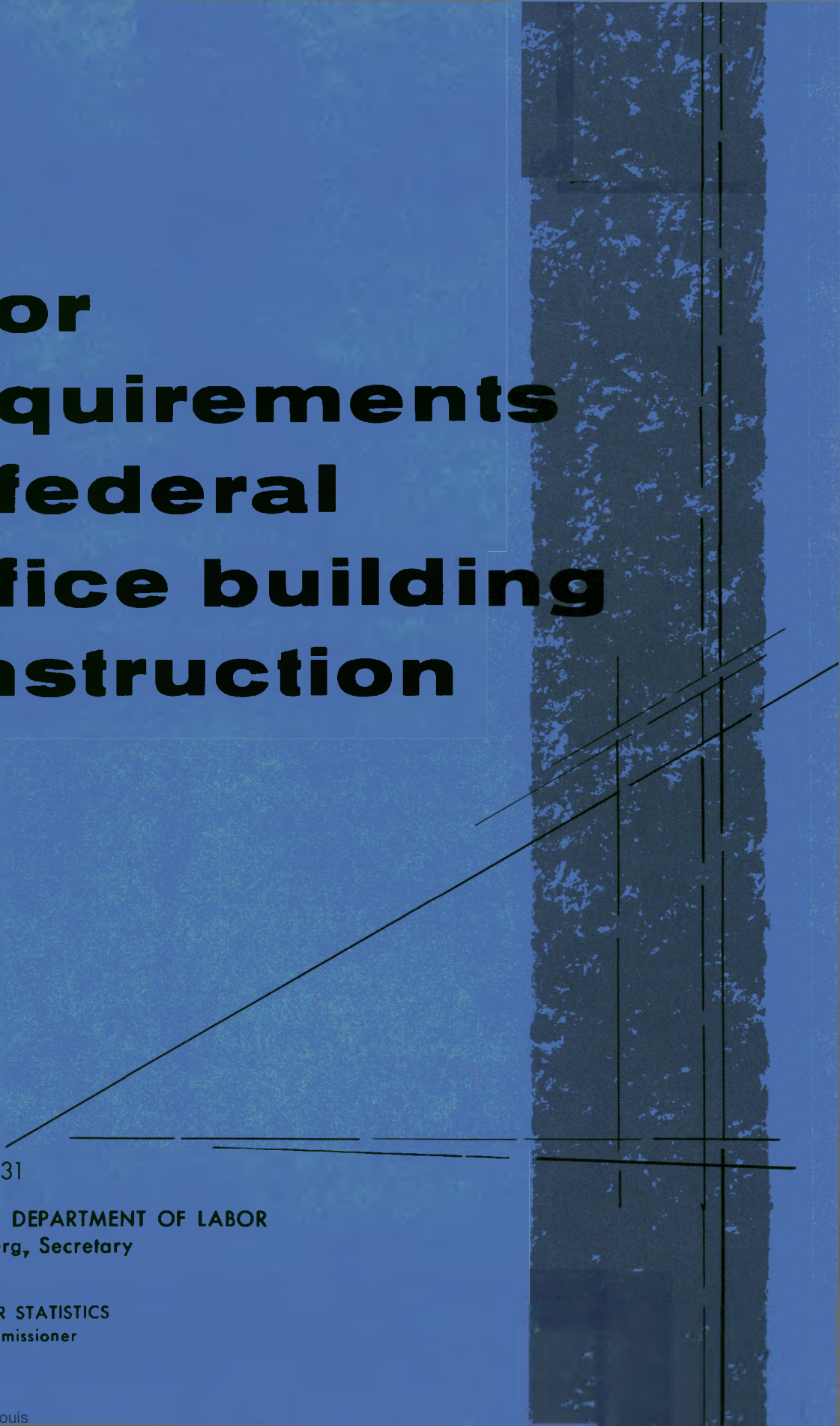
labor requirements for federal office building construction



Bulletin No. 1331

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Arthur J. Goldberg, Secretary

BUREAU OF LABOR STATISTICS
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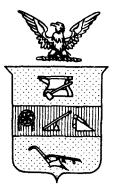

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Preface

This study of labor requirements for the construction of Federal office buildings is the third 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 concerned with schools and highways. Surveys currently underway cover hospitals; 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, public, and college student). 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 Roland V. Murray. Herman J. Rothberg directed the collection of statistical data and 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 Buildings Service of the General Services Administration for its cooperation throughout the study, and for providing much of the basic data for the determination of direct labor requirements. The Bureau also appreciates the cooperation of the construction contractors who supplied the materials data on which the estimates for indirect requirements were based.

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LABOR REQUIREMENTS FOR FEDERAL OFFICE BUILDING 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 the site of employment 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. Federal office construction was selected for early study in the series for several reasons. Although not of major importance in the Nation's overall construction activity, the backlog of needs for Federal office space is growing rapidly with the increase in population and in Federal responsibilities. By 1975, the total construction need for this type of building will approach $4 billion, and will involve possibly several thousand projects, according to estimates made in 1959. 1/ This is in addition to the rather substantial program then underway. This prospect, coupled with the wide geographical distribution of the needs, and the direct Federal control over planning and funding, make Federal office construction an important consideration in any program of public works construction.

Nature of Survey

This report is based on a survey of 22 Federal building projects constructed under contract in various localities of the United States by the Public Buildings Service of the General Services Administration. This construction was accomplished within the 3-year period from the fall of 1957 to the fall of 1960. Most of the construction, however, took place in 1959. (See appendix table A for list.) The buildings were selected as being typical of those providing office space for civilian functions of the Federal Government. Although much of the space was designed for use as post offices, the

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1/ U.S. Congress, House of Representatives. Independent Offices Appropriations for 1960: Hearings before the Subcommittee of the Committee on Appropriations (86th Cong., 1st Sess., Washington, Government Printing Office, 1959), pp. 1199-1200.

survey did not include any projects devoted exclusively to this use. This latter type of building is currently constructed under the sponsorship of the Post Office Department. 2/

The study was confined to new construction; provision of space by extension or rehabilitation of existing structures was not included. The survey did not cover the furnishing and equipping of the buildings, except for those items which are permanently fixed in place so as to constitute integral parts of the buildings, such as elevators, communications systems, and some types of post office and laboratory equipment.

The survey was designed primarily to determine the number of man-hours represented by a fixed dollar volume ($1,000) of Federal building contract construction. Man-hours, as defined for the survey, include both on-site construction employment and the off-site employment required to produce and deliver the 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 the workers in each construction trade. Data for off-site labor include employment in the off-site (e.g., office and warehousing) activities of the 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 the raw materials to the final manufacturing stage.

Certain types of employment, however, were not covered by the survey. The work of preparing the plans and specifications of the projects was excluded (although a rough supplementary estimate for these functions is provided in a later section of the report). Labor involved in producing office furniture and equipment was not covered, although the survey did include built-in laboratory equipment requiring substantial amounts of on-site installation labor. Also excluded was the labor time involved in installations by public utility employees, as well as any site preparation, landscaping, or highway work not covered by the construction contract. Finally, employment created by the respending of the wages and profits of the workers and their employers--the multiplier effect--was not considered within the scope of the study.

2/ In general, the Public Buildings Service is responsible for the construction of federally owned public buildings. Currently, most buildings designed for exclusive use as post offices are not federally owned but are built under the sponsorship of the Post Office Department, through its commercial leasing program. These were not covered in this study.

General Survey Findings

Construction of Federal office buildings in 1959 created a total of 227 man-hours of employment for each $1,000 of construction contract. Of these man-hours, 97 were for on-site employment in the construction industry, and 130 for various off-site activities. (See chart 1.) The latter covered the labor required to produce and deliver materials and equipment used by the on-site workers, plus employment of the contractors in administrative, warehousing, and other off-site activities. The man-hours were allocated as follows:

	Man-hours per $1,000 of contract	
	Number	Percent
Total man-hours	227	100
Construction:		
On-site	97	43
Off-site	10	4
Manufacturing	79	35
Transportation	9	4
Trade and service	20	9
Other industry employment	12	5

As pointed out in the following section, post offices 3/ form a homogeneous subgroup of the general category of Federal office buildings, and are therefore occasionally treated separately in this report. On-site construction man-hours for post office construction were 106 per $1,000 of construction contract, compared with 97 for all Federal office buildings studied.

A detailed compilation of the off-site man-hours required in the construction of post offices was not made, but rough calculations indicate that these higher on-site hours were almost balanced by lower off-site hours, so that the total requirements were nearly identical. (The lower off-site man-hours resulted from a lower materials cost per $1,000 of post office construction and the use of relatively more materials of a less highly fabricated

