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Labor and Material Requirements for Commercial Office Building Construction



U.S. Department of Labor
Bureau of Labor Statistics
March 1982

Bulletin 2102

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U.S. Department of Labor
Raymond J. Donovan, Secretary

Bureau of Labor Statistics
Janet L. Norwood, Commissioner
March 1982

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Preface

This bulletin presents the results of the first survey by the Bureau of Labor Statistics of labor and material requirements for commercial office building construction. The bulletin also presents estimates of the employment impact of commercial office building construction in 1980; the estimates are based on this survey of projects completed in 1974 and other data. It also describes recent trends in construction design, technology, and management. A summary was published in the May 1981 issue of the *Monthly Labor Review*.

The study is one in a series on the employment-generating effects of construction activities. Other published studies cover civil works, highways, hospitals, college housing, schools, private one-family houses, private multifamily housing, public housing, and Federal office buildings.

Data from these studies are used to assess the impact of private and public construction expenditures on jobs and occupations. The Department of Labor uses the occupational information in projecting construction labor requirements to help determine training needs and prevent labor shortages or surpluses. Market research

analysts and companies that manufacture equipment and supplies are interested in the data collected on the amount and kinds of materials used in construction. In addition, resurveys indicate trends in onsite labor requirements.

The Bureau gratefully acknowledges the cooperation of the Bureau of the Census of the Department of Commerce in drawing an initial sample frame. The Bureau also wishes to thank the general and special trade contractors and owners and developers who provided data for the survey.

The study was prepared in the Bureau's Office of Productivity and Technology by Barbara J. Bingham, assisted by Maurice G. Wright, under the supervision of Robert Ball in the Division of Technological Studies, John J. Macut, Chief. Karen J. Horowitz of the Office of Economic Growth assisted in the development of indirect employee-hour estimates.

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Chapter I. Introduction

Commercial office building construction accounts for a significant portion of new construction activity in the United States. The amount of office space built each year depends on general economic conditions and on an area's outlook for growth, current occupancy rates, money market conditions, government incentives, and the availability of labor.

Value put in place for commercial office buildings from 1972 to 1979¹, in millions of current dollars, was as follows:

1972	\$5,269	1976	\$4,763
1973	5,984	1977	5,269
1974	6,118	1978	6,574
1975	4,973	1979	9,461

In 1972 constant dollars (current-dollar value adjusted for price change), commercial office building construction dropped from a high of \$5,475 million in 1973 to \$3,454 million in 1976. Since then, the value put in place has been increasing; it reached \$4,834 million in 1979.

From 1973 to 1975, most office construction was in the suburbs. Since that time, much of the increase in office space has been in low and mid-rise buildings constructed at the edges of large cities and in the suburbs. Most of this space has been occupied by expanding companies. There is likely to be a surplus of office space by 1983 when most of the larger buildings currently under construction will be completed.²

Many office buildings are now being designed for mixed use. Retail space, theaters, and even apartments, for example, may be found in buildings primarily designed for office use.

¹ Bureau of the Census, U.S. Department of Commerce, *Value of New Construction Put in Place, 1947 to 1974* (December 1975); and *Construction Report, C30-80-5* (May 1980). Bureau of the Census data on the annual value of new construction represent value put in place, while F.W. Dodge data represent contract value. Annual Census values are usually greater than the corresponding data reported by F.W. Dodge.

² "A Towering Rise in Downtown Construction," *Engineering News Record*, Mar. 5, 1979, pp. 91-92, 97; and "Office Contracts Leap; New Trends Appear," *Engineering News Record*, March 23, 1978, p. 39.

Scope and methods of survey

The BLS survey was based on a sample of commercial office buildings completed between May 1, 1973, and August 31, 1974.³ Most of the value of construction was put in place during 1972 and 1973. Therefore data in the accompanying tables are shown as referring to 1972-73.

The Bureau of the Census supplied a sample of 651 projects in the 48 contiguous States, which BLS refined. A final sample of 83 projects was selected to represent a universe of 2,846 projects, with a total construction value of approximately \$2.7 billion.⁴ The sample was stratified by cost class and broad geographic region.

Data on onsite construction labor requirements were collected directly from owners, developers, and contractors. Offsite construction labor requirements were estimated from the ratio of nonconstruction workers to total workers for general building and special trade

³ The length of time between the data year and the year of publication is due to several factors. A considerable amount of time was needed to define and refine the universe, design and select the sample, and collect, compile, and verify the data. Each surveyed project required many visits to contractors and subcontractors. Additional time was required for preparation and publication of the results. Nevertheless, the data presented indicate trends in labor requirements and are useful in analyzing changes in the factors over time. Data also serve as benchmarks to develop current estimates of employment-generating effects of construction expenditures.

⁴ The total construction value of projects in the universe of this survey is less than the value put in place for commercial office buildings as reported by the Bureau of the Census for 1972 or 1973. Restrictions on the type of commercial office buildings and contract work included in the survey are a major reason for this difference. Some of the items excluded are: Projects under \$100,000, additions, renovations, projects financed by public funds, certain "out-of scope" contract operations like installation of public utilities, and buildings where office space accounted for less than 75 percent of the square footage. In addition, this survey was designed so that its total construction value would represent the building costs for projects completed after May 1, 1973 and before Aug. 31, 1974. Value put in place data, however, measure all construction activity that takes place during a given year—regardless of completion date. Survey data also include only the contract value specified in the sample provided by Census; in many cases finishing costs or customizing work was not part of the surveyed contract and therefore those costs were not included.

contractors in the contract construction industry.⁵ Indirect labor data were developed by aggregating the materials, supplies, and equipment values by general type, and then deflating the dollar total for each type by the appropriate Producer Price Index. These constant-dollar values of materials, equipment, and supplies were processed through the Bureau's input-output tables to generate estimates of final demand. Sector pro-

ductivity factors were then applied to derive employee hours for the manufacturing industries; trade, transportation, and services industries; and mining and all other industries. These estimates are the indirect labor hours generated by construction activity. Employment generated by the spending of workers' wages and salaries and contractors' profits (employment multiplier or so-called ripple effect) is outside the scope of this report.

⁵ Offsite employee hours represent the builder's administrative, estimating, and warehousing activities. The following procedure was used to calculate offsite construction employee hours: (1) Employee hours worked by administrative personnel were subtracted from total onsite hours obtained in the survey. The number of administrative hours was taken from survey data. (2) The percentage that these adjusted onsite hours were of total hours was found in *Employment and Earnings, United States, 1908-78, Bulletin 1312-11* (Bureau of Labor Statistics, 1979) and a total hours figure was calculated. (3) From this total hours figure, onsite hours (including administrative hours) were subtracted to obtain offsite hours. (Administrative hours were subtracted from onsite hours only for calculation of total hours because

the administrative hours are not included in the construction worker employment figures in Bulletin 1312-11. Administrative hours worked onsite are included in all onsite hour data presented.)

Employment and Earnings data from SICs 15 and 17 were used in the calculation of offsite hours for building surveys. SIC 161 was used for highways; 162 for civil works; all contract construction for sewer works; and SIC 17 for housing surveys. However, some SIC series did not extend far enough to be used for several older surveys. Therefore, all contract construction data were used in older highways and civil works surveys and SIC 17 was used in some older building construction surveys.

Chapter II. Employee-hour Requirements

Summary

For every \$1,000 of contract value for commercial office buildings completed in 1974, 97.5 employee hours were required. Of these, 42.0 were in the construction industry. The remaining hours were distributed throughout other industries as shown in the tabulation below.

	<i>Hours per thousand current dollars</i>	
	<i>In 1972-73</i>	<i>In 1980</i>
All industries	97.5	41.9
Construction	42.0	17.9
Onsite	37.2	15.9
Offsite	4.8	2.0
Other industries	55.5	24.0
Manufacturing	33.0	13.9
Trade, transportation, and services	16.6	7.5
Mining and all other industries	5.9	2.6

Onsite hours, which ranged from a low of 11.7 hours to a high of 72.4 hours, can be affected by many factors, including strikes, weather conditions, restrictive or changing building codes, the use of prefabricated or standardized building components, the availability of skilled labor, soil conditions, project size and design, and order time for materials.

Estimates for 1980 indicate that approximately 41.8 employee hours would be required per 1,000 current dollars of contract value.⁶ An expenditure of \$1 billion on commercial office building construction in 1973 would have created over 49,000 jobs, 23,000 in the con-

⁶ The 1972-73 onsite hours required for commercial office building construction were adjusted for price and productivity factors to estimate 1980 labor requirements. The 1980 estimates are based on 1972-73 commercial office building survey data and the rate of change in onsite hours between 1959 and 1973 for Federal office building construction.

The price deflator used is the nonresidential building deflator or the average of the Census single-family housing deflator, the Turner Construction Co. deflator, and the Federal Highways Administration deflator: 1959=59.5, 1972=100, 1972-73=104.6, 1980=217.9 (preliminary). The rate of change was based on the 1973 Federal office building survey: -2 percent annually. From this rate a compound interest factor for the 6-1/2 year span was derived and applied to the hours, which were adjusted by the cost index.

struction industry.⁷ The Bureau estimates that a \$1 billion expenditure in 1980 would have created 21,900 jobs, 9,800 in the construction industry.

	<i>Jobs per billion current dollars</i>	
	<i>In 1973</i>	<i>In 1980</i>
All industries	48,383	21,900
Construction	23,067	9,800
Onsite	20,667	8,800
Offsite	2,400	1,000
Other industries	23,316	12,100
Manufacturing	15,752	6,700
Trade, transportation, and services	8,066	4,200
Mining and all other industries	2,498	1,300

Onsite hours

By occupation. Skilled workers accounted for 68 percent of all onsite construction hours. The percentage was higher than average in the West, at 77 percent, and lower in the South, at 65 percent (table 1).⁸

Among the various skilled trades, carpenters accounted for the largest percentage of onsite hours in all

⁷ Employment-year estimates were computed using 1,800 hours for onsite construction and 2,000 hours for offsite construction. Average hours per job in 1973 for other industries were as follows: Agriculture—2,374; mining—2,173; construction—2,028; manufacturing—2,095; transportation—2,149; communications—2,080; public utilities—2,152; wholesale trade—2,136; retail trade—2,019; finance, insurance and real estate—1,991; services—1,862; and government enterprises—2,134.

Average hours per job in 1979 for other industries are as follows: Agriculture—2,311; mining—2,266; construction—1,912; manufacturing—2,068; transportation—2,050; communications—2,075; public utilities—2,161; trade—1,742; finance, insurance and real estate—1,899; services—1,776; and government enterprises—2,087.

⁸ Data were provided for the continental United States and 4 broad geographic regions: *Northeast*—Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; *North Central*—Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; *South*—Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; and *West*—Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

four regions; their proportion ranged between 15 and 23 percent. Electricians were next highest, with a range of 5 to 11 percent. All other skilled worker groups accounted for less than 10 percent each of total onsite hours.

Semiskilled and unskilled workers averaged 24 percent of the onsite hours, ranging from 18 percent in the Northeast to 28 percent in the South. Hours of professional and clerical workers ranged from 3 percent in the West to 14 percent in the Northeast.

By type of contractor. General contractors consistently accounted for the largest percentage of onsite labor although their proportion varied among the regions (table 2). In the South, general contractors accounted for 40 percent of the onsite labor, much higher than the national average of 34 percent. Heating, ventilating, and air-conditioning (HVAC) subcontractors claimed the next highest percentage of onsite hours in every region except the Northeast, where electrical subcontractors accounted for a larger percentage than heating, ventilating, and air-conditioning subcontractors.

By building characteristics. Except in the Northeast, the construction of buildings containing only offices required fewer employee hours per \$1,000 of contract value than buildings containing a combination of offices and apartments or shopping facilities. Buildings containing only offices had lower labor requirements per 100 square feet in the United States and in all four regions (table 3). In a building containing only offices, some efficiencies may be realized because of the repetitive design, which also allows for increased use of modular materials.

On the average, concrete-framed buildings had higher labor requirements per \$1,000 and per 100 square feet than buildings with other types of framing⁹ (table 4). Buildings with concrete exterior walls required more labor than those with masonry, wood, or other types of exteriors. Buildings with plaster walls and ceilings required more employee hours than those with any other type of interior wall or ceiling. When buildings with different floor base types were compared, those with concrete floors required the most labor. Terrazzo-floored offices required more hours per \$1,000 and per 100 square feet than buildings which had vinyl or vinyl-asbestos flooring, carpet, or other floor coverings.

Buildings heated with forced air had higher labor requirements than those heated by hot water, radiant, or other types of heat. When employee-hour require-

ments were compared for buildings with different types of heating fuel, no consistent trend was evident: Oil-heated buildings required more hours per 100 square feet than those using electricity, gas, or "other" types of fuel, but, per \$1,000, "other" fueled buildings required the most labor. Data for buildings with different roof bases and types of roofing were also inconsistent. Projects with wood roofing and those with concrete roof base had higher labor requirements per \$1,000, but buildings with built-up roofs and those with wood or plywood roof bases had higher requirements per 100 square feet. Buildings with central air-conditioning (as opposed to other types of air-conditioning) and buildings with elevators and escalators (as opposed to none), required more labor. Some of these differences in labor requirements undoubtedly reflect differences in each building's cost or other project characteristics.

By location. On average, more labor was required to build a commercial office building in a nonmetropolitan area than in a metropolitan area (table 5). This may reflect the fact that labor tends to be less expensive in nonmetropolitan areas and therefore is more readily substituted for equipment. In the Northeast, however, hours per \$1,000 were slightly higher, and hours per 100 square feet were more than twice as high, in metropolitan areas.

By number of floors and cost class. Employee-hour data stratified by project cost size and by number of floors above ground did not show any clear relationship between hours and cost, or hours and building height. However, hours per \$1,000 did decline as the number of floors below ground increased. Buildings which had four to five floors below ground showed less than one-third the average labor requirement—11.7 hours per \$1,000 contract value. Also, only 19.3 hours were required per 100 square feet for this group of buildings—less than one-fourth the average for all projects. Caution should be used in drawing any conclusions from these data, however, because the number of such buildings was small (four) and they were all located in one region (North Central).

Distribution of time for onsite employment

As a case study, a few projects were analyzed for the pattern of time spent on the site by various occupational groups and types of contractors over the course of the entire construction period (tables 6 and 7). The results are likely to reflect the pattern for the majority of projects but are not based on a statistically valid sample. Seasonal fluctuations may influence some patterns since the construction of large office buildings takes from 2 to 6 years.

The construction period was divided into 10 equal parts. On average, the percentage of total hours ex-

⁹Employee-hour requirements are affected by a number of factors such as location, size of project, type of structure, labor skills, and local building codes and customs. The effects of these separate factors cannot be isolated. Therefore, caution should be used in making generalizations about the relationships between the type of building materials and onsite labor requirements.

Table 1. Percent distribution of onsite employee hours by occupation and region, commercial office building construction, 1972-73

Occupation	United States	Northeast	North Central	South	West
All occupations 1/	100.0	100.0	100.0	100.0	100.0
Skilled workers	68.4	68.1	68.6	64.8	77.0
Carpenters	19.2	18.0	15.3	20.2	22.5
Electricians	6.4	10.8	6.5	6.0	4.6
Plumbers	4.7	7.0	4.7	4.4	4.0
Cement finishers	4.2	3.4	5.6	2.6	6.3
Sheet-metal workers	4.0	3.0	5.0	-	7.8
Bricklayers	3.3	4.0	4.5	-	4.0
Iron workers, structural	3.2	2.3	4.4	2.7	-
Glaziers	-	-	-	3.0	-
Iron workers, reinforcing	-	-	-	2.6	-
Other skilled workers	-	-	-	-	4.0
Semiskilled and unskilled workers	24.2	18.0	23.3	28.0	19.4
Laborers, helpers, and tenders	22.6	17.0	20.9	26.6	18.3
Professional and clerical workers	7.4	13.9	8.1	7.2	3.6
Superintendents and general supervisors	6.4	13.1	7.1	5.8	3.1

¹ For skilled workers, data are shown separately only for the 7 occupations with the highest percentage of onsite hours in each

region. For the other two groups, data are shown separately only for the single largest occupation.

Table 2. Percent distribution of onsite employee hours by type of contractor and region, commercial office building construction, 1972-73

Type of contractor	United States	Northeast	North Central	South	West
All contractors	100.0	100.0	100.0	100.0	100.0
General contractors	34.1	28.0	26.8	40.2	32.7
Subcontractors: 1/					
Heating, ventilating, and air-conditioning	10.8	12.2	9.7	11.5	9.6
Electrical	6.8	13.9	8.0	5.5	4.7
Masonry	5.4	7.9	7.4	3.6	6.0
Concrete work	5.4	3.8	8.7	3.6	6.0
Plastering and lathing	4.3	2.6	-	7.8	-
Structural steel	4.0	-	5.4	3.8	4.2
Excavation, footings, foundation, and grading	3.8	8.9	6.8	-	-
Glass and glazing	3.6	-	-	4.7	-
Carpentry	-	6.0	-	-	7.6
Wallboard	-	-	3.7	3.1	-
Plumbing	-	-	4.2	-	4.8
Roofing, gutter work, flashing, and siding	-	2.0	-	-	3.7

¹ Data are shown only for the 8 types of contractors with the highest percentage of onsite hours in each region.

