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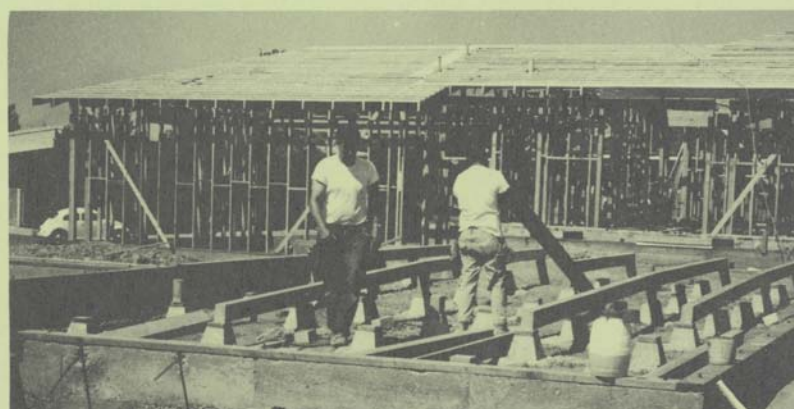
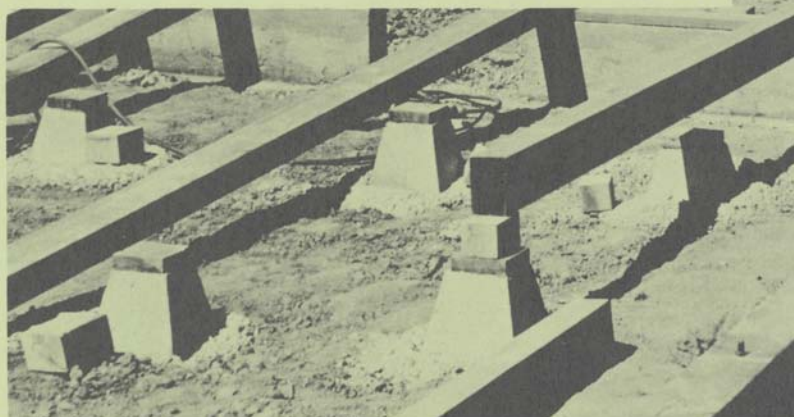
PACIFIC SOUTHWEST Forest and Range Experiment Station



FLOOR FOUNDATIONS: preferences of architects and builders in six Southwestern United States markets

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In a typical single-family home in the United States, the volume of wood products used in its construction can vary by as much as 3,000 feet per house—depending on the type of floor foundation selected. Because of this importance of floor design, the Forest Service has been evaluating the design trends and market preferences that affect the types of floor foundations. In an earlier report (Harpole and Dickerhoof 1971), we summarized results of one phase of the study—the preferences and attitudes of new home buyers in six Southwestern United States markets among three types of floor foundations: (a) concrete slab, (b) wood crawl-space, and (c) a new design that combines a low-profile wood floor with underfloor plenum.

This paper reports another phase of the study, in the same six markets. Builders and architects were asked about their preferences between concrete slab and wood crawl-space construction, and for their opinions about the new plenum design.

The six markets selected were considered representative of the many housing markets in the Southwest. They were the counties in which these cities are located: in California—Fresno, Los Angeles, Oakland-Martinez, Sacramento, and San Diego; in Arizona—Phoenix (fig. 1).

The number of architects was estimated on the basis of telephone directory listings found in each market (table 1). A representative sample was then drawn from this population. The number of builders

