For Europeans, a window with air infiltration is a problem, which means more expenses with the heating system and/or with doctors to heal a cool or an influenza. On the other hand, the inhabitant of the tropics does not associate bare window with money expenses; on the contrary, they know that simpler windows are cheaper. But nowadays, when a dweller, that has incorporated this concept, buys an air conditioner to improve its thermal comfort, it will be shocked by the problems that window's slits may cause. Therefore, slits became heat sources and energy and money sink. The same happens with the architect who associates window with a simple device: although it stipulates that a building will have central air conditioning, no care will be taken to improve the quality of the windows, or to think about double glazing or setting insulation on the walls.

About behaviour: in Europe, bedroom windows are opened in the morning, after everyone leaves the room. The internal cold air is renewed by the external, which is warm because heated by the sun. At night, windows remain closed to avoid the cold air to enter. In tropical America, following this imported culture, people have the same procedure, although the effect is quite different. Windows should be opened during the night, cooling the building and allowing ventilation, and closed during the day, to inhibit the warm air to enter and heat the internal space, using mechanical fans for ventilation if necessary.

CONCLUSIONS

Traditional architecture teaching in tropical countries is in crisis. The discipline contents do not reflect the necessary integration between architecture and local environment - meaning climate, landscape, history, inhabitants psychology, etc. Architects reproduce design solutions caring for formal aesthetics, forgetting that their goal is environment changing to make it comfortable, pleasant and of first quality. As Latin American universitiy professors in architecture, our proposition is to move our teaching to the concepts enhance and simplified formalization, based on the local reality. In Brazil, specifically, this means to rely teaching on the experiences of the Brazilian Modernism movement (Bruand, 1981) starting in the forties, incorporating the concepts and tecnologies developed over the last years.

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Double Facades - The Reduction of Cooling Energy in Summer and the Use of Solar Energy During the Winter

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Keywords

double facade; natural ventilation; insulation, transparent insulation; overheating; cooling; upgrading; renovation; air exchange; ach

1 Double facades - state of the art and necessary improvements

Double facades are designed to allow natural ventilation especially in buildings, where this is in general not possible due to high outdoor noise levels and / or high wind speed levels (high rise buildings). These facades were recently realised at numerous prominent buildings in Germany.

To reduce wind speed and noise a second (glass) facade is positioned in front of the inner building facade. The space between the facades is used to position the sun protection devices energetically optimal outside the primer building, but well protected from wind and weather influence. The risk of overheating of double facades in summer is evident, but can be cleared with a well dimensioned space between the facades and optimised openings.

2 Reduction of cooling energy in summer

According to German building regulations, for artificial conditioned buildings certain defined room climate conditions must be guaranteed. DIN 1946 requests temperatures of 27 °C as an upper limit for summer conditions, a fresh air supply of 30 m^3/h for small office spaces (60 m^3/h for bigger office spaces) and at least 30% relative humidity. To maintain the requested room conditions, the insert of energy is necessary, e.g. in form of air conditioning.

For rooms without natural ventilation there is no upper limit set by regulations for room temperatures, no minimum limit for air changes per hour (ach) and no order for relative humidity. In case of natural ventilation these values depend on the pressure differences between the room and the environment (ach) respectively on the outer climate (temperatures and humidity). Because no special conditions are demanded, no energy will be put in to guarantee those conditions, if a certain connection of the inner room climate to the outer climate is tolerated by the user.

At high rise buildings no movable outer sun protection is possible due to wind induced problems. Solar energy always enters the building system and has to be removed later, e.g. by room conditioning. The entry of solar energy into the building can be controlled effectively with a sun protection in the space between the inner and outer facade, like it is possible with a double facade and the gain of solar energy in summer can be reduced by 30 % in a high rise building (see also Oesterle at al., 1997). A ventilation system is not necessary, because the windows can be opened. If temperatures beyond 27 °C can not be tolerated during a few days in summer, cooling can be provided with minimised expenditure with water-pipes in the solid ceiling (see fig. 1.).

To improve double facades especially in terms of preventing overheating in summer, a detailed computational fluid dynamic calculation is necessary. The results of these calculations correspond with the experience, we have got from detailed measurements in two office buildings (Victoria Insurance Company, Düsseldorf and a high rise building in Dortmund).

The high-rise building in Dortmund was upgraded with a double facade and the full air condition system was removed without replacement. Long term measurements in Dortmund have shown, that the ventilation rate was in average 3 times greater , than the necessary ventilation rate (fig. 2.). The peak temperatures during the summer 1997 did not exceed the temperatures outside the building.