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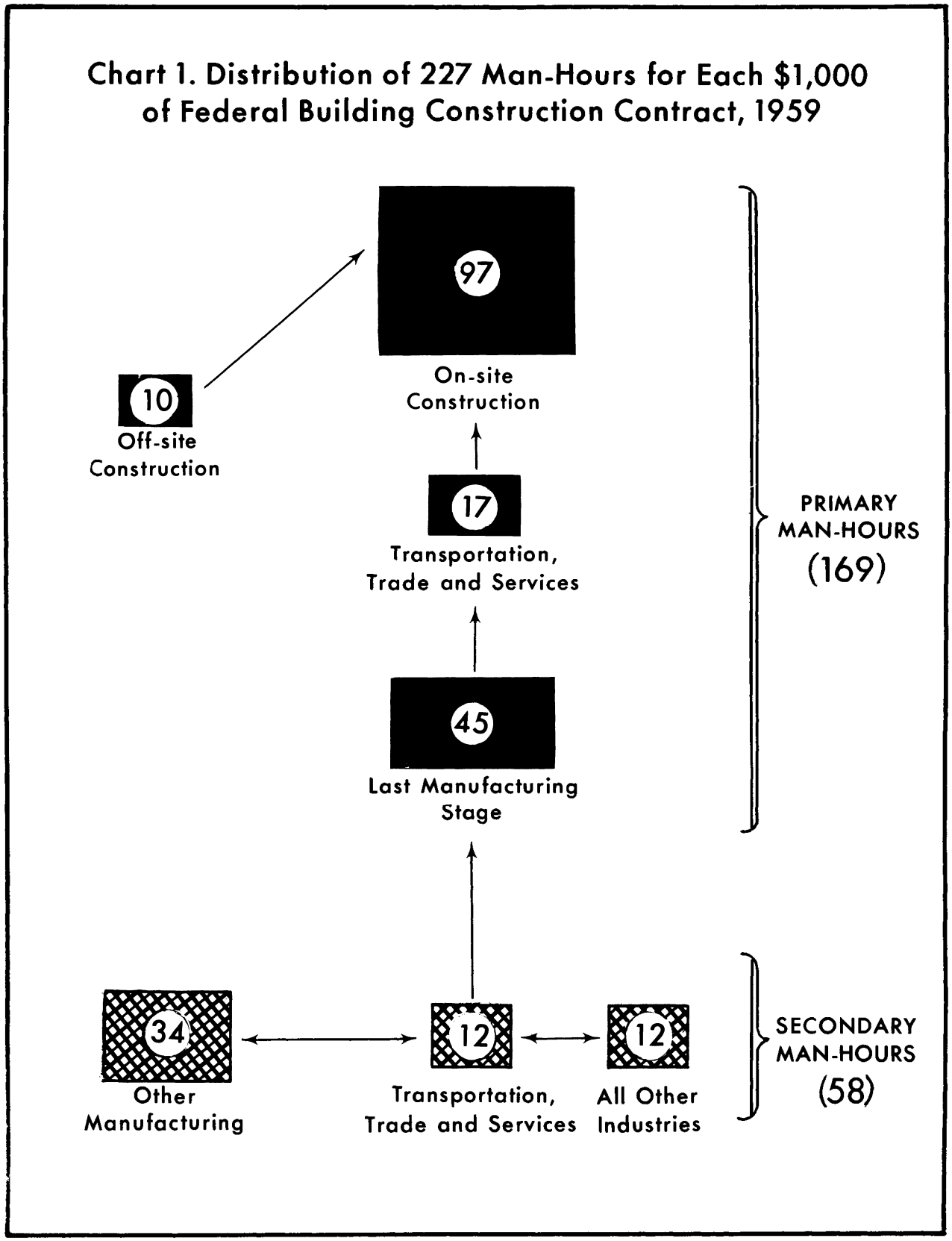
3/ With space for other Federal activities.

Chart 1. Distribution of 227 Man-Hours for Each $1,000



type.) On the average, the post offices studied cost a little under $1 million each and required somewhat less than 1½ years to build. Thus during this period, each project provided continuous work for an average of 40 workers at the construction site and, in addition, a slightly greater amount of employment in off-site activities. 4/

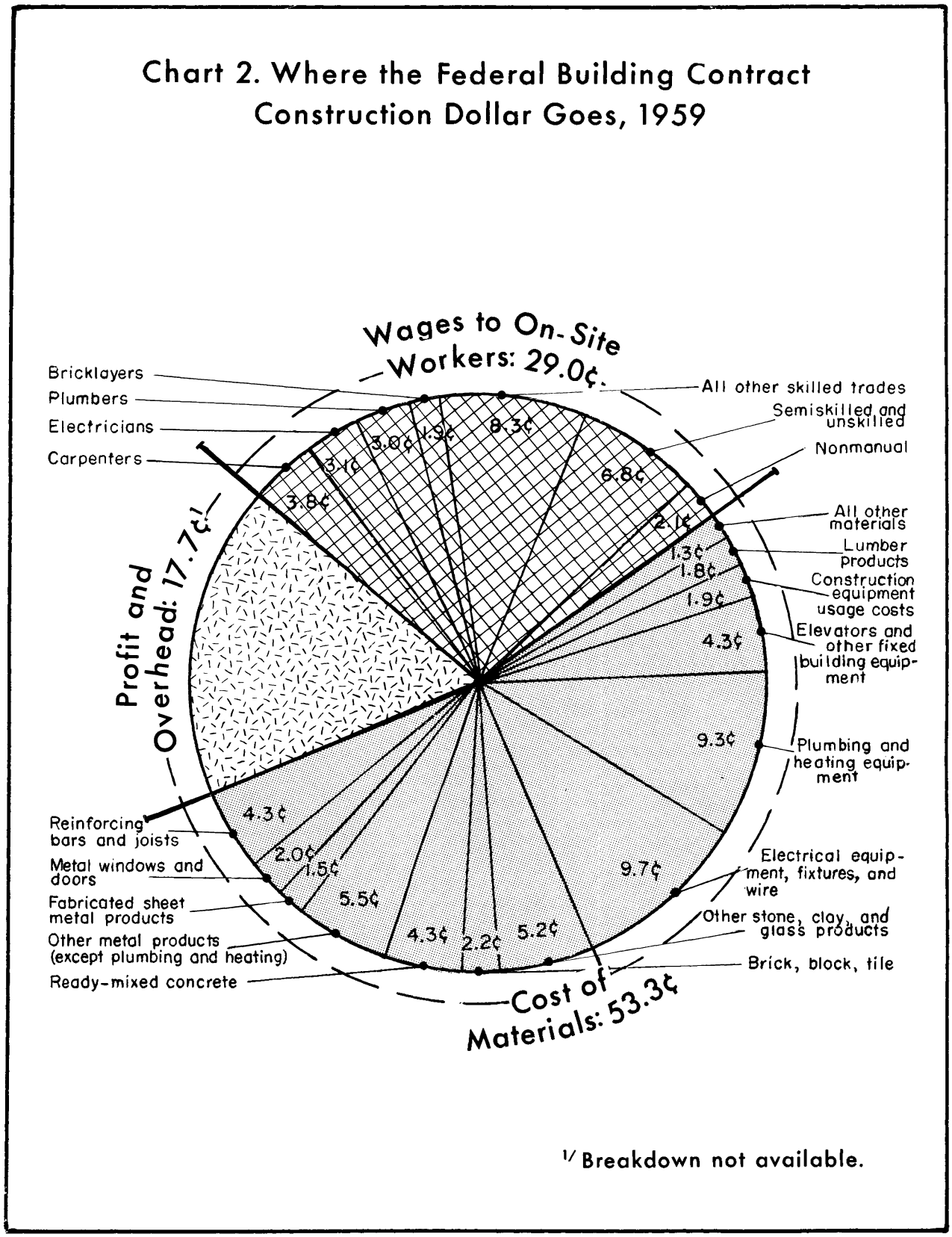
During recent years, an average of about $75 million a year has been spent on all types of Federal administrative buildings. This would indicate that this construction has been the source of about 9,000 jobs annually--4,000 at the site of construction and 5,000 off site. The needs previously mentioned for this construction, however, suggest a potential considerably above this level.

The survey disclosed rather wide ranges of man-hour and materials requirements among the individual projects, reflecting differences in type, purpose, and size of building, geographical location, and local construction 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, 53 cents of the construction dollar was expended on materials purchases, and 29 cents for wages to workers at the construction site, whose earnings averaged $2.98 per hour (chart 2). All of these are discussed in later sections of this report.

The study of labor requirements provided several types of information relating to the kinds of material used, the types of employment generated, the timing of employment, and the share of total employment used by the various special-trades contractors. These also are discussed in later sections of this report.

4/ The annual employment estimate of construction workers is based on 50 times the 1959 average employment in contract construction work of 35.8 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. Where the Federal Building Contract



Building Characteristics

As previously mentioned, the 22 projects surveyed were typical of construction by the Public Buildings Service to provide office and other working space for Federal agencies. Several types of buildings were represented, reflecting the need for construction to serve a variety of activities.

Fourteen of the projects were typical Federal buildings. Although each provided public post office facilities, in addition they contained office facilities for from 3 to 16 other Federal agencies. Each building contained at least two stories, exclusive of basement, if any. Typically, the first floor housed the post office space, with upper floors assigned to other agencies. Facilities for U.S. courts were commonly provided on the uppermost floor of multistoried buildings. For convenience, this group of buildings is sometimes referred to, elsewhere in this report, as post office buildings, although this designation is not precise.

Three of the five Federal office buildings housed various local or regional Federal activities and contained no public-use post office space. The two other Federal office building projects were unique. One was the complex of buildings comprising the headquarters for the Bureau of Old-Age and Survivors Insurance in Baltimore, Md., housing the central operations of the Old-Age, Survivors, and Disability Insurance Program, and containing what was, at least at the time of construction, reported to be the largest electronic data-processing unit in the world. The other was the Communicable Disease Center in Atlanta, Ga., housing administrative, laboratory, conference, instruction, and related facilities of the U.S. Public Health Service. An additional three projects were laboratory-office buildings providing facilities for soils research activities of the U.S. Department of Agriculture.

Total and unit costs of these elements of the sample are tabulated below:

	Number of projects	Total cost	Cost per square foot
Total	22	$60,446,085	$18.80
Post office buildings	14	17,791,531	19.47
Federal office buildings:			
OASI Headquarters	1	24,172,301	16.95
Communicable Disease Center	1	9,965,433	25.52
Other	3	7,423,263	16.56
Laboratory-office buildings	3	1,093,557	18.92

The unit costs reflect, among other factors, the characteristics of the projects; for example, the relative simplicity of the OASI building toward one extreme, and unique installations of the Communicable Center at the other.

Ten of the post office buildings and four of the Federal office buildings, including the Communicable Disease Center, were built under the lease-purchase program. 5/ This relatively short-lived program provided for the construction of buildings to Federal specifications by private investors. The buildings were then to be purchased by the Federal Government through periodic payments over a specified number of years. Projects constructed under that program, as administered, were unusual only with respect to funding, and not with respect to construction features or practices. The other projects in the sample were funded by the usual method of direct appropriation of Federal moneys.

Despite the variation in size and function of the sample projects, there was considerable uniformity in some construction features. Structural framing was commonly of reinforced concrete, although five of the smaller buildings had framing entirely of steel, or steel in conjunction with load-bearing masonry. In each building, masonry was used extensively in the exterior walls; these were generally of face brick, with a backing of common brick, concrete block, or clay tile. Extensive use was made of exterior trim, however, in the form of stone (granite, limestone, and marble), metal (aluminum and steel), glass, tile, and enameled steel panels. In the more monumental types of buildings, large areas, particularly at the base, were faced with stone. Roofs were generally of poured concrete, with uniformly a built-up composition surface. Floors were of poured concrete, without exception. Asphalt tile was by far the most common floor covering, although other materials were used for special purposes, such as terrazzo in public traffic areas and cork tile in the courtrooms. Almost all permanent interior walls were plastered, but there was extensive use of drywall construction on steel studs for movable partitioning. Ceilings were either of plaster or acoustical tile. Most buildings had aluminum windows; a few used steel, particularly in security areas; only one used wood sash and trim. Central air conditioning was practically universal. Elevators were provided for all buildings of more than two stories; there were, however, no elevators in two story buildings, although shafts for later installation were provided. Fluorescent lighting was standard.

