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Building Maintenance and Repair Data for Life-Cycle Cost Analyses: Report Generator

by
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This report describes one aspect of a larger research project that has provided improved maintenance resource data to help in the planning, design, maintenance, and operation of buildings on Army facilities. Data bases and computer systems were developed to assist: (1) planners in preparing planning documentation, (2) designers in life-cycle component selection, and (3) maintainers in resource planning. These data bases and computer systems are currently used by U.S. Army Corps of Engineers (USACE) designers at the District and installation levels, and by resource programmers at the USACE Headquarters, Army Major Command, and installation levels. These research products may also prove useful to other Government agencies as well as to the private sector.

This report describes life-cycle cost (LCC) database development for building component maintenance and repair, as well as a project-specific report generator. This is one of a series of Special Reports on the life-cycle cost data base.

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FOREWORD

This research was conducted for the Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers (HQUSACE) and the Office of the Assistant Chief of Engineers (OACE) under various Research, Development, Testing, and Evaluation (RDTE) and reimbursable funding documents. Work began under RDTE in 1980 and continued in reimbursable projects during 1984-1989. The technical monitor for the RDTE part was Dr. Larry Schindler, CEMP-EC, and for the reimbursable part was Ms. Val Corbridge, DAEN-ZCP-B.

The work was performed by the Facility Systems Division (FS), U.S. Army Construction Engineering Research Laboratory (USACERL). The Principal Investigators were Dr. Edgar Neely and Mr. Robert Neathammer. Dr. Michael O'Connor is Chief of FS. The USACERL technical editor was Mr. William J. Wolfe, Information Management Office.

LTC E.J. Grabert, Jr. is Acting Commander of USACERL, and Dr. L.R. Shaffer is Director.

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BUILDING MAINTENANCE AND REPAIR DATA FOR LIFE-CYCLE COST ANALYSES: REPORT GENERATION

1 INTRODUCTION

Background

Maintenance* and repair (M&R) cost estimates are needed during planning, design, and operations/maintenance of Army facilities. During planning, life-cycle costs are needed to evaluate alternative ways to meet requirements (e.g., lease, new construction, renovation of existing facilities). During design, M&R requirements for various types of components, such as built-up or shingle roofs, are needed to help minimize the total life-cycle cost of the building. Finally, once the facility has been constructed, future predictions of M&R costs are needed to program enough funds to ensure that Army facilities are maintained properly, i.e., that they do not deteriorate from lack of maintenance.

The Directorate of Engineering and Construction (EC), Headquarters, U.S. Army Corps of Engineers (HQUSACE),** asked the U.S. Army Construction Engineering Research Laboratory (USACERL) to coordinate the assembly of a single, centralized maintenance and repair data base for use by Corps designers. This research was required because designers were not able to obtain reliable maintenance and repair data to support their life-cycle cost (LCC) analysis from installations or from the technical literature. One of the first tasks in the research effort was to determine if reliable data bases that could be adapted for Corps use, existed in government or private industry. Research showed that comprehensive data bases of maintenance costs for government and private sector facilities did not exist. The little data available always depended on widely varying standards of maintenance used to maintain the facilities for which the data was collected and thus was unreliable for prediction purposes. Recognizing this, HQUSACE asked USACERL to develop a maintenance and repair cost data base. This data is for use by U.S. Army Corps of Engineers (USACE) designers in performing life-cycle cost analyses during the design of new facilities. Initial results were presented in several USACERL reports.[1]

Soon after this request, the Facilities Programming and Budgeting Branch of the Facilities Engineering Directorate asked USACERL to develop prediction models for future maintenance requirements for Army facilities. The EC Programming Office, which is responsible for Military Construction, Army (MCA) planning, also requested that USACERL provide methods and automated tools to help installations perform economic analyses. Part of the objective was to allow analysts to obtain future maintenance cost data.

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* In this report, maintenance means all work required to keep a facility in good operating condition, including all maintenance, repair, and replacement of components required over the life of a facility.

** At the time of this request, EC was part of the Office of the Chief of Engineers, which has since reorganized. In addition, EC has now become the Directorate of Military Programs (CEMP).

[1] R.D. Neathammer, *Life-Cycle Cost Database Design and Sample Cost Data Development*, Interim Report (IR) P-120/ADA-0997222 (U.S. Army Construction Engineering Research Laboratory [USACERL], February 1981); R.D. Neathammer, *Life-Cycle Cost Database: Vol I, Design*, and *Vol II, Sample Data Development*, Technical Report (TR) P-139/ADA126644 and ADA126645 (USACERL, January 1983), Appendices E through G.

In response to these requests, USACERL began a multi-year effort to develop a comprehensive M&R research program for buildings. This coordinated program is the key to all detailed estimation of future maintenance costs for Army facilities.

Research Performed and Reports Published

This is one of several interrelated reports addressing maintenance resource prediction in the facility life-cycle process. This report includes all labor, material, and equipment resources required to accomplish M&R over the life of the facility. The total research effort is described in a USACERL Technical Report.[2] This multi-year research project has produced several products, four of which are described below.

The first research product is a data base containing maintenance tasks related to all building construction components, such as a shingle roof or a sink. This task data base provides labor, material, and equipment resource information as well as the frequency of task occurrence. This information is published in a series of four USACERL Special Reports titled *Maintenance Task Data Base for Buildings*.[3] Each volume approaches one engineering system: (1) architectural, (2) heating, ventilating, and air-conditioning (HVAC), (3) plumbing, and (4) electrical. Figure 1 shows an example from this data base. This data is also available in electronic form. The data base is used in a personal computer (PC) system under the IBM Disk Operating System (DOS). This computer program allows a facility to be defined by entering the components and component quantities comprising the facility. The tasks are used to determine the resources required annually to maintain the facility.

The second research product is a component resource summary for the first 25 years of a facility. The tasks for the component are scheduled and combined into one set of annual resource requirements. This annual resource information is published in a series of four USACERL Special Reports titled *Maintenance Component Data Base for Building Systems*.[4] Figure 2 shows an example from this data base. The data base is also available in electronic form. This data can be used to perform various types of economic analysis, e.g., one for a 20-year life using an 8 percent discount rate.

The third research product is a set of 25-year present worth tables for use by designers in selecting components for design features with little or no effect on building energy use (using a discount rate of 10 percent) and components for design features with a significant effect on building energy use (using a discount rate of 7 percent). The task resources were scheduled for the first 25 years of facility

[2] E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler *Maintenance Resource Prediction in the Facility Life-Cycle Process*, TR P-91/10 (USACERL, 1991).

[3] E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler, *Maintenance Task Data Base for Buildings: Architectural Systems*, Special Report (SR) P-91/23 (USACERL, 1991); E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler, *Maintenance Task Data Base for Buildings: Heating, Ventilation, and Air-Conditioning Systems*, SR P-91/21 (USACERL, 1991); E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler, *Maintenance Task Data Base for Buildings: Plumbing Systems*, SR P-91/18 (USACERL, 1991); E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler, *Maintenance Task Data Base for Buildings: Electrical Systems*, SR P-91/25 (USACERL, 1991).

[4] E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler *Maintenance Component Data Base for Buildings: Architectural Systems*, SR P-91/27 (USACERL, 1991); E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler *Maintenance Component Data Base for Buildings: Heating, Ventilation, and Air-Conditioning Systems*, SR P-91/22 (USACERL, 1991); E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler *Maintenance Component Data Base for Buildings: Plumbing Systems*, SR P-91/30 (USACERL, 1991); E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler *Maintenance Component Data Base for Buildings: Electrical Systems*, SR P-91/19 (USACERL, 1991).

