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INFLUENCE OF STRUCTURAL GLASS ON WORKING ENVIRONMENT QUALITY AND HEALTHCARE BENEFITS

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Abstract. Structural glass is a material which transparency allows abundant daylight, productivity gains as well as many health benefits. Many medically focused healthcare stages related to environment conditions are influenced by the direct amount of daylight provided by the design of the façade structure. Structural glass usage in the facades is mostly analysed within the context of sustainability regarding energy consumption and increasing green building leverage, but certain studies show that human working life quality is also affected by it. This includes increasing serotonin level as well as lowering stress and depression levels. In order to achieve healthcare benefits, many forms of using structural glass are being suggested in the literature regarding specific design approaches towards its transparency and translucency levels without neglecting the stress state and strength of the glass panels. The paper presents brief literature review of the topic and possible design approaches regarding human productivity and healthcare in its working environment.

Keywords: structural glass, healthcare benefits, working environment, structural design.

AIMS AND BACKROUND

The use of glass has been underlined by its transparency and translucency, providing natural lightening and connection to external environment, resulting in more humane and healthier interior living and working conditions. Designers and architects use it as a primary concept for dematerialisation of the building design taking the spatial relation of the object to its 'disappearance'. The industrial and technological evolutions of novel connection components and designs have broadened the possibilities for even bigger improvement in the use of glass providing not only environmental benefits but adding value to users' health and wellbeing. The scope of the use of glass in architecture is becoming highly extensive and hence the requirements in the glass industry are growing bigger and more complex.

Within the context of sustainability, research is made on different ecological factors and influences of the traditional buildings which provide comfort and life quality taking in account maintaining the energy efficiency[1]. Following the same approach, current environmental questions related to glass are mostly concerned

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with energy performance, like the use of shading devices to mediate heat gain and glare; and insulated or treated glass to reduce the energy demand and therefore produce environmental impact of the building. According to Glass for Europe Association[2], a lot of stylish and comfortable low energy buildings already exist and operate in many European cities proving that glass can highly contribute to energy efficiency performance of the object. The known concepts of glass elements including perforated designs, reflective louvers and different coating techniques take the transparency and translucency characteristics in function of improving working conditions and human health on different levels.

Numerous research studies have found that access to daylight in various types of buildings provides a healthier and healing environment (hospitals), and increases focus, learning and productivity (educational buildings and offices). General health benefits focus mostly on the effect of the provided daylight in maintaining human circadian cycles, or 'body clock' which is directly connected to productivity and satisfaction of people. Additionally, long list of other health issues are addressed, including: rickets, osteomalacia, eyestrain, migraine, autism, sleep disorders, seasonal affective disorder (SAD), depression, Vitamin D deficiency, the Alzheimer disease and stress[3]. In another research, a discrepancy in the amount of light received from artificial and natural light source is being investigated, where illumination measurements show that natural daylight provides up to 2000 lux while artificial light rarely reaches 100 lux. This increase in illumination, particularly its intensity in the morning, is directly linked to the circadian synchronisation. Seasonal affective disorder (SAD) is suffered due to shifts in the natural circadian rhythm where people are deprived of daylight and its synchronising effect[4].

Research about office health working conditions define comfort conditions as reasons for fatigue, which include drafty window, light reflections, lack of sunlight, and dull lighting in general. On the other hand, the comfort conditions most likely to reduce the occurrence of reported fatigue, include the best views, comfortable humidity, no noise distractions and no lighting problems[5]. Today, light is being provided with artificial means in various sophisticated and technologically advanced ways that try to mimic and ultimately replace daylight. Regulatory restrictions define the amount of minimum daylight tolerance especially in healthcare buildings. Unlike many other applications where artificial lighting may even replace completely the daylight, healthcare application is with high demands on natural lighting[6,7].

The healthcare benefits of daylight are thoroughly investigated within medical research as well, one of them pointing it out as a possible approach for increasing the serotonin level in human blood. People working indoors with sufficient daylight provided, have shown signs of increased satisfaction and lowered stress levels[8].

