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A COMPARATIVE ANALYSIS OF FUNCTIONAL CHARACTERISTICS OF SUN-PROTECTIONS MEANS FOR CIVIC BUILDINGS IN SUNNY CLIMATE CONDITIONS

Sergei V. Stetsky

Moscow State Civil Engineering University, National Research University
E-mail: agpz@mgsu.ru

ABSTRACT

The functional qualities different means of protecting buildings from excessive sunlight are compared. Summertime and external spaces in the solar climates are considered. Devices for protection from the sun are considered, specifically stationary and adjustable sunscreens. A comparative analysis of their main functional characteristics is given.

Conclusions are drawn about the need for a comprehensive application of sunscreens of various types in a "clear sky" environment, typical for regions with the sunny climate characteristics. Stationary sunscreens contribute to an increase in indoor daylight due to the reflection of the sun's rays from them and redistribution of rays within interiors.

Keywords: sun-protection means, functional characteristics, comprehensive application, summer and communication premises, stationary and regulated sun-protection devices, aesthetic qualities of sun-protection

In a hot and sunny climate, the insolation of premises should be minimised, and in summer it should be excluded altogether, because in these climate conditions, it causes considerable overheating of rooms and light discomfort [1–5].

The effective protection of premises against thermal and light exposure to sunlight when using natural (passive) methods of creating a microclimate environment in the premises can be categorised as means of sun-protection, the main of which are [1–8]: 1) the compass orientation of rooms; 2) the planning solution of buildings; 3) the shading effect of the surrounding buildings; 4) elements of large-scale facade architecture; 5) summer and communal outdoor areas; 6) sun-protective devices (SPD).

SPD, which can be external and internal, stationary and dynamic, often aesthetically improve the architectural quality of the facades of the buildings. In addition, some summer recreational and communal outdoor areas (loggias, balconies and galleries) can be considered as stationary SPD, due to the external horizontal and vertical shading elements which are part of their design, Fig. 1, [1–5, 8–12]. In this case, arcades, galleries, loggias, balconies and verandas are important means of sun protection for windows, walls and open spaces.

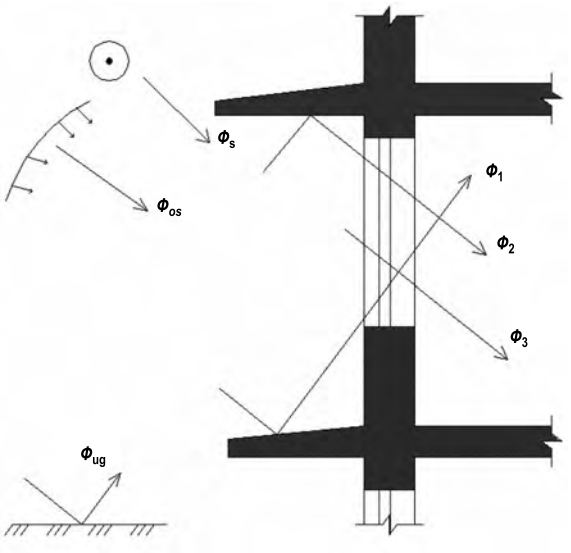
Table.1 shows the characteristics of the main sun-protection means, the analysis of the effectiveness of which should be based on a comparison of their functional qualities, which, in addition to limiting insolation, include lighting and aesthetic aspects, Table 2.

In this case, in particular, the role of horizontal elements of external stationary SPD in the sunny climate conditions is considered to be very positive in the lighting industry, which has been convincingly proved in a number of papers [2–7, 13–17].

In Fig. 2, it is shown that the generally accepted understanding of the shading effect of horizontal SPD based on the standard (normative) theory of diffuse outdoor lighting does not "work" in the sunny climate and clear sky, since the sun's rays reflected from the ground's surfaces and below-lo-

a – A cult buildings in Dar-es-Salaam, Tanzania;
b – An administrative building in city of Zanzibar, Tanzania;
c – A residential building in Lattakia, Syria;
d – An educational building in Lattakia, Syria.

