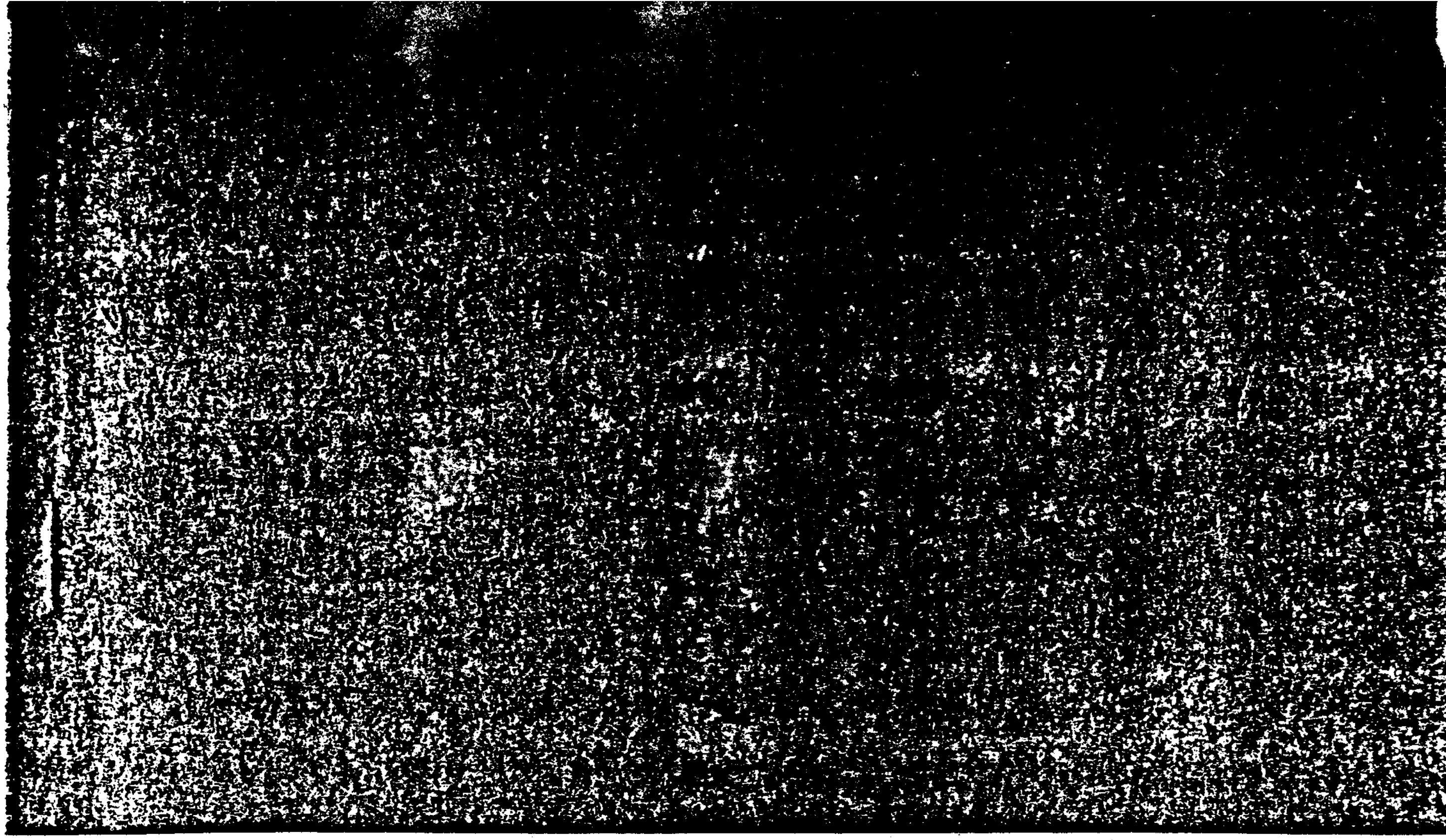
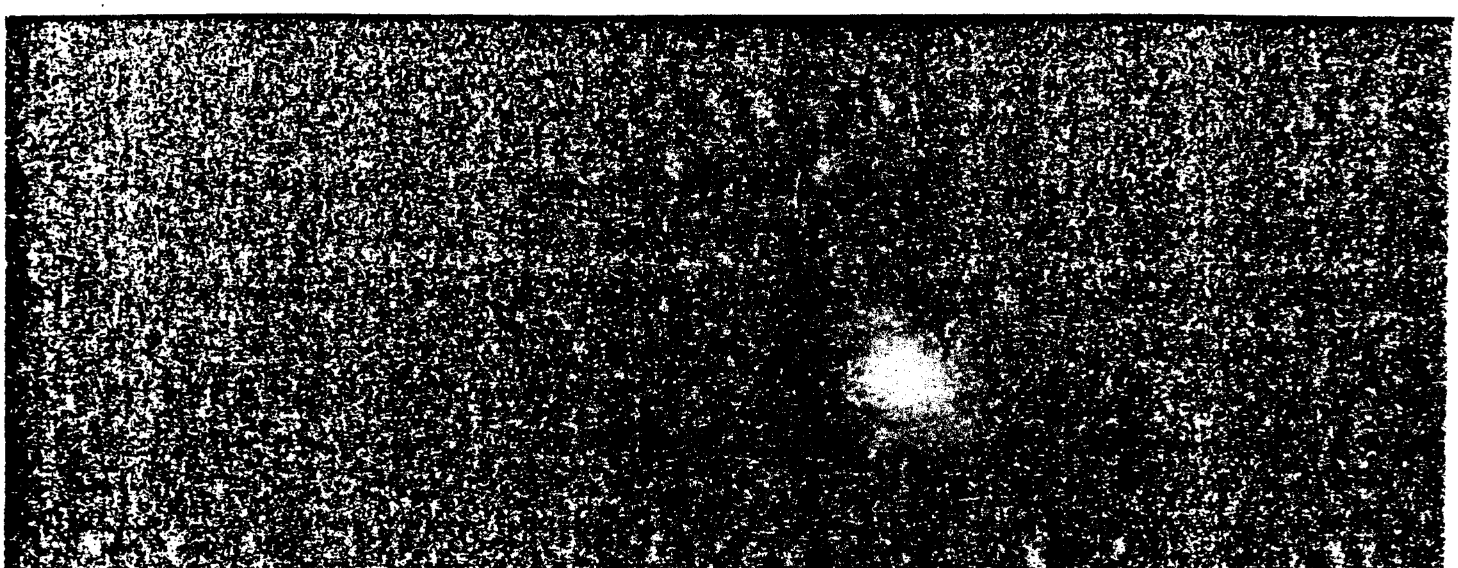