Table 3. Onsite employee hours per \$1,000 of contract cost and per 100 square feet by project type and region, commercial office building construction, 1972-73

Project type	United States		Northeast		North Central		South		West	
	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.
All projects	37.2	83.3	37.0	129.8	32.4	68.4	44.2	103.2	31.7	60.9
Offices only	36.0	80.2	37.3	127.6	30.5	65.8	43.6	100.2	30.5	57.5
Combination of offices, apartments and shopping facilities	40.9	92.7	34.9	146.7	37.7	75.2	45.4	110.6	36.7	75.6

Table 4. Onsite employee hours per \$1,000 of contract cost and per 100 square feet by selected building characteristics and region, commercial office building construction, 1972-73

Characteristic	United States		Northeast		North Central		South		West	
	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.
All projects	37.2	83.3	37.0	129.8	32.4	68.4	44.2	103.2	31.7	60.9
Framing:										
Steel	35.5	87.3	36.3	123.1	30.0	69.9	44.1	13.9	24.0	46.0
Concrete	43.6	83.9	1/	1/	44.2	73.6	43.5	91.4	44.8	150.8
Masonry	31.6	66.8	72.4	328.7	27.2	54.2	57.7	107.3	33.5	97.1
Wood	35.3	58.8	39.5	128.1	42.4	132.9	2/	2/	33.7	49.3
Exterior walls:										
Concrete	42.1	101.9	27.2	220.2	37.6	68.0	47.5	117.6	36.2	118.0
Masonry (brick)	35.4	69.5	38.0	85.7	29.2	60.8	39.5	77.7	39.1	62.4
Wood	35.2	57.7	32.2	101.2	47.2	188.7	45.5	80.9	30.9	43.4
Other	34.1	86.3	1/	1/	29.0	82.4	43.2	114.4	27.8	60.5
Interior walls:										
Drywall	37.2	82.3	36.5	128.0	31.2	62.7	43.9	102.5	32.8	63.4
Plaster	47.2	104.9	55.6	197.2	43.7	97.7	46.2	96.0	2/	2/
Movable partitions	33.8	87.3	2/	2/	1/	1/	2/	2/	18.4	33.0
Other	39.1	98.2	2/	2/	30.2	69.0	1/	1/	2/	2/
Floor base:										
Concrete	38.0	87.7	36.9	129.6	32.2	67.9	44.2	103.2	34.1	73.2
Wood 1 plywood	28.1	47.1	38.2	131.8	37.0	93.1	2/	2/	26.4	41.1
Floor covering:										
Terrazzo	42.4	93.4	2/	2/	2/	2/	42.4	93.4	2/	2/
Carpet	36.0	84.5	37.1	125.8	32.9	70.4	47.4	133.8	30.0	59.4
Vinyl/vinyl- asbestos	37.0	91.2	1/	1/	32.1	65.1	40.1	129.2	56.4	199.1
Other	39.7	76.9	2/	2/	26.3	60.4	42.8	87.5	28.4	42.0
Ceiling:										
Drywall	30.6	53.4	2/	2/	28.4	53.1	32.9	85.6	35.6	44.7
Plaster	38.7	99.4	2/	2/	38.7	99.4	2/	2/	2/	2/
Acoustical tile	37.8	87.1	37.0	129.8	33.1	71.5	44.9	107.6	31.4	62.8
Other	35.4	55.4	2/	2/	2/	2/	35.4	55.4	2/	2/
Heating:										
Forced air	39.6	91.3	36.8	97.4	37.8	80.9	45.2	110.8	32.9	71.3
Hot water	35.3	79.9	34.4	98.3	29.8	70.9	52.2	116.5	18.4	33.0
Radiant	32.2	68.4	37.4	194.0	26.0	48.6	36.4	84.2	32.6	40.6
Other	35.4	55.4	2/	2/	2/	2/	35.4	55.4	2/	2/
Heating fuel:										
Electricity	34.6	77.2	36.7	125.6	27.0	57.2	42.2	98.2	28.8	52.0
Gas	39.8	91.6	72.4	328.7	32.1	76.0	46.4	108.6	36.2	76.9
Oil	35.5	134.9	35.1	141.9	37.0	115.0	2/	2/	2/	2/
Other	49.3	76.2	2/	2/	49.3	76.2	2/	2/	2/	2/
Air-conditioning:										
Central air	37.4	85.6	36.7	130.4	32.4	68.3	44.2	104.0	32.0	65.2
Other	33.2	51.8	45.8	115.8	37.6	92.7	40.9	68.8	30.5	45.1
Elevator/escalator:										
Elevator/escalator	37.8	90.8	37.5	161.8	33.1	69.6	43.2	101.9	30.8	78.6
None	35.2	64.2	35.7	87.5	29.8	63.8	54.6	116.4	32.7	49.5
Roofing:										
Asphalt/asbestos	29.5	60.3	53.6	119.6	27.7	54.3	1/	1/	42.1	138.9
Built-up	38.1	90.8	36.7	130.4	34.6	75.7	43.6	102.3	29.9	66.5
Wood	39.5	58.0	37.4	110.4	61.0	121.2	2/	2/	38.6	54.0
Other	38.6	65.6	2/	2/	2/	2/	51.3	116.4	31.7	47.3
Roof base:										
Steel decking	38.8	98.6	37.8	145.2	33.2	78.5	44.6	100.0	42.1	138.9
Concrete	40.5	94.4	1/	1/	37.7	63.9	43.9	104.9	33.1	93.5
Wood/plywood	30.2	51.0	34.3	79.7	29.4	55.3	2/	2/	30.0	46.6
Other	1/	1/	2/	2/	1/	1/	2/	2/	2/	2/
Parking facilities:										
Indoor	38.6	84.9	2/	2/	49.3	76.2	46.2	146.0	27.8	75.5
Surface	37.0	83.4	37.1	131.6	28.4	66.1	44.4	106.5	30.0	46.6
Indoor and surface	36.8	81.2	2/	2/	31.4	66.2	44.6	79.1	44.5	141.0
No parking	39.6	84.2	33.4	94.1	1/	1/	40.8	82.6	2/	2/

¹ No projects in sample.

² Fewer than 3 projects in universe.

Table 5. Onsite employee hours per \$1,000 on contract cost and per 100 square feet by selected project characteristics and region, commercial office building construction, 1972-73

Characteristic	United States		Northeast		North Central		South		West	
	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.	Per \$1,000	Per 100 sq. ft.
All projects	37.2	83.3	37.0	129.8	32.4	68.4	44.2	103.2	31.7	60.9
Location:										
Metropolitan area	36.9	82.1	37.2	144.2	31.2	62.8	43.5	102.8	31.7	60.9
Nonmetropolitan area	41.1	96.2	34.3	66.9	37.2	97.7	57.2	109.6	1/	1/
Construction value: 2/										
\$100,000 - \$249,999	44.2	71.4	41.4	176.5	44.6	98.8	53.9	102.8	37.1	44.0
\$250,000 - \$499,999	35.4	75.2	34.7	74.9	40.9	95.4	47.2	99.7	14.9	25.6
\$500,000 - \$999,999	32.6	68.5	33.4	94.1	24.5	48.4	43.1	86.2	28.6	62.5
\$1,000,000 - \$2,999,999 ...	34.5	80.3	37.8	160.3	28.0	57.2	40.1	101.6	31.2	51.7
\$3,000,000 - \$4,999,999 ...	45.4	96.2	1/	1/	1/	1/	45.4	96.2	1/	1/
\$5,000,000 and over	39.3	96.8	3/	3/	36.1	78.4	46.1	117.0	33.0	92.5
Floors above grade:										
1 floor	37.7	74.4	35.6	81.7	31.2	71.8	57.4	135.3	39.2	60.0
2 to 3 floors	33.2	70.8	37.6	149.5	30.0	62.5	42.6	83.8	26.7	45.4
4 to 10 floors	38.4	96.0	3/	3/	28.1	52.4	41.8	110.2	42.1	138.9
11 to 35 floors	40.5	88.6	1/	1/	40.6	78.8	45.2	96.5	33.0	92.5
36 to 60 floors	38.9	106.9	1/	1/	3/	3/	45.9	117.9	1/	1/
Floors below grade:										
1 floor	37.9	82.2	37.1	125.8	34.6	71.2	43.8	102.2	31.2	53.1
2 to 3 floors	35.8	99.4	3/	3/	3/	3/	46.5	108.9	33.0	92.5
4 to 5 floors	11.7	19.3	1/	1/	11.7	19.3	1/	1/	1/	1/

¹ No project in sample.

³ Fewer than 3 projects in universe.

² Does not include 1 sampled project under \$100,000.

Table 6. Percent of onsite hours in each tenth of construction time by selected occupational group, commercial office building construction

Occupation	Tenth of construction time										Total onsite hours
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	
All occupations	9.1	10.1	10.4	12.4	13.1	12.9	13.9	9.4	5.1	3.6	100.0
Supervisors	12.2	10.4	9.7	12.5	11.5	11.1	11.6	9.8	5.6	5.5	100.0
Professional, technical, and clerical workers ..	14.0	9.2	11.8	18.7	14.8	13.1	7.1	6.4	3.3	1.5	100.0
Skilled workers:											
Construction workers ..	6.7	8.7	9.6	11.6	14.3	14.4	15.2	9.7	5.7	4.1	100.0
Operating engineers ...	20.0	14.4	11.5	12.4	10.9	10.2	10.3	7.2	2.4	.8	100.0
Semiskilled and unskilled workers:											
Laborers, helpers, and tenders	10.5	12.4	11.8	14.6	11.2	10.8	14.2	10.2	2.8	1.6	100.0
Truckdrivers	65.8	7.6	19.0	3.8	2.5	.4	-	-	.3	.6	100.0
Custodial workers	1.3	7.2	12.2	10.4	8.1	8.2	8.3	-	25.4	19.0	100.0

NOTE: Data in this table are based on a small case study, not a statistical sample. Detail may not add to 100.0 percent due to rounding.

Table 7. Percent of onsite hours in each tenth of construction time by type of contractor, commercial office building construction

Type of contractor	Tenth of construction time										Total onsite hours
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	
All contractors ..	9.1	10.1	10.4	12.4	13.1	12.9	13.9	9.4	5.1	3.6	100.0
General contractors	13.2	13.5	13.2	16.8	13.4	11.7	9.3	7.0	1.4	.6	100.0
Selected subcontractors:											
Concrete work	3.5	32.1	28.3	21.4	9.6	3.6	1.3	1/	1/	.1	100.0
Structural steel	14.4	16.8	23.0	22.2	15.4	4.6	2.3	1.0	.4	1/	100.0
Heating, ventilating, and air-conditioning	3.3	5.8	6.7	8.7	24.4	25.0	10.5	8.1	4.8	2.7	100.0
Electrical	5.2	6.3	7.4	12.0	12.6	15.0	24.8	11.4	3.4	1.8	100.0
Glass and glazing	1/	1.7	6.6	3.1	6.3	15.8	18.6	13.2	3.4	31.3	100.0

¹ Less than 0.1 percent.

statistical sample. Detail may not add to 100.0 percent due to rounding.

NOTE: Data in this table are based on a small case study, not a

pendent rose gradually over about two-thirds of the total time span and then declined rather quickly.

By occupation. The onsite hours expended over time followed a generally expected pattern. Supervisory hours were spread more evenly over the duration of construction than hours of any other occupational group, a pattern consistent with the supervisory function: Supervisors in each craft are usually present even if only a few workers are at the site.

Truckdrivers did most of their work at the beginning of construction, when dirt and materials are transported, as did operating engineers, who are used extensively in excavation and framing work. Custodial workers had an inconsistent pattern, though the large proportion towards the end of the time period would be expected because they prepare the buildings for customizing and occupancy.

By contractor. The general contractor, whose responsibilities cover the entire construction period, had the most even distribution of hours, although they tapered off somewhat towards the end of the project as overall construction work wound down. As would be expected, hours spent on concrete work peaked early, and remained fairly high until the fourth period, when they dropped sharply; most concrete work involves pouring the foundation, and sometimes the framing, which must be done early in the construction cycle. This was also generally true for structural steel work, though its peak was not as high and it came after the peak for concrete work (or after the pouring of concrete foundations or piles). The pattern of hours for heating, ventilating, and air-conditioning contractors reflected the fact that most of their work cannot be done until much of the steel and concrete work is completed.

As expected, most electrical work was done after the rough-in plumbing, ductwork, and other heating and air-conditioning work were completed. Glass and glazing work also followed an expected pattern except for an unexplained rise at the end.

Offsite and indirect hours

Of the 97.5 employee hours required per \$1,000 of commercial office building construction, 4.8 hours, or 5 percent, were for offsite construction (compared to 37.2 percent for onsite hours and 57 percent for indirect hours). Offsite employee hours represent builders' administrative, estimating, and warehousing activities.

Offsite construction hours were estimated from the ratio of nonconstruction workers to total workers for general building and special trade contractors in the contract construction industry.

Indirect hours represent the labor required to produce and distribute the materials, equipment, and supplies used in construction.¹⁰ Indirect employee hours were developed in three broad industry groups; manufacturing; trade, transportation, and services; and mining and all other industries.

	<i>Hours per \$1,000 in 1973</i>
Total indirect hours	55.5
Manufacturing	33.0
Trade, transportation, and services	16.6
Transportation	3.9
Wholesale trade	5.3
Retail trade	4.9
Services	2.5
Mining and all other industries ...	5.9
Mining	1.6
Agriculture	.8
Construction	.6
Communications	.5
Public utilities	.4
Finance, insurance, and real estate	1.4
Government enterprises	.6

For every \$1,000 of commercial office building construction, an estimated 33 hours—or 59 percent of all indirect hours—were generated in the manufacturing industry. This large percentage is due to the nature of construction in that most labor not used onsite is used in the manufacture of building materials. As prefabrication increases, the manufacturing industry's percentage of hours should become even larger.

The next largest industry group totaled 16.6 hours or 30 percent of all indirect hours. Of these, transportation accounted for 3.9 hours; wholesale trade, 5.3; retail trade, 4.9; and services, 2.5. Of the remaining hours, 1.6 were expended in mining, 1.4 in finance, insurance, and real estate, and less than 1 hour in each of the other industries. Estimates for 1980 show total indirect hours declined to 24 hours per \$1,000; 13.9 in manufacturing; 7.5 in trade, transportation, and services; and 2.6 in mining and all other industries.

¹⁰ The Office of Economic Growth and Employment Projections, Bureau of Labor Statistics, uses the input-output tables of the Bureau of Economic Analysis, U.S. Department of Commerce, to generate the indirect hours from the materials, equipment, and supply cost data provided by this survey.

Chapter III. Costs

Costs by project characteristic

Average cost per square foot for surveyed commercial office buildings was \$22.36 in 1972-73 dollars. (In 1980 dollars this cost would be \$46.58.) The cost varied considerably from the national average in two of the regions—the Northeast, where average cost was highest at \$35.13; and the West, where it was lowest at \$19.18 (table 8).

Cost per square foot did not correspond in any way to average project cost. The average cost per square foot also did not vary much for the United States by building cost class, except that projects in the lowest cost class had the lowest cost per square foot—\$16.16. Costs for projects stratified by number of floors above and below grade varied only slightly from the average, with three exceptions: The highest buildings and those with two to three floors below grade were relatively costly, at \$27.51 and \$27.80 per square foot, respectively, while those with four to five floors below grade were much less costly, at \$16.47 per square foot. Building characteristics other than the number of floors below grade may have been more important determinants of costs in the latter case. For example, these projects were only in the North Central region which had the highest percentage of incomplete interiors, as indicated in the tabulation below.¹¹

¹¹ In the construction of commercial office buildings, a separate contract is often let for customizing work (completing the interior office space to tenant specifications). If customizing work was done under a separate contract, that contract was not surveyed.

Data were available on the percent of the interior of the building that was completed under each contract (as surveyed). These data did not seem to relate consistently in any way to cost on a square foot basis (or to onsite hours). The percent of the interior completed was as follows:

	United States	North-east	North Central	South	West
All buildings.....	78	94	65	79	89
Office buildings	79	94	65	77	95
Combination of offices, apartments, and retail space	74	92	66	89	58

Costs by building characteristic

Cost per square foot was the highest for steel-framed buildings—the most common type of framing in the projects surveyed—at \$2.21 above the average cost (table 9). Buildings with wood frames cost only \$16.64 per square foot, while concrete and masonry-framed buildings were near the average U.S. cost of \$22.36. Buildings with the most common type of exterior wall—masonry (brick)—had a slightly lower than average cost, while buildings with wood exteriors cost even less. Projects with concrete and “other” types of walls had a higher than average cost.

