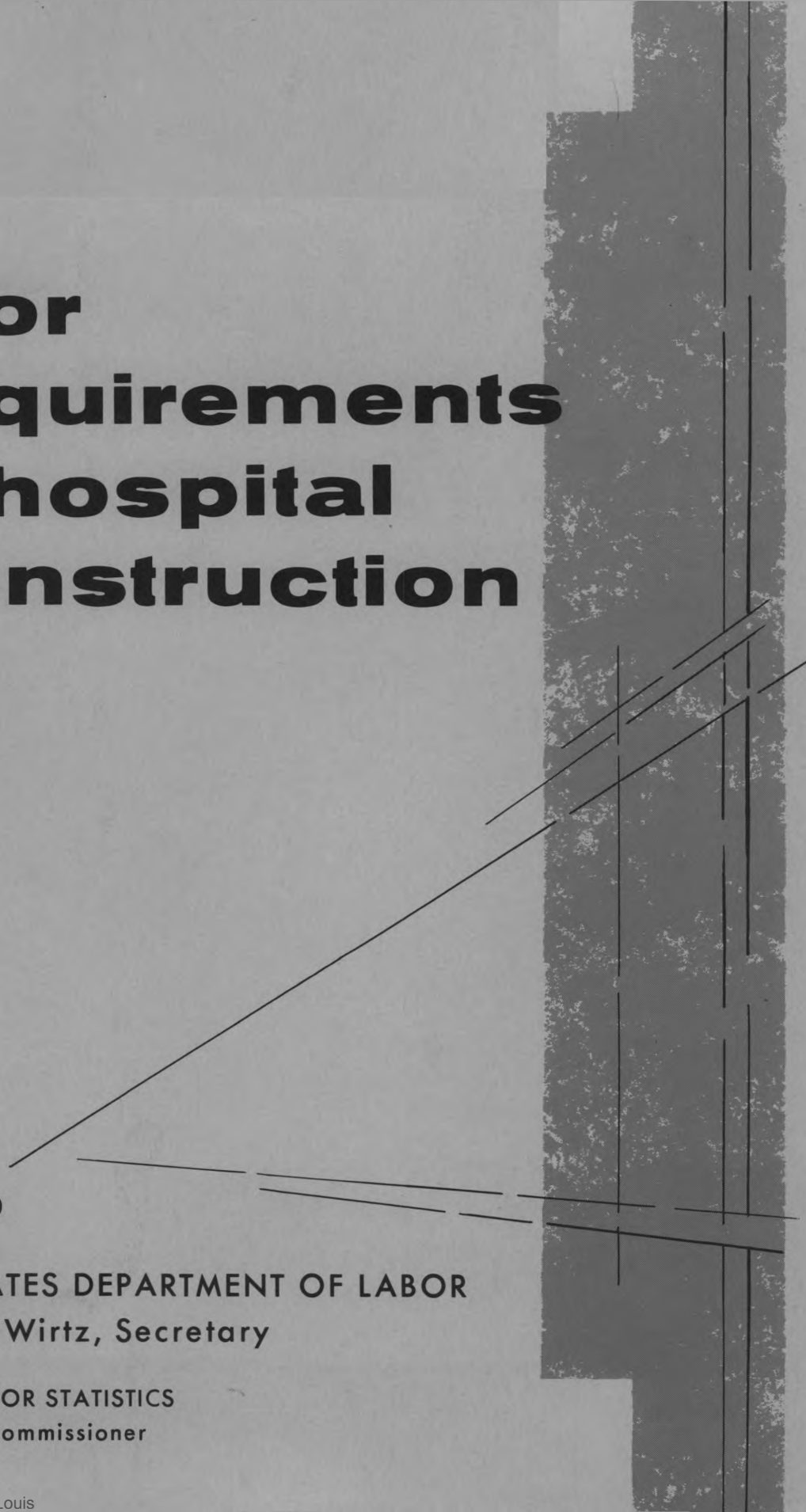
labor requirements for hospital construction



Bulletin No. 1340

UNITED STATES DEPARTMENT OF LABOR
W. Willard Wirtz, Secretary

BUREAU OF LABOR STATISTICS
Ewan Clague, Commissioner

Labor Requirements for Hospital Construction, Bulletin No. 1340

Errata Sheet

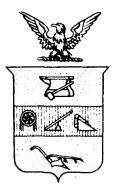
(1) Page 15, second paragraph, last sentence, should read:

"However, a very rough adjustment for price change indicates that on-site man-hours per $1,000 (in constant prices) for hospital construction have declined by approximately one-third in the past 20 years."

(2) Page 15, fourth paragraph, first sentence, should read:

"It is interesting to note that the decrease over the 20 years in site man-hours appears to be about the same as that for schools and about twice as large as that for Federal buildings."

labor requirements for hospital construction



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Preface

This study of labor requirements for the construction of general hospitals is the fourth in a series of such studies authorized by the 86th Congress for various types of construction that might be affected by Government action. Previous studies were made for schools, highways, and Federal office buildings. Surveys currently in preparation cover the civil works activities of the Corps of Engineers, such as the construction of dams and levees and dredging of channels, and several segments of the housing industry (private single-family dwellings, public housing, and housing for college students). Other surveys are in the planning stages.

The studies are being made by the Bureau of Labor Statistics, Division of Productivity and Technological Developments, under the supervision of James F. Walker. This report was prepared by Herman J. Rothberg, who also directed the collection of statistical data. Ronald E. Kutscher was in charge of the group determining the employment created by the use of building materials.

The Bureau is grateful to the Public Health Service of the U.S. Department of Health, Education, and Welfare and the Departments of Health of the various States for their generous cooperation and for making available the data which were tabulated to determine the direct labor requirements for federally aided hospital projects. The Bureau also appreciates the cooperation of the construction contractors who supplied the materials data on which the estimates for indirect requirements were based, as well as the on-site man-hour data for nonfederally aided projects.

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LABOR REQUIREMENTS FOR HOSPITAL CONSTRUCTION

Introduction

New construction is a major component of the Nation's output of goods and services and an important source of employment. It creates jobs not only at project sites but also in the many manufacturing, trade, and transportation industries which furnish materials required in the construction process. Because of their far-reaching employment impact, construction projects are often regarded as a means of counteracting cyclical unemployment.

To measure the labor requirements for various types of construction, the Bureau of Labor Statistics has undertaken a series of studies. Hospital construction--public and private, profit and nonprofit--was selected for early study because it represents a relatively substantial part of all nonresidential building construction expenditures and because of the widespread expression of need for additional hospital facilities of all types. Expenditures for the construction of hospital and related medical facilities (including Federal facilities and those federally assisted) were at an annual rate of $1.16 billion in 1961 and accounted for about 7.5 percent of the total nonresidential building construction that year. Federal funds accounted for $220 million or almost one-fifth of all hospital construction expenditures, with $165 million of this sum devoted to assisting various State and local public and private nonprofit groups to meet demonstrated need for hospital and related facilities under the Hill-Burton program. (See appendix A.) This program, initiated in 1946, was influential in helping to bring hospital facilities to areas that never before had hospitals, or in some cases, had inadequate facilities. The extent to which the program aided in generating the construction of hospital facilities is indicated by the fact that from its inception through December 31, 1961, $4.67 billion in total costs were approved under the program; and for every $1.45 of the Federal share, $3.22 was spent by the assisted States or local public and private nonprofit groups.

It is estimated that almost $4 billion will be spent in the 3-year period 1962 through 1964 for the construction of hospital and related medical facilities. 1/ A few thousand projects will probably be involved. The Public Health Service anticipates that to meet future needs for hospital facilities, increasingly higher expenditures of Federal, State, and local public funds as well as private moneys, will be required for hospital construction through the latter sixties and early seventies. Emphasis is expected on construction devoted to expansion and renovation of "big city" hospitals, chronic disease hospitals, and skilled nursing homes. Although general hospitals 2/, both

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1/ Unpublished preliminary estimates of the Division of Hospital and Medical Facilities, Public Health Service, U.S. Department of Health, Education, and Welfare.

2/ For definition of "general hospitals," as used in this study, see appendix A.

new and additions to existing ones, are the subject of this study, the findings may be useful in estimating man-hour requirements for the other types of hospital projects indicated. Equipment and facilities of general hospitals encompass the needs of all types of hospitals and related facilities.

Nature of Survey

This report is based on a survey of selected public and private profit and nonprofit general hospitals constructed in various localities of the United States. Data were collected for 46 projects, chosen as a representative sample of hospitals on which construction was begun sometime between mid-1958 and mid-1959. Construction of both new general hospitals and additions, whether separate buildings or extensions to existing ones, were studied. 3/

Although the survey did not cover moveable, unattached furnishings and equipment used in the hospitals studied, it did include built-in equipment unique to a hospital, such as X-ray dark room equipment, sterilizing equipment, pharmacy and laboratory equipment, cabinets at nurses stations, and other items, such as elevators and communications systems, which are permanently fixed in place so as to constitute integral parts of the buildings.

The survey was designed primarily to determine the number of man-hours represented by a fixed dollar volume ($1,000) of general hospital construction. Man-hours, as defined by the survey, include both on-site construction employment and the off-site employment required to produce and deliver materials used in the construction. Data for on-site labor include total man-hours for the supervisory, engineering, clerical, and custodial employees at the site, as well as those for workers in each construction trade. For almost four-fifths of the projects, additional data were obtained on wages and timing of employment. Data for off-site labor include employment in the off-site (e.g., office and warehousing) activities of construction contractors; in building materials and equipment manufacture and distribution; and finally, employment in all the other industries which are affected directly or indirectly by the production and distribution of building materials from raw material to the final manufacturing stage.

Certain types of employment, however, are not covered by the survey. Excluded are preparation of plans and specifications of the projects; production of movable furniture and administrative office equipment; the labor time involved in installations by public utility employees, as well as any site preparation, landscaping, and highway work not covered by the construction contract. No estimate was made of the labor generated by the money expended for contractors' overhead, other than off-site administrative salaries. The major part of such overhead consists of salaries and profit. It is believed

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3/ For a more detailed description of method and for a list of States included in each region, see appendix A.

that the other overhead items such as rent, bonds, insurance, taxes (including payroll taxes), welfare payments, and office supplies, generate relatively little employment. Employment created by the respending of wages and profits of the workers and their employers--the multiplier effect--was not considered within the scope of the study.

