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The Spatial Arrangement and Structural Solutions Concept of a Small Rural Public Building in Ukraine

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Abstract Purpose of the article is to develop the small rural public building spatial arrangement and structural solution concept that meets following requirements: compactness; planning decisions flexibility; inclusivity; construction scheme integrity and rigidity; construction and operational building costs reduction; materials consumption reducing with their energy efficiency increasing; construction time reducing; durability; labor costs reducing and heavy machinery use reduction. The research methodology involves a comprehensive approach in formulating a concept, based on literary sources analysis and domestic and foreign experience, identifying the criteria that it should meet. Actual rural public buildings types are identified: cooperative public buildings; libraries; administrative service centers; clinical primary care centers; public safety centers. The small rural public building spatial arrangement solution is determined: one-story, maximum with one inner bearing wall, low plinth and pitched roof with large overhangs. The basic structural elements characteristics are determined: bases of bored and cast-in-place piles, connected by monolithic reinforced concrete grill; insulated floor on soil, which upper coupler structure allows partitions direct bracing; single-layer walls made of light concrete blocks; prefabricated reinforced concrete floor slabs; wooden rafter system; simple, double-slope roof, covered with steel profiled sheets with a protective coating. The scientific novelty is to formulate a requirements list for small rural public building spatial arrangement and structural solution, which corresponds to rural united territorial communities' modern needs and capabilities. The developed concept introduction into design and construction practice throughout Ukraine will enable territorial communities to solve a large range of tasks independently according to available resources.

Keywords Current nomenclature of rural public buildings · Spatial arrangement and structural solution concept · Inclusivity of buildings · Flexibility of planning solutions · Unification

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1 Introduction

The state policy of Ukraine in the local self-government field envisages power decentralization. That means the transfer of a large part of the powers, resources and responsibilities to the united territorial communities (UTC) and rests on the interests of the rural settlements inhabitants. This policy is based on the provisions of the European Charter of Local Self-Government and world standards for public relations. Within the scope of their mandate, and in accordance with the resources available, UTCs today address a number of economic, environmental and social problems, including, inter alia, the development of community infrastructure and the provision of quality services to the public over the full public services range. The infrastructure development and the expansion of services, including administrative ones, necessitate the forming of a rural public buildings new topical types nomenclature, which would be economically and energy efficient and would meet the new, more stringent norms of inclusivity. Therefore, the issue of developing the concept of a spatial arrangement planning and constructive solution of a small public building for a village that meets the resource and economic capabilities of the united territorial communities and is in line with the Energy Strategy of Ukraine for the period until 2035 [1].

Researches in the field of effective economic structures of low-rise buildings were carried out by domestic and foreign authors: Dudykevych [2], Melnyk et al. [3], Sanytskyi et al. [4], Tymchenko et al. [5], Lobodenko et al. [6], Date et al. [7], Cheng et al. [8], Craig and Grinham [9].

Modern foreign practice of design and construction of small rural public buildings is covered in sources [10–15].

Features of actual public rural buildings architectural and planning organization were investigated in the works of Lytvynenko [16], Kuzmenko et al. [17–19], Shulyk et al. [20].

However, the most cost-effective, energy-efficient, and inclusive spatial arrangement and structure solutions for small public buildings, most relevant to rural settlements today, have received insufficient attention in existing research and design practice.

2 Main Part

2.1 Purpose of the Article

The purpose of the article is to develop the small rural public building spatial arrangement and structural solution concept that meets following requirements: compactness; planning decisions flexibility; inclusivity; construction scheme integrity and rigidity; construction and operational building costs reduction; materials consumption reducing with their energy efficiency increasing; construction time reducing; durability; labor costs reducing and heavy machinery use reduction.

These requirements meet the capabilities of the united territorial communities and allow in the shortest possible time to complete the construction and commissioning of a public building on their own.

2.2 Research Methodology

The research methodology involves a comprehensive approach in formulating a concept, based on analysis of literary sources and domestic and foreign experience, identifying the criteria that it should meet, and the development of this complex architectural and structural a solution that covers all stages of the construction of the building and to a certain extent operational costs and meets the capabilities of the united territorial communities in providing infrastructure tours of rural settlements and satisfaction of services to the population.

