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DOE-2: A COMPUTER PROGRAM FOR BUILDING ENERGY SIMULATION

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☞ **Bugged by 2.1C??** — To date, 47 bugs in 2.1C have been fixed. If you would like to "trade-in" your old 2.1C tape for our bug-free version, please call Kathy Ellington (415-486-5711) for instructions.

☞ **Directory of Services** — The DOE-2 program, and its position as benchmark software in the A/E community, has generated an array of program-related software and services. With this issue of the USER NEWS, we are presenting a sampling of these products and services by printing a "Directory" of DOE-2 related software, services, and documentation on the inside back page of this newsletter. This first "Directory" is by no means complete and some companies may have been overlooked; therefore, all readers are urged to contact us with other sources. Note that the NTIS order form has been incorporated into the Directory of Services.

☞ **Program Certification** — After January 1, 1987, it became mandatory for new non-residential buildings constructed in the State of California to meet standards set by the California Energy Commission (CEC). We have learned that MICRO-DOE2 (a microcomputer version of DOE-2.1C) has now been certified by the CEC. for use in standards compliance. Acrosoft International, developer and distributor of MICRO-DOE2, has published a Compliance Manual for their California users; the contents of their Manual were adopted from CEC publications with changes reflecting the features of MICRO-DOE2. The Manual may be ordered from Acrosoft; see the Directory of Services for Acrosoft's address.

☞ **European Weather Data** — Isidore Marcus of EMPA, an organization offering full DOE-2 program support to European users, has made available eight Swiss weather data files. For further information please write him at EMPA, Ueberlandstrasse 129, CH-8600 Duebendorf, Switzerland.

☞ **ACEEE Summer Study** — The 1988 conference on Energy Efficiency in Buildings will be held Aug 28-Sep 3 at the Asilomar Conference Center in Pacific Grove, CA. Hosted by the American Council for an Energy-Efficient Economy, this year's summer study will examine the role of energy conservation in today's changing economic and political environment. Deadline for submittal of abstracts is January 27, 1988. For information contact ACEEE '88, Chuck Goldman, Bldg. 90H, Lawrence Berkeley Laboratory, Berkeley, CA 94720. Phone (415) 486-6048 or telex 910-366-2037.

[*The following article describes a comparison of DOE-2 predictions with measurements on a European office building. It was written by members of the Building Science Department of EMPA, (EMPA, Euberlandstrasse 129, CH-8600 Dubendorf, Switzerland) a government-sponsored research organization in Switzerland. The work discussed here was performed as part of an International Energy Agency project (IEA Annex IV) to validate different European and American building simulation programs. The article was excerpted from "Verification du Programme de Simulation des batiments DOE-2", which appeared in SWISS ENGINEER AND ARCHITECT, No.15-16/87, pp. 246-249, July 23, 1987. Translation by Jean-Michel Nataf of the Simulation Research Group, LBL.*]

Validation of DOE-2: The Collins Building

by

Thomas Baumgartner, Juerg Gass
Isidore Marcus, and Gerhard Zweifel
EMPA
Switzerland

Introduction The Collins Building, situated near Glasgow, has been the target of an international measurement project. The building has four levels and a basement (fig. 1). Its facades are oriented north-south and east-west. The second and third floors have a landscaped office layout covering an area of 4,300 square meters.

