

Energy Conservation Study

A PERFORMANCE
COMPARISON OF
A WOOD-FRAME
AND A
MASONRY STRUCTURE

American Forest & Paper Association

ENERGY CONSERVATION STUDY

In today's world of escalating energy prices and shortages, the cost of maintaining year-round comfort in residential and other buildings has become increasingly significant. At the same time, people have come to expect uniform temperatures in their homes, offices and shops, unaffected by seasonal climate changes.

These conflicting requirements make protection against weather conditions a highly significant factor to architects, builders and home buyers today. As a result, greater attention is being given to building materials and types of construction and to their effects on the economies of uninterrupted living comfort.

A PERFORMANCE COMPARISON OF A WOOD-FRAME AND A MASONRY STRUCTURE

Wood-frame construction has the advantage of providing superior protection against both hot and cold weather. This advantage is derived, in part, from the unique anatomical structure of wood—an insulating property possessed by no other structural building material. A microscopic view of a section of wood reveals a cellular structure that contributes to its strength, plus millions of tiny air spaces that make wood an excellent insulator.

In addition, stud walls of wood-frame construction provide spaces for the thicker insulation necessary to take full advantage of the benefits of modern climate control technology with reasonable cost and without sacrificing valuable living space.

WOOD-FRAME THERMAL PERFORMANCE DEMONSTRATED

The outstanding thermal properties of wood construction have been recognized for many years. However, until recently the degree and extent of its advantages had not been established through comparative tests with other popular types of construction.

To obtain factual information on the relative energy conservation of insulated wood-frame and masonry structures for the building industry and the home buying public, the National Forest Products Association (now American Forest & Paper Association) conducted two research projects. These projects were designed to compare the effects of the two construction systems and their respective materials on heating and air-conditioning economy and comfort.

One study investigated energy consumption in the Beltsville, Maryland climate (Washington, D. C. area) where, despite the hot summers, most climate control energy is used in the winter. The second was in the warm climate of Tempe, Arizona (Phoenix area), where an extended air-conditioning period is necessary.

In both studies, two test structures of the same interior dimensions were erected—one an insulated wood-frame building over a crawl space, the other an insulated masonry building with a concrete slab-on-ground floor. All four structures were built in accordance with good local construction practice. At each site the two structures were exposed simultaneously to identical weather conditions and controlled interior temperatures during full heating and cooling seasons. The test structures were not intended for occupancy other than in the course of data collection, nor were they intended to simulate full-size living areas.

Results of the Beltsville, Maryland, study demonstrated the advantages of wood-frame construction during both heating and cooling seasons. Energy savings in favor of the frame structure averaged 26 percent for heating and 18 percent for air-conditioning. A full report on this investigation and its results is given in *Technical Report No. 2, Heating and Air-Conditioning Study of a Wood-Frame and a Masonry Structure*, available from the American Forest & Paper Association.

Insulated wood-frame construction also proved its value in the Tempe study, as reported herein.

Detailed investigations and analyses for the Tempe study were conducted by Dr. Alva H. Jared, in partial fulfillment of requirements leading to a Doctoral degree, and are reported fully in his dissertation “The Effects of an Extreme Climatic Condition on the Relative Efficiencies of Heating and Air Conditioning a Frame Structure and a Masonry Structure,” Arizona State University, 1968.

The study was supported by the Arizona Lumber and Builders Supply Association and the National Forest Products Association, in cooperation with Arizona State University. The test structures were erected at the Arizona State University Farm in Tempe, Arizona.

This report includes a description of the test structures, their instrumentation and conditions of exposure, together with the results of the study.

Dr. Jared’s cooperation in undertaking and skillfully carrying out this study, and in preparing the original manuscript from which this report has been extracted, is gratefully acknowledged.

FINDINGS AND CONCLUSIONS

Data from this research study indicate that energy conservation, as demonstrated by heating and air-conditioning economy, is influenced by the type of building materials and construction methods used.

During the summer cooling season, the wood-frame structure used substantially less energy than did the masonry structure, and was thus 30.2 percent more efficient to air-condition. Interior wall surface temperatures of the frame structure were considerably cooler than the corresponding walls of the masonry structure.

The wood-frame structure also provided savings in heating energy costs, operating 23 percent more efficiently during the three month heating season. Interior walls of the frame structure were much warmer in the winter period than the comparable walls of the masonry building, indicating a greater degree of comfort to occupants.

The windows containing wood components proved to be more desirable from the standpoint of retarding heat flow than were the windows containing aluminum components. Low interior surface tempera-

tures during the heating season indicated that the aluminum window frames were a source of heat loss.

Heat transfer was more apparent through the concrete slab floor of the masonry structure than through the floor of the frame structure. During the air-conditioning season the concrete floor was 2°F warmer and during the heating season it was 2°F cooler than the insulated floor of the frame structure. This indicated that energy losses due to heat flow through the concrete floor system contributed significantly to the reduced operating economy of the masonry test structure.

Much of the advantage enjoyed by the wood-frame structure can be attributed to the effect of insulation in reducing heat loss or heat gain. Other economies can be gained by selecting building components, such as windows, that exhibit high insulating characteristics.

The results of this study demonstrate that economies in summer air-conditioning and winter heating can be achieved through the use of insulated wood-frame construction where extreme climatic conditions exist.

BASIS OF STUDY

The objective of the investigation was to ascertain the relative economics of heating and air-conditioning an insulated wood-frame structure and a comparable insulated masonry structure during identical environmental exposure. The results of a comparative test would reflect the differing characteristics of the two systems of construction. To facilitate meaningful comparison of data the number of variables was minimized, involving different types of walls, floors and windows. All other elements of the structures were kept the same to prevent differences in energy consumption not related to the scope of the research.

Additional investigations were made to identify the various elements of the structure that contributed to the difference in energy consumption, such as walls, ceilings, floors and window frames. These temperature measurements were intended to indicate where heat transmission occurred, without quantifying the relative amounts of energy lost through the different building elements.

All data in this report were obtained during the 52 week test period beginning April 1, 1966, and ending March 31, 1967. This period included one air-conditioning season, one heating season and two short seasons which required both heating and air-conditioning to maintain interior design temperatures.

Both test structures were built in accordance with good normal construction practices. They were designed by a professional architectural firm and constructed by local tradesmen. Care was taken that both structures contained equal interior cubic volumes, with equal interior surface areas of ceilings, floors, walls, doors and window glass.