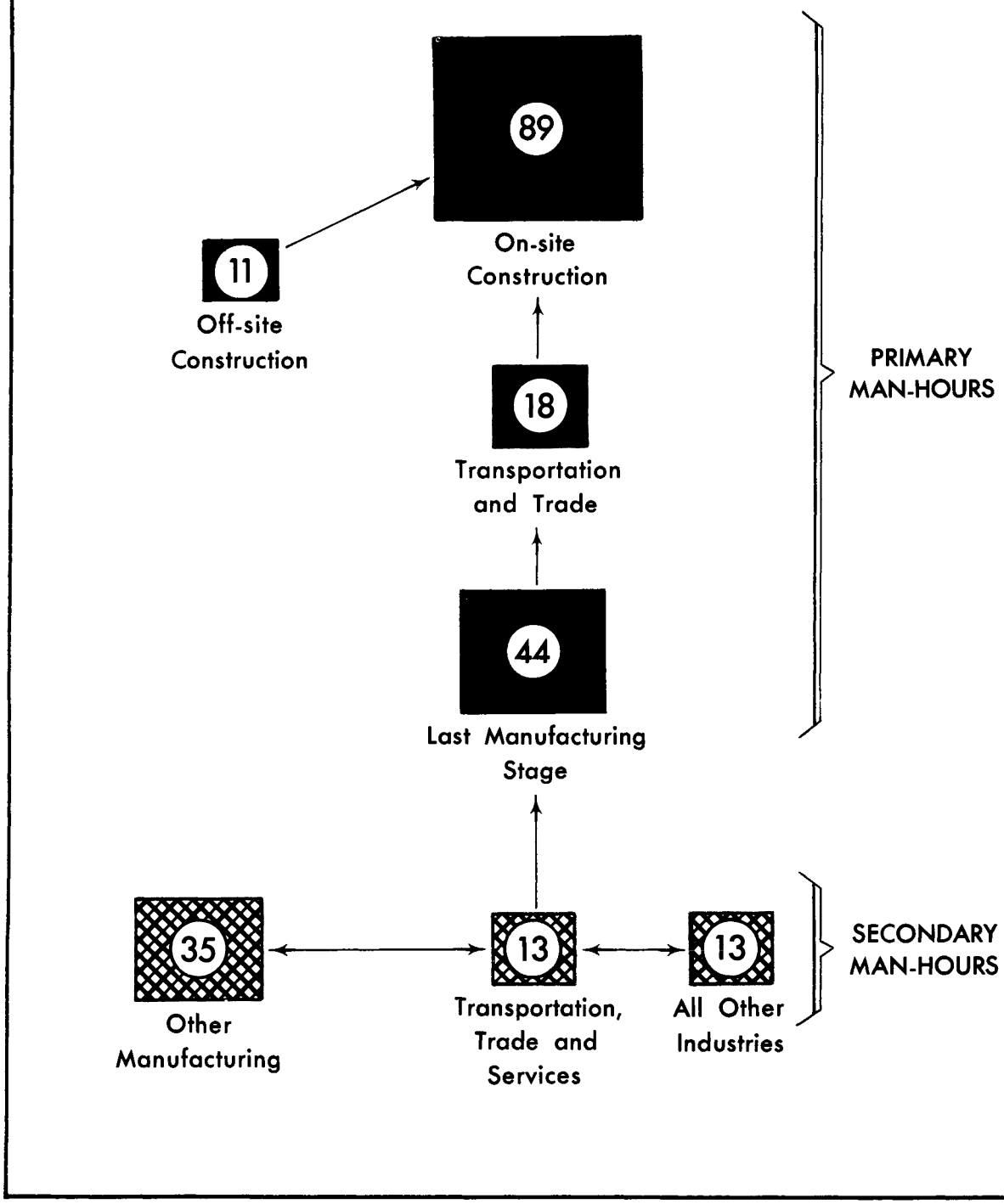
General Survey Findings and Characteristics

For every $1,000 of construction contract concerned in the building of general hospital structures in 1959-60, 223 man-hours of employment were created. Of these, 89 were for employment at the construction site and 134 were required for various off-site activities. (See chart 1.) The latter included all labor needed to produce and deliver materials and equipment used by the on-site workers, plus employment by the construction contractors in administrative, warehousing, and certain other off-site operations. Total man-hours were allocated as follows:

	Man-hours per $1,000 of contract	
	Number	Percent
Total man-hours	223	100
Construction:		
On-site	89	40
Off-site	11	5
Manufacturing	79	35
Transportation	9	4
Trade and service	22	10
Other industry employment	13	6

As pointed out in later sections of this report, new hospitals and additions to existing hospitals (with their related alterations) form two relatively homogeneous subgroups to make up the general hospital construction category and are therefore occasionally analyzed separately. Thus, on-site construction man-hours for additions amounted to 94 per $1,000 of construction contract amount or 9 percent more than 86 man-hours required for the new hospitals. This appeared to be due mainly to alteration and repair work as part of the additions. Detailed compilations of the off-site man-hours for both of these subgroups were not made. However, while average cost of materials (including rental or depreciated cost of construction equipment) for all the projects was $544 per $1,000 of contract amount, the average was $513 for additions and $557 for new hospitals. Since off-site hours (except those in the construction industry) are developed from cost data on the value of materials used at the site, it would indicate that the increased on-site hours for additions were virtually balanced by the lower off-site hours as represented by lesser materials cost per $1,000 of contract, so that total requirements for both of the subgroups are almost identical. (Lower materials cost per $1,000 of contract value for additions appears to result mainly from the fact that on-site hours including those used for alteration and repair work consume a larger part of each $1,000 of contract amount than do the hours for new hospitals.)

Chart 1. Distribution of Man-Hours for Each $1,000 of Hospital Construction Contract, 1959-60



The average cost of the hospitals studied was about $1.5 million (exclusive of site and planning cost) and it was the same for new projects and for additions. Average hospital construction time was approximately a year and a half. Therefore, the hospital projects provided on the average the equivalent of continuous work for 49 workers for 18 months at the construction site. A somewhat greater amount of employment was provided in off-site activities. 4/

During recent years, an average of about $1 billion a year has been spent for the construction of all hospital and related medical facilities. This would indicate that such construction has been the source of about 117,000 jobs annually--67,000 of these off-site. Meeting the anticipated needs previously noted, however, suggests the creation of an even higher level of employment.

The survey disclosed wide ranges of man-hour and materials requirements among individual projects, reflecting differences in size of building, geographical location, and local practices. There were also marked variations in such related measures as average hourly earnings and site wages as percentages of construction cost. On the average, however, 54 cents of the construction dollar was spent for materials purchases, and 29 cents for wages to on-site workers (earnings averaged $3.18 per hour). (See chart 2.)

Building Characteristics

The size and cost of the 46 hospital projects surveyed averaged as follows:

	Average
Floor space	56.5 thousand square feet
Cost per square foot	$25.93
Number of beds	86
Cost per bed	$16,947
Hospital construction cost	$1,463,723

The size and cost of individual hospitals, of course, varied considerably and reflected differences in design and type of construction, and metropolitan versus nonmetropolitan needs. (See table 1.) For example, included in the sample is a small, one-story, 18-bed wood frame, brick-veneered building, costing less than $100,000. It has a multi-purpose delivery-operating room, a small laboratory, including a small X-ray unit, and a waiting room. Its very low cost per square foot was $6.50, and per bed, $2,887.

4/ The annual employment estimate of construction workers is based on 50 times the 1959 average employment in contract construction work of 35.7 hours a week as reported in the Bureau's Earnings and Hours series. For other types of employment, 2,000 hours were considered a year's employment.

Chart 2. Percent Distribution of On-Site Wages and Materials Used for Each $1,000 of Hospital Construction Contract, 1959-60

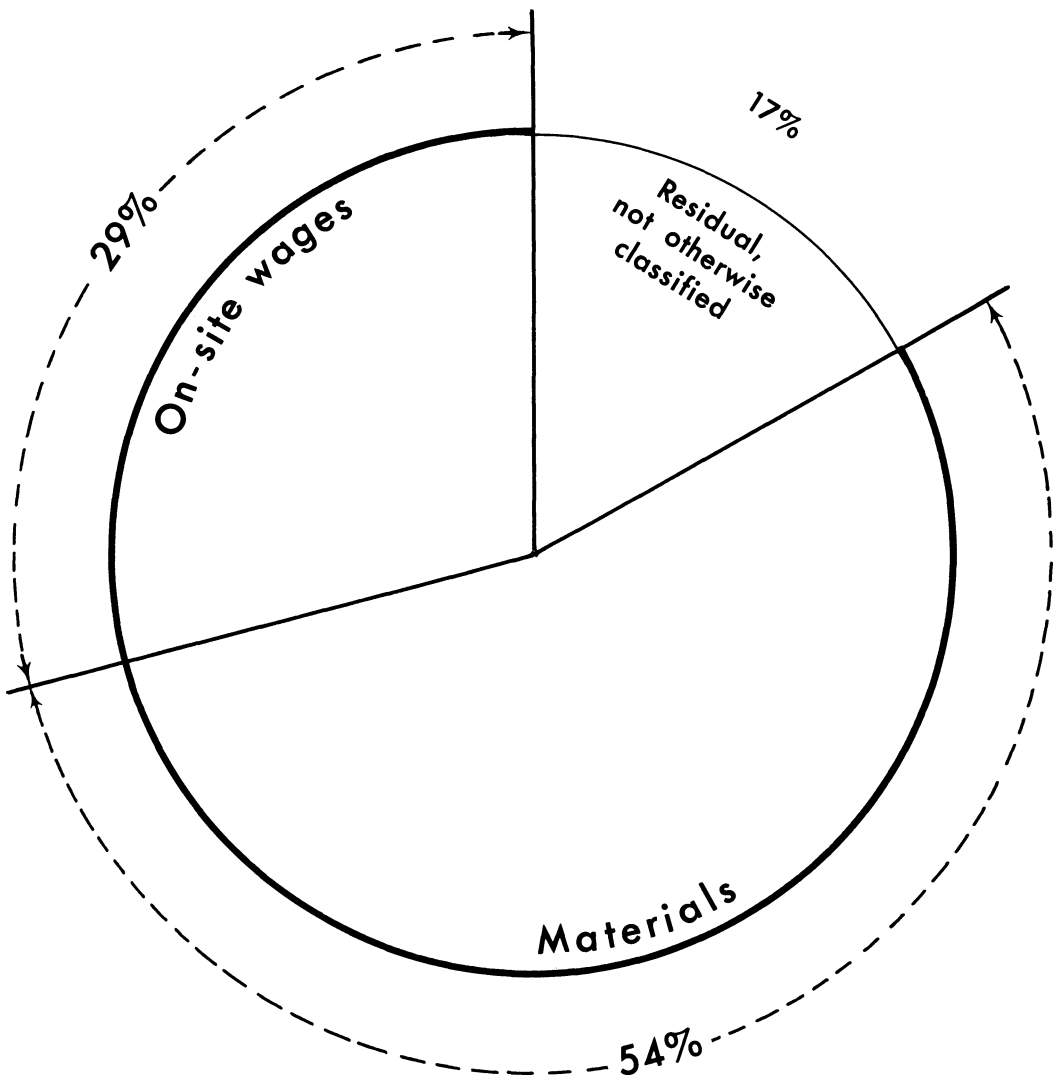


Table 1. Number and Cost of 46 Hospital Construction Projects, by Selected Characteristics and Region, 1959-60 1/

Characteristic	United States			Northeast			North Central			South			West		
	Number	Cost per--		Number	Cost per--		Number	Cost per--		Number	Cost per--		Number	Cost per--	
		Square foot	Bed (thousands)		Square foot	Bed (thousands)		Square foot	Bed (thousands)		Square foot	Bed (thousands)		Square foot	Bed (thousands)
All hospitals	46	$25.93	$16.9	6	$23.90	$11.4	16	$27.44	$19.1	16	$23.66	$16.8	8	$29.63	$19.9
New	32	25.49	17.5	3	24.13	16.1	11	25.89	15.7	13	23.53	17.7	5	30.49	20.8
Additions	14	27.00	15.7	3	23.73	9.4	5	30.17	28.2	3	24.64	12.4	3	27.70	18.1
In a metropolitan area	20	26.39	17.2	4	23.39	9.4	6	30.01	20.2	5	22.48	17.3	5	30.32	21.1
Not in a metropolitan area	26	24.91	16.4	2	24.73	17.1	10	23.37	17.1	11	26.19	16.0	3	25.79	14.6
Construction cost group:															
Under $500,000	17	22.23	12.4	1	(2/)	(2/)	6	20.53	12.3	7	22.17	12.9	3	27.93	12.5
$500,000-$999,999	9	23.05	14.5	1	(2/)	(2/)	4	23.57	16.6	4	23.44	12.0	--	--	--
$1,000,000-$1,999,999	10	24.14	17.7	2	21.69	15.9	3	24.77	22.0	2	24.05	13.1	3	25.70	21.6
$2,000,000 and over	10	27.74	18.1	2	26.60	9.5	3	31.64	21.0	3	23.88	20.2	2	31.84	20.8
Type of structural framing:															
Steel	14	28.47	15.3	3	25.57	10.1	4	27.54	15.3	4	30.22	17.4	3	30.85	21.5
Reinforced concrete	17	25.08	19.7	2	21.69	15.9	6	29.12	26.9	5	22.93	18.3	4	28.10	18.0
Load-bearing masonry	13	22.37	13.2	1	(2/)	(2/)	6	23.36	15.1	6	21.74	11.9	--	--	--
Wood	2	24.37	11.0	--	--	--	--	--	--	1	(2/)	(2/)	1	(2/)	(2/)
1 story	24	23.25	14.6	1	(2/)	(2/)	9	23.53	16.8	11	22.75	12.5	3	24.95	17.8
2-4 stories	11	26.07	20.0	3	21.39	16.2	5	28.15	26.6	1	(2/)	(2/)	2	29.64	15.3
5 or more stories	11	26.75	16.8	2	26.60	9.5	2	29.72	16.3	4	23.82	18.7	3	30.57	21.7
Elevators	29	26.30	17.5	5	24.13	11.5	12	27.78	19.6	6	23.83	18.2	6	30.15	19.8
No elevators	17	23.26	13.6	1	(2/)	(2/)	4	23.74	14.1	10	22.94	12.5	2	25.18	21.2
Air-conditioned:															
Full	28	25.58	18.2	1	(2/)	(2/)	10	28.75	20.2	15	23.67	16.9	2	27.14	18.7
Partial	13	27.29	15.0	5	24.32	10.8	4	23.63	16.6	--	--	--	4	31.34	20.2
Not air-conditioned	5	22.30	15.2	--	--	--	2	16.24	8.6	1	(2/)	(2/)	2	24.76	20.2
Full or partial basement	28	26.23	17.3	4	23.48	9.3	12	27.85	19.4	7	23.75	17.6	5	30.22	21.1
No basement	18	24.85	15.8	2	24.51	16.2	4	25.00	17.0	9	23.33	14.3	3	27.73	16.7
Exterior:															
Masonry	39	25.01	17.0	6	23.90	11.4	14	27.27	22.3	14	23.75	17.3	5	26.74	17.8
Curtain wall	5	29.46	16.7	--	--	--	2	27.88	14.0	2	21.97	10.3	1	(2/)	(2/)
Other	2	29.06	18.3	--	--	--	--	--	--	--	--	--	2	29.06	18.3

