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SOME EXPERIENCES WITH BUILDING SIMULATION IN CZECH CONSTRUCTION INDUSTRY

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ABSTRACT

This paper describes a new approach of using simulation directly in construction industry in Czech Republic. Building simulation is used by facade manufacturer in order to present the prediction results to investors, architects and other building specialists to generate discussions and create cooperation. This is necessary for optimal design of highly glazed or intelligent buildings. The paper presents examples of three studies where simulation was used to support design in different stages of the project. The need for simplified simulation tools ready to use during the meeting with investors and architects allowing fast decision making is identified. The paper is concluded with future work which is needed to gain full acceptance by Czech investors and architects.

INTRODUCTION

After political changes in the early 90's a boom started in construction industry in the Czech Republic. The demand for office space significantly increased. Czech market opened up to foreign companies and investors but also to new visions and ideas about building features.

Now, 10 years later, new Czech buildings look futuristic but they are still designed in traditional way. Most architects work separately from specialists and contact them only when the design is almost finished and it is impossible to change any of the design concepts. There exist no tradition of consulting engineers making integrated building analysis in Czech Republic. Thus real integration of building and systems remains a dream.

NEW APPROACH

Our current experiences show that it is nevertheless possible to use building performance simulation tools directly in everyday practice of a facade manufacturer. It is obvious that the building envelope plays a very important role in comfort and energy consumption issues.

Advantage can be taken of the facade interacting with other building systems like HVAC, etc but it has to integrated in the building design. Therefore we try to bring together investors, architects, construction teams, HVAC designers, and other specialists and present them alternative design and concepts to generate discussion and create cooperation.

These studies are used in different stages of building design. Some influence the architectural design significantly, some merely try to optimize already fixed design. Others aim to provide detailed data to HVAC engineers where traditional methods fail.

In following different examples of such practical simulation studies are presented. These studies were used in different building design stages, thus having different impact on the building design:

EARLY DESIGN STAGE – FACADE CONCEPT

In the early design stage, the architects and investors were discussing which facade concept and which materials to select for their new office building in Prague. The alternatives for facade were:

- single polygonal, insulating clear glass – P1
- single polygonal, high-performance glass – P2
- single curved, solar control glass – C1
- single curved , low-e glass – C2
- double facade,insulating clear glass, shading – D

Fig. 1: Single polygonal facade design – P.

A simulation study using was carried out to evaluate dynamic thermal performance of different design variants. The simulation models allowed to consider subtle differences in glazing materials and architectural design for different variants.

The main output was simple graph comparing maximal external gains entering the building via facade (fig. 2). It was concluded that active external shading Dsh in the double facade would reduce external heat gains to 33% compare to single facade with the same double glazing in polygonal design P1. The double facade without shading D has similar gains to polygonal facade with high-performance glazing.

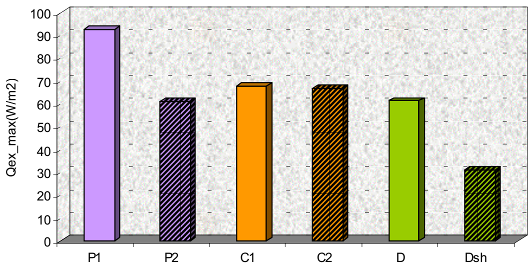

Fig. 2: Max. ext. gains per floor unit area for different facade design variants.

The results of this study were presented at a decision-making meeting with architect and investor. The architect used the results to convince the investor about his preferred design of double facade (fig. 3). Even if the building cost would be slightly higher, the operating costs will be dramatically reduced.

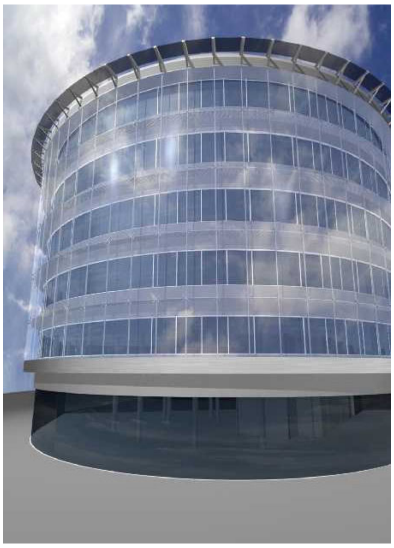

Fig. 3: Double facade design – D.

