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The characteristics of glazed compartments using the example of winter gardens

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Abstract: The article presents the description of glass-walled cubature facilities in the form of winter gardens. The following items have been presented: the characteristics of winter gardens, construction, and material solutions including appropriate glazing. Winter gardens provide additional thermal protection for the building, stabilize air humidity and protect against noise. Properly designed with the right shape and structure, they form a harmonious whole together with the building, increasing living comfort.

Keywords: winter gardens, glazed compartments, thermal insulation

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Introduction

Nowadays, modern construction profiles and innovative finishing materials give winter gardens modern architectural forms. Architects design variously shaped winter gardens, ranging from the traditional, based on a rectangular or semicircular plan or regular and irregular polygons, to futuristic and innovative solutions. Winter gardens are intended for all-year-round use, they are an extension or enlargement of the living space. They form a connection between two buildings and can be added to the side of an existing building serving as a dining room, leisure room or workspace. They have an impact on the embellishment of the residence, as well as on its aesthetics and functionality. They allow the growth of tropical plants all year round in their original form and saturated colors (Mierswa & Kawollek, 1996). The greenery contained in them has a beneficial effect on human health and well--being. Residents are provided with protection against precipitation and constitute a thermal buffer and an element of thermal protection for the building (Figiel, 2018).

Properly selected partitions also enable the thermal comfort of rooms, thus limiting the demand for usable energy.

1. General characteristics of glazed compartments

External glazed compartments are most often found in the form of a light curtain wall with a mullion-transom structure. Undeniably aesthetic values, favorable construction and operational parameters make it the most-used technology today. For this reason, manufacturers are developing ready system solutions that allow the designer to avoid mistakes at the design stage. The curtain wall in the mullion--transom system is a light-weight, skeletal self-supporting structure. The role of structural elements are fulfilled by vertical columns stiffened by the use of horizontal transoms. This assembly attached to the supporting structure of the building forms a kind of truss, whose fields are filled with shield panels in the form of insulating glass units. The construction elements have box cross-sections, adapted to the installation of fillings, gaskets or various types of connectors, as well as allowing ventilation, drainage and condensation removal. Curtain walls can be divided into hanging walls, fixed to the ceiling face and filling or mounted between construction elements of a building, for example, beams and columns (Markiewicz, 2008). However, in the case of winter gardens it is an independent supporting structure, having walls and a roof, somehow "glued" to the external wall of the building.

2. Characteristics of winter gardens

Winter gardens are objects with glazed external walls, they are often added to a residential building, and are being more and more often used as year-round rooms. Conservatories serve as a place to rest and for social gatherings, they can also be used as a place to work because of the calming atmosphere provided by the presence of various types of plant species (Borkowska-Gorączko et al., 2007). Winter gardens can be divided into two types depending on their design: Seasonal winter gardens - the construction of such gardens made of polycarbonate plates or individual panes of glass is light and weighs several hundred kilograms. Due to its construction, it is difficult to maintain a positive temperature on cooler days. Therefore, it is rather used in a garden intended mainly for potted plants that can stay on the terrace when the outside temperatures are lower. It rarely used as a place to spend time by the household members on cold winter evenings. Due to its weight, it can be easily added to a terrace or balcony, allowing it to be used at any time (murator.pl, 2019a).

All-year winter gardens - have a heavy construction, reaching up to 2 tons due to the fact that it is made of profiles and insulating glass units filled with argon. It has a low heat transfer coefficient and is resistant to both wind and rainwater penetration. Thanks to this, it can be used for year-round use, even on cold days. However, this type of garden must have solid foundations. Poor preparation or the incorrect condition of the surface may cause cracking of the glass and unsealing of the structure. The weight of the construction does not allow such a solution to be used

on the terrace or balcony of a building. The decision to create an all-year-round garden should be taken into account during the initial design phase of the building (murator.pl, 2019a).