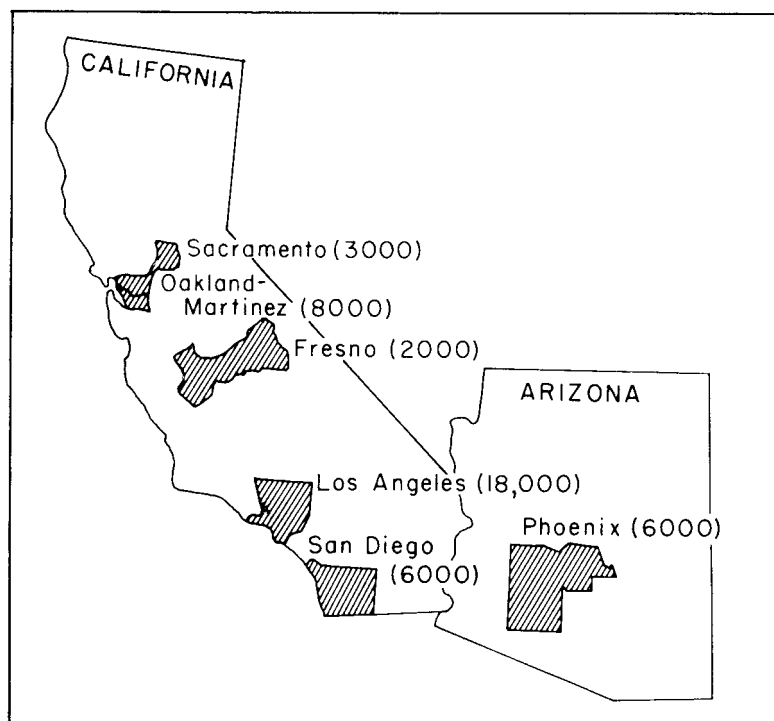


Figure 1—The six markets surveyed for preferences of architects and builders in floor construction consisted of one or more counties corresponding to the cities shown. Numbers in parenthesis (in thousands) show the average annual number of one-unit housing permits issued from 1963 through 1967.

Table 1—Population estimates, sample size, and sample responses of architects and builders surveyed in six South-western housing markets, 1969

Sample characteristics	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
Estimate of total populationNo.	397	557	65	266	30	77	358	1,100	90	380	108	146
Sample Size ... No.	40	68	33	33	15	14	36	58	27	46	32	26
Total number of responsesNo.	27	44	29	25	13	10	24	42	21	35	23	11
Responses of sample pct.	67	65	88	76	87	71	67	72	74	76	72	62
Respondents design-ing one-story SFRH ¹ No.	9	24	15	16	6	7	10	16	11	23	13	15
Respondents design-ing one-story SFRH ¹ pct.	23	35	45	48	40	50	28	28	41	50	41	58
Estimated popula-tions designing and/or building one-story SFRH No.	132	303	34	171	14	54	149	42	47	249	61	140

¹SFRH = Single-family residential homes.

was estimated on the basis of the membership listings of the Home Builders' Association in each market. Members of these associations were estimated to include about 35 percent of all new home builders in each market. We mailed nearly identical questionnaires to both architects and builders. Responses from architects ranged from a low of 67 percent in the Oakland-Martinez and Los Angeles markets to a high of 88 percent in Sacramento. Builder responses ranged from a low of 62 percent in Phoenix to a high of 76 percent in the Sacramento and San Diego markets.

We conducted follow-up telephone calls and personal interviews with both respondents and nonrespondents to identify any important market charac-

teristics that might have otherwise been overlooked in the mail questionnaires. Architects and builders who did only commercial work, or did not design or build one-story single-family homes were asked not to complete their questionnaires.

In the evaluation of questionnaires, the responses from each market were considered to be representative of the local distribution of preferences and opinions. Estimates of the prevalence of preferences and opinions in the Southwest were based upon the weighting of the different market responses by the estimated local populations of architects who designed and builders who built one-story single-family homes.

COMPARISONS OF FLOOR FOUNDATIONS

Architects and builders were asked to indicate the three most important advantages and three most important disadvantages that they associated with using concrete slab and wood crawl-space construction (*figs. 2,3*). Regardless of the type of floor system they preferred architects and builders generally agreed about what was important to consider when evaluating floor foundations (*tables 2, 3, 4, 5 in Appendix*).

Builders and architects commonly agreed that wood crawl-space floors offer better access to piping and were less tiring to walk on than concrete-slab floors. But they also frequently pointed out that steps were required to reach from outdoor ground levels to typical crawl-space floor levels, and that concrete-slab foundations could be constructed with lower material and labor costs. And they noted that it is easier to achieve a low ground-hugging appearance

