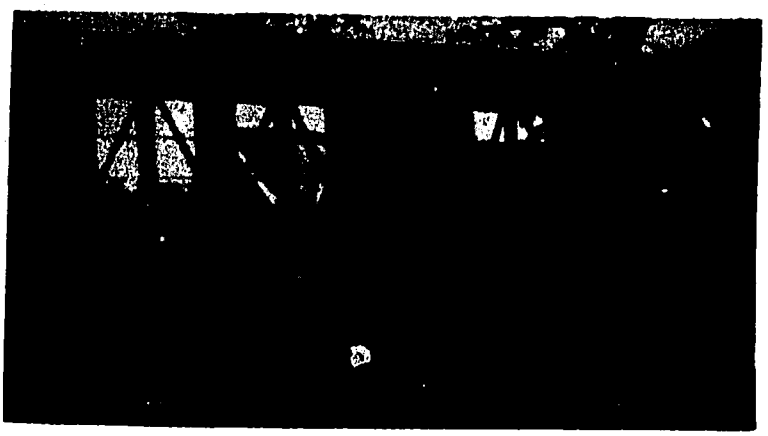

Figure 15. Three walls completed.

11. Set the Roof in Place

After the walls are completed the roof is lifted into place in two sections, bolted together and anchored to the wall plate.

12. Place Cornice

A wire screen soffit, hung in place, is recommended to provide protection from rodents, birds, etc., and yet allow free passage of air over the rooms.

13. Set Door Steps

A wall slab laid on 8" x 8" x 16" hollow concrete blocks provides a satisfactory door-step.

ADDITIONS TO THE TWO-ROOM HOUSE

One of the considerations in the design of the prefabricated concrete house was ease of expanding by adding other rooms later. One of the more common local methods of expanding the small lumber homes is by means of a shed-like addition, since there is no need for disturbing the original building when such an addition is made.

This shed idea is also used here for adding rooms to the two-room prefabricated concrete house. The photo, figure 16, shows a concrete house which has the shed added. The plan shown in figure 17 is one suggestion for making such an extension.

The wall at the rear of the shed is five slabs high instead of the six used on the original structure and the posts must be shortened to match. This can easily be done by placing a "header" in the regular form before casting.

It is important that the plans for the future expansion of the house be followed by placing slotted posts in the correct positions to accommodate this intention.

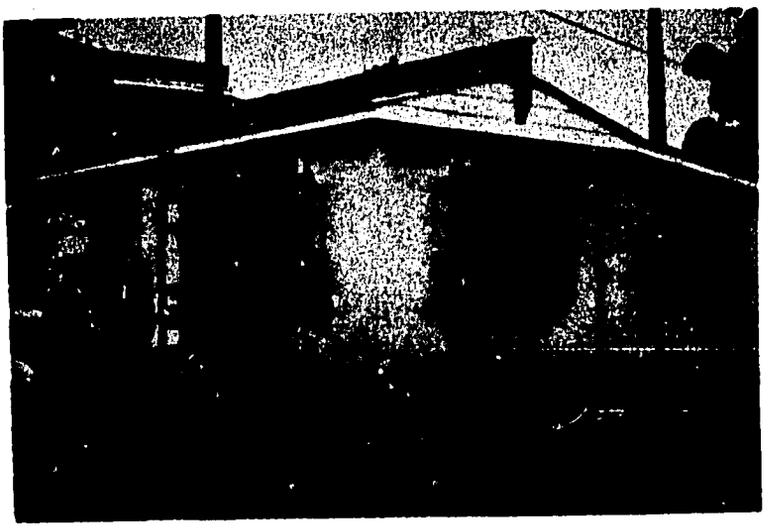

Figure 16. A shed addition for a prefabricated concrete house.