Fig.1. Traditional design solutions of summer and communal outdoor spaces, typical for sunny climate regions



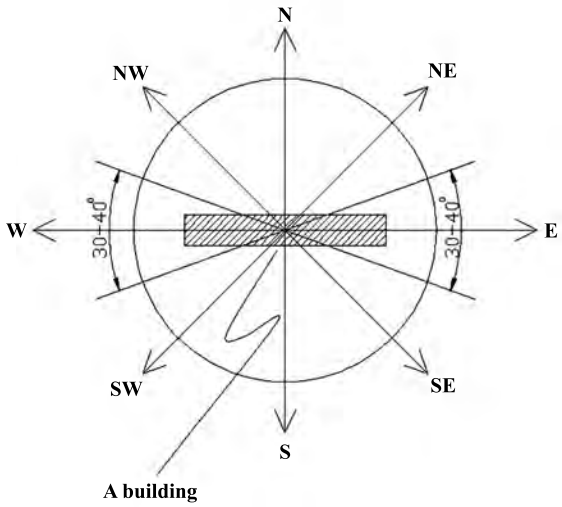
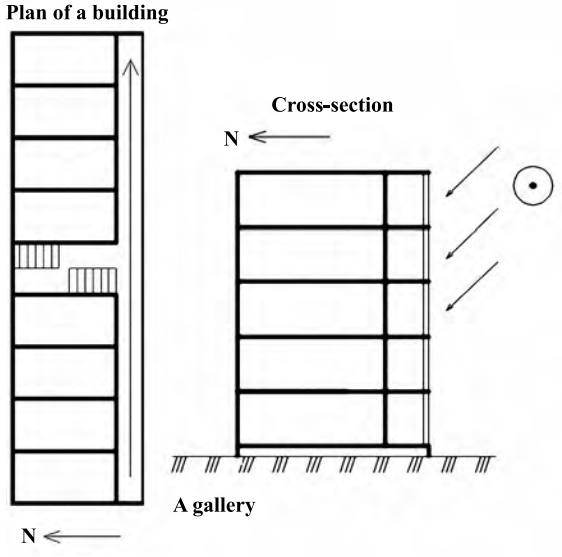
Φ_s - Luminous flux from the sun;
Φ_{os} - Luminous flux from an overcast sky;
Φ_{ug} – Light, reflected from the ground's surface;
Φ_1 - Luminous flux from top surface of a canopy;
Φ_2 - Luminous flux from bottom surface of a canopy (awning);
Φ_3 – Luminous flux, penetrating in a premise directly from sun and sky.

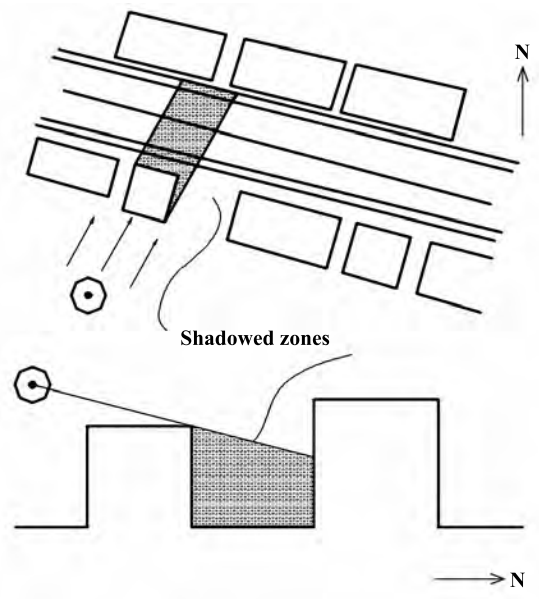
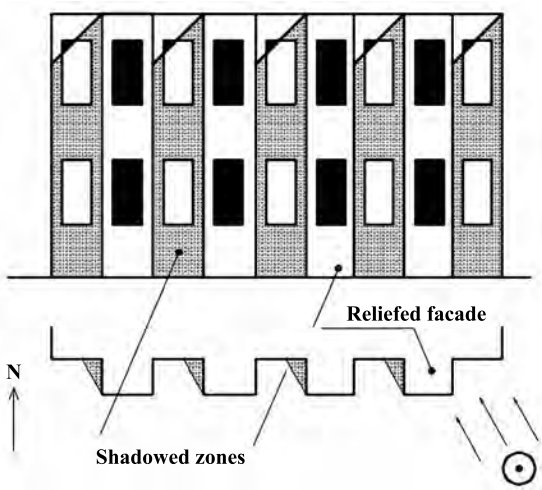
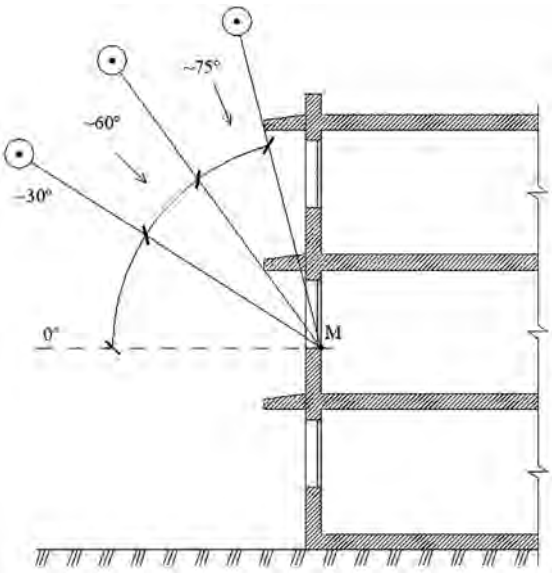
Fig. 2. Luminous fluxes coming into interiors from side natural lighting and implementation horizontal canopies awnings as SPD

cated SPD increase the levels of daylight factor *D* in the premises. As practice shows, this *D* increase can be as high as 10 % – 30 % in the zones furthest from the window, which is extremely important from the point of view of comparison of calculated and normalised values of *D* for natural side illumination, which are determined in the most distant point from the windows [1–6, 18].

The studies that determined the increase in *D* when using stationary SPD in clear-sky conditions during the last decade were conducted at the Department of Architecture of Civil and Industrial Buildings (now the Department of Design of Buildings and Structures) at the Moscow State University of Civil Engineering [7, 13–17, 19–20]. Studies of the internal light environment in residential buildings in Beirut, Lebanon [13, 14] concerned premises without SPD, where temporary layouts of combined SPD were installed over the windows. These consisted curved visors and narrow side screens. This made it possible to determine the *D* both in the presence and in the absence of a SPD, both under clear sky conditions and diffuse outdoor lighting on the basis of calculated and full-scale studies,

Table 1. Architectural, structural and urban development aspects of sun protection, in hot and sunny climate conditions

№№	Major methods of sun protection and explanatory diagrams	Details
1	2	3
1		Orientation Latitude orientation is optimal, i.e. with southern and northern window aspects. Longitudinal axis of the building runs east – west (± 15 ÷ 20°). The most efficient sun protection is on the south facade in the form of stationary horizontal sun-protection devices, such as canopies (awnings).
2		Planning solution The most efficient are buildings with galleries or loggias, wherein communal and leisure functions are combined with sun-protection functions of horizonal stationary SPD.

3		Shadowing effect of the surrounding development Under low sun-position in the case of dense development, narrow streets and opposite – development, a shadowing effect for certain surrounding buildings with surrounding occurs. Such an effect functionally adds some efficiency to the action of stationary SPD.
4		Reliefed facades. Under latitude orientation of buildings low rays of rising or dawning sun may be effectively screened with elements of facades architecture, which act as vertical sun-protective screens.
5		The universal horizontal stationary SPD: it ensures the sun-protection functions to be fulfilled in summer and transition seasons. Passive heating of interiors due to solar radiation in cold season is carried out under the sun height from 30º to 60º

