

tent and the undertakings free from political and partisan interference, construction of new projects by day-labor is likely to be high in cost and low in quality.

#### REFERENCES

- Federal Legislation and Rules and Regulations Relating to Highway Construction Administered by the Public Road Administration. Hearings before the Committee on Roads, House of Representatives, Seventy-Fourth Congress, First Session, January 22, 23, 1935
- Transactions of the American Society of Civil Engineers, 1919-1920.
- Proceedings, Association of Highway Officials of the North Atlantic States—1934.
- American Association of State Highway Officials.
- Highway Administration and Finance, Agg and Brindley, 1927.
- American Road Builders' Association, Proceedings, 1935-1936.
- Estimates and Costs of Construction, Frank Whitworth Stubbs, Jr.—1938.
- Economics of Construction Management, J. L. Harrison—1932.
- Force Account on Unit Price Construction Contract—A Report by the Bureau of Municipal Research of Philadelphia—1928.
- The Associated General Contractors of America.
- Bureau of Contract Information, Inc.
- Public Works Magazine

## WAGE EARNER EMPLOYMENT RESULTING FROM HIGHWAY CONSTRUCTION

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#### SYNOPSIS

Employment data are reported from 508 highway projects built under PWA allotments costing a total of \$23,101,018. Most of the work was by contract.

It was found that payrolls of on-site wage earners exclusive of administrative and supervisory employees accounted for 27.85 per cent of the cost on grading and drainage, 19.94 per cent on bituminous paving, 25.09 per cent on concrete paving and 25.78 per cent on bridges. The overall percentage for wages in this class was 24.91. Percentage of the total for materials was 45.1 and for other costs and profits was 29.99.

Additional wage employment was produced away from the site of the work in the production and delivery of materials, and in repairs and replacements of the construction machinery and equipment used. The ratio of off-site to on-site man-hours of work was found to be 1.09 for all types of work. This ratio was 0.91 on grading and drainage, 0.96 on bituminous paving, 1.16 on concrete paving and 1.43 on bridges.

Before considering the relationship between expenditures on highway construction and resulting employment, it is important to note the governing background of our present highway resources and the type of improvement which they need. The highway system, improved progressively from year to year for almost a generation, has reached a high state of development. Simultaneous increase in the traffic burden has been constantly raising the standards which must be met for fully satisfactory

service. The current need therefore is quite different from what it was a few years ago. The basic work of creating a paved highway system, to overcome its imperfections and to keep pace with future developments in our vehicles and their manner of use.

Part of this unfinished business is the improvement of minor roads, to extend year-round highways to those not now reached by them. This is important, and doubtless will receive full attention. While the less expen-

sive types of surfacing will be used, application will be made of the lessons in design and in construction methods learned in development of the primary road system.

Another part of the unfinished business, on which a start was made during the past decade, is the improvement of State and Federal highway systems to fit the traffic load which has developed since many of the component parts were planned. Loads have become heavier, vehicle use has increased, and customary speeds of all types of vehicles have increased greatly. At the same time, advances in construction methods and machinery have permitted use of design features which were prohibitive in cost or otherwise unfeasible 10 to 15 years ago. Increased knowledge on the part of highway and traffic engineers has produced other design features which were unknown or had reached only elementary form at the same recent period.

Under these circumstances, the post-war highway problem will be to improve a mature system for greater traffic capacity, greater safety, reduced urban congestion, and greater comfort of users. The projects needed for these accomplishments will require careful selection according to relative urgency, careful and competent engineering design and construction by field organizations qualified for exacting work.

Work of this nature requires materials, and requires machinery and equipment. Consequently payrolls at the site can be only one among several major parts of the contract price, at the same time, site employment is accompanied by extensive off-site employment.

A guide to employment on work of this type during the immediate post-war period is to be found in PWA projects carried out during 1939.<sup>1</sup> These were done for the most part

<sup>1</sup> Tabulations were made by the Bureau of Labor Statistics from reports on material purchases, site pay rolls and man-hours of site employment made to it by the contractors and subcontractors.