Building characteristics for which projects showed considerably lower than average cost were wood or plywood floors (24 percent of all projects), those with drywall ceilings (a small percent of the projects, since

Table 8. Number of projects and cost per square foot by selected project characteristics and region, commercial office building construction, 1972-73

Characteristic	United States		Northeast		North Central		South		West	
	Number of projects	Cost per square foot	Number of projects	Cost per square foot	Number of projects	Cost per square foot	Number of projects	Cost per square foot	Number of projects	Cost per square foot
All projects ...	2,846	\$22.4	358	\$35.1	620	\$21.1	846	\$23.4	1,021	\$19.2
Location:										
Metropolitan area	2,326	22.3	269	38.7	446	20.1	590	23.6	1,021	19.2
Nonmetropolitan area ..	519	23.4	89	19.5	173	26.3	256	19.2	0	1/
Construction value: 2/										
\$100,000 - \$249,999 ..	1,143	16.2	89	42.7	190	22.2	380	19.1	484	11.8
\$250,000 - \$499,999 ..	366	21.2	168	21.6	98	23.4	41	21.2	60	17.2
\$500,000 - \$999,999 ..	485	21.0	13	28.2	94	19.8	154	20.0	223	21.8
\$1,000,000 - \$2,999,999	595	23.3	85	42.4	210	20.5	215	25.3	84	16.6
\$3,000,000 - \$4,999,999	35	21.2	0	1/	0	1/	35	21.2	0	1/
\$5,000,000 - and over ..	68	24.6	3/	3/	26	21.7	21	25.4	17	28.0
Floors above grade:										
1	1,047	19.7	155	22.9	271	23.0	221	23.6	400	15.3
2 to 3	1,454	21.3	201	39.8	282	20.8	378	19.7	594	17.0
4 to 10	250	25.0	3/	3/	42	18.6	196	26.4	9	33.0
11 to 35	85	21.9	0	1/	23	19.4	44	21.3	17	28.0
36 to 60	9	27.5	0	1/	3/	3/	8	25.7	0	1/
Floors below grade:										
1	2,812	21.7	356	33.9	614	20.5	839	23.4	1,004	17.0
2 to 3	30	27.8	3/	3/	3/	3/	8	23.4	17	28.0
4 to 5	4	16.5	0	1/	4	16.5	0	1/	0	1/

¹ No project in sample.

² Does not include one sample project less than \$100,000.

³ Fewer than 3 projects in universe.

Table 9. Number of projects and cost per square foot by selected building characteristics, commercial office building construction, 1972-73

Characteristic	United States		Northeast		North Central		South		West	
	Number of projects	Cost per square foot	Number of projects	Cost per square foot	Number of projects	Cost per square foot	Number of projects	Cost per square foot	Number of projects	Cost per square foot
All projects	2,846	\$22.4	358	\$35.1	620	\$21.1	846	\$23.4	1,021	\$19.2
Framing:										
Steel	1,241	24.6	228	34.0	157	23.3	431	25.8	425	19.2
Concrete	346	21.6	1/	1/	56	16.6	230	21.0	58	33.7
Masonry	565	21.1	26	45.4	279	19.9	185	18.6	74	29.0
Wood	694	16.6	102	32.4	127	31.3	0	2/	464	14.6
Exterior walls:										
Concrete	453	24.2	59	59.2	122	18.1	221	24.7	51	32.6
Masonry (brick)	1,593	19.6	206	22.6	471	20.8	483	19.7	433	16.0
Wood	520	16.4	90	31.4	18	40.0	42	17.8	370	14.0
Other	279	25.3	1/	1/	9	28.4	100	26.4	167	21.8
Interior walls:										
Drywall	2,600	22.2	319	35.1	507	20.1	800	23.4	975	19.3
Plaster	119	22.2	39	35.5	35	22.4	45	20.8	0	2/
Movable partitions	48	25.8	0	2/	1/	1/	2/	2/	46	17.9
Other	78	25.1	0	2/	77	22.9	1/	1/	0	2/
Floor base:										
Concrete	2,159	23.0	282	35.2	562	21.0	846	23.4	470	21.4
Wood/plywood	686	16.8	77	34.5	58	25.1	0	2/	552	15.6
Floor covering:										
Terrazzo	43	22.0	0	2/	0	2/	43	22.0	0	2/
Carpet	2,126	23.5	356	33.9	377	21.4	454	28.0	940	19.8
Vinyl/vinyl-asbestos	288	24.6	1/	1/	201	20.2	77	32.2	7	35.3
Other	389	19.4	0	2/	42	22.9	272	20.5	74	14.8
Ceiling:										
Drywall	118	17.5	0	2/	64	18.7	24	26.0	31	12.6
Plaster	18	25.7	0	2/	18	25.7	0	2/	0	2/
Acoustical tile	2,667	23.1	358	35.1	538	21.6	781	24.0	990	20.0
Other	42	15.6	0	2/	0	2/	42	15.6	0	2/
Heating:										
Forced air	1,901	23.1	234	26.4	365	21.4	667	24.5	635	21.7
Hot water	251	22.6	26	28.6	88	23.8	90	22.3	46	17.9
Radiant	652	21.2	99	51.9	167	18.7	46	23.1	340	12.5
Other	42	15.6	0	2/	0	2/	42	15.6	0	2/
Heating fuel:										
Electricity	1,674	22.3	304	34.2	333	21.2	572	23.0	465	18.0
Gas	1,103	23.0	26	45.4	247	23.7	275	23.4	556	21.3
Oil	54	38.0	28	40.4	26	31.1	0	2/	0	2/
Other	14	15.4	0	2/	14	15.4	0	2/	0	2/
Air-conditioning:										
Central air-conditioning	2,590	22.8	332	35.6	603	21.1	786	23.5	869	20.4
Other air-conditioning	256	15.6	26	25.3	17	24.6	61	16.8	152	14.8
Elevators/escalators:										
Elevator/escalator	1,017	24.0	101	43.2	279	21.0	431	23.6	207	25.5
No elevator/escalator	1,828	18.2	257	24.5	340	21.4	416	21.3	814	15.1
Roofing:										
Asphalt/asbestos shingles	309	20.4	13	22.3	285	19.6	1/	1/	9	33.0
Built-up	2,037	23.8	332	35.6	317	21.9	840	23.4	547	22.2
Wood	214	14.7	13	29.6	18	19.9	0	2/	184	14.0
Other	285	17.0	0	2/	0	2/	4	22.7	281	14.9
Roof base:										
Steel decking	820	25.4	190	38.4	345	23.6	276	22.4	9	33.0
Concrete	726	23.3	1/	1/	62	17.0	571	23.9	91	28.2
Wood/plywood	1,298	16.9	166	23.2	211	18.8	0	2/	920	15.5
Other	1/	1/	0	2/	1/	1/	0	2/	0	2/
Parking area:										
Indoor	39	22.0	0	2/	14	15.4	6	31.6	20	27.1
Surface	2,497	22.6	345	35.5	479	23.2	752	24.0	920	15.5
Indoor and surface	250	22.1	0	2/	125	21.1	44	17.7	81	31.7
No parking	60	21.1	13	28.2	1/	1/	45	20.2	0	2/

¹ Fewer than 3 projects in universe.

² No projects in sample.

94 percent of surveyed projects had acoustical tile ceilings), noncentral air-conditioning (9 percent), wood roofing (only 8 percent), and wood or plywood roof base (46 percent). Generally, buildings that make extensive use of wood materials are likely to cost less per square foot than other buildings.

Oil-heated buildings showed unusually high cost—\$38 per square foot. However, only 1 percent of all projects used oil for heating.

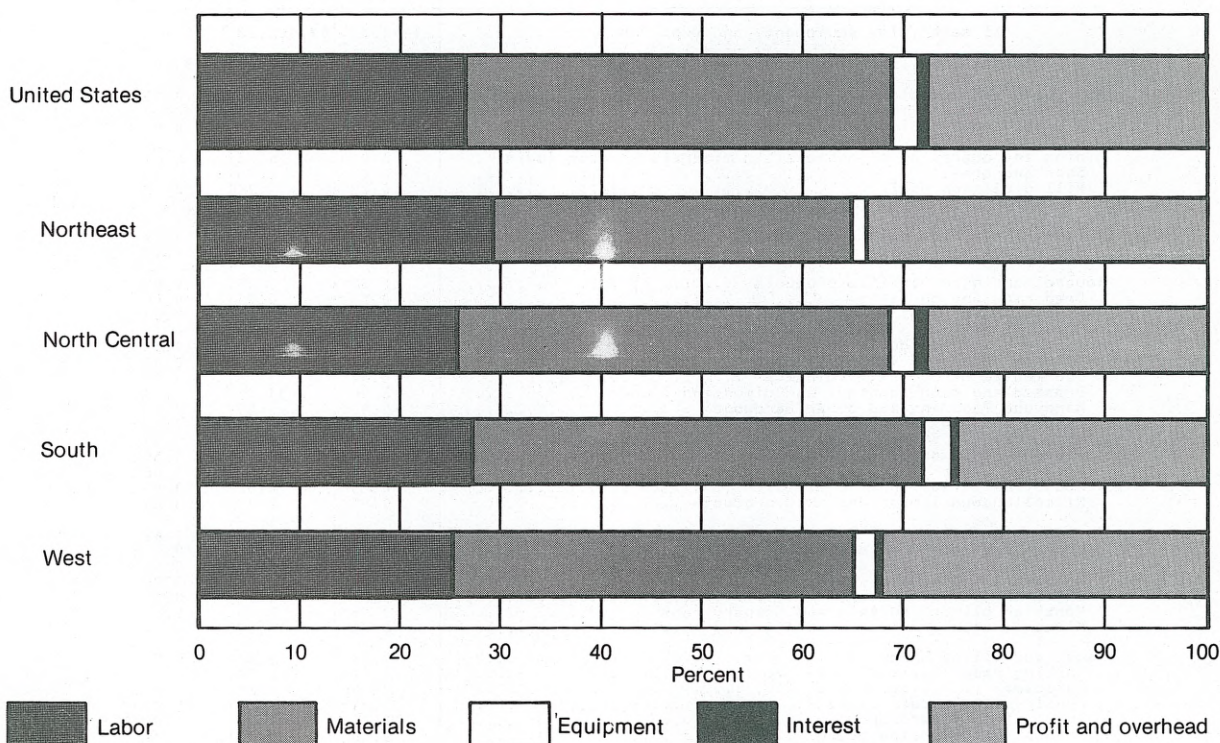
Average project cost and components of cost

The average total construction cost for surveyed commercial office buildings was \$947,084. Buildings

constructed in the West cost the least, at \$584,299, while those in the Northeast were slightly higher, but still below the average, at \$776,372. Both the North Central and Southern projects showed higher than average costs at \$1,264,162 and \$1,224,771, respectively. Over 50 percent of all commercial office buildings surveyed cost less than \$500,000. Seventy-five percent cost less than \$1 million.

Project costs were divided into five components, proportions of which averaged as follows: Materials, 42.2 percent of total project costs; labor, 26.7 percent; equipment, 2.7 percent; interest expense, 0.6 percent; and profit and overhead, 27.9 percent. (See chart 1.) Cost

Chart 1. Construction cost components, United States and regions, commercial office building construction, 1972-73



components in the North Central region and the South were close to the national average (although the South did have an appreciably lower proportion of profit and overhead) while projects in the Northeast and West differed considerably from the national average. Projects in the Northeast were relatively higher than average in labor cost and in profit and overhead (29.2 percent and 33.3 percent, respectively). Projects in the West were higher than average in profit and overhead and lower in materials cost.

Materials costs

The materials and equipment or product groups that

represented the greatest proportion of total costs were: Stone, clay, glass, and concrete products—23.9 percent (including window glass—4.0 percent, other precast concrete products—4.6 percent, and ready-mix concrete—7.2 percent); fabricated metal products—22.2 percent; primary metals—12.6 percent (including 8.4 percent for structural steel); machinery, except electrical—11.4 percent (which includes elevators and escalators at 4.2 percent, and air-conditioning equipment at 4.9 percent); lumber and wood products, except furniture—7.6 percent; electrical machinery, equipment, and supplies—7.6 percent; and, construction equipment—6.0 percent (tables 10, 11, and 12).

Table 10. Value of materials, equipment, and supplies per \$1,000 of cost and per 100 square feet and percent distribution, commercial office building construction, 1972-73

Item	Value per \$1,000 of contract cost	Value per 100 square feet	Percent distri- bution 1/
All materials, equipment, and supplies	\$448.31	\$1,002.38	100.00
Materials, built-in equipment, and supplies	421.48	942.38	94.01
Agricultural products	1.91	4.26	0.43
Nursery products including sod	1.86	4.15	0.41
Miscellaneous agricultural products	0.05	0.11	0.01
Mining and quarrying of nonmetallic minerals, except fuels .	3.01	6.73	0.67
Sand and gravel	2.21	4.95	0.49
Fill dirt, top soil	0.79	1.78	0.18
Textile mill products	6.18	13.82	1.38
Carpeting, rugs, mats, and pads	6.13	13.72	1.37
Miscellaneous textile mill products	0.05	0.10	0.01
Apparel and other textile products	0.38	0.85	0.09
Draperies and curtains	0.35	0.77	0.08
Miscellaneous apparel and other textile products	0.03	0.08	0.01
Lumber and wood products, except furniture	33.87	75.72	7.55
Kitchen cabinets, vanities, prebuilt	0.34	0.76	0.08
Fabricated structural laminates	4.34	9.70	0.97
Dressed and rough boards, and dimension lumber	13.94	31.17	3.11
Hardwood flooring and other hardwood	0.40	0.89	0.09
Wooden shingles and excelsior	0.39	0.88	0.09
Millwork	6.90	15.42	1.54
Plywood, softwood	6.08	13.59	1.36
Treated lumber	0.28	0.63	0.06
Acoustical tile, cork	0.23	0.52	0.05
Miscellaneous lumber and wood products	0.98	2.17	0.21
Furniture and fixtures	1.92	4.28	0.42
Wooden cabinets, radio, TV, and medicine	0.47	1.06	0.11
Wooden cabinets, office	0.19	0.42	0.04
Wood partitions	0.24	0.53	0.05
Metal partitions	0.77	1.73	0.17
Venetian blinds, curtain and drapery rods	0.15	0.34	0.03
Miscellaneous furniture and fixtures	0.09	0.19	0.01
Paper and allied products	4.15	9.28	0.93
Masking tape	0.17	0.38	0.04
Wallpaper	0.56	1.24	0.12
Construction paper	0.14	0.32	0.03
Insulation, fiberboard	0.18	0.40	0.04
Insulation, asbestos board	0.18	0.39	0.04
Acoustical tile, asbestos board	2.13	4.77	0.48
Acoustical tile, wood fiber	0.71	1.59	0.16
Miscellaneous paper and allied products	0.08	0.19	0.01
Chemicals and allied products	4.44	9.94	0.99
Oxygen, acetelyne, and other industrial gases	0.21	0.46	0.05
Paint	2.10	4.69	0.47
Putty, calking, and glazing compounds	0.75	1.67	0.17
Silicones	0.15	0.34	0.03
Concrete admixtures, hardeners	0.58	1.29	0.13
Sealants	0.20	0.46	0.05
Adhesives	0.10	0.21	0.02
Miscellaneous chemicals and allied products	0.37	0.81	0.09
Petroleum refining and related products	8.88	19.86	1.98
Fuels, diesel fuel, gas, oil, grease	0.70	1.57	0.16
Asphalt paving	4.71	10.53	1.05
Membrane waterproofing vapor barrier	1.58	3.53	0.35
Asphalt tar and pitches	1.81	4.04	0.40
Miscellaneous petroleum refining and related products	0.09	0.19	0.02
Rubber and miscellaneous plastic products	4.71	10.53	1.05
Rubber products	0.44	0.98	0.10
Conduit and conduit fittings (plastic)	0.32	0.71	0.07
Plastic pipe and tubing	0.69	1.55	0.15
Insulation, styrofoam and other plastic insulation	1.09	2.43	0.24
Vinyl tile	0.13	0.28	0.03
Vinyl wall covering	1.05	2.34	0.23
Laminated plastic panels and counter tops	0.35	0.78	0.08
Plastic vapor barrier sheets	0.25	0.55	0.06
Miscellaneous rubber and plastic products	0.40	0.90	0.08

See footnotes at end of table.

Table 10. Continued—Value of materials, equipment, and supplies per \$1,000 of cost and per 100 square feet and percent distribution, commercial office building construction, 1972-73

Item	Value per \$1,000 of contract cost	Value per 100 square feet	Percent distrib- ution
Stone, clay, glass, and concrete products	\$107.14	\$239.54	23.90
Window glass	18.12	40.52	4.04
Mirrors	0.20	0.44	0.04
Cement	2.00	4.47	0.45
Brick (clay)	2.72	6.08	0.61
Ceramic tile	1.91	4.27	0.43
Clay sewer pipe	0.41	0.92	0.09
Other structural clay products	0.80	1.79	0.18
Plumbing fixtures and accessories, vitreous china	1.90	4.26	0.42
Concrete block and brick	7.12	15.91	1.59
Concrete pipe	0.27	0.61	0.06
Other precast concrete products	20.79	46.48	4.64
Terrazzo	0.15	0.33	0.03
Ready-mix concrete	32.48	72.62	7.24
Lime	0.26	0.57	0.06
Gypsum products	5.66	12.66	1.26
Marble and other cut stone	1.42	3.17	0.32
Asbestos cement pipe	0.24	0.53	0.05
Vinyl asbestos tile	0.67	1.49	0.15
Insulation, asbestos (including sprayed on)	0.39	0.88	0.09
Crushed rock, slag, miscellaneous aggregate	3.81	8.52	0.85
Insulation, vermiculite and perlite	0.10	0.21	0.02
Insulation, fiberglass (mineral or glass wool)	2.77	6.19	0.62
Acoustical tile, fiberglass (mineral wool)	2.51	5.61	0.56
Miscellaneous stone, clay, glass, and concrete products ..	0.42	1.01	0.10
Primary metal industries	56.27	125.81	12.55
Structural steel	37.82	84.55	8.44
Steel, galvanized, and ferrous noncast iron pipe	5.22	11.67	1.16
Nails, wires, staples, ferrous	0.73	1.64	0.16
Cable and wire, ferrous	0.23	0.51	0.05
Cast iron products	0.13	0.28	0.03
Cast iron pipe and fittings	2.43	5.43	0.54
Copper pipe and tubing	3.31	7.39	0.74
Cable and wire, nonferrous	4.48	10.01	1.00
Miscellaneous primary metal industries	1.94	4.34	0.44
Fabricated metal products	99.57	222.63	22.21
Builders' hardware	5.26	11.76	1.17
Plumbing fixtures, metal, and enameled iron	2.69	6.02	0.60
Plumbing accessories, fittings and trim, brass	1.88	4.20	0.42
Radiators and heaters (nonelectric)	0.78	1.75	0.17
Condensers	2.38	5.31	0.53
Prefabricated structural steel	17.55	39.23	3.91
Prefabricated structural aluminum	2.97	6.64	0.66
Metal doors	3.94	8.80	0.88
Metal windows	3.64	8.14	0.81
Fabricated metal plate products	0.79	1.77	0.18
Storage tanks	0.10	0.23	0.02
Cooling towers	0.36	0.80	0.08
Copper sheet metal	0.41	0.91	0.09
Aluminum sheet metal	1.27	2.85	0.28
Galvanized sheet metal	10.74	24.02	2.40
Fabricated sheet metal, all other	4.67	10.44	1.04
Registers, grilles, diffusers	2.25	5.03	0.50
Metal acoustical suspension systems	1.67	3.73	0.37
Ornamental and architectural metal work	4.20	9.40	0.94
Prefabricated metal buildings, curtain walls	12.13	27.13	2.71
Metal reinforcing bars	13.48	30.14	3.01
Metal nuts, bolts, washers, screws, rivets	1.32	2.94	0.29
Wire mesh	2.74	6.12	0.61
Clips, fasteners	0.18	0.40	0.04
Safes and vaults	0.10	0.23	0.02
Plumbing accessories, metal other than brass	1.26	2.82	0.28
Metal planking and ladders	0.13	0.29	0.03
Plumbing products unclassified	0.14	0.31	0.03
Miscellaneous fabricated metal products	0.53	1.23	0.10
Machinery, except electrical	51.28	114.64	11.43
Elevators, escalators, and dumbwaiters	18.83	42.09	4.20
Pumps	1.07	2.40	0.24
Compressors	0.68	1.51	0.15
Blowers, exhaust and ventilating fans	1.59	3.55	0.35
Sprinkler systems (fire prevention)	1.40	3.14	0.31
Warm air furnaces	4.42	9.87	0.98

See footnotes at end of table.

