INSTITUTO SUPERIOR TÉCNICO
Universidade Técnica de Lisboa

PERFORMANCE EVALUATION OF SOLAR SHADING SYSTEMS

Inês Dionísio Palma Santos

Resumo alargado da dissertação para obtenção do Grau de Mestre em Engenharia Civil

Júri

Presidente: Prof. Jorge Manuel Caliço Lopes de Brito
Orientador: Prof. António Heleno Domingues Moret Rodrigues
Vogal: Prof.ª Maria Helena Póvoas Corvacho

Outubro de 2007

A. ENERGY AND DAYLIGHT PERFORMANCE EVALUATION OF SOLAR SHADING SYSTEMS

A.1 Introduction

Energy savings are essential for the general long term solution of the problems with use of energy from fossil fuels. In buildings, to maintain a good indoor environment, energy is used for heating, cooling and electrical lighting. If correctly selected and used, solar shading systems may decrease significantly the overheating and cooling demand of buildings without largely increasing the electrical lightning demand.

In this master dissertation a simple and user-friendly method of how to evaluate the energy and daylight performance of solar shading systems in buildings in an early design phase is illustrated. The method is based on the use of two simulation tools: *WIS* and *BuildingCalc/LightCalc* (*BC/LC*). A case study of a landscaped office building in which different solar shading systems were applied is presented and two different locations are studied: Copenhagen and Lisbon. Also some suggestions are given on how to overcome the lack of information characterizing the solar shading systems available in the market.

A.2 Solar shading systems

There are many different types of solar shading systems available in the market. When designing a building besides the aesthetical component, also the energy performance and indoor comfort including temperature and daylight must be taken into account.

The solar shading systems should be as flexible as possible so they can adapt to the outdoor conditions. According to their position on the window, they may be characterized in internal, interpane and external. The external solar shading systems are the most efficient in reducing the cooling loads. As they are placed outside they reflect the solar rays before they enter the room. Also the heat they absorb is dissipated to the outside air by radiation and convection. The solar control glasses are not included in the groups referred before but also constitute a type of solar shading system. They are integrated in the window, replacing the panes.

In this dissertation different types of internal, interpane and external roller blinds and venetian blinds were studied. Also external glass lamellas systems and solar control glasses were investigated. The glass lamellas are a promising system: besides acting as a solar shading system they allow good indoor daylight conditions.

A.3 Method to evaluate the performance of different solar shading systems: *WIS* and *BuildingCalc/LightCalc*

To evaluate the performance of different solar shading systems two softwares were used: *WIS* (developed by TNO Building and Construction Research in Delft) and *BuildingCalc/LightCalc* (BC/LC - developed in Matlab at Technical University of Denmark).

With *WIS* it is possible to calculate the thermal and optical properties of window systems combining solar shading systems with glazings available in the market. With *BC/LC*, it is possible to evaluate the energy and daylight performance of rooms in which the window systems defined in *WIS* are applied. It is possible to set different systems: heating, cooling, ventilation, venting and variable solar shading which is the main focus of this dissertation. The systems are controlled by different settings which can be specified for different periods.

The solar shading systems may be automatically controlled according to the indoor temperature. If at the same time the indoor daylight is not enough to accomplish the standard requirements, electrical lightning is switched on and its energy demand is calculated.

A.4 Case study - Landscaped office building

The test room is a storey of a landscaped office building located first in Copenhagen (North Europe) and then in Lisbon (South Europe).

The inner dimensions of the room are 20m width, 10m depth and 3.3m height (see **Figure 1**).

