Productivity Reports

Labor and material requirements for commercial office building projects

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The Bureau of Labor Statistics has completed its first study of labor and material requirements for commercial office building construction, similar to studies on school building and Federal office building construction. Based upon this survey of projects completed in 1974, the Bureau estimates that each $1 billion of construction outlays for commercial office building construction in 1980 generated 21,900 jobs, including 9,800 in the construction industry. The Bureau estimates that during the survey period, each $1 billion of expenditures generated 49,000 jobs with 23,000 of them in construction.[1] The tabulation compares these data for 1973 and 1980:

	In current dollars	
Industry	*Jobs per $1 billion expenditure in 1973*	*Jobs per $1 billion expenditure in 1980 (preliminary)*
All industries	49,383	21,900
Construction	23,067	9,800
Onsite construction	20,667	8,800
Offsite construction	2,400	1,000
Other industries	26,316	12,100
Manufacturing	15,752	6,500
Trade, transportation, and services	8,066	4,200
Mining and all other industries	2,498	1,300

Viewed in another perspective, for each $1,000 expended on commercial office building construction during the survey year, 97.5 employee-hours were required. Of these, 42 were in the construction industry, 37.2 onsite and 4.8 offsite. The remainder of the required hours, 55.5, were in other industries: 33 in manufacturing; 16.6 in trade, transportation, and services; and 5.9 in mining and other industries.[2]

The Bureau estimates that for each $1,000 of expenditures on this type of construction in 1980, 41.8 employee-hours were required.[3] The industrial breakdown of these estimated hours are: 17.9 in construction, 15.9 onsite and 2 offsite; 13.7 in manufacturing; 7.6 in trade, transportation, and services; and 2.6 in mining and other industries.

Construction of commercial office buildings accounts for a significant portion of new construction activity in the United States. The Bureau of the Census reported that the value of commercial office building construction totaled $9.5 billion in 1979.[4]

Survey's scope and uses

The survey, designed to collect information on the number of employee-hours required to construct commercial office buildings, was based upon a sample of these buildings completed in fiscal year 1974.[5] (Most of the value of construction for these projects was put in place during 1972 and 1973.[6]) A sample of 651 projects with a construction value greater than $100,000 (built in the 48 contiguous States) was supplied by the Bureau of the Census and was then verified by the Bureau of Labor Statistics. The 83-project subsample was stratified by cost class and by broad geographic region—North, South, North Central, and West.[6] The subsample was representative of a universe of projects with a total construction value of about $2.7 billion.

These survey data are used to assess the impact of private and public construction expenditure on jobs and occupations. The occupational information which the studies provide is used by the Department of Labor in an effort to produce estimates of the employment-generating effects of construction expenditures, and to update construction labor requirements, knowledge of which can help determine training needs and prevent labor shortages or surpluses. Market research analysts and companies that manufacture equipment and supplies are interested in the detailed data collected on the amounts and types of materials used in construction. In addition, resurveys provide data on trends in labor requirements through the current year. These trends give an indication of construction productivity.

Onsite labor requirements

Data on onsite construction labor requirements were collected directly by the Bureau from owners, developers, and contractors. Onsite hours, which ranged from a low of 11.7 to a high of 72.4, can be affected by many

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factors. These include strikes, weather conditions, changing building codes, the use of prefabricated or standardized building components, the availability of skilled labor, soil conditions, project size and design, and order and delivery time for materials.

Regional and national data on onsite employee-hours were collected by type of occupation.[7] The data show that skilled workers accounted for 68 percent of all onsite construction hours. Among the various skilled trades, carpenters accounted for the largest percentage —15 to 23—of onsite hours in all four regions. The occupation with the next largest proportion was electrician, whose percentages ranged from 5 to 11. All other skilled worker groups accounted for less than 10 percent each of total onsite hours. Semiskilled and unskilled workers accounted for 24 percent of onsite hours, and professional and clerical workers, 7 percent.

Employee-hour data were also collected by type of construction operation. General contractors consistently accounted for the largest percentage of onsite labor in all four regions, although the percentages varied. The general contractors' percentage in the Nation was 34; 28 in the Northeast, 27 in the North Central region, and 33 in the West. The South, however, had a much higher average percentage, 40. Heating, ventilating, and air-conditioning subcontractors claimed the next highest percentage of onsite hours in the Nation and in the North Central, South, and West regions. In the Northeast, however, the electrical subcontractors accounted for a larger percentage of onsite hours than heating, ventilating, and air-conditioning subcontractors.