Task Code: 0311356

Component: SHINGLES System: ROOFING Subsystem: ROOF COVERING

Task Description: REPLACE NEW OVER EXISTING - SHINGLED ROOF

Unit of Measure: SQUARE FEET Frequency of Occurence: H: 18.00 A: 20.00 L: 22.00

Persons per Team: 2 Task Duration: 0.0150 hours Once every (H,A,L) years

Trade: ROOFER Task Classification: 1

Labor Resources

Subtask Description	Labor Hours
1. SET UP/SECURE/TAKE DOWN LADDER	0.000160
2. REPLACE WITH NEW SHINGLE	0.012887
3. CLEAN UP	0.010000

Material Resources

Description	Quantity	Unit Cost
SHINGLE	1.0 SF	0.2600
MASTIC	1.0 SF	0.1500
		0.4100

SUMMARY

Resources	Direct	Indirect	Total
Labor Hours	0.023047	0.006914	0.029961
Material Cost $	0.410000		0.410000
Equipment Hours			0.014981

Figure 1. Typical Task Data Form.

Typical Components Summary

CACES No.: 031134 - Roll Roofing | 031135 - Shingles

Labor Hours	Materials $	Equipment Hours	YR	Labor Hours	Materials $	Equipment Hours
0.0076	0.0165	0.0039	1	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	2	0.0024	0.0220	0.0013
0.0090	0.0165	0.0046	3	0.0026	0.0220	0.0014
0.0076	0.0165	0.0039	4	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	5	0.0032	0.0330	0.0017
0.0090	0.0165	0.0046	6	0.0026	0.0220	0.0014
0.0076	0.0165	0.0039	7	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	8	0.0024	0.0220	0.0013
0.0090	0.0165	0.0046	9	0.0026	0.0220	0.0014
0.0414	0.7496	0.0207	10	0.0032	0.0330	0.0017
0.0076	0.0165	0.0039	11	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	12	0.0026	0.0220	0.0014
0.0090	0.0165	0.0046	13	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	14	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	15	0.0034	0.0330	0.0018
0.0090	0.0165	0.0046	16	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	17	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	18	0.0026	0.0220	0.0014
0.0090	0.0165	0.0046	19	0.0024	0.0220	0.0013
0.0414	0.7496	0.0207	20	0.0332	0.4675	0.0167
0.0076	0.0165	0.0039	21	0.0026	0.0220	0.0014
0.0076	0.0165	0.0039	22	0.0024	0.0220	0.0013
0.0090	0.0165	0.0046	23	0.0024	0.0220	0.0013
0.0076	0.0165	0.0039	24	0.0026	0.0220	0.0014
0.0076	0.0165	0.0039	25	0.0032	0.0330	0.0017

All data is per square foot of roof area.

Figure 2. Typical Component Summary.

life using the average frequency of occurrence for each task. Individual task resources were summed for each year to produce one total labor hour, equipment hour, and material cost requirement for each facility age. The yearly component resource values were multiplied by the appropriate present worth factor to produce a present worth value for every year. The present worth values for each year were added for the 25 years to produce one set of 25-year summary resource values that the designer can use very easily and quickly. The 25-year summary values are published in a series of four USACERL Special Reports titled *Building Maintenance and Repair for Life-Cycle Cost Analysis*.[5] Figure 3 shows an example from this database. The data base is also available in electronic form. The first three resource columns provide data that allows designers to calculate the life-cycle costs at any location by multiplying by the correct labor rate, equipment rate, and material geographic adjustment factor. The multiplication and addition have been performed for the Military District of Washington, DC, at a particular time, and results are given in the fifth column of Table 3. The right section of the table presents the information in a format that can be accepted by typical life-cycle cost analysis computer programs (e.g., the Corps of Engineers' Life Cycle Cost in Design (LCCID) program.[6] This report describes a generic report generator program that produces life-cycle data for any set of economic conditions.

The fourth research product is a PC system that describes facilities after you enter the components within the facility. The system predicts future year resources by applying the individual tasks and then forming resource summaries by subsystems, systems, facilities, installations, reporting installations, Major Commands (MACOMS), and the Army as a whole. A summary-level computer system was also developed for use by the Department of the Army (DA) and MACOMS. The summary-level system applies the most basic data contained in the current facility real property inventory files: (1) current facility use, (2) floor area, and (3) construction date.

Objectives

The two major objectives of this report are to present: (1) the information required to produce life-cycle cost analysis data for any specific project related economic conditions, (2) an overview of the total research effort, including the reports published on this research program.

Approach

The first research activity was to survey the literature for available maintenance data and review the historical data available at Army installations. No comprehensive task resource data base was located. A review of historical data revealed that installations have always been underfunded and that the (limited) available data shows only when work *was* performed, not when it *should have been* performed. The Navy had developed a series of manuals dealing with labor hours required to perform several basic maintenance tasks. This work had been adopted by the Department of Defense (DOD) for tri-service use, published as Technical Bulletins (TBs) Series 420 under the general title *Engineered Performance Standards*.

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[5] E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler *Building Maintenance and Repair Data for Life-Cycle Cost Analyses: Heating, Ventilation, and Air-Conditioning Systems*, SR P-91/20 (USACERL, 1991); E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler *Building Maintenance and Repair Data for Life-Cycle Cost Analyses: Plumbing Systems*, SR P-91/24 (USACERL, 1991); E.S. Neely, R.D. Neathammer, J.R. Stirn, and R.P. Winkler *Building Maintenance and Repair Data for Life-Cycle Cost Analyses: Electrical Systems*, SR P-91/26 (USACERL, 1991).

[6] Linda Lawrie, *Development and Use of the Life Cycle Cost in Design Computer Program (LCCID)*, TR E-85/07/ADA162522 (USACERL, November 1985).

EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS ($ PER UNIT MEASURE)													
COMPONENT DESCRIPTION		PRESENT WORTH OF ALL 25 YEAR MAINTENANCE AND REPAIR COSTS (d=10%)				PRESENT MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS							
		By Resources			Washington D.C. Total	Annual Maintenance and Repair			Replacement and High Costs Tasks				
	um	labor	material	equipment		labor	material	equipment	Yr	labor	material	equipment	
ARCHITECTURE													
ROOFING													
ROOF COVERING													
BUILTUP ROOFING	SF	0.03987	0.37166	0.01994	1.25	0.00487	0.03167	0.00244	28	0.04938	0.70490	0.02469	
PLACE NEW MEMBRANE OVER EXISTING-BUILDUP									14	0.02414	0.69960	0.01207	
MOD. BIT./THERMOPLASTIC	SF	0.02415	0.33069	0.01208	0.86	0.00245	0.03218	0.00123	20	0.05659	0.85860	0.02829	
THERMOSETTING	SF	0.01667	0.23941	0.00833	0.61	0.00173	0.02202	0.00086	20	0.03683	0.69960	0.01841	
SLATE	SF	0.01809	0.10432	0.00904	0.50	0.00253	0.01458	0.00126	70	0.06885	6.04200	0.03442	
CEMENT ASBESTOS	SF	0.01760	0.24341	0.00881	0.63	0.00246	0.03403	0.00123	70	0.05437	0.75190	0.02718	
TILE	SF	0.01519	0.20982	0.00759	0.54	0.00212	0.02933	0.00106	70	0.10169	3.07400	0.05084	
ROLL ROOFING	SF	0.07156	0.42684	0.03578	2.01	0.00757	0.01556	0.00378	10	0.04141	0.74963	0.02070	
SHINGLES	SF	0.02222	0.22132	0.01111	0.71	0.00262	0.02383	0.00131	40	0.04118	0.74497	0.02059	
REPLACE NEW OVER EXISTING-SHINGLED ROOF									20	0.02998	0.43460	0.01498	
METAL	SF	0.01422	0.11058	0.00711	0.42	0.00199	0.01546	0.00099	30	0.36265	2.17300	0.18132	
FIBERGLASS RIGID STP. ROOF	SF	0.02161	1.15262	0.01080	1.63	0.00228	0.06266	0.00114	20	0.04543	6.01550	0.02272	
CONCRETE, SEALED PANEL ROOF	SF	0.04260	0.11748	0.02131	1.06	0.00596	0.01642	0.00298	60	0.06123	24.07419	0.03061	
CONCRETE, SEALED PANEL RF4	SF	0.03950	0.08408	0.01974	0.96	0.00552	0.01175	0.00276	300	0.04342	24.07419	0.02171	
CONCRETE, SEALED POURED	SF	0.09872	0.62996	0.04936	2.81	0.01380	0.08807	0.00690	500	3.81056	18.03219	1.90528	
FIBERGLASS, RIGID ROOF	SF	0.03832	1.15262	0.01915	2.00	0.00468	0.06266	0.00234	20	0.04133	6.01550	0.02066	

See NOTES on the last page of this table for Explanation of Column Headings

Figure 3. LCC Analysis.

Next, a sample of USACE District offices was surveyed to determine what data sources they used and to solicit their opinions on structure and content of a maintenance data base. An advisory committee composed of District personnel, installation representatives, and private sector consultants met and agreed that there was no accurate historical data available. They recommended that a data base be developed using the Engineered Performance Standards rather than historical data.

The third activity was to develop a task resource data base. This task resource data base included all labor, material, and equipment resources required to produce accurate maintenance and repair data. Once the basic task data base was developed, a component summary data base was created by summing all task resources for a component. Individual task labor hour, equipment hour, and material costs resources were summarized by facility age for the first 25 years of the facilities' lives.

Life-cycle cost data bases were generated from the component data base. Component summaries were input into this computer program to compute present worth values for each component.

Scope

This report describes the user friendly computer input screens required to generate project specific life-cycle cost analysis data tables. These tables can be used by designers performing life-cycle cost analysis in the private or government sectors.

Mode of Technology Transfer

The tables pertinent to designer use will be issued as a supplement to Technical Manual (TM) 5-802-1, *Economic Studies for Military Construction Design—Applications* (DA, 31 December 1986).

2 PROBLEM DEFINITION

In the facility life-cycle process, costs are incurred in construction, operation, maintenance, and disposal of a facility. In the past, emphasis during the planning, design, and construction phases has been placed on estimating initial construction costs. The impact of operating and maintaining facilities has always been a secondary consideration. In many cases, the O&M costs are far greater than initial construction costs. Building owners are concerned with the total ownership costs of facilities rather than just the initial construction costs.

The Army has realized the importance of performing total life-cycle cost analyses for facilities at the design stage and of accurately forecasting these costs for funds programming. In 1980, HQUSACE asked USACERL to develop a method to estimate future building maintenance costs. In 1982, the programming branch of the former Facilities Engineering Directorate asked USACERL to develop effective models to help forecast facility maintenance resource requirements based on actual facilities.

Life-cycle cost economic studies are an integral part of facility design in the MCA program. Requirements for performing these studies are given in:

- Statutes, the Code of Federal Regulations, and Executive Orders for performing analyses when energy is a key cost, and for wastewater treatment plants
- USACE *Architectural and Engineering Instructions Design Criteria* (HQUSACE, 13 March 1987)
- TM 5-802-1, *Economic Studies for Military Construction Design—Applications* (DA, 31 December 1986).

The main purpose of these studies is to minimize the life-cycle costs of Army facilities.

To perform life-cycle cost analyses on facility designs, four categories of costs are needed: initial, operating, maintenance, and salvage. Initial costs are usually easy to estimate through existing cost estimating systems such as the Corps of Engineers Computer Assisted Cost Estimating System (CACES), standard publications such as Means, or Dodge, or by contacting local vendors and contractors. Operating costs can be estimated by using energy consumption models such as the Corps of Engineers Building Loads Analysis and System Thermodynamics (BLAST)[7] program or the Trane Company's Trace program. However, accurate estimates of maintenance costs are not available.

There are no comprehensive data bases of maintenance costs for building components either in the private sector or state/federal governments. Some historical data is available from the Building Owners' and Managers' Association reports. This data is essentially restricted to only a few of the building types found in the Army inventory and therefore could not solve the entire problem. Within the Army, the Integrated Facilities System (IFS) contains some historical data, but lacks a feature for defining several types of a building component (e.g., having brick and wood exteriors or three types of floor covering). Moreover, the data in IFS has not been kept current. For example, at one installation several family housing units were shown as having wood siding when, in fact, they had been covered with aluminum siding several years before.

[7] J.A. Amber, D.J. Leverenz, and D.L. Herron, *Automated Building Design Review Using BLAST*, TR-E-85/03/ADA151707 (USACERL, January 1985).

3 THE COMPUTER PROGRAM

Introduction

The computer programs and data required to produce both printed tables and ASCII computer file outputs are enclosed on two diskettes labeled "LCCA1" and "LCCA2". This section describes how to load the programs into your personal computer and how to run the program to produce output. The programs are written in dBase III.* The phrases Beneficial Occupancy and Beneficial Use are synonymous. The phrase used depends on the client's preference. In this report, Beneficial Use is used.

Loading Computer Programs and Data

First you must create a new directory to store the programs and data. The computer must be able to store 7 MB of information. The next step is to copy the two files on the two diskettes into the directory. The third step is to type LCCA1 and press and enter key; then LCCA2 and again press the enter key. The last step is to delete files LCCA1.EXE and LCCA2.EXE.

Running the Program

While in the new directory, the main program can be called by typing "LCCA" and pressing the enter key. Figure 4 shows the main menu for the maintenance and resource data for life-cycle cost analysis.

```
                    Maintenance and Repair Database for
                        Life-Cycle Cost Analysis

                              Version 1.1


                       Generate New Database
                       Report on an Existing Database
                       Export Database to an Ascii File


 Use arrow keys to highlight; <Enter> selects                  F10 - Exit
```

Figure 4. Main Menu.

*dBase III is a product of Ashton-Tate, Inc., 20101-T. Hamiliton, Torrance, CA, 90502.

Special Keys

Several special keys are used by this program:

- F4 edit key is used to edit parameters on the screen.
- F5 edit key is used to set the phrases printed on report headers
- F6 start processing key is used to start the generation of a new data set, a report, or the creation of an ASCII file.
- F10 exit key is used to move back to the previous screen.
- Down and up arrows are used to move the highlight over the field to be edited or selected.
- Enter key is used to select the highlighted option or to move to the next field to be edited.

Program Functions

The program performs three basic functions:

1. The first option, *Generate New Data Set*, allows the user to define the basic input parameters required to produce a new data base.

2. The second option, *Report on Existing Data Set*, allows the user to create one of five different reports from the current data base.

3. The third option, *Export Data to an ASCII File*, allows the user to create a data file with no headers or footers for loading into other computer programs such as spreadsheet programs.

Generate New Data Set

The time to perform this function can vary between 1 and 2 hours depending on computer and printer speeds. Selection of this option displays the input screen shown in Figure 5. An explanation of each field is given in the following paragraphs:

1. Location: The user can enter the exact location for the data base to be produced. This phrase will be printed on each report. The default phrase "Washington, DC" is in Figure 5.

2. Date of Study: The date of study will be printed on each output report.

3. Years Between Date of Study and Beneficial Use Date: The user may enter any number zero or greater. The default value of "3.00" is shown in Figure 5.

