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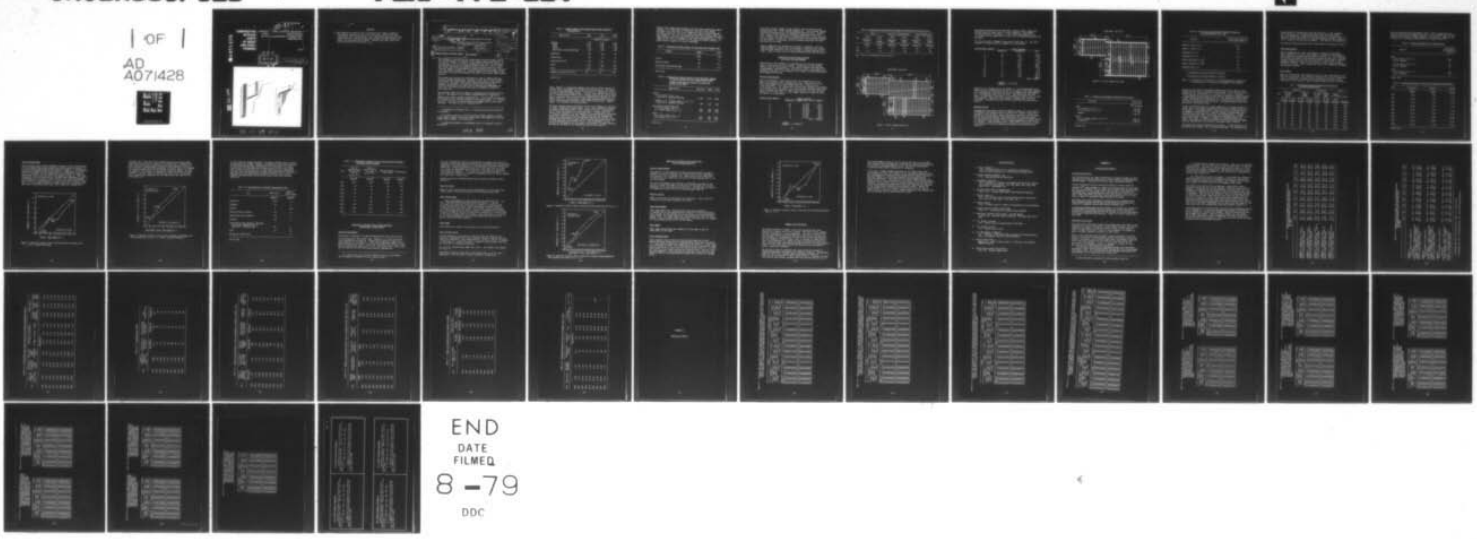

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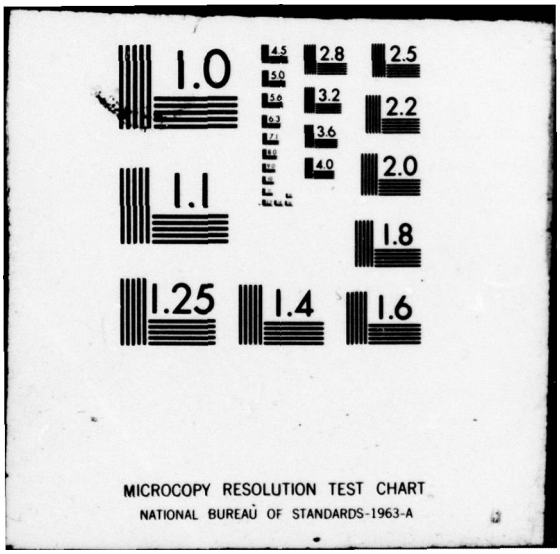
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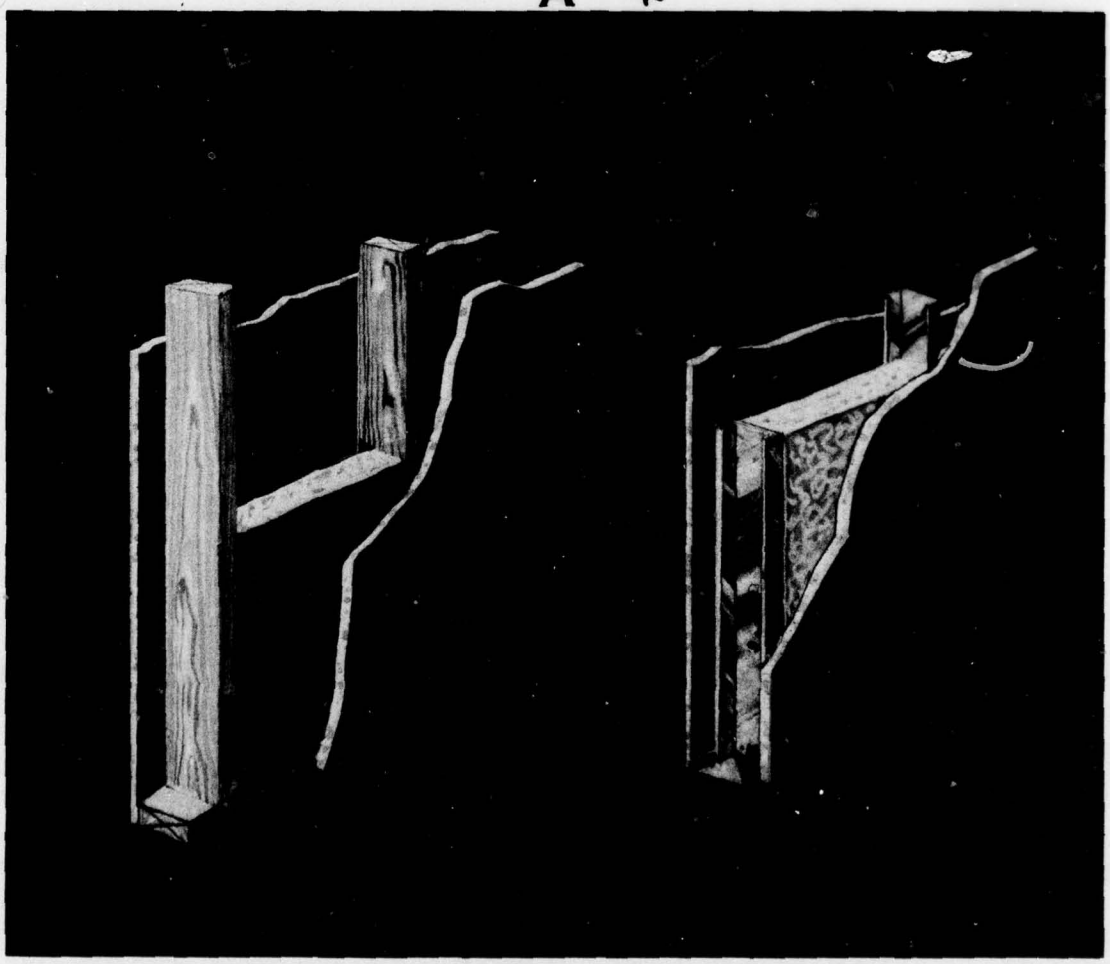
COMPARATIVE IN-PLACE COSTS OF WOOD AND STEEL FRAMING

RESEARCH PAPER FPL 334

FOREST PRODUCTS LABORATORY
FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
MADISON, WIS.

1979



Abstract

The comparative in-place costs of wood and steel light residential framing were examined for the period 1970-1978. Material and labor requirements were calculated for floor, nonload-bearing partition, and load-bearing wall framing systems using Douglas-fir and southern pine lumber, and galvanized steel shapes. Material and labor costs were those prevailing in the Chicago area.

(6) COMPARATIVE IN-PLACE COSTS OF WOOD AND STEEL FRAMING

By

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U.S. Department of Agriculture

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(9) Forest Service research paper,

Introduction

New residential construction has traditionally been the largest market for softwood lumber, and framing is the biggest single application. As the figures in table 1 indicate, framing uses have grown in importance proportionately as other residential markets were lost. Use of lumber for siding, sheathing, and subflooring has declined drastically since 1959 due largely to displacement by softwood plywood whose lower in-place cost made lumber uneconomical. Softwood lumber use for framing, on the other hand, has declined moderately and remains the premier light-framing material.

This market position was not maintained for lack of competition from suitable framing alternatives. Concrete, in the form of cast-in-place floor slabs, and cinder blocks maintained large shares of the market, primarily in the South. The use of concrete slab flooring has expanded considerably since World War II because the displacement of coal by oil for heating reduced the need for basements in which to store bulk fuel.

More economic application of lumber for framing also contributed to the decline. The advent of roof trusses enabled builders to space roof members more widely, thereby saving material. Floor joist[2/] spacing too has widened as more builders switched to 24-inch on center (o.c.) spacing from the traditional 16 inches because the plywood glued to the joists increases stiffness by up to 70 percent (1).[3/]

1/ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

2/ A joist is one of a series of parallel beams, usually 2 inches thick, used to support floor and ceiling loads, and supported in turn by larger beams, girders, or bearing walls.

3/ Underlined numbers in parentheses refer to literature cited in this report.

Table 1.--Lumber usage in new single-family homes inspected by the F.H.A.

Application	1959	1962	1968
	- - - - fbm/ft^2 of floor - - - -		
Framing	5.50	5.55	5.03
Roofs	2.11	2.05	1.78
Walls	1.24	1.33	1.22
Floors	.92	.94	.90
Partitions (nonload-bearing)	1.23	1.23	1.13
Sheathing	.86	.50	.33
Subflooring	.60	.46	.37
Millwork and trim	1.33	1.32	1.31
Other	.94	.92	.34
Total	9.23	8.75	7.38
Framing as percent of total	60	63	68

Source (5).

Steel, however, is potentially lumber's most serious threat because of similar labor requirements and performance characteristics. But steel to date has had negligible success in carving out a significant niche in the new residential framing market. In 1974, steel and bar truss joists had a 1-percent market share in floor framing versus 58 percent for wood and a 0.3-percent share in exterior wall framing versus 88 percent for lumber (table 2). In partitions, steel studs captured almost 3 percent due to some marketing successes in multifamily construction. However, lumber still retained a 97 percent share.

Two major reasons explain the failure of the steel industry to penetrate the light residential framing market. First, steel marketing is geared to handle large-volume orders. Steel sheets are sold to rolling mills which convert the product to joists and studs. In many cases, the rolling mills themselves do the remainder of the marketing by delivering the product directly to the user. These operations can economically handle only large orders with considerable lead time for delivery (3). Although some distribution yards carry light-gage structural steel, most building suppliers and retailers do not. This arrangement all but places steel framing out of the reach of the 25,000 or so small builders who make up the bulk of the residential construction industry.

Second, steel framing has generally cost more than conventional lumber framing. In a 1970 study of comparative in-place costs, Gerald Koenigshof (3) found steel to be competitive only in nonload-bearing partitions (table 3). For floor joists and exterior walls, lumber was less expensive. By 1972, the comparisons were less favorable to wood as lumber prices soared in response to all-time high housing starts. But lumber prices fell in 1974 and, as the figures in table 2 indicate, steel failed to exploit its earlier advantage.

