THE HEAT BALANCE LOADS CALCULATOR:
A Windows-based program for calculating heating and cooling loads for buildings

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ABSTRACT
The Heat Balance Loads Calculator (HBLC) is a powerful software tool for calculating heating and cooling loads for buildings. It allows the user to access complex heat-balance algorithms using a Windows interface. Geometric inputs are entered graphically using intuitive click-and-drag mouse functions. HBLC creates an input file for the Building Loads Analysis and System Thermodynamics simulation program (BLAST), making some of the most powerful and accurate algorithms for calculating heating and cooling loads available through a símple, Windows-based program.

INTRODUCTION

Simplicity and accuracy are a necessary tradeoff in nearly all engineering applications. Most systems being analyzed by engineers are very complex. Time constraints do not allow every detail to be accounted for in the analysis. This is especially true when analyzing heating and cooling loads in buildings. Weather data, scheduled loads, and other thermal aspects of building design are usually approximated in order to complete the calculations in a reasonable amount of time.

The uniqueness and strength of the Heat Balance Loads Calculator (HBLC) is the fact that time constraints are satisfied by simplifying the input while retaining rigorous computational algorithms. HBLC provides a visually stimulating, easy-to-understand graphical interface to the Building Loads Analysis and System Thermodynamics computer simulation program. BLAST is a very powerful energy analysis program which calculates thermal loads using an implementation of the heat balance method. As a result, a simpler yet more accurate method of performing loads calculations is made available through the Heat Balance Loads Calculator.

OBJECTIVE OF THE SOFTWARE

HBLC provides practicing mechanical engineers and architects with easy access to the complex, BLAST heat balance load calculation algorithms. The software is intended to quickly calculate zone heating and cooling loads for most commercial building configurations. Hourly zone load profiles and block loads for design days and design years are computed and graphically displayed by the program.

TECHNICAL BASIS

Computational Algorithms

The heat balance method has long been recognized as a fundamentally sound approach to heating and cooling load calculations. Of the building simulation programs in the public domain, the BLAST program [BSO, 1993] contains an implementation of the heat balance procedure which is widely recognized and has been extensively validated [Herron, 1981, Yuill, G.K., Phillips, E.G., 1981].

The BLAST heat balance is formulated on the assumption of a "well stirred" zone, that is, the air temperature in a zone is assumed to be uniform. The inside surfaces of all building elements receive heat by various means. These include: conduction from the back, radiation exchange with a number of other surfaces in the zone (including other building elements, lights and equipment), solar beam radiation which may enter the zone through windows and finally convection heat transfer to the air mass. It is this latter heat flux which produces the heating or cooling load.

The temperature of the air mass reflects the balance between this convection heat transfer from the surfaces and the net energy transported into and out of the zone by the HVAC system. The zone air is assumed to have no capacitance, is always in steady state equilibrium, and it is transparent to radiative heat transfer between the walls. These assumptions are generally accepted as reasonable for normal circumstances. Zone thermal loads, such as lights, equipment, people, and outside air are scheduled on an hourly basis.

Since HBLC is based on energy simulation algorithms, the program may be used to calculate hourly zone loads for a single 24 hour design day, or bring energy analysis into the design procedure by estimating energy demand for the entire year.

Weather data for energy estimates is read from a weather file for each hour of the year.

The User Interface

Environment Selection

The outside environment is specified by selecting both a location and weather information from HBLC libraries. Over a hundred locations are available from the on-line locations library, and new locations may be defined by the user by inputting the latitude, longitude, time zone, and monthly ground temperatures of the site. Design day weather information is available for each of the library locations, and design days for other locations may be defined by the user. Additionally, Weather files for energy estimates with hourly data in TMY and TRY formats are available separately for over 350 locations.

Building Geometry

Perhaps the most convenient feature of HBLC is the method of defining the building's walls, floors and roofs. An entire building with multiple zones may be defined through simple click-and-drag mouse operations. -(See Figure 1). A new zone, which appears as a simple rectangle on the screen may be reshaped in seconds into any orthogonal polygon. Up to fifty simultaneous thermal zones at various elevations may be defined for a single building.

When subsurfaces are added to a wall, an elevation view of that wall will appear. Windows and doors and overhangs are added by clicking screen buttons, and they are sized by clicking and dragging the surface's edge. (See Figure 2).

Surface constructions (walls, roofs, floors, windows, and doors) are selected through the HBLC library of pre-defined building elements. The library is actually a dynamic database containing layer-by-layer material information for each element. If the desired element is not in the library, the user may define the element by specifying its composition.