Table 10. Continued—Value of materials, equipment, and supplies per \$1,000 of cost and per 100 square feet and percent distribution, commercial office building construction, 1972-73

Item	Value per \$1,000 of contract cost	Value per 100 square feet	Percent distri- bution 1/
Air-conditioning equipment	\$21.93	\$49.03	4.89
Sewage disposal and water treatment equipment	0.20	0.45	0.04
Miscellaneous machinery, except electrical	1.16	2.59	0.25
Electrical machinery, equipment, and supplies	34.16	76.37	7.62
Transformers	0.92	2.06	0.21
Electrical switchboards and panel boards	5.57	12.46	1.24
Electrical motors and generators	2.09	4.66	0.47
Electric motor controls	1.38	3.09	0.31
Welding supplies	0.21	0.48	0.05
Household hot water heaters	0.21	0.48	0.05
Electric lamps and bulbs	0.43	0.97	0.10
Lighting fixtures and nonelectric lamps and bulbs	11.40	25.49	2.54
Emergency lighting systems	0.13	0.28	0.03
Current-carrying devices	1.89	4.22	0.42
Conduit and conduit fittings (metal)	4.47	10.00	1.00
Noncurrent-carrying devices	1.18	2.64	0.26
Intercom, fire and burglar alarm systems	0.61	1.37	0.14
Electric heaters, nonhousehold	2.31	5.16	0.52
Miscellaneous electrical machinery, equipment, and supplies	1.34	2.99	0.27
Instruments and related products	2.27	5.08	0.51
Gas and water meters, gauges, air thermometers	0.13	0.28	0.03
Temperature controls	1.90	4.24	0.42
Miscellaneous instruments and related products	0.25	0.55	0.05
Miscellaneous manufacturing industries	1.35	3.03	0.30
Fire extinguishers, portable	0.10	0.23	0.02
Other miscellaneous manufacturing industries	1.25	2.80	0.27
Total contractors' construction equipment	26.83	60.00	5.99
Lumber and wood products, except furniture	0.02	0.05	0.00
Fabricated metal products	2.43	5.43	0.54
Small hand tools (nonpower)	0.90	2.01	0.20
Scaffolding (metal)	1.45	3.24	0.32
Miscellaneous fabricated products	0.08	0.18	0.02
Machinery, except electrical	22.18	49.58	4.95
Power cranes, draglines, shovels (power)	6.05	13.53	1.35
Tractors and bulldozers	1.82	4.07	0.41
Backhoes and trenchers	1.98	4.42	0.44
Drill rigs	0.15	0.33	0.03
Scrapers, graders	0.69	1.55	0.15
Rollers and all other heavy construction equipment	1.51	3.38	0.34
Mixers, pavers, and related equipment	0.43	0.96	0.10
Front-end loaders	0.72	1.61	0.16
Hoists and monorails	1.90	4.25	0.42
Forklifts	0.46	1.02	0.10
Power hand tools	1.80	4.02	0.40
Compressors, pumps, jack hammers, and accessories	1.62	3.62	0.36
Miscellaneous machinery, except electrical 2/	3.06	6.84	0.68
Transportation equipment	2.21	4.94	0.49
Trucks (highway)	2.10	4.69	0.47
Wheelbarrows	0.11	0.25	0.03

1 Percent distribution is the same for both value columns.

2 Contains "Nonelectric engines and motors."

NOTE: All individual items under 10 cents are included in the last line item in each group. Detail may not add to totals due to rounding.

Table 11. Incidence of use of major types of material and equipment, commercial office building construction, 1972-73¹

Type of material or equipment	Percent of total cost	Number of projects in universe that used product
All materials and equipment	100.0	2,846
Structural steel	9.0	2,077
Ready-mix concrete	7.7	2,746
Air-conditioning equipment ..	5.2	2,297
"Other" precast concrete products	4.9	1,488
Elevators, escalators, and dumbwaiters	4.5	850
Window glass	4.3	2,260
Prefabricated structural steel	4.2	895
Dressed and rough boards, and dimension lumber	3.3	2,731
Metal reinforcing bars	3.2	2,106
Prefabbed metal buildings, curtain walls, and parts ..	2.9	572
Lighting fixtures and nonelectric lamps and bulbs	2.7	2,193
Galvanized sheet metal	2.6	2,633

¹ Excludes items accounting for less than 2 percent of total cost.

Table 12. Incidence of use of types of material and equipment in at least 80 percent of the commercial office building projects, 1972-73

Type of material or equipment	Number of projects that used product	Percent distribution of cost
All materials and equipment	2,846	100.0
Ready-mix concrete	2,746	7.7
Dressed and rough boards, and dimension lumber	2,731	3.3
Sand and gravel	2,647	.5
Power cranes, draglines, shovels	2,636	1.4
Galvanized sheet metal	2,633	2.6
Builders' hardware	2,593	1.2
Asphalt and tar pitches	2,587	.4
Insulation, fiberglass (mineral or glass wool)	2,475	.7
Paint	2,474	.5
Powered handtools	2,458	.4
Cement	2,455	.5
Backhoes and trenchers	2,437	.5
Concrete block, brick	2,428	1.7
Rollers and all other heavy construction equipment	2,426	.4
Membrane waterproofing vapor barrier	2,367	.4
Gypsum products	2,301	1.3
Putty, calking, and glazing compounds	2,300	.2
Air-conditioning equipment ...	2,297	5.2
Fuels; diesel fuel, gas, oil, grease	2,296	.2

Chapter IV. Other Characteristics

Construction time

Nationally, the average length of time required to construct a commercial office building was 47.2 weeks. Projects in the South took considerably longer—60.0 weeks—while those in the West were completed 8.8 weeks faster than the national average. In the United States as a whole, projects costing less than \$1 million took less than average time to complete. The next three cost classes each showed a substantial increase in time required for completion over the class below. Completion time for buildings costing at least \$1 million ranged from a low of 58.2 weeks to a high of 115 weeks (table 13). Regionally, the only consistency found in the data was that projects costing \$5 million and over took longer to build than any other group of projects. (These projects had an average completion time of more than 106 weeks.)

Regionally, construction time and project cost showed the same pattern—projects in high-cost regions took longer to build. The one exception was the North Central region where construction time was the same as the national average but project cost was higher.

Building size

Average square feet for all projects was 42,358. For the regions, the square foot average was as follows: Northeast, 22,103; North Central, 59,920; South, 52,421; and West, 30,460. These large regional variations in size may account for many of the differences noted in cost, time, and labor requirements.

Hourly earnings

The average wage for all occupations in this survey was \$7.16 per hour. Earnings were highest in the West—at \$7.99—followed closely by the North Central region and then the Northeast. Earnings in the South were 13 percent lower than the U.S. average—at \$6.19 (table 14). This relationship between wage rates in the South and in the other three regions is consistent with that observed in several other BLS construction surveys.

The highest average hourly wage for occupations in-

volved in the construction of commercial office buildings was \$9.40, received by supervisors and general foremen. Others with earnings over \$8 an hour were: Scraper operators, sprinkler fitters, sheet metal workers, plumbers, pipefitters, structural and ornamental ironworkers, and bricklayers. Workers receiving the lowest hourly pay were laborers, helpers and tenders, custodial workers, and clerical workers.

Skilled workers were paid between 4 and 10 percent more than the average for all occupations, and semi-skilled and unskilled workers were paid between 20 and 30 percent less than the average.

Contractors

The number of contractors per project varied from 22 in the Northeast to 30 in the West; the national average was 26. Most projects had only one general contractor and very few had prime contractors (table 15).

General contractors accounted for the largest proportion of construction cost in all four regions. Heating, ventilating, and air-conditioning (HVAC) contractors had the next highest proportion. In all regions except the West, electrical contractors followed. (In the West, structural steel contractors followed.) A ranking by type of contractor in each region and in the United States as a whole is given in table 16.

Nationally, 68 percent of the surveyed contractors had formal labor-management agreements. (Contractors on a single project are usually all union or all non-union.) The tabulation below shows that, as expected, the lowest percentage of union contracts was in the South, 57. The highest percentage, about 86, was in the West.

	Percent
United States	68.2
Northeast	61.8
North Central	75.1
South	56.9
West	86.5

Table 13. Average number of weeks of construction time by cost class and region, commercial office building construction, 1972-73

Cost class	United States		Northeast		North Central		South		West	
	Percent of projects	Number of weeks	Percent of projects	Number of weeks	Percent of projects	Number of weeks	Percent of projects	Number of weeks	Percent of projects	Number of weeks
All projects	100.0	47.2	100.0	42.3	100.0	47.2	100.0	60.0	100.0	38.4
Less than \$100,000	5.4	30.0	1/	1/	1/	1/	1/	1/	15.0	30.0
\$100,000 - \$249,999	40.2	43.4	24.9	34.4	30.7	48.5	44.9	55.3	47.4	33.6
\$250,000 - \$499,999	12.9	42.3	46.8	39.9	15.8	48.2	4.8	53.0	5.8	32.0
\$500,000 - \$999,999	17.0	40.4	3.6	43.0	15.2	30.6	18.2	39.2	21.9	45.2
\$1,000,000 - \$2,999,999	20.9	58.2	23.9	53.3	34.0	45.4	25.4	74.4	8.2	54.1
\$3,000,000 - \$4,999,999	1.2	78.2	1/	1/	1/	1/	4.1	78.2	1/	1/
Over \$5,000,000	2.4	115.0	0.7	108.0	4.3	107.6	2.5	131.8	1.7	106.6

¹ No projects in sample.

NOTE: Detail may not add to total due to rounding.

Table 14. Average hourly earnings for selected onsite construction workers by occupation and region, commercial office building construction, 1972-73

Occupation	United States	Northeast	North Central	South	West
All occupations	\$7.16	\$7.91	\$7.97	\$6.19	\$7.99
Skilled workers	7.66	8.42	8.31	6.78	8.33
Boilermakers	6.83	7.15	8.35	3.00	-
Bricklayers	8.12	7.67	8.71	7.30	8.61
Carpenters	7.30	8.36	7.96	6.61	7.74
Cement finishers	7.68	8.62	9.04	6.07	7.44
Drywall applicators	7.27	9.05	7.51	5.97	7.13
Drywall finishers	7.62	8.55	8.05	6.44	8.80
Electricians	7.67	8.41	8.26	6.70	8.64
Elevator constructors	7.86	8.46	7.76	7.30	9.28
Glaziers	7.59	8.67	8.09	6.96	8.54
Insulation workers	7.23	7.98	6.83	6.94	7.69
Iron workers, ornamental	9.03	9.10	10.13	8.59	8.89
Iron workers, reinforcing	7.85	9.79	8.25	7.05	9.18
Iron workers, structural	8.35	9.14	9.12	6.78	9.84
Lathers	7.86	8.81	8.53	6.97	8.32
Machinists	5.75	3.61	7.56	6.74	6.50
Marble setters	6.90	-	8.35	6.77	-
Millwrights	7.61	-	8.12	7.60	-
Painters	6.63	7.70	6.93	5.78	8.23
Paperhangers	7.90	7.74	7.76	6.83	9.85
Pipefitters	8.40	9.64	8.72	7.92	8.78
Plasterers	6.88	8.71	8.29	6.42	7.75
Plumbers	8.05	8.55	7.57	7.67	9.38
Roofers	7.52	8.51	8.85	6.12	7.30
Sheet-metal workers	8.56	8.91	8.43	7.12	9.59
Sprinkler fitters	8.95	8.46	9.43	7.52	10.95
Soft floor layers	5.81	7.19	7.23	5.51	8.15
Terrazzo workers	7.89	-	7.80	7.63	9.94
Tile setters	7.33	8.74	8.09	6.46	7.63
Skilled workers, other	6.94	6.98	8.19	6.07	7.17
Backhoe operators	7.06	6.72	8.25	4.79	8.53
Bulldozer operators	7.50	8.18	8.23	5.42	8.57
Crane-shovel-dragline operators	7.78	10.21	8.58	7.25	9.45
Front-end loader operators	7.36	8.42	8.22	4.96	8.66
Grader operators	7.18	10.19	8.16	3.83	8.87
Pile driver operators	7.61	9.92	10.67	6.95	7.75
Pump and compressor operators	5.57	8.07	8.06	4.86	6.93
Roller operators	6.28	9.24	8.41	3.48	8.53
Scraper operators	8.74	13.00	8.28	6.29	8.73
Tractor operators	7.12	6.77	8.42	5.97	7.89
Trencher operators	7.62	14.00	7.87	5.53	8.48
Operating engineers, n.e.c.	8.26	7.48	9.02	7.31	8.86
Semiskilled and unskilled workers	5.20	5.93	6.36	4.45	5.61
Laborers, helpers, and tenders	5.18	5.92	6.37	4.43	5.61
Truckdrivers	6.18	6.20	7.03	4.21	6.58
Custodial workers	4.84	5.01	7.92	3.01	4.49
Other semiskilled workers	5.38	8.03	5.14	5.70	3.49
Professional and clerical workers	8.87	7.99	9.76	7.69	13.77
Clerical workers	3.80	4.01	4.04	3.42	5.79
Professional and technical workers ..	7.60	12.17	7.95	5.59	14.48
Superintendent and general supervisors	9.40	7.98	10.45	8.39	14.04

NOTE: Data not available.

Table 15. Average number of contractors per project by type of contractor and region, commercial office building construction, 1972-73

Type of contractor	United States	Northeast	North Central	South	West
All contractors .	26.3	21.6	23.6	26.2	29.7
General contractors	1.2	1.1	1.1	1.2	1.2
Prime contractors ..	.1	.1	.2	.2	.1
Subcontractors	22.4	17.3	18.8	21.6	27.0
Sub-subcontractors .	2.6	3.2	3.5	3.3	1.4

Table 16. Percent distribution of contract cost by type of contractor, commercial office building construction, 1972-73

Type of contractor	United States	Northeast	North Central	South	West
All contractors	100.0	100.0	100.0	100.0	100.0
General contractors	29.4	27.9 (1)	24.0 (1)	34.0 (1)	29.5 (1)
Subcontractors: 1/ Heating, ventilating, and air- conditioning	12.4	12.8 (2)	13.3 (2)	13.6 (2)	9.7 (2)
Electrical	8.4	10.2 (3)	9.6 (3)	7.6 (3)	7.6 (4)
Structural steel	7.0	3.8 (7)	9.0 (4)	4.7 (6)	9.4 (3)
Concrete work	5.5	7.4 (5)	7.2 (5)	4.6 (7)	4.4 (7)
Glass and glazing	5.5	2.5 (10)	6.6 (6)	7.2 (4)	2.9 (10)
Excavation, footings, foundation, and grading	4.0	9.8 (4)	4.9 (7)	2.4 (9)	-
Elevators	3.7	-	4.1 (9)	5.1 (5)	-
Plumbing	3.2	3.0 (9)	3.3 (10)	-	5.1 (6)
Masonry	3.1	4.0 (6)	4.4 (8)	-	3.0 (9)
Carpentry	-	3.6 (8)	-	-	6.2 (5)
Plastering and lathing	-	-	-	4.1 (8)	-
Wallboard	-	-	-	2.0 (10)✓	4.0 (8)
All other	17.6	15.0	13.5	14.7	15.7

¹ Data are shown separately only for the 10 types of contractors with the highest percentages of contract cost in each region.

NOTE: Numbers in parentheses indicate rank. Detail may not add to total due to rounding.