Building characteristics. On the average, for the United States and all regions except the Northeast, the construction of buildings containing offices only required fewer employee-hours per $1,000 than those buildings containing a combination of offices, apartments, or shopping facilities. Labor requirements for such buildings were also lower per 100 square feet in all four regions. In a building containing only offices, some efficiencies may be realized because of the repetitive design and opportunity for increased use of modular materials, thus reducing labor requirements.

Data were also collected by various building characteristics for hours per $1,000 (table 1) and hours per 100 square feet (table 2).[8] (Detailed comparisons for each building characteristic in every region have not been made because of the difficulty in isolating and fully explaining differences in labor requirements. Comparisons reflect many other differences besides those in individual characteristics.) On the average, concrete framed buildings had higher labor requirements than buildings with other types of framing by both contract value and area. Buildings with concrete exterior walls required more labor nationally than those with masonry, wood, or other types of exterior walls. Data for both interior walls and ceiling types showed that buildings with plaster walls and ceilings had the highest employee-hour requirements. Concrete again is the material used in buildings requiring the most labor, when buildings with

Table 1. Onsite employee-hours per $1,000 of cost, by selected building characteristic, for commercial office building construction, by region, 1972–73

Building characteristic	United States	Northeast	North Central	South	West
All projects	37.2	37.0	32.4	44.2	31.7
Framing					
Steel	35.5	36.3	30.0	44.1	24.0
Concrete	43.6	(2)	44.2	43.5	44.8
Masonry	31.6	72.4	27.2	57.7	33.5
Wood	35.3	39.5	42.4	(1)	33.7
Exterior walls					
Concrete	42.1	37.2	37.6	47.5	36.2
Masonry (brick)	35.4	38.0	29.2	39.5	39.1
Wood	35.2	32.2	47.2	45.5	30.9
Other	34.1	(2)	29.0	43.2	27.8
Interior walls					
Drywall	37.2	36.5	31.2	43.9	32.8
Plaster	47.2	55.6	43.7	46.2	(1)
Movable partitions	33.8	(1)	(2)	(1)	18.4
Other	39.1	(1)	30.2	(2)	(1)
Floor base					
Concrete	38.0	36.9	32.3	44.2	34.1
Wood/plywood	28.1	38.2	37.0	(1)	26.4
Floor covering					
Terrazzo	42.4	(1)	(1)	42.4	(1)
Carpet	36.0	37.1	32.9	47.8	30.0
Vinyl/vinyl-asbestos	37.0	(2)	32.1	40.1	56.4
Other	39.7	(1)	26.3	42.8	28.4
Ceiling					
Drywall	30.6	(1)	28.4	32.9	35.6
Plaster	38.7	(1)	38.7	(1)	(1)
Acoustical tile	37.8	37.0	33.1	44.9	31.4
Other	35.4	(1)	(1)	35.4	(1)

Building characteristic	United States	Northeast	North Central	South	West
Heating					
Forced air	39.6	36.8	37.8	45.2	32.9
Hot water	35.3	34.4	29.8	52.2	18.4
Radiant	32.2	37.4	26.0	36.4	32.6
Other	35.4	(1)	(1)	35.4	(1)
Heating fuel					
Electricity	34.6	36.7	27.0	42.2	28.8
Gas	39.8	72.4	32.1	46.4	36.2
Oil	35.5	35.1	37.0	(1)	(1)
Other	49.3	(1)	49.3	(1)	(1)
Air-conditioning					
Central air	37.4	36.7	32.4	44.2	32.0
Other	33.2	45.8	37.6	40.9	30.5
Elevators/escalators					
Elevators/escalators	37.8	37.5	33.1	43.2	30.8
None	35.2	35.7	29.8	54.6	32.7
Roofing					
Asphalt/asbestos	29.5	53.6	27.7	(2)	42.1
Built-up	38.1 nl	36.7	34.6	43.6	29.9
Wood	39.5	37.4	61.0	(1)	38.6
Other	38.6	(1)	(1)	51.3	31.7
Roof base					
Steel decking	38.8	37.8	33.2	44.6	42.1
Concrete	40.5	(2)	37.7	43.9	33.1
Wood/plywood	30.2	34.3	29.4	(1)	30.0
Other	(2)	(1)	(2)	(1)	(1)
Parking facilities					
Indoor	38.6	(1)	49.3	46.2	27.8
Surface	37.0	37.1	28.4	44.4	30.0
Indoor and surface	36.8	(1)	31.4	44.6	44.5
No parking	39.6	33.4	(2)	40.8	(1)