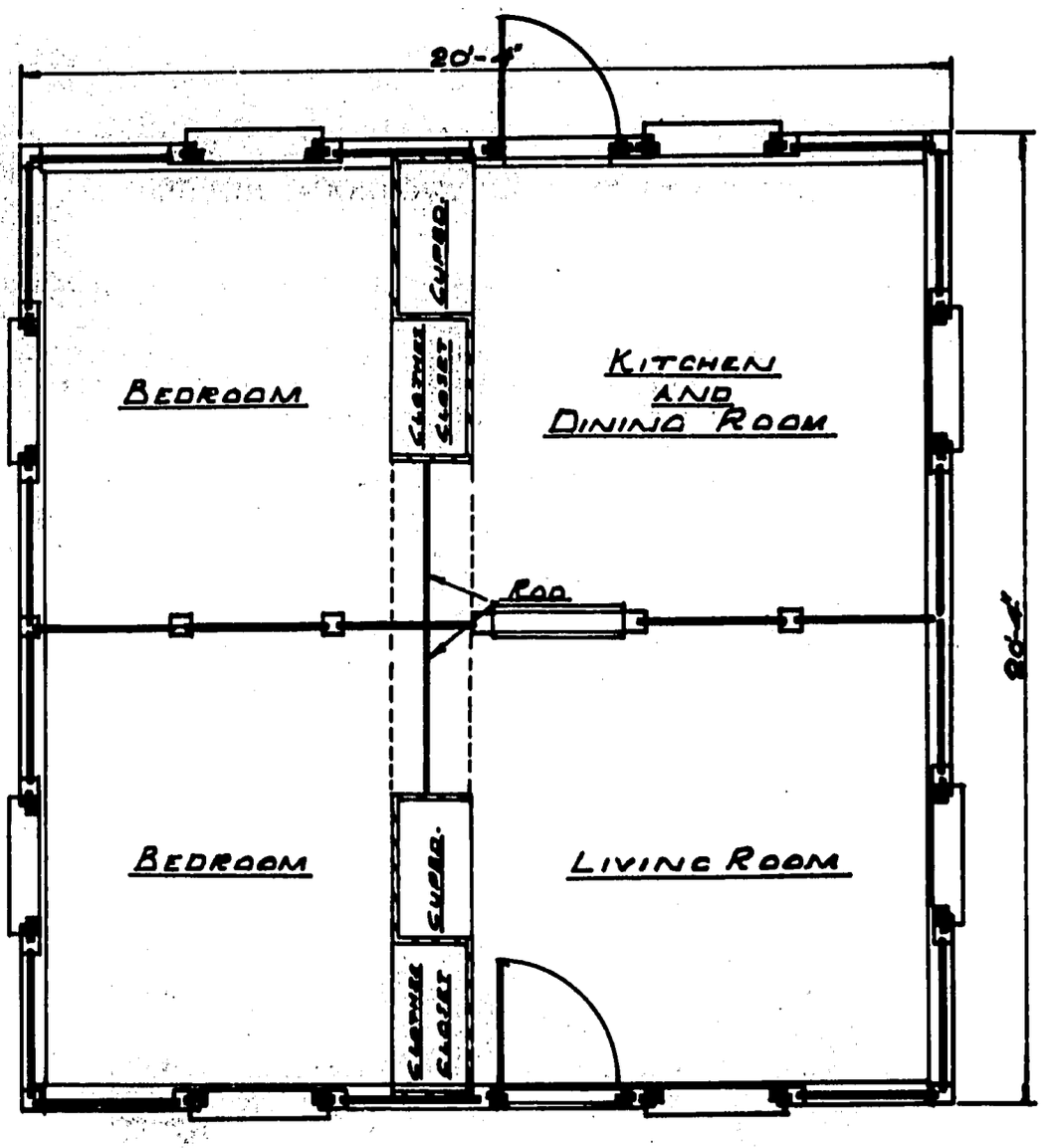

Figure 17. Floor plan with shed addition.