Table 2.--Residential market shares of wood and steel framing--1974

Market	Lumber	Steel
	Pct	Pct
Floors	58	1.0
Exterior walls	88	0.3
Partitions (nonload-bearing)	97	2.8

Source (2).

Table 3.--Comparative in-place costs of wood and steel framing in Chicago during 1970 for large purchases made directly from the mill (dol/ft^2 of floor and dol/lin ft of wall)

Application	Material	Labor	Total
Floors			
2 x 10 joists, 24 in. o.c. with 3/4-in. plywood flooring	0.387	0.112	0.499
Nominal 2 x 8, 18-gage joists, 24 in. o.c., with 3/4-in. plywood flooring	.499	.106	.605
Partitions (nonload-bearing)			
2 x 4 wood studs, 24 in. o.c.	.697	.698	1.395
2 x 4 steel studs, 24 in. o.c.	.649	.333	.982
Walls			
2 x 4 wood studs, 24 in. o.c.	.872	.745	1.617
Steel studs, 24 in. o.c.	1.302	.560	1.867

Source (3).

This paper examines changes in the in-place costs of wood and steel framing since 1970. Three systems examined are: floor framing systems, nonload-bearing partitions, and load-bearing exterior walls. In-place costs vary by region because of different transportation and labor costs. However, for the purpose of showing the trend, any one location will do because the impact of inflation has been fairly uniform throughout the country. Accordingly, prices and wages prevailing in Chicago were used in this study.

Table 4 summarizes the findings of the study. In general, the cost competitiveness of lumber and steel framing in 1978 was little changed from 1970 when lumber was less costly except in nonload-bearing partitions. (Data in table 4 are for large purchases direct from the mills.)

Comparative In-Place Costs of Wood and Steel Flooring Systems

This portion of the analysis is concerned with the relative in-place costs of wood and steel floor framing. The spacing of the framing, however, affects the thickness of the plywood flooring with the wider-spaced members requiring thicker, more costly panels. Accordingly, the estimated costs are for the complete floor system, including the plywood underlayment/subflooring.

Material Requirements

Material requirements vary with the size and configuration of the home, joist spacing, floor irregularities, etc. The particular plan used by Koenigshof and in this study called for a floor area of 1,047 square feet. With conventional front-to-rear framing using nominal 2- by 8-inch joists, 16 inches o.c., with blocking only under partitions and no bridging, the amount of lumber required was 1.56 board feet per square foot of floor (fig. 1). The lumber required to frame the floor in figure 1 is listed below.

Circled item, figure 1	Lumber required		
	(Quantity)	Length (all 2 x 8's)	(Fbm)
1	10	4 foot	53.3
2	68	14 foot	1,269.6
3	5	10 foot	66.6
4	3	10 foot	40.0
5	2	12 foot	32.0
6	4	16 foot	85.3
7	3	14 foot	56.0
8	2	12 foot	32.0
		Total	1,634.8

$$\frac{1,634.8}{1,047.0} = 1.56 \text{ fbm/ft}^2$$

Table 4.--In-place costs of wood and steel framing in 1970 and 1978 (all for 24 in. o.c.)

Year	Floors		Partitions (nonload-bearing)		Walls (load-bearing)	
	Wood	Steel	Wood	Steel	Wood	Steel
	Douglas-fir 2 x 10	2 x 8 18 gage	Douglas-fir studs	26 gage studs	Douglas-fir studs	20 gage studs
	Dol/ft^2	Dol/ft^2	Dol/lin ft	Dol/lin ft	Dol/lin ft	Dol/lin ft
1970	0.51	0.60	1.41	0.98	1.64	1.86
1978	1.13	1.24	3.02	1.89	3.56	3.60

Note: Data for large purchases direct from mills.

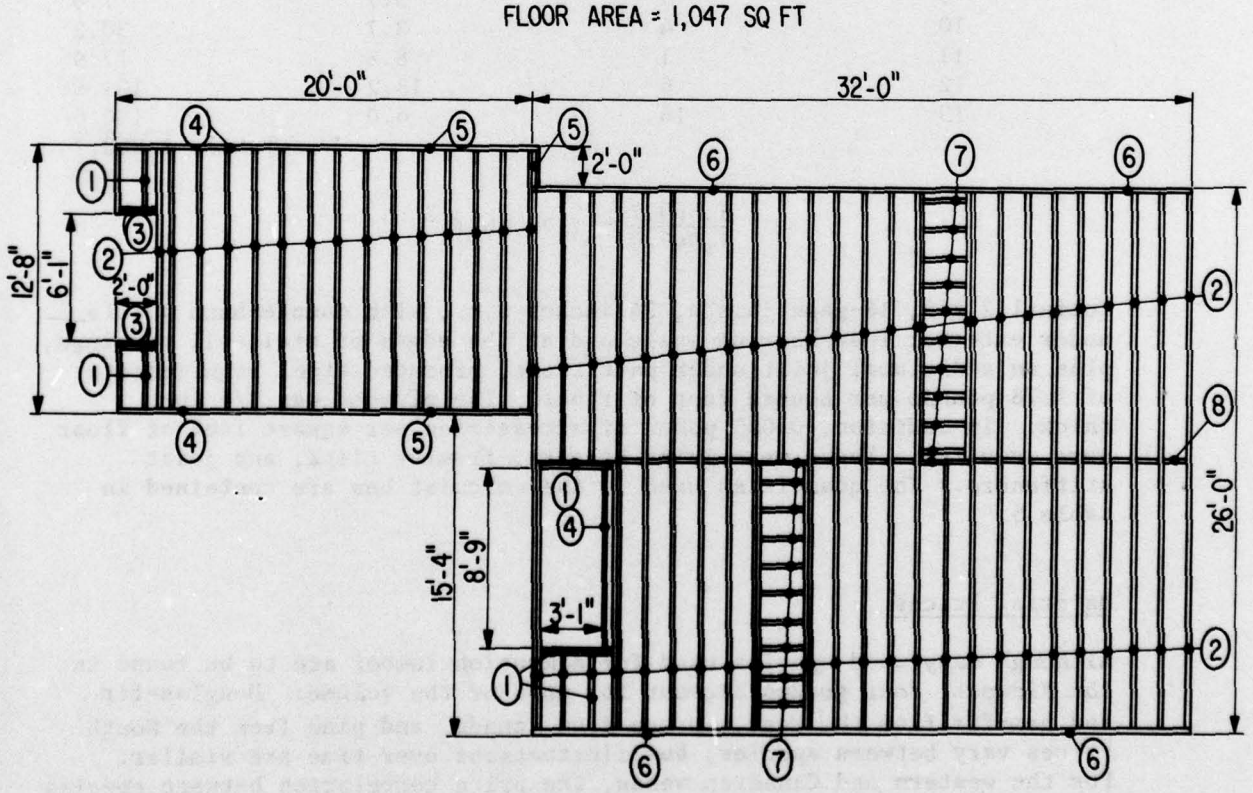

Figure 1.--Floor framed with wood.

The plywood required was 5/8 inch thick, exterior grade, tongue and grooved along two edges, with a C grade crossband. With nominal 2-x 10-inch joists, 24 inches o.c., the lumber requirement fell to 1.25 board feet per square foot of floor, but 3/4-inch-thick plywood was necessary.

The floor plan was "reframed" using steel joists (fig. 2). The steel required to frame the floor in figure 2 is listed below.

Circled item, figure 2	Steel required		
	(Quantity)	(Length-ft)	(Lb)
1	10	12.3	250.9
2	2	3.1	12.6
3	2	1.9	7.8
4	4	20.0	163.2
5	2	1.9	7.8
6	15	25.7	786.5
7	4	32.0	261.1
8	1	12.7	25.9
9	1	3.7	7.6
10	4	3.7	30.2
11	1	8.8	17.9
12	6	13.2	161.6
13	16	4.0	130.6
		Total	1,863.7

$$\frac{1,863.7}{1,047.0} = 1.78 \text{ lb/ft}^2$$

Nominal 2 x 8, 18-gage joists, 24 inches o.c., with double-band joists under exterior load-bearing walls and at the edges of stairwell openings, plus an additional joist under partitions, produced steel requirements of 1.78 pounds per square foot of floor. The plywood was 3/4 inch thick. In addition, 0.095 pound of accessories per square foot of floor were required. These were joist hangers, framing clips, and joist stiffeners. The quantities used in the calculations are contained in table 5.

Material Prices

Although many wood species used for dimension lumber are to be found in the Midwest, four groups account for most of the volume: Douglas-fir and hem-fir from the West, spruce from Canada, and pine from the South. Prices vary between species, but fluctuations over time are similar. For the western and Canadian woods, the price correlation between species is especially strong because of their common dependency on the eastern U.S. markets. Since southern pine is used mainly in the South, it does not necessarily follow the same price patterns as the western woods (table 6).

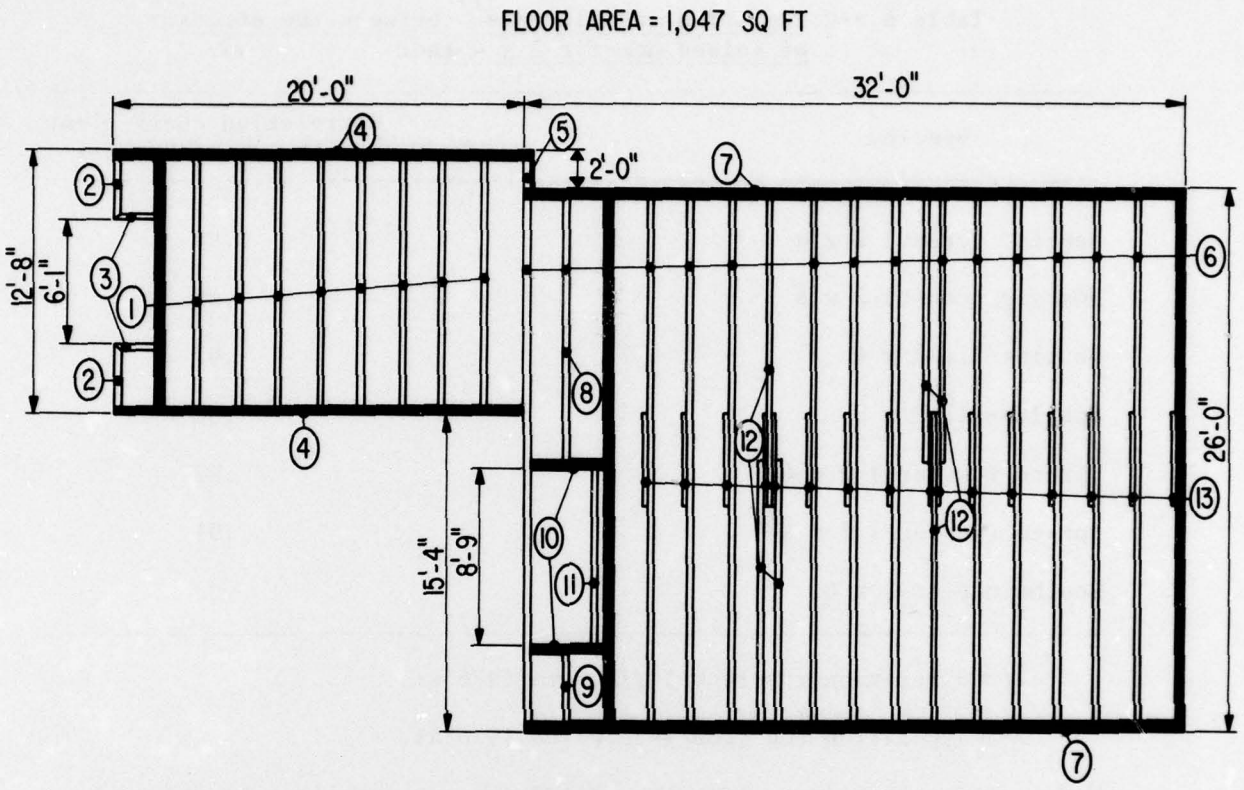

Figure 2.--Floor framed with steel.

