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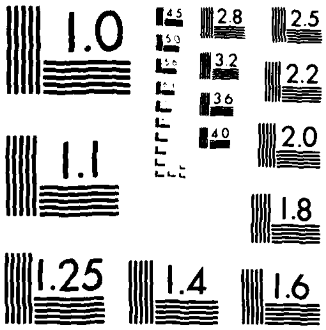

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US Army Corps of Engineers
Construction Engineering Research Laboratory

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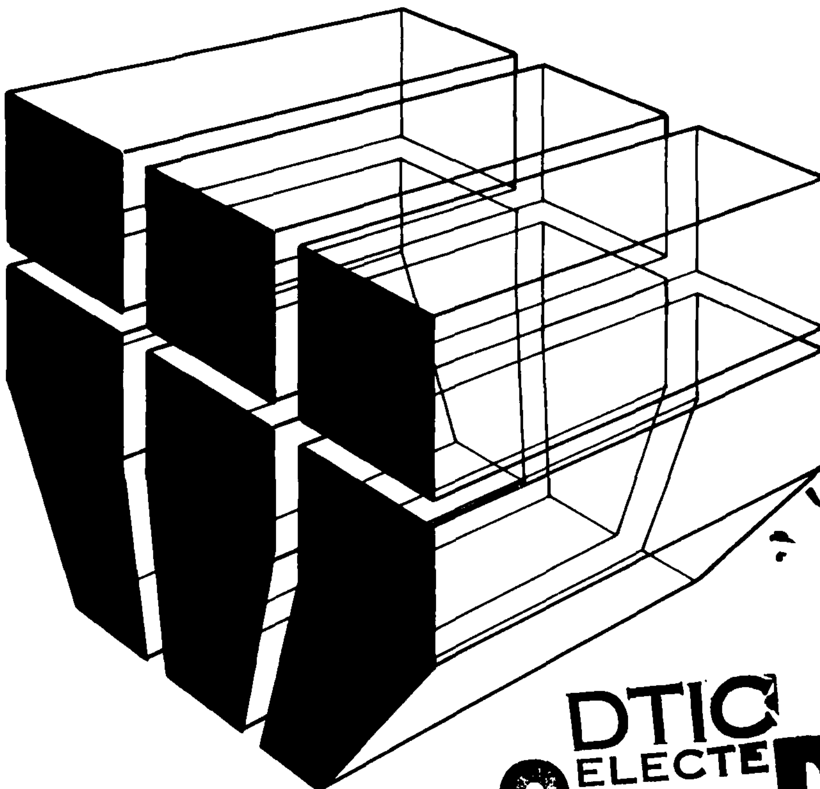
TECHNICAL REPORT E-85/03
January 1985
(Energy Conservation Design Review)

AUTOMATED BUILDING DESIGN REVIEW USING BLAST



by
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This document describes a method for using the Building Loads Analysis and System Thermodynamics (BLAST) energy simulation computer program to review the energy effectiveness of new Army facility designs. This review method covers both aspects of the Army's energy criteria: prescriptive energy standards and facility energy design budgets. The method compares the energy criteria with information contained in a BLAST output deck. This deck contains most of the information needed to review a new design for compliance with energy criteria.

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> A special BLAST Design Review Summary Report was developed which provides, in an easy-to-read, standard format, the information needed to check a design for energy criteria compliance. A description of the prototype design review procedure was published in USA-CERL TR-E-190, Use of the Building Loads Analysis and System Thermodynamics (BLAST) Computer Program To Review New Army Building Designs for Energy Efficiency. This procedure was field-tested at Missouri River Division, Omaha District, and Kansas City District. The review procedure and the Review Summary Report were modified based on the results of the field test. The modifications, which are presented in this report, further enhance the procedure's utility by providing the user with more information about the building design, making the Review Summary Report more of a stand-alone document, and providing easy instructions so that a person with little or no BLAST expertise can use the report.

This report describes how U.S. Army Corps of Engineers Districts can use the BLAST Review Summary Report to review the energy effectiveness of new facility designs submitted by architect/engineer firms who use BLAST. The pros and cons of alternative methods for doing design reviews which do not require the use of BLAST are also discussed.

This report supersedes TR-E-190.

FOREWORD

This work was performed for the Directorate of Engineering and Construction, Office of the Chief of Engineers (OCE), under Project 4A162781AT45, "Energy and Energy Conservation"; Task Area A, "New Construction Energy Design"; Work Unit 010, "Energy Conservation Design Review." Mr. J. McCarty, DAEN-ECE-E, was the OCE Technical Monitor.

The work was performed by the Energy Systems Division (ES) of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). Mr. R. G. Donaghy is Chief of USA-CERL-ES.

Appreciation is expressed to Ms. Linda Lawrie (USA-CERL) for her work in developing the BLAST modifications needed to provide the BLAST Review Summary Report, and to Dwight Beranek (Missouri River Division), Gary Harper and Harriet Jones (Kansas City District), and Phil Wagner (Omaha District) for their efforts and comments during field testing of the review procedure.

COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

AUTOMATED BUILDING DESIGN REVIEW USING BLAST

1 INTRODUCTION

Background

In response to Executive Order 20003 and a rapidly increasing utility bill, the Department of Defense has set a goal to make new military construction as energy-efficient as is economically possible.[1] The Army's minimum goal is to have post-FY85 new construction 45 percent more energy-efficient than FY75 new construction.[2] Since most of the Army's new construction is designed by private architect/engineer (A/E) firms under contract to U.S. Army Corps of Engineers Districts, the Corps must ensure that these A/Es develop new designs that meet the Army's energy efficiency goals. To do this, the Corps provides A/E prescriptive standards which a design must incorporate and facility energy design budgets with which a design must comply.

When an A/E firm designs a new facility for the Corps, the firm must review pertinent Corps documents and identify those prescriptive standards that apply to its project's facility type and location. These standards must then be included in the design. An energy analysis of the design must also be done to check it against the applicable energy budget. If the building does not meet its energy budget, it must be redesigned until it does or until the Corps grants a waiver. The responsible Corps District reviews the A/E submissions to ensure that the prescriptive standards and energy budget requirements have been satisfied.[3]

This process has two immediate problems. First, since there are no standard formats or requirements for submitting data on compliance with prescriptive standards, the District's review can be very time-consuming, since the reviewer must search out or calculate the required data. Second, since the validity of the energy analysis for budget compliance depends almost entirely on whether the input to the energy analysis method accurately describes the building's design and operation, the District must find some way to judge how accurately the A/E's building description has been input to the analysis method. Overcoming these problems requires a review method which allows District personnel to rapidly evaluate A/E design submissions for (1) overall energy effectiveness, (2) conformance to energy guidance, (3) completeness, and (4) the accuracy of the energy analysis used to establish budget compliance.[4]

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[1]Executive Order 20003. Relating to the Energy Policy and Conservation, July 20, 1977.
[2]Army Energy Plan (Department of the Army, August 1980).
[3]Interim Energy Budgets for New Facilities, Engineer Technical Letter (ETL) 1110-3-309 (Office of the Chief of Engineers [OCE], 30 August 1979).
[4]Mission Area Deficiency 102.036, "Computer-Aided Architectural Design," Section IIA (September 1981).

The easy way to standardize energy evaluation formats and to speed up the review process is to use detailed energy analysis computer programs. These programs could be designed to automatically analyze the building description input and to report the information needed to compare the building design with the Corps' prescriptive standards; the reviewer could then systematically and quickly check the design for compliance. The programs could also report on how energy-impacting design features, such as lighting or infiltration, have been input into the energy analysis program. The reviewer could then determine if the designer has submitted an accurate building description and energy analysis for certifying compliance with the energy budget.

The Corps' facility energy analysis computer program, the Building Loads Analysis and System Thermodynamics (BLAST) program--a detailed energy analysis program which can analyze the annual energy consumption of alternative building designs[5]--can provide this type of design review data. Therefore, to take advantage of the information contained in this program, the U.S. Army Construction Engineering Research Laboratory recently developed a special BLAST design review report and design review procedure based on the Corps of Engineers facility energy criteria. The procedure is an automated method, based on use of BLAST energy-use simulation computer program, which Army reviewers can use to review design submissions to ensure they meet the Corps' criteria for facility energy effectiveness. The report and procedure were published in USA-CERL Technical Report E-190.[6] This report supersedes TR E-190.

Objective

The objective of this study was to field test, evaluate, and provide final improvements to the automated review method based on user suggestions.

Approach

The review procedure and special BLAST review report were field-tested at Division and District offices.

The field test results were then used as a basis for:

1. Evaluating the ability of the special BLAST review report and the review procedure to help a reviewer ensure that a facility design complies with energy criteria and can help develop energy-efficient buildings.

[5] D. C. Hittle, The Building Loads Analysis and System Thermodynamics (BLAST) Program Version 2.0 Users Manual, Volume I, Technical Report E-153/ADA072272 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], 1979).

[6] D. J. Leverenz, D. L. Herron, J. A. Eidsmore, and R. E. O'Brien, Use of the Building Loads Analysis and System Thermodynamics (BLAST) Computer Program to Review New Army Building Designs for Energy Use, Technical Report E-190/A134487 (USA-CERL, 1983).