2.3 Results

The Main Types of Buildings The following types of public buildings relevant to the modern Ukrainian countryside can be distinguished: a cooperative building of a public center, a public safety center, an administrative services center (ASC), a clinical primary care center. If the first type usually includes large hall-type premises and the second—large garages for storing both firefighters and police special vehicles (and sometimes school buses), the last two types can be classified as small public buildings.

Basic Spatial Arrangements of Buildings Given the current requirements of inclusivity and the need to exclude the use of elevators/lifts for reasons of economy, such buildings should be exclusively one-story. On the second floor, it is advisable to have staff apartments. However, given the small size of staff apartments, the need to maximize its isolation from the public part of the building, the desirability of providing communication with the land plot, as well as sufficient, as a rule, the area of land, even when designing public buildings with office accommodation for staff, it is advisable to provide such housing also one-story, locking it horizontally to the public part. The locking can be done according to one of three schemes: linear, offset and angular (Fig. 1). Based on the requirements of compactness, it is necessary to design such buildings rectangular in plan, approximate in proportion to the square.

It is advisable to use a frameless structural system. Maximum design flexibility can be ensured by using single or double span designs (preferably with longitudinal load-bearing walls). The distance between the load-bearing walls is determined by the most common dimensions of reinforced concrete circle hollow floor slabs: 7200 mm for single spans and 6000 mm for two spans (Fig. 2a, b). In this case, a one-span

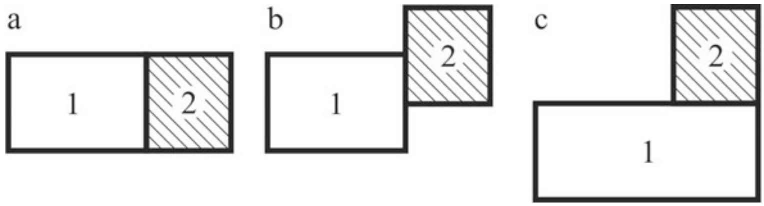

Fig. 1 Block diagrams of public (1) and residential (2) parts of rural public buildings with housing for staff: **a**—linear; **b**—offset; **c**—angular

scheme can be used for the smallest buildings (for example, ASCs), and a two-span scheme—for buildings of a larger size.

The height of the premises is assumed to be a minimum normatively permissible—3.0 m.

It should also be noted that in accordance with the new rules on the inclusivity of buildings [21, p. 13], with new construction it is necessary to provide all entrances and exits flush with the ground without arranging a porch, which certainly requires a deepening of the entrance node inside the building and leads to an increase in the transit area and, thus increasing the volume and making the building more expensive. Such a decision is relatively unacceptable for relatively small buildings. Planning the floor at the level of the land marking requires a complex of constructive (arrangement of storm sewage system with possible heating of the site before entering) and organizational (regular cleaning of the paving around the perimeter of the building from the snow. In rural areas, such measures may be too costly. Therefore, it is advisable to place the floor 0.45 m above the perimeter paving level, and to connect the ground before the entrance, limited by the retaining walls, to a 5% gradient (1:20) with a steep descent. It is also necessary to arrange a deep overhang above the entrance, which will create appropriate comfort for visitors and provide protection of the building from atmospheric precipitation and other adverse conditions.

Foundations and Floor Arrangement It is proposed to use bored and cast-in-place piles with a monolithic reinforced concrete grill, which provides rigidity and integrity of the structure, reduces the building mass and, accordingly, reduces the cost of materials and construction. The grill forms the basement of the walls, which is proposed to be insulated with extruded expanded polystyrene. The floor is offered to arrange the combined on soil. In this case, a monolithic reinforced floor slab (100–150 mm thick) is proposed to be placed above the insulation of extruded expanded polystyrene. The plate should allow the internal partitions of brick (up to 120 mm thick), aerated concrete blocks (up to 200 mm thick), as well as of gypsum boards on a metal frame to support it.

