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Five-Year Summary of Fort Irwin, CA, Family Housing Comparison Test: Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units

by
Robert D. Neathammer

To determine if manufactured/factory-built family housing is more cost-effective in providing housing than conventional construction, Congress directed that a test be conducted of construction methods. In 1982, Congress authorized the construction of 200 units of manufactured/ factory-built housing at Fort Irwin, CA, and concurrently, 144 units of conventionally built units.

Congress directed the Department of Defense (DOD) to conduct a fair and reliable study comparing the operation and maintenance (O&M) costs of manufactured housing to those of conventional housing. DOD reported to Congressional committees on the conditions and parameters under which this test would be conducted and the results of the test after the housing had been in use for 5 years.

To compare these two types of construction, DOD identified the annual O&M costs, determined the cost to correct all outstanding repairs, and obtained user satisfaction. Differences in O&M costs were identified and the reasons for those differences determined.

This is a summary of the 5-year study. Compared are the first 5 years of O&M costs and occupant satisfaction.

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FOREWORD

This research was conducted for the U.S. Army Engineering and Housing Support Center (USAEHSC), under the following Intra Agency Orders (IAOs) from Fort Irwin and Headquarters, U.S. Army Forces Command: FHAA022-83, dated August 1983; R039-84, dated May 1984; S040-85, dated January 1985; T016-86, dated November 1986; CERL-87, dated December 1987, CERL-88, dated June 1988, and CERL-89, dated 2 March 1989.

The Technical Monitor for the Engineering and Housing Support Center was Mr. Alex Houtzager (CEHSC-HM-O). Other technical advisors from USAEHSC were Mr. Robert Lubbert and Mr. Joe Hovell. Coordination and advice from the Forces Command were provided by Mr. Bill Mann, FCEN-RDM.

The efforts of Mr. Thomas Cragg, Fort Irwin Deputy Director of Engineering and Housing, were critical in coordinating the work of the two contractors involved during the 5 years—Boeing Services, Inc. and Dynalectron Corp. His staff provided essential contributions to the study in developing cost data and in coordinating housing surveys. The BLAST Support Office of the University of Illinois provided energy analyses of the units as designed. Mr. Jeff Spitler coordinated this effort.

The work was performed by the Facility Systems Division (FS), U.S. Army Construction Engineering Research Laboratory (USACERL). The Principal Investigator was Mr. Robert Neathammer. Principal assistance was provided by Mr. Robert Doerr, with contributions by Mr. Thomas Napier, Ms. Mary Chionis, Mr. William Dolan, Mr. John Shonder, Mr. Victor Storm, Mr. Larry Augustine, and Mr. Mark Imel. Dr. Michael J. O'Connor is Chief of USACERL-FS. The USACERL technical editor was Mr. William J. Wolfe, Information Management Office.

MAJ (P) Thomas Sydelko is Commander of USACERL, and Dr. L.R. Shaffer is Director.

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1 INTRODUCTION

Background

Congress believes that use of manufactured (factory built) military housing, rather than conventionally built units, will result in lower overall costs and provide durable housing meeting contemporary housing standards. To verify this belief, Congress directed the Department of Defense (DOD) to construct 200 units of manufactured housing at Fort Irwin, CA, and compare them with similarly designed, conventionally built housing.[1] DOD was also directed to perform a study comparing the operation and maintenance (O&M) costs of the two types of construction over a 5-year period.

The manufactured units to be constructed would meet Federal Manufactured Housing Construction and Safety Standards (FMHCSS); however, upgrades in certain criteria would be specified to bring the units into conformance with DOD standards. These areas of concern include net usable floor space, energy efficiency, fire and life safety, and durability of certain materials and components. The study would compare the impact of the modified FMHCSS versus standard DOD criteria, except for the essential criteria listed above.

The study was conducted during the first 5 years the housing units were occupied; initial occupancy on some units started in February 1983. The study compares 200 two-bedroom manufactured units to 144 two-bedroom, conventionally built units. The two types of units were similar in floor area, floor plans and materials used. The conditions and parameters for this test were submitted to Congress and this is the final report of the study results.

The data collected address O&M costs and user satisfaction for both types of housing. The study identifies not only the differences, if any, in O&M costs, but also the reasons for the differences and their importance for future construction criteria, construction methods, and occupant satisfaction.

Objective

This report's objective is to summarize the O&M costs and the occupant satisfaction data for both conventionally built and manufactured housing from construction through the first 5 years of occupancy.

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[1] Report No. 97-44, *Military Construction Authorization Act* (House of Representatives Committee on Armed Services, 1982), pp 8-9.

Approach

The first step was to develop uniform data collection and data analysis procedures. The cost comparisons and analyses for this study were established in USACERL Special Report (SR) P-140.[2] Data were collected throughout the study and summarized/reported yearly. First year data were reported in USACERL Interim Report (IR) P-85/14,[3] second year data in USACERL IR P-86/06,[4] third year data in USACERL IR P-87/10,[5] fourth year data in USACERL IR P-88/09,[6] and 4 1/2 year data in USACERL IP P-89/14.[7]

Individuals were assigned to quarters with no distinction between the two types of units. The units all have the same floor area and were to be occupied by essentially the same ranks/ages of sponsors; i.e., the assignment of families was not biased by the type of construction.

Scope

Costs were limited to buildings themselves, as the intent of the study was to compare O&M costs of the two types of constructions. Thus, sidewalks, driveways, streets, lawns, playgrounds, and utility lines outside the buildings were not included. Also, the replacement costs of refrigerators, kitchen stoves, and utility meters were excluded. (Because of these exclusions, the unit cost data in this report *was not comparable* to standard unit cost data reported for family housing in many Army financial reports, which normally includes costs such as streets and utilities.)

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[2] M. J. O'Connor, *Fort Irwin Housing Comparison Test*, Special Report (SR) P-140/ADA130349 (USACERL, 1983).

[3] R. D. Neathammer, *Fort Irwin, CA, Family Housing Comparison Test: Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, Interim Report (IR) P-85/14/ADA159740 (USACERL, 1985).

[4] R. D. Neathammer, *Fort Irwin, CA, Family Housing Comparison Test; Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, IR P-86/06/ADA175995 (USACERL, 1986).

[5] R. D. Neathammer, *Three-Year Summary of Fort Irwin, CA, Family Housing Comparison Test; Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, IR P-87/10/ ADA180001 (USACERL, 1987).

[6] R. D. Neathammer, *Four-Year Summary of Fort Irwin, CA, Family Housing Comparison Test; Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, IR P-88/09/ADA190017 (USACERL, 1988).

[7] R. D. Neathammer, *May 1984 to September 1988 Summary of Fort Irwin, CA, Family Housing Comparison Test: Operation and Maintenance Costs of Manufactured vs. Conventionally Built Units*, IR P-89/14/ADA209421 (USACERL, 1989).

2 REVIEW OF TEST PLAN

This section gives a short review of the test plan and the final data analyses. Data were collected in two areas: O&M costs and occupant satisfaction.

USACERL SR P-140 detailed the cost data collection plan and analysis methods. Four basic questions on costs will be answered:

1. Were the average annual O&M costs significantly different?

2. If different, where were they significantly different?

3. Why did the costs differ?

4. What criteria, design features, etc., need to be changed as a result?

Overall maintenance costs and utility costs were compared separately. If significant differences were found, it is important to determine their causes.

In addition to the overall cost comparison, the maintenance costs for major building components were compared. These comparisons provide more detail about where and why cost differences occur.

Costs to restore each unit to a comparable level of "new plus fair wear and tear" were determined at the end of the test period. This was done to determine if the durability of the two types of construction is comparable.

Occupant satisfaction with the overall apartments and each physical part of the unit was compared for the two types of construction. When occupant satisfaction differed for a building component, that component was evaluated to determine the reason for the difference. Fort Irwin installation personnel were also asked to give an informal evaluation of the housing units (Appendix A).

One maintenance practice may affect the test results and was accounted for in the final evaluation. No "routine" or "preventive" maintenance was performed through 30 September 1986, although the contractor originally planned to do so. That is, no seasonal maintenance on the heating/cooling systems was done--no periodic filter changes, etc. This could have impacted the breakdown repairs of these systems. However, the effect did not bias the test, as both types of units were treated the same. From 30 September 1986 to 30 September 1988, Dynalectron performed scheduled maintenance (called cyclic maintenance). The workers checked all building components and performed needed repairs. The Army did not renew this program in FY89. Vacant quarters maintenance was performed when occupants moved out; i.e., a team inspected the unit and either performed minor maintenance or wrote a work order (WO) to have work done.

3 DESCRIPTION OF THE FAMILY HOUSING UNITS

Manufactured Housing Units (MHUs)

These 200 units consist of 50 two-story fourplexes (two units on each of the first and second floors). Net floor area is 950 sq ft/unit.* These were constructed on perimeter footing with wood floors and crawl spaces. Each upper unit has a balcony-porch and each lower one has a patio with privacy fencing. Figure 1 shows front and rear views of typical buildings. Each unit has a refrigerator, gas range, gas water heater, garbage disposal, dishwasher, central air conditioning, and gas-fired forced-air furnace (all provided by the contractor). Each unit has two bedrooms, a kitchen, living-dining area, family room, one bathroom, utility room, and a one-car garage. The garage was constructed on site.

A detailed description of the construction process including photographs and floor plans for the units is shown in Appendix B.

The notice to proceed date was 10 Jan 83. Initial occupancy was:

61	units	Dec 83
7	units	Jan 84
64	units	Feb 84
57	units	Apr 84
9	units	May 84
2	units	Jun 84

Conventionally Built Units (CBUs)

The 144 units consist of 13 sixplexes, 6 fiveplexes, and 9 fourplexes, all two-story buildings. Net floor area is 950 sq ft/unit. These units were constructed on perimeter footings with building slab. Each unit has two bedrooms, a kitchen, living-dining area, family room, one bathroom, utility room, either a fenced patio or balcony-porch (for upper unit), and a one-car garage. Figure 2 shows front and rear views of typical buildings. The fourplexes have two units on each level. There are two units on the second story in the five- and sixplexes with the additional unit(s) on the first level. The CBUs also have a refrigerator, gas range, gas water heater, garbage disposal, dishwasher, central air conditioning, and gas-fired forced-air furnace.

The notice to proceed date was 3 May 82. Initial occupancy was:

8	units	Feb 83
28	units	Mar 83
38	units	Apr 83
31	units	May 83
23	units	Jun 83
14	units	Jul 83
2	units	Aug 83

*Metric conversions: 1 cu ft = 0.028 m^3; 1 sq ft = 0.093 m^2; °C = 0.55 x (°F-32).

A detailed description of all units can be found in the Los Angeles District Office report.[8] The buildings were not specifically adapted to the desert environment but are typical Southern California design.

Costs

A clear cut initial cost comparison was not possible. The 144 CBUs were part of a 254 unit project. The cost for this project was $51.83/sq ft. The 200 MHUs costs were $51.22/sq ft. However, the supervision and administration costs for the MHUs were based on the same 5 percent rate used for the CBUs. More actual labor was required since quality assurance inspection was required at the manufacturing plant as well as at the construction site. It was estimated that the additional labor would have raised the cost to $55/sq ft (no records were kept as these are all indirect costs).

General Comparison

Fort Irwin is located in a high desert environment. Annual rainfall averages 4 in. and temperatures often exceed 100 °F. The housing construction was not adapted to this climate but is representative of Southern California design.

The exterior finish of both types is basically stucco. Exterior trim is painted wood. There is some brick veneer on the garages. Asphalt shingles were used on both types, and gutters and downspouts were installed.

On the interiors, walls are painted gypsum board. Floors on the second level are carpeted and are vinyl tile or vinyl sheet covering on the first floor.

Water piping is copper in the CBUs and polybutylene in the MHUs.

Windows are single pane in the MHUs and are thermal pane in the CBUs.

Floors in MHUs are wood on crawl spaces and in CBUs are concrete slabs.

Grass was planted in the immediate yard area of the buildings, but not in play yard areas. Each first floor unit has a concrete patio, each second story unit a wooden balcony-porch. There is a wooden privacy fencing for each first floor unit.

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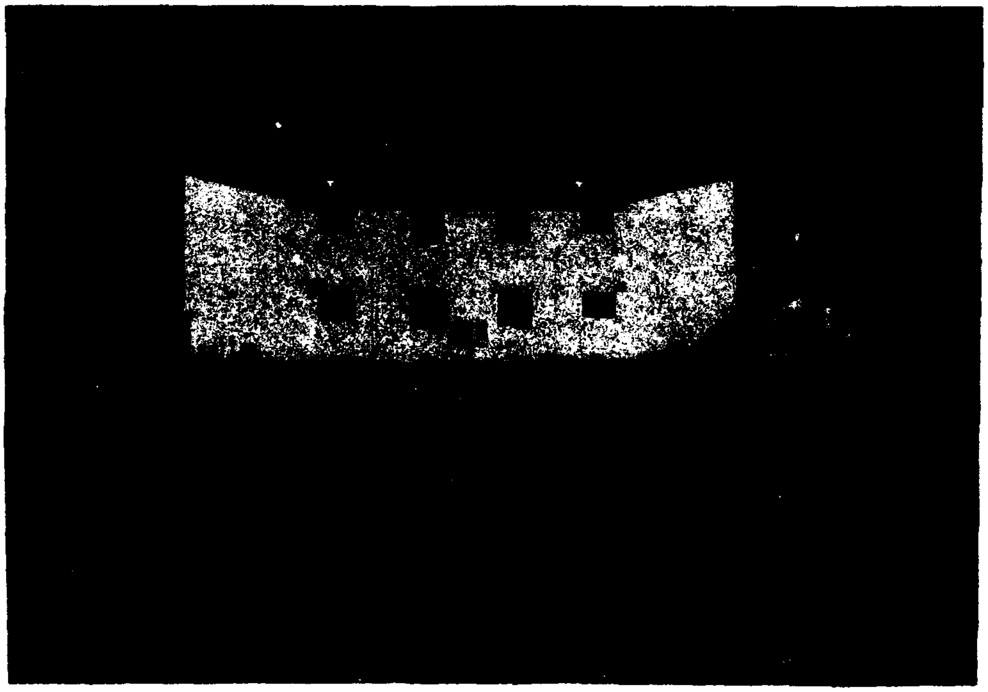
[8] *Fort Irwin Family Housing Study--A Report on Manufactured/Factory-Built Housing and Site-Built Housing, Fort Irwin, CA* (U.S. Army Corps of Engineers, Los Angeles District, September 1984).

Front View - MHU



Rear View - MHU

Figure 1. Front and rear views of typical MHUs.

Front View - CBU

Rear View - CBU

Figure 2. Front and rear views of typical CBUs.

4 DATA COLLECTION PROCEDURES

Data were collected at a level of detail such that any differences found between the two types of construction can be explained. Appendix C lists the housing units and their identification numbers used in the data collection. Appendix D lists the building components and subcomponents. Each service order was coded to one of these so that costs of components could be compared. A discussion of the data collected is included in USACERL SR P-140.

Data Collection

Discussions were held with the technical monitor, U.S. Army Engineering and Housing Support Center (USAEHSC) representatives, the Forces Command HQ representative, Fort Irwin personnel, and representatives of the base operations contractor, Boeing Services International (BSI), to establish the best methods of collecting the data.

BSI was contracted to segregate all service orders for maintenance for the test units and report cost data to USACERL through the Fort Irwin Directorate of Engineering and Housing (DEH) on a monthly basis. BSI was also contracted to read gas and electric meters at the end of each month and report similarly.

Self-help data reports* and occupancy data were to be forwarded quarterly. An occupant satisfaction questionnaire was to be given to each vacating family with a mail-back envelope to USACERL.

A new contractor, Dynalectron, became the base operations contractor effective 1 October 1986 and performed the same services described above.

Data Verification

USACERL verified the reported data several ways. Each original work order (WO) document was checked against the reported data forwarded by the contractor. Discrepancies were resolved on verification visits to Fort Irwin. Additionally, the contractor had set up separate accounting codes for the two groups of units and the total billed was compared to the total obtained from summing all the individual WO data.

USACERL developed a computer program to compare gas and electricity monthly meter readings. When apparently erroneous data occurred, the contractor was notified and corrections made.

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*Self-help is a program whereby occupants obtain supplies and materials from a central warehouse to make minor repairs themselves.

Data Analysis

Maintenance Costs

Maintenance costs were compared on a unit-month basis and yearly basis. The data were also summarized by building component to determine if one or more components for one of the types of units had large maintenance costs. If so, the reasons for these costs were determined; i.e., what criteria or design features should be reviewed/changed?

Cost differences could have been caused by material quality, installation, differences inherent to manufactured or conventional construction, and possible errors in specifications for the two projects.

Warranty work referred to the construction contractor was not included in the cost comparison since no cost data were available or applicable, as it was not a cost to the government. However, the cost of a service call to assess a problem was included.

Energy Consumption

Gas and electricity consumption were compared on a unit-month basis and a yearly basis. Since most of the MHUs were not completed until May 1984, prior energy consumption data for the CBUs was not used in comparisons. (Energy consumption comparisons are only valid for the same time frame because of varying weather conditions.)

Occupancy Effects

Occupant characteristics data were also collected. These data were analyzed to ensure that both types of units had a similar distribution of occupants (ages, numbers) during the 5 years. If required, these data were correlated with O&M costs to help explain differences in costs.

Self-Help Data

These data were summarized to see if maintenance costs had been affected.

Occupant Satisfaction Survey

Data from the questionnaires were analyzed to determine any differences in satisfaction with the two types of units.

5 WHOLE HOUSE ENERGY TESTS

Energy evaluations of sample units of each type of construction were performed immediately after construction was completed on each of the two groups of housing and again after 5 years of occupancy. The objective was to determine if energy characteristics had changed over the 5-year period. Three whole-house energy tests were performed. Appendices E and F give details of the tests for the CBUs and MHUs, respectively.

House Tightness

The number of air changes per hour were measured with the following results:

	Immediately After Construction			After 5 Years		
Type	No. Units	Average Air Change Per Hour	Standard Deviation (%)	No. Units	Average Air Change Per Hour	Standard Deviation (%)
CBU	15	13.0	1.06	15	12.1	1.70
MHU	12	10.9	2.67	14	9.7	1.60

There was a statistically significant difference between the two types of construction for both the initial and 5-year tests, the MHUs being more airtight on the average. Neither type of unit changed significantly over the 5 years. These results indicate that the MHUs should have had less air infiltration/leakage.

Furnace Efficiency

The furnace efficiency results were as follows:

	Immediately After Construction			After 5 Years		
Type	No. Units	Average Efficiency (%)	Standard Deviation (%)	No. Units	Average Efficiency (%)	Standard Deviation (%)
CBU	13	66.2	6.24	14	64.2	12.2
MHU	16	79.3	3.36	15	77.3	2.84

The furnace efficiencies of the MHUs were significantly higher than those of the CBU for both the initial and 5-year tests. Neither type of unit changed significantly over the 5 years.

