

Day-Lighting and Sun Protection in Hospital Facilities – Assessment of the Used Solutions

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Abstract. The paper is a recapitulation of research into hospital buildings, focused on defining the advantages and disadvantages of the applied sun-protection systems and indication of the types of benchmark solutions. Proper selection of sun-protection systems in health care units is very important, because it contributes to creating the conditions of day lighting and their impact on patients' physiology. Moreover, sun protection systems influence the architecture of buildings - their external image and aesthetics of the interiors, ergonomics of rooms, providing comfort for the main groups of users: patients and medical staff, and contributing to energy-efficiency of buildings. The scope of the presentation is to draw particular attention to the complexity of this issue from users' perspective.

Keywords: day-lighting, hospital, sun protection, sun blinds.

1 Statement of the Objective and Significance of the Proposed Presentation

Exterior walls and facades should secure access of natural light to the interiors, protect from excessive sunlight, or increasing natural light distribution into rooms of bigger depth. These functions are served by facades equipped with technical solutions, including, for example, movable sun-protection shields. Hospital buildings are structures of specific requirements concerning natural lighting conditions and sun-lighting of rooms. The quantity, size, proportions and arrangement of windows are of great importance. Nevertheless, the selection of appropriate sun protection is equally important, as it exerts an impact on the psychological comfort of patients and the comfort of their stay at hospital. However, the selection of appropriate sun protection is equally important, as it exerts an impact on the psychological comfort of patients and the comfort of their stay at hospital. Modern technologies offer many visually attractive systems of sun-protection devices, but not all of them may be used in hospital facilities, not only because of efficiency but also due to the fact that the effects

such as shading and contrasts in the interiors, or changes of colors of the light may contribute to wrong assessment of the patient's health condition or hinder such assessment. The objective of the described research is to analyze the advantages and disadvantages of various sun protection systems in view of their applicability to hospital facilities, and to indicate preferred solutions that should be proposed at the design stage, or solutions that may be implemented in the course of the performance of the facilities. The scope of this paper is to draw attention to the importance and essence of these issues.

2 Description of Methods

Nowadays, computer simulations are used to evaluate the effectiveness of sun protection systems, but the authors of this paper have adopted a different approach- from users', human perspective. Thus, in the course of the research the methods typical for environmental studies were used:

- In-situ tests and observations conducted in hospital buildings in Poland,
- Pilot interviews with users of hospitals (children aged 3-12, youngsters aged 13-18, parents, medical, technical and administrative staff),
- Participative studies; assessment of experience, knowledge and needs of hospital users – at three stages:
 - Stage I – precise preparation of the studies;
 - Stage II – focus meetings, analyses conducted with the participation of users (workshops for children and young people, surveys/interviews, AEDET and ASPECT questionnaires, photographic analyses;
 - Stage III - meeting, recapitulation of the collected data.

The theoretical bases of the conducted research were analyses of professional literature evaluating the state of knowledge of the discussed issue, which revealed that the publications devoted to sun- protection systems mostly focus on office facilities (for more information – see: [6-8]); whereas, as far as the architecture of health care buildings is concerned, the issue of sun-protection shields is only marginally discussed, and, mainly in the context of the influence of sun-protection systems on the aesthetics and colors selection of the interiors, or as one of details of building facades.

3 Definition of the Scope of Research

Short descriptions and photographs of the researched hospital units are presented below. The majority of the studied medical facilities are pediatric hospitals which consented to the cooperation in the research. In Poland, the following hospitals were involved:



Fig. 1. Entrance area to children's hospital in Radziszów (photo. Magdalena Jamrozik-Szatanek)



Fig. 2. The North wing of the pediatric oncology hospital in Chorzów (photo. Magdalena Jamrozik-Szatanek)



Fig. 3. Western façade and the main entrance (photo. Magdalena Jamrozik-Szatanek)

CHILDREN'S REHABILITATION CENTER IN RADZISZÓW. Situated in the suburban area in Wieliczka Foothills and surrounded by greenery. Divided into segments, the shell of the building preponderates over the local environment, a part of the building is suspended. It is colourful and its horizontal character is enhanced by balconies of hospital beds units (see also [4]).