2. Evaluating the report's and the procedure's impacts on design review costs, time, and staffing levels.

3. Evaluating District and Division suggestions for improving the review report and procedure, and making revisions as needed.

Mode of Technology Transfer

The BLAST review report was implemented as part of the December 1982 update to the BLAST 3.0 program; the availability and recommended use of the BLAST review procedure will be announced in an Engineering Improvement Recommendation System (EIRS) Bulletin, and the user instructions will be issued as an update to the BLAST Users Manual.

2 DEVELOPMENT OF AN AUTOMATED METHOD TO REVIEW THE ENERGY EFFICIENCY OF BUILDING DESIGNS

The first step in developing the BLAST Design Review Summary Report and evaluation method was to identify Corps criteria related to energy-efficient new facilities. These criteria would then be used to decide:

1. If the data required for the building description in the BLAST input deck are detailed enough to let a reviewer evaluate a design accurately against Corps criteria.

2. What output must be included in the BLAST review report.

To do this, USA-CERL evaluated two types of Corps criteria: design energy budgets and prescriptive standards. Design energy budgets define the level of energy efficiency the Army expects of its buildings. Prescriptive standards pinpoint specific areas where designs are expected to be conservative.

Prescriptive Standards

Table 1 lists some documents which give the Army's energy prescriptive standards for new construction. In general, these standards include:

1. Building orientation: the long axis of a building usually should be oriented east-west.

2. Indoor temperatures: standards for indoor temperatures vary according to the function of the space (office, warehouse), heating or cooling season, and working or nonworking hours. As a general rule, office space should be 68°F (20°C) during working hours in the heating season and 78°F (25°C) during the cooling season.

3. Lighting: lighting standards vary according to space type and use. For office space, illumination levels should not exceed 50 footcandles at work stations, 30 footcandles in work areas, and 10 footcandles in nonworking areas.

4. Outside air: outside air quantities must conform to Table 8-5 in DOD 4270.1-M, December 15, 1983. The recommended outside air quantity for general office space is 5.0 cfm/person (9.0 m^3/h/person).

5. Ventilation: ventilation standards are given in air changes per hour for several different types of facilities. Army barracks should have 30 to 60 air changes per hour for summer ventilation.

6. Solar equipment: the standards deal with sizing energy solar systems relative to conventional energy systems.

7. U-value: the standards list minimum overall values for walls, floors, and ceiling/roof for seven different heating degree day ranges.

Table 1

Some Source Documents for Prescriptive Standards

Army Regulation (AR) 11-27, Army Energy Program (Department of the Army [DA], 20 July 1976).

AR 420-49, Heating, Energy Selection, and Fuel Storage, Distribution and Dispensing Systems (DA, 19 November 1976)

Engineer Technical Letter (ETL) 1110-3-254, Use of Electrical Power for Comfort Space Heating (Office of the Chief of Engineers [OCE], 25 August 1976).

ETL 1110-3-256, Mechanical Design Guidance (OCE, 28 September 1976)

ETL 111-3-282, Energy Conservation (OCE, 10 February 1978)

ETL 1110-3-294, Interior Design Temperatures (OC[illegible] [illegible]bruary 1978)

ETL 1110-3-302, Evaluation of Solar Energy (OC[illegible], 14 March 1979)

ETL 1110-3-309, Interim Energy Budgets for New Fa[illegible]cies (OCE, 30 August 1979)

Technical Manual (TM) 5-803-5, Installation Design Manual (DA, 1 March 1981)

TM 5-810-5, Plumbing (DA, 31 May 1972)

DOD 4270.1-M, Construction Criteria Manual (Department of Defense [DOD], 1972)

DOD 4270.1-M, Construction Criteria Manual (DOD, 1978)

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8. Windows and doors: the standards cover percent glazing, use of insulating glazing, and shading. The standard for percent glazing requires that no more than 10 percent of a north wall be glazed in regions with 4000 or more heating degree days (HDD) and no more than 15 percent of the total wall area if winter design temperatures are below 20°F (-6°C) or summer temperatures exceed 90°F (30°C).

Compliance with prescriptive standards will lead to a relatively efficient building design by ensuring that the energy impacts of individual building elements have been considered. However, compliance does not guarantee that the design is as energy-efficient as is cost-effectively possible. Also, prescriptive standards do not provide a basis for comparing the energy use of alternative designs.

Design Energy Budgets

All new designs currently must comply with the design energy budgets in ETL 1110-3-309, which specifies a maximum energy use per square foot of floor area per year. New guidance about energy use will be available in the near future. The budgets are given by building functional type and climatic region. Building functional type is based on the five-digit Military Construction, Army (MCA) category code. Twelve basic categories are used: office, hospital, prison, school, institutional, housing, storage, industrial, service, research and development, utilities, and other. Table 2 lists the seven climatic regions, based on HDD and cooling degree day (CDD) ranges:

Table 2

Energy Budget Climatic Regions

Region	HDD	CDD
1	>7000	<2000
2	5500-7000	<2000
3	4000-5500	<2000
4	2000-4000	<2000
5	0-2000	<2000
6	0-2000	>2000
7	2000-4000	>2000

The design energy budgets range from 15 kBtu/sq ft/year (47 kW-hr/m^2/year) for utilities in Region 5 to 200 kBtu/sq ft/year (16 to 631 kW/hr/m^2/year) for hospital buildings in Regions 1 and 2. Besides being a way to evaluate design options and make energy design decisions, energy budgets can be used to compare the energy efficiency of different design alternatives.

However, to be valid, the energy analysis used to get the design energy budget must adequately account for the energy-impacting features of the design. The energy features that must be included in the analysis for evaluation by the reviewer are:

1. Building envelope. The building geometry, construction, fenestrations, and materials must be adequately assessed. (Many of these considerations are also evaluated under the prescriptive standards.)

2. Internal loads. Building loads (e.g., people, lights, and equipment) can reduce the heating load and increase the cooling load. Therefore, load sizing (peak and average) and scheduling must be evaluated to ensure that the loads are reasonable for the facility design.

3. Infiltration and ventilation. Depending on the outdoor wet- and dry-bulb temperature, the introduction of outdoor air, whether by design (ventilation) or leakage (infiltration), can increase or decrease the heating and cooling loads. As with internal loads, the size and scheduling of these air changes must be evaluated to ensure that they are reasonable. Consideration must also be given to whether the building zones are occupied or unoccupied.

Section V

Section V summarizes plant data, including the size, operating hours, average operating ratio, and maximum load for each piece of equipment. Also provided are type, peak operating ratio, percent of total operating hours at peak (within 5 percent), chiller coefficient of performance (COP), and boiler efficiency. This information allows the reviewer to evaluate the effectiveness of the plant's various components.

Section VI

Section VI contains information the reviewer needs to check that scheduled loads (people, lights, equipment, etc.) were used properly in the energy analysis. For each zone, this section lists each schedule and the dates it was used. The design peak load is the load listed in the BLAST input deck. The design peak load per unit area is simply the design peak load divided by the zone floor area. This section also lists the number of hours per week a load is on and the average value for a load for the period it is on. These values are not used to check prescriptive standards, but to help check that loads and schedules are reasonable for energy-use calculations.

Section VII

Section VII covers infiltration, natural ventilation, and mechanical ventilation. Both the number of air changes per hour and the volume flow rates are given since prescriptive standards are given in both units. Maximum and minimum levels are given for times when a zone is occupied and when it is unoccupied. Peak dates and times are shown below the volume flow rate. Also shown is the energy loss due to infiltration and the infiltration loss as a percent of the load. This allows the reviewer to determine if an appropriate amount of infiltration was used in the model and, if so, whether adjusting design infiltration/ventilation would significantly impact energy consumption.

Section VIII

Section VIII lists zone temperatures so that the reviewer can see if a design meets the prescriptive standards for temperature. Temperatures are given under 12 conditions for each zone, including the maximum and minimum temperatures when the zone is occupied and unoccupied, times when heating is on and when cooling is on, and times when neither heating nor cooling is on. Asterisks mean that the condition does not exist. For example, if cooling was never on when a zone was unoccupied, the maximum and minimum temperatures under the "Cooling, Unoccupied" column would be shown as a series of asterisks. A zone is considered occupied at any time the occupancy schedule is greater than zero.

SYSTEM LOAD

NUMBER	TOTAL HEAT 1000BTU	TOTAL COOL 1000BTU	TOTAL ELECT 1000BTU	TOTAL GAS 1000BTU	TOTAL AREA FT**2	UNMET HEATING 1000BTU	UNMET COOLING 1000BTU	ENERGY BUDGET 1000BTU /FT**2
1	4.437E+0[illegible]	0.	1.500E+06	2.176E+04	8.597E+03	3.885E+03	0.	2.286E+02
TOTAL	4.437E+0[illegible]	0.	1.500E+06	2.176E+04	8.597E+03	3.885E+03	0.	

ENERGY BUDGET FOR ALL SYSTEMS=2.286E+02 1000BTU /FT**2

PLANT LOAD

NUMBER	ELECTRICITY 1000BTU	BOILER FUEL 1000BTU	GAS TURBINE FUEL 1000BTU	DIESEL FUEL 1000BTU	PURCH HOT WATER 1000BTU	PURCH CHILL WATER 1000BTU
1	1.5[illegible]E+0[illegible]	6.771E+05	0.	0.	0.	
TOTAL	1.5[illegible]E+06	6.771E+05	0.	0.	0.	