4. Years Between Beneficial Use Date and End of Study Date: The user may enter any whole number. The default value of "25" is shown in Figure 5. This period is often known as the building economic or functional life.

```
                Maintenance and Repair Database for
      Life-Cycle Cost Analysis -- Data Generation Parameters

Location: Washington, D.C.
Date of Study: June, 1989
Years Between Date of Study and Beneficial Use Date:  3.00 years

Years Between Beneficial Use Date and End of Study Date: 25     years

Location Adjustment Factor for Material Costs:    1.00
(from Washington, D.C. to the Actual Location)
Material Cost Inflation Factor:   1.06
(from June, 1985 to the Date of Study)
HVAC Zone (Enter 1 - 11):   5

Real Discount Rate (excluding inflation):  10.00 Percent

Task Scheduling (1 = Midyear, 2 = End of Year):  2

F4 - Edit Resource Costs      F6 - Start Processing       F10 - Exit
```

Figure 5. Options Input Screen.

5. Location Adjustment Factor for Material Costs: This value adjusts the Washington, DC, costs to the actual location for the LCCA. Factors are given in Appendix A.

6. Material Cost Inflation Factor: This value will change the July 1985 costs to the actual date for the start of the study. This value can be calculated by using a construction index such as Engineering News Record. Divide the index for the start of the study by the index for July 1985 to calculate this factor.

7. HVAC Zone: There are 10 HVAC zones in the United States (Figure 6). Zone 11 is for Germany. Enter the correct zone for the actual location. Task frequencies are a function of the HVAC zone.

8. Real Discount Rate: Enter the discount factor expressed as a percentage.

9. Task Scheduling: The user may schedule the performance of tasks at either: (1) mid-year, or (2) end of the year. Figure 5 shows the default (2) end of the year.

10. F4 - Edit Resource Costs: The user may add the correct labor and equipment rates for the actual location. The screen shown in Figure 7 will be displayed. The user may enter the actual values by pressing the F4 edit parameters key. Washington, DC, rates are shown as default values.

11. F6 Start Processing: when all data have been entered, press the F6 start processing key to begin processing. The old data base will be deleted first, then the new data base will be generated. The system will display the component ID as the components are processed.

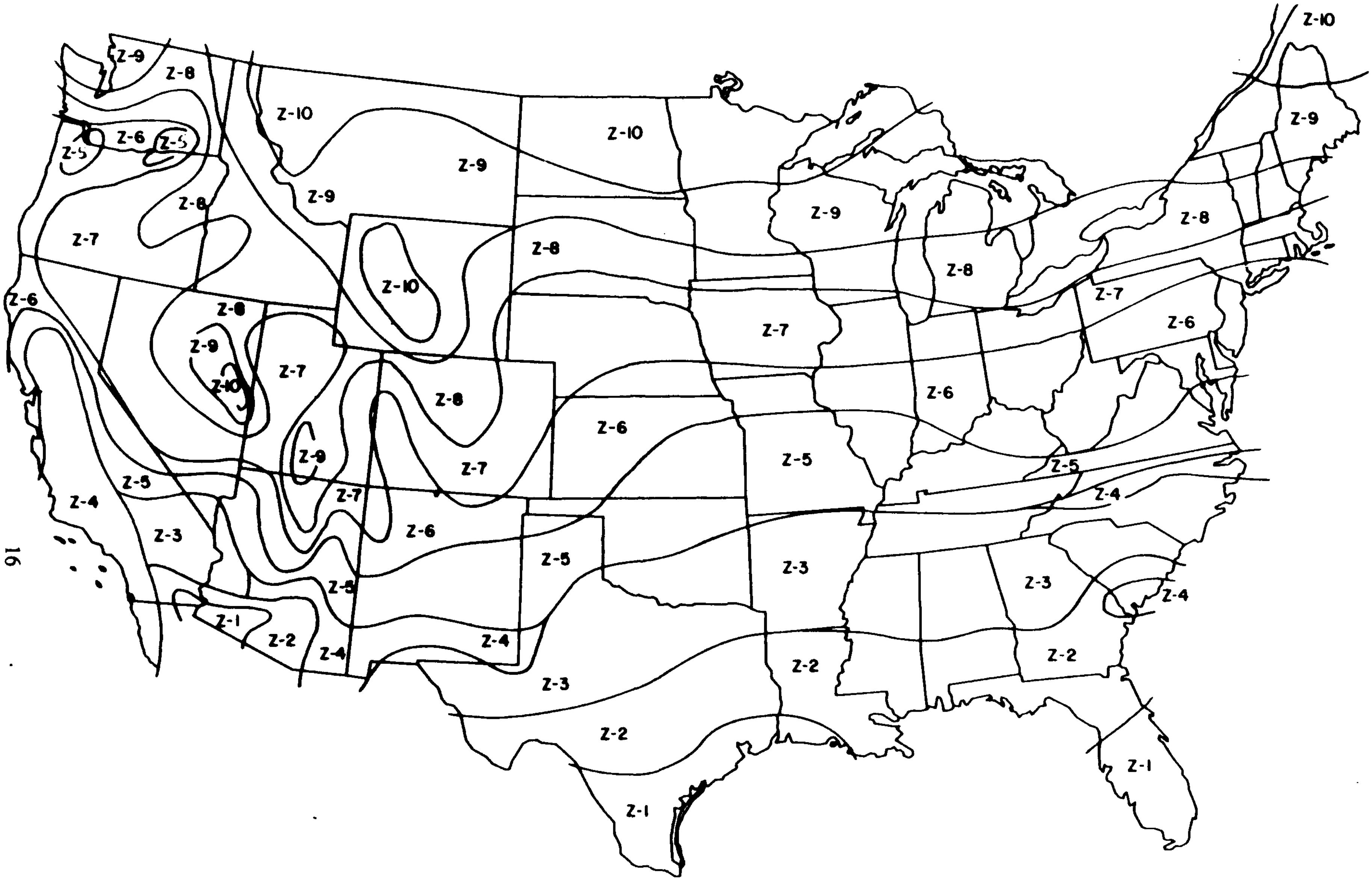

Figure 6. HVAC Zone Map.

Maintenance and Repair Database for
Life-Cycle Cost Analysis -- Resource Costs Edit Screen

Trade	Labor Rate ($/hr)	Equipment Rate ($/hr)
Carpentry	20.46	3.20
Electrical	22.45	3.20
Plumbing	17.99	3.20
Painting	20.46	3.20
Air Conditioning	19.48	3.20
Heating	19.48	3.20
Masonry	20.46	3.20
Roofing	20.46	3.20
Steamfitting	17.90	3.20

F4 - Edit Parameters F6 - Start Processing F10 - Exit

Figure 7. Resource Costs Edit Screen.

Report on Existing Data Set

The time to generate reports varies depending on the computer and printer speeds. The time to produce a 40-page report covering all systems may range from 3 to 5 hours. The system allows the user to produce five different reports (Figures 8-12):

1. Total Unit Costs: this report contains three columns: (a) component description, (b) unit of measure, and (c) total unit cost. An example page is shown in Figure 8. This is the same type of information as given in the "Washington, DC" column of Figure 3.

2. Resources and Total Unit Costs: this report has the three columns described earlier and three new columns showing the labor hours, material costs, and equipment hours for each component. An example page is shown in Figure 9. This is the same type of information as given in the left side of Figure 3.

3. Computer Input - Unit Costs: this report shows five columns: (a) component description, (b) unit of measure, (c) unit costs for annual maintenance, (d) year of task occurrence, and (e) unit costs for replacement and high cost tasks. The replacement task is always given on the same line as the component description. High cost tasks are listed below the component description. An example page is shown in Figure 10. This data has been calculated by applying the labor, equipment rate, and material adjustment and cost escalation factors to the right side of Figure 3.

4. Computer Input - Resource and Unit Costs: this report provides labor hours, material cost, and equipment hour resources in addition to the basic report described in (3) above. An example page is shown in Figure 11. This is the same type of information as given in the right half of Figure 3.