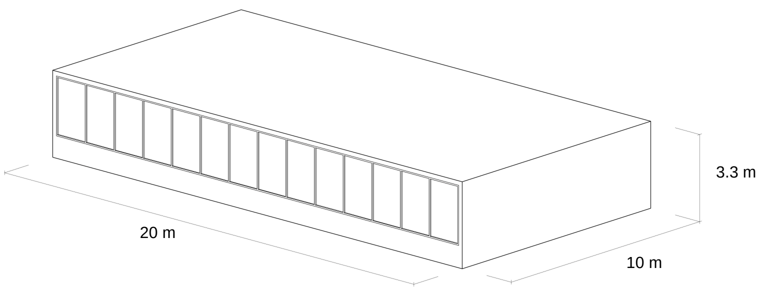

Figure 1 - Room drawing

The window will occupy most of the façade. The reference glazing is a triple pane with a U-value of 0.68W/m^{2}K, g-value of 0.49 and visual transmittance of 0.68. The frame has a U-value of 0.73W/m^{2}K.

The overall UA-value of the envelope of the building in Copenhagen is 15.46W/K (this value takes into account the sum of transmission losses through the elements facing outside excluding the window). For the building in Lisbon not so good thermal solutions were chosen and the UA-value is 61.85W/K.

The heat capacity of the building was assumed to be middle light and also the heat capacity of the furniture was taken into account.

Different systems were defined to simulate different periods of the year and distinct using conditions (winter / summer / working hours / non-working hours).

Two different scenarios were studied: no mechanical cooling available (when there is need for cooling the cooling systems are activated in the following order: shading, venting and increased mechanical ventilation); mechanical cooling available (when the previous solutions are not enough, the mechanical cooling is activated). The first scenario is the more environmental friendly one since no energy for cooling is used. However, in most cases this solution is not enough to achieve the indoor comfort level required, especially regarding south Europe countries like Portugal.

The office is equipped with district heating and cooling. There is a heat exchanger (with an efficiency of 0.85) incorporated with the heating system. The heating system and the mechanical cooling (when available) are only active during working hours. The heating setpoint is 20ºC while the cooling setpoint is 22ºC (in this way the cooling process will start before the indoor temperature reaches 26ºC which is a measure of discomfort).

Only during working hours mechanical ventilation is active with an airchange rate of $0.9h^{-1}$. Venting is set only during non-working hours (in Lisbon during all the year and in Copenhagen only outside the coldest months).

The internal loads due to people and equipment were also taken into account.

The artificial lightning level is automatically controlled during the working hours in order to keep a general indoor lightning level of 200lux and a level of 500lux at working areas.

A.5 Energy Performance and indoor comfort evaluation

A.5.1 Requirements and expected results

To be in accordance with the Danish building code the office room should have a total energy demand for heating, cooling and lightning lower than $78kW/m^2$.year (however, for the nowadays purpose of saving energy at least half of this value would be expected).

In Portugal, as a complement to the requirement for total energy demand for heating, cooling and lightning (estimated as $104kWh/m^2$), there are also limits for the different types of energy needed in a building: for this office room the limit for heating $52kWh/m^2$ while for cooling it is $32kWh/m^2$.

Regarding indoor comfort, it was assumed that the landscaped office building should fulfil category **II** of the indoor environment standard (prENrev15251:2006): this means less than 108 working hours per year above 26º and a PPD index (predicted percent of dissatisfied) lower than 10%.

A.5.2 Results and discussion

In **Tables 1** and **2** it is presented the performance of the building for the different solutions of solar shading systems in combination with the reference glazing for both locations: Copenhagen and Lisbon. The results painted as grey are the ones that do not fulfil the standards.

Table 1 - Energy and indoor comfort performance of the landscaped office room in **Copenhagen** for the reference glazing and for the combination of the reference glazing with the different solar shading systems