Chapter V. Recent Trends in Design, Technology, and Management

Construction contractors, materials manufacturers, developers, architects, and others involved in the construction industry constantly search for ways to reduce building costs and construction time. However, technological changes normally are evolutionary rather than revolutionary. New ideas, which usually affect only one facet of construction, are continually being developed. The ideas are first tested on one or two projects; if successful and accepted, they spread gradually throughout the industry. New ideas in design and construction that have saved time and cost have frequently involved lighter or stronger materials, new combinations of materials which are largely prefabricated offsite, increased use of modular systems in design and construction, innovative management techniques, and increased use of computers.

In the 1970's, the general trends and changes in commercial office building design and construction included some that were basically technological, and others that were related to design, government regulations, tenant requirements, etc. Some of these trends and changes were: Increased environmental considerations; better techniques for programming and planning interior space; improved heating, ventilating, and air-conditioning systems; better insulation and increased use of heat-reducing glass; improvements in the design and detailing of glass curtain walls; design advances for rigid-framing; increased use of modules; and new solutions to high-rise wind-load problems.¹² Several of these changes are discussed below.

Design and materials

High-rise design. High-rise towers present many challenges to engineers and architects—and one of the most difficult is designing a structure to resist wind loads. Some new designs, which reflect changes in technology, have concentrated on this problem. They include the bundled-tube and truss-tube systems for steel structures up to 140 stories, and the framed-tube, tube-in-tube, and modular-tube systems for similarly tall concrete structures.¹³

¹² Mildred F. Schmertz., ed., *Office Building Design* (New York, McGraw-Hill 1975), p. viii.

Modular construction. One common, but fairly new technology that has had a large impact is the module. A module is based on standardization of sizes of materials, designs, and client requirements, and its use often speeds up both design and construction. (Five feet is the most common module size.) Modules can be used extensively in structural framing, lighting, air-conditioning and heating, power supply and communications, partitions, and built-in or movable furniture.

Precast concrete. The use of precast concrete, versus cast-in-place concrete, is another instance where innovation saves labor and construction time (and in the following example also provides better quality control). An 8-million-dollar addition to a hotel, in which a modular precast concrete building system was used, was completed in 30 percent less time than would have been possible if cast-in-place concrete had been used.¹⁴

Another innovative application of precast concrete is the use of precast concrete bents which serve as primary architectural elements. Because bents are cast in one piece, they do not have the heavy joint lines of precast concrete. (These lines are usually very unattractive so precast concrete components ordinarily cannot be used as architectural elements.) Bents also eliminate the need for shear walls because they are able to bear weight and resist moment forces. Besides being able to take wind loads, rigid bents reinforce the gravity-load-carrying ability of the structure. The continuity between beams and columns permits longer spans because they are less subject to cracking and deflection. A structural engineering firm developed these precast bents to fill a Dallas owner's need for long, column-free areas in a building. (Another similar system is used in Switzerland.)

During the planning of the building, prestressed double-Ts, beams, and columns were discovered to be the most cost-effective way of meeting the need for long-span, column-free space. Even though long spans were needed only in work areas, their use throughout the building became economically advantageous because of

¹³ Ibid.

¹⁴ "System Cuts 30 Percent From 'Building Time,'" *Engineering News Record*, May 31, 1979, p. 11.

the benefits a system of repetitive structural elements could provide. Very few units were required because a beam and two columns were cast simultaneously in each bent. This also helped reduce construction time.¹⁵

Prefabricated brick panels. To save time and money, builders of a Baltimore office building used another new design, a prefabricated exterior wall system, which is a variation of existing techniques. The wall can bear its own weight and is almost structurally independent of the rest of the building. The wall system consists of over 1,000 brick panels attached to lightweight steel studs or channels. The load of the panels is transferred through the channels directly to the foundation; no vertical load is on the frame.¹⁶ The panels, which are 12 feet high and 10 to 24 feet wide, are fabricated offsite.

Another project used prefabricated brick panels, which doubled as formwork, to reduce cost. This masonry bearing wall system is very economical and flexible, and eliminates the need for several trades and construction steps.¹⁷ The masonry contractor installs the brick, reinforcing steel, grout, insulation, and some windows. As a result, fewer workers, carpenters, concrete workers, fireproofing ironworkers, and insulation workers are needed to build the wall. The panels also make long spans and cantilevers possible. The brick panel is the form into which a steel cage is placed; it is then pumped full of grout. The structural framing for this system is erected more slowly than a conventional design, but the project as a whole can be completed faster because the inside wall requires no finishing. The wall's designers believe that for a brick appearance, this option is the least expensive.

Energy conservation

One concern that currently dominates the industry is energy conservation.¹⁸ Fuel shortages, the need to cut costs, and the emergence of energy conservation performance standards have led to a myriad of new ideas and methods as well as increased implementation of older energy conservation techniques. Through building design and the choice of materials and mechanical systems, energy can be conserved in two basic ways—actively and passively. Active conservation systems like solar equipment are usually much more expensive, so the estimated payback period is examined closely before an owner will agree to such a system. The increasing cost of energy, however, is generally making payback periods shorter.

¹⁵ "Precast Bent Disguises Strength With Good Looks," *Engineering News Record*, Dec. 13, 1979, pp. 40-41, 153.

¹⁶ "Prefab Wall Bears Own Weight to Lighten Construction Costs," *Engineering News Record*, Feb. 1, 1979, p. 14.

¹⁷ "Prefab Brick Panels Double as Formwork to Slash Labor Costs," *Engineering News Record*, Oct. 13, 1977, pp. 28-29.

¹⁸ "Energy Saving Paces Design as Technology Makes Gain," *Engineering News Record*, Jan. 18, 1979, p. 88.

Many passive conservation features are now routinely included in office building designs. These include solar-oriented siting, double-glazed windows or tinted glass, reduction of window area, internal heat recovery systems, energy-efficient lighting, computerized heating and cooling systems, openable and recessed windows, and earth berms. Most of these features do not add significantly to the cost of construction.

An example of energy-conscious design is an \$11 million building in Michigan that will save \$21,000 a year through its energy-conserving walls.¹⁹ Only 20 percent of the wall area is glass; the rest is aluminum panel. The glass is double insulated and tilted. At the bottom of the windows, stainless steel sills bounce sunlight onto a second reflector inside to reduce requirements for inside light and heat.

Some more innovative, expensive, and elaborate (and less common) designs emphasizing conservation are: Extensive atriums; low, broad building configurations (as opposed to office towers); special patented insulated curtain wall and ceiling systems; solar heating; elaborate heat recovery systems (requiring no heating plant); well-water cooling; and underground buildings.

A relatively low, broad building, for instance, can provide increased usable space and yet have less outside surface area than a tower building—which leads to energy savings. Such a design also reduces structural cost because not as much heavy steel or concrete framing is needed. One such building designed recently also made extensive use of atriums—there were three, stacked in heights from 7 to 12 stories.²⁰ Although building an interior curtain wall and an atrium wall incurs an additional cost, curtain wall is less expensive than exterior wall. It also provides an overall cost saving of 40 to 50 percent over an exterior wall because the interior curtain walls do not need to be watertight, double glazed, or wind resistant.

Heating is another area of design innovation. A new 2-million-square-foot office building in Canada (where temperatures can drop to -40 degrees F.) does not have a conventional heating plant.²¹ The building's heat recovery and storage system is fed by heat from the building's machinery, its occupants, and the lights. Heat from the building core is transferred to the outer parts of the building; excess heat is stored. Other features of the building include insulated curtain wall and ceiling systems, a computer system with sensors that controls the heating and cooling system, and a glass curtain wall that is designed to reflect 85 percent of the solar heat. Its builders claimed that the structure would be the

¹⁹ "Architect Clads Michigan Office Tower with Energy-conserving Wall," *Engineering News Record*, Feb. 10, 1977, p. 13.

²⁰ "Making Tower, Short, Broad Cuts Cost," *Engineering News Record*, Jan. 11, 1979 p. 16.

²¹ "Building Without Boilers May Set Energy Record," *Engineering News Record*, Feb. 8, 1979, p. 20.

most energy efficient building in the world, and would use only 35,000 British thermal units per square foot annually. (Btu's are a measure of heating requirements or efficiency. The mean annual Btu consumption for New York City office buildings, for instance, is estimated at 112,800. Single-purpose buildings with no public areas such as retail space, however, consume many fewer Btu's than those designed for mixed use.)

A Minnesota office building incorporates another unique design feature, a well-water heat pump.²² The building costs nearly 50 percent less to operate than nearby conventional buildings. The solar orientation of the building also contributes to this cost savings. As in many large structures, cooling is required year round for the core of the building,

To maximize savings in both energy and time, the construction of a 28-story building in New Orleans was speeded up through the use of fast tracking, a work-scheduling technique. Working together closely on the fast-track schedule, the general contractor and the architect-engineer saved at least 6 to 7 months of construction time. The 1.1-million-square-foot building was designed to save as much energy as possible during construction, as well as during occupancy. The two-atrium design, which was used to expand the floor areas, resulted in a shorter building whose structural system required fewer materials and took fewer days to build. Atriums themselves can help reduce a building's energy consumption 30 to 50 percent. This particular atrium design also reduced the energy required in materials fabrication, transportation, and construction.²³

This building was designed to consume 30 to 50 percent less energy when occupied than comparable buildings. Some specific energy-saving building features included a low glass-to-floor area ratio of 1:10 (the ratio for a conventional building is 1:5), two atriums (solar heat gain with atriums is cut due to a reduction in outside walls and smaller lighting and air-conditioning needs), and a flexible mechanical system which allows for simultaneous heating and cooling in different parts of the building.

Management and management tools

Systems techniques. In general, prefabrication is most fully used in construction through systems techniques. Systems techniques is the term used for the process of combining prefabricated components into single integrated units through the use of mass production and assembly. Systems techniques, or systems building, can be employed to erect or install exteriors, flooring, ceiling, walls, mechanical and lighting elements, or several

combinations of these elements. Generally, this will reduce onsite labor requirements and increase offsite and indirect labor hours.

Computer use. The increased use of computers has had a more limited impact on the industry. At first, the fairly small savings gained from single applications of large mainframe computers, coupled with the industry's traditionally slow acceptance of change, resulted in limited computer use. Only a few larger firms fully realized the potential of the computer in each of the phases of phases of the construction (planning, designing, managing, and building) as well as its ability to integrate all of these functions.²⁴

However, the recent advent of smaller, less expensive and easier to use computers, plus the availability of prepackaged software programs, has made it easier for contractors to utilize computers, although they are still not commonplace. (Only about one-third of all civil engineers and two-fifths of contractors use small computers.)²⁵ Nevertheless, the growing complexity and cost of construction design and management will continue to increase the usefulness of computers even for smaller firms as they contend with an increasing number of environmental and energy regulations; local, State, and Federal laws; community group pressures; and labor demands. Growing client involvement and inflation must also be considered. These complex constraints emphasize the need to coordinate all available information and to make rapid responses, which a computer can facilitate in most instances. Even small construction contractors could use a computer for many offsite functions, such as accounting, preparing graphics, drafting, compiling bids, and calculating payrolls.

Management methods. Other innovations in construction which are more widespread and have been employed for a longer period of time than computers are in methods of managing. Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and fast tracking (the overlapping of phases of construction that are ordinarily sequential), all try to speed up the construction process through tight coordination and cooperation among the owners, architects, engineers, and various contractors. This coordination often begins during the design phase; contractors are sometimes brought in for early consultations, some materials can be ordered far in advance of use, and actual construction may even be started before the design is made final. Very often, systems building is used in conjunction with fast tracking. PERT and CPM tightly control this overlapping by providing a detailed time and cost

²²"Latent Well Water Energy Cuts Heat, Cooling Cost," *Engineering News Record*, Sept. 27, 1979, pp. 22,23.

²³"Speedy Erection Built in by Design," *Engineering News Record*, Apr. 5, 1979, p. 24, 25.

²⁴"Construction's Newest Tool Is Small, Low Cost, Highly Productive," *Engineering News Record*, Aug. 4, 1977, p. 20.

²⁵"Optimizing the Construction Process" (Editorial), *Engineering News Record*, Aug. 4, 1977, p. 80.

schedule and identifying the critical path. (The critical path is that sequence of events which, if delayed, would delay the entire project.)

Another change is the emergence of the construction

manager. A construction manager (who can be a general contractor or a specialized company) oversees and manages the entire project for the owner and is found most frequently on large construction projects.

Chapter VI. Comparison with Other Construction Studies

Commercial vs. Federal office building surveys

Because this is the first BLS survey of commercial office buildings, no analysis of trends in labor requirements for this type of construction can be made. However, among its more recent surveys, the Bureau has completed one on Federal office building construction. The following sections discuss some major points of interest in the two office building surveys.²⁶

Buildings in both office building studies were constructed in a similar time period and had basic structural similarities.²⁷ In both surveys a majority of the buildings had masonry exterior walls, drywall interior walls, concrete floor bases, acoustical tile ceilings, and built-up roof coverings. A majority in both also had central air-conditioning, forced-air heating, and outdoor parking lots. A majority of all Federal buildings surveyed were one to three stories; over 85 percent of commercial office buildings were one or two stories high.

Employee hours. Commercial office buildings required 5.5 fewer total hours per \$1,000 (or 12 percent fewer hours) than all projects in the Federal office building survey (table 17). Commercial office building onsite construction labor requirements were also lower—by 13 percent (37.2 hours compared to 42.8 hours). However, offsite hour requirements for all types of Federal office buildings were slightly lower than for commercial office buildings.

A comparison of onsite hours required for commercial office building construction and Federal office building construction more narrowly defined (i.e., excluding social security buildings, laboratory-office buildings and border stations) showed an even greater disparity; 37.2 hours versus 45.5 hours, respectively.

Onsite hour requirements per 100 square feet were also lower for commercial office buildings than for Federal office buildings—53 percent lower.

Onsite labor requirements of the various types of contractors were widely disparate in the two surveys (ta-

ble 18.) In most cases percentage differences were very large, but absolute differences were not. One disparity of note was the difference in onsite employee hours for general contractors—12.7 for commercial office buildings and 16.1 for Federal office buildings.

Cost. Average cost per project was \$947,084 for commercial buildings, compared to \$2,780,000 for Federal office buildings. This disparity may account for some of the differences in onsite labor requirements between the two surveys. Cost per square foot also differed considerably. Surveyed commercial office buildings cost over 45 percent less per square foot than Federal office buildings: \$22.36 and \$41.28, respectively. Commercial office buildings in nonmetropolitan areas had an even greater cost difference—53 percent.

Commercial office buildings cost less than Federal buildings in every region; in the Northeast—41 percent less, in the North Central region—36 percent less, in the South—35 percent less, and in the West—51 percent less. The relationship between each region's cost, and the metropolitan, non-metropolitan projects' average cost per square foot, and the average national cost within each survey was the same for the two surveys except in the South. Federal office building cost data seemed, however, to show much greater regional variability than commercial office building data did. In the South, commercial projects were slightly higher than the national average in cost per square foot, while Federal office building projects were lower than average in cost. In both surveys buildings in the Northeast cost much more per square foot than those in the Nation as a whole (57 percent greater for commercial office buildings and 44 percent greater for Federal office buildings (table 19).

The proportion of costs attributable to the major components of cost differed widely in the two studies. The largest difference was in profit and overhead—12 percent less for Federal office buildings than for commercial buildings (table 20).

Costs of the various operations involved in office building construction differed for a few types of contractors. In particular, heating, ventilating, and air-conditioning work and concrete work accounted for higher percentage, and plumbing a lower percentage in commercial office building projects (table 21). How-

²⁶ John G. Olsen, "Decline Noted in Hours Required to Erect Federal Office Buildings," *Monthly Labor Review*, October 1976, pp. 18-22.

²⁷ The Federal office buildings survey included social security buildings, "Federal office buildings", laboratory-office buildings, and border stations. A majority of the construction value for both surveys was put in place during the same time period—1972-73.

Table 17. Employee hours per \$1,000 cost and per 100 square feet, commercial office building and Federal building construction, 1972-73

Type of construction	Per \$1,000 1/			Per 100 square feet
	Total	Onsite	Offsite	Onsite
Commercial office buildings	42.0	37.2	4.8	83.3
All Federal buildings 2/ ..	47.5	42.8	4.7	176.8
Federal office buildings .	N.A.	45.5	N.A.	195.6

¹ Current dollars.

laboratory-office buildings, and border stations.

² Includes Federal office buildings, social security buildings,

N.A. = Not available.

Table 18. Onsite employee hours per \$1,000 of contract cost (current dollars) by type of contractor, commercial office building and Federal office building construction, 1972-73

Type of contractor	Commercial office buildings	Federal office buildings
All contractors ..	37.2	42.8
General contractors	12.7	16.1
Subcontractors:		
Heating, ventilating, and air-conditioning	4.0	5.9
Electrical	2.6	4.2
Masonry	2.0	1.2
Concrete work	2.0	.8
Plastering and lathing	1.6	2.7
Structural steel	1.5	1.4
Excavation, footings, foundation, and grading	1.4	.9
Plumbing	1.1	2.6
Carpentry	1.3	.8

Table 19. Cost per square foot, commercial office building and Federal office building construction, 1972-73

Area and region	Commercial office buildings	Federal office buildings
All projects	\$22.36	\$41.28
Area:		
Metropolitan	22.26	38.69
Nonmetropolitan	23.45	49.53
Region:		
Northeast	35.13	59.63
North Central	21.10	33.08
South	23.36	36.17
West	19.18	39.42

Table 20. Components of cost, commercial office building and Federal office building construction, 1972-73

Component	Percent of total cost	
	Commercial office buildings	Federal office buildings
Total contract cost	100.0	100.0
Onsite wages	26.7	34.0
Materials, equipment, and supplies	44.8	50.0
Profit and overhead ...	1/ 28.5	16.0

¹ Includes interest expense.