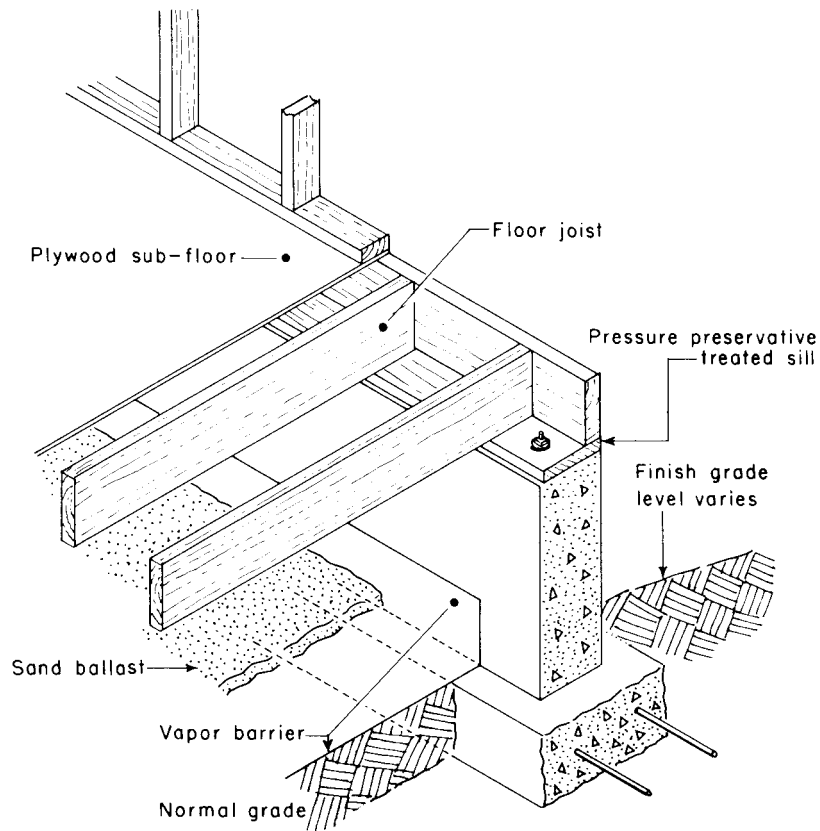


Figure 2—The crawl-space floor is the most common floor design used in the Southwest, where terrain and soil conditions present technical problems.

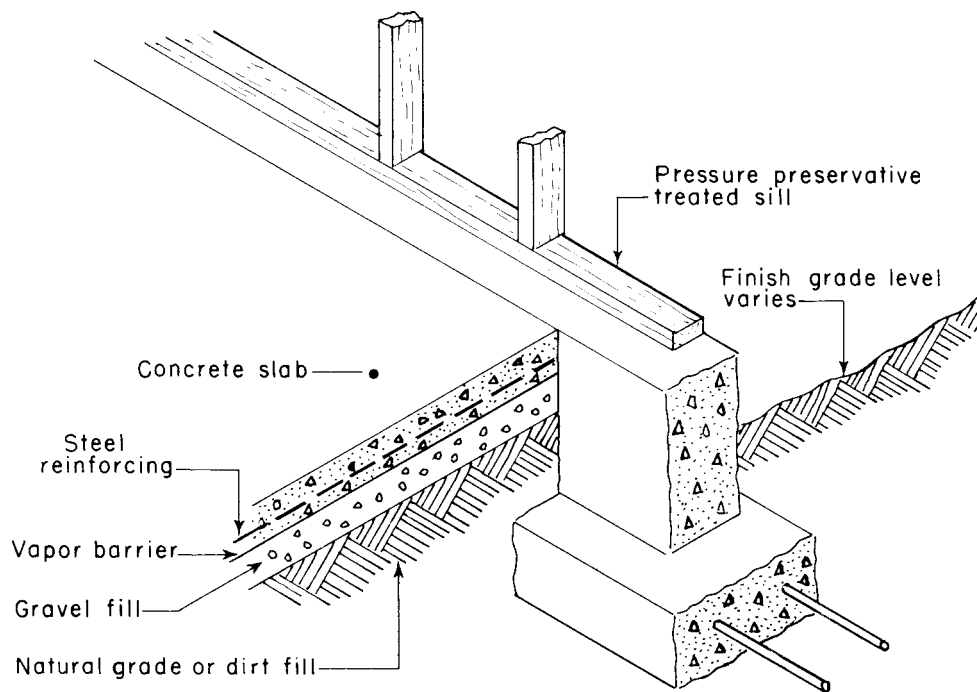


Figure 3—The concrete slab floor is often used in homes in the Southwestern United States.

with concrete-slab floors than with wood crawl-space floors.

Architects were more sensitive to design considerations than builders. They repeatedly cited crawl-space floors as advantageous for sloping sites—even in Phoenix, where all architects and builders preferred concrete-slab foundations. Architects indicated more

frequently than builders, that they thought crawl-space floors were warmer than concrete-slab floors, that concrete-slab floors could be a potential problem because of cracks, and that concrete-slab floors afforded better indoor-outdoor convenience. Architects and builders consistently indicated the importance of the cost of materials and labor in their evaluations of both floor types.