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.
2/ Insufficient coverage to warrant presentation.

Also included in the projects studied is a new, multistoried, "big city" hospital of reinforced concrete frame and masonry exterior, costing about $5 million. It is air conditioned throughout, has five elevators and more than 300 beds. It is supplied with operating rooms, delivery rooms, diagnostic and deep-therapy rooms, X-ray rooms, completely equipped laboratories, a large emergency department, and ample provisions for outpatients and physical therapy. The most modern signaling and call systems for doctors, nurses, and patients have been installed. Written communications and small packets are transmitted between hospital areas through a pneumatic airtube system, thereby reducing handling costs of paperwork, records, supplies, and medications. Kitchen and laundry facilities are in keeping with the overall demands of the hospital. There are separate nurses quarters and an individual heating plant. For this hospital, cost per square foot was $32.30 and $16,190 per bed.

Hospitals constructed in metropolitan areas--about 43 percent of the projects studied--were generally larger and more expensive in terms of total cost, cost per square foot, and cost per bed, than those built in nonmetropolitan areas. Contributing to the higher total and unit costs of large urban area hospitals is the vastly increased amount of built-in equipment unique to a hospital such as that described above. This equipment and the structural features necessary to accommodate it are included in the construction contract cost of the projects studied.

Additions were constructed at an average cost of $27 per square foot compared with $25.49 for new hospitals. This slightly higher cost appears to be attributable mainly to the added labor required to make the necessary alterations and repairs which were a part of almost all the construction contracts for additions.

Despite variations in size and location of the sample projects, there was considerable uniformity in most hospital construction features, except for structural framing. Reinforced concrete was used for framing on 37 percent of the projects, steel on 30 percent. Both types were employed in all regions and for buildings of all heights. Load-bearing masonry was used for 28 percent of the projects. Of these, all were one-story buildings except one which had two stories. The remaining projects were framed in wood.

Concerning the more uniform construction features, masonry was the principal exterior wall material in 85 percent of the hospitals, and formed some part of the outer walls in most of the other projects. Extensive use was made also of exterior trim in the form of metal (aluminum and steel), glass, and tile. Roof decks were usually of concrete (poured, mainly, with a few precast), although some gypsum and steel were used. They were invariably covered with a built-up composition surface. All floors were of concrete; most were poured, some were precast. Asphalt and vinyl tile were by far the commonest floor covering. However, terrazzo and ceramic tile were used extensively for operating, laboratory, kitchen, and lavatory areas. In the operating room suites, specially mixed cement containing some carbon black was used in conjunction with the terrazzo to provide conductive flooring. This has the effect of

making all equipment and personnel in the area nonconductive by drawing-off or "bleeding" static electricity. Most permanent interior walls were of plaster. Ceilings were either of plaster or acoustical tile. Lead-lined doors, walls and ceilings were commonly used in X-ray equipment areas as a radiation shield. Most buildings had preglazed aluminum window sashes and frames. Air conditioning, central or unit, was installed in almost all the hospitals. Elevators were provided for all buildings with more than one story above grade. All the new hospitals had fully equipped kitchens and laundries.

This construction was accomplished within the 3½-year period from the summer of 1958 to the fall of 1961. Most of the construction, however, took place during 1959-60.

On-Site Man-Hour Requirements

Average man-hours at the construction site, obtained by dividing total man-hours by total construction contract cost, numbered 88.8 per $1,000 of construction contract, for all the hospital projects.

About 54 percent of the individual projects ranged from 80 to 100 man-hours. However, the overall range was much wider, reflecting special circumstances associated with the projects which tended to increase or decrease unit labor requirements. Apart from the variation in labor requirements exhibited by a ranking of individual projects, the survey also disclosed the existence of marked differences in group averages when the data were analyzed by various criteria such as size, location, characteristics of construction, and by whether the projects represented construction of new hospitals or of additions. (See table 2.) For some of these criteria, group averages revealed that man-hour requirements per dollar paralleled requirements per square foot; in others, the measures took divergent paths. Differences in design, materials, and relative costs affect the comparisons, particularly between regions.

Construction of new hospitals generally required fewer man-hours per $1,000 than additions. The higher man-hour requirements for additions appeared to be due to some alteration work on preexisting structures as a part of the construction contract of most additions. This work, consisting largely of tearing down or breaking through wall, floor, and ceiling areas, required added labor of both skilled (carpenters, plumbers, electricians) and unskilled workers--to raze in order to rebuild. Thus, compared with new hospitals, the ratio of labor to materials costs would necessarily be higher. The extent of such work varied with the degree of accommodation necessary to merge the old and the new structures.

In some situations, the additions were used mainly to provide added bed space and nurses stations, with the changes involving only minor tearing out and rebuilding of wall areas and tying together the necessary supporting facilities (e.g., plumbing, heating, and electrical) in order to link the addition to an existing structure. In other cases, particularly among larger hospitals in metropolitan areas, the hospital authorities used the additions to house newer, more modern and efficient medical, surgical, and administrative equipment. In such instances, more extensive changes were sometimes required in the older structures to fit them into the new arrangement in which the addition became the core of the hospitals' patient servicing functions.

Analysis of the man-hour requirements for all the projects by size and location further emphasized the effect of the higher man-hour requirements per $1,000 for additions. When considered by cost class, as construction contract cost of the projects rose, man-hours per $1,000 remained relatively constant. Projects in metropolitan areas were found to use slightly more man-hours than those in nonmetropolitan areas. However, when new hospitals only were considered, (less two atypical hospital projects in the South), there emerged a

Table 2. On-Site Man-Hour Requirements for Hospital Construction Projects, by Selected Characteristics and Region, 1959-60 1/

Characteristic	United States			Northeast			North Central			South			West		
	Man-hours per--			Man-hours per--			Man-hours per--			Man-hours per--			Man-hours per--		
	$1,000 of cost	1,000 square feet	Bed	$1,000 of cost	1,000 square feet	Bed	$1,000 of cost	1,000 square feet	Bed	$1,000 of cost	1,000 square feet	Bed	$1,000 of cost	1,000 square feet	Bed
All hospitals	88.8	2,301	1,504	91.4	2,185	1,040	85.7	2,353	1,634	95.3	2,254	1,602	81.1	2,404	1,615
New	86.4	2,202	1,516	86.1	2,076	1,383	76.9	1,991	1,204	96.1	2,262	1,704	78.6	2,396	1,631
Additions	94.3	2,546	1,481	95.4	2,263	893	98.9	2,985	2,791	89.1	2,196	1,102	87.5	2,423	1,580
In a metropolitan area	89.5	2,362	1,540	94.4	2,208	883	87.3	2,621	1,764	95.6	2,149	1,654	82.6	2,505	1,740
Not in a metropolitan area .	87.1	2,169	1,426	86.8	2,146	1,487	82.5	1,928	1,409	94.7	2,480	1,513	71.4	1,841	1,046
Construction cost group:															
Under $500,000	88.6	1,969	1,098	(2/)	(2/)	(2/)	91.0	1,869	1,122	92.5	2,050	1,194	78.3	2,188	978
$500,000-$999,999	87.6	2,019	1,272	(2/)	(2/)	(2/)	79.7	1,879	1,326	91.2	2,138	1,092	--	--	--
$1,000,000-$1,999,999	90.2	2,178	1,597	87.4	1,896	1,391	82.6	2,045	1,820	104.9	2,524	1,378	87.4	2,247	1,885
$2,000,000 and over	88.5	2,455	1,602	92.3	2,454	873	87.1	2,757	1,829	94.3	2,253	1,901	78.9	2,513	1,640
Type of structural framing:															
Steel	80.6	2,295	1,232	94.1	2,407	947	74.0	2,039	1,130	84.8	2,564	1,473	75.6	2,331	1,622
Reinforced concrete	95.8	2,403	1,888	87.4	1,896	1,391	95.4	2,778	2,564	99.8	2,288	1,823	89.7	2,521	1,611
Load-bearing masonry	84.4	1,889	1,113	(2/)	(2/)	(2/)	85.2	1,990	1,289	84.3	1,833	1,005	--	--	--
Wood	74.4	1,391	816	--	--	--	--	--	--	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)
1 story	83.8	1,950	1,221	(2/)	(2/)	(2/)	82.2	1,935	1,383	91.9	2,090	1,144	67.5	1,683	1,200
2-4 stories	95.4	2,486	1,909	91.4	1,955	1,480	91.9	2,588	2,443	(2/)	(2/)	(2/)	92.5	2,741	1,415
5 or more stories	87.9	2,351	1,479	92.3	2,454	873	82.3	2,447	1,338	93.5	2,228	1,746	81.0	2,476	1,757
Elevators	89.1	2,344	1,557	91.9	2,217	1,054	85.7	2,379	1,678	95.8	2,282	1,746	82.9	2,501	1,641
No elevators	85.8	1,995	1,169	(2/)	(2/)	(2/)	86.7	2,057	1,221	93.1	2,134	1,164	62.7	1,579	1,331
Air-conditioned:															
Full	90.6	2,316	1,646	(2/)	(2/)	(2/)	85.3	2,453	1,726	95.6	2,263	1,613	82.8	2,247	1,550
Partial	84.0	2,293	1,260	92.0	2,238	990	82.4	1,947	1,367	--	--	--	78.7	2,466	1,590
Not air conditioned	95.9	2,140	1,461	--	--	--	117.6	1,909	1,016	(2/)	(2/)	(2/)	94.4	2,338	1,910
Full or partial basement ...	88.0	2,310	1,523	95.1	2,234	886	86.1	2,398	1,671	92.5	2,197	1,626	80.7	2,438	1,699
No basement	91.5	2,273	1,442	86.3	2,117	1,399	83.3	2,083	1,417	106.4	2,482	1,520	82.8	2,294	1,383
Exterior:															
Masonry	92.0	2,300	1,560	91.4	2,185	1,040	90.9	2,480	2,032	95.3	2,263	1,652	82.4	2,203	1,465
Curtain wall	76.6	2,258	1,282	--	--	--	72.8	2,030	1,016	94.3	2,071	969	(2/)	(2/)	(2/)
Other	91.1	2,647	1,664	--	--	--	--	--	--	--	--	--	91.1	2,647	1,664

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.
2/ Insufficient coverage to warrant presentation.

pattern of lower man-hour requirements for the larger projects and for those in metropolitan areas where, obviously, larger hospitals predominate. By size of hospital, the following appeared:

Construction contract cost	Man-hours per $1,000
Under $500,000	86.1
$500,000 to $999,999	83.5
$1,000,000 to $1,999,999	83.0
$2,000,000 and over	76.5

By location, the new metropolitan area hospitals required 77.0 man-hours and the nonmetropolitan, 83.1. Contributing to the lower man-hour requirements per $1,000 of the costlier, larger projects was the fact that such projects afforded maximum utilization of laborsaving equipment, such as cranes, elevators, and conveyors, and more efficient organization. These same advantages were available to contractors for the larger addition projects which also would probably have reflected the same pattern of lower man-hour requirements as project cost rose but for the additional "tearing down" hours involved in necessary changes.

