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EXPERIMENTAL COMPARISON OF PERFORMANCES OF DAYLIGHTING SYSTEMS

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ABSTRACT

Different building components for the improvement of daylight penetration in buildings are available today on the market. Most of them are unfortunately characterised by an absence of objective assessment of their luminous performances (daylight factor, visual comfort, etc.), leaving building designers with no clear understanding of their energy savings potential. Several state-of-the-art daylighting devices (lightshelf, microlouvres, holographic panels, etc.) were compared experimentally using 1:10 scale models, as well as 1:1 scale mock-up rooms. This paper gives an overview of theses performance values, putting an emphasis on their comparison with those of a conventional double glazing facade.

RÉSUMÉ

Divers dispositifs d'éclairage naturel ont fait l'objet d'un développement industriel et sont ainsi disponibles sur le marché. Peu d'entre eux ont bénéficié d'une évaluation objective de leurs performances lumineuses (facteur de lumière du jour, confort visuel, etc.), dont dépend leur potentiel d'économie d'énergie. Plusieurs dispositifs d'éclairage naturel ont été comparés expérimentalement pour cette raison par l'intermédiaire de maquettes à l'échelle 1:10 et de modules d'expérimentation grandeur nature. Cette communication rend compte de ces mesures expérimentales, pour lesquelles une façade conventionnelle munie d'un double vitrage a servi de référence.

INTRODUCTION

Daylighting products are getting more and more numerous on the market, as a larger consensus is reached on the issue of "building sustainability" in many European countries. Most of these products were however never objectively characterised regarding daylight performances, which are usually expressed in terms of daylighting factor profiles and expected daylighting autonomy, as well as through visual comfort and performance indicators [IES87].

The assessment of such performances was carried out at LESO-PB/EPFL within the framework of different research projects (DEMONA : Forschungs- und Demonstrationsmodule für innovative Tageslicht-Technologien [DEM97], IEA Task 21 "Daylighting in Building" [Sca98]). The results of this assessment, carried out by the way of two different methodologies (scale models, mock-up rooms) are given in this paper.

INVESTIGATED DAYLIGHTING SYSTEMS

Different kinds of daylighting systems were investigated experimentally in the following two manners :

- by means of on-site daylighting performance monitoring, carried out within two daylighting test modules [DEM97];
- by means of measurements on 1:10 scale models of the same modules, carried out in a sky simulator [Mic98].

Most of them were studied within the framework of IEA Task 21 : reference [Sca98] gives an overview of the broad range of systems considered, using the different experimental facilities of the participating countries. The scale models were investigated using the EPFL scanning sky simulator, who offered outstanding features for this kind of performance assessment (automatic calibration procedure, versatility of sky luminous distribution, etc.).

Mock-up rooms

Two test modules, with identical geometrical dimensions (3.05 x 6.55 x 3.05 m) and photometrical properties (glazing ratio : 0.26, ρ_{floor} : 0,15, ρ_{walls} : 0.80), were used to assess the performance on a 1:1 scale basis. Both are placed on the same circular platform to guarantee strictly identical outdoor conditions. The modules stand side by side; there are no physical obstructions around them at an altitude above 10° over the horizon.

Figure 1 shows a front view of the two mock-up rooms; one of them is used as a reference and is equipped, in consequence, with a conventional double glazing facade.