Wall Heat Transfer Characteristics

This parameter was not initially measured for the CBUs because of unfavorable weather during the testing period. This parameter was calculated for both types of construction using the designed wall construction.

Type	No. Units	Average Heat Loss (Btu/hr-°F)
CBU	16	1072
MHU	15	1220

Summary

The whole house energy tests do not conclusively indicate which type of unit would use less energy for heating/cooling. The CBUs are more energy efficient considering only the wall heat loss test, but the MHUs perform better when tested for air tightness and furnace efficiency. Additionally, the CBUs are built on concrete slabs while the MHUs have a crawl space. Concrete slabs are better (use less energy) than crawl spaces. This has an impact on the first floor units' energy use.

Thus the tests are inconclusive in predicting which type of construction would use more energy for heating/cooling.

6 OPERATION AND MAINTENANCE (O&M) COSTS

O&M costs for each type of unit were compared over the first 5 years of occupancy. For CBUs, this was 1 Aug 83 through 31 Jul 88 and for MHUs, 1 Jun 84 through 31 May 89.

Overall Costs

The total housing unit-months and maintenance costs for the first 5 years of occupancy are shown in Table 1. (Maintenance includes all types of repairs and "preventive maintenance" performed.)

Table 1

Unit/Month Costs in First 5 Years Occupancy

Type	No. Unit Months	Total Cost ($)	Cost/Unit/ Month ($)	Cost/Unit/ Year ($)
CBU	8,640	239,841	27.76	333
MHU	12,000	460,248	38.35	460

Discussion

The MHUs cost about $10/month more than the CBUs over the first 5 years of occupancy; the difference in cost per unit per year of an MHU is $127. There were large increases in M&R costs in years 4 and 5. This is illustrated in Table 2, which shows M&R costs per year of occupancy.

Table 2

Yearly M&R Costs by Type Construction

Year	Total CBU ($)	Cost/ Unit ($)	Total MHU ($)	Cost/ Unit ($)
1	31,592	219	34,164	171
2	29,107	202	59,076	295
3	44,391	308	63,717	319
4	45,565	316	114,728	574
5	89,186	619	188,563	943
5-Year Total	239,841	333	460,248	460

These increased costs were attributable mainly to the interior painting done in units vacated for the first time and in those which required painting on change of occupancy. Table 3 shows the painting costs per year of occupancy.

Table 3

Interior Painting Costs

Year	Total CBU ($)	Cost/ Unit ($)	Total MHU ($)	Cost/ Unit ($)
1	603	4	259	1
2	1,288	9	4,684	23
3	7,312	51	13,741	69
4	11,537	80	24,386	122
5	29,779	207	80,499	402

Costs per unit have been increasing over time. Figure 3 shows the cumulative cost per unit per month for ages 15 to 60 months, illustrating this trend. (Note: these costs are the average over the total number of units, not the actual cost to paint one unit.) The costs for the MHUs increased slightly faster than for the CBUs. This can also be seen in Figure 4, which shows costs per unit per year.

Table 4 shows the yearly costs excluding interior painting. This table shows that the MHUs' costs increased slightly faster than did the CBUs. Figure 5 displays this data.

Table 4

Yearly M&R Costs Excluding Interior Painting Costs

Year	Total CBU ($)	Cost/ Unit ($)	Total MHU ($)	Cost/ Unit ($)
1	30,989	215	33,905	170
2	27,819	193	54,392	272
3	37,079	257	49,976	250
4	34,028	236	90,342	452
5	59,407	413	108,064	540

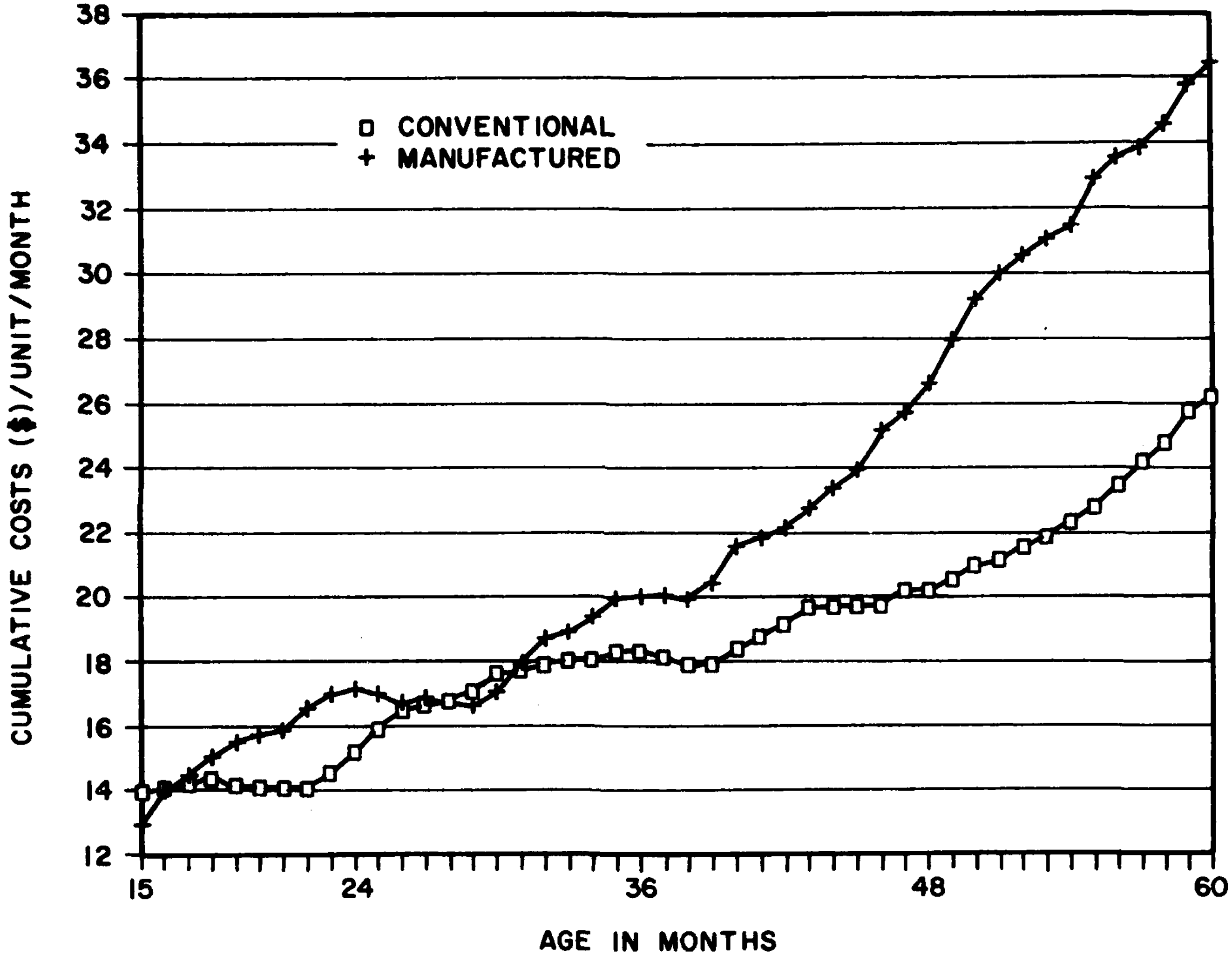

Figure 3. Cumulative cost per unit per month for ages 15-60 months.

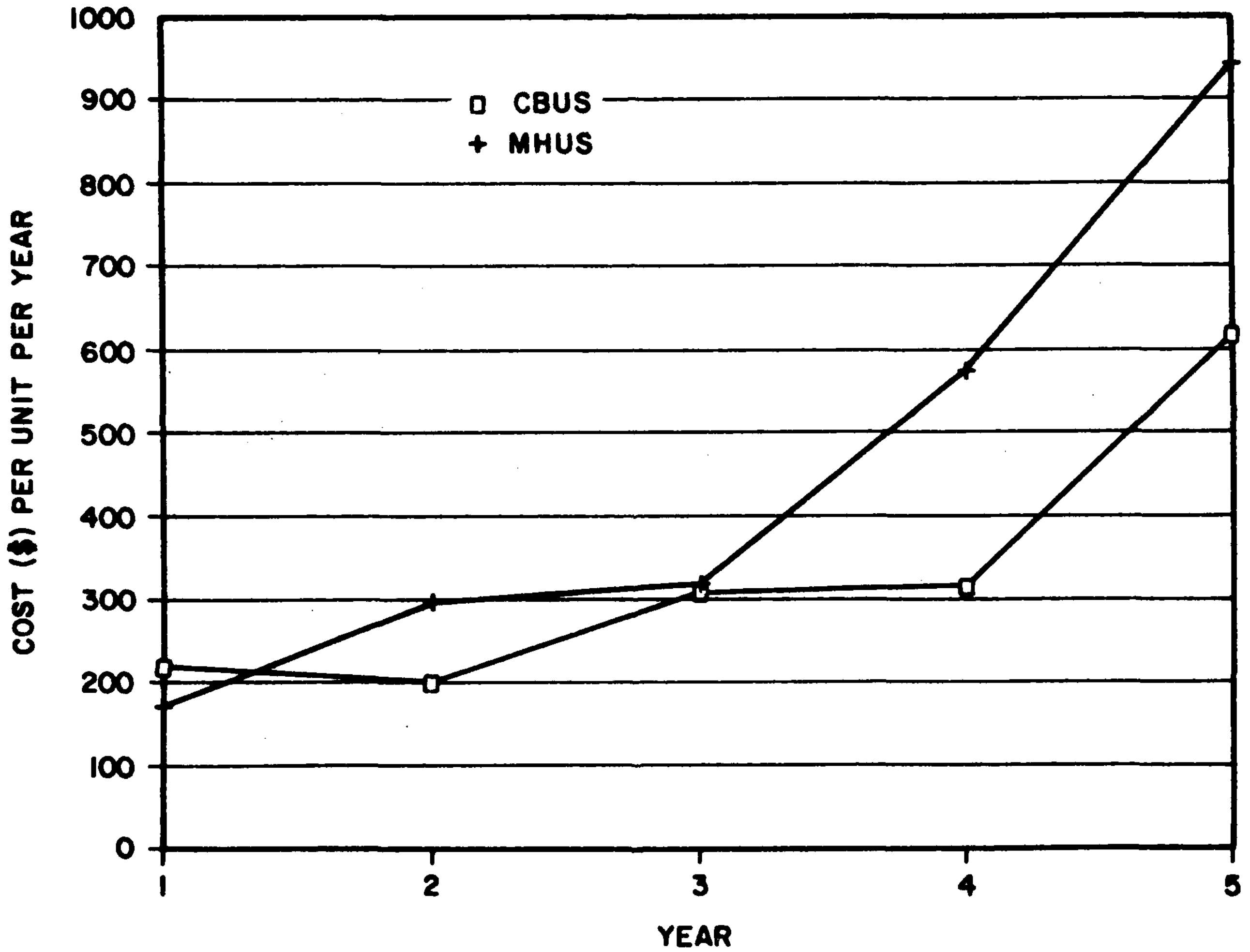

Figure 4. Total costs per unit per year.

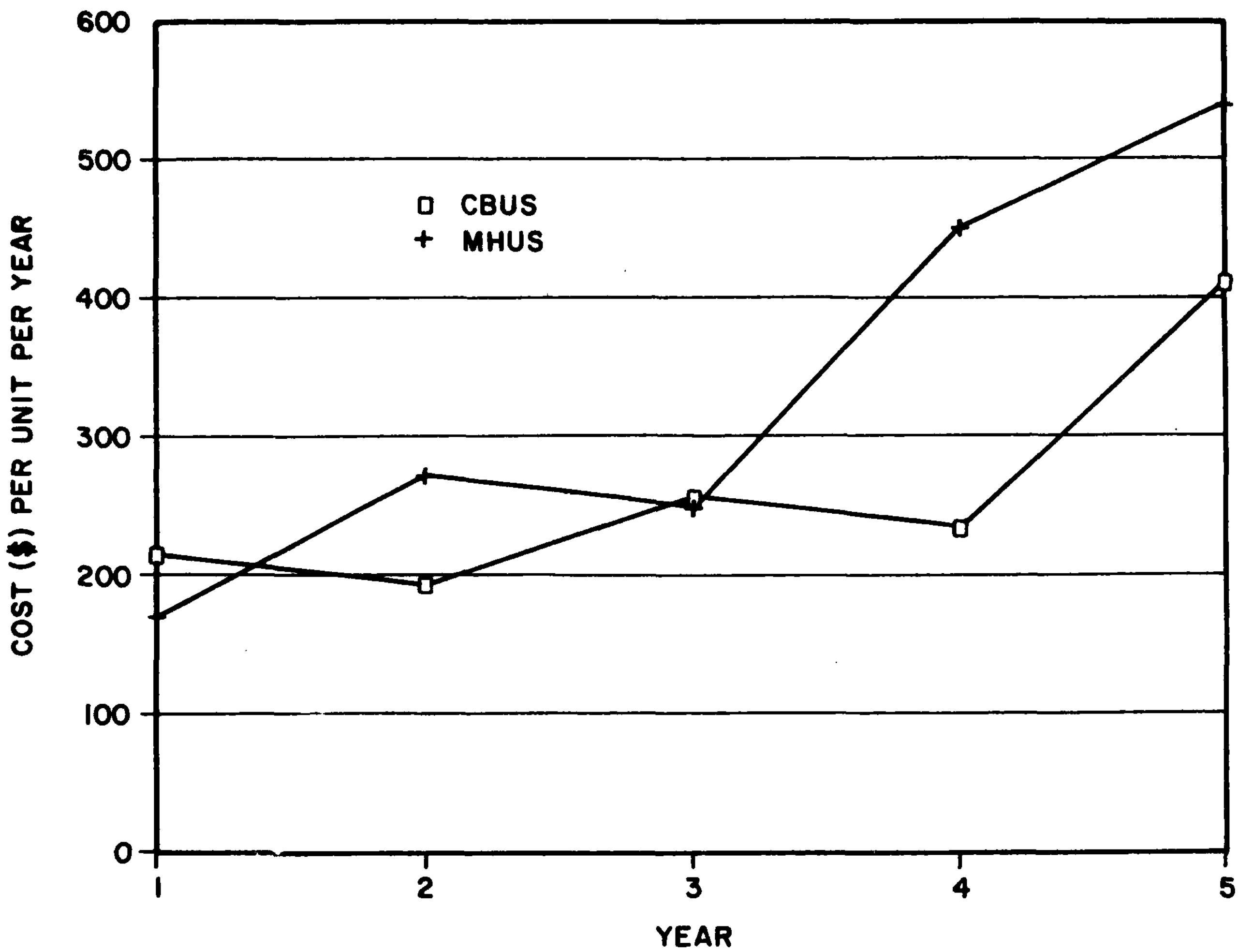

Figure 5. Costs per unit per year excluding interior painting costs.

Costs Excluding Certain Equipment Costs

Since the purpose of this study was to compare maintenance costs attributable to method of construction, another table was generated excluding certain costs. Table 5 gives the costs for the 5 years of occupancy of each type unit, excluding any costs for maintenance of water heaters, garbage disposals, dishwashers, ranges, range hoods, and refrigerators (equipment not part of the construction process).

Table 5

Unit Costs Excluding Certain Equipment Costs

Type	No. Unit Months	Total Cost ($)	Cost/Unit/ Month ($)	Cost/Unit Year ($)
CBU	8,640	208,761	24.16	290
MHU	12,000	387,548	32.30	388

The difference in cost per unit per year between types of construction is $98/year. Compared to the $127 in Table 1, this is a better estimate of the cost difference attributable to the type of construction.

Frequencies of Maintenance Per Housing Unit

For the MHUs, the number of WOs for a housing unit ranged from 5 to 75. For the CBUs, the range was from 10 to 77. Table 6 lists the frequencies.

Table 6

Frequency of Maintenance Actions

MHU		CBU	
No. of WOs	No. of Units With These Totals	No. of WOs	No. of Units With These Totals
100+	12 (9)*	100+	2
90-99	13 (9)	90-99	1
80-89	30 (22)	80-89	13
70-79	36 (26)	70-79	15
60-69	39 (28)	60-69	28
50-59	31 (22)	50-59	25
40-49	21 (15)	40-49	37
30-39	17 (12)	30-39	17
20-29	1 (1)	20-29	5
1-19	0	1-19	1

*Number in parentheses is computed by multiplying number of units by .72(144/200) for comparison to CBUs.

It should be noted that the "number of work orders" refers to the number of component actions. Whenever a change of occupancy occurs, numerous building components were repaired--there was one official WO number, but each component action was considered a WO for analysis purposes. This can be seen in Table 7.

Table 7

Component Actions and Work Orders

	MHU			CBU		
Year	Number Component Actions	Number WOs	Average Number WOs/Unit	Number Component Actions	Number WOs	Average Number WOs/Unit
Year 1	1,718	1,610	8	1,139	1,128	8
Year 2	1,938	1,371	7	989	863	6
Year 3	2,183	1,273	6	1,404	877	6
Year 4	4,048	1,867	9	1,592	869	6
Year 5	3,735	2,028	10	2,920	1,335	9
Total	13,622	8,149	40	8,094	3,072	35

Maintenance Per Component

Table 8 lists the frequencies of work orders and costs per building component for the two types of units. However, the costs were not directly comparable across the two types of units since there were 200 MHUs and 144 CBUs. Table 9 shows the cost data adjusted by multiplying the MHU costs by 0.72 (144/200). Also shown in Table 9 are the 5-year costs on a unit basis.

Table 9 shows that the total cost was less than $500 for both types for 24 of the 78 components. For 38 of the other 54 components, the MHUs had a higher cost.

Most of the costs shown in Tables 8 and 9 were for building components independent of type of construction. For example, over $10K was spent on the ranges for each type unit, $9K for CBUs and $32K for MHUs was spent on dishwashers, over $10K on light fixtures for each type, etc. The most significant costs for components which differ for the types were roofing surface, doors/frames, storm windows and screens, and piping. Although a large difference existed for painting, this cost depended on rotation of occupants and occupant wear and tear. Complete quarters painting was done on 148 MHUs and only 65 CBUs.

Note the $17,210 cost for exterior-trim painting of MHUs and $0 for CBUs. The exterior trim was to be painted on a cyclic basis. The CBU cycle in 1988 was deferred.

If the costs in Table 5 which excluded equipment costs are adjusted by removing all painting costs, the costs become:

	Total Cost ($)	Cost/Unit/Year ($)
CBU	158,027	219
MHU	246,057	246

One difference in the construction of the two types was the use of copper piping for the CBUs and polybutylene for the MHUs. There have been two major breaks in a "tee" joint in the ceiling of the first floor units of the MHUs. A detailed analysis of plumbing service orders shows a higher cost for MHUs for the category leaking or broken piping. Costs for each of the 5 years are shown below:

Year	CBUs ($)	MHUs ($)
1	525	785
2	471	2146
3	358	511
4	440	1391
5	52	2242
Total	1847	7076

Table 10 summarizes Table 9 data into the 12 major building component codes (Appendix D). Although the 0201-0220 structure is a high cost item, Table 9 shows most of these costs are doors and windows related and much of the damage to these items was occupant caused.