Table 21. Percent distribution of contractor cost by type of contractor, commercial office building and Federal office building construction, 1972-73

Type of contractor	Commercial office buildings	Federal office buildings
All contractors	100.0	100.0
General contractor	29.4	38.6
Subcontractors:		
Heating, ventilating, and air-conditioning	12.4	8.7
Electrical	8.4	7.4
Structural steel	7.0	6.4
Concrete work	5.5	2.2
Excavation, footings, foundation, and grading	4.0	3.2
Elevators	3.7	2.1
Plumbing	3.2	6.3
Masonry	3.1	2.7
Carpentry	3.1	1.7
Plastering and lathing .	2.2	4.3
All other	17.8	16.3

NOTE: Detail may not add to total due to rounding.

ever, the only large difference was in the general contractors' percentage of contract cost, which was higher for Federal office buildings than for commercial office buildings (38.6 versus 29.4 percent). This higher percentage corresponds to the higher labor requirement for general contractors working on Federal office buildings.

Comparison with other BLS construction surveys

Onsite labor. Even though the various surveys were conducted over different time periods and data from each survey have not been adjusted for price change, broad comparisons can be made between the commercial office building survey and the more recent construction surveys²⁸ (table 22). Except for highways and public housing, commercial office building construction required fewer onsite employee hours per 1,000 current dollars (37) than any other type of construction surveyed. More labor was required to construct elementary and secondary schools and Federal office buildings (42 and 43 hours per \$1,000, respectively) than commercial office buildings. The next group of surveys, which are in the 47 to 50 hours per 1,000 current dollar range, include college housing, sewer works, and multifamily housing construction. Offsite employee hour data vary between 3 and 9 hours for all of the above surveys.

Among the more recent building construction surveys (i.e., excluding highways, sewer works, and civil works construction), the onsite employee hours attributable to the various occupations varied by more than 10 percentage points from the hours for commercial office buildings in only two instances (table 23). Carpenters contributed 35 percent of all hours in private single-family housing (1969) compared to 19 percent for commercial office building construction (much more wood is used in single-family housing construction), and "other" skilled trades showed a much lower percent in public housing construction (1968)—7 percent versus 19 percent.

Cost components. A comparison of the components of cost in building construction surveys with those for

commercial office buildings reveals that the proportion for onsite wage and salaries for public housing, college housing, and Federal office building construction was from 5 and 10 percent higher than in commercial office building construction. The proportion in private single-family housing was more than 6 percent lower than commercial office buildings (table 24).

Materials, supplies, and built-in equipment accounted for at least 5 percent more of the total cost of Federal office buildings, general hospitals, nursing homes, and college housing than of commercial office buildings.

The overhead and profit components varied the most among the various types of construction. Federal office buildings, college housings hospitals, and nursing home construction all had overhead and profit components at least 10 percent lower than commercial office building construction. Private single-family housing, on the other hand, had a profit and overhead component that was over 7 percent greater than that for commercial office buildings.

Materials. Among the six building surveys, the percent of cost for lumber and wood products and fabricated metal products varied the most (table 25). Lumber and wood products in commercial office buildings, elementary and secondary schools, and general hospitals accounted for between 4 and 8 percent of cost, contrasted with 37 percent in single-family housing. The proportion spent for stone, clay, glass, and concrete products fell within a fairly narrow range, from a low of 18 percent for hospitals to 25 percent for public housing. Petroleum refining products and construction equipment accounted for less than 7 percent of cost in all building surveys.

Three surveys had a cost of 9 percent for primary metal products. Among the other three, the percentage for single-family housing was lower, and for commercial office buildings and schools higher than 9 percent. Single-family housing construction again had the lowest percentage (13) for a product group—fabricated metal—though multifamily housing had only a slightly higher percentage (16). The other survey's percentages in fabricated metals ranged between 22 (for commercial office buildings) and 31 (for hospitals). The three housing surveys had the lowest cost percentages (2 to 4) for nonelectrical machinery, though the other three surveys were not much higher (8 to 12 percent). Percentages for electrical and electronic machinery were scattered over a range of 7 to 16 percent for the studies shown.

²⁸ The survey years referred to in table 22 are years during which most of the construction took place. Those are the years used in developing offsite data and for projecting labor requirements. In tables 23 to 25, the years refer to the completion date of the surveyed projects.

Table 22. Employee hours per 1,000 current dollars of contract cost by industry, all construction studies, 1958-76

Type of construction and year	Total, all industries	Construction		Manufacturing	Trade, transportation, and services	Mining and all other
		Onsite	Offsite 1/			
Commercial office buildings: 1972-73	97.5	37.2	4.8	33.0	16.6	5.9
Public housing: 1960 2/	246.0	113.7	15.9	65.3	36.9	14.2
1968 2/	175.1	79.6	11.9	47.8	26.7	8.8
1975	3/	33.2	7.1	3/	3/	3/
Elementary and secondary schools: 1959 2/	231.8	86.0	11.7	78.0	41.4	14.8
1965 2/	193.2	72.3	8.8	65.8	34.4	12.0
1971-72	114.1	41.6	6.0	40.8	18.8	6.8
Federally aided highways: 1958 2/	250.7	97.3	9.0	66.1	52.5	25.8
1976	80.5	32.2	3.3	22.8	15.4	6.9
Federal office buildings: 1959 2/	235.8	97.1	10.9	79.2	35.7	12.9
1972	3/	42.8	4.7	3/	3/	3/
College housing: 1960-61 2/	236.3	93.6	14.1	77.5	37.2	13.8
1971-72	3/	48.3	8.1	3/	3/	3/
Civil works, total: 1960	3/	3/	3/	3/	3/	3/
1971-72	3/	47.4	3.9	3/	3/	3/
Land projects: 1960	213.4	84.7	4.5	53.2	46.9	24.1
1971-72	3/	43.2	2.5	3/	3/	3/
Dredging projects: 1960 2/	251.4	133.9	15.6	56.8	31.6	13.5
1971-72	3/	57.0	7.0	3/	3/	3/
Sewer works: Lines: 1963 2/	208.8	85.9	4.8	75.9	27.2	15.0
1971	128.3	48.0	3.0	48.8	18.8	9.7
Plants: 1963 2/	208.1	82.7	5.7	80.0	27.1	12.6
1971	127.4	47.0	4.0	51.6	17.6	7.2
Private multifamily housing: 1971 2/	137.5	50.0	6.5	46.9	26.1	8.1
Private single-family housing: 1962 2/	215.7	72.1	11.0	68.6	48.7	16.1
1968-69 2/	145.6	51.9	8.2	47.2	29.6	8.7
General hospitals: 1959-60 2/	226.0	88.8	12.3	78.0	34.2	12.7
1965-66 2/	189.0	76.1	9.8	64.0	29.6	9.5
Nursing homes: 1965-66 4/	192.7	73.7	8.4	66.6	33.6	10.4

¹ Revised. Revision based on adjustment to 1979 benchmarks of *Employment and Earnings* series. Some SIC groupings were not revised for earlier years; thus, data on offsite construction hours are not strictly comparable. Differences, however, would be slight. See text footnote 5.

² Indirect data revised from original study results due to reprocess-

ing materials through improved input-output tables.

³ Not available.

⁴ Estimated except for onsite construction hours. Based on case study.

NOTE: Detail may not add to total due to rounding.

Table 23. Percent distribution of onsite employee hours per 1,000 current dollars of contract cost by occupation, all construction studies, 1958-76

Type of construction and year	All occupations	Administrative and supervisory	Bricklayers	Carpenters	Electricians	Iron workers	Operating engineers	Painters	Plasterers and lathers	Plumbers and pipe fitters	Other skilled construction trades	Laborers, helpers, and tenders	Other occupations (including truck drivers)
Commercial office buildings: ¹ 1974	100.0	7.4	3.3	19.2	6.4	1.6	4.0	1.9	2.1	6.2	19.0	22.6	6.3
Elementary and secondary schools: ¹ 1959	100.0	3.9	9.3	18.7	7.1	4.0	1.9	3.3	2.7	9.4	7.9	29.1	2.8
1965	100.0	3.6	9.2	16.5	7.3	1.5	2.7	3.5	2.0	9.6	10.1	30.9	3.1
1972	100.0	4.4	6.0	16.8	11.0	0.9	2.4	2.8	2.7	9.6	16.9	22.3	4.2
Federally aided highways: ¹ 1958	100.0	10.4	1/	1/	1/	2/51.4	1/	1/	1/	1/	38.2	1/	1/
1976	100.0	6.3	-	5.7	1.2	3/20.3	24.3	1.4	-	1.2	5.9	33.2	2.6
Federal office buildings: ¹ 1959	100.0	6.0	5.2	12.6	9.1	1.5	2.4	2.1	3.8	8.7	11.8	32.5	4.2
1973	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/
Collage housing: ¹ 1961	100.0	3.4	10.0	16.9	6.6	1.1	1.7	3.6	3.4	9.7	7.8	31.8	3.9
1972	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/
Civil works: ¹ Land projects 1960	100.0	10.1	-	6.4	-	3.1	24.1	-	-	-	6.9	23.0	26.4
1972	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/
Dredging projects 1960	100.0	4.7	-	-	-	-	1.1	-	-	-	1.7	1.7	4/90.8
1972	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/	1/
Sewer works, total: ¹ 1963	100.0	11.2	1.7	7.7	1.5	1.9	17.4	.7	-	2.5	2.7	39.1	13.4
1971	100.0	12.9	1.0	6.9	2.9	1.9	20.4	.8	-	3.3	5.4	30.0	14.4
Lines: ¹ 1963	100.0	11.6	1.3	2.4	.1	.4	19.6	-	-	.4	1.2	44.9	18.1
1971	100.0	13.5	.2	1.2	.4	.2	27.3	-	-	-	3.0	33.7	20.6
Plants: ¹ 1963	100.0	11.0	2.0	14.3	3.3	3.9	14.6	1.5	-	5.1	4.6	31.8	7.9
1971	100.0	12.3	1.9	14.0	5.7	4.5	11.5	1.9	-	7.2	9.8	25.1	5.9
Private multifamily housing: ¹ 1971	100.0	5.8	5.0	25.4	5.9	2.3	2.9	4.0	1.7	7.6	11.3	25.8	2.3
Private single-family housing: ¹ 1962	100.0	3.0	5.5	34.6	2.8	-	1.4	9.5	2.0	5.2	12.2	23.3	.5
1969	100.0	2.8	5.7	34.9	3.0	-	1.8	7.3	1.7	4.3	20.0	27.9	.5
Public housing: ¹ 1960	100.0	4.0	7.6	19.1	4.1	2.1	2.7	4.4	6.8	7.8	6.5	30.9	4.0
1968	100.0	3.6	7.8	20.3	5.8	3.5	3.1	4.9	3.0	9.3	6.6	30.2	1.9
General hospitals: ¹ 1960	100.0	3.9	5.4	13.2	8.8	3.5	1.6	2.8	6.2	14.2	12.0	26.7	1.7
1966	100.0	3.2	5.0	13.0	9.9	3.1	1.8	2.6	6.1	15.6	13.1	25.7	.7
Nursing homes: ¹ 1966 5/	100.0	4.4	6.4	15.2	7.8	2.2	1.8	4.7	5.6	13.7	11.2	26.7	.4

¹ Not available.

² Includes apprentices and on-the-job trainees and laborers, helpers, and tenders.

³ Includes blue-collar worker supervisors.

⁴ Includes mostly ships' masters, captains, mates, crew, and support personnel.

⁵ Based on case study.

Table 24. Percent distribution of construction contract costs, all construction studies, 1958-76

Type of construction and year	Total contract costs	Onsite wages and salaries	Materials, supplies, and built-in equipment	Construction equipment	Overhead and profit ^{1/}
Commercial office buildings:					
1974	100.0	26.7	42.2	2.7	28.5
Elementary and secondary schools:					
1972	100.0	28.2	44.4	2.1	25.3
1965	100.0	25.8	54.2	1.0	19.0
1959	100.0	26.7	54.1	1.4	17.8
Federally aided highways:					
1976	100.0	23.8	46.7	2/	29.5
1958	100.0	23.9	50.6	2/	25.5
Federal office buildings:					
1973 3/	100.0	34.0	50.0	4/	16.0
1959	100.0	29.0	51.4	1.9	17.7
College housing:					
1972 3/	100.0	36.0	51.1	4/	13.0
1961	100.0	29.3	52.6	1.6	16.5
Civil works, total:					
1972 3/	100.0	26.0	29.0	22.0	22.0
1960	100.0	29.1	26.2	22.1	22.6
Land projects:					
1972	100.0	25.0	32.0	20.0	24.0
1960	100.0	26.0	35.0	19.3	19.7
Dredging projects:					
1972	100.0	30.0	24.0	28.0	19.0
1960	100.0	32.3	17.3	24.9	25.5
Sewer works, total:					
1971	100.0	24.7	40.7	11.5	23.1
1963	100.0	25.3	46.6	9.9	18.2
Lines:					
1971	100.0	24.3	35.2	16.7	23.8
1963	100.0	24.3	44.5	11.2	20.0
Plants:					
1971	100.0	25.2	47.0	5.6	22.2
1963	100.0	26.6	49.2	8.2	16.0
Private multifamily housing:					
1971	100.0	27.9	44.2	3.0	24.8
Private single-family housing:					
1969 5/	100.0	20.4	43.4	.9	35.3
1962 5/	100.0	22.1	47.2	1.0	29.7
Public housing:					
1975 3/	100.0	32.7	48.7	4.4	14.2
1968	100.0	32.4	41.9	1.5	24.2
1960	100.0	35.5	45.0	2.5	17.0
General hospitals:					
1966	100.0	29.6	50.4	1.3	18.7
1960	100.0	28.2	53.2	1.2	17.4
Nursing homes:					
1966 6/	100.0	28.7	53.7	1.2	16.4

¹ Includes offsite wages, fringe benefits, construction financing costs, inventory, and other overhead and administrative expenses as well as profit.

² Equipment included with overhead and profit.

³ Estimated.

⁴ Equipment included in materials.

⁵ Includes selling expenses.

⁶ Estimated. Based on case study.

NOTE: Detail may not add to totals due to rounding.

Table 25. Percent distribution of cost of materials, supplies, and equipment by product group, all construction studies, 1958-76

Type of construction and year	Total materials, supplies, and equipment	Mining and quarrying of non-metallic minerals except fuel	Lumber and wood products except furniture	Furniture and fixtures	Chemical and allied products	Petroleum refining and related products	Stone, clay, glass and concrete products	Primary metal products	Fabricated metal products ¹	Machinery except electrical	Electrical and electronic machinery, equipment, and supplies	Construction equipment (rental value and depreciation)	Material and supplies, n.e.c.
Commercial office buildings: 1974	100.00	.67	7.55	.42	.99	1.98	23.90	12.55	22.21	11.43	7.62	5.99	4.69
Federal office buildings: 1959	100.00	.41	3.31	.34	1.03	.88	21.60	7.32	32.81	6.91	18.20	3.59	3.61
1973	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/
Elementary and secondary schools: 1959	100.00	.83	9.90	1.50	1.41	2.02	24.59	13.07	26.78	2.47	9.27	4.64	3.74
1965	100.00	1.62	9.13	2.90	.96	2.27	24.67	11.68	24.41	5.30	8.78	4.45	3.83
1972	100.00	.85	6.09	3.67	1.41	1.72	20.15	11.03	24.06	7.71	12.32	4.52	6.47
Private multifamily housing: 1971	100.00	1.34	18.67	3.89	2.21	1.74	22.12	8.85	15.59	3.72	9.36	6.51	6.00
Private single-family housing: 1962	100.00	.79	40.05	-	2.22	2.30	23.58	5.50	14.60	.46	6.49	2.03	1.99
1969	100.00	.89	37.40	3.28	1.82	1.80	21.33	5.05	12.90	1.90	6.77	2.00	4.87
Public housing: 1960	100.00	.80	14.10	.30	1.80	1.70	27.10	8.00	28.50	2.30	8.40	5.30	1.80
1968	100.00	.80	14.40	.30	2.00	2.20	24.70	9.20	27.20	2.50	11.30	3.50	1.80
1975	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/
General hospitals: 1960	100.00	.42	4.16	.86	.81	.97	18.98	6.82	35.05	8.48	15.60	2.86	5.89
1966	100.00	.51	4.66	.44	.77	.80	18.40	8.61	31.11	12.11	15.62	2.50	4.47
Nursing homes: 1966 4/	100.00	.53	9.06	.27	1.24	1.82	20.16	6.23	33.32	11.03	10.78	2.15	3.41
College housing: 1961	100.00	.78	10.67	1.70	1.18	1.05	25.78	6.11	33.90	2.92	11.35	2.94	1.62
1972	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/
Federally aided highways: 1958	100.00	11.34	1.76	-	.80	17.09	16.77	-	19.48	-	-	3/	32.75
1976	100.00	12.42	.85	-	.97	17.58	14.04	-	21.22	-	-	3/	32.92
Civil works: Land projects: 1960	100.00	17.46	4.15	-	3.87	12.65	9.09	1.33	13.20	.59	.24	35.39	2.05
1972	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/
Dredging projects: 1960	100.00	-	-	-	3.93	28.07	-	-	1.49	1.40	-	58.98	6.13
1972	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/	2/
Sewer works: Lines: 1963	100.00	4.65	.79	-	.36	3.02	55.87	8.79	2.39	3.02	.74	20.19	.20
1971	100.00	3.43	1.53	-	1.14	4.82	40.77	7.38	2.20	4.48	1.03	32.22	1.00
Plants: 1963	100.00	2.27	1.64	-	.98	1.85	16.78	14.48	13.16	22.34	9.51	14.25	2.75
1971	100.00	1.11	2.46	.22	.87	1.25	15.62	11.22	13.87	33.51	6.72	10.59	2.54

¹ Includes vitreous china plumbing fixtures except for Federally aided highways, private office buildings, elementary and secondary schools (1971), and single-family and multifamily housing.