Identical heating and air-conditioning equipment (electric heat pumps) were installed in each test unit. These were of sufficient capacity to precisely maintain inside design temperatures. Electric energy was used to heat and cool the structures. Kilowatt hour meters provided accurate measurement of fuel consumption.

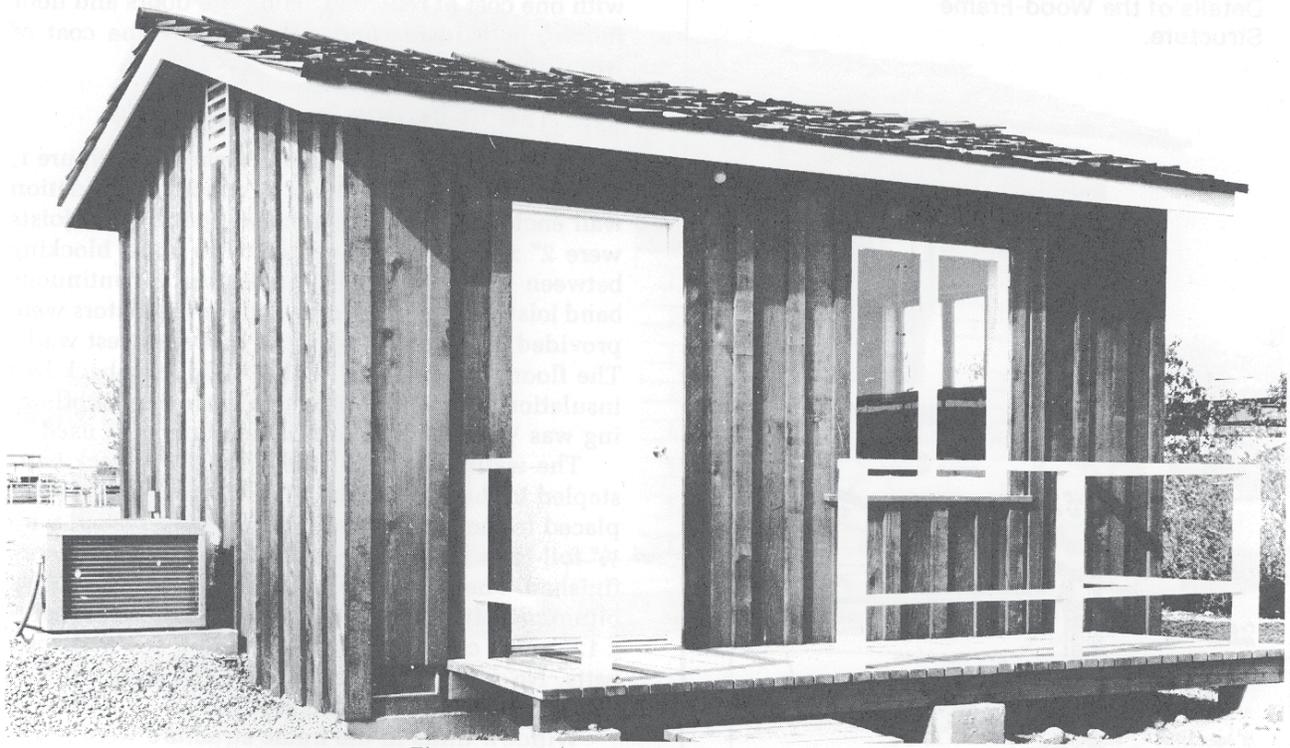


Figure 1— Wood- Frame Test Structure

TEST STRUCTURES

Common Elements of Structures

The two test structures were erected at the Arizona State University farm, Tempe, Arizona. One structure was an insulated wood-frame building with a crawl space. The other was an insulated scoria block masonry structure erected on a concrete slab. Each contained identical interior cubic volumes of 1,399.5 cubic feet. The interior dimensions of each building were 15' 2½" long by 11' 2½" wide; clear ceiling heights were 8' 1½".

Both structures were oriented in the same easterly direction, with the masonry structure approximately 20 feet south of the frame structure. Thus each had equivalent exposure to wind and sunlight and at no time did one structure shade the other.

The two buildings were similar with respect to door and window arrangement. Located in their east walls were pre-hung exterior flush doors with wood jambs and aluminum thresholds. There were 15.5 square feet of glass area in each structure, equally distributed be-

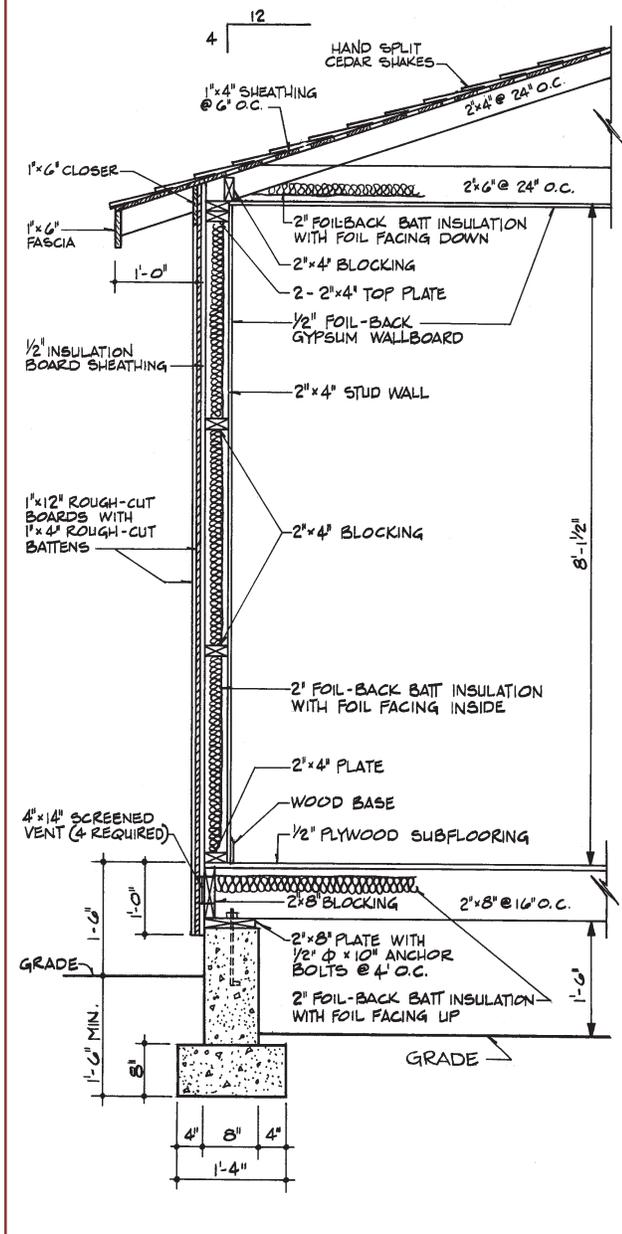
tween the north and east walls. No window or door openings were provided in the south and west walls.

