ENERGY AND INDOOR CLIMATE IN BELGIAN OFFICES: RESULTS OF A SURVEY

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Abstract

About 100 office buildings in the Flanders and Brussels regions have been subject to a survey of energy aspects and indoor climate parameters. Building characteristics and energy use have been mapped for all buildings; for 48 of them a database has been built containing building and room dimensions, materials used for the building shell, windows, glazing, solar shading, occupancy, equipment characteristics (heating, ventilation, cooling, lighting, office equipment, …). Moreover, detailed measurements were performed in 10 buildings regarding thermal and visual comfort parameters, indoor air quality and air flows, energy use and effective power, etc.

This huge amount of data has been analysed and synthesized into an assessment of the equipment of the actual office buildings park regarding energy use and indoor climate, as well as a set of recommendations for improvement of the energy performance of such buildings.

The data base has proved to be a valuable tool in the preparation of an energy performance regulation for new office buildings in the Flanders Region and also in the preparation of an energy audit and certification scheme for the Brussels Capital Region.

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KEYWORDS

energy performance, indoor climate, thermal comfort, visual comfort, standardization, building regulation

BACKGROUND AND PURPOSE OF THE STUDY

Realising good living and working conditions in buildings is a major task for any building project, whether new built or renovated. Indoor climate conditions have a major impact on the productivity of the employees in office buildings and hence there is an economical argument to optimise design, execution, running and maintenance of such buildings and their services. But more and more also environmental concerns are driving to optimal design for a minimal energy cost over the lifetime of the building.

New building regulations are developed to guarantee better performances of the buildings and for the authorities to get a better control on the overall energy consumption.

The way towards sustainable development is a long and difficult one, but buildings which consist in a medium to long term investment, should be designed such that they contribute …

But how do perform our existing buildings and what is their impact on the energy consumption and the indoor comfort of the users?

In Belgium, few data are available on the actual performances of office type buildings regarding energy use and indoor climate. Therefore a broad survey study was set up to get a better idea of the actual office building stock and the performances of the building services in such buildings. One of the additional aims of this 'KANTOOR 2000' study ("Office 2000") was to support the authorities in designing new regulations and standards of energy performance of new and refurbished buildings. This study was set up with the support of the Flemish and Brussels regional authorities and a large number of companies from the energy and construction products industry.

87 office buildings have been surveyed and analysed. On site measurements concerning indoor climate and energy use (thermal comfort in winter and summer, indoor air quality, visual and acoustical comfort, HVAC-installations, office equipment, lighting…) were used to give an overview of the actual situation in Flanders and Brussels, the possibilities for improvement, the technical and non-technical barriers to be resolved and the main challenges for the future. The project resulted in a detailed database of buildings and their energetic and comfort characteristics and revealed interesting possibilities for improvement of the energy performance of buildings on the one hand and a better indoor environment on the other. Also, this type of information database should support policy makers in creating a legislative framework in which construction of energy friendly buildings with good indoor climate is stimulated. For the first time in the Flemish and Brussels region, criteria to evaluate the performance of a building from the point of view of energy consumption and comfort become available to both the construction industry and their clients, starting from this project.

BUILDING SELECTION

Due to the supporting structure of the project, only office type buildings located in Flanders and in the Brussels Capital Region were included in the survey.

In total some 175 buildings were selected but only 87 of them fulfilled the basic requirements and were finally investigated in the most general way (overall building characteristics and energy use). Out of these, 47 buildings were investigated in more detail, room by room. Finally, 9 of the latter buildings were studied in great detail with specific measurements.

Buildings are of varying age, most more recent, many of them underwent a major renovation in the 80-ies or 90-ies.

BUILDING CHARACTERISTICS

Although a majority of office buildings are of the smaller size, more buildings were selected from the higher ranges of surfaces, since these buildings are more representative for the office type. Figure 1 shows the distribution of the gross floor areas for the 87 buildings.

In the 52 buildings subject to a room by room survey, 52 % of the office rooms are of the cellular type, 48% are landscape offices. Both types are mixed in most of the buildings with a varying degree from 2 to 100 % of the floor area as cellular offices. The floor area per person is also widely varying: from 1.5 m^2 per person (!) up to 100 m^2 for an executive office! The averages are 19 m^2/p for cellular offices and 16 m^2/p for landscape offices. The occupation of 8477 work places (from 3 to 1219 per building) in the 52 buildings is varying over time: on the average less than 60 % of the work places are occupied during the office hours; the effective use over all the time is even less than 10%.