Table 8

Maintenance Actions Performed and Costs Per Component

Component No.	Component Description	Maintenance/Repair Actions CBU (N=8,094)*		Maintenance/Repair Actions MHU (N=13,622)		Cost ($) CBU (Total= 239,839)		Cost ($) MHU (Total= 460,248)	
101	Roofing surface	94	(1%)**	306	(2%)	7308	(3%)	25628	(6%)
103	Flashing, vents	12		5		322		348	
104	Gutters and downspouts	186	(2%)	307	(2%)	2509	(1%)	4603	(1%)
105	Other roof repairs	0		2		0		16	
201	Foundation and anchorage	2		2		18		24	
202	Structure	9		53		152		1751	
203	Insulation	3		0		42		0	
204	Masonry	6		7		177		161	
205	Exterior siding	4		2		207		238	
206	Exterior doors and frames	295	(4%)	545	(4%)	5665	(2%)	11386	(2%)
207	Storm and screen doors	388	(5%)	565	(4%)	10357	(4%)	19231	(4%)
208	Windows and frames	100	(1%)	172	(1%)	1842		3607	
209	Storm windows and screens	190	(2%)	202	(1%)	3646	(2%)	3315	
210	Exterior trim	0		2		0		26	
211	Porch/deck	2		2		32		87	
212	Interior drywall	111	(1%)	202	(1%)	2771	(1%)	6327	(1%)
213	Wall coverings and paneling	9		1		186		2	
214	Interior doors	692	(9%)	901	(7%)	13671	(6%)	12431	(3%)
215	Interior casework	31		54		404		726	
216	Bathroom accessories	87	(1%)	123		1561		1288	
217	Kitchen accessories, cabinets	121	(2%)	261	(2%)	1727		3408	
218	Drapery hardware	12		50		211		632	
219	Other exterior/interior	111	(1%)	174	(1%)	2367	(1%)	3172	
220	Garage doors	375	(5%)	318	(2%)	7935	(3%)	5176	(1%)
301	Resilient flooring	46		210	(2%)	1541		4416	
302	Carpet and pad	8		18		105		1218	
304	Underlayment/substrate	2		6		13		70	
305	Other flooring	10		36		873		1411	
401	Paint, walls and ceilings	130	(2%)	193	(1%)	48945	(20%)	119951	(26%)
403	Paint, touchup, interior	30		90		1010		2909	
404	Bathtub, shower caulking	56		155	(1%)	686		1687	
405	Other interior painting	25		13		563		766	
501	Paint, exterior walls	3		3		92		45	
502	Paint, exterior doors, frames	4		3		124		61	
503	Paint, exterior trim	0		12		0		17759	(4%)
504	Exterior caulking	0		1		0		20	
506	Other exterior painting	1		3		20		75	
601	Heating plant, valve	93	(1%)	35		2864	(1%)	1686	
602	Motors, blowers, pumps	51		66		3463	(1%)	4430	
603	Ducts	1		16		15		736	

*N = Number of maintenance actions

**Percents are given for number maintenance actions and costs when the value is 1% or more of the total.

Table 8 (Cont'd)

Component		Maintenance/Repair Actions				Cost ($)			
No.	Description	CBU		MHU		CBU		MHU	
604	Piping	6		0		174		0	
605	Diffusers, grills	7		51		139		664	
607	Heating controls	111	(1%)	68		4384	(2%)	2215	
608	Other heating	316	(4%)	562	(4%)	4656	(2%)	6813	(1%)
701	Cooling coils, compressor	31		30		5857	(2%)	1261	
702	A/C motors, blowers, pumps	67		86		4974	(2%)	3728	
703	A/C piping, ducting	5		23		148		714	
704	A/C refrigerant	311	(4%)	175	(1%)	11900	(5%)	6422	(1%)
705	A/C insulation	1		0		7		0	
706	A/C controls	75		69		3223	(1%)	2753	
707	Other cooling	315	(4%)	452	(3%)	4687	(2%)	6519	(1%)
801	Water heater	175	(2%)	307	(2%)	3992	(2%)	9837	(2%)
803	Piping, supply	96	(1%)	326	(2%)	3484	(1%)	10306	(2%)
804	Faucets and shower heads	296	(4%)	932	(7%)	6332	(3%)	19609	(4%)
805	Lavatories	240	(3%)	504	(4%)	3701	(2%)	12548	(3%)
806	Water closets	448	(5%)	749	(6%)	8630	(4%)	13865	(3%)
807	Bathtub/shower unit	57		251	(2%)	902		4840	(1%)
809	Other plumbing	80	(1%)	162	(1%)	1817		2974	
901	Service entrance	2		2		65		188	
902	Panel box/circuit breakers	39		131		1037		3714	
903	Branch circuits	14		20		382		1348	
904	Wall receptacles	171	(2%)	344	(3%)	2074		4980	(1%)
905	Doorbells and chimes	0		1		0		4	
906	Light fixtures	648	(8%)	674	(5%)	10984	(5%)	10302	(2%)
907	Vents, fans	26		26		495		353	
908	Other electrical	31		30		674		2005	
1001	Garbage disposal	203	(3%)	422	(3%)	4271	(2%)	7953	(2%)
1002	Dishwasher	195	(2%)	591	(4%)	9413	(4%)	32946	(7%)
1003	Range	447	(6%)	832	(6%)	11258	(5%)	15315	(3%)
1004	Range hood	22		33		419		428	
1005	Refrigerator	62		180	(1%)	1051		4781	(1%)
1006	Other equipment	68		150	(1%)	675		1440	
1201	Water supply	63		90		1110		2338	
1202	Gas supply	53		88		1525		2556	
1203	Electrical service	26		29		727		2458	
1204	Sanitary/sewer lines	4		4		469		191	
1205	Other utility service	0		1		0		8	
1300	Miscellaneous	83	(1%)	110		779		1049	

**Percents are given for number maintenance actions and costs when the value is 1% or more of the total.

Table 9

Maintenance Costs per Component, Adjusted by Number of Units

Component		Costs ($)				
No.	Description	CBU	MHU	MHU Adjusted*	CBU/144**	MHU/200**
101	Roofing surface	7308	25628	18452	50.75	128.14
103	Flashing, vents	322	348	251	2.24	1.74
104	Gutters and downspouts	2509	4603	3314	17.42	23.02
105	Other roof repairs	0	16	12	0.00	0.08
201	Foundations and anchorage	18	24	17	0.13	0.12
202	Structure	152	1751	1261	1.06	8.76
203	Insulation	42	0	0	0.29	0.00
204	Masonry	177	161	116	1.23	0.81
205	Exterior siding	207	238	171	1.44	1.19
206	Exterior doors and frames	5665	11386	8198	39.34	56.93
207	Storm and screen doors	10357	19231	13846	71.92	96.16
208	Windows and frames	1842	3607	2597	12.79	18.04
209	Storm windows and screens	3646	3315	2387	25.32	16.58
210	Exterior trim	0	26	19	0.00	0.13
211	Porch/deck	32	87	63	0.22	0.44
212	Interior drywall	2771	6327	4555	19.24	31.64
213	Wall coverings and paneling	186	2	1	1.29	0.01
214	Interior doors	13671	12431	8950	94.94	62.16
215	Interior casework	404	726	523	2.81	3.63
216	Bathroom accessories	1561	1288	927	10.84	6.44
217	Kitchen accessories, cabinets	1727	3408	2454	11.99	17.04
218	Drapery hardware	211	632	455	1.47	3.16
219	Other exterior/interior	2367	3172	2284	16.44	15.86
220	Garage doors	7935	5176	3727	55.10	25.88
301	Resilient flooring	1541	4416	3180	10.70	22.08
302	Carpet and pad	105	1218	877	0.73	6.09
304	Underlayment/substrate	13	70	50	0.09	0.35
305	Other flooring	873	1411	1016	6.06	7.06
401	Paint, walls and ceilings	48945	119951	86365	339.00	599.76
403	Paint, touchup, interior	1010	2909	2094	7.01	14.55
404	Bathtub, shower caulking	686	1687	1215	4.76	8.44
405	Other interior painting	563	766	552	3.91	3.83
501	Paint, exterior walls	92	45	32	0.64	0.23
502	Paint, exterior doors, frames	124	61	44	0.86	0.31
503	Paint, exterior trim	0	17759	12786	0.00	88.80
504	Exterior caulking	0	20	14	0.00	0.10
506	Other exterior painting	20	75	54	0.14	0.38
601	Heating plant, valve	2864	1686	1214	19.89	8.43
602	Motors, blowers, pumps	3463	4430	3190	24.05	22.15
603	Ducts	15	736	530	0.10	3.68
604	Piping	174	0	0	1.21	0.00
605	Diffusers, grills	139	664	478	0.97	3.32
607	Heating controls	4384	2215	1595	30.44	11.08
608	Other heating	4656	6813	4905	32.33	34.07

*The MHU column adjusted by multiplying by 0.72.
**These are costs per unit for the 5 years.

Table 9 (Cont'd)

Component		Costs ($)				
No.	Description	CBU	MHU	MHU Adjusted	CBU/144	MHU/200
701	Cooling coils, compressor	5857	1261	908	40.67	6.31
702	A/C motors, blowers, pumps	4974	3728	2684	34.54	18.64
703	A/C piping, ducts	148	714	514	1.03	3.57
704	A/C refrigerant	11900	6422	4624	82.64	32.11
705	A/C insulation	7	0	0	0.05	0.00
706	A/C controls	3223	2753	1982	22.38	13.77
707	Other cooling	4687	6519	4694	32.551	32.60
801	Water heater	3992	9837	7083	27.72	49.19
803	Piping, supply	3484	10306	7420	24.19	51.53
804	Faucets and shower heads	6332	19609	14118	43.97	98.05
805	Lavatories	3701	12548	9035	25.70	62.74
806	Water closets	8630	13865	9983	59.93	69.33
807	Bathtub/shower unit	902	4840	3485	6.26	24.20
809	Other plumbing	1817	2974	2141	12.62	14.87
901	Service entrance	65	188	135	0.45	0.94
902	Panel box/circuit breakers	1037	3714	2674	7.20	18.57
903	Branch circuits	382	1348	971	2.65	6.74
904	Wall receptacles	2074	4980	3586	14.40	24.90
905	Doorbells and chimes	0	4	3	0.00	.02
906	Light fixtures	10984	10302	7417	76.28	51.51
907	Vents, fans	495	353	254	3.44	1.77
908	Other electrical	674	2005	1444	4.68	10.03
1001	Garbage disposal	4271	7953	5726	29.66	39.77
1002	Dishwasher	9413	32946	23721	65.37	164.73
1003	Range	11258	15315	11027	78.18	76.58
1004	Range hood	419	428	308	2.91	2.14
1005	Refrigerator	1051	4781	3442	7.30	23.91
1006	Other equipment	675	1440	1037	4.69	7.20
1201	Water supply	1110	2338	1683	7.71	11.69
1202	Gas supply	1525	2556	1840	10.59	12.78
1203	Electrical service	727	2458	1770	5.05	12.29
1204	Sanitary/sewer lines	469	191	138	3.26	0.96
1205	Other utility service	0	8	6	0.00	0.04
1300	Miscellaneous	779	1049	755	5.41	5.25
	Totals	239,839	460,248	320,396	1,619	2,225

Table 10

Maintenance Actions Performed and Costs for Component Group
5-Year Summary

Component Group	Description	Maintenance/Repair Actions CBU	Maintenance/Repair Actions MHU	Cost ($) CBU	Cost ($) MHU	Cost ($) MHU Adjusted
		(N=8,094)	(N=13,622)	(Total = 239,841)	(Total = 460,248)	(Total = 331,379)
0101-0105	Roofing	292 (4%)	620 (5%)	10,139 (4%)	30,595 (7%)	22,028
0201-0220	Structure	2548 (31%)	3636 (27%)	52,971 (22%)	72,985 (16%)	52,549
0301-0305	Floor coverings	66 (1%)	270 (2%)	2,532 (1%)	7,115 (2%)	5,123
0401-0405	Interior painting	241 (3%)	451 (3%)	51,205 (21%)	125,313 (27%)	90,225
0501-0506	Exterior painting	8 (0%)	22 (0%)	236 (0%)	17,959 (4%)	12,930
0601-0608	Heating	585 (7%)	798 (6%)	15,695 (7%)	16,545 (4%)	11,912
0701-0707	Air conditioning	805 (10%)	835 (6%)	30,794 (13%)	21,398 (5%)	15,407
0801-0809	Plumbing	1392 (17%)	3232 (24%)	28,858 (12%)	73,983 (16%)	52,268
0901-0908	Electrical	931 (12%)	1228 (9%)	15,711 (7%)	22,893 (5%)	16,483
1001-1006	Equipment	997 (12%)	2208 (16%)	27,087 (11%)	62,863 (14%)	45,261
1201-1205	Utility service	146 (2%)	212 (2%)	3,832 (2%)	7,549 (2%)	5,435
1300	Miscellaneous	83 (1%)	110 (1%)	779 (0%)	1,049 (0%)	755

Self-Help Repairs

Total costs for self-help were minimal. The self-help materials issued to occupants were mostly furnace filters and light bulbs.

Impact of Inflation on Comparisons

All of the costs in Table 10 were charged at the time of occurrence. There was about a 1-year difference between the two types of units since the CBUs were occupied about 1 year earlier than the MHUs. To assess the impact of inflation on the overall comparisons, costs were all converted to 1989 prices by multiplying all costs in a given year by that year's inflation factor. Inflation factors for the years 1983 through 1989 were determined from "The Home Maintenance and Repair Index" in the *Economic Report of the President* (Table B-59, Consumer Price Indexes, selected classes, 1946-1988, Jan 89), and in the *Monthly Labor Review* (Table 30, Jul 89). The yearly indices and inflation factors used in this study are shown below:

Year	Index	Inflation Factor
1989	117.0	1.000
1988	114.9	1.020
1987	111.8	1.047
1986	107.9	1.084
1985	106.5	1.099
1984	103.7	1.128
1983	99.9	1.171

Figure 6 shows cumulative inflated costs per unit over time. This is the same graph as that in Figure 2, except that the costs are inflated. Note that the difference between the two types at the end of 5 years was about the same, but the magnitude of both had increased. This can also be seen in Table 11.

Table 11

Comparison of Actual and Inflated Costs

Type	No. Unit Months	Total Cost ($)	Cost/Unit/ Month ($)	Cost/Unit/ Year ($)
CBU	8,640	239,839	27.76	333
CBU-Infl	8,640	257,892	29.85	358
MHU	12,000	460,248	38.35	460
MHU-Infl	12,000	481,752	40.14	482

The difference for cost/unit/year is $127 for actual costs and $124 for inflated costs. The smaller difference for inflated costs is caused by the higher inflation rate for the first year of costs for CBUs.

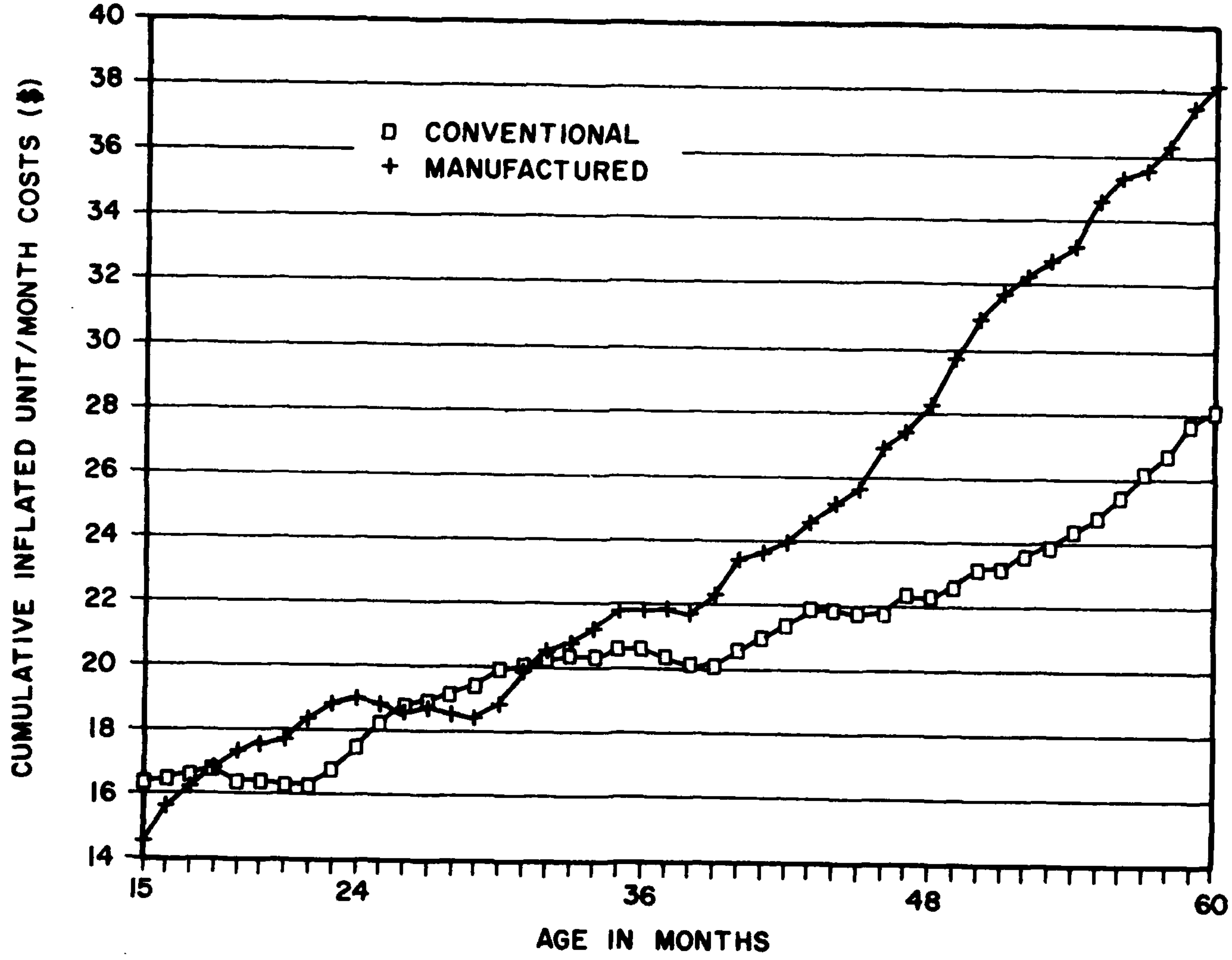

Figure 6. Cost per unit per month over time, adjusted for inflation.

7 ENERGY COSTS

Comparisons of gas and electricity consumption began in May 1984, since most MHUs were not occupied before then.

Electricity Consumption

The average usage (kWh) per housing unit is shown in Table 12. For the entire 60-month data collection period, an MHU used an average total of 45,265 kWh, while a CBU used an average total of 44,762 kWh. This was a difference of 503 kWh ÷ 60 months = 8.4 kWh/month. At the September 1989 rate of $0.0925/kWh, an MHU cost $0.78 more than a CBU for electricity per month.