The ceilings in both structures consisted of 2" x 6" joists placed 24" on center with ½" foil-back gypsum dry-wall fastened to the bottom of the joists. Joints were taped and finished. The ceiling was insulated with 2" foil-back batt insulation with the foil to the inside. The insulation was stapled to the side of the ceiling joists.

The eaves of the test structures provided a one foot overhang around the complete perimeter of the buildings. Open eaves were used, with 1" x 6" drop siding applied as decorative exposed roof sheathing. A 1" x 6" fascia enclosed the rafter ends.

Roofs were gable type with a 4 in 12 slope and were surfaced with handsplit wood shakes nailed to 1" x 4" roof sheathing placed 6" on center. Attic ventilation was provided by 12" x 18" screen ventilators; one in each gable end.

Figure 2—Construction Details of the Wood-Frame Structure



Interior walls and ceilings of both buildings were painted with one coat of light pink interior house paint. Exposed undersides of the eaves were stained with one coat of redwood stain. The doors and door frames, both inside and out, received one coat of white enamel.

The Wood-Frame Test Structure

The wood-frame test structure, shown in Figure 1, was erected on a continuous 8" concrete foundation wall enclosing an 18" deep crawl space. Floor joists were 2" x 8" at 16" on center, with solid blocking between the ends of joists instead of a continuous band joist. Four 4" x 14" crawl space ventilators were provided, divided between the east and west walls. The floor was insulated with 2" thick foil-back batt insulation with the foil placed to the inside. Subflooring was 1/2" plywood. No finished floor was used.

The walls were insulated with 2" foil-back batts stapled to the sides of the 2" x 4" studs with the foil placed to the inside. The interior was finished with 1/2" foil-back gypsum drywall; joints were taped and finished. The exterior wall covering consisted of 1/2" bituminous fiberboard sheathing clad with vertical 1" x 12" rough cut redwood boards and 1" x 4" redwood batts. No coating was applied to the exterior wall surfaces of the frame structure.

Window units in the frame structure were of the casement type, with wood sash and frames. Special frame units were needed to provide the same glass area as in the masonry building. A wooden porch 13' long by 4' 3" wide was installed on the east side of the structure.

Construction details for the wood-frame test structure are shown in Figure 2.

The Masonry Test Structure

The masonry test structure, shown in Figure 3, was erected on a 4" concrete slab. The slab was placed over compacted earth fill topped by 4" of gravel and a 6 mil polyethylene vapor barrier. No finish floor was installed on the slab.

Walls were constructed of 4" x 8" x 16" two-core, three-web scoria building block. This block, a typical and common building material for the Arizona region, utilizes quarried volcanic cinders as the coarse aggregate. Loose vermiculite fill was placed in the core voids to insulate the masonry block. Although the majority of block homes in the Phoenix region do not utilize core insulation, the vermiculite was added to provide a *better*



Figure 3—Masonry Test Structure

Figure 4—Construction Details of the Masonry Structure

than average masonry wall to compare with the insulated frame wall.

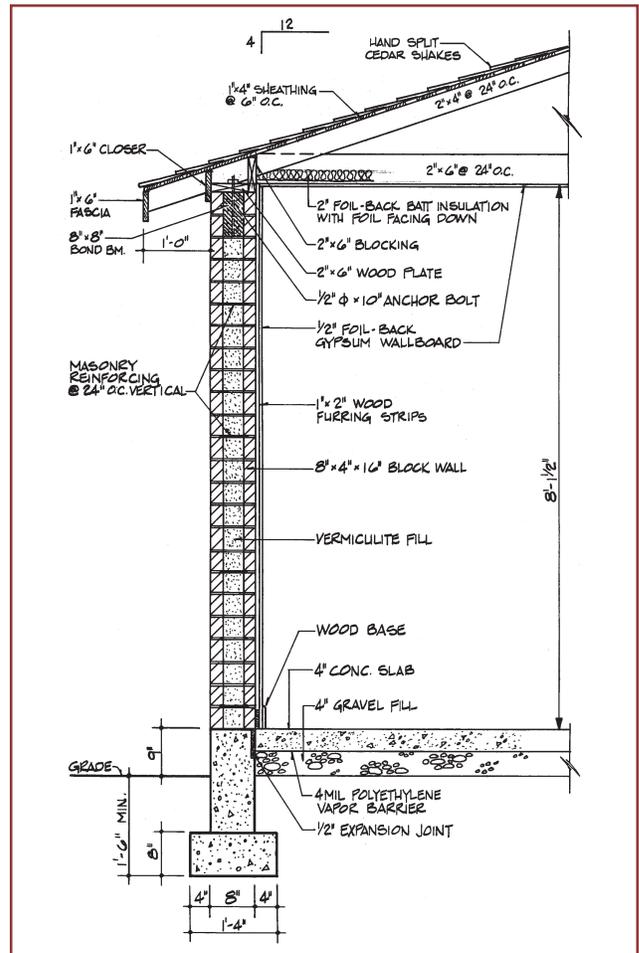
The interior of the masonry structure was finished with ½" foil-back gypsum drywall nailed to 1" x 2" vertical furring strips placed 2' on center. Drywall joints were taped and finished.

The gable ends of the masonry structure were framed and clad with the same materials as the walls of the wood-frame structure. A 4" concrete slab porch 12' 8" long and 4' wide was provided on the east side of the masonry structure. Wood railings and posts were installed.

Window units were of the double sliding modular aluminum type with double strength, single thickness glass.