		system properties[1]						without mechanical cooling					with mechanical cooling[2]				
ID	**Position/Type** (Product name)	**U-value** **[W/m²K]**	**g-value** **[-]**	**SSC** **[-]**	τ_v **[-]**	**VSC** **[-]**	**Ra** **[%]**	**heating** **[kWh/m²]**	**lightning** **[kWh/m²]**	**total[3]** **[kWh/m²]**	**T>26ºC** **[h]**	**PPD** **[%]**	**heating** **[kWh/m²]**	**cooling** **[kWh/m²]**	**lightning** **[kWh/m²]**	**total[4]** **[kWh/m²]**	**PPD** **[%]**
REF	**Reference Glazing**	0.68	0.49	1.00	0.68	1.00	96	0.55	3.21	8.56	260	12	0.61	22.58	3.21	31.20	7
A	**Internal Roller Blinds**																
1	Verosol Roller 818-000 UT light-grey	0.60	0.40	0.82	0.33	0.49	95	0.50	3.78	9.94	182	11	0.54	17.83	3.62	27.42	7
2	Verosol SilverScreen white ED01 HT	0.51	0.25	0.51	0.05	0.07	94	0.41	7.15	18.27	101	9	0.41	12.47	6.69	29.59	8
B	**Interpane Roller Blinds**																
3	Verosol Roller 818-000 UT light-grey	0.72	0.30	0.61	0.32	0.47	95	0.65	3.71	9.93	103	9	0.66	12.28	3.61	21.94	8
4	Verosol SilverScreen white ED01 HT	0.70	0.10	0.20	0.05	0.07	94	0.80	6.63	17.38	2	8	0.80	5.40	6.41	22.21	8
C	**External Roller Blinds**																
5	Verosol SilverScreen white ED01 HT	0.62	0.04	0.08	0.01	0.01	94	0.77	6.33	16.58	0	8	0.77	3.24	6.18	19.46	8
D	**Internal Venetian Blinds**																
6	Luxaflex venetian blind High Mirror 4078	0.58	0.23	0.47	0.00	0.00	90	0.46	4.51	11.72	214	12	0.49	19.79	4.30	31.02	7
E	**Interpane Venetian Blinds**																
7	Luxaflex venetian blind High Mirror 4078	0.57	0.07	0.14	0.00	0.00	91	0.48	4.32	11.28	89	9	0.48	11.35	4.21	22.34	8
F	**External Venetian Blinds**																
8	Aluminium lamellas_60mm	0.62	0.01	0.02	0.00	0.00	0	0.67	4.14	11.00	0	8	0.67	4.00	4.09	14.88	8
G	**External Glass Lamellas**																
9	SGG_Antelio Silver_500mm	0.63	0.28	0.57	0.20	0.29	94	0.84	4.10	11.09	74	9	0.85	9.12	4.05	20.09	8
H	**Solar Control Glazings**																
10	SSG Reflectasol Green	0.96	0.17	0.35	0.21	0.31	88	3.78	5.65	17.91	0	9	3.78	3.97	5.65	21.88	9
I	**Combinations**																
11	SGGReflectGreen+ExtAlumLamellas_60mm	0.85	0.01	0.02	0.00	0.00	0	0.62	5.40	14.11	0	8	0.62	3.32	5.30	17.17	8

Table 2 - Energy and indoor comfort performance of the landscaped office room in **Lisbon** for the reference glazing and for the combination of the reference glazing with the different solar shading systems