Generally, for most projects, lower man-hour requirements were associated with greater than average use of skilled craftsmen. Higher proportions of laborers and helpers were usually related to higher man-hour requirements per $1,000 of contract (table 3).

Regional Group Comparisons

Man-hour requirements on the site of construction varied by region. (See table 4.) The factors previously discussed, affecting the man-hours, were also responsible, to a considerable degree, for the regional variations. Half of the projects in the Northeast were additions and, except for one small new hospital, they accounted for all the metropolitan area hospital construction in the region. This is reflected in the more-than-average man-hour requirements for the region and the substantially higher man-hours for metropolitan hospitals compared with those in nonmetropolitan areas. When only new hospitals are considered, man-hours are below the average for every region except the South. In that region, the higher requirements reflect a more frequent use of laborers and helpers. Moreover, the two atypical projects previously noted were in the upper range of man-hour requirements and substantially influenced the total man-hour requirements for the region. One of these two projects was a large nonmetropolitan hospital on which the workers received the second lowest average hourly earnings and total man-hours were the highest of all the projects studied. The other project, in an urban area, contained many expensive, custom-built features.

Table 3. On-Site Man-Hour Requirements per $1,000 of Hospital Construction Contract, by Proportion of Lower Skilled Labor Employed 1/ and Region, 1959-60 2/

Percent lower skilled workers of total	Man-hours per $1,000 of contract				
	United States	Northeast	North Central	South	West
All workers	88.8	91.4	85.7	95.3	81.1
25.0 and under	80.6	92.5	76.2	77.5	81.4
25.1-35.0	95.8	90.3	96.5	98.0	76.3
35.1 and over	111.2	--	--	111.2	--

1/ For purposes of this comparison, laborers, helpers, and tenders were considered lower skilled.

2/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.

Table 4. Distribution of Hospital Construction Projects, by Number of On-Site Man-Hours Required for Each $1,000 of Construction Contract, by Region, 1959-60 1/

Percent of man-hours required	United States	Northeast	North Central	South	West
Average man-hours for all projects	88.8	91.4	85.7	95.3	81.1
Man-hour range	Percent of projects				
Under 70.0	4.3	--	--	--	25.0
70.0-79.9	19.6	16.7	25.0	18.8	12.5
80.0-89.9	39.1	50.0	43.8	31.2	37.5
90.0-99.9	15.2	16.7	12.5	12.5	25.0
100.0-109.9	8.7	16.7	6.2	12.5	--
110.0-119.9	8.7	--	12.5	12.5	--
120.0 and over	4.4	--	--	12.5	--

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.

Labor Requirements in Earlier Periods

It would be of considerable interest to compare labor requirements on current hospital construction with those on construction in earlier periods. Unfortunately, however, only a limited amount of information is available and it cannot readily be used for comparison with current data. The two major problems are the change in cost (price) of construction and changes in physical specifications.

Changes in costs of materials and of labor, and of the relative proportions of each, affect the total price of construction. Adequate price indexes are not available for adjusting satisfactorily the dollar values of building construction costs over periods of time. However, a very rough adjustment for price change indicates that the total value of materials put in place per man-hour (in constant prices) for hospital construction has declined by approximately one-third in the past 20 years. 5/

This decrease reflects several factors. One is the efficiency resulting from increased mechanization of tools and of materials handling equipment. Another is the greatly increased amount of built-in modern hospital equipment (physiotherapy, diagnostic, etc.) owing to advances in medical techniques. This equipment substantially increases the construction contract dollar total, yet requires relatively little on-site labor for installation. Still another factor is the transfer of some operations from site to shop, as in the case of concrete batching and mixing, and some cabinetry and other carpentry work. Changes in design are also a factor. However, in some situations, design changes and other factors may have been responsible for some increase in on-site man-hours, thus nullifying part of the decrease in hours.

It is interesting to note that the decrease over the 20 years in the total value of materials put in place per man-hour appears to be about the same as that for schools and about twice as large as that for Federal buildings. 6/ Although too much significance should not be attached to the precise degree of difference, because of a lack of comparable data over the period, it does appear that the decreases in requirements for the three types of construction are in reasonable relation. For some time, rapidly expanding school population and hospital patient needs have brought extreme pressures on local communities and private groups to provide additional facilities as rapidly as possible. Architects, materials suppliers, and contractors have cooperated in providing construction using a larger amount of subassemblies and prefabricated items. No such extreme pressures on cost and speed have been exerted

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5/ Based on unpublished BLS data for public works projects built in the late 1930's.

6/ Labor Requirements for School Construction (BLS Bulletin 1299, 1961), p. 9. Labor Requirements for Federal Office Building Construction (BLS Bulletin 1331, 1962), p. 9.

on Federal office building construction. Thus, Federal buildings for the most part continue to use large areas of exterior and interior stonework and present an appearance of permanence and a somewhat monumental quality which is traditional. Most hospital and school construction, built to accommodate urgent and immediate need, is without some of these massive building features.

Requirements by Occupation

Distribution of man-hour employment by broad skill areas disclosed that 68 percent of the total on-site man-hours were worked by those in the skilled trades. Semiskilled and unskilled workers accounted for 28 percent of the hours, and nonproduction employees (supervisors, engineers, and clerks), 4 percent (table 5).

Within the skilled trades, the workers in three predominant crafts--plumbers, carpenters, and electricians--accounted for 54 percent of all skilled man-hours. Plumbers worked 21 percent of the skilled hours and 14 percent of total on-site hours. Carpenters were next in occupational importance with a little more than 19 percent of the skilled hours; electricians followed with 13 percent. Although there were variations among projects in the proportion of hours worked by each of these crafts, as well as the others, there were relatively few exceptions in the order of skilled craft importance.

The lead position of plumbers reflects the extensive work required in hospitals to provide for general sanitation and nursing needs, laboratory and therapy installations, and adequate patient lavatory and toilet facilities. The proportion of electricians' hours also attests to the broad application of electrical usages in connection with proper lighting, surgical and medical equipment, calling and signaling systems, and control systems.

Variations from region to region in ratios of man-hours worked by different trades reflect, for example, differences in regional design and construction needs, as well as work practices. In the West, for instance, plumbers and carpenters each worked 17 percent of total on-site man-hours. This equal sharing of on-site time appears to reflect added carpenter hours owing to greater-than-average use of wood products in the West. In the Northeast, where carpenter hours were also about the same as those of plumbers, the higher proportion of construction cost devoted to additions (including the related changes to existing buildings) may be responsible for the use of more carpenters. This also appears to account for the fact that a higher proportion of electricians were employed in the Northeast than elsewhere.

In the matter of work practices, a number of factors affect the regional distribution by occupation, apart from the construction requirements. For example, organization of work crews and job classification may be affected by the relative participation of local unions. Local custom influences the

Table 5. On-Site Man-Hour Requirements per $1,000 of Hospital Construction Contract, by Occupation and Region, 1959-60 1/

Occupation	United States		Northeast		North Central		South		West	
	Man-hours worked	Percent	Man-hours worked	Percent	Man-hours worked	Percent	Man-hours worked	Percent	Man-hours worked	Percent
All occupations	88.8	100.0	91.4	100.0	85.7	100.0	95.3	100.0	81.1	100.0
General supervisors	2.8	3.1	2.8	3.0	3.0	3.5	3.1	3.2	1.9	2.3
Professional, technical, and clerical	.7	.8	1.3	1.4	.3	.4	1.1	1.2	.3	.4
Plumbers	12.7	14.3	12.4	13.5	12.7	14.8	12.0	12.6	14.1	17.4
Carpenters	11.7	13.2	12.7	13.9	9.9	11.6	11.4	12.0	14.0	17.3
Electricians	7.8	8.8	11.1	12.1	7.4	8.7	7.2	7.5	7.5	9.2
Bricklayers	4.8	5.4	5.9	6.4	5.5	6.4	5.8	6.1	1.4	1.8
Sheet-metal workers	4.3	4.8	1.9	2.1	4.6	5.4	3.8	4.0	5.9	7.3
Ironworkers	3.1	3.5	3.9	4.3	2.7	3.1	3.1	3.3	3.2	3.9
Ornamental	.6	.7	.7	.7	.6	.7	.4	.5	.8	1.0
Reinforcing	1.4	1.6	1.7	1.8	1.1	1.3	1.5	1.6	1.4	1.8
Structural	1.1	1.3	1.6	1.7	1.0	1.2	1.2	1.2	.9	1.1
Plasterers	2.9	3.2	3.4	3.7	2.4	2.7	3.0	3.1	3.1	3.8
Lathers	2.7	3.0	3.3	3.6	2.2	2.5	2.3	2.4	3.7	4.6
Painters	2.5	2.8	2.3	2.5	2.6	3.0	2.5	2.6	2.3	2.9
Asbestos workers	1.5	1.7	1.1	1.2	1.7	2.0	1.7	1.7	1.2	1.5
Operating engineers	1.4	1.6	1.4	1.5	1.1	1.3	1.7	1.8	1.2	1.4
Terrazzo workers and tile setters	1.4	1.6	1.1	1.2	1.8	2.1	1.2	1.3	1.3	1.6
Cement finishers	1.3	1.5	1.4	1.5	1.0	1.2	1.3	1.3	1.8	2.2
Roofers	.6	.7	.6	.6	.5	.6	.7	.7	.5	.7
Elevator mechanics	.6	.7	.7	.8	.6	.7	.6	.6	.8	.9
Glaziers	.5	.6	.4	.5	.6	.7	.6	.6	.3	.4
Soft floor layers	.4	.4	.7	.7	.3	.4	.1	.1	.7	.8
Laborers	17.4	19.6	18.8	20.5	16.6	19.4	21.8	22.9	10.6	13.0
Helpers and tenders	6.3	7.1	3.7	4.1	6.1	7.2	8.6	9.1	4.5	5.6
Truckdrivers	.6	.7	.5	.5	.9	1.1	.6	.6	.5	.6
Watchmen	.3	.4	.2	.2	.1	.1	.8	.8	--	--
Other	.5	.6	.1	.1	1.0	1.1	.4	.4	.4	.4

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.

NOTE: Because of rounding, sums of individual items may not add to totals.

opportunity of union membership and journeyman jobs for minority groups 7/. Finally, local availability of lower-paid labor may affect the extent to which laborsaving equipment is employed.

These factors particularly influence the division between skilled and unskilled workers. In the South, unskilled and semiskilled employees accounted for 34 percent of total man-hours, compared with 20 percent in the West; the percentages for skilled trades were 62 and 78 percent, respectively.

The persistence in all regions of a relatively large proportion of man-hours by lesser skilled workers is noteworthy, particularly in view of the complexity of hospital construction. Approximately 28 percent of all on-site employment was by unskilled and semiskilled employees, despite considerable mechanization in materials handling, excavating, cleaning, and similar jobs formerly performed almost exclusively by laborers. This suggests that the nature of construction operations may limit the degree of mechanization that can profitably be used.