[1] No projects in sample.

[2] Less than 3 projects in universe.

Table 2. Onsite employee-hours per 100 square feet, by selected building characteristic, for commercial office building construction, by region, 1972–73

Building characteristic	United States	Northeast	North Central	South	West
All projects	83.3	129.8	68.4	103.2	60.9
Framing					
Steel	83.7	123.1	69.9	113.9	46.0
Concrete	93.9	(2)	73.6	91.4	150.8
Masonry	66.8	328.7	54.2	107.3	97.1
Wood	55.8	128.1	132.9	(1)	49.3
Exterior walls					
Concrete	10.19	220.2	68.0	117.6	118.0
Masonry (brick)	69.5	85.7	60.8	77.7	62.4
Wood	57.7	101.2	188.7	80.9	43.4
Other	86.3	(2)	82.4	114.4	60.5
Interior walls					
Drywall	82.3	128.0	62.7	102.5	63.4
Plaster	104.9	197.2	97.7	96.0	(1)
Movable partitions	87.3	(1)	(2)	(1)	33.0
Other	98.2	(1)	69.0	(2)	(1)
Floor base					
Concrete	87.7	129.8	67.9	103.2	73.2
Wood/plywood	47.1	131.8	93.1	(1)	41.1
Floor covering					
Terrazzo	93.4	(1)	(1)	93.4	(1)
Carpet	84.5	125.8	70.4	133.8	59.4
Vinyl/vinyl-asbestos	91.2	(2)	65.1	129.2	199.1
Other	76.9	(1)	60.4	87.5	42.0
Ceiling					
Drywall	53.4	(1)	53.1	85.6	44.7
Plaster	99.4	(1)	99.4	(1)	(1)
Acoustical tile	87.1	129.8	71.5	107.6	62.8
Other	55.4	(1)	(1)	55.4	(1)
Heating					
Forced air	91.3	97.4	80.9	110.8	71.3
Hot water	79.9	98.3	70.9	116.5	33.0
Radiant	68.4	194.0	48.6	84.2	40.6
Other	55.4	(1)	(1)	55.4	(1)
Heating fuel					
Electricity	77.2	125.6	57.2	98.2	52.0
Gas	91.6	328.7	76.0	108.6	76.9
Oil	134.9	141.9	115.0	(1)	(1)
Other	76.2	(1)	76.2	(1)	(1)
Air-conditioning					
Central air	85.6	130.4	68.3	104.0	65.2
Other	51.8	115.8	92.7	68.8	45.1
Elevators/escalators					
Elevators/escalators	90.8	161.8	69.6	101.9	78.6
None	64.2	87.5	63.8	116.4	49.5
Roofing					
Asphalt/asbestos	60.3	119.6	54.3	(2)	138.9
Built-up	90.8	130.4	75.7	102.3	66.5
Wood	58.0	110.4	121.2	(1)	54.0
Other	65.6	(1)	(1)	116.4	47.3
Roof base					
Steel decking	96.6	145.2	78.5	100.0	138.9
Concrete	94.4	(2)	63.9	104.9	93.5
Wood/plywood	51.0	79.7	55.3	(1)	46.6
Other	(2)	(1)	(2)	(1)	(1)
Parking facilities					
Indoor	84.9	(1)	76.2	146.0	75.5
Surface	83.4	131.6	66.1	106.5	46.6
Indoor and surface	81.2	(1)	66.2	79.1	141.0
No parking	84.2	94.1	(2)	82.6	(1)

[1] No projects in sample.