Walls Modern requirements for the level of resistance of heat transfer of external walls ($R_{q\,min} \geq 3.3$ m^2 K/W for most of the territory of Ukraine, except for the southern regions) significantly narrow the range of choice of materials for single-layer walls. In our opinion, light concrete blocks will be appropriate for rural areas,

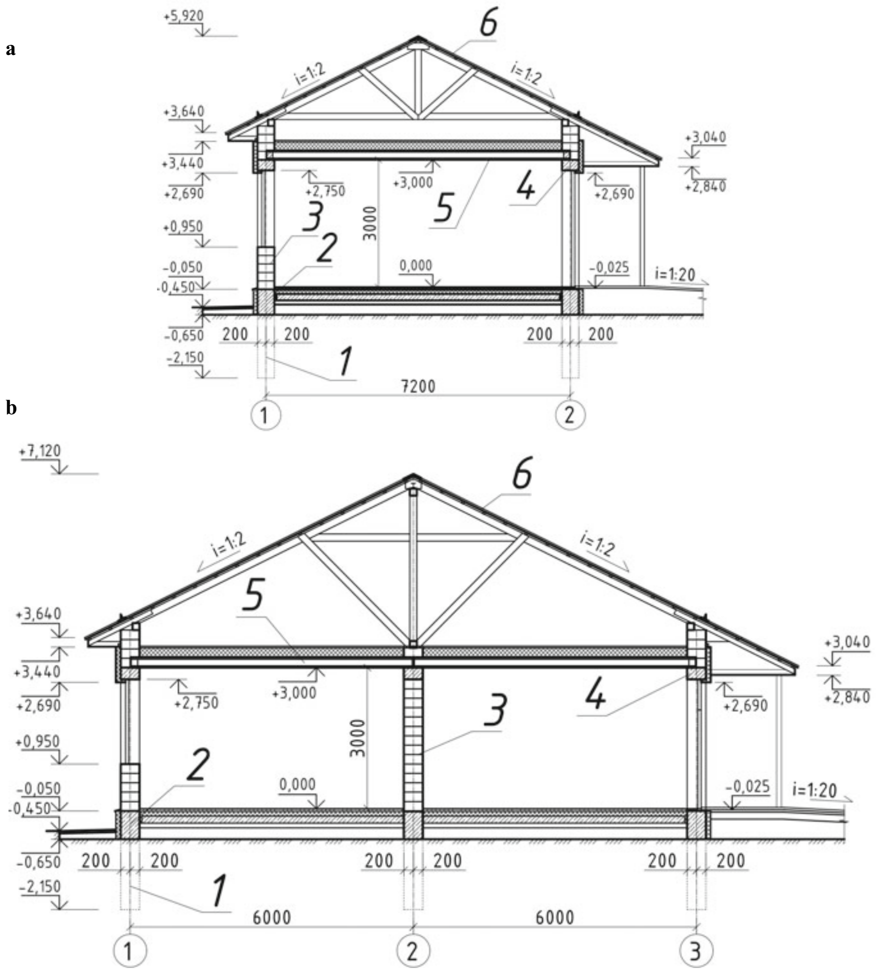

Fig. 2 Cross-sectional diagram of a small rural public building (**a**—one-span scheme, **b**—two-span scheme): 1—bored and cast-in-place piles; 2—monolithic reinforced concrete grill; 3—walls of aerated concrete blocks 400 mm thick; 4—monolithic reinforced concrete belt under the floor slabs; 5—concrete hollow floor slabs insulated with mineral wool slabs; 6—pitched roof of metal profiled sheets on wooden patches and rafters

as the most common material in Ukraine. They are quite lightweight, so they do not require heavy handling, and generally lead to savings in transport costs, which is very important for limited-capacity UTCs.

