Adjusting daylight and solar heating in office buildings

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Adjusting daylight and solar heating in office buildings – a practice based investigation of new decorative and functional solutions

The research is rooted in textile knowledge, and conducted by a small team with competences in textile engineering, textile- and graphic design. The Team is lead by the Associate Professors Joy Boutrup & Vibeke Riisberg in collaboration with Research Assistants Annette Andresen, Mette Ploug, Seiko Takanashi Marquard.

Introduction

In both old and new office buildings there is a need to regulate daylight and temperature according to changes during the day and the seasons. For the employes strong sunlight often cause problems when working on computer screens, and increase of temperature in the office space can be most impeding. But it is also important to have sufficient and changing daylight in our working environment, as it is vital to our health and state of mood. Several research projects have documented the problematic (e.g. J. Christoffersen et al., 1999; M.G. Figueiro et al, 2002). However, these investigations are mainly concerned with measurements of sufficient daylight, health issues, building regulations and architectural problems. They do not consider the aesthetic aspects of the working environment or suggest new interior design solutions.

This project seeks to merge aesthetical, functional and theoretical reflections into decorative shadings, which can adjust daylight and solar heating in offices. We see decoration as an active changeable element, which can provide a pleasurable experience to the employees. The objective is also to explore new solutions that will take maximum advantage of daylight in order to save energy. Our research is practice based and carried out through a series of experimental investigations of ornament, textile materials and – techniques in combination with polarizing, UV- and IR-filtrating foils.

Existing solutions

As a starting point, we did a survey of existing shadings on the market, and made a small qualitative study of daylight adjustment in six office buildings – five of them taken into use between year the 2000 and 2005, and one in 1984. The latter was included because the facade had been renovated in 2005, adding heat – reflecting ridges to improve the climate in the building. Heat – reflecting ridges had also recently been mounted on one of the new buildings

that were taken into use in 2003. This resulted in a 40% reduction of the energy consumption, which had been used to cool down the building.

Our study showed that there is a relatively small range of products, which can be mounted on the facade or inside the building. In all six cases there were two sets of shadings, either one outside and one inside or two inside.

The shadings on the market are generally roller blinds and Venetian blinds or flat panels – the majority is without decoration and in white or neutral grey tones. They all have an anonymous appearance, which does not seek to give the user any tactile or visual pleasure. This we would like to challenge in our research.

Folding curtains have good properties in diffusing light, but are rarely used in offices today – we did not find any in the six buildings. According to Anne Jørgensen, design director at the Danish textile manufacturer KVADRAT, many architects and building administrators presume that folding curtains need more cleaning that blinds. This need not be the case with the new high – tech coatings for textiles.

The conclusion of the study is that problems with light and heat are still not solved in office buildings. Artificial light is often turned on all day, even during the summer, because the blinds are down – a circumstance, which increases energy consumption.

Decoration
The point of departure for our research is a conviction that decoration is more than just frippery. We believe that ornament can bring about more pleasure to the users of a working environment, and also become an integrated functional element in the shading.

According to the design historian David Brett decoration is an expression of a deep human need for visual pleasure. This he defines as a group of values, which include social recognition, perceptual satisfaction, psychological reward and erotic delight. These values appear in public on buildings, furniture, clothing, etc., but they are experienced by each of us as individuals. Brett also considers decoration:

"… a disposition not unlike the faculty of language and counting, immanent in our nature without which we would not be complete human beings. Just as there are no societies that do not speak or count, so there are none that do not decorate, embellish or make patterns" (D. Brett, 2005, p. 6).

Textiles
Textiles are both flexible and strong, because the material is made of fibers held together by friction. In regard to light diffusion textiles possess specific properties, which are defined through the choice of fibers, yarns and construction of the goods. When the light passes through the yarn, it is diffused due to the differences in refraction index between fiber material and air. This means that light diffusion can be designed by the choice of fibers and

density of yarn and construction. Furthermore, the finishing techniques and the layout of the decoration can play an active role in the distribution of daylight in a room. Fabrics and foils can be manipulated and decorated in various printing techniques and laser cutting to obtain different levels of transparency and diffusion.

Apart from its functional properties, textiles also have specific tactile, poetic and aesthetic qualities, which are linked to our early subjective emotions and bodily experiences. These experiences are at the same time collective and included in our common cultural references (J. Attfield, 2000). This aesthetic, technical, functional and cultural knowledge is the vocabulary of the textile profession, which we are using in our practice - based experiments.