5/ Not to be confused with the commercial leasing program mentioned in footnote 2.

On-Site Man-Hour Requirements

The average number of man-hours required at the construction site was 97.1 per $1,000 of construction contract for all projects. This figure is heavily influenced, however, by the very low requirements--83.4 man-hours per $1,000--for the OASI building, a very large building of relatively simple design, on which maximum benefits of the use of laborsaving equipment and organization were possible. Requirements on other individual projects ranged upward from the OASI figure, with 10 projects included in a range of 100-110; the median requirement was 107.6 man-hours per $1,000 of construction contract. Requirements for the more homogeneous group of post office buildings showed almost as great a range, but the average (weighted average) requirements of 106.5 did not differ markedly from the median requirement of 107.6 on the 14 projects.

Table 1 presents several measures related to labor requirements, by such categories as type, size, and location of building. One relationship that appears significant is the almost consistent decrease in man-hour requirements with the increase in cost of project. This relationship held true for the post office sample, as well as the overall sample. This is the factor which influences some of the differences noted in other breakdowns. Thus, the lower requirements for projects located in metropolitan areas reflect the fact that these projects averaged several times as large as those in nonmetropolitan areas. Similarly, the lower requirements for multistory projects are due to the fact that these were invariably the larger projects. Even on a regional basis, the regions having the larger projects tend to have lower man-hour requirements, despite other regional influences.

Labor Requirements in Earlier Periods

It would be of considerable interest to compare labor requirements for current Federal building construction with requirements for previous periods. Unfortunately, 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 dollar values of building construction costs over periods of time. However, a very rough adjustment for price change indicates that on-site man-hours per $1,000 (in constant prices) of Federal building construction have declined by approximately one-sixth in the past 20 years. 6/

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

Table 1. Costs and Labor Requirements of Federal Office Building Construction Projects, by Selected Characteristics, 1959

Characteristics	Number of projects	Cost per square foot	Man-hours per--		Average hourly earnings	Percent of cost	
			$1,000 of cost	1,000 square feet		On-site wages	Materials
All projects	22	$18.80	97.1	1,826	$2.98	29.0	53.3
Post office buildings 1/	14	19.47	106.5	2,073	2.90	30.9	50.6
Federal office buildings	5	18.35	90.2	1,656	3.07	27.7	55.2
OASI Headquarters	1	16.95	83.4	1,414	3.09	25.8	56.4
Communicable Disease Center	1	25.52	101.0	2,578	2.93	29.6	52.8
Other (general use)	3	16.56	98.0	1,623	3.20	31.4	54.6
Laboratory-office buildings	3	18.92	106.2	2,009	2.46	26.1	49.6
Construction cost group (in thousands):							
All projects:							
$500 and under	8	18.60	115.7	2,153	2.49	28.8	49.9
$501-$1,000	5	20.19	111.3	2,248	2.70	30.1	52.6
$1,001-$2,500	4	20.95	108.4	2,271	2.99	32.4	48.8
$2,501-$5,000	2	16.34	95.7	1,565	3.23	30.9	54.6
$5,001-$10,000	2	21.35	97.6	2,084	3.06	29.9	52.5
$10,001 and over	1	16.95	83.4	1,414	3.09	25.8	56.4
Post office buildings 1/:							
$500 and under	6	18.94	117.7	2,229	2.51	29.6	49.6
$501-$1,000	3	20.02	111.0	2,223	2.67	29.7	53.0
$1,001-$2,500	4	20.95	108.4	2,271	2.99	32.4	48.8
$2,501-$5,000	--	--	--	--	--	--	--
$5,001-$10,000	1	17.42	93.0	1,620	3.26	30.3	52.1
$10,001 and over	--	--	--	--	--	--	--
1 or 2 stories (above ground)	12	19.18	121.9	2,338	2.57	31.3	50.9
Post office buildings 1/	8	19.20	125.0	2,401	2.56	32.0	51.0
Other	4	19.08	110.9	2,116	2.61	29.0	50.7
3 or more stories (above ground)	10	18.74	93.0	1,742	3.07	28.6	53.6
Post office buildings 1/	6	19.58	99.3	1,944	3.07	30.5	50.5
Other	4	18.34	89.7	1,646	3.07	27.6	55.3
Metropolitan area	8	18.44	92.3	1,702	3.10	28.6	54.0
Post office buildings 1/	3	18.82	100.8	1,897	3.16	31.9	50.1
Other	5	18.33	89.9	1,647	3.08	27.7	55.2
Nonmetropolitan area	14	19.90	110.5	2,199	2.71	30.0	51.1
Post office buildings 1/	11	19.96	110.4	2,205	2.74	30.2	51.0
Other	3	19.41	111.0	2,154	2.51	27.9	51.7
All projects 2/:							
Northeast	2	17.34	110.4	1,914	2.93	32.4	45.5
North Central	7	20.35	100.2	2,040	3.15	31.5	50.1
South	11	18.83	96.0	1,807	2.90	27.9	54.4
West	2	14.98	89.2	1,336	3.22	28.7	58.0
Post office buildings 1/:							
Northeast	2	17.34	110.4	1,914	2.93	32.4	45.5
North Central	6	20.27	100.2	2,031	3.16	31.7	50.2
South	6	18.89	115.7	2,185	2.52	29.1	52.7
West	--	--	--	--	--	--	--

1/ With space for other Federal activities.
2/ For a list of States included in each region, see appendix A.

This decrease reflects two chief factors. One is the efficiency resulting from increased mechanization of tools and of materials-handling equipment. The other is the transfer of some operations from site to shop, as in the case of concrete batching amd mixing, and some pipe and duct work. This reduces on-site man-hours per dollar of cost, even though it may not reduce overall hours.

It is interesting to note that the decrease over the 20 years in site man-hours appears to be only about half as large for Federal buildings as for schools. 7/ 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 two types of construction are in reasonable relation.

For some time, the rapidly expanding school population has brought great pressures on local communities to provide additional classrooms as rapidly and as cheaply as possible. Architects, materials suppliers, and contractors have cooperated in providing construction using a minimum amount of hand labor and heavy materials handling and a large amount of subassemblies and prefabricated items. No such extreme pressures on cost and speed have been exerted for Federal office building construction. Moreover, the kind of construction typical of the modern school would not be considered appropriate for Federal buildings, particularly public-use buildings, where a somewhat monumental quality has been traditional, and where emphasis is on those features which lend an appearance of solidity and permanence. Hence there has been continued use in Federal buildings of large areas of exterior and interior stone work, and interior plastered walls, as compared with the lighter exteriors and the interior dry walls and bare masonry walls of schools.

Requirements by Occupation

The distribution of man-hour employment by broad area of skill was identical for both the total sample and the sample of post offices only (tables 2 and 3). About 60 percent of the total hours were worked by skilled trades, 34 percent by semiskilled and unskilled workers, and 6 percent by nonmanual personnel (supervisors, professional, technical and clerical employees).

Within the skilled trades, workers in the four predominant building crafts--carpenters, plumbers, electricians, and bricklayers--accounted for 60 percent of skilled man-hours in both samples. There was, however, a considerable variation in the proportion of hours worked by each of these crafts,

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7/ Labor Requirements for School Construction, BLS Bulletin No. 1299 (1961), p. 9.

Table 2. On-Site Man-Hour Requirements per $1,000 of Federal Office Building Construction Contract, by Occupation and Region, 1959

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	97.1	100.0	110.4	100.0	100.2	100.0	96.0	100.0	89.2	100.0
Supervisors	3.6	3.7	3.7	3.3	4.5	4.5	3.1	3.3	4.9	5.5
Professional, technical, and clerical	2.2	2.3	1.4	1.3	1.7	1.6	2.3	2.4	3.4	3.8
Construction trades:										
Carpenters	12.2	12.6	19.7	17.8	13.9	13.9	11.3	11.8	10.3	11.6
Electricians	8.8	9.1	9.7	8.8	7.5	7.5	9.3	9.7	7.6	8.5
Plumbers	8.5	8.7	10.8	9.8	8.8	8.7	8.5	8.8	6.0	6.7
Bricklayers	5.0	5.2	5.7	5.1	5.6	5.6	5.0	5.2	3.0	3.3
Sheet-metal workers	4.9	5.0	4.5	4.1	6.1	6.1	4.3	4.4	7.0	7.9
Operating engineers	2.3	2.4	1.6	1.4	1.8	1.8	2.6	2.7	1.8	2.0
Reinforcing-iron workers	2.1	2.2	.4	.3	2.9	2.9	1.8	1.9	3.7	4.2
Asbestos workers	2.1	2.1	1.3	1.2	2.1	2.1	2.2	2.3	1.2	1.4
Cement finishers	2.0	2.1	2.3	2.0	1.8	1.8	2.0	2.1	2.6	2.9
Painters	2.0	2.1	3.9	3.5	1.8	1.8	1.9	2.0	2.7	3.1
Plasterers	2.0	2.0	3.6	3.2	2.1	2.1	1.7	1.8	3.6	4.0
Lathers	1.8	1.8	3.8	3.5	2.5	2.4	1.3	1.3	2.9	3.3
Structural-iron workers.	1.2	1.2	2.2	2.0	.6	.6	1.3	1.4	.9	1.0
Ornamental-iron workers.	.8	.8	1.2	1.1	1.0	1.0	.8	.8	.1	.1
Elevator mechanics	.7	.8	.9	.8	.7	.7	.7	.7	1.3	1.5
Roofers	.7	.7	.5	.4	.6	.6	.8	.8	.3	.4
Tile setters and terrazzo workers	.5	.5	.4	.4	.7	.7	.4	.4	.3	.4
Glaziers	.4	.4	.9	.8	.6	.6	.3	.3	.5	.5
Soft-floor layers	.2	.2	.4	.4	.3	.3	.1	.1	.9	1.0
Laborers	25.3	26.1	28.6	25.9	24.3	24.2	26.4	27.5	15.5	17.3
Helpers and tenders	6.2	6.4	2.7	2.4	7.4	7.4	6.0	6.2	7.0	7.8
Truckdrivers	.9	.9	.4	.3	.5	.5	1.0	1.1	1.4	1.6
Watchmen	.2	.2	0	0	.2	.2	.3	.3	0	0
Other	.4	.4	.1	.1	.2	.2	.5	.5	.3	.3

Note: Because of rounding, sums of individual items may not equal totals.