Apprentices. Apprentices in formal, registered apprenticeship programs accounted for 5.3 percent of all man-hours worked at the site of the sample projects, or 8.1 percent of skilled-trade man-hours (table 6). Apprentice electricians accounted for 18 percent of the total hours worked in their craft, a greater proportion than in any other trade. For three trades--asbestos workers, elevator mechanics, operating engineers--which reported no apprentices, formal programs do not exist or are just evolving. Training is usually acquired on an informal basis by assisting a journeyman in his work until the trainee is regarded as fully qualified to perform at the journeyman level. In some instances, fixed time periods at the job before becoming eligible for upgrading have been informally established through local work practices. Workers in a learning status, whether called "improvers" in the case of asbestos work, "helpers" in elevator work, or "oilers" in equipment operation, are grouped with Helpers and tenders in this report. High rates of apprentice employment are generally associated with shortages of skilled journeymen in the craft, or with some smaller crafts.

General and Special Trade Contractors' Shares

Employees of the general contractors and three special trade contractors, Plumbing and heating, Electrical, and Plastering and lathing, accounted for 79 percent of the total man-hours required for the construction of all the hospital projects. (See table 7.) The general contractors' share, averaging 39.1 percent of all the projects, was highest in the South (42.0). There, a preponderance of smaller hospital projects resulted in the general contractors' assumption of some of the special trade duties because the amount of work requiring certain special trade workers was insufficient to warrant use of a separate subcontractor.

7/ Employment Outlook in the Building Trades (BLS Bulletin 967, 1949).

Table 6. Apprentices as Percent of On-Site Employment on Hospital Construction Projects, by Occupation and Region, 1959-60 1/

Occupation	United States	North-east	North Central	South	West
	Percent of apprentices				
All workers	5.3	4.2	6.0	5.1	5.3
Skilled trades only	8.1	6.1	9.0	8.2	7.4
Bricklayers	7.4	4.4	8.5	7.9	1.4
Carpenters	4.2	3.2	6.8	2.6	4.7
Cement finishers	5.0	12.2	2.7	4.9	.2
Electricians	18.2	12.2	11.2	27.2	20.9
Glaziers	7.8	2.8	2.4	12.0	23.6
Ironworkers	2.7	.5	4.5	1.9	5.2
Ornamental	4.2	2.7	9.2	—	--
Reinforcing	2.1	--	.9	2.5	8.6
Structural	2.7	--	5.6	1.8	--
Lathers	10.6	8.1	7.4	12.4	17.7
Painters	4.9	--	5.4	5.8	6.0
Plasterers	4.6	(2/)	9.4	3.2	2.5
Plumbers	10.1	9.9	11.9	9.5	5.4
Roofers	7.4	--	13.0	6.7	3.4
Sheet-metal workers	11.2	1.2	18.5	6.2	7.5
Soft floor layers	6.0	3.1	10.1	--	3.1
Terrazzo workers and tile setters	4.2	8.7	3.6	2.7	11.0

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.

2/ Less than 0.05 percent.

Table 7. Percent of Total On-Site Man-Hour Requirements for Hospital Construction, by Type of Contractor and Region, 1959-60 1/

Type of contractor 2/	United States	North-east	North Central	South	West
All types	100.0	100.0	100.0	100.0	100.0
General	39.1	35.9	37.4	42.0	34.7
Plumbing and heating	22.1	16.8	23.7	22.2	23.4
Electrical	9.2	14.2	8.8	8.0	8.6
Plastering and lathing	8.1	9.8	7.2	8.1	9.2
Masonry	4.1	7.4	3.7	3.3	5.3
Tile and terrazzo work	4.0	3.3	5.1	3.6	2.3
Structural and ornamental metal	2.7	3.2	3.1	2.4	1.8
Painting	2.5	2.5	2.5	2.5	2.9
Roofing and sheet metal	1.3	.6	1.5	1.2	2.5
Site preparation and excavation	.8	1.3	.5	1.0	.8
All other types	6.0	4.9	6.5	5.6	8.5

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.
2/ Based on data from federally aided hospital projects only.

NOTE: Because of rounding, sum of individual items may not equal 100.

Table 8. Average Number of Contractors per Hospital Construction Project, by Cost Group and Region, 1959-60 1/

Cost group	United States	North-east	North Central	South	West
All groups	26	27	25	23	35
Under $500,000	17	(2/)	19	14	20
$500,000-$999,999	21	(2/)	22	22	—
$1,000,000-$1,999,999	31	26	25	24	46
$2,000,000 and over	41	34	43	42	42

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.
2/ Insufficient coverage to warrant presentation.

Plumbing and heating and Electrical contractors together accounted for 31.3 percent of the total man-hour requirements nationally. This percentage varied but slightly among the four regions, including the South, reflecting the relatively heavy requirements for these services in the construction of hospital facilities. Plastering and lathing contractors accounted for 8.1 percent of the total man-hour requirements nationally and this was close to the percentage among the various regions, evidencing the almost universal use of plaster for interior walls as well as its substantial use for ceilings in the sample projects.

The average number of prime and subcontractors on each project was 26. (See table 8.) However, this number varied considerably with size of project, because the larger and more costly ones required a higher degree of contractor specialization.

The Cost of Direct Wages 8/

Wage payments to on-site labor averaged 28.8 percent of the total contract amount for the 36 hospitals, (new construction and additions, combined), for which such data were available. (See table 9.) New construction averaged 27.8 percent for wages; additions averaged 31.6 percent. The percentages reflect the combined effect of man-hour requirements and wage rates for individual projects.

Higher-than-average hourly earnings were generally accompanied by above average wages as a percent of contract amount, where s man-hours remained relatively constant. However, for new hospitals only, higher-than-average hourly earnings among the projects were partially offset by lower man-hour requirements.

Variations in average hourly earnings probably reflect the distribution of work between metropolitan and nonmetropolitan areas more than any other single factor. Usually, wage rates tend to be higher in metropolitan areas than in less densely populated areas in the same region. Among other things, this appears to account for the fact that multistory buildings, buildings with several elevators, and in general, costlier projects, are associated with higher average hourly earnings, since these projects are usually in the larger urban centers.

8/ For this study, as in prior publications in this series, "direct wages" include pay for all hours worked, including premium overtime pay. Excluded are vacation and holiday pay or other labor costs, such as employer contributions to social security, insurance, and welfare, and pension funds.

Table 9. Average On-Site Hourly Earnings on Hospital Construction Projects, by Selected Characteristics and Region 1/, 1959-60 2/

Characteristic	United States		Northeast		North Central		South		West	
	Average hourly wage	Wages as percent of contract	Average hourly wage	Wages as percent of contract	Average hourly wage	Wages as percent of contract	Average hourly wage	Wages as percent of contract	Average hourly wage	Wages as percent of contract
All hospitals	$3.18	28.8	$3.43	31.9	$3.30	28.1	$2.94	28.2	$3.72	30.3
New	3.15	27.8	3.31	28.7	3.29	25.3	2.96	28.7	3.79	30.8
Additions	3.26	31.6	3.54	35.1	3.31	33.1	2.75	24.5	(3/)	(3/)
In a metropolitan area	3.31	30.6	3.54	35.1	3.33	28.8	3.17	30.5	3.85	35.1
Not in a metropolitan area	2.94	25.6	3.31	28.7	3.22	26.3	2.51	23.9	3.55	25.3
Construction cost group:										
Under $500,000	2.92	25.5	--	--	2.98	25.7	2.66	24.8	3.40	26.6
$500,000-$999,999	2.91	25.9	(3/)	(3/)	3.31	26.4	2.28	22.2	--	--
$1,000,000-$1,999,999	3.11	28.0	(3/)	(3/)	3.37	27.3	2.34	24.5	3.85	31.9
$2,000,000 and over	3.28	30.0	3.51	32.4	3.32	29.0	3.19	30.0	--	--
Type of structural framing:										
Steel	3.20	26.2	3.44	32.4	3.05	22.6	2.95	25.0	3.66	24.8
Reinforced concrete	3.14	30.6	(3/)	(3/)	3.30	31.6	2.97	29.6	3.76	34.8
Load-bearing masonry	3.35	28.9	--	--	3.78	32.2	2.65	23.2	--	--
Wood	(3/)	(3/)	--	--	--	--	--	--	(3/)	(3/)
1 story	2.94	24.8	--	--	3.13	25.7	2.49	23.6	3.66	24.7
2-4 stories	3.11	30.1	3.24	30.7	3.24	29.6	(3/)	(3/)	3.76	34.8
5 or more stories	3.29	29.7	3.51	32.4	3.44	28.3	3.16	29.6	--	--
Elevators	3.23	29.4	3.43	31.9	3.32	28.2	3.03	29.0	3.71	33.7
No elevators	2.76	24.0	--	--	3.01	26.1	2.41	23.3	3.75	23.5
Air-conditioned:										
Full	3.14	28.6	(3/)	(3/)	3.30	28.1	2.95	28.4	3.85	31.9
Partial	3.41	30.4	3.44	32.4	3.30	27.2	--	--	3.50	26.4
Not air-conditioned	2.84	24.7	--	--	(3/)	(3/)	(3/)	(3/)	(3/)	(3/)
Full or partial basement	3.25	29.2	3.50	33.6	3.29	28.1	3.13	29.2	3.50	26.4
No basement	2.97	27.4	(3/)	(3/)	3.32	27.6	2.20	23.8	3.80	31.2
Exterior:										
Masonry	3.17	29.3	3.43	31.9	3.32	30.0	2.97	28.4	3.55	25.3
Curtain wall	3.05	23.3	--	--	3.24	23.6	(3/)	(3/)	--	--
Other	3.85	35.1	--	--	--	--	--	--	3.85	35.1

1/ Based on federally aided projects only.
2/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.
3/ Insufficient coverage to warrant presentation.

Some of the hospital projects differed substantially in the ratio of wages to total construction. Aside from the extent of alteration work which generally accompanied construction of additions, there were special conditions involved such as site problems, or unusual labor arrangements such as travel time included at regular hourly rates. The range of wages as a percent of contract for which a distribution of hospital projects could be made (36 hospitals) was as follows:

Percent wages were of contract cost	Percent of hospitals studied
Under 20.0	5.6
20.1-22.5	11.1
22.6-25.0	22.2
25.1-27.5	19.4
27.6-30.0	19.4
30.1-32.5	5.6
32.6 and over	16.7

Off-Site Employment

For each man-hour of employment performed on the construction sites, an additional 1.5 man-hours of work were required to produce and distribute the necessary construction materials, supplies, and equipment used in construction of general hospitals. These projects, thus, gave rise to 134 man-hours of such employment per $1,000 of contract, compared with 89 hours on-site.

Off-site employment is generated in many places, but can be classified in the following categories:

1. Construction industry--off-site: administrative, estimating, and warehousing functions.

2. Manufacturing activities producing fabricated and raw materials and equipment.

3. Transportation, warehousing, and distribution of fabricated and raw materials and equipment.

4. All other industries directly or indirectly affected by the production of fabricated and raw materials. Various interindustry transactions eventually affect all additional industries such as agriculture, forestry, and mining.

There are, of course, other people affected in types of employment which this study did not attempt to cover. Some of these are mentioned on page 2. Of the workers omitted, the most numerically important groups, who would be directly affected by a hospital construction program, were employees in architectural firms, utility companies, and State and local governments. These employees and their functions were not included in the construction contract cost. A large area of employment also excluded from the calculations of man-hour effects, as mentioned earlier, is that created by the respending and investing of wages and profits arising in various areas of economic activity within the scope of this study.

Although the ratio of on-site to off-site employment requirements is commonly used in analyzing employment requirements in the construction industry, another type of distinction based upon the economic relations of the labor-generating areas is also useful. Therefore, employment requirements have also been divided into primary and secondary man-hour needs. As shown in the following tabulation and chart 1, the primary man-hour requirements, estimated at 162, arise in the activities at the site and those most directly related to the construction activity. Included in these, in addition to site employment, are off-site construction employment, employees of manufacturing industries represented at the "last stage of manufacturing" for materials prior to shipment to the site, and employees in transportation, trade, and service organizations dealing in materials used at the site.