5. Total Maintenance and Repair Costs: this report is shown in Figure 12.

PRESENT VALUE OF ALL 25 YEAR
MAINT. AND REPAIR COSTS (d=10%)

($ PER UNIT MEASURE)

LOCATION: Washington, D.C.

STUDY STARTS 3 YEARS BEFORE BENEFICIAL USE

COMPONENT DESCRIPTION	UM	UNIT COST	YRS
ARCHITECTURE			
ROOFING			
ROOF COVERING			
BUILTUP ROOFING	SF	1.19410	28
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP			14
MOD.BIT./THERMOPLASTIC	SF	0.82710	20
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R			20
THERMOSETTING	SF	0.58110	20
MEMBRANE REPLACEMENT - THERMOSETTING ROOF			20
SLATE	SF	0.48760	70
CEMENT ASBESTOS	SF	0.61260	70
TILE	SF	0.52520	70
ROLL ROOFING	SF	1.91020	10
TOTAL ROOF REPLACEMENT - ROLL ROOF			10
SHINGLES	SF	0.67690	40
REPLACE NEW OVER EXISTING - SHINGLED ROOF			20
METAL	SF	0.41330	30
FIBERGLASS RIGID STP. ROOF	SF	1.55970	20
CONCRETE,SEALED PANEL ROOF	SF	1.01530	60
CONCRETE,SEALED PANEL RF4	SF	0.90120	300
CONCRETE SEALED POURED	SF	2.66930	500
FIBERGLASS, RIGID ROOF	SF	1.89850	20
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID			20

See NOTES on the last page of this table
for Explanation of Column Headings

Figure 8. Maintenance and Repair Data Base for LCC Analysis Unit Cost.

6. After selecting a report format, the user must select the engineering systems to be included within the report as shown in Figure 13. The user can include all systems or select one of the four systems (architectural, plumbing, electrical, or HVAC).

PRESENT VALUE OF ALL 25 YEAR
MAINT. AND REPAIR COSTS (d=10%)

($ PER UNIT MEASURE)

LOCATION: Washington, D.C.
STUDY STARTS 3 YEARS BEFORE BENEFICIAL USE

COMPONENT DESCRIPTION	UM	BY RESOURCES			UNIT COST	YRS
		LABOR	MATERIAL	EQUIPMENT		
ARCHITECTURE						
ROOFING						
ROOF COVERING						
BUILTUP ROOFING	SF	0.03810	0.35468	0.01900	1.19410	28
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP						14
MOD.BIT./THERMOPLASTIC	SF	0.02320	0.31535	0.01130	0.82710	20
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R						20
THERMOSETTING	SF	0.01600	0.22832	0.00810	0.58110	20
MEMBRANE REPLACEMENT - THERMOSETTING ROOF						20
SLATE	SF	0.01760	0.09943	0.00850	0.48760	70
CEMENT ASBESTOS	SF	0.01730	0.23203	0.00830	0.61260	70
TILE	SF	0.01480	0.20013	0.00710	0.52520	70
ROLL ROOFING	SF	0.06800	0.40704	0.03470	1.91020	10
TOTAL ROOF REPLACEMENT - ROLL ROOF						10
SHINGLES	SF	0.02100	0.21105	0.01120	0.67690	40
REPLACE NEW OVER EXISTING - SHINGLED ROOF						20
METAL	SF	0.01390	0.10547	0.00700	0.41330	30
FIBERGLASS RIGID STP. ROOF	SF	0.02090	1.09922	0.01030	1.55970	20
CONCRETE,SEALED PANEL ROOF	SF	0.04100	0.11204	0.02020	1.01530	60
CONCRETE,SEALED PANEL RF4	SF	0.03710	0.08014	0.01920	0.90120	300
CONCRETE SEALED POURED	SF	0.09370	0.60060	0.04720	2.66930	500
FIBERGLASS, RIGID ROOF	SF	0.03620	1.09922	0.01840	1.89850	20
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID						20

See NOTES on the last page of this table for Explanation of Column Headings

Figure 9. Maintenance and Repair Data Base for LCC Analysis Resources and Unit Cost.

7. The report can be printed to a printer, a file, or both as shown in Figure 14. The user must enter the name of the file in the following format:

- Prefix (1 to 8 characters) (Example: 12345 or LIFECOST)
- Period (.)
- Suffix (0 to 3 characters) (Example: AB or DAT)
- Filename: 12345.AB or LIFECOST.DAT

PRESENT VALUE OF ALL 25 YEAR
MAINT. AND REPAIR COSTS (d=10%)

($ PER UNIT MEASURE)

LOCATION: Washington, D.C.
STUDY STARTS 3 YEARS BEFORE BENEFICIAL USE

COMPONENT DESCRIPTION	UM	ANNUAL UNIT COST	YRS	REPLACE UNIT COST
ARCHITECTURE				
ROOFING				
ROOF COVERING				
BUILTUP ROOFING	SF	0.14	28	1.79
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP			14	1.23
MOD.BIT./THERMOPLASTIC	SF	0.09	20	2.11
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R			20	2.11
THERMOSETTING	SF	0.06	20	1.51
MEMBRANE REPLACEMENT - THERMOSETTING ROOF			20	1.51
SLATE	SF	0.07	70	7.56
CEMENT ASBESTOS	SF	0.09	70	1.95
TILE	SF	0.08	70	5.32
ROLL ROOFING	SF	0.18	10	1.66
TOTAL ROOF REPLACEMENT - ROLL ROOF			10	1.66
SHINGLES	SF	0.08	40	1.65
REPLACE NEW OVER EXISTING - SHINGLED ROOF			20	1.10
METAL	SF	0.06	30	10.17
FIBERGLASS RIGID STP. ROOF	SF	0.11	20	7.02
CONCRETE,SEALED PANEL ROOF	SF	0.15	60	25.42
CONCRETE,SEALED PANEL RF4	SF	0.13	300	25.03
CONCRETE SEALED POURED	SF	0.39	500	102.09
FIBERGLASS, RIGID ROOF	SF	0.16	20	6.93
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID			20	6.93

See NOTES on the last page of this table for Explanation of Column Headings

Figure 10. Maintenance and Repair Data Base for LCC Analysis Computer-Input Cost.

8. The total number of lines on a printed page including all margin lines must be entered. A normal 8-1/2 x 11 in. paper printed six lines per inch would be 66 lines. At 12 lines per inch using compressed print this would be 132 lines.

9. The report can be started by pressing the F6 (Start Report Key). Messages will be displayed as the calculation proceeds.

Export Data to an ASCII Data File

The user can transfer the report data from this program to any other program through the use of an ASCII file as shown in Figure 15. A file composed of the rows and columns of data will be produced. This file will contain no headers nor footers. The ASCII file can be read into any other computer program. All file names are in the format ASCII.XY where X is equal to the Report Requested Number (1 to 5) and Y is equal to the Systems to be Included Number (1 to 5).