² Not available.

³ Construction equipment estimate included in materials and supplies, n.e.c.

⁴ Based on case study.

NOTE: Detail may not add to total due to rounding.

Appendix A. Survey Scope and Methods

The study was designed to develop estimates of the employee-hour requirements for the construction of all private commercial office buildings in the 48 contiguous United States.

Sample selection. The Bureau of the Census selected a sample of commercial office building projects valued at \$100,000 or more which, based upon Census studies, had a high probability of completion between May 1, 1973 and August 31, 1974. A gross sample of 650 was selected to assure that at least 250 would have been completed in that period. Weights were assigned based upon the probability of selection. Sample information was based on data from the Bureau of the Census and F.W. Dodge Co. BLS then screened the sample by telephone to eliminate as many out-of-scope projects as possible. A subsample of 100 projects was selected from the 250 projects that remained. This subsample was stratified by geographic location and cost class. The four geographic regions are defined in footnote 8. The cost classes were as follows: \$100,000 to \$249,999; \$250,000 to \$499,999; \$500,000 to \$999,999; \$1,000,000 to \$2,999,999; \$3,000,000 to \$4,999,999; and \$5,000,000 and over. (After collection, one project was found to have a final contract cost of slightly under \$100,000.)

Excluded from the sample were the following types of office construction:

1. Additions to existing office buildings.
2. Renovations or remodeling of existing office buildings.
3. Office buildings whose construction cost \$100,000 or less.
4. Any office building construction financed or guaranteed by Federal, State, or local governments.
5. Office building construction not completed between May 1, 1973 and August 31, 1974. For this survey, the completion date was the date the building was ready for occupancy or the date on which all substantive construction stopped.

6. Any office building which had 25 percent or more of the above-grade square footage allocated to use other than commercial office space.

In refining the initial sample it was discovered that the number of subcontractors on a large project could run as high as several hundred. It was decided that, when there were more than 40 subcontractors, only a subsample of these subcontractors would be contacted. In most cases, all general and prime contractors and all subcontractors whose contract value was 4 percent or more of the total project value were scheduled for survey. The number of additional subcontractors surveyed was determined as follows: Subtract the total of general, prime, and 4-percent contractors from the figure 25. Divide the resultant figure into the number of contractors with less than 4 percent of the total project amount.

This number is the sample interval number. The "start" number was determined by the last digit of the schedule number and the interval number.

The interval number was then used to determine the remaining projects in the subsample. If additional contractors were identified after subsampling was done, the first 20 encountered were scheduled.

Two supplemental samples were drawn to ensure that a statistically acceptable number of projects would be in the final collection sample. The final number of projects in the sample was 83; 13 projects in the Northeast; 27 in the South; 30 in the North Central; and 13 in the West.

Data on monthly labor hours were collected only on a subsample of eight projects because of time and cost considerations. As a result, data on monthly hours are to be considered a case study only and are not necessarily representative of the universe.

Weights for sample units within a cell were calculated by using the reciprocal of the probability of selection. Nonresponse was compensated for within a cell by increasing the weights associated with all the responding units in that cell by a single factor. Individual weights were multiplied by original sample weights provided by the Bureau of the Census.

If data were missing partially or completely for a given subcontractor, the subcontractor was asked to

estimate the missing data. If the subcontractor was not available, an estimate was obtained from the general contractor.

Except for nonresponding sample units and data estimated by the contractors, there are no known sources of nonsampling error. Data on sampling error will be available from the Bureau of Labor Statistics on request.

Although overall estimates of employment are believed to be reasonably accurate, detailed data would have a wider margin of sampling error and may be subject to other limitations. Employee-hour and material requirements are affected by a number of factors such as location, size of project, type of structure, architectural design, availability of certain materials or equipment, labor skills, and local building codes and customs. The effects of these separate factors cannot be isolated.

Data collection procedures. After receiving their lists

of assigned projects, data collectors usually contacted the owner-developers to secure their cooperation. They then verified that the work contractors performed was within the scope of the survey. The general contractors were telephoned and their cooperation sought. A refusal by the general contractor usually resulted in that project being dropped from the sample. Visual inspection of the construction project and visits to the general and prime contractors followed. At this time, the data collectors obtained all A-form data, some payrolls, the materials and equipment used by these contractors (for the B-forms) and a list of all subcontractors. Next, all subcontractors were contacted and their respective B-forms filled out.

After all the data for a sample project were collected, they were checked for completeness and internal consistency and forwarded to Washington, D.C. for editing, coding for computer processing and analysis.

Appendix B. Forms Used for Data Collection

Bureau of Labor Statistics
Survey of Labor and Material Requirements
for Private Office Building Construction

U.S. Department of Labor



General Information

O.M.B. No. 44R 1606

Approval Expires September 30, 1977

The information collected on this form by the Bureau of Labor Statistics will be accessible only to authorized persons and will be used only for the statistical purposes stated at the time of collection.

Name of Office Building

Location (street address)

(city, county, state)

Office Use Only

Survey Identification		Schedule Number (Enter 3 digit code)			SMSA (Enter 1 digit code)	State (Enter 2 digit code)		Region (Enter 1 digit code)
0	7							

BLS 2652.07A (December 1975)

1. Total Value of Construction Contract

This will ordinarily agree with the sum of the general and prime contracts adjusted for any and all change orders. This must also include the value of equipment and materials supplied by the project's sponsor. This must exclude speciality work contracted by tenants and work related to out-of-scope activities described in Technical Memorandum No. 7. (Round to whole dollars.)

\$		001
----	--	-----

2. Construction Dates

2a. Beginning Date of Construction

Mo.	Day	Year	002

2b. Ending Date of Construction

			003

2c. Total number of weeks in construction (include down/time)

	004
--	-----

3. Type of Construction

The building(s) is described as:

Code

1 - Offices only

2 - Offices and apartments

3 - Offices and other commercial areas (specify) _____

4 - Offices, apartments, and other commercial areas (specify) _____

	005
--	-----

4. Square Footage

What is the total square footage of the building(s) covered in this contract?

	sq.ft.	006
--	--------	-----

5. Building Characteristics

5a. Number of stories above ground level.

Code

1 - less than 2

2 - 2 but less than 4

3 - 4 but less than 11

4 - 11 but less than 36

5 - 36 but less than 61

6 - 61 or more

	007
--	-----

5b. Number of stories below ground level.

Code

1 - less than 2

2 - 2 but less than 4

3 - 4 but less than 6

4 - 6 or more

	008
--	-----

5c. Are elevators (including freight elevators) or escalators installed in the building(s)?

Code

1 - Yes

2 - No

	009
--	-----

5d. Is air-conditioning provided?

Code

1 - Yes, central air conditioning

2 - Yes, other than central air conditioning

3 - No

	010
--	-----

5e. Is automobile parking space provided?

Code

1 - Yes, in or under the building.

2 - Yes, outdoor "offstreet parking."

3 - Yes, both in or under the building and outdoor.

4 - No

	011
--	-----

5f. What is the major type of heating provided?

Code

1 - Forced air (*duct heating*)

2 - Hot water

3 - Radiant heating (*electric*)

4 - No heat

9 - Other (*specify; e.g., steam or solar*) _____

012

5g. What is the major type of heating fuel provided?

Code

1 - Electricity

2 - Gas

3 - Oil

4 - Coal

5 - No fuel

9 - Other (*specify; e.g., solar*) _____

013

6. Building Materials

For each building feature listed below, select the predominant type of material (in terms of dollar costs for the entire project) which best describes that feature.

6a. Framing

Code

1 - Steel

2 - Concrete; pre-cast, poured, etc.

3 - Masonry; block or brick

4 - Wood

9 - Other (*specify*) _____

014

6b. Exterior Walls

Code

1 - Steel

2 - Concrete; pre-cast, poured, etc.

3 - Masonry; block or brick

4 - Wood

9 - Other (*specify*) _____

015

6c. Interior Walls

Code

1 - Drywall

2 - Plaster

3 - Movable partitions

9 - Other (*specify*) _____

016

6d. Floor Base

Code

1 - Concrete

2 - Wood/Plywood

9 - Other (*specify*) _____

017

6e. Floor Covering

Code

1 - Wood

2 - Terrazzo

3 - Carpet

4 - Vinyl/vinyl-asbestos tile

5 - Linoleum

9 - Other (*specify*) _____

018

6f. Ceiling

Code

1 - Drywall

2 - Plaster

3 - Acoustical tile (*including suspension type*)

9 - Other (*specify*) _____

019

6g. Roof Base

Code

- 1 - Steel decking
 2 - Concrete
 3 - Wood/Plywood
 9 - Other (specify) _____

020

6h. Roof Cover

Code

- 1 - Asphalt/asbestos shingles
 2 - Built-up
 3 - Wood
 9 - Other (specify) _____

021

7. General Contractor Information (Data in this area are to be obtained solely from the general contractor.)

If more than one general contractor, report for the general contractor having the largest dollar portion of the project amount.

Report all percentages and dollars to the nearest whole number.

WHOLE NUMBERS

7a. Approximately what percentage of the building interior was fully completed in the contract cost?

022

7b. What percentage of the general contractor's 1974 total dollar volume was for:

Private office building(s)?

023

Other commercial building(s)?

024

Public office building(s)?

025

Other (specify) _____

026

(The percentages in reporting fields 023-026) TOTAL

100 %

7c. What was the general contractor's approximate 1974 dollar volume of business in private office building construction? (Round to whole dollars.)

027

7d. What factors can the general contractor identify as having contributed toward raising or lowering employee-hour requirements (productivity) during construction of this private office building, as contrasted to a similar project on which he participated during the past two years?

Enter an (X) in only one box (1-raised requirements, 2-lowered requirements, or 3-no effect) for each category listed.

Category	Raised Requirements	Lowered Requirement	No Effect	
1. Strikes	☐ 1	☐ 2	☐ 3	028
2. Weather	☐ 1	☐ 2	☐ 3	029
3. Building codes	☐ 1	☐ 2	☐ 3	030
4. Apprenticeship programs	☐ 1	☐ 2	☐ 3	031
5. Prefabricated components	☐ 1	☐ 2	☐ 3	032
6. Standardized components	☐ 1	☐ 2	☐ 3	033
7. Supply of skilled workers	☐ 1	☐ 2	☐ 3	034
8. Other (specify) _____	☐ 1	☐ 2	☐ 3	035
9. _____	☐ 1	☐ 2	☐ 3	036
10. _____	☐ 1	☐ 2	☐ 3	037

8. Number of Contracts.

How many of the following types of contracts were let for this project?

General

038

Prime

039

Subcontracts

040

Sub-subcontracts

041

Remarks

Bureau of Labor Statistics
Survey of Labor and Material Requirements
for Private Office Building Construction

U.S. Department of Labor



Contract Information

O.M.B. No. 44R 1606

Approval Expires September 30, 1977

The information collected on this form by the Bureau of Labor Statistics will be accessible only to authorized persons and will be used only for the statistical purposes stated at the time of collection.

Name of Contractor

Name of Project

Location of Project (street address)

(city, county, state)

Office Use Only

Schedule Number (Enter 3 digit code)			Contract Number (Enter 3 digit code)			Major Operations Code (Enter 2 digit code)		Superior Contract Number (Enter 3 digit code)		

BLS 2652.07B (November 1975)

Contract Amount

\$	095
----	-----

\$	096
----	-----

Code	
1 - Yes	097
2 - No	

Briefly describe the work performed for the contract. Also, identify the important kinds of heavy equipment, materials, and occupations used or supplied under this contract.

Report any sub-subcontractors who worked on the identified project. For each sub-subcontractor, assign a contract number. For the contract number, refer to the SO-302 form (formerly the "C" form).

Contract Number	Name, Address, and Phone	Value of Sub-subcontract
		\$

Date of Visit	Name and Title of Person Contacted	Field Economist

Part II Construction Equipment

- a. Enter total on-site equipment costs (sum of all items reported in column C, lines 100-109 and 110-198 on the continuation sheets).
If none, enter "0."

\$	199
----	-----

b. Instructions

Complete columns A through D as follows:

Column A — List all equipment used on-site as a tool of construction. (Exclude equipment required solely for personal use.) Record each piece of equipment separately.

Column B — Enter the equipment code for each piece of equipment listed in column A. (Refer to the Coding Manual for Labor and Materials Requirements Surveys, November, 1972.)

Column C — Enter, in whole dollars, the contractor's depreciation cost or the rental cost for each piece of equipment. If this data cannot be obtained, enter the rental cost equivalent; refer to the Technical Memorandum for the Rental Cost Equivalent procedure.

Column D — Code for the information reported in Column C as follows: Code

1 - contractor owned equipment

2 - contractor rented equipment

For additional entries, use continuation sheet(s) for Construction Equipment BLS 2652B (Rev. Nov. 1975).
In the column "Office Use," begin the continuation sheet with the appropriate line item number.

Explain in the spaces provided at the bottom of the page, any unusual entries.

Column A Description of Construction Equipment	Column B Equipment Code	Column C Depreciation or Rental Cost (express in whole dollars)	Column D Enter Code 1 or 2	Office Use Line Item Number
		\$		100
				101
				102
				103
				104
				105
				106
				107
				108
				109

Enter Line Item Number	Remarks or Work Area

Part III Materials, Supplies, and Built-In Equipment Costs

Instructions

Complete columns E through I as follows:

Column E — Enter the building materials, supplies, or built-in equipment used in or during construction. Dissimilar items are to be reported separately (i.e., rivets should be reported separately from structural steel bar beam).

Column F — Enter the materials code for the building material, supply, or built-in equipment listed in Column E. (Refer to the Coding Manual for Labor and Material Requirement Surveys, November, 1972.)

Column G — Enter in whole dollars the cost of materials reported in Column E. (Include all taxes and delivery fees.)

Column H — If the data in Column G does *not* include sales tax, enter the sales tax rate (to one decimal) in column H.

Example: 5½% — enter as

5	3
---	---

; 5% — enter as

5	0
---	---

.

Column I — Code for the material cost reported as follows: **Code**

3 - material cost is absolute (hard data)

4 - material cost is estimated

For additional entries, use continuation sheet(s) for Materials, Supplies, and Built-in Equipment BLS 2652B (Rev. Nov. 1975).

In the column "Office Use," begin the continuation sheet with the appropriate line item number.

- a. In whole dollars, report the total cost of all materials and supplies used during construction (sum of all costs in Column G, lines 200-229 and 230-598 on the continuation sheet). Include all taxes and delivery fees.

If none, enter "0."

If "0" is reported for material cost, leave Column I blank.

Column I	Office Use
Enter Code 3 or 4	Line Item Number
	599

\$

Column E Material Item	Column F Materials Code	Column G Total Cost Including All Taxes and Delivery Fees	Column H Sales Tax Rate if Taxes not Included in Column G (report to one decimal)	Column I Enter Code 3 or 4	Office Use Line Item Number
		\$		%	200
					201
					202
					203
					204
					205
					206
					207
					208
					209
					210
					211
					212
					213
					214

Enter Line Item Number	Remarks or Work Area

Part III Materials and Supplies Costs—Continued

Column E Material Item	Column F Material Code	Column G Total Cost Including All Taxes and Delivery Fees	Column H Sales Tax Rate if Taxes not Included in Column G (report to one decimal)		Column I Enter Code 3 or 4	Office Use Line Item Number
		\$		%		215
						216
						217
						218
						219
						220
						221
						222
						223
						224
						225
						226
						227
						228
						229

b. Referring to the list of materials and supplies reported in line item number 200-229 and 230-598 on the continuation sheets, record the sales tax rate for the greatest dollar amount of taxable materials purchased.

	%	098
3	3	%

Express a fractional percentage as follows: 3¼ percent as

Enter Line Item Number	Remarks or Work Area

Column J	Column K	Column L	Office Use
Occupation Code	Whole Hours	Gross Earnings Related to Hours (express in whole dollars)	Line Item Number
		\$	628
			629
			630
			631
			632
			633
			634
			635
			636
			637
			638
			639

Column J Occupation Code	Column K Whole Hours	Column L Gross Earnings Related to Hours (express in whole dollars)	Office Use Line Item Number
		\$	640
			641
			642
			643
			644
			645
			646
			647
			648
			649
			650
			651

c. Report the total number of overtime hours for all occupations listed in column J (lines 600-651 and 652-997 on the continuation sheets.)

If none, enter "0."

		998
--	--	-----

Enter Line Item Number	Remarks or Work Area

Part V Contract Reconciliation

Total value of subcontracts let by this contractor

\$

Total equipment cost, (from line 199, page 3)

+

Total material cost, (from line 599, page 4)

+

Total labor cost from this "B" form (from line 999, page 6)

+

Total labor cost from attached payrolls (approx.)