Secondary man-hour requirements have been defined as those associated with all other requirements indirectly related to the needs at the site. Such activities totaling 61 hours or 27 percent of total man-hour requirements affect all parts of the economy as the impact of primary activity is reflected in demand for basic materials and related transportation, trade, and services. 9/ The following tabulation shows man-hours of employment associated with $1,000 of hospital construction.

	Total	Primary activities	Secondary activities
All industry groups	223	162	61
Construction	100	100	--
On-site	89	89	--
Off-site	11	11	--
Manufacturing	79	44	35
Transportation	9	5	4
Trade and service	22	13	9
Other	13	--	13

Some industries are represented in both the primary and secondary sectors. For example, the sand and gravel industry furnishes material directly to the construction industry and also to the ready-mix concrete industry which in turn sells to the construction industry.

Builders' Off-Site Employment

An exact study of off-site employment of contractors was not attempted, since it was almost impossible to relate accurately such employment to the projects being studied. Builders' off-site employment was occupied not only with the projects studied but also with other current or future projects of the builders.

The estimate of 11 man-hours of such work for each $1,000 of contract is based on the difference between construction worker employment and total employment in the contract construction industry. 10/ This estimate also includes self-employed craftsmen who may have worked at the site.

9/ Secondary man-hours were estimated on the basis of a study made by the Bureau of 1947 interindustry relationships. See W. Duane Evans and Marvin Hoffenberg, Interindustry Relations Study for 1947, Review of Economics and Statistics, Vol. XXXIV (1952), Cambridge, Mass. For methods employed, see appendix A.

10/ Administrative, engineering, estimating, and clerical workers accounted for about 14 percent of total employment in the construction industry. About one-fourth of this employment was involved at the site.

Combining this employment with on-site employment results in an estimate of 100 hours of employment in the construction industry for each $1,000 of general hospital construction.

Employment in Transportation, Trade, and Service

Distribution of construction materials from the producing industries requires employment of workers in the transportation, warehousing, and trade industries. The estimate of 18 hours of primary employment per $1,000 of contract is based on the difference between producer's value and delivered value of materials used at the site. This estimate covers only the distribution of materials from the producers to construction site and does not include the distribution of materials among industries prior to shipment of the completed products.

"Last Manufacturing Stage" Employment

The sector of the economy most affected by hospital construction, other than the construction industry, is manufacturing. An estimated 44 man-hours were required for each $1,000 of total contract for production of the construction materials used in the building of hospitals. This estimate, however, includes only employment required in the last manufacturing process of the materials. 11/ Employment generated by this activity is distributed in many industries directly affected by construction activity. For example, it includes sawmills cutting rough lumber for forms, and establishments making millwork items from lumber, but does not include employment in sawmills producing lumber for millwork products. The latter is included in the estimate of secondary employment discussed below.

Employment in Secondary Activities

In addition to the 44 man-hours previously noted for primary employment for each $1,000 of hospital construction contract in the factories making construction materials, an additional 35 hours were required in secondary manufacturing activities.

Transportation industries required 4 hours of employment to transport the materials to and from the industries indirectly affected.

Trade and service industries as a group required 9 hours of employment for each $1,000 of hospital construction to meet the needs of secondary business activity.

Other business activities, primarily agriculture, forestry, and mining, accounted for the remaining 13 hours of secondary man-power requirements.

11/ Included in the bill of materials were the supplies and the expended value of the equipment used by construction contractors.

Construction Time

Average construction time required for the projects surveyed was approximately a year and a half. (See table 10.) The construction period varied on individual projects, however, from 21 weeks on the smallest to 151 weeks on one of the largest.

Significant differences existed not only by size of project but also by region, due to the influence of climatic conditions. In the Northeast and North Central regions, more-than-average construction time was required, in contrast with the West and South, where less-than-average time was used. In fact, in the South, where construction is usually a year-round industry, construction time for comparable projects was consistently below average.

Employment by Construction Periods

Construction time for each hospital was divided into 10 equal parts. For example, a hospital which took 15 months to complete was studied in ten 1.5 month periods. This permitted the combination of projects of various sizes to obtain a typical employment pattern. Thus, the percent of total man-hours, for all the hospitals by decile, were as follows:

1st	3.8	6th	13.9
2d	8.4	7th	13.0
3d	11.9	8th	10.5
4th	13.4	9th	7.1
5th	14.3	10th	3.7

Generally, employment started slowly, built up to a peak in the fifth period, and dropped off sharply in the last two. Seventy-seven percent of the on-site employment occurred in the third through the eighth periods, that is, in the middle 60 percent of the elapsed time. Employment accounted for about 4 percent of the total man-hours in both the first and the last periods. (See chart 3.)

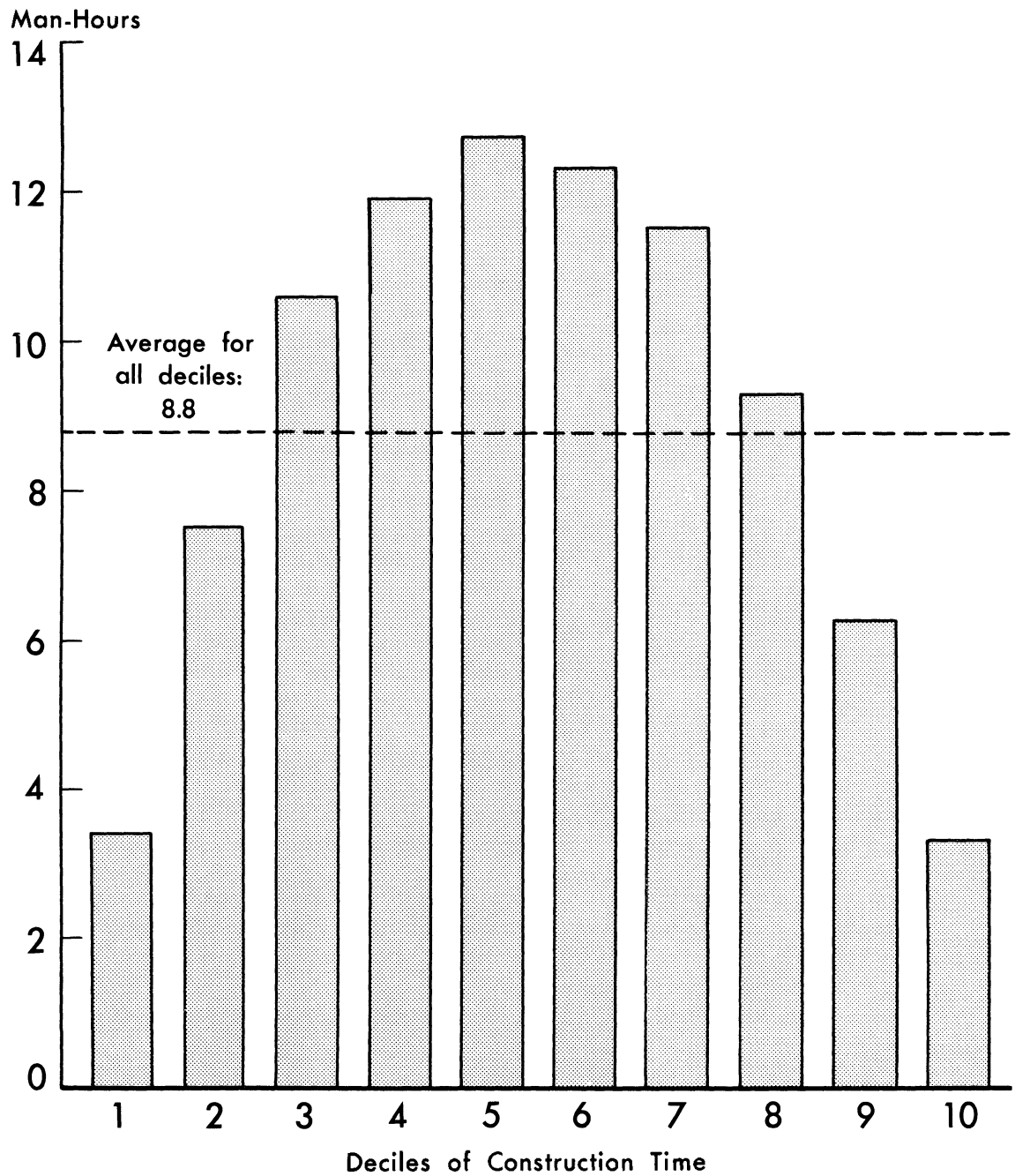
Table 10. Average Number of Weeks Required for Construction of Hospitals, by Cost Group and Region, 1959-60 1/

Cost group	United States	Northeast	North Central	South	West
All groups	77	90	81	68	74
Under $500,000	53	(2/)	66	50	45
$500,000-$999,999	69	(2/)	70	62	--
$1,000,000-$1,999,999	79	82	81	80	76
$2,000,000 and over	118	125	126	109	114

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.

2/ Insufficient coverage to warrant presentation.

Chart 3. On-Site Man-Hours of Construction Labor for Each $1,000 of Hospital Construction Contract By Decile of Construction Time



Materials Used

Costs of materials represented 54.4 percent of total contract value of all projects. For new hospital projects only, the average materials value was 55.7 percent, and for additions projects the average was 51.3 percent. These totals include depreciation charges or rental costs for construction equipment used and costs of the small amounts of supplies consumed, in addition to the materials or fixed equipment incorporated in the structures. Although the lower materials value of the additions projects may reflect some reduced materials requirements for a few operations, it appears primarily to be due to the higher percentage of total contract amount paid to on-site labor as a result of alteration and repair work on such projects. The majority of all the projects were within 5 percent of the overall average for materials costs:

Percent materials cost of total contract amount	Percent of projects
45-49	22
50-54	26
55-59	28
60-64	20
65 and over	4

The difference between the total construction contract value and the sum of materials and wage costs amounted to 16.8 percent of the cost of all the projects. This represented the total of those overhead costs which cannot be attributed to specific projects, such as administrative off-site salaries, expenses of central office and yard operation, insurance and taxes, plus other overhead, and profit. These two components (overhead costs and profit) could not be separated in this survey.

Table 11 presents the costs of major materials and groups of materials used in each $1,000 of construction for all the hospital projects, and also shows these cost breakdowns for new projects and for additions. The groups, and the items within the groups are ranked by amounts spent for the products, on all projects. Although the table presents the costs of materials in terms of their dollar value, the individual items may be readily reduced to the familiar magnitudes of percentages. Thus, the sum of $543.80 shown for "All hospital projects" under "All products" would be 54.4 percent.

The proportion of total materials costs per $1,000 of contract amount for new hospital projects was somewhat higher than that for additions. However, analysis of the relative materials costs by each of the major materials groups for all of the projects, and separately, for new projects and additions, indicated fairly constant relationships between and within each of the construction categories.

Table 11. Total Cost of Material Components for Each $1,000 of Hospital Construction Contract, 1959-60 1/

Selected products and product groups	All hospital projects	New hospital projects	Hospital addition projects
All products	$543.80	$556.70	$512.80
Metal products (except plumbing and heating)	145.90	150.00	136.10
Fabricated structural metal products	97.20	102.50	84.70
Reinforcing bars and joists	36.50	38.80	31.00
Structural steel	21.50	23.60	16.20
Fabricated sheet-metal	14.60	15.30	13.10
Metal windows	12.20	12.00	12.50
Metal doors	7.80	8.00	7.40
Ornamental metal	3.90	4.20	3.30
Other	.80	.70	1.10
Other fabricated metal products	10.90	10.30	12.60
Builder's hardware	10.60	9.90	12.10
Other	.40	.30	.40
Other metal products	37.70	37.30	38.80
Metal casework	13.60	13.80	13.10
Copper products	8.30	8.40	8.30
Galvanized sheet-metal	4.90	4.10	6.80
Partitions, lockers, and shelves	3.80	3.40	4.70
Other	7.10	7.60	6.00
Stone, clay, and glass products	105.50	103.60	110.00
Cement, concrete, and gypsum products	51.60	51.80	51.30
Ready-mix concrete	27.60	26.00	31.50
Gypsum products	8.80	8.50	9.50

See footnote at end of table.