		system properties[1]						without mechanical cooling					with mechanical cooling[2]				
ID	**Position/Type** (Product name)	**U-value** **[W/m²K]**	**g-value** **[-]**	**SSC** **[-]**	τ_v **[-]**	**VSC** **[-]**	**Ra** **[%]**	**heating** **[kWh/m²]**	**lightning** **[kWh/m²]**	**total[3]** **[kWh/m²]**	**T>26ºC** **[h]**	**PPD** **[%]**	**heating** **[kWh/m²]**	**cooling** **[kWh/m²]**	**lightning** **[kWh/m²]**	**total[4]** **[kWh/m²]**	**PPD** **[%]**
REF	**Reference Glazing**	0.68	0.49	1.00	0.68	1.00	96	0.00	1.54	3.84	1009	28	0.00	61.27	1.54	65.10	5
A	**Internal Roller Blinds**																
1	Verosol Roller 818-000 UT light-grey	0.60	0.40	0.82	0.33	0.49	95	0.02	2.90	7.25	667	20	0.02	47.65	2.65	54.29	5
2	Verosol SilverScreen white ED01 HT	0.51	0.25	0.51	0.05	0.07	94	0.02	9.53	23.84	451	14	0.02	36.50	8.43	57.59	6
B	**Interpane Roller Blinds**																
3	Verosol Roller 818-000 UT light-grey	0.72	0.30	0.61	0.32	0.47	95	0.02	2.86	7.16	454	15	0.03	37.06	2.64	43.67	5
4	Verosol SilverScreen white ED01 HT	0.70	0.10	0.20	0.05	0.07	94	0.04	8.83	22.12	168	9	0.04	20.50	8.03	40.60	6
C	**External Roller Blinds**																
5	Verosol SilverScreen white ED01 HT	0.62	0.04	0.08	0.01	0.01	94	0.08	8.17	20.51	108	8	0.08	14.57	7.65	33.78	6
D	**Internal Venetian Blinds**																
6	Luxaflex venetian blind High Mirror 4078	0.58	0.23	0.47	0.00	0.00	90	0.01	4.45	11.14	763	22	0.02	51.64	3.85	61.26	5
E	**Interpane Venetian Blinds**																
7	Luxaflex venetian blind High Mirror 4078	0.57	0.07	0.14	0.00	0.00	91	0.02	4.22	10.57	431	14	0.02	35.07	3.73	44.40	6
F	**External Venetian Blinds**																
8	Aluminium lamellas_60mm	0.62	0.01	0.02	0.00	0.00	0	0.03	3.87	9.71	136	9	0.04	17.43	3.56	26.35	6
G	**External Glass Lamellas**																
9	SGG_Antelio Silver_500mm	0.63	0.28	0.57	0.20	0.29	94	0.04	3.55	8.91	392	13	0.04	31.21	3.23	39.33	6
H	**Solar Control Glazings**																
10	SSG Reflectasol Green	0.96	0.27	0.55	0.21	0.31	90	0.33	3.80	9.82	159	10	0.34	17.31	3.80	27.13	7
I	**Combinations**																
11	SGGReflectGreen+ExtAlumLamellas_60mm	0.85	0.01	0.02	0.00	0.00	0	0.06	6.78	16.99	117	8	0.06	15.60	6.30	31.39	6

*Notes about **Tables 1** and **2**:*

Tables 1 and **2** are organized in three distinct groups of columns:

System properties - where the performance of the different solar shading systems in combination with the reference glazing is presented (U-value - thermal transmittance coefficient; g-value - solar heat gain coefficient, SSC - solar shading coefficient - ratio between the g-value of the solar shading system combined with the reference glazing and the g-value of the reference glazing; τ_V - visual transmittance; VSC - visual shading coefficient - ratio between the τ_V of the solar shading system combined with the reference glazing and the τ_V of the reference glazing; and rendering index (Ra). These values were obtained in *WIS* and refer to the solar shading systems completely activated).

Without mechanical cooling - the values presented in these columns were calculated in *BuildingCalc/LightCalc*. They represent the performance of the landscaped office room (previously described) when different solutions for solar shading systems are applied on its façade. No mechanical cooling was set. The performance of the office room with the different solar shading systems is presented in terms of energy demand for heating and lightning, total energy demand, hours of overheating and PPD index. To calculate the total energy demand the lightning demand was multiplied by the factor 2.5.

With mechanical cooling - these columns also refer to the performance of the building with the different solutions for the solar shading systems. In this case mechanical cooling was applied to eliminate completely the hours of overheating (as 22ºC is the setpoint defined for cooling, no hours above this temperature will be registered).

The results for the reference glazing for the office room in Copenhagen show that the total number of working hours with overheating per year is 260 which is higher than the requirement, 108. However, using mechanical cooling (air-conditioning system), the indoor comfort may be achieved with a total energy demand of 31kW/m^2.year. With most types of solar shading systems the indoor comfort may be achieved even without the use of mechanical cooling. However, if better indoor comfort level is desired, mechanical cooling may be used and the total energy demand may be reduced to 50% (for the case of the external venetian blind) when compared to the reference glazing.