DETAILED DESIGN: SUPPORT FOR FACADE DEVELOPMENT AND HVAC DESIGN

According to the architectural design the building on fig. 4 should look like crystal – ig. completely glazed and transparent, with prevailing South orientation. The facade consists of separate modules of 1.8 x 3.6 m, ig. floor to floor height. These modules are constructed as a glazed double skin with internal aluminum blinds.

Fig. 4: Fully glazed building.

Traditionally, because of Czech regulations, the HVAC designers are focused on heating problems. However in these kind of fully glazed buildings, the real problems are the very high cooling loads, for which there are no stipulations in Czech standards. Additionally, it is usually more difficult to provide thermal comfort in summer than in heating season.

The proposal was to slightly ventilate the facade cavity, and to fit aluminum blinds inside (fig.5). For such design it was necessary to use simulation tools to generate data supporting facade development and HVAC design.

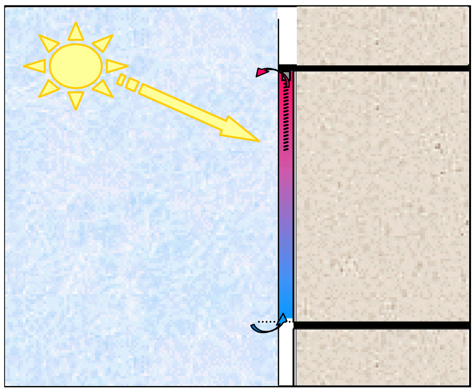

Fig. 5: Double skin concept.

Figure 6 shows the increase of temperature gradient in the facade cavity and external load as function of shading percentage. It can be seen that even though with more shading the temperature in cavity is rising up to 11,2 °C, the external load through facade decreases down to 57%.

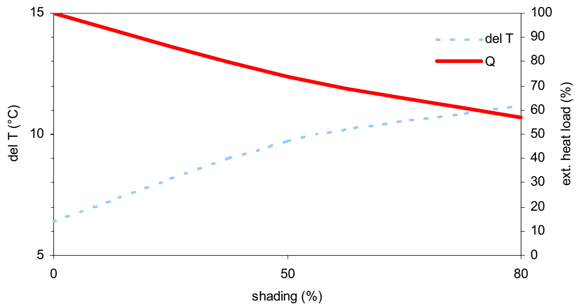

Fig. 6: Temperature gradient and external gains in relation to shading.

The graph in Figure 6 was presented to investors and was used as strong argument for installing controllable shading inside the facade cavity. This study will continue as the project will evolve. We intend to analyze thermal comfort issues next.

DETAILED DESIGN: FACADE THERMAL PERFORMANCE

This project was about reconstructing and converting an old factory hall in Prague into a modern office space. The architect designed a new two-floors superstructure build on the top of original building (Figure 7). The superstructure is completely enclosed by the glass shell which basically forms the double facade arises.

Fig. 7: Visualization of factory reconstruction.

The architects and other members of construction team was interested to know how this special construction will perform. We have conducted an extensive study predicting the thermal behavior of the building both in winter and in summer time. It was proposed to control the double facade space so it would be closed in winter to serve as thermal buffer zone. During the summer the controllable flaps would open to allow the natural ventilation through facade and active shading would reduce the solar radiation gains (Figure 8).

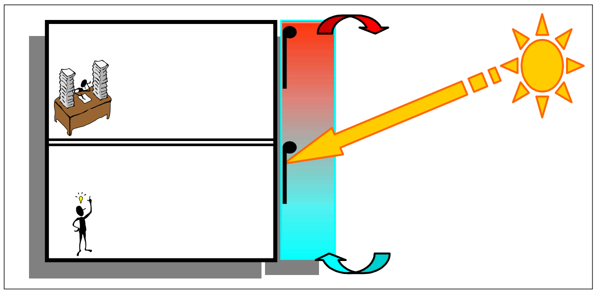

Fig. 8: Double facade concept for summer.