Table 11. Total Cost of Material Components for Each $1,000 of Hospital Construction Contract, 1959-60 1/--Continued

Selected products and product groups	All hospital projects	New hospital projects	Hospital addition projects
Cement, concrete, and gypsum products--Continued			
Concrete block	$6.30	$7.10	$4.30
Cement	3.80	3.70	4.00
Precast concrete products	3.50	4.60	.70
Concrete pipe	.70	.90	.20
Other	1.00	1.00	1.00
Structural clay products	21.70	19.50	27.20
Brick and structural tile	12.10	10.40	16.30
Ceramic tile	8.10	7.20	10.20
Other	1.60	1.90	.70
Other stone, clay, and glass products	32.10	32.40	31.60
Fiber glass products	9.70	9.60	10.00
Cut stone	6.40	6.60	5.90
Vinyl tile (including vinyl-asbestos)	5.50	5.10	6.60
Window glass	3.30	3.10	3.60
Sand and gravel	2.30	2.10	2.90
Asphalt tile	1.50	1.90	.70
Other	3.40	4.10	1.90
Fixed hospital equipment	77.70	81.20	69.20
Elevators	22.50	19.80	29.00
X-ray and related equipment	12.80	15.10	7.30
Sterilizers and autoclaves	12.20	13.20	9.70
Kitchen equipment	7.20	9.70	1.00
Refrigerators	6.70	6.50	7.20
Laundry equipment	4.90	5.00	4.60
Ranges	3.40	3.70	2.80

See footnote at end of table.

Table 11. Total Cost of Material Components for Each $1,000 of Hospital Construction Contract, 1959-60 1/--Continued

Selected products and product groups	All hospital projects	New hospital projects	Hospital addition projects
Fixed hospital equipment--Continued			
Laboratory equipment	$2.90	$2.70	$3.30
Compressed air and oxygen systems	2.50	2.80	1.60
Other	2.60	2.60	2.70
Electrical equipment, fixtures, and wire	65.30	68.20	58.50
Lighting fixtures	15.40	15.90	14.20
Noncurrent-carrying devices	10.80	10.90	10.70
Switchboards and panelboards	10.70	11.40	9.10
Intercom and fire alarm system	6.00	5.70	6.70
Electric generating units	5.80	6.50	4.20
Wire and cable	5.10	5.30	4.90
Transformers	3.20	3.80	1.80
Program systems	1.90	2.70	.10
Other	6.40	6.10	6.90
Heating, ventilating, and air-conditioning equipment	53.80	57.90	44.10
Radiators, convectors, and boilers	14.90	16.30	11.70
Air-conditioning equipment	14.60	16.30	10.40
Temperature controls	10.30	11.30	8.00
Blowers, exhaust, and fans	4.80	4.50	5.60
Unit heaters and ventilators	2.40	2.70	1.40
Warm air furnace	.10	.10	.10
Other	6.80	6.70	7.00
Plumbing products	47.00	46.90	47.10
Plumbing fixtures	15.50	16.20	14.00
Steel and galvanized pipe	14.50	13.10	18.00
Valves and specialties	10.00	10.00	10.20

See footnote at end of table.

Table 11. Total Cost of Material Components for Each $1,000 of Hospital Construction Contract, 1959-60 1/--Continued

Selected products and product groups	All hospital projects	New hospital projects	Hospital addition projects
Plumbing products--Continued			
Cast iron pipe	$5.80	$6.50	$4.10
Other	1.10	1.20	.90
Lumber and lumber products	22.60	21.10	26.40
Millwork	16.20	14.70	19.70
Rough and dressed lumber	5.40	5.10	6.10
Other	1.00	1.30	.50
Petroleum products	5.30	5.90	4.00
Asphalt paving	1.40	1.90	.40
Asphalt and tar pitches	1.30	1.30	1.20
Asphalt felts	1.00	.90	1.00
Other	1.70	1.80	1.30
Paint and other chemical compounds	4.40	4.50	4.00
Paint	2.50	2.60	2.40
Other	1.90	2.00	1.60
All other	16.30	17.40	13.60
Construction equipment	11.20	11.90	9.50
Insulating board	.50	--	.30
Other	4.60	4.90	3.80

1/ Although construction of projects studied extended over a 3½-year period, most of the construction took place in 1959-60.

NOTE: Group totals include products not shown separately. Because of rounding, sums of components may not equal totals.

The most important broad materials category, "Metal products (except plumbing and heating)," accounted for almost 15 percent of the total construction contract amount of all the projects studied. 12/ The items used in structural framing--"Reinforcing bars and joists," and "Structural steel"--made up about two-fifths of the "Metal products" group, and metal doors and windows, about one-seventh. This group does not represent the total contribution of the metalworking industries, since it excludes the metal products shown separately in the equipment categories.

By far the largest single item among "Stone, clay, and glass products" was ready-mixed concrete, which at 2.8 percent, accounted for more than one-quarter of the value of the group. This material constituted the frames of more than one-third of the projects, and the floors and roof decks of most of them. The small amounts of the raw materials of concrete separately shown--cement, sand, and gravel--were used in specialized applications such as terrazzo work.

"Fixed hospital equipment," the third most important broad materials category, accounted for almost 8 percent of the total contract cost of all the hospital projects. Elevators accounted for more than one-quarter of the value of this group. The "X-ray" and "Sterilizers and autoclaves" items together made up almost one-third. For additions alone, these latter two items were considerably below the percentage shown for all projects and the somewhat higher percentage shown for new hospitals. This reflected, in part, some additions in which this type of equipment was not required because the existing structures were adequately equipped with them. This was also true with regard to "Kitchen equipment."

"Electrical equipment, fixtures, and wire" amounted to 6.5 percent of the total cost of all the projects.

The proportion, 5.4 percent, shown for the group "Heating, ventilating, and air-conditioning equipment" completely covers equipment requirements for this type of work. The extensive duct materials needed for air exchange throughout a building are included in "Fabricated sheet-metal products" or in "Galvanized sheet-metal" under the "Other metal products" group.

Other major materials groups were "Plumbing products," representing 4.7 percent of total projects cost, and "Lumber products," 2.3 percent. "Millwork" accounted for almost three-quarters of the total cost of the latter group and included wood casework. The largest amount of lumber products was used in the West.

12/ Each "percent of construction contract" represents about $11.6 million of annual expenditures at the current (1961) annual rate of all hospital and related medical facilities construction (e.g., $169.4 million of metal products is represented by the 14.6 percent).

Changes in Materials

A comparison of construction costs in the present study with those in the study made about 20 years ago indicates that the proportion that materials represent of total construction cost has changed only moderately between the two periods, increasing from 50 percent to 54 percent. However, the proportions that individual materials represent shows some very marked changes, reflecting different materials usages for similar purposes, changing standards and requirements, and different price movements. The following tabulation presents some of these changes for a number of groups of materials. Data from the current survey are shown for all projects studied. Although little is known of the characteristics of the projects in the older survey, it is believed that they were relatively comparable with those in the current study as they included only new construction, presumably, of new hospitals and additions.

Materials group 1/	Percent of total materials cost	
	20 years ago	Current study
All materials	100.0	100.0
Iron and steel and their products	36.0	44.3
Structural steel	6.5	4.0
Reinforcing steel	3.5	6.9
Plumbing supplies and fixtures	8.2	8.8
Heating and ventilating equipment	10.1	10.2
Hardware, miscellaneous	2.4	2.0
Metal doors, windows, shutters, and trim	2.5	3.8
Wire and wire works products	.4	.1
Other iron and steel products	2.4	8.5
Stone, clay, and glass products	32.5	18.2
Cement	7.5	.7
Brick, hollow tile, and other clay products	9.5	2.6
Sand, gravel, and crushed stone	5.0	.7
Marble, granite, slate, and other stone products	2.2	1.2
Concrete and concrete products	3.6	7.1
Wall plaster and wall board	1.5	1.7
Tiling, floor and wall, and terrazzo	2.4	1.7
Glass	.8	2.5
Forest products	15.5	4.4
Electrical wiring, fixtures, and supplies	5.4	11.2
Roofing, insulation, and waterproofing	2.7	.6
Paints, varnishes, and other chemicals	1.1	.5
Sheet metal	.9	2.3
All other materials	5.9	18.6

1/ Products were grouped to conform with the previous study.

Note: Because of rounding, group totals may not add to 100.

These comparisons illustrate some basic shifts over the years. Additional new fixed equipment has had the effect of reducing the relative importance of older materials, even though the latter are still used extensively. Thus, although some masonry such as brick, hollow tile, and other clay products was used as the exterior material in nearly all of the projects in the current study, it accounted for only 3 percent of total materials cost, compared with 10 percent in the earlier study.

A change in construction method during the period is strikingly illustrated. Twenty years ago, concrete was commonly batched and mixed at the construction site; the use of ready-mixed concrete was just beginning to assume significance. Today, ready-mixed concrete is more commonly used on construction jobs. This accounts in part for the decline in the total for cement, and sand, gravel, and crushed stone (the raw materials of concrete) from almost 13 percent of material cost to 1 percent, and for the increase in concrete and concrete products from almost 4 to 7 percent. The rise in use of new types of materials, not necessarily serving entirely new purposes, and the decline in more traditional materials are reflected in the increases for glass and metal doors, windows, shutters and trim, and the decrease in forest products. For example, 20 years ago, fiberglass was a novel building material; today, it is preferred for several acoustical and thermal applications.

Requirement Comparisons With School, Public Building, and Highway Construction

A comparison of requirements for the four types of construction studied by the Bureau for this series of reports reveals that although total man-hours per $1,000 of contract are remarkably similar, there is some variation in requirements among the affected industries:

	Total man-hour requirements per $1,000 of construction contract			
		Buildings		
	Highways 1/	Schools	Federal office buildings	Hospitals
All industries	219	212	227	223
Construction, on site	94	84	97	89
Off-site	125	128	130	134
Construction	5	10	10	11
Manufacturing	60	78	79	79
Transportation	15	8	9	9
Trade and service	13	20	20	22
Mining	23	(2/)	(2/)	(2/)
Other	9	12	12	13

1/ Data for highways relate to 1958; data for schools and Federal buildings relate to 1959. If the highway data were adjusted for increases in prices and productivity between 1958 and 1959, the total hours would probably not differ substantially from those for schools.

2/ Included in "Other."

Comparison of data for the "Buildings" group shows that on-site time for hospitals was approximately 6 percent more than that for schools, and 8 percent less than that for public buildings. However, schools and public buildings involved the construction of new buildings only, whereas the hospital projects included additions to existing buildings. When new hospitals only were considered, the on-site hours were virtually the same as those for schools. The higher requirements for public buildings appear to reflect their previously noted more monumental quality. The somewhat higher off-site requirements for hospitals than for schools or public buildings appear to be due in some measure to the relatively large amount of fixed, built-in hospital equipment. Requiring relatively little time at the site in relation to its cost, this type of equipment tends to increase the off-site hours in the manufacturing and nonmanufacturing industries.

When "Buildings" are compared with "Highways" it should be borne in mind that because of the basic differences in locations and construction processes, relatively more operations are performed at the site of highway than of building construction. For example, the bulk of the concrete used in highway work is batched and mixed on-site by the contractor's own forces; ready-mixed concrete is used only for the smaller applications. On the other hand, as previously noted, most concrete used in building construction is ready-mixed. Moreover, the highway contractor's forces produce and process more than half of the aggregate required in their concrete, using sources as close as possible to the batch plants. Further, maintenance and other supporting services are necessarily performed on-site to a greater extent for highway than for building construction. This in part accounts for the differences shown in off-site requirements in the construction industry.

