USING OF PERSONAL COMPUTER IN OPTIMIZING ENERGY CONSUMPTION OF BUILDINGS IN HUNGARY

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ABSTRACT

The thermal character of a building can be qualified by the energy consumption and the indoor temperatures. With the help of recently developed computer program fitted to the capacity of PC-s the users can calculate more alternatives in a very easy way, that leaves the only task of selecting the most effective one from energy saving aspect. The thermal balance is calculated on the basis of analytical functions taking into account periodical heat loads. The outputs of the program are the energy consumption, the thermal performance of the HVAC system and the frequency function of the indoor temperature for the passive, though occupied, period of the building use.

L'usage du petit système individuel pour optimiser la consommation d'énergie d'un bâtiment en Hongrie

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MOTS-CLEFS

Conception assistée par ordinateur, consommation d'énergie, simulation, énergie solaire

RÉSUMÉ

Les propriétés thermiques d'un bâtiment peuvent être qualifiées par la consommation d'énergie et la température interieure. A l'aide d'un nouveau programme adapté à la capacité du P.S.I. les utilisateurs peuvent calculer plusieurs alternatives très simplement. Le seul devoir est de choisir l'alternatives la plus efficace du point de vue de l'économie d'énergie. La balance thermique est calculée à la base des fonctions analytiques supposant les charges thermiques périodiques. Les sorties du programme sont la consommation d'énergie, le rendement thermique du système de chauffage et la fonction de fréquence de la température intérieure en une période passive de l'usage du bâtiment occupé.

INTRODUCTION

The need for computer aided design based on smaller PC largerly increased in Hungary too. The presented program is simplified enough that the designers, architects, building phisicists etc. could get results quickly for preliminary dimensioning, comparison of different variations and user behaviours in the field of building energetics. The computed results does not give too much information about the exact thermal processes but are enough for the design process to avoid major errors.

This computer program was developed by a team organised from the TUB Thermal Laboratory and ÉTI staffs and hereby the authors express their thanks to their colleague, E.Balázs for participating in this work.

GENERAL PURPOSES

The fundamental aim of the program is to make possible the calculation of the energy consumption for the active periode of building and the indoor temperature for the passive, though occupied, period for some variations of a building. Another purpose is to estimate the thermal quality of the given building and to check the meeting of standard requirements, if any the first stage of design.

For comparison of different variations of a certain building and different user behaviours of the same variation the program involves an interactive possibility. The results are as follows:

- power consumption of heating system for a season, month, given period,
- cooling load and energy to be removed from the building,
- specific values of above mentioned parameters referred to unit area or unit volume, if desirable or prescribed,
- hourly values of indoor temperature for the day that represents the summer design conditions and different month,
- the indoor temperature frequency function for the passive, though occupied, period of a season, month or a given period /the passive status means that no HVAC system is working/.

DATA INPUT, PRECALCULATION

The data input is developed in an interactive way via keyboard with detailed questions and comments. After digitalization of geometry-topology data they are checked using graphic display. The skyline formed by surrounding buildings and terrain configurations is described by "free" or "shadowed" angles. Any surface bounding a room may contain one or more structural parts such as windows, doors etc. The orientation of surface and thermal coupling of spaces to walls an other structural boundary elements are indicated.

The problem of wall sizes has been solved in a practical way. In indicating geometry data external wall sizes are considered as conform with the internal ones. The difference between them in reality may be 10-20 %. This step is the condition of applying equations for onedimensional energy flows. The fin effect and cold bridge effect can modify the heat flow in the range of 20-100 %. A way to compute the effect of multidimensional energy flow is to apply simplified relationships of so called linear U-values rendered to the unit length of structural members or configurations causing multidimensional temperature fields. The linear U-values are tabelled in the User's Manual.

The thermal characteristics for opaque walls are as follows:

- absorption factors to visible and infrared wave-length,
- conductance, density, specific heat and thickness of each layer,
- equivalent thermal resistance of air gaps.

The transparent structures are defined by U-value and shading coefficient.

The movable structures such as curtains, blinds, mobile insulations represent a special problem. The practical solution in the program is that each movable structure has two or more different conditions characterized by two or more data-sets of thermal characteristics. The user behaviour, also the time schedule of curtains, blinds etc. are important factors of the thermal quality of a given building, that is, working out a rational time schedule of these movable structures.

For the walls, roofs, etc. the usual characteristics, such as air-to-air conductance and the values referring to the periodic conditions, such as decrement factor, time-lag, heat absorption factor are produced.

For the evaluation of the thermal behaviour of the building a separate subroutine takes into account the meteorological input data, that includes the clear and covered sky conditions in hourly steps. Two parameters, outdoor temperature and global radiation incident on horizontal surface are prepared for the calculations. The ratio between the clear and covered conditions are produced by random-generator for every month. The daily variation of the outdoor temperature is approximated with a sine wave, the maximum value belongs to 2 p.m. Meteorological databooks contain data for clear day radiation and mean value for a given month. The subroutine calculates the covered day radiation, assuming that the average of the daily random mean values should be equal to the monthly mean irradiation. The subroutine takes into account the monthly average sun-coordinates for the calculation of the solar irradiation incident on vertical surfaces as a function of time.

HEAT BALANCE CALCULATION

The original thermal characteristics, such as decrement factor, timelag, heat absorption factor are applied to the sinusoid time functions. A time function can be produced by superimposing of a series of individual responses given by the building to a subsequent series of impulses derived from these time functions.