No paint or special block sealer was applied to the exterior of the masonry walls, nor were the aluminum sash and frames painted. The porch railing and posts were given one coat of outside white paint.

Construction details of the masonry test structure are given in Figure 4.

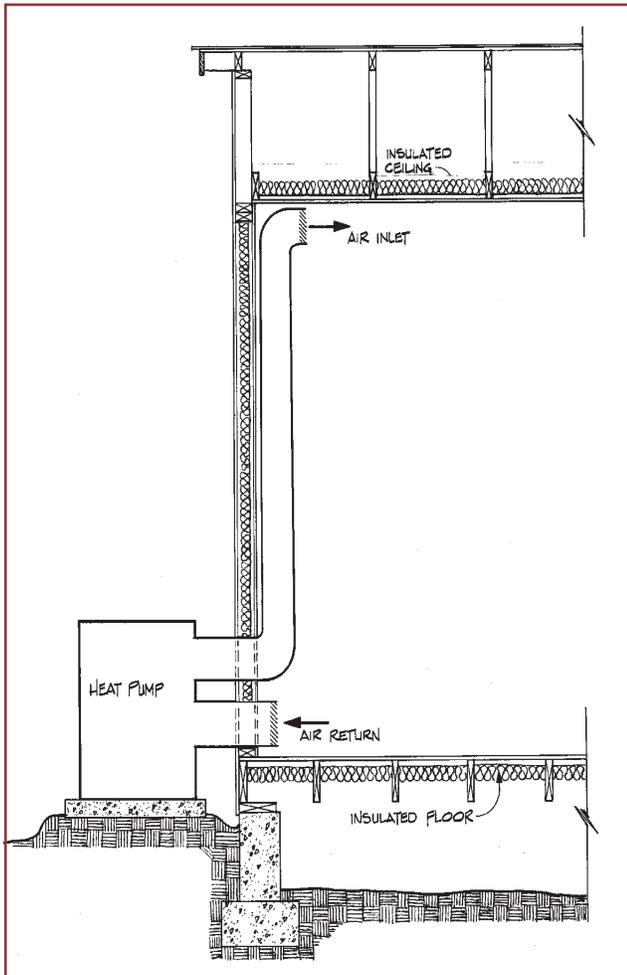


HEATING AND AIR-CONDITIONING EQUIPMENT

Each structure was equipped with a heat pump rated at 17,000 British thermal units per hour (BTU/hour) to provide appropriate interior temperature regulation during periods requiring heating or air-conditioning or both. The heat pump capacity was determined by calculating theoretical heat losses and heat gains through the various elements of each building. Figure 5 illustrates the heat pump and ductwork installation for the test structures.

Both heat pumps were tested using the American Society for Testing and Materials guarded hot/cold box testing apparatus prior to installation in the test structures. The calorimeter data provided from this test indicated approximately 17,500 BTU/hour capacity at 95° ambient temperature while delivering 610 cubic feet per minute. The capacity at 45° ambient temperature was 19,700 BTU/hour with equal air delivery.

Figure 5—Schematic of Heat Pump and Ductwork Installation



The heat pumps were installed on concrete slabs adjacent to the south wall of each structure. The metal ductwork entered the structure above the floor level with the exposed ductwork extending to approximately 18" below the ceiling and containing an adjustable register. The return air opening was placed at floor level and adjacent to the incoming duct.

Since the heat pumps had the capacity to provide either cold air or hot air to the structure, a special thermostat was installed in each structure to maintain the desired inside temperature within a range of 71-73°F. The thermostats were placed 5' 6" above the floor and approximately in the center of the structure. Temperatures were registered on a recording potentiometer. Thus, very accurate calibration of the thermostat and the potentiometer in each structure was maintained throughout the duration of the study.

INSTRUMENTATION OF TEST STRUCTURES

The instrumentation used in this study was designed to: (1) measure temperatures at various positions associated with the test structures for both comparison and equipment adjustment; (2) record specific temperatures at respective positions throughout the test structures; (3) ascertain kilowatt hour consumption of the respective heat pumps. A discussion of the specific devices follows.

Thermocouples

The temperature-sensing device used in this study was the Honeywell type T copper-constantan thermocouple. The operating range of these thermocouples was from -75° to +200° F with the limit of error being $\pm 1\frac{1}{2}$ ° for the complete range of the scale.

Globe thermometers, consisting of 4" diameter hollow copper spheres coated with flat black paint and having thermocouples at their centers, were placed in the corners of each test structure 3' above the floor and 18" from each wall. An additional diameter globe thermometer was placed 5' 6" high in the approximate center of each structure to ascertain the temperature at that location. This type of thermometer registers the combined effects of air temperature and radiated heat in the environment in which it is placed. Since the human body is affected by the same combination, the globe thermometer is commonly used to indicate bodily comfort conditions.

The thermostats controlling the heat pumps were adjusted to produce identical air temperatures according to the centrally located globe thermometers.

A thermocouple tree was constructed in each structure for the purpose of measuring the vertical temperature differential at the center of the structure. An exposed button-type thermocouple was fastened to a post 6" above the floor, another was fastened 5' 6" above the floor, and the third was fastened 6" below the ceiling.

Wall, floor, and ceiling temperatures were recorded throughout the heating and air-conditioning seasons by means of thermocouples on the surfaces and within the interiors of the respective elements. Thermocouples were also placed in strategic locations in the soil under the floors and around the structures. Principal information relating to comfort and thermal efficiency is reported herein. Additional detail is available from Dr. Jared's doctoral dissertation.

Figure 6 shows the locations of the thermocouples and globe thermometers used in both test structures.

Temperatures of the exterior wall surfaces at the center of the wall were measured by thermocouples on the surface of the wood siding or the masonry exterior. These were located directly opposite the thermocouples at the center of the interior wall surfaces to determine the temperature differential between the outside and the inside surfaces.

Window frame temperatures were also recorded. Thermocouples were fastened to the interior and the exterior surfaces of each wood and aluminum window frame.

An outside air datum reference was established by placing a thermocouple 18" above ground on the north side of a shaded post. The post was located behind the two structures, approximately 30' to the west.

The additional thermocouples placed in various positions in the test structures were for the purposes of gathering comparative data and for equipment adjustment information. A total of 188 thermocouples were installed to yield the complete temperature readings for this research study.