A study of material purchases, on-site employment and off-site employment on earlier Federal road projects financed by the Emergency Relief Appropriation Acts of 1935 and 1936 is reported in Labor Requirements in Road Construction, by Lillian Lunenberg, *Monthly Labor Review*, April 1939

under private contracts awarded by the political units to which the PWA allotments were made. Further improvements in machinery and in construction methods are to be expected, as are also further changes in design standards, but in all these respects the period shortly following the war is likely to resemble that which preceded. Accordingly adjustment for intervening changes in the pattern of work seems unjustified and has not been attempted.

The projects tabulated were in 4 groups—grading and drainage, concrete paving, bituminous paving, and bridges. There were 508 contracts included, all below \$250,000, for a total contract price of approximately \$23,100,000 and an average contract price of approximately \$45,500 (Table 1)

TABLE 1  
CERTAIN PWA HIGHWAY CONTRACTS  
EXECUTED IN 1939, BY TYPE OF WORK

Type of work	Number of contracts	Total amount of contract	Average amount of contract
Total	508	\$23,101,018	\$45,474
Grading and drainage	144	6,191,906	42,999
Bituminous paving	98	5,518,623	56,261
Concrete paving	19	1,081,989	56,947
Bridges	247	10,318,500	41,785

Source Unpublished tabulations of Bureau of Labor Statistics

Distribution among the three major classifications of the contract price, shown in Table 2, is remarkably uniform for these four types of work. Except for bituminous paving, site payrolls constituted 25 to 28 percent of the entire price. For bituminous paving the payrolls were only 20 percent, but this lower figure results from the low hourly earnings on this work, which was carried out principally in areas of low wage rates. Since the inexpensive "low" types of bituminous paving are constructed largely in such areas, this difference is real and not merely the result of biased geographical distribution of the sample. If adjustment for average hourly earnings equal to those in grading and drainage were justified, it would move the payroll percentage up to the range of the other projects.

It is noteworthy that this distribution agrees so closely with that of \$263,000,000 Federal and State highway work of all types carried out during 1933 and 1934 and summarized in

Table 4 of "An Economic and Statistical Analysis of Highway—Construction Expenditures"<sup>2</sup>. This table shows, for all types of work combined, 24.39 percent of contract price required for pay rolls, 48.75 percent for materials, and 26.86 percent remaining for other costs and profits. The primary reason for this close agreement is that reductions in unit costs resulting from use of improved machinery and methods have been accompanied by design changes and changes in hourly earnings. While it is the opinion of some engineers that this uniformity will continue for many years, circumstances can readily be contemplated in which this would not be the case. The principal of these are divergent changes in the prices of various materials, and divergent changes between wage levels and material prices as a whole.

expenditures by the sponsoring units for engineering and designing services, administrative costs and purchase of right-of-way.

On-site employment and hourly earnings are also shown in Table 2. The projects were tabulated by size as well as by type, and were divided into those below \$50,000, those from \$50,000 up to \$100,000 and those from \$100,000 up to \$250,000. These separations are omitted from the accompanying tables. For each type of work except bridges, average hourly earnings were almost independent of the size of the contract, the differences being scarcely more than those resulting from different geographical distribution of the work and hence different local wage levels. For bridges, however, hourly earnings increased consistently with the size of the contract because of changes in the character of the project. A

TABLE 2  
PAYROLL AND MATERIAL EXPENDITURES, SITE EMPLOYMENT, AND HOURLY EARNINGS, ON CERTAIN PWA HIGHWAY CONTRACTS EXECUTED IN 1939, BY TYPE OF WORK

Type of work	Dollar expenditures			Per cent of total			Man hours of site employment	Average hourly earnings
	Payrolls	Materials	Other costs and profits	Payrolls	Materials	Other costs and profits		
All types	\$5,754,801	\$10,418,341	\$6,927,876	24.91	45.10	29.99	9,145,767	62.9
Grading and drainage	1,724,635	2,388,402	2,078,889	27.85	38.67	33.67	2,829,493	61.0
Bituminous paving	1,099,411	2,690,850	1,723,362	19.94	48.80	31.26	2,344,040	46.9
Concrete paving	271,433	449,304	361,192	25.09	41.63	33.38	385,272	70.5
Bridges	2,659,322	4,889,725	2,764,453	25.78	47.41	26.80	3,686,952	74.1

Source: Unpublished tabulations of Bureau of Labor Statistics

The information obtained then is suitable to 1939, and to any other period presenting a similar technical and economic pattern. If post-war wage and price levels are different, as is not unlikely, but there is no change in the internal pattern, the general picture will remain valid but hourly earnings and the project cost for any given unit of employment will be changed correspondingly.

Hours and years of employment for wage earners on and off the site, and the contract cost per unit of such employment, have been computed or estimated. There is additional employment for salaried employees in all stages of operations, but estimates of this have been omitted and this report deals with employment of wage earners only. Cost figures are for construction contracts only, exclusive of

\$200,000 grading job is likely to be similar to a \$25,000 grading job in its characteristics, but a \$200,000 bridge is likely to be quite different from a \$25,000 bridge and to require a larger proportion of non-local specialized workmen.

For grading and draining, site wages were almost 28 percent of contract price. Earnings of 61.0 cents per hour would have given a weekly wage of \$20.74 and an annual wage of \$1,037, on the basis of an average work week of 34 hours (with 15 per cent of scheduled time lost for bad weather and other causes) and a work year of 50 weeks. It is realized of course that in most parts of the country the work year is much shorter than 50 weeks, but a man-year of employment is a standard unit even though divided among two or more workers. Three workers dividing two man-years of employment on highway work would need only one additional man-year on other work to be fully employed. For a million dollars of grading

<sup>2</sup> *Public Roads*, June 1935. By C. F. Rogers, R. E. Hertel and R. W. Kruser.

contracts, 457,000 man-hours or 269 man-years of site employment were provided, at a con-

was \$2.88 per man-hour and \$4,888 per man-year. Average hourly earnings were 66.0 cents on the smallest contracts, under \$50,000, were 76.0 cents on contracts from \$50,000 up to \$100,000, and were 83.5 cents on the contracts from \$100,000 up to \$250,000.

TABLE 3  
SITE EMPLOYMENT PROVIDED AND COST PER UNIT OF EMPLOYMENT ON CERTAIN PWA HIGHWAY CONTRACTS EXECUTED IN 1939 BY TYPE OF WORK

Type of work	Site employment per \$1,000,000 of contracts		Contract cost per unit of site employment	
	Man-hours	Man-years	Per man-hour	Per man-year
All types	395,900	232 90	\$2 53	\$4,294
Grading and drainage	457,000	268 80	2 19	3,720
Bituminous paving	425,100	250 05	2 35	3,999
Concrete paving	356,100	209 45	2 81	4,774
Bridges	347,800	204 60	2 88	4,888

Source Unpublished tabulations of Bureau of Labor Statistics

Employment mentioned thus far has been only that of wage earners at the construction site, but even more wage employment is produced away from the site. This is in the production and delivery of materials and in repairs and replacements to offset the wear and deterioration of the construction plant.

An approximate distribution of the materials used in the different types of work is given in Table 4. The principal of these were cement, iron and steel products, aggregates, petroleum products, bituminous paving mate-

TABLE 4  
MATERIAL PURCHASES PURCHASED AND EQUIPMENT EXPENDITURES PER MILLION DOLLARS OF CONTRACT ON CERTAIN PWA HIGHWAY CONTRACTS EXECUTED IN 1939, BY TYPE OF WORK

Expenditures	Type of work				
	All types	Grading and drainage	Bituminous paving	Concrete paving	Bridges
Material purchases					
Total	\$451,000	\$385,700	\$495,200	\$415,300	\$474,100
Cement	65,200	35,100	39,600	152,800	91,000
Iron and steel products	74,000	67,500	36,600	48,200	168,300
Lumber	27,600	27,000	16,300	5,400	70,700
Paving materials and mixtures	32,800	10,800	132,200	32,800	8,100
Petroleum products	69,900	78,000	78,200	17,900	20,800
Sand, gravel, crushed stone	70,700	50,100	97,600	91,800	66,800
All other	110,800	117,200	94,700	66,400	48,400
Equipment repairs and replacements	164,900	184,600	171,900	183,600	147,400

Source Unpublished tabulations of Bureau of Labor Statistics.

tract cost of \$2.19 and \$3,720 each, respectively (Table 3).

For bituminous paving, earnings were 46 9 cents per hour, \$15 95 per theoretical work week, and \$797.50 per year. The site employment provided per million dollars of contracts was 425,100 man-hours, or 250 man-years, and the contract cost for these was \$2 35 and \$3,999.

Earnings on concrete paving were considerably higher—70.5 cents per hour, \$23.97 per week, and \$1,198 per year. Employment per million dollars of contracts was 356,100 man-hours or 209 man-years, and contract cost for each of these units of employment was \$2 81 and \$4,774.

Earnings were highest on bridges—74.1 cents per hour, \$25.19 per week and \$1,260 per year Contract cost of site employment

rials, and lumber. Iron and steel products included culverts, reenforcing steel and many other items, and also a large tonnage of structural steel for some of the bridges Petroleum products were mainly fuel and lubricants for the construction machinery. It should be noted that some of the largest purchases were of materials for which a considerable part of the cost is distributed in non-wage channels For these, a considerable part of the factory selling prices must be paid by the producer or by his sources of material in interest on the large capital investment necessary and in royalties to the owners of natural resources used Such payments do not result in wage employment directly, but only after investment or consumption expenditures by the recipients. Indirect and uncertain employment of this nature has been omitted in the

computations. Employment in production and delivery of materials is therefore proportionately lower than in building construction, where such materials are a smaller part of the total.

It will also be noted that materials of each classification are used to some degree on all types of work. While each contract was

adjoining older pavement, and other use of bituminous materials, both grading and paving commonly included culverts; and other departures from the strict classifications occurred.

Table 5 shows the direct and indirect man-hours of off-site employment used in the supply of materials. As would be expected, it is highest for bridges and lowest for grading and

TABLE 5  
WAGE EMPLOYMENT IN THE MANUFACTURE AND DISTRIBUTION OF MATERIALS AND OF EQUIPMENT EXPENDITURES PER MILLION DOLLARS OF CONTRACTS ON CERTAIN PWA HIGHWAY CONTRACTS EXECUTED IN 1939, BY TYPE OF WORK

Type of purchase	All types		Grading and drainage		Bituminous paving		Concrete paving		Bridges	
	Man-hours	Man-years	Man-hours	Man-years	Man-hours	Man-years	Man-hours	Man-years	Man-hours	Man-years
<b>Materials</b>										
Total	329,000	164.50	280,800	140.40	325,300	162.65	312,000	156.00	392,400	196.20
Cement	40,000	20.00	21,500	10.75	24,300	12.15	93,700	46.85	55,800	27.90
Iron and steel products	55,900	27.95	50,900	25.45	27,600	13.80	36,400	18.20	127,000	63.50
Lumber	32,900	16.45	32,200	16.10	19,500	9.75	6,400	3.20	84,400	42.20
Paving materials and mixtures	10,300	5.15	3,400	1.70	41,400	20.70	10,300	5.15	2,500	1.25
Petroleum products	21,900	10.95	24,500	12.25	24,500	12.25	5,600	2.80	6,500	3.25
Sand, gravel, crushed stone	84,400	42.20	59,800	29.90	116,500	58.25	109,500	54.75	79,700	39.85
All other	83,800	41.90	88,500	44.25	71,500	35.75	50,100	25.05	36,500	18.25
<b>Equipment repairs and replacements</b>	122,200	61.10	136,800	68.40	127,400	63.70	136,000	68.00	109,200	54.60

Source: Unpublished tabulations of Bureau of Labor Statistics.

TABLE 6  
WAGE EMPLOYMENT PER MILLION DOLLARS OF CONTRACTS AND CERTAIN RATIOS FOR CERTAIN PWA HIGHWAY CONTRACTS EXECUTED IN 1939, BY TYPE OF WORK

Type of employment	Wage employment per million dollars of contracts, by type of work									
	All types		Grading and drainage		Bituminous paving		Concrete paving		Bridges	
	Man-hours	Man-years <sup>1</sup>	Man-hours	Man-years <sup>1</sup>	Man-hours	Man-years <sup>1</sup>	Man-hours <sup>1</sup>	Man-years <sup>1</sup>	Man-hours	Man-years <sup>1</sup>
Total	847,100	423.55	874,600	437.30	877,900	438.95	804,100	402.05	849,500	424.75
On-site	395,900	197.95	467,000	233.50	425,100	212.55	356,100	178.05	347,800	173.90
Off-site	451,200	225.60	407,600	203.80	452,800	226.40	448,000	224.00	501,700	250.85
Materials	329,000	164.50	280,800	140.40	325,300	162.65	312,000	156.00	392,400	196.20
Construction equipment	122,200	61.10	136,800	68.40	127,400	63.70	136,000	68.00	109,200	54.60
Contract cost per man-hour	\$1.18		\$1.14		\$1.14		\$1.24		\$1.18	
Contract cost per man-year		\$2,181		\$2,094		\$2,099		\$2,307		\$2,196
Ratio of off-site to on-site man-hours										
Total off-site	1.14		0.91		1.07		1.26		1.44	
Materials	0.83		0.61		0.77		0.88		1.13	
Construction equipment	0.31		0.30		0.30		0.38		0.31	

<sup>1</sup>A man-year has been computed as 1,700 man-hours for on-site employment, 2,000 man-hours for off-site employment; and a weighted average of these 2 figures for total employment.

Source: Unpublished tabulations of Bureau of Labor Statistics.

primarily for a single type of work, in many cases it included supplementary work as well. Thus bridge contracts commonly included grading and paving of approaches, as well as the finish surface of the bridge floor itself; concrete paving commonly included some type of bituminous paving of approaches at intersections, perhaps some bituminous patching of

drainage. The composite for all types of work in the proportions in which they were distributed here is approximately 0.83 hours for production and distribution of materials to each hour at the site. Man-years of off-site employment have been computed at 2,000 hours each—50 weeks of 40 hours.

Equipment wear on highway work is severe,

and of course it is necessary for the contractors to maintain their plants in order to continue in business. Repairs are needed from time to time, as well as preventive maintenance to replace parts before they cause breakdowns or cut down production. In addition, machines are completely rebuilt or replaced when certain stages of deterioration are reached, and machines are also replaced because of obsolescence. A good measure of these expenditures is given in a study made by the Bureau of Public Roads, *An Economic and Statistical Analysis of Highway-Construction Expenditures*, to which reference has already been made. This showed that 55 percent of the contractors' margin for overhead and profit was required for repairs and depreciation of equipment. Depreciation charges are converted into employment through the purchase of replacement equipment. While the purchases take place somewhat irregularly, on a large program carried out by many contractors, total purchases are likely to be very close to total depreciation. Accordingly purchases of equipment and of repair parts and the resulting wage employment have been estimated as shown in Tables 4 and 5.

Total wage employment resulting from contract expenditures of \$1,000,000 as given in Table 6 is 847,100 hours. Of this total, there are approximately 1.14 off-site man-hours for each hour worked at the site. The range between the different types of work is not great; the maximum figure of 877,800 which is for bituminous paving is only 9 per cent greater than the minimum figure of 804,100 for concrete paving. The differences between types in the individual subdivisions of employment tend to compensate when these subdivisions are added. The cost per man-hour ranges from approximately \$1.14 in grading and drainage to approximately \$1.24 in concrete paving. Average cost per man-year ranged from \$2,094 for grading and drainage to \$2,307 for concrete paving, with an average of \$2,181. These figures are not cheap, but they measure the cost of employment resulting from permanent and valuable improvements, and the wage payments are distributed among workers in heavy industries, basic materials industries and complicated manufacturing, as well as among the workers at the construction site.

## CURRENT AND POST-WAR APPLICATION OF ROAD LIFE DATA

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### SYNOPSIS

The problem of determining which roads and how much mileage should comprise our state highway systems is the essence of efficient administrative planning. One of the basic items involved in arriving at the size of a state road system is the amount of revenue available. Next, the annual expenditure requirements upon existing roads of each surface type must be estimated closely. The relationship between expenditure requirements and anticipated revenue will then enable the administrator to determine the maximum number of miles which can be constructed and efficiently operated. This involves the use of a system of priorities in the selection of new highway designations, and in the selection of projects for the improvement and maintenance of the existing highway system.

Road life data are of material assistance to the highway administrator in making new designations and in selecting projects for new construction. When a mile of new road is completed, there is likely to be a strong temptation to regard it as a permanent improvement and to move on to the next mile to be built. Actually that mile begins to be a definite expense from the moment of its completion, and this expense continues and normally increases each year until finally