Low-Cost Wood Homes for Rural America—Construction Manual

Agriculture Handbook No. 364

U.S. Department of Agriculture ● Forest Service



Low-Cost Wood Homes For Rural America-Construction Manual

By L. O. ANDERSON, Engineer
Forest Products Laboratory

Agriculture Handbook No. 364, May 1969

U.S. Department of Agriculture • Forest Service

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Better Utilization of Wood In Low-Income Rural Housing

R. F. Blomquist and H. F. Zornig

Abstract

Five home designs are described to meet the need for better housing for low-income rural families. Homes feature the intelligent use of wood and wood products as much as possible, are intended for simple and efficient construction with typical building labor available in rural areas, and are designed to meet the goal of a three-bedroom home with at least 1000 square feet for $6000 without land, external utilities, interest, and financing. Pole-frame and wood pier foundation systems are widely used in order to reduce construction costs through elimination of masonry work. Scale models are illustrated. Actual building of prototype homes is now underway under the Federal Housing Administration's Experimental Housing Program.

Editor's Note: Just prior to priding, we learned that summary sheets are now available for all of the designs mentioned. Inquiries should be sent to the Div. of Information & Education, Forest Service, USDA, So. Agric. Bldg., Washington, D.C. 20250. Summary sheets indicate procedures for ordering detailed plans. and specifications.

MUCH IS BEING WRITTEN about the housing problems in the United States. This is a multifacet problem, involving 'both urban and rural living, all geographical areas, all income levels, and all single and multifamily living units. There is a great deal of emotion involved, and many different approaches are suggested for meeting the rapidly growing needs for adequate housing of our population during the remainder of the twentieth century. By the year 2000, 100 million: additional Americans will be stacked on top of the 140 million already living in our 'urban areas.' There is 'no doubt that these areas face tremendous housing problems. Having more people living in our cities increases critical problems associated with land use, transportation, job opportunity, housing, protective services, and *pollution.

One solution might be to stop the migrations from rural to urban' areas that have occurred for some years, and actually reverse such movements. Obviously this doesn't mean sending city people back to the farms, but moving them back to smaller rural communities, where they can live under less congested conditions and be employed in industries that are being relocated in such communities, where space, beauty, outdoor recreation, moderate land and building costs, and underemployed people are available now. This is the goal of the U. S. Department of Agriculture's "Communities of Tomorrow" program as part' of the "Agriculture/2000" plan.[1,2] This program for improving the rural communities is already underway, but it has a long way to go. The 1968 Housing Bill contains a number of features that will provide better housing in rural. areas, as well as in urban areas.

The problem of providing better housing for low-income rural families has been receiving special attention in the U. S. Department of Agriculture. The Forest Service is an important part of the program, not only because it is interested in wood and wood utilization in housing, but also because forestry and the production of forest prod& are essentially rural industries. Rural poverty in the United States has no geographical boundaries. It is present in all sections of the country, and is particularly acute in the South, where the Forest. Service's Athens Housing Research project is located. This rural poverty is not limited to one race or ethnic group. Only a small portion of the rural 'poor actually still live on farms. Most live in small communities in rural areas. Contrary to popular opinion, 'whites outnumber npn-whites among the rural poor by a large margin. Negroes, American Indians, Mexican-Americans, and various migrant worker groups live in atrocious homes, and one in wery 13 houses in rural America is officially classified as unfit to live in, according to the President's Advisory Commission on Rural Poverty?

According to 1964 estimates, based on Social Security Administration poverty criteria, approximately 25 percent of the total rural population was poor, or living in poverty. Here, a family income below $3,000 is considered in the poverty category. More than 70 percent of poor families in rural America live on less than $2,000 per year, and one-fourth exist on less than $1,000.

Deteriorating and dilapidated housing is among the undesirable situations that accompany low incomes. The 1960 U. S. Census of Housing indicated about 4 million rural units, or 27 percent of all occupied rural housing, were deteriorating or dilapidated. Approximately 1.5 million units do not provide safe and adequate shelter, and do endanger health, safety, and well-being of occupants. Clearly, the need for better, economical housing for low-income rural families is a real problem.

In 1967, the Housing Research Project at Athens, Georgia, undertook a study of ways to provide better housing for such low-income rural families, primarily in the South and Southeast, as part of the broader research program of the Forest Service, which includes similar work at the U. S. Forest Products Laboratory

[1]Anonymous. 1967. Communities of tomorrow — agriculture/2000. U. S. Dept. of Agr., Washington, D.C.

[2]Anonymous. 1967. Agriculture/2000. U. S. Dept. of Agr., Washington, D. C.

[3]Anonymous. 1967. The people left behind. A report by the President's National Advisory Commission *on* Rural Poverty, U. S. Govt. Printing Office, Washington. D. C.

The authors are, respectively, Project Leader-Housing Research, and Research Architectural Engineer-Housing Research, Southeastern Forest Experiment Station, Forestry Sciences Laboratory, Athens, Ga. This paper was received for publication in June 1969.