[2] Less than 3 projects in universe.

different floor base types are compared. Terrazzo floored offices required more hours per $1,000 and per 100 square feet than buildings with vinyl or vinyl-asbestos flooring, carpet, or "other" floor coverings. Further survey data indicated that forced air heated buildings had higher labor requirements than those heated by hot water, radiant, or "other" types of heat. Data for buildings with different types of heating fuel were conflicting —oil heated buildings required more hours per 100 square feet than those using electricity, gas, or "other" types of fuel. However, per $1,000, "other" fueled buildings required the most labor. Data for buildings with different roof base types and roofing types were also inconsistent. Projects with wood roofing and those with concrete roof base had higher labor requirements per $1,000, but built-up roofed buildings, and wood or plywood roof base buildings had higher requirements per 100 square feet. Both buildings with central air-conditioning, as opposed to those with unit air-conditioning, and those buildings with elevators and escalators, as opposed to none, required more labor.

Project characteristics. National data for both hours per $1,000 (table 3) and hours per 100 square feet (table 4) indicated that more labor was required to build a commercial office building outside metropolitan areas than within metropolitan areas. This relationship did not exist in the Northeast, however, where hours per $1,000 for metro projects were slightly higher than for buildings in nonmetro areas, and hours per 100 square feet for metro projects were more than twice as high as those in nonmetropolitan areas.

Employee-hour data stratified by project cost size and by number of floors above ground did not show a consistent relationship between hours and cost, and hours and building height. However, hours per $1,000 declined in inverse relation to the number of floors below ground.

Indirect and offsite labor requirements. Indirect hours represent the labor required to produce and distribute the materials, equipment, and supplies used in construction activity.[9] A total of 55.5 indirect employee hours was generated in three industry groups: manufacturing; trade, transportation, and services; and mining and all other industries. The hours by industry were:

Manufacturing	33.0	All other industries	5.9
Trade, transportation, and services	16.6	Mining	1.6
Transportation	3.9	Agriculture	0.8
Wholesale trade	5.3	Construction	0.6
Retail trade	4.9	Communications	0.5
Services	2.5	Public utilities	0.4
		Finance, insurance, and real estate	1.4
		Government enterprises	0.6

For every $1,000 of commercial office building construction, the estimated indirect hours generated by the manufacturing industry were 33. This is the largest contribution of indirect hours, 59 percent, and is due to the nature of construction, where most labor is onsite or in the manufacture of materials. In addition, as prefabrication increases, the manufacturing industry's percentage of hours should grow.

Of the 97.5 employee-hours required per $1,000 of commercial office building construction in the survey period, 5 percent were for offsite construction, compared to 38 percent for onsite hours and 57 percent for indirect hours.[10] The offsite employee-hours, 4.8, represent the builders' administrative office, estimating, and warehousing activities. (Offsite construction hours were estimated from the ratio of nonconstruction workers to total workers for general building contractors in the contract construction industry.)

Costs and project characteristics

Average total cost for surveyed commercial office buildings was $947,084. Buildings in the West cost the least at $584,299. Those in the Northeast were somewhat higher, averaging $776,372. By contrast, buildings constructed in the North Central region averaged $1,264,162, and South region projects averaged $1,224,771. Cost per square foot did not correspond in any way to average project cost. It should be noted that over 75 percent of the projects cost less than $1 million.

Component costs for surveyed projects averaged 42.2 percent for materials, 26.7 percent for labor, 2.7 percent for equipment, 0.6 percent for interest expense, and 27.9 percent for profit and overhead. Projects in the North Central and South had cost components that closely paralleled the national averages (although the South did have appreciably lower profit and overhead). By contrast, projects in the Northeast had higher average labor costs (29.2 percent) and profit and overhead (33.3 percent), and correspondingly lower relative costs for materials (35.6 percent) and equipment (1.8 percent). The West showed lower relative costs for materials (39.7 percent) and a higher profit and overhead (32.3 percent).

