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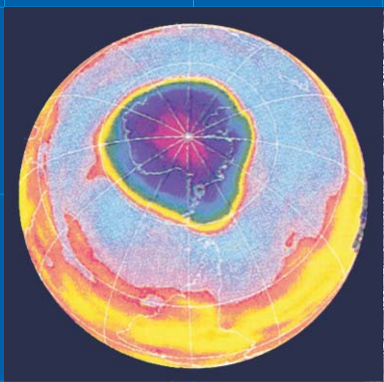

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DOUBLE-SKIN FAÇADE AS A CONTRIBUTION TO SUSTAINABLE ARCHITECTURE : THE FEDERAL OFFICE OF STATISTICS TOWER IN NEUCHÂTEL (SWITZERLAND)

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ABSTRACT

Taking the criteria of sustainability into account in the design process involves interactive optimization between the environmental, socio-cultural and economic criteria of the project. As the principle climatic interface and an important architectural component, the façade represents a fundamental element in this context, as shown by the one specifically developed for the Federal Office of Statistics (FOS) tower in Neuchâtel. Intensive collaboration between architects, engineers and constructors indeed results in high performances in terms of energy consumption and comfort, while simultaneously contributing considerably to the building's expression and identity.

RESUME

La prise en compte des critères de développement durable dans le processus de conception architecturale implique une recherche d'optimisation entre des critères environnementaux, socioculturels et économiques. En tant que principale interface climatique et élément expressif prépondérant, la façade joue dans ce contexte un rôle crucial, à l'instar de celle développée spécifiquement pour la tour de l'Office fédéral de la statistique à Neuchâtel. Grâce à une collaboration intensive entre architectes, ingénieurs et constructeurs, sa conception a en effet permis d'atteindre une haute performance en termes de consommation énergétique et de confort, tout en contribuant fortement à l'identité architecturale du bâtiment.

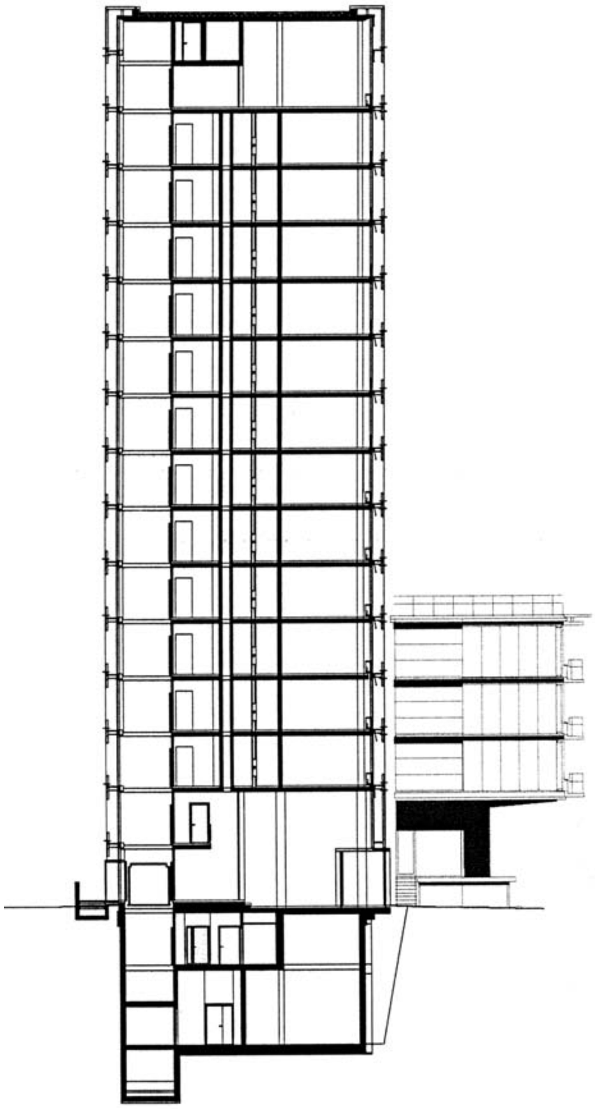
INTRODUCTION

The realization of the FOS tower constitutes the extension of the first building as well as being the flagship of the Ecoparc project, promoting the sustainable regeneration of a large urban wasteland in the area surrounding Neuchâtel railway station [1]. Thus, the building represents a tangible experiment to integrate sustainability into the design process and its conception includes numerous of environmental, socio-cultural and economic criteria [2]. Making a selection among the multiple dimensions of the project, the present paper focuses on the specific aspects of the double-skin façade. This component is indeed particularly representative of the holistic, interdisciplinary and evaluative approach that was adopted for the whole building. It is notably characterized by a coherent integration of aesthetics, energy and comfort aspects. After one year of monitoring, the first results moreover tend to confirm the pertinence of the different choices made.