PREFERENCES AMONG ARCHITECTS AND BUILDERS

Architects' and builders' preferences for floor-foundation varied. Sacramento architects preferred crawl-space designs more often than the local builders (*table 6 in Appendix*). In Fresno, the situation was reversed; that is, builders preferred crawl-space designs more often than did architects. In Los Angeles, builders preferred concrete-slab floors more often than crawl-space floors. About 30 percent of the architects in that market indicated that they had no particular preference between either crawl-space or concrete-slab foundations.

In some markets, builders and architects were closely aligned in their preferences, although, preferences for either crawl-space or concrete-slab design varied from one market to another. In Phoenix, all builder and architect respondents preferred concrete-slab floors; but in the Oakland-Martinez market, both builders and architects strongly favored crawl-space designs. In comparing preferences in the Southwest among architects, builders, and new home buyers, we noted striking differences. In most of the six markets

we studied, the percentage of new home buyers who preferred crawl-space construction was higher than that of either the local builders or architects (Harpole and Dickerhoof 1971). This difference was conspicuous in Phoenix, where 19 percent of the new home buyers queried preferred a crawl-space floor foundation when all of the local architects and builders preferred concrete-slab foundations.

On the basis of preferences—for either crawl-space or concrete-slab designs—respondents were asked to indicate the three most important factors that influenced their choice (*tables 7,8 in Appendix*). Variations between markets in climate, topography, customs, and other nonstructural aspects appeared to influence the importance each respondent placed upon different structural considerations. Such factors as the local building traditions, the preferences of customers, the favorability of terrain and soil conditions, and the predictability of performance were typical of those most often cited as having influenced a final choice.

ATTITUDES TOWARD NEW DESIGN

The low-profile wood floor with underfloor plenum appears to be a good alternative to the concrete-slab and crawl-space floors (*figs. 4, 5*). An important advantage of this new type of construction is that it combines most of the characteristics cited as important either in crawl-space or in concrete-slab floors; that is, warm floors, adaptability to sloping sites, a close indoor-outdoor relationship, and low ground-hugging appearance. The underfloor area is used as a plenum to distribute conditioned air to each room in the house—eliminating the need for ductwork. The height of the plenum (height of the floor framing above the ground vapor barrier) can be varied to meet design preferences or building code requirements.

Floor framing does not have to differ from that normally used for wood crawl-space construction, although some experimentation has been done with floor framing and prefinished floor panels over a plenum only 4 inches deep (Stout 1960).

In 1966, the University of Florida in cooperation with the Forest Service began a study of plenum floor construction (Caldwell and Dickerhoof 1969). This test emphasized the use of a shallow (about 6 inches between the floor joists and ground level) plenum for heating and cooling with a wood floor and floor frame (*fig. 5*). The moisture content in the wood floor framing maintained a seasonal range between 6

Figure 4—The low-profile plenum floor uses a new method of cool and warm air distribution. The underfloor plenum provides an air supply. Underfloor ductwork is not necessary