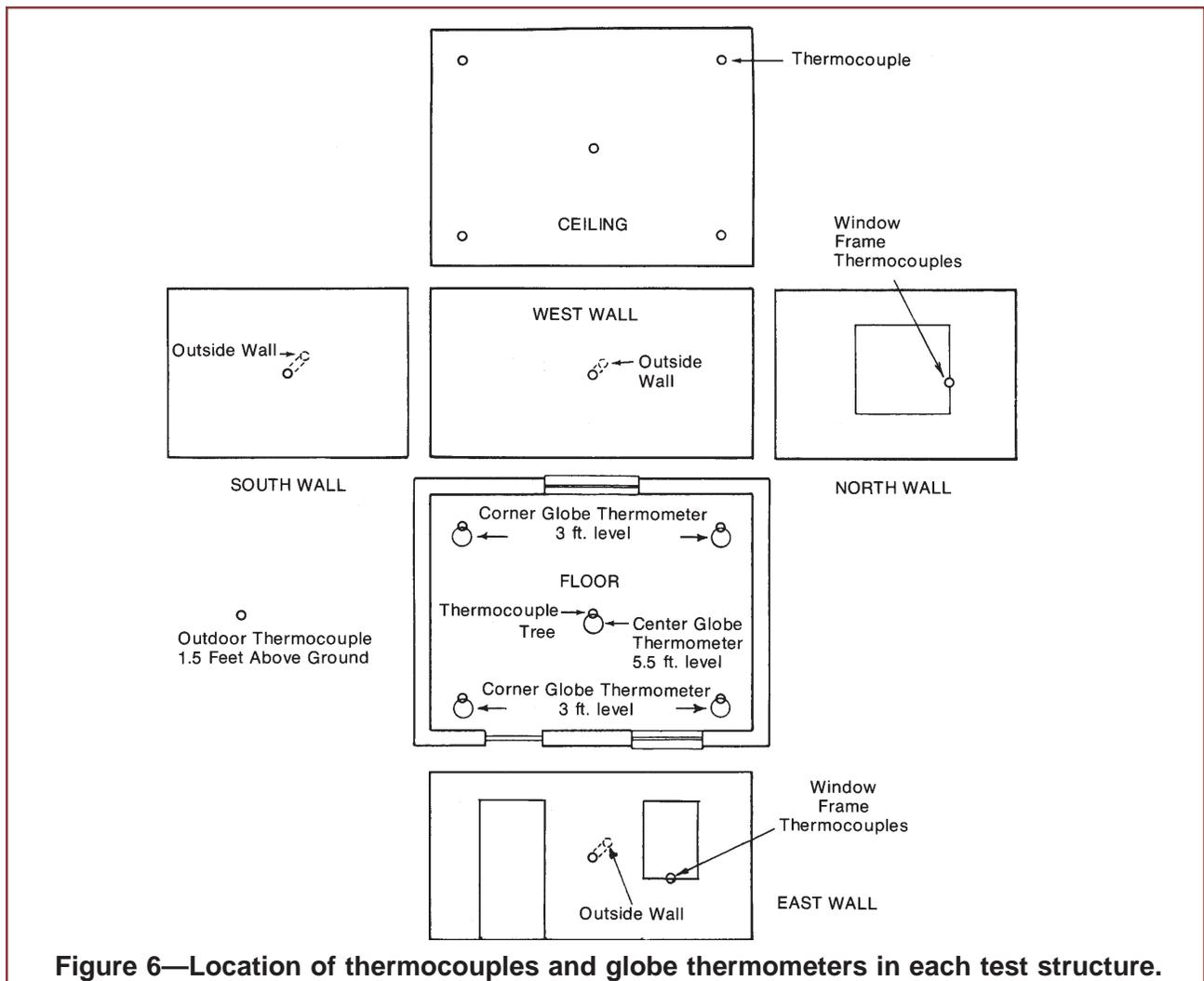


Figure 6—Location of thermocouples and globe thermometers in each test structure.

Potentiometers

Each test structure was equipped with a Honeywell type 153 ELECTONIK 16 point recording potentiometer. It was equipped with a 16 point print wheel and provisions for continuous recording on paper rolls. The recording cycle produced one recording every two minutes. An illustration of one potentiometer with connecting attachment appears in Figure 7. The instruments were regulated to simultaneously record the temperatures of identical thermocouples in each test structure, resulting in an accurate comparison of conditions in both structures. Both instruments were serviced and calibrated for accuracy by certified technical representatives.

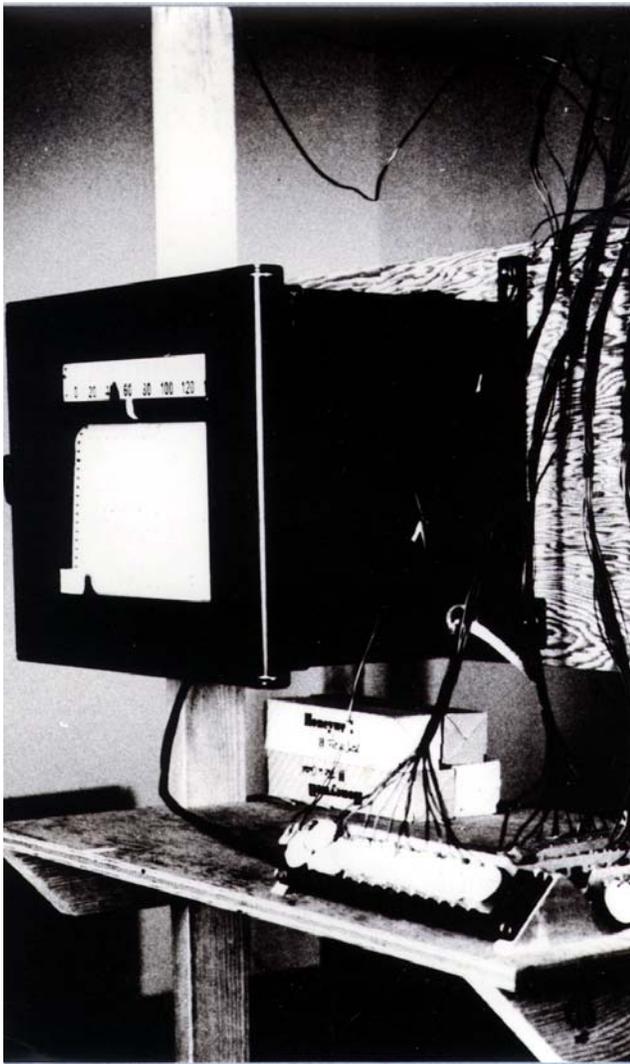


Figure 7—Recording Potentiometer.