3. Location in terms of compass points

Conservatories can be located on each side of the building, but most often they are built on the garden side. Depending on the side of the building which is to be chosen, you should think about what functions the garden should perform, as each side has its pros and cons (Borkowska-Gorączko et al., 2007):

- **eastern side** - is optimal when creating a studio or dining room in the garden. Thanks to good sun exposure, it provides ideal conditions for rest and also has a good effect on plant growth. It also protects against excessive sunlight in the afternoon,
- **southern side** - it is very sunny and heats up easily. A large amount of sunlight can affect plant growth in a positive way, and heating costs in the winter may be lower. In the summer, strong sun may, however, result in very high temperatures, so it is necessary to use a ventilation system and blackout elements,
- **western side** - in summer it is exposed to strong sunlight, which will cause high temperatures inside the garden, so it is worth applying ventilation and sun protection. There is little sunshine in winter,
- **northern side** - is beneficial for the studio, atelier or dining room. Thanks to low sun exposure, and even lighting, the rooms can be cool and shaded, even on hot days. In winter, however, expect higher heating costs (murator.pl, 2019a).

To enjoy the winter garden fully and for as long as possible, care should be taken to ensure the appropriate climate conditions that will prevail in it. In order to feel comfortable, inside the garden, care should be taken in the proper heating systems and effective ventilation (Borkowska-Gorączko et al., 2007). On hot summer days, the temperature in the room can excessive, which is why it should be remedied by using blinds and curtains, which create a light barrier against strong sunlight. However, this is often not enough and room ventilation may be needed. The simplest and also the cheapest is natural ventilation which can be achieved by creating holes at the foot of the walls and in the roof. Negative pressure is created, which causes the flow of fresh air from the lower ventilators, while the accumulating hot air rises towards the roof and is released through the roof ventilators. Ventilation openings should be adjustable so as not to lose heat during the winter. When natural ventilation is not enough, fans may be used, however, this is associated with much higher costs (murator.pl, 2019b).

4. Construction and material solutions of winter gardens

When constructing winter gardens, a decision should be made whether the garden will be used throughout the year or only seasonally. The main factor is to ensure appropriate heat and humidity conditions by using appropriate glazing. When using double-glazed units, one must take into account the large mass of the

structure, and thus requires an appropriate support frame. The supporting structure of a winter garden is usually made as a mullion-transom. For smaller one-storey gardens, only the columns supporting the wall plate and the roof are sufficient. The materials used to make the skeleton should meet certain requirements, which implies the use of such raw materials as:

– **Aluminum** - thanks to its advantages it is the most commonly used material in the production of winter gardens. It is resistant to temperature and humidity changes and its mechanical properties give it a high resistance to deformation or cracks. In addition, it is a non-rusting material with a low tare weight that facilitates assembly, and its high strength makes it possible to reduce the profile cross-section, giving the structure a slender appearance.
– **Wood** - a natural raw material, used in traditional construction, it gives the interior a coziness lacking with aluminium. For the construction of a winter garden structure, glued wood is used, most often pine or spruce. Mullions and transoms are glued to the front notches. Glued wood, unlike aluminum, increases the width of the profile up to several centimeters, giving the frame a massive appearance and reducing the area of the glazing. In addition, it must be protected by painting, as well as the use of external aluminum profiles and gaskets to protect against water (Klindt & Klein, 1982). Due to the often modular construction of glazed compartments and readily available solutions and systems available on the market, it is possible to shape the cubature of the winter garden almost in any way by adapting it to the variously shaped external walls of the building, adapting to bends or recesses without restrictions (Flaga & Vogt, 2004).