Table 5.--Material requirement coefficients for floors

Material	Coefficient
	Ft^2 of floor
Wood	
2 x 8 joists, 16 in. o.c.	1.55 fbm
2 x 10 joists, 24 in. o.c.	1.25 fbm
Plywood	1.06 ft^2
Steel	
2 x 8, 18-gage joists, 24 in. o.c.	1.85 lb
Accessories	0.095 lb

Source (3).

Table 6.--Correlation coefficients[1/] between the prices of inland hem-fir 2 x 4 and:

Species	Correlation coefficient with inland hem-fir
Hem-fir (coast) 2 x 4	0.99
Hem-fir (coast) 2 x 8	.98
Douglas-fir 2 x 4	.97
Douglas-fir 2 x 8	.96
Spruce (western) 2 x 4[2/]	.97
Spruce (western) 2 x 8[2/]	.91
Southern pine 2 x 4	.83

1/ Correlation run from 1971:04 to 1976:41.

2/ Correlation run from 1973:01 to 1976:41.

Note: A correlation coefficient of 1.0 indicates perfect correlation, a coefficient of 0.0 indicates no systematic relationship.

Because of the stable relationships between the western species, only Douglas-fir was used to represent western woods. F.o.b. mill prices for kiln-dried, No. 2 and Better, 2- x 8-inch 12-foot and 2- x 10-inch 12-foot Douglas-fir were used in this study as reported by Random Lengths, a weekly price reporting publication (6). For comparison with southern lumber, kiln-dried, No. 2 and Better, 2- x 8-inch 12-foot southern pine was used as reported by the same source. The plywood species were also Douglas-fir and southern pine.

To get the delivered prices of these commodities, a freight charge was added. Most of the lumber originating from the West arrives by rail in the Midwest. For southern woods, a large (52 pct) and growing portion of shipments is made by truck. However, because of unavailable data, delivery costs were based only on railroad transportation. Freight rates from Portland, Oreg., to Chicago, and from Hattiesburg, Miss., to Chicago were used. In addition, a markup for handling charges was added. The markup is usually 10 percent if the builder buys the lumber directly from the mill; 15 percent if purchased from a retailer.

Delivered steel prices consisted of five parts: (1) The base price for galvanized steel sheets, (2) a thickness adjustment, (3) transportation

charge based on a 50-mile haul from the fabricator to the finishing mill, (4) the cost of converting the sheet into joists and studs, (5) the shipping cost of the final product based on a 100-mile haul. In addition, if the steel studs or joists were marketed through a distributor, a markup of 25 percent was assumed. (For details, see appendix A.)

The delivered material prices used in the study are contained in table 7.

Labor Requirements

Table 8 summarizes the labor requirements calculated by Koenigshof. These estimates were used in this analysis. Implied is the assumption that productivity stayed constant between 1970 and 1978. This is plausible because the same on-site method of assembly was assumed. Aggregate industry productivity may have increased due to greater use of preassembled components, such as floor trusses or walls, which are merely erected on the site. These innovations are not yet widespread throughout the industry, however.

Labor Wages

Wages of construction labor depend on levels of skill and whether or not the crew is unionized. In residential construction, the use of nonunion crews is widespread, although less in the Chicago area than in most other parts of the country. Data on nonunion wages were not available,

Table 7.--Delivered material prices calculated for the Chicago area for direct purchases from mill

Year	Douglas-fir				Southern pine		Steel	
	Kiln dried No. 2 and Better		CD exterior underlayment		Kiln dried no. 2 and Better	CD exterior underlayment	Nominal 2 x 8-18 gage	Fasteners
	2 x 8-12	2 x 10-12	5/8 inch	3/4 inch	2 x 8-12	5/8 inch	Joists	
	Dol/Mfbm	Dol/Mfbm	Dol/Mfbm	Dol/Mfbm	Dol/Mfbm	Dol/Mfbm	Dol/100 lb	Dol/100 lb
1970	147	159	162	183	126	148	14.70	25.00
1971	181	191	185	211	158	169	15.60	26.00
1972	212	225	241	267	174	210	16.50	27.60
1973	253	276	249	288	202	222	16.60	28.30
1974	245	269	241	276	188	215	20.80	35.30
1975	249	252	259	296	179	222	24.90	40.40
1976	287	318	308	359	229	277	26.40	43.50
1977	338	364	361	420	277	333	28.50	47.10
1978	367	377	395	435	323	349	29.90	49.50

hence the calculations were based on union scales as reported by the National Association of Homebuilders (4). It was assumed that the labor would be divided evenly between carpenters and laborers. Wages in the Chicago area, including fringe benefits, are shown in table 9.

Table 8.--Labor requirements for framing floors

Material	Man-minutes per square foot of floor
Wood	
2 x 8 joists, 16 in. o.c.	0.70
5/8-in. plywood	.45
2 x 10 joists, 24 in. o.c.	.55
3/4-in. plywood	.35
Steel	
2 x 8 joists, 24 in. o.c.	.50
3/4-in. plywood	.35

Source (3)

Table 9.--Construction wages in Chicago (including fringe benefits)

Year	Carpenters	Laborers	Average
	Dol/h	Dol/h	Dol/h
1970	7.95	7.00	7.47
1971	8.90	7.30	8.10
1972	9.83	7.75	8.79
1973	10.28	8.02	9.15
1974	10.83	8.50	9.67
1975	11.43	8.92	10.18
1976	12.35	9.63	10.99
1977	13.15	10.30	11.73
1978	14.46	11.33	12.90

Source (4).

Total In-Place Costs

Total in-place costs of floor framing in Chicago in 1978 varied between $1.12 per square foot using southern pine joists spaced 16 inches o.c. to $1.24 using 18-gage steel joists spaced 24 inches o.c. (for materials purchased in volume directly from the mills). Comparisons of floors with 2 x 10 Douglas-fir and 18-gage steel joists spaced 24 inches o.c. showed that only in 1973 was steel less expensive (fig. 3). There was an apparent trend favoring steel as the 18-percent advantage for wood in 1970 dropped to 10 percent by 1978. However, this may be misleading because 1970 was a depressed year for wood prices while 1978 was a boom year. On the average, Dougalas-fir lumber costs were 10 percent lower than steel, and southern pine lower still (tables B-1 through B-4).

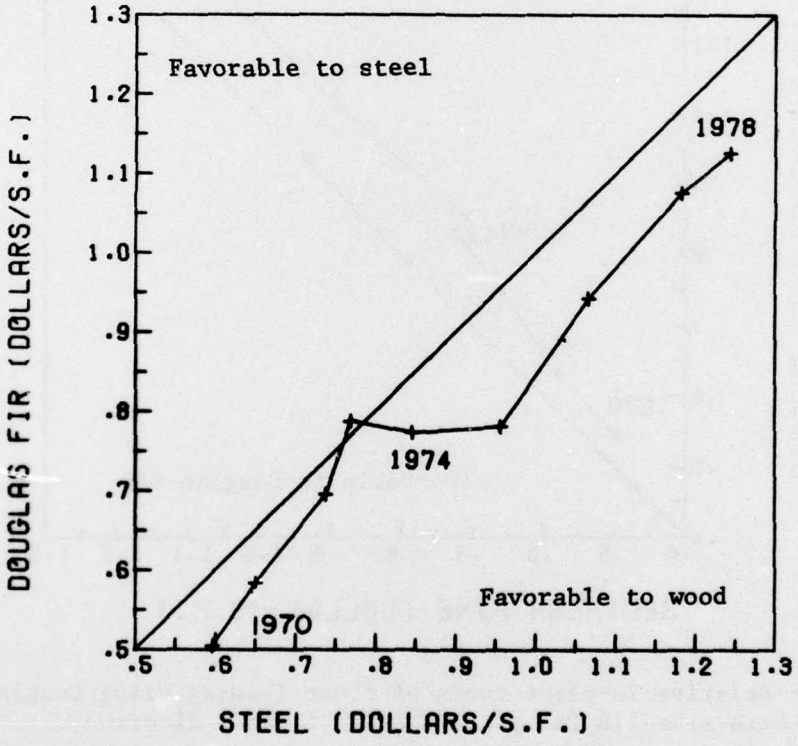

Figure 3.--Relative in-place costs of wood and steel flooring (24 in. o.c., 3/4-in. plywood flooring).

Although steel joists made little headway during this period, market shifts had occurred due to lumber price differentials. Southern pine floor framing was consistently less costly than Douglas-fir (fig. 4). Over the years, southern lumber producers translated this cost advantage into greater market shares at the expense of western lumber. In 1970, for instance, 30.5 percent of Douglas-fir lumber was shipped into the Northeast. By 1976, only 19.5 percent went there (13). At the same time, southern pine shipments into the same region rose from 21.6 to 24.9 percent (7),

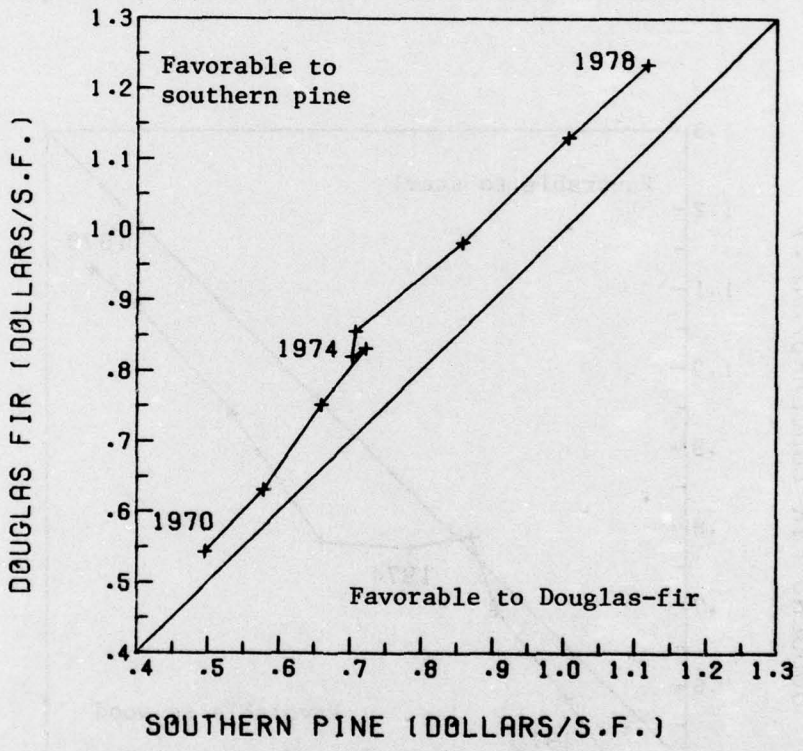

Figure 4.--Relative in-place costs of floor framing using Douglas-fir and southern pine (16 in. o.c., 5/8-in. plywood flooring).