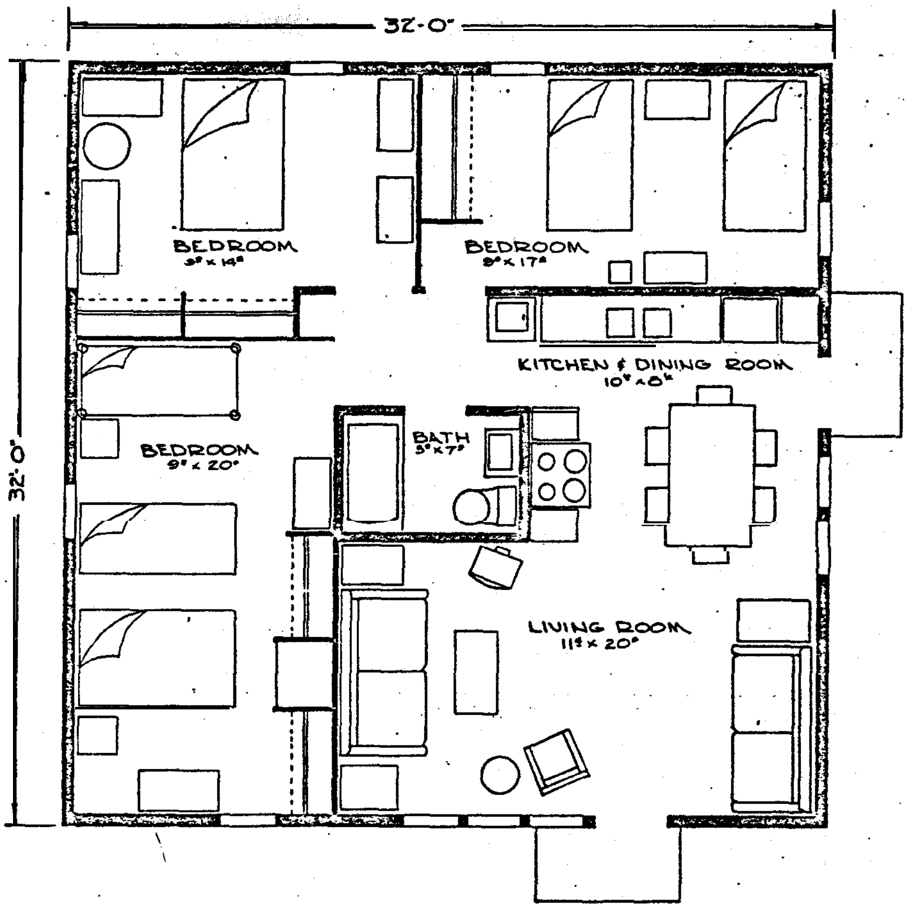

Figure 1. — Floor plan, SE-1 design.

in Madison, Wis, The target for the Athens study was to provide good housing for rather large rural families, with at least 1,000 square feet of livable area, and three bedrooms, for *a* cost of $6,000 without land, external utilities, legal fees, permits, and, of course, interest and financing charges. Wood and wood products were to be used as efficiently as possible, and the houses were to provide good livability, durability, and easy maintenance, be attractive, and be simple enough in construction for relatively unskilled building labor that is available in some rural areas. This was quite a challenge, because conventional middle-income housing in cities was running from $12 to $16 per square foot, as compared to the $6 target figure. Obviously something had to be omitted in such low-cost housing.

There are two ways to provide housing for low-income *families:* build what they can actually afford, or build what they want (or what someone else thinks they must have as a minimum) and then subsidize any additional costs from public funds. We chose to follow the former course.

The first step was to review a number of conventional. house plans and building techniques, to see what features might be omitted or modified. Special attention was given to simplifying construction, reducing the number of building trades required, and making one component serve more than one function. Some obvious deletions at the start were much of the architectural trim, particularly inside, elimination of some doors between rooms and on *closets* and cupboards, and elimination of much of the masonry work usually involved, particularly in foundations.

A' combination of wood sheathing and siding on walls was considered important, and widely used, along with inexpensive, easy-to-maintain natural finishes. Some obvious potential economics, such as wider spacing. of joists, rafters, and studs, were considered. A single-layer wood floor replaced the conventional three layers of subfloor, underlayment, and finish. Trim around eaves was eliminated; as were eave troughs. Carports and porches were eliminated or reduced to a minimum.

Such changes and eliminations were naturally not popular, and some housing experts immediately predicted unacceptability of the designs. All suggestions were considered, some modifications were made during development of the plans and designs, but always the cost target was kept foremost. It should be noted that each of the several designs discussed in this paper has been through a series of evolutionary changes, and should not yet be considered as the final design. Each design contains some new experimental features that have not been entirely tested in the laboratory or in an actual building. Plans are now underway to test these features in. a prototype building.

Five specific designs will be discussed briefly. The first three are one-story structures, relatively conventional in general appearance and in most construction features, although all contain some experimental features that will require further study before wide adoption. The last two designs are unconventional and were developed to see how wood products might be used in unusual designs for good low-cost houses.

Plan SE-1

The first design, designated SE-;, is for a square house on a flat site.

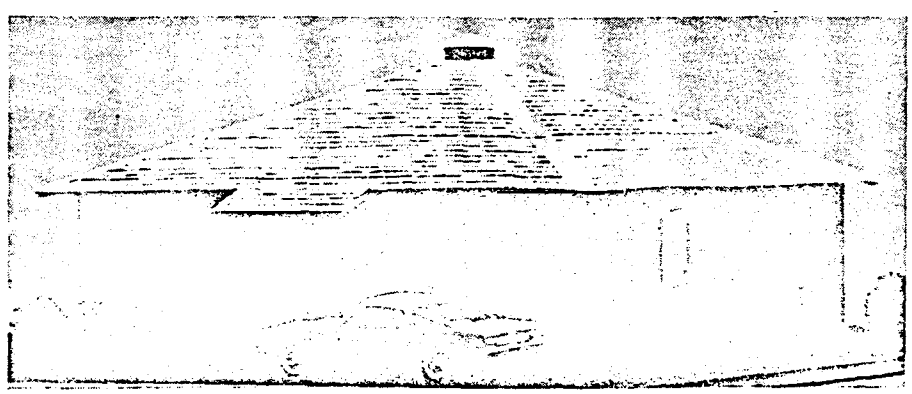

Figure 2. — Model, SE-1 design.