Gas Consumption

The type of fuel used was liquid propane (LP). LP is delivered to a central facility on post and is converted to gas and distributed to housing units through underground pipes. The average monthly usage (cu ft) per housing unit is shown in Table 13.

For the 60-month period, an MHU used an average total of 97,716 cu ft while a CBU used an average total of 92,854 cu ft. This is a difference of 4,862 cu ft ÷ 60 months = 82 cu ft/month. At the September 1989 cost of $0.0185/cu ft an MHU cost $1.50 more than a CBU for gas per month.

Consumption Comparison by Unit Location

The average consumptions over the 5 years were compared by unit numbers to determine if any trends were present. It was expected that second story units would use more energy than those on the first story since the second story units have a roof and first story ones do not. In the CBUs, units C and D are second story units in fourplexes, D and E are second story units in fiveplexes, and E and F are second story units in sixplexes. In MHUs, C and D are second story units.

Electricity

Tables 14 and 15 show the average consumptions by unit numbers for CBUs and MHUs, respectively. In Table 14, unit D is shown to have been the highest average user (for the nine fourplexes, unit D is higher five times) while Table 15 shows that the upper two units, C and D were the highest users.

Gas

Tables 16 and 17 show the average consumptions by unit numbers. Table 14 shows that unit A had the highest consumption in 14 buildings. For the MHUs the second story units were the highest users in 33 of the 50 buildings.

Cost Comparison Summary

The averages for dwelling unit energy consumption and cost for the 5-year period (May 1984 to April 1989) are given in Table 18. The MHUs on the average have cost $27 more per year for gas and electricity than the CBUs.

Meter Problems

Many meters have become defective over the past 5 years. For the CBUs 24 electric and eight gas meters have failed while for the MHUs 12 electric and four gas have failed.

Comments

The data in Chapter 5 (better air tightness and higher furnace efficiencies for the MHUs) would indicate the MHUs should use less energy than the CBUs. However, this is offset by the higher overall heat loss of the MHUs. Detailed energy simulations (performed using the Building Loads Analysis and System Thermodynamics* program) indicate two design/construction features that cause the higher wall-heat loss: the MHUs have more window/door glass area; and the MHUs have single-pane glass while the CBUs have thermal-pane. Additionally, the CBUs were built on concrete slabs while the MHUs have crawl spaces, which are less energy efficient.

Energy consumptions of individual units were compared. Any units with unusually high consumptions over the tenancy of several different occupants were checked to try to determine the cause of the high energy consumption, but no patterns were found.

*Building Loads Analysis and System Thermodynamics (BLAST) was developed by USACERL and is used throughout the Department of Defense for military construction projects.

Table 12

Average Monthly Electricity Consumption (kWh) Per Housing Unit

		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Monthly Avg
		1984 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1985 Jan	Feb	Mar	Apr	Monthly Avg
Year 1	MHU	781	1007	1219	1264	1001	558	446	486	485	428	423	634	727
	CBU	704	960	1171	1132	908	583	434	471	464	418	444	550	687
		1985 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1986 Jan	Feb	Mar	Apr	Monthly Avg
Year 2	MHU	680	1180	1452	1421	644	574	525	514	508	448	466	468	740
	CBU	661	1014	1426	1312	700	610	547	493	482	435	465	484	719
		1986 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1987 Jan	Feb	Mar	Apr	Monthly Avg
Year 3	MHU	829	1149	1281	1521	746	572	460	571	500	429	474	592	760
	CBU	789	1071	1270	1335	857	633	451	607	510	512	492	639	767
		1987 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1988 Jan	Feb	Mar	Apr	Monthly Avg
Year 4	MHU	660	1033	1169	1442	1009	679	503	520	476	487	464	470	743
	CBU	679	1060	1265	1227	1099	755	568	515	494	485	520	476	761
		1988 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1989 Jan	Feb	Mar	Apr	Monthly Avg
Year 5	MHU	766	964	1336	1438	1013	823	530	506	550	494	490	697	801
	CBU	771	885	1220	1406	1019	845	581	530	580	501	543	678	796

Table 13

Average Monthly Gas Consumption (cu ft) Per Housing Unit

		1984 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1985 Jan	Feb	Mar	Apr	Monthly Avg
Year 1	MHU	900	680	580	630	580	1410	2410	3560	3550	2940	2710	1470	1787
	CBU	710	640	540	600	540	1110	2080	3190	3220	2790	2390	1280	1591

		1985 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1986 Jan	Feb	Mar	Apr	Monthly Avg
Year 2	MHU	950	610	620	660	710	1050	2680	2850	2550	2270	1710	1390	1504
	CBU	830	570	590	680	660	890	2420	2560	2400	2120	1680	1370	1398

		1986 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1987 Jan	Feb	Mar	Apr	Monthly Avg
Year 3	MHU	920	570	610	620	850	1210	1750	3330	3410	2600	2520	1070	1623
	CBU	900	660	740	730	830	1110	1580	3090	3310	2670	2530	1160	1612

		1987 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1988 Jan	Feb	Mar	Apr	Monthly Avg
Year 4	MHU	800	660	630	620	600	680	2020	3920	3320	2690	2040	1460	1621
	CBU	800	790	690	680	690	710	2120	3530	3380	2620	1990	1340	1605

		1988 May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1989 Jan	Feb	Mar	Apr	Monthly Avg
Year 5	MHU	1240	680	560	640	660	720	2110	3170	3760	3070	1790	910	1608
	CBU	1130	660	620	680	680	740	1830	2830	3600	2970	1760	870	1533

Table 14

CBU Average Electric Consumption (kWh/mo) by Dwelling Unit

Unit	A	B	C	D	E	F
3680	828	632	534	997	768	693
3681	716	648	650	762	---	---
3684	656	588	930	706	---	---
3685	753	953	653	724	672	783
3690	740	781	625	774	682	759
3691	684	592	676	750	---	---
3693	826	575	560	821	740	897
3694	811	860	919	1138	---	---
3695	858	605	748	812	---	---
3700	784	712	701	730	776	870
3705	541	716	534	909	748	---
3712	712	806	587	877	702	737
3715	627	513	699	636	763	647
3720	789	589	730	1036	889	825
3721	918	660	771	771	728	---
3722	795	885	612	716	808	---
3723	853	742	729	666	722	---
3724	645	679	793	738	---	---
3725	638	741	792	835	696	---
3727	831	472	742	705	980	---
3731	688	719	730	911	---	---
3732	753	696	699	627	853	857
3738	772	649	573	638	672	810
3742	837	580	603	866	---	---
3743	702	832	930	917	794	690
3745	857	648	691	788	654	748
3747	909	616	771	892	---	---
3750	818	602	767	807	824	729
Number of Times Unit Was Highest	5	3	3	10	3	4

Table 15

MHU Average Electric Consumption (kWh/mo) by Dwelling Unit

Unit	A	B	C	D
3800	744	750	645	750
3801	698	691	1097	690
3802	768	768	731	802
3803	549	792	1004	1221
3804	795	622	857	817
3805	676	684	559	802
3806	875	618	785	747
3807	711	504	752	774
3809	683	783	580	658
3811	677	649	908	807
3812	674	609	799	846
3813	624	673	823	678
3814	696	529	758	744
3815	658	627	686	731
3816	685	612	705	572
3818	621	688	736	630
3820	612	894	728	863
3821	795	752	726	893
3822	626	698	776	765
3823	626	720	744	768
3824	874	789	783	773
3825	705	589	711	829
3826	794	742	960	922
3827	669	940	706	813
3828	583	655	778	821
3829	727	729	750	775
3831	740	1050	975	761
3832	736	664	906	873
3833	871	758	743	614
3834	694	716	858	744
3835	713	766	826	832
3837	727	995	863	886
3839	778	776	779	708
3840	774	794	890	908
3841	837	778	713	702
3842	618	630	962	727
3843	695	616	709	696
3844	776	449	636	891
3845	849	820	741	819
3846	780	903	756	948
3848	875	558	951	679
3850	599	776	758	799
3851	650	831	784	646
3852	640	539	763	661
3853	648	683	861	848
3854	652	628	610	739

Table 15 (Cont'd)

Unit	A	B	C	D
3855	646	534	1032	874
3856	792	617	1693	917
3857	952	813	631	774
3858	707	626	632	822
Number of Times Unit Was Highest	6	6.5	19	17.5

Table 16

CBU Average Gas Consumption (cu ft/mo) by Dwelling Unit

Unit	A	B	C	D	E	F
3680	1421	1328	1342	1324	1311	1415
3681	1962	1613	1547	1273	---	---
3684	1692	1828	987	1335	---	---
3685	2230	1438	1547	1826	1555	1392
3690	1593	1238	1387	1354	1368	1361
3691	1846	1959	1712	1548	---	---
3693	2544	1461	1307	1947	1639	1574
3694	1431	1534	2220	1765	---	---
3695	2401	1440	1716	1046	---	---
3700	1441	1190	1561	1620	1616	1467
3705	1489	1234	1799	1061	1052	---
3712	1709	1535	1115	1415	1312	1699
3715	2172	1321	1351	1866	1389	1748
3720	1431	1301	1513	1760	1415	1214
3721	2473	1840	1381	1348	1698	---
3722	1855	1724	1381	1492	1563	---
3723	1505	2121	1889	1273	1492	---
3724	3161	1580	1235	1402	---	---
3725	1781	1443	1631	1377	1255	---
3727	1483	1217	1896	1863	1180	---
3731	1715	1448	1591	1465	---	---
3732	1305	1477	1021	1807	1479	1444
3738	1759	1433	1453	1891	1162	1467
3742	1686	1197	1944	1581	---	---
3743	1811	1358	1279	1423	2014	1476
3745	1395	936	1472	1380	1365	1330
3747	1293	1463	1651	1142	---	---
3750	1915	1454	1469	1577	1283	1790
Number of Times Unit Was Highest	14	3	6	4	1	0

Table 17

MHU Average Gas Consumption (cu ft/mo) by Dwelling Unit

Unit	A	B	C	D
3800	1599	1695	1641	1894
3801	1475	1642	1793	1838
3802	2357	1262	1786	1749
3803	1400	1356	2142	2554
3804	1727	1519	2020	1591
3805	1237	1593	1532	1633
3806	1371	1503	1499	2004
3807	1834	1378	1547	1966
3809	1884	1495	1820	1464
3811	1545	2262	2148	2128
3812	1681	1667	2571	1799
3813	1572	1446	1939	1617
3814	1475	1218	1504	1515
3815	1626	1469	1322	1201
3816	1773	1526	2070	1827
3818	1379	1418	1261	1961
3820	1590	1371	1469	2115
3821	1468	1613	1652	1673
3822	1134	1727	1448	1604
3823	1625	1647	1411	1395
3824	1715	1517	1614	2252
3825	1841	1376	1759	1521
3826	1514	1278	1723	1489
3827	1810	2265	1855	1776
3828	1240	1311	2048	1319
3829	1876	1489	1554	1652
3831	1623	1554	1931	2035
3832	1508	1199	1938	1912
3833	1257	1616	1351	1761
3834	1882	1541	1740	1255
3835	1383	1880	2140	1723
3837	1554	1703	1675	1476
3839	1332	1668	1222	1573
3840	1583	1505	1526	1752
3841	1841	1211	1610	1560
3842	1369	1392	2091	1615
3843	1919	1382	1786	1527
3844	1323	1321	1929	1967
3845	1715	1615	2215	1559
3846	1498	1436	1558	2149
3848	1520	1042	1480	1734
3850	1392	1405	1107	1707
3851	1786	1337	1378	1914
3852	1568	1633	1627	1589
3853	1583	1283	1540	1613
3854	1455	1458	1273	1628

Table 17 (Cont'd)

Unit	A	B	C	D
3855	1958	1266	1318	1546
3856	1295	1819	1250	1305
3857	1790	1717	1797	1733
3858	1595	1626	2009	1751
Number of Times Unit Was Highest	9	8	12	21

Table 18

Five-Year Summary of Energy Consumption

	MHU		CBU	
Unit	Gas	Electricity	Gas	Electricity
Average Consumption/Year Per Housing Unit	19,543 cu ft	9,053 kWh	18,571 cu ft	8,952 kWh
Average Cost/Year Per Housing Unit	$362	$837	$344	$828

8 OCCUPANT SATISFACTION

Questionnaire

One part of the study assessed occupants' satisfaction with their housing. The use of lower cost housing for Army personnel would not be cost effective if it created morale problems or lower reenlistment rates. A questionnaire developed at USACERL and approved by HQFORSCOM, USAEHSC, and HQUSACE is given in Appendix G. A copy of the questionnaire with a mail-back envelope (to USACERL) was given to each vacating family by the contractor approximately 2 weeks before they left. The family was encouraged to complete and mail it back when they vacated.

A total of 466 completed questionnaires were obtained from vacating occupants and in four special surveys of occupants who had lived in the unit for more than 1 year. For analysis purposes, only occupants who had lived in their quarters for at least 12 months were considered, since they had been through both heating and cooling seasons.

The responses from occupants of the two types of units were compared by performing cross tabulations. The following paragraphs show results for key questions and for questions for which occupants of the two housing types differed significantly (95 percent confidence level). There were 222 valid responses from occupants of CBU and 236 for MHU.

Q5. How would you rate the condition of your quarters?

	Excellent	Better than Average	Average	Below Average	Poor
CBU	26%	40	33	1	0
MHU	21	42	32	5	0

No statistically significant difference was found in responses between occupants of the two housing types.

Q6. In general, how satisfied have you been with these quarters?

	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
CBU	32%	59	7	2
MHU	31	59	10	0

No significant difference was found.

Q7E. In general, are you satisfied with your kitchen cabinets?

	Satisfied	Not Satisfied	No Opinion
CBU	77%	21	2
MHU	92	8	0

There was a difference between CBU and MHU occupants. As will be discussed in Chapter 10, there have been problems with the finish on the cabinets in the CBUs.

Q7J. In general, are you satisfied with living/dining room floors?

	Satisfied	Not Satisfied	No Opinion
CBU First Floor	67%	30	3
CBU Second Floor	89	10	1
MHU First Floor	68	30	2
MHU Second Floor	80	18	2

There was a statistically significant difference between first and second floor occupants of the two housing types. Second floor units have carpet while first floor units have tile/vinyl. Second floor occupants were more satisfied.

Q7J1. How would you rate cleanability of living/dining room floors?

	Easy to Clean	Hard to Clean	No Opinion
CBU First Floor	62%	30	8
CBU Second Floor	79	10	11
MHU First Floor	74	18	8
MHU Second Floor	62	23	15

There was a statistically significant difference between occupants of CBU and MHU for cleanability of living/dining room floors, as the first floor occupants' are less satisfied.

Q7K. In general, are you satisfied with the bedroom floors?

	Satisfied	Not Satisfied	No Opinion
CBU First Floor	72%	26	2
CBU Second Floor	96	1	3
MHU First Floor	73	26	1
MHU Second Floor	85	13	2

There was a statistically significant difference: second floor (carpet) occupants were more satisfied.

Q7K1. How would you rate cleanability of bedroom floors?

	Easy to Clean	Hard to Clean	No Opinion
CBU First Floor	67%	27	6
CBU Second Floor	79	11	10
MHU First Floor	75	18	7
MHU Second Floor	70	15	15

There was a statistically significant difference between first floor and second floor occupants for cleanability of bedroom floors with more first floor occupants (vinyl/tile) rating it as hard to clean.

Q7M. In general, are you satisfied with the interior walls?

	Satisfied	Not Satisfied	No Opinion
CBU First Floor	63%	35	2
CBU Second Floor	77	20	3
MHU First Floor	77	21	2
MHU Second Floor	79	17	4

There was a statistically significant difference: more dissatisfaction was shown by CBU first floor occupants.

Q9-10. There was no difference between CBU and MHU for noise/odor annoyance from other quarters.

Q15. Please list three things about your apartment you like most.

Of 1025 items listed:

Garage	- 14%	Separate laundry room	- 7%
Air conditioner	- 8%	Kitchen arrangement	- 5%
Dishwasher	- 7%	Design	- 5%

Q16. Please list three things about your apartment you do not like.

Of 722 items listed the following were listed most frequently:

Floors	- 9%	Bathroom too small	- 4%
Neighbors' noise	- 6%	Paint on walls	- 4%
Thin walls	- 6%	Lawn sprinklers	- 4%

Q17. Please make any general comments about your apartment:

Of 214 comments, these occurred most frequently:

Satisfied with apartment	-	31%
Very satisfied with apartment	-	27%
Cheap construction	-	14%

Discussion

Overall, there was no difference in satisfaction of occupants of the two types of housing. Even where significant differences were found for specific questions, the majority of each group were satisfied with their housing.

9 OCCUPANT DEMOGRAPHICS AND OCCUPANCY RATES

Detailed records of the vacancies of the units and characteristics of the occupants were analyzed to ensure the two types of units had the same types of occupants.

Characteristics of Occupants

The military rank of occupants was virtually the same for both types of units. Table 19 shows the number and percent of occupants with various ranks.

Table 19

Profile of Occupants' Ranks

Type	E2-E3	E4	E5	E6	E7	E8-E9
CBU	0 (0%)	287 (47%)	210 (34%)	78 (13%)	34 (6%)	4 (0%)
MHU	3 (0%)	363 (47%)	266 (35%)	89 (12%)	34 (4%)	8 (1%)

The number of family members was also very similar for both types of units as can be seen in Table 20.

Table 20

Frequencies of Family Sizes

Type	2	3	4	5
CBU	251 (41%)	282 (46%)	81 (13%)	0 (0%)
MHU	325 (42%)	315 (41%)	125 (16%)	1 (0%)

The ages of sponsors of families for the two types also were very similar as can be seen in Table 21.

Table 21

Number and Percents of Families by Age of Sponsor Member

Age (%)	CBU	MHU
18-19	6 (1%)	8 (1%)
20-22	124 (20%)	170 (22%)
23-25	187 (30%)	258 (34%)
26-28	144 (23%)	158 (21%)
29-32	76 (12%)	82 (11%)
33-34	35 (6%)	44 (6%)
35-39	32 (4%)	33 (4%)
40-47	10 (2%)	12 (2%)

It is concluded that the families occupying the two types of units were very similar and that differences found between the types for maintenance costs or utilities costs were not related to the occupants being different; i.e., there were no biases in assignment of families to the units.

Occupancy Rates

The occupancy rates for the types of units was very similar—98.0 percent for the CBUs and 97.8 percent for the MHUs. A total of 1045 occupancy changes occurred for both types of units. There were a few cases when the vacancy periods were very long, but no difference was apparent between the types of units. Table 22 summarizes these long vacancies.

Table 22

List of Vacancies Greater Than 50 Consecutive Days

Type	Unit No.	Vacancy Length Days	Year Occurred
CBU	3695-B	95	1986
CBU	3720-B	71	1986
CBU	3723-D	356	1986-7
CBU	3724-A	90	1986
CBU	3732-D	107	1987-8
MHU	3800-D	60	1985
MHU	3820-C	63	1986
MHU	3821-C	58	1986
MHU	3829-C	135	1984-5
MHU	3834-B	83	1986
MHU	3835-D	166	1984-5
MHU	3839-C	149	1986
MHU	3846-D	72	1986
MHU	3848-B	282	1984-5
MHU	3857-C	132	1986

Reasons for the lengthy vacancies are not known except for 3723-D and 3848-B. For the first, the problem was a bad floor in the kitchen and for the latter, damage was caused during a drug raid.

10 NEW PLUS FAIR WEAR AND TEAR INSPECTIONS

The purpose of these inspections was to determine if there was a difference in the durability of the two types of units. Inspections of a sample of each type were performed after 5 years' occupancy.

The exteriors of all 28 CBU buildings and 50 MHU buildings were inspected. A sample of 40 units was selected for each type and interior inspections were performed on these units. The contractor was instructed to determine what costs were required to repair the units to bring them to a state of "new plus 5 years of wear and tear"; i.e., any wear or tear attributed to occupants or due to unusual weather were to be excluded. Emphasis was placed on the building components which can be associated with construction methods. (Refrigerators, ranges, dishwashers, water heaters, electrical fixtures, and electrical receptacles were not inspected.) Inspectors were to look for specific problems such as:

- Unusual settling of the structure
- Warping/buckling of building components
- Cracks in the interior ceiling, floors, and walls
- Joint separations in the wall joints (exterior and interior) and around windows and doors
- Plumbing damage due to structure flexing.

Appendix H contains the inspection forms used by the contractor.

CBUs

Tables 23 and 24 summarize the results of the inspections.

Exterior

The major exterior problem was shingle damage. The contractor's investigation revealed that many of the shingles had only two, sometimes one, fastener per strip while the Uniform Building Code specifies four per strip. Other considerations are the low roof pitch, high heat in the desert, and high winds at Fort Irwin. Thus, improper design and installation of materials have contributed to the problem. No costs are given to correct this problem as the repairs were completed and costs are accumulated in the maintenance costs in Chapter 6.

Another problem was cracking of the stucco and veneer, mainly due to settling of the structure.

The problem with the air conditioners was that lawn sprinklers were improperly located adjacent to the compressor units. This resulted in clogging and eventual replacement of the condenser.

Although damages were not included, the sprinklers have also stained stucco walls and the privacy fences.

Table 23

CBU - Exterior Fair Wear and Tear Inspection Results

Building Numbers	Problem Description	Estimated Cost ($) Per Unit	Cost ($) Total
24 of 28 buildings	Shingle damage	0	0
3743	Warped facias	350	350
3684, 3685, 3690, 3691, 3693, 3694, 3695, 3700, 3705, 3712, 3715, 3725, 3727, 3738, 3747	Wall joints need regrouting	75	1125
3720, 3721, 3722, 3723, 3724	Wall joints need regrouting	25	125
3725	Cracks in stucco	75	75
3695, 3700	Cracks in stucco	100	200
3705	Cracks in stucco	350	350
3712, 3724, 3727, 3745	Cracks in stucco	150	600
3724	Cracks in veneer	150	150
3694	Cracks in veneer	1000	1000
3860	Veneer separation	850	850
3685, 3720, 3721, 3722, 3747	Structural cracks	450	2250
3727	Structural cracks	1000	1000
3700	Wall cracks due to garage settling	450	450
3694	Structural wall damage due to garage settling	350	350

Table 23 (Cont'd)

Building Numbers	Problem Description	Estimated Cost ($) Per Unit	Cost ($) Total
3742	Repair flashing on brick	100	100
3724	Reseal flashing on vencer	75	75
3700	Regrout doors	150	150
3720, 3721	Reset, regrout doors	600	1200
3681	Reset, regrout doors	350	350
3725	Replace 10 windows	250	250
3727	Repair window	175	175
3750	Repair window trim	150	150
3700	Resct garage door	175	175
3620, 3685	Patio cracks	100	200
3750	Patio cracks	150	150
3720	Reset porch post	30	30
3721	Bad insulation on freon line	25	25
3693, 3700, 3712, 3694, 3720, 3721, 3723, 3725, 3743	Bad A/C condenser	870	6000
		Total	19,755
		Total without A/C costs	11,905
		Cost per unit	83

Table 24

CBU - Interior Fair Wear and Tear Inspection Results

Unit Numbers	Problem Description	Estimated Cost Per Unit	Cost ($) Total
3732E	Carpet in hallways wearing badly	400	400
3723D	Living room carpet loose, uneven	500	500
3732C	Kitchen linoleum cracked	250	250
3690D	Minor crack in hallway ceiling	50	50
3685A	Water damage, hallway ceiling	50	50
3747E	Water damage, bedroom ceiling	100	100
3685F	Water damage, bedroom ceiling	150	150
3685A	Water damage, dining area ceiling	150	150
3705E	Water damage, bedroom ceiling	250	250
3723A	Repaint bedroom ceiling	50	50
3680E	Window needs caulking	25	25
3685B	Crack above door	125	125
3750D	Door runner separating from overhead	75	150
3694A	Laminate coming off counter top	50	50
3680B, 3685B, 3694A, 3732C	Utility room cabinets finish peeling	100	400
3680E	Bathroom cabinet needs refinishing	50	50
25 of 40 units	Kitchen cabinet veneer peeling/wearing badly	250	6,250
		Total	9,000
		Cost per Unit	62

Another defect was cracking of driveways. This is not a current problem as no repairs are needed, but it does indicate either improper soil compaction or concrete curing.

A lesson learned from the study of these buildings is that gutters and downspouts should not be used at Fort Irwin. First, there is very little rain and no real need for them. Second, high winds rapidly tear them loose. It is the policy to not replace them.

Another problem not shown in Table 23 was the quality of the garage doors. These are insubstantial and all have warped. Eventually they will all have to be repaired/replaced. Figures 7 and 8 show typical doors, one with a damaged corner and one warped.

The total cost to return the exteriors of the units to a fair wear and tear condition after 5 years' use was $83 per dwelling unit.

Interior

The major problem with the interiors was the kitchen cabinet finish. The veneer peeled/wore badly. This problem was not attributable to type of construction, but to an inferior product.

Otherwise, the interiors were in very good condition. The cost to return the interiors to a fair wear and tear condition after 5 years' use was $62 per dwelling unit.

MHUs

Tables 25 and 26 summarize results of the inspections.

Exterior

The major problem with these buildings was the eaves. These units were manufactured about 200 miles from Fort Irwin and transported by truck. Evidently, in order to meet highway width restrictions, the eaves could not be built on the modules. Rather, they were fastened to the roof with metal straps and folded onto the roof for transportation. At Fort Irwin, they were folded down. No permanent method of securing them to the building was used. As a result, in 1988, the straps began to deteriorate and one eave fell to the ground. Figures 9 through 12 show the problem. Those appearing in poor condition were temporarily fixed by putting up bracing. Then a contract was let to refasten all of them permanently. This cost is shown in Table 26 and is about $1,673 per dwelling unit. This problem was not necessarily attributable to the manufactured housing process, but to poor design and quality assurance.

Similarly to the CBUs, these buildings also showed abnormal shingle damage. Although no material problems were found, the same conclusion can be made—that asphalt shingles with this roof pitch are not suitable for use in the high heat and high winds at Fort Irwin.

There was absolutely no need for gutters and downspouts as discussed above for the CBUs.

The CBUs also had numerous cracks in the stucco.

Many cracks were found in the concrete patio floors. The slabs are 4 in. thick and if soil compaction is not very good, cracking results. A 6-in. slab probably would not have cracked under slight settling.

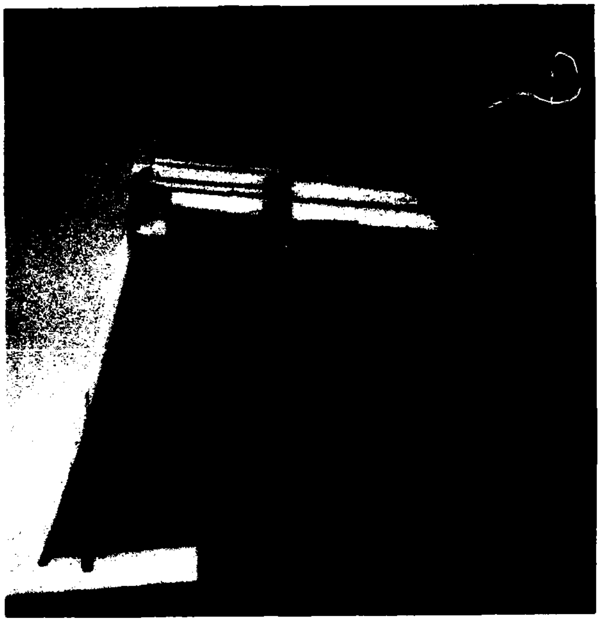

Figure 7. Damaged garage door corner.

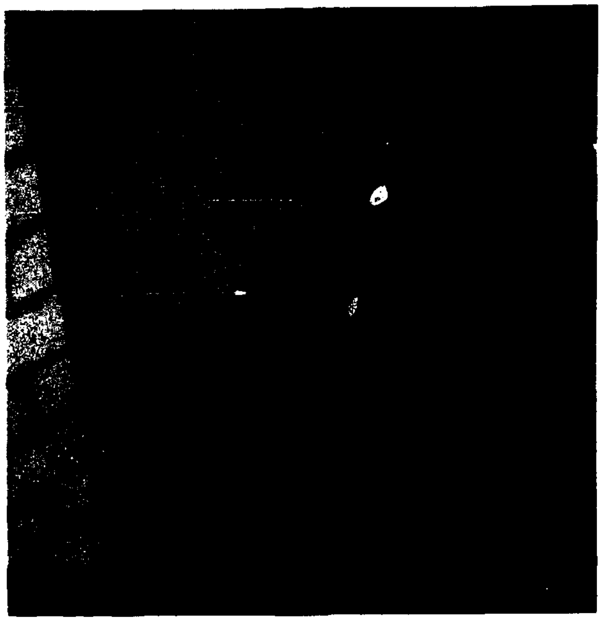

Figure 8. Warped garage door.

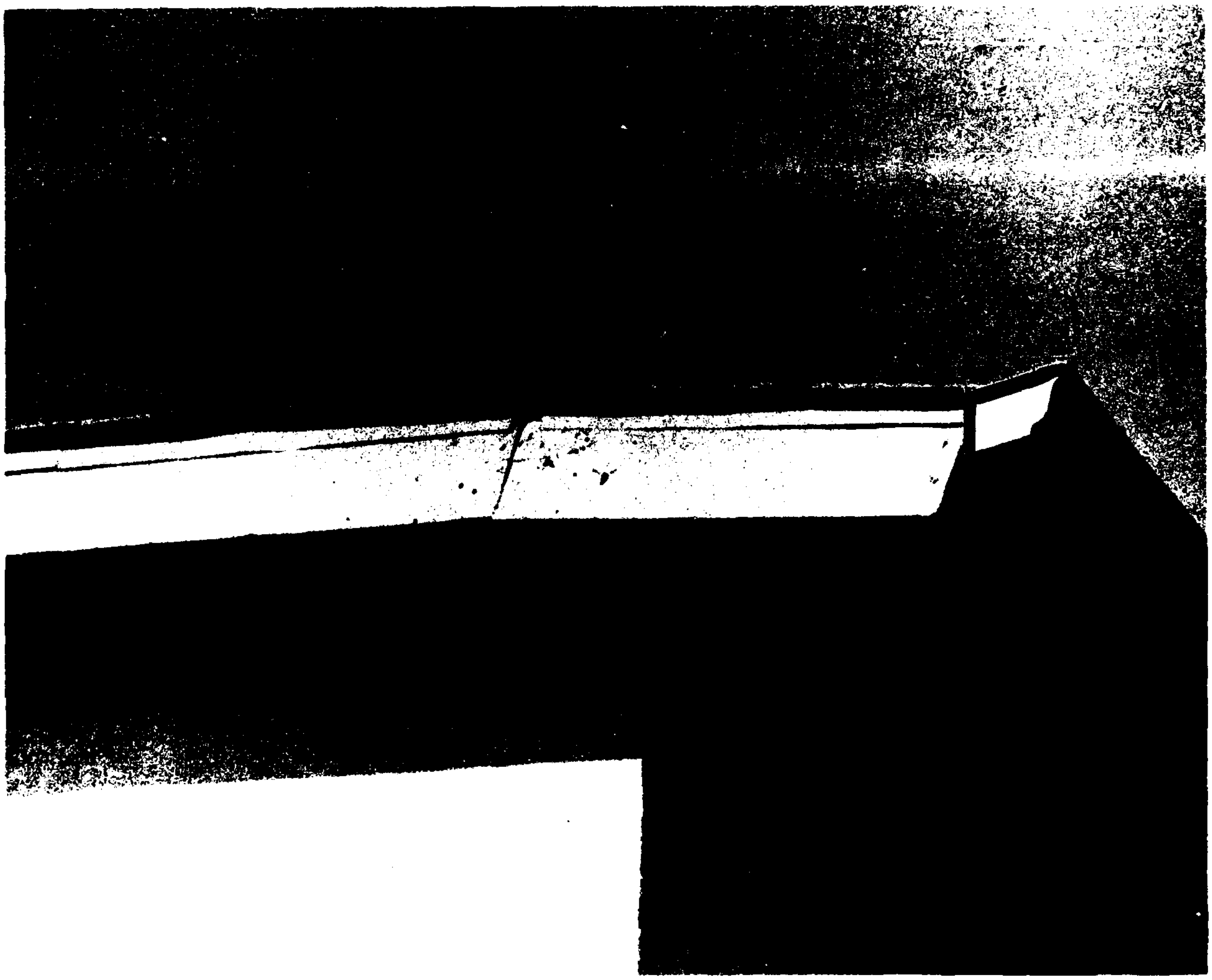

Figure 9. Eave construction-manufactured unit.

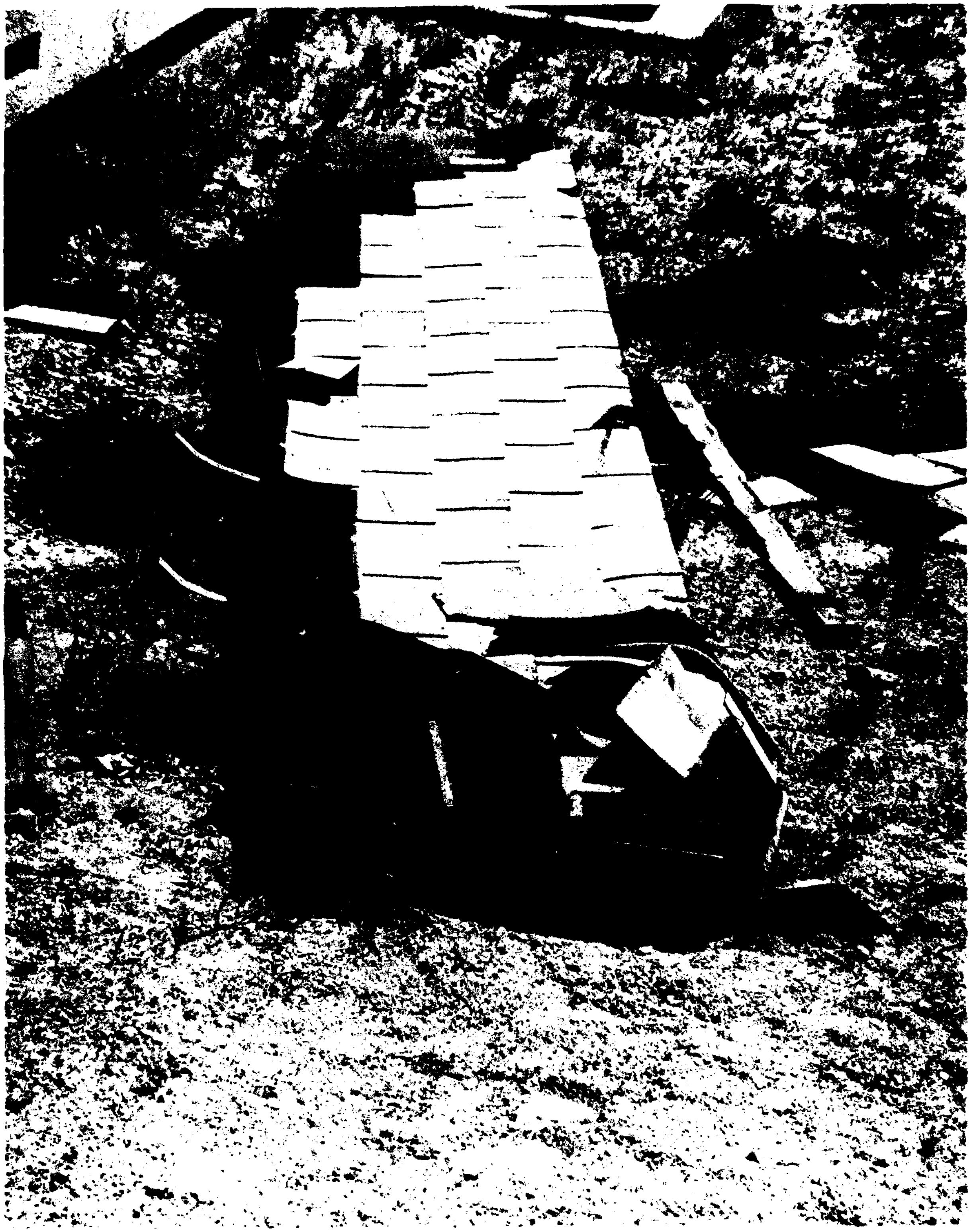

Figure 10. Eave section which fell off a manufactured unit.