PRESENT VALUE OF ALL 25 YEAR MAINT. AND REPAIR COSTS (d=10%)

($ PER UNIT MEASURE)

LOCATION: Washington, D.C.
STUDY STARTS 3 YEARS BEFORE BENEFICIAL USE

COMPONENT DESCRIPTION	UM	ANNUAL MAINTENANCE AND REPAIR			UNIT COST	REPLACEMENT AND HIGH COST TASKS				UNIT COST
		LABOR	MATERIAL	EQUIPMENT		YRS	LABOR	MATERIAL	EQUIPMENT	
ARCHITECTURE										
ROOFING										
ROOF COVERING										
BUILTUP ROOFING	SF	0.00488	0.03171	0.00244	0.14	28	0.04938	0.70490	0.02469	1.79
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP						14	0.02414	0.69960	0.01207	1.23
MOD.BIT./THERMOPLASTIC	SF	0.00248	0.03218	0.00119	0.09	20	0.05659	0.85860	0.02829	2.11
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R						20	0.05659	0.85860	0.02829	2.11
THERMOSETTING	SF	0.00174	0.02202	0.00088	0.06	20	0.03683	0.69960	0.01841	1.51
MEMBRANE REPLACEMENT - THERMOSETTING ROOF						20	0.03683	0.69960	0.01841	1.51
SLATE	SF	0.00259	0.01458	0.00124	0.07	70	0.06885	6.04200	0.03442	7.56
CEMENT ASBESTOS	SF	0.00254	0.03402	0.00122	0.09	70	0.05437	0.75190	0.02718	1.95
TILE	SF	0.00217	0.02934	0.00103	0.08	70	0.10169	3.07400	0.05084	5.32
ROLL ROOFING	SF	0.00754	0.01556	0.00386	0.18	10	0.04141	0.74963	0.02070	1.66
TOTAL ROOF REPLACEMENT - ROLL ROOF						10	0.04141	0.74963	0.02070	1.66
SHINGLES	SF	0.00259	0.02384	0.00140	0.08	40	0.04118	0.74497	0.02059	1.65
REPLACE NEW OVER EXISTING - SHINGLED ROOF						20	0.02996	0.43460	0.01498	1.10
METAL	SF	0.00204	0.01546	0.00103	0.06	30	0.36265	2.17300	0.18132	10.17
FIBERGLASS RIGID STP. ROOF	SF	0.00232	0.06266	0.00113	0.11	20	0.04543	6.01550	0.02272	7.02
CONCRETE,SEALED PANEL ROOF	SF	0.00601	0.01643	0.00297	0.15	60	0.06123	24.07419	0.03061	25.42
CONCRETE,SEALED PANEL RF4	SF	0.00544	0.01175	0.00282	0.13	300	0.04342	24.07419	0.02171	25.03
CONCRETE SEALED POURED	SF	0.01374	0.08807	0.00692	0.39	500	3.81056	18.03219	1.90528	102.09
FIBERGLASS, RIGID ROOF	SF	0.00463	0.06266	0.00236	0.16	20	0.04133	6.01550	0.02066	6.93
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID						20	0.04133	6.01550	0.02066	6.93

See NOTES on the last page of this table for Explanation of Column Headings

Figure 11. Maintenance and Repair Data Base for LCC Analysis—Resources and Cost.

EPS BASED MAINTENANCE AND REPAIR COST DATA FOR USE IN LIFE CYCLE COST ANALYSIS ($ PER UNIT MEASURE) PAGE 2
LOCATION: Washington, D.C. STUDY STARTS 3 YEARS BEFORE BENEFICIAL USE DATE OF STUDY: June, 1989 STUDY PERIOD: 28 YEARS

COMPONENT DESCRIPTION	UM	PRESENT VALUE OF ALL 25 YEAR MAINTANCE AND REPAIR COSTS (d=10%)				ANNUAL MAINTENANCE AND REPAIR PLUS HIGH COST REPAIR AND REPLACEMENT COSTS						
		BY RESOURCES			UNIT COST	ANNUAL MAINTENANCE AND REPAIR			REPLACEMENT AND HIGH COST TASKS			
		LABOR	MATERIAL	EQUIPMENT		LABOR	MATERIAL	EQUIPMENT	YRS	LABOR	MATERIAL	EQUIPMENT
ARCHITECTURE												
ROOFING												
ROOF COVERING												
BUILTUP ROOFING	SF	0.03810	0.35468	0.01900	1.19410	0.00488	0.03171	0.00244	28	0.04938	0.70490	0.02469
PLACE NEW MEMBRANE OVER EXISTING -BUILTUP									14	0.02414	0.69960	0.01207
MOD.BIT./THERMOPLASTIC	SF	0.02320	0.31535	0.01130	0.82710	0.00248	0.03218	0.00119	20	0.05659	0.85860	0.02829
MEMBRANE REPLACEMENT OR REPAIR - M.B./T. R									20	0.05659	0.85860	0.02829
THERMOSETTING	SF	0.01600	0.22832	0.00810	0.58110	0.00174	0.02202	0.00088	20	0.03683	0.69960	0.01841
MEMBRANE REPLACEMENT - THERMOSETTING ROOF									20	0.03683	0.69960	0.01841
SLATE	SF	0.01760	0.09943	0.00850	0.48760	0.00259	0.01458	0.00124	70	0.06885	6.04200	0.03442
CEMENT ASBESTOS	SF	0.01730	0.23203	0.00830	0.61260	0.00254	0.03402	0.00122	70	0.05437	0.75190	0.02718
TILE	SF	0.01480	0.20013	0.00710	0.52520	0.00217	0.02934	0.00103	70	0.10169	3.07400	0.05084
ROLL ROOFING	SF	0.06800	0.40704	0.03470	1.91020	0.00754	0.01556	0.00386	10	0.04141	0.74963	0.02070
TOTAL ROOF REPLACEMENT - ROLL ROOF									10	0.04141	0.74963	0.02070
SHINGLES	SF	0.02100	0.21105	0.01120	0.67690	0.00259	0.02384	0.00140	40	0.04118	0.74497	0.02059
REPLACE NEW OVER EXISTING - SHINGLED ROOF									20	0.02996	0.43460	0.01498
METAL	SF	0.01390	0.10547	0.00700	0.41330	0.00204	0.01546	0.00103	30	0.36265	2.17300	0.18132
FIBERGLASS RIGID STP. ROOF	SF	0.02090	1.09922	0.01030	1.55970	0.00232	0.06266	0.00113	20	0.04543	6.01550	0.02272
CONCRETE,SEALED PANEL ROOF	SF	0.04100	0.11204	0.02020	1.01530	0.00601	0.01643	0.00297	60	0.06123	24.07419	0.03061
CONCRETE,SEALED PANEL RF4	SF	0.03710	0.08014	0.01920	0.90120	0.00544	0.01175	0.00282	300	0.04342	24.07419	0.02171
CONCRETE SEALED POURED	SF	0.09370	0.60060	0.04720	2.66930	0.01374	0.08807	0.00692	500	3.81056	18.03219	1.90528
FIBERGLASS, RIGID ROOF	SF	0.03620	1.09922	0.01840	1.89850	0.00463	0.06266	0.00236	20	0.04133	6.01550	0.02066
TOTAL ROOF REPLACEMENT - FIBERGLASS RIGID									20	0.04133	6.01550	0.02066

See NOTES on the last page of this table for Explanation of Column Headings

Figure 12. Maintenance and Repair Data Base for LCC Analysis.

```
            Maintenance and Repair Database for
        Life-Cycle Cost Analysis -- Report Screen 1


    Report Requested (1, 2, 3, 4 or 5): 1

       [1]  Total Unit Costs
       [2]  Resources and Total Unit Costs
       [3]  Computer Input - Unit Costs
       [4]  Computer Input - Resources and Unit Costs
       [5]  Total Maintenance and Repair Costs

    Systems to be Included (1, 2, 3, 4 or 5): 1

       [1]  All
       [2]  Architectural
       [3]  Plumbing
       [4]  Electrical
       [5]  HVAC


 F6 - Continue                                      F10 - Exit
```

Figure 13. Report Screen One.

```
            Maintenance and Repair Database for
        Life-Cycle Cost Analysis -- Report Screen 2


    Print Data (1, 2 or 3):   1

       [1]  Printer
       [2]  File Name:
       [3]  Both Printer and File Name:

    Printer Type (1 or 2):  1

       [1]  HP LaserJet
       [2]  Standard Printer


    Actual Lines per Printed Page:  44  lines


 F6 - Start Reports                                 F10 - Exit
```

Figure 14. Report Screen Two.

```
Maintenance and Repair Database for
Life-Cycle Cost Analysis -- Export Screen 1

Report Requested (1, 2, 3, 4 or 5): 1

    [1]  Total Unit Costs
    [2]  Resources and Total Unit Costs
    [3]  Computer Input - Unit Costs
    [4]  Computer Input - Resources and Unit Costs
    [5]  Total Life-Cycle Cost Analysis

Systems to be Included (1, 2, 3, 4 or 5): 1

    [1]  All
    [2]  Architectural
    [3]  Plumbing
    [4]  Electrical
    [5]  HVAC

F6 - Generate                                    F10 - Exit
```

Figure 15. Export Screen One.

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APPENDIX: Geographical Location Adjustment Factors

State	Location	ACF Index
Alabama	State Average	0.86
	Birmingham	0.96
	Mobile	0.86
	Montgomery	0.76
	Anniston Army Depot	0.81
	Huntsville	0.88
	Fort McClellan	0.80
	Redstone Arsenal	0.88
	Fort Rucker	0.80
Alaska	State Average	2.25
	Anchorage	1.92
	Delta Junction	2.70
	Fairbanks	2.13
	Adak	3.88
	Aleutian Islands	3.86
	Anchorage NSGA	1.92
	Barrow	4.18
	Burnt Mtn.	6.86
	Clear	3.10
	Eielson AFB	2.13
	Elmendorf AFB	1.92
	Galena	3.73
	Fort Greely	2.70
	Fort Richardson	1.92
	Fort Wainwright	2.13
Arizona	State Average	1.02
	Flagstaff	1.02
	Phoenix	0.99
	Tucson	1.05
	Fort Huachuca	1.22
	Yuma Proving Ground	1.31
	Yuma	1.31
Arkansas	State Average	0.89
	Pine Bluff	0.93
	Little Rock	0.83
	Fort Smith	0.92
	Fort Chaffee	0.92
	Pine Bluff Arsenal	0.93
California	State Average	1.21
	Los Angeles	1.20
	San Diego	1.18
	San Francisco	1.25

State	Location	ACF Index
California (Cont'd)	Beale	1.28
	Bridgeport NWTC	1.27
	Castle	1.13
	Centerville Beach	1.32
	Desert Area	1.18
	Edwards AFB	1.30
	El Centro	1.27
	George AFB	1.31
	Fort Hunter Liggett	1.29
	Fort Irwin	1.20
	Le Moore NAS	1.20
	March AFB	1.18
	Mather AFB	1.17
	McClellan AFB	1.17
	Monterey Area	1.23
	Presidio of Monterey	1.23
	Norton AFB	1.16
	Oakland Army Base	1.33
	Fort Ord	1.24
	Hueneme Area	1.20
	Riverside	1.18
	Sacramento	1.15
	Sacramento Army Depot	1.15
	Presidio of San Francisco	1.25
	San Nicholas Island	2.59
	Sharpe Army Depot	1.13
	Sierra Army Depot	1.33
	Stockton	1.15
	Travis AFB	1.27
	Vandenburg AFB	1.38
Colorado	State Average	0.98
	Colorado Springs	0.94
	Denver	1.04
	Pueblo	0.96
	Fort Carson	1.01
	Fitzsimmons AMC	1.06
	Pueblo Army Depot	0.96
	Peterson AFB	0.94
	Rocky Mountain Arsenal	1.06
Connecticut	State Average	1.13
	Bridgeport	1.16
	Hartford	1.10
	New London	1.14
Delaware	State Average	0.99
	Dover	1.04
	Lewes	0.98
	Milford	0.96

State	Location	ACF Index
Delaware (Cont'd)	Lewes NF	1.04
	Dover AFB	1.04
District of Columbia	Washington	1.03
	Fort McNair	1.03
	Walter Reed AMC	1.03
Florida	State Average	0.89
	Miami	0.95
	Panama City	0.92
	Tampa	0.79
	Cape Canaveral	0.96
	Cape Kennedy	0.96
	Gulf Coast	0.85
	Homestead AFB	0.88
	Homestead	0.88
	Jacksonville Area	0.85
	Key West NAS	1.08
	Orlando	0.80
	Pensacola Area	0.85
	McDill AFB	0.77
	Eglin AFB	0.77
	Tyndall AFB	0.92
Georgia	State Average	0.80
	Albany	0.82
	Atlanta	0.87
	Macon	0.70
	Athens	0.90
	Atlanta-Marietta	0.93
	Fort Benning	0.71
	Columbus	0.71
	Fort Gillem	0.87
	Fort Gordon	0.94
	Kings Bay	0.93
	Fort McPherson	0.87
	Fort Stewart	0.84
Hawaii	State Average	1.28
	Hawaii	1.29
	Honolulu	1.27
	Maui	1.29
	Alimanu	1.27
	Barbars Point NAS	1.34
	Fort Debussy	1.27
	EWA Beach Area	1.34
	Helemano	1.34
	Hickam Army Air Field	1.27
	Kaneohe MCAS	1.34
	Moanalua	1.27
	Pearl City	1.27

State	Location	ACF Index
Hawaii (Cont'd)	Pearl Harbor	1.27
	Pohakuloa	1.32
	Schofield Barracks	1.27
	Fort Shafter	1.27
	Tripler AMC	1.27
	Wheeler Army Air Field	1.34
Idaho	State Average	1.11
	Boise	1.05
	Idaho Falls	1.08
	Mountain Home	1.19
	Mountain Home AFB	1.20
Illinois	State Average	1.03
	Belleville	0.96
	Chicago	1.09
	Rock Island	1.03
	Rock Island Arsenal	1.06
	St. Louis Support Ctr	0.96
	Savannah Army Depot	1.05
	Scott AFB	1.03
	Fort Sheridan	1.10
Indiana	State Average	0.99
	Indianapolis	1.03
	Logansport	0.99
	Madison	0.94
	Fort Benjamin Harrison	1.07
	Crane	1.10
	Crane AAP	1.10
	Grissom AFB	1.06
	Indiana AAP	1.02
	Jefferson Proving Ground	0.94
Iowa	State Average	1.02
	Burlington	1.04
	Cedar Rapids	0.98
	Des Moines	1.05
	Iowa AAP	1.06
Kansas	State Average	0.94
	Manhattan	0.97
	Topeka	0.96
	Wichita	0.88
	Kansas AAP	0.94
	Fort Leavenworth	0.94
	Fort Riley	0.97
	Sunflower AAP	0.97
Kentucky	State Average	0.96
	Bowling Green	0.99
	Lexington	0.96
	Louisville	0.93

State	Location	ACF Index
Kentucky (Cont'd)	Fort Campbell	0.93
	Fort Knox	0.99
	Lexington/Bluegrass Army Depot	1.06
	Louisville NAS	0.93
Louisiana	State Average	0.92
	Alexandria	0.87
	New Orleans	0.94
	Shreveport	0.94
	Barksdale AFB	0.94
	England AFB	0.87
	Gulf Outport New Orleans	0.94
	Louisiana AAP	0.94
	Fort Polk	0.94
Maine	State Average	0.93
	Bangor	0.85
	Caribou	0.99
	Portland	0.94
	Brunswick	0.93
	Cutler	0.98
	Northern Area	1.17
	Winter Harbor	0.98
Maryland	State Average	0.97
	Baltimore	0.95
	Fredrick	0.94
	Lexington Park	1.01
	Aberdeen Proving Ground	0.94
	Annapolis	1.03
	Fort Detrick	0.94
	Harry Diamond Lab	1.00
	Fort Meade	0.95
	Patuxent River Area	1.08
	Fort Ritchie	0.90
Massachusetts	State Average	1.10
	Boston	1.13
	Fitchburg	1.08
	Springfield	1.08
	Army Mtls & Mech Research Ctr	1.13
	Fort Devens	1.15
	Natick Research & Development Ctr	1.13
	South Weymouth	1.13
Michigan	State Average	1.06
	Bay City	1.02
	Detroit	1.14
	Marquette	1.03
	Detroit Arsenal	1.14
	Northern Area	1.25
	Republic (Elfcom)	1.10