The first experiments
We decided to do the first series of experiments as flat horizontal sliding panels, since it would give us the opportunity to work with overlaying different ornamentation and materials. The hypothesis is that:

- It is possible to unite decoration and function in a new type of interior screen

- The optimal regulation can be obtained by combinations of materials with different properties regarding light and heat

- It is possible to do this using two or more adjustable layers with patterns creating new visual impressions by combination

In order to limit the experiments, we used only white, grey and silver tones. 9 different materials were selected and printed or cut with 5 geometric patterns – all constructed from the same hexagon grid. The patterns were designed to form an open and closed position in pairs of 2 layers – allowing more or less light in the room. From the first 32 samples 14 were selected and tested in a 1:4 scale model of an office at Designskolen Kolding. In the model we measured the light at different positions, but had no means to measure the heat. The light measurement data were processed into graphic diagrams to compare the screening effect of each combination. Different places in the model were measured in order to get a picture of the general distribution of light. All combinations were documented with a digital camera during the process. The aesthetic appearance of each combination was discussed between the members of the team. This aspect clearly has to be developed and structured into user surveys in connection with the further development of patterns.

Preliminary findings
These first experiments mainly had the purpose of testing different materials and their patterning properties. The actual patterns were chosen as representative, with the intention to be perceived as relatively neutral and of no narrative connotation. The aesthetic results of some combinations could be described as poetic, delicate and fragile, both visually and in the fabric tactility. This was particularly linked to the devoré samples. Others were

perceived as disagreeable, with hard pointed forms and too much contrast when exposed to backlight. This effect is due to the pattern layout in combination with pigment or transfer printing, which shut out the light completely. Further descriptions and analysis of the aesthetic appearance will be the subject of a future article.

The experiments made it clear that the design of pattern, the choice of material and technique as well as the variation of backlight in daytime and artificial light in the evening poses a huge challenge, which is further complicated by the need for functional performance to distribute daylight and moderate the solar heating. But the experiments also confirmed the idea that textiles and other fiber based materials are diffusing the light and removing the glare, while the IR-reflecting foils generally reduce the amount of light and heat, but have no positive effect on the glare. The preliminary findings show that a combination of materials will be necessary for an effective screening against heat and glare.

The second series of experiments in 1:1 scale

On the basis of the first findings a new series of experiments were planned and carried out in 1:1 scale. The results were later tested in the same office the 1:4 model had been based on. As a point of departure for developing the new ornamentation, we chose 3 distinctly different motif categories: Flowers, Textures and Geometric – all well known within the textile vocabulary (Meller & Elffers 1991). The reason for this choice was partly a wish to establish a common frame of reference, which could be recognized by a wide group of users, partly to further investigate the visual and functional effect of combining 2 different materials with 3 different motifs in 2 layers.

Before selecting designs for printing the 1:1 panels, a relatively long sketching phase took place. Based on a visual analysis of historical documents a great number of different means of expressions were explored and brought into new designs. Scale and proportion between figure and ground were studied in relation to printing techniques, the size of the window and a standard panel system. In the system 2 or 3 layers can be combined sliding the panels horizontally. An on going evaluation took place in the group until finally 3 motifs were selected: One big flower with no repetition, one texture – opening gradually towards the top and resembling the surface of a melon, and one geometric repeat pattern with oval shapes in different sizes.

The 3 motifs were printed as devoré on a ‘silver fabric’ – woven with a flat aluminium coated yarn - and on a cotton/polyester fabric. Devoré is a technique that locally removes some fibers from the fabric, and in the finished fabric the printed pattern will show as more open areas with enhanced transparency and translucency.

Over 3 sunny days in July we registered 14 combinations with a digital camera. And in order to find out, if the screening could reduce the solar heating, we also used a thermal camera. To measure the room temperature 2 digital thermometers were placed in the window and next to the computer on the working desk. The light intensity was measured 3 different places in the

room with a Lux Meter. At this point, we have not yet had the opportunity to compare and analyze all the measurements and the variation of aesthetic expressions in the 14 combinations. But one immediate observation is, that the exclusion of color seems to make it difficult to remember the various combinations, even though they are in fact very different. This suggests a wider focus in future research experiments raising the question on the role of color and memory. This observation along with a hypothesis on textile genre identification will be tested in the future on a group of potential users.

Parallel experiments

Parallel to the experiments with the adjustable flat panels, we have explored designs in deployable structures and honey combs. This has widened the perspectives and some of the 3-D structures have shown promising potentials in screening for heat and glare. The first full size prototype has been made in a flexible and diffusing non-woven material decorated with a heat reflecting print. Next step is to test the prototype in an office and to measure if it brings about the desired heat-reduction and fulfill the theoretical calculation in relation to diffusing and directing the light.

The design of new woven qualities is a field, in which we have also initiated investigations based on the experiences and results from the first experiments. This implies working with different weave constructions, density and yarns. By combining the density and materials the light adjusting properties can be planned and new visual and tactile expressions emerge. These investigations are strongly linked to a topic, I have not touched upon in this paper, namely the legislations on flame retarding materials in public buildings, and our goal to create more environmentally friendly and sustainable solutions for interior screens.

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Litterature

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