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CCB - VKB : Refurbishment of an existing office building designed to reduce its energy consumption below 100 kWh/m² per year

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Abstract

Samyn & Partners conceived with the studies of the Belgian Building Research Institute, the refurbishment of an existing office building in one of the most polluted avenues in Brussels. Designed to save maximum energy, the building meets all modern comfort standards, respects the environment and creates attractive and enjoyable working space.

DESIGN APPROACH AND AIMS

A more sustainable redesigning of the city is a long term approach. Today architects should prepare for this, but they have to deal with existing buildings with many unfavorable urban environmental factors : many spaces have no choice of orientation, are often set in noisy streets, with their window openings in contact with dusty and polluted air. They are overshadowed by surrounding buildings.

Samyn & Partners [1] has submitted a proposal (not retained) with technical expertise by the Building Physics and Indoor Climate Division of the Belgian Building Research Institute (BBRI) in the framework of a limited architectural competition. The project design consists in refurbishing an existing office building with a total area of 8700 m² in a very hostile environment in downtown Brussels (see Figure 1).

This former industrial building is converted into a head office building (CCB - VKB [2]) which is 25 metres high and 50 metres long, located on one of the major business city streets.

The general design approach of Samyn & Partners is marked by a serious concern for low cost, energy use control, as well as maintenance and operating costs, and makes use of the most diverse range of materials [3]. Energy concerns have to be achieved without detriment to the visual, hygrothermal and acoustic comfort of the occupant, even in noisy and polluted areas.

In this project, the natural solar energy is fully employed : the proportion of usable daylight is increased by a wealth of construction techniques. Daylight is redirected to avoid glare and provide high quality illumination during daytime hours, so that the proportion of artificial light (and internal heat gains) can be reduced.

Figure 1: Photo-montage of the Caisse-Congé du Bâtiment by Samyn and Partners

The Belgian Building Research Institute (BBRI) is in charge of the lighting, thermal and indoor climate studies. The hygrothermal comfort based on the natural ventilation strategies during the night, and the use of the thermal storage capacity of the existing structure brings about proper comfort quality inside and low energy consumption.

TRANSLATING THE AIMS INTO BUILDINGS.

In order to avoid noisy disturbances from the road and for thermal reasons, a double skin facade is placed alongside the street. The double skin façade provides good acoustic insulation. The building has a "U" shaped base erected around a wide internal courtyard with two levels of parking areas underneath (see Figures 2 and 3). For reasons of energy and thermal comfort, the South-Western façade is also composed of a double skin. The courtyard is fitted with a wooden terrace, planted with trees providing a quiet and pleasant space which contrasts with the polluted street on the opposite side.

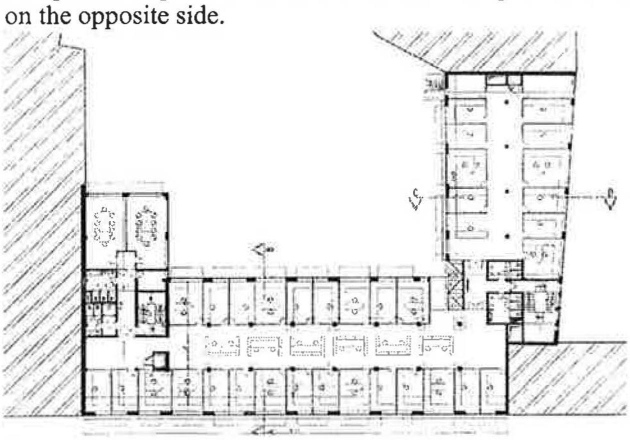

Figure 2: Plans of the first and second floors

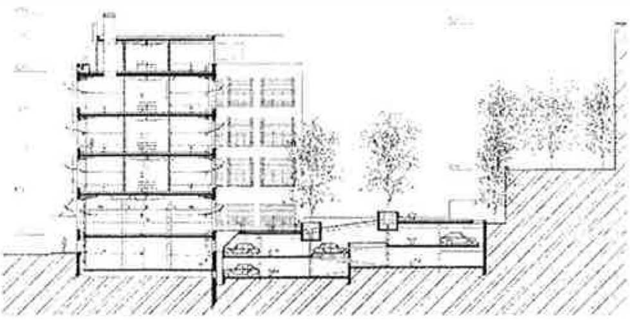

Figure 3: Section AB

Heat recovery

Hygienic ventilation air is taken in the courtyard, mechanically circulated through the double skin up to the building roof from where it is distributed in the offices. This operation of the façade allows to pre-heat the ventilation air by collecting solar gains and the thermal losses through the original façade. The accumulation of losses leads to an equivalent U-value of about 0.2 W/m² K.