Table 3. On-Site Man-Hour Requirements per $1,000 of Post Office Building 1/ Construction Contract, by Occupation and Region, 1959

Occupation	United States		Northeast		North Central		South	
	Man-hours worked	Percent	Man-hours worked	Percent	Man-hours worked	Percent	Man-hours worked	Percent
All occupations	106.5	100.0	110.4	100.0	100.2	100.0	115.7	100.0
Supervisors	4.8	4.5	3.7	3.3	4.6	4.6	5.4	4.7
Professional, technical, and clerical	1.4	1.3	1.4	1.3	1.7	1.7	.9	.8
Construction trades:								
Carpenters	15.2	14.3	19.7	17.8	13.6	13.6	16.6	14.3
Electricians	7.5	7.1	9.7	8.8	7.5	7.5	6.9	6.0
Plumbers	8.7	8.2	10.8	9.8	8.7	8.7	8.1	7.0
Bricklayers	6.4	6.0	5.7	5.1	5.6	5.6	7.9	6.8
Sheet-metal workers	5.0	4.7	4.5	4.1	6.2	6.2	3.0	2.6
Operating engineers	2.0	1.8	1.6	1.4	1.9	1.9	2.3	2.0
Reinforcing-iron workers	2.4	2.2	.4	.3	3.0	3.0	1.9	1.6
Asbestos workers	2.0	1.8	1.3	1.2	2.1	2.1	1.9	1.6
Cement finishers	1.9	1.8	2.3	2.0	1.8	1.8	2.0	1.8
Painters	2.5	2.4	3.9	3.5	1.8	1.8	3.3	2.9
Plasterers	2.9	2.7	3.6	3.2	2.2	2.2	4.0	3.5
Lathers	2.4	2.2	3.8	3.5	2.5	2.5	1.8	1.5
Structural-iron workers	1.2	1.1	2.2	2.0	.6	.6	2.0	1.7
Ornamental-iron workers	.7	.6	1.2	1.1	1.0	1.0	0	0
Elevator mechanics	.6	.6	.9	.8	.7	.7	.3	.2
Roofers	.7	.6	.5	.4	.6	.6	.9	.8
Tile setters and terrazzo workers	.6	.6	.4	.4	.7	.7	.6	.5
Glaziers	.7	.6	.9	.8	.6	.6	.7	.6
Soft floor layers	.3	.3	.4	.4	.3	.3	.2	.1
Laborers	28.4	26.7	28.6	25.9	23.8	23.7	36.1	31.2
Helpers and tenders	7.4	7.0	2.7	2.4	7.6	7.6	8.4	7.3
Truckdrivers	.5	.5	.4	.3	.5	.5	.5	.4
Watchmen	.1	.1	0	0	.2	.2	0	0
Other	.2	.2	.1	.1	.2	.2	.2	.1

1/ With space for other Federal activities. No building of this type was constructed in the West during the period of the survey.

Note: Because of rounding, sums of individual items may not equal totals.

as well as the others, from job to job. Thus, the percentage of total project man-hours worked by carpenters ranged from 7 to 23, by electricians from 2 to 12, and by plumbers from 4 to 14.

These variations probably reflect primarily the design requirements of individual projects, and, to a lesser extent, divisions of work arising in part from local union jurisdictions. Thus, the percentage of man-hours for electricians was highest on the OASI building, with its exceptional electronic data-processing facilities, and for plumbers was highest (with a minor exception) for the CDC project with its laboratory installations.

In post office construction, special requirements are minimized. This is reflected in the occupational distribution. Thus, for each of the mechanical and allied trades (plumbers, electricians, sheet-metal workers, asbestos workers, elevator mechanics), man-hour proportions are less for post office buildings, whereas for each of the finishing trades (painters, plasterers, lathers, tile setters and terrazzo workers, glaziers, soft floor layers) they are greater. Further, in the post office sample, plumbers account for relatively more hours than do electricians. This is the more common relationship, and the reverse of that in the overall sample.

Variations from region to region in the ratios of man-hours worked by different trades on the sample of all projects reflect chiefly the chance distribution of the different types of buildings among the regions. The variations for post offices only are probably more significant as far as inherent regional factors such as climatic design requirements and work practices are concerned. In the latter connection, a number of factors affect the regional distribution by occupation, apart from the construction operations required by the specifications of the buildings. The relative strength of local unions, for example, affects the organization of work crews and the classification of jobs. Local custom influences the opportunity of union membership and of journeyman jobs for minority groups, and this influence is differently felt in different crafts. 8/ Finally, the local availability of lower paid labor may affect the extent of mechanization.

These factors particularly influence the division between skilled and unskilled workers. Thus, for post office construction, unskilled and semi-skilled workers accounted for 39 percent of total man-hours in the South compared with 32 percent in the North Central region; the percentages for skilled workers were 56 and 61, respectively.

8/ Employment Outlook in the Building Trades, BLS Bulletin No. 967 (1949), p. 26.

Table 4. Apprentice Man-Hours as a Percent of Total Man-Hours Worked on Federal Office Building Construction, by Occupation and Region, 1959

Occupation	United States	North-east	North Central	South	West
All workers	3.9	7.2	3.4	3.9	4.6
Construction trades only	6.5	10.8	5.5	6.6	7.3
Carpenters	6.3	6.7	3.6	7.3	6.6
Electricians	12.0	19.4	5.9	13.5	9.0
Plumbers	9.8	29.6	5.9	9.0	21.0
Bricklayers	3.2	2.2	5.4	2.4	.9
Sheet-metal workers	10.7	20.5	15.6	7.3	12.9
Operating engineers	0	0	0	0	0
Reinforcing-iron workers	4.0	0	4.5	4.5	0
Asbestos workers	0	0	0	0	0
Cement finishers	2.3	0	3.6	2.2	.5
Painters	1.2	1.2	.4	.7	7.4
Plasterers	2.4	.8	.7	3.5	1.5
Lathers	8.7	7.4	9.7	9.6	2.6
Structural-iron workers	.7	6.4	1.2	.1	0
Ornamental-iron workers	2.5	0	1.8	3.0	0
Elevator mechanics	0	0	0	0	0
Roofers	4.5	0	19.0	.9	3.0
Tile setters and terrazzo workers	4.3	0	3.5	4.4	10.8
Glaziers	1.3	0	0	1.4	9.5
Soft floor layers	16.0	1.4	10.6	22.1	19.0

The persistence in all regions of a relatively large proportion of man-hours representing employment of lesser skilled workers is noteworthy. About a third of all on-site employment represented unskilled and semiskilled labor, 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 be used profitably.

Apprentices. Apprentices accounted for 3.9 percent of all man-hours worked at the site of the sample projects, or 6.5 percent of skilled trade man-hours (table 4). These data reflect only the work of participants in formal, registered apprenticeship programs, since only these may be classified as apprenctices on the payrolls used as the source of on-site labor requirements information. For the three trades--asbestos workers, elevator mechanics, operating engineers--which reported no apprentices, formal programs either did not exist or were only just evolving. In these trades, training is usually acquired on an informal basis by assisting a journeyman in his work over a period of years. Workers in this 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 other tables of this report. High rates of apprentice employment are associated with shortages of skilled journeymen in the craft, or with some smaller crafts.

General and Special Trades Contractors' Shares

Employees of general contractors accounted for 40 percent of the total man-hours required for the construction of all the sample projects, although for seven projects this percentage exceeded 60. (See table 5.) Variations in the proportion of work done by general contractors reflect local construction practices, as well as special requirements of the projects. Illustrating the former, although masonry was usually subcontracted, there were nine projects involving substantial amounts of brickwork where the bricklayers were employees of the general contractor. These tended to be the smaller projects. The effect of special project requirements is noted in the comparison of all projects with the post office sample only. One effect of excluding data on the special types of projects is to reduce the proportion of work done by special trades contractors and thus increase the general contractor's proportion. This is due primarily to a reduction in the Plumbing, heating, and air conditioning and Electrical categories, for which OASI and Communicable Disease facilities had heavy requirements.

Table 5. Percent of Total On-Site Man-Hour Requirements for Federal Office Building Construction, by Type of Contractor and Region, 1959

Type of contractor	United States	North-east	North Central	South	West
	All projects				
All types	100.0	100.0	100.0	100.0	100.0
General	39.6	51.6	43.3	37.9	34.6
Special trades:					
Plumbing, heating, and air conditioning	20.1	16.0	19.7	20.8	17.6
Electrical	9.8	10.0	7.7	10.5	10.1
Masonry	7.9	0	6.7	8.9	8.2
Plastering and lathing	4.8	8.9	6.3	3.6	9.5
Structural and ornamental metalwork	3.5	3.2	2.7	3.6	5.5
Painting	2.1	3.5	1.9	2.0	3.2
Site preparation, excavation, and foundations	2.1	.8	2.5	2.0	2.5
Elevator and other equipment installation	1.5	1.7	1.4	1.5	2.3
Tile and terrazzo work	1.4	.9	1.5	1.4	.9
Roofing and sheet-metal work	1.2	1.5	1.4	1.2	.6
Other	5.9	1.9	5.0	6.6	5.1
	Post office buildings 1/				
All types	100.0	100.0	100.0	100.0	--
General	46.1	51.6	42.9	49.2	--
Special trades:					
Plumbing, heating, and air conditioning	17.0	16.0	19.5	13.8	--
Electrical	7.3	10.0	7.7	6.0	--
Masonry	7.5	0	6.9	10.5	--
Plastering and lathing	7.5	8.9	6.5	8.5	--
Structural and ornamental metalwork	2.0	3.2	2.8	.7	--
Painting	2.4	3.5	1.9	2.9	--
Site preparation, excavation, and foundations	2.0	.8	2.6	1.6	--
Elevator and other equipment installation	1.1	1.7	1.4	.4	--
Tile and terrazzo work	1.5	.9	1.5	1.5	--
Roofing and sheet-metal work	1.5	1.5	1.3	1.8	--
Other	4.1	1.9	5.0	3.3	--

1/ With space for other Federal activities.

Note: Because of rounding, sums of individual items may not equal 100.0.

The average number of prime and subcontractors on each sample project was 22. This number varied considerably, however, with size of project (in cost terms), the larger projects showing a higher degree of specialization:

Cost group (thousands)	Average number of contractors
All groups	22
$500 and under	18
$501 - $1,000	20
$1,001 - $2,500	26
$2,501 - $5,000	28
$5,001 - $10,000	37
$10,001 and over	46

The Cost of Direct Wages

Wage payments to on-site labor represented 29 percent of the total value of the construction contracts for all sample projects, and 31 percent for post office buildings only (table 1). These percentages reflect the combined effect of man-hour requirements and wage rates. The effect of increased average hourly earnings in raising the percentage is partially offset by the tendency of higher hourly earnings to be associated with lower man-hour requirements. Nevertheless, the range in this ratio was rather wide--from 23 to 39 percent.