OUT-DOOR TOILETS AND BATHS BUILT WITH PRE-CAST CONCRETE UNITS

Out-door toilets in rural areas are generally constructed with lumber, and although they may be sanitary when new, that feature is lost when the wood deteriorates. Grooved concrete post and thin slab wall construction is ideal for these sanitary privies and is competitive in cost with those built of lumber. The floor slab is cast with holes at the corners to receive either dowels or bolts imbedded in the bottom ends of the posts. Anchor bolts imbedded in the top ends of the posts secure the roof to the building.

A combination toilet and bath using the same type of construction as described above is also shown. (See figure 18.) Where sufficient water is available a water closet may be substituted for the privy shown on the plan. The floor slab for the two sections of the combination toilet and bath should be cast in one piece to provide a tie for the bottom end of the walls.

LIST OF MEMBERS AND BILL OF MATERIALS FOR A PRE-CAST CONCRETE OUT-DOOR TOILET

List of Members

1 concrete floor slab - 3" x 48" x 48"
1 concrete toilet riser with seat and cover
1 sheet metal vent - 2" diameter x 8' long
4 concrete corner posts - 4" x 4" x 80-1/2"
2 top plates - 2" x 4" x 52" - (front and rear plates)
2 top plates - 2" x 4" x 44" - (side plates)
2 door jambs complete with dowels (front top plate serves as head)
1 door complete with hinges and fasteners
15 concrete wall slabs
3 pieces asbestos roofing - 20-1/2" x 60" (or substitute)

Bill of Materials

4-3/8" x 8" carriage bolts for top ends of posts
1 piece 3" x 12" welded mesh - 8 gauge - for floor
1 piece 3" x 12" welded mesh - 8 gauge - 48" x 80" for post reinforcing
1 piece 18 gauge - 2" mesh poultry netting - wall slab reinforcing 60 square feet
4 - 1/2" x 12" steel dowels for bottom ends of posts
2-3/8" x 6" steel dowels for bottom ends of door jambs
4 bags cement
0.3 cubic yard sand
0.5 cubic yard broken stone
1 - 2" x 4" x 14' - door frame
1 - 1/2" x 1-1/4" x 14' - door frame
1 - 2" x 4" x 16' - top plates - (roof frame)
1 - 1" x 12" x 3' - toilet seat and cover
7 - 1" x 6" x 6' - for door
1 - 1" x 4" x 12' - for door
2 - 8" T-hinges
1 - 3" hook and eye
1 home made door handle for exterior of door
1 pair 3" x 2" light weight tight pin butts for toilet lid
1 galvanized iron vent pipe 2" diameter x 8' long
3 sheets asbestos roofing - 20-1/2" x 60" for roof
1 pre-cast concrete toilet seat riser
1/2 pound special roofing nails with weather seal washers
1 pound miscellaneous nails for door, door frame, etc.
1 quart oil paint for woodwork
1/2 gallon exterior concrete wall paint - (can be homemade)

In Barbados, the cost of the above is approximately US $35.00. Labor for pre-casting and erecting is approximately US $15.00. Ten per cent should be added for forms and other overhead. Four men are required to set the floor slab after which two men can assemble the building in less than two hours.