For Lisbon the scenario is different. For the reference glazing, the total number of working hours of overheating per year is 1009 which is extremely high. On the other hand, when using mechanical cooling, the cooling demand is 61kW/m^2.year which doubles the requirement, 32kW/m^2.year. In this way, this solution is not possible for Lisbon. Results for the different solutions of solar shading systems show that most of them are not able to allow the required indoor comfort without the use of mechanical cooling. And even with mechanical cooling some of them are not viable solutions since the cooling demand is higher than the limit (32kW/m^2.year). This is not the case of the illustrated external venetian blind that together with mechanical cooling can reduce in more than 50% the total energy demand of the office room when comparing to the situation with only the reference glazing.

A.6 Daylight performance evaluation

Using only *LightCalc* (*LC*) instead of *BuildingCalc/LightCalc* (*BC/LC*), it is possible to evaluate the distribution of daylight in the room for a certain time, sky condition and solar shading system position.

In an office room the general level of daylight factor should be around 2% while for working areas it should be 5%. These values correspond respectively to 200lux and 500lux during an overcast situation (in which the global illuminance is commonly 10000lux).

Some daylight simulations were performed in *LC* for the different solar shading systems. The results show that for the reference glazing, during overcast sky, the indoor daylight is enough to accomplish the requirement for general lightning level but not for working areas. By the other hand not all the solar control glasses provide the required general level of indoor daylight.

Results show also that the roller blinds and venetian blinds must be completely retracted during overcast sky. When activated they do not provide the required levels of daylight.
The glass lamellas systems are the shading systems type that better daylight performance has.

A.7 Some tips on how to overcome the lack of data available for solar shading systems

As it was stated before there is lack of information about the properties of the solar shading systems available on the market. Most manufactures do not have available the thermal properties of their products and regarding optical properties they only have integrated data and no spectral data. In this way, it is more difficult for the designer to access the performance of solar shading systems.
Some tips on how to make use of the data usually given by the manufactures were suggested (for *WIS* and *BuildingCalc/LightCalc* simulations). Some cases were tested using solar shading systems whose complete data was available in the *WIS* database. Results between complete and simplified data were compared and show that the use simplified data is valid. However, only few cases were studied and more research should be done in this field.

A.8 Conclusions

The combination of *WIS* and *BC/LC* is a very promising tool when evaluating and comparing the performance of buildings with different types of solar shading systems in an early design phase. From the simple model of the room and the thermal/optical properties of shadings systems it is possible to calculate in an hourly basis the yearly energy demand for heating, cooling and lightning as well as some indoor comfort parameters.
One of the main advantages of *BuildingCalc/LightCalc* is that it is able to perform dynamic simulations: different setting for distinct periods of the day (working hours and non working hours) and year (summer and winter) can be defined making simulations closer to reality. The shading system is automatically controlled and its effect on indoor daylight taken into account.
However, the way the shading system is activated is not yet very close to reality: it is activated when the indoor temperature is higher than the cooling setpoint. This means that during overcast situations in which the indoor temperature is higher than the cooling setpoint the shading system is activated. In this way, the natural light entering the room is less and the electrical lightning demand may be wrongly increased. Thus, the shading activation should also somehow depend on the luminance of the sky and on the indoor daylight.
Nowadays there is still lack of data about the thermal and optical properties of the solar shading systems. Some particular cases studied show that the use of simplified data gives raise to results close to the ones obtained with the complete data. However, only few cases were studied and more research should be done in this field.

B. GLASS LAMELLA SYSTEMS: COMPARING MEASUREMENTS WITH *IESVE/RADIANCE* SIMULATIONS

B.1 Introduction

As referred before, the glass lamellas are a promising type of solar shading system: besides acting as typical solar shading systems reducing the solar gains and consequently the cooling demand, they may at the same time allow better indoor daylight levels than the common shading systems thanks to the transparent properties of glass. By the other hand during overcast days if they are correctly tilted they may slightly increase the indoor daylight especially on the back part of the room.