Scheduled Loads

HBLC allows scheduled load definitions for all load types, including people, lights, equipment, and outside air. Up to thirty-two loads may be scheduled for a given thermal zone. HBLC contains fifty library schedules available for application to these loads, most of which are ASHRAE standard schedules. If the desired schedule is not available, a user-defined schedule can be defined either graphically or numerically. Weekday, weekend, holiday, and special days all have maximum percentages for each hour of that day, and these percentages can be changed easily and viewed simultaneously in bar graph form. (See Figure 3)

The figure shows that scheduled loads may be input in great detail if desired. For most applications, however, the user will find a suitable, pre-defined library schedule. The user may define the splits between latent or sensible loads and between the convective and radiative components of a load. All scheduled loads are presented in a table format with reasonable default parameters.

Systems and Plants

Although HBLC is intended to be primarily a loads calculator, the BLAST simulation engine behind the program gives it the capability to do a complete energy analysis of a building. There are twenty types of air handling systems and twenty-seven types of central plant equipment available when a more detailed energy analysis is required.

Output Viewer

The Output Viewer allows users to plot and visually evaluate selected reports. Figure 4 illustrates the type of graphical output available in HBLC.

ACKNOWLEDGMENTS

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REFERENCES

BSO (BLAST Support Office, University of Illinois), 1993, BLAST Users Manual.

Herron, D., 1981, "Comparison of the BLAST Computer Program Simulations and Measured Energy Use For Army Buildings," Technical Report E-174, U.S. Army Construction Engineering Research Laboratory, (USA-CERL), Champaign, IL, 1981. (Available through NTIS, Report No. CERL-TR-E-174.)

Yuill, G.K., Phillips, E.G., 1981 "Comparison of BLAST Program Predictions with the Energy Consumptions of Two Buildings," ASHRAE Transactions, Vol. 87, Part 1, pp. 1200-1206, 1981.