NUMBER	UNMET HEATING LOAD 1000BTU	UNMET COOLING LOAD 1000BTU	UNMET ELECTRIC LOAD 1000BTU	FLOOR AREA SERVED FT**2	ENERGY BUDGET 1000BTU /FT**2
1	1.356E+02	0.	0.	8.597E+03	2.538E+02
TOTAL	1.356E+02	0.	0.	8.597E+03	

BUILDING ENERGY BUDGET=2.538E+02 1000BTU /FT**2

Figure 1 (con't)

****
ENERGY BUDGET
****

BUILDING NAME (CATEGORY [illegible])=
LOCATION =FORT WORTH, TX TMY
PROJECT TITLE =FT HOOD DENTAL CLINIC

HEATING DEGREE DAYS=2387.1
COOLING DEGREE DAYS=2435.5
REQUIRED ENERGY BUDGET=60

ZONE LOAD

NUMBER	TOTAL HEAT 1000BTU	TOTAL COOL 1000BTU	TOTAL ELECT 1000BTU	TOTAL GAS 1000BTU	TOTAL AREA FT**2	ENERGY BUDGET 1000BTU /FT**2
100	0.	0.	0.	0.	9.384E+03	0.
1	[illegible]	6.788E+04	6.950E+04	0.	5.890E+02	2.332E+02
2	0.	5.654E+04	3.917E+04	2.176E+04	2.650E+02	4.190E+02
3	[illegible]	5.249E+04	4.591E+04	0.	1.330E+03	8.403E+01
4	[illegible]	1.376E+04	1.723E+04	0.	7.670E+02	4.853E+01
5	4.[illegible]	3.018E+04	2.911E+04	0.	6.840E+02	8.669E+01
6	7.[illegible]E+01	3.411E+04	1.980E+04	0.	7.710E+02	7.001E+01
7	[illegible].11[illegible]E+00	3.736E+04	3.396E+04	0.	9.235E+02	7.712E+01
8	0.	1.268E+05	1.429E+05	0.	3.740E+02	2.769E+02
9	7.44[illegible]E+03	7.302E+04	5.522E+04	0.	1.242E+03	1.092E+02
10	4.[illegible]E+03	3.761E+04	4.273E+04	0.	1.050E+03	1.003E+02
	---------	---------	---------	---------	---------	
TOTAL	1.81[illegible]E+04	5.577E+05	4.954E+05	2.176E+04	1.798E+04	

ENERGY BUDGET FOR ALL ZONES=6.07[illegible]E+01 1000BTU /FT**2

Figure 1 (con't)

****
TEMPERATURE
****

NUMBER	CONTROLS	HEATING OCCUPIED MAX	HEATING OCCUPIED MIN	HEATING UNOCCUPIED MAX	HEATING UNOCCUPIED MIN	COOLING OCCUPIED MAX	COOLING OCCUPIED MIN	COOLING UNOCCUPIED MAX	COOLING UNOCCUPIED MIN	NO HEATING OR COOLING OCCUPIED MAX	NO HEATING OR COOLING OCCUPIED MIN	NO HEATING OR COOLING UNOCCUPIED MAX	NO HEATING OR COOLING UNOCCUPIED MIN
0	******NO CONTROL*****	******	******	******	******	******	******	******	******	******	******	76.85	64.42
1	CLINIC CONTROLS	******	******	69.00	67.99	70.11	68.27	69.27	68.00	******	******	68.00	58.00
2	CLINIC CONTROLS	******	******	******	******	86.88	69.25	79.22	68.15	******	******	******	******
3	CLINIC CONTROLS	68.00	67.88	68.00	67.83	70.52	68.00	69.74	68.00	******	******	58.00	58.00
4	CLINIC CONTROLS	68.00	67.98	68.00	67.94	69.67	68.01	69.25	68.00	******	******	68.00	58.00
5	CLINIC CONTROLS	******	******	68.00	68.00	73.75	68.45	71.49	68.01	******	******	68.00	58.00
6	CLINIC CONTROLS	******	******	68.00	67.96	71.82	68.46	69.59	68.00	******	******	68.00	58.00
7	CLINIC CONTROLS	******	******	68.00	67.98	71.06	68.26	69.67	68.00	******	******	68.00	68.00
8	CLINIC CONTROLS	******	******	******	******	88.29	72.16	80.70	69.67	******	******	******	******
9	CLINIC CONTROLS	68.00	67.83	68.00	67.78	71.33	68.00	69.79	68.00	******	******	68.00	68.00
10	CLINIC CONTROLS	68.00	67.89	68.00	67.84	70.04	68.00	69.47	68.00	68.00	68.00	68.00	58.00

****
INFILTRATION AND VENTILATION
****

NUMBER FROM THRU	OCCUPIED MAX	OCCUPIED MIN	UNOCCUPIED MAX	UNOCCUPIED MIN	DESIGN PEAK LOAD
NO INFILTRATION:					
NO NATURAL VENTILATION:					
MECHANICAL VENTILATION: BY ... 01JAN 31DEC, CONSTANT	4114	4114	4114	4114	4114

INFILTRATION HEAT LOSS = 0 , 0 PERCENT OF THE HEATING LOAD
INFILTRATION HEAT GAIN = 0.0 , 0 PERCENT OF THE COOLING LOAD

Figure 1 (con't)

SCHEDULED LOADS

ZONE NUMBER	FROM	THRU	SCHEDULE	DESIGN PEAK LOAD		DESIGN PEAK LOAD PER FT**2	# HOURS PER WEEK	AVERAGE LOAD WHEN LOAD SCHEDULED	
PEOPLE:									
1	1JAN	31DEC	ALL ZONES PEOPLE	4.00	PEOPLE	6.791E-03	50.0	2.620E+00	PEOPLE
2	1JAN	31DEC	ALL ZONES PEOPLE	2.00	PEOPLE	7.519E-03	50.0	1.310E+00	PEOPLE
3	1JAN	31DEC	ALL ZONES PEOPLE	11.0	PEOPLE	8.271E-03	50.0	7.205E+00	PEOPLE
4	1JAN	31DEC	ALL ZONES PEOPLE	2.00	PEOPLE	2.608E-03	50.0	1.310E+00	PEOPLE
5	1JAN	31DEC	ALL ZONES PEOPLE	4.00	PEOPLE	5.848E-03	50.0	2.620E+00	PEOPLE
6	1JAN	31DEC	ALL ZONES PEOPLE	31.0	PEOPLE	4.021E-02	50.0	2.031E+01	PEOPLE
7	1JAN	31DEC	ALL ZONES PEOPLE	7.00	PEOPLE	7.580E-03	50.0	4.585E+00	PEOPLE
8	1JAN	31DEC	ALL ZONES PEOPLE	5.00	PEOPLE	5.133E-03	50.0	3.275E+00	PEOPLE
9	1JAN	31DEC	ALL ZONES PEOPLE	11.0	PEOPLE	8.857E-03	50.0	7.205E+00	PEOPLE
10	1JAN	31DEC	ALL ZONES PEOPLE	8.00	PEOPLE	7.619E-03	50.0	5.240E+00	PEOPLE
LIGHT:									
1	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	5.73	1000BTU	9.728E-03	168.	2.878E+00	1000BTU
2	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	2.18	1000BTU	8.196E-03	168.	1.095E+00	1000BTU
3	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	7.14	1000BTU	5.368E-03	168.	3.586E+00	1000BTU
4	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	3.96	1000BTU	5.163E-03	168.	1.989E+00	1000BTU
5	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	3.28	1000BTU	4.795E-03	168.	1.647E+00	1000BTU
6	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	2.73	1000BTU	3.541E-03	168.	1.371E+00	1000BTU
7	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	4.37	1000BTU	4.732E-03	168.	2.195E+00	1000BTU
8	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	3.96	1000BTU	4.066E-03	168.	1.989E+00	1000BTU
9	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	9.28	1000BTU	7.472E-03	168.	4.660E+00	1000BTU
10	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	6.41	1000BTU	6.105E-03	168.	3.219E+00	1000BTU
ELECT EQUIP:									
1	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	10.2	1000BTU	1.739E-02	168.	5.143E+00	1000BTU
2	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	6.82	1000BTU	2.564E-02	168.	3.425E+00	1000BTU
3	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	3.41	1000BTU	2.564E-03	168.	1.713E+00	1000BTU
4	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	0.	1000BTU	0.	168.	0.	1000BTU
5	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	3.41	1000BTU	4.985E-03	168.	1.713E+00	1000BTU
6	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	1.82	1000BTU	2.361E-03	168.	9.140E-01	1000BTU
7	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	3.41	1000BTU	3.692E-03	168.	1.713E+00	1000BTU
8	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	28.9	1000BTU	2.964E-02	168.	1.450E+01	1000BTU
9	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	3.41	1000BTU	2.746E-03	168.	1.713E+00	1000BTU
10	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	3.41	1000BTU	3.248E-03	168.	1.713E+00	1000BTU
GAS EQUIP:									
1	1JAN	31DEC	CLINIC LIGHTS AND EQUIPMENT	5.00	1000BTU	1.880E-02	168.	2.511E+00	1000BTU

NO OTHER EQUIP LOADS

Figure 1 (con't)

