User acceptance study of the EE-SYLK daylighting system

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ABSTRACT

In the EE-SYLK project a new daylighting system has been developed and evaluated. The new daylighting focused on ways of bringing the natural light deeper and more evenly distributed in office spaces by using a special sunblind and optic ceiling. Light technical, thermal and user-friendliness evaluations have been performed on the product.

The evaluation was done by comparison of two identical offices, one with the new daylighting system and one with a normal horizontal white sunblind under identical circumstances. We evaluated in different weather conditions, seasons and with different positions of the louvers of the sunblind.

The thermal evaluation showed that both systems have similar thermal performance. From the light technical evaluation it can be concluded that the system brings up to 35 % more light and more uniform light at the workstations in the office.

In this paper the user acceptance evaluation method is described in more detail. The test person's selection, the test set up, testing procedure and enquiry is explained. The method did not reveal the purpose of the test and can also be applied for evaluation of other daylighting systems and office equipment. Finally the user acceptance results are presented and interpreted.

INTRODUCTION

The main objectives of any daylighting systems for use in offices [1] are: reduction of lighting energy consumption, obtain a more uniform light distribution, prevent the office from heating on sunny days, to be user friendly, allow visual contact with the outside and prevent glare effects.

In the EE-SYLK project such a new daylighting system has been developed. The project also focused on the light technical and thermal evaluation and especially the user acceptance.

First a short system description of the new EE-SYLK daylighting system is included in the paper.

Afterwards results of the light technical and thermal evaluation are summarised, more results can be found in [3]. The light technical and thermal behaviour were evaluated by comparison of a reference office with a new daylighting office. Both offices had the same dimensions, orientation and contain dimmable fluorescent lighting fixtures with daylight responsive control. The reference office had a conventional white horizontal solar blind. The new daylight office was equipped with the newly developed EE-SYLK daylighting system.

Finally a practical user acceptance method is presented together with the results.

The success of energy saving lighting systems will depend on the acceptance of the staff. Dissatisfaction with the lighting system can even lead to the boycotting of the systems and therefore the expected energy savings will never be reached. But, user acceptance studies can also support market introduction if they proof that with the new system a better working environment can be achieved that justify a higher system cost. Furthermore, the user acceptance

Fig 1. Schematic diagram of new daylighting system

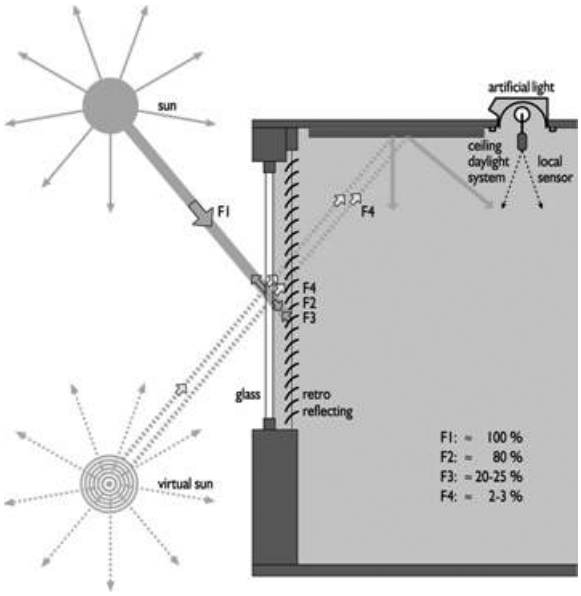


Fig 2 Pictures of evaluation offices

Room A: with new daylight system

Room B: with normal solar blinds

studies can reveal important information about user behaviour for improving prototypes and designing new user oriented systems.

In order to be cost effective a user acceptance study on prototype systems must be fast, limited in number of test persons, flexible to adapt to improvements and still reveal important data on system acceptance and user behaviour. Therefore a practical user acceptance set up and method has been worked out in the project. It is useful for prototype evaluation of office daylighting systems and other office equipment.

