SOFTWARE FOR BUILDING LOAD CALCULATIONS

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Abstract: *In this paper, a software tool for thermal design and energy simulation related to buildings is proposed. In design mode, software covers the calculation of heating, cooling and latent room loads, internal comfort analysis and codes/standards checks. Linked modules deal with the performance of HVAC (Heating, Ventilating, and Air Conditioning) plant and natural ventilation. Components prepared as a library of working code modules are ready for immediate implementation as stand-alone performance model or as components to be integrated with a complete building simulation program.*

Keywords: *thermal design, thermal analysis, building loads, heat balance model, heat transfer*

INTRODUCTION

Building energy consumption accounts for approximately 40% of the global energy demands; the bulk of this energy is needed to compensate for thermal energy losses or gains that occur in building envelope systems. Conventional strategies to mitigate thermal energy losses or gains in enclosures rely on passive insulation materials, separate heating and cooling systems then compensate for energy losses or gains that do occur.

Large commercial buildings that require air conditioning all year round are energy-intensive. Air conditioning typically contributes more than half of the energy consumption of a commercial building. As the building sector accounts for more than one-third of the total electrical consumption, it is imperative that today's buildings be designed for energy efficient operation throughout its lifetime. To achieve this, the response of a building to weather conditions and load changes need to be well understood. Conventional design methodologies are now being surpassed by computerized engineering tools that allow the performance of the building to be simulated long before its construction.

Meanwhile, building authorities worldwide have begun or completed the drafting of building performance standards taking advantage of the proliferation of personal computers and the rapid increase in computational power available to run sophisticated building norms and simulation programs. Concentrated efforts to reduce energy consumption will help to mitigate ad-

verse impacts on our environment. Achieving energy efficiency also helps to reduce our dependence on fuel imports and improve our economic competitiveness.

European Committee for Standardization (CEN) formulated EUROPEAN STANDARD NORME **EN 12831** in March 2003, as part of European's efforts to improve building energy efficiency. This Standard gives the method of calculation of the thermal transmittance of building elements in contact with the external air and deals with elements in thermal contact with the ground.

On the base of this Standard Bulgarian National Calculation Tool (Method) be developed and published. The calculation method is based on the delivered energy needed under standard indoor and outdoor conditions. The basic process of the calculation is divided into two stages:

- Calculation of energy demand (calculated on the standard use) of the building, or its zones; the calculation of heat losses, and heat gains, required in each space in order to maintain specified internal conditions;

- Calculation of energy consumption (building, zones, according to the energy demands); the calculation of the energy required by the energy systems (boilers, AHU units, DHW systems, lighting, etc.) needed to provide the necessary heating or cooling, or humidity control, etc.

The procedure for demonstrating compliance with the Building Regulations for buildings other than dwellings is by calculating the annual energy use for a proposed building and comparing it with the energy use of a comparable 'notional' building. Both calculations make use of standard sets of data for different activity areas and call on common databases of construction and service elements.

This standard specifies a calculation method for calculation of the heat supply needed under standard design conditions in order to make sure that the required internal design temperature is obtained. The standard describes calculation of the design heat load:

- On a room by room or heated space by heated space approach, for the purpose of dimensioning the heat emitters;
- On a whole building or building entity approach, for the purpose of dimensioning the heat supply.

The standard also provides a simplified calculation method.

The set values and factors required for calculation of the heat load should be determined in a national annex to this standard. Annex tabulates all factors, which may be determined on a national level and gives default values for cases where no national values are available.

SCOPE of EN 12831 Standard

The standard specifies methods for calculating the design heat loss and the design heat load for basic cases at the design conditions.
Basic cases comprise all buildings:
- With a limited room height (not exceeding 5 m);
- Assumed to be heated to steady state conditions under design conditions.

Examples of such buildings are: residential buildings; office and administration buildings; schools; libraries; hospitals; recreational buildings; buildings used in the catering trade; department stores and other buildings used for business purposes; industrial buildings.

Principle of the calculation method

The calculation method for the basic cases is based on the following hypotheses:
- The temperature distribution (air temperature and design temperature) is assumed to be uniform;
- The heat losses are calculated in steady state condition assuming constant properties, such as values for temperature, characteristics of building elements, etc.