Solar protection

During the summer, the façade is still ventilated mechanically at daytime in order to evacuate the heat gains due to the absorbtion of the solar radiation by the shading system installed in the gap. The warm air is then rejected while the fresh ventilation air is taken on the roof of the building [4].

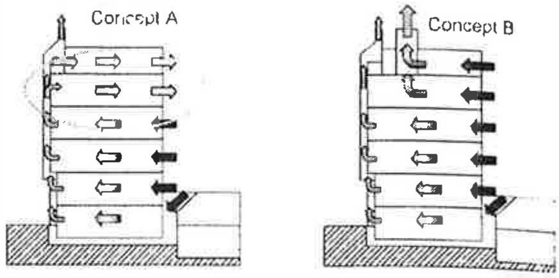

Figure 4: Night time ventilation (free cooling system)

The south-eastern façade facing the inner courtyard allows for natural ventilation during the night. The proposal consists in keeping the existing concrete structure, redesigning the façade and reorganising the interior space. The good existing thermal storage capacity is exploited to allow for free-cooling during the night. The double skin façade acts as a thermal chimney : cool air from outside is driven from the courtyard through the three lower levels through the double skin to outside at the top (see Figure 4). Upper levels are ventilated naturally by an independent thermal chimney (see Figure 5) to avoid re-circulation risks.

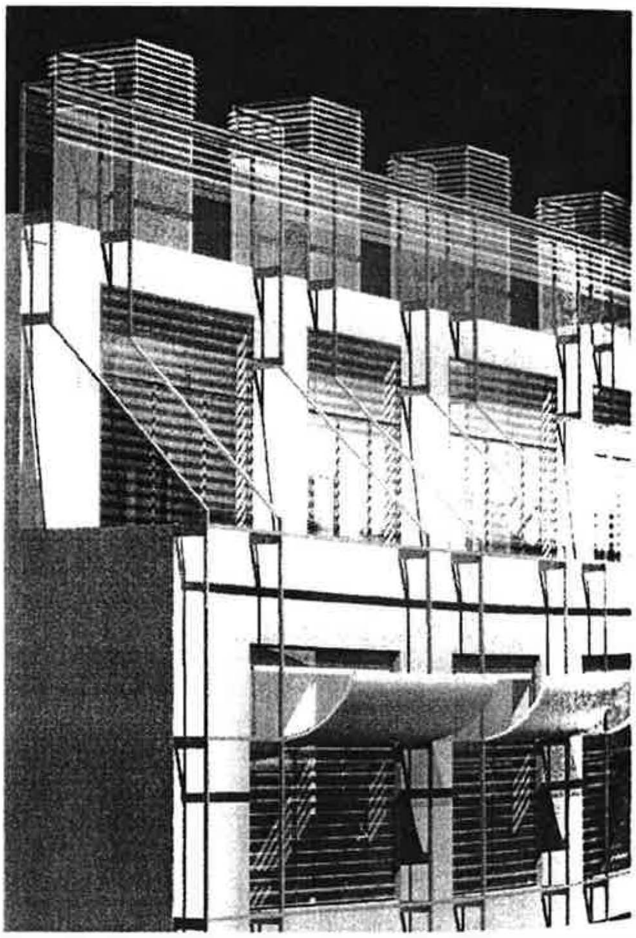

Figure 5: Thermal chimneys at the top of the double skin

In order to increase the thermal storage surface capacity, raised floors are composed of concrete paving stones at each level. In summer, the concrete structure is cooled by night-time ventilation, and in winter the concrete mass keeps the heat. No suspended ceilings are provided thus allowing for the use of the concrete ceiling structure for thermal storage capacity.

Visual comfort

The very high ceilings and wide openings allowing for a large window to wall area would ensures a very high level of daylighting, but also, a high probability of glare coupled with a lack of natural light in the centre (the building is 17m wide). This possible problem is solved by introducing lightshelves and venetian blinds on each window. These lightshelves designed following the principles developed by R. Compagnon from the EPFL of Lausanne [5], reflect the natural light so as to reach the middle of each area (up to 500 lux, March 21 at 9h00) and prevent glare troubles near the windows and reflections on computers screens (see Figure 6).