Differences in industry impact between highways and the buildings segments reflect differences in the construction process. In the case of highways, skilled workers operate extremely expensive units of equipment to move earth and place materials of a relatively low order of fabrication; in building construction, most of the journeymen manually place materials of relatively high cost and degree of fabrication. Thus, in the preceding tabulation, manufacturing man-hours are considerably lower for highway than for building construction, whereas mining hours are higher, reflecting the labor used in extracting rock, sand, and gravel.

Some of the basic differences are further illustrated by the percent distribution of construction costs:

		Buildings		
	Highways 1/	Schools	Federal office buildings	Hospitals
Total	100.0	100.0	100.0	100.0
Materials	50.6	54.1	51.3	53.3
On-site wages	23.9	25.7	29.0	28.8
Equipment 2/	12.0	1.4	1.9	1.1
Other 3/	13.5	18.8	17.8	16.8

1/ Based on data from the U.S. Bureau of Public Roads.
2/ Rental or depreciation charges.
3/ Overhead and profit.

Materials requirements for highways and buildings, although similar in percent of total construction cost, are different in type. For highways, four-fifths of the total materials value was accounted for by concrete (cement and bituminous), structural and reinforcing steel, and equipment fuels and lubricants. These represented a relatively minor portion of total materials costs for buildings.

Similarly, the share of total on-site wages received by some construction trades differed radically on the two types of construction. Thus, on highway construction nearly one-third of all on-site wages were paid to equipment operators (excluding truckdrivers), compared with less than one-thirtieth on building construction. Truckdrivers received more than 10 percent of all on-site wages for highway construction, but less than 1 percent for building construction. Unskilled workers, however, appeared to receive only a little more of the on-site wage dollar in high ay than in building construction, although available data do not afford a precise comparison.

APPENDIX A. Scope and Method of Survey

This study was designed to develop estimates of man-hour requirements associated with the construction of both public and private profit or nonprofit general hospitals. Project data obtained from or relating to activity at the construction site, as well as information based on secondary data such as the Census of Manufactures, were utilized.

General hospitals, as defined by the Department of Health, Education, and Welfare, are for inpatient medical or surgical care of acute illness or injury and for obstetrics, of which not more than 50 percent of the total patient days during the year are customarily assignable to the following categories of cases: chronic convalescence and rest, drug and alcoholic, epileptic, mental deficiency, mental, nervous and mental, and tuberculosis. Construction of hospitals (or nursing homes) primarily engaged in serving the medical needs of patients with illnesses falling in the latter descriptive categories was not included in the study.

Characteristics of the Universe and Selection of the Sample

A single, complete listing of all public and private general hospital construction started between mid-1958 and mid-1959, the period selected for study, was not available. It was, therefore, necessary to use several sources to obtain what was considered to be a representative, if not exhaustive, universe from which to draw a sample of projects for survey purposes. 13/ Approximately four-fifths of the projects in the universe so established consisted of nonprofit public and voluntary general hospitals, constructed with Federal financial assistance (as provided in the Hill-Burton Act), and the remaining fifth were not so assisted. (Hospitals built entirely with Federal funds--i.e., for veterans, armed service personnel, etc.--were excluded.)

As distinguished from the earlier studies concerning public school and Federal public building construction, where only new schools or buildings were considered, the hospital projects studied included new hospitals, additions to existing hospital structures, and alterations to the existing structures where these were part of the construction contracts for the addition projects. Situations involving renovations only, as distinct from alterations as part of an addition project, were not studied.

13/ Sources included contract award reports of F. W. Dodge Corp., Modern Hospital Publishing Co., Inc., and Construction Statistics Office of the Bureau of the Census. Also, the "Hospital and Medical Facilities Project Register, December 31, 1959," Division of Hospital and Medical Facilities, the Public Health Service, U.S. Department of Health, Education, and Welfare. All sources were crosschecked and project duplications eliminated.

Additions (and alterations incident thereto) were felt to be too important a part of total hospital construction to be excluded from the study. In 1959 and 1960, approximately 63 percent of Federal assistance funds for hospital and related projects were provided for additions and alterations projects. Moreover, the demand for construction of additions was believed comparable to that for new hospital construction.

The projects in the universe were stratified by four geographic regions (Northeast, North Central, South, and West), by total construction cost, and by metropolitan and nonmetropolitan area. 14/

A sample of 46 projects, approximately one-quarter of known units of the total universe, was selected. The projects were selected at random from the above three groupings. Although construction of the projects studied extended over a 3½-year period, most of the construction took place in the period July 1959 through June 1960.

Man-Hour Estimates. The customary presentation of employment data for construction projects includes estimates for on-site and off-site employment. Such a presentation is followed by this study. In addition, however, there is an economic distinction which can be made in analyzing man-hour requirements for construction. The basic grouping in this instance would be the primary and secondary labor effects of construction expenditures, with the primary sector including the on-site employment plus the off-site employment directly related to the activity at the site.

Primary man-hour requirements, for purposes of this report, include, in addition to all on-site labor, the construction contractor's office employment, the labor required in those manufacturing industries which fabricate the construction materials used on the site--that is, the "last stage of manufacturing" companies, plus all trade, distribution, and services involved in placing the construction materials at the site. Secondary employment includes all other labor requirements necessary to produce and transport the raw materials and semifinished products to the factories which finally produce the items used at the site.

14/ The States included in each of the regions were as follows: 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.

Data for on-site hours were generally collected from payroll sources. All other labor requirements discussed below, whether considered primary or secondary, were established by use of secondary data.

Collection of On-Site Man-Hour Data

Although the type of construction labor and materials requirements data sought was similar for both nonfederally and federally aided hospital projects, the sources for the data differed. For the construction of nonfederally assisted hospitals, those financed entirely by various levels of local governments, private individuals or voluntary groups, data were obtained by field representatives from local authorities, hospital administrators, architects, contractors, and other direct participants in these projects. For the federally assisted hospital projects, man-hour data were made available from records which were required under the Federal assistance program. Access to these records made possible the collection of some additional detail for these projects. This included information on wage relationships, timing of construction operations, and requirements by type of contractor.

Under the Federal legislation whereby Federal assistance may be granted for the construction of public and voluntary nonprofit hospitals of all types, after study and survey by a State substantiates the need, the individual States are given the authority for administering the program /Hospital Survey and Construction Act of 1946 (Hill-Burton); now referred to, with its amendments, as Title VI of the Public Health Service Act/. 15/ General coordination and supervision are exercised by the Public Health Service of the U.S. Department of Health, Education, and Welfare. Financing is by all parties, jointly, under a variable matching formula, depending on need and ability to pay.

When a hospital is built with a Federal grant, each prime contractor and subcontractor engaged on the project is required by the legislation to submit to the administrator of the sponsoring hospital, a copy of each weekly payroll showing (with other information) the daily and weekly hours worked, the gross weekly earnings, and the occupation of each mechanic and laborer on the particular project. Through the cooperation of HEW, the Departments of Health of the various States, and the hospital administrators, copies of the payrolls for the federally aided hospital projects in the sample, along with lists of the contractors on the jobs, were made available to the Bureau. These payrolls provided the data for estimating on-site man-hour requirements, as well as data on wages for all hourly rated workers on the projects. Data for on-site salaried employees, not accounted for on the payrolls, were obtained by the field agents from the contractors. In a few cases, the requested payroll records were not available or were inadequate as data sources. For these situations, alternate projects were substituted.

15/ Public Law 725, 79th Congress, as amended, approved August, 1946.

In the nonfederally aided hospitals, the data for on-site labor requirements were generally derived from payroll or labor cost records, or daily work force reports, obtained directly from the contractors engaged on the projects. Only summary man-hour data by occupation were requested from the contractors. For a small number of contractors whose records could not be used to isolate the data for specific hospital projects, estimated hours and materials costs were substituted.

Off-Site Man-Hours

From contractors and subcontractors cooperating in the study, a price list was obtained of the value of each type of material used in the sample projects. These material listings were classified into categories consistent with 5-digit Census of Manufactures product groups. For each of these product groups, the average amount used per $1,000 of contract construction was determined. Once the average use was calculated, each figure was reduced by a ratio representing the difference between valuation by the purchaser and valuation by the producer. 16/ Since all data reported by contractors were in purchasers' value, reduction to producers' value made the figures consistent with Census data published on these various components. These figures on average dollar value, stated in producers' value of each construction material used per $1,000 of contract value were necessary for each of the succeeding steps.

Primary Distribution Industries Employment

Man-hours in the distribution industries (trade, transportation, warehousing, freight forwarding, etc.) at the primary level with respect to construction activity were estimated from the difference between producer and purchaser value for each construction material. The differences were summed and allotted to trade or transportation sectors by a ratio obtained from inputs by these sectors to new construction found in the 1947 input-output analysis.

A second allocation was made among industries within the transportation sector (rail, truck, etc.) on the basis of 1959 value of production of the industry. The man-hours for each distribution sector were then determined by multiplying the value allotted to this sector by man-hours needed to produce $1,000 of product in the distribution sectors.

Primary Manufacturing Employment

Primary employment in manufacturing was considered to be that required to produce items in the construction bill of materials in their final stage of fabrication. In this stage, man-hours resulting from hospital construction were developed by multiplying average value of each construction component by a ratio of manufacturing man-hours to $1,000 of production. 17/

16/ The ratio used for this reduction was the purchaser-to-producer ratio for these components in hospital construction, as developed for use in the 1947 interindustry analysis.

17/ This ratio was established by using the 1959 Survey of Manufactures.

Secondary Employment in All Industries

Secondary employment is defined as the employment in all industries involved in the production and transportation of building materials and equipment, from basic extraction to, but not including, the final manufacturing stage.

To determine all the secondary man-hours involved in each construction product, it was necessary to determine the contribution from each of the sectors of the economy to the construction bill of materials. To obtain these contributions from each sector, an interindustry inverse matrix was used. The matrix was calculated for the United States economy in 1947 by the Bureau of Labor Statistics. 18/ Since this matrix is stated in 1947 prices, all prices of the construction components were deflated to 1947 levels and then grouped into industry classifications which were consistent with the interindustry study's 57-sector aggregation. This provided the value of construction goods, stated in 1947 prices, for each interindustry sector. Each of these figures was in turn multiplied by the corresponding coefficients of the inverse matrix. This procedure indicated the contribution necessary from each of the sectors to produce the specified construction item used. These products which were stated in 1947 prices were then reinflated to 1959 prices (the year consistent with the bill of materials).

Sector contributions to each of the separate construction items were summed to obtain total contributions from each sector of the economy to the construction bill of materials. To translate dollars of product contributed by each sector into employment required by this sector, a ratio of employment to $1,000 of production was used. These ratios were developed for each of 57 interindustry sectors. 19/

Total Man-Hour Requirements

From each off-site stage (primary distribution, primary manufacturing, and secondary industry), a man-hour figure per $1,000 of hospital construction contract was obtained. When these were summed with direct or on-site man-hours, the total employment effect, within the definition used by the study, was determined. However, the procedures used in estimating employment generated by hospital construction did not include all such employment. The technique used

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18/ For a further description, see the article by W. Duane Evans and Marvin Hoffenberg, op. cit.

19/ Both price and unit employment ratios were actually calculated on a 450-order aggregation and summed to the 57-order aggregation. The employment figure was converted to man-hours using BLS average annual hours in each of the separate sectors.

for the off-site segment covers only employment generated by direct purchases of materials and supplies and implicit in depreciation of construction equipment. The following areas of employment related to the volume of construction activity were not covered: (1) Architectural, surveying, estimating, and other planning employment; (2) inspection or supervision by the architect or the government during construction; (3) the labor time involved in installations of public utility employees, as well as any site preparation not covered by the construction contract; (4) the labor generated by the money expended for contractors' overhead, other than off-site administrative salaries; (5) employment generated by purchases of movable furniture and equipment; (6) the "multiplier" effect of the respending of wages and profits; and (7) the construction and equipment of new production facilities, if needed to supply construction materials.

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