The decisive factor in regards of thermal insulation and exposure is appropriate glazing. The type of glass also determines the aesthetic parameters. The main features of glass compartments should be: the ability to obtain heat from solar radiation, reducing the amount of heat radiation lost in cold periods and thermal insulation which is a factor determining the amount of heat loss. Heat gains depend on the transmission of solar radiation through the pane, the bigger the transmission, the more heat energy goes inside the room, enabling it to heat up. High heat gains can be obtained by using glass characterized by: colorlessness, transparency and thin glass. Thermal gains are reduced through the use of double glazed units, stained glass, various types of prints, coatings and films, as well as dispersion and reflective structures. An interesting solution on the glazing market are materials with variable solar transmittance, such as:

– **heat-absorbing glass** - due to absorbing solar radiation, and consequently increasing its temperature, it changes color to white, reflecting excess rays and reducing heat gains,
– **photochromic glass** - by absorbing UV and infrared radiation it changes its color, limiting the transmission of solar radiation,
– **electrochromic glass** - is a material with controllable solar transmittance. Transmittance can be adjusted by applying electrical voltage, causing the color to change to blue and thereby reducing the amount of radiation penetrating into the interior,

– **gasochromic glass** - permeability control is based on the introduction of hydrogen-containing gas into the inter-pane chamber, which in reaction with a tungsten trioxide coating and a plasma catalyst causes coloration of the pane set (Neufert, 2003). The electronically-controlled gas flow enables its removal and, as a consequence, the glass becomes colorless again,
– **liquid crystal blinds** - glass with electrically controlled light transmission. The opaque film contains LCD crystals. Under the influence of an electric impulse, their arrangement changes and the film becomes transparent.

An important factor in the design of glazed compartments is the maximum reduction of heat loss. Single glass is a weak insulator, therefore it is only suitable for seasonal constructions. The most important parameter for assessing glazing in terms of minimizing heat loss is thermal insulation. It depends mainly on the number of panes used in the system, coatings covering the panes, and in particular on the filling gases formed between the glazing of the chamber. Heavy noble gases such as xenon, krypton or argon are the most preferred (Markiewicz, 2008).

5. Design concepts of a residential building with a winter garden - student work

The article presents the design concept of the master thesis on the example of a single-family house with a built-in winter garden. The student has made detailed solutions of the designed building so that the object meets all current principles and assumptions of building standards as well as heat humidity conditions (Figs. 1 and 2). The work was done in the ArchiCAD computer program (Tubielewicz-Michalczuk, 2019).

Fig. 1. Design concepts for a single-family residential building with a winter garden - Master thesis: author Krzysztof Polechoński, 2018.
(supervisor: PhD, Eng., Arch. Malwina Tubielewicz-Michalczuk).
The project was made in the ArchiCAD program for which the author has a license

