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SPECIAL FEATURES OF THE SPACE PLANNING SOLUTION OF A MOBILE DOME HOUSE MADE OF WOOD

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Abstract. We propose a variant of the space-planning solution of a two-story dome house, which is related to the structural one, based on a certain number of typical building structures: columns, floor panels and, of course, the bearing elements of the dome, which allows assembling the "key ready" building in a few weeks, without the use of heavy construction equipment. A geodesic grid with a hexagonal cell distributes the stresses evenly over the entire surface of the dome, the sphere of which has the smallest ratio of the area of the external walls to the internal volume among all the figures of the same capacity. Thus, with the minimum total area of walls and roof, there is a minimum of the energy consumption for temperature and humidity control in the room. The house, with a foundation diameter of 12 m, is designed for a family of 4–5 people. The structural scheme of the house is mixed and consists of a self-supporting wooden dome frame and interior columns, on which a flat-slab floor of cross-beam panels supported at the corners rests. The dome framework is made of standard rectilinear glued wood parts, which are connected by the steel connectors to form hexagonal cells that allow for window openings anywhere on the surface. The distribution of the internal hemisphere space provides the opportunities that you do not have in classical design. The features of the curved wall surface are considered in the design of the designer furniture, which can emphasize your individuality.

Keywords: domed house made of glued wood, geodesic domed grid.

Introduction. Domed construction has been known globally since the 1970s [1, 2], but the domed house is still a rather new trend in the residential architecture. A domed building is a one- or two-story structure that differs from a typical prismatic building by the necessity to consider the curvature of the exterior walls. This leads to the creation of the specific zones with the limited usability, which can be considered a disadvantage or an advantage, depending on the proposed architectural solution. In order to avoid the traditional forms, it is necessary to present the significant advantages of the dome that will be fundamental for the potential customers. Large-span domed structures are mainly used in the design of the exhibition centers, stadiums, industrial buildings or scientific institutions. Those who choose the dome will receive not only an unusual futuristic appearance, aesthetic pleasure and free interior layout, but also the minimum foundation requirements, the possibility of the construction in the earthquake endangered zones, the minimal heat dissipation area and natural convection ventilation. But the modern globalized world requires another feature from a private house – mobility. More and more people are changing their accommodation depending on the availability of work, climate, and family circumstances. Therefore,

designing a mobile domed house is an urgent task. We offer our own version of the space-planning solution, which is related to the structural one, based on a certain number of typical building structures: columns, floor panels and, of course, the load-bearing elements of the dome, which allows you to erect “key ready” building in a few weeks without the use of heavy construction equipment. And if it is necessary, it can be quickly disassembled and transported to a new location.

The purpose of the research is to develop a space-planning solution for a mobile domed house made of wood.