FIGURES

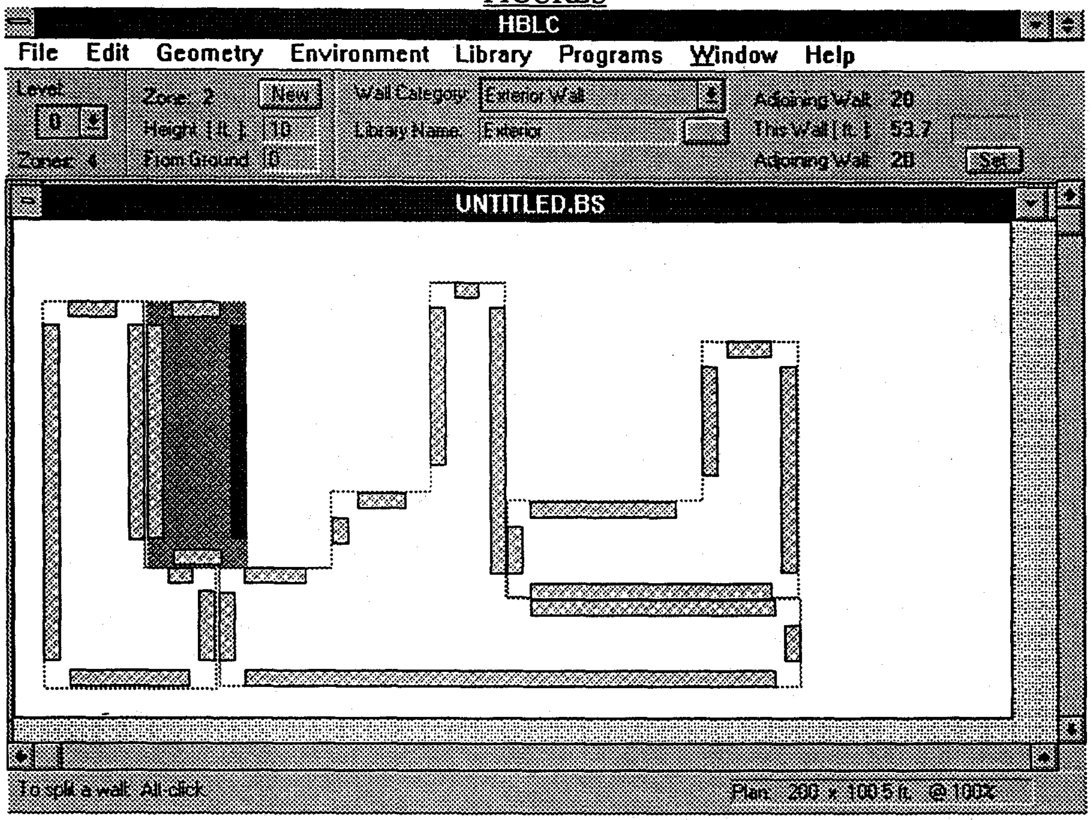

Figure 1. Plan View

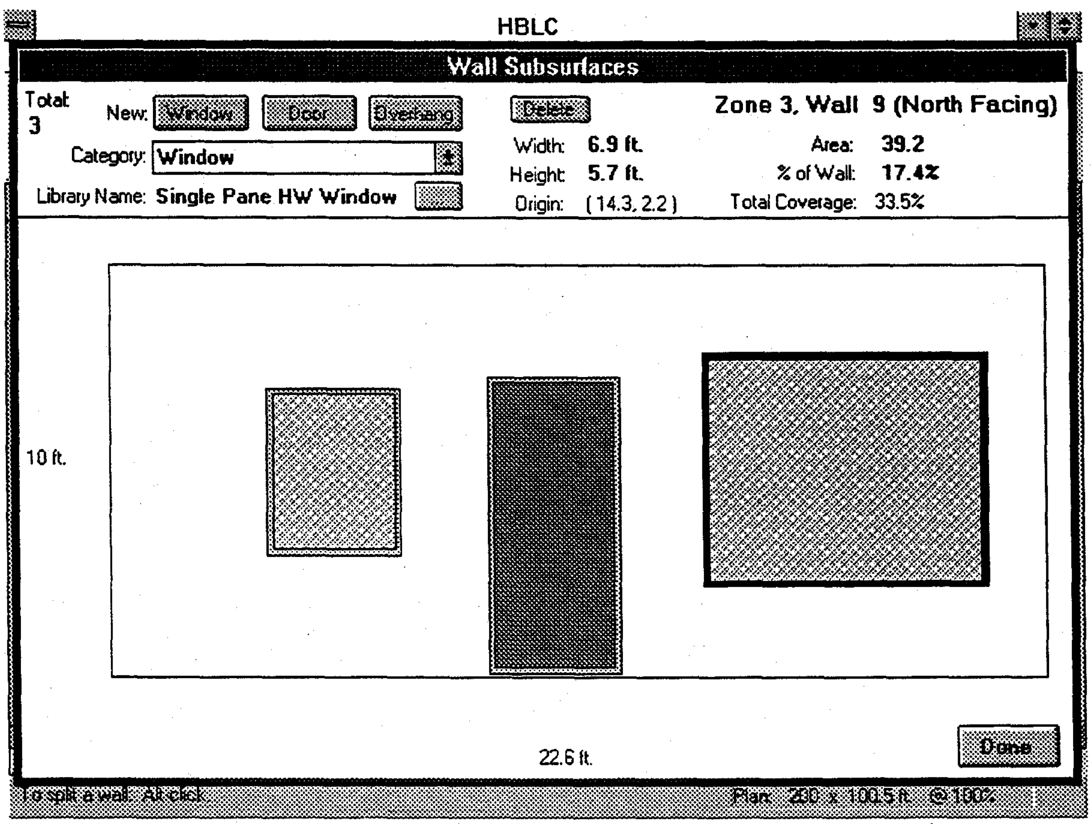

Figure 2. Elevation View of Wall