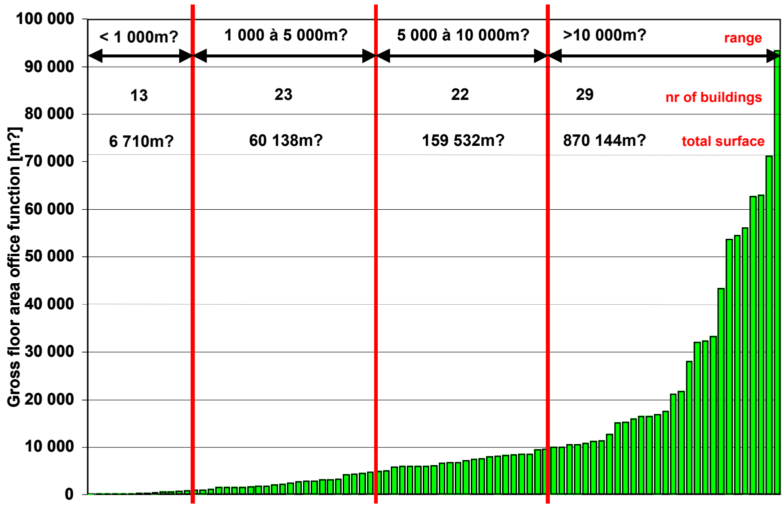

Figure 1 Gross floor area for office function of investigated buildings

BUILDING SHELL

The thermal characteristics of the shell show that a lot of energy may be conserved if better insulation were applied. U-values are quite high, as is shown on Figure 2.

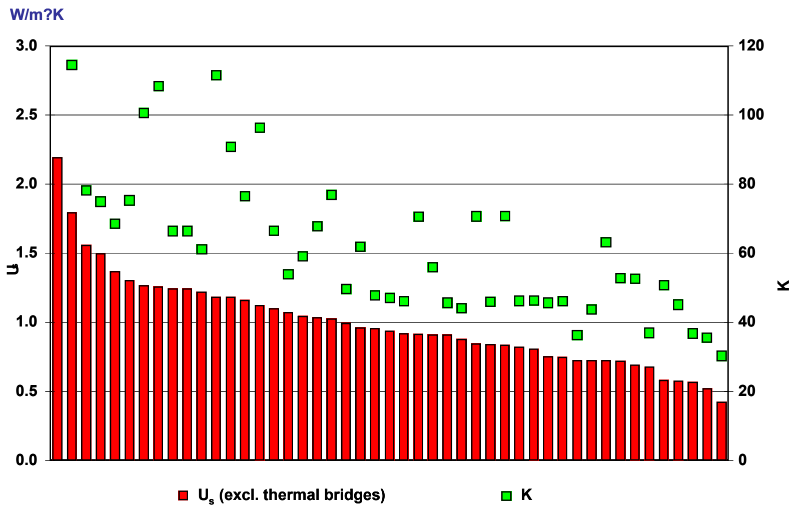

Figure 2 Mean U value of the building shell and K-value (level of global thermal insulation)

Simulations show that even very moderate insulation leads to a substantial reduction of the transmission losses. The average K-value (level of global thermal insulation according to NBN B62-301) can easily be reduced from 63 to 36. 85 % of the buildings obtain a value below K45.

As can be expected, the glazing in the facades is responsible for the larger part of the transmission losses: 14 % of the shell area accounts for 37 % of the transmission losses.

However, the glazing not only determines the heat losses but is also for the larger part responsible for the heat gains and hence for the thermal comfort in summer conditions.