Some daylight measurements were performed in the two experimental rooms of the Daylight Laboratory at SBi (Danish Building Research Institute, Hørsholm, Denmark): both rooms are equal except that one of them, named the test room, was equipped with a glass lamellas system on its façade; the other one is called the reference room. The model of the experimental rooms was built in *IESve/Radiance* and measurements were compared with simulations.

B.2 The Daylight Laboratory at SBi

B.2.1 The experimental rooms

The Daylight Laboratory in Hørsholm (Denmark) consists of two identical experimental rooms oriented 7.5º east of the exact south direction. The two experimental rooms are identical, each measuring 3.5m by 6.0m with a floor to ceiling height of 3.0m (see **Figure 2**). The space in front of the experimental rooms is a field of grass and it is essentially empty from obstructions, apart from the distant row of trees towards south and the group of trees towards the south-west direction (see **Figure 3**).

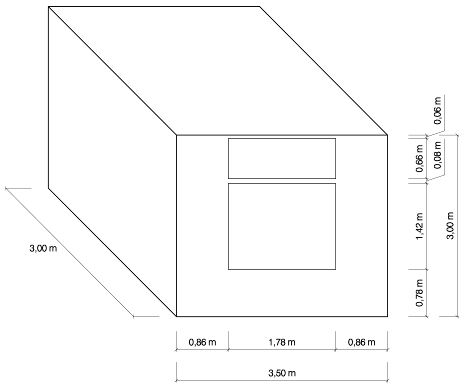

Figure 2 - Geometry of the experimental rooms of the Daylight Laboratory at SBi.

Figure 3 - Landscape view from the Reference room of the Daylight Laboratory at SBi.

The windows of the experimental rooms (illustrated in **Figure 2**) are double-pane: the U-value in the middle of the glazing is 1.1W/m^{2}K and the light transmittance is 72%. The reflectance of the walls, ceiling and roof are respectively 62%, 88% and 11%. The experimental rooms are equipped with two tables each whose reflectance is 80%. As stated before the only difference between both experimental rooms is regarding the glass lamellas system: only the test room has a glass lamellas system, the other one is the reference room. The glass used for the lamellas is *Antelio Silver - SGG* whose visual transmittance is 66% and visual reflectance 31%. The glass lamellas, supported by horizontal and metallic profiles, are 8mm thick and 0.5m wide. (see **Figure 4**)

B.2.2 The measuring conditions

The illuminance values were measured with lux meters located in different points of the working plane and ceiling of the experimental rooms (see **Figure 5**)

Figure 4 - Picture of the glass lamellas system mounted on the façade of the Test room

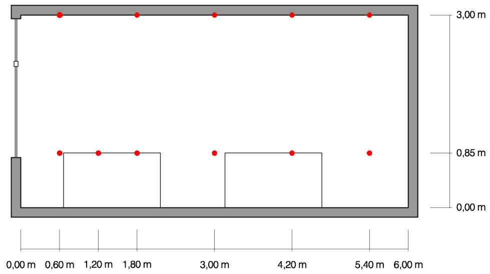

Figure 5 - Section of the Test room/Reference room with the location of the measuring points.

The measurements were performed for four different cases which correspond to different sky conditions and glass lamellas positions of the Test room (see **Figure 6**). For each case measurements of the Test room and Reference room were performed simultaneously so the influence of the lamellas could be assessed.

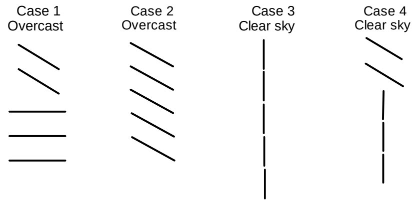

Figure 6 - Case studies: sky conditions and position of the glass lamellas for the Test room.

B.3 Modelling in *IESve/Radiance*

The model of the experimental rooms was built in *IESve* according to the description previously made. The landscape was simply modelled as a field of grass with a length of 20m (see **Figure 7**).