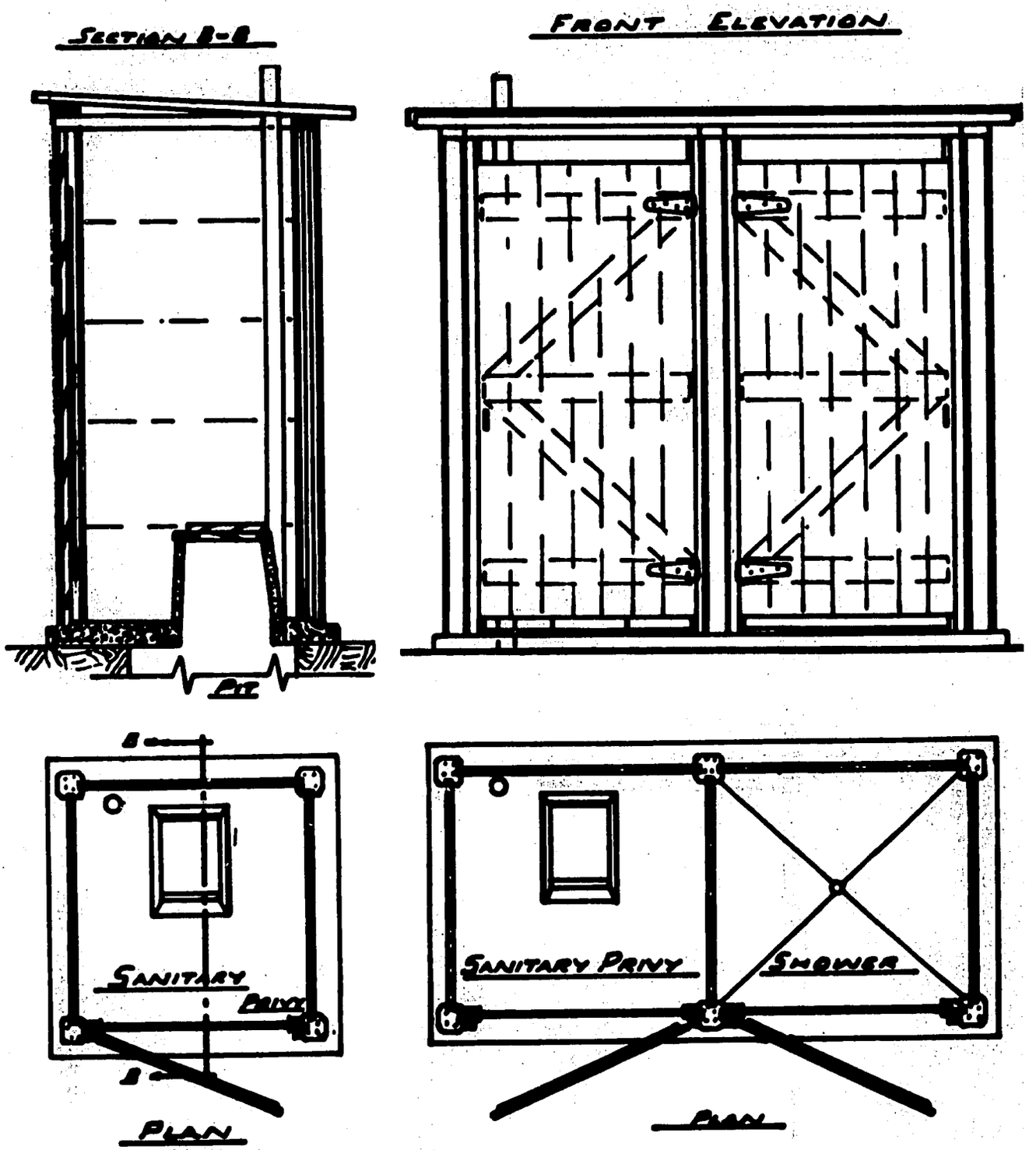

Figure 18. Latrine and combination shower unit.

A FOUR-ROOM HOUSE

Design

The floor plan (figure 19) is one of a number of suggestions for a four-room house constructed with pre-cast concrete units. Figure 20 shows the same house with toilet and shower bath added.