Average hourly earnings	Number of projects	Man-hours per $1,000	Percent wages of cost
All projects	22	97	29
Under $2.25	3	1/ 134	1/ 26
$2.25 - $2.49	0	--	--
$2.50 - $2.74	4	1/ 109	1/ 29
$2.75 - $2.99	5	1/ 107	1/ 31
$3.00 - $3.24	6	1/ 103	1/ 32
$3.25 and over	4	1/ 100	1/ 34

1/ Average of individual project measures.

Overtime work (i.e., those hours paid for at premium rates) was not a significant factor in raising the wage portion of total cost. These hours averaged 2.1 percent of total man-hours worked on all projects and on post office buildings only. (See table 6.) The rate of overtime work varied widely among the various trades. Thus, cement finishers accounted for 11 percent of all overtime hours compared with only 2 percent of total man-hours

Table 6. Overtime 1/ Man-Hours as a Percent of All Man-Hours Worked in Federal Office Building Construction, by Tenths of Total Construction Time and by Occupation, 1959

Occupation	All periods	1st tenth	2d tenth	3d tenth	4th tenth	5th tenth	6th tenth	7th tenth	8th tenth	9th tenth	Last tenth
All occupations	2.1	2.7	2.6	2.7	2.5	2.4	1.7	1.3	1.7	2.1	2.2
Supervisors	0.4	0.2	0.3	0.1	0.1	0.1	0.1	0.3	0.8	1.3	0.3
Professional, technical, and clerical	1.9	.2	.6	1.5	2.1	2.0	1.7	2.5	3.4	2.9	2.7
Construction trades:											
Carpenters	1.0	1.3	1.9	1.2	.6	.9	.8	.5	.7	.8	1.7
Electricians	.9	.7	1.8	2.4	.4	.3	.3	.5	.9	1.6	1.7
Plumbers	.5	.3	.1	.1	.1	(2/)	.1	.4	1.2	1.8	.9
Bricklayers	.1	0	.4	.2	.1	.1	(2/)	.1	.1	.1	.4
Sheet-metal workers	.6	0	0	0	.2	.7	1.1	.2	.4	1.0	(2/)
Operating engineers	6.5	9.0	4.9	6.4	7.9	6.5	5.4	3.4	6.7	10.3	4.7
Reinforcing-iron workers	1.5	.4	1.5	1.9	1.6	1.7	.9	.2	0	6.1	2.7
Asbestos workers	1.1	0	0	0	0	.9	.5	.1	.5	.8	9.6
Cement finishers	11.2	3.0	12.8	13.6	14.8	19.5	15.7	8.1	2.9	3.3	2.5
Painters	1.2	1.5	0	0	5.1	0	0	.1	1.5	.8	1.9
Plasterers	.3	0	0	0	0	1.1	0	.1	.5	.2	0
Lathers	.2	0	0	1.2	0	0	0	(2/)	.6	.2	0
Structural-iron workers	1.1	1.8	.9	2.2	.4	.5	.5	.8	2.5	3.5	3.0
Ornamental-iron workers	.1	0	0	0	0	0	.2	.1	.1	0	0
Elevator mechanics	2.8	0	0	0	.7	.5	.6	1.2	1.4	9.9	2.1
Roofers	2.7	0	3.3	4.3	2.4	2.9	1.8	3.6	2.2	.7	.3
Tile setters and terrazzo workers	1.3	0	0	0	0	0	1.9	1.0	1.0	1.2	3.4
Glaziers	6.7	0	0	0	0	0	5.0	8.9	6.1	6.1	8.1
Soft floor layers	3.2	0	0	0	0	0	0	0	.5	4.1	4.6
Laborers	3.2	2.2	3.3	3.9	3.9	4.2	3.1	2.1	2.4	2.6	2.5
Helpers and tenders	3.4	9.0	3.8	3.2	4.8	3.8	3.2	2.4	3.8	3.2	4.1
Truckdrivers	5.2	4.8	2.9	6.7	9.8	6.9	3.0	4.1	3.8	4.7	4.8
Watchmen	3.6	.1	.4	.1	.4	2.0	2.9	.7	2.2	16.6	41.4
Other	5.9	3.9	4.2	1.8	8.7	8.8	9.6	9.1	5.4	5.1	0

1/ Hours for which premium rates were paid.
2/ Less than 0.05 percent.

worked. During the peak period of cement finishing activity, nearly one-fifth of all hours worked by this craft were at overtime rates, reflecting a basic requirement that such work must be completed while the concrete is still at a proper degree of plasticity. On the other hand, the number of overtime hours worked by bricklayers was almost negligible.

Occupational shares

Distribution of the on-site earnings among the various occupations is shown in table 7. These shares reflect the volume of work by each occupation as well as the wage rates. Thus, despite a relatively low hourly rate, common labor accounted for a greater part of the construction dollar, over 5 cents, than any other class of worker. The three leading groups of craftsmen--carpenters, electricians, and plumbers--together received about the same portion of the total wage bill as all other skilled trades combined. Many of the minor trades are not always separately distinguished, particularly in nonmetropolitan areas, where their work is performed by more widely recognized trades. For example, ceiling and floor tiles may be installed by special tradesmen in some areas, but in others are frequently installed by carpenters.

The division of projects between metropolitan and nonmetropolitan areas probably influences the variations noted in average hourly earnings (tables 1 and 7) more than does any other single factor. Usually, wage rates tend to be higher in metropolitan areas than in less densely populated areas in the same region. This accounts for the relatively high average hourly earnings for most crafts in the South, where the greater part of the sample was concentrated in large metropolitan areas. It also accounts for the fact that the multistory buildings and the costlier projects are associated with higher average hourly earnings, since these projects are usually in the larger urban centers.

Table 7. Average Hourly Earnings and Distribution of On-Site Earnings on Federal Office Building Construction, by Occupation and Region 1/, 1959

Occupation	United States		North Central		South	
	Percent of total on-site earnings	Average hourly earnings	Percent of total on-site earnings	Average hourly earnings	Percent of total on-site earnings	Average hourly earnings
All occupations	100.0	$2.98	100.0	$3.15	100.0	$2.90
Supervisors	5.2	$4.22	6.2	$4.32	4.7	$4.13
Professional, technical, and clerical	2.0	2.67	1.3	2.54	2.2	2.69
Construction trades:						
Carpenters	13.0	3.09	14.1	3.19	12.4	3.04
Electricians	10.7	3.52	8.8	3.68	11.7	3.51
Plumbers	10.3	3.52	9.9	3.56	10.8	3.53
Bricklayers	6.7	3.82	6.8	3.81	6.8	3.81
Sheet-metal workers	5.5	3.29	6.1	3.12	5.1	3.36
Operating engineers	2.7	3.37	2.0	3.49	3.1	3.34
Reinforcing-iron workers .	2.6	3.47	3.3	3.53	2.3	3.46
Asbestos workers	2.7	3.76	2.5	3.77	2.9	3.78
Cement finishers	2.4	3.52	2.0	3.52	2.6	3.51
Painters	2.1	2.98	1.8	3.07	2.1	3.05
Plasterers	2.4	3.50	2.5	3.81	2.0	3.30
Lathers	2.1	3.48	2.9	3.67	1.5	3.33
Structural-iron workers ..	1.5	3.72	.7	3.69	1.8	3.67
Ornamental-iron workers ..	1.1	3.86	1.1	3.64	1.1	4.00
Elevator mechanics	1.0	3.93	.8	3.73	1.0	4.00
Roofers	.7	2.80	.5	2.58	.8	2.83
Tile setters and terrazzo workers	.6	3.48	.8	3.52	.5	3.46
Glaziers	.4	3.12	.7	3.41	.3	3.15
Soft floor layers	.3	3.17	.4	3.40	.1	3.06
Laborers	17.6	2.01	18.2	2.37	17.7	1.87
Helpers and tenders	5.1	2.39	6.1	2.59	4.9	2.28
Truckdrivers	.7	2.18	.4	2.44	.8	2.12
Watchmen	.1	1.27	.1	1.80	.1	1.12
Other	.5	3.44	.2	3.17	.6	3.48

1/ Insufficient data to justify presentation for the Northeast and West.

Note: Because of rounding, sums of individual items may not equal 100.0.

Off-Site Employment

For each man-hour of employment performed on the construction site, an additional 1.3 man-hours were required to produce and distribute the necessary construction materials, supplies, and equipment used in the construction of Federal buildings. Thus, these projects gave rise to 130 man-hours of such employment per $1,000 of contract, compared with the 97 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 which are directly or indirectly affected by the production of fabricated and raw materials, including agriculture, forestry, and mining.

There are, of course, other groups affected which this study did not attempt to cover. Some of these are mentioned on page 2 of the introductory section. Of those omitted, the most numerically important groups directly affected by a Federal building construction program were employees of architectural firms (p. 25), utility companies, and the Federal Government. 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, in this study, employment requirements have also been divided into primary and secondary man-hour needs. As shown in the following tabulation and chart 1, primary man-hour requirements, estimated at 169, arise in activities at the site and those rigidly related to the volume of construction activity. Included in these requirements, in addition to site employment, are off-site construction employment, employment by manufacturing industries represented at the "last stage of manufacturing" for materials prior to shipment to the site, as well as employment in transportation, trade, and service organizations dealing in materials used at the site.

Secondary man-hour requirements have been defined as including those associated with all other requirements indirectly related to the needs at the site. Such employment, totaling 58 hours or 26 percent of total man-hour requirements, spreads to all parts of the economy as the impact of primary activity is reflected in demand for basic materials and related transportation, trade, and service. 9/ The following tabulation shows man-hours of employment associated with $1,000 of Federal building construction:

	Total	Primary activities	Secondary activities
Total	227	169	58
On-site:			
Construction	97	97	--
Off-site	130	72	58
Construction	10	10	--
Manufacturing	79	45	34
Transportation	9	5	4
Trade and service	20	12	8
Other	12	--	12

Some industries are represented in both the primary and secondary sectors since their products or services are used in site activity and by manufacturers producing items for site activity. For example, the sand and gravel industry furnishes materials directly to the construction industry and also to the ready-mixed concrete industry which in turn sells to the construction industry.