Table 3. Onsite employee-hours per $1,000 of cost by selected project characteristic for commercial office building construction, by region, 1972–73

Project characteristic	United States	Northeast	North Central	South	West
All projects	37.2	37.0	32.4	44.2	31.7
Location					
Metropolitan area	36.9	37.2	31.2	43.5	31.7
Nonmetropolitan area	41.1	34.3	37.2	57.2	(1)
Construction value					
$100,000-249,999 [3]	44.2	41.4	44.6	53.9	37.1
$250,000-499,999	35.4	34.7	40.9	47.2	14.9
$500,000-999,999	32.6	33.4	24.5	43.1	28.6
$1,000,000-2,999,999	34.5	37.8	28.0	40.1	31.2
$3,000,000-4,999,999	45.4	(1)	(1)	45.4	(1)
$5,000,000 and over	39.3	(2)	36.1	46.1	33.0
Floors above ground					
1 floor	37.7	35.6	31.2	57.4	39.2
2 to 3 floors	33.2	37.6	30.0	42.6	26.7
4 to 10 floors	38.4	(2)	28.1	41.8	42.1
11 to 35 floors	40.5	(1)	40.6	45.2	33.0
36 to 60 floors	38.9	(1)	(2)	45.9	(1)
Floors below ground					
1 floor	37.9	37.1	34.6	43.8	31.2
2 to 3 floors	35.8	(2)	(2)	46.5	33.0
4 to 5 floors	11.7	(1)	11.7	(1)	(1)

[1] No project in sample.
[2] Less than 3 projects in universe.
[3] Does not include one sampled project less than $100,000.

Table 4. Onsite employee-hours per 100 square feet, by selected project characteristic, for commercial office building construction, by region, 1972–73

Project characteristic	United States	Northeast	North Central	South	West
All projects	83.3	129.8	68.4	103.2	60.9
Location					
Metropolitan area	82.1	144.2	62.8	102.8	60.9
Nonmetropolitan area	96.2	66.9	97.7	109.6	(1)
Construction value					
$100,000-249,999 [3]	71.4	176.5	98.8	102.8	44.0
$250,000-499,999	75.2	74.9	95.4	99.7	25.6
$500,000-999,999	68.5	94.1	48.4	86.2	62.5
$1,000,000-2,999,999	80.3	160.3	57.2	101.6	51.7
$3,000,000-4,999,999	96.2	(1)	(1)	96.2	(1)
$5,000,000 and over	96.8	(2)	78.4	117.0	92.5
Floors above ground					
1 floor	74.4	81.7	71.8	135.3	60.0
2 to 3 floors	70.8	149.5	62.5	83.8	45.4
4 to 10 floors	96.0	(2)	52.4	110.2	138.9
11 to 35 floors	88.6	(1)	78.8	96.5	92.5
36 to 60 floors	106.9	(1)	(2)	117.9	(1)
Floors below ground					
1 floor	82.2	125.8	71.2	102.2	53.1
2 to 3 floors	99.4	(2)	(2)	108.9	92.5
4 to 5 floors	19.3	(1)	19.3	(1)	(1)

[1] No project in sample.
[2] Less than 3 projects in universe.
[3] Does not include one sampled project less than $100,000.

Costs per square foot averaged $22.36 overall and varied by region: $35.13 in the Northeast, $21.10 in the North Central, $23.36 in the South, and $19.18 in the West.

Nationally, the average length of time required to complete the construction of commercial office buildings 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.

Average square feet for all surveyed projects was 42,358. For the regions, the average square footage was: Northeast, 22,103; North Central, 59,920; South, 52,421; and West, 30,460. Just over half of the projects had two to three floors above ground, while a third had one floor above ground.

Commercial and Federal office buildings

Because this is the first BLS survey of commercial office buildings, there is no previous study with which to make comparisons. However, a survey of Federal office building construction was published by the Bureau in

1976.[11] Buildings in both studies were constructed at about the same time and therefore provide the opportunity to compare some data, although some structures in the Federal office building study were not similar to those of the surveyed commercial office buildings. (The Federal office buildings survey included Federal office buildings, social security buildings, laboratory-office buildings, and border stations.) 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; while over 85 percent of commercial office buildings were one or two stories. In addition, a majority of the construction value for both surveys was put in place during the same period, 1972–73.