SYSTEM DATA

SYSTEM 1 MULTIZONE "MAIN FAN SYSTEM", SERVING ZONES 1,2,3,4,5,6,7,8,9,10

MIXED AIR CONTROL FIXED AMOUNT, 4114 CFM
COLD DECK CONTROL=FIXED SET POINT, 60 F

HOT DECK CONTROL=OUTSIDE AIR CONTROLLED, (120 AT 10, 80 AT 70)

SYSTEM OPERATION=ON,01JAN THRU 31DEC
HEATING COIL OPERATION=OFF,01APR THRU 30SEP
PREHEAT COIL OPERATION=ON,01JAN THRU 31DEC
HEAT RECOVERY OPERATION=OFF,01JAN THRU 31DEC
MIN VENTILATION SCHEDULE=ON,01JAN THRU 31DEC
SYSTEM ELEC DEMAND SCHED=ON,01JAN THRU 31DEC

EXHAUST FAN OPERATION=ON,01JAN THRU 31DEC
HEATING COIL OPERATION=ON,01OCT THRU 31MAR
COOLING COIL OPERATION=ON,01JAN THRU 31DEC
HUMIDIFIER OPERATION=ON,01JAN THRU 31DEC
MAX VENTILATION SCHEDULE=ON,01JAN THRU 31DEC

ZONE	SUPPLY AIR VOLUME	MINIMUM AIR FRACTION	EXHAUST AIR VOLUME	REHEAT CAPACITY	BASEBOARD HEAT CAPACITY	RECOOL CAPACITY	ZONE MULTIPLIER
1	1744	0.1	1000	0	0	0	1
2	456	0.1	0	0	0	0	1
3	2016	0.1	0	0	0	0	1
4	751	0.1	600	0	0	0	1
5	[illegible]2	0.1	0	0	0	0	1
6	833	0.1	0	0	0	0	1
7	884	0.1	0	0	0	0	1
8	823	0.1	0	0	0	0	1
9	2045	0.1	0	0	0	0	1
10	2105	0.1	0	0	0	0	1

PLANT DATA

TYPE	SIZE (KBTUH)	MAX LOAD (KBTUH)	OPER HOURS	AVERAGE OPER RATIO	PEAK OPER RATIO	PERCENT HOURS AT PEAK	CHILLER COP OR BOILER EFF
BOILER	[illegible]	[illegible]	4368	.508	1.0	10	.67

Figure 1 (con't)

****
SURFACE CONSTRUCTIONS
****

	U WITHOUT FILM COEFF (B/H*F**2*R)	
CPCEIL	.202	
FINISH FLOORING - TILE 1 / 16 IN		19.808
C11 - 8 IN HW CONCRETE		1.499
B1 - AIRSPACE RESISTANCE		1.111
B3 - 1 IN INSULATION		.301
CPFLOOR	.100	
DIRT 12 IN		.100
CPWALL	.977	
A1 - 1 IN STUCCO		4.802
C11 - 8 IN HW CONCRETE		1.499
E1 - 3 / 4 IN PLASTER OR GYP BOARD		
EWALL1	.345	
BRICK - FACE 4 IN		2.312
CONCRETE - CEMENT MORTAR 1 / 2 IN		9.976
CONCRETE - CEMENT MORTAR 1 / 2 IN		9.976
CONCRETE - CEMENT MORTAR 1 / 2 IN		9.976
CONCRETE - CEMENT MORTAR 1 / 2 IN		9.976
C3 - 4 IN HW CONCRETE BLOCK		1.411
B1 - AIRSPACE RESISTANCE		1.111
BUILDING BOARD - GYPSUM PLASTER 1 / 2 IN		2.254
SINGLE PANE TINTED WINDOW	21.186	
GLASS - GREY PLATE 1 / 4 IN		21.186
WINDOW PANEL	.160	
GLASS - HEAT ABSORBING PLATE 1 / 2 IN		10.638
INSULATION - CELLULAR GLASS 2 IN		.198
C3 - 4 IN HW CONCRETE BLOCK		1.411
BUILDING BOARD - GYPSUM PLASTER 1 / 2 IN		2.254
PWALL2	.405	
C8 - 8 IN HW CONCRETE BLOCK		.900
B1 - AIRSPACE RESISTANCE		1.111
BUILDING BOARD - GYPSUM PLASTER 1 / 2 IN		2.254
PWALL1	.555	
BUILDING BOARD - GYPSUM PLASTER 1 / 2 IN		2.254
B1 - AIRSPACE RESISTANCE		1.111
BUILDING BOARD - GYPSUM PLASTER 1 / 2 IN		2.254
ROOF1	.076	
E2 - 1 / 2 IN SLAG OR STONE		19.904
E3 - 3 / 8 IN FELT AND MEMBRANE		3.514
A3 - STEEL SIDING		5200.000
E4 - CEILING AIRSPACE		1.000
B6 - 2 IN INSULATION		.100
E5 - ACOUSTIC TILE		.560
FLOOR1	.202	
B3 - 1 IN INSULATION		.301
B1 - AIRSPACE RESISTANCE		1.111
C11 - 8 IN HW CONCRETE		1.499
FINISH FLOORING - TILE 1 / 16 IN		19.808

Figure 1 (con't)

BUILDING ENVELOPE DATA

NOTE-SURFACES IN ZONES DESIGNATED AS ATTIC OR CRAWLSPACE ARE NOT INCLUDED

*NORTH= 0. EAST= 90.0

	AREA (FT**2)	U (B/H*F**2*R)	AZIMUTH* (DEGREES)	TILT (DEGREES)	PER CENT GLAZING
ROOF	8596.50	.072	*****	0.0	0.0
ROOF1	8596.50	.072	*****	0.0	
EXTERIOR WALL	405.90	.369	0.0	90.0	14.0
EWALL1	295.11	.267	0.0	90.0	
SINGLE PANE TINTED WINDOW	56.61	1.115	0.0	90.0	
WINDOW PANEL	53.28	.141	0.0	90.0	
EXTERIOR WALL	864.00	.432	180.0	90.0	21.3
EWALL1	573.02	.267	180.0	90.0	
SINGLE PANE TINTED WINDOW	184.42	1.115	180.0	90.0	
WINDOW PANEL	106.56	.141	180.0	90.0	
EXTERIOR WALL	922.50	.375	270.0	90.0	14.0
EWALL1	713.17	.267	270.0	90.0	
SINGLE PANE TINTED WINDOW	129.42	1.115	270.0	90.0	
WINDOW PANEL	79.92	.141	270.0	90.0	
EXTERIOR WALL	751.50	.399	90.0	90.0	17.2
EWALL1	542.17	.267	90.0	90.0	
SINGLE PANE TINTED WINDOW	129.42	1.115	90.0	90.0	
WINDOW PANEL	79.92	.141	90.0	90.0	
FLOOR OVER CRAWL SPACE	8596.50	.159	*****	180.0	0.0
FLOOR1	8596.50	.159	*****	180.0	
	------	-----			-----
	20136.00	.402 (OVERALL WALL AVERAGE)			17.0 PERCENT OF TOTAL WALL AREA
		.156 (BUILDING OVERALL AVERAGE)			5.8 PERCENT OF TOTAL FLOOR AREA

FLOOR AREA OF BUILDING	=	8596.50	FT**2
APPROX EXTERIOR SURFACE AREA	=	20136.00	FT**2
APPROXIMATE VOLUME	=	77367.49	FT**3
APPROX EXTERIOR SURFACE AREA/VOLUME	=	.260	

Figure 1 (con't)

*** PLAN VIEW OF BUILDING SURFACES ***

MIN X = [illegible] FT
MAX X = [illegible] FT
MIN Y = [illegible] FT
MAX Y = [illegible] FT
[illegible] = [illegible]

* = BUILDING SURFACE, + = SHADOWING SURFACE

```
   Y+            N
   1             1
-X--+--+X     W--+--E
   1             1
  -Y             S
```