New daylight system description

A unique daylighting system was developed in the project. Figure 1 shows schematically the new EE-SYLK daylighting system. The solar blind consists of retro-reflective material. This coated material reflects at the angle of incidence independently of the blind angle and mirrors slightly on the glass. The reflection on glass creates a directed beam of light on the ceiling (see fig. 2.). The ceiling mirrors provide the appropriate light distribution. This more uniform light will result in energy saving through light fixtures equipped with a daylight responsive dimming system. The system has the additional advantage that the internally reflected light reflects towards the normally shaded side of the room and the externally reflected light does not cause glaring effects in the opposite building.

Evaluation rooms characteristics

The evaluation has been carried out in two south (158°) oriented offices (7 x 3,45 m2 floor, 1,5 x 3,07 m2 window) located in Belgium (N 51° 12.99' E 5° 5.27'), see figure 2. Thermal insulating glazing (Glaverbel, Thermoplus Superlite 4-12-4 mm) with solar factor 67 % was installed.

The following parameters were measured in each office: 5 illuminance sensors (lux), 1 luminance, room temperature (°C) and heating power consumption (kWh).

The following outdoor parameters were measured: vertical solar irradiation (W/m2), horizontal solar irradiation (W/m2) and the outdoor temperature (°C).

The evaluation was done around autumnal equinox without artificial lighting under different weather conditions and blind angles. The IEA task 21 evaluation protocol [5] for daylighting systems was used as a guideline.

Summary of thermal and light technical evaluation

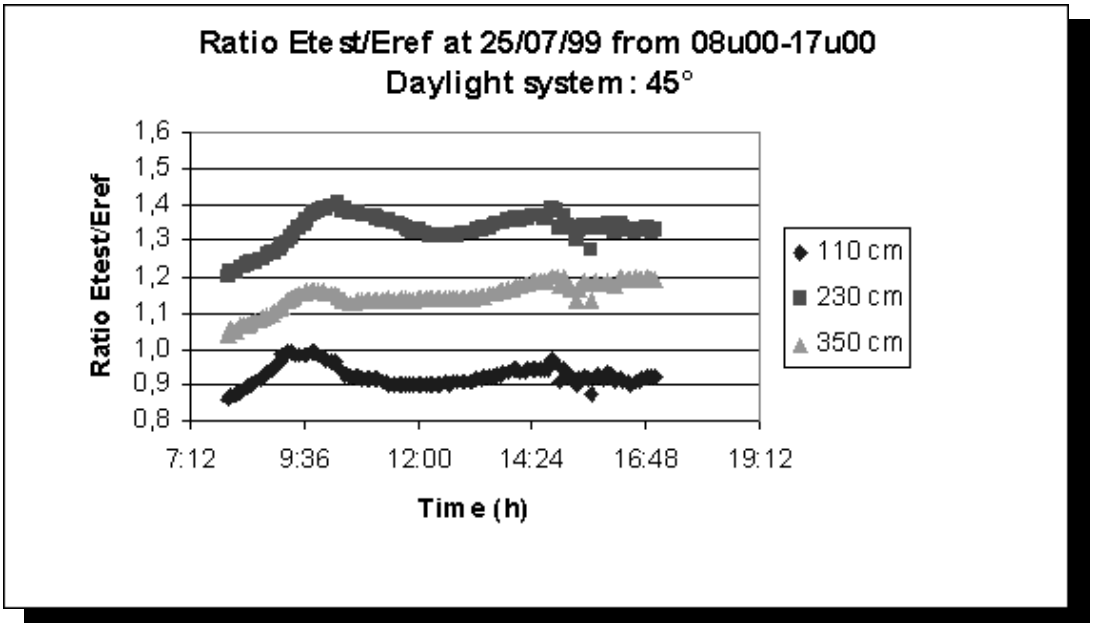
Thermal evaluation

Thermal evaluation was performed during the weekend, with both offices closed and heated up to the same temperature. This allows making energy balances and comparing both systems. This method is similar to [2] but requires no air conditioning. From these measurements it was concluded [3] that both solar blinds have similar thermal performance.

