INTERPLAY CLIMATE-HUMAN-BUILDING: USER-FRIENDLY PLANNING TOOLS FOR NEW CHALLENGES IN BUILDING

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Summary

As an interface between indoor and outdoor climate, facade plays a key role in planning. This paper focuses on user-friendly planning tools. Existing FacadeTool demonstrates the possibilities of assessments related to the façade concept and building configuration at the very early planning stage; establishing a quick and inexpensive basis for ongoing design decisions. Furthermore, FacadeTool's validation with the Thermal Lab of UT Austin examines to what degree of accuracy the input mask is able to represent key aspects of energy and room climate.

Keywords: user friendly-planning tools, façade concept, key-factors, education, validation

1 Introduction

The following aspects can be taken into account regarding the development of international buildings [1]. Primarily, requirements of comfort and energy efficiency are increasing. To achieve this objective, the building configuration has to be optimized as early as possible in the planning process. Moreover, planning time and costs should be reduced. As demands on planning increase more and more, additional planning methods and tools are needed, namely, decision-making guides that restrict the number of variations worth pursuing in a fast and cost-effective way. In view of the level of detail involved, conventional simulation programs are of limited value in the early planning phase. Furthermore, universities must provide students with the tools and framework for enlisting these new challenges. If given the chance to be dynamic partners within a sustainable design process, they will serve as an essential link between architects, engineers, builders and other experts.

2 Example of user-friendly planning tool

User-friendly planning tools like the FacadeTool [2] have been developed to provide a fast and cost-saving mechanism for choosing planning variants during the conceptual design phase, when many parameters are unspecified. The user can apply the tool without specific input from their design, in essence, enabling the consideration of variants prior to drawing the first line. By these means, FacadeTool compensates for experience planners usually don't have unless they have been building in other climate zones for a long time.

A large parameter study of a single zone model (based on the thermal simulation program ESP-r) [3] can be executed to be able to compare the variants. Based on data from Meteonorm [4], any location worldwide defined by the latitude and longitude can be entered in. While ESP-r is only used as a solver running in the background, the FacadeTool is the pre- and post-processor for the huge number of calculations for any one location. The uniqueness of FacadeTool lies therein that it provides a real automated parameter study for every worldwide location. Many different combinations of façade concepts can be compared without having to define a reference case as a starting point for further examinations.

A preset representative office room with average internal loads, office hours, and air changes per hours is defined. The comfort zone was set according to ASHRAE-55 [5]. The user can choose variants in orientation (north, east, south, west), amount of glazing (30 %, 50 %, 70 %), type of glazing (two sun protection and two thermal protection glazings), sun shading elements (none, internal, external, blind), insulation (none, 5 cm, 10 cm, 20 cm), building concept (with and without thermal mass, night ventilation). For additional inquiry, users can independently define the dimensions of the room, internal loads, office hours, comfort criteria, air change per hour, amount of glazing and southern inclination. Shading surroundings can be defined as simple blocks in front of the four main facades.

The results for each of these choices and combinations can be seen: annual energy demand for heating and humidifying, as well as for cooling and dehumidifying for the comfort zone according to ASHRAE-55 as well as interior and exterior surface temperatures for all walls. As an ideal heating or cooling configuration is being considered, the output is always the net-energy-demand. Furthermore, if no active cooling or heating system is incorporated, operative room temperatures above and below the comfort area could be regarded.

3 User-friendly-planning tools tested with real world conditions

Though user-friendly-planning tools are primarily developed to show tendencies when considering different variants, the following items come into question: (i) do results reflect reality? and (ii) is the input mask sufficient to be taken as a profound decision-making guide? The results from the FacadeTool were compared with the data gathered in the Thermal Lab in a 6-day experiment. The comparison was obvious, given that the idea of both the digital model and the research facility was the same: to model a typical office room with only one opening on the façade and adiabatic inner walls, for comparison of different building performance with respect to energy and room climate.

3.1 Thermal Lab

The two Thermal labs [6], located in the School of Architecture (UTSoA) on the campus at the University of Texas at Austin, are an outdoor testing facility for state-of-the-art research on innovative façade design. They make the consideration of both fully and partially air conditioned rooms possible; in order to simultaneously evaluate the energy demand, room climate conditions and daylight provision of different façade and variants. The only opening is on the south façade. It can be modified or replaced to test different façade concepts. The air is supplied through two exhaust openings closest to the south wall. The cooling system consists of a chiller.