In this study, no attempt was made to calculate indirect costs of using one material over another. However, according to a 1975 study conducted for the United States Steel Corporation, the differential in related construction costs between wood and steel joists was $0.11 per square foot in favor of steel (table 10). When these data were extrapolated for other years by assuming that changes were proportional to changes in wages and the resulting savings subtracted from the cost of steel framing, the gap between wood and steel joists effectively vanished (table 11).

Table 10.--Differentials in related construction costs

Area	Wood joists	Super-C steel joists
	Dol/ft^2	Dol/ft^2
Electrical	0.03	0
Plumbing	.02	0
Drywall	0	0.01
Setting kitchen cabinets	.01	0
Cleanup and waste disposal	.02	0
Callback	.03	0
Construction loan interest, resulting from faster completion due to reduction in callback time	.01	0
Total	.12	.01
Savings per square foot		.11

Source (12).

Table 11.--Comparative in-place cost of wood and steel flooring, including related savings

Year	Cost of wood flooring (Douglas-fir 2 x 10, 24 in. o.c.)	-	Cost of steel flooring (18 gage, 24 in. o.c.)	+	Related savings with steel	=	Wood-steel
	Dol/ft^2		Dol/ft^2		Dol/ft^2		Dol/ft^2
1970	0.51		0.60		0.08		-0.01
1971	.58		.65		.09		.02
1972	.70		.74		.09		.05
1973	.79		.77		.10		.12
1974	.77		.85		.10		.02
1975	.78		.96		.11		-.03
1976	.94		1.07		.12		-.01
1977	1.08		1.18		.13		-.03
1978	1.13		1.24		.14		.03

Comparative In-Place Costs of Wood and Steel Nonload-Bearing Partitions

Material Requirements

The material requirements of nonload-bearing partitions vary with the size and spacing of the studs[4/] used. Nominal 2- x 3-inch wood studs can be employed but seldom are. Typical wall construction uses 2 x 4 studs spaced 16 or 24 inches o.c. With 16-inch spacing, lumber requirements vary between 5.8 and 7.7 board feet per lineal foot of wall. With 24-inch spacing, the range is 5.2 to 7.1. The factors used in the study were 6.7 and 6.1 for 16- and 24-inch spacing, respectively.

4/ A stud is one of a series of slender wood structural members used as supporting elements in walls and partitions.

For steel, Koenigshof based his calculations on 26-gage studs which are commonly used for this purpose and which were approved by the International Conference of Building Officials as a satisfactory alternate construction method (8). Several possibilities exist for stud size, but 2 x 2 and 2 x 3 studs are apparently most often used. Two types of construction were chosen for analysis: 2 x 3 studs at 16-inch intervals and 2 x 4 studs spaced 24 inches o.c. Material requirements were 3.8 and 4.0 pounds per lineal foot, respectively.

Drywall costs were excluded because they are about the same for both materials.

Material Prices

Material prices were derived in the same manner as for flooring, with lumber grades of kiln-dried Douglas-fir and southern pine studs.

Labor Requirements

Labor requirements for steel partitions are about half those for wood. Nonload-bearing partitions spaced 16 inches o.c. require 3.1 minutes for steel per lineal foot to install in a typical house versus 6.5 minutes for wood. Steel studs spaced 24 inches require 2.7 minutes per lineal foot versus 5.6 for wood. Steel studs require less time because they are easier to install, prepunched to facilitate wiring and plumbing, and can be adjusted to variations in ceiling height in the track to which they are fastened. Wood studs have to be drilled for wiring and plumbing, be well fitted between the top and bottom plates, and require more fasteners.

Labor Wages

Labor wages were assumed to be the same as for flooring (table 9).

Total In-Place Costs

The most expensive steel partition cost less than the cheapest wood alternative throughout the 8 years examined. Moreover, the gap favoring steel over Douglas-fir studs widened from 43 percent in 1970 to 47 percent in 1978 (fig. 5). Failure by steel to capture a larger market share can be attributed to inadequate marketing.

As in floors, southern pine lumber was consistently cheaper than Douglas-fir (fig. 6).

Differential fastener costs favor wood slightly but are of too small a magnitude to alter the above results (tables B-5 through B-9).

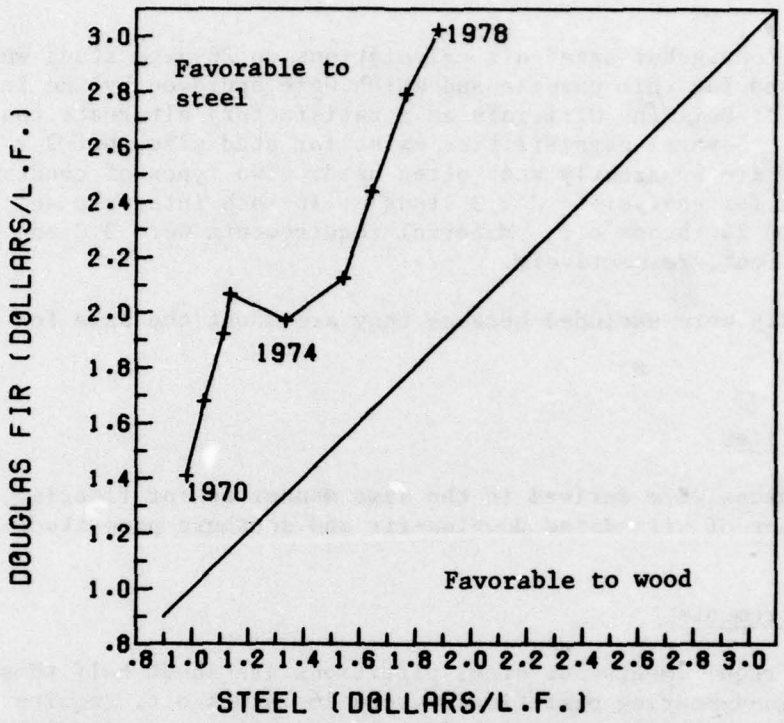

Figure 5.--Relative in-place costs of wood and steel partitions (24 in. o.c.).

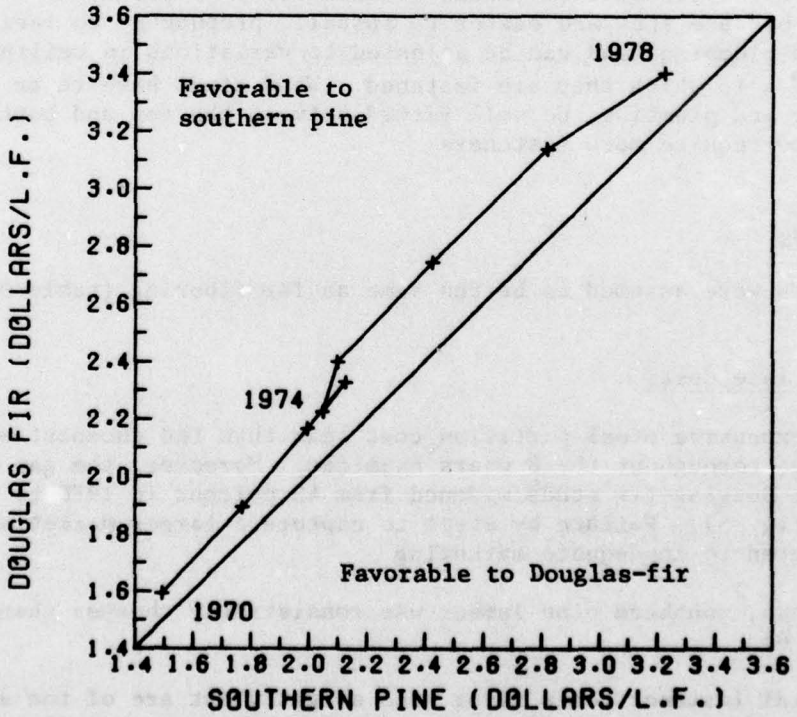

Figure 6.--Relative in-place costs of partition framing using Douglas-fir and southern pine studs (16 in. o.c.).

Comparative In-Place Costs of Wood and Steel Load-Bearing Walls

Material Requirements

The quantity of wood required to frame load-bearing walls can vary between 6.3 and 10.1 board feet per lineal foot of wall, depending on stud spacing, size of windows, etc. Factors used in the study were 8.5 board feet per lineal foot of wall for 16-inch spacing and 7.7 for 24-inch spacing.

The steel requirements are difficult to determine on account of the variety of sizes and shapes of studs that are available and are used depending on the load required of each stud. Calculations are based on 8.5 pounds per lineal foot of wall using 20-gage studs (3).

Material Prices

Lumber stud prices are the same as for partitions. Steel prices are calculated in the manner described for floors.

Labor Requirements

Labor requirements for installing wood studs were estimated at 6.3 minutes for 16-inch spacing and 6.0 minutes for 24-inch intervals. Steel systems can vary between 75 and 125 percent of the time needed to install wood. For bigger operations with experienced crews, the lower amount is typical and was used in the study. The times were 4.7 minutes for 16-inch spacing and 4.5 for 24-inch widths.

Labor Wages

Labor wages and crew mix were assumed to be the same as used in other parts of the study.

Total In-Place Costs

Total in-place costs of wood and steel load-bearing walls varied between $3.37 per lineal foot for southern pine studs spaced 24 inches o.c., and $3.88 for Douglas-fir studs spaced 16 inches o.c. Steel studs were in between at $3.60. The competitive position of Douglas-fir studs deteriorated vis-a-vis steel over the period covered (fig. 7). In 1970, wood cost $1.64 per lineal foot versus $1.86 for steel. By 1972, steel was less expensive. Wood recovered the advantage in 1974 but its lead shrank by 1978 to less than $0.05 per lineal foot (tables B-10 through B-15).