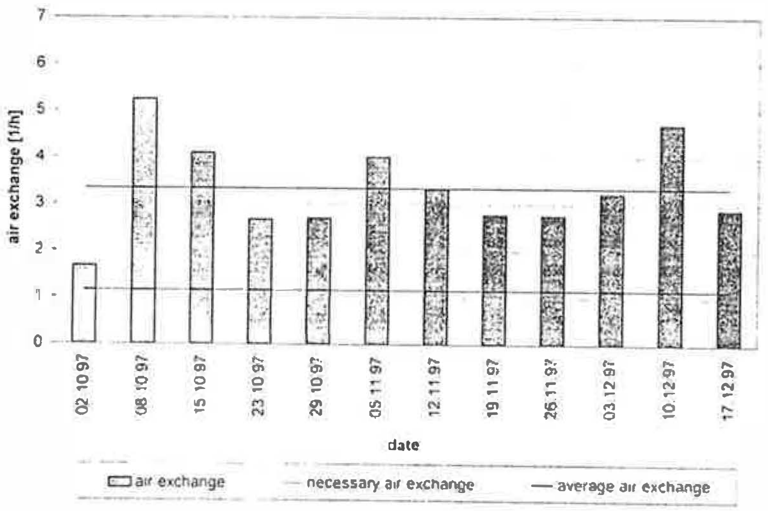

Fig. 1. Air exchanges per hour in a high-rise-building office room (131sqm) renovated with a double facade in Dortmund

The Victoria Insurance company has built a new building in Düsseldorf (1997), equipped with a double facade. The building has two parts, one high rise building and one 7-storey building, facing a street with high outside noise level. The cooling of the office rooms is guaranteed by water pipes, that are put into the concrete ceiling. We started detailed long term measurements in spring 1997 in one office room on the east side of the 7-storey building. Fig. 2. shows that the room temperature was convenient on a hot summer day with a minimised amount of cooling energy. At the 15[th] of August 1997 the peak heat transfer through the ceiling was 19,3 W/m² and the average heat transfer was 10,7 W/m². The temporary storage of thermal energy in the ceiling buffers the cooling load during the day, so that a constant cooling load of the water pipes is possible.

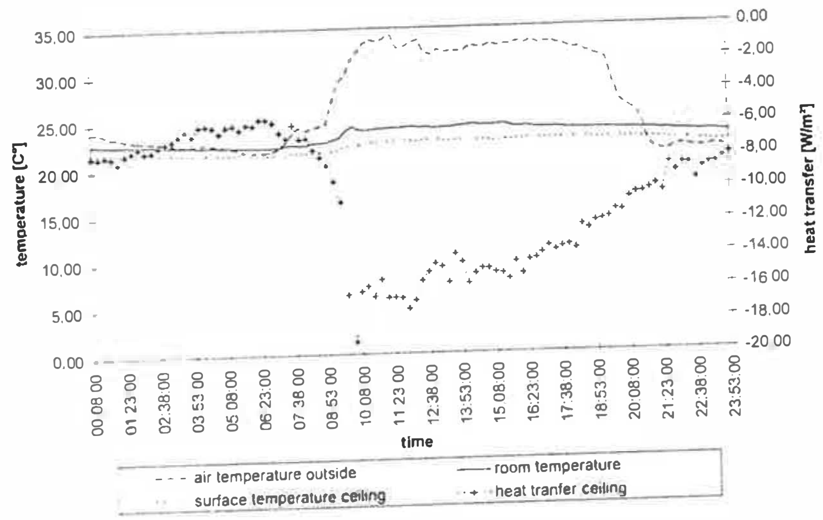

Fig. 2. Room temperatures and cooling energy at the Victoria Insurance Company, Düsseldorf at the15[th] of august, 1997

3 The double facade as a thermal collector to upgrade existing buildings

The main reason to build a double facade at a new erected building, is to make a natural ventilation in high rise buildings or at locations with high outdoor noise level possible. The second facade layer is usually build to reduce wind forces and noise.

The second glass-facade can principally also be regarded and function as a great solar collector and as an improved thermal insulation during the winter time, if certain requirements are met. The ventilation openings, which are necessary to avoid overheating in summer must be closed during the winter. A thermally insulated construction and glazing improves the thermal insulation of the building. The necessary air exchange rate during the winter can be provided by a simple ventilation system, that transports the used air out of the building. The fresh air enters through minimal openings in the facade (see [Nolte at al., 1997]) and can be warmed up by solar radiation in the space between the inner and outer facade. A facade, constructed with heat protection glazing (k-value 1,2 W/(m²K)), has become nearly as cheap as with conventional insulating glazing and almost comparable to the so-called „transparent insulation" (k-value 1,0 W/(m²K)).