The procedure for basic cases can be used for the majority of buildings:
- With a sailing height not exceeding 5 m;
- Heated or assumed to be heated at a specified steady state temperature;
- Where the air temperature and the operative temperature are assumed to be of the same value.

Data required

The Standard provides information on the appropriate data required for performing the heat load calculation. The following data is required:
- *Climatic data*. The following climatic data is used: external design temperature (winter and summer), annual mean external temperature, solar radiation (zone)
- *Internal design temperature*. The internal temperature used for calculation of the design heat loss (gains) is the internal design temperature. For the basic case, the operative temperature and the internal air temperature are assumed to be of the same value.
- *Building data*. The building data include geometrical characteristics of building and all rooms; thermal characteristics of envelope elements; thermal characteristics of linear thermal bridges, internal heat sources, optical characteristics of windows; thermal accumulation characteristics of building elements and other.

The objectives of calculating the design heat load is to ensure an acceptable internal thermal environment at design exterior temperature conditions. The internal design temperature for heating is given at a national level. The design for internal thermal environment should be based on EN ISO 7730, where the quality of the thermal environment is expressed by the PMV (Predicated Mean Vote) and PPD (Predicated percentage of dissatisfied) values.

Introduction to CDLoad

There are currently many computerized Building design calculation (BDC) codes and programs available to professionals. As different BDC codes vary in complexity, calculation algorithms, ease of use and cost, the codes have their advantages and disadvantages. The user's experience and computer literacy skills also play an important role in performing building energy simulation. It is foreseen that BDC will be more frequently and widely applied in building design and analysis as it can be under-taken with greater ease and lower costs using personal computers.

Despite their great popularity the BDS codes have some drawbacks. As a basic drawback of these software products can be pointed the difficult inserting in system the specific requirements of national standards and build a specific climatic and other data for calculations.

Another drawback of the BDS programming systems is that it is difficult to make analyses about long-term system characteristics. Apart from that they do not allow to be made analyses about the influence of separate constructive parameters in the installation scheme.

CDLoad is a computer program that provides a heat losses and heat gains in rooms of building, the total design heat load of the building entity, analysis of a building's energy consumption. CDLoad calculates designed heat loads and gains for building and rooms and yearly energy use of a building given a description of the building geometry, construction, use and HVAC and lighting equipment. It was originally based on the CEN Standards.

The organization of the programming system contains three basic modules. As a basic infrastructural part of the system it appears the module of collecting the constructive and climatic data for building.

The second structural part of the programming system is a set of programming modules for calculating and analyzing the thermal performance and design load of building. They are organized as separate programming structures according to the common infrastructural part of the programming system.

The third part of the programming system organizes the preservation of results from the calculations and a preparation of the necessary data. It is worked out a universal system for showing results for different periods of the simulation interval. Technical and economical estimations for building systems can be generated on the base of received results.

The main problem in algorithm for such kind of programs is organization of data base system for a project. The part of data can be prepared as a specialized data for project and other data can be prepared as a common data, which can be used for all projects. This data organization must be very flexible. On figure 1 is presented a scheme of data files and relating binds in this system.

Files specified for a given project are saved in separated directory, created for the project and that files are prepared as a special files with direct access in Pascal programming tool (Delphi). Files containing the common data base are prepared as a standard base data – Paradox. Data from this files is accessible for all projects.

WINDOWS environment for the CDLoad Delphi program (fig.2) provides for user friendly input of data, processing and viewing of the results. The program estimates the energy heat loss and gains and energy consumption of a building taking into account the site location, the building structure and the type of building services installed to maintain the desired environmental conditions. It enables a designer to investigate alternatives and make energy comparisons quickly and effectively for a very wide range of building configurations and air conditioning systems using actual measured climatic data.

Computer Platform

CDLoad program needs PC running Windows 95, 98, XP, Vista, 100 MB Ram or paging disk, 100 MB disk space, CD-Rom drive.

Data input is interactive (mouse driven) via WINDOWS dialogue boxes, selection lists drop down lists and entry fields on a series of screens running through general Project information to individual space data and for all the building services plant, capacities, operating schedules, etc. Buttons on the toolbar and special keys allow the user to copy individual values, columns of data or complete screens from space to space or system to system and there is a facility for making global changes.