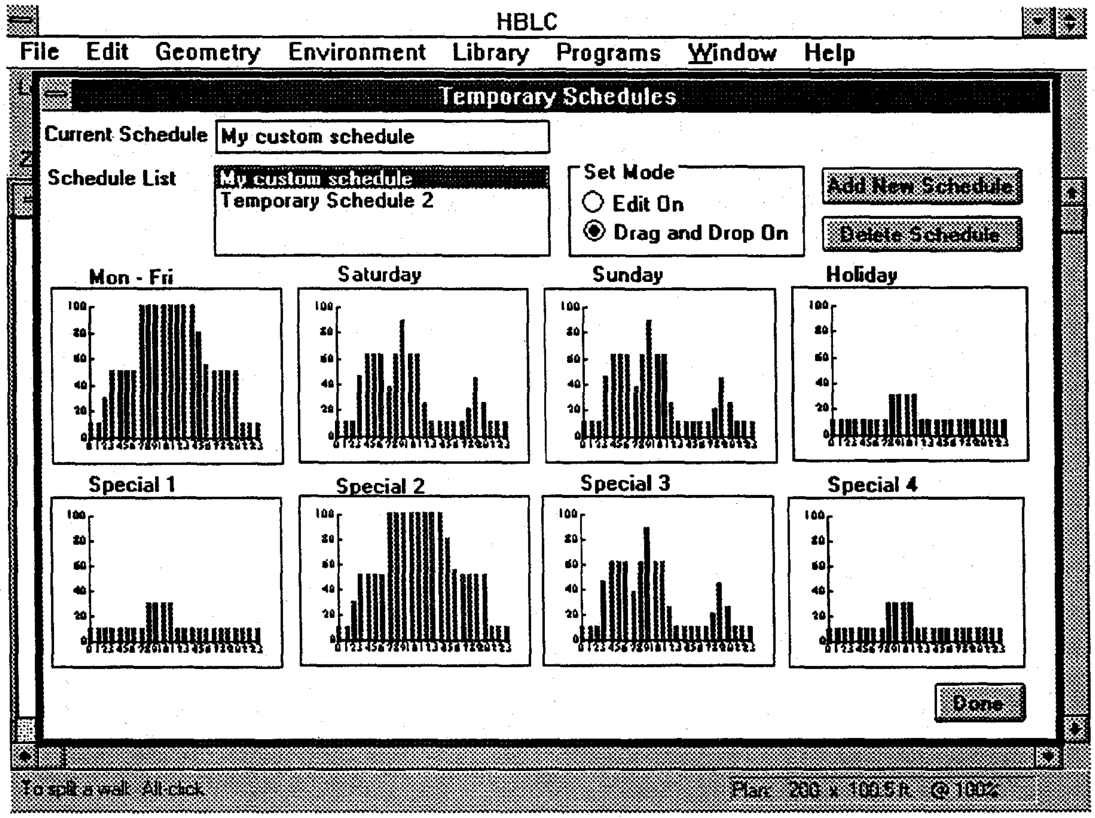

Figure 3. Editing Schedules

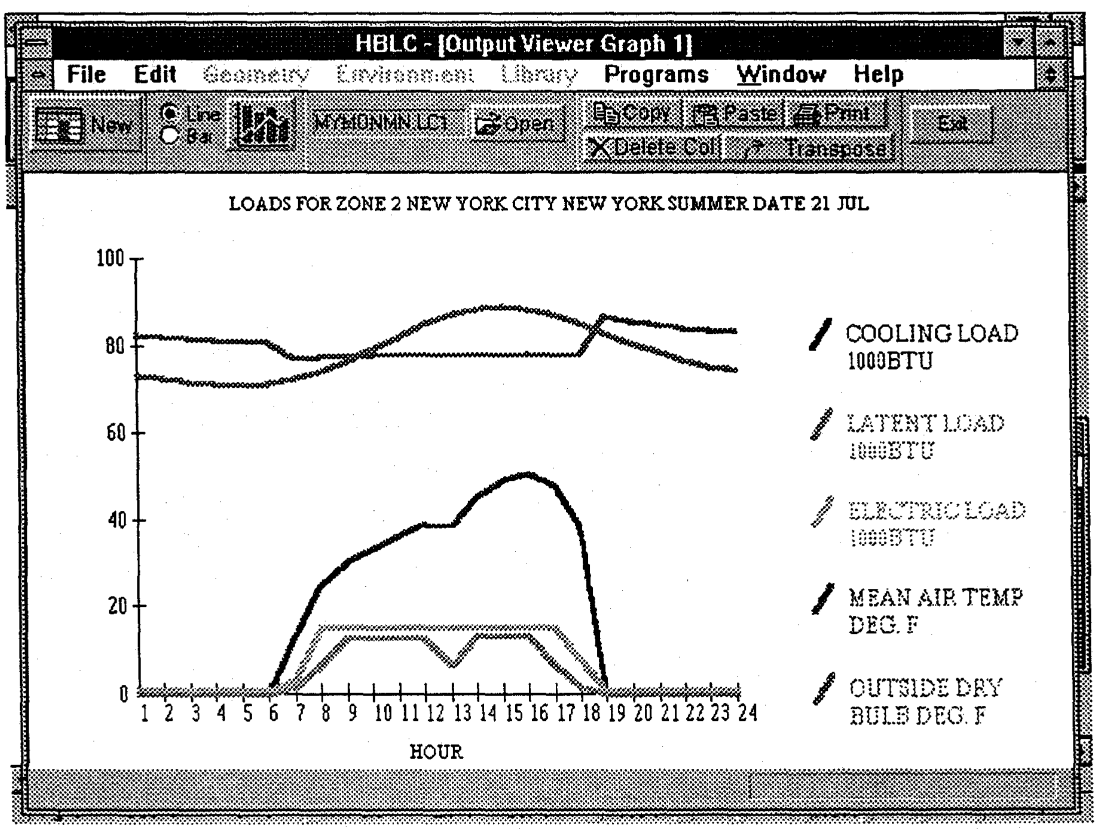

Figure 4. Output Viewer