Builders' Off-Site Employment

An exact study of contractors' off-site employment was not attempted, since it was almost impossible to relate accurately such employment with the projects being studied. Builders' off-site employment was not only concerned with the project studied, but with work involving other current or future projects as well.

9/ Secondary man-hours were estimated on the basis of a study made by the Bureau of 1947 interindustry relationships. See article by W. Duane Evans and Marvin Hoffenberg, "The Interindustry Relations Study for 1947," Review of Economics and Statistics, Cambridge, Mass., Vol. 34, May 1952, pp. 97-142. For methods employed, see appendix A to this bulletin.

The estimate of 10 off-site man-hours 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 includes some self-employed craftsmen who may have worked at the site.

Combining this employment with on-site employment results in an estimate of 107 hours of employment in the construction industry for each $1,000 of Federal building 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 17 11/ 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 producers to construction site and does not include distribution, etc. of materials among industries prior to shipment of the completed products.

"Last Manufacturing Stage" Employment

The sector of the economy most affected by building construction, other than the construction industry itself, is manufacturing. An estimated 45 man-hours were required for each $1,000 of total contract for production of construction materials used in the buildings. This estimate, however, includes only employment required in the last manufacturing process of the materials. 12/ Employment generated by this activity is distributed in many industries which are directly affected by activity in the construction industry. For example, it includes employment in 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 45 man-hours of primary employment required for each $1,000 of construction contract in factories making construction materials, an additional 34 man-hours were required in secondary manufacturing activities.

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.

11/ Not comparable with the corresponding figure of 13 previously published for schools. The latter figure would have been 18 under an improved method of estimation.

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

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

Trade and service industries as a group required 8 hours of employment for each $1,000 of Federal building construction to meet the needs of secondary business activity.

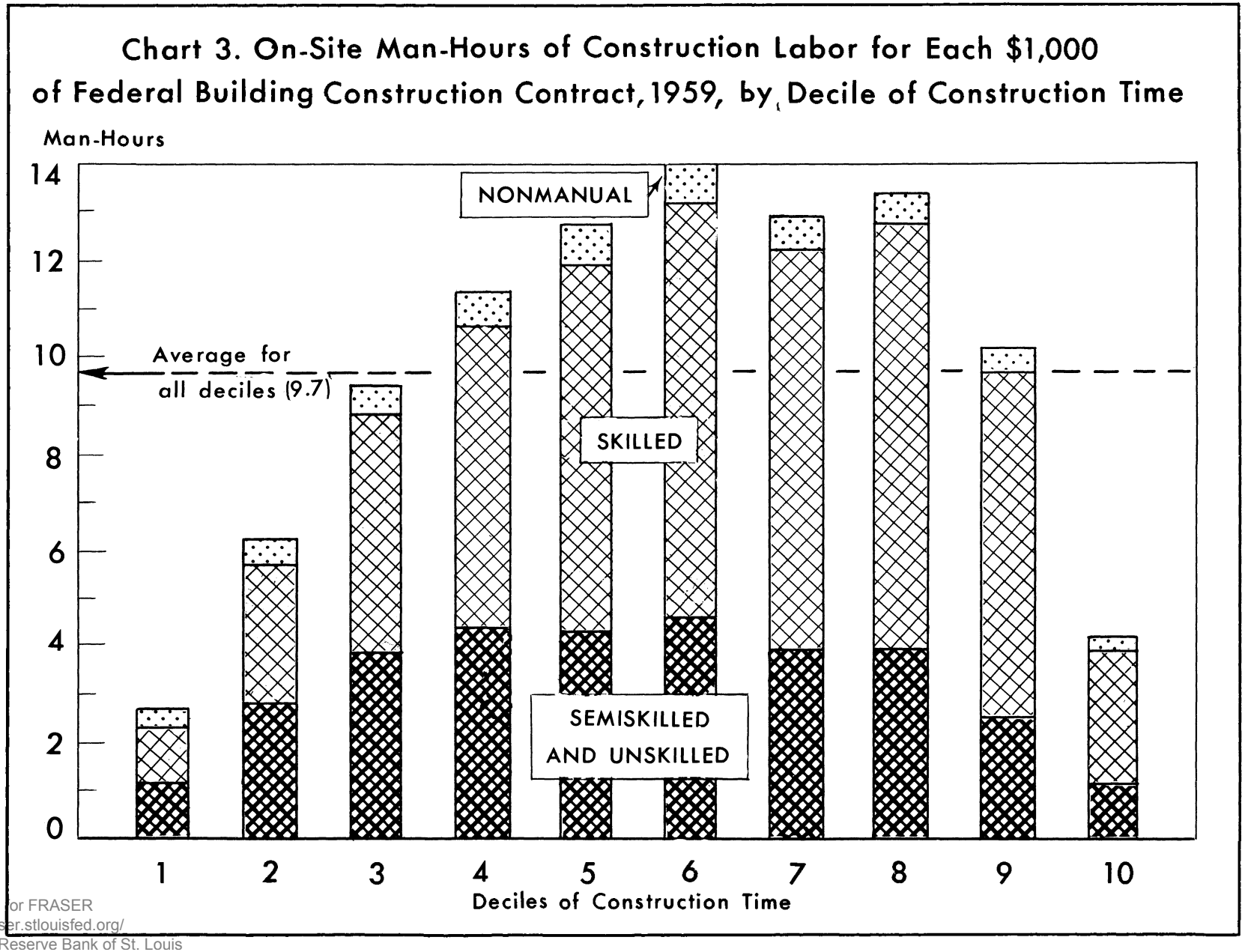
Other business activities, primarily agriculture, forestry, and mining, accounted for the remaining 12 of the 58 hours of secondary manpower requirements.

Supplementary Employment

The figures hitherto presented relate only to employment generated by expenditures under the construction contract. However, as previously noted, employment is affected by other expenditures directly related to specific construction projects. Chief among these is employment in engineering and architectural fields for design and specification preparation and in related activities, such as preliminary surveying and testing and inspection by the architect or sponsor during construction.

For Federal buildings, these activities required an additional expenditure amounting to nearly $7.50 for every $100 of construction cost--$5 for the preparation of designs and specifications, and $2.50 for other activities. These expenditures were estimated to provide about 15 man-hours of employment per $1,000 of construction contract, in addition to the 227 man-hours generated by the construction cost alone.

Chart 3. On-Site Man-Hours of Construction Labor for Each $1,000



Construction Time

Average construction time for the projects surveyed was about a year and a half. Construction time varied on individual projects, however, from 38 weeks on the smallest project to 135 weeks on one of the largest. This increase in construction time with increase in project cost is further illustrated in the following tabulation:

Cost group (thousands)	Average number of weeks required for construction
All groups	73
$500 and under	54
$501 - $1,000	72
$1,001 - $2,500	90
$2,501 - $5,000	98
$5,001 - $10,000	128
$10,001 and over	133

Occupational Employment by Construction Periods

In order to measure the distribution of employment, the construction time for each project was divided into 10 equal periods, and data on the number of man-hours worked were tabulated for each of these periods. This permitted the combination of man-hours for projects of various sizes in order to obtain typical employment patterns as shown in table 8 and chart 3 for all buildings studied. These data as well as those for post offices only show man-hour employment rising from less than 3 percent of total in the first period to more than 14 percent in the peak sixth period, dropping gradually in the next three periods, and dropping sharply in the last period.

The sequence of work by the structural, mechanical, and finishing trades is apparent. Also apparent is a tendency for the work of the smaller, more specialized crafts to be concentrated into smaller periods of time.

Contractor Employment by Construction Period

Man-hour data were also tabulated by tenths of total construction period for each of the major types of contractor (table 9). The data thus distributed may be readily reconciled with the occupational distributions just discussed. It is interesting to note the similarity of the distribution of the general contractor and carpenter man-hours. In each, 63 percent of total man-hours were applied in the first half of the construction period. Once the forms for the concrete frames of the buildings had been substantially completed, general contractor and carpenter man-hour employment dropped to a lower but relatively stable level for the remainder of the period.

Table 8. Percent of On-Site Employment for Federal Office Building Construction in Each Tenth of Total Construction Time, by Occupation, 1959

Occupation	1st tenth	2d tenth	3d tenth	4th tenth	5th tenth	6th tenth	7th tenth	8th tenth	9th tenth	Last tenth
All occupations	2.7	6.4	9.7	11.8	13.0	14.4	13.3	13.8	10.5	4.3
Supervisors	5.3	8.5	9.8	11.7	13.3	12.9	11.6	10.9	9.4	6.6
Professional, technical, and clerical	6.2	10.2	12.1	13.7	13.4	13.0	10.7	8.4	7.2	5.1
Construction trades:										
Carpenters	4.1	11.4	18.6	16.8	12.2	8.4	6.8	8.3	9.2	4.2
Electricians	.4	2.0	5.6	9.4	12.3	14.0	14.1	17.9	17.6	6.6
Plumbers	.7	3.4	7.7	11.6	15.4	16.1	13.8	14.6	11.5	5.2
Bricklayers	(1/)	1.2	3.2	10.9	20.9	32.9	18.3	10.2	1.8	.5
Sheet-metal workers	.1	1.2	2.9	8.3	15.9	17.5	19.2	17.4	12.6	4.8
Operating engineers	13.4	15.0	11.1	10.4	9.8	10.8	10.2	11.1	6.8	1.4
Reinforcing-iron workers	5.2	17.8	22.1	22.6	17.0	8.7	4.0	1.7	.6	.2
Asbestos workers	0	0	.2	4.0	13.9	19.1	18.5	23.0	14.8	6.4
Cement finishers	.8	3.8	8.8	15.8	16.5	13.7	11.4	14.0	11.8	3.4
Painters	.4	.1	.3	2.0	.9	.8	4.8	21.0	47.9	21.8
Plasterers	0	0	0	.2	1.6	10.3	34.1	39.8	12.2	1.7
Lathers	0	(1/)	.5	1.8	5.3	21.6	33.1	28.0	8.9	.8
Structural-iron workers	2.2	5.2	14.8	15.0	18.4	17.1	14.8	7.8	3.0	1.7
Ornamental-iron workers	.1	.2	0	3.2	7.0	27.1	21.7	22.7	14.9	3.2
Elevator mechanics	0	(1/)	.1	3.4	8.9	15.8	22.1	24.9	19.4	5.3
Roofers	.1	1.7	9.0	11.8	13.9	22.6	27.3	11.1	1.9	.6
Tile setters and terrazzo workers	0	0	0	.2	.4	3.0	11.4	36.8	40.0	8.2
Glaziers	0	0	0	0	0	10.6	19.2	24.3	38.0	7.9
Soft floor layers	0	0	0	0	0	0	.4	28.3	47.4	23.8
Laborers	4.1	10.0	14.4	15.2	13.3	12.4	10.3	10.1	6.7	3.5
Helpers and tenders	.9	2.2	2.0	6.4	13.9	21.7	19.7	19.9	10.8	2.5
Truckdrivers	11.5	9.3	11.8	10.8	10.0	8.8	8.3	12.5	10.9	6.0
Watchmen	7.0	9.7	10.5	13.3	13.0	13.4	10.5	9.7	11.1	1.8
Other	8.6	11.9	5.2	5.2	7.8	9.4	13.4	20.8	11.3	6.3

1/ Less than 0.05 percent.