Kilowatt Hour Meters

Kilowatt hour meters were installed to measure the amount of fuel consumed by each heat pump in operation. Each meter was accurate to within 1 kilowatt hour of fuel consumption. The data on economic operating efficiency of the test structures were obtained from these meters.

Data Collecting Procedure

The data from this array of instrumentation were collected between April 1, 1966 and March 31, 1967. This period included one air-conditioning season, one heating season, and two periods where both heating and air-conditioning were alternately required to maintain the desired 71-73°F temperature range inside the structures.

Complete thermocouple recordings were made in each test structure between 7:30 a.m. and 11:30 a.m. every seventh day throughout the entire test period. Sixteen of the thermocouples in each structure were continuously recorded 24 hours per day, to check the performance of heating and air-conditioning systems and to observe continuing temperature variations as influenced by changing weather conditions. However, only those temperatures recorded for the thermocouples during the weekly time period were utilized. Kilowatt hour meter readings were also noted each seven days and the last day of each calendar month to measure the power consumed in each structure.

INVESTIGATION RESULTS

The periods of test to which both structures were subjected covered an entire heating season and an entire air-conditioning season, as well as periods when both heating and air-conditioning were required to maintain the desired inside temperature. Fuel consumption data and interior temperature conditions in both the wood-frame structure and the masonry block test structure are discussed in the following section.

Energy Consumption

The quantities of electricity required to maintain a constant temperature in both the frame structure and the masonry structure during the 12 month test period, April 1, 1966 through March 31, 1967, are shown in Figure 8. Kilowatt hours of fuel consumption are tallied for each calendar month. For the total test period the masonry block building consumed 4,135 kilowatt

hours of electricity, while in the same period the wood-frame structure consumed 3,182 kilowatt hours.

Fuel requirements of the wood-frame structure were substantially lower than the requirements of the masonry structure during the air-conditioning season. In this five month period from May through September, the frame structure was 30.2 percent more efficient to air-condition than was the masonry test structure.

Throughout the complete heating season, December 1966 through February 1967, the masonry structure consistently consumed greater amounts of electricity than did the wood-frame test structure. The frame structure was 23 percent more efficient during this heating season than was the masonry test structure.

During the four months that required both heating and air-conditioning to maintain the desired interior temperature, the masonry structure was more efficient than the frame test structure. For these transitional seasons of moderate but fluctuating temperatures, the masonry

wall served as a heat reservoir to absorb daytime heat and slowly dissipate it during the cool nights, thus partially offsetting the need for heating, and for air-conditioning during the morning hours. Conversely, the frame structure insulated against the penetration of daytime heat and cooler night temperatures.

Monthly savings in fuel consumption by the wood-frame test structure during the entire test program are illustrated in Figure 9. The frame building conserved 6½ times more energy per month during the cooling season than the masonry building saved per month during the transitional seasons. Similarly, the average rate of frame building energy conservation during the heating season was more than double the masonry structure savings in the Spring and Fall. During the full one-year test period, the wood-frame test structure exhibited a 23 percent energy saving advantage over the masonry test structure.

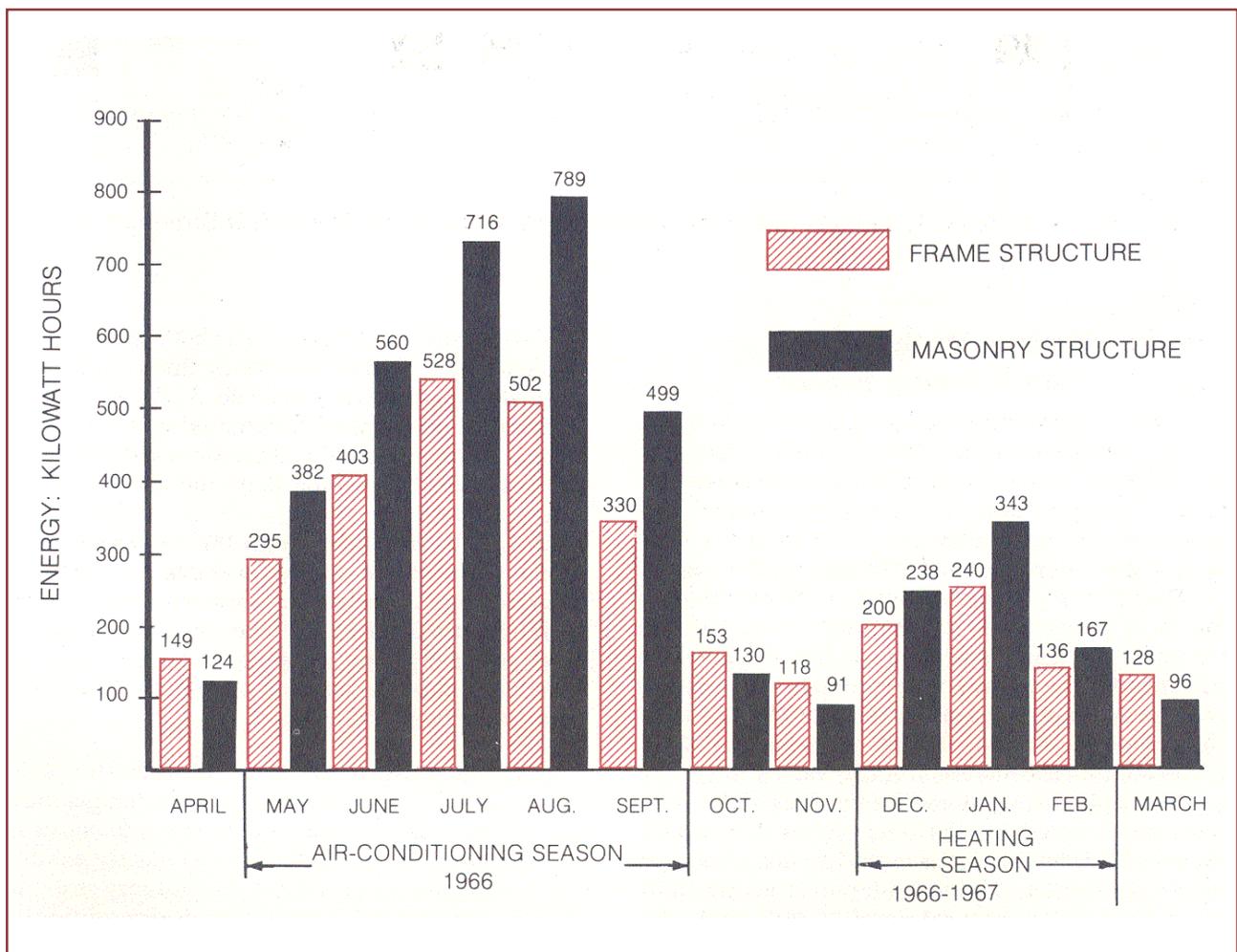


Figure 8—Monthly Power Consumption.