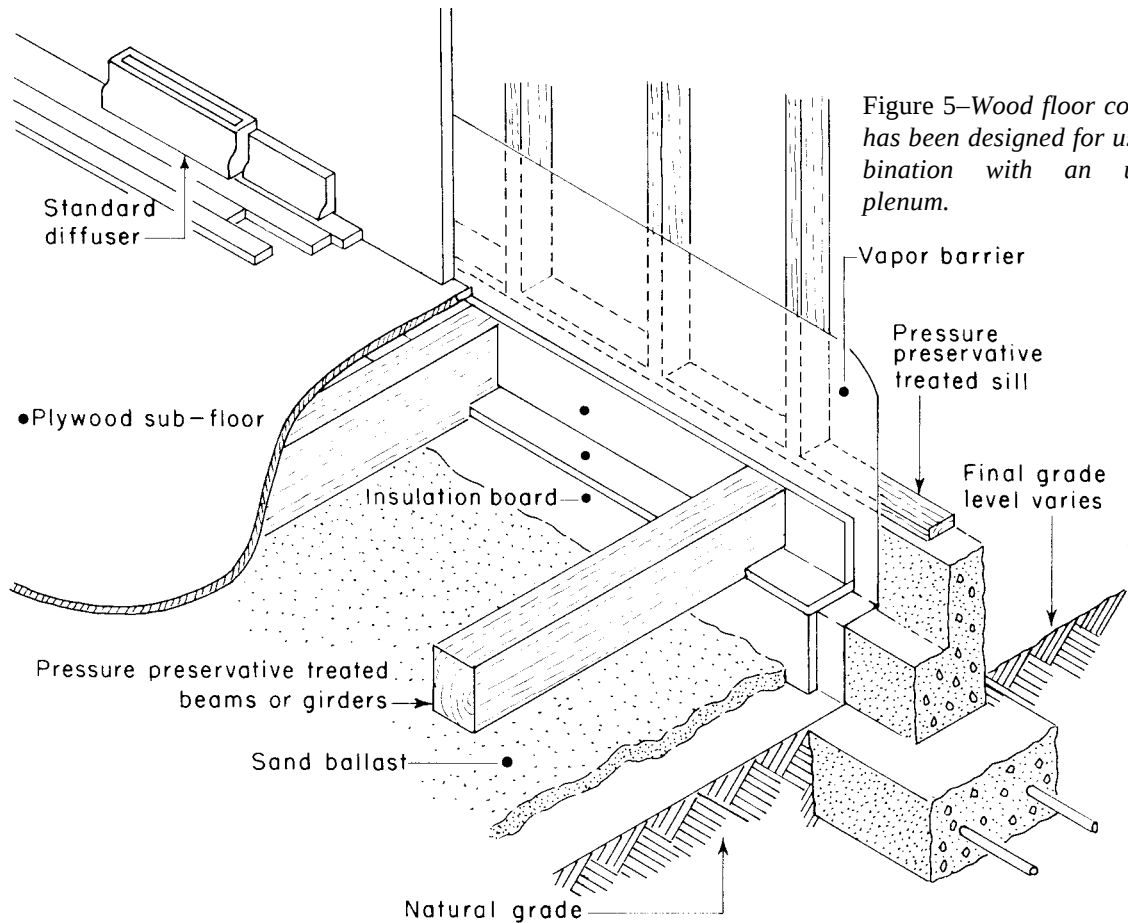
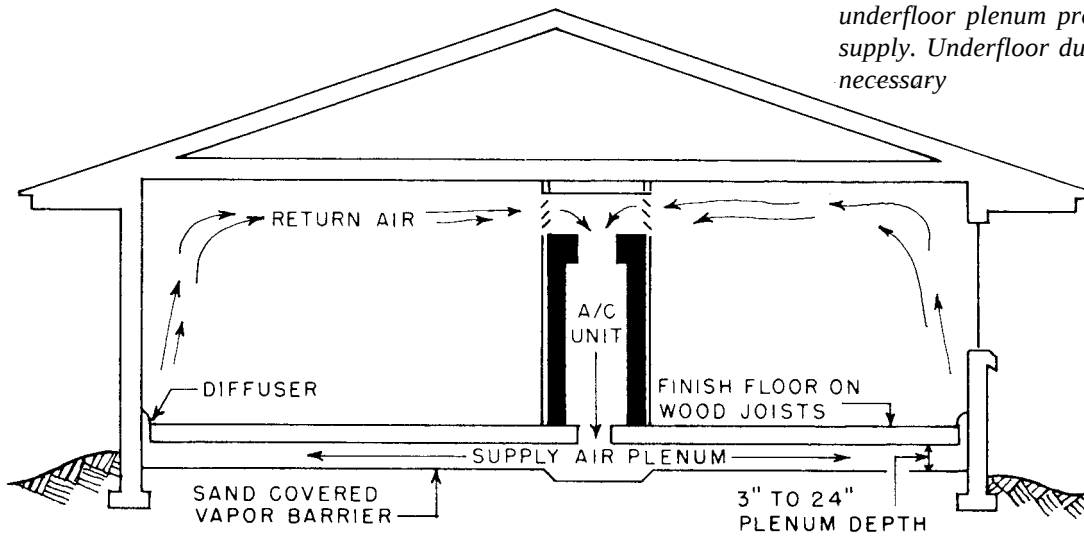


Figure 5—Wood floor construction has been designed for use in combination with an underfloor plenum.

and 13 percent—a desirable range (Fasick and Dickerhoof 1970; Miller and Wagner 1969). Continuous test observations suggest that the plenum design can maintain a desirable environment—even under different adverse conditions of hot, cold, and humid climates (Miller and Wagner 1969; Stout 1960; Talbot 1963).

In Fresno, we found that underfloor plenum design had been used in about 1,300 homes. Home owners who were contacted indicated that they thought this type of floor was especially superior in terms of underfoot comfort. Because conditioned air is in continuous contact with the underside of the floor, the floor itself becomes an agent of heat transfer—creating warm or cool floors with the underfoot resiliency typical of crawl-space floor construction. Some problems have been encountered in Fresno where sites with hard pan soil can create water drainage problems under and around some houses. But site evaluation is important to avoid problems that may occur—whether in crawl-space, concrete slab, or underfloor plenum design.