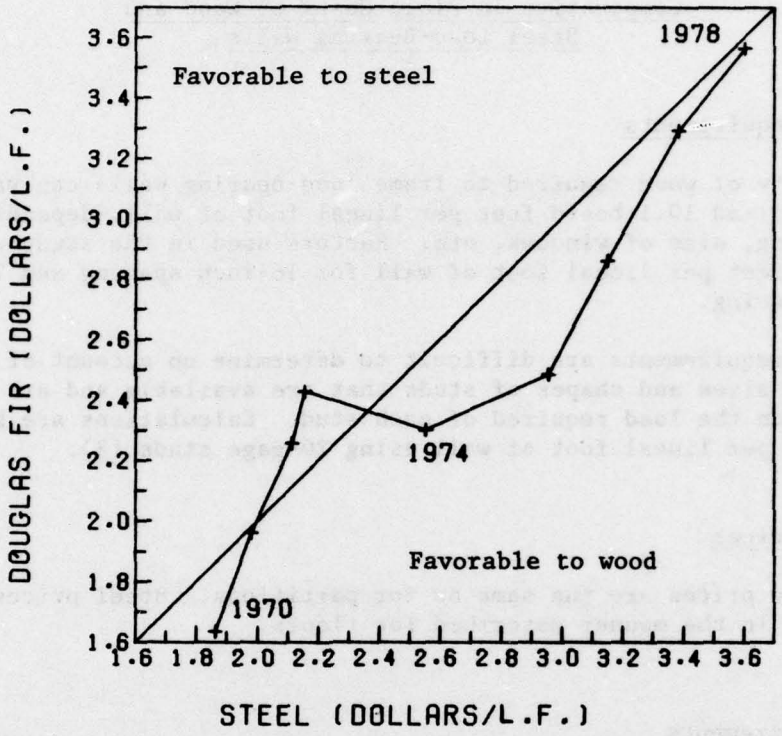

Figure 7.--Relative in-place costs of wood and steel load-bearing walls (24 in. o.c.).

Summary and Conclusions

The rapid escalation of lumber costs in the seventies more than doubled the in-place cost of wood framing. The cost of steel framing, however, increased by a similar magnitude. The rapid increases after the 1973/1974 energy crisis and subsequent energy price increases put steel framing at a disadvantage relative to wood in the mid seventies. But the resumption of double-digit rates of increase in lumber prices left the two materials at roughly the same relationship by 1978 as in 1970. Wood and steel flooring and load-bearing walls were approximately similar in cost while steel nonload-bearing partitions continued to enjoy a large price advantage.

The ability of steel to penetrate the large and varied residential light-framing market was hampered by inadequate marketing. Few building suppliers carry steel framing, making procurement lengthy and steel all but inaccessible to small volume builders. Framing with steel also requires more advance planning than with wood because the size of

the framing members cannot be cut to size on the site as with lumber. These factors have been important in preventing significant penetration of residential framing markets by steel, but not in nonresidential construction where steel framing use is widespread.

If the cost of lumber framing continues to rise faster than steel, the prospects for steel will improve in the residential market as well. Wood consumption will remain strong through the mid eighties because of the heavy demand for new housing caused by the maturing postwar baby boom generation. This means further strong demand pressures on lumber prices on top of the effects of inflation. Steel prices, however, are apt to rise no faster than the overall inflation rate now that the 1973/1974 multiplying of energy prices has been absorbed and inflation in the energy sector subsides to more moderate levels. Unless the forest products sector can moderate the historically rapid rise in lumber prices of the past 3 years, lumber framing will fall behind steel and the possibilities of substitution will grow.

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APPENDIX A

Calculating Procedures

Delivered Wood Prices

Mill selling prices for lumber and plywood are reported weekly by three industry price reporting publications (Crows, Madison's Lumber Reporter, Random Lengths). Wood prices used were those from Random Lengths.

Plywood flooring prices were derived by adding to exterior grade CD plywood net[5/] price charges for tongue and grooving along two long edges and for a C crossband. Prior to June 1977, southern pine plywood prices were reported on a Coast index basis, meaning that to calculate the delivered price, the prevailing rail rate from the West Coast had to be used. After June 1977, the price reporting switched to an f.o.b. mill basis to which the southern freight rate had to be added.

Delivered prices were calculated on the basis of rail transportation. Hauls between Portland and Chicago and Hattiesburg and Chicago were selected to represent western and southern shipping costs.

An additional handling and delivery markup of 10 percent was assumed for wood purchased by a builder direct from the mill, and 15 percent if picked up in truckload quantities by the builder at the rail yard before the retailer inventoried the material. Tables A-1 and A-2 contain the data used.

Delivered Steel Prices

Delivered steel prices were calculated by adding base steel sheet prices (adjusted for various thicknesses), transportation charges, and costs of converting the sheets to studs and joists. Because of the uniform nature of wages and prices in the U.S. steel industry, no attempt was made to estimate regional variations in steel costs.

There are few published data available on steel stud and joist prices. Various construction estimating guides contain some quotes. These are, however, too general to be of use in this study. Accordingly, stud and joist costs were estimated for 1971-1978 by extrapolating the 1970 prices used by Koenigshof. Tables A-3 through A-7 contain the data. The steps in the calculations were as follows:

(1) Base price and thickness adjustment charges were determined. The Bureau of Labor Statistics publishes monthly the price of galvanized steel sheets (10). The 1970 base price and thickness adjustments were extrapolated to 1978 using these data (table A-3).

5/ With wholesaler discounts of 5 and 3 percent taken out.

(2) Transportation charges were estimated. There were two shipping costs involved: From the steel mill to the finishing mill and from the finishing mill to the user or the distribution yard. Hauls of 50 and 100 miles were assumed, respectively. The 1970 estimates were extrapolated using the Bureau of Commerce's price deflator for transportation services (11) (table A-4).

(3) Conversion costs were calculated. To calculate the changes in conversion costs since 1970, an average unit labor cost index in the steel finishing industry was constructed. The changes in total costs were assumed to be proportional to the changes in this index.

The index was derived by first calculating a productivity index, a measure of output per hour in the industry. The total dollar value of shipments, as reported in the Annual Survey of Manufacturers (9), was divided by an appropriate price index to derive a constant dollar value of shipments. This in turn was divided by the total man-hours worked, as reported in the ASM, and converted to an index with the 1970 value set at 1.0 (table A-5). Then, total hourly worker compensation was determined by adding up hourly wages and fringe benefits (table A-6). This was divided by the productivity index derived above to get the unit labor costs, and again transformed into an index with 1970 equal to 1.0. Conversion costs were extrapolated using these numbers (table A-7).

Total delivered cost of steel studs and joists were calculated by adding up the components. If the steel was marketed through a distribution yard, a markup of 25 percent was assumed. Table A-8 contains the data for 18-gage steel joists. The 1975 study conducted for the United States Steel Corporation offers a comparison with these calculations. The United States Steel estimate of $0.29 per pound was within the range estimated with the preceding procedures.

Table A-1.--Lumber prices, freight rates, and delivered costs for large purchases direct from the mill ($1 Mbf)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
Commodity: Douglas-fir 2 x 8-12	98.1	124.9	152.3	188.5	176.1	175.4	206.2	247.7	270.0
Freight, Portland-Chicago, 2,250 lb	35.7	39.5	40.2	41.4	46.8	51.1	54.9	59.4	63.3
Total (10 pct markup included)	147.2	180.8	211.7	252.9	245.2	249.2	287.2	337.8	366.6
Commodity: Douglas-fir 2 x 10-12	108.5	133.5	163.6	209.0	196.5	176.8	232.6	269.8	278.0
Freight, Portland-Chicago, 2,300 lb	36.5	40.4	41.1	42.3	47.8	52.2	56.1	60.7	64.7
Total (10 pct markup included)	159.5	191.3	225.2	276.4	268.7	251.9	317.6	363.6	377.0
Commodity: Southern pine 2 x 8-12	99.6	127.3	140.9	165.3	149.8	138.9	181.9	224.2	264.0
Freight, Hattiesburg-Chicago, 2,250 lb	14.6	15.9	17.3	18.1	20.9	23.6	26.3	27.8	29.8
Total (10 pct markup included)	125.6	157.5	174.0	201.7	187.8	178.8	229.0	277.2	323.2
Commodity: Douglas-fir studs	71.0	99.0	126.0	140.0	113.0	125.0	156.0	195.0	209.0
Freight, Portland-Chicago, 2,200 lb	34.9	38.6	39.3	40.5	45.8	50.0	53.7	58.1	61.9
Total (10 pct markup included)	116.5	151.4	181.3	198.5	174.7	192.5	230.7	278.4	298.0
Commodity: Southern pine studs	77.6	105.4	124.5	135.5	115.1	111.3	140.9	182.9	218.5
Freight, Hattiesburg-Chicago, 2,200 lb	14.3	15.5	16.9	17.7	20.4	23.1	25.7	27.2	29.1
Total (10 pct markup included)	101.1	133.0	155.5	168.5	149.0	147.8	183.8	231.1	272.4

Table A-2.--Plywood prices, freight rates, and delivered costs for large purchases direct from the mill ($1 Msf)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
Commodity:									
5/8-in. Douglas-fir plywood CD exterior	86.5	102.2	151.7	157.9	140.9	151.9	189.6	237.0	252.0
Special charges: Tongue and grooving along two edges plus C crossband	30.4	32.8	33.0	33.4	38.5	40.3	44.2	40.5	54.0
Freight: Portland-Chicago, 1,900 lb.	30.1	33.4	34.0	35.0	39.5	43.1	46.4	50.2	53.5
Total (10 pct markup included)	161.7	185.2	240.6	248.9	240.8	258.8	308.2	360.5	395.4
Commodity:									
3/4-in. Douglas-fir plywood CD exterior	101.0	120.2	170.0	187.7	166.5	178.7	227.6	282.4	300.0
Special charges: Tongue and grooving along two edges plus C crossband	30.4	32.8	33.0	33.4	38.5	40.3	44.2	40.5	54.0
Freight: Portland-Chicago, 2,225 lb.	35.3	39.1	39.8	41.0	46.2	50.5	54.3	58.8	62.6
Total (10 pct markup included)	183.4	211.3	267.1	288.3	276.3	296.5	358.7	419.9	458.3
Commodity:									
5/8-in. Southern pine plywood CD exterior[1/]	83.8	98.6	134.5	144.1	130.0	132.1	176.2	235.6	255.8
Special charges: Tongue and grooving along two edges plus C crossband	30.4	32.8	33.0	33.4	38.5	40.3	44.2	40.5	54.0
Freight: Hattiesburg-Chicago[2/]	30.1	33.4	34.0	35.0	39.5	43.1	46.4	36.9	25.2
Total (10 pct markup included)	158.7	181.3	221.6	233.7	228.8	237.0	293.5	344.3	368.5

1/ Through June 1977, West Coast rate, after f.o.b. mill price.

2/ Through June 1977, Portland-Chicago rate, after Hattiesburg-Chicago.