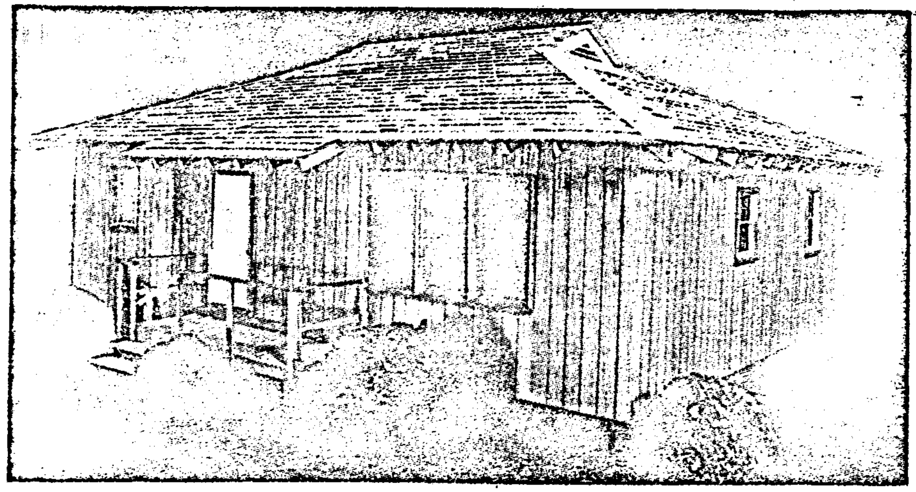

Figure 4.— Model, SE-2 design.

A square plan requires, the least exterior wall length for a given floor area of any rectangular dwelling. The floor plan is shown in Figure 1, and a finished model is shown in Figure 2. Many such low-cost houses would normally be built on a concrete slab floating on the ground. Accordingly, a floating wood floor system was considered, and two were designed. One uses treated 2 by 4 sleepers laid flatwise on the ground, or on a leveling course of sand, and in either case over a vapor barrier. A single layer of tongue-and-grooved pine flooring is nailed across the sleepers. The space under the floor is used as a shallow return air plenum to the furnace fan. A simple concrete block foundation wall encloses the wood floor and supports the exterior walls. Interior load-bearing walls are supported by a 2 by 12 treated wood footing.

In the other floor system, a plywood. underlayment is nailed to a four-foot grid of 2 by 4 sleepers and the space under the floor between the grid is filled with sand or sandy soil. All the wood in contact with the ground or directly on the soil cover is pressure treated with suitable preservatives..Other wood is not treated.

Walls and roof are conventional stud construction; softwood plywood is used. as exterior combination sheathing and siding; gypsum board or other paneling is used for interior finish. Windows and doors are conventional wood units. An experimental feature is the single iayer of particleboard that is used for interior partition walls. In this case, walls are designed so that closets and other built-ins serve as stiffeners for the particleboard panels, as does some of the trim. The central section of the attic is floored and provided with a pull-down stair for extra storage, a feature badly needed in small houses for large families. Ceilings and walls are insulated.

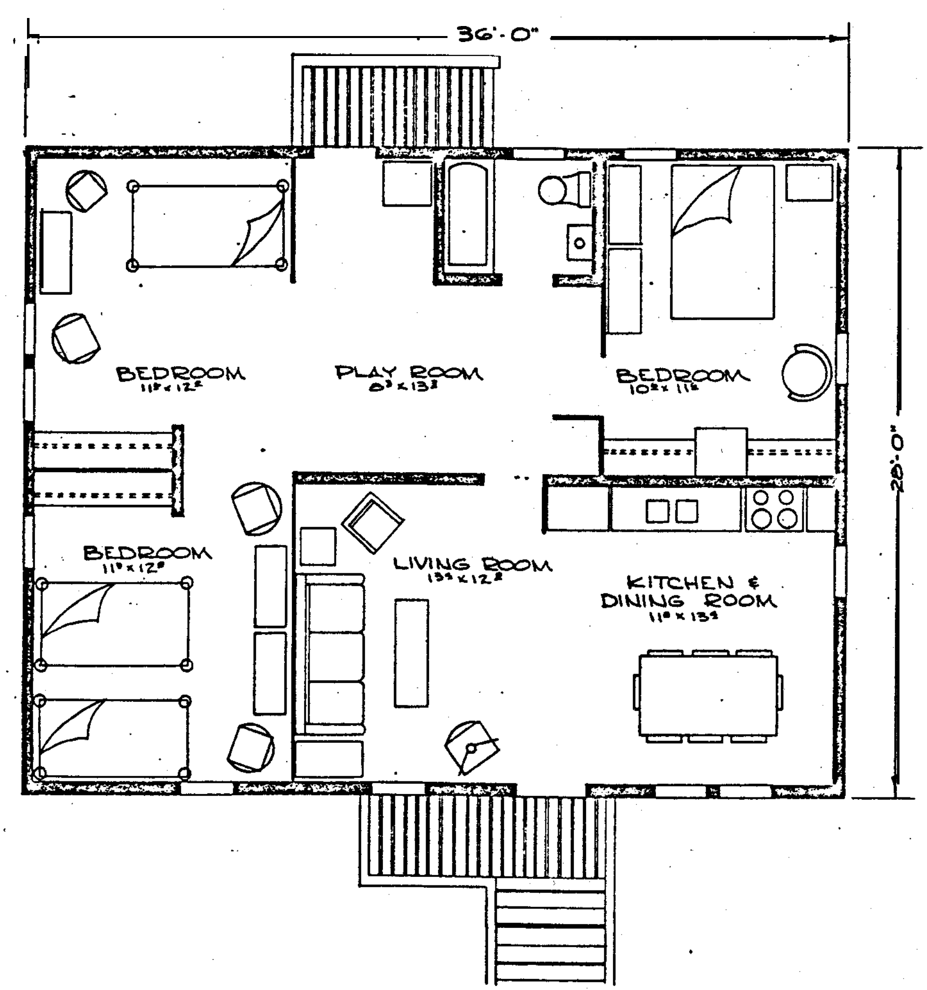

Figure 3.— Floor plan, SE-2 design.