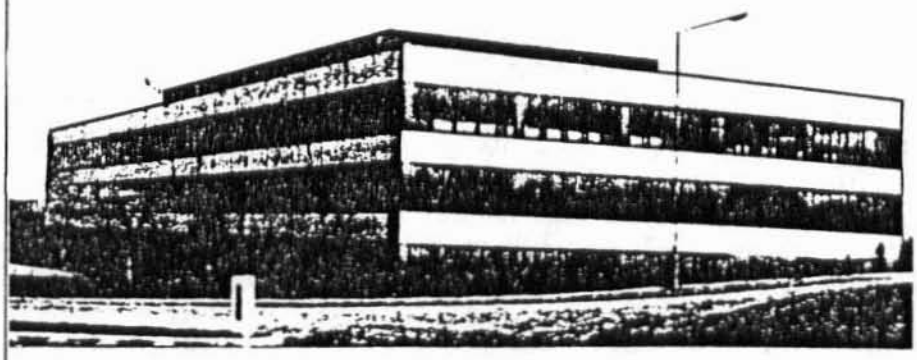

Fig. 1: View of the Collins Building

The construction is steel frame with concrete floors. Half of the facade is insulated double glazing with sun-control glass; the other half is marble-clad opaque wall. The HVAC system for the second and third floors serves a central zone and four peripheral zones, each five meters deep. These zones, as well as the first-floor offices, are conditioned with a variable air volume (VAV) system, with return air vented through the luminaires into a plenum. A separate system supplies warm air to the peripheral zones to compensate for transmission losses through the facade. A detailed description of the HVAC system can be found in J. Gass and T. Baumgartner, "Messprojekt Collins-Gebaeude in Glasgow", *Schweizer Ingenieur and Architekt*, 12/83, pp. 336-338.

Building Modeling for the Simulation Calculations A model of the entire building was prepared from detailed specifications. However, after analysis of the data, the target goal (to obtain the exact energy consumption of the building) proved too ambitious. Validation of a simulation program requires measurements on each particular element of the building. This was not feasible for a project of this size. Thus, only the second and third floors of the building were used for validation purposes.

Validation The validation of DOE-2 was carried out by comparing calculations with measured data over week-long periods. These short calculation periods allowed discrepancies between the actual operation of the building and the initial input specifications to be taken into account. The following figures show the results obtained with the HVAC system off for a weekend in September and with HVAC system on for a week in July.

Figure 2 shows calculated and measured air temperature (1.8 meters above the floor) in the west zone of the second floor during a three-day weekend in September. The HVAC system was off, lights and electrical appliances had been fully on Saturday morning and partially on Sunday and Monday.

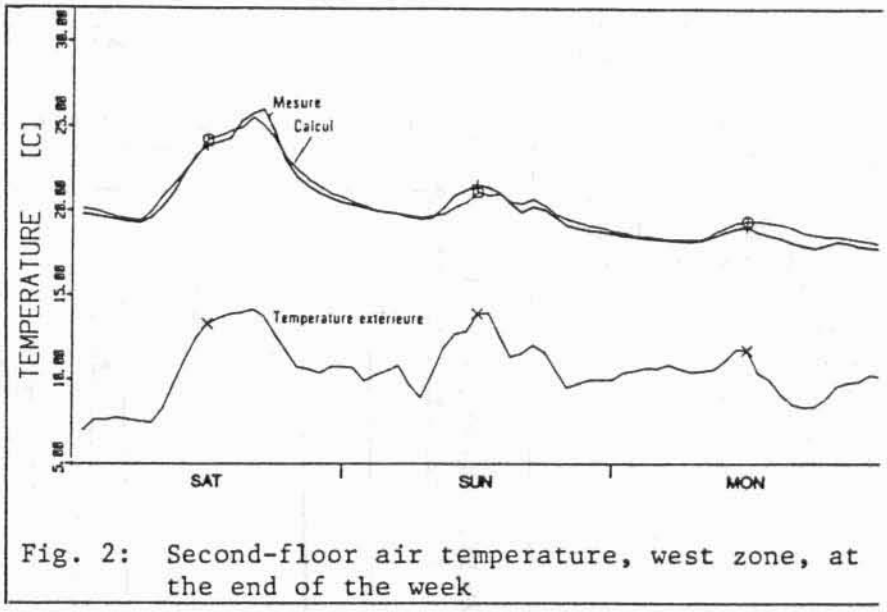

Fig. 2: Second-floor air temperature, west zone, at the end of the week

The Saturday morning temperature rise was caused by solar gain and heat gain from lights and electrical appliances; it is well reproduced by DOE-2. The smaller temperature rise on Sunday, due to solar gain, is less well reproduced (1°C difference). The reason is that the heat gain due to lighting was more uniformly distributed in the office than that due to solar radiation. Thus, the temperature calculated by DOE-2 corresponds better to the measured data.

In fig. 3, we show the second floor core zone air temperature during a very sunny week in July. The HVAC system was manually turned on for two hours on Sunday afternoon. This could not be reproduced exactly by DOE-2; therefore, there is a difference of 0.5 to 1°C between the calculated and measured temperature values during the first three days of the week. The time span over which the initial conditions play a role in the temperature evolution represents the "memory capacity" of the building.

The temperature rise at the end of the afternoon, followed by a steep decrease (especially on Mondays) is due to the different turn-off times for the HVAC and lighting systems. The HVAC system is generally turned off two hours before lighting.

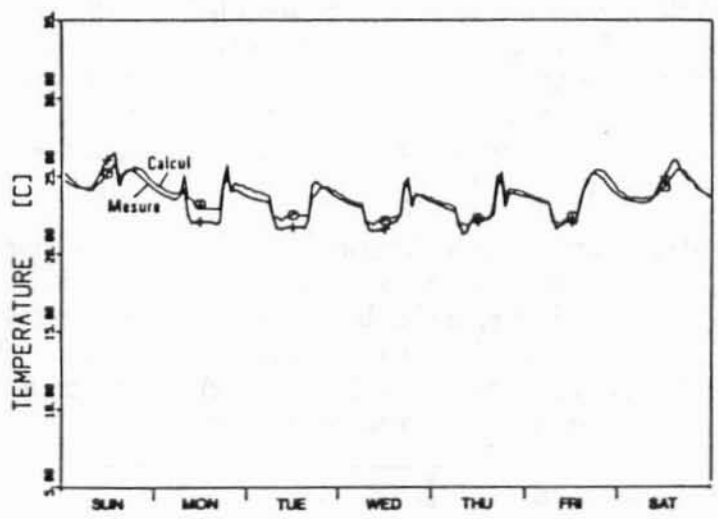

Fig. 3: Second-floor air temperature; core zone

Figure 4 shows the hour-by-hour heat extraction by the VAV system. The calculated load is systematically about 20% higher than the measurements. This is a consequence of DOE-2's simplified treatment of heat transfer from the occupied zones to the plenum, which results in a calculated plenum air temperature that is 1.5°C higher than the measured value. The heat extraction rate is overestimated since it is proportional to the temperature difference between plenum and supply air.

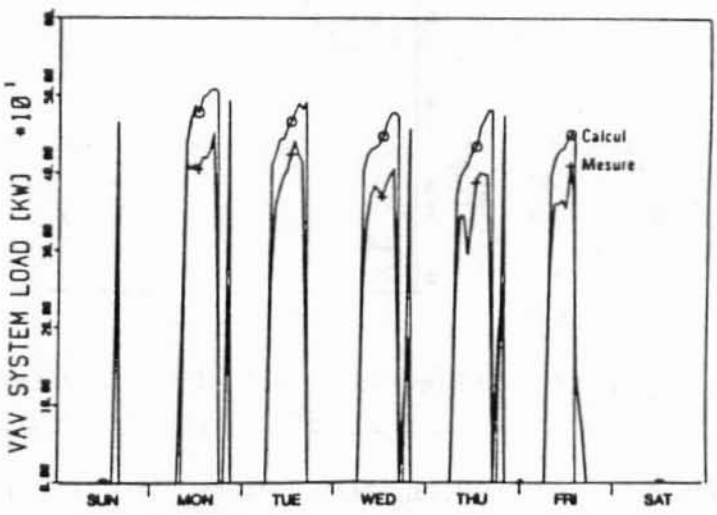

Fig. 4: VAV system heat extraction rate

Conclusion The verification work on the DOE-2 program demonstrates that the mathematical model predicts energy consumption accurately within a 5% range. Furthermore, the assumptions that the user has to make during input data preparation can lead to a 20% error. However, the main purpose of a simulation program is not to calculate the absolute value of annual energy use, but rather to assist in the choice of optimal building and system parameters through comparison of alternative designs.