+

TOTAL ON-SITE COSTS (APPROX.)

\$

Total contract amount, (from line 095, page 2)

\$

Total on-site costs (approx.), see above

-

APPROXIMATE TOTAL PROFIT AND OVERHEAD

\$

$$\frac{\text{Approx. total profit and overhead}}{\text{Total contract amount}} = \% \text{ profit and overhead}$$

%

Explain any unusual profit and overhead percentages (over 35% or under 10%) or any unusual expense requirements.

Appendix C. Bibliography

Construction Labor Requirements Studies by BLS Office of Productivity and Technology

Civil works construction

Bingham, Barbara J., "U.S. Civil Works Construction Shows Decrease in Required Labor," *Monthly Labor Review*, October 1978, pp. 24-29.

This study was based on a sample of 45 projects completed in 1971 and 1972 under the supervision of the Corps of Engineers. It provided data on labor hours, material and labor costs, and other project characteristic data for both dredging and land projects. Also, a comparison was made with the data from an earlier civil works survey published in 1964.

Labor and Material Requirements for Civil Works Construction by the Corps of Engineers (BLS Bulletin 1390), 1964, 28 pp.

A statistical study of onsite and offsite employee-hour and wage requirements for dredging and land projects in the U.S. Corps of Engineer's civil works program from 1959 to 1960.

College housing construction

Bingham, Barbara J., "Labor Requirements for College-Housing Construction," *Monthly Labor Review*, May 1979, pp. 28-34.

A 37-project sample was surveyed in this study of college housing projects constructed under the supervision of the Department of Housing and Urban Development and completed in 1973. The article summarized the findings on employee-hour requirements, project costs, and other college housing characteristics and compared them to an earlier survey published in 1965.

Labor and Material Requirements for College Housing Construction (BLS Bulletin 1441), 34 pp.

A survey of 43 college housing projects which were administered by the Community Facilities Administration. The survey was designed primarily to determine the employee hours required per \$1,000 of college housing construction.

Miller, Stanley F., "Labor and Material Required for College Housing," *Monthly Labor Review*, September 1965, pp. 1100-1104.

A summary of BLS Bulletin 1441.

Commercial office building construction

Bingham, Barbara J., "Labor and Material Requirements for Commercial Office Building Projects," *Monthly Labor Review*, May 1981, pp. 41-48.

A summary of BLS Bulletin 2102.

Federally-aided highways

Prier, Robert J., "Labor and Material Requirements for Federally-Aided Highways," *Monthly Labor Review*, December 1979, pp. 29-34.

A study of federally-aided highway projects completed in 1976. The article discusses trends in highway labor requirements since 1958, and provides data on minority employment, occupational distribution, and material usage. Estimates of labor requirements are shown for 1978.

Finger, Diane S., "Labor Requirements for Federal Highway Construction," *Monthly Labor Review*, December 1975, pp. 31-36.

A study of labor and material requirements for federally-aided highway projects completed during 1973. The study examines the trends between 1958 and 1973.

Ball, Robert, "Labor and Materials Required for Highway Construction," *Monthly Labor Review*, June 1973, pp. 40-45.

Discussion of labor and material trends in highway construction between 1958 and 1970.

Labor and Material Requirements for Construction of Federally-Aided Highways, 1958, 1961, and 1964 (BLS Report 229), 1966, 17 pp.

Study providing measures for 1958, 1961, and 1964 of the labor and material requirements for federally-aided highways, with separate measures of the requirements for onsite and offsite construction. For onsite construction, the study also provides a comparison of annual labor requirements for 1947-64.

Wakefield, Joseph C., "Labor and Material Requirements: Highway Construction, 1958 and 1961," *Monthly Labor Review*, April 1963, pp. 394-98.

A summary comparison of the 1958 and 1961 highway surveys.

Kutscher, Ronald E. and Waite, Charles A., "Labor Requirements for Highway Construction," *Monthly Labor Review*, August 1961, pp. 858-61.

Summary of findings of the 1958 highway survey.

Federal office building construction

Olsen, John G., "Decline Noted in Hours Required to Erect Federal Office Buildings," *Monthly Labor Review*, October 1976, pp. 18-22.

This report presents the results of a survey of 68 elementary and secondary school construction projects completed in 1972. The report provides detailed data on employment requirements by occupation and type of contractor and information on contract costs and materials requirements. Survey results are compared with the findings of two similar studies of school construction in 1959 and 1965.

Olsen, John G., "Labor and Material Requirements for New School Construction," *Monthly Labor Review*, April 1979, pp. 38-41.

A summary of Publication Number BLS/LAB Constr-72/81.

Labor and Material Requirements for School Construction (BLS Bulletin 1586), June 1968, 23 pp.

A survey of selected elementary and secondary public schools constructed primarily during 1964-65. In addition to providing information on labor requirements, the study also includes data on the types and values of materials used, wages paid, occupations, and use of apprentices.

Finn, Joseph T., "Labor Requirements for School Construction," *Monthly Labor Review*, August 1968, pp. 40-43.

A summary of BLS Bulletin 1586.

Labor Requirements for School Construction (BLS Bulletin 1299), 1961, 50 pp.

A study of primary and secondary employee hours required per \$1,000 of new school construction based on contracts awarded for 85 elementary and 43 junior and senior high schools throughout the United States.

Epstein, Joseph and Walker, James F., "Labor Requirements for School Construction," *Monthly Labor Review*, July 1961, pp. 724-30.

A summary of BLS Bulletin 1299.

Sewer works construction

Labor and Material Requirements for Sewer Works Construction (BLS Bulletin 2003), 1979, 55 pp.

This report gives the results of a study of new sewer works construction in the U.S. completed by August 31, 1973. Most of the construction was done in 1971. The sample consisted of 145 contracts for sewer works: 82 sewer lines and 63 wastewater treatment plants. Data include onsite labor requirements per \$1,000 of contract cost by occupation at the national and regional levels, a detailed listing of the types and values of the materials and equipment used, and the offsite labor hours required to manufacture and transport the materials. Comparison is made with an earlier 1963 study.

Ball, Robert and Finn, Joseph T., "Labor and Material Requirements for Sewer Works Construction," *Monthly Labor Review*, November 1976, pp. 38-41.

Summarizes the 1971 study of sewer works construction which updates a study done in 1962-63. Provides data on labor and material requirements for construction of sewer lines and plants for the United States.

Labor and Material Requirements for Sewer Works Construction (BLS Bulletin 1490), 1966, 31 pp.

Study designed to measure employee hours required for each \$1,000 of new sewer facilities construction contract. The basis for this study was 138 contracts for new sewer works in the years 1962-63.

Other Reports, Articles, and Summaries

Ball, Claiborne M., "Employment Effects of Construction Expenditures," *Monthly Labor Review*, February 1965, pp. 154-58.

A summary of labor requirements for eight types of construction broken down by offsite and onsite hours, by occupation, and by region.

Finn, Joseph T., "Material Requirements for Private Multifamily Housing," *Construction Review*, April 1976, pp. 4-10.

This article summarizes the results of the survey of labor and building materials requirements for private multifamily housing (BLS Bulletin 1892) with reference to the value of the materials, supplies, and equipment used in this type of construction. A detailed listing of the cost of these materials, supplies, and equipment per \$1,000 of construction contract cost and per 100 square feet is included. In addition, comparisons are made between the results of this study and the public housing (BLS Bulletin 1821) and private one-family housing (BLS Bulletin 1755) studies.

Ball, Robert, "The Contract Construction Industry," *Technological Trends in Major American Industries* (BLS Bulletin 1474), 1966, pp. 32-38.

Discusses economic trends in the industry with emphasis on the impact of technological change on employment, occupations, job skill, and productivity.

"Construction Labor Requirements," reprint of Chapter 33 of *BLS Handbook of Methods* (BLS Bulletin 1910), 1976.

Description of techniques of construction labor requirements studies.

Mark, Jerome A. and Ziegler, Martin, "Measuring Labor Requirements for Different Types of Construction," Paper presented before the Conference on the Measurement of Productivity in the Construction Industry, sponsored by the National Commission on Productivity and the Construction Industry Collective Bargaining Commission, Washington, D.C., September 14, 1972.

Discussion of the BLS program of labor and materials requirements and analysis of the potential of using data from the program to measure productivity by type of construction.

Weinberg, Edgar, "Mechanization and Automation of Building Site Work," National Response Paper for the Economic Commission for Europe, Committee on Housing, Building, and Planning, Third Seminar on the Building Industry, Moscow, October 1970.

Discussion of current technology and labor requirements at the construction site.

Weinberg, Edgar, "Reducing Skill Shortages in Construction," *Monthly Labor Review*, February 1969, pp. 3-9.

A statistical study of 26 new office building projects completed in 1973 under the jurisdiction of the General Services Administration. In addition to data on labor requirements, the study provides information on building characteristics and contract operations.

***Labor Requirements for Federal Office Building Construction* (BLS Bulletin 1331), 1962, 43 pp.**

A statistical study of onsite and offsite labor requirements for 22 Federal office building projects in various localities of the United States over a 3-year period from the fall of 1957 to 1960.

Murray, Roland V., "Labor Requirements for Federal Office Building Construction," *Monthly Labor Review*, August 1962, pp. 889-93.

A summary of BLS Bulletin 1331.

Hospital construction

***Labor and Material Requirements for Hospital and Nursing Home Construction* (BLS Bulletin 1691), 1971, 50 pp.**

A study similar to the one done in 1962 but with data shown per square foot as well as per \$1,000 of construction contract cost. Covers hospitals and nursing homes constructed in 1965-66.

Riche, Martha Farnsworth, "Man-hour Requirements Decline in Hospital Construction," *Monthly Labor Review*, November 1970, p. 48.

Summary of BLS Bulletin 1691.

***Labor Requirements for Hospital Construction* (BLS Bulletin 1340), 1962, 46 pp.**

A statistical study of onsite and offsite labor requirements for construction of selected public and private, profit and nonprofit, general hospitals in various localities of the United States between mid-1958 and mid-1959.

Rothberg, Herman J., "Labor Requirements for Hospital Construction, 1959-60," *Monthly Labor Review*, October 1962, pp. 1120-24.

A summary of BLS Bulletin 1340.

Private multifamily housing construction

***Labor and Material Requirements for Private Multifamily Housing Construction* (BLS Bulletin 1892), 1976, 69 pp.**

Discusses labor and material requirements for the construction of private multifamily housing projects. Data were obtained from a survey based on a probability sample representing all privately owned structures of five units or more located in metropolitan areas where building permits were issued during 1969 for 500 units or more of this type. The survey covered 89 projects in 22 Standard Metropolitan Statistical Areas. Most of the construction took place in 1971.

Ball, Robert, "Labor and Material Requirements for Apartment Construction," *Monthly Labor Review*, January 1975, pp. 70-73.

Summarizes the first construction labor requirements study of private multifamily housing construction.

Private single-family housing construction

***Labor and Material Requirements for Construction of Private Single-Family Houses* (BLS Bulletin 1755), 1972, 30 pp.**

A study of labor and material requirements for construction of single-family housing in 1969.

Ball, Robert and Ludwig, Larry, "Labor Requirements for Construction of Single-Family Houses," *Monthly Labor Review*, September 1971, pp. 12-14.

Summary of BLS Bulletin 1755, a study of labor and material requirements for single-family housing construction in 1969.

***Labor and Material Requirements for Private One-Family House Construction* (BLS Bulletin 1404), 1964, 37 pp.**

A statistical study of onsite and offsite labor requirements for constructing single-family houses developed from a sample of one-family houses built in 1962 in various localities of the United States.

Rothberg, Herman J., "Labor and Material Requirements for One-Family Houses," *Monthly Labor Review*, July 1964, pp. 797-800.

A summary of BLS Bulletin 1404.

Public housing construction

Prier, Robert J., "Labor Requirements Decline for Public Housing Construction," *Monthly Labor Review*, December 1980, pp. 40-44.

A study of public housing projects completed in 1975. The article compares this study to the ones done in 1960 and 1968. It discusses trends in labor requirements and distribution of costs.

***Labor and Material Requirements for Public Housing Construction, 1968* (BLS Bulletin 1821), 1974, 20 pp.**

A study based on findings of a survey of 48 public housing projects sponsored by the Housing Assistance Administration of the Department of Housing and Urban Development.

Finn, Joseph T., "Labor Requirements for Public Housing," *Monthly Labor Review*, April 1972, pp. 40-42.

Summary of a study of labor requirements for public housing construction in 1968.

***Labor and Material Requirements for Public Housing Construction* (BLS Bulletin 1402), May 1964, 42 pp.**

A report based on findings of a survey of 31 public housing projects which the Public Housing Administration administered. Projects were selected in various States to represent four broad geographic regions of the conterminous United States.

School construction

***Labor and Material Requirements for Elementary and Secondary School Construction* (Publication Number BLS/LAB Constr-72/81), 1981, 47 pp. (Available from National Technical Information Service, U.S. Department of Commerce.)**

Discussion of methods for reducing occupational shortages.

Ziegler, Martin, "BLS Construction Labor Requirements Program," Paper presented before the North American Conference on Labor Statistics, San Juan, Puerto Rico, June 1971.

Construction labor requirements program and objectives are discussed.

Finn, Joseph T., "Material Requirements for Sewer Works Construction," *Construction Review*, January 1979, pp. 4-13.

This article summarizes the results of the survey of labor and material requirements for sewer works construction during 1971 (BLS

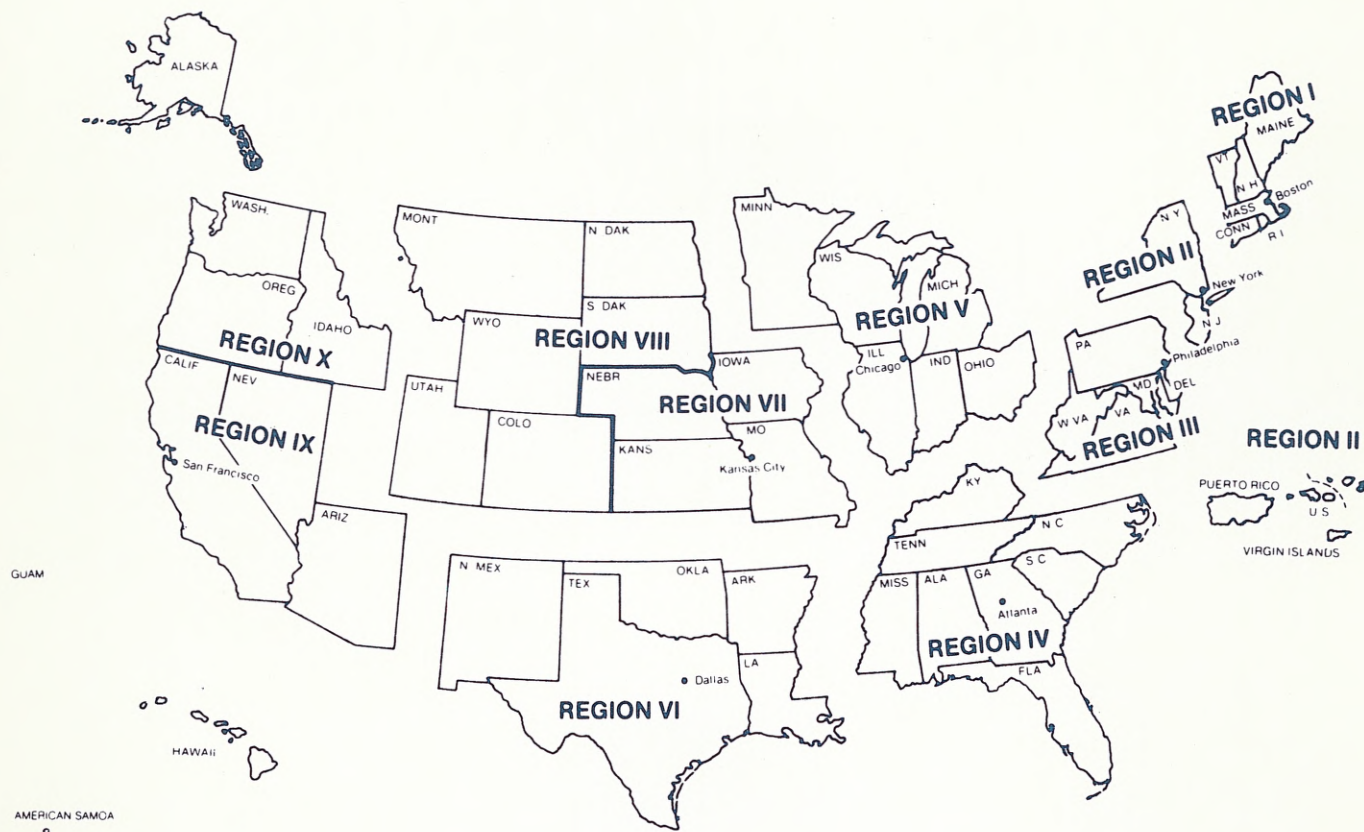
Bulletin 2003) with reference to the value of the materials, supplies, and equipment used in this type of construction. A detailed listing of the cost of these materials, supplies, and equipment per \$1,000 of construction contract cost and per 100 square feet is included. In addition, comparisons are made with the results of an earlier study of sewer works construction during 1963.

Ball, Robert, "Material Requirements for Private Office Buildings and Other Selected Types of Construction Activities," A paper presented before the Construction Marketing Seminar, Chicago, Illinois, September 28, 1978.

Discusses material and equipment requirements for the construction of private office buildings and other types of building construction studied by BLS.

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