Table 9. Percent of On-Site Employment for Federal Office Building Construction in Each Tenth of Total Construction Time, by Type of Contractor, 1959

Type of contractor	1st tenth	2d tenth	3d tenth	4th tenth	5th tenth	6th tenth	7th tenth	8th tenth	9th tenth	Last tenth
All types	2.7	6.4	9.7	11.8	13.0	14.4	13.3	13.8	10.5	4.3
General	4.3	10.9	16.5	16.5	14.5	12.1	8.3	7.6	6.2	3.1
Special trades:										
Plumbing, heating, and air conditioning	.7	2.7	5.5	9.4	14.2	15.7	16.3	16.8	13.3	5.3
Electrical	.5	2.5	5.9	9.5	12.2	14.0	14.0	17.5	17.1	6.7
Masonry	0	.4	1.1	7.4	19.5	34.7	22.3	12.6	1.5	.5
Plastering and lathing	0	(1/)	.1	.9	3.6	17.1	34.2	36.1	6.8	1.3
Structural and ornamental metal work	3.4	9.6	16.1	15.3	13.5	14.5	11.8	9.1	5.5	1.2
Painting	.1	(1/)	.3	1.9	.9	.7	4.7	21.7	48.1	21.4
Site preparation, excavation, and foundations	31.6	32.4	13.1	12.0	3.7	1.0	1.4	2.5	1.5	.8
Elevator and other equipment installation	0	.5	.1	3.1	8.3	16.1	22.7	25.0	19.6	4.7
Tile and terrazzo work	0	0	0	.2	.3	2.7	11.1	38.0	38.8	9.0
Roofing and sheet-metal work	.1	1.8	6.9	7.5	12.9	24.2	26.6	13.9	4.9	1.2
Other	1.4	3.3	7.9	13.8	11.6	6.5	9.1	17.8	19.4	9.3

1/ Less than 0.05 percent.

Materials Used

Costs of materials represented 53.3 percent of total construction contract value of all projects. This average is affected by the value for the OASI building, which, at 56.4, was among the three highest for individual projects. (It may be recalled that wages as a percentage of cost was lower on this than on any other project.) The average value for post offices only was 50.6, and the median value for all projects and for post offices only was 50.1. Most projects were in a range of 5 percent from the latter figure:

Percent materials cost of total cost	Number of projects
41 - 45	4
46 - 50	7
51 - 55	7
56 - 60	3
61 - 65	1

The difference between the total construction contract cost and the sum of materials and wage costs amounted to 18 percent of the cost of all projects and of post offices only. This represented the total of those overhead costs which cannot be attributed to specific projects (expenses of central office and yard operation, insurance, taxes, etc.) and profit. These two components (overhead costs and profit) could not be separated in this survey.

Table 10 presents the costs of major materials and groups of materials used in each $1,000 of construction of post offices and of all Federal buildings. The groups, and items within the groups, are ranked by their relative importance. The table is perhaps more meaningful if values are reduced to the familiar magnitudes of percentages by shifting the decimal point one place to the left. Thus, the totals for "All products" become 53.3 percent for all buildings and 50.6 for post offices only. These totals include depreciation charges or rental costs for construction equipment used, and costs of the small amounts of supplies consumed. All other items in the table represent materials or fixed equipment incorporated in the structures.

It will be noted that almost all individual materials items show greater percentages for post offices than for all projects, while the reverse is true for equipment items. This reflects the specialized needs of several buildings in the non-post-office portion of the sample. For example, electrical equipment and accessory items constituted 9.7 percent of the total construction cost of all buildings surveyed, but only 5.2 percent of the cost of the post

Table 10. Total Cost of Material Components for Each $1,000 of Federal Building Construction Contract, 1959

Selected products and product groups	All buildings	Post office buildings 1/
All products	$532.50	$506.10
Metal products (except plumbing and heating)	133.30	154.60
Fabricated structural metal products	102.50	121.40
Reinforcing bars and joists	43.30	53.50
Fabricated sheet-metal products	15.10	11.80
Structural steel	13.50	17.20
Metal windows	11.00	13.30
Metal doors and frames	8.80	12.60
Ornamental metal	6.80	5.60
Wire mesh	3.70	6.70
Other fabricated metal products	6.90	8.30
Builders' hardware	6.70	8.10
Other metal products	24.00	25.00
Copper products	8.90	9.60
Galvanized sheet metal	8.10	9.40
Aluminum sheet metal	3.80	1.70
Partitions, lockers, and shelves	1.80	2.50
Stone, clay, and glass products	117.20	129.50
Cement, concrete, and gypsum products	60.80	70.70
Ready-mixed concrete	43.00	43.30
Concrete block	7.60	13.00
Gypsum products	6.30	8.00
Cement	3.00	5.20
Structural clay products	18.50	19.60
Brick	12.20	13.90
Structural glazed tile	2.70	2.30
Ceramic tile	1.50	2.10
Other stone, clay, and glass products	37.90	39.20
Fiber glass products	14.80	10.50
Marble and other cut stone	9.60	12.50
Window glass	3.00	4.80
Asphalt tile	2.70	4.00
Sand and gravel	2.20	3.60
Crushed rock and other aggregate	1.90	2.10

See footnote at end of table.

Table 10. Total Cost of Material Components for Each $1,000 of Federal Building Construction Contract, 1959--Continued

Selected products and product groups	All buildings	Post office buildings 1/
Electrical equipment, fixtures, and wire	$96.90	$51.70
Lighting fixtures	30.80	22.80
Conduit	18.00	7.80
Switchboards and panelboards	17.30	8.90
Wire and cable	7.90	3.30
Current-carrying wiring devices	4.20	1.40
Noncurrent-carrying wiring devices (other than conduit)	4.00	1.60
Program systems	3.50	1.50
Intercom and fire alarm systems	3.30	1.00
Transformers	2.80	3.40
Electric generating units	2.30	0
Heating, ventilating, and air-conditioning equipment	65.50	48.60
Air-conditioning equipment	34.70	23.30
Radiators, convectors, and boilers	8.10	7.00
Temperature controls	7.90	7.90
Blowers, exhaust, and ventilating fans	4.40	1.80
Oil burners and warm air furnaces	3.50	2.70
Pumps	2.50	2.00
Storage tanks	1.80	2.10
Fixed building equipment (other than plumbing, heating, or electrical)	42.50	29.30
Elevators and escalators	26.40	17.80
Laboratory equipment	7.50	0
Mailboxes	3.60	8.90
Plumbing products	27.40	37.90
Steel and galvanized pipe	10.60	11.60
Plumbing fixtures	7.80	13.30
Cast-iron pipe	4.80	7.90
Valves and specialties	2.80	3.60
Construction equipment (depreciation or rental)	19.10	11.70
Lumber products	17.60	27.50
Millwork	8.20	14.60
Rough and dressed lumber	6.70	10.70

See footnote at end of table.

Table 10. Total Cost of Material Components for Each $1,000 of Federal Building Construction Contract, 1959--Continued

Selected products and product groups	All buildings	Post office buildings 1/
Paints and other chemical compounds	$5.50	$5.70
Paints	2.40	3.30
Petroleum products	4.70	7.20
Asphalt and tar pitches	1.30	2.00
All other groups	2.80	2.30

1/ With space for other Federal activities.

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

office buildings. 13/ The former figure is another reflection of the peculiar requirements of the OASI building, in which these electrical items made up nearly 16 percent of total cost.

The most important broad materials category, "Metal products," accounted for over 15 percent of the total cost of post offices. However, this by no means represents the total contribution of the metalworking industries to this construction, since it excludes the metal products shown separately in the equipment categories. The items used in structural framing--"Reinforcing bars and joists," "Structural steel," and "Wire mesh"--made up half of the "Metal products" group for post offices, and metal doors and windows, about one-sixth.

By far the largest single item among "Stone, clay, and glass products" was ready-mixed concrete, which, at 4.3 percent, accounted for more than one-third of the value of the group. This material constituted the frames and floors of most of the buildings. The small amounts of the raw materials of concrete separately shown--cement, sand and gravel, and aggregate--were used in specialized applications such as terrazzo work. Masonry units--brick, block, and structural tile--which formed much of the exterior walls of the buildings surveyed are all included in "Stone, clay, and glass products" and together made up about a fourth of the group.

Electrical equipment and accessories accounted for 5.2 percent of the total cost of the post offices, and almost half of this was for lighting fixtures alone.

The proportion, 4.9 percent, shown for the group "Heating, ventilating, and air-conditioning equipment" should not be regarded as completely covering materials requirements for this class of work. The extensive duct work needed for air exchange throughout a building was included in "Fabricated sheet-metal products" and in "Galvanized sheet-metal" under the general "Metal products" group.

Other major materials groups were "Plumbing products," representing 3.8 percent of total post office cost; "Fixed building equipment," 2.9 percent; and "Lumber products," 2.8 percent. The current low level of utilization of the last-named was further emphasized by the fact that most "Rough and dressed lumber," comprising nearly 40 percent of the group's total, actually did not represent the value of lumber incorporated in the building structure, but instead, represented the value of lumber used up in form building.

13/ Each "percent of construction contract" represents about $750,000 of annual expenditures at the current annual rate of Federal office building construction (e.g., $10 million of metal products is represented by the 13.3 percent).