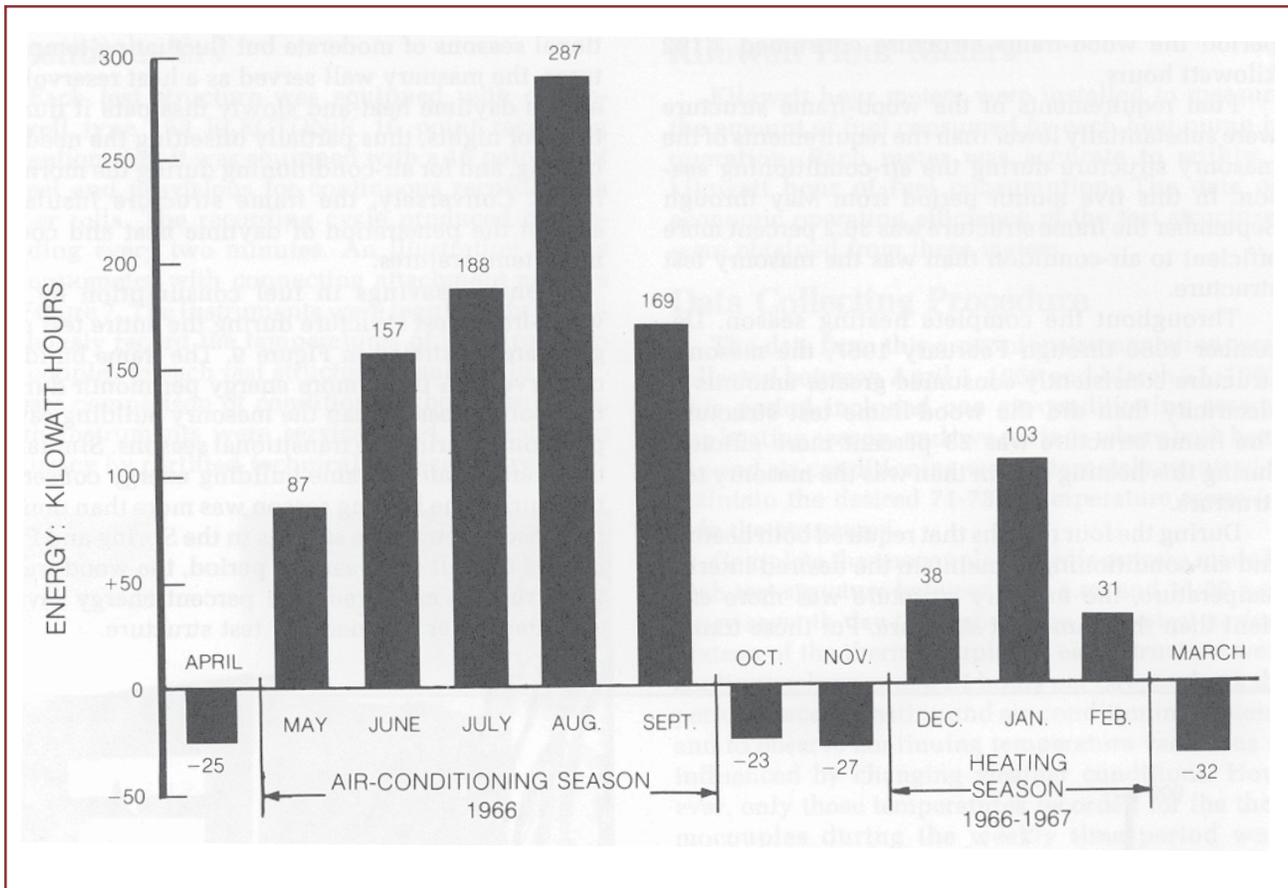


Figure 9—Monthly Savings in Energy Consumption by the Wood-Frame Test Structure.

Comfort Factors During the 1966 Air-Conditioning Season

Table 1 summarizes the key thermocouple temperatures recorded in the 1966 air-conditioning season. Figures in the table represent the average and range of temperatures of single thermocouples and groups of thermocouples computed from the total weekly measurements made throughout the season.

The interior control temperature, as recorded by the room center globe thermometer, indicated that the room air temperatures in the wood-frame and masonry test structures were accurately controlled within the design temperature range of 71°-73° F. The season average for the masonry structure was 72° F, while the frame structure average was 73° F.

Temperatures registered by the four globe thermometers situated near the room corners showed that the overall air temperatures in the two test structures were very similar. The wood-frame structure indicated an average temperature of 72.5° F while the masonry test structure indicated an average of 72° F.

Ceiling surface temperature in both test structures averaged 72° F, further indicating that a uniform air circulation pattern was produced. At the room center the vertical temperature differential was very small. In each structure only 3° F difference existed between the position 6" above the floor and the position 6" below the ceiling.

A review of the data from the recording potentiometers indicated the wood-frame test structure exhibited wall, floor and window temperatures very closely approximating the interior design temperatures, while in the masonry structure these temperatures were closer to exterior conditions. This is demonstrated by the following:

1. The walls of the masonry test structure exhibited higher interior surface temperatures than did the walls of the wood-frame structure. This 6.5°F differential clearly exhibits the heat gain through the masonry structure experienced during the air-conditioning season.