This design provides 1,024 square feet, and sleeping space for up to 10 persons in three large bedrooms. Cost estimates in early 1968 indicated that the house could be built to meet the target requirements, although costs on all the houses will now be higher because of recent significant increases in both materials and labor. Cost estimates for all houses are based on the 1967 National Construction Estimator for Light and Heavy Construction.'

Plan SE-2

This is a design for a sloping site, and emphasizes a foundation. system of preservative-treated wood piers. No masonry work is required, thus, the foundation could even be installed in freezing weather, It is a rectangular design, with 1,008 square feet, and features an open play area that doubles as a' hallway and is directly coniiected to a large bunk room for children. Construction is again relatively conventional, but the particleboard partition system is used between some rooms, and the foundation and floor system is detailed.

FAL Pacific Estimators. 1967. National Construction Estimator, 15th Edition. Craftsman Book Company, Los Angeles, Calif.

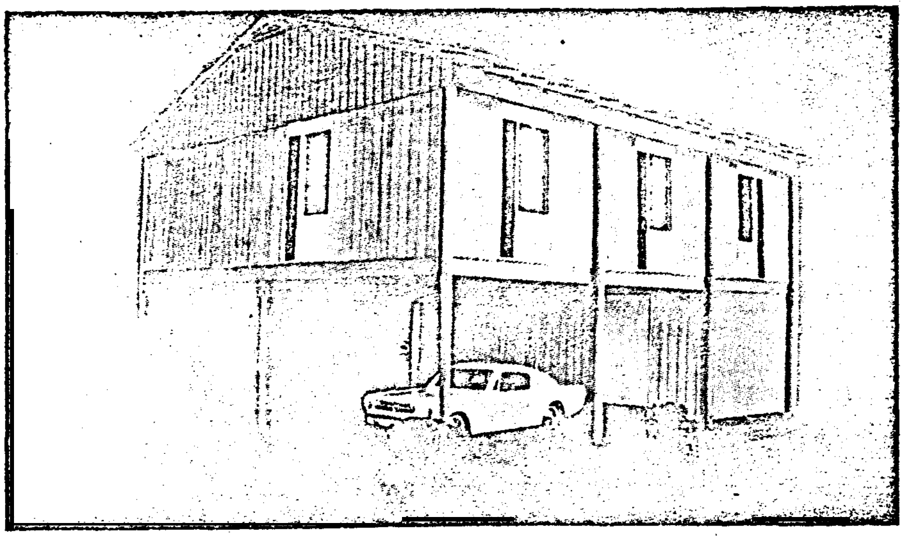

Figure 5. — Model, SE-3 design.

The floor plan is shown in Figure 3; the exterior of the model is shown in Figure 4. Cost estimates in early 1968 indicated that the target of $6 per square foot could be met.

Plan SE-3

This is another design for a sloping site, and features a pole-frame system, supporting the roof, with a secondary line of wood piers down the centerline as additional support for the floor. Pole-frame construction, although well established for farm structures and shop buildings, is quite new for houses,[5] particularly for small ones. This efficient system raised some important technical questions that had to be resolved. Round treated poles were chosen for their greater availability and more certain uniformity of treatment compared *to* sawn timbers. Such poles could be placed outside of, inside of, or in line with exterior walls, which can be nonbearing because roof loads are carried on the poles. Earlier designs with poles inside the exterior walls were developed, particularly to take advantage of the cantilevering of the floor beyond the poles. The big problem was obstructions inside the *small rooms* with the pole placement. Fitting walls directly in line with poles offered problems, so we placed the walls just inside the poles, and used the poles as accent features.

The house is illustrated by the model in Figure 5, which shows it from the lower level. Because exterior walls could be nonbearing, thin -modular sandwich panels were designed. These' are nail-glued in a small shop with simple carpenter tools, can be trucked to the site in a pickup truck, and are easily erected by two men. Construction of the house is shown in further detail in Figure 6. Similar modular sandwich panels are also used as interior partitions.

Because conventional wood window units did not fit in the 2-inch walls, a simple and inexpensive window wall unit was designed by combining a fixed glass area with sliding panels of hardboard for ventilation (Fig. 5). The window unit is the same size as the modular wall panel. Details were developed for fastening and joining the various component panels to each other and to the other structural elements. Because thin prefabricated panels are difficult to wire, a combination wood baseboard and raceway system was developed to conceal horizontal wiring, provide wall outlets, and also provide baseboard heating. A stressed-skin floor

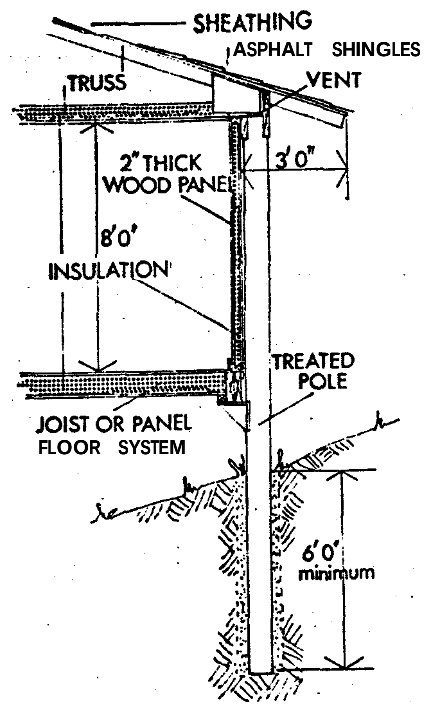

Figure 6. — construction detail, wall and pole system, SE-3 design.