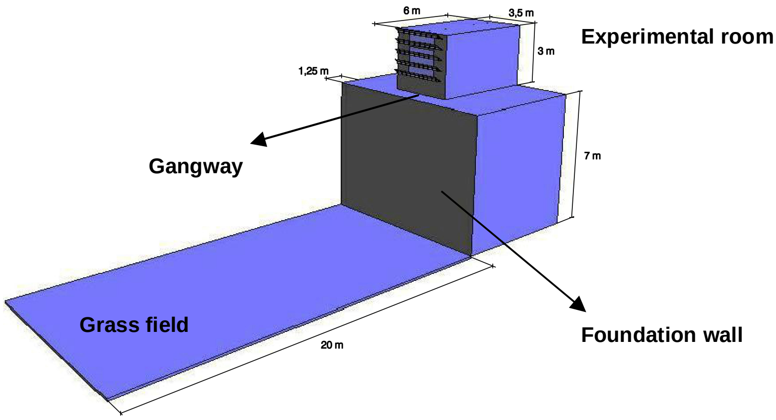

Figure 7 - Model of the experimental rooms built in *IESve*

In *Radiance* there are different types of materials according to the way the surfaces perform when exposed to light: *plastic*, *metal*, *glass*, *dielectric* and *trans*. Excluding the windows glazings which were defined as *glass* and the glass lamellas which were defined as *trans*, all the other surfaces in the model were defined as *plastic*.

For Case 1 and Case 2 the *CIE overcast sky* was chosen for the simulations. For Case 3 and Case 4 the option *Sunny sky* which corresponds to a completely clear sky with full sun was chosen.

B.4 Results and Comparison with the measurements

B.4.1 Case 1

In **Figures 8** and **9**, it is presented the results from measurements and *IESve/Radiance* simulations of the daylight factors at the working plane of both reference and test rooms for Case 1.

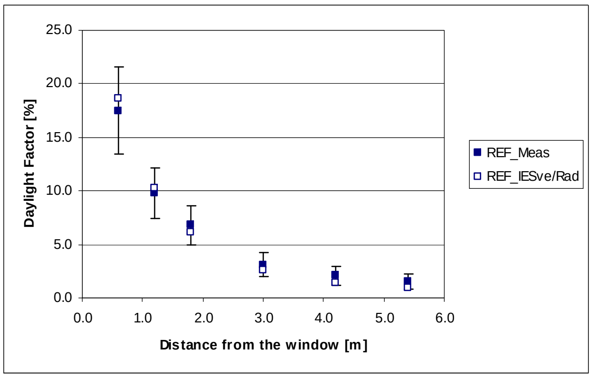

Figure 8 - Measured and simulated daylight factors for the working plane in the reference room for Case1. The standard deviation is visible for each measurement

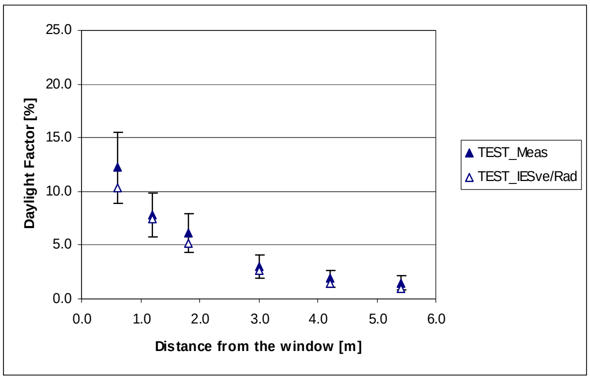

Figure 9 - Measured and simulated daylight factors for the working plane in the test room for Case1. The standard deviation is visible for each measurement

It is always difficult to fit measurements with simulations. The reality is always more complex than the way the models describe it. However, the results from *IESve/Radiance* simulations are relatively close to the measurements, they are inside the ranges defined by the measurements and correspondent standard deviations. The important thing to conclude is that the performance of the glass lamellas is similar when comparing measurements with *IESve/Radiance* simulations. Both for the measurements and simulations the glass lamellas allow an homogenization of the daylight factor along the depth of the room.