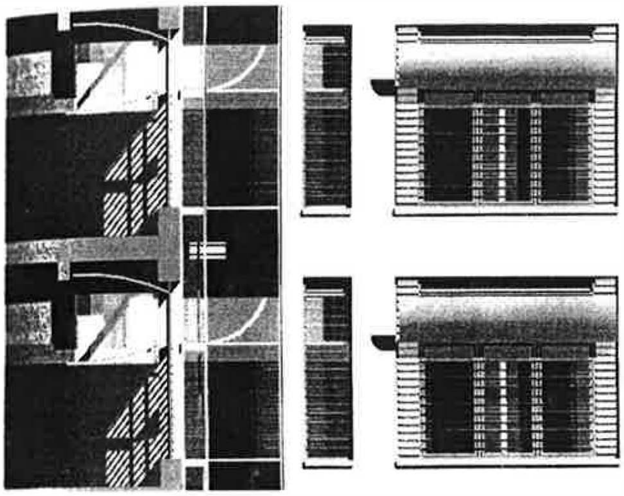

Figure 6: Lightshelves

These lightshelves allow each occupant to close their blinds while natural light penetrates deeply into the middle of the building. This system avoids the «blinds close - lights on» effect [6] and, which incites to switch lights on even during sunny days. The curved ceiling shape plays a role in reflecting daylight uniformly and avoiding shaded areas created by the masonry elements of the façade.

Daylight distribution simulated with the Adeline Software for the 21 March at 9h00 with a clear sky are shown in Figures 7 to 9. Daylight simulation for the first case (see Figure 7), illustrates a bad daylight distribution and the need to use shading devices to avoid glare troubles in the office where 13.000 lux are provided near the window for only 350 lux in the corridor. Figure 8 shows the capacity of the shading device to reduce the illuminance level in the office, but does not provide enough light in the corridor (90 lux). The last case (see Figure 9) demonstrates that the use of lightshelves combined with shading devices under them provides a good daylight distribution.

Materials have also been carefully chosen in order to favour daylight illumination. Window frames are mirrored to increase the diffusion of natural light. Office separation panels are painted white and fitted with a glazed area on each upper part, in order to distribute the light while at the same time maintaining office privacy.

To achieve a lower electrical consumption level and minimise internal heat gains, efficient light bulbs (compact fluorescent lamps) with daylight compensation are proposed. Lights fittings are integrated into the lightshelves to avoid direct shadows.