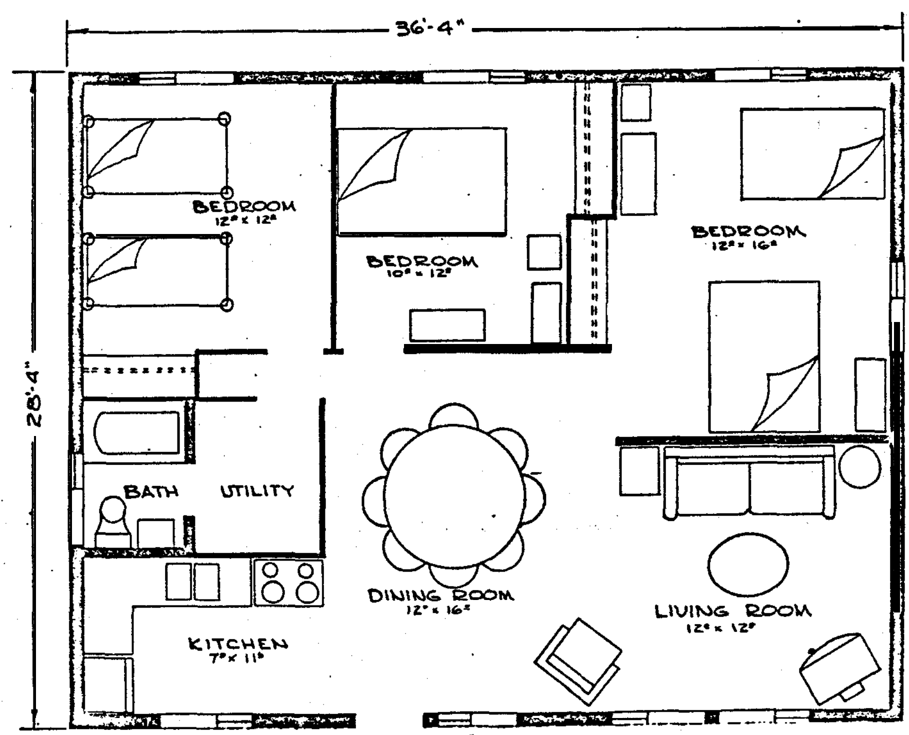

Figure 7. — Floor plan, SE-3 design.

[5]McAlister, R. H. 1967. Pole framing -inexpensive solution *to* rural-housing construction. Proceedings Amer. Soc. Agr. Eng. November, p. 30, 31, 37.

. panel system is offered as an alternate to the conventional joist system. All stressed-skin panels are of plywood, glue-nailed to wood framing members, with the necessary batt insulation.

This design provides 1,008 square feet (Fig. 7). A feature of the design is good use of the space under the house (Fig. s), a portion of . which is enclosed with a plywood-sheathed wall to provide an additional storage room. At the same time, the walls serve as part of the bracing system of the poles. Other bracing is provided by treated poles laid on the ground and anchored to the pole foundation, -thus avoiding the need for cross .bracing. Carport storage is provided below the house. This design could also be built for the $6 target figure in early 1968.

Less Conventional Designs

In order to see how costs could be decreased in wood houses, without the restrictions of conventional buiiding practices, we developed and considered a number of other designs. Of these, two were particularly interesting and promising, and were developed further. At the present time, both are considered strictly as experimental designs, with significant unproved features that will require , further study before wide adoption. Again, these designs are based on a good background knowledge of wood and wood construction, and no real problems are anticipated. These designs are presented as examples of new approaches to better, low-cost housing made of wood. They represent particularly efficient ways to enclose housing space. Each design has received .favorable comment, both from an appearance and a design standpoint.

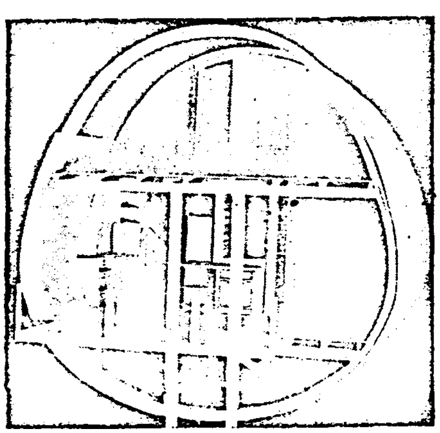

Figure 8. — Tubular house, partial erection (model), showing laminated ribs and floor system installed on posts.

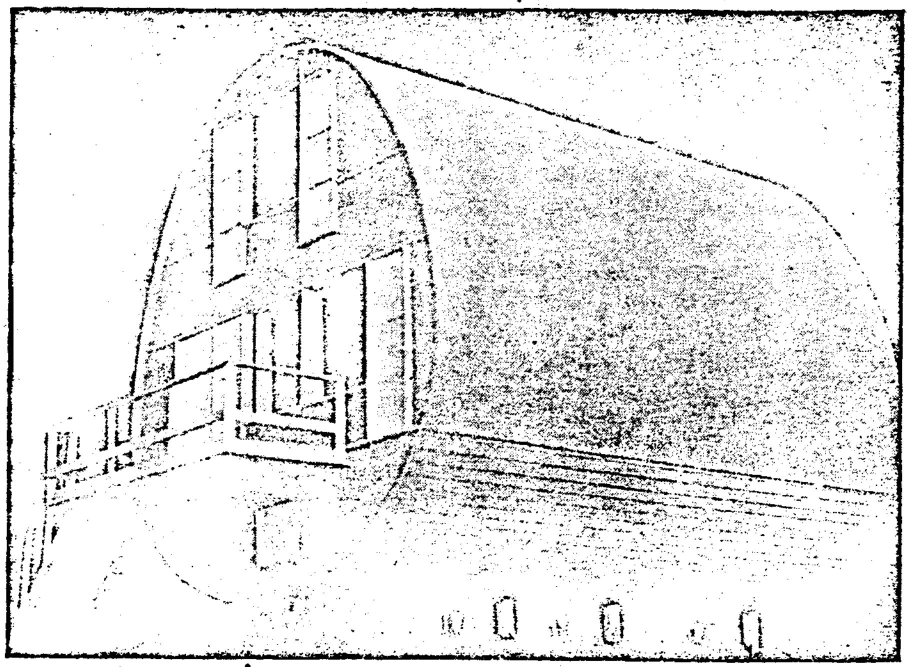

Figure 9. — Model of completed tubular house.