Changes in Materials

A comparison of post office construction costs shown in the present study and in the previously mentioned study made about 20 years ago indicates that the proportion all materials represent of total construction cost has changed only moderately between the two periods, decreasing from 52 to 49 percent, excluding equipment-use costs, which could not be segregated in the former survey. 14/ The proportion that individual materials represent of total materials cost, however, shows very marked changes, reflecting not only different materials usages for similar purposes, but also changing building standards and requirements, and differential price movements. The tabulation on the following page presents these changes for a number of groups of materials. Data from the current survey are shown for all projects studied, as well as for post offices only. Although little is known of the characteristics of the projects in the older survey, it is probable that they are more nearly comparable with the post office group of the current survey than with the overall group.

These comparisons illustrate several basic shifts which have occurred over the years. One of these is the appearance of new types of fixed equipment accepted as standard in modern buildings. Thus, the increase in the heating and ventilating category reflects the air conditioning which is almost universal in modern office buildings. This addition of new equipment has the effect of reducing the relative importance of older materials, even though their volume of use is still extensive. Thus, although brick was the common exterior material in the current study, it accounted for less than 4 percent of total material cost, as compared with more than 8 percent in the earlier survey.

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, the procession of concrete mixer trucks during a pour at a construction job is a common sight. This accounts for the decline in the total for cement, sand and gravel, and crushed stone (the raw materials of concrete) from 14 percent of total materials cost to 2 percent, and in part for the increase in concrete products from 4 to 12 percent.

14/ See footnote 6, this bulletin. A decrease was also noted in the percentage of total cost going to on-site labor--from 31 to 29 percent. The residual costs, representing other expenses and profit, thus increased from 17 to 22 percent over the period. It is likely that a significant part of this increase is due to increases in such overhead costs as those for social security and other taxes, contributions to welfare programs and other fringe benefits, modern recordkeeping, and charges arising from wider equipment usage.

The rise of new types of materials, not necessarily serving entirely new purposes, and the decline of more traditional materials are reflected in the increases for glass and metal doors, sash, frames, and trim and the decrease in forest products. For example, 20 years ago, fiber glass was a novel building material; today, it is the preferred material for several acoustical and thermal applications.

Materials group 1/	Percent of total materials cost		
	Twenty years ago	Current study	
		All projects	Post offices
All materials	100.0	100.0	100.0
Iron and steel and their products	36.8	42.1	48.0
Structural and reinforcing steel	11.9	11.0	14.3
Plumbing supplies and fixtures	8.2	5.3	7.5
Heating and ventilating equipment 2/	7.4	12.8	9.8
Hardware	2.6	1.3	1.6
Metal doors, sash, frames, and trim	2.3	3.8	5.2
Wire and wire works products	.4	.7	1.4
Other products of iron and steel	4.0	7.2	8.1
Stone, clay, and glass products	33.8	21.9	25.3
Cement	8.3	.6	1.1
Brick, hollow tile, and other clay products	8.2	3.3	3.5
Sand and gravel	4.3	.4	.7
Marble, granite, slate, and other stone products	4.1	1.9	2.5
Concrete products	3.8	10.0	11.5
Wall plaster and wall board	1.9	1.2	1.6
Tiling, floor and wall, and terrazzo	1.3	.3	.5
Crushed stone	1.0	.4	.4
Glass	.9	3.5	3.2
Forest products	16.2	3.5	5.7
Lumber and timber	8.5	.7	1.2
Planing mill products	7.7	.7	1.1
Electrical wiring, fixtures, and supplies	4.8	18.4	10.5
Roofing, roof insulation, waterproofing, and caulking	2.8	.9	.9
Paints and varnishes	1.2	.7	1.1
Copper and sheet metal	.8	2.7	2.6
Other	3.6	9.8	6.0

1/ Products were grouped to conform with previous study.
2/ In current study, includes air-conditioning equipment.

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

Comparisons With School and Highway Construction

A comparison of requirements for the three 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 considerable variation in requirements among the affected industries:

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

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."

In analyzing this table, 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 as between highways and the buildings segments reflect differences in the construction process. In the case of highways, many 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 place by hand 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 of extracting rock, sand, and gravel.

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

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

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 quite 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 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 went to equipment operators (excluding truckdrivers), as compared with less than one-thirtieth on building construction. Truckdrivers received over 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 highway than in building construction, although the data available do not afford a precise comparison.

Appendix A. Scope and Method of Survey

Characteristics of the Universe and Selection of the Sample

This study is an attempt to measure labor requirements for construction of the types of general administrative buildings needed for nonmilitary activities of the Federal Government. With some exceptions, such buildings are constructed under the authority of the Public Buildings Service of the General Services Administration. The survey was based, therefore, on a sample of office building projects completed, or substantially completed, by PBS during fiscal 1960. The sample of 22 projects (table A), representing about half of the universe, was drawn with consideration to type of project (whether primarily post offices, general Federal office buildings, office-laboratories, or unique projects), total construction contract cost, and broad regional location. 15/ Sampling within the cells was not uniform, owing to the desirability of representing some cells with only one project, and variable weights were therefore assigned to the sample projects. Unless otherwise specified, all data presented in this report are based on weighted data.

It should be noted that the study is not representative of all construction under PBS, which from time to time is responsible for many types of construction, including hospitals, colleges, and warehouses.

Man-Hour Estimates

Estimates of total man-hour requirements in this study are a combination of data resulting from two different procedures. For the on-site activities, which are segregated and specific, direct primary labor data were available. For all other activities, however, such as the manufacture and transportation of building materials, which are in their nature diffuse and nonspecific with respect to a particular project, an estimating procedure was used. The two methods are described below.

15/ 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; West--Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Table A. Projects Included in Survey of Labor Requirements for the Construction of Federal Office Buildings, 1959

Type of building	Construction contract cost 1/ (thousands)	Floor area (1,000 square feet)	On-site man-hours per $1,000 cost	Percent of total cost		Weight 2/	Construction	
				On-site wages	Materials		Started	Completed
All buildings 3/	$60,446	3,261	97.1	29.0	53.3	41	November 1957	November 1960
Headquarters, Bureau of Old-Age and Survivors Insurance, Baltimore, Md.	$24,172	1,426	83.4	25.8	56.4	1	November 1957	June 1960
Communicable Disease Center, Atlanta, Ga.	9,965	390	101.0	29.6	52.8	1	April 1958	July 1960
Federal office buildings:								
Albuquerque, N. Mex.	4,166	280	88.1	28.2	58.9	1	March 1958	April 1960
Huntington, W. Va.	2,665	138	107.8	35.2	48.0	1	April 1958	December 1959
Mt. Hope, W. Va.	592	30	124.2	37.1	53.9	1	June 1958	November 1959
Post office buildings: 4/								
Omaha, Nebr.	7,226	415	93.0	30.3	52.1	1	April 1958	November 1960
Kansas City, Kans.	1,904	82	107.6	34.0	45.5	2	March 1958	November 1959
Burlington, Iowa	1,105	48	120.7	36.8	55.6	2	March 1958	November 1959
Lafayette, La.	1,005	50	99.2	27.8	50.1	3	October 1958	June 1960
Biloxi, Miss.	918	44	102.0	28.5	61.1	3	April 1958	November 1959
Leavenworth, Kans.	857	36	88.5	29.7	44.5	2	March 1959	July 1960
Abingdon, Va.	532	33	150.7	31.7	48.2	3	November 1958	February 1960
Redwood Falls, Minn.	397	17	96.2	24.3	52.0	2	June 1958	August 1959
Durham, N.H.	371	22	113.6	36.7	42.6	1	May 1958	June 1959
McKinney, Tex.	317	19	133.1	35.2	53.4	3	May 1958	June 1959
Marshfield, Mo.	286	13	103.7	31.3	51.1	2	June 1958	July 1959
Lafayette, Tenn.	266	12	107.6	28.7	45.0	3	September 1958	October 1959
Manning, S.C.	252	16	144.0	24.1	49.7	3	June 1958	July 1959
Burlington, Vt.	2,357	136	109.9	31.7	45.9	1	June 1958	March 1960
Laboratory office:								
Morris, Minn.	507	22	100.1	26.3	46.2	1	August 1958	November 1959
Oxford, Miss.	471	27	108.6	22.9	53.4	2	August 1958	September 1959
Riverside, Calif.	116	7	109.8	38.9	41.4	2	November 1958	August 1959

1/ Includes net effect of change orders; i.e., modifications of original plans or specifications subsequent to contract award.
2/ Number of projects represented by sample project.
3/ Cost and area figures unweighted; all others weighted.
4/ With space for other Federal activities.

On-Site Man-Hours

With minor exceptions, all Federal construction is subject to the provisions of the Davis-Bacon Act, which requires that wages paid to mechanics and laborers must be at rates not lower than those prevailing on similar construction in the locality. By administrative regulation, each contractor on Federal construction is required to file copies of his weekly project payroll with the Federal agency supervising the project. These payrolls are thus a primary source of data on production man-hours worked, and wages paid, on a project. In the current study, the payroll files for the sample projects were made available for data transcription through the cooperation of the PBS and its regional offices.

These payrolls were the basic source of the on-site labor data for the study. However, certain classes of on-site labor are not required to be reported on the weekly payrolls. These include salaried employees (e.g., superintendents, engineers, and clerks) and self-employed contractors. Moreover, the processing of the payrolls for this study developed an occasional question as to completeness or meaning. This additional information or clarification was obtained by BLS field representatives in the course of their visits to each contractor for materials data. Where these supplementary data were obtained in summary form only, they were converted to the detail required on a judgment basis.

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 the contractors were in purchasers' value, the reduction to producers' value made it consistent with Census data published on these various components. These figures on average dollar value, stated in producers' value of each construction material per $1,000 of contract value were necessary for each of the succeeding steps.

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

Primary Distribution Industries Employment

Man-hours in the distribution industries (trade, transportation, warehousing, freight forwarding, etc.) at 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 as 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 the 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, the man-hours resulting from public building construction were found by multiplying the average value of each construction component by a ratio of manufacturing man-hours to $1,000 of production. 17/

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 calculate all of 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 and then grouped into industry classifications which were consistent with the interindustry study's 57-sector aggregation. This gave the value of construction goods stated in 1947 prices, for each interindustry sector. Each of these figures was in turn

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

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

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 inflated to 1959 prices (the year consistent with the bill of materials).

The sector contributions to each of the separate construction items were summed to obtain the 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 the 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 Federal building 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 new Federal building construction did not include all such employment. The technique used for the off-site segment covers only employment generated by direct purchases of materials and supplies and implicit in the 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) employment generated by purchases of movable furniture and equipment; (4) the "multiplier" effect of the respending of wages and profits; and (5) construction and equipment of new production facilities, if needed to supply construction materials.

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.

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