B.4.2 Case 2

For Case 2, results are similar to Case 1. The most important difference is that according to both measurements and *IESve/Radiance* simulations the glass lamellas are able to slightly increase the daylight factor (0.1%) at the working plane near the back wall.

B.4.3 Case 3

For Case 3 the indoor daylight was evaluated by an artificial parameter named “daylight factor for sunny sky”, DFfactorSS [%]. This parameter is similar to the daylight factor but also includes the direct radiation.

For this Case the important conclusion is that during sunny days when the glass lamellas are completely closed acting as a solar shading system they reduce slightly the indoor daylight inside the room. However if compared to typical solar shading systems this decrease is insignificant, when completely activated typical solar shading systems may totally block the light to enter into the room. It is also important to refer that the decrease in daylight caused by the lamellas is similar when comparing measurement with *IESve/Radiance* simulations (see **Figure 10** but take into account that the “daylight factor for sunny sky” is represented in logarithmic scale, in this way, at first glance, it may seem that the decrease in daylight caused by the lamellas is higher for *IESve/Radiance* simulations than for measurements).

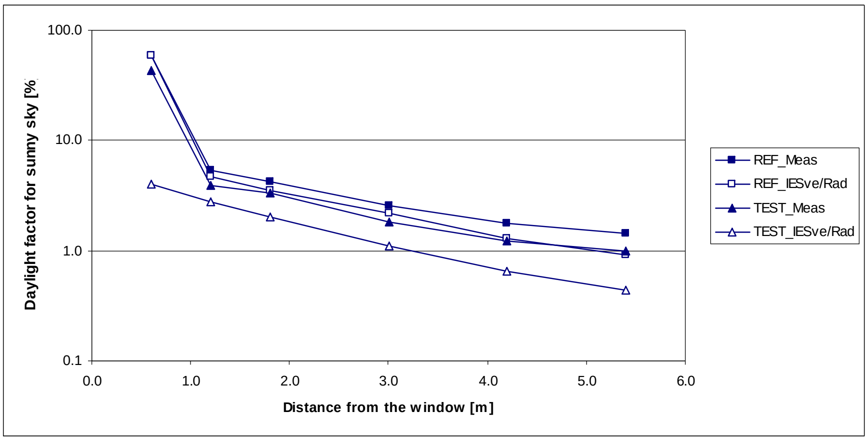

Figure 10 - Measured and simulated "daylight factor for sunny sky" at the working plane for both reference and test rooms. The values refer to May 3rd at 10.07.

B.4.4 Case 4

The comments made before for Case 3 are also valid for Case 4 since the results are very similar for both cases. The main difference is that according to the measurements, for instance at noon, the daylight in the back part of the room is higher in the test room than in the reference room. Comparing to Case 3, this means that the two upper lamellas which are set in the 30º position (see **Figure 6**) are able to increase the daylight in the back part of the room. By the other hand, according to the simulations the lamellas are not able to increase the light in the back of the room. Instead they decrease it. For cases of sunny sky with some lamellas opened the algorithm "mkillum" available in the original version of *Radiance* should be used to obtain more accurate results.

B.5 Conclusions and further work

Comparing measurements with simulations is always a delicate process even with the most highly developed software. For instance the distribution of the sky is defined according to standard procedures which are of course not found in reality. Also during measurements many uncontrolled factors may vary.

Daylight measurements in the experimental rooms of the Daylight Laboratory at SBi were compared with *IESve/Radiance* simulations. The results seem to show that IESve/Radiance is valid when simulating the daylight performance of glass lamellas systems (as a *trans* material) under overcast sky and also under sunny sky if the lamellas are closed. For simulations under sunny sky and with some lamellas opened it is advised to use the original version of *Radiance* to obtain more accurate results.

There are two experimental rooms also at DTU and one of them has already a glass lamellas system mounted on its façade. The other will be the reference room. Some daylight measurements and comparison with *IESve/Radiance* and original *Radiance* simulations are already planned. It would be also interesting to evaluate the performance of glass lamellas systems in real scale buildings located in cities.