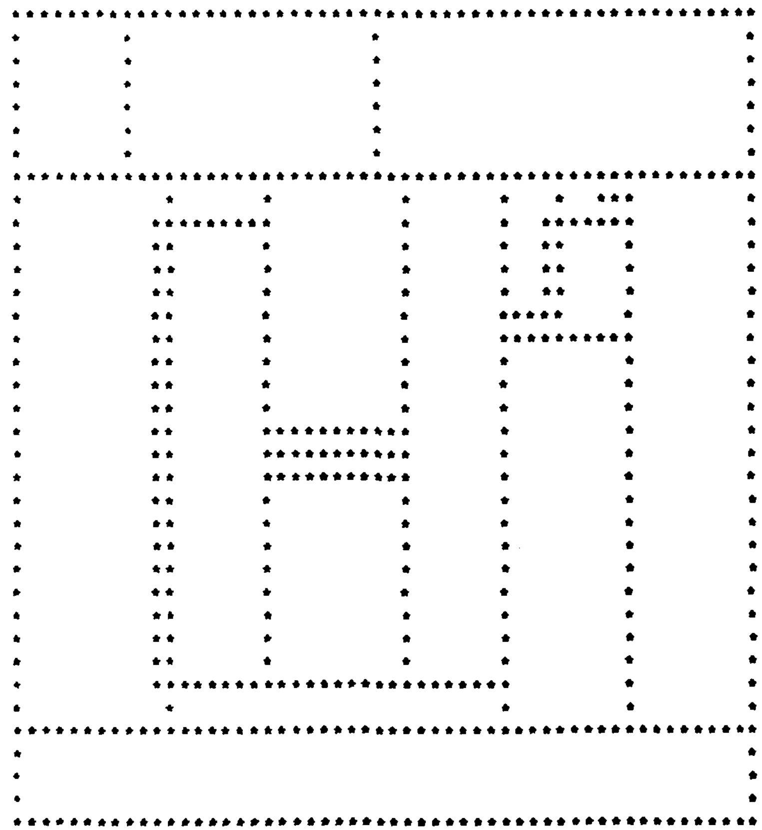

Figure 1 (Cont'd)

```
*****************************************************************
**                                                             **
**          R E V I E W   S U M M A R Y   R E P O R T          **
**                                                             **
*****************************************************************
1 BUILDING                                         SIMULATION PERIOD =  1 JAN 1979 - 31 DEC 1979
1 SYSTEM                                           LOCATION = FORT WORTH, TX      TMY
1 PLANT                                            HEATING DEGREE DAYS = 2387.1
                                                   COOLING DEGREE DAYS = 2435.5
PROJECT = FT HOOD DENTAL CLINIC                    GROUND TEMPS = 61,62,65,68,71,75,75,71,68,65,62


FOR ZONE  1000 FLOOR AREA        9384.00 FT**2      CEILING HEIGHT       2.5 FT
      APPROXIMATED VOLUME        23451. FT**3

FOR ZONE     1 FLOOR AREA         589.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME         5301. FT**3

FOR ZONE     2 FLOOR AREA         266.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME         2394. FT**3

FOR ZONE     3 FLOOR AREA        1330.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME        11970. FT**3

FOR ZONE     4 FLOOR AREA         767.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME         6903. FT**3

FOR ZONE     5 FLOOR AREA         684.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME         6156. FT**3

FOR ZONE     6 FLOOR AREA         771.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME         6939. FT**3

FOR ZONE     7 FLOOR AREA         923.50 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME         8311. FT**3

FOR ZONE     8 FLOOR AREA         974.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME         8766. FT**3

FOR ZONE     9 FLOOR AREA        1242.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME        11178. FT**3

FOR ZONE    10 FLOOR AREA        1050.00 FT**2      CEILING HEIGHT       9.0 FT
      APPROXIMATED VOLUME         9450. FT**3
```

Figure 1. Sample Review Summary Report.

4 OVERVIEW OF THE BLAST REVIEW SUMMARY REPORT

BLAST Review Summary Report

The Review Summary Report is broken into nine sections. Section I covers general project data and is used to verify the overall project description, location, floor plan, and dimension. Sections II through VI cover the building envelope, system data, plant data internal loads, infiltration/ventilation, and temperatures. Section IX covers the energy budget data. Figure 1 is a sample Review Summary Report for a 9400 sq ft (865 m^2) dental clinic. Each section of the report is described in more detail below.

Section I

Section I lists general project data, including project name, location, simulation dates, heating and cooling degree days, ground temperatures, and the weather tape used to perform the annual energy analysis. These data are used to verify that the correct project information has been input to the program. The plan view and zone volumes are provided so that the reviewer can check the building's basic configuration and orientation.

Section II

Section II lists information about the building envelope. A reviewer can use this information to check whether a design complies with prescriptive standards. The design's U-values and percent glazing for surfaces in each direction are given. The areas for exterior surfaces are given so the reviewer can verify that the correct facility dimensions were input.

Section III

Section III describes the wall, roof, and floor sections used in the BLAST model. It lists each component of the surface from the outside to the inside. The thermal characteristics of the specified materials can be found in the BLAST library. This information should be used to verify that the correct materials were used in the model.

Section IV

Section IV lists basic operating information for each system. For each fan system modeled, the following information is provided: type, zones served, design volume flow rate, and applicable equipment schedules. This information helps the reviewer determine whether the system is operating as expected.

Although knowledge of BLAST is always helpful in interpreting a BLAST analysis, the reviewers felt that "...the review report enhances the capability of interpreting and reviewing the report. This fact signals the report has broad application regardless of the reviewer's BLAST expertise."[7] More examples have been added to the instructions to make reviews even easier for persons with little or no BLAST expertise.

The next chapters describe review using the BLAST Review Summary Report; the improvements suggested in the field test have been added to the procedure described in USA-CERL TR-E-190.

[7] Dwight Beranek, letter to USA-CERL, subject: "Field Test - BLAST Review Report" (24 April 1984).

3 FIELD TEST OF THE BLAST REVIEW SUMMARY REPORT

The desi~n review procedure was field-tested to allow primary users (Division and District designers and reviewers) to evaluate the energy review procedure in order to ensure that it is complete and useful to their work. The objective of the field test was to assess how well the Review Summary Report reduced review time and increased the quality of the review, and to identify any needed changes that would make the report more complete, understandable, and useful to the users.

In the field test, the District designers used the Review Summary Report to help them improve the energy effectiveness of a design and to help evaluate compliance with prescriptive standards and energy budgets. The District then sent the design, along with the Review Summary Report, to the Division for review. The designers and reviewers were asked to comment on the time and effort saved or lost by using the Review Summary Report and whether the quality of their work was improved through its use. They were asked to recommend changes to improve its applicability to their work.

The field test was conducted at the Kansas City and Omaha Districts and the Missouri River Division. The projects used were a Child Care Center at Fort Carson, CO, and a Battalion Headquarters Building at Fort Riley, KS.

The Review Summary Report was considered to be a very successful tool. It was useful to designers because it allowed them to more readily debug the BLAST runs and verify compliance with prescriptive standards prior to submittal for review. Designers reported a decrease in the time required to complete energy analysis, but were not able to quantify the decrease. The Review Summary Report is useful to designers because it makes it faster and easier to verify that the BLAST model is correct and the prescriptive standards met. Review time was reduced to approximately one tenth of what it would have been without the report. Scheduling errors in a model that would not otherwise have been detected were easily found using the Review Report. Incorrect modeling of infiltration was detected and corrected. Not only were more errors detected and corrected in each design, but more reviews were conducted.

The Division and both Districts currently use the report routinely when using BLAST for energy analysis. However, there were many suggestions to make the report even more useful for routine work. Most improvements involved providing more information about the design and making the Review Summary Report more of a stand-alone report. The major comments included:

1. The reviewer should be able to do a comprehensive review without having to read any other portion of the BLAST output unless a serious problem arises which requires more detailed evaluation of the analysis; hence, the SURFACE CONSTRUCTIONS, SYSTEM DATA, and PLANT DATA sections were added.

2. Mechanical ventilation should be added to the INFILTRATION AND VENTILATION section.

3. The calculation of energy budgets was changed to <u>not</u> include unmet loads.

The specification of actual ventilation rates is part of the prescriptive standard.

4. Mechanical system and control. The reviewer must ensure that the mechanical system and control (thermostat) schedule used in the energy analysis simulation meet the facility's comfort criteria. Besides reviewing the selection of the mechanical system and its configuration, the reviewer must check that the system is sized properly and that the schedules are set so that the occupied and unoccupied maximum and minimum temperatures for all heated and cooled spaces are adequate.

Following identification of Army energy standards, the building description in a BLAST input deck was analyzed to determine if it contained enough information to evaluate the facility against the Army's prescriptive standards. The minimum BLAST run inputs (e.g., people, lights, equipment, infiltration, ventilation) needed to certify that the design would comply with energy budgets were then established. The BLAST program was modified to produce a special report providing all necessary data for:

Comparing a facility design with the Army's prescriptive energy standards.

Checking that the BLAST input used to judge the design's energy budget compliance was appropriate and accurate.

Checking that a facility design complied with the design energy budget at the envelope, system, and plant levels.

Finally, an energy review procedure based on this special BLAST review report was developed that the design review team could use to review designs for compliance with Corps energy criteria.

Section IX

Section IX lists the energy budget data, including the category code, location, HDD, CDD, and the required energy budget. This section has three parts: ZONE LOADS, SYSTEM LOADS, and PLANT LOADS. An energy budget is given at each level so that the reviewer can evaluate not only the overall energy efficiency, but also individual zone, system, and plant efficiency. In the zone and system load sections, total heating, cooling, electric, and gas loads are listed to show how a load is distributed. The energy budget in the zone load section is the zone load per square foot over the simulation period; it does not include the system and plant loads. The budget is reported for each zone and as a total for all the zones. The energy budget in the system section is the system load per square foot over the simulation period; it includes zone and system loads. The plant load section lists the electricity, boiler fuel, gas turbine fuel, diesel fuel, purchased hot water, and purchased chilled water. Although unmet plant loads are listed for each plant, unmet system loads are not considered, and therefore, are not included in the calculations. When a plant is modeled, the percent difference between the required energy budget and the calculated plant energy is reported.

Summary

All loads must be met if the design Review Summary Report is to give a correct energy budget. If there are significant unmet loads, the budget is only an approximation and should not be used to validate compliance with design energy budgets. If there are no unmet loads, the overall energy budget on the plant report is the value the reviewer should use to compare a design's performance with the design energy budget.