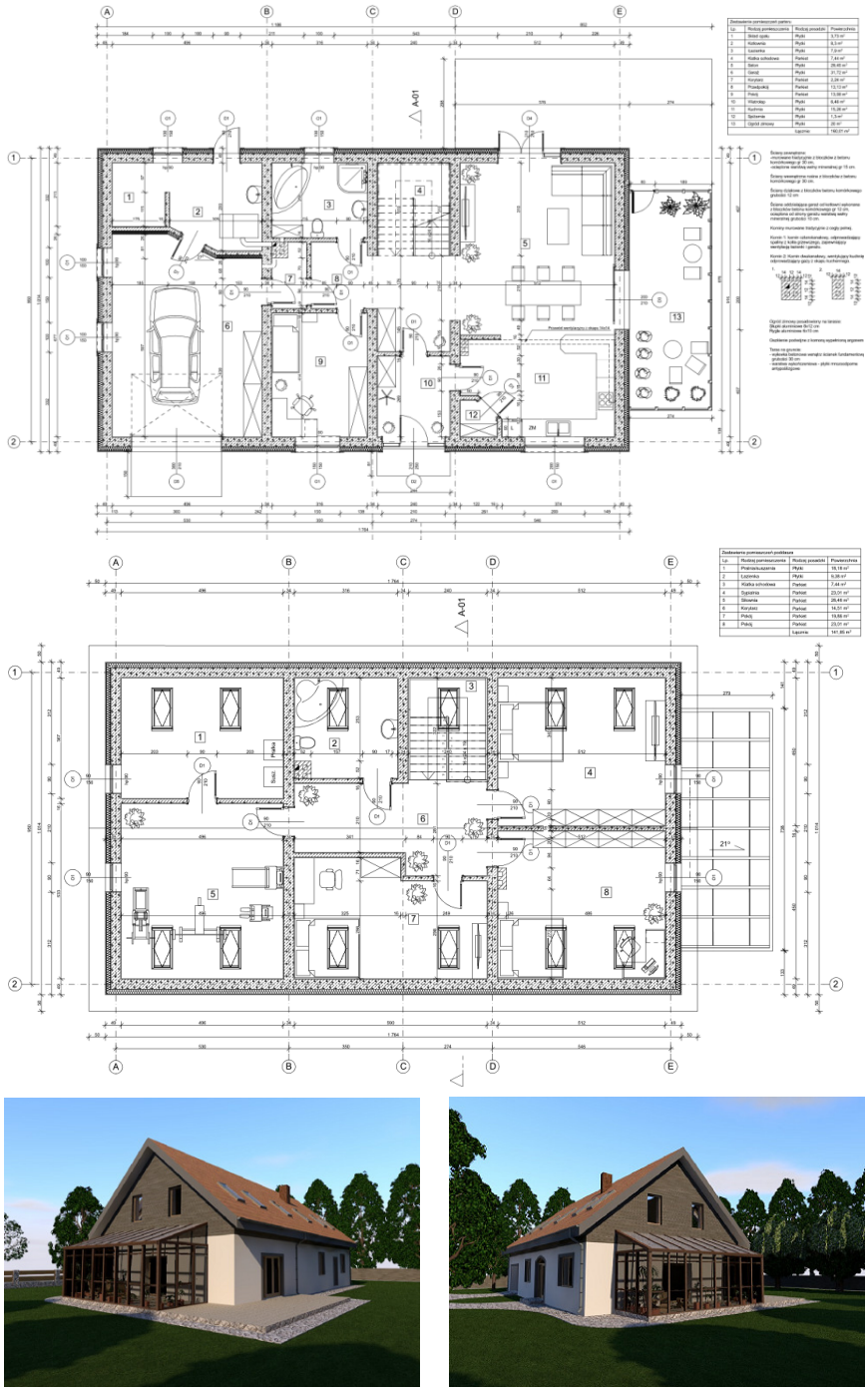

Fig. 2. Design concepts for a single-family residential building with a winter garden - Master thesis: author Krzysztof Polechoński, 2018.
(supervisor: PhD, Eng., Arch. Malwina Tubielewicz-Michalczuk).
The project was made in the ArchiCAD program for which the author has a license

Conclusions

The design of the winter garden is best taken into account at the concept stage of the building body in order to anticipate the best structural, technological and material solutions. The location relative to the direction affects the functions it has to perform. The design should also include wind and snow loads. When selecting glass, one should be guided by its ability to obtain heat and the speed of losing it in winter. The reduction of heat gains can be achieved by: insulated glass, printing, films or coatings, tinted glass, diffusing and reflective structures. If the structure is to be used throughout the year and protect the room against heat loss in the winter and excessive heat in the summer, it is best to choose glazing consisting of a larger number of glass panes. The glazing should have coatings filled with gases in the glass chambers. The use of the right kind of guides allows the roof and wall parts to be fully opened. A winter garden designed in this way increases the aesthetics of the living quarters and creates favorable conditions for breeding unique plant species that increase the visual qualities of the interior and also has a positive effect on air quality.

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Charakterystyka przeszklonych ścian na przykładzie ogrodów zimowych

Streszczenie: Przedstawiono charakterystykę obiektów kubaturowych o przeszklonych ścianach w postaci ogrodów zimowych. Zaprezentowano charakterystykę ogrodów zimowych,

rozwiązania konstrukcyjno-materiałowe, jak również odpowiednie przeszklenia. Ogrody zimowe stanowią dodatkową ochronę cieplną budynku, stabilizują wilgotność powietrza oraz chronią przed hałasem. Prawidłowo zaprojektowane o odpowiednim kształcie i konstrukcji tworzą wraz z budynkiem harmonijną całość, podnosząc komfort zamieszkania.

Słowa kluczowe: ogrody zimowe, przeszklone ściany, izolacja termiczna