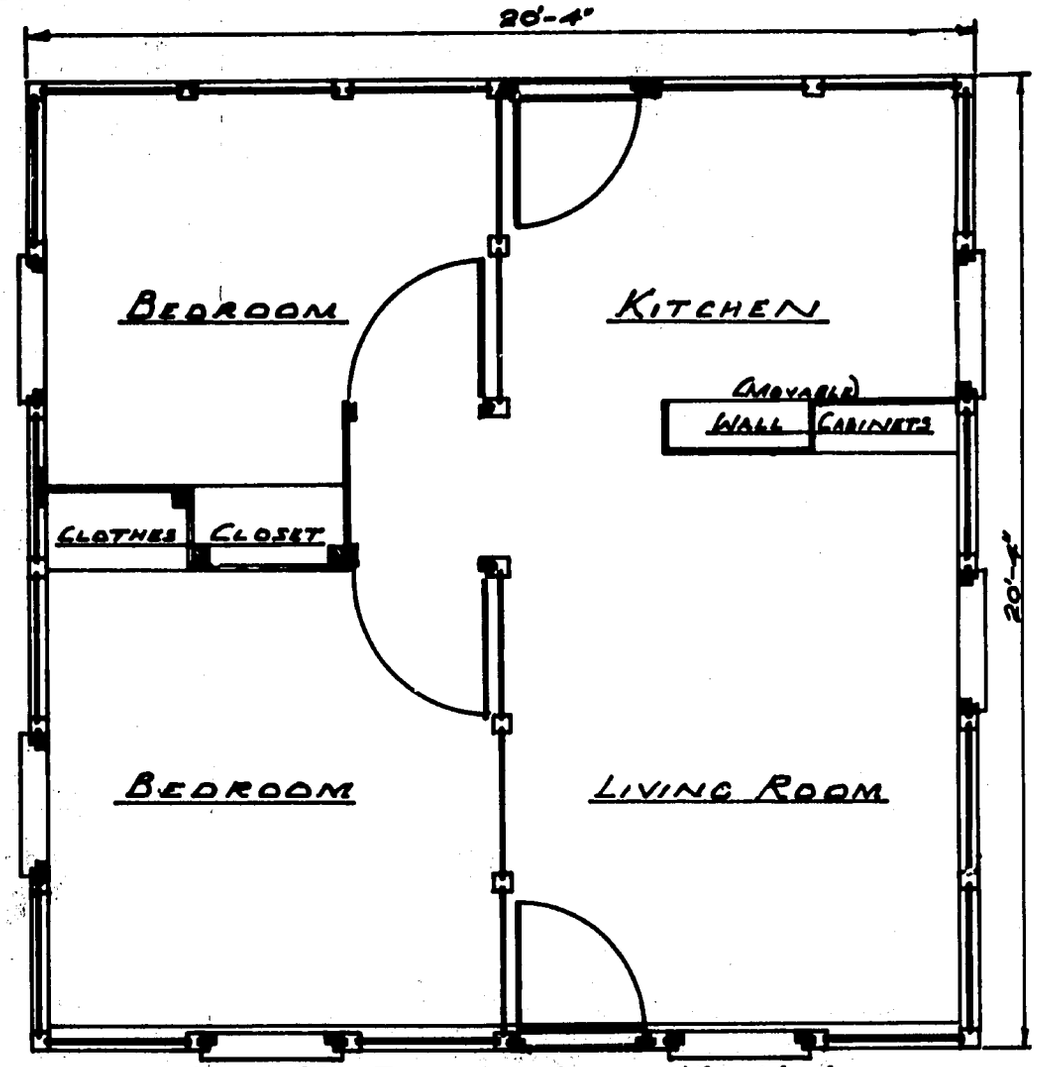

Figure 19. Four-room house without bath.