Most of the architects and builders we queried indicated that they were interested in the plenum floor design. Their interests were based upon their own expectations, preferences, and knowledge of their local markets. And as might be expected, some respondents in each area replied that they would not consider using the plenum even if it cost less than any of the designs they were now using. The importance

attributed to different factors varied, but the most frequent expectations cited as advantages of the plenum construction were warm floors, more efficient heating and cooling, low-profile appearance, and elimination of ductwork (*table 9 in Appendix*). Architects responded more often to the design factors than builders; these factors included warm floors and low profile appearance.

The principal reservations of builders and architects toward the plenum floor had to do with heating efficiency, cooling efficiency, and cost of construction (*table 10 in Appendix*). A related Forest Service study that estimated the costs of plenum, concrete-slab and crawl-space construction in 24 cities found that plenum construction would not cost as much as crawl-space construction and in most cities not as much as slab construction (Dickerhoof and Lawrence 1971). A major reason for this economy was the savings in ductwork. A typical cost estimate for the installation of insulated ductwork in a 1,680-square-foot house in the Southwest was \$425 in 1970.

In the study of new home buyers' attitudes and preferences, we found that more than 60 percent of the respondents said they would consider buying a house with an underfloor plenum even if it cost more than a house with concrete slab construction (Harpole and Dickerhoof 1971). More than 75 percent of the new home buyer respondents in Los Angeles, Oakland-Martinez, and Sacramento reported an interest in this type of floor design.

SUMMARY

Harpole, George B., and H. Edward Dickerhoof

1971. Floor foundations: preferences of architects and builders in six Southwestern United States markets. Berkeley, Calif., Pacific SW. Forest & Range Exp. Sta. 11 p., illus. (USDA Forest Serv. Res. Paper PSW-74).

Oxford.. 833.11-4079 .5):(79).

Retrieval Terms: floor foundations; builder preference; concrete slabs; wood frame with crawl space; wood floor (low-profile); Arizona; California.

The preferences and opinions of architects and builders among three types of floor foundations were studied in six markets in the Southwestern United States. The three types were (a) concrete slab, (b) wood crawl-space, and (c) a new design that combines a low profile wood floor with underfloor plenum. Questionnaires were mailed to a selected sample totaling 428 architects and builders in counties in

which these cities are located: in California—Fresno, Los Angeles, Oakland-Martinez, Sacramento, and San Diego; in Arizona—Phoenix. They were followed up by telephone calls and personal interviews.

Architects' and builders' preferences for crawl-space and concrete slab floors were found to vary among the six markets. The builders in the Fresno, Sacramento, and Oakland-Martinez markets indicated

strong preferences for crawl-space floors. Most of the architects in the Sacramento and Oakland-Martinez markets also preferred this type of design. But most of the architects in the Fresno, Los Angeles, San Diego, and Phoenix markets, and most of the builders in the Los Angeles, San Diego, and Phoenix markets preferred the concrete slab floors.

The crawl-space floor was often cited by architects and builders in all markets for a number of special advantages, such as adaptability to terrain, underfloor access, underfoot comfort and warmth, and attractiveness of hardwood floors when installed. Home builders and architects are aware of these advantages in crawl-space floors, but they are also aware of some disadvantages that they consider important. Crawl-space construction is commonly considered to be too costly, in most instances, to compete in cost-conscious markets. And many respondents did not like the design of crawl-space construction because of profile appearance and indoor-outdoor access. They often thought of it as more susceptible to termites and other insects.

Of the builders who preferred concrete-slab construction rather than crawl-space construction, the most frequently given reasons were that fewer "call backs" were expected, and it was the most commonly used type in the area. Another advantage often cited was the speed with which concrete construction could proceed where the terrain conditions were

favorable. Still other advantages mentioned were the relative low cost of labor and materials, and the indoor-outdoor convenience.

The disadvantages of using concrete-slab floors are apparently not serious, or they are disadvantages that can be overcome. Many builders and architects indicated that a concrete-slab is more tiring to walk on. But, by using carpets and padded underlayments over slabs builders are able to reduce potential customer complaints about underfoot discomfort and cold floors while at the same time offering a touch of luxury. Builders did not mention any customer complaints about carpet installation costs or future carpet maintenance or replacement costs. Nor does poor access to piping deter most architects or builders from using concrete-slab construction.