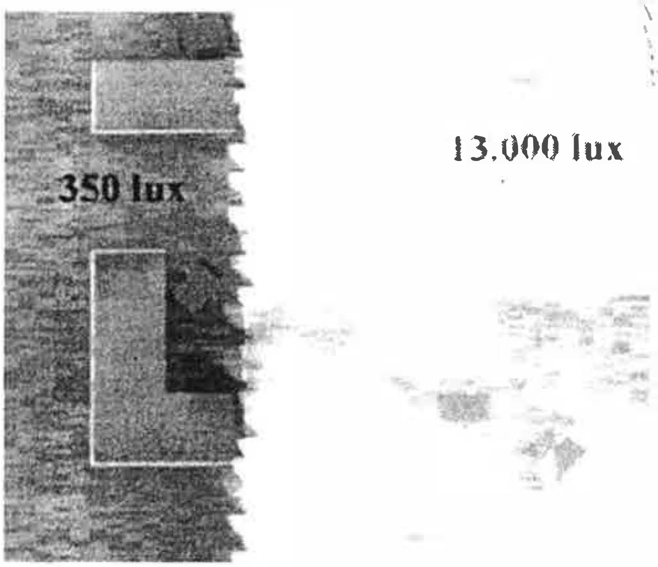

Figure 7: Standard case without shading devices and lightshelves

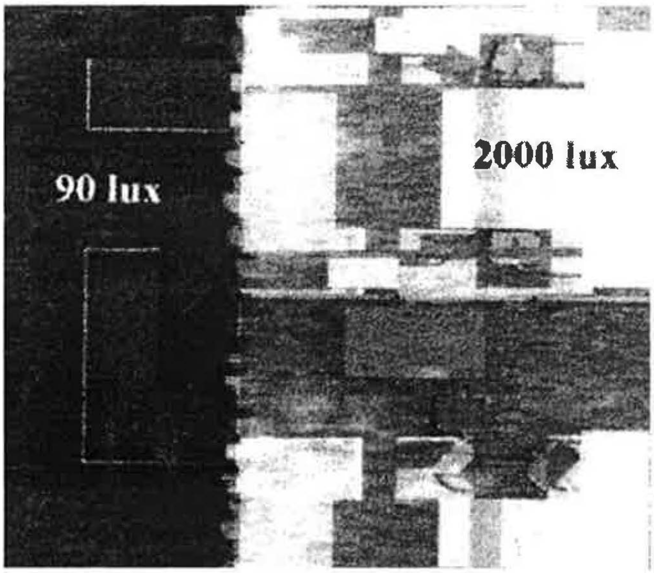

Figure 8: Standard case with shading devices

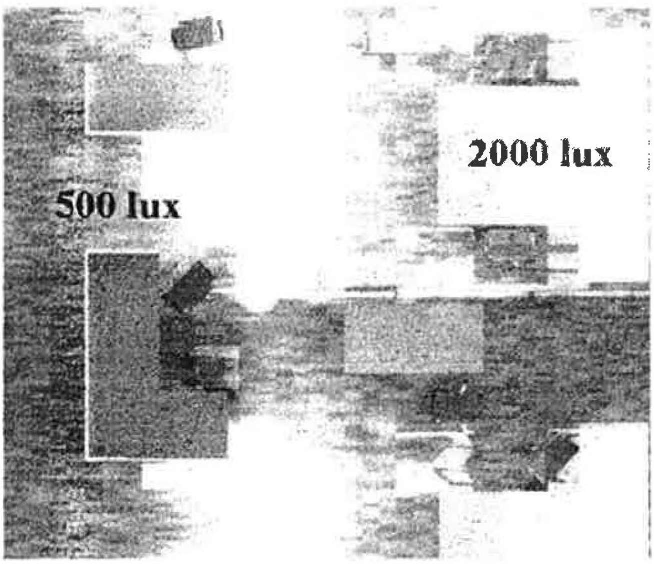

Figure 9: Standard case with shading devices under lightshelves

Air quality and hygienic ventilation

The CCB-VKB building combines two different techniques which reduce the energy consumption due to ventilation. The first technique consists in using the preheated air located between the two glazed façades. In addition, a heat exchanger between the extracted air and the inlet air allows to recover a large amount of energy.

Secondly, occupants and construction materials are potential sources of air pollution [7] in office buildings. In order to reduce the ventilation outflow to a minimum rate, construction materials and furnitures are non air pollutant (hence carpet, vinyl paintings, asbestos... are excluded). BBRI estimates a ventilation rate of 15 000 m³/h for a typical building occupation [2].

Maintenance

Previous experiences of double skin façades designed by Samyn & Partners [8] show that maintenance costs are equal or inferior to a typical stone façade.

For the maintenance of the façade alongside the street, sliding ladders and life lines allow cleaning of the external glazed façade. The courtyard façade is openable and enables an easy upkeep. The cleaning of the inner glazed façade is accessible by the opening of inner wooden framed windows.

Rain water along the glazed façade is collected by a thin conducts network included in the external glazed frame element. Window elements have the same sized in order to be replaced easily and to be produced in large quantity at a low price.

ENERGY CONSUMPTION

Figure 10 shows a comparison of delivered energy in kWh/m² per year between the CCB-VKB Building and a typical naturally ventilated office building (Good Practice) [9]. The estimated energy consumption of the building is 50 kWh/m² per year without the office equipment energy consumption.

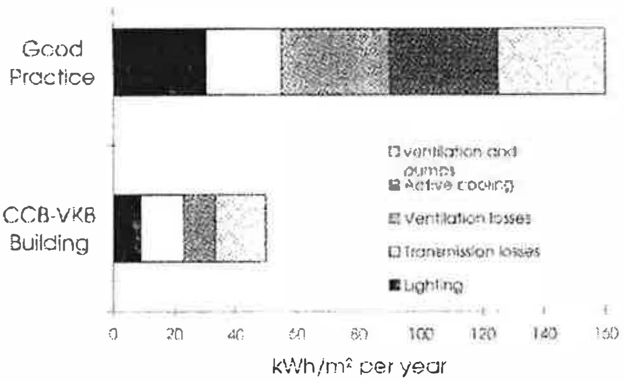

Figure 10 : Delivered energy comparison.

BBRI estimates that this consumption will save 100 kWh/m² per year in comparison to a typical naturally ventilated office building without any reduction of internal comfort whilst improving the occupant's quality of life.

CONCLUSION

Designed to guarantee energy consumption below 100 kWh/m² per year, the CCB-VKB project allows for the best natural lighting, the lowest energy consumption and savings on maintenance and management costs. It meets the client's corporate image combined with traditional human values and comfort.

This refurbishment example of an existing building shows clearly that solutions can be found to participate in every scale, towards a more sustainable and environmentally friendly city.

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