ARCHITECTURAL AND TECHNICAL CONCEPT

Integration of sustainability criteria into the design process

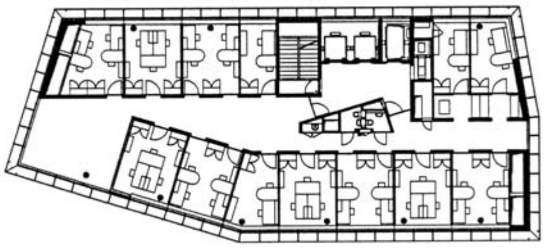
With its specific typology, the FOS tower has become an urban landmark. On the city scale, it indicates the localization of the railway station. On the site scale, it reinforces the new strategic vocation of the Ecoparc area and clarifies the implementation of the first FOS building [3]. The tower is 50 meters high and includes a cultural area on the ground floor, which is directly in contact with the urban context - 297 workplaces distributed on 12 office floors and conference rooms on the top floor. A footbridge makes the junction with the first FOS building at 5^{th-}floor level.

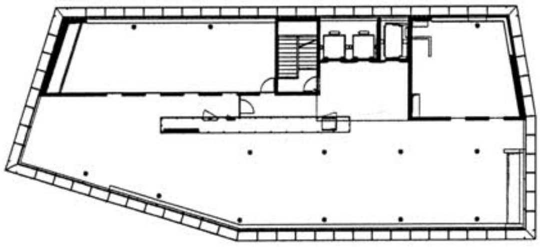


Figures 1-2 : Cross section and south-eastern view (document Bauart, photo R. Walti)

The form and expression of the FOS tower have emerged from an architectural transposition of different urban issues. In order to give an emblematic and coherent response to them, the building's shape is a kind of glass monolith, whose geometry is the direct result of the generating lines of the site. Its volume thereby presents multiple facets, which accentuate its verticality and generate different perceptions, depending on the point of view.

The choice of a double-skin façade is essentially due to the search for coherence with the climatic strategy already adopted for the first FOS building, i.e. maximal use of natural ventilation and passive night cooling [4]. In this way, a double-skin façade presents the advantage of creating a peripheral tempered space, necessary in a high-rise building like this to enable the opening of windows, and providing efficient protection for solar blinds [5]. This choice is also coherent in terms of esthetics, the external skin reinforcing the monolithic aspect of the building and the diversity of its perceptions.

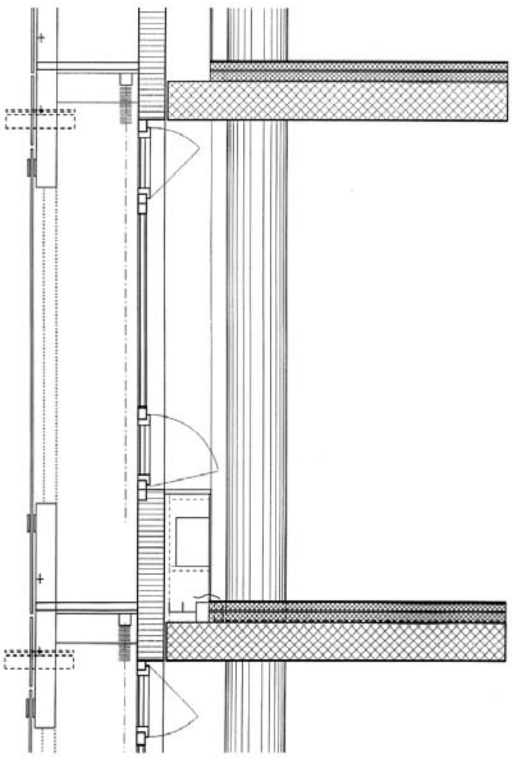




Figures 3-4 : Typical floor plan and top floor plan (documents Bauart)

Parameters taken into account for the façade conception

As research carried out by Faist has shown, summer comfort requires specific care in buildings with double-skin façades because this kind of façades presents a higher risk of overheating than other ones [6]. Depending of the specific project conditions, the choice of the right typology for the interstitial space is therefore crucial [7]. For the FOS tower, many dynamic simulations were made with *TRNSYS* and *FLOVENT* and led to the choice of a mono-lateral ventilation type with a systematic separation between each level and shifted openings in order to avoid by-pass. The position of the blinds and the clear color of the internal skin were chosen in order to limit the risk of overheating.