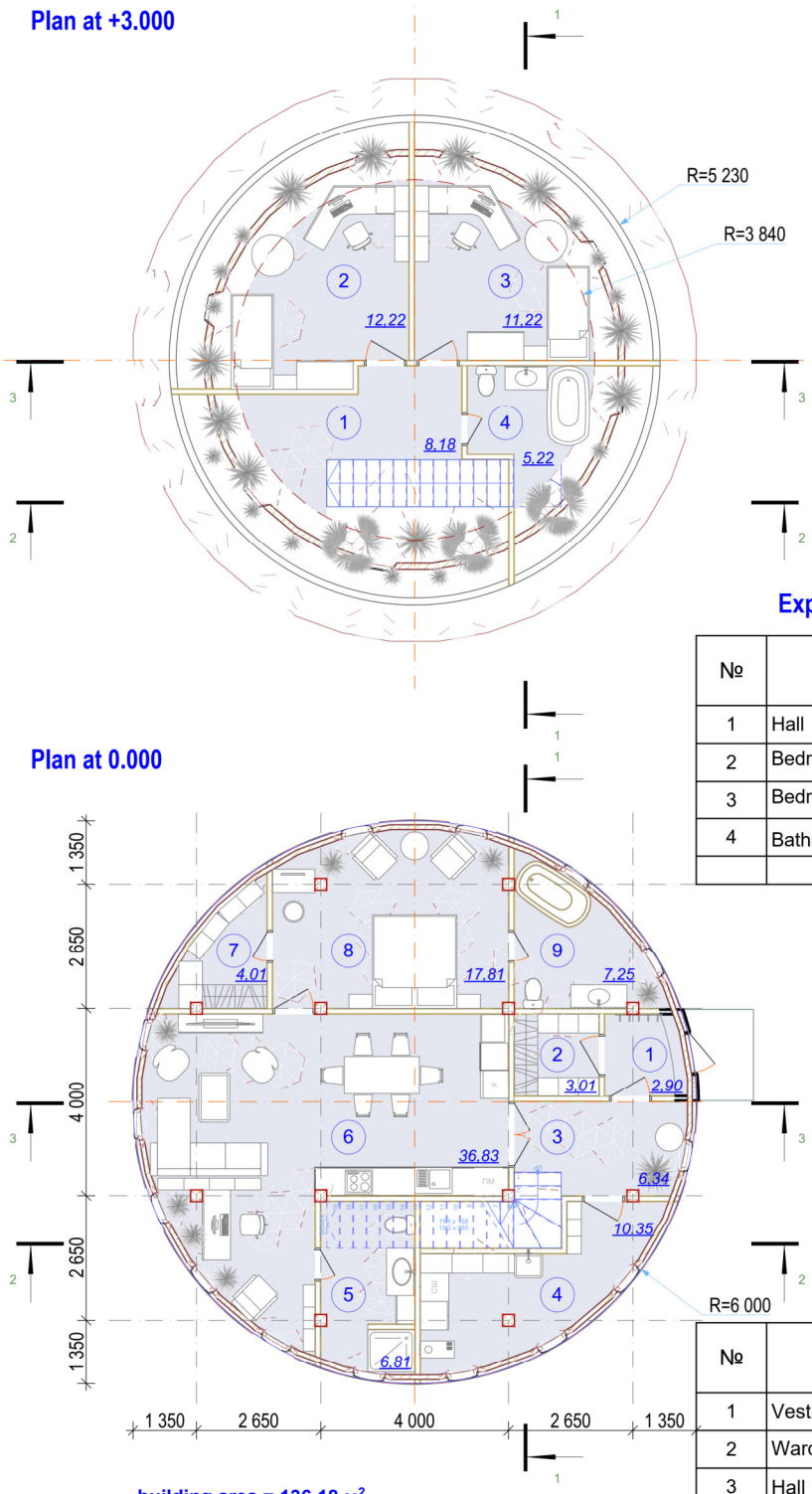
Analysis of the existing formative and constructive solutions. The domed structures have a wide variety of space forms, design solutions, and technologies. According to the structure, they are divided into ribbed, rib-and-ring, reticulated, plated, solid skeletons; according to the shape – spherical, elliptical, pointed, umbrella; according to the height – high, at the height of 1/2-1/5 of the diameter and shallow, at the height of up to 1/5 of the diameter. Ribbed domes consist of separate flat ribs built in a radial direction and adjacent to the curb plate in the top part [9]. The dome is supported by a foundation or a curb plate in the form of a polygon with rigid or hinged joints at the corners. A flooring rests on the ribs, which provides the overall stability of the ribs from the plane, reducing the calculated length of the ribs. The arrangement and introduction of the ring girders into the operation leads to the formation of a rib-and-ring structure. In this structure, the rings work not only for local bending due to roof loads, but also transmit the normal forces from the dome ribs, and in the case of a rigid connection of the rings to the ribs, they also transmit the bending moments. When the additional braces are introduced, rib-and-ring domes with the braces are formed [5,8]. The domes with the braces in each cell are called reticulated domes. The well-known Schwedler dome was a statically determined system. The further development of reticulated domes was based on the development of various means of cutting the surfaces into the structural elements to form the load-bearing framework. There are two methods of cutting the dome surface: meridional with the use of regular polygons inscribed in a sphere. They are called geodesic domes. Their founder was the American architect, designer, engineer and inventor Buckminster Fuller, who, based on the structure of the ancient Greek icosahedron, created the Dimaxion, or geodesic dome, designed for the use in the architectural structures [6,10]. The formation of the ribbed and similar domes is reduced to determining the shape and position of a flattened arch formed from two diametrical ribs. The formation of reticulated domes is more complicated. The surfaces of the reticulated shells are limited by the parallel transfer surface and the surface of rotation. In general, the reticulated domes are built on a sphere. They are often formed on the basis of a meridional-ring cutting system, the idea of which is to divide the surface by meridional and parallel planes into triangular and trapezoidal elements. There are many other systems, such as star and rhombic. We are interested in the systems based on polygons inscribed in a sphere. The sphere is cut along the geodesic lines running through the apexes of the inscribed polygons. These polygons are usually a dodecahedron with 12 pentagonal sides and an icosahedron with 20 triangular sides [6].

The advantages of a dome house. The dome can cover large surfaces using a minimum material quantity. The geodesic grid distributes the stresses evenly over the entire surface, which makes it possible to change from a triangular to a more economical hexagonal layout. The sphere has the smallest ratio of the external wall area to the internal volume among all the figures with the same capacity. In other words, with the minimum total area of the walls and roof, there is a minimum of energy consumption for controlling the temperature and humidity in the room [6]. Comparing the sphere with a prism building of the same capacity, we get a surface reduced by a quarter and a correspondingly reduced number of the structures, which gives double savings both in material and installation speed. Due to the aerodynamic effect of the dome, the wind has minimal effect on it. The structural basis of the dome is a strong and stable frame made of the standard elements. The low weight of wooden parts simplifies the construction work, which does not require complex lifting mechanisms and a large number of the

erectors. The interior space can be planned in any way and depends only on the customer's wishes and the architect's ideas. It is possible to place the windows and the entrance doors in any part of the house. The planning solution and the division of the internal space of the hemisphere is a special stage where we want to focus in detail. There are such opportunities here that you do not have in classical design. Almost any design fantasy becomes possible, for example, the furniture zones can be separated by straight partitions, and walk-throughs and openings can be made with any curved shapes [3].

A space planning and constructive solution. The house, with a diameter of 12 m along the foundation, is designed for a family of 4–5 people. The height of the first floor, considering the thickness of the floor, is 2.7 m, the second one, in the center of the dome, is 3 m, the column step in the central part is 4 m, in the part adjacent to the walls – 2.65 m. The perimeter columns, considering the curvature of the dome wall, are placed at a distance of 1 m from it. The total area of the house is 136.18 м^2. The area of the ground floor is 97.85 м^2, the area of the first floor is 38.33 м^2. On the ground floor, the central part is occupied by a roomy kitchen with a large dining table. In the same space as the kitchen there is a comfortable living room, where it is convenient to gather with the whole family. The living room has an area that can be used as a study. The living room is adjoined by a large, bright bedroom with its own dressing room and bathroom. On this floor there is also a guest bathroom, a utility room – used as a laundry room, as well as for placing the boilers for heating and hot water. At the entrance, there is a vestibule and a cold weather clothing store. The roomy hall has a staircase leading to the first floor. The staircase is L-shaped, which simplifies its erection and reduces the cost of the construction. The first floor has two bedrooms with a shared bathroom. One of the problems of dome houses is the need to purchase expensive non-standard furniture due to the horizontal and vertical curvature of the walls. Therefore, we offer a planning solution for a domed house with a maximum number of parallel and perpendicular walls, which will significantly reduce the cost of the interior finishing work and the selection of the standard furniture.

The structural scheme of the house is usually mixed and consists of a self-supporting wooden dome framework [4] and internal columns supported by a beam-less slab of cross-beam panels supported at the corners. The absence of the beams along the columns reduces the number of standard sizes of the building elements and speeds up the installation work. The slabs can be fully assembled at the factory or delivered to the construction site as the individual elements. In the construction of a two-story house, the columns for one floor along the perimeter are delivered to the site in finished form. In the proposed variant of the house with the diameter of 12 m, the central floor slab П1 has the dimensions of 4 x 4 m in plan. The perimeter slabs of the dome are of two sizes: rectangular with one curved cantilever side П2 and triangular with one curved cantilever side П3. An additional standard size is the П4 slab, which has an opening for the inter-floor staircases (see Fig. 4). The framework of the dome is made of standard straight glued wood parts, which are connected by the steel connectors to form the hexagonal cells, which make it possible to form the window openings in any place on the surface, depending on the architect's creative imagination and the customer's wishes. The roof is made of soft tiles with OSB roofing and mineral wool insulation. The foundations for the columns can be in the form of a reinforced concrete monolithic slab, or in the form of a reinforced concrete strip for the dome framework and columnar reinforced concrete, or from the screw piles for the columns – depending on the terrain conditions and the composition of the foundation.