5 USING THE BLAST REVIEW SUMMARY REPORT

Just as the design of an energy-efficient building is not simple, neither is the energy design review. Even if prescriptive standards and energy budgets are satisfied, the building design still may not be as energy-efficient as is cost-effectively possible. Also, energy budgets may sometimes be too restrictive; in such cases, a waiver should be sought. The BLAST Review Summary Report was developed not to provide a final answer, but to give the reviewer most of the information needed to make reasonable judgments about a building design's overall energy efficiency. It is intended to augment the reviewer's (or designer's) existing engineering knowledge and experience by listing important design data in a systematic format.

Beginning a Design Review

If the Review Summary Report is to be used for review, a BLAST energy analysis must be performed. The following BLAST reports should be specified: ZONE LOADS, ZONES, SYSTEM LOADS, and COIL LOADS. The Review Summary Report will be produced automatically for all annual simulations.

Analyzing the BLAST Review Summary Report

Section I--General Building Data

Section I of the design Review Summary Report gives general data about the project, location, simulation period, and facility plan, including:

1. Project name: as specified by the designer. This is used to check that the correct BLAST analvsis has been submitted.

2. Simulation period: the duration of the energy analysis simulation, and is used to check that a 1-year simulation was run and that the appropriate year, corresponding to the selected weather type, was specified.

3. Location: the location used in the simulation (as specified on the BLAST weather file), and usually the year of the weather tape.

4. Heating/cooling degree days: the number of heating and cooling degree days, calculated from the specified weather tape. These data are used to see if the selected weather tape is appropriate (if the tape is not for the exact project location) and to pick the energy budget region (Table 2).

5. Building, systems, plant: the number and types of buildings, HVAC systems, and heating and cooling plants into which the project has been divided.

6. Ground temperatures: the monthly ground temperatures under the building. Note that these should be higher than undisturbed ground temperatures due to the cumulative effect of heat transfer from the building to the ground. A reasonable approximation for the temperature of the ground beneath

the building is the average of the undisturbed ground temperature and the building temperature.

7. Zone floor areas, ceiling heights, and approximate volumes: these data, along with the plan view, allow the reviewer to verify the building configuration against the plans.

8. Plan view: a plan view of the facility's thermal zones, plus a compass point showing the building's orientation. The SOLAR DISTRIBUTION is given to indicate the level of detail of shading calculations. If SOLAR DISTRIBUTION = -1, the plan view may not represent the actual building shape. The plan's maximum X and Y dimensions are given to provide a scale for the drawing. The reviewer should check the plan against the design to see that the scale and orientation are accurate and that the building has been appropriately zoned for the thermal analysis. Note that the building surfaces are designated differently from shadowing surfaces in the plan view.

Section II--Building Envelope Data

Section II contains information about the building envelope, including:

1. Building exterior surface descriptions: a summary of the building exterior surfaces, grouped by surface category (roofs, slabs-on-grade floors, exterior walls, basement walls, floor). Walls are subdivided by construction type, orientation, and tilt. Roofs and floors are subdivided by construction type, orientation, and tilt unless they are flat, in which case they are subdivided only by construction type. For each exterior surface listed, the construction type is given by its BLAST library name, and each surface subfeature (window, door, etc.) is specified. The subfeatures are grouped by construction type. This list should be checked to ensure that the surfaces, construction type, and subfeatures have been specified properly. If the reviewer is unfamiliar with the construction type specified, Section III of the Review Summary Report will give the construction materials making up these surfaces.

2. Area: this column lists both the total area of each surface and the area of each subfeature making up that surface. The total surface area of the building is also given. Since this is a composite area, all north-facing exterior walls of one construction type are combined, even if the actual building may have two, three, four or more actual walls. For this composite wall, all subfeatures on all the walls that make it up are also combined. For example, if the building has four brick walls facing north and three of these walls have a wood door, the Review Summary Report will show only one north-facing brick wall with one wood door, but with an area equal to the total of the original four walls and three doors. The reviewer should check that the total surface area and all construction features are accounted for. Even if the plan view is correct, an incorrect designation of interior vs. exterior surfaces, incorrect wall heights, or improper wall and door specifications can give incorrect surface areas.

3. U-Value: the U-value for each wall subfeature plus the area-weighted U-value of each exterior surface of the same construction type, facing direction, and tilt. The area-weighted U-value of all the walls and the area-weighted U-value of the entire envelope are also given. The U-value of each subfeature is given so that the reviewer can determine which features cause

the greatest energy loss. The U-values are used to check the appropriate prescriptive standards.

4. Azimuth: the facing direction of the walls where 0 is north, 90 east, 180 south, and 270 west. Roofs and floors which are flat do not face in any particular angular direction, so azimuth is not reported for those surfaces. The azimuth is used to check window direction.

5. Tilt: the angle between the outward-pointing normal of the surface and a vertical axis. The default is 0 for roofs, 90 for walls, and 180 for floors. Tilts other than the defaults should be checked against the drawings to verify that the surfaces are in fact tilted as listed.

6. Percent glazing: the percent of each surface that is glazed. These numbers should be checked against prescriptive standards for glazing. There may be more than one type of exterior surface facing a given direction (azimuth) due to the specification of different construction types or tilts. If this is the case, the total percent glazing in that direction is calculated by multiplying the area of each type surface by its percent glazing, summing the results for the surfaces facing one area, and dividing the glaze area by the total area facing that direction. At the bottom of the column is the total amount of glazing divided by the total wall area times 100 (percent of total wall area), and the total amount of glazing divided by the total floor area times 100 (percent of total floor area). These numbers should be checked against prescriptive standards.

7. Floor area: the floor area of the building should be checked against the specifications to make sure that the area is appropriate to the design. Incorrect building geometry input can show up here as too large or too small a floor area.

8. Approximate exterior surface area: the exterior surfaces, as given in the building exterior surface description, are summed to provide the total area exposed to the environment. Because ATTICS and CRAWLSPACES are not included in the building exterior surface description, FLOOR OVER CRAWLSPACE and CEILING UNDER ATTIC are considered exterior surfaces. This value is another quick check of the building description and, in particular, of the building's heat transfer surfaces.

9. Approximate volume: the sum of the appropriate zone volumes given in the zone descriptions. Volume divided by floor area gives an estimate of the building's wall heights.

Section III--Surface Constructions

Section III lists the components of all the wall, roof, and floor sections used, which allows the reviewer to verify the materials used to model them. Each block contains the surface name as it appears in the Building Envelope Data section followed by the materials which make up the surface, listed from outside to inside. The overall U-value for the surface, not including film coefficients, is shown next to the surface name. The U-value for each component is shown next to the component name. This information should be used to confirm the appropriateness of the wall, roof, and floor models, particularly in cases when the designer does not use standard BLAST library surfaces.

Section IV--System Data

Section IV lists the operation information about each fan system. One block describes one system. Each block contains:

1. System Number: the user-specified system number.

2. System Name: the user-specified system name.

3. System Type: the BLAST name which identifies the system type, such as multizone or dual-duct variable volume.

Only those of the following equipment schedules which apply to the system type will show in the Review Summary Report. For example, FANCOIL HEATING OPERATION will show only when a fancoil unit is modeled. The only exception to this is when the user specifies in the input a schedule that does not apply to the given system type. In this case, the inapplicable schedule will be reported in the Review Summary Report and denoted by asterisks. This error does not affect the calculations, but may indicate the user's lack of understanding of the system model.

4. System Operation: more than one may be specified. This describes the operation of all the fans and coils in the system. Any time the system is OFF, all the components only operate when there is a load. When SYSTEM OPERATION=ON the components are either all operating constantly by default, or are operating on the user-specified schedule. One way to reduce energy consumption is to set the system operation to OFF so that the system runs only when there is a load. However, this will stop all mechanical recirculation of air and intake of fresh air. If continuous ventilation is desired, the system operation should be ON. A common operating schedule is ON during working hours to provide ventilation and OFF during nonworking hours to provide circulation only to meet the loads. The reviewer must decide if the system operation described adequately models the building's anticipated operation.

5. Exhaust Fan Operation: the schedule on which the exhaust fan operates. If the EXHAUST AIR VOLUME (see p 30) is zero, no air will be exhausted even if the schedule shows the exhaust fan to be ON. Also, if the system operation is OFF, the exhaust fan will not operate.

6. Preheat Coil/Heating Coil/Cooling Coil/Reheat Coil/Recool Coil/Fancoil Heating/Fancoil Cooling/Tstat Baseboard Heat Operation: the schedule on which the respective coils operate. In general, operating a heating coil and a cooling coil at the same time seasonally is inefficient. Sometimes it is necessary to have both heating and cooling available in order to maintain reasonable indoor comfort, particularly in the spring and fall. Nevertheless, many Army installations simultaneously shut off heating coils and turn on the cooling coils and vice versa. The designer and the reviewer should agree on the appropriate coil shutoff dates.

7. Humidifier Operation: the schedule on which the humidifier operates.

8. Heat Recovery Operation: the schedule on which the heat recovery operates. Note that if the system is OFF, no heat will be recovered since no air is circulating (unless there is a load).

9. Minimum Ventilation Schedule: the schedule which restricts the minimum amount of outside air introduced into the system.

10. Maximum Ventilation Schedule: the schedule which restricts the maximum amount of outside air introduced into the system.