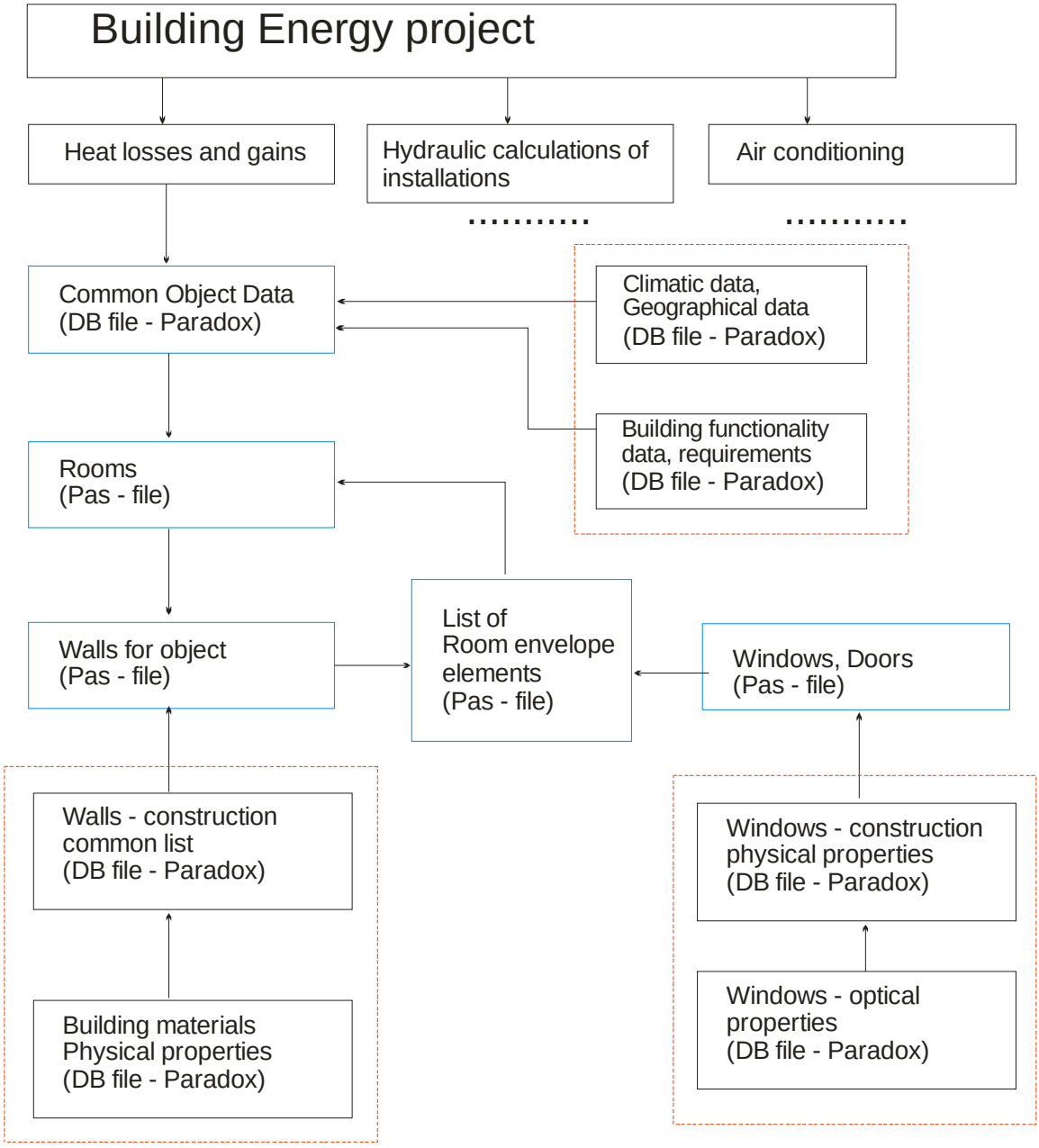

Fig.1 . Data files for **CDLoad** software

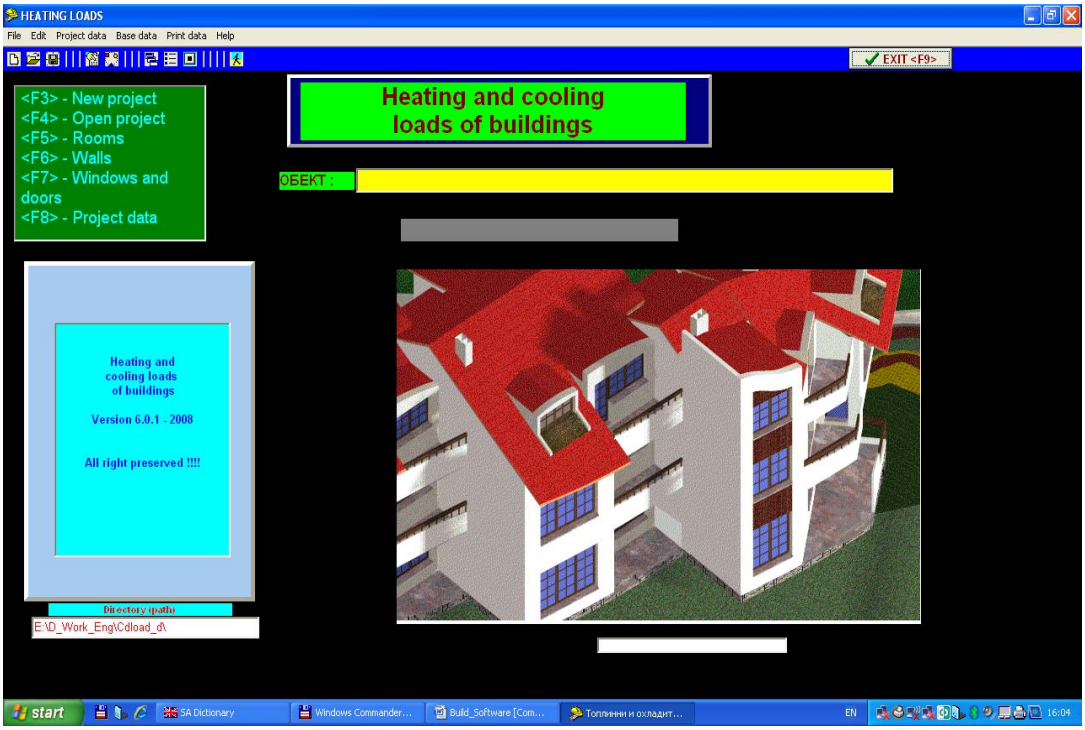

Fig. 2. Main screen of the program CDLoad

CONCLUSION

New technologies in planning, design and operation for energy efficiency of buildings often require the use of computers, and with the developing of desktop computing, building energy simulation is expected to grow in importance. A new energy performance standard is being proposed for use in European countries so as to achieve higher efficiency levels and greater energy savings. We demonstrated engineering compliance software, **CDLoad**, tailored for use by professionals to perform calculations aimed at achieving energy efficiency in buildings and compliance of energy performance standards. Software is approved in CHAMBER OF ENGINEERS IN THE INVESTMENT DESIGN and is adopted as official design software for *HVAC (Heating, Ventilating, and Air Conditioning) projects.*

REFERENCES

[1] Shtrakov St, M. Batova (2002), *Solar energy and thermal building analysis, EuroSun 2002*, Bologna , June, 2002.

[2] ASHRAE. ASHRAE Standard 90.1-89, American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., Georgia, U.S.A, 1989.
[3] ASHRAE (1997). ASHRAE Handbook of Fundamentals 1997, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, USA.
[4] ASHRAE (1980). ASHRAE Handbook of Fundamentals 1980, American Society of Heating, Refrigerating and Air-Conditioning Engineers, New York, USA.
[5] Hensen, J. L. M., J. A. Clarke, J. W. Hand, and P. Strachan. Joining Forces in Building Energy Simulation, In Proc. 3rd IBPSA World Congress on Building Simulation '93, International Building Performance Simulation Association, Adelaide, August 1993, pp. 17-24, 1993.
[6] Hensen, J. L. M., M. Janak, N. G. Kaloyanov, and P. G. S. Rutten. Introducing Building Energy Simulation Classes on The Web, ASHRAE Transactions, 104(1A), pp.488-494, 1998.