Explication of premises at +3.000

№	Name	Area
1	Hall	8,62
2	Bedroom	12,60
3	Bedroom	11,58
4	Bathroom	5,53
		38,33 м²

Explication of premises at 0.000

№	Name	Area
1	Vestibule	3,05
2	Wardrobe	3,15
3	Hall	6,69
4	Utility room	10,68
5	Bathroom	7,06
6	Kitchen - living room	37,40
7	Bathroom	4,19
8	Bedroom	18,15
9	Bathroom	7,48
		97,85 м²

Fig. 1. Floor plans

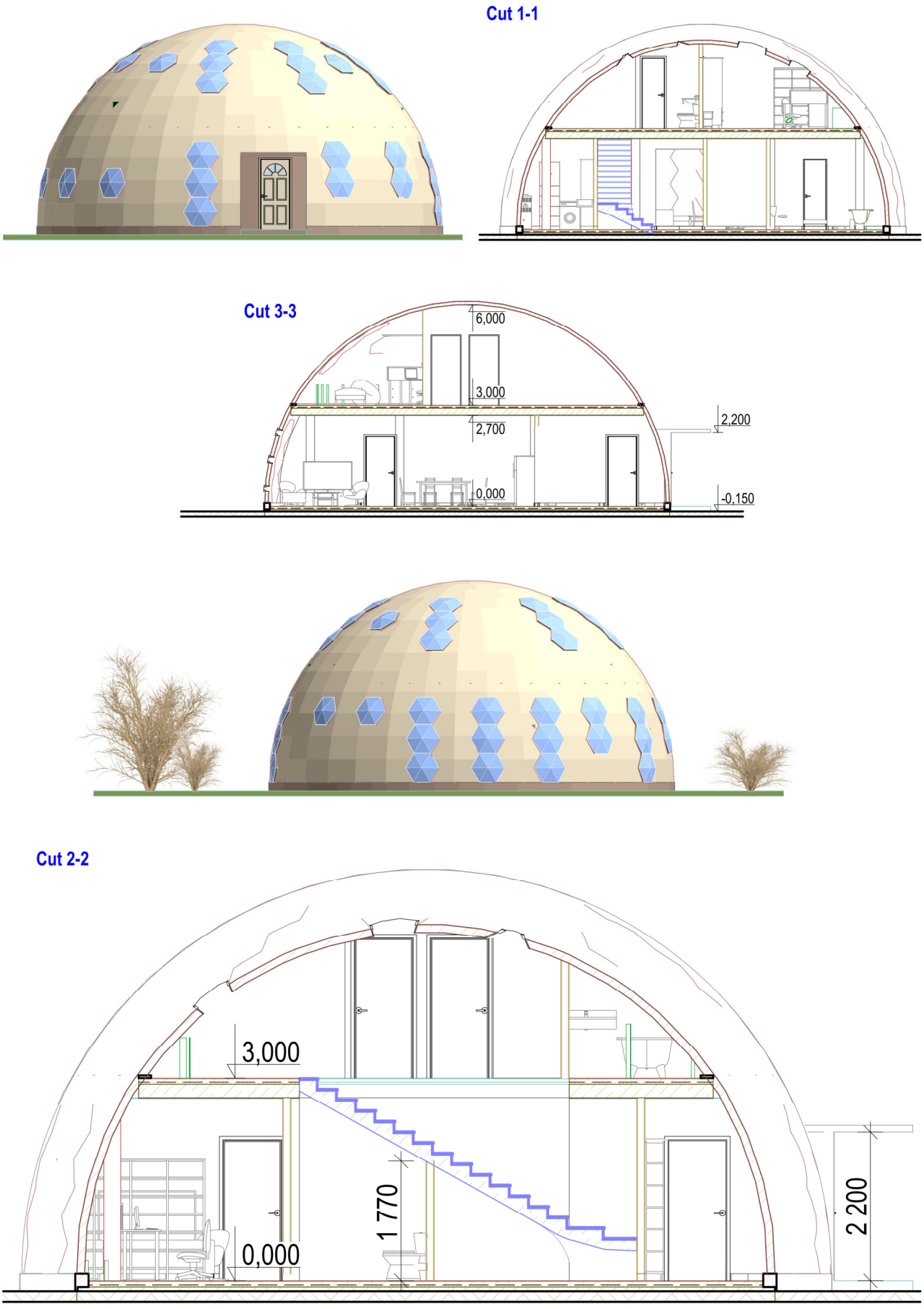


Fig. 2. Sections, facades

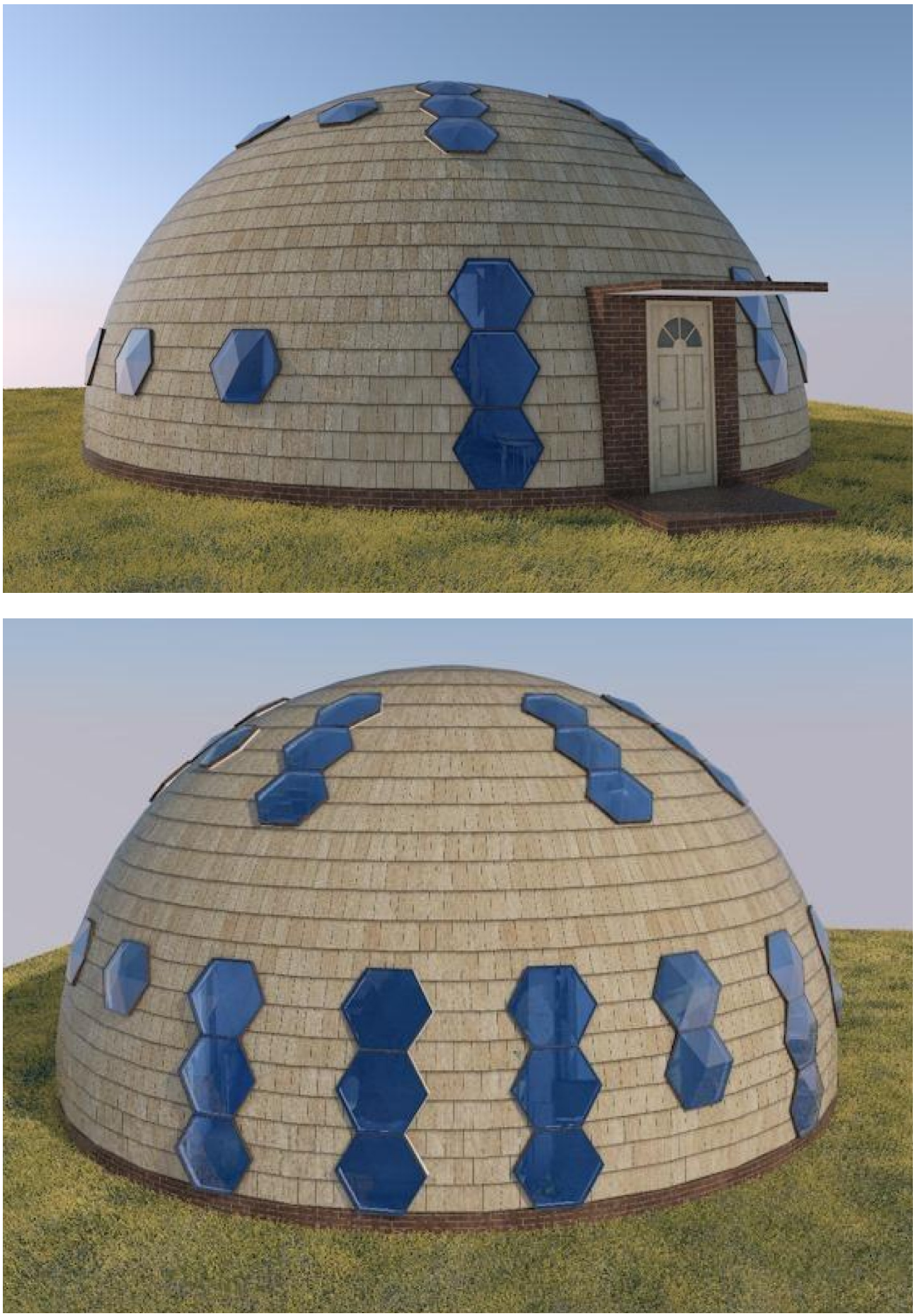


Fig. 3. Visualization

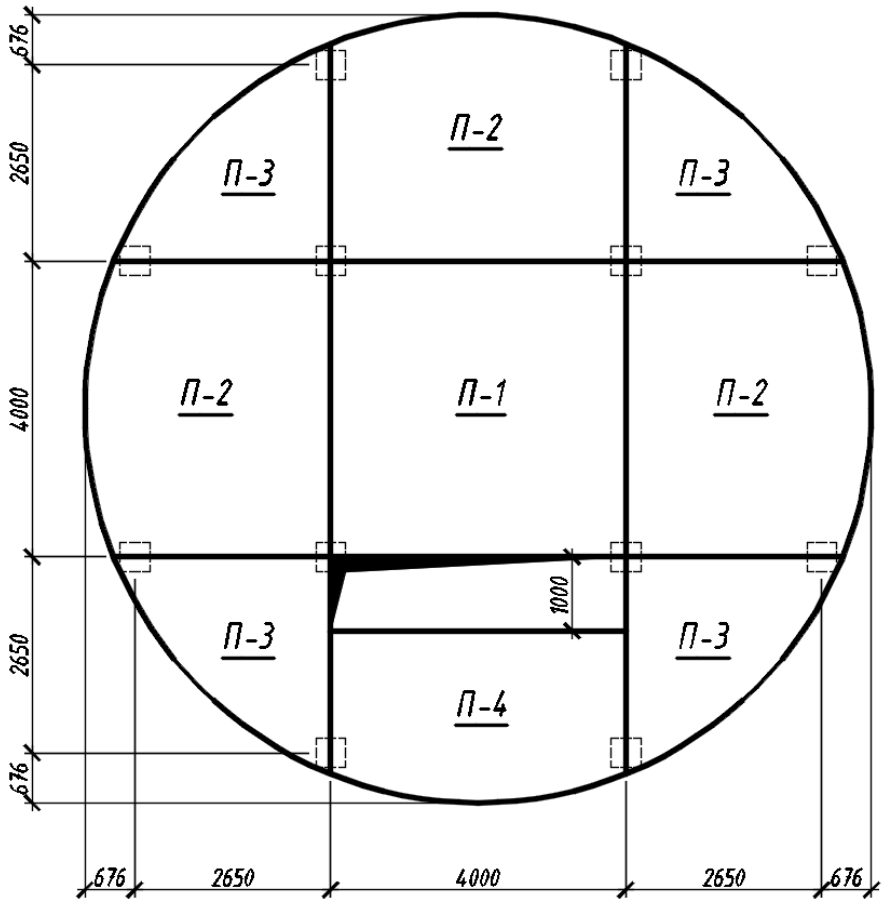


Fig. 4. Floor slab plan

Conclusions

1. A two-story domed house made of glued wood was designed.
2. The structural scheme of the house is mixed and consists of a self-supporting wooden dome framework and internal columns, on which a beam-less floor slab of crossbeam panels supported at the corners rests.
3. The dome framework is made of typical rectilinear parts of glued wood, which are connected by the steel connectors to form the hexagonal cells.