Light technical evaluation

Light measurements were carried out with louvers at different angles, with clear- and overcast sky and in differ-

Fig. 3 Clear sky and louvers at 45°



ent seasons [3]. Figure 3 shows the most important situation that also was used during the user acceptance with clear sky and louvers at 45°. In this case the system brings up to 35 % more light at a point 2.3 m into the room, this is also the position were the office desk is mostly located. At the window (1,1 m) the light is reduced, this provides more uniform light on the workstations. The system works also with overcast sky and for diffuse light. For example, with overcast sky and horizontal louvers up to 30 % more lat 2.3 m was measured. There is an improvement in all blind angles and weather conditions [3] and therefore the system is very suited for use with manual operated louvers.

User acceptance research procedures

Test persons selection

The group of test persons must be sufficient large [4] in order to reduce the error margin and must be selected in order to represent the target group [4].

Therefore 68 persons were selected from the Vito company personnel (430 in total) that carry out regular office work and that reflect the Belgian office work force with respect to age and gender. The test persons were also chosen among the Vito employees who do not work in close collaboration with the EE-SYLK research group, so they had no idea about the objectives of the test. It was only announced that they would participate in an ergonomic office evaluation for 20 minutes of time.

Test set up

Test were carried out in both evaluation rooms (§ 3). Both offices were identical; the only difference was the presence of the new EE-SYLK daylighting system in office A.

Because we searched to potential disadvantages of the system it was chosen to put the desk and computer in parallel with the window and to face the users with the window. Therefore the test was also carried out with open sky and between 10-11h30 and 14-16h in a period about equinox for ensuring representative low angles of solar altitude. The position was at about 2.30 m from the window. This situation ensures the maximum contrast during testing.

The artificial lights were switched off.

Test method description

- Standard market research methods were used [4].
- 68 people were asked to participate to an ergonomic test for 20 minutes of time without revealing the real purpose. The real purpose of the test, i.e. daylight system testing, was not mentioned in order to exclude subjective test reactions. This was also checked just before the test.
- People did receive a short computer and reading task in both offices.
- After the task they were asked to fill in an enquiry in each office.
- In the last office there were asked to indicate which office they prefer (A, B or neutral) and why.
- Afterwards for a selected group of people in depth interviews were carried out and there normal working office space was visited.

Enquiry

The enquiry contains a series of subjective room impression characteristics that are related to office ergonomics, see also list in table 1.

They were asked to quote for this between 1 and 5.

Table 1. Enquiry results of user's preference related to room characteristic

Users room impression characteristic	score for room A new system	score for room B standard system	deviation A-B %
Pleasant (1) - unpleasant (5)	2.99	3.25	8
Interesting (1) - boring (5)	3.35	3.79	12
Sympathetic (1) - unsympathetic (5)	3.12	3.37	7
Bright (1) – dim (5)	2.01	2.76	27
Clear (1) - unclear (5)	2.01	2.50	19
Uniform light (1) – contrastful (5)	2.59	2.84	9
Warm (1) – cold (5)	2.63	2.94	10
Quiet (1) – noisy (5)	2.24	2.43	8
Informal(1) –formal (5)	3.19	3.29	6
Odour(1) - no odour (5)	3.01	3.19	6
Nice view (1) -awful view (5)	3.47	3.81	9
Orderly (1) - messy (5)	1.87	1.87	0
Dusty (1) -clean (5)	3.84	4.01	4

Fig. 4 Extract of user acceptance enquiry

What is your impression about this room?

	1	2	3	4	5	
pleasant	_	_	_	_	_	unpleasant

For example for the room impression characteristic 'pleasant' is included in figure 4.

User acceptance results and analysis

User room impression characteristics

The scores of the enquiry were processed and the difference (%) between the rooms was calculated (table 1).