State	Location	ACF Index
Michigan (Cont'd)	Selfridge AFB	1.14
Minnesota	State Average	1.08
	Duluth	1.05
	Minneapolis	1.09
	St. Cloud	1.10
	Twin Cities AAP	1.09
Mississippi	State Average	0.84
	Biloxi	0.87
	Columbus	0.81
	Jackson	0.84
	Columbus AFB	0.81
	Gulfport Area	0.87
	Meridian	0.92
Missouri	State Average	0.92
	Kansas City	0.92
	St. Louis	0.99
	Rolla	0.85
	Lake City AAP	0.93
	Fort Leonard Wood	0.91
Montana	State Average	1.15
	Billings	1.15
	Butte	1.18
	Great Falls	1.12
	Malmstrom AFB	1.12
Nebraska	State Average	1.03
	Grand Island	1.00
	Lincoln	1.05
	Omaha	1.05
	Offutt AFB	1.05
Nevada	State Average	1.18
	Hawthorne	1.26
	Las Vegas	1.13
	Reno	1.15
	Fallon	1.28
	Hawthorne AAP	1.26
	Nellis AFB	1.13
New Hampshire	State Average	1.09
	Concord	1.06
	Nashua	1.06
	Portsmouth	1.14
	Cold Regions Research Lab	1.17
New Jersey	State Average	1.08
	Newark	1.11
	Red Bank	1.08
	Trenton	1.06
	Bayonne	1.10
	Bayonne Mil Ocean Term	1.09

State	Location	ACF Index
New Jersey (Cont'd)	Fort Dix	1.03
	Earle	1.10
	Lakehurst	1.05
	Fort Monmouth	1.09
	Picatinny Arsenal	1.20
New Mexico	State Average	1.03
	Alamogordo	0.99
	Albuquerque	1.03
	Gallup	1.06
	Holloman AFB	1.05
	Kirtland AFB	1.03
	White Sands Missile Range	1.09
	Fort Wingate	1.06
New York	State Average	1.12
	Albany	1.07
	New York City	1.24
	Syracuse	1.05
	Brooklyn	1.24
	Fort Drum	1.18
	Fort Hamilton	1.24
	Seneca Army Depot	1.15
	U.S. Military Academy	1.17
	Watervliet Arsenal	1.07
North Carolina	State Average	0.76
	Fayetteville	0.76
	Greensboro	0.75
	Wilmington	0.78
	Fort Bragg	0.76
	Camp Lejeune Area	0.86
	Cherry Point	0.86
	Goldsboro	0.77
	Pope AFB	0.82
	Seymour AFB	0.77
	Sunny Point Mil Ocean Term	0.78
North Dakota	State Average	1.03
	Bismarck	1.02
	Grand Forks	0.98
	Minot	1.10
	Grand Forks AFB	0.98
	Stanley R. Hicklesen CPX	1.03
	Minot AFB	1.12
Ohio	State Average	1.00
	Columbus	1.03
	Dayton	0.98
	Youngstown	0.99
	Cleveland	1.14
	Wright-Patterson AFB	0.98

State	Location	ACF Index
Oklahoma	State Average	0.93
	Lawton	0.90
	McAlester	0.91
	Oklahoma City	0.98
	Altus AFB	0.94
	Enid	1.01
	McAlester AAP	0.91
	Fort Sill	0.90
Oregon	State Average	1.05
	Pendleton	1.08
	Portland	1.07
	Salem	0.99
	Charleston	1.11
	Coos Head	1.08
	Umatilla Army Depot	1.18
Pennsylvania	State Average	1.00
	Harrisburg	0.91
	Philadelphia	1.05
	Pittsburgh	1.04
	Carlisle Barracks	0.93
	New Cumberland Army Depot	0.91
	Fort Indiantown Gap	1.07
	Letterkenny Army Depot	1.07
	Mechanicsburg Area	0.91
	Tobyhanna Army Depot	1.14
	Warminster Area	1.04
Rhode Island	State Average	1.11
	Bristol	1.13
	Newport	1.11
	Providence	1.10
	Davisville	1.17
South Carolina	State Average	0.82
	Charleston	0.81
	Columbia	0.82
	Myrtle Beach	0.84
	Beaufort Area	0.89
	Charleston AFB	0.81
	Fort Jackson	0.82
	Sumter	0.80
South Dakota	State Average	0.95
	Aberdeen	0.95
	Sioux Falls	0.94
	Rapid City	0.96
	Ellsworth AFB	0.98
Tennessee	State Average	0.84
	Chattanooga	0.86
	Kingsport	0.72

State	Location	ACF Index
Tennessee (Cont'd)	Memphis	0.95
	Arnold AFB	0.90
	Milan AAP	0.98
	Holston AAP	0.71
Texas	State Average	0.85
	San Angelo	0.76
	San Antonio	0.86
	Fort Worth	0.93
	Fort Bliss	0.96
	Carswell AFB	0.93
	Chase Field - Beeville	0.97
Texas (Cont'd)	Corpus Christi Army Depot	0.92
	Corpus Christi	0.92
	Dallas	0.93
	Dyess AFB	0.94
	Fort Hood	0.89
	Kingsville	0.99
	Red River Army Depot	0.78
	Fort Sam Houston	0.86
	William Beaumont AMC	0.96
	Bergstrom AFB	0.95
	Brooks AFB	0.86
	Randolph AFB	0.86
	Kelly AFB	0.86
	Lackland AFB	0.86
Utah	State Average	1.03
	Ogden	1.05
	Salt Lake City	1.00
	Tooele	1.06
	Dugway Proving Ground	1.03
	Hill AFB	1.07
	Tooele Army Depot	1.05
Vermont	State Average	0.99
	Burlington	1.00
	Montpelier	1.00
	Rutland	0.96
Virginia	State Average	0.95
	Norfolk	0.95
	Radford	0.95
	Richmond	0.94
	Arlington	1.04
	Arlington Hall Station	1.04
	Arlington National Cemetery	1.04
	Fort Belvoir	1.04
	Cameron Station	1.04
	Dahlgren	1.10
	Fort Eustis	0.96

State	Location	ACF Index
Virginia (Cont'd)	Humphreys Engineer Center	1.03
	Fort A. P. Hill	0.92
	Fort Lee	0.93
	Fort Monroe	0.94
	Fort Myer	1.03
	Norfolk-Newport News Area	0.95
	Fort Pickett	0.98
	Quantico	1.03
	Nadford AAP	1.02
	Port Story	0.95
	Vint Hill Farms Station	1.08
Washington	State Average	1.09
	Spokane	1.08
	Tacoma	1.07
	Yakima	1.11
	Fairchild AFB	1.13
	Jim Creek	1.34
	Fort Lewis	1.07
	Pacific Beach	1.27
	Puget Sound Area	1.15
	Seattle Area	1.12
	Widbey Island	1.12
	Yakima Firing Center	1.18
West Virginia	State Average	0.95
	Bluefield	0.92
	Clarksburg	0.95
	Charleston	0.99
	Sugar Grove	1.15
Wisconsin	State Average	1.06
	LaCrosse	1.04
	Madison	1.02
	Milwaukee	1.13
	Badger AAP	1.06
	Clam Lake	1.20
	Fort McCoy	1.11
Wyoming	State Average	1.08
	Casper	1.07
	Cheyenne	1.10
	Laramie	1.08
	F. F. Warren AFB	1.10

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