Tubular House

An original design was a perfectly round, tubular shell which.. evolved out of thinking about the exceptional strength of curved roof systems and tubular shapes. The round cross section was later modified to an aircraft fuselage shape for a more pleasing appearance. Essentially, the structure consists of a double Iine of treated wood. posts or poles, set in pairs 8 feet apart. To these pairs of poles, horizontal beams are bolted. at the first and second floor levels. Glulam circular arches or ribs, made in halves and joined at -the top-and bottom on the site, are then bolted to the lower sections of the poles and to the ends of the horizontal beams. This construction is shown in Figure S, which also shows interior construction.

'Two-inch tongue - and - grooved lumber sheathing is nailed to the outside of the ribs. Over this, a foamed-in-place polyurethane insulation is applied. Typical construction involves a 2-pound per cubic foot density foam, 1 inch thick. A coat of aluminum paint, neoprene, or asphaltic emulsion is applied over the foam to serve as a protective coating. The ends of the house are simple frame and sheathing construction, with the special window unit of SE-3; the' outside of these end walls is also coated with the foam and finish, which serves as sealant, insulation, and final finish. Interior walls and floors are essentially light, conventional construction. Spiral 'stairs can be used, or conventional wood stairs. The finished mode1 is shown in Figure 9. The original design provides a total of 900 square feet, half on each floor, and early 1968 cost estimates indicated a finished cost of about $6 per square foot. A "stretched" version, 8 feet longer, provides 1,188 square feet, and the estimated cost per square foot was $5.20 in early 1968. Both designs' provide very good space utilization, an unusual and attractive exterior, and are adaptable to either flat or sloping sites. Various modifications have been considered wherein the exterior plastic foam and finsh can be eliminated and the lumber roof sheathing covered with rigid insulation and conventional roll or sheet roofing. The laminated ribs are obviously an important design feature and must be properly fabricated, preferably by an experienced laminator. Ribs are 2-11/16 inches wide and 4-1/2 inches deep, built up of nominal one-inch . softwood lumber. Minimum bending radius is 8 feet. The rib construction is rather simple' and could probably be laminated by the builder in a small shop with nailgluing. However, good quality control may be difficult to achieve by this method except under special, controlled shop conditions.

The field application of the foamed polyurethane insulation is becoming a widely used technique, primarily for large commercial freezers and cold-storage rooms. Applicators are located in many parts of the country and can come to a building site with all the necessary metering and spray application equipment readily available in small trucks. After the insulation is in place, the same equipment can be used to apply the plastic finish; similar finishes can be put on by roller or brush. Although still not common in rural areas, there is no reason why such insulation application cannot be done efficiently and economically. Actual commercial application costs were used in the estimates for the tubular house. Data. on the long-term outdoor durability of the plastic insulation-finish system are still incomplete. Limited available information indicates good durability against the elements.- Recently, some large roof structures on commercial buildings have been covered with this system.

Round House

'Another unusual design is the round house, built on a circular concrete slab on a flat site. Concrete is used for the floor because of the ease. of fabricating the round slab, compared to a wood system. The walls of this house are of rough-sawn, properly dried 2 by 8 softwood planks, set on end around the perimeter of the brick foundation enclosing the slab. Planks are joined at the edges with a hardboard spline that is inserted in grooves cut in each edge of the planks. There is no other wall framing. Planks are nailed to the treated-wood sill around the slab, and toenailed to each other at the top. A wood fascia board around the outside at the top also serves to hold the planks together.

Another circular wall of planks is placed about the center of the 'slab. It forms an atrium hall, 8 feet in diameter, in the original 32-foot diameter house. This size provides a total area of 804 square feet. A larger version, with a 38-foot diameter and a IO-foot diameter hall, provides an area of 1,134 square feet.

Across the top of the plank walls, 4 by 6 rough-sawn softwood beams are placed radially out from the center. The beams are supported in notches cut into the tops of some planks. Beams are placed 4 feet apart at the perimeter walls, held in place by suitable nailing, and then covered with lumber or plywood roof sheathing.. The original design, illustrated in the model in Figure 10, has a fiat roof. However, a conical-shaped roof would be possible, although it would require longer planks for the inside, circular wall and would complicate interior wall construction. Two. round houses, one each of the two sizes previously mentioned, have been built and sold in *Hope Mills, North Carolina.

The roof is covered with the same plastic foam insulation and plastic top finish described for the tubular house. Fixed windows are provided in the exterior walls simply by leaving out sections of two planks, side by side, and installing fixed glass in a simple wood frame. Ventilation can be provided by a sliding hardboard panel system in some. plank openings, in the same way as in the window-wall panel system in SE-3. Interior partition walls are all non-bearing, and can be placed at any radius between the interior hall wall and the exterior wall. A frame-type plumbing wall is provided between the bath and kitchen areas; other partitions are of the particleboard system described in SE-l.

Although some critics are pessimistic, experience indicates good utilization of space, and good furniture placement, even in the three-bedroom version of the 32-foot diameter house (Fig. 11). The rough-surfaced planks would be given a transparent stain finish in different shades, as desired. A smooth finish could be used on the 'interior surfaces of the planks. Obviously, some problems can be expected with dimensional changes in the planks in coming to equilibrium with normal room conditions. To reduce. such problems to a minimum, it is very important to use properly-dried lumber. Experiments are underway in the laboratory on full-size plank wall assemblies to study and observe such dimensional changes, particularly in width across the grain, as well as tendencies to cup or warp. Calculated amounts of movement on southern pine planks would indicate that the dimensional movements can be readily tolerated if the lumber is properly dried before installation.

Recent Developments

It is fully recognized that many good house designs have been developed over the years, including some experimental designs of wood, and yet never used in actual construction. One possible obstacle to wide acceptance of such designs is the general lack of complete design work, including provisions for joining and fastening all components, provisions for wiring, plumbing, and heating or air conditioning, particularly for stressed-skin panel designs, and various other minor but important and frustrating construction features. In our designs, every effort was made to solve these problems. Although it is impossible to indicate all of them here, complete detailed drawings and specifications are available for each design. Simple, one-page summary sheets have been prepared and have been widely distributed. Persons 'wishing to review the construction features more fully, with an eye to actual construction, are provided with the detailed drawings and specifications without

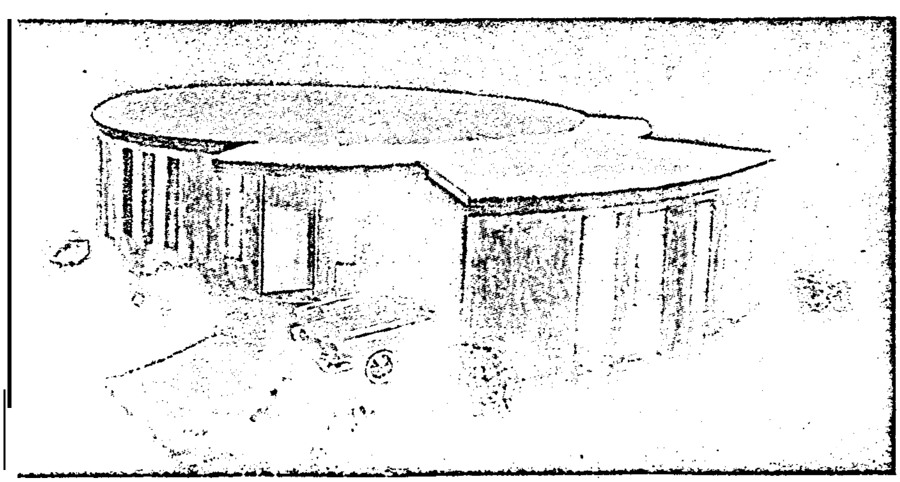

Figure 10. — Model, round house (32 foot diameter).

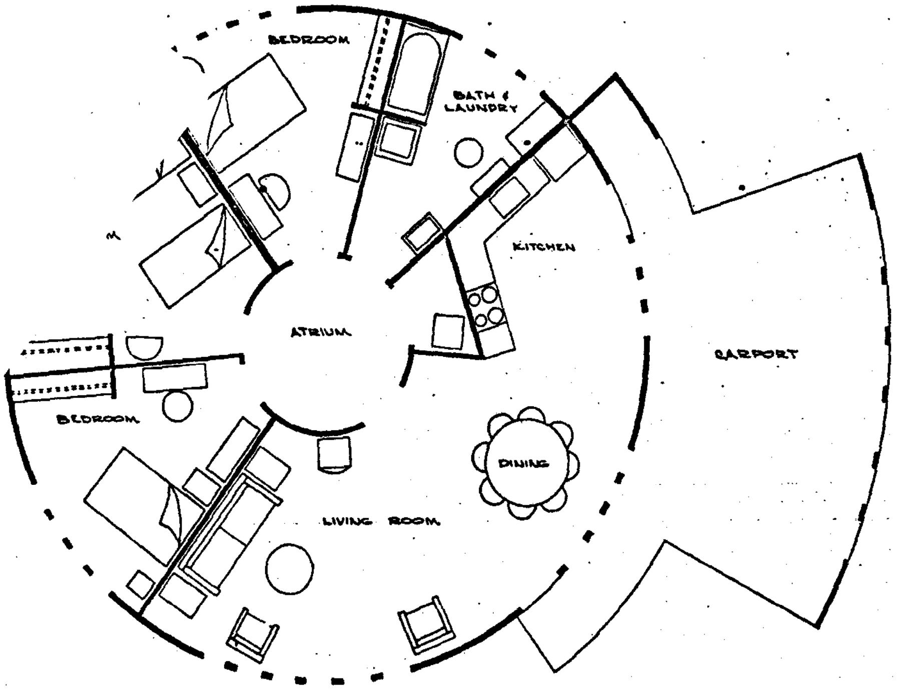

Figure 11. — Floor plan, round house.

charge upon request. At present, such documents have only been prepared for the conventional designs SE-l, SE-Z; and SE-3. Preliminary drawings for the. tubular and round houses were prepared and circulated on a limited basis for review and comments, and have now been revised and are ready for distribution.

Nothing is really gained from such design efforts until actual houses are constructed to try out the designs, This involves money and time, and is probably not an efficient use of limited research funds. We have recently built a small experimental structure in Athens that includes most of the unproved features of all five house designs, to study experimentally the possible problems with the floating wood floor system of SE-l, the pole and pier systems of SE-2 and SE-3, the particleboard partition system, the plank wall of the round house, the window-wall unit, the panel wall system of SE-3, and other features. Therefore, efforts have been made to interest actual builders in. constructing prototype houses with private funds, for sale to families. When they are occupied, data on both construction and livability may be obtained. More reliable cost data can also be obtained from such efforts, and many ideas for improved design and construction features can be accumulated.

At the present time, one commercial builder in Hope Mills, North Carolina, has built one of the 32-foot round houses as a private venture and sold it to a family who is now living in it. Although the, builder didn't follow all of our details. and, recommendations, the results were satisfactory, and no serious problems or complaints have been noted.

This same builder has also received a commitment from the Federal Housing Administration for building one of each of the five houses described under the FHA Experimental Housing Program. He started construction. in March 1969. At present he has completed the larger version, of the round house, the tubular house (shown on the cover of this issue), and the SE-3 pole-frame house. We are following this work carefully and are assisting him in some of the technical problems that may occur. We hope to get good cost estimates and opinions on livability from the actual occupants. Some instrumentation of wood components, with thermocouples and moisture probes, is also underway. Efforts will be continued to get other prototypes built and occupied in different areas, and then to follow up on the results. The design work on additional houses will also continue with high priority not only for rural houses, but also -for low-income urban and suburban dwellings.

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