☞ ☞ ☞ The Heat Exchanger ☜ ☜ ☜

by

Bruce Birdsall

Question: What happens when I input the following in LOADS?
SET-DEFAULT FOR EXTERIOR-WALL HEIGHT=9
CONSTRUCTION=B-WALL ..
SET-DEFAULT FOR ROOF TILT=0 CONSTRUCTION=ROOF-1 ..

Answer: This causes a *serious mistake* in your simulation; in DOE-2, ROOF is equivalenced to EXTERIOR-WALL. The first SET-DEFAULT is therefore over-written by the second one and all walls (and the windows in them) are simulated as horizontal surfaces and the walls are assigned the roof construction!

Question: When simulating an incremental heat pump (HP) system, why are the cooling values in the SS-D report so large?

Answer: SS-D reports the cooling load passed to PLANT. In the case of the HP system, the cooling load is the heat rejected to the cooling tower and is the sum of the evaporator load (reported in SS-A) plus the heat of compression (reported in SS-H).

It is fairly obvious, but one should never input a chiller in PLANT when using the HP system. The BDL processor does not check for such an error and will accept the input. The simulation results in a double accounting for heat of compression, first in the HP unit and second in the chiller. If there are other systems in the run, they must be of the packaged type.

Question: I tried simulating a warm-up cycle as described in the Sample Run Book 31-Story Office building, Run 1. It doesn't work!

Answer: My humble apology! The input as described on page 237 should have read as follows:

S-CTRL=SYSTEM-CONTROL
COOLING-SCHEDULE=COOLON
HEATING-SCHEDULE=HEATON
COOL-CONTROL=SCHEDULED
HEAT-SET-T=90
COOL-SET-SCH=SAT-SETPT
MIN-SUPPLY-T=60
MAX-SUPPLY-T=100
MAX-HUMIDITY=55 ..

The omissions and errors are **boldfaced** to draw your attention to them. Please make a notation in your Sample Run Book of this change.

■■■■■ DIRECTORY ■■■■■

DOE-2 Related Software, Services, and Publications

■■ SOFTWARE ■■

DOE-2.1B for Micros (PC-DOE)
Lynda Osborn
Tri-Fund Research Corp.
1050-17th Street #900
Denver, CO 80285
Phone: (303) 595-0610

DOE-2.1C for Micros (MICRO-DOE2)
Gene Tsai
Acrosoft International
3120 S. Wadsworth Blvd.
Denver, CO 80227
Phone: (303) 969-0170

■■ UTILITY PROGRAMS ■■

DOE-2 Pre- and Post-Processor Software (report customizer, database, browser, scan, microclimate, Calif. Title 24)
James Trowbridge
Trowbridge Software Engineering
4884-D Sunset Terrace
Fair Oaks, CA 95628
Phone: (916) 962-3001

Graphs from DOE-2
Ernie Jessup
E. Jessup & Associates
4977 Canoga Avenue
Woodland Hills, CA 91364
Phone: (818) 884-3997

■■ SERVICE BUREAUS ■■

DOE-2 Computer Service
Dashka Slater
Berkeley Solar Group
3140 M.L. King Jr. Way
P.O. Box 3289
Berkeley, CA 94703
Phone: (415) 843-7600

■■ TRAINING ■■

Master Classes and Tutorials
Bruce Birdsall
"In Support of Energy Software"
166 Caldecott Lane, Suite 113
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(please write for information)

■■ DOCUMENTATION ■■

____ Complete 2.1C Documentation
PB-852-11449 $274.00/each

____ 2.1C Update Package
PB-852-11431 $ 87.00/each

____ Engineers Manual
DE-830-04575 $ 38.50/each

To Order by Separate Titles:

____ BDL Summary (2.1C)
DE-850-12580 $ 13.95/each

____ Users Guide (2.1A)
LBL-8689, Rev.2. $ 42.95/each

____ Sample Run Book (2.1C)
DE-850-12582 $ 48.95/each

____ Reference Manual (2.1A)
LBL-8706, Rev.2 $ 90.95/each

____ DOE-2 Supl. (2.1C Update)
DE-850-12581 $ 24.95/each

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