RESULTS AND DISCUSSION

Designing for daylight. Planning for daylight has to be incorporated in the conceptual phase of the design process in order to enhancing building daylight utilisation while achieving maximum energy efficiency and user acceptance. Providing daylight reduces lighting energy use and influences both heating and cooling loads. Daylight planning has different objectives at different stages of the building design, some of them being: choosing the shape and the proportions of the building while making the conceptual design; designing the façade and selecting and integrating the systems and services, including artificial lighting, during design phase; selecting the materials and construction element types within final (construction) planning; and lighting control and maintenance of systems for the commissioning and post-occupancy phase.

Daylight is inseparably linked to solar gain and there are a number of ways to control solar gains from windows and facades; the simplest method is the direct solar gain approach, where a shading system simultaneously controls the visual and thermal environments. More advanced techniques, such as collector windows and double-skin facades, allow some degree of separate control over the thermal and visual environments. In passive solar design concepts, solar gains are controlled by the orientation and the application of shading systems as a function of the sun position[9].

The first choice of structural glass type for solar gain and ensuring good quality of light has been body tinted glass and highly reflective coating. Today focus however is transparency and achieving high solar factor and light transmission. Glass types manufactured using magnetically enhanced cathodic sputtering offer best performance depending on selected metals and their combination. Hence, the level of reflection is reduced while gaining low emission coating. Whereas wide range of choice for this kind of glass type, there are restrictions related mostly to cost and availability regarding technology and unit size. Other solar control product concept is thermotropic and photochromic glass, which respond to the state of the sun. On low amount of sunlight, the glass is clear, higher amount the glass should darken reducing glare and preventing overheating. Thermotropic glass (Fig. 1) responds to temperature of the glazing, darkening as the glazing temperature rises.

Fig. 1. Suntuitive glass windows (thermotropic glass) installed at an educational facility in Keller, Texas, USA

The photochromic glazing (Fig. 2), on the other hand, reacts to increasing of light intensity that causes metal molecules in the glass to move from being stacked in columns to being spread out and decreasing the translucency.

Fig. 2. Photochromic glazing by Sage Glass (Saint Gobain)

The photochrome is laminated between two sheets of heat strengthened float glass. This type of glass can achieve changes in light transmission from 75 to 25% and a solar factor which changes from 53 to 23%. The biggest disadvantage of the photochromic glass type is its reaction to solar radiation levels, which increases the heating demands during wintertime.

As an improved concepts regarding the stated problem, is an electrochromic glazing (Fig. 3). This composite type of glass changes its state in response to electrical current. Thus, this concept can be regulated manually and even integrated the management system of the building, constantly or if needed changing its state[10].

Fig. 3. Electrochromic glazing by IQ glass (business building)

Different approach regarding daylight and shading is using incorporated reflected louvers (Fig. 4). These elements can be found in insulated glass units helping the dispersion and/or diffraction of the transmitted light. The main disadvantage is the restriction of vision provided by the louvers.

Fig. 4. Design concept of shading using louvers

On the other hand, need of shading caused the development of new glass composites that combine structural glass to different materials and shapes. There are existing architectural solutions on shading using tinted glass elements in form of louvers, which are part of the facade design, providing shading but decoration as well (Fig. 5).

Fig. 5. Façade design of EPFL building, Switzerland

CONCLUSIONS

Having in mind the daylight planning and incorporating it in the design process, climate-based daylight modelling will become a routine part of the evaluation of daylight at this stage. The use of such metrics as a design-generator, places performance evaluation tools at the forefront of today's architectural design process. Better use of daylight in buildings is an issue that structural engineers and architects are becoming increasingly aware of. The known concepts of glass structure elements used in facades and their influence on the light transmission make working indoors not necessarily being associated with suboptimal exposure to bright light. Thus, using different coating or design shapes and concepts can directly influence healthcare issues related to daylight and decrease the levels of stress and dissatisfaction.

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