Commercial office buildings required 7.4 fewer total hours per $1,000 than projects in the Federal office building survey (15 percent fewer hours). Commercial office building onsite labor requirements were also lower —37.2 hours compared to 42.8 hours. However, the biggest percent difference was for offsite hours—4.8 hours for commercial office buildings and 6.6 for all types of Federal office buildings. Commercial office buildings also required fewer hours per 100 square feet. The tabulation summarizes these comparisons in hourly requirements:

1972–73 office buildings	*Per $1,000 (current)*			*Per 100 square feet*		
	Total	*Onsite*	*Offsite*	*Total*	*Onsite*	*Offsite*
Commercial office buildings	42.0	37.2	4.8	94.0	83.3	10.7
All Federal buildings	49.4	42.8	6.6	204.1	176.8	27.2

Average cost per project was about $947,000 for commercial office buildings, compared with $2,780,000 for Federal office buildings. This difference may account for some of the disparity in labor requirements shown in the text tabulation. Cost per square foot also differed considerably. Surveyed commercial office buildings cost about 45 percent less per square foot than the surveyed Federal office buildings: $22.36 to $41.28. Commercial office buildings cost less in every region: in the Northeast—41 percent less; in the North Central—36 percent less; in the South—35 percent less; and in the West—51 percent less.

The major components percent of construction costs for the two studies again showed there were large variances in the data. The largest difference was a much lower profit and overhead component for Federal office buildings—12.5 percent less than commercial buildings' profit and overhead.

Industry overview

How much commercial office building construction is done each year is heavily dependent on the economy—and in particular on each area's outlook for growth: the current local office occupancy rates; money market conditions; local, State, and Federal incentives; and available labor. In 1979, the value put in place for private office building construction was $9.5 billion, a considerable increase over 1975's $5 billion even if inflation is taken into account.[12] Most of this newly constructed space is being occupied, or will be occupied, by existing companies that are expanding.

The future activity level of this particular segment of construction is even harder to predict than the level of the economy, on which construction activity depends so much. However, some estimates show that there will be a surplus of office space by 1983 when most larger buildings now under construction will be completed.[13]

Technology and construction

Recent trends. Rarely are there any major "breakthrough" type technological changes in construction. Rather, new ideas, which usually affect one facet of construction, are continually being developed. The ideas are first tested on one or two projects, and then, if successful and accepted, spread gradually throughout the industry. New ideas in design and construction that have led to savings in time and cost have often involved lighter or stronger materials; new materials combinations which were largely prefabbed offsite; increased use of modular systems in design and construction; innovative management techniques like fast-tracking, which is the overlapping of construction phases that are ordinarily sequential; and increased use of computers.

In the early 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, energy consumption, government regulation, tenant requirements, and so forth. Among the trends and changes in this period were: increased environmental considerations; better interior space programming and planning techniques; improved heating, ventilating, and air-conditioning systems; better insulation and increased use of solar heat-reducing glass; improvements in the design and detailing of glass curtain walls; design advancements for rigid-framing, increased use of modules; and new solutions to high-rise wind-load problems.[14]

Energy. Owners, architects, engineers, and contractors are all looking for new ways to reduce energy costs. Fuel shortages, the general need to cut costs, and the emergence of energy conservation performance standards have led to a myriad of new ideas as well as increased implementation of older energy conservation techniques. Through building design and the choice of materials and mechanical systems to be used, energy can be conserved in two basic ways: actively and passively. The former (like solar equipment) is usually much more expensive, so the estimated payback period is examined closely before an owner will agree to such a design. The ever rising cost of energy, however, is making many of the payback periods shorter.

Some of the routine features now included in many of the office building designs are: 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 much to the cost of building and are passive conservation measures.

Some of the more innovative, expensive, and elaborate (and less common) features found in conservation-oriented designs include: extensive atriums, low and 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 construction cost because less heavy steel or concrete framing is needed.

High-rise towers present many challenges to engineers and architects. One of the most difficult challenges is designing the structure to resist wind-loads. One industry expert summarizes some of the new structural solutions to high-rise problems by explaining the new possibilities for growth in skycrapers, brought about by the advent of bundled-tube and stress-tube systems for steel structures, and framed-tube, tube-in-tube, and modular-tube systems for tall concrete structures.[15]

One common but fairly new technological development used in design and construction that has had a large impact, is the module. A module, which is based on standardization of sizes of materials, designs, and client requirements, can reduce the time required for both design and construction. Modules are often used extensively in structural framing, lighting, air-conditioning and heating, power supply and communications, partitions, and built-in or movable furniture.

