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THE AULA MAGNA: A 1200-SEATS MULTIPURPOSE HALL FOR THE UNIVERSITE CATHOLIQUE DE LOUVAIN CONCEIVED TO SAVE MAXIMUM ENERGY.

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ABSTRACT

Samyn and Partners conceived a 1200-seat multipurpose hall for the Université Catholique de Louvain based on the studies carried out at the BBRI (CSTC-WTCB). Designed to save maximum energy, the building uses environmentally-friendly strategies.

KEYWORDS

Building design, double-skin façade, energy savings, free-cooling, thermal comfort, sustainable architecture.

1. DESIGN APPROACH AND AIMS

Since 1996, Samyn and Partners (the design was carried out by Ph. Samyn, Gh. André, Y. Avoiron, F. el Sayed, J.-F. Roger-France, B. Thimister, E. Krzeslo, C. Van Haeren) is in charge of the design of a hall aimed at staging large scale academic events capable of assembling 1200 people. This multipurpose hall called "Aula Magna" will be located on the site of the Université Catholique de Louvain in Louvain-la-Neuve, Belgium, between the Grand-Place and a lake. The building must also cater to the greatest possible and desired number of events for the town and the region. The building (see Figure 1) is laid out on a rectangular plan (31.5m by 72 m and 19 m high) including an 8m10 structural grid. The box-like building is covered by a glazed outer façade which encloses a box in the inside, lined with wood. Between these two skins there is a 55 centimeter cavity.

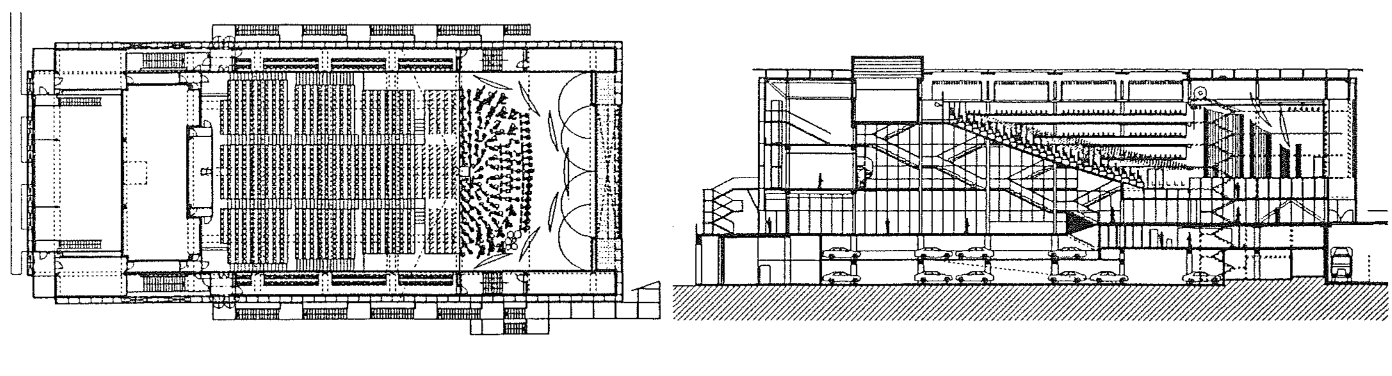

Fig. 1. Fourth level plan and longitudinal section.

The lateral façades which amount to about 1200 m² of glazing, are oriented to the South-East and the North-West (see Figure 2). The project is organized so that the major lecture hall is located above a large public lobby (called foyer) extending over the whole building including access stairs to the lecture hall and restricted lobbies. Two underground levels are reserved for a public parking area.

In order to become an example for the University and for the city of the year 2000 (scheduled building completion), the Aula Magna uses as little energy as possible. Samyn and Partners has a general approach characterized by a serious concern for energy-use control with special care for the environment and in particular with regard to energy and natural ressources saving, both in terms of energy production for the building as well as in its operation and maintenance (Samyn and Capron, 1996). The Indoor Climate Division of the Belgian Building Research Institute (BBRI) is in charge of the building physics study of the building. The team of Professor G. Vermeir of the Katholieke Universiteit Leuven is responsible for the acoustical study of the building and Flow Transfer International is the services engineer.

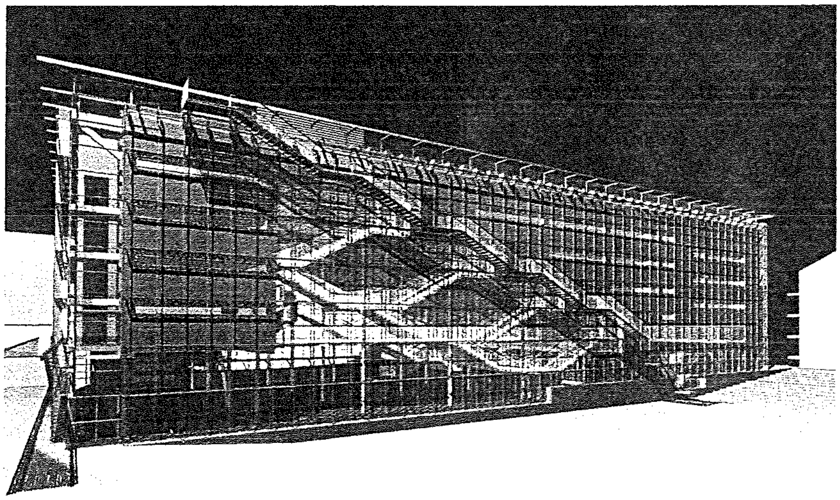

Fig. 2. The lateral façade of the Aula Magna for the Université Catholique de Louvain.

Energy concerns have to be achieved in order to obtain a good visual, hygrothermal and acoustical comfort of the occupant. The fully glazed façade has to fulfill comfort requirements while avoiding or limiting the use of active cooling during the summer and minimising heat demand during winter. Another aspect of energy saving is the use of natural light. Lecture halls usually have no natural light and consume a lot of electrical energy. The Aula Magna is designed with openings in the auditorium roof in order to provide the possibility to give lectures with daylight during the day. Visual comfort is also simulated by the BBRI (CSTC-WTCB, 1997).

2. TRANSLATING THE AIMS INTO BUILDINGS.

Environmentally-friendly design with "passive techniques" consists in controlling the summer indoor climate by the use of efficient protections against solar gains and the application of an intensive night ventilation strategy. It also means avoiding or limiting the use of an active cooling system. The solar gain factor is evidently the most important parameter in the design of the transparent envelope. Solar control is achieved by using a movable transparent shading system and clear glass in order to guarantee a clear transparency of the building.

Design and optimisation of the glazed façades.

Three types of glazed systems have been taken into early consideration in the search of the most energy efficient and transparent façade: a simple façade made of improved double glazing and fitted with an external solar protection (SP), the same façade but with an inner solar protection (SP) and finally a double façade made of two layers of improved double glazing (IDG) and ordinary double glazing (ODG), incorporating a movable shading system (SP) in the cavity. Figure 3 shows the total energy transmittance of the different types of façades simulated by WIS Software (WIS, 1994-1996).

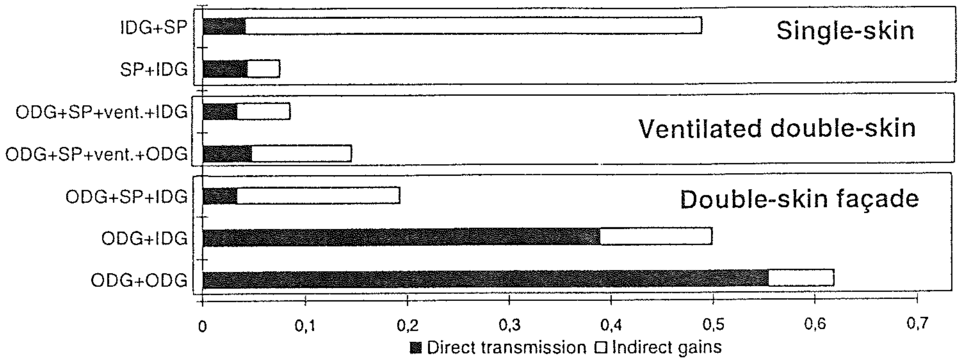

Fig. 3. Total solar energy transmittance of different types of glazed façades under consideration.

Simulation results show that only a single façade with an external solar protection or a ventilated double façade could reduce sufficiently the solar gains in the foyer. Ventilation of the gap between the two façades allows to evacuate the solar heat gains in summer. The double-skin façade acts as a thermal chimney: intake ventilation grills and openable windows are placed at the bottom and the top of the façade. The choice of a double skin is retained for better durability and maintenance costs of an inner protected solar protection and, also, for better thermal insulation properties (total U-value of 1.2 W/m²K) which reduce the heating energy consumption.

Starting from the double skin façade concept, different types of double glazed façades have been compared in order to obtain the most energy efficient solution. Dynamical simulations of the summer thermal behaviour of the foyer have been performed by the BBRI to determine the impact of the double-skin choice on the active cooling load (CSTC-WTCB, 1997).