In two examples, one facade planed and one at the begin of the construction we use a second facade to upgrade existing office buildings to realise a good thermal insulation in winter and an effective heat protection in summer to reduce the consumption of fossil energy effectively.

To upgrade an existing building at the University in Dortmund thermally an additional (double) facade is planed [Nolte at al., 1997]. The additional totally glazed facade will reduce the use of heating energy to 50 % of the current value. CFD calculations, done together with Schmidt Reuter Partner in Cologne show clearly, that the additional facade does not lead to an overheating of the office rooms behind the facade. The air, warmed up by the secondary heat emittance of the sun blinds, caused by absorbed solar radiation, leaves the facade through the upper flaps and does not enter the room.

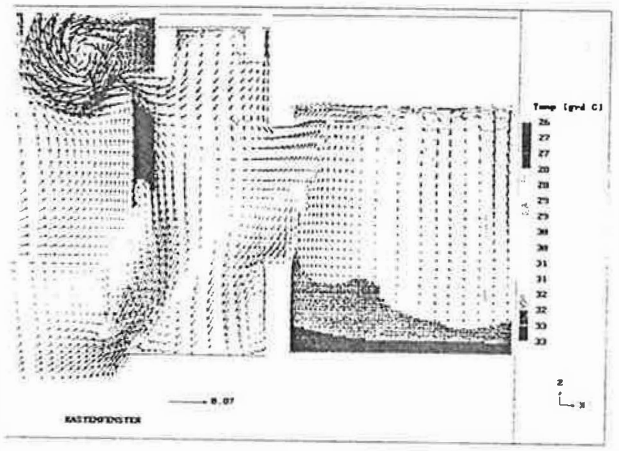

Fig. 3. CFD calculation for the double facade at a university building in Dortmund

For the high rise building of the state court of justice in Hamm, built 1955, the we suggested a second facade to upgrade the building thermally. The building has no air conditioning or ventilation systems and air conditioning systems were not to be installed in the building. The second facade leads to a reduction of heating energy in wintertime of approximately 65 %. An upgrading of this building with a double facade has several advantages: The deep rib bearing structure of the facade is very difficult to insulate with conventional insulation, the sun blinds can be placed, well protected against wind forces, in the space between the two facades, and the necessary natural ventilation is provided. Due to the rib structure of the facade, the total cost for the double facade is only slightly above the cost of a conventional insulation.

4 Conclusions and outlook

Compared to a conventional design of office buildings with full air-conditioning, overheating in new buildings can be reduced effectively and cooling and ventilation energy can be spared with double facades. A new use of thermally insulated double facades is to upgrade old buildings. It may help to save a large amount of heating energy during wintertime and to use the advantages of double facades during the summer.

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EXTERNAL SHADING DEVICES: OPPORTUNITIES AND PERFORMANCE TO CONTROL DAYLIGHT AND SOLAR HEAT GAIN

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ABSTRACT

In the past few years, a new way of designing buildings has been developed, which is known as *energy conscious design*. According to this philosophy, buildings have to be designed so that the building shape, orientation and, above all, envelope allow to assess comfort conditions with a minimum use of building services.

As a consequence, the role assumed by the building envelope is becoming increasingly important, acting as a selective filter of thermal, luminous and acoustic flows exchanged between the internal and the external environments. In particular, the adoption of external shading devices is becoming more widespread.

The actual functional role of external shading devices is to control solar radiation and daylighting. By reducing solar gain, however, these can produce the undesired effect of drastically reducing also the availability of daylight.

In order to provide designers with useful information about the integrated performance of different shading devices types, this paper carried out an integrated analysis of their energy and luminous behaviour.

A computer program, developed by the authors, is used to analyse the energy behaviour of various simple shading devices; a graphic tool has been devised for the evaluation of the sky component and a scale-model is used to evaluate the effect of each device on daylight. Initial results are here presented.

KEYWORDS

Shading devices; solar shading; energy conscious design; daylighting

INTRODUCTION

The last few years have been characterised by a strong growth of technological research addressing the area of the design of building envelope components which actively interact with climate. The active properties of these components allow the designer to establish environmental comfort conditions while minimising the use of building services.

Among these components, external shading devices have acquired an important role in performing the function of controlling and redirecting inward light and heat flows. In investigating the influence of external

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