4. The sphere of the dome house has the smallest ratio of the area of the external walls to the internal volume among all the figures of the same capacity.

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ОСОБЛИВОСТІ ОБ'ЄМНО - ПЛАНУВАЛЬНОГО РІШЕННЯ МОБІЛЬНОГО КУПОЛЬНОГО БУДИНКУ З ДЕРЕВИНИ

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Анотація. Ми пропонуємо варіант об´ємно – планувального рішення двоповерхового купольного дому, який пов´язаний з конструктивним, на базі певної кількості типових будівельних конструкцій: колон, панелей перекриття і звичайно несучих елементів купола, що дозволяє зібрати будівлю «під ключ» за декілька тижнів, без застосування важкої будівельної техніки. Геодезична решітка з шестикутною коміркою рівномірно розповсюджує напруження по всій поверхні купола, сфера якого має найменше відношення площі зовнішніх стін до внутрішнього об´єму серед всіх фігур однакової ємності. Тобто при мінімальні загальній площі стін і покрівлі – мінімум енерговитрат на контроль температури і вологості в приміщенні. Будинок, діаметром по фундаменту 12 м, розроблений для сім'ї кількістю 4-5 людини. Конструктивна схема дому змішана і складається з самонесучого дерев´яного каркасу купола і внутрішніх колон, на які спирається безбалочне перекриття з перехресно - балкових панелей, обпертих по кутах. Каркас купола виконується з типових прямолінійних деталей з клеєної деревини, які з´єднуються сталевими конекторами, з утворенням шестикутних комірок, що надають можливість виконувати віконні прорізи в будь - яких місцях поверхні. Розподіл внутрішнього простору напівсфери надає можливості, яких ви не маєте в класичному проектуванні. Особливості криволінійної поверхні стін враховані в дизайні авторських меблів, що можуть підкреслити вашу індивідуальність.

Ключові слова: купольний будинок з клеєної деревини, геодезична купольна решітка.