- Floor surface temperatures recorded at four positions indicated that the average floor temperature in the masonry structure was 2° F warmer than it was in the wood-frame test structure. Heat transmission through the concrete slab floor added to the air-conditioning requirements.
- The data from thermocouples installed on window frames in both buildings indicated no great

outside temperature difference between the aluminum and wood frames. During periods of sunlight, however, the aluminum frames displayed materially higher inside temperatures than the wood frames, as shown in Table 1. Since temperature recordings were made in the morning, the east wall was normally exposed to direct sunlight.

Table 1

AIR-CONDITIONING SEASON
Summary of Selected Thermocouple Temperatures

LOCATION OF THERMOCOUPLES IN THE TEST STRUCTURES	NUMBER OF THERMO- COUPLES INVOLVED	TEMPERATURE, DEGREES FAHRENHEIT			
		WOOD-FRAME STRUCTURE		MASONRY STRUCTURE	
		TEMPERATURE RANGE	AVERAGE TEMPERATURE	TEMPERATURE RANGE	AVERAGE TEMPERATURE
Globe Thermometer at Room Center (Control)	1	67-76	73	65-75	72
Globe Thermometer at Room Cor- ners	4	64-78	72.5	68-78	72
Exterior Surface of Walls at Center	3	61-108	80.5	65-108	83
Interior Surface of Walls at Center	3	62-75	69	68-82	75.5
Floor Surface Near Corners	4	68-75	72	66-80	74
Ceiling Surface Near Corners . . .	4	69-75	72	67-76	72
Thermocouple "Tree" at Room Center:					
Floor Surface	1	69-93*	76*	70-73	71
Six Inches Above Floor	1	65-82	74	67-80	73.5
5'6" Above Floor	1	67-76	73	65-75	72
Six Inches Below Ceiling	1	67-75	71	64-74	70.5
Ceiling Surface	1	66-74	71.5	68-73	70
Window Frames:					
East—Inside	1	79-87	82.5	96-117	100
East—Outside	1	89-128	113.5	92-127	113
North—Inside	1	71-81	76	68-83	75
North—Outside	1	72-91	81	70-88	79.5
Outside Air Temperature at Test Structure—(Morning only) . . .	1	73-102	87	73-102	87

*—This extreme floor temperature was a result of exposure to direct sunlight.

**Comfort Factors During the
1966-67 Heating Season**

Table 2 presents the temperature data obtained in both test structures during the 1966-67 heating season. Figures in the table represent the average and range of temperatures of single thermocouples and groups of thermocouples computed from the weekly measurements made throughout the heating season.

The controlled room temperature in the two buildings averaged 72.5°F and 73°F as indicated by the room-center globe thermometers. Air temperatures at the room corners were very similar, but were slightly lower than those at room center. These averages varied by 0.5°F between the two test structures. The average ceiling surface temperature in both test structures during the 1966-67 heating season was 70°F. The vertical temperature gradient measured at the room

center thermocouple tree was only 2°F in both structures.

During the three month heating period, December 1966 through February 1967, the data indicated relative performance similar to that during the air-conditioning season. A review of the potentiometer recordings indicated the following:

1. The walls of the wood-frame test structure had warmer interior surface temperatures than did the walls of the masonry structure. This 4.5°F differential demonstrates the superior insulation properties of the wood-frame structure.

2. The floor surface temperatures in the wood-frame structure averaged 2°F warmer than in the masonry building.
3. The inside temperature of the north window frame indicated the wood frame was 11.5° F warmer than the corresponding position on the aluminum window frame of the masonry test structure. Similar averages of the inside surface temperatures of the east window frames indicated that exposure to direct sunlight in the morning hours had provided an increase in temperature on the inside surface of this window frame.

Table 2

HEATING SEASON
Summary of Selected Thermocouple Temperatures

LOCATION OF THERMOCOUPLES IN THE TEST STRUCTURES	OF THERMO- COUPLES INVOLVED	TEMPERATURE, DEGREES FAHRENHEIT			
		WOOD-FRAME STRUCTURE		MASONRY STRUCTURE	
		TEMPERATURE RANGE	AVERAGE TEMPERATURE	TEMPERATURE RANGE	AVERAGE TEMPERATURE
Globe Thermometer at Room Center (Control)	1	70-76	73	70-76	72.5
Globe Thermometer at Room Cor- ners	4	69-73	71	63-72	70.5
Exterior Surface of Walls at Center	3	26-58	37	27-59	38
Interior Surface of Walls at Center	3	60-70	65.5	52-71	61
Floor Surface Near Corners	4	66-76	69	63-70	67
Ceiling Surface Near Corners	4	67-73	70	67-71	70
Thermocouple "Tree" at Room Center:					
Floor Surface	1	68-71	68.5	68-70	69
Six Inches Above Floor	1	68-74	71	68-75	71.5
5'6" Above Floor	1	70-76	73	70-76	72.5
Six Inches Below Ceiling	1	70-74	72.5	70-79	74.5
Ceiling Surface	1	70-73	70.5	69-73	71
Window Frames:					
East—Inside	1	54-67	62	54-68	63
East—Outside	1	39-64	54.5	49-64	59
North—Inside	1	60-68	65.5	49-61	54
North—Outside	1	37-55	43	35-55	44
Outside Air Temperature at Test Structure (Morning only)	1	23-57	39.5	23-57	39.5

SUMMARY

The energy conservation potential of two test structures in the extreme Arizona climate was compared in this study. Insulated wood-frame construction proved its value, over the 12 month test period, by re-

quiring 23 percent less energy than needed for the masonry structure. During the hot summer months, energy consumption in the frame structure was 30 percent less than in the insulated masonry building. And in the relatively mild Arizona winter, the wood-frame structure consumed 23 percent less energy.

POSTSCRIPT

The Beltsville, Maryland study was conducted in 1960-61 and the Tempe, Arizona study in 1966-67, when heating and air-conditioning energy was relatively inexpensive and the standard for “good” insulation in much of the country was 2" batts in wood-frame walls. A good many buildings at that time were constructed without any added insulation.

The greatly increased cost of energy in the '70's and the potential for energy shortages have changed the standard by which insulating performance is judged. “Good” insulation now involves insulation equivalent to batts completely filling the 3 1/2" stud spaces in a wood-frame wall, plus comparable insulation for ceilings, floors and other building elements.

If the Tempe or Beltsville studies had been conducted under current standards for wood-frame insulation, even greater savings of energy could have been demonstrated.

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