Table A-3.--Galvanized steel sheet prices and thickness adjustment factors

Year	Price of galvanized steel sheets (BLS)	Base price of electro-galvanized steel sheets	Base price of hot-dipped galvanized steel	Thickness adjustments			Total price		
				26 gage	20 gage	18 gage	26 gage electro-galvanized	20 gage hot-dipped	18 gage hot-dipped
	Dol/100 lb								
1970	10.80	9.19	9.35	2.15	1.55	1.30	11.34	10.90	10.65
1971	11.31	9.62	9.79	2.25	1.62	1.36	11.87	11.41	11.15
1972	12.02	10.23	10.41	2.38	1.72	1.44	12.61	12.13	11.85
1973	12.09	10.29	10.47	2.40	1.73	1.45	12.69	12.20	11.92
1974	15.85	13.50	13.73	3.14	2.26	1.90	16.64	15.99	15.63
1975	18.48	15.74	16.01	3.65	2.64	2.21	19.39	18.65	18.22
1976	19.99	17.02	17.32	3.95	2.85	2.39	20.97	20.17	19.71
1977	21.75	18.53	18.85	4.30	3.10	2.60	22.83	21.95	21.45
1978	22.83	19.43	19.77	4.55	3.28	2.75	23.98	23.05	22.52

Table A-4.--Transportation costs

Year	Index of transportation services (1972 = 1.0)	From steel to finishing mill (50 miles)	From finishing to building site (100 miles)	Total shipping costs
		Dol/100 lb	Dol/100 lb	Dol/100 lb
1970	0.888	0.21	0.36	0.57
1971	.965	.23	.39	.62
1972	1.000	.24	.41	.65
1973	1.022	.24	.41	.65
1974	1.077	.26	.44	.70
1975	1.132	.28	.46	.74
1976	1.275	.30	.52	.82
1977	1.402	.33	.57	.90
1978	1.529	.36	.62	.98

Table A-5.--Index of productivity in the finishing mill industry (1970 = 1.0)

Year	Value of industry shipments (SIC 3316)	÷	Price index of structural steel shapes (1967 = 1.0)	=	Value of industry shipments (1967)	÷	Total man-hours worked (production workers)	=	Output per man-hour	Index of productivity (1970 = 1.0)
	Million Dol				Million Dol		Million h		67 Dol/h	
1970	1,136		1.15		988		26.6		37.1	1.00
1971	1,110		1.27		874		23.4		37.4	1.01
1972	1,636		1.35		1,212		31.8		38.1	1.03
1973	2,028		1.41		1,438		34.0		42.3	1.14
1974	2,650		1.79		1,480		34.1		43.4	1.17
1975	1,703		2.16		788		21.9		36.0	.97
1976	2,249		2.27		991		25.1		39.5	1.06
1977	2,480		2.38		1,042		25.8		40.4	1.09
1978	2,800		2.60		1,077		26.0		41.4	1.12

Table A-6.--Index of average unit labor costs in industry, SIC 3316 (1970 = 1.0)

Year	Average hourly wages	+	Average hourly fringe benefits	=	Total average hourly compensation	÷	Productivity index (1970 = 1.0)	=	Average unit labor costs	Index of average unit labor costs (1970 = 1.0)
	Dol/h		Dol/h		Dol/h				Dol	
1970	4.24		0.84		5.08		1.00		5.08	1.00
1971	4.65		.90		5.55		1.01		5.50	1.08
1972	5.10		1.01		6.11		1.03		5.93	1.17
1973	5.46		1.20		6.66		1.14		5.84	1.15
1974	6.17		1.31		7.48		1.17		6.39	1.26
1975	6.70		1.51		8.21		.97		8.46	1.67
1976	7.33		1.61		8.94		1.06		8.39	1.65
1977	7.87		1.75		9.62		1.09		8.83	1.74
1978	8.50		1.90		10.40		1.12		9.25	1.82

Table A-7.--Costs of converting steel sheets to studs

Year	Unit labor cost index (1970 = 1.0)	Conversion costs		
		26 gage	20 gage	18 gage
		Dol/100 lb	Dol/100 lb	Dol/100 lb
1970	1.00	4.36	3.85	3.53
1971	1.08	4.71	4.15	3.81
1972	1.17	4.96	4.38	4.02
1973	1.15	4.96	4.38	4.02
1974	1.26	5.50	4.85	4.45
1975	1.67	7.29	6.43	5.90
1976	1.65	7.29	6.43	5.90
1977	1.74	7.58	6.70	6.14
1978	1.82	7.93	7.00	6.42

Table A-8.--Estimated delivered costs of 18-gage steel joists

Year	Base price	Thickness adjustment	Transportation charges	Conversion costs	Total	Including 25 percent markup	U.S.S. study
				Dol/100 lb			
1970	9.35	1.30	0.57	3.53	14.75	18.44	--
1971	9.79	1.36	.62	3.81	15.58	19.47	--
1972	10.41	1.44	.65	4.02	16.52	20.65	--
1973	10.47	1.45	.65	4.02	16.59	20.74	--
1974	13.73	1.90	.70	4.45	20.78	25.98	--
1975	16.01	2.21	.74	5.90	24.86	31.08	28.75
1976	17.32	2.39	.82	5.90	26.43	33.04	--
1977	18.85	2.60	.90	6.14	28.49	35.62	--
1978	19.77	2.75	.98	6.42	29.92	37.40	--

APPENDIX B

Statistical Tables

Table B-1.--In-place cost per square foot of constructing floors with Douglas-fir 2- by 8-inch by 12-foot joists, 16 inches o.c. and 5/8 inch plywood flooring (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	FRAMING							R. PLYWOOD FLOORING							TOTAL
	MATERIALS			LABOR			TOTAL	MATERIALS			LABOR			TOTAL	IN-
	PER SQ.FT. OF FLOOR	PRICE PER BD.FT.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	WAGE PER MAN-MIN.	COST PER SQ.FT. OF FLOOR	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	PRICE PER SQ.FT.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	WAGE PER MAN-MIN.	COST PER SQ.FT. OF FLOOR	COST PER SQ.FT. OF FLOOR	PLACE COST PER SQ.FT. OF FLOOR
YR	BD.FT.	$	$	MINS.	$	$	$	SQ.FT.	$	$	MINS.	$	$	$	$
70	1.55	.147	.228	.70	.125	.088	.315	1.06	.162	.172	.45	.125	.056	.228	.543
71	1.55	.181	.281	.70	.135	.094	.375	1.06	.185	.196	.45	.135	.061	.257	.632
72	1.55	.212	.329	.70	.146	.102	.431	1.06	.241	.255	.45	.146	.066	.321	.752
73	1.55	.253	.392	.70	.153	.107	.499	1.06	.249	.264	.45	.153	.069	.333	.832
74	1.55	.245	.380	.70	.161	.113	.492	1.06	.241	.255	.45	.161	.072	.328	.820
75	1.55	.249	.386	.70	.170	.119	.505	1.06	.259	.275	.45	.170	.076	.351	.856
76	1.55	.287	.445	.70	.183	.128	.573	1.06	.308	.326	.45	.183	.082	.409	.982
77	1.55	.338	.524	.70	.195	.136	.660	1.06	.361	.383	.45	.195	.088	.470	1.131
78	1.55	.367	.569	.70	.215	.150	.719	1.06	.395	.419	.45	.215	.097	.515	1.235
70	1.55	.154	.238	.70	.125	.088	.326	1.06	.169	.180	.45	.125	.056	.236	.561
71	1.55	.189	.293	.70	.135	.094	.388	1.06	.193	.205	.45	.135	.061	.266	.654
72	1.55	.222	.344	.70	.146	.102	.446	1.06	.252	.267	.45	.146	.066	.333	.779
73	1.55	.264	.410	.70	.153	.107	.517	1.06	.260	.276	.45	.153	.069	.345	.862
74	1.55	.256	.397	.70	.161	.113	.510	1.06	.252	.267	.45	.161	.072	.340	.849
75	1.55	.260	.403	.70	.170	.119	.522	1.06	.271	.287	.45	.170	.076	.364	.886
76	1.55	.300	.465	.70	.183	.128	.593	1.06	.322	.341	.45	.183	.082	.424	1.017
77	1.55	.353	.548	.70	.195	.136	.684	1.06	.377	.400	.45	.195	.088	.488	1.172
78	1.55	.384	.595	.70	.215	.150	.745	1.06	.413	.438	.45	.215	.097	.534	1.280

Table B-2.--In-place cost per square foot of constructing floors with southern pine 2- by 8-inch by 12-foot joists, 16 inches o.c. and 5/8 inch plywood flooring (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	FRAMING							R. PLYWOOD FLOORING							TOTAL
	MATERIALS			LABOR			TOTAL	MATERIALS			LABOR			TOTAL	IN-
	PER SQ.FT. OF FLOOR	PRICE PER BD.FT.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	WAGE PER MAN-MIN.	COST PER SQ.FT. OF FLOOR	COST PER SQ.FT. FLOOR	PER SQ.FT. OF FLOOR	PRICE PER SQ.FT.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	WAGE PER MAN-MIN.	COST PER SQ.FT. OF FLOOR	COST PER SQ.FT. FLOOR	PLACE COST PER SQ.FT. OF FLOOR
YR	BD.FT.	$	$	MINS.	$	$	$	SQ.FT.	$	$	MINS.	$	$	$	$
70	1.55	.126	.195	.70	.125	.088	.283	1.06	.159	.169	.45	.125	.056	.225	.508
71	1.55	.158	.245	.70	.135	.094	.339	1.06	.181	.192	.45	.135	.061	.253	.592
72	1.55	.174	.270	.70	.146	.102	.372	1.06	.222	.235	.45	.146	.066	.301	.673
73	1.55	.202	.313	.70	.153	.107	.420	1.06	.234	.248	.45	.153	.069	.317	.737
74	1.55	.188	.291	.70	.161	.113	.404	1.06	.229	.243	.45	.161	.072	.315	.719
75	1.55	.179	.277	.70	.170	.119	.396	1.06	.237	.251	.45	.170	.076	.328	.724
76	1.55	.229	.355	.70	.183	.128	.483	1.06	.294	.312	.45	.183	.082	.394	.877
77	1.55	.277	.429	.70	.195	.136	.566	1.06	.344	.365	.45	.195	.088	.452	1.018
78	1.55	.323	.501	.70	.215	.150	.651	1.06	.368	.390	.45	.215	.097	.487	1.138
70	1.55	.132	.204	.70	.125	.088	.292	1.06	.166	.176	.45	.125	.056	.232	.524
71	1.55	.165	.256	.70	.135	.094	.351	1.06	.189	.201	.45	.135	.061	.261	.612
72	1.55	.182	.282	.70	.146	.102	.384	1.06	.232	.246	.45	.146	.066	.312	.696
73	1.55	.211	.327	.70	.153	.107	.434	1.06	.245	.259	.45	.153	.069	.328	.763
74	1.55	.197	.305	.70	.161	.113	.417	1.06	.239	.254	.45	.161	.072	.326	.744
75	1.55	.187	.290	.70	.170	.119	.409	1.06	.248	.263	.45	.170	.076	.339	.748
76	1.55	.239	.371	.70	.183	.128	.499	1.06	.307	.326	.45	.183	.082	.408	.907
77	1.55	.290	.449	.70	.195	.136	.585	1.06	.360	.381	.45	.195	.088	.469	1.054
78	1.55	.338	.523	.70	.215	.150	.674	1.06	.385	.408	.45	.215	.097	.505	1.178