Figures 5-6 : Detail section of the double-skin façade (document Bauart) and view of the interstitial space (photo Th. Jantscher)

Economic and ecological criteria have also been integrated into the decision process. These aspects have led to a particularly simple design for the façade construction, in part specifically developed for this building. A life-cycle analysis influences the choice of material for the façade structure, which is in steel and not in aluminum as usual for this kind of façade.

Energy concept and indoor comfort management

The conception of the façade constitutes an important part of the energy concept of the whole building. This one is based on a bio-climatic approach, trying to combine satisfactory user comfort with minimal non-renewable energy consumption. Following through with the Ecoparc project philosophy, the process is based primarily on a strong reduction in energy demand, secondly on the integration of renewable sources to carry out the residual demand.

In winter, the FOS tower is characterized by small losses because of the high thermal quality of the roof (U_{roof} = 0,23 W/m2K), the façade ($U_{façade}$ = 0,78 W/m2K) and the ground (U_{ground} = 0,78 W/m2K). A double flow ventilation system provides the necessary quantity of air, with a rate of almost 40 m^3/pers.

The user is still free to open his/her window, but the automatically-controlled external skin remains closed. The building also benefits from internal and solar gains that are intensified by the double-skin façade. The residual demand is partly satisfied by the seasonal solar stock of the first FOS building (2'400 m^3 related with 1'200 m^2 of roof solar captors), which had a power reserve, and for the remainder by a gas heating production (also located in the first FOS building).

In summer, the external skin openings are automatically regulated and the solar protections are automatically down, in order to reduce solar gains. The user is still free to open her/his window and to move the solar protections. The windows of the internal skin are in principle opened only when the indoor temperature is higher than the outdoor one. During the night, the windows of both skins are opened.

The important thermal mass in the offices allows an efficient night cooling of the whole building. The specific form of the building is comparable with an aircraft wing and is particularly suitable for the efficiency of natural ventilation. As a complement and security, the winter ventilation system can also be used in summer, up to almost 80 m^3/pers, and is coupled with an adiabatic cooling system. The expected values for the summer comfort in the offices are presented in Table 1.

Types of cooling strategy	**Nb hours > 28 °C**	**T_{peak} [°C]**
No adiabatic cooling, only passive night cooling	54	32
Adiabatic cooling and passive night cooling	26	30.5
Active cooling as complement to the adiabatic and passive night cooling	10	29

Table 1 : Expected values in the offices (data Sorane).

This approach, which received the Minergy label, was clearly explained to the users, in order to raise awareness of the concept of sustainability and to detail their specific role in appropriate window-opening management. The importance of this communication is a part of the Ecoparc project philosophy and was already experimented with fulfillment in the first FOS building [1].

RESULTS

Actually the whole building is monitored in order to optimize its energy consumption and the summer comfort in the offices. The first results are presented here, in particular the effective energy consumption of the building (cf. Table 2) and measured temperatures in the north and south offices during some typical summer days (cf. Fig. 7).

As Figure 7 shows, the peak temperatures in the offices are under 28°C in accord with the simulations. The night cooling provides the means to decrease the temperature of 2°C supplementary, but it is lightly less performing as expected. The reason is that not all occupants let their office window opened during the night because of some water entry problems that happened during strong stormy days. For that reason, the strategies will be soon adapted and the blind shutters (solar protection) will be automatically put down while it is raining during the night and weekend.

	Project values		**Reference values**		
	Expected	**Measured**	**SIA limit value**	**SIA target value**	**Minergie**
	[MJ/m²y]	**[MJ/m²y]**	**[MJ/m²y]**	**[MJ/m²y]**	**[MJ/m²y]**
Heating	80	90	360	216	144
Electricity	80*	113**	180	90	90

Table 2 : Energy consumption values of the building (data Sorane, July 2005).