3.2 Study

During the 6-day study in November 2012, sensors collected air temperatures in the middle of the room at three different levels as well as on surfaces. No sun shading measurement was considered. In the simulation model only those parameters, which could be manually defined by the user in the input mask of the FacadeTool were changed. Local weather data was gathered. Because ESP-r uses hourly values, the mean values of each 60-minute block were calculated and therefore the peaks could not being considered.

Tab. 1 *Boundary conditions of the research facility and the simulation model*

Boundary conditions	**Thermal Lab**	**Digital model**
Size of room (interior)	w = 3,62, d = 3,98, h = 2,82m	w = 3,62, d = 3,98, h = 2,82m
Orientation	11° east of solar south	11° east of solar south
Amount of glazing	92 %	92 %
Type of glazing	sun protection, VE 1-2M, 70/33	sun protection, 60/30
U-value outer walls	0,1 W/m^{2}K	0,18 W/m^{2}K
Thermal mass	light-weight	light-weight
Internal loads	350 W	350 W
Air change per hour	0,1 h^{-1}	0,1 h^{-1}
Cooling setpoint temp.	21,4 °C	21,4 °C
Cooling system	chiller, forced ventilation	ideal cooling, no plant system

3.3 Results

The measured power differed from that of the simulated one by up to 20 % **(Fig.1**, left**)**. This is due to the rising sensor temperature in the lab – up to 23.5 ºC – as the sensors in the middle of the room were not shaded from solar radiation. Assuming that the measured power has its higher peaks because of exposed sensors, the power in the lab would decrease. The experiment will be repeated in the spring, this time with shaded sensors. The measured surface temperatures differ from the simulated ones with a large degree of variance, e.g. at the internal glazing surface up to 7 K, without considering the forced ventilation of the lab in the simulation model. Considering this and therefore incorporating the appropriate convection coefficients in the simulation model, the two courses (measurements in the lab and simulation results) generated almost the same results **(Fig.1**, right) and the difference of surface temperatures on the west, east and south wall is 1,5 K at its maximum variance.

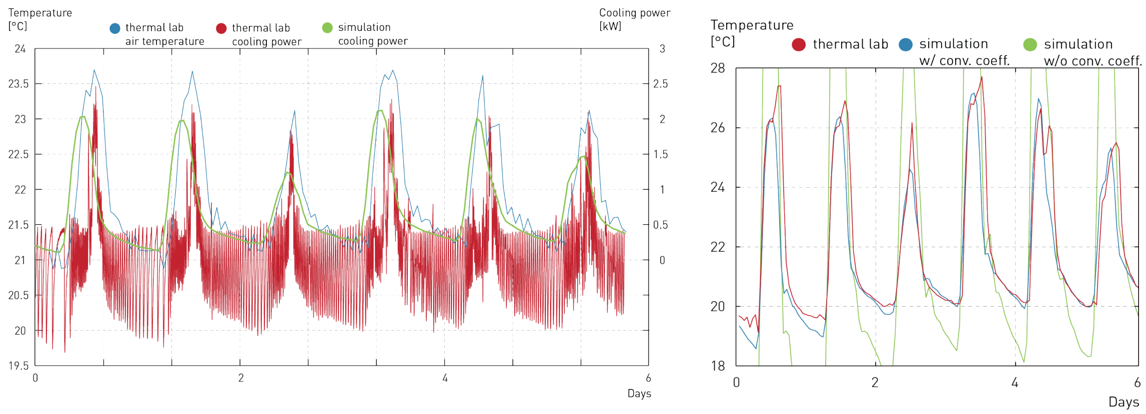

Fig. 1 *Comparing cooling power and interior surface temperatures for glazing as results from the simulation and experiment for 6 days.*

4 Discussion

The first validation of FacadeTool in a 6-day experiment with the Thermal Lab at UT Austin showed that the eligible parameters in the input mask of the tool are sufficient to provide an adequate estimate of the façade variants, in terms of energy and room climate aspects. Thereby, the following has to be considered: No plant system has been incorporated into the FacadeTool. To be able to more accurately illustrate the surface temperatures and the subsequent operative room temperature as they correspond to different ventilation strategies, different convective coefficients for walls, the ceiling and floor can be incorporated into the input mask. The variance between the results of the simulation and the experiment in terms of cooling energy demand is a result of measurement uncertainty and is going to be considered in a following study. Accordingly, the FacadeTool will be further validated in subsequent experiments, with sunshading systems as well as different ventilations strategies included. Aspects of daylighting will be incorporated in the FacadeTool.

References

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