PEDIATRIC AND ONCOLOGY CHILDREN'S CENTER IN CHORZÓW. The hospital is located in the very centre of the city. Surrounded by compact urban settlements, it is shaped as the "H" letter, inside which the entrance to the building is placed. The shell of the building comprises mansard roofs covered with brick tiles, and white walls.

PEDIATRIC CHILDREN'S CENTER IN SOSNOWIEC. Located in the vicinity of the housing estate and the park, surrounded by tall trees. The shell of the building is divided into multi-colored segments, and the entrance zone highlighted. There is a greenery courtyard inside the building site.

For the sake of comparison, studies of selected hospitals in Italy were carried out, in consideration of the climatic differences, reflected in the applied sun-protection systems. The selected hospitals include:



Fig. 4. Courtyard and the main entrance to Children's Hospital in Florence (photo. Magdalena Jamrozik-Szatanek)



Fig. 5. The main entrance to Sandro Pertini Hospital (photo. Magdalena Jamrozik-Szatanek)



Fig. 6. The main entrance to the new Bambino Gesu Hospital unit in Rome (photo. Magdalena Jamrozik-Szatanek)

MEYER CHILDREN'S HOSPITAL IN FLORENCE is situated in the suburban zone and embedded in the green hills of Toscana. The hospital complex consists of historical buildings perfectly adjoined to the modern architecture of the entrance hall and patients' beds unit. The roofs have skylights formed as "Pinocchio" caps.

SANDRO PERTINI HOSPITAL IN ROME is located at the 8 km distance from the very centre of Rome. Due to its two-storey structure it has a friendly and inviting scale. The facades are rhythmically partitioned by semi-circular pilaster. Inside the hospital site there are two courtyards with greenery, playgrounds and recreation spaces.

BAMBINO GESU CHILDREN'S HOSPITAL IN ROME. This low hospital facility, surrounded with stone walls, is situated next to the Basilica of Saint Paul Behind the Walls. The facades of the Hospital are divided by vertical pillars and the spaces between them filled with glass and white panels. They also have sun-breakers that protect the Hospital from excessive sunlight.

The objective of making the comparison between the pediatric hospital facilities in Poland and Italy was to demonstrate the wide range of sun-protection solutions applied in hospital buildings.

4 Discussion of the Results

4.1 Factors Considered in the Assessment

The studies and observations of hospital facilities in Poland revealed that usually only internal protection solutions are used, including: vertical blinds and shades, or, in few cases- venetian blinds. From the users' perspective, they have an important advantage – ease of control and adjustment to individual needs; however, such protection systems are often insufficient. In consequence, on sunny days of the hot seasons the users (patients and medical staff) feel discomfort caused by dazzle and overheat inside the hospital (including patients' rooms). This is very disturbing, as the interiors of Polish hospitals are rarely air-conditioned. Whereas, in Italy, due to different climatic conditions and the resulting excess sunlight, external shields are most popular (roller blinds, awnings, shades, sun-breakers, etc.). Interior blinds are used as elements supporting sun protection systems, commonly in the spaces and rooms that require isolation from the external environment, for example: patients' rooms, staff rooms (doctors' duty rooms, nurse duty rooms). Furthermore, the protection solutions entail more than single elements and give a possibility of choice. For example, in the patients' rooms in Mayer Children' Hospital, children can shield the window with venetian blinds, curtains, and, in addition, their beds are isolated by hangings (the main function of which is to separate the patient from other roommates, but they may also serve as additional sun-protection devices, etc.).

The outcome of the research has been compiled in tables that contain the characteristics and assessment of sun-protection systems, their advantages and disadvantages in view of a specific nature of hospital facilities.