Any periodic function can be approximated with a series of subsequent impulses and the response to it can be approximated as a sum of the responses to the individual impulses. This method is the basis of the computation of the thermal balance. It is schematically illustrated on Fig.1. /A daily period in the program is approximated by 24 impulses./

Fig. 2 shows the chart of the program-structure. The function of subroutines in the first and second lines have been mentioned above. The center part function of the program is the subroutine of computing the response of the room /or building/. The result is a series of hourly values of the indoor temperature for a day of the Test Reference Year.

Concerning the indoor temperature the input optionally accepts for each hour of each day one of the next three possibilities:
- The indoor temperature is prescribed. The fixed value can be prescribed supposing that the HVAC system is working /active period/. In this case the next step of the computation is the determination of the heat output of the HVAC system necessary to the prescribed indoor temperature /considering the periodic character of the effects/.

- There are two values of the indoor temperature for a given hour. These are the limits of the acceptable indoor temperature range. In this case it is assumed that the HVAC system does not work, but the response is acceptable. If not, a modification is necessary which can be decided in an interactive way.

- There is no indoor temperature requirement for the given hour. This means that the HVAC system does not work and the room is not occupied, that is, the actual value of the indoor temperature is indifferent.

For the active period the actual value of heating output is computed taking into consideration the periodic character of the thermal process. The maximum of this value is the capacity - the design output - of the system. The sum of the hourly values /for season, month etc./ gives the energy consumption for the system. Obviously, the heating and cooling loads are separately calculated.

In this case of intermittent heating a two-hour pre-heating period is assumed. If the pre-heating period proved to be too short - compared to the capacity of system - a longer period will be calculated.

For the passive, though occupied, period in case of a not acceptable indoor temperature the program-user has different possibilities.

The first possibility is to declare only a single value of indoor temperature for a given hour, that is, to "switch on" the HVAC system. In this case the given period will be considered as active one, the heat output and the energy consumption will be calculated.

The possibility mentioned above is sometimes inevitable but primary aim of the intervention is to find a variation providing the acceptable indoor temperature without the operation of the HVAC system /passive status/. The possible interventions are as follows:

- Modification of the air-change rate. Depending on the indoor and outdoor temperature increasing or decreasing of the indoor temperature is possible. The air-change rate is limited by the minimal - hygienical requirement - and the maximal - draught effect - values.

- Modification of the time-schedule of movable insulation, blind, etc. This possibility is usable first of all in the summer period to avoid the diurnal overheating and undercooling in night-time. The modification can be important if the building is designed as a passive solar house.

- Modification one or more geometrical or thermal data i.e. size or type of window, insulation of walls, etc. In this case the majority of computation has to be repeated.

- Modification of heat gains. Sometimes it is possible to modify some component of casual heat gains /e.g. lighting/.

- Last but not least it is possible to accept the indoor temperature value if it falls out the interwal defined previously, and continue the computation.

CONCLUSION

The presented PC program is a simplified one compared to the majority of simulation methods. This is because the program targets and performs preliminary dimensioning, comparison of different variations and users'behaviours. The pre-evaluation permits quick revelation of design errors. If the preliminary outputs are adverse or differ from expectations, the computation may be repeated modifying certain input data.

Repeatition affects of course only some program parts involving the modified input or relevant partial result. The fundamental thermal characteristics of building, the ourdoor conditions and casual heat gains are considered. Assumption of periodical process is acceptable and favourable using an other test reference year concept. The interactive part of the program facilitates the process of designing. Output does not give too much information as regards the details but the results are sufficient for the design process to avoid conceptional errors. On the basis of variations examined the best solution can be selected and its further analysis can be carried out by detailed simulation methods.

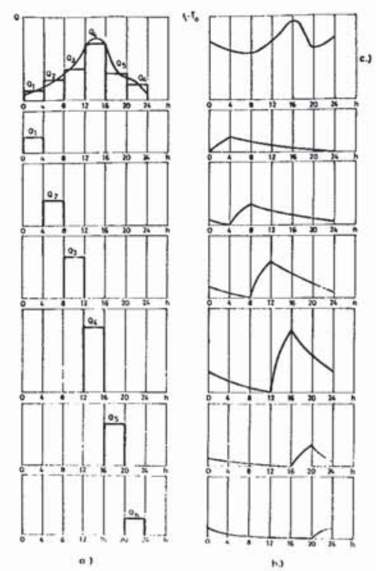

Fig.1.

Principle of calculating response time functions

a/ Apṕroximation of periodic function by impulses

b/ The response to a single impulse

c/ Superposition of response

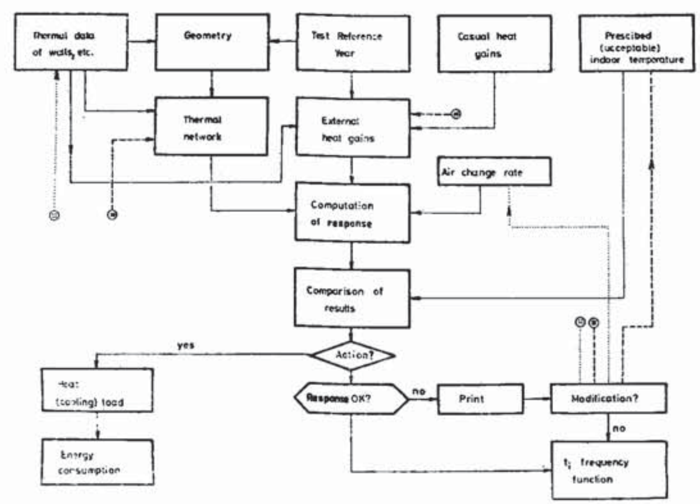

Fig.2 Chart of the program structure