11. System Electrical Demand Schedule: the schedule for any other system electrical loads, such as fans, not otherwise accounted for.

The following sub-blocks show zone-specific parameters for the system. One block describes one zone and contains those of the following parameters which are applicable.

1. Supply Air Volume: the design maximum volume flow rate delivered to the zone.

2. Minimum Air Fraction: the smallest percentage of the Supply Air Volume allowed. Applicable to variable volume systems.

3. Exhaust Air Volume: the exhaust air volume flow rate. The Exhaust Fan Operation must be on when the air is to be exhausted; i.e., both amount and schedule must be specified for exhaust air fans to operate.

4. Reheat/Recool/Baseboard Heat Capacity: the capacity of the respective coils. Note that the corresponding operation schedule must be ON for the coil heating/cooling to be available.

5. Reheat/Baseboard Heat Energy Supply: the heat supply source. The available sources are hot water, steam, electricity, or gas.

Section V--Plant Data

Section V describes the equipment used to model the plant and reports operating characteristics of each piece of equipment. Each line describes one component and includes:

1. Type: the BLAST name that describes the type of component, such as boiler, chiller, gas turbine, or heat pump.

2. Size: the nominal capacity of the equipment.

3. Operating Hours: the number of hours the equipment operated during the time span of the model.

4. Max Load: the maximum load on the equipment during the time period specified. If this is the same as the size, it is possible that the equipment is too small to meet the load. Unmet plant loads should be investigated if this does occur.

5. Average Oper Ratio: the average over the specified time period of the part-load ratio while the equipment was operating. A low average operating ratio indicates that smaller equipment might be used (if the maximum load is significantly less than the nominal size) or that multiple pieces of smaller equipment (with a total capacity equal to that of the larger equipment) might provide more efficient heating or cooling.

6. Peak Oper Ratio: the highest part-load ratio achieved by the equipment. A low peak operating ratio suggests oversized equipment. Most equipment runs much more efficiently near full load than at low part load.

7. Percent Hours at Peak: the percent of the total operating hours the equipment was operating within 5 percent of the peak operating ratio.

8. Chiller COP/Boiler Efficiency: the COP or efficiency as appropriate to the equipment. Used to evaluate the overall effectiveness of the equipment.

Section VI--Scheduled Loads

Section VI has subsections for scheduled loads caused by people, lights, and electric, gas, and other equipment. Each type of load is subdivided by zone and schedule. Each line includes:

1. Zone number: one zone number entry for each schedule is specified for that zone.

2. "From - Thru": the effective date for the following schedule. Within each zone, the combined schedules for each type of load should cover the entire year. The cases where this is not true are unusual and should be verified.

3. Schedule: the name for each schedule. These schedules come from the BLAST library or are defined in the BLAST input deck. Whether a library schedule or a schedule specified in the BLAST input deck is used, a description of the schedule is given in the zone description of the normal BLAST output. The reviewer should check the schedules to see if they are appropriate for the zone and type of load being scheduled.

4. Design Peak Load: the design load specified in the BLAST input deck. The actual zone load is calculated hourly based on this design peak load and the specified schedule.

5. Design Peak Load Per Sq Ft: the design peak load density is provided so the reviewer can check whether the size of the design peak load is appropriate for the size of the space. Some typical load densities can be found in the ASHRAE Handbooks.[8] The reviewer should be familiar with typical values (such as 0.01 people per square foot for general office space) so the validity of the design peak load can be checked quickly.

[8] ASHRAE Handbook 1982 Applications (ASHRAE, 1982).

6. Number of Hours Per Week: the number of hours each week when the load is scheduled to be more than 0. The reviewer can use this value to judge whether the schedule is appropriate and accurate. For example, if people in an office space are scheduled for less than 40 hours per week, the reviewer might suspect an error in the scheduling. The total number of hours per week is 168.

7. Average Load When Load Scheduled: the reviewer can use this value to check the schedule. An error in defining a schedule will show up here (e.g., using 10 percent load instead of 100 percent load for a constant load). The average will generally be a typical amount for the zone. Exceptions will occur in zones where there are large loads of short duration, such as classrooms having one or two classes during the day and a cleaning staff at night. The average number of people in the zone in this case is not very indicative of the "typical" load. In most cases when creating a schedule, cleaning and security personnel present during nights and weekends can be neglected without significantly changing the loads. (This is discussed in more detail in the Temperature Section below.)

[illegible] and Ventilation

Section VII describes the infiltration and natural ventilation that are in the zone description and appear as zone loads and the mechanical ventilation introduced by the mechanical system. Infiltration, natural ventilation and mechanical ventilation are reported separately. Within these three subdivisions, the zone number, effective date of the schedules, and the schedule names are reported for each zone. Volume flow rates of air in air changes per hour and cubic feet per minute (cfm) or cubic meters per second (m^3/s) are given for five conditions (where appropriate, the date of the condition is shown under the volume flow rates).

1. Occupied Max: the maximum flow rate that occurs when the zone is occupied. For ventilation, this cannot exceed the design peak. However, infiltration may exceed the design peak, because this value is adjusted based on windspeed and indoor/outdoor temperature differences. It should be the largest of the four actual flow rates, but may be smaller than the design amount. The time of the maximum occupied flow rate is shown on the bottom row, labeled MO/DA/HR, in the form month/day/hour of max.

2. Occupied Min: the minimum volume flow rate that occurs when the zone is occupied. This value is usually given as a standard for ventilation for health and safety.

3. Unoccupied, Max/Min: these values can be less than the Occupied Max or Occupied Min because fresh air requirements can be greatly reduced when there are no people in the zone. During the summer, nighttime ventilation for cooling may increase the ventilation rate during unoccupied hours.

4. Design Peak Load: the amount specified in the BLAST input deck. It may be exceeded for infiltration because of variations in windspeed and indoor/outdoor air temperature differences. The design peak ventilation should be the highest ventilation flow rate.

The infiltration heat loss and heat gain are reported for each zone, both as total energy lost and as percent of the total zone load. These should be used to determine if infiltration losses are excessive.

Section VIII--Temperature

Section VIII shows 12 temperatures for each zone, including the maximum and minimum temperatures when the zone is occupied, when it is unoccupied, when the heating is on, when the cooling is on, and when neither the heating nor cooling is on. Asterisks (******) appear when the condition does not exist. For example, there may be no time when the cooling is on and the zone unoccupied. Asterisks would then appear in the maximum and minimum columns for Cooling, Unoccupied. Each line describes the temperature patterns for one zone:

1. Zone Number: zone number for which the information applies.

2. Control Strategy Name: specifies the name of the control strategy for the zone temperature. The details of the control are given in the zone description of the default BLAST output. When more than one control strategy is used, all the control names are listed, but only one set of temperatures for each zone is given. In uncontrolled zones, the statement "***** NO CONTROLS *****" will appear. In that case, asterisks (******) should appear in all columns for "Heating" and "Cooling" because there are no instances when heating or cooling is on, since no heating or cooling is available to the zone.

3. Heating, Occupied, Max: should not exceed Army standards for maximum temperature during the heating season (68°F [20°C] for general office space).

4. Heating, Occupied, Min: should not be so low as to cause undue discomfort for the occupants. The reason there is a maximum and minimum occupied temperature is because of the throttling ranges used in most building controls. These two numbers can, with certain controls, be equal.

5. Heating, Unoccupied, Max: may be set back from the "Heating, Occupied, Max" because the comfort of occupants is not a consideration. Generally, 55°F (13°C) is the appropriate temperature for unoccupied office space. Misleading results may occur if an occupancy schedule is defined which includes short unoccupied periods (lunch hours, for example) when temperature setback is not possible. If temperature setback is used, it is suggested that a minimal number of people be scheduled during hours when it is not feasible to set back zone temperatures.

6. Heating, Unoccupied, Min: should be high enough to prevent damage to property. This may be equal to the "Heating, Unoccupied, Max" for some control strategies.

7. Cooling, Occupied, Max: should be within a reasonable comfort range for occupants.

8. Cooling, Occupied, Min: should not be below Army standards for minimum temperature during cooling season (78°F [25°C] for general office

space). Again, the difference between the maximum and minimum occupied cooling temperatures accounts for control throttling ranges.

9. Cooling, Unoccupied, Max and Min: in general, cooling should not be on when the space is unoccupied. Some specific special cases might include computer rooms, where heat-generating equipment requires special cooling to keep from damaging the equipment, or storage areas in hot climates. If cooling is on, the temperature should be only low enough to meet the specific requirement.

10. No Heating or Cooling, all cases: temperatures in the zones when either (a) the zone temperature is within the designated temperature range so no heating or cooling is needed or (b) the heating and cooling system is turned off by the designers. These temperatures should be within the temperature range appropriate to the space, such as that required to keep materials in warehouses or storage spaces from being damaged or to provide warehouse operators with a reasonable comfort range.

When evaluating the temperatures, the reviewer must carefully watch the interaction between people and control schedules. The control schedule determines the temperatures in the space; the people schedule determines whether the space is occupied. Thus, if the night setback temperature appears in the occupied minimum column, it may be because of the scheduling of occupants (usually janitorial, maintenance, or security staff) during setback hours. Another example is not scheduling people during normal heating and cooling periods (such as morning warmup, lunch periods, holidays), which may cause normal temperatures to appear in the unoccupied maximum column. These conditions are reasonable, but make it difficult to review the temperatures in the design Review Summary Report. For this reason, close consideration must be given to specifying people and control schedules. One might want to schedule a small workforce during warmup periods, lunch hours, etc., and ignore small workforces during temperature setback times. Obviously, this is at the discretion of the designer and reviewer.

