New types of windows' forms as a fundamental to reach multifunctional properties of windows in agricultural facilities

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Abstract. The presented article deals with problems of internal environmental characteristics in premises of agricultural facilities in regions with hot and sunny climate. Environmental conditions are being considered in close linkage with forms, proportions and sizes of windows traditionally used in regions in question and with geometrics of new types of windows. It was stated that windows in the said climate have a great effect on the different microclimatic environmental regimes in the premises in question, i.e. on the internal lighting of interiors, thermal gains due to solar radiation, noise penetration, etc. Also, the paper considers another variable – the informative quality of a window. This one not only dictates the geometrics of window openings, but also needs a vast experimental research to be conducted on subjective appraisal of quantity and quality of outdoor information through considered windows.

1 Introduction and theoretical background

Windows in buildings, which are situated in southern regions with hot and sunny climate, play an important part in creation of comfortable indoor microclimate in premises. The positive part of windows in the said conditions is usually as follows: to supply interiors with natural illumination and to provide psychological contact with external environment. The negative role is overheating of interior due to sun rays in the case of insolational process and excessive noise penetration into a premise. Hence, a small window reduces the positive characteristics as well as the negative ones, and vice versa. So it is necessary to find an optimal design solution in order to maximize positive characteristics of a window and minimize the negative ones. As it was stated before in works of numerous domestic and foreign researchers, the traditional type of windows in, say, architecture of Near East countries (see figure 1), are narrow and vertical. Such a form ensures less insolational heat gains into an interior without costly external sun protection devices [1-8].

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Fig. 1. Shapes of windows typical for Islam architecture (orthodox church and mosque in Lattakia, Syria).

2 Desk and field studies

Scientific studies conducted in the “Design of Buildings and Structures” (D.B.S.) Chair of Moscow State University of Civil Engineering (MSUCE) were based on main conclusions and recommendations of the above-mentioned researches in order to achieve new results in the process of creating comfortable indoor environment in buildings under climate conditions in question. It was determined that:

- i/ - Lighting of interior in a premise with side system of natural light (i.e. with windows) is greater with vertical windows, as compared with horizontal windows of the same area.
- ii/ - Informative and psychological contact of observers with outdoor environment is greater with horizontal windows, as compared with vertical windows of the same area.
- iii/ - Heat gains due to the insolation lasting are less for vertical windows, as compared with horizontal windows of the same size, provided that thickness of an external wall remains the same for both cases and external sun-protective devices are absent (see figures 2, 3 and 4).

Fig. 2. Elevation of different geometrics of windows with equal area.

Fig. 3. A graph of geometric daylight factor dependence from shapes and proportions of window openings.

Note: The design point is situated in the centre of a room on the floor level. The sizes of a room are $L \times B \times H = 4 \times 3 \times 3$ m

Fig. 4. An insolation lasting for different proportions of windows. Where:

- 1 – a window with $h_1 = 2,0$ m and $b_1 = 1,0$ m;
- 2 – a window with $h_2 = 1,0$ m and $b_2 = 2,0$ m;

BC – an insolation period for high and narrow window;
AD – an insolation period for low and wide window.

To satisfy the above-mentioned requirements for comfortable indoor microclimate we suggest a new form of a window, which consists of vertical and horizontal parts (see figure 5), easy for calculations of natural lighting and insolation lasting. The upper narrow part of the windows is efficient for natural lighting, sun protection and contact with the outdoor environment due to observation of the sky vault and appraisal of weather, cloudiness and external lighting conditions. The lower wide part of the window is not high and that is why it is not very efficient from the point of view of natural lighting and insolation. Moreover, its low efficiency in providing these microenvironmental regimes is also explained by surrounding development, vegetation, etc.

Fig. 5. Informative qualities of different parts of the offered shape of the window.

The example of the offered type of a window with simplified geometrics has the following sizes: the vertical part of 2000 mm height and 1000 mm width; the horizontal part of 1000 mm height and 2000 mm width. The window is installed in the wall of 500 mm thickness.

The lower part of a window is also very important to observe the nearby urban surrounding to gain more information about the neighbourhood. Such a psychological contact is traditionally highly evaluated in countries of Near East region. The scientific approach to this phenomenon requires deep and wide studies on subjective appraisal on the informative characteristics of windows. These studies were conducted in our country as well as abroad [2, 3, 5, 8, 12, 14, 16, 17, 18]. The relative contemporary studies on this matter were conducted in MSUCE by a number of post-graduates and members of the staff of D.B.S Chair [9, 10, 11, 12, 13, 14, 15].

The foreign countries (Syria, Lebanon and Afghanistan) are situated in between 30° and 40° of northern latitude, and in Russian Federation studies were conducted for North Caucasus. The conditions of natural lighting and insolation for these territories are very similar. The summary results of the above-mentioned investigations as regards to natural lighting of interiors, insolation and subjective appraisal of informative characteristics of the window of offered shape, compared to a window of typical ordinary rectangular shape are submitted in Table 1.

Table 1. A summary of the field and desk studies’ results of different qualities of windows in question.

Numbers of window types	Geometrics of windows	Environmental factors					
		Natural lighting (G.D.F. %)		Insolation lasting (hours) in summer time with southern aspect		Psychological contact (points out of 5)	
		Values of factors examined					
		Objective appraisal	Subjective appraisal	Objective appraisal	Subjective appraisal	Objective appraisal	Subjective appraisal
1	Horizontal window (Figure 2, position 3)	2.5%	Not enough lighting	3.5 hours	Sun protection is not good	-	2.5 points
2	Square window (Figure 2, position 2)	3.895%	Lighting is satisfactory	3.0 hours	Sun protection is satisfactory	-	3.0 points
3	Vertical window (Figure 2, position 1)	4.35%	Lighting is comfortable	2.0 hours	Sun protection is good	-	3.5 points
4	Offered type of a window	-	-	2.5 hours	Sun protection is satisfactory	-	4.5 points

3 Conclusions

1. The importance and efficiency of a new, non-traditional type of windows in hot and sunny climate conditions have been shown. The validity of the new type of a window depends mainly on its natural lighting efficiency and informative-psychological properties. Such a characteristics ensure comfortable parameters of indoor microenvironment as regards to internal natural lighting and visual contact with outdoor environment. Sun-protective properties of the window type in question, however, are not improved greatly, as compared with ordinary shape of typical rectangular window.
2. It was shown that, regardless the narrow vertical and low horizontal parts of the window in question, the sun protection of a premise with such a window is not high. That is why it is evident that the outdoor sun protection device must be used additionally. These structures should be used of combined type, with horizontal canopy and vertical ribs adjacent to a vertical portion of the window. The exact type and sizes of the sun

protection offered are to be designed in connection with the exact shape of a window and the height of the Sun in determined region and season of the year.

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