The use of precast concrete, versus cast-in-place concrete, is another example of an idea which produces savings in labor and construction time, and in this case also provides better quality control. For example, an $8 million hotel addition, which was built using a modular precast concrete building system, was completed 30 percent faster than would have been possible if cast-in-place concrete had been used.[16]

Another innovation in the use of precast concrete is precast concrete bents, which eliminates the need for shear walls because the bents themselves are able to bear weight and resist moment forces. They can also serve as the primary architectural elements.[17] Because the bents are cast in one piece, they do not have the heavy joint lines common to precast concrete. These lines are usually very unattractive, so the concrete structures cannot be used as architectural elements. Very few units are required because they cast a beam and two columns simultaneously in each bent. This also helps reduce construction time.

Other changes in construction processes. In general, prefabrication is most fully utilized in construction through the use of systems techniques. This is the process of combining prefabricated assemblies and components into single integrated units using industrialized production, assembly, and methods. Systems or systems building can be employed in erecting or installing exteriors, flooring, ceiling, walls, mechanical and lighting elements, or several combinations of these elements. Generally this will lead to a reduction in onsite labor requirements and an increase in offsite and indirect labor hours.

Another change in the design and management of construction projects, the increased use of computers, has had a more limited impact because of the industry's slow and cautious reaction to innovation, and the state-of-the-art in computers which offered little incentive to change. In the past, the large mainframe computers were often used only for one application and this resulted in relatively small incremental savings. The recent advent of the smaller, less expensive, and easier to use computers, plus the availability of prepackaged software programs, have made it easier for computers to be used in all phases of construction: planning, designing, managing, and building. However, they are still not commonplace. Only a few larger firms have fully integrated systems.[18] Only about one-third of civil engineers and 40 percent of contractors use small computers.[19] In the future, the increasing complexity and cost of construction design and management will increase the potential usefulness of computers even to smaller firms. The design and construction firms will have to contend with an ever increasing number of environmental and energy regulations; local, State, and Federal laws; community group pressures; and labor demands. There is also growing client awareness and increasing inflation to consider. All of these complex constraints simply emphasize the need for coordination of all available information and the need to be able to make rapid responses, all of which a computer can facilitate. In addition, construction contractors could use a computer while carrying out many of their business functions, such as accounting, drawing graphics, drafting, preparing bids, and compiling payrolls.

Another change in construction, which is more widespread and has been employed for a longer period of time, is in the method of managing. Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and fast-tracking all try to speed the construction process through tight coordination and cooperation among a project's owners, architects, engineers, and various contractors. This coordination often begins during the design phase; contractors are sometimes brought in for early consultations, some materials are ordered far in advance of use, and actual construction may even be started. Very often, systems building is used in conjunction with fast-tracking. PERT and CPM are systems of management that allow for tight control of this overlapping by providing a detailed time and cost schedule, and identifying the critical path, the sequence of events which, if delayed, would slow the entire project.

Another variation, that is actually a change in manager and not method of management, is the emergence of construction managers. A construction manager, who can be a general contractor or a specialized company, oversees and manages the entire project for the owner. They are found most frequently on large construction projects. □

——*FOOTNOTES*——

[1] 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 the other industries are: 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.

[2] 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 then processed through the Bureau's input-output model to generate estimates of final demand. Sector productivity 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 the construction activity.

Offsite construction labor requirements were estimated from the ratio of nonconstruction workers to total workers for general building contractors in the contract construction industry, as shown in *Employment and Earnings.*

[3] The 1972–3 onsite hours required for commercial office building construction were adjusted for price and productivity factors in estimating the 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 is the average of the Census Bureau single family housing deflator, Turner Construction Co. deflator, and the Federal Highways Administration deflator (or the non-residential building deflator): 1959 = 59.5, 1972 = 100, 1972–3 = 104.6, 1980 = 217.9 (preliminary). The annual rate of change used was −2 percent. From this rate a compound interest factor for the 6 1/2-year span was applied to the hours, which were adjusted by the cost index.

[4] U.S. Department of Commerce, "Table 1—New Construction Put in Place, *Construction Reports* (C30:-80-5) May 1980, p. 4.

[5] 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, to design and select the sample, and to collect, compile, and verify the data. For each surveyed project, many personal visits to contractors and subcontractors, with followup visits, were required. 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 factors over periods of time. The data also serve as benchmarks for developing current estimates of employment generating effects of construction expenditures.

[6] Although the overall U.S. and regional data provided by the survey are believed to be accurate, the detailed data would have a wider margin of sampling error and may be subject to other limitations. Except for the nonresponding sample units and the data estimated by the contractor, there are no known sources of nonsampling error. Sampling variances will be made available at the Bureau of Labor Statistics.

[7] Data were provided for the continental United States and four 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.

[8] Employee-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.

[9] The Office of Economic Growth, 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. The data used in this study were prepared by Karen Horowitz.

[10] Offsite employee-hours represent the builder's administrative office, estimating, and warehousing activities. The following procedure was used to calculate offsite construction employee-hours. Employee-hours worked by administrative personnel were subtracted from total onsite hours obtained in the survey. The amount of administrative hours was taken from survey data. The percentage that these "adjusted" onsite hours were of total hours was found in *Employment and Earnings, United States* 19–08–78, Bulletin 1312–11. (Bureau of Labor Statistics, 1979) and a total hour figure was calculated. From this total hour 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 *Employment and Earnings.* Administrative hours worked onsite are included in all onsite hour data presented.

[11] See John G. Olsen, "Decline noted in hours required to erect Federal office buildings," *Monthly Labor Review,* October 1976, pp. 18–22.

[12] The Bureau of the Census, U.S. Department of Commerce, dollar amounts for value put in place are higher than F.W. Dodge's contract value data. The following Census data on value put in place for commercial office building construction are in billions of current dollars:

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

Data for 1972–73 are from U.S. Department of Commerce, "Table A-2.—New Construction Put in Place in the United States in Current and Constant (1972) Dollars," *Construction Review*, March 1979, p. 23; 1974–79 data are from U.S. Department of Commerce, "Table 1—Value of New Construction Put in Place," *Construction Reports* (C30-80-5), May 1980, p. 24.

[13] "A towering rise in downtown construction," *Engineering News Record*, March 5, 1979, p. 97.

[14] Schmertz, Mildred F., editor, *Office Building Design* (McGraw-Hill Book Company, New York), 1975, p. viii.

[15] Schmertz, *Office Building Design*, p. viii.

[16] "System cuts 30 percent from 'building time'," *Engineering News Record*, May 31, 1979, p. 11.

[17] "Precast bent disguises strength with good looks," *Engineering News Record*, December 13, 1979, pp. 40–41.

[18] "Construction's newest tool is small, low cost, highly productive," *Engineering News Record*, August 4, 1977, p. 20.

[19] "Optimizing the construction process" (editorial), *Engineering News Record*, August 4, 1977, p. 80.

The pension punch

. . . It has been estimated that pension funds overall control more than $.5 *trillion*, of which nearly half is to be found in funds set up and controlled at least in part by unions. While such funds are often technically directed by some combination of employer and union representatives, the experience of the Teamsters Central States Fund is instructive as to the extent the employer-named directors seldom constitute an independent force.

Half a trillion dollars is a *massive* source of investment capital which constitutes a massive threat should an employer be the recipient of fund capital or seeking capital from the fund. Several observers, who implicitly support such uses of pension capital for union organizational purposes, have criticized the current operation of these funds because, for example, large portions of the fund investments surveyed have gone to nonunion firms. Yet this criticism seems misplaced, even granting the validity of the observer's point of view: the problem is not that an unacceptable amount of pension fund money is going to support nonunion firms but that union officials are not using this fact as a lever to accomplish their aim of transforming these firms into unionized enterprises. After all, you can't induce a firm to unionize by threatening to withdraw needed capital (capital the firm has become used to having) if it isn't already invested there. Whatever the criticisms, however, it is evident that some unions and some union activists have been vigorously exploring the limits of the pension fund "card"; they are testing various techniques for using this card in well-orchestrated unionizing stratagems . . .

—JAMES T. BENNETT AND MANUAL H. JOHNSON
Pushbutton Unionism
(Fairfax, Va., George Mason University, Contemporary Economics & Business Association, 1980), pp. 13–14.