Table B-3.--In-place cost per square foot of constructing floors with Douglas-fir 2- by 20 inch by 12-foot joists, 24 inches o.c. and 3/4 inch plywood flooring (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	FRAMING							R. PLYWOOD FLOORING							TOTAL
	MATERIALS			LABOR			TOTAL	MATERIALS			LABOR			TOTAL	IN-
	PER SQ.FT. OF FLOOR	PRICE PER BD.FT.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	WAGE PER MAN-MIN.	COST PER SQ.FT. OF FLOOR	COST PER SQ.FT. FLOOR	PER SQ.FT. OF FLOOR	PRICE PER SQ.FT.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	WAGE PER MAN-MIN.	COST PER SQ.FT. OF FLOOR	COST PER SQ.FT. FLOOR	PLACE COST PER SQ.FT. OF FLOOR
YR	BD.FT.	$	$	MINS.	$	$	$	SQ.FT.	$	$	MINS.	$	$	$	$
70	1.25	.159	.199	.55	.125	.069	.267	1.06	.183	.194	.35	.125	.044	.238	.505
71	1.25	.191	.239	.55	.135	.074	.313	1.06	.211	.224	.35	.135	.047	.271	.584
72	1.25	.225	.281	.55	.146	.080	.362	1.06	.267	.283	.35	.146	.051	.334	.696
73	1.25	.276	.345	.55	.153	.084	.429	1.06	.288	.305	.35	.153	.054	.359	.788
74	1.25	.269	.336	.55	.161	.089	.425	1.06	.276	.293	.35	.161	.056	.349	.774
75	1.25	.252	.315	.55	.170	.093	.408	1.06	.296	.314	.35	.170	.059	.373	.782
76	1.25	.318	.397	.55	.183	.101	.498	1.06	.359	.381	.35	.183	.064	.445	.943
77	1.25	.364	.455	.55	.195	.107	.562	1.06	.420	.445	.35	.195	.068	.513	1.076
78	1.25	.377	.471	.55	.215	.118	.589	1.06	.435	.461	.35	.215	.075	.536	1.126
70	1.25	.166	.208	.55	.125	.069	.277	1.06	.191	.203	.35	.125	.044	.247	.523
71	1.25	.200	.250	.55	.135	.074	.324	1.06	.221	.234	.35	.135	.047	.281	.605
72	1.25	.235	.294	.55	.146	.080	.374	1.06	.279	.296	.35	.146	.051	.347	.721
73	1.25	.289	.361	.55	.153	.084	.445	1.06	.301	.319	.35	.153	.054	.373	.818
74	1.25	.281	.352	.55	.161	.089	.440	1.06	.289	.306	.35	.161	.056	.362	.802
75	1.25	.263	.329	.55	.170	.093	.423	1.06	.309	.328	.35	.170	.059	.388	.810
76	1.25	.332	.416	.55	.183	.101	.516	1.06	.375	.398	.35	.183	.064	.462	.978
77	1.25	.381	.476	.55	.195	.107	.583	1.06	.439	.465	.35	.195	.068	.534	1.117
78	1.25	.394	.493	.55	.215	.118	.611	1.06	.455	.482	.35	.215	.075	.557	1.168

Table B-4.--In-place cost per square foot of constructing floors with 2- by 8-inch, 18-gage steel joists, 24 inches o.c. and 3/4 inch plywood flooring (top half of table for large purchases direct from mill, bottom half for large purchases from distribution yard)

	FRAMING										R. PLYWOOD FLOORING							TOTAL
	STEEL JOISTS			ACCESSORIES			LABOR			TOTAL	MATERIALS			LABOR			TOTAL	IN-PLACE COST PER SQ.FT. OF FLOOR
	PER SQ.FT. OF FLOOR	PRICE PER LB.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	PRICE PER LB.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	WAGE PER MAN-MIN.	COST PER SQ.FT. OF FLOOR	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	PRICE PER SQ.FT.	COST PER SQ.FT. OF FLOOR	PER SQ.FT. OF FLOOR	WAGE PER MAN-MIN.	COST PER SQ.FT. OF FLOOR	COST PER SQ.FT. OF FLOOR	
YR	LBS.	$	$	LBS.	$	$	MINS.	$	$	$	SQ.FT.	$	$	MINS.	$	$	$	$
70	1.85	.147	.273	.095	.250	.024	.50	.125	.063	.359	1.06	.183	.194	.35	.125	.044	.238	.597
71	1.85	.156	.288	.095	.260	.025	.50	.135	.067	.380	1.06	.211	.224	.35	.135	.047	.271	.651
72	1.85	.165	.306	.095	.276	.026	.50	.146	.073	.405	1.06	.267	.283	.35	.146	.051	.334	.739
73	1.85	.166	.308	.095	.283	.027	.50	.153	.076	.411	1.06	.288	.305	.35	.153	.054	.359	.770
74	1.85	.208	.384	.095	.353	.034	.50	.161	.080	.498	1.06	.276	.293	.35	.161	.056	.349	.847
75	1.85	.249	.460	.095	.404	.038	.50	.170	.085	.583	1.06	.296	.314	.35	.170	.059	.373	.957
76	1.85	.264	.489	.095	.435	.041	.50	.183	.091	.622	1.06	.359	.381	.35	.183	.064	.445	1.066
77	1.85	.285	.527	.095	.471	.045	.50	.195	.097	.669	1.06	.420	.445	.35	.195	.068	.513	1.183
78	1.85	.299	.554	.095	.495	.047	.50	.215	.107	.708	1.06	.435	.461	.35	.215	.075	.536	1.244
70	1.85	.184	.341	.095	.313	.030	.50	.125	.063	.433	1.06	.191	.203	.35	.125	.044	.247	.680
71	1.85	.195	.360	.095	.325	.031	.50	.135	.067	.459	1.06	.221	.234	.35	.135	.047	.281	.740
72	1.85	.206	.382	.095	.345	.033	.50	.146	.073	.488	1.06	.279	.296	.35	.146	.051	.347	.835
73	1.85	.208	.385	.095	.354	.034	.50	.153	.076	.495	1.06	.301	.319	.35	.153	.054	.373	.867
74	1.85	.260	.481	.095	.441	.042	.50	.161	.080	.603	1.06	.289	.306	.35	.161	.056	.362	.965
75	1.85	.311	.575	.095	.505	.048	.50	.170	.085	.708	1.06	.309	.328	.35	.170	.059	.388	1.095
76	1.85	.330	.611	.095	.544	.052	.50	.183	.091	.754	1.06	.375	.398	.35	.183	.064	.462	1.216
77	1.85	.356	.659	.095	.589	.056	.50	.195	.097	.812	1.06	.439	.465	.35	.195	.068	.534	1.346
78	1.85	.374	.692	.095	.619	.059	.50	.215	.107	.858	1.06	.455	.482	.35	.215	.075	.557	1.415

Table B-5.--In-place cost per lineal foot of constructing partitions with Douglas-fir studs, 16 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER BD.FT.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	BD.FT.	$	$	MINS.	$	$	$
70	6.72	.116	.780	6.51	.125	.814	1.593
71	6.72	.151	1.015	6.51	.135	.879	1.894
72	6.72	.181	1.216	6.51	.146	.950	2.167
73	6.72	.198	1.331	6.51	.153	.996	2.327
74	6.72	.175	1.176	6.51	.161	1.048	2.224
75	6.72	.192	1.290	6.51	.170	1.107	2.397
76	6.72	.231	1.552	6.51	.183	1.191	2.744
77	6.72	.278	1.868	6.51	.195	1.269	3.138
78	6.72	.298	2.003	6.51	.215	1.400	3.402
70	6.72	.121	.815	6.51	.125	.814	1.629
71	6.72	.158	1.061	6.51	.135	.879	1.940
72	6.72	.189	1.272	6.51	.146	.950	2.222
73	6.72	.207	1.391	6.51	.153	.996	2.387
74	6.72	.183	1.229	6.51	.161	1.048	2.278
75	6.72	.201	1.349	6.51	.170	1.107	2.456
76	6.72	.241	1.623	6.51	.183	1.191	2.814
77	6.72	.291	1.953	6.51	.195	1.269	3.223
78	6.72	.312	2.094	6.51	.215	1.400	3.493

Table B-6.--In-place cost per lineal foot of constructing partitions with Douglas-fir studs, 24 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER BD.FT.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	BD.FT.	$	$	MINS.	$	$	$
70	6.11	.116	.709	5.60	.125	.700	1.409
71	6.11	.151	.923	5.60	.135	.756	1.679
72	6.11	.181	1.106	5.60	.146	.818	1.924
73	6.11	.198	1.210	5.60	.153	.857	2.067
74	6.11	.175	1.069	5.60	.161	.902	1.971
75	6.11	.192	1.173	5.60	.170	.952	2.125
76	6.11	.231	1.411	5.60	.183	1.025	2.436
77	6.11	.278	1.699	5.60	.195	1.092	2.791
78	6.11	.298	1.821	5.60	.215	1.204	3.025
70	6.11	.121	.741	5.60	.125	.700	1.441
71	6.11	.158	.965	5.60	.135	.756	1.721
72	6.11	.189	1.156	5.60	.146	.818	1.974
73	6.11	.207	1.265	5.60	.153	.857	2.122
74	6.11	.183	1.118	5.60	.161	.902	2.019
75	6.11	.201	1.226	5.60	.170	.952	2.178
76	6.11	.241	1.476	5.60	.183	1.025	2.500
77	6.11	.291	1.776	5.60	.195	1.092	2.868
78	6.11	.312	1.904	5.60	.215	1.204	3.108

Table B-7.--In-place cost per lineal foot of constructing partitions with southern pine studs, 16 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER BD.FT.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	BD.FT.	$	$	MINS.	$	$	$
70	6.72	.101	.679	6.51	.125	.814	1.493
71	6.72	.133	.894	6.51	.135	.879	1.773
72	6.72	.155	1.045	6.51	.146	.950	1.995
73	6.72	.168	1.132	6.51	.153	.996	2.128
74	6.72	.149	1.001	6.51	.161	1.048	2.049
75	6.72	.148	.993	6.51	.170	1.107	2.100
76	6.72	.184	1.235	6.51	.183	1.191	2.426
77	6.72	.231	1.553	6.51	.195	1.269	2.822
78	6.72	.272	1.831	6.51	.215	1.400	3.230
70	6.72	.106	.710	6.51	.125	.814	1.524
71	6.72	.139	.934	6.51	.135	.879	1.813
72	6.72	.163	1.092	6.51	.146	.950	2.043
73	6.72	.176	1.184	6.51	.153	.996	2.180
74	6.72	.156	1.047	6.51	.161	1.048	2.095
75	6.72	.155	1.038	6.51	.170	1.107	2.145
76	6.72	.192	1.291	6.51	.183	1.191	2.483
77	6.72	.242	1.624	6.51	.195	1.269	2.893
78	6.72	.285	1.914	6.51	.215	1.400	3.313