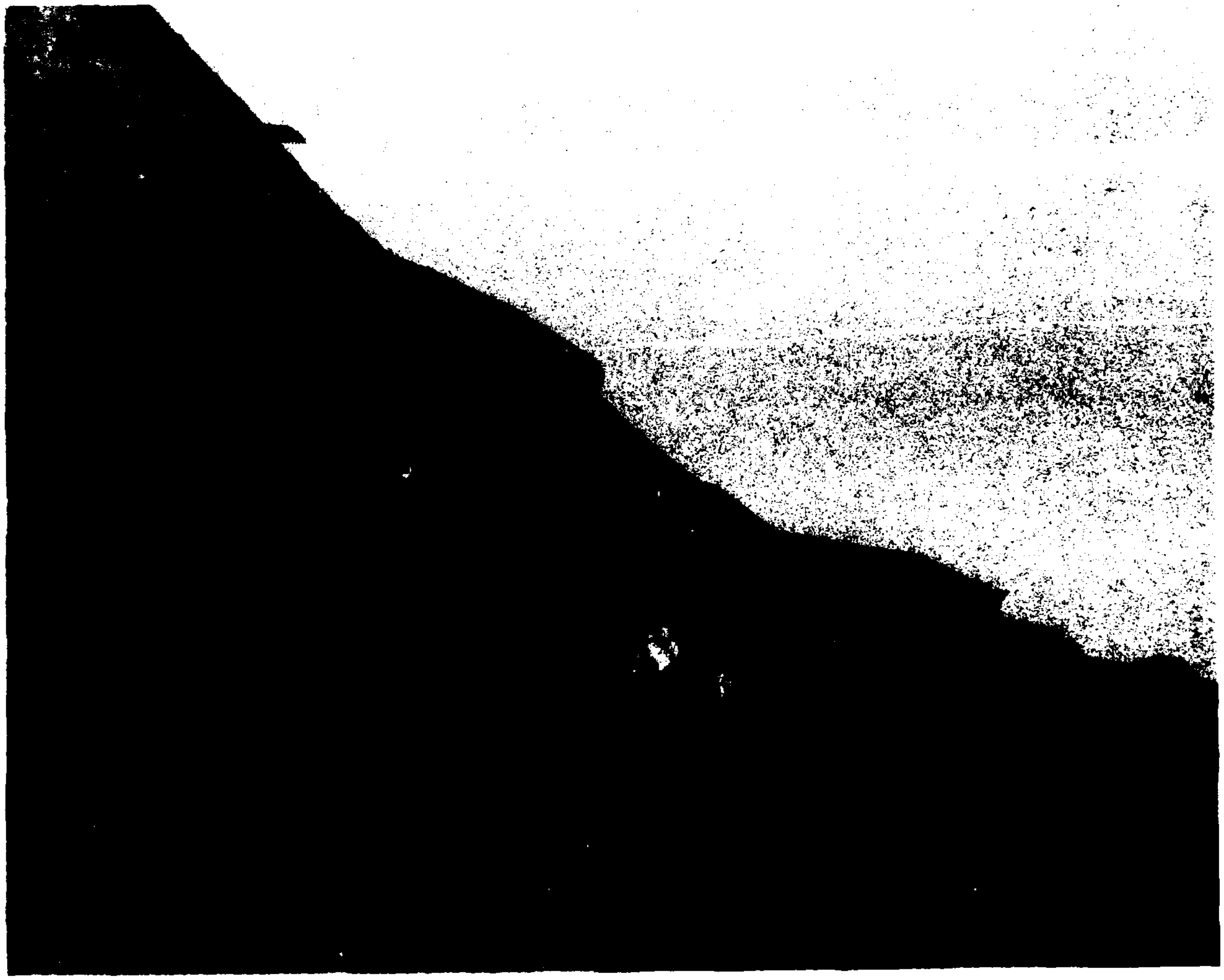

Figure 11. Section of roof from which eave section was located.

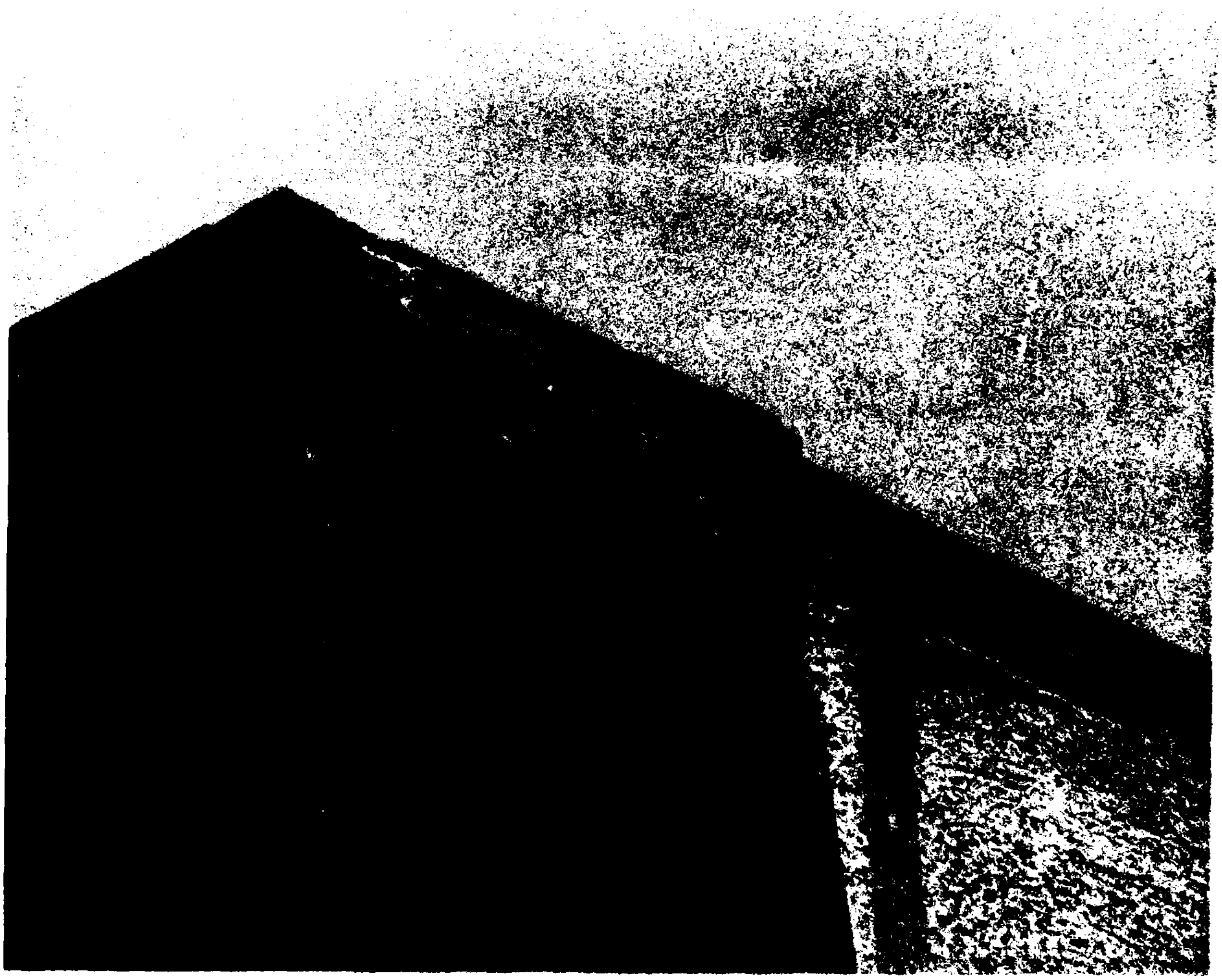

Figure 12. Corner of roof at which eave was located.

The total cost to return the units to a fair wear and tear condition after 5 years' use was $80 per dwelling unit.

Interior

As for the CBUs, the quality of the kitchen cabinets is questionable because the surface showed excessive wear.

Otherwise, there were problems with floor surfaces. Cracks did not appear in the CBUs and may result from the type of construction—modules fastened together.

The cost to return the interiors to a fair wear and tear condition after 5 years' use was $22 per dwelling unit.

Discussion

A comparison of the fair wear and tear restoration costs per unit is shown below:

	Exterior	Interior
CBU	$83	$62 (w/cabinet finish cost) or $19
MHU	$16,100 (w/eaves cost) or $80	$22

Total costs to restore the units are: CBUs, $83 + $19 = $102 per unit and MHUs, $80 + $22 = $102. This does not include the cost for the kitchen cabinet finish for the CBUs or eaves for the MHUs.

Table 25

MHU - Exterior Fair Wear and Tear Inspection Results

Building Numbers	Problem Description	Estimated Cost ($) Per Unit	Cost ($) Total
47 of 50 buildings	Shingle damage	0	0
48 of 50 buildings	Cracks in at least one driveway	0	0
All 50	Eaves need to be structurally rebuilt		334,435
44 of 50 buildings	Numerous cracks in stucco		9,450
3822, 3825	Cracks in patio floor	50	100
3801, 3823	Cracks in patio floor	75	150
3800, 3802, 3809	Cracks in patio floor	100	100
3824, 3826, 3832, 3855, 3856, 3858	Cracks in patio floor	150	900
3853	Cracks in patio floor	175	175
3851	Cracks in patio floor	225	225
3804, 3857	Cracks in patio floor	300	600
3806, 3807, 3815, 3821	Cracks in patio floor	400	1600
3827	Cracks in patio floor	600	600
3833	Structural wall damage	400	400
3812, 3816, 3818, 3834, 3835, 3850	Minor cracks in porch entrance floor	100	600
3814, 3815	Major porch floor cracks	200	400
3813, 3831	Major porch floor cracks	300	600
		Total cost	350,535
		Cost per unit	1,753
		Total cost without eaves	16,100
		Cost per unit without eaves cost	80

Table 26

MHU - Interior Fair Wear and Tear Inspection Results

Unit Numbers	Problem Description	Estimated Cost ($) Per Unit	Cost ($) Total
15 of 40 units	Excessive wear on kitchen cabinets	100	1500
3835B	Hallway tiles buckling/ cracking	25	25
3801B, 3806B, 3826A 3833D, 3837D, 3843A 3854B	Hallway tiles lifting/ buckling	50	350
3845B	Hallway tiles lifting/ buckling	100	100
3825A	Hallway tiles lifting/ buckling	150	150
3818B	Hallway tiles lifting/ buckling	250	250
3853B	Broken tile, living room	20	20
3801B	Broken tile, living room	50	50
3852D	Broken tile, living room	100	100
3855C	Broken tile, living room	150	150
3818B	Broken tile, living room	250	250
3854B	Broken tile, dining area	25	25
3833A, 3854A	Broken tile, dining area	50	100
3845B	Broken tile, dining area	100	100
3814D, 3851C	Kitchen linoleum cracked/ buckling	50	100
3816C	Broken tile, bedroom	15	15
3852B	Cracked tile, bedroom	25	25

Table 26 (Cont'd)

Unit Numbers	Problem Description	Estimated Cost Per Unit	Cost ($) Total
3826A, 3854B	Cracked tile, bedroom	50	100
3825A	Cracked tile, bedroom	75	75
3811B	Cracked tile, bedroom	100	100
3806D, 3854B	Cracked, buckling tile utility room	50	100
3811D	Slight wall settling	75	75
3801B, 3806C	Slight wall settling	30	60
3829C	Ceiling settling crack	25	25
3854D	Ceiling settling crack	50	50
3857D	Ceiling damage, roof leak	175	175
3854B	Front door separating from stucco	20	20
3825A	Water leak at window	50	50
3851C	Replace weather stripping at front door	50	50
3851C	Doors separating	180	180
		Total	4,370
		Cost per unit	22

11 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Maintenance Costs

Five years is too short a period of time to determine if there is a significant difference in maintenance costs between manufactured and conventionally built units. For example, settling and shifting of the MHUs may occur at a later time. Floor problems such as warping and buckling may also take longer to become serious. Also, by the end of this study, all units had not yet been painted, either on their exterior or interior. An 8 or 10-year comparison period would show these costs.

After 5 years' occupancy, there is only a small difference in maintenance costs between the two types of units. The MHUs cost $98 more per unit for maintenance (ignoring equipment costs, such as ranges and dishwashers). An analysis shows that the maintenance costs for the MHUs were biased by the number of interior and exterior paintings. Removal of these costs reduces the maintenance difference to $27 more per year for the MHU units.

The durability of the two types of construction is similar; the costs to restore the units to "new plus 5 years wear and tear" are nearly equal.

Several design and construction deficiencies were found in the housing project at Fort Irwin:

- The "fold over" eaves method did not provide a permanent method of securing the eaves on site. This defect cost the government more than $300,000 to correct.

- The use of inadequately fixed asphalt shingles, in combination with insufficiently pitched roofs, subjected roofing materials to damage from the high winds and heat of the desert environment.

- Gutters and downspouts, routinely affixed during construction, had little utility in the arid climate, and were subject to damage from high desert winds.

Energy Costs

MHUs cost more than CBUs for energy used—$27 more per unit per year for gas and electricity.

Occupant Characteristics and Satisfaction

Overall, the satisfaction rate for the two types of housing was similar for both "condition" and "satisfaction with quarters."

Analysis of characteristics of occupants of both CBUs and MHUs showed no bias on the assignment of quarters; rank, age, and family size of occupants were virtually the same.

CBU occupants were unhappy with kitchen cabinets. Their dissatisfaction was reflected in the fair wear and tear inspections that showed a finish problem with CBU kitchen cabinets.

In both types of housing, occupants with carpeting were more satisfied with their floors.

Recommendations

It is recommended that this type of manufactured housing be considered as an alternative in future Army housing projects.

Maintenance and energy consumption data should continue to be collected—the former at least until all buildings have had exterior trim painted. Monthly meter readings are not necessary. Quarterly readings would be sufficient. The decision to extend the test should be made yearly, after analysis of the previous year's data. The test should be discontinued when the cost difference between the two types of housing exceeds $500 per unit per year.

The following design changes should be required in any manufactured buildings purchased in the future:

- The "fold over" eaves method must also provide a permanent method of securing the eaves on site.
- In a desert environment with high winds, buildings designed with a shallow roof pitch should not be constructed with asphalt shingles.
- No gutters or downspouts should be used in a desert environment, with the exception of small gutters over stairwells.
- Thermal pane windows should be used.
- Access panels should be provided for major plumbing junctures such as supply line "tees."
- Specifications for garage doors should be tightened to prevent the warping caused by substandard garage door materials experienced at Fort Irwin.
- Patio floors should be of either 6 in. or reinforced concrete. Quality assurance on patio and driveway concrete should be increased.
- Lawn sprinklers should be located so that they do not spray water on the air-conditioning condenser or the building walls.

Quality assurance inspection should be improved to prevent defects in shingle application.

APPENDIX A:

FORT IRWIN INSTALLATION HOUSING ASSESSMENT

DEPARTMENT OF THE ARMY
HEADQUARTERS, NATIONAL TRAINING CENTER AND FORT IRWIN
FORT IRWIN, CALIFORNIA 92310-5000

REPLY TO
ATTENTION OF

AFZJ-EH 23 January 1990

MEMORANDUM FOR Commander, US Army Construction Engineering Research Laboratory, ATTN: CECER-FS/Mr. Neathammer, 2902 Newmark Drive, Champaign, IL 61824-4005

SUBJECT: Evaluation of Modular vs Conventionally Built Housing

1. I am writing in response to your request for the National Training Center's subjective evaluation of the strengths and weaknesses of modular housing vs conventionally built housing based on our experience.

2. In summary, I feel that both types of housing provide adequate quarters. Residents' satisfaction was about the same in both types. In fact most residents probably did not know how the units were built and could not tell a difference from living in them. Our maintenance and minor repair experience was not materially different between the units. Certainly, one was not harder than the other to repair.

3. Major areas of concern have been with the failure of the modular contractor to properly install roof overhangs resulting in about $400,000 in critical repairs; the failure of flexible water piping compression fittings in the modular housing with a potential cost of approximately $500,000 and roof construction in both types of housing which has proved inadequate for the climate.

FOR THE COMMANDER:

JOHN E. WRIGHT
LTC, EN
Director of Engineering
and Housing

APPENDIX B:

DESCRIPTION OF THE MHU CONSTRUCTION PROCESS

The MHUs were not typical of manufactured housing in that the manufacturer was not allowed to design the housing. Instead the contractor was given designs based on the fourplexes being built using conventional construction methods and was required to manufacture accordingly. Thus, it is possible that given the opportunity to both design and manufacture, the final structure might be somewhat different and less costly.

The concept used was to manufacture complete modules in the factory which could be transported (about 200 miles from the factory in the Los Angeles area to Fort Irwin) and assembled on site. Thus, the process involved several steps: manufacture of complete modules (electrical, plumbing, HVAC, etc., included at the plant); construction of perimeter footings at the site; transportation of modules to the site; assembly of the modules into fourplexes using a crane; joining modules together including connection of piping and electrical wiring; application of stucco exterior finish; roofing at the module joints and securing of eaves; and on-site construction of the garages. On-site construction was limited by contract to foundations, utilities, slabs, garages, exterior finishes, final painting, exterior stairways and balconies. Figures B1 through B6 show factory work, modules on trucks, crane assembly and a completed fourplex without stucco and garages.

As is discussed in Chapter 10, the eaves were attached using flat metal straps and folded onto the roof for transportation (this decreased the width for highway transportation). Upon assembly at the site, the eaves were folded down and secured with only a few nails. This was a defect in the design/construction, as the eaves began to loosen and one actually fell to the ground. All eaves were then permanently secured at a cost of over $6000 per building.

The MHUs are essentially the same as the CBUs; floor plans of the two types are very similar. Figures B7 through B10 show sample floor plans for the MHUs and the CBUs.

Figure B1. Construction in the factory.

Figure B2. Two modules loaded on truck.

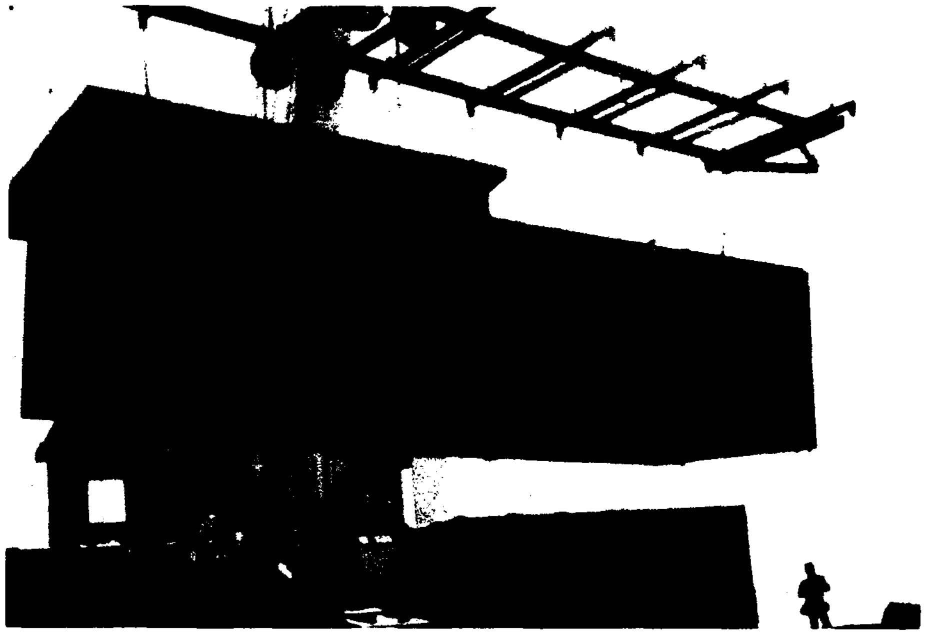

Figure B3. Module being set in place by crane.

Figure B4. Near completion of one building.

Figure B5. Completed assembly of modules.

Figure B6. Overview of buildings without garages.