* *The expected value here corresponds only to electricity consumption for HVAC and lighting (computers and other user machines were not included).*

** *The measured value corresponds to the total electricity consumption of the building, i.e. with computers and all user machines.*

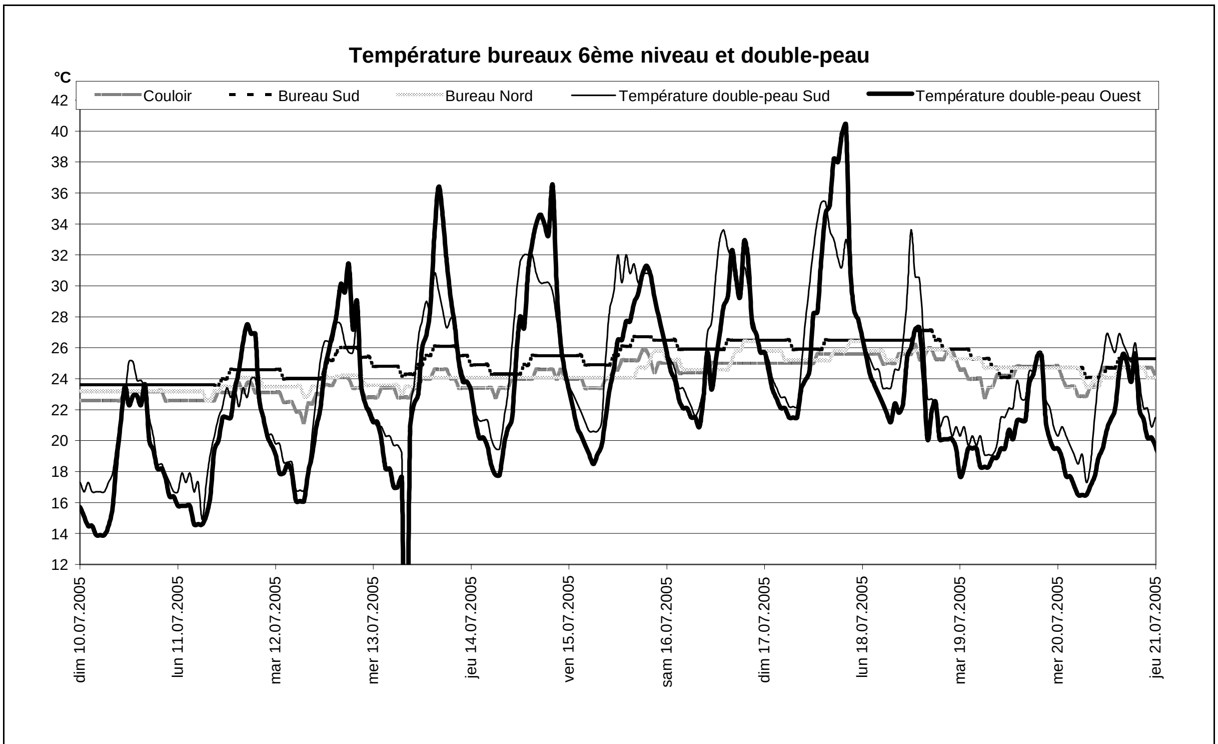


Figure 7 : Measured temperatures in the north and south offices during some typical summer days (data Sorane, July 2005).

After one year in operation, the effective performances of the building can be considered as really satisfying in comparison with usual reference values (cf. Table 2). The constant monitoring and some strategic adaptations should moreover enable to reach a complete optimization in the near future.

DISCUSSION

The search for optimization between environmental, socio-cultural and economic criteria requires a holistic, interdisciplinary and evaluative approach. This should not be conceived as parallel to the design process, but as an integrated part of it. The conception and the realization of the double-façade for the FOS tower thus constitute a tangible demonstration of interdisciplinary project conception. The first results tend to show that it is possible to reach high performances in terms of energy consumption and comfort, with coherent architectural expression and at the usual cost for this kind of office building, i.e. less than 100'000 CHF/workplace.

These results are due to a precise conception, bearing summer thermal comfort in mind especially. Based on intensive collaboration between architects, engineers and constructors, the team philosophy was to look for the most appropriate solutions and the optimal means to reach the objectives.

In this way, the choice of the double-skin façade has to be related to the project specificity. Its potential application to another building requires an in-depth analysis, which should be based on the site, the program and the typology of the project. Confirming considerations from other research, it clearly appears that the use of double-skin façade does not automatically imply improvement of the building's sustainability [8] [9]. Only a strong adequation with the project requirements and an effective optimization during the whole design process can provide a significant contribution to sustainable architecture.

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