Table B-8.--In-place cost per lineal foot of constructing partitions with 2- by 3-inch, 26-gage steel studs, 16 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from distribution yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER LB.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	LBS.	$	$	MINS.	$	$	$
70	3.75	.163	.610	3.10	.125	.387	.998
71	3.75	.172	.645	3.10	.135	.418	1.063
72	3.75	.182	.683	3.10	.146	.453	1.136
73	3.75	.183	.688	3.10	.153	.474	1.162
74	3.75	.228	.856	3.10	.161	.499	1.356
75	3.75	.274	1.028	3.10	.170	.527	1.555
76	3.75	.291	1.090	3.10	.183	.567	1.658
77	3.75	.313	1.174	3.10	.195	.604	1.779
78	3.75	.329	1.233	3.10	.215	.666	1.900
70	3.75	.203	.763	3.10	.125	.387	1.150
71	3.75	.215	.806	3.10	.135	.418	1.225
72	3.75	.228	.854	3.10	.146	.453	1.307
73	3.75	.229	.860	3.10	.153	.474	1.334
74	3.75	.285	1.071	3.10	.161	.499	1.570
75	3.75	.343	1.285	3.10	.170	.527	1.812
76	3.75	.363	1.363	3.10	.183	.567	1.930
77	3.75	.391	1.468	3.10	.195	.604	2.072
78	3.75	.411	1.542	3.10	.215	.666	2.208

Table B-9.--In-place cost per lineal foot of constructing partitions with 2- by 4-inch, 26-gage steel studs, 24 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from distribution yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER LB.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	LBS.	$	$	MINS.	$	$	$
70	3.99	.163	.649	2.67	.125	.334	.983
71	3.99	.172	.686	2.67	.135	.360	1.047
72	3.99	.182	.727	2.67	.146	.390	1.117
73	3.99	.183	.732	2.67	.153	.409	1.141
74	3.99	.228	.911	2.67	.161	.430	1.341
75	3.99	.274	1.094	2.67	.170	.454	1.548
76	3.99	.291	1.160	2.67	.183	.489	1.649
77	3.99	.313	1.249	2.67	.195	.521	1.770
78	3.99	.329	1.312	2.67	.215	.574	1.886
70	3.99	.203	.811	2.67	.125	.334	1.145
71	3.99	.215	.858	2.67	.135	.360	1.218
72	3.99	.228	.909	2.67	.146	.390	1.299
73	3.99	.229	.915	2.67	.153	.409	1.324
74	3.99	.285	1.139	2.67	.161	.430	1.569
75	3.99	.343	1.368	2.67	.170	.454	1.821
76	3.99	.363	1.450	2.67	.183	.489	1.939
77	3.99	.391	1.562	2.67	.195	.521	2.082
78	3.99	.411	1.640	2.67	.215	.574	2.214

Table B-10.--In-place cost per lineal foot of constructing walls with Douglas-fir studs, 16 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER BD.FT.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	BD.FT.	$	$	MINS.	$	$	$
70	8.48	.116	.984	6.30	.125	.787	1.771
71	8.48	.151	1.280	6.30	.135	.850	2.131
72	8.48	.181	1.535	6.30	.146	.920	2.455
73	8.48	.198	1.679	6.30	.153	.964	2.643
74	8.48	.175	1.484	6.30	.161	1.014	2.498
75	8.48	.192	1.628	6.30	.170	1.071	2.699
76	8.48	.231	1.959	6.30	.183	1.153	3.112
77	8.48	.278	2.357	6.30	.195	1.228	3.586
78	8.48	.298	2.527	6.30	.215	1.354	3.882
70	8.48	.121	1.028	6.30	.125	.787	1.816
71	8.48	.158	1.339	6.30	.135	.850	2.189
72	8.48	.189	1.605	6.30	.146	.920	2.524
73	8.48	.207	1.755	6.30	.153	.964	2.719
74	8.48	.183	1.551	6.30	.161	1.014	2.566
75	8.48	.201	1.702	6.30	.170	1.071	2.773
76	8.48	.241	2.048	6.30	.183	1.153	3.201
77	8.48	.291	2.465	6.30	.195	1.228	3.693
78	8.48	.312	2.642	6.30	.215	1.354	3.996

Table B-11.--In-place cost per lineal foot of constructing walls with southern pine studs, 16 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER BD.FT.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	BD.FT.	$	$	MINS.	$	$	$
70	8.48	.101	.857	6.30	.125	.787	1.645
71	8.48	.133	1.128	6.30	.135	.850	1.978
72	8.48	.155	1.319	6.30	.146	.920	2.238
73	8.48	.168	1.429	6.30	.153	.964	2.393
74	8.48	.149	1.264	6.30	.161	1.014	2.278
75	8.48	.148	1.253	6.30	.170	1.071	2.324
76	8.48	.184	1.559	6.30	.183	1.153	2.712
77	8.48	.231	1.960	6.30	.195	1.228	3.188
78	8.48	.272	2.310	6.30	.215	1.354	3.664
70	8.48	.106	.896	6.30	.125	.787	1.684
71	8.48	.139	1.179	6.30	.135	.850	2.030
72	8.48	.163	1.379	6.30	.146	.920	2.298
73	8.48	.176	1.494	6.30	.153	.964	2.458
74	8.48	.156	1.321	6.30	.161	1.014	2.335
75	8.48	.155	1.310	6.30	.170	1.071	2.381
76	8.48	.192	1.629	6.30	.183	1.153	2.782
77	8.48	.242	2.049	6.30	.195	1.228	3.277
78	8.48	.285	2.415	6.30	.215	1.354	3.769

Table B-12.--In-place cost per lineal foot of constructing walls with Douglas-fir studs, 24 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER BD.FT.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	BD.FT.	$	$	MINS.	$	$	$
70	7.65	.116	.887	5.98	.125	.747	1.635
71	7.65	.151	1.155	5.98	.135	.807	1.962
72	7.65	.181	1.385	5.98	.146	.873	2.258
73	7.65	.198	1.515	5.98	.153	.915	2.430
74	7.65	.175	1.339	5.98	.161	.963	2.302
75	7.65	.192	1.469	5.98	.170	1.017	2.485
76	7.65	.231	1.767	5.98	.183	1.094	2.861
77	7.65	.278	2.127	5.98	.195	1.166	3.293
78	7.65	.298	2.280	5.98	.215	1.286	3.565
70	7.65	.121	.928	5.98	.125	.747	1.675
71	7.65	.158	1.208	5.98	.135	.807	2.015
72	7.65	.189	1.448	5.98	.146	.873	2.321
73	7.65	.207	1.584	5.98	.153	.915	2.498
74	7.65	.183	1.400	5.98	.161	.963	2.362
75	7.65	.201	1.536	5.98	.170	1.017	2.552
76	7.65	.241	1.847	5.98	.183	1.094	2.942
77	7.65	.291	2.223	5.98	.195	1.166	3.389
78	7.65	.312	2.383	5.98	.215	1.286	3.669

Table B-13.--In-place cost per lineal foot of constructing walls with southern pine studs, 26 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from retail yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER BD.FT.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	BD.FT.	$	$	MINS.	$	$	$
70	7.65	.101	.773	5.98	.125	.747	1.521
71	7.65	.133	1.017	5.98	.135	.807	1.825
72	7.65	.155	1.190	5.98	.146	.873	2.063
73	7.65	.168	1.289	5.98	.153	.915	2.204
74	7.65	.149	1.140	5.98	.161	.963	2.103
75	7.65	.148	1.131	5.98	.170	1.017	2.147
76	7.65	.184	1.406	5.98	.183	1.094	2.500
77	7.65	.231	1.768	5.98	.195	1.166	2.934
78	7.65	.272	2.084	5.98	.215	1.286	3.370
70	7.65	.106	.809	5.98	.125	.747	1.556
71	7.65	.139	1.064	5.98	.135	.807	1.871
72	7.65	.163	1.244	5.98	.146	.873	2.117
73	7.65	.176	1.348	5.98	.153	.915	2.263
74	7.65	.156	1.192	5.98	.161	.963	2.154
75	7.65	.155	1.182	5.98	.170	1.017	2.199
76	7.65	.192	1.470	5.98	.183	1.094	2.564
77	7.65	.242	1.848	5.98	.195	1.166	3.014
78	7.65	.285	2.179	5.98	.215	1.286	3.464

Table B-14.--In-place cost per lineal foot of constructing walls from 20-gage steel studs, 16 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from distribution yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER LB.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	LBS.	$	$	MINS.	$	$	$
70	8.50	.153	1.302	4.73	.125	.591	1.893
71	8.50	.162	1.375	4.73	.135	.639	2.014
72	8.50	.172	1.459	4.73	.146	.691	2.149
73	8.50	.173	1.469	4.73	.153	.724	2.192
74	8.50	.215	1.831	4.73	.161	.762	2.592
75	8.50	.258	2.195	4.73	.170	.804	2.999
76	8.50	.274	2.331	4.73	.183	.866	3.196
77	8.50	.295	2.512	4.73	.195	.922	3.434
78	8.50	.310	2.638	4.73	.215	1.017	3.654
70	8.50	.191	1.628	4.73	.125	.591	2.219
71	8.50	.202	1.719	4.73	.135	.639	2.358
72	8.50	.214	1.823	4.73	.146	.691	2.514
73	8.50	.216	1.836	4.73	.153	.724	2.560
74	8.50	.269	2.289	4.73	.161	.762	3.050
75	8.50	.323	2.743	4.73	.170	.804	3.547
76	8.50	.343	2.913	4.73	.183	.866	3.779
77	8.50	.369	3.140	4.73	.195	.922	4.062
78	8.50	.388	3.297	4.73	.215	1.017	4.314

Table B-15.--In-place cost per lineal foot of constructing walls with 2-gage steel studs, 24 inches o.c. (top half of table for large purchases direct from mill, bottom half for large purchases from distribution yard)

	MATERIALS			LABOR			TOTAL
	PER LINEAL FT.	PRICE PER LB.	COST PER LINEAL FT.	PER LINEAL FT.	WAGE PER MAN-MIN.	COST PER LINEAL FT.	COST PER LINEAL FT.
YR	LBS.	$	$	MINS.	$	$	$
70	8.50	.153	1.302	4.49	.125	.561	1.863
71	8.50	.162	1.375	4.49	.135	.606	1.981
72	8.50	.172	1.459	4.49	.146	.656	2.114
73	8.50	.173	1.469	4.49	.153	.687	2.156
74	8.50	.215	1.831	4.49	.161	.723	2.554
75	8.50	.258	2.195	4.49	.170	.763	2.958
76	8.50	.274	2.331	4.49	.183	.822	3.152
77	8.50	.295	2.512	4.49	.195	.876	3.387
78	8.50	.310	2.638	4.49	.215	.965	3.603
70	8.50	.191	1.628	4.49	.125	.561	2.189
71	8.50	.202	1.719	4.49	.135	.606	2.325
72	8.50	.214	1.823	4.49	.146	.656	2.479
73	8.50	.216	1.836	4.49	.153	.687	2.523
74	8.50	.269	2.289	4.49	.161	.723	3.012
75	8.50	.323	2.743	4.49	.170	.763	3.507
76	8.50	.343	2.913	4.49	.183	.822	3.735
77	8.50	.369	3.140	4.49	.195	.876	4.015
78	8.50	.388	3.297	4.49	.215	.965	4.262

U.S. Forest Products Laboratory.

Comparative in-place costs of wood and steel framing, by Henry Spelter. Madison, Wis., For. Prod. Lab., 1979.
41 p. (USDA For. Serv. Res. Pap. FPL 334).

A comparison of the in-place costs of wood and steel framing in light residential construction for period 1970 to 1978.

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