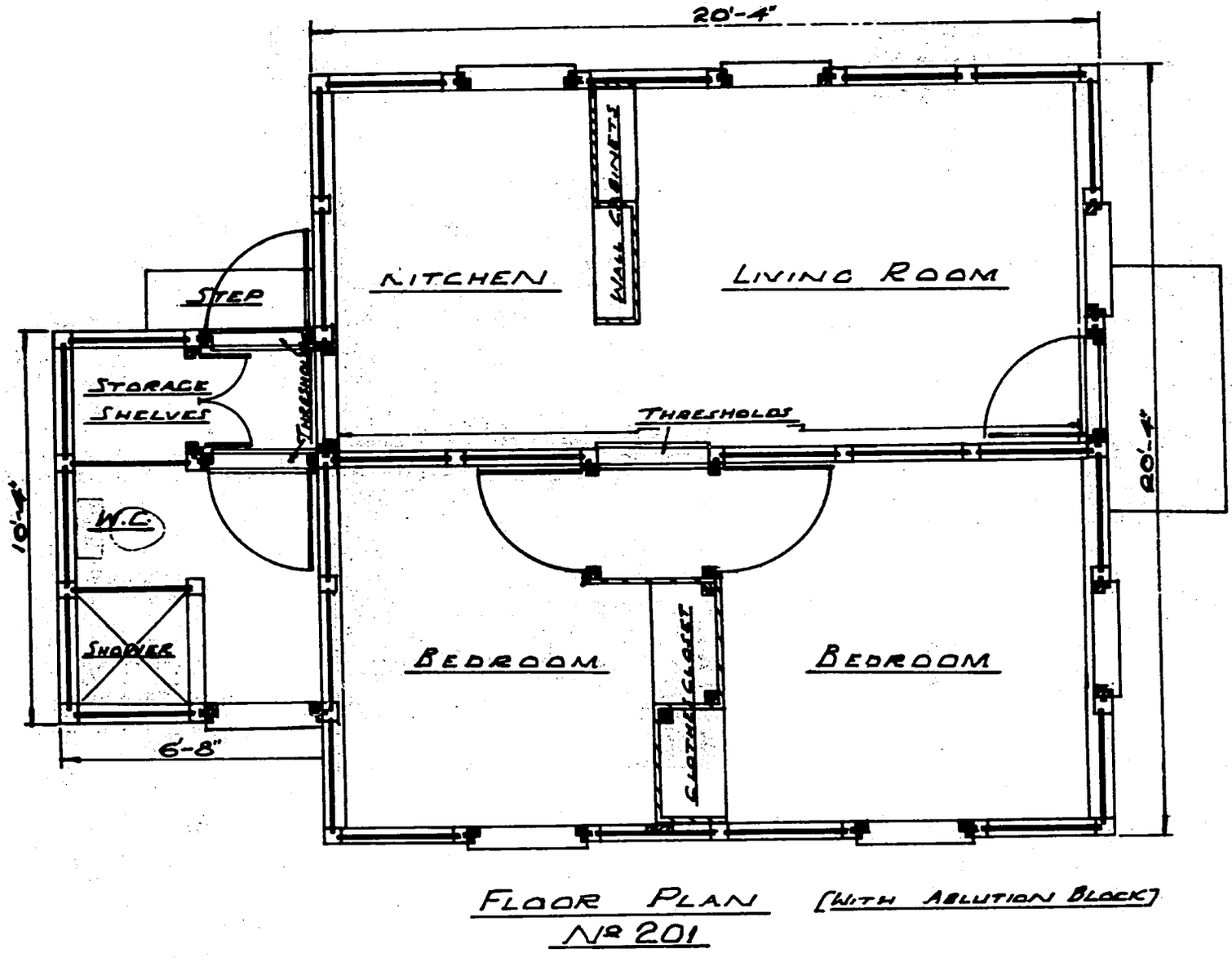

Figure 20. Floor plan of 4-room house with bath addition.

Construction

The construction procedures for erecting the four-room house are basically the same as those used in building the two-room house. Either concrete slabs or lumber floors may be used. A simple gable roof is recommended, and the number of roof sections will depend upon the weights of materials used, since in most cases it will be necessary to handle them with manpower. The roof sections should be bolted together and also anchored to the plate as described for the two-room house. Figure 21 shows a crew at work constructing a four-room concrete "Chattel House," using pre-cast concrete units.

Figure 21. A 4-room prefabricated concrete house under construction.

Pre-cast concrete post and slab walls can be used to reduce the cost of construction for permanent type dwellings and are suitable for middle income family housing as well as for low-cost homes. This method of construction also provides a simple and fast method for unskilled aided self-help housing groups, since there are few skills to be learned.