To predict the thermal performance of such facade is really complex task which can be done only by using dynamic simulation tools.

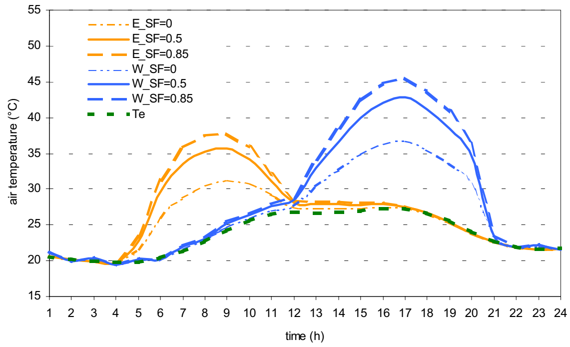

Fig. 9: Double facade outlet air temperature.

Figure 9 shows the temperature of the air leaving double facade space for different shading levels (SF). The air overheating is shifted in time for eastern (E) and western (W) offices. On a hot summer day, when external temperatures Te reach 27°C and shading is closed (SF = 0.85), the outlet air temperature can be higher by 11°C on the eastern side and by 17°C on the western building side.

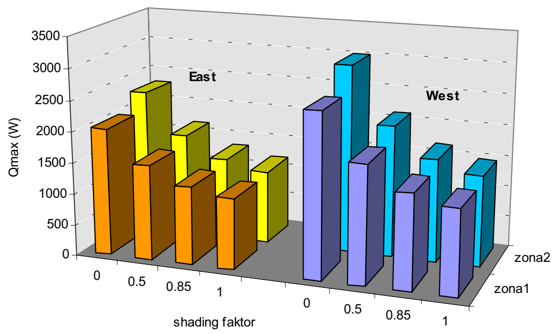

Fig. 10: Maximum cooling loads.

The maximum cooling load for several levels of shading is presented on Figure 10. The results are evaluated for different offices (zona1 and zona2) with different orientation. The cooling load reduces significantly with more shading, even if the temperature in double facade is increased.

This study contributed to design optimization and successful realization of the building. The building has been build and its current state is on Figure 11.

Fig. 11: Realized reconstruction.

SIMULATION TOOLS

The above presented studies were carried out with comprehensive simulation tools that are excellent for detailed integrated analysis by domain experts. The user interface and other developments should, in our view, aim to be efficient for experts in the field; ie. there is no need to make the interface and other features such that these tools can be potentially used by a lay-person.

On the other hand, in practice, very often design decisions need to be made on the spot during a design team meeting. In those cases there is no time to do any research for that specific building first. The domain experts will very often react intuitively based on his/her experience. For those cases, we feel there is a strong need for more generic design tools or guides which can be used during meetings with investors, architects and other design team members.

These ideal tool would provide highly graphical outputs easy to understand by people not specialized in our field.

CONCLUSIONS

Traditionally, and still today in many projects, there are hardly any consulting engineers involved in the building design process in Czech Republic. Their role was/is usually performed by the contractors. This is one of the main barriers to the wide-spread use of building performance simulation in the Czech Republic.

One way to help to resolve this is to add building performance simulation to the services of a facade producer and contractor. Simulation can be introduced at different stages of the project resulting in different impacts on the design. Presentation of simulation analysis of the building opens up discussions and can create cooperation between specialist, architect and investor and thus results in better buildings.

We have also identified the need for flexible and easy to use tools which could instantly provide relevant decision making arguments regarding comfort and energy consumption issues.

A lot of work still needs to be done to show the importance and usefulness of building simulation to investors, architects and other building professionals in Czech Republic. Building performance simulation can help to design modern buildings, which are high in quality both for people now and in the future.

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