When the advantages and disadvantages of both the wood crawl-space and concrete-slab floors are weighed, the concrete-slab design appears to hold a commanding preference in those markets that have relatively more favorable terrain for this type of floor and are least affected by cold weather.

More than 60 percent of the architects and builders queried in this study replied that they would consider using the new underfloor plenum design. As with any new development, architects and builders have to be convinced that this type of floor is practical, is cost competitive, and is acceptable to new home buyers.

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APPENDIX: Survey Results

A sample of architects and builders in six markets surveyed in the Southwestern United States were asked about the . . .

- Advantages and disadvantages in using wood crawl-space floor foundation (*tables 2,3*).
- Advantages and disadvantages in using concrete-slab floor foundation (*tables 4, 5*).
- Preference between wood crawl-space floors and concrete-slab floors (*table 6*).

• What factors most often influence a preference for wood crawl-space floor or concrete-slab floor (*tables 7,8*).

• Advantages and disadvantages anticipated by respondents in using a low-profile wood floor with underfloor plenum (*tables 9, 10*).

Each person queried was asked to cite the most important advantages or disadvantages or the most important factors that affected their choice. The tables below list only the answers most often given.

Table 2—Advantages most often cited for using wood crawl-space construction

Advantages cited	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
	Percent													
Good for sloping site	89	67	85	68	64	16	100	44	91	83	62	35	88	57
Good access to piping	78	62	74	73	86	84	90	69	83	61	39	35	77	64
Warmer than concrete floors in winter	22	42	47	25	—	26	50	19	28	9	69	27	40	24
Less tiring to walk on compared with concrete slab	11	38	59	50	86	58	40	44	55	48	62	14	39	42
Attractive appearance of hardwood floors	—	12	—	25	—	—	10	12	—	26	8	14	5	16
All weather construction facilitated	22	12	6	12	14	100	20	12	—	9	—	6	14	15

¹ Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.

Table 3—Disadvantages most often cited for using wood crawl-space construction

Disadvantages cited	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
	Percent													
Higher labor or material cost of both	100	63	59	55	50	74	50	87	72	78	85	47	73	71
Difficult to achieve low ground-hugging appearance	56	46	59	73	50	26	100	63	55	56	39	27	69	54
Steps up from ground required	56	46	85	37	50	42	40	31	64	53	39	35	51	40
Termite threat	22	12	32	18	50	16	20	25	36	17	54	27	29	20
Difficult to heat	11	—	6	32	64	—	40	25	19	26	8	—	23	17
Insect threat		12	21	12	14	16	10	12	28	13	39	6	14	12

¹ Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.

Table 4—Advantages most often cited for using concrete-slab construction

Advantages cited	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
	<i>Percent</i>													
Low labor cost	89	41	47	37	—	58	30	50	36	53	85	61	57	49
Indoor-outdoor convenience	56	33	85	55	86	42	80	12	83	48	46	14	69	31
Low ground-hugging appearance	67	55	53	80	—	42	80	69	72	66	39	35	65	62
Low cost of concrete material	78	67	65	68	—	26	60	69	72	75	92	82	70	69
Predictability of performance	—	8	21	18	—	16	20	44	28	31	39	53	17	30
Absence of squeak and other floor generated noise	—	—	6	—	57	—	20	—	9	—	—	—	10	—

¹Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.

Table 5—Disadvantages most often cited for using concrete-slab construction

Disadvantages cited	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
Not good for sloping sites	100	62	59	62	64	16	100	37	83	92	39	47	85	56
Poor access to piping	67	62	65	55	50	58	60	50	64	39	46	35	61	50
Potential problem with cracks	45	—	32	32	36	16	40	56	28	34	62	47	43	34
More tiring to walk on	22	30	79	32	64	42	40	44	36	44	39	20	38	36
Cold floors	22	38	32	32	—	42	50	25	36	17	31	27	35	28
Difficult to construct in mud	—	12	—	18	14	42	—	12	—	22	—	20	1	17

¹Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.

Table 6—Preference for wood crawl-space or concrete-slab floor construction in new homes built or designed

Floor construction preferred	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
	<i>Percent</i>													
Crawl-space	77	88	79	55	14	84	30	19	19	26	—	—	42	41
Concrete slab	11	12	15	43	86	16	40	81	72	66	100	100	43	57
No preference	12	—	6	2	—	—	30	—	9	8	—	—	15	2

¹Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.