Note that if significant unmet system loads occur, the temperatures listed are invalid. This is because the LOADS program assumes that the system has sufficient capacity to achieve the specified control sequence. If the system is, in fact, undersized, the systems program will report unmet loads and the assumption (by the LOADS program) of sufficient capacity is unreasonable, causing the reported temperatures to be invalid. A warning will appear if the unmet system loads exceed 5 percent of the total load.

Section IX--Energy Budget

Section IX has four subsections. The first includes project and weather data needed to choose the applicable design energy budget. The remaining subsections identify zone loads, system loads, and plant loads, respectively.

The first subsection gives:

1. Category Code: the five-digit MCA category code used to identify the type of building for the design energy budget.

2. Location: gives the location of the weather tape used, the type of weather tape (i.e., TRY for test reference year), and the year of the weather tape (where applicable).

3. Project Title: includes any information needed to identify the project. It is in the BLAST input deck as the PROJECT statement. It can be up to three lines (240 characters) long, and may include such things as the name of the project, the actual location of the building, names of the engineers, design option, etc.

4. Heating Degree Days and Cooling Degree Days: read from the weather tape. They are used to check whether the weather tape is appropriate and to identify the appropriate energy budget. If HDD and CDD are not given on the weather tape, UNKNOWN appears in place of actual numeric values.

The second subsection, Zone Load, gives the loads for each zone. One line describes one zone and lists:

1. Zone Number to which the line of data applies.

2. Total Heat/Cool: the total sensible heating/cooling required per year by the zone to maintain it at the conditions specified for the zone control.

3. Total Elect: the zone's annual total electrical load, including lights and internal electric equipment. For energy budget checks, any electrical consumption by internal equipment should be subtracted from the energy budget because internal equipment loads should not be included in budget calculations.

4. Total Gas: the annual gas load due to gas equipment in the zone. For energy budget checks, this should be zero.

5. Total Area: the floor area for each zone. The reviewer should make sure this value is correct.

6. Energy Budget: the amount of energy required by the zone per unit area during the simulation period. This value can be used to identify the zones that use particularly large or small amounts of energy.

7. Energy Budget for All Zones: shows the energy consumed by all the zones per unit area during the simulation period. This value can be used to evaluate the energy effectiveness of the building without considering the systems and plants.

The third subsection, System Loads, gives the loads for each system. One line describes one system and lists:

1. System Number: identifies the system the data belongs to and corresponds to the detailed system description in the usual BLAST output.

2. Total Heat/Total Cool: the energy required by the system to provide heating/cooling. These values include the zone loads, plus any additional system loads, such as those caused by ventilation or system inefficiencies. If the system cannot meet the heating/cooling requirements, this value is the amount the system could provide. The portion of the system load that cannot be met is reported as an unmet load.

3. Total Elect/Total Gas: the total amount of electricity/gas required by the zones and the system. This value should be greater than or equal to the corresponding value for the zones. The electric load will include the system fan power.

4. Area: the total floor area served by the system. The reviewer can make sure this value is correct by summing the floor areas of the zones served by the system.

5. Unmet Heating/Cooling: the portion of the load that the system could not meet. Unmet loads will arise when the system is undersized, the air flow rate is too low, or the hot- or cold-deck temperatures are too low or too high. The unmet loads do not include system inefficiencies.

6. Energy Budget: the energy required by the system, including zone loads, per unit area during the simulation period. However, if unmet loads occur, the energy budget will be inaccurate because only available energy is reported, not the amount required to meet the loads. The energy budget for each system is provided so that the reviewer can detect any variations in the energy effectiveness of different systems.

7. Energy Budget for All Systems: the energy consumed per unit area during the simulation period by the building. This value includes the systems, but not the plants. It can be used to evaluate the energy effectiveness of the building and its air-handling systems without considering the plants.

The fourth subsection, Plant Loads, gives the loads for the plants. Each plant is described by one line which lists:

1. Plant Number: identifies the plant to which the data belong and corresponds to the detailed plant description in the usual BLAST output.

2. Electricity, Boiler Fuel, Gas Turbine Fuel, Diesel Fuel, Purchased Hot Water, and Purchased Chilled Water: the source energy inputs to the plant that ensure all the building's energy requirements can be met.

3. Unmet Loads: the portion of the load required by the system that the plant cannot meet. Undersized or improperly scheduled equipment can cause unmet loads. These unmet loads do not include plant inefficiencies or the system unmet loads.

4. Floor Area Served: the floor area served by the plant. The reviewer can check this value by summing the floor areas of the systems served by the plant.

5. Energy Budget: the energy required by the individual plant per unit floor area during the simulation period. The budget will be inaccurate if unmet loads exist. The energy budget for each plant is included so that the reviewer can detect any variations in the energy effectiveness of different plants.

6. Building Energy Budget: the "bottom line" energy budget which accounts for all zones, systems, and plants. This is the value the reviewer compares to the design energy budgets. However, this value is not valid if significant unmet loads exist in either the systems or plants subsection. Note that only met systems loads are considered in the plant load calculations. It is important that the reviewer consider any unmet loads before comparing this value with the design energy budgets or approving the designs. Unmet loads indicate that the design is not operating as desired with the zone loads, and thus comfort conditions are not being met. For example, the temperature report is invalid if unmet loads exist.

6 ENERGY DESIGN REVIEW WITHOUT BLAST

The design review method described in this report requires that a BLAST analysis be made on each new building submitted to a Corps District. This can be accomplished for A/E-contracted designs by having the District contract designs only to those A/E firms which already use BLAST as part of their design process, since generating the BLAST Review Summary Report will cost the A/E no more than generating any other BLAST output. However, this is not likely to happen in the near future. The alternatives are to require designers to do a BLAST analysis of the projects, or to have the District reviewer do a BLAST analysis of the design submission. These are the options usually chosen by the District, although they both increase the overall design cost and review time. For this reason, it has been suggested that District design review procedures be developed that are not based on the BLAST program. The pros and cons of this idea are discussed below.

Manual Review Method

The District could require designers who do not use the BLAST program to manually produce a report in the same or similar format to the BLAST Review Summary Report. The reviewers who participated in the field test of the Review Summary Report were asked if hand-completed forms of the same format would be just as useful. Hand-completed forms were judged to be more useful than no summary at all, but the review time would not be significantly faster because of the reviewer's tendency to check the handwritten values against the computer printout. This checking would also require the reviewers to be familiar with the analysis method used. Also, much of the information used to evaluate the model's validity would either not be available or could be incorrectly reported both in the summary and in the analysis. Because the report would be prepared manually, the reviewer could not be sure that the data were accurate. That is, there would be no way of automatically checking that the data in the review report were the same data used in the energy analysis.

Computer-Aided Review Method

To show design budget compliance, some form of computer energy analysis will probably be required. If this is the case, it may be possible to develop special review reports similar to the BLAST Review Summary Report for other simulation programs.

The main problems in this approach are (1) getting the developers of simulation programs other than BLAST to develop a review report similar to the BLAST Review Summary Report and (2) getting access to these usually proprietary programs so that USA-CERL can develop the review reports. In either case, other computer programs may not generate the kind of data needed to generate a review report of the same quality and accuracy as the BLAST Review Summary Report.

An alternative may be the Corps' Computer-Aided Engineering and Architectural Design System (CAEADS).[9] The BLAST program has been interfaced to CAEADS, so energy review reports can be generated for any project using CAEADS. Furthermore, the SKETCH portion of CAEADS can be used to simplify the development of BLAST input decks. This could make the option of having the reviewer do BLAST runs for projects submitted by A/Es more practical. Also under development is an interface of CAEADS with other automated drafting systems, which could make it very easy for the reviewer to use BLAST during the design review. These various interface programs are presently under development at USA-CERL.

[9]Janet Spoonamore, CAEADS -- Computer-Aided Engineering and Architectural Design System, Technical Manuscript P-133/A-117972 (USA-CERL, 1982); and Computer-Aided Engineering and Architectural Design System, Volumes I and II, Technical Report P-97/ADA065827 and ADA067719 (USA-CERL, 1979).

7 CONCLUSIONS AND RECOMMENDATIONS

Field testing of the standard format of the automated method for producing review data, which is currently available in an output report from the BLAST computer program, was very successful. The field test showed that review time was reduced by approximately 90 percent and the quality of the review was improved.

Based on the field test results, the procedure has been modified in several ways that further enhance its utility. These changes provide the user with more information about the design and make the Review Summary Report more of a stand-alone report. By listing important design data in a systematic format, the BLAST Review Summary Report helps the designer verify that the BLAST model is correct and that the Army's prescriptive standards for energy-efficient building designs are met. In addition, instructions have been made easier so that persons with little or no BLAST expertise can use the procedure.

Producing hand-completed forms of the same format provided by the BLAST Review Summary Report would increase the time and cost of a review compared to producing no summary or automatically providing the Review Summary Report.

It is recommended that the review procedure described in this report be used to review all designs for which BLAST is used for energy analysis.

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