It should be noted that aerated concrete blocks are a fairly good insulation material. The thermal conductivity of D500 gas concrete in dry form is 0.12 W/m K, which is 4 times less than in solid brick (0.45–0.55 W/m K) and slightly below the thermal conductivity of wood (0.15 W/m K). Despite its excellent thermal properties, aerated concrete is a sufficiently strong material for erection of load-bearing walls. The most common aerated concrete blocks have a B2.5 compression strength class and can have a density of D350–D600. Such blocks can be erected supporting walls with a total height of up to 20 m. It is suggested to use 1–2 structural spans to reduce the weight of reinforced concrete overlap.

The use of a monolithic reinforced concrete belt to support the reinforced concrete hollow floor slabs allows not only to increase the strength and spatial rigidity of the building (including resistance to deformation of the foundations under the foundations), but also to use the belt as a window and door lintel in the outer and inner walls. To prevent the formation of a cold bridge from the outside, the belt is insulated with mineral wool plates at least 100 mm thick.

The use of aerated concrete blocks with a thickness of 400 mm allows to achieve resistance of heat transfer of walls not less than 4.16 m^2 K/W (without taking into account external and internal equipment). In addition, if necessary, the wall can be additionally insulated with mineral wool panels up to 150 mm thick, which will increase the heat transfer resistance of the wall to at least 7.9 m^2 K/W. Alternatively, heat-efficient multilayer polystyrene concrete wall blocks developed by PoltNTU scientists can be used [22].

Overlapping The use of proven standard products (6 and 7.2 m reinforced concrete hollow slabs) for such a responsible structural element ensures proper fire resistance, durability and ease of design and installation. A thickness of 200 mm of mineral wool slabs is proposed to provide a reduced overlap heat transfer resistance of at least 5.0 m^2 K/W (at $R_{q\ min} \geq 5.0$ m^2 K/W). The design of the overlap allows increasing the layer of insulation if necessary.

Roof In order to organize ventilation and prevent overheating in the winter, it is advisable to provide a roof attic with an increase in roof removal (up to 700 mm) in winter protection. It will allow to manage without means of drainage of rain and melt water, will create conditions for the organization of thermal insulation in the future. It also does not require the construction of an anti-ice system, which is very energy-intensive and expensive, especially in rural settlements and will be almost unrealistic to implement within the UTC. The most rational is a double-slope roof. The roof is made of profiled zinc-coated steel sheets, painted. Roofing system and patches can be made of local wood in the form of truss trusses (for one-span scheme) or in the form of sling rafters with support on the inner wall (two-span scheme). A 1:2 roof slope ensures good precipitation in all climatic zones of the country.

2.4 Scientific Novelty

The scientific novelty is to formulate a list of requirements for a large-scale planning and constructive solution of a small public building for rural settlements, which not only corresponds to the current normative documents of Ukraine in the field of construction, but also to the modern needs and opportunities of rural united territorial communities.

2.5 Practical Importance

The concept of a large-scale planning and constructive solution of a small community building for rural settlements can be used in the design of such buildings to solve the important social problem of developing the infrastructure of the village and expanding the full range of services for the population. The introduction of the developed concept into design and construction practice throughout Ukraine will allow the territorial communities to independently solve a large range of tasks within their powers and according to available resources.

3 Conclusions

Thus, the concept of small rural public buildings spatial arrangement and constructive solution has been developed, enabling the development of integrated territorial communities' infrastructure and extension of services to the rural population at low cost. This is of great socio-economic importance for the sustainable development of settlements.

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Application of the Modern Finishing Materials in Interiors of the Preschool Educational Institutions

N. E. Novoselchuk

Abstract The article is aimed to systematize the list of finishing materials and requirements which can be used for interiors of preschool institutions. In order to study the declared subject, factual, empirical, and systemic methods have been used in the article. The scientific novelty is in systematization and supplement of a list of finishing materials which can be used in interiors of the preschool institutions. The criteria of environmental friendliness, operational safety, compliance with fire safety requirements, and several other requirements are taken into account, depending on the functional purpose of a premise. The practical value is concentrated in obtaining the results that can help to make the microclimate of preschool institutions better and reduce the risks for children's health. Main issues associated with the use of hazardous finishing materials in children's preschool institutions, in particular, the problem of the formaldehyde migration level are highlