

7
25
.26
1

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT

26

**DEVELOPMENT OF UNIFORM PROCEDURES
FOR ESTABLISHING CONSTRUCTION
EQUIPMENT RENTAL RATES**

NAS-NRC

DEC 13 1966

LIBRARY

HIGHWAY RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

HIGHWAY RESEARCH BOARD 1966

Officers

J. B. McMORRAN, *Chairman*
EDWARD G. WETZEL, *First Vice Chairman*
DAVID H. STEVENS, *Second Vice Chairman*
D. GRANT MICKLE, *Executive Director*
W. N. CAREY, JR., *Deputy Executive Director*

Executive Committee

REX M. WHITTON, *Federal Highway Administrator, Bureau of Public Roads (ex officio)*
A. E. JOHNSON, *Executive Secretary, American Association of State Highway Officials (ex officio)*
LOUIS JORDAN, *Executive Secretary, Division of Engineering, National Research Council (ex officio)*
WILBUR S. SMITH, *Wilbur Smith and Associates (ex officio, Past Chairman 1964)*
DONALD S. BERRY, *Chairman, Department of Civil Engineering, Northwestern University (ex officio)*
E. W. BAUMAN, *Managing Director, National Slag Association*
MASON A. BUTCHER, *County Manager, Montgomery County, Md.*
J. DOUGLAS CARROLL, JR., *Executive Director, Tri-State Transportation Committee, New York City*
C. D. CURTISS, *Special Assistant to the Executive Vice President, American Road Builders' Association*
HARMER E. DAVIS, *Director, Institute of Transportation and Traffic Engineering, University of California*
DUKE W. DUNBAR, *Attorney General of Colorado*
JOHN T. HOWARD, *Head, Department of City and Regional Planning, Massachusetts Institute of Technology*
EUGENE M. JOHNSON, *Chief Engineer, Mississippi State Highway Department*
PYKE JOHNSON, *Retired*
LOUIS C. LUNDSTROM, *Director, Automotive Safety Engineering, General Motors Technical Center, Warren, Mich.*
BURTON W. MARSH, *Executive Director, Foundation for Traffic Safety, American Automobile Association*
OSCAR T. MARZKE, *Vice President, Fundamental Research, U. S. Steel Corporation*
J. B. McMORRAN, *Superintendent of Public Works, New York State Department of Public Works*
CLIFFORD F. RASSWEILER, *President, Rassweiler Consultants, Short Hills, N.J.*
T. E. SHELBURNE, *Director of Research, Virginia Department of Highways*
DAVID H. STEVENS, *Chairman, Maine State Highway Commission*
JOHN H. SWANBERG, *Chief Engineer, Minnesota Department of Highways*
EDWARD G. WETZEL, *The Port of New York Authority, New York City*
J. C. WOMACK, *State Highway Engineer, California Division of Highways*
K. B. WOODS, *Goss Professor of Engineering, School of Civil Engineering, Purdue University*

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Advisory Committee

J. B. McMORRAN, *New York State Department of Public Works, Chairman*
DONALD S. BERRY, *Northwestern University*
A. E. JOHNSON, *American Association of State Highway Officials*
LOUIS JORDAN, *National Research Council*
DAVID H. STEVENS, *Maine State Highway Commission*
EDWARD G. WETZEL, *The Port of New York Authority*
REX M. WHITTON, *Bureau of Public Roads*

Advisory Panel on Maintenance

BURTON C. PARKER, *Massachusetts Department of Public Works, Chairman*
H. J. RATHFOOT, *Michigan State Highway Department*
A. G. CLARY, *Highway Research Board*

Section on Equipment (FY '65 and FY '66 Register)

NEAL ANDERSEN, *California Division of Highways*
PERCY L. BLACKWELL, *Bureau of Public Roads*
L. H. GUNTER, *North Carolina State Highway Commission*
EMMETT H. KARRER, *Ohio State University*
H. S. KERR, *H. B. Zachry Company*
J. J. LAING, *Bureau of Public Roads (Deceased)*

Program Staff

W. A. GOODWIN, *Program Engineer*
H. H. BISSELL, *Projects Engineer*
K. W. HENDERSON, JR., *Projects Engineer*
L. F. SPAINE, *Projects Engineer*
W. L. WILLIAMS, *Assistant Projects Engineer*
HERBERT P. ORLAND, *Editor*
M. EARL CAMPBELL, *Advisor*

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT

26

**DEVELOPMENT OF UNIFORM PROCEDURES
FOR ESTABLISHING CONSTRUCTION
EQUIPMENT RENTAL RATES**

T. S. DUDICK AND F. I. RAVENSCROFT

//

**ERNST AND ERNST
WASHINGTON, D. C.**

RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION
OF STATE HIGHWAY OFFICIALS IN COOPERATION
WITH THE BUREAU OF PUBLIC ROADS

SUBJECT CLASSIFICATIONS:

MAINTENANCE, GENERAL

CONSTRUCTION AND MAINTENANCE EQUIPMENT

HIGHWAY RESEARCH BOARD

DIVISION OF ENGINEERING NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

1966

7
125
0.26
e.1

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by Highway Planning and Research funds from participating member states of the Association and it receives the full cooperation and support of the Bureau of Public Roads, United States Department of Commerce.

The Highway Research Board of the National Academy of Sciences-National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, non-profit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway departments and by committees of AASHO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are responsibilities of the Academy and its Highway Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

This report is one of a series of reports issued from a continuing research program conducted under a three-way agreement entered into in June 1962 by and among the National Academy of Sciences-National Research Council, the American Association of State Highway Officials, and the U. S. Bureau of Public Roads. Individual fiscal agreements are executed annually by the Academy-Research Council, the Bureau of Public Roads, and participating state highway departments, members of the American Association of State Highway Officials.

This report was prepared by the contracting research agency. It has been reviewed by the appropriate Advisory Panel for clarity, documentation, and fulfillment of the contract. It has been accepted by the Highway Research Board and published in the interest of an effectual dissemination of findings and their application in the formulation of policies, procedures, and practices in the subject problem area.

The opinions and conclusions expressed or implied in these reports are those of the research agencies that performed the research. They are not necessarily those of the Highway Research Board, the National Academy of Sciences, the Bureau of Public Roads, the American Association of State Highway Officials, nor of the individual states participating in the Program.

NCHRP Project 13-1 FY '65
NAS-NRC Publication 1471
Library of Congress Catalog Card Number: 66-62101

FOREWORD

By Staff

Highway Research Board

A problem of national major concern in both contracted construction and highway maintenance is that of establishing equitable equipment rental rates. This report describes the results of research directed to the development of a rate formula which accounts for the variables of equipment type, use, and region. Fiscal management personnel should find it particularly interesting from the viewpoint of the researchers' conclusions concerning needed changes in management practices in order to ultimately develop a workable formula.

Annual costs for highway construction and maintenance literally run into the billions of dollars. Of this cost, equipment charges constitute a considerable expenditure. In maintenance alone, the AASHO has estimated that some 30 percent of the outlay goes into equipment charges. In deference to the the size of current and anticipated future construction and maintenance costs, a uniform method for determining equitable equipment rental rates is needed if some measure of control is to be realized relative to the outlay for equipment. Nonuniform methods presently exist because of the many factors which must be recognized and evaluated in arriving at equipment rental rates in any continental region. A readily usable formula is desired—one which accounts for the purposes for which rental rates are used and for all of the factors which affect equipment rental costs. An essential adjunct to such a formula would be guidelines for the steps involved in obtaining and evaluating information pertinent to each of the factors in the formula for various types, different uses, and different regions.

The firm of Ernst and Ernst has researched this problem by first surveying the practices of the state highway departments and other organizations and then analyzing the resulting information to identify the factors pertinent to a rate determination. A formula has been developed which expresses equipment costs as an hourly rate, and a trial application was made in one state possessing a range of equipment types. Guidelines have been established for the procedures which the researchers have designated as prerequisites to the development of equitable rates; the fundamental basis for the guidelines is set forth; and recommendations have been made for changes in current accounting standards utilized by both state highway departments and contractors so as to make the guidelines workable.

This document constitutes a final report on the research. However, it should not be construed that a total solution to this complex problem has been, or could have been, achieved in the one-year period. This same problem has been researched by others over the years, yet the same basic problem persists today. The results from the present study are of value, however, from the viewpoint of a different perspective

on the multiplicity of problems inherent in attempting to establish one formula which will fit all situations throughout the United States. Although some of the proposed remedial measures could be put to use immediately, others are controversial and deserve further extensive study to fully document their practicability and worth.

CONTENTS

1	SUMMARY
2	CHAPTER ONE Introduction Study Approach
5	CHAPTER TWO Current Practices Highway Construction Highway Maintenance Other Uses of Equipment Rental Rates
11	CHAPTER THREE Equipment Costs Operating Costs Major Repairs and Overhauling Ownership Costs Profit
16	CHAPTER FOUR Equipment Rental Rate Formula Operating Costs Ownership Costs Total Hourly Cost Formula Applying to Department Maintenance Equipment
17	CHAPTER FIVE Guidelines for Procedures Equipment Data and Records Determination of Rental Rates Rented Equipment Implementation of Guidelines Additional Recommendation
31	REFERENCES
32	APPENDIX Questionnaire on Current Equipment Rental Rate Practices of State Highway Departments

FIGURES

- 19 **Figure 1.** **Example of equipment ledger card.**
- 20 **Figure 2.** **Example of fuel receipts.**
- 22 **Figure 3.** **Example of equipment operating cost record.**

TABLES

- 3 **Table 1.** **Expenditures for Highway Construction by Expending Agency and by System, 1962-1965.**
- 4 **Table 2.** **Expenditures for Highway Maintenance by Expending Agency, 1962-1965.**
- 6 **Table 3.** **Summary of Responses to Project Questionnaire and to BPR Survey on Equipment Rental Practices in Highway Construction Work Paid for on a Force Account Basis.**
- 7 **Table 4.** **Equipment Rental Practices for Highway Maintenance Work by Department Forces.**
- 8 **Table 5.** **Useful Life of Selected Contractor Equipment and Percentage of Over-Age Equipment Held.**
- 8 **Table 6.** **Comparison of Rental Rates for Selected Equipment: Rates in Metropolitan Washington, D.C., Area Expressed as Percentage of AED National Averages.**
- 9 **Table 7.** **Percentage Decrease of AED Monthly Rates Compared to Weekly Rates for Equipment Included in BPR Arlington Study.**
- 15 **Table 8.** **Average Depreciation Periods Used by State Highway Departments for Selected Types of Maintenance Equipment.**
- 24 **Table 9.** **Example of Computation of Hours Available for Use of Selected Types of Equipment.**
- 26 **Table 10.** **Example of Estimated Ownership Costs of Selected Equipment.**
- 29 **Table 11.** **Example of Hourly Equipment Ownership Cost for Selected Units of Equipment.**

DEVELOPMENT OF UNIFORM PROCEDURES FOR ESTABLISHING CONSTRUCTION EQUIPMENT RENTAL RATES

SUMMARY

The objective of the study reported herein was to develop uniform procedures for establishing equitable rental rates for equipment used in highway construction. The procedures developed also may be applied to maintenance work.

A survey of state highway department practices determined that the major current use of rental rates is to reimburse contractors for equipment costs when unit prices for construction work do not apply. In most cases the rates used either are modifications of the rental rates published by the Associated Equipment Distributors or are based on the schedule of equipment ownership costs as promulgated by the Associated General Contractors of America. Use of these bases introduces certain deficiencies because (a) they are national averages, (b) they include inapplicable costs, and (c) such formulas do not recognize that the equipment used may be fully depreciated.

An examination of the bases reported by the states led to an identification of the appropriate equipment costs and other factors pertinent to rate determination. Upon completion of the identification phase, a formula to express equipment costs as an hourly rate was developed. Also, a case study, using the actual equipment data of one state highway department, was made to experience the problems of applying the formula and to demonstrate the development of rental rates.

The research outlined in the foregoing showed that there are two interrelated problems of obtaining complete cost data. Information pertaining to ownership costs, particularly indirect costs, in relation to specific units or types of equipment must be determinable; in addition, contractor cost systems vary in complexity depending on the size of the organization and its need for cost information. So that state highway departments may obtain complete information on a uniform basis, the guidelines in the report describe both the information needed and the desired sources and records for the accumulation of data, and indicate methods of allocating indirect equipment costs. The allocation of costs to specific types of equipment is also described.

The guidelines were developed on the premise that the rates at which contractors are reimbursed for equipment use should be based on actual costs, and cost information should be susceptible to verification by the highway department.

The cost system outlined can be applied to the accounting for state- or county-owned equipment; rates used internally for the allocation of equipment costs to maintenance districts or other cost centers would be on a similar fully-allocated cost basis.

Finally, one problem encountered during the course of the study, the solution of which is outside the scope of the assignment, is the lack of uniformity in the classification of equipment. It is suggested that to develop equipment rates on a uniform basis, it is desirable that equipment be classified uniformly.

CHAPTER ONE

INTRODUCTION

In December 1964 it was estimated (1) that total disbursements for highways in 1965 would amount to more than \$13.4 billion, of which \$6.7 billion was for highway construction (exclusive of the cost of right-of-way and engineering) and \$3.2 billion was for maintenance; that is, approximately \$10 billion, or 74%, was to be spent on highway work involving the use of equipment. It has been stated (2, p. 137) that "on the average, equipment charges comprise 30% of the outlay for highway maintenance," and it has been estimated by industry representatives that of construction costs, 12% is incurred for equipment.

Based on these percentages, the use of equipment would account for expenditures in the order of \$1.7 to \$1.8 billion in 1965. During the course of this study, however, data obtained from a limited number of states indicated that approximately 28% of contracted construction expenditures represented equipment. If this percentage is applied to the gross figures, annual equipment costs for construction and maintenance could be as much as \$2.8 billion.

The increase in expenditures for construction and maintenance work over the past several years is apparent from Tables 1 and 2, respectively.

The estimated cost of construction to complete the Interstate system, as of January 1, 1964, was approximately \$24 billion (3). This represents less than one-half of the expenditures for the construction which it is reasonable to anticipate will be incurred in the next decade, particularly as the new Appalachia program gets under way. Interstate system construction represents 38% of the total construction costs estimated for 1965 (Table 1). If this relationship holds true for the remainder of the Interstate program, total construction costs for the decade ending in 1973 would be in the range of \$60 to \$65 billion; equipment costs, assumed at 12%, would be in the order of \$7.5 billion. In addition, even if annual expenditures do not rise above the 1965 level, approximately \$32 billion will be spent in the same period on maintenance, of which equipment will represent approximately \$9.6 billion. The total expenditures for equipment in this period can be conservatively estimated at more than \$17 billion. Control of such an amount through equitable equipment rental rates is highly desirable.

The objective of this study was to develop procedures which may be applied uniformly in the establishment of equitable rental rates for equipment used in the highway work. Specifically, the objectives are:

1. To ascertain the purposes for which equipment rental rates are used.

2. To identify each of the cost factors which must be considered in determining equipment rental rates.

3. To develop a formula which can be used for establishing equitable equipment rental rates.

4. To outline procedures which will serve as guidelines for obtaining and evaluating the information needed to determine the factors in the formula.

These objectives pertain to both highway construction and maintenance operations, inasmuch as a method of recovering equipment costs, either by a contractor or by a state highway department, can be applied to both types of work.

STUDY APPROACH

Data Collection

Data relating to the uses of equipment rental rates and the underlying cost factors were obtained by personal interviews, review of annual maintenance reports, and returns from a questionnaire to the state highway departments.

PERSONAL INTERVIEWS

The following highway departments and organizations were visited and appropriate personnel interviewed:

District of Columbia Department of Highways and Traffic

New Jersey State Highway Department

Commonwealth of Pennsylvania Department of Highways

Commonwealth of Virginia Department of Highways
Bureau of Public Roads, Construction and Maintenance Division, Washington, D. C.

Bureau of Public Roads, Arlington (Va.) District,
Direct Construction Division

Associated Equipment Distributors

Associated General Contractors of America

American Road Builders' Association

Associated Pennsylvania Constructors

In addition, several contractors and equipment rental companies were contacted.

REVIEW OF ANNUAL MAINTENANCE REPORTS

The 1964 maintenance reports submitted by 51 state highway departments, including Puerto Rico and the District of Columbia, to the Bureau of Public Roads were reviewed for information pertaining to equipment rental rates. Subsequently, as a result of this review, eight states were contacted as a preliminary step in data collection.

TABLE 1

EXPENDITURES FOR HIGHWAY CONSTRUCTION BY EXPENDING AGENCY AND BY SYSTEM, 1962-1965 ^a

SYSTEM AND AGENCY	EXPENDITURE (\$MIL.)			
	1962	1963 ^b	1964 ^c	1965 ^c
Interstate system, rural and urban:				
Participating program:				
Federal funds	1,372	1,772	2,049	2,077
Participating funds	214	235	240	236
Non-participating program	379	285	191	218
Total	1,965	2,292	2,480	2,531
Other Federal aid, primary system:				
Participating program:				
Federal funds	485	524	518	517
Participating funds	436	488	479	469
Non-participating program	566	567	524	589
Total	1,487	1,579	1,521	1,575
Federal aid, secondary system:				
Participating program:				
Federal funds	206	237	233	232
Participating funds	177	220	215	209
Non-participating program	374	332	320	353
Total	757	789	768	794
Other state roads	381	421	463	473
Other local roads and streets	987	1,035	1,089	1,140
Other Federal, not classified	150	177	173	157
Total Federal funds	2,213	2,710	2,973	2,983
Total non-Federal funds	3,514	3,583	3,521	3,687
Over-all total	5,727	6,293	6,494	6,670

^a From Ref. (4).^b Includes estimated data from sources other than the Federal Government and state highway departments^c Estimated.

QUESTIONNAIRE

Following the preliminary investigation mentioned, a questionnaire (Appendix A) was sent to the 52 state highway departments. This step was taken to obtain a complete review of current equipment rental practices. The data obtained from the questionnaire are summarized in Tables 3 and 4 and are discussed in Chapter Two.

Development of Formula and Procedures

During the initial stages of data collection it was determined that the majority of state highway departments establish equipment rental rates by two basic methods, as follows:

1. Rates are based on published schedules; e.g., Associated Equipment Distributors' *Rental Rates* (5). The prime example of this method is the establishment of rates at which contractors are reimbursed for the use of equipment on construction, outside the scope of a contract, performed under a work-change order, when the

basis of payment is the "force account" or cost-plus method.

2. Some highway departments develop a schedule of equipment rental rates for internal accounting purposes. These rates, which are based on past experience, apply particularly to department-owned maintenance equipment and are used to allocate equipment costs to road sections, or specific projects, or work functions, or against specific allocations of funds.

RENTAL RATES

Inasmuch as many state highway departments use Associated Equipment Distributors' *Compilation of Averaged Rental Rates for Construction Equipment* (5) to establish a schedule of equipment rental rates, this publication was extensively reviewed. In addition, representatives of AED were interviewed in both Washington, D. C., and Oak Brook, Ill. The information obtained is discussed in Chapter Two.

TABLE 2

EXPENDITURES FOR HIGHWAY MAINTENANCE ^a BY
EXPENDING AGENCY, 1962-1965 ^b

AGENCY	EXPENDITURE (\$MIL.)			
	1962	1963	1964 ^c	1965 ^d
Federal Government	29	30	28	29
State agencies ^e :				
Rural state-administered highways	973	992	1,036	1,104
Municipal extensions of state highways	120	141	172	179
Local rural roads	13	18	19	20
Local municipal roads and streets	7	7	7	8
Total	1,113	1,158	1,234	1,311
Local rural governments:				
Rural state-administered highways	3	4	6	7
Local rural roads	903	920	958	980
Local municipal roads and streets	33	35	37	39
Total	939	959	1,001	1,026
Municipalities:				
Municipal extensions of state highways	12	14	16	14
Local municipal roads and streets	746	777	800	822
Total	758	791	816	836
Over-all total	2,839	2,938	3,079	3,202

^a Including Traffic services. ^b From Ref. (1). ^c Preliminary figures. ^d Amounts forecast for 1965. ^e Including District of Columbia.

AGC OWNERSHIP EXPENSE

Some state highway departments use the Associated General Contractors' *Contractors' Equipment Ownership Expense* (6) as a basis for establishing equipment rental rates used in the reimbursement of contractors for work which cannot be quoted on a fixed price basis. It is not a schedule of equipment rental rates but a compilation of data on contractors' average annual costs of owning and maintaining construction equipment of various types, sizes, and capacities and is intended as a guide only. It was evaluated, and representatives of AGC were interviewed in Washington, D. C. This publication also is discussed in Chapter Two.

STUDY OF LOCAL EQUIPMENT RENTAL RATES

The rates at which equipment is rented in a particular locality are not necessarily AED or AGC formulated rates, as equipment frequently is available from local rental companies which are not equipment distributors. A study conducted by the Arlington (Va.) District, Region 15, Bureau of Public Roads, compared local rental rates obtained from equipment rental firms, general contractors, and other industry sources in the metropolitan area of Washington, D. C., with AED rates for truck cranes, crawler loaders, and crawler bulldozers. This study was evaluated, and the responsible personnel were interviewed. It also is discussed further in Chapter Two.

PILOT STUDY OF DEVELOPMENT OF RENTAL RATES

Nationally established equipment rental rates require adjustment to obtain a basis for equipment charges that is acceptable to both contractors and state highway departments. In addition, these rates are not used in connection with the ownership and operation of maintenance equipment by state highway departments or counties. The records and procedures relating to the equipment of the highway department of one state were examined in considerable detail because of the completeness of the information and the assortment of equipment held. From the information obtained during this examination, a better understanding was gained of the problems involved in establishing rental rates. Many of the factors, both financial and other, that have to be considered were recognized, and as the guidelines for procedures to establish rental rates took shape, actual data were used to calculate rates, so that the methodology developed was factual rather than theoretical.

This state highway department owns approximately 17,000 units of equipment, of which roughly 13,000 units are "rented" to the maintenance districts (each district covers a county). The remainder of the equipment includes numerous small items which were not included in the pilot study. Ten broad classes of equipment, consisting of 54 types of different capacities and sizes, approximately 2,500 units in total, were selected for this study. Procedures were developed which will apply to all types of equipment and to all highway work, construction and maintenance, contracted and noncontracted, for which equipment is used.

CURRENT PRACTICES

Data relating to the current use of equipment rental rates were collected through a combination of personal interviews, written requests for information, and a questionnaire (Appendix A) to the state highway departments. The information obtained by means of the questionnaire is summarized in Tables 3 and 4. Information relating to both construction and maintenance work, on both a contract and noncontract basis, was requested.

HIGHWAY CONSTRUCTION

In 1963 state highway departments awarded construction contracts of more than \$4.3 billion for Federal-aid and other programs (7). This amount included \$53 million authorized for force account work, representing only slightly more than 1% of construction awards. In other words, the overwhelming majority of construction is performed under contract. Contracted construction has been defined (2, p. 125) as "construction work performed under a contract or agreement at stipulated prices per work unit, for the labor, supervision, materials, supplies, and equipment required to properly complete the work agreed upon." Because, however, most highway construction work is priced on a unit basis (e.g., 9,000 cubic yards structure excavation at \$3.25 per cubic yard), the amount included for equipment rental cannot be ascertained.

The need to determine a rate at which a contractor is reimbursed for the use of equipment under his control develops only when the work specifications are changed and when the contractor and highway officials cannot negotiate a unit price for the extra work involved. Under these conditions (i.e., when negotiated unit prices are not applicable) the contractor will be reimbursed on a "force account" or cost-plus basis, and equipment is then identified as one element of cost. At present, equipment use is reimbursable at agreed rates, which are negotiated either as each situation arises or with a local association of highway construction contractors.

The majority of state highway departments use a published schedule of equipment rental rates, particularly AED's "Rental Rates" (5), to negotiate the rate at which the contractor will be reimbursed for equipment use. Table 3 shows that 28 of 40 state highway departments use either the AED or AGC schedules as a guide in determining rates. A survey of equipment rental rates made in 1961 by the Construction and Maintenance Division of the Bureau of Public Roads showed that all 46 responding states made use of AED or AGC recommended rates, or both, as the basis for establishing rates at which to reimburse contractors.

Inapplicability of AED Rental Rates

The use of AED rates has several deficiencies, as follows:

1. The rates quoted are based on a survey of 800 member firms and are national averages.
2. The foreword to the 17th edition (5) includes these statements: "Because of length of working season, climatic factors, labor rates, local practices, and soil conditions, the ranges of rental rates vary substantially throughout the United States.

"There are also wide ranges of rates even in the same trading area, especially in the case of higher-priced equipment. Rates charged by a distributor or by competing distributors in the same locality may vary substantially on an identical or comparable piece of equipment. The reason for these local significant differences is that the rate of depreciation is vitally affected by the following factors: the same models may be new, practically new, rebuilt, or in varying conditions because of age or prior use; the use to which the equipment is placed (such as terrain, hard service in rocky or abrasive soil); the operator's skill and reputation for proper use and maintenance.

* * *

"It makes no better sense for a distributor to rent, or for a contractor to expect to rent, construction equipment on the basis of average national statistics drawn from reports of distributors in various parts of the country than for a contractor to bid jobs on the basis of average published bid prices on similar jobs in various parts of the country."

3. AED rates are intended to represent averages of rates charged by equipment lessors; it is therefore presumed that all of the costs and expense of such firms, as well as the profit they hope to receive, are covered by these rates.

4. The annual costs, as itemized in the AED publication, which an equipment distributor would use in determining whether any given rental rate covers "cost," are: depreciation, insurance, taxes, interest on investment, repairs and maintenance, rental department costs, selling costs, unbilled transportation costs, overhead and other administrative costs. Lessor rates are established to recover selling costs, which are not incurred by a contractor.

5. Lessor rates provide for a rate of profit which is peculiar to rental of equipment. The contractor's rate of profit should be oriented to the total job rather than to the rental of equipment. The following extract from a state "Field Manual" (8) is pertinent to this point: "Payment for Extra Work: . . . there is a basic principle that must be kept in mind when considering this subject. That is, that equipment rental and equipment ownership

expenses are two distinctly different things. Rental implies a profit in the rate, while ownership expense is a net cost containing no profit. We do not pay the contractor a rental price for his equipment; we *reimburse* him the amount of his ownership expense."

6. Lessor rates include an allowance to cover the risks involved when the equipment is used by someone not under the control of the owner.

7. Lessor rates include an allowance for depreciation on all equipment; contractor-owned equipment may include

units which are fully depreciated and for which AED rates, therefore, cannot justifiably be used, particularly as depreciation is a major cost of owning equipment. The results of a survey of 243 contractors made in late 1961 (9) showed that in the opinion of the contractors a considerable percentage of their equipment had outlived their estimates of useful life. The details of this survey are given in Table 5. The percentages of "over-age" equipment shown vary from 20 to 52%. This survey was made during the time that Bulletin F, the Treasury Department's

TABLE 3

SUMMARY OF RESPONSES TO PROJECT QUESTIONNAIRE AND TO BPR SURVEY ON EQUIPMENT RENTAL PRACTICES IN HIGHWAY CONSTRUCTION WORK PAID FOR ON A FORCE ACCOUNT BASIS

QUESTION	RESPONSES (NO.)	
	PROJECT QUEST.	BPR SURVEY
1. Basis of equipment charges:		
AED schedule, current edition, without discount	11	} 29
current edition, discount applied	8	
prior editions	2	
edition not specified	2	
AGC schedule, current edition	3	} 11
prior edition	1	
Combination of publ. schedules and other sources	1	6
Negotiations independent of published schedules	3	0
Internally developed by highway department	9	0
Total responses	40	46
2. Unit of measurement by which rates charged: ^a		
Hour	33	46
Day	9	
Week	6	
Month	10	
Mile	4	
Not specified	5	
Total responses	35	46
3. Rental rates charged for:		
(a) Time to move equipment to and from job site	18	11
Total responses	36	36
(b) Time spent on repairs and maint. on job site	8	4
Total responses	33	32
(c) Other nonoperating time while on job site	8	10
Total responses	29	36
4. Freight charges borne by highway department	20	—
Total responses	33	—
5. Same rates for contractor-owned and rented equipment	22	10
Total responses	24	11
6. Items other than ownership costs included in rate:		
Fuel and lubricants	30	21
Labor cost of field repairs	25	32
Materials cost of field repairs	25	32
Profit	21	28
None	4	—
Total responses ^b	36	33

^a BPR survey concerned only with hourly equipment rental rates.

^b Total responses to BPR survey vary for each cost element.

TABLE 4

EQUIPMENT RENTAL PRACTICES FOR HIGHWAY MAINTENANCE WORK BY DEPARTMENT FORCES

QUESTION	RESPONSES (NO.)	
	OWNED EQUIPMENT	RENTED EQUIPMENT
1. Basis of equipment charges:		
AED rates	1	5
AGC schedule	0	1
Internally developed	30	9
Independent negotiations	2	10
None or not applicable	5	8
Total responses	38	33
2. Unit of measurement by which rates charged:		
Hour	26	25
Day	4	5
Week	1	4
Month	5	5
Mile	17	5
Not specified	4	2
No basis	5	7
Total responses	38	33
3. Rental rates charged for:		
(a) Time to move equipment to and from job site	18	14
Total responses	27	25
(b) Time spent on repairs and maint. on job site	13	6
Total responses	25	24
(c) Other nonoperating time on job site	12	7
Total responses	24	22
4. Freight charges borne by highway department		11
Total responses		19
6. Items other than ownership costs included in rate:		
Operator's wages	1	17
Fringe benefits of labor	5	15
Fuel and lubricants	25	19
Labor cost of field repairs	22	15
Materials cost of field repairs	22	13
Profit	1	15
None	1	0
Total responses	26	20

standard of judging useful lives of depreciable property, was being revised; the contractors' estimates of useful lives were lower than those allowed by Bulletin F in some instances. Today, the useful lives of construction equipment, as set forth in Revenue Procedure 62-21 (10), are:

Light general purpose trucks	4 years
Heavy general purpose trucks	6 years
Automobiles	3 years
Contract construction equipment	5 years

These standards are in line with the contractors' estimates of years of useful life shown by the survey. It is reasonable to assume that a considerable percentage of equipment is over age in 1965 and that a rental rate which assumes no fully depreciated equipment will overstate costs.

8. A majority of rental rate schedules used by state highway departments are based on AED rental rates; these rates are based on costs which do not include operating costs. The highway departments' rates include the reimbursement of operating costs, particularly fuel, oil, and lubricants, and in many instances the cost of field repairs. This is undoubtedly intended to compensate for noncontractor type costs included in the AED rates. However, it is difficult to rationalize how this is accomplished with any degree of precision.

Use of AGC Percentages

The method recommended by AGC to measure equipment ownership expense more closely approaches the re-

TABLE 5

USEFUL LIFE OF SELECTED CONTRACTOR EQUIPMENT AND PERCENTAGE OF OVER-AGE EQUIPMENT HELD^a

EQUIPMENT	USEFUL LIFE ^b (YR)	OVER-AGE EQUIPMENT HELD (%)
Air compressors	6	35
Motor graders	6	22
Trenchers and ditchers	5	40
Cranes, shovels, and hoes	6	37
Tractor-shovels and loaders	4	32
Tractors	5	37
Self-propelled scrapers	5	30
Off-highway dump units	6	48
Trucks, off-highway dump	5	32
pick-up	4	32
regular	4	52
Truck mixers and agitators	5	24
Concrete spreaders and finishers	4	52
Self-propelled rollers and compactors	6	32
Welding machines	7	20

^a From Ref. (9). ^b Estimated

quirements of a contractor's cost reimbursement rate, yet is used to a lesser extent than the AED rates.

It is recommended to the contractor that he apply the data, given as percentages of capital invested in equipment, to his own acquisition costs, including the factor of replacement cost. Adjustment of the basic factors in the formula to his own individual experience is necessarily recommended.

The annual costs included in the formula as costs of ownership are depreciation, major repairs and overhauling (including painting), interest on investment, insurance, taxes, storage, and the direct overhead involved in providing storage and handling the equipment in and out of storage. They are considered to be the equipment ownership costs incurred in lump sum or unit price work and cost-plus-a-fee or force account contracts. There is no provision in the formula for a mark-up on costs.

The purpose of the schedule is to "supply convenient and reliable information concerning problems of equipment ownership . . ." (6, p. 1). The first edition was published in 1920 after four years of investigation. The latest (5th) edition, published in 1962, is based on a survey performed in 1947 and 1948, the results of which were incorporated in the third edition in 1949. Since then, revisions have been mainly in the form of adding new types of equipment and through the means of a sample of contractors' opinion rather than an industry survey.

The renting of equipment by a contractor to others is considered to be a different situation, involving "intangible costs which one without special experience is likely to underestimate" (6, p. 3), and is beyond the scope of this schedule.

The use of a schedule which shows equipment costs in the form of a relationship to the investment in equipment has the advantage of establishing criteria which do not

fluctuate from year to year as the equipment market changes. However, there are some disadvantages, as follows:

1. The percentage rates shown are averages and "individual experience may vary within a fairly broad range from the averages . . ." Also, they represent "an approximate average of conditions under which the equipment has been operated." Furthermore, they are subject to adjustment and some of the basic factors considered to justify adjustments of the rates are "weather conditions, job location, length of construction season, type of work, and care of equipment . . ." (6, p. 1).

2. The percentages which represent the following cost factors are unchanged or almost unchanged since 1930:

ITEM	PERCENT OF CAPITAL INVESTMENT	
	1962	1930
Interest on investment	5	5
Storage and equip. overhead	3½	4
Insurance	1	1
Taxes	1½	1
Total	11	11

The percentages which have changed are depreciation and major repairs and overhauling. This is true of the majority of comparable equipment, but not of all equipment. For example, automobiles were considered to have useful lives of two to four years, depending on size, both in 1930 and in 1962. The percentages for all the marine equipment shown in both editions are the same.

Study of Local Equipment Rental Rates

The study of equipment rental rates conducted by the Arlington (Va.) District, Region 15, Bureau of Public Roads, was primarily concerned with weekly rates. The average local rates obtained, expressed as percentages of AED weekly rates, are given in Table 6. The report (11)

TABLE 6

COMPARISON OF RENTAL RATES FOR SELECTED EQUIPMENT: RATES IN METROPOLITAN WASHINGTON, D. C., AREA EXPRESSED AS PERCENTAGES OF ASSOCIATED EQUIPMENT DISTRIBUTORS NATIONAL AVERAGES^a

EQUIPMENT	CONTRACTOR RATE (% OF AED WEEKLY RATES)		
	DAILY	WEEKLY	MONTHLY
Truck cranes	92.5	92.5	87.4
Crawler loaders	118.8	107.1	95.9
Crawler bulldozers	104.6	95.4	86.1
All above equipment	107.2	99.3	90.3

^a From Ref. (11).

concluded that "the AED weekly rates, although they do not include the cost of fuel and lubricants, were approximately equal to the weekly rates charged by local rental firms" (11, p. 3), which do include these costs; it also showed that local monthly rates were about 10% below weekly rates, whereas comparable AED monthly rates are approximately 30% below AED weekly rates (Table 7). Based on this study, a recommendation was made that the hourly rates for rented equipment, including fuel and lubricants but excluding operators, should "be equal to the current weekly rates recommended by the Associated Equipment Distributors projected on an hourly basis" (11, p. 7). A distinction was made between equipment owned by the contractor and equipment which is rented. The use of contractor-owned equipment would be paid for at 75% of AED weekly rates projected on an hourly basis. This conclusion was reached as hourly rates calculated from manufacturers' retail prices, using AGC percentages, were found to be comparable. The data submitted on the questionnaire (Table 3) indicate that the large majority (90% of responses) of state highway departments are charged the same rates by contractors for contractor-owned and rented equipment.

The Arlington study showed that local rental rates are different from the national averages published by the AED, particularly as they include the cost of fuel and lubricants; that for metropolitan Washington, at least, monthly rates are closer to the weekly rates than in the case of AED rates; and that costs of owning equipment are less than rental rates.

Validity of Published Schedules as Basis for Rates

Both AED and AGC advise that their schedules are of national averages and that local conditions will determine rates in a given situation. It has been stated that local competitive market conditions are a basic consideration in the determination of rental rates. Therefore, national average rental rates, such as the AED schedule, cannot be applied directly to a local situation; the averaging of rates, based primarily on local supply and demand for equipment, will not necessarily produce rates which approximate contractor costs of owning equipment in a given local situation. This conclusion is given credence by the practice of state highway departments of reimbursing contractors at AED rates for equipment costs which include the cost of fuel and lubricants and of field repairs and of establishing the rates as a percentage (as low as 70%) of the AED rates; these practices are probably adjustments made to compensate for the difference between local and average conditions. The scope of this study did not include an evaluation of each individual basis used, therefore these adjustments were not studied in detail.

Other Factors Involved in Use of Rental Rates

Eighteen of the 36 states which responded to the questionnaire indicated that a rental rate is paid for the time during which a piece of equipment is transported to and from the job site. This applies when additional or special equipment is brought to the job site as a result of "extra"

TABLE 7

PERCENTAGE DECREASE OF AED MONTHLY RATES COMPARED TO WEEKLY RATES FOR EQUIPMENT INCLUDED IN BPR ARLINGTON STUDY^a

EQUIPMENT	AED RENTAL RATE ^b (\$/HR)		DECREASE (%)
	WEEKLY	MONTHLY	
Lifting crane, truck mounted, gasoline powered:			
20 ton	12.22	8.86	27
25 ton	14.55	10.05	31
30 ton	17.90	12.22	32
35 ton	20.28	14.43	29
45 ton	27.70	19.15	31
60 ton	38.85	24.98	36
Crawler front loader, diesel, with manual shift:			
1½ cu yd	7.70	5.22	32
1½ cu yd	7.78	5.39	31
1¾ cu yd	10.25	7.23	29
2½ cu yd	12.45	9.18	26
Crawler bulldozer, diesel, with gear drive:			
36-44 dhp	5.90	3.97	33
45-59 dhp	8.18	5.36	34
72-79 dhp	9.60	6.93	28
80-91 dhp	10.55	7.20	32
92-115 dhp	12.80	8.77	31
116-131 dhp	15.33	10.36	32

^a From Ref. (11).

^b Weekly and monthly rates converted to hourly basis by dividing by 40 and 176, respectively.

work. Twenty of 33 states responding indicated that, in addition, any freight charges involved are paid by the highway department. Twenty-five of 33 states do not reimburse the contractor for time spent on repairs and maintenance on-site, although some states indicated that such time up to a low maximum (½ to 1 hour per occurrence) would be rental time. Only 8 of 29 states pay contractors for standby or "idle" time of their equipment.

Finally, 22 of 24 states indicated that the agreed rental rate is the same, irrespective of whether the equipment is contractor-owned or rented.

Other Uses of Rental Rates

The other major use of equipment rental rates in the highway construction industry is in rental agreements between a contractor and a third party; e.g., rental company, equipment distributor, or another contractor. This use of equipment rental rates is beyond the scope of this study, which is concerned only with the use of equipment on behalf of or by state highway departments and the Bureau of Public Roads. The only exception, which is considered in Chapter Five, is the rental rate paid by a contractor to another business entity which has either the same or a closely related ownership as the contractor company.

In addition, equipment rental rates are used by some highway departments in the development of estimated

construction costs prior to the advertisement of construction contracts; these estimates are used as a standard against which to evaluate contractors' bid prices. Little information was obtained from the state highway departments regarding the use of equipment rental rates for this purpose. The responses received indicated some use of discounted AED rates and, in one instance, of the AGC schedule. Some states indicated that bids are evaluated by comparison with previous bids for similar work.

HIGHWAY MAINTENANCE

Highway maintenance work is performed either under contract or by highway department personnel, who will use equipment owned by the highway department and rented equipment (on some occasions, equipment is rented on a fully-operated basis—i.e., the charge for the operator is included in the rental rate). The information obtained through the questionnaire which pertains to rental rates for equipment used in noncontract work is summarized in Table 4.

Contracted Maintenance

Contracted maintenance work includes work performed by county authorities under contract to the state highway department. Where information was obtained, it appears that most contracted maintenance is performed on a basis similar to that for contracted construction; i.e., a unit price or a lump sum basis. In one specific instance, when the work is performed by the county authorities, equipment charges are considered separately and are based on the costs incurred by the county road commissions.

Department Force Maintenance

Generally, maintenance work performed by department forces involves the use of equipment owned by the state highway department and, on occasion, equipment rented from rental agencies, local contractors, and others as the need for additional equipment at specific times of the year arises. For example, trucks, equipped for snow removal, are rented from local contractors during the winter on an "as needed" basis. Frequently, this equipment is operated by lessor personnel.

In response to the questionnaire 30 of 38 states indicated that for department-owned equipment, a "rental" schedule is developed within the highway department. This "rental" schedule is used to distribute equipment costs, on a per-hour basis, to road sections and to projects, possibly by work functions, and to charge maintenance allotments. These rental rates are not truly rental rates but a method of accounting for costs within a highway department, usually without an element of profit (some states accumulate funds for the replacement of equipment through a limited profit element). In addition, this system furnishes information essential for equipment management.

With the trend toward greater mechanization in highway operations, the importance of equipment cost will increase. Rental systems of state highway departments have been developed along different lines, reflecting differences of opinion, policy, departmental organization, and state law. However, these systems enable the department to make a forecast of annual equipment requirements and cost and to establish rental rates which will bring about an approximate liquidation of that cost over a 12-month period. In many states there is centralized control of highway department equipment operations; the organization is usually under the supervision of an equipment engineer or superintendent, who is in charge of all equipment operations and whose responsibilities include the determination of rental rates.

The differences in rental rates between states are caused not only by the variation in the amount of costs incurred but also by differences in the types of costs included in the calculation of the rates. In addition, such factors as the provision that the minimum charge for equipment on a time rental basis be 8 hours per day, unless the equipment is out of service for at least half a day, will result in variations in rates.

The responses to the questionnaire indicated that the bases of establishing rates for equipment rented from outside the highway department were more varied. Some states use the AED schedule as a basis and some develop their own schedule; others negotiate rates on an individual basis with perhaps an established schedule of maximum rates. Under these circumstances, local demand for and supply of the required equipment will be the most important factor in establishing rates. For example, a contractor will rent a grader to the highway department for snow removal. This equipment would not otherwise be utilized, and he is, therefore, willing to accept a rate which is only slightly more than his operating costs. The equipment is generally rented by the hour and frequently on a fully-operated basis. Seventeen of 20 states indicated that the operator's wages were included in the rates. Fuel costs are normally included, and more frequently than not, the cost of field repairs and an element of profit are also included.

OTHER USES OF EQUIPMENT RENTAL RATES

Equipment rental rates are used to charge governmental agencies, other than highway departments, for the use of equipment. For example, roads under the jurisdiction of a State Forestry Commission may be maintained by highway department personnel. The costs, including those pertaining to equipment, are charged to the benefiting agency. The information obtained indicates that, generally, equipment charges are the rental rates used internally by the highway department. Only ten states provided information on this use of equipment rental rates.

CHAPTER THREE

EQUIPMENT COSTS

The term "equipment costs" refers to the over-all cost entailed in providing and utilizing the services of equipment, excluding the wages of operators and other labor-related costs, such as payroll taxes and workmen's compensation insurance.

Equipment costs may be classed as (a) operating and ownership costs, (b) variable and fixed costs, and (c) direct and indirect costs.

Operating costs are those costs which are incurred as a result of the use of the equipment (e.g., fuel, maintenance, and the replacement of expendable parts such as tires). Ownership costs are those costs which are incurred by virtue of having title to a piece of equipment (e.g., taxes, insurance, and depreciation). Generally, operating costs are variable and ownership costs are fixed.

The term "fixed cost" is relative only; costs are fixed within specific periods of time. For example, the amount of personal property taxes levied on the acquisition cost of equipment held is a fixed cost of owning a given unit of equipment. As long as the rate of tax is unchanged or if the tax is levied on the "book" value of a unit of equipment, the tax expense is a fixed cost for a given year. Generally, costs are considered fixed when they are fixed for the period of a year. An example of a variable cost is fuel cost, which is increased with every hour of operation.

Direct costs are those costs which can be attributed to the ownership or operation of a specific unit or type of equipment. Indirect costs are those which cannot be so directly attributed and which must be allocated on an equitable basis to the individual unit or type of equipment to ensure that each unit or type assumes its share of total equipment cost. The extent to which the indirect costs of highway construction and maintenance work are allocable to equipment is indeterminate. For example, a part of the salary of a construction company official whose responsibilities include the approval for payment of invoices for equipment could be, theoretically, considered a cost of acquiring equipment. Practically, such an allocation will not be made; the salary will be considered a general and administrative expense. The criterion used to determine indirect equipment costs will be that the expense must be directly attributable to the ownership and use of equipment (e.g., the wages of an equipment clerk, which is not attributable to a specific unit or type of equipment).

OPERATING COSTS

Operating costs refer to "the cost of supplies consumed in operating or servicing equipment, including any servicing obtained from commercial concerns. It also includes any

consequential amounts of labor involved in the servicing, other than that of operators on duty with the equipment" (2, p. 139). The servicing of equipment referred to is defined as the day-to-day maintenance of the equipment and minor repairs performed on the job site (e.g., a worn part is replaced).

The following is a list, by no means complete, of operating cost items:

- Fuel
- Oil
- Tires and tubes
- Tire repairs
- Greasing
- Expendable parts (e.g., shovel teeth, grader blades)
- Antifreeze
- Small tools
- Maintenance labor

These costs are directly attributable to the operation of each individual unit of equipment and vary directly with the use of the equipment. They are measurable on a per operating unit basis (e.g., hour, mile).

Freight and Related Costs

The cost of loading, shipping, erecting, and dismantling equipment is incurred to place a piece of equipment on location in an operable condition (except for the necessary initial servicing). This is an operating cost, as it would not be incurred if the equipment were not to be used. It does not vary directly with the use of equipment but with the frequency with which the location of the equipment is changed. For example, the boom of a crane may be dismantled for the transportation of the unit and reattached when the unit reaches the work site. The cost of this operation is a fixed cost for the one specific project, and its contribution to the hourly cost of operation will vary inversely with the use of the equipment. These costs will have to be treated separately from other operating costs; as they are fixed in relation to a specific project (e.g., construction contract, maintenance assignment), the charges involved should be a separate item and not included in an equipment rental rate. The following, relating to equipment rental rates for force account work of the Bureau of Public Roads, Arlington District, is an example:

"Payment for transporting machinery or equipment . . . shall be equal to the actual cost of transporting said machinery or equipment to or from the job site or \$60.00, whichever is the lesser" (11, p. 8). The establishment of a maximum charge is desirable.

MAJOR REPAIRS AND OVERHAULING

The costs of major repairs and overhauling are "the costs of parts, assemblies and materials installed or consumed in repairing or overhauling operations, together with the labor expended in the performance of these operations. Also, the term embraces the cost of any commercial services procured in connection with these operations, together with the cost of any repairing or overhauling performed by commercial shops" (2, p. 139). A direct cost which should be included under this definition is the cost of transporting the unit to a repair shop, unless the equipment is not returning to the same job site; if not, such transportation cost is as if the equipment were being transferred to another location, irrespective of the repair work. These costs include indirect costs, such as depreciation and maintenance of shop equipment, the replacement of shop tools and the compensation (including associated payroll expenses) of supervisory labor and other labor not directly employed upon but related specifically to these operations. The cost of materials consumed and the labor expended directly should be charged to the individual unit of equipment upon which the work is performed. Accumulated indirect costs will have to be allocated to the specific units upon which work is performed during a given period of time, probably a year. The simplest method of allocation is on the basis of the dollar value of direct materials and labor.

The cost of major repairs and overhauling does not include the cost of rebuilding used equipment; i.e., substantially restoring it to its original value. Such costs should be capitalized, increasing the book value of the equipment. Modifications made to equipment which change the nature, capacity, or speed of the equipment should be treated as rebuilding work.

One essential distinction between major repairs and the servicing of equipment which is classified as an operating cost is that major repair work is performed at a location other than the job site. However, when equipment is employed on a large construction project and repair facilities are provided on-site, repair work performed should be considered as if it were performed at a separate location.

The AGC "Ownership Expense" (6) includes major repairs and overhauling as an ownership cost. Generally, these costs would not be incurred if the equipment were not used and therefore are not truly ownership costs. However, as major repairs and overhauling of equipment cannot be attributed directly to a specific job, the annual cost, direct and indirect, thereof should be treated as an ownership expense and allocated to specific jobs or other cost centers through the mechanism of a rental rate.

OWNERSHIP COSTS

Ownership costs are those annual equipment expenses which cannot ordinarily be identified with a specific project.

Insurance

Insurance is the annual cost of premiums on policies covering equipment; risks covered will include such items as fire and theft, property damage, and third party liability. The variable elements which determine insurance cost are the value of the equipment and the premium rate; but for a given year, these elements are fixed.

Insurance expense may be directly attributable to specific units, types, or classes of equipment or to all equipment held. If, for example, insurance expense can be directly related to a class of equipment (e.g., graders), the expense can be allocated to the specific type (e.g., 85-hp self-propelled diesel graders), using the basis on which the premium is calculated (e.g., book value). The allocated expense of the specific type will be one of the costs to be recovered through the rental rate.

Taxes

Taxes include the personal property taxes on the assessed valuation of the equipment, but do not include state or Federal income taxes; tax levied on income is not an expense, but part of the distribution of profit. For the purpose of calculating a rental rate, personal property taxes must be allocated to each type of equipment using the basis on which the tax is levied (i.e., the assessed value of the equipment).

Storage Expense

Storage expense includes the costs associated with storing equipment between successive jobs or operations. It includes the occupancy and maintenance costs of storage warehouses and/or yard, the wages of watchmen, and the direct overhead involved in providing the storage facilities and of handling the equipment in and out of storage. Under this heading it is appropriate to include the costs associated with storage and dispensing of fuel where this is provided by the party directly controlling the equipment. The costs of trucks used to dispense fuel in the field, including the labor costs involved, are also included. These costs, included in this category because the fuel facilities will normally be located in the storage area, must be allocated to specific types of equipment before calculating rental rates.

Equipment Overhead

There are overhead costs which are directly attributable to the ownership and use of equipment. For example, in a typical state highway department, there will be an equipment engineer or supervisor and a supporting clerical staff. The wages and salaries of this staff, the associated payroll costs, the occupancy and maintenance costs of their work area, the office supplies, postage, telephone and telegraph expense, and the maintenance and depreciation of office equipment are all directly attributable to the ownership of equipment and as such must be included in an equipment overhead pool and allocated to specific types of equipment.

In a state organization these costs, although many and varied, can be clearly traced to the function of owning and operating equipment. They should be associated with all equipment, owned or rented, which come under the direct control of the state highway department.

In a contractor organization similar costs may not be so well defined. In a large contracting business specific personnel may perform functions akin to their counterparts in the state organization and the costs associated therewith be charged to an equipment overhead pool; but a small contractor organization probably will not segregate these functions so clearly. In such cases, the costs of those functions may be part of the general overhead pool. Some may be directly traceable to and therefore allocated to equipment and some will be part of the contractor's general overhead expense. Under no circumstances, however, can an overhead item simultaneously be part of both equipment overhead and general overhead.

The variation in the classification of an overhead item as "equipment" or as "general" will result in a variation between two contractors in the equipment rental rate for the same type of equipment. The alternative is to disregard any distinction in overhead cost items and to class them all as general overhead costs. Although this is practical for contractor organizations, it is not desirable; for state highway departments it is impossible, as their accounting systems are designed in terms of fiscal accounting, based on appropriation and allotments. There is no equivalent to the use of "burden" or a general overhead rate in industry. Therefore, it is desirable that irrespective of the size of the contractor, overhead costs should be allocated to equipment as far as possible.

Depreciation

"Depreciation is a measure of the declining value of property due to age and wear. Depreciation is normally based on the original cost of the equipment, including transportation and erection charges, less the estimated remaining or salvage value, if any, at the time the equipment is retired from service" (2, p. 140). The original cost of the equipment will include the cost of expendable parts which will be replaced. The depreciable value of the equipment will be written off annually over the useful life of the equipment by one of several methods. The amount of depreciation charged off is not an actual cost, however, but only an estimate of the decline in value.

The useful life of equipment is determined by two factors; one is physical, the other is economic. Equipment decreases in value because of normal wear and tear from use and operating conditions. In addition, a decline in value can be experienced due to climatic factors; i.e., equipment can deteriorate even if it is not used. For the most part, however, the decline in value due to physical factors is a variable cost because it varies with the hours of use. This depreciation is offset by maintenance and repair work on the equipment, and the amount of such work, particularly preventive maintenance, will affect the length of the equipment's physical life. It would seem

that given sufficient repairs and maintenance, the life of the equipment could be extended almost indefinitely. In practice, however, increases in the costs of repairs and maintenance associated with old age place a limitation on the life of the equipment, a point at which it is more economical to replace the equipment or reassign it to some restricted use.

The second and, particularly for contractors, the more important factor is the decline in economic value of equipment due to obsolescence.

"The net earnings of a machine (revenue minus costs) decline as physical deterioration takes place and result in a drop in revenue. But, the chief influence on revenue is the competition of improved models which can do the job at a cheaper price. It is through the interrelation of revenue and costs that obsolescence manifests itself. Obsolescence is independent of hours of operation . . . That portion of the economic decline due to aging may be thought of as a fixed cost, for it has a time variance (rather than hours of operation)" (12, p. 5).

"Obsolescence is that economic inferiority of a machine to its successors which results from technological improvements in each newer replacement machine" (12, p. 10). It is a combination of "(1) production obsolescence, a result of increased productivity of newer models, (2) maintenance and operating cost obsolescence, resulting because better designs lower maintenance and operating costs, and (3) cost growth, reflecting the increased cost of the improved models, assuming a dollar of constant value" (12, p. 38). In addition, in a period of inflation, the decreasing value of money will further increase the cost growth factor and has tended to obscure the technical improvements in equipment.

Obsolescence is the more important factor to the contractor in his determination of economic life, which, in turn, controls the amount of annual depreciation expense. He must remain in a competitive position, and to do so obsolete equipment must be replaced. Theoretically, investment in equipment is recovered through the amortization of the cost; i.e., depreciation. In practice, working capital made available through the depreciation allowance is used for reinvestment in new equipment. The rate of depreciation effectively represents the rate of reinvestment; i.e., the period over which cost is amortized is the length of replacement cycle (assuming that at the end of the cycle the economic usefulness of the equipment is at an end).

The Internal Revenue Code allows as a deduction from taxable income an allowance for the depreciation of equipment. "The purpose of the allowance is to recover through annual deductions the cost (or other basis) of the property over its economic life" (10, p. 15). Current depreciation guidelines permit the contractor, generally, to establish the economic life of construction equipment as five years (10, p. 16). This is in keeping with contractors' own estimates of useful life, as shown by the survey discussed in Chapter Two. The contractor may also use a shorter economic life, if he can justify it. Whatever economic life is established for tax purposes, the actual replacement practices and policy of the contractor must

be consistent with it. This consistency can be demonstrated through the "reserve ratio" test. The ratio of the reserve for depreciation to the acquisition cost of equipment of the contractor is compared to tables of reserve ratios prepared by the Internal Revenue Service. These tables contain a calculated reserve ratio range for a given method of depreciation, economic life, and rate of growth (positive or negative) of total investment in equipment. If the contractor's reserve ratio is within the established range, his equipment replacement practices are in keeping with his estimate of the useful life of his equipment. This test may be used by the contractor to prove that his equipment cost is not being amortized over a period which is shorter than the useful life of the equipment to him. It does not prove that the useful life assigned to the equipment is the economic life. It can only be assumed that a contractor will own equipment for its economic life to conserve working capital and that therefore "the reserve ratio test is the most definitive test so far devised to judge the useful service life of assets" (12, p. 33).

For state-owned equipment, which is not ordinarily used on work involving price competition, the factor of obsolescence is seldom recognized. Useful lives are determined on the basis of physical lives, limited by the increasing costs of major overhauls as the equipment ages. The depreciation periods used by state highway departments range from five to ten years, depending on the type of equipment. A selected list of average depreciation periods used by state highway departments is given in Table 8.

In addition to the assigned service life, the amount of depreciation in any given year will be affected by the method of depreciation used. The three major methods used are as follows:

1. Straight-line method. This represents the decline in book value created by equal deductions over the life of the equipment. There is normally a residual or salvage value of equipment which is not included in the value to be depreciated.

2. Sum-of-years-digits method. The digits in the lifetime are summed and deductions are taken successively backwards, using first the ratio of the highest year to the sum. For example, if a piece of equipment has a life of 4 years, the sum of the digits is 10, and the first year's deduction from book value is 4/10 of depreciable value. For tax purposes use of this method is restricted to new equipment.

3. Double-declining-balance method. Deductions are made by applying twice the straight-line percentage to the declining book value. No salvage value is used in the computation. For tax purposes this method applies to new equipment; a similar 150% declining-balance method applies to used equipment.

From an accounting convenience viewpoint, the most desirable of these is the straight-line method of depreciation. Use of accelerated methods of depreciation (e.g., double-declining-balance method) by some contractors

and straight-line depreciation by others means that for an identical piece of equipment, with the same assigned service life, the annual depreciation expense will vary and this variation will be reflected in a varying equipment rental rate.

The annual depreciation expense, no matter how it is determined for a specific unit or type of equipment, is a fixed cost for that year. The impact of that fixed cost on an equipment rental rate depends on the number of months in the year during which the equipment can be used and the utilization of the equipment obtained during that time period. The utilization of equipment is most frequently measured in hours, but is sometimes measured in miles (e.g., for automobiles and trucks). Although the hourly depreciation cost of equipment is generally computed by determining annual depreciation first and then dividing that amount by the estimated number of hours of operation within a year, other more direct methods could be used. The useful life of a unit of equipment could be measured as the total number of operating hours without reference to its life in years; but this would preclude consideration of obsolescence in determining equipment life.

The allowable annual depreciation expense should be the acquisition cost of the equipment (including shipping and erection charges) less salvage value spread over the years of economic life by the straight-line method.

Interest

Interest refers to "the contractor's average cost of obtaining money for the purchase of equipment. This cost is composed of interest on short-term loans or monthly equipment notes held by the manufacturer or distributor" (6, p. 2). This expense is incurred only by contractors; it is not incurred, generally, by state highway departments for the purchase of equipment.

From the contractor's point of view, interest is a cost that he must incur so that he may buy equipment. However, it is considered to be an unallowable cost for the purpose of reimbursing contract costs. This is not without precedent. The *Armed Services Procurement Regulations* state, relative to construction contracts, "Interest on borrowings (however represented), bond discounts, costs of financing and refinancing operations . . . are unallowable except for interest assessed by state or local taxing authorities . . ." (Para. 15-205.17) For the purpose of this study, the cost of financing equipment purchases, incurred by the contractor, is not a cost of owning the equipment; it is a cost associated with borrowing funds.

Funds borrowed to purchase equipment are akin to the investment in equipment that the contractor makes from his own funds. The interest should be paid out of the net earnings derived from that investment. If interest is considered as a reimbursable cost, the contractor who borrows funds has a financial advantage over his counterpart who finances equipment purchases from working capital. For example:

	Contractor A	Contractor B
Investment in equipment:		
Own funds	\$1,000,000	\$ 500,000
Borrowed funds	0	500,000
Total Investment	\$1,000,000	\$1,000,000
Net earnings on investment	100,000	100,000
Interest paid	0	50,000
Net earnings after interest	100,000	50,000
Rate earned on own funds	10%	10%

If contractor B is reimbursed for the interest paid, he earns 20% (\$100,000/\$500,000) on his investment.

It was assumed in the foregoing example that the rate of interest on borrowed funds is equal to the yield from the use of those funds. In practice the rate of interest may be less, and the excess earned is the reward earned by the contractor for the risk he takes by borrowing funds.

Determination of Hourly Ownership Costs

Ownership costs are incurred on an annual basis and are generally fixed costs. Depreciation is included in this category because once the economic life of the equipment has been determined annual depreciation is established. In addition, the annual costs of major repairs and overhauling will have to be treated as an ownership cost as it is incurred in relatively large amounts at irregular intervals and cannot be attributed directly to a specific job or the use of the equipment over a shorter period of time.

To establish the hourly cost of ownership, the number of hours of use must be known or estimated. For the purpose of developing an equipment rental rate, this hourly cost will have to be estimated. The major factor affecting the calculation will be the anticipated hours of use of the equipment. The anticipated use is determined by (a) the length of the working season and (b) the utilization of the equipment within the season. The utilization is measured as straight-time hours of operation, on a one-shift basis. The unforeseeable nature of the use of equipment during overtime work, or an additional shift, precludes consideration of the effect on the hourly rate. It should be noted, therefore, that rental rates paid for the use of equipment beyond eight hours per day will cover only operating costs.

PROFIT

There is no element of profit associated with the ownership and operation of equipment. The profit of the contractor is a function of his total prime cost (i.e., materials, labor, and equipment); state highway departments do not own and operate equipment for profit, and any excess of

TABLE 8

AVERAGE DEPRECIATION PERIODS USED BY STATE HIGHWAY DEPARTMENTS FOR SELECTED TYPES OF MAINTENANCE EQUIPMENT *

TYPE OF EQUIPMENT	DEPRECIATION PERIOD (YR)
Air compressor, truck-mounted	7
Bulldozer, tractor attachment	7
Conveyor, belt, on wheels	5
Crane, crawler	10
Distributor, bitumen	8
Finishing machine, concrete	5
Grader, motor	8
Heater, tank car	8
Mixer, bituminous	7
Mower, sickle bar	5
Pump, water	6
Road roller	10
Roller, sheepsfoot	10
Roller, trench	10
Scarifier, rotary	5
Scraper, self-propelled	7
Shovel, crawler	10
Snowplow, V	7
Sprinkler, water, truck-mounted	7
Tractor, wheel	6
Trucks, multi-use	5
Vibrator, pneumatic	5
Welding outfit, electric	5

* From Ref. (2, p. 141).

rental income over costs is incidental. Three exceptions to this may be noted, as follows:

1. Some states are legally permitted to accrue funds to replace equipment by establishing rental rates which result in a limited profit. To establish equipment rental rates by uniform methods, any consideration of profit should be omitted.

2. The rates at which equipment is rented by state highway departments, as described in Chapter two under "Highway Maintenance, Department Force Maintenance," will include a profit element. This is inevitable and is controlled by local supply and demand of equipment.

3. When a contractor rents equipment and is reimbursed the invoiced cost of rental, the profit of the lessor is charged to the state highway department. It is the responsibility of the contractor to provide equipment to perform the contract; ordinarily, the state highway department should not incur additional costs because the contractor chooses to rent equipment. The contractor should be required to justify his choice. This is of particular significance when the equipment is rented from a business entity under the same or closely related control as the construction company.

EQUIPMENT RENTAL RATE FORMULA

The formula needed to develop rental rates must be sufficiently flexible in its application to accommodate the inclusion or exclusion of specific equipment costs (for example, personal property taxes are not levied on state-owned equipment). There is one basic formula composed of two distinct parts, one covering operating costs and the other covering ownership costs, which is applicable to each type of equipment for which a rental rate is to be developed.

Consideration has been given to the variations in equipment costs which occur as a result of differences in the type and the use of equipment and the region in which it is used. However, these variations will be quantitative rather than qualitative. The use of historic cost in the development of rental rates will account for variations in cost due to these factors. For example, depreciation is an equipment cost, regardless of the type or the use of equipment or of the region in which it is used. Fuel is an equipment cost whenever equipment is used, regardless of how the equipment is used. The quantitative differences in equipment costs are not a consideration in the development of an equipment rental rate formula, only in its computation. In addition, variations in equipment costs due to the type of equipment will be in terms of including or excluding certain operating costs; the applicability of these costs depends on the nature of the equipment. For example, a crawler-mounted unit will not incur the cost of replacing tires. The variations in costs of this type are too numerous for specific consideration in the development of a general formula.

OPERATING COSTS

Operating costs are variable in nature and are directly attributable to the use of the individual unit of equipment; they can be measured on a per operating unit basis (that is, an hour). The only other unit of measurement to be considered is the mile; this should be considered as the unit upon which to measure the use of automotive equipment (automobiles, pickups, trucks) when the use of such equipment is irregular when measured in terms of hours. The continuous use of a truck to move earth on a construction site is measured in terms of hours; the sporadic use of an automobile by a District Engineer is measured in terms of miles.

The hourly cost of operating a unit of equipment is the sum of operating costs incurred during a specified period divided by the number of hours of operation in that period. The specific period will depend on the type of work performed. Generally, for maintenance equipment owned by a state highway department this period is the fiscal year. In effect, this is also the working season of the equipment. Small amounts of operating costs incurred "off-season"

(e.g., fuel consumed during equipment overhauling) should be associated with the off-season activity. One exception should be made—when equipment is used for a distinct secondary purpose (e.g., graders used for snow removal), the operating costs and time should be accumulated separately so that a separate hourly operating cost may be calculated. For contracted work the specific period will be the length of the contract or one working season, whichever is less.

Operating hours exclude time taken to perform maintenance or minor repair work and the time during which the equipment is at the job site but is not in use. The inclusion or exclusion of time taken to transport a unit of equipment to and from its job site will depend on its nature. If a unit is transported under its own power, transportation time should be included in the base. The inclusion of such time, where appropriate, will eliminate the variation in hourly cost which would otherwise occur, due to the variability of transportation time, which is a function of distance to the job site and the duration of the work.

Hourly operating cost may be expressed:

$$h_1 = \frac{f + g + m + l}{o} \quad (1)$$

in which

- f = cost of fuel and oil, etc., used to produce the power by which the equipment is operated;
- g = cost of greases, lubricants, antifreeze, etc., without which the equipment could not be operated;
- m = cost of materials consumed in minor repairs to equipment, including expendable parts such as tires;
- l = cost of labor, other than that of the operator, expended on minor repairs; and
- o = number of operating hours.

OWNERSHIP COSTS

Ownership costs are expressed as annual costs and are generally fixed costs. For the purpose of formula development, the costs of major repairs and overhauling, although not ownership costs and not fixed, are included because they are measurable only as annual costs. The calculation of annual depreciation is discussed in Chapter three.

Calculation of an hourly ownership cost for a specific unit or type of equipment is complicated by the fact that some ownership costs are not directly attributable to the specific unit or type. At this point, it is assumed that the ownership costs can be attributed or allocated to the individual unit or type. Methods by which ownership costs can be obtained and allocated to the specific unit or type are discussed in Chapter Five.

The base of the formula will be the total hours during the working season. The working season will vary from

region to region and will be subject to agreement between the state highway department and the local contractor organization for different types of equipment. The same working season should be used by the highway department for its own equipment of the same type. This will facilitate comparison between the costs of state-owned and contractor-owned equipment.

The working season is normally expressed in months, and each month is of 176 working hours (6, p. 3). The hourly ownership cost should be computed on the base of the total "normal" working hours within the working season; that is, 176 times the number of months in the season. This rate can then be applied to all hours of equipment use during "straight time." It will be applied also to transportation time, maintenance time, and all other time when the equipment is on the job site (that is, standby time).

Retention of an idle unit of equipment on the job site should be based on (a) a foreseeable need for that equipment and (b) the need being sufficiently proximate that the reimbursement of ownership costs, through the mechanism of the hourly rate, during the period of standby time is less than the cost of transporting the unit from and back to the job site. The decision to retain equipment on the job site must be made by a member of the highway department at the supervisory level. Similarly, the highway department should have the right to have removed from the job site equipment for which there is no further use.

The hourly ownership cost may be expressed:

$$h_2 = \frac{d + r + t + i + s + b}{w} \quad (2)$$

in which

- d = estimated depreciation in value;
- r = costs of major repairs and overhauling;
- t = personal property taxes;
- i = insurance expense;

s = storage expense;

b = burden, or equipment overhead; and

w = total hours in working season.

TOTAL HOURLY COST

The total hourly cost of the equipment while it is in operation is, therefore,

$$T = h_1 + h_2 = \frac{f + g + m + l}{o} + \frac{d + r + t + i + s + b}{w} \quad (3)$$

and the total hourly cost of the equipment while it is not in operation but the costs are chargeable to a project is h_2 .

FORMULA APPLYING TO DEPARTMENT MAINTENANCE EQUIPMENT

Highway departments do not incur all the equipment costs included in the general formula. The operating costs will be the same, but the element of personal property taxes will be excluded from ownership costs. Therefore, for highway department equipment the hourly ownership cost formula will be

$$h_2 = \frac{d + r + i + s + b}{w} \quad (4)$$

In addition, it may not be practical under a governmental accounting system to determine storage expense or equipment overhead. The occupancy and maintenance costs of buildings and grounds used for equipment storage may be difficult to quantify. Certain equipment overhead items, such as the telephone and telegraph expense, will be allocated costs. However, every effort should be made to determine these costs, on an allocated basis if necessary, to determine the full cost of owning equipment.

CHAPTER FIVE

GUIDELINES FOR PROCEDURES

The fundamental principle on which the guidelines are based is that equipment rental rates should be based on actual equipment costs. The variation in type and use of equipment and the region in which it is used will therefore be reflected. The actual full costs of operating and owning equipment should be determinable; and they must be determinable on the basis of uniform accounting standards. It is not suggested, however, that the highway department be responsible for setting up a contractor's books for him, only the establishment of uniform accounting criteria which contractors should meet so that the highway department can

readily determine whether the rates charged for equipment use are based on actual cost. In other words, procedures should be set forth outlining uniform accounting standards which contractors could use as a guide in costing and pricing. These same standards should also be applied to the internal accounting of the highway department and could be applied to all construction work.

At present, there is wide variety in the use of cost accounting systems on the part of contractors, state highway departments, and county organizations. This variety is recognized; the guidelines will be applicable to cost

systems of varying complexity. It would be ideal if all equipment users had a cost accounting system which provided all the necessary information directly. However, some form of cost system must exist before these guidelines can be applied.

Equipment rental rates—that is, the rates at which the contractor or the appropriate governmental unit is reimbursed for the use of equipment—initially must be estimated, giving consideration to prior experience, both in terms of cost and of utilization. Actual costs will vary from the estimate due to conditions peculiar to the individual situation. A distinction must be made between the estimated rental rate applicable to the contractor and that applicable to the highway department. The highway department should have available actual cost and utilization data from prior years; the contractor should have similar information, but it is not available to the highway department. For internal accounting the highway department can develop rental rates, provided the information needed for the factors in the equipment cost formula is available; the records which are necessary to accumulate this information are described in the following.

EQUIPMENT DATA AND RECORDS

This section describes the data and the records which are desirable for an accurate accounting for the cost and use of equipment. It is intended both as a guide for the verification of contractor costs and the determination of the costs of operating and owning highway department equipment.

Equipment Inventory Records

Equipment is defined as property, other than materials and supplies, which maintains identity throughout the work, does not become part of the work, and is movable. It does not include small tools, such as hand shovels and wheelbarrows, which have a relatively short life and which are properly classified as supplies. Larger items which are attachments for units of equipment (for example, bulldozer blades) and can be transferred from unit to unit are separate items of equipment.

A primary requirement of the proper control of equipment is the recording of equipment held. The standard method is to keep an equipment ledger with a separate sheet or card for each item of equipment. Each ledger card should show a description of the unit with respect to make, model, and size, with a more detailed description of major features (an example of the equipment ledger card is shown in Figure 1). It is necessary to identify the unit initially in terms of these characteristics. For used equipment, it may be necessary to examine the manufacturer's identification plates or obtain advice from an equipment firm to establish these data.

At the time the information is posted to the card, an identification number should be assigned to the item of equipment and provision made for the marking of the unit with this identification number, if this has not already been accomplished. The card also should include a record of engine changes and information pertaining to acquisition

and disposal of the unit. As a minimum, the date and cost of acquiring the unit and date of and amount realized by disposal should be recorded. (Other information which could also be shown include manufacturer's number, title number, name and address of supplier, number and date of purchase order, date of delivery, trade-in allowance, cash outlay, name and address of buyer, purchase order number and date of replacement unit, and the identification number of the replacement.) The total of the cost of the individual units shown in the equipment ledger will be equal to the total shown in a control account in the general ledger. Provision may also be made on the same card to show what auxiliary equipment (e.g., bulldozer blade) is attached to the unit. Information pertaining to the attachment would be minimal, as the detailed information would be recorded on its own ledger card. When an attachment is transferred to another unit, the information pertaining to this separate item of equipment would be transferred to the card of the unit to which it becomes attached.

Accurate records of depreciation are also an important part of equipment control, particularly with regard to decisions as to the disposal of equipment and the acquisition of replacements. The basis of depreciation, the estimated useful life, residual equipment value, and the annual depreciation expense can be recorded on the back of the ledger card.

Another requirement is accurate knowledge of the location of a particular unit of equipment at any time. This is needed for equipment inventory control and is the basis for the taking of a physical inventory. If the equipment ledger could be arranged on the basis of maintenance district (or county) for state highway departments, and on the basis of contracts by contractors, with an additional category of "unassigned equipment," and another category of units being repaired, in both cases, it would facilitate inventory taking and the recording of the transfer of equipment from district to district, or contract to contract; it would also demonstrate the quantity of equipment unassigned or undergoing repair. Summary cards for each separate class of equipment, in terms of type, size and capacity, would be maintained, showing the number of units in and the acquisition cost and accumulated depreciation of each class of equipment.

Equipment rented by a highway department and by a contractor should be treated in a manner similar to owned equipment. Accurate records of the type, physical characteristics, and location of rented equipment are just as important as for owned equipment to maintain proper control of its use. Acquisition cost information would be replaced by rental rate.

It is recommended that all contractor organizations under contract to a state highway department, and the state highway department or any subdivision thereof, should have an equipment ledger as previously outlined.

Equipment Cost Records

The objective of accumulating equipment costs is to develop an annual tabulation in which all costs, direct and indirect, are posted for each individual unit and summarized by

1. Type of Equipment		Equipment Number	
Description	2. Manufacturer (Name)		(Address)
	3. Model No.	4. Year	5. Serial No.
	6. Capacity or Size		
	Additional Description		
Engines		Basic Driving Engine	Auxiliary Engine (Truck cranes, etc.)
	Manufacturer		
	Model No.		
	Serial No.		
Acquisition Data	Gas or Diesel		
	Condition		Condition
	F.O.B. Cost		Depreciation
	Freight		Amount realized
	Erection		Gain or (loss)
	Total Cost	\$	Total Cost
	Date		Date
Attachment	Equipment No.		
	Item		
	Date Attached		
	Date Detached		

Figure 1. Example of equipment ledger card.

classes, each class being comprised of equipment of the same type, model, and capacity. In addition, a class may be subdivided by the year of acquisition or estimated useful life. The summarization is necessary because equipment rental rates are usually established by class of equipment; the recording of costs by individual unit is desirable for the control of equipment use and cost. Equipment costs, then, will enter the cost accounting system on a unit basis and, in terms of the total of each cost element, will also be a part of the financial accounting system. The cost which enters the financial accounting system in total may be a summary of the costs associated with the individual units, or the total amount of a specific cost may enter the financial accounting system first and be allocated to the individual units.

Certain equipment costs must be allocated, and the extent to which costs are allocated depends on the particular system. Some equipment costs, discussed in Chapter Three, may not be allocated at all.

The allocation of costs to a particular unit or class of equipment should be made on the basis by which the cost is incurred. Furthermore, all costs which are not directly chargeable to a unit of equipment should be allocated. For example, personal property taxes levied on the basis of book value should be allocated to the specific equipment unit or class in accordance with the book value of the equipment class. Storage expenses may be made up of the wages of a watchman, the occupancy costs or rental of a yard, and other related costs. The watchman's wages could be allocated on the basis of the value of the equipment,

the occupancy costs on the basis of the square footage required to store the equipment.

Sources of Equipment Costs

The purpose of the following descriptions of the sources of equipment costs is to indicate some, but by no means all, sources of data.

All *operating costs* should be traceable to the specific unit of equipment. This is necessary because the amount of these costs incurred by the specific unit will vary directly with the use of the individual unit under different conditions. Operating costs should be accumulated on a separate record for each unit of equipment. Documentary evidence of the amount of these costs is required. This applies to both highway departments and contractors. The extent to which such documents are readily available depends on the specific cost system.

Fuel costs will require more documentary evidence than other operating costs, inasmuch as they are incurred more frequently. When fuel is dispensed from the equipment user's own storage facilities, a form showing the date, the identification number of the equipment, and the quantity, unit price, and total price of fuel received should be made out (a recommended form is shown in Figure 2). When fuel is purchased from an outside source, a credit ticket or a receipt for cash purchases, giving the same information, is the evidence of cost incurred. These documents can be used to record initially the costs of all types of fuel, oil, antifreeze, etc.

Meter Reading Stop		Date	FUEL, OIL AND ANTI-FREEZE RECEIPT (Original)		DEPARTMENT OF HIGHWAYS	
Start		Equipment Number				
		Ticket Number				
Quan.	Unit	Item	Unit Price	Amount		
	Gals.	Gasoline				
	Qts.	Motor Oil				
	Gals.	Kerosene				
	Pts.	Anti-Freeze, Permanent				
	Pts.	Anti-Freeze, Regular				
	Gals.	Fuel Oil				
Received of			Of			
Vendor or Employee Issuing Material			Place, Job or Dist. No.			
By		For	Of			
Employee Receiving Material		Superintendent or Supervisor	Div. Dist. or Sec. No.			

Figure 2. Example of fuel receipts.

Maintenance and minor repairs costs will include the replacement of expendable parts and is composed of materials and labor costs. These items should be identified with the specific unit of equipment in a manner similar to the identification of fuel costs. All material and labor costs of a specific maintenance or repair job should be recorded on one document, indicating the quantity, unit costs, and total costs of materials and labor. An additional source of evidence of labor cost should be the time sheet of the mechanic employed, when this work is performed by the equipment user's own personnel.

Ownership costs include major repair and overhauling costs and are recorded on an annual basis. As previously noted, certain cost items would have to be allocated to a unit of equipment. The information included in the documents (e.g., invoices, tax forms, insurance policies) will vary from situation to situation. This variation will determine the extent to which cost allocation is necessary.

Major repairs and overhauling costs should be handled in the same manner as the costs of maintenance and minor repairs. A shop job cost sheet, showing quantities, unit prices, and total prices of materials and labor, would be the source document. The prime cost of each repair job is the base for allocating the shop overhead, which should be expressed as a predetermined burden rate. Commercial work will be evidenced by invoices. All documents should identify the date of the work and the number of the equipment.

Insurance and taxes costs will be revealed by insurance policies, invoices for insurance premiums, and tax bills. The bases for these costs should be determined and the expenses allocated thereby to each unit of equipment.

Storage expense and equipment overhead costs, which are determinable, will be allocated in accordance with the bases appropriate to the circumstances.

Depreciation will be based on the estimated economic life of the equipment. The acquisition cost of the equipment will be spread over the years of useful life as determined by the equipment owner. Reference should be made to the life of the equipment estimated by the manufacturer to determine if the assigned life is appropriate. The acquisition cost should be evidenced by the original bill of sale. Both the depreciable value and the assigned life will be altered if the equipment has been rebuilt. Invoices or other documentary evidence, such as shop job cost records, will support the additional capitalized cost. If the new assigned life is in doubt, the opinion of an equipment engineer may be required.

Recording Equipment Costs

There are differences in the frequency with which equipment costs should be recorded based on the nature of the costs.

POSTING OPERATING COSTS

Data from the original documents should be posted to a record for each unit periodically. The data could be summarized periodically (for example, for a month) and posted to an equipment cost record. This information and

records pertaining to the number of hours of use of each unit of equipment could be the basis of a monthly analysis of hourly operating costs, which would be a means of monitoring equipment costs. The equipment cost record should show separately whatever costs the equipment user wishes, although it is desirable to have the cost of the fuel (e.g., gasoline) recorded as a separate item because it probably will be the largest operating cost element. The following is a suggested breakdown of operating costs:

- Fuel
- Lubricants
- Antifreeze
- Greasing
- Tires and tubes
- Parts
- Repairs

An example of an equipment cost record is shown in Figure 3.

Records should be set up in a manner that permits all equipment operating costs pertaining to a contract or to the use of equipment by a maintenance district to be traced. In other words, when a unit of equipment is no longer employed for a contract or by a maintenance district, the operating costs of that unit should be summarized for the appropriate total period of time. The use of this procedure for department equipment would facilitate the measurement of differences in operating costs due to the location of the work and differences in terrain. It would also facilitate the allocation of maintenance funds to the districts.

POSTING OWNERSHIP COSTS

The recording of ownership costs is different from the recording of operating costs. Depreciation, insurance, and taxes are incurred as annual amounts and can be posted annually, both to the general ledger accounts and to the cost records. More frequent recording of these costs will be required only if total equipment costs for a shorter period of time are desired. Major repairs and overhauling costs will be posted more frequently as these costs are incurred. Storage expense and equipment overhead items will be accumulated as part of the financial accounting system and allocated annually.

Sources and Recording of Equipment Use

Equipment use may be classified in two ways. Obviously, equipment is in use when it is being operated: equipment also is utilized while it is not being operated but is available for a specific job. The contractor desires the highway department to reimburse him for all the time a unit of equipment is assigned to a contract, not only for the hours of operation. The maintenance district is charged for the time the equipment is under its control, not only for the hours of operation.

Once a unit of equipment is assigned to a contract or maintenance district, the length of time from the hour when it begins to travel to its assigned location until it is returned to the contractor's yard or highway department's

Note: Hours of operation exclude time expended on repairs and maintenance at the job site.

Figure 3. Example of equipment operating cost record.

Again, it is at the discretion of the responsible highway department project supervisor to determine when it is desirable to keep equipment on site but inactive; thus, he will control the total period of time for which an equipment rental rate will be charged.

Operating time should be determined by the time reported by its operator, who should make a distinction between the time that the equipment is actually operating and the time taken up by maintenance and repairs. This is necessary if any degree of control is to be achieved over time expended in field maintenance and repairs. The hourly operating cost is charged for operating time which excludes such maintenance. Therefore, it is desirable to keep this time as low as possible; otherwise, the hourly operating cost will be inflated.

The operational use of equipment under the control of a contractor should be checked by highway department personnel and records of such use maintained on a day-to-day basis so that contractor records of equipment use can be verified. The records maintained by highway department personnel should identify the specific units of equipment in operational use, the operator if possible, and indicate "down" time caused by repairs and maintenance. Equipment which is not in operational use should also be noted.

The operational use of highway department equipment will be under the control of supervisory level highway personnel, and it should be a function of the supervisor to ensure that operating time is reported correctly.

Nonoperational use is determined as the difference between operating time and total assignment time.

Total and operating time should be recorded on the same form as operating costs.

DETERMINATION OF RENTAL RATES

In practice it is the exception rather than the rule to maintain records of all operating and ownership costs for each unit of equipment. Costs are recorded for a class of equipment; rental rates are developed on this basis and estimated contractor hourly costs will be developed in a similar fashion. One type of cost may be accumulated on a broader base than another. For example, a record of fuel costs for all 150-drawbar-hp diesel crawler tractors may be maintained, but field repair costs may be summarized for all crawler tractors, insurance for all tractors, and taxes for all equipment. In other words, the group of equipment for which it is possible to ascertain readily

the amount of a specific cost element may vary from cost element to cost element.

In addition, it is impractical to develop a rental rate or an hourly cost for each unit of equipment. The equipment assigned to a specific contract will not be determined until the work commences, and a contractor's estimated hourly costs will be the average for all units of a particular type he holds. Similarly, internal rental rates set by the highway department will be based on all units of a type. However, it is possible to relate the total amount of a specific cost incurred to the total acquisition cost of a group of equipment, the group varying as previously indicated, and express that relationship as a percentage of acquisition cost. When the percentage has been established, it can be applied to the acquisition cost of the specific unit or group of equipment assigned to a contract or maintenance district.

Tables 9, 10, and 11 illustrate the calculations involved in computing the hourly costs of ownership of various classes of equipment. The figures are based on information obtained from the maintenance equipment records of a state highway department.

Table 9 gives an example showing the computation of the number of equipment hours available within the working season. This computation provides the base of the formula, the number of hours over which the ownership costs will be spread. It should be noted that the hours calculated will be used in relation to ownership costs only. The operating hours will be determined by utilization within the working season. This utilization can be expressed as a percentage of the hours available for use, this percentage being a measure of the effective use of the equipment.

Table 10 gives an example of the acquisition cost of various types of equipment and the estimated costs of ownership, by cost element. These costs were calculated by applying a percentage to the acquisition cost of the class of equipment. It should be noted that where fully depreciated equipment is still in use, no allowance for depreciation is made.

The percentages applied in the illustration are constant for insurance, taxes, and storage and overhead expense. In practice a constant percentage representing each of these cost elements would probably be applicable to book value rather than acquisition cost, and book value should be considered the alternative basis of the allocation of these costs to specific units or groups of equipment. The percentage applied to compute depreciation depends on the useful life of the type of equipment. The repairs and maintenance costs shown are figures projected from actual experience and are susceptible to expression as percentages which could be applied to specific acquisition or book values.

Table 11 gives the final computations, the division of hours available for use into total ownership costs, which result in the hourly ownership cost rates.

A similar procedure may be followed with respect to operating costs and hours; the average utilization and operating costs provide an average hourly cost which can

be used as an estimate, and an adjustment of total charges can be made later in the light of actual data.

In summary, the steps to be followed are as follows:

1. Standard hourly ownership and hourly operating cost rates are developed on the basis of prior cost experience factored by a reasonable level of utilization. The organization which estimates the rates has the responsibility of developing them realistically on the basis of all appropriate costs.
2. The total charge for the use of contractor equipment should be verified by the highway department. The verification of contractor costs by a governmental agency is not without precedent; contractors are required to make cost data available to auditors in other industries.
3. The costs of using state-owned equipment are determined and (a) will be the basis of the following year's hourly rates and (b) will determine an adjustment to charges made against specific maintenance funds. The costs of equipment owned by a governmental unit below the state level and which are reimbursed by the state should be subject to verification in the same manner as contractor costs.

RENTED EQUIPMENT

Equipment may be rented either by a contractor or by the highway department. Ordinarily a contractor should be reimbursed as if he owned the equipment, for the costs of ownership described in Chapter Three. The contractor probably will bear operating costs himself and they can be verified. The rental paid will be higher than the reimbursed costs, but (a) the contractor does not have working capital tied up in this equipment, a savings equal to the income that can be earned on that capital, and (b) the contractor is proposing to undertake a contract, so the choice of resources to be used is his and he should be prepared to justify to the satisfaction of the highway department a decision to rent equipment. A possible exception is a situation where specialized equipment is required. In addition, as a contractor should be reimbursed for costs only, the practice of renting equipment from a lessor under the same or essentially the same ownership as the contractor organization would not result in increased costs to the highway department.

The highway department may have occasion to rent additional equipment, and rental rates will reflect local supply and demand for such equipment. However, because the highway department's requirement will be for additional equipment of types already owned, the rates paid normally should be no more than the cost of operating and owning state-owned equipment, after adjusting for such costs as taxes which the lessor incurs but which the highway department does not incur.

IMPLEMENTATION OF GUIDELINES

The cost of implementing the guidelines set forth in this report will vary because of differences in the following:

1. Compensation of highway department personnel.

TABLE 9

EXAMPLE OF COMPUTATION OF HOURS AVAILABLE FOR
USE OF SELECTED TYPES OF EQUIPMENT

EQUIPMENT TYPE	NO. OF UNITS	TOTAL AVAILABLE EQUIPMENT TIME (HR/YR)	AVERAGE USABLE TIME (%)	ACTUAL TIME AVAILABLE FOR USE (HR)
Air compressors, portable, gasoline-powered, free air at 100 psi:				
105 cfm	20	41,600	50	20,800
125 cfm	78	162,240	50	81,120
210 cfm	66	137,280	50	68,640
315 cfm	8	16,640	50	8,320
All	172	357,760	50	178,880
Bituminous distributors, truck-mounted, complete with power unit, spray bar, etc.:				
1,000 gal	8	16,640	50	8,320
1,250 gal	88	183,040	50	91,520
All	96	199,680	50	99,840
Concrete mixers, portable, tilt, gasoline- driven:				
3½-S	5	10,400	67	6,968
10-S	3	6,240	67	4,181
11-S	22	45,760	67	30,659
12-S	1	2,080	67	1,394
14-S	2	4,160	67	2,787
All	33	68,640	67	45,989
Conveyors, portable, powered, belt:				
18" x 20'	2	4,160	50	2,080
18" x 30'	2	4,160	50	2,080
All	4	8,320	50	4,160
Gradalls, truck-mounted, gasoline-powered: ¾ cu yd				
	38	79,040	67	52,957
Graders:				
Self-propelled, diesel, tandem drive, with scarifier:				
70 hp	132	274,560	67	183,955
75 hp	35	72,800	67	48,776
85 hp	68	141,440	67	94,765
100 hp	26	54,080	67	36,234
125 hp	312	648,960	67	434,803
Self-propelled, gasoline, tandem drive: 50 hp				
	35	72,800	67	48,776
All	608	1,264,640	67	847,309
Pumps, portable, on wheels, gasoline-driven:				
Centrifugal, 2 in.	190	395,200	50	197,600
Centrifugal, 3 in.	42	87,360	50	43,680
Centrifugal, 4 in.	7	14,560	50	7,280
Diaphragm, 4 in.	32	66,560	50	33,280
All	271	563,680	50	281,840
Rollers:				
Two-wheel, tandem, gasoline:				
5 to 8 ton, variable	1	2,080	67	1,394
8 to 10 ton, variable	20	41,600	67	27,872
8 to 12 ton, variable	19	39,520	67	26,478
10 to 12 ton, variable	84	174,720	67	117,062

TABLE 9—Continued

EQUIPMENT TYPE	NO. OF UNITS	TOTAL AVAILABLE EQUIPMENT TIME (HR/YR)	AVERAGE USABLE TIME (%)	ACTUAL TIME AVAILABLE FOR USE (HR)
Three-wheel, two-axle, gasoline:				
6 to 8 ton, variable	10	20,800	67	13,936
8 to 10 ton, variable	4	8,320	67	5,574
10 to 12 ton, variable	374	777,920	67	521,206
Sheepsfoot, tamping, double drum	3	6,240	67	4,181
Vibrating, steel-wheeled, manually-guided, 24 in.	252	524,160	67	351,187
Wobble-wheel, self-propelled, 9-wheel, 15 tons	65	135,200	67	90,584
All	832	1,730,560	67	1,159,474
Shovels and cranes:				
Power shovel, crawler-mounted, gasoline:				
½ cu yd	6	12,480	75	9,360
¾ cu yd	33	68,640	75	51,480
Power shovel, truck-mounted, gasoline:				
½ cu yd	20	41,600	75	31,200
Crane-shovel, crawler-mounted, gasoline:				
½ cu yd	23	47,840	75	35,880
Crane-shovel, truck-mounted, gasoline:				
½ cu yd	7	14,560	75	10,920
All	89	185,120	75	138,840
Tractors:				
Crawler, diesel, gear drive:				
51-60 dhp	5	10,400	67	6,968
75-85 dhp	13	27,040	67	18,117
Crawler, gasoline:				
31 dhp	3	6,240	75	4,680
Bulldozer, crawler, diesel:				
51-60 dhp	16	33,280	67	22,298
75-85 dhp	3	6,240	67	4,181
150 dhp	1	2,080	67	1,394
Two-wheel drive, rubber-tired, front end loader, with backhoe, gasoline:				
½ cu yd	11	22,880	67	15,330
¾ cu yd	13	27,040	67	18,117
Two-wheel drive, rubber-tired, front end loader, with backhoe, diesel:				
½ cu yd	11	22,880	67	15,330
1 cu yd	79	164,320	67	110,094
Four-wheel drive, rubber-tired, front end loader, gasoline:				
1 cu yd	153	318,240	67	213,221
1¼ cu yd	24	49,920	67	33,446
1½ cu yd	48	99,840	67	66,893
Four-wheel drive, rubber-tired, front end loader, with backhoe, diesel:				
1¼ cu yd	5	10,400	67	6,968
1½ cu yd	22	45,760	67	30,659
All	407	846,560	67	567,696
TOTAL, ALL ABOVE EQUIPMENT	2,550	5,304,000	64	3,376,985

TABLE 10
EXAMPLE OF ESTIMATED OWNERSHIP COSTS OF SELECTED EQUIPMENT

EQUIPMENT TYPE	OWNERSHIP COSTS FOR FISCAL YEAR ENDED 6-30-66 (\$)						TOTAL
	ACQUISITION COST (\$)	INSUR- ANCE	TAXES	STORAGE AND OVER- HEAD	MAIN- TENANCE AND REPAIRS	DEPRECIA- TION	
Air compressors, portable, gasoline-powered, free air at 100 psi:							
105 cfm	39,845	398	598	1,395	3,414	0	5,805
125 cfm	273,511	2,735	4,103	9,573	4,867	43,201	64,479
210 cfm	194,490	1,945	2,917	6,807	19,138	0	30,807
315 cfm	41,325	413	620	1,446	1,264	0	3,743
All	549,171	5,491	8,238	19,221	28,683	43,201	104,834
Bituminous distributors, truck-mounted, complete with power unit, spray bar, etc.:							
1,000 gal	45,784	458	687	1,602	8,418	0	11,165
1,250 gal	835,861	8,359	12,538	29,255	90,495	37,543	178,190
All	881,645	8,817	13,225	30,857	98,913	37,543	189,355
Concrete mixers, portable, tilt, gasoline- driven:							
3½-S	2,346	23	35	82	510	0	650
10-S	2,985	30	45	104	255	0	434
11-S	35,099	351	526	1,228	1,376	0	3,481
12-S	772	8	12	27	0	0	47
14-S	2,924	29	44	102	21	0	196
All	44,126	441	662	1,543	2,162	0	4,808
Conveyors, portable, powered, belt:							
18" x 20'	3,085	31	46	108	44	0	229
18" x 30'	3,064	31	46	107	281	0	465
All	6,149	62	92	215	325	0	694
Gradalls, truck-mounted, gasoline-powered: ¾ cu yd							
	1,303,400	13,034	19,551	45,619	37,740	185,118	301,062
Graders:							
Self-propelled, diesel, tandem drive, with scarifier:							
70 hp	1,023,395	10,234	15,351	35,819	92,772	95,307	249,483
75 hp	352,586	3,526	5,289	12,341	39,422	0	60,578
85 hp	927,594	9,276	13,914	32,466	85,957	0	141,613
100 hp	259,978	2,600	3,900	9,099	44,337	0	59,936
125 hp	4,211,797	42,118	63,177	147,413	435,474	695,362	1,383,544
	6,775,350	67,754	101,631	237,138	697,962	790,669	1,895,154
Self-propelled, gasoline, tandem drive: 50 hp							
	187,528	1,875	2,813	6,563	20,473	0	31,724
All	6,962,878	69,629	104,444	243,701	718,435	790,669	1,926,878
Pumps, portable, on wheels, gasoline-driven:							
Centrifugal, 2 in.	41,120	411	617	1,439	4,444	2,744	9,655
Centrifugal, 3 in.	13,279	133	199	465	1,383	0	2,180
Centrifugal, 4 in.	3,327	33	50	116	467	0	666
Diaphragm, 4 in.	12,236	122	184	428	1,338	0	2,072
All	69,962	699	1,050	2,448	7,632	2,744	14,573
Rollers:							
Two-wheel, tandem, gasoline:							
5 to 8 ton, variable	3,436	34	51	120	340	0	545
8 to 10 ton, variable	99,768	998	1,497	3,492	7,339	5,008	18,334
8 to 12 ton, variable	104,938	1,049	1,574	3,673	7,375	9,494	23,165
10 to 12 ton, variable	514,530	5,145	7,718	18,009	29,833	41,861	102,566
	722,672	7,226	10,840	25,294	44,887	56,363	144,610

TABLE 10—Continued

EQUIPMENT TYPE	OWNERSHIP COSTS FOR FISCAL YEAR ENDED 6-30-66 (\$)						
	ACQUISITION COST (\$)	INSUR- ANCE	TAXES	STORAGE AND OVER- HEAD	MAIN- TENANCE AND REPAIRS	DEPRECIA- TION	TOTAL
Three-wheel, two-axle, gasoline:							
6 to 8 ton, variable	35,472	355	532	1,242	6,049	0	8,178
8 to 10 ton, variable	20,000	200	300	700	2,109	0	3,309
10 to 12 ton, variable	2,245,463	22,455	33,682	78,591	194,276	128,737	457,741
	<u>2,300,935</u>	<u>23,010</u>	<u>34,514</u>	<u>80,533</u>	<u>202,434</u>	<u>128,737</u>	<u>469,228</u>
Sheepsfoot, tamping double drum	3,161	32	47	111	184	0	374
Vibrating, steel-wheeled, manually-guided, 24 in.	625,069	6,251	9,376	21,877	36,188	62,507	136,199
Wobble-wheel, self-propelled, 9-wheel, 15 tons	347,425	3,474	5,211	12,160	7,256	34,743	62,844
All	<u>3,999,262</u>	<u>39,993</u>	<u>59,988</u>	<u>139,975</u>	<u>290,949</u>	<u>282,350</u>	<u>813,255</u>
Shovels and cranes:							
Power shovel, crawler-mounted, gasoline:							
½ cu yd	64,036	640	961	2,241	5,197	0	9,039
¾ cu yd	473,746	4,737	7,106	16,581	33,578	23,774	85,776
	<u>537,782</u>	<u>5,377</u>	<u>8,067</u>	<u>18,822</u>	<u>38,775</u>	<u>23,774</u>	<u>94,815</u>
Power shovel, truck-mounted, gasoline:							
½ cu yd	339,960	3,400	5,099	11,899	10,757	33,996	65,151
Crane-shovel, crawler-mounted, gasoline:							
½ cu yd	300,074	3,001	4,501	10,503	17,843	0	35,848
Crane-shovel, truck-mounted, gasoline:							
½ cu yd	60,069	601	901	2,102	5,631	426	9,661
All	<u>1,237,885</u>	<u>12,379</u>	<u>18,568</u>	<u>43,326</u>	<u>73,006</u>	<u>58,196</u>	<u>205,475</u>
Tractors:							
Crawler, diesel, gear drive:							
51-60 dhp	36,973	370	555	1,294	1,002	0	3,221
75-85 dhp	61,162	612	917	2,141	5,380	0	9,050
	<u>98,135</u>	<u>982</u>	<u>1,472</u>	<u>3,435</u>	<u>6,382</u>	<u>0</u>	<u>12,271</u>
Crawler, gasoline:							
31 dhp	15,366	154	230	538	0	2,195	3,117
Bulldozer, crawler, diesel:							
51-60 dhp	99,946	999	1,499	3,498	7,436	0	13,432
75-85 dhp	40,563	406	608	1,420	2,203	0	4,637
150 dhp	24,940	249	374	873	421	3,563	5,480
	<u>165,449</u>	<u>1,654</u>	<u>2,481</u>	<u>5,791</u>	<u>10,060</u>	<u>3,563</u>	<u>23,549</u>
Two-wheel drive, rubber-tired, front end loader, with backhoe, gasoline:							
½ cu yd	58,325	583	875	2,041	8,793	0	12,292
¾ cu yd	83,999	840	1,260	2,940	9,107	9,971	24,118
	<u>142,324</u>	<u>1,423</u>	<u>2,135</u>	<u>4,981</u>	<u>17,900</u>	<u>9,971</u>	<u>36,410</u>
Two-wheel drive, rubber-tired, front end loader, with backhoe, diesel:							
½ cu yd	60,621	606	909	2,122	9,005	0	12,642
1 cu yd	743,980	7,440	11,160	26,039	67,058	54,969	166,666
	<u>804,601</u>	<u>8,046</u>	<u>12,069</u>	<u>28,161</u>	<u>76,063</u>	<u>54,969</u>	<u>179,308</u>

TABLE 10—Continued

EQUIPMENT TYPE	OWNERSHIP COSTS FOR FISCAL YEAR ENDED 6-30-66 (\$)						
	ACQUISITION COST (\$)	INSUR- ANCE	TAXES	STORAGE AND OVER- HEAD	MAIN- TENANCE AND REPAIRS	DEPRECIA- TION	TOTAL
Four-wheel drive, rubber-tired, front end loader, gasoline:							
1 cu yd	953,527	9,535	14,303	33,373	129,377	81,639	268,227
1¼ cu yd	251,094	2,511	3,766	8,788	1,694	33,896	50,655
1½ cu yd	423,312	4,233	6,350	14,816	30,507	60,473	116,379
	<u>1,627,933</u>	<u>16,279</u>	<u>24,419</u>	<u>56,977</u>	<u>161,578</u>	<u>176,008</u>	<u>435,261</u>
Four-wheel drive, rubber-tired, front end loader, with backhoe, diesel:							
1¼ cu yd	121,260	1,213	1,819	4,244	786	17,323	25,385
1½ cu yd	267,168	2,672	4,008	9,351	0	38,167	54,198
	<u>388,428</u>	<u>3,885</u>	<u>5,827</u>	<u>13,595</u>	<u>786</u>	<u>55,490</u>	<u>79,583</u>
All	<u>3,242,236</u>	<u>32,423</u>	<u>48,633</u>	<u>113,478</u>	<u>272,769</u>	<u>302,196</u>	<u>769,499</u>
TOTAL, ALL ABOVE EQUIPMENT	18,296,714	182,968	274,451	640,383	1,530,614	1,702,017	4,330,433

2. Number of contracts handled.
3. Cost systems of contractors.
4. Number of units and types of equipment involved.
5. Need to verify equipment cost data.
6. Highway departments' internal cost accounting systems.

The cost experienced and the time required may therefore differ considerably, and no meaningful estimate can be developed.

Contracted Work

The step involved for contracted work will fall into two phases.

PHASE I—CONTRACT PERIOD

The use of the specific units of equipment assigned to the contract should be checked by highway department personnel. During the course of the contract highway department personnel should maintain records of equipment onsite and the use of that equipment. Hours expended on cost-plus work should be distinguished from unit price work.

Summaries of the records of equipment use will be forwarded to the appropriate department so that hours of use charged by the contractor can be verified.

PHASE II—VERIFICATION OF COST DATA

This phase should consist of verifying the hours charged using the time records accumulated by department personnel at the job site and of verifying contractor costs.

Department Equipment

For department equipment, the steps necessary to implement the guidelines set forth in this report are those necessary to establish or modify an internal cost accounting system so that the records and procedures conform with those described. The specific steps depend on the existing system; therefore, no attempt has been made to outline these steps or to estimate the time and cost involved.

The responsibilities of the equipment engineer should include control of the renting of additional equipment. His knowledge of equipment should be extended to include knowledge of all equipment used in highway construction. This has particular application to the purchase of equipment types hitherto not acquired. His responsibility will include the determination of an initial rental rate based on the manufacturers' recommendations as to operating costs, modified necessarily in the light of his own experience.

ADDITIONAL RECOMMENDATION

One of the more important aspects of good equipment accounting is the need for a clear, well-defined system of equipment classification. Variations in equipment rates will result from variations in the classification of equipment. Published schedules group equipment together in terms of a characteristic (e.g., engine horsepower), with differences in classification between the several schedules. Therefore, it is recommended that a uniform system of equipment classification be adopted by all highway departments and that parties under contract to the highway departments be required to conform to that system when submitting information.

TABLE 11

EXAMPLE OF HOURLY EQUIPMENT OWNERSHIP COST FOR
SELECTED UNITS OF EQUIPMENT

EQUIPMENT TYPE	NO. OF UNITS	TIME AVAILABLE FOR USE (HR)	TOTAL OWNER- SHIP COSTS(\$)	HOURLY EQUIPMENT OWNERSHIP COST(\$)
Air compressors, portable, gasoline-powered, free air at 100 psi:				
105 cfm	20	20,800	5,805	0.28
125 cfm	78	81,120	64,479	0.79
210 cfm	66	68,640	30,807	0.45
315 cfm	8	8,320	3,743	0.45
All	172	178,880	104,834	0.59
Bituminous distributors, truck-mounted, complete with power unit, spray bar, etc.:				
1,000 gal	8	8,320	11,165	1.34
1,250 gal	88	91,520	178,190	1.95
All	96	99,840	189,355	1.90
Concrete mixers, portable, tilt, gasoline- driven:				
3½-S	5	6,968	650	0.09
10-S	3	4,181	434	0.10
11-S	22	30,659	3,481	0.11
12-S	1	1,394	47	0.03
14-S	2	2,787	196	0.07
All	33	45,989	4,808	0.10
Conveyors, portable, powered, belt:				
18" x 20'	2	2,080	229	0.11
18" x 30'	2	2,080	465	0.22
All	4	4,160	694	0.17
Gradalls, truck-mounted, gasoline-powered: ¾ cu yd				
	38	52,957	301,062	5.69
Graders:				
Self-propelled, diesel, tandem drive, with scarifier:				
70 hp	132	183,955	249,483	1.36
75 hp	35	48,776	60,578	1.24
85 hp	68	94,765	141,613	1.49
100 hp	26	36,234	59,936	1.65
125 hp	312	434,803	1,383,544	3.18
	573	798,533	1,895,154	2.37
Self-propelled, gasoline, tandem drive: 50 hp				
	35	48,776	31,724	0.65
All	608	847,309	1,926,878	2.27
Pumps, portable, on wheels, gasoline-driven:				
Centrifugal, 2 in.	190	197,600	9,665	0.05
Centrifugal, 3 in.	42	43,680	2,180	0.05
Centrifugal, 4 in.	7	7,280	666	0.09
Diaphragm, 4 in.	32	33,280	2,072	0.06
All	271	281,840	14,573	0.05
Rollers:				
Two-wheel, tandem, gasoline:				
5 to 8 ton, variable	1	1,394	545	0.39
8 to 10 ton, variable	20	27,872	18,334	0.66
8 to 12 ton, variable	19	26,478	23,165	0.87
10 to 12 ton, variable	84	117,062	102,566	0.88
	124	172,806	144,610	0.84

TABLE 11—Continued

EQUIPMENT TYPE	NO. OF UNITS	TIME AVAILABLE FOR USE (HR)	TOTAL OWNER- SHIP COSTS(\$)	HOURLY EQUIPMENT OWNERSHIP COST(\$)
Three-wheel, two-axle, gasoline:				
6 to 8 ton, variable	10	13,936	8,178	0.59
8 to 10 ton, variable	4	5,574	3,309	0.59
10 to 12 ton, variable	374	521,206	457,741	0.88
	388	540,716	469,228	0.87
Sheepsfoot, tamping, double drum	3	4,181	374	0.09
Vibrating, steel-wheeled, manually guided, 24 in.	252	351,187	136,199	0.39
Wobble-wheel, self-propelled, 9-wheel, 15 tons	65	90,584	62,844	0.69
All	832	1,159,474	813,255	0.70
Shovels and cranes:				
Power shovel, crawler-mounted, gasoline:				
1/2 cu yd	6	9,360	9,039	0.97
3/4 cu yd	33	51,480	85,776	1.67
	39	60,840	94,815	1.56
Power shovel, truck-mounted, gasoline:				
1/2 cu yd	20	31,200	65,151	2.09
Crane-shovel, crawler-mounted, gasoline:				
1/2 cu yd	23	35,880	35,848	1.00
Crane-shovel, truck-mounted, gasoline:				
1/2 cu yd	7	10,920	9,661	0.88
All	89	138,840	205,475	1.48
Tractors:				
Crawler, diesel, gear drive:				
51-60 dhp	5	6,968	3,221	0.46
75-85 dhp	13	18,117	9,050	0.50
	18	25,085	12,271	0.49
Crawler, gasoline:				
31 dhp	3	4,680	3,117	0.67
Bulldozer, crawler, diesel:				
51-60 dhp	16	22,298	13,432	0.60
75-85 dhp	3	4,181	4,637	1.11
150 dhp	1	1,394	5,480	3.93
	20	27,873	23,549	0.84
Two-wheel drive, rubber-tired, front end loader, with backhoe, gasoline:				
1/2 cu yd	11	15,330	12,292	0.80
3/4 cu yd	13	18,117	24,118	1.33
	24	33,447	36,410	1.09
Two-wheel drive, rubber-tired, front end loader, with backhoe, diesel:				
1/2 cu yd	11	15,330	12,642	0.82
1 cu yd	79	110,094	166,666	1.51
	90	125,424	179,308	1.43

TABLE 11—Continued

EQUIPMENT TYPE	NO. OF UNITS	TIME AVAILABLE FOR USE (HR)	TOTAL OWNER- SHIP COSTS(\$)	HOURLY EQUIPMENT OWNERSHIP COST(\$)
Four-wheel drive, rubber-tired, front end loader, gasoline:				
1 cu yd	153	213,221	268,227	1.26
1¼ cu yd	24	33,446	50,655	1.51
1½ cu yd	48	66,893	116,379	1.74
	225	313,560	435,261	1.39
Four-wheel drive, rubber-tired, front end loader, with backhoe, diesel:				
1¼ cu yd	5	6,968	25,385	3.64
1½ cu yd	22	30,659	54,198	1.77
	27	37,627	79,583	2.12
All	407	567,696	769,499	1.36
TOTAL, ALL ABOVE EQUIPMENT	2,550	3,376,985	4,330,433	1.28

REFERENCES

1. U.S. BUREAU OF PUBLIC ROADS. *Total Disbursements for Highways, All Units of Government, 1962-1965*. Table HF-2 (Dec. 1964).
2. AMER. ASSOC. OF STATE HIGHWAY OFFICIALS. *Manual of Uniform Highway Accounting Procedures* (1958).
3. ARBA SPEECH-OF-THE-MONTH CLUB. *The 1965 Interstate Cost Estimate*. Table IV (Feb. 1965).
4. U.S. BUREAU OF PUBLIC ROADS. *Estimated Capital Expenditures for Highways, 1962-1965, by Federal Systems, by Expending Agencies*. Table HF-21 (Dec. 1964).
5. ASSOC. EQUIPMENT DISTRIBUTORS. *Compilation of Averaged Rental Rates for Construction Equipment, 1965/66*. 17th Ed. (Oct. 15, 1965).
6. ASSOC. GENERAL CONTRACTORS OF AMERICA. *Contractors' Equipment Ownership Expense*. 5th Ed. (1962).
7. U.S. BUREAU OF PUBLIC ROADS. *Highway Statistics, 1963*. Table CA-3, p. 100 (Mar. 1965).
8. *Field Manual*, Sect. 9.4(d). Bur. of Construction, Illinois Div. of Hwys.
9. "Equipment Depreciation Reform Needed, Survey Shows." *Constr. Methods and Equip.* (Jan. 1962).
10. U.S. TREASURY DEPT. *Depreciation Guidelines and Rules*. Revenue Procedure 62-21 (1962); revised (Aug. 1964).
11. CAMPBELL, J. R., and ZIMMERMAN, M. "Report on Equipment Rental Rates." Memorandum to District Engineer, Arlington District, Region 15, BPR (Mar. 17, 1965).
12. DOUGLAS, JAMES. *Obsolescence as a Factor in the Depreciation of Construction Equipment*. Dept. of Civil Engineering, Stanford Univ. (May 1963).

APPENDIX

QUESTIONNAIRE ON CURRENT EQUIPMENT RENTAL RATE PRACTICES OF STATE HIGHWAY DEPARTMENTS

No.	Type of Work	Contract Construct
1.	<p>What is basis of equipment charges incurred by the State, directly or indirectly:</p> <p>(a) AED "Green Book?"</p> <p>Which edition?</p> <p>% discount applied to AED rates:</p> <p>(b) AGC "Equipment Ownership Expense?"</p> <p>Which edition?</p> <p>% discount applied to AGC rates, if any:</p> <p>(c) Negotiations independent of a published schedule?</p> <p>(d) Developed internally at State or County level?</p> <p>(e) Other (describe)</p>	
2.	<p>By what unit or measurement are the rates charged: (a) hour</p> <p>(b) day</p> <p>(c) week</p> <p>(d) month</p> <p>(e) mile</p> <p>(f) other (describe)</p>	
3.	<p>Are rental rates charged for:</p> <p>(a) Time taken to move equipment to and from job site? (if not, explain)</p> <p>(b) Time spent in repairs and maintenance on the job site? (if not, explain)</p> <p>(c) Other time during working day that equipment is not in use? (if not, explain)</p>	
4.	<p>Are freight charges (involved in moving equipment) borne by:</p> <p>(a) The highway department?</p> <p>(b) The contractor?</p> <p>(c) Other party (please explain)</p>	
5.	For equipment used by a contractor, does he charge the same rate for his own equipment as for equipment he leases?	
6.	<p>Do rates charged cover the following costs:</p> <p>(a) Operator's wages</p> <p>(b) Fringe benefits of labor</p> <p>(c) Fuel</p> <p>(d) Oil</p> <p>(e) Lubricants</p> <p>(f) Cost of labor, other than operator, for repairs and maintenance on site</p> <p>(g) Cost of materials for repairs on site</p> <p>(h) Other costs (please explain)</p> <p>(i) Profit</p>	
7.	Are on-site records kept by highway department personnel showing hours of use of each type of equipment?	
8.	<p>Of total cost of work, what % do you estimate is expended on:</p> <p>(a) Materials</p> <p>(b) Labor</p> <p>(c) Equipment</p> <p>(d) Other costs (please describe)</p> <p>(e) Profit</p> <p>(f) Total</p>	
9.	If highway department personnel estimate cost of contracted work prior to or after receiving bids, which type of equipment rates (see No. 1 and No. 2) are used?	100%

If space for reply is inadequate, please use back of form or separate sheet.

Use appropriate symbol so answers are keyed to question.

Published reports of the
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Highway Research Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

NCHRP
Report No.
—*

Title

- | | | | |
|----|---|------------------------------------|--------|
| | A Critical Review of Literature Treating Methods of Identifying Aggregates Subject to Destructive Volume Change When Frozen in Concrete and a Proposed Program of Research—Intermediate Report (Project 4-3(2)) | 81 pp. | \$1.80 |
| 1 | Evaluation of Methods of Replacement of Deteriorated Concrete in Structures (Project 6-8) | 56 pp. | \$2.80 |
| 2 | An Introduction to Guidelines for Satellite Studies of Pavement Performance (Project 1-1) | 19 pp. | \$1.80 |
| 2A | Guidelines for Satellite Studies of Pavement Performance | 85 pp.+ 9 figs., 26 tables, 4 app. | \$3.00 |
| 3 | Improved Criteria for Traffic Signals at Individual Intersections—Interim Report (Project 3-5) | 36 pp. | \$1.60 |
| 4 | Non-Chemical Methods of Snow and Ice Control on Highway Structures (Project 6-2) | 74 pp. | \$3.20 |
| 5 | Effects of Different Methods of Stockpiling Aggregates—Interim Report (Project 10-3) | 48 pp. | \$2.00 |
| 6 | Means of Locating and Communicating with Disabled Vehicles—Interim Report (Project 3-4) | 56 pp. | \$3.20 |
| 7 | Comparison of Different Methods of Measuring Pavement Condition—Interim Report (Project 1-2) | 29 pp. | \$1.80 |
| 8 | Synthetic Aggregates for Highway Construction (Project 4-4) | 13 pp. | \$1.00 |
| 9 | Traffic Surveillance and Means of Communicating with Drivers—Interim Report (Project 3-2) | 28 pp. | \$1.60 |
| 10 | Theoretical Analysis of Structural Behavior of Road Test Flexible Pavements (Project 1-4) | 31 pp. | \$2.80 |
| 11 | Effect of Control Devices on Traffic Operations—Interim Report (Project 3-6) | 107 pp. | \$5.80 |
| 12 | Identification of Aggregates Causing Poor Concrete Performance When Frozen—Interim Report (Project 4-3(1)) | 47 pp. | \$3.00 |
| 13 | Running Cost of Motor Vehicles as Affected by Highway Design—Interim Report (Project 2-5) | 43 pp. | \$2.80 |
| 14 | Density and Moisture Content Measurements by Nuclear Methods—Interim Report (Project 10-5) | 32 pp. | \$3.00 |
| 15 | Identification of Concrete Aggregates Exhibiting Frost Susceptibility—Interim Report (Project 4-3(2)) | 66 pp. | \$4.00 |
| 16 | Protective Coatings to Prevent Deterioration of Concrete by Deicing Chemicals (Project 6-3) | 21 pp. | \$1.60 |
| 17 | Development of Guidelines for Practical and Realistic Construction Specifications (Project 10-1) | 109 pp. | \$6.00 |
| 18 | Community Consequences of Highway Improvement (Project 2-2) | 37 pp. | \$2.80 |
| 19 | Economical and Effective Deicing Agents for Use on Highway Structures (Project 6-1) | 19 pp. | \$1.20 |
| 20 | Economic Study of Roadway Lighting (Project 5-4) | 77 pp. | \$3.20 |
| 21 | Detecting Variations in Load-Carrying Capacity of Flexible Pavements (Project 1-5) | 30 pp. | \$1.40 |
| 22 | Factors Influencing Flexible Pavement Performance (Project 1-3(2)) | 69 pp. | \$2.60 |
| 23 | Methods for Reducing Corrosion of Reinforcing Steel (Project 6-4) | 22 pp. | \$1.40 |
| 24 | Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants (Project 7-1) | 116 pp. | \$5.20 |
| 25 | Potential Uses of Sonic and Ultrasonic Devices in Highway Construction (Project 10-7) | 48 pp. | \$2.00 |
| 26 | Development of Uniform Procedures for Establishing Construction Equipment Rental Rates (Project 13-1) | 33 pp. | \$1.60 |

THE NATIONAL ACADEMY OF SCIENCES is a private, honorary organization of more than 700 scientists and engineers elected on the basis of outstanding contributions to knowledge. Established by a Congressional Act of Incorporation signed by President Abraham Lincoln on March 3, 1863, and supported by private and public funds, the Academy works to further science and its use for the general welfare by bringing together the most qualified individuals to deal with scientific and technological problems of broad significance.

Under the terms of its Congressional charter, the Academy is also called upon to act as an official—yet independent—adviser to the Federal Government in any matter of science and technology. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency and its activities are not limited to those on behalf of the Government.

THE NATIONAL ACADEMY OF ENGINEERING was established on December 5, 1964. On that date the Council of the National Academy of Sciences, under the authority of its Act of Incorporation, adopted Articles of Organization bringing the National Academy of Engineering into being, independent and autonomous in its organization and the election of its members, and closely coordinated with the National Academy of Sciences in its advisory activities. The two Academies join in the furtherance of science and engineering and share the responsibility of advising the Federal Government, upon request, on any subject of science or technology.

THE NATIONAL RESEARCH COUNCIL was organized as an agency of the National Academy of Sciences in 1916, at the request of President Wilson, to enable the broad community of U. S. scientists and engineers to associate their efforts with the limited membership of the Academy in service to science and the nation. Its members, who receive their appointments from the President of the National Academy of Sciences, are drawn from academic, industrial and government organizations throughout the country. The National Research Council serves both Academies in the discharge of their responsibilities.

Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by several thousand of the nation's leading scientists and engineers, the Academies and their Research Council thus work to serve the national interest, to foster the sound development of science and engineering, and to promote their effective application for the benefit of society.

THE DIVISION OF ENGINEERING is one of the eight major Divisions into which the National Research Council is organized for the conduct of its work. Its membership includes representatives of the nation's leading technical societies as well as a number of members-at-large. Its Chairman is appointed by the Council of the Academy of Sciences upon nomination by the Council of the Academy of Engineering.

THE HIGHWAY RESEARCH BOARD, organized November 11, 1920, as an agency of the Division of Engineering, is a cooperative organization of the highway technologists of America operating under the auspices of the National Research Council and with the support of the several highway departments, the Bureau of Public Roads, and many other organizations interested in the development of highway transportation. The purposes of the Board are to encourage research and to provide a national clearinghouse and correlation service for research activities and information on highway administration and technology.



1789921