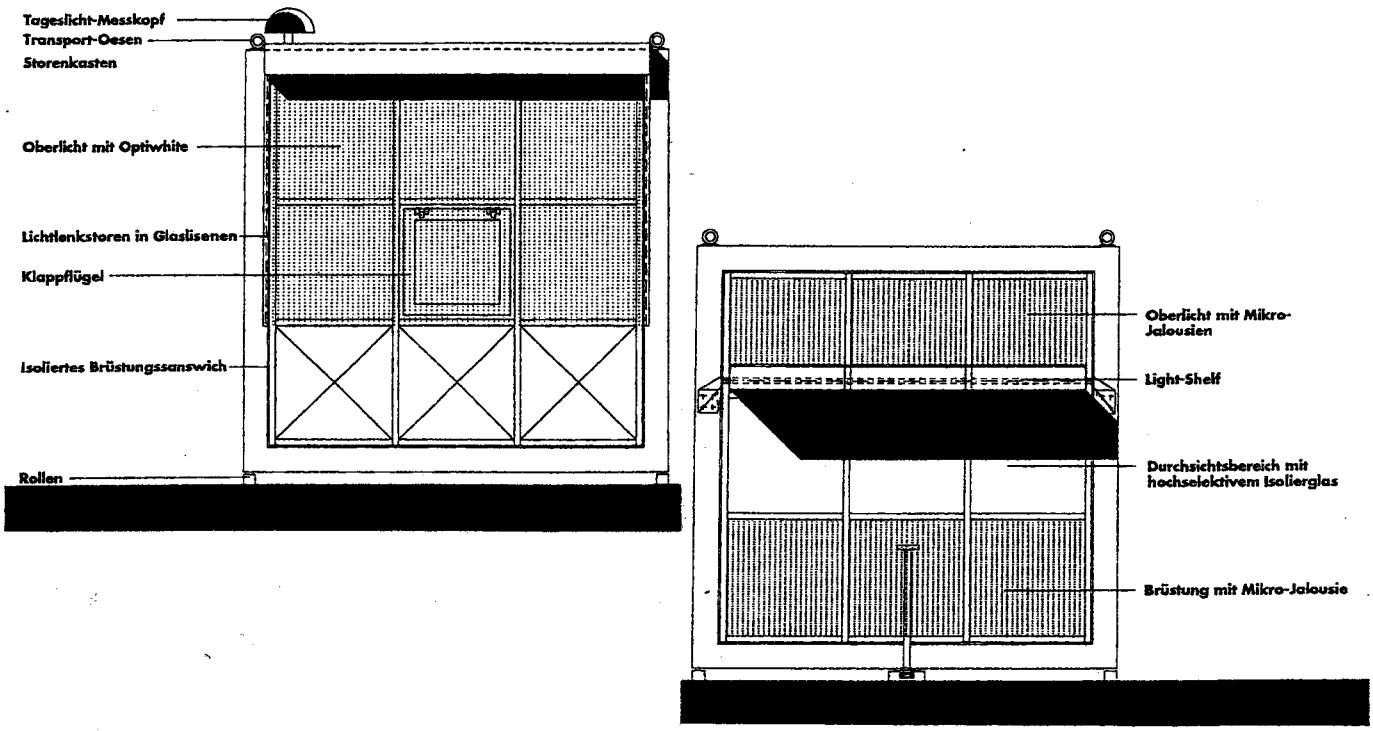

Figure 1 : Front view of the two daylighting test modules (1:1 scale models)
Left : reference module Right : Aluminium lightshelf and microlouvres

Several state-of-the-art daylight devices were installed on the test module [DEM87], including :

- microlouvres integrated within glazings
- aluminium lightshelf
- sun directly glass
- engraved glazed pannels

Scale models

One to ten scale models of the same modules were used to perform measurements under the sky simulator. Special attention was given to the accurate modelling of the main geometrical and photometrical features of the modules [Mic98] (window frames, reflection coefficient, etc.). Figure 2 shows a cross-section of the modelled daylighting systems, as well as the reference facade (double glazing).

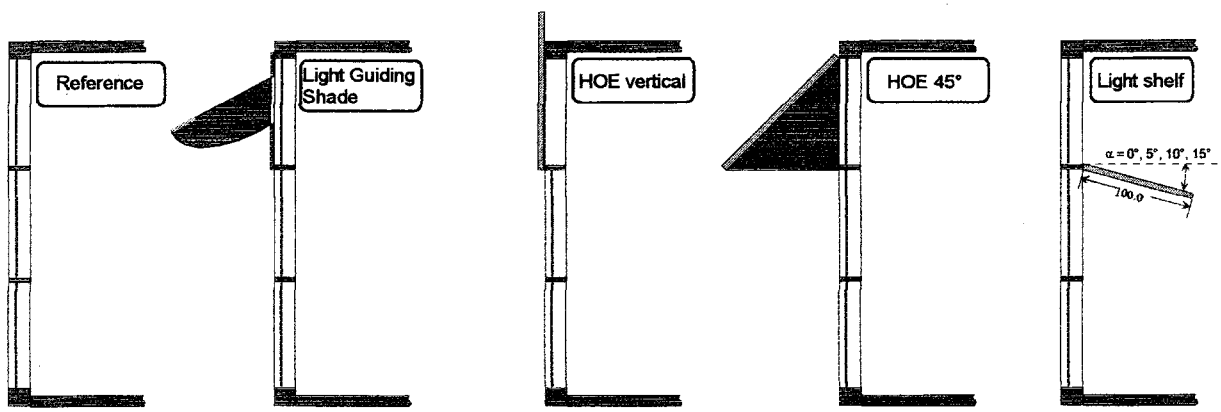

Figure 2 : Cross-sections of the 1:10 scale model of the reference facade (left) and the daylighting systems (right) placed on the sky simulator.

Several devices were designed and produced in the different IEA countries and included :

- anidolic ceiling (EPFL, Switzerland)
- light guiding shades (QUT, Australia)
- holographic optical elements (ILB, Germany)
- aluminium and glazed lightshelves (SINTEF, Norway)

The same assessment procedure was used for all systems, analysed using the EPFL sky simulator.

EXPERIMENTAL DAYLIGHTING PERFORMANCE

Mock-up rooms

Full scale daylighting systems were monitored for different cloud conditions, including overcast and clear skies [Ber96]. The cloud cover was carefully checked for overcast conditions; daylighting systems illumination by direct sun (with / without sun on the facade) was used to distinguish the two sunlighting situations.

Figure 3 shows the daylight factor profile observed perpendicularly to the facade for a combination of a 20° slanted aluminium lightshelf and window integrated microlouvres. Figure 4 shows the same figure observed for clear sky and expressed in horizontal work plane illuminance for a 100'000 Lux external global illuminance.

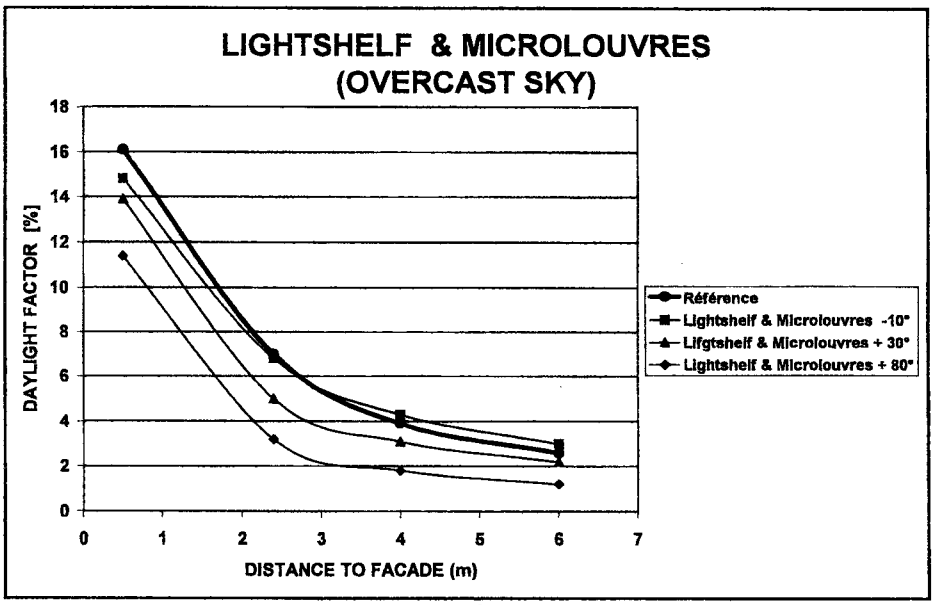

Figure 3 : *Daylight factor profile observed in mock-up rooms for a combination of a 20° slanted lightshelf and window integrated microlouvres (overcast sky).*

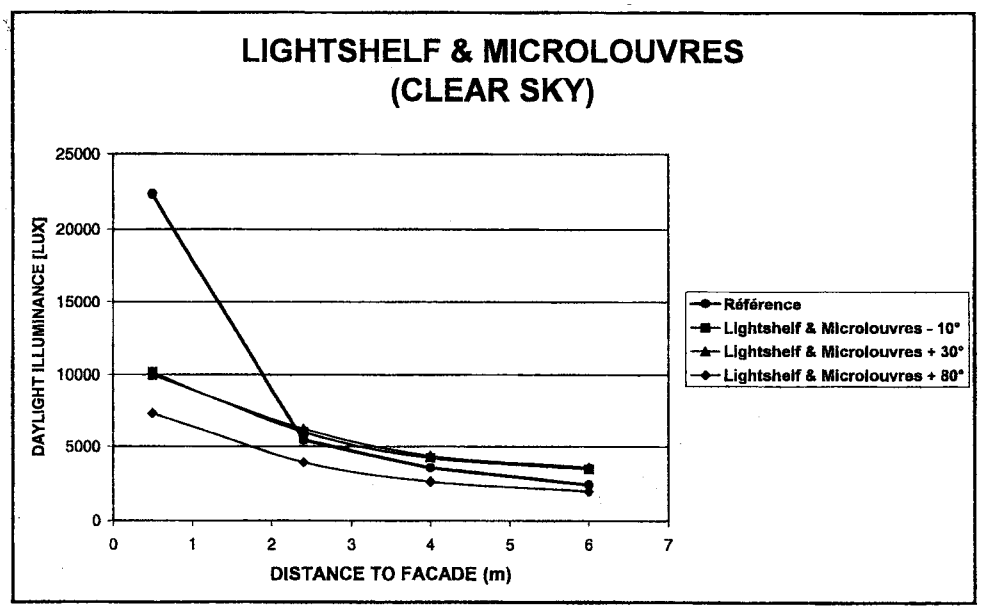

Figure 4 : *Workplane illuminance normalised for 100'000 Lux external global illuminance (clear sky).*

This slight improvement of the daylight factor (as well as the work plane illuminance) at a distance of more than 4 meters from the facade is the most positive daylighting performance observed for the investigated systems. All of them, excepting lightshelf and microlouvres, significantly decreased these figures in comparison to the reference facade. The sun directing glass shows similar disappointing daylight factor values, but improves illuminance values for clear sky conditions.

Scale models

Scale model measurements were performed under CIE overcast sky luminance distributions [IES87]. Daylight factor profiles were monitored that way and completed with an assessment of the daylighting autonomy and lighting provision using IDMP statistical data [Mic97].

Figure 5 shows a comparison of the systems' daylight profiles observed in this manner; the values obtained for the reference facade (double glazings) are shown in the same figure for comparison.

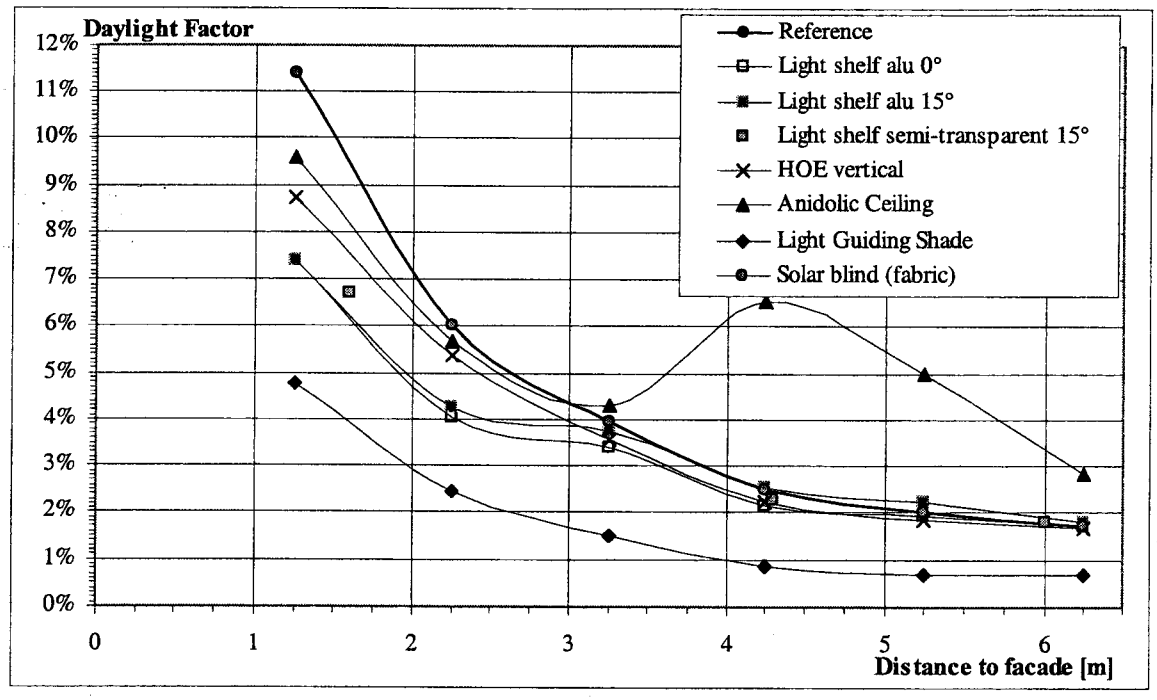

Figure 5 : Daylight factor profiles observed in scale models for different daylighting systems (overcast sky)

The performance assessed within scale models confirmed those of mock-up rooms. It appears in consequence that :

- a large majority of daylighting systems shows lower daylight factors in comparison with the reference facade.
- the 15° slanted aluminium lightshelf slightly improves daylight factors, when compared to the reference, at distances of more than 4 meters from the facade.
- a substantial improvement of the daylight factor is only achieved by the anidolic ceiling (values higher than 5% instead of 2% for the reference).

Most of these devices provide a more uniform illuminance distribution in the room, performing as shading systems rather than daylight systems. The improvement of visual comfort achieved in that manner, is not directly linked to energy savings, which remain associated with higher provisions and daylight factor values.

CONCLUSION

Most of the building components for the improvement of daylight penetration into buildings that are available on the market were never assessed experimentally regarding their daylighting performance. Several state-of-the-art daylighting devices have as a consequence been monitored using 1:10 scale models and 1:1 scale mock-up rooms.

Most of these systems show daylighting performances lower than a double-glazed conventional facade, closer to shading systems than illumination systems. Only one system (the anidolic ceiling) improves substantially the daylight factor values deep into a room, when other systems decrease these values or at best, just slightly improve them (lightshelf, microlouvres).

The achievement of energy savings in buildings rely on a clear understanding of the daylighting performance of such systems. It is expected that this work will contribute to supporting the designers in their quest for outstanding daylighting systems and significant daylighting performances.

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