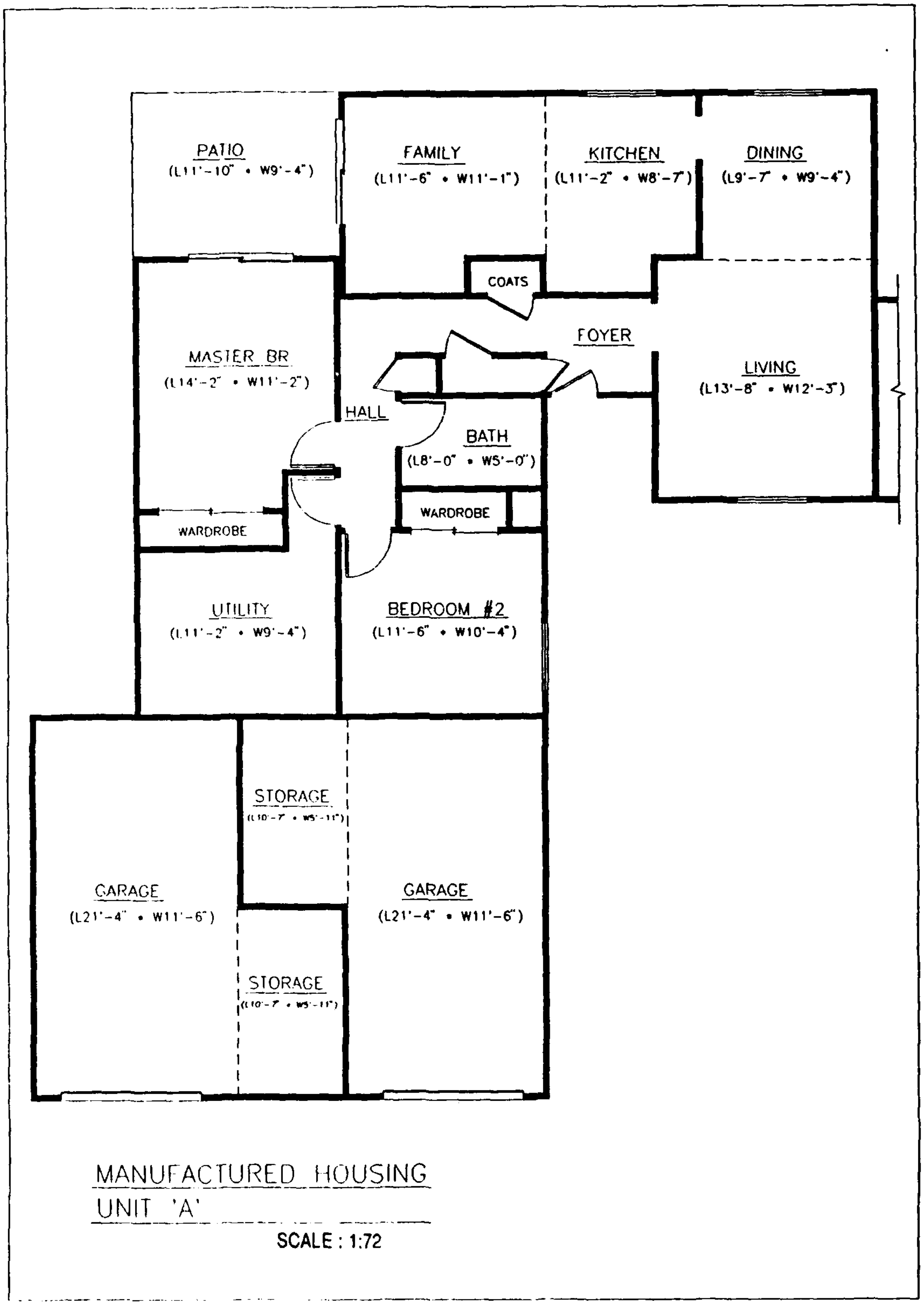

Figure B7. Floor plan for first floor MHU, Type A.

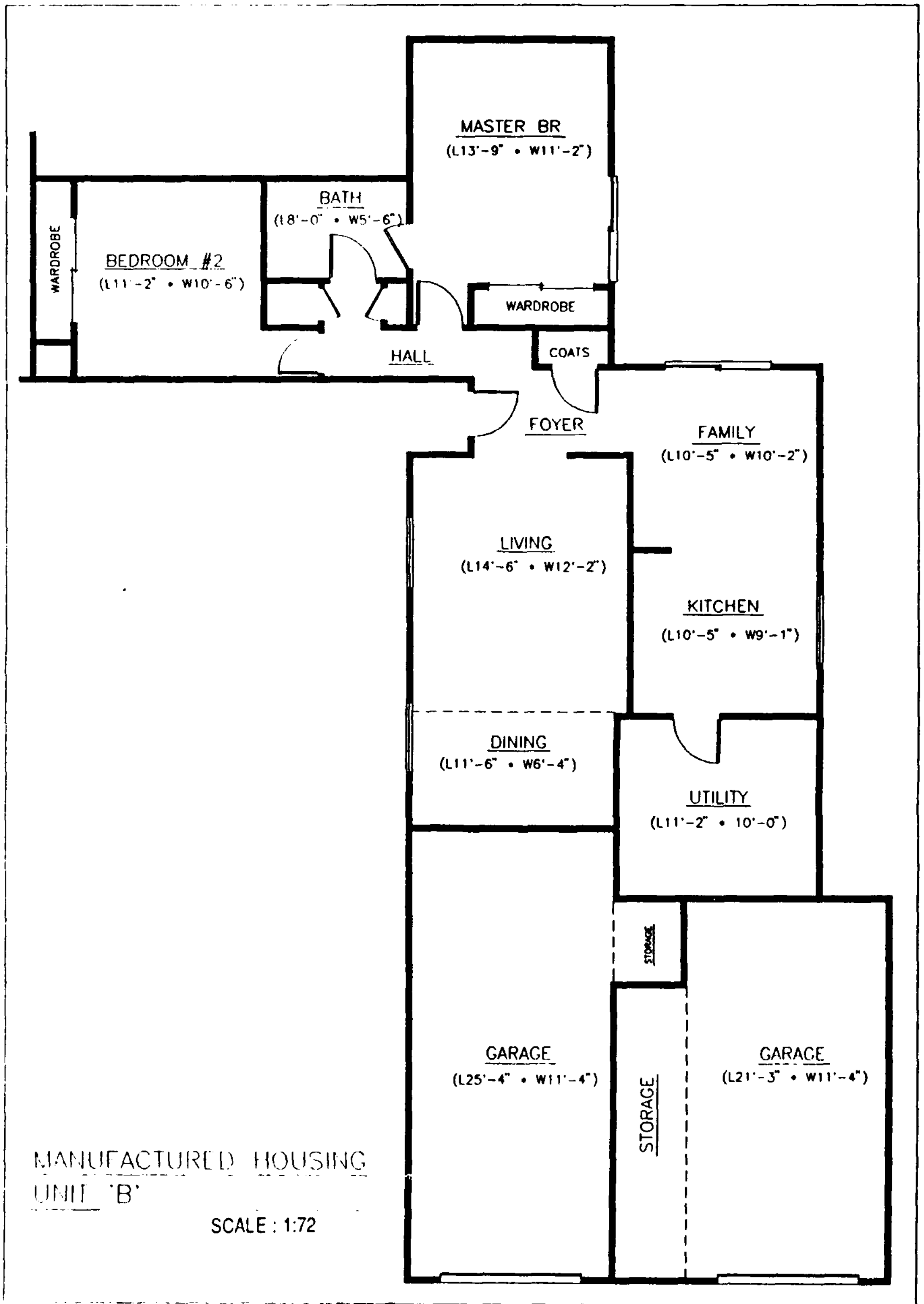

Figure B8. Floor plan for first floor MHU, Type B.

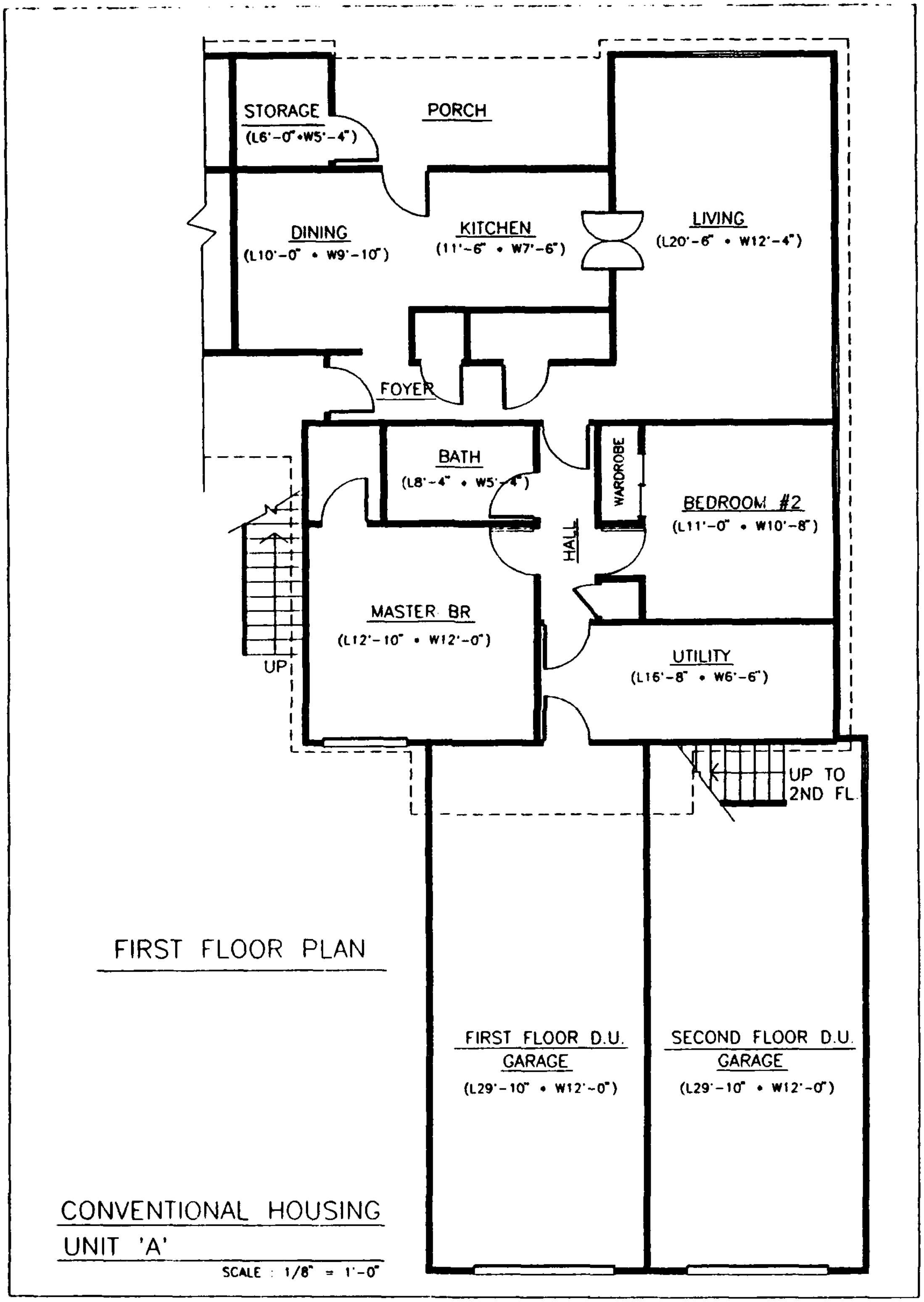

Figure B9. Floor plan for first floor CBU, Type A.

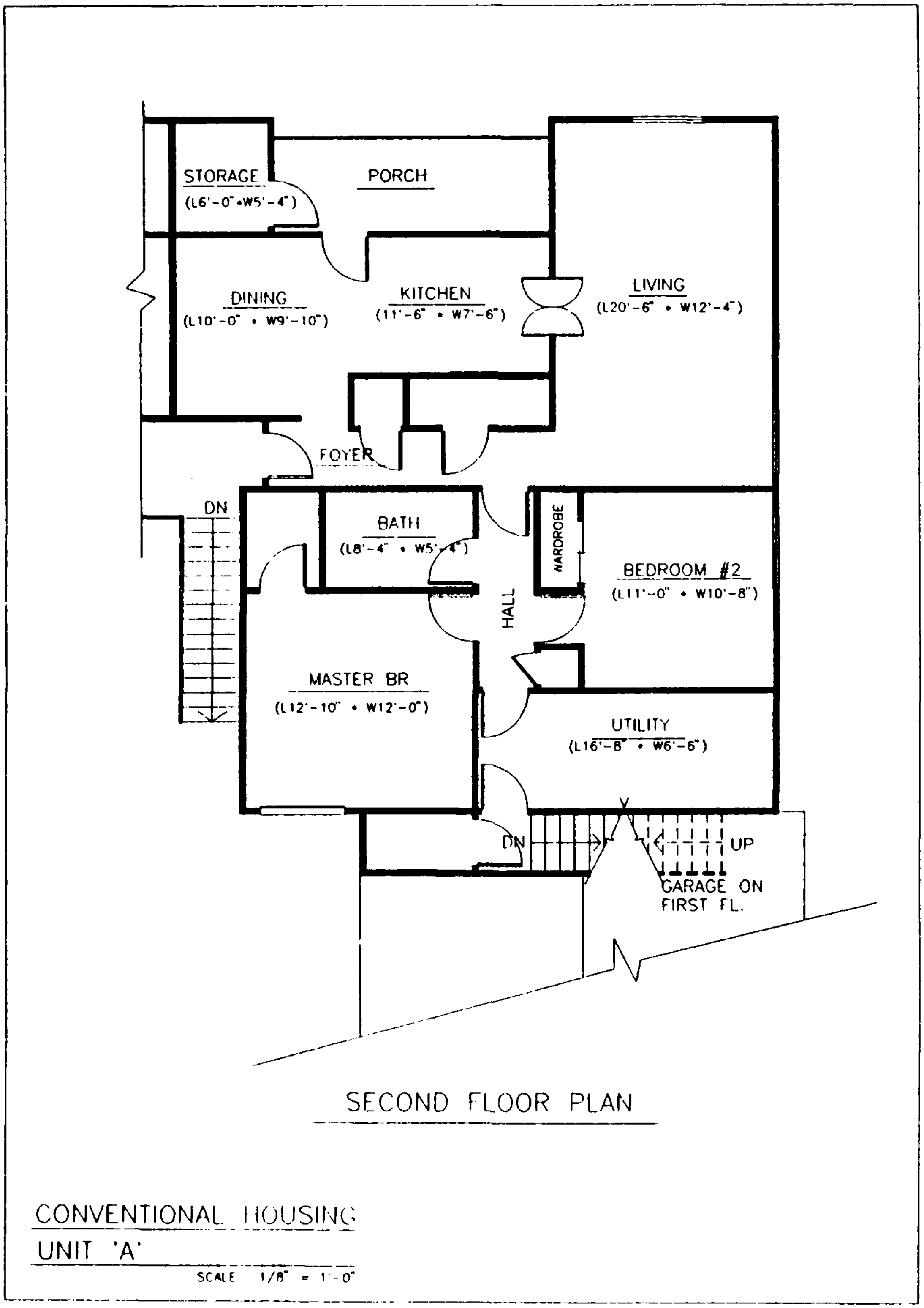

Figure B10. Floor plan for second floor CBU, Type A.

APPENDIX C:

LIST OF HOUSING UNITS

Conventionally Built

3680 A-F	3705 A-E	3727 A-E
3681 A-D	3712 A-F	3731 A-D
3684 A-D	3715 A-F	3732 A-F
3685 A-F	3720 A-F	3738 A-F
3690 A-F	3721 A-E	3742 A-D
3691 A-D	3722 A-E	3743 A-F
3693 A-F	3723 A-E	3745 A-F
3694 A-D	3724 A-D	3747 A-D
3695 A-D	3725 A-E	3750 A-F
3700 A-F		

Manufactured (Each with four apartments, A-D)

3800	3821	3841
3801	3822	3842
3802	3823	3843
3803	3824	3844
3804	3825	3845
3805	3826	3846
3806	3827	3848
3807	3828	3850
3809	3829	3851
3811	3831	3852
3812	3832	3853
3813	3833	3854
3814	3834	3855
3815	3835	3856
3816	3837	3857
3818	3839	3858
3820	3840	

APPENDIX D:

BUILDING COMPONENT/SUBCOMPONENT CODES

01 Roofing

0101	Roofing surface
0102	Fasteners
0103	Flashing, vents, protrusions
0104	Gutter and downspouts
0105	Other roof repairs

02 Structure

0201	Foundation and anchorage
0202	Structure, incl. framing and sheathing, stairs, cracked wall
0203	Insulation and moisture protection
0204	Masonry
0205	Exterior siding, incl. skirting
0206	Exterior doors and frames, incl. hardware and weatherstripping
0207	Storm and screen doors
0208	Window and frames, incl. hardware and weatherstripping
0209	Storm windows and screens
0210	Exterior trim
0211	Porch/deck construction
0212	Interior drywall, incl. fasteners and accessories
0213	Wall coverings and paneling
0214	Interior doors, frames, and hardware, incl. bifold and sliding
0215	Interior casework and finish carpentry
0216	Bathroom accessories, mirror
0217	Kitchen accessories, cabinets
0218	Drapery hardware
0219	Other exterior/interior repair, venetian blinds
0220	Garage door

03 Floor Coverings

0301	Resilient flooring
0302	Carpet and pad
0303	Ceramic flooring
0304	Underlayment/substrate
0305	Other flooring repairs

04 Interior Painting

0401	Walls and ceilings, incl. patching
0402	Trim
0403	Touch-up
0404	Bathtub/shower unit caulking
0405	Other Interior painting

05 Exterior Painting

0501	Walls, siding, incl. skirting
0502	Doors, frames, trim
0503	Exterior trim, incl. window, fascia, rake, soffit, etc.
0504	Caulking and sealing
0505	Glazing
0506	Other exterior painting

06 Heating

0601	Heating plant, valve
0602	Motors, blowers, pumps, G-60
0603	Ducts
0604	Piping
0605	Diffusers, grills
0606	Insulation
0607	Heating controls
0608	Other heating repairs, instructions for thermostat, turn on gas

07 Air Conditioning

0701	Cooling coils, compressor, condenser, valve, contactor
0702	Motors, blowers, pumps, transformer, fuses
0703	Piping, ducting
0704	Refrigerant
0705	Insulation
0706	Controls, delay module, relay
0707	Other cooling repairs, instruct thermostat use, filter

08 Plumbing

0801	Water heater
0802	Water softener
0803	Piping, supply, incl. valves, arrestors
0804	Faucets and shower heads
0805	Lavatories, incl. support and fasteners, caulking

0806 Water closets (i.e., toilets and commodes), incl. support and seals, caulking
0807 Bathtub/shower unit
0809 Other plumbing repair

09 Electrical

0901 Service entrance
0902 Panel box, incl. circuit breakers
0903 Branch circuits, incl. junctions, fasteners
0904 Wall receptacles and switches
0905 Doorbells, chimes
0906 Light fixtures
0907 Vents, fans
0908 Other electrical repair

10 Equipment

1001 Disposal
1002 Dishwasher
1003 Stove, range
1004 Range hood
1005 Refrigerator
1006 Other equipment

11 Utility Plant Equipment

Not applicable

12 Utility Service

1201 Water supply
1202 Gas supply
1203 Electrical service
1204 Sanitary/sewer
1205 Other utility service

13 Miscellaneous

APPENDIX E:

ENERGY EFFICIENCY TESTS OF 15 CONVENTIONALLY BUILT HOUSING UNITS

The objective of these tests was to provide data concerning the energy efficiency of conventionally built housing. Tests were performed to determine the airtightness of the units (a measure of the resistance to air infiltration), furnace efficiencies, and heat transfer characteristics of the building envelope.