Table 7—Factors cited most often that influenced preference for wood crawl-space construction

Factors	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
	<i>Percent</i>													
Clients prefer crawl-space construction	73	90	81	97	100	50	67	100	—	65	—	—	69	87
Predictability of performance	73	43	41	32	100	19	33	32	—	35	—	—	55	37
Traditional to area	43	71	15	76	—	88	—	—	—	17	—	—	26	57
Favorable terrain and soil conditions	28	38	15	21	—	19	67	—	—	65	—	—	34	31
Familiarity with materials and construction	15	43	15	12	—	31	33	—	44	35	—	—	21	30
Speed of construction	15	10	—	—	—	50	33	32	—	—	—	—	16	13

¹ Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.

Table 8—Factors cited most often that influenced preference for concrete-slab construction

Factors	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
	<i>Percent</i>													
Few call backs required	—	31	—	27	—	100	25	85	—	60	—	—	8	56
Favorable terrain and soil conditions	—	—	40	27	58	100	51	8	—	33	69	40	44	22
Speed of installation	100	100	40	42	58	100	—	46	65	47	54	61	39	52
Traditional to the area	—	—	—	—	—	—	25	54	38	53	77	82	40	50
Better protection from termites	100	—	40	—	17	—	51	15	26	26	23	6	39	13
Clients prefer concrete-slab construction	—	—	—	27	42	—	76	—	—	19	15	14	32	9

¹ Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.

Table 9—Advantages *most often anticipated for using underfloor plenum construction*

Advantages expected	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
	<i>Percent</i>													
Warm floors	22	4	47	7	14	—	40	—	19	5	15	—	29	3
More efficient heating and cooling	33	25	38	7	36	—	10	19	55	31	23	20	27	21
Low profile appearance	33	8	21	7	14	16	10	—	19	9	—	—	18	5
Elimination of ductwork	11	29	38	19	14	16	10	6	19	5	8	6	14	13

¹ Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.

Table 10—Disadvantages *most often anticipated for using underfloor plenum construction*

Disadvantages expected	Market													
	Oak-Martinez		Sacramento		Fresno		Los Angeles		San Diego		Phoenix		Southwest ¹	
	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr	Arch	Bldr
	<i>Percent</i>													
Reservation on cost	11	12	6	12	14	—	40	31	36	17	46	41	28	22
Question heating and cooling efficiency	23	17	26	12	—	—	10	12	28	17	39	—	21	12
Local building codes	—	8	21	12	14	32	20	6	—	17	—	6	9	10
Poor access to underfloor area	23	8	12	—	—	—	—	—	9	13	—	—	9	4

¹ Based on estimated market populations of architects and builders designing and/or building one-story single-family residential homes.



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The Pacific Southwest Forest and Range Experiment Station

represents the research branch of the Forest Service in California and Hawaii.

Harpole, George B., and H. Edward Dickerhoof 1971. Floor foundations: preferences of architects and builders in six Southwestern United States markets. Berkeley, Calif., Pacific SW. Forest & Range Exp. Sta., 11 p., illus. (USDA Forest Serv. Res. Paper PSW-74) Mail questionnaires and follow-up interviews were used to determine preferences among three types of floor foundations: concrete slab, wood crawl-space, and a new design that combines a low-profile wood floor with underfloor plenum. Crawl-space construction was preferred in the Sacramento and Oakland-Martinez markets; concrete slab was preferred in the Los Angeles, San Diego, and Phoenix markets. Preference was about evenly divided in the Fresno market. More than 60 percent of the respondents would consider the new underfloor plenum design. <i>Oxford:</i> 833 .11 –(079 .5): (79). <i>Retrieval Terms:</i> floor foundations; builder preference; concrete slabs; wood frame with crawl space; wood floor (low-profile); Arizona; California.	Harpole, George B., and H. Edward Dickerhoof 1971. Floor foundations: preferences of architects and builders in six Southwestern United States markets. Berkeley, Calif., Pacific SW. Forest & Range Exp. Sta., 11 p., illus. (USDA Forest Serv. Res. Paper PSW-74) Mail questionnaires and follow-up interviews were used to determine preferences among three types of floor foundations: concrete slab, wood crawl-space, and a new design that combines a low-profile wood floor with underfloor plenum. Crawl-space construction was preferred in the Sacramento and Oakland-Martinez markets; concrete slab was preferred in the Los Angeles, San Diego, and Phoenix markets. Preference was about evenly divided in the Fresno market. More than 60 percent of the respondents would consider the new underfloor plenum design. <i>Oxford:</i> 833 .11 –(079 .5): (79). <i>Retrieval Terms:</i> floor foundations; builder preference; concrete slabs; wood frame with crawl space; wood floor (low-profile); Arizona; California.
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