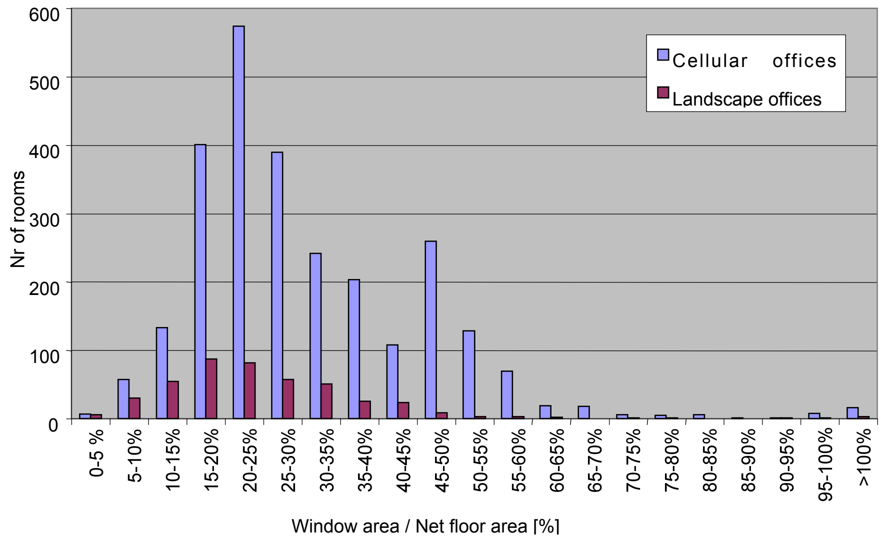

Figure 3 Distribution of window area over floor area

Whereas the German standard DIN 5034-1 recommends 10% of the floor area as glazed surface in the façade, the Figure 3 shows some of the 3300 investigated rooms having no window at all, but the vast majority of offices show percentages of 20 % and more (on the average 31 % for cellular and 25% for landscape type offices). These windows are often equipped with a solar shading device (71%), of which the vast majority are inside shading blinds. Only 18 % are also equipped with a movable outside solar protection system.

It was not possible to perform building shell air tightness measurements on a large number of buildings. Only 2 buildings were pressurized as part of a detailed study. The n_{50}-values yield 1 h^{-1} for a new built, energy efficient building and 2.8 h^{-1} for a renovated building.

EQUIPMENT

Building service installations have been surveyed in 52 buildings. These comprise heating, cooling, ventilation, air conditioning, humidification and hot water supply. Cooling is found in 13% of the buildings. Most striking is that 57% of the buildings are equipped with no ventilation system at all, except the possibility of opening windows. The performance of the HVAC systems is often rather poor: leaking air distribution systems, poor control and maintenance of the heating and cooling circuits, over dimensioned systems, etc.

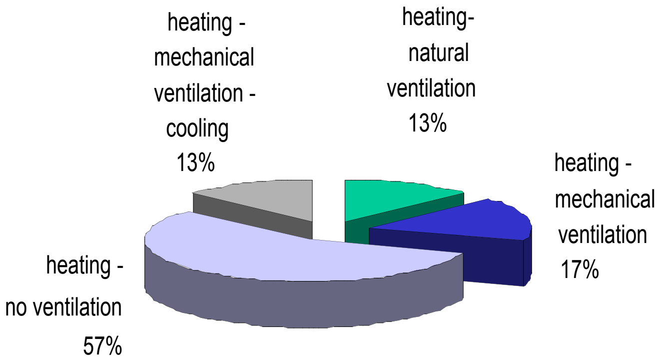

Figure 4 Type of HVAC systems found in 52 buildings

Furthermore, an interesting study has been done on the office equipment (PC's, printers, photocopiers etc.). These appliances often are huge electricity consumers, as well as a burden on the cooling load of the building and hence, on the thermal comfort of the occupants. In 2486 rooms of 46 buildings, 17725 office appliances were mapped. This leads to a building average heat load of 7.0 W/m^2 during daytime hours, with variations from 1.5 to 13 W/m^2 between buildings.

THERMAL COMFORT

Temperature measurements in 34 buildings in winter and in summer periods showed a large number of buildings with important overheating problems. During the monitored period in 30 buildings, the temperature exceeded 25 °C during 55% of the office hours in one building and 28 °C during 10 % of office time in 4 buildings.

INDOOR AIR QUALITY

CO_2-concenterations were monitored in 9 buildings. Poor air quality was obviously found in non-ventilated buildings. In others, very low CO_2-levels were found, leading to high energy demand in winter. 2 Buildings equipped with a demand controlled ventilation system showed good air quality for a reduced energy cost.

ENERGY USE

Energy consumption data have been analysed for all 87 buildings. The average normalised fuel consumption varies from 128 kWh/m^2 for the smaller buildings (up to 5000 m^2) to 95 kWh/m^2 for the larger ones (above 10000 m^2). The specific electricity use goes from 76 kWh/m^2 for the smaller categories to 105 kWh/m^2 for the larger ones. Within each category there is a huge spread between buildings: 25 to 220 kWh/m^2 electricity and 35 to 340 kWh/m^2 fuel. Air conditioned buildings all together consume twice as much electricity as non cooled ones.

CONCLUSIONS

A huge amount of data have been collected and analysed on 87 office buildings. This database forms a valuable instrument for building policy preparation. As such, it has been used for the preparation and evaluation of the new standards to be set in the energy performance regulation for new built and renovated office buildings developed for the Flemish region. An audit procedure and energy certification scheme for existing office buildings will be largely based on this experience as well. These items are core requirements in the new European Directive on the energy performance of buildings.

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