Type of façade	Peak net cooling power demand (sensible)	Peak net cooling power demand (sensible + latent)	Hours/year during which the cooling system is used
Original double-skin	145 kW	230 kW	52 h
Incorporated blinds façade	175 kW	260 kW	86 h
Double incorporated blinds façade	130 kW	215 kW	33 h

Table 1. Peak cooling power demand for different types of façades.

The peak net cooling demands resulting from the simulations are given in Table 1 for different double-skins. The incorporated blinds façade consists in the integration of an incorporated venetian blind in a double framed window. The double incorporated blinds façade is composed of a double skin with incorporated blinds at exterior double glazing. The total yearly energy consumption of the foyer has been simulated for the three types of advanced façades as well as for the preliminary design option (double glazing without solar protection).

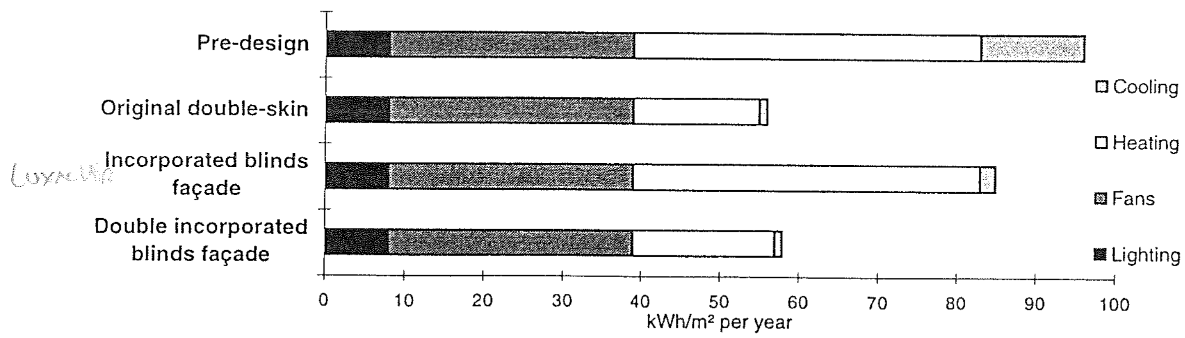

Fig. 4. Yearly energy consumption of the foyer for different façades options.

Results given in Figure 4 show similar performances for the double incorporated blinds façade and the original double skin, while the cost of the incorporated blinds façade is significantly higher. The double-skin allows much lower U-values and higher surface temperatures than incorporated blinds façade (Central U-value of the incorporated blinds is about 2 W/m²K). In terms of sustainability, the original double skin concept has the advantage of being an advanced glazed system made of rather simple components: ordinary and improved clear double glazing and a shading system which does not need to have a high mechanical resistance and which is well protected from both the outdoor climate and the deterioration by the building occupants. Therefore, the double glazed façade with solar protection in the cavity is retained. The principle of a double-skin façade incorporating a shading system provides good thermal comfort and reduces the energy consumption, such as other similar types of façades developed by Samyn and Partners (Roger-France, 1996).

Design of the lecture hall and cooling demand.

The high volume of the lecture hall coupled with the number of spectators allows a mechanical low flow ventilation rate. For acoustical reasons, natural ventilation is avoided and the lecture hall is mechanically ventilated. Hygienic ventilation air is taken from the top and pulsed under each seat of the lecture hall. The exhaust air is then rejected through the suspended ceilling to the top. Thanks to a demand controlled ventilation system based on the measurement of the CO_2 level, the ventilation rates are driven by activities. BBRI demonstrates that only 360 kWh of cooling power demand is necessary during a short period of extreme unusual temperatures.

Simulations (CSTC-WTCB, 1997) have revealed that no cooling plant is required due to the use of the low temperature provided from the ground water. Feasibility studies show, however, that for such a small power demand, it is less expensive to occasionnally use a small cooling plant during peak temperatures in summer with less energy consumption rather than using ground water temperature. It also mentions that natural light is introduced into the lecture hall thanks to openings in the roof, which induces to reduce electrical consumption and helps in defining this building as a sustainable architecture.

3. CONCLUSION

BBRI estimates that the energy consumption of the building will be lower than 80 kWh/m² per year with a maximum occupation during hot summer conditions (CSTC-WTCB, 1997). The energy efficient strategy designed by Samyn and Partners, based on studies carried out by the BBRI, will save maximum energy. Among different energy efficient strategies options, a glazed double skin incorporating a shading system, is from a strict economical point of view less relevant than a simpler configuration, but is preferred for environmental, durability and sustainability reasons. Designed to guarantee a minimum energy consumption without any reduction of internal comfort, this new lecture hall will become an example of a sustainable building for the Université Catholique de Louvain.

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