I. Tests Performed Upon Completion of Construction

Tests were conducted over 4 days in June 1983 on three types of buildings: a fourplex, a fiveplex, and a sixplex. Weather conditions were typical of the high desert area: light to negligible winds, clear skies, low humidity, and temperatures ranging from lows near 70 °F to highs near 110 °F.

House Tightness

A blower door apparatus was used to measure each unit's tightness. The blower door consisted of a variable speed fan, a digital tachometer to measure the fan blade rotation speed, and an inclined manometer to measure pressure differences. The fan could be operated to induce a positive or negative pressure difference in the house with respect to the outdoors.

To perform this test, the fan was fitted tightly into an outside door frame. A barbed fitting which penetrates the blower door was fitted with rubber tubing and connected to one side of the manometer. The other side of the manometer was open to the house. When the fan was operated, it could either force air into the house (pressurized) or force air out of the house (depressurized) depending on the direction of rotation. In either case, the pressure difference between the house and the outdoors could be read on the manometer. The fan speed was adjusted until a specified pressure difference existed (usually 0.1 or 0.2 in. of water). The fan speed required to achieve a given pressure was correlated to air flow, which indicated how tightly the house was sealed.

Each of the units was tested at 0.1 and 0.2 in. H_2O pressurized, and 0.2 in. H_2O depressurized. Some of the more obvious leaks (furnace room doors, dryer vents, attic doors) were then taped, and the house was again tested at 0.2 in. H_2O depressurized.

As shown in Table E1, airtightness was adequate, requiring no corrective work.

Furnace Efficiency

The furnaces in all the units were propane-fired. Tests were performed with a Fuel Efficiency Monitor (FEM), a hand-held automatic flue gas analyzer which measures the flue gas temperature, oxygen content, and ambient conditions and uses this information to calculate and display the percent efficiency of the furnace.

Each housing unit was first cooled down to allow the furnace to operate. The thermostats in the houses were of the "energy-saving" type, and included night setback and temperature limits. These were disconnected before each test so that the heating and air conditioning could be manually adjusted. The safety relief on the front of each furnace was covered so that room air would not be introduced into the flue. The furnace was then turned on, and a sample was taken of the intake air using the FEM. A 1/8-in. hole was then drilled in the flue of the furnace. After allowing a few minutes for the furnace to reach steady state, the FEM probe was inserted into the flue pipe and a sample was taken of the exhaust gas. The FEM took 2 to 3 min to calculate the furnace efficiency.

Table E1 shows the furnaces' operational efficiencies.

Wall Heat Transfer Characteristics

A Thermo Flow Energy Meter (TEM) was obtained to test the heat transfer characteristics of the walls. The TEM is an infrared radiometer which displays heat flow digitally in units of Btu/hr/sq ft. It can be used to detect insulation defects and to estimate the thermal resistance of exterior walls.

Due to unfavorable weather, the TEM could not be used to calculate R-values. The device was also useful for detecting insulation voids. No insulation voids were found.

Table E1

CBU Energy Efficiency Data After Construction

Building/Unit	UA* Btu/Hr-°F	No. Air Changes** Per Hour	Furnace*** Efficiency (%)
3720A	213	11.4	52.6
3720B	181	12.1	61.3
3720C	181	13.1	62.8
3720D	213	12.8	67.2
3720E	304	12.4	71.7
3720F	304	13.2	73.0
3724A	181	11.8	61.9
3724B	181	13.3	62.6
3724C	304	13.0	71.4
3724D	304	15.1	72.3
3725A	181	11.7	61.6
3725B	181	12.8	****
3725C	213	13.9	69.3
3725D	304	13.4	72.7
3725E	304	14.8	****

*These are calculated values based on the wall construction. U = heat transfer coefficient; A = area.

**The following rating of air changes per hour at 0.2 in. water column is based on work currently being done by Mansville Corp. for the U.S. Navy; 0 to 5, objectionably tight; 5 to 10, excellent; 10 to 15, satisfactory; 15 and above merits corrective work.

***Most gas fired furnace manufacturers claim 80 percent efficiency.

****Unable to test furnace due to lack of access to the units.

II. Tests Performed after Five Years' Occupancy

The house tightness and furnace efficiency tests were performed again in May 1988. Results are summarized below in Table E2.

Table E2

CBU Energy Efficiency Data Five Years After Construction

Unit No.	No. Air Changes Per Hour	Furnace Efficiency (%)
3720A	11.0	58.5
3720B	11.4	68.6
3720C	12.9	65.8
3720D	10.2	70.6
3720E	10.6	74.2
3720F	10.8	59.5
3724A	10.6	68.9
3724B	11.6	57.8
3724C	14.4	67.4
3724D	12.3	70.4
3725A	11.3	66.0
3725B	11.8	24.1
3725C	14.4	68.8
3725D	16.2	67.3
3725E	12.4	74.5

Again, no wall insulation tests were performed because of weather conditions.

APPENDIX F:

ENERGY EFFICIENCY TESTS OF 16 MANUFACTURED HOUSING UNITS

The objective of these tests was to provide data on the energy efficiency of manufactured housing units which will be compared to existing energy efficiency data taken on conventionally built housing units. Tests were performed to determine the airtightness of the units (a measure of the resistance to air infiltration), furnace efficiencies, and heat transfer characteristics of the building envelope.

I. Tests Performed Upon Completion of Construction

Tests were conducted on three types of fourplexes; Type I (Building 3809), II (Building 3802), and IV (Buildings 3800 and 3806). The tests were conducted over 4 days in April 1984. The weather during the testing was mild for high desert area; medium to strong winds, overcast skies, low humidity, and temperatures ranging from morning lows of 40 °F to highs near 80 °F.

House Tightness

To measure the tightness of each housing unit a blower door apparatus was used, as described in Appendix E.

Each of the manufactured housing units was tested at 0.1, 0.2, and 0.3 in. of water during pressurization and then tested at 0.1 and 0.2 in. under depressurization. Then air leaks were taped (furnace doors and kitchen vents) and the unit was retested at 0.2 in. during pressurization. During the final day the winds were gusting so high that no consistent manometer reading could be taken, so Building 3809 had no data for air infiltration.

The results of the USACERL testing, as presented in Table F1, demonstrate that the airtightness of all the units except one is acceptable. Unit 3800-C had a significantly higher value than the other units and should have corrective work done to improve its tightness.

During the airtightness testing, several leaks were found. In Type II, Unit 3802-C, serious leaks were found in the door to the furnace room. In Type IV, Units 3800 and 3806, leaks were found while depressurizing around the furnace vents and doors (Unit A in both buildings). Also, leaks were found around sliding doors (Unit 3800-C), kitchen window area (Unit 3806-D), utility outlets (Unit 3800-D), and a crack in the dining room wall (Unit 3806-D).

Table F1

MHU Energy Efficiency Data After Construction

Building/Unit	UA* Btu/Hr-°F	No. Air Changes Per Hour	Furnace Efficiency (%)
3800A	296	9.9	75.5
3800B	296	11.5	81.8
3800C	363	18.4	80.5
3800D	363	11.3	82.6
3802A	271	9.0	70.1
3802B	271	10.1	75.1
3802C	370	12.1	81.8
3802D	370	11.3	80.3
3806A	296	8.0	78.2
3806B	296	9.8	77.4
3806C	363	8.7	80.7
3806D	363	10.6	82.2
3809A	249	**	80.9
3809B	249	**	82.0
3809C	336	**	80.7
3809D	336	**	79.6

*These are calculated based on the wall construction. U = heat transfer coefficient; A = area.
**Unable to test airtightness due to high winds.

Furnace Efficiency

The furnaces in all of the units were propane-fired. Tests were performed using a Fuel Efficiency Monitor (FEM), as described in Appendix E. A carbon monoxide meter similar to the FEM was used to ensure that each furnace's burner was completely combusting its fuel and that there was no unusual concentration of carbon monoxide.

The testing was performed in the early morning hours so there would be a low outdoor temperature to start the furnace. The safety relief on the front of each furnace was taped over to prevent room air from entering the flue. A 1/8-in. hole was drilled into the flue near the furnace. The furnace was turned on and a sample of the ambient air was taken. The furnace was then left to reach steady state (approximately 15 min) and then the FEM probe was inserted into the hole and a sample of the exhaust gas was taken. The FEM took approximately 2 to 3 min to calculate and display the efficiency. Three samples were taken to ensure furnace steady state. The hole in the flue was then taped closed.

The furnace efficiencies are typical for the size and type of furnace installed.

Wall Heat Transfer Characteristics

A Thermo Flow Energy Meter (TEM), as described in Appendix E, was used to test the heat transfer characteristics of the exterior walls of each unit and to detect insulation defects.

This testing was done in the early morning hours because there must be a constant temperature difference of at least 20 °F between outdoor and indoor temperatures. First the outdoor and indoor temperatures were taken until they appeared steady; next the TEM was aimed at an interior wall and the net heat flow reading was recorded. Then the TEM was aimed at an exterior wall and the heat flow through the wall was recorded. Finally the same measurement was made on the outside of the exterior wall (being sure that the area was shaded from sunlight). These results were used in conjunction with a standardized chart to determine the wall's thermal resistance. After these measurements were taken, the TEM was used to detect areas of high net flow readings, which indicate areas of insulation defects. There appear to be a number of insulation voids in Type I, II, and IV Units.

The UA values were calculated for the units, representing the overall heat transfer for the unit inclusive of walls, windows, doors, and roof (heat transferred from one unit to the next unit was considered negligible). The insulation voids listed in Table F2 were determined when the net heat flow varied by 10 Btu/hr-°F.

Table F2

Insulation Void Locations

Building/Unit	Location of Void
3802A	Void area at upper left corner of window in front bedroom.
3802C	Void area above sliding glass door in dining room.
3802D	Void area at right electrical outlet in dining room.
3806C	Void areas in all wall-to-wall seams (corners).
3806D	Void areas in all wall-to-wall seams (corners).
3809B	Void area at upper right corner of sliding glass door in dining room.

II. Tests Performed After Five Years Occupancy

The house tightness and furnace efficiency tests were performed again 5 years after construction. Results are given in Table F3.

Table F3

MHU Energy Efficiency Data 5 Years After Construction

Building/Unit	No. Air Changes Per Hour	Furnace Efficiency (%)
3800A	7.8	75.9
3800B	9.4	80.2
3800C	*	76.3
3800D	10.2	72.8
3802A	9.6	71.2
3802B	10.2	80.4
3802C	10.8	79.1
3802D	*	*
3806A	8.6	79.9
3806B	10.3	77.1
3806C	11.4	79.8
3806D	12.9	76.6
3809A	7.4	78.7
3809B	7.0	73.9
3809C	10.2	79.2
3809D	10.3	78.3

*No test performed.

APPENDIX G:

OCCUPANT SATISFACTION QUESTIONNAIRE

Quarters No: ______________
Date: ____________________

HOUSING SATISFACTION QUESTIONNAIRE FOR RESIDENTS OF NEW HOUSING

This questionnaire is designed to assist the Director of Engineering and Housing in evaluating the new housing you are occupying. Your careful completion of this questionnaire will help us to continue to improve new Army family housing. Please mail the questionnaire in the attached envelope.

1. How many total years have you lived in military family housing? _____years

2. Please identify the different types of quarters you have lived in during these years.

   _____detached dwelling unit (house)

   _____duplex (two units)

   _____multi-level, three or more families

   _____single-level, three or more families

3. How long have you occupied these new quarters?
   _____years _____months

4. List all family members (include yourself) who occupy *these quarters*, including sex and ages (do not list by name).

	Relationship	Sex	Age
a.	____________	___	___
b.	____________	___	___
c.	____________	___	___
d.	____________	___	___
e.	____________	___	___

5. How would you rate the condition of your quarters? (Circle one)

   a. Excellent
   b. Better than average
   c. Average
   d. Below average
   e. Poor

6. In general, how satisfied have you been with these quarters? (Circle one)

   a. Very satisfied
   b. Satisfied
   c. Dissatisfied
   d. Very Dissatisfied

7. For each item below, please check the appropriate answer for the questions.

	In general, are you satisfied with the item?			Is the item		
	Satisfied	Not Satisfied	No Opinion	Hard to Clean	Easy To Clean	No Opinion
a. Bathroom floor	____	____	____	____	____	____
b. Bathroom tubs and showers	____	____	____	____	____	____
c. Bathroom sink and faucets	____	____	____	____	____	____
d. Kitchen floor	____	____	____	____	____	____
e. Kitchen cabinets	____	____	____	____	____	____
f. Kitchen sink and faucets	____	____	____	____	____	____
g. Range/ oven	____	____	____	____	____	____
h. Refrigerator	____	____	____	____	____	____
i. Dishwasher	____	____	____	____	____	____
j. Living/Dining room floors	____	____	____	____	____	____
k. Bedroom floors	____	____	____	____	____	____
l. Doorknobs and locks	____	____	____	____	____	____
m. Interior walls	____	____	____	____	____	____
n. Electric outlets/ switches	____	____	____	____	____	____
o. Light fixtures	____	____	____	____	____	____
p. Windows	____	____	____	____	____	____
q. Doors	____	____	____	____	____	____
r. Garage	____	____	____	____	____	____
s. Closet/interior storage space	____	____	____	____	____	____
t. Exterior storage space	____	____	____	____	____	____
u. Kitchen and bath exhausts	____	____	____	____	____	____

Any comments on above? ____

____

8. Did any of the items listed in question 7 require repair?

_____Yes _____No

If No, skip to question 9.

If Yes, were repairs accomplished by _____Occupant _____FE/Contractor

Briefly describe occurrences (if self help, was it easy in comparison to other gov't quarters?, etc)____

____

____

9. Is there another set of quarters above you? _____Yes _____No

If No, skip to question 10.

If Yes:

has noise from it ever annoyed you and/or your family? _____Yes _____No

have odors from it ever annoyed you and/or your family? _____Yes _____No

10. Is there another set of quarters below or adjoining yours? _____Yes _____No

If No, skip to question 11.

If Yes:

has noise from it ever annoyed you and/or your family? _____Yes _____No

have odors from it ever annoyed you and/or your family? _____Yes _____No

11. Is the floor plan of your quarters satisfactory? _____Yes _____No

If No, please explain____

____

____

12. Has your air conditioning been satisfactory? _____Yes _____No

If No, please explain____

____

____

13. Has your heating been satisfactory? _____Yes _____No

If No, please explain____

____

____

14. In general, how satisfied are you with:

	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
a. The exterior of your building	____	____	____	____
b. Front/rear yards and play areas	____	____	____	____
c. The housing complex	____	____	____	____
d. Parking facilities	____	____	____	____

15. Please list three things about your apartment you like most.

____

____

____

16. Please list three things about your apartment you do not like.

____

____

____

17. Please make any general comments about your apartment.

____

____

____

THANK YOU VERY MUCH FOR YOUR COOPERATION

APPENDIX H:

INSPECTION FORMS FOR FAIR WEAR AND TEAR INSPECTIONS

EXTERIOR INSPECTION FORM FOR FORT IRWIN TEST UNITS

BUILDING NO. ______

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
1. Roof				
a. Surface	_____	_____	____________________	_______
b. Decking	_____	_____	____________________	_______
c. Supports	_____	_____	____________________	_______
d. Eaves	_____	_____	____________________	_______

Comments: ____

____

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
2. Walls				
a. Surface	_____	_____	____________________	_______
b. Sheathing	_____	_____	____________________	_______
c. Windows	_____	_____	____________________	_______
d. Joints	_____	_____	____________________	_______
e. Vents	_____	_____	____________________	_______

Comments: ____

____

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
3. Foundation				
a. Foundation	_____	_____	____________________	_______
b. Drains	_____	_____	____________________	_______
c. Vents	_____	_____	____________________	_______

Comments: ____

____

EXTERIOR INSPECTION FORM (CONT'D)

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
4. Patios/Balconies				
a. Floor	_____	_____	____________________	______
b. Supports	_____	_____	____________________	______

Comments: ____

____

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
4. Porch Entrances				
a. Floor	_____	_____	____________________	______
b. Supports	_____	_____	____________________	______

Comments: ____

____

INTERIOR INSPECTION FORM FOR FORT IRWIN TEST UNITS

UNIT NO. ______

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
1. Hallways				
a. Floors	____	____	____________________	______
b. Walls	____	____	____________________	______
c. Ceiling	____	____	____________________	______

Comments: ____

____

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
2. Living Room				
a. Floor	____	____	____________________	______
b. Walls	____	____	____________________	______
c. Ceiling	____	____	____________________	______
d. Windows	____	____	____________________	______
e. Doors	____	____	____________________	______

Comments: ____

____

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
3. Dining Area				
a. Floor	____	____	____________________	______
b. Walls	____	____	____________________	______
c. Ceiling	____	____	____________________	______
d. Windows	____	____	____________________	______
e. Doors	____	____	____________________	______

Comments: ____

____

INTERIOR INSPECTION FORM (CONT'D)

		Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
4.	Kitchens				
a.	Floor	____	____	____________	____
b.	Walls	____	____	____________	____
c.	Ceiling	____	____	____________	____
d.	Windows	____	____	____________	____
e.	Doors	____	____	____________	____
f.	Plumbing	____	____	____________	____

Comments: ____

____

		Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
5.	Master Bedroom				
a.	Floor	____	____	____________	____
b.	Walls	____	____	____________	____
c.	Ceiling	____	____	____________	____
d.	Windows	____	____	____________	____
e.	Doors	____	____	____________	____

Comments: ____

____

		Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
6.	Second Bedroom				
a.	Floor	____	____	____________	____
b.	Walls	____	____	____________	____
c.	Ceiling	____	____	____________	____
d.	Windows	____	____	____________	____
e.	Doors	____	____	____________	____

Comments: ____

____

INTERIOR INSPECTION FORM (CONT'D)

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
7. Utility Room				
a. Floor	____	____	____________	____
b. Walls	____	____	____________	____
c. Ceiling	____	____	____________	____
d. Doors	____	____	____________	____
e. Plumbing	____	____	____________	____

Comments: ____

____

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
8. Bathroom				
a. Floor	____	____	____________	____
b. Walls	____	____	____________	____
c. Ceiling	____	____	____________	____
d. Door	____	____	____________	____
e. Plumbing	____	____	____________	____

Comments: ____

____

	Abnormal Damage (Y/N)	Caused By Occ (Y/N)	Description	Repair Cost Est ($)
9. Garage				
a. Floor	____	____	____________	____
b. Walls	____	____	____________	____
c. Ceiling	____	____	____________	____
d. Doors	____	____	____________	____

Comments: ____

____

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