4.1.1 Exterior Blinds

The place of mounting sun protection elements is important to their effectiveness. The exterior blinds are more effective, but also more expensive, because they should be constructed in a manner that prevents their damage caused by atmospheric factors, including pollution, temperature differences, to prevent thermal expansion of the material, which, in turn, may lead to damaging paint coatings on the bottom of slats, or permanent deformation of metal lamellas. Also, wind power may also damage or destroy the elements of the exterior sun-protection system. Therefore, it is recommended to use automatic control of putting up and down the blinds, depending on the impact of the wind. The use of movable blinds with altering angle of the slats is really effective.

Table 1-4. Hospital buildings - advantages and disadvantages of exterior sun protection systems (elaborated by the authors on the bases of [1-3], [5-8])

Table 1.

	<p>Awnings Made of the material covered with impregnate that has antifungal and antistatic properties. Example of use: Fig. 7. Sandro Pertini Hospital in Rome (photo. Magdalena Jamrozik-Szatanek)</p>	
<p style="text-align: center;">Advantages</p>	<p style="text-align: center;">Disadvantages</p>	
<p>They provide shading, reduce excess heat and sunlight of the rooms, and partly protect from rain or snow falls but also, to a certain degree, from the wind.</p>	<p>In the case of stronger wind blows they should be folded, to prevent their damage; they give insufficient protection against rainfalls and often get dirty.</p>	

Table 2.

	<p>Façade louvers – “sun breakers” They have the form of pergolas, canopies, screens on the facade, shields adjoined to the walls, they may be movable or immovable, automatically controlled. Example of use: Fig. 8. Bambino Gesu Children’s Hospital in Rome (photo. Magdalena Jamrozik-Szatanek)</p>	
<p>Advantages:</p>	<p>Disadvantages:</p>	
<ul style="list-style-type: none"> • They contribute to clear, modern external image of the building, shade, to a certain degree, partly control sun dazzle, and redirect sunlight (but are not completely self-sufficient, usually aluminum slats can be replaced by photo-galvanic cells). 	<ul style="list-style-type: none"> • Heated air may be transferred, due to the set-up of the slats, directly to the glazing, which intensifies the excess heat in the rooms, • They do not provide thermal insulation in the winter season, • They may limit the view from the window, • In the case of metal blinds and holders unpleasant noise effects may occur (rasps, clangs), under the changing atmospheric conditions lamellas should be cleaned regularly, to maintain their property of light reflection. 	

Table 3.

	<p>Exterior roller blinds</p> <p>The blinds curtain consists of slats made of aluminum or aluminum tape filled with polyurethane foam; the slats may be glazed or have ventilation openings.</p> <p>Example of use:</p> <p>Fig. 9. Sandro Pertini Hospital in Rome (photo. Magdalena Jamrozik-Szatanek)</p>
<p>Advantages:</p> <ul style="list-style-type: none"> • They protect the windows and doors from the external impacts (rain, wind, sun rays, noise), • They prevent the cooling of rooms in the autumn and winter seasons, because when they are closed, there is the space filled with air between the shell and the pane, providing good insulation, • They constitute important elements of protection people and their possessions (if installed for such purpose, it is essential to strengthen their profiles and use special mounting technology,, • The blinds may be manually operated, or operated by electric drives, also, there is an option of solar energy drives. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> • The system is not very efficient as far as sun protection is concerned, • They provide visual isolation, because, when rolled down, they obscure the whole surface of the window; therefore, it is necessary to provide an option of manual rolling up the blinds, as in case of electricity failure (fire), they may make it impossible to evacuate people from the building.

Table 4.

	<p>Exterior louvers</p> <p>The slats are made of aluminum, steel, glass, and constitute an important decorative element of the façade.</p> <p>Example of use:</p> <p>Fig. 10. Sandro Pertini Hospital in Rome (photo. Magdalena Jamrozik-Szatanek)</p>
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Table 4. (continued)

Advantages:	Disadvantages:
<ul style="list-style-type: none"> • They provide insulation from thermal and solar radiation, • They shade the interiors in an effective way, • They improve light dispersion, and, when property set-up, offer the possibility of unhindered airing and visual contact with the exteriors, • They may be automatically controlled or operated by electric drives, • Glass louvers do not obscure the view from the window, and, at the same time, reduce the dazzle effect, • They may be equipped with photo-galvanic cells, although such solution is still expensive. 	<ul style="list-style-type: none"> • They contribute to the generation of streaky shadows, which, in turn, may cause disorientation and contrast in the field of vision, • There are problems with maintaining the cleanliness of the horizontal slats, due to settling of dust, • Unpleasant noise may be generated when the set-up of the slats is being changed.

4.1.2 Interior Blinds

Interior systems are not effective in terms of thermal protection, but investors prefer this solution because of cost-efficiency and the fact that they are not exposed to damaging atmospheric impacts. They are also popular among users, because they are flexible and may be adjusted to individual preferences, offer easy access and operation. They are important elements of the aesthetics of the interiors, but, as such, are also subject of hygienic and sanitary requirements. In the case of glass facades and double pane windows, it is possible to fit various types of movable blinds (venetian blinds, roller blinds) into the sealed space between the panes. In comparison with interior shields, such solution is more durable and it is easier to maintain cleanliness, because the material of the blinds or the slats, or other accessories are protected against dust, dirt and other pollutants.

Tables 5-8. Hospital buildings-advantages and disadvantages of interior sun protection systems (elaborated by the authors on the bases of [1-3], [5-8])

Table 5.

	<p>Interior roller blinds</p> <p>They are made of fabrics of varying light permeability, from partly transparent, to completely opaque; they come in different colours and patterns, resistant to the impact of sun rays; in one colour, multi-coloured, with overprints, Jacquard, etc. Moreover, the market offers attested, antiseptic, antibacterial, anti-allergic fabrics.</p> <p>Example of use:</p> <p>Fig. 11. Pediatric And Oncology Children’s Center In Chorzów (photo. Magdalena Jamrozik-Szatanek)</p>
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Table 5. (continued)

Advantages:	Disadvantages:
<ul style="list-style-type: none"> • They constitute important elements of interior design, but also aesthetic elements of glazed surfaces visible from the outside, • Roller blinds with runners reduce the circulation of heated air and, to a certain extent, protect against cooling the rooms at cold nights (at daytime, the blinds are usually rolled up to let in sun-light), • There is an option of using inflammable fabrics. 	<ul style="list-style-type: none"> • Less effective than exterior sun protection systems, because the heat partially remains between the fabric and the pane, • At a low angle of sun rays infiltration, discomforting dazzle may occur, or the necessity of rolling down and using artificial light, • The blinds made of materials in strong colors may evoke disrupted reception of colors in the interior space, which may be detrimental for the psychical condition of patients, but may also make it difficult for doctors to assess the condition of the patient (for example: apparent paleness or skin flush).

Table 6.

	<p>Venetian blinds Lamellas are made of various materials: aluminum, wood, or wood-like materials, in a wide range of colors. Example of use: Fig. 12. Mayer Children’s Hospital in Florence (photo. Magdalena Jamrozik-Szatanek)</p>	
Advantages:	Disadvantages:	
<ul style="list-style-type: none"> • They provide moderate light distribution- it should be taken into account that the blinds as such should not function as secondary source of dazzle, • In the summertime they may contribute to temperature reduction in the interior space by 5-7°C, whereas, in the wintertime temperature increase by 2°C, • For the sake of energy-efficiency, automatic control of the blinds is recommended in synchronization with darkening fluorescent lamps. 	<ul style="list-style-type: none"> • They limit the view from the exteriors, and, partially, from the interiors, • At sunny days they may generate disturbing streaky/patterned shadows, • Pollutants can easily settle on horizontal lamellas and their cleaning is very time-consuming. 	

Table 7.

	<p>Vertical blinds They make it possible to shade glazed surfaces with big dimensions, the rails are mounted to the ceiling or the wall and may be bend into an arch according to specified and customized dimensions. A wide range of colors, textures and materials- fabrics, PVC, with different properties. Example of use: Fig. 13. Children’s Rehabilitation Center in Radziszow (photo. Magdalena Jamrozik-Szatanek)</p>
<p>Advantages:</p>	<p>Disadvantages:</p>
<ul style="list-style-type: none"> • Rotary vertical lamellas may be easily and precisely adjusted to achieve the required quantity and direction of the incoming sunlight, • They constitute an important interior design element , yet, when used on big glazed surfaces may essentially influence the aesthetics of the facade colour-lines. 	<ul style="list-style-type: none"> • Due to considerable weight of long material strips, mounted only at the top, damages to the chain mechanism may occur at frequent use, also, similarly to roller blinds made of colourful materials, they may have a negative impact on the assessment of colours of interiors.

Table 8.

	<p>Hangings They are fabrics hinged without restraints and can be moved along the mounting rail and their important quality is the decorative function. Example of use: Fig. 14. Mayer Children’s Hospital in Florence (photo. Magdalena Jamrozik-Szatanek)</p>
<p>Advantages:</p>	<p>Disadvantages:</p>
<ul style="list-style-type: none"> • If the material is property selected, they may contribute to the deadening of sounds and partly reduce heat losses from glazes surfaces, their main function is to separate patients from other room-mates; they are usually hung up on frame constructions by the beds, but not in front of the windows. 	<ul style="list-style-type: none"> • They are less flexible as far as sun-light protection is concerned, as when drawn, they cause complete visual isolation along the entire height of the window.

5 Conclusions

In consideration of a specific nature of hospital buildings, each of the above mentioned systems should be assessed in consideration of: possibility of a compromise between the required, for sanitary and hygiene reasons, sun lighting and sun protection, possibility of providing visual contact with the external environment; color schemes of the material which may change due to temperature (vertical blinds and roller blinds); generation of annoying contrasts and patterned shades (venetian blinds or imprints on glass); maintaining cleanliness; potential for creating the aesthetics of the interiors and facades; energy-efficiency and effectiveness in providing a feeling of comfort in the interiors.

After the recapitulation of professional literature studies and the research performed by the authors of the paper in hospital buildings, it may be stated that none of the discussed solutions is perfect. In view of the effectiveness of sun-protection, exterior systems seem to be the best solution, but, the demand for interior blinds is bigger. Roller blinds or vertical blinds are preferred by patients, because they provide an option of individual adjustment. However, special attention should be given to the selection of the materials, and preference given to fabrics in pastel colors, without imprints, inflammable, antiseptic and anti-allergic. As far as hospitals are concerned, systems difficult to adjust should be avoided, especially, if they restrict the view from the windows (for example: big-size vertical blinds). Likewise, systems generating streaky/ patterned shadows (venetian blinds, glass with imprints) or other patterns are undesirable. Technical and accessory rooms located at lower parts of the building façade may be protected by anti-break systems, but this solution is not recommended in patients' rooms. It seems that the best compromise is to choose sets of double-glazed windows with sun protection shields placed in the sealed space between the panes. Such solution combines the advantages of interior blinds, as they have an aesthetic potential, are more efficient as far as sun-protection is concerned, and, provide the insulation against the impact of pollutants (both internal and external). This may be a reference or benchmarking solution for hospital solutions. The entire positive effect of sun-protection systems may be achieved by adjusting different configuration of panes in sets (protection against sunlight, low-emission, sound-proof, self-cleaning), operated manually or by electric drives.

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