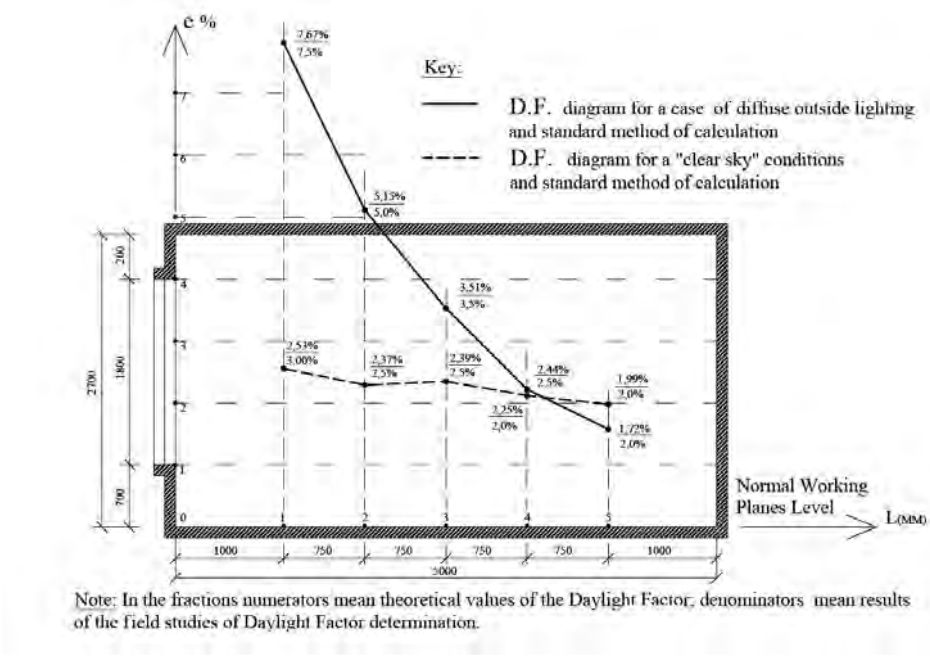


Fig. 3. Daylighting factor diagrams in a room without combined SPD

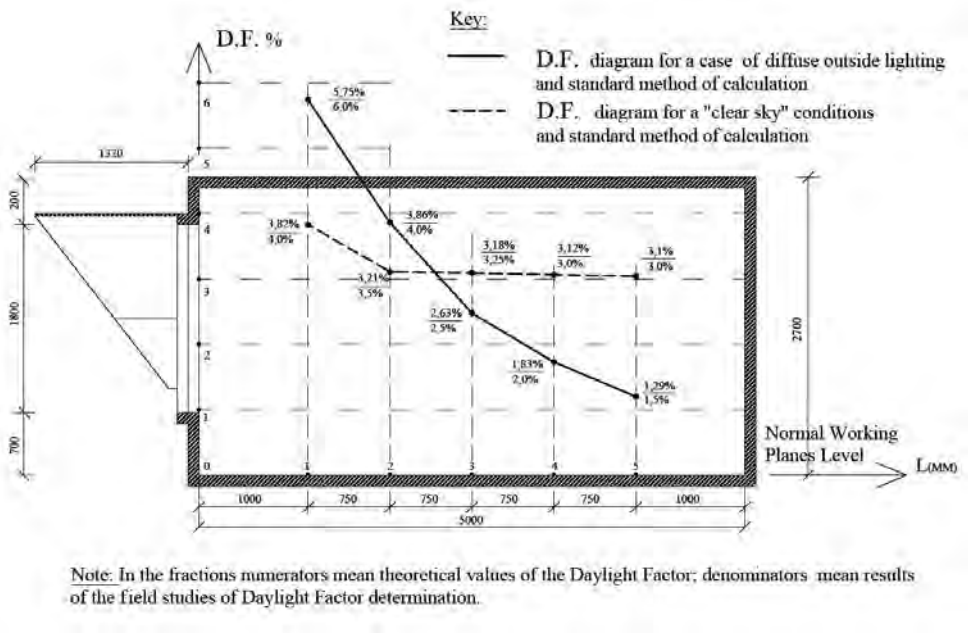


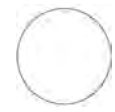
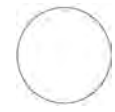
Fig. 4. Daylighting factor diagrams in a room with combined S.P.D

Fig. 3. The results of the studies showed a significant positive effect of outdoor SPD on daylight coefficient levels inside premises in regions with a sunny climate and the nature of outdoor lighting corresponding to clear sky conditions. At the same time, there was a decrease in *D* when using the SPD in conditions of diffuse outdoor lighting, which is expected due to the smaller reflected luminous fluxes from the SPD to the interiors of rooms under a cloudy sky than under a clear one.

CONCLUSIONS

1. A comparative analysis of the functional characteristics of various sunscreen products that meet the basic requirements for their physical, technical and aesthetic qualities shows that the most effective sunscreens in hot and sunny climates are both different types of SPDs and various summer and communal external spaces. In part, these requirements are met by the elements of large-scale facade clad-

Table 2. Comparative functional characteristics of different types of sun-protection means

№№	The versions of sun-protection means.	Factors under consideration		
		Sun-protection	Natural lighting	Aestetics
1	2	3	4	5
1	Orientation of premises on the horizon sides (aspect)			
2	Planning solution of buildings			
3	Shadowing effect of a surrounding development			
4	Relief facades			
5	Summer and utility outdoor premises			
6	Sun - protection devices			

Key:

 Maximum efficiency of the resource

 Medium efficiency of the resource

 Minimum efficiency of the resource

ding, and the geometry of the objects surrounding the construction.

2. The analysis confirms the conclusion that the optimal ratio of functional and aesthetic qualities of sunscreening means is possible only with the optimal combination of stationary and regulated SPD with elements of large facade cladding and with summer and communal external areas (taking into account their aesthetic qualities).

3. A significant positive effect of external stationary SPD on *D* levels in rooms in regions with a sunny climate was determined both in full-scale studies and in theoretical studies using the "clear sky" technique. Moreover, in diffuse external illumination, the SPD weakens the internal illumination more than the lower SPD amplifies it with a small reflection of the luminous fluxes.

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Sergei V. Stetsky,
Ph.D. Associate Professor at the chair "Buildings and structures design" of Moscow State University of Civil Engineering. Graduated from Moscow Civil Engineering Institute in 1970 with a specialty in Civil Engineering, author and co-author of more than 60 scientific articles, textbooks, study manuals