From table 1 it can be concluded that the new daylighting system scored better for lighting conditions (luminary & clear).

Room preference

This is the summary of preferences indicated after the test:

54 % preferred room A (new system), from these 81 % indicated because of the light.

28 % had no preference for room A/B

18 % preferred room B, from these 42 % indicated because of the light.

In depth interviews

For these in depth interviews 8 persons were selected from the 18 % group that preferred room B. The objective was to learn more about possible disadvantages of the system.

These were the conclusions:

- 3 men and 5 women;
- 5 people say they are extremely sensitive to light, 2 very sensitive and 1 sensitive;
- they were introduced again in the test offices and were asked how they would like to put the angle of the louvers. 5 persons would like almost closed, 2 completely closed and 1 would keep 45° (test value);
- all persons said that they have no problem working in office A if they can choose the position of the louvers themselves.

There were also 5 interviews with regular users of offices that were equipped during one year with the new system. They were all very positive and indicated that especially the horizontal louvers were a big advantage over the vertical that normal are used standard in the company. Vertical louvers are disliked because of zebra shading effects in offices oriented to sun.

CONCLUSIONS

A new daylighting system was presented. Thermal and light technical measurements were carried out. A practical user acceptance evaluation method for prototypes was used. The method is also useful for evaluation of other office lighting equipment.

The following conclusions were made with respect to the EE-SYLK system:

Light technical: the system works under all weather conditions and focusing scales of the layers of the sunblind and up to 30 % more light was measured on the desk.

Thermal evaluation: the system has similar performance as horizontal white sunblind.

User acceptance study: a group of test persons, which work daily in an office, have worked alternately in two identical offices. One of the offices was equipped with the

new daylighting system and the other one with a regular white sunblind. The test persons were completely unaware of the purpose of the study. We did a survey each time after they finished their work in one of the rooms. The inquiry did not reveal the purpose of the study, the questions about the lighting were hidden between questions about all kind of other things in the room such as the noise, the smell etc.. 68 % of the test persons noticed spontaneously the difference in the lighting of both rooms. 72 % of the test persons preferred the room with the new daylighting system or did not prefer one of the rooms.

Some general conclusion from the user acceptance study concerning daylighting systems:

The user acceptance study learned that people can differ strongly in preference for what concerns lighting conditions. It can be energy consuming to tune the light conditions to a standard that fits to almost all test persons. One standard condition that gives all users maximum satisfaction will even simply not exist. Therefore it is important that people can interact and tune the lighting system individually on a simple way. Only a system fulfilling this requirement can lead to maximum energy saving.

REFERENCES

[1] Baker, N., Fanchiotti A. and Steemers K. (1993). *Daylighting in Architecture*, published by James & James Ltd., ISBN 1-873936-21-4, pp.2.1-2.19.

[2] Lee E.S, Di Bartolomeo D.L. and Selkowitz S.E. (1998), *Thermal and Daylighting Performance of an Automated Venetian Blind and Lighting System in a Full-Scale Private Office*, Lawrence Berkeley National Laboratory report (LBNL-40509).

[3] P. Van Tichelen,I. De Laet, Frans Taeymans and Frans Adams, *Energy savings from the EE-SYLK daylighting system*, Vito &ETAP Lighting, Brighton June 2000, proceedings of WREC 2000, ISNB 0 080 43865 2, Pergamon press.

[4] P. Offermans, B.Gijs, M. De Laet, *Marktonderzoek* (market research handbook in Dutch), 3de Ed., Deurne, MIM,1995 ISBN 90 341 0812 0

[5] S. Hygge and H.A. Löfberg with the contribution of subtask D participants, *POE Post occupancy evaluation of daylight in buildings - A report of IEA* Task 21: Daylight in Buildings - subtask: Monitoring Case Studies / Annex 29, 1999

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ACRONYMS

EE-SYLK: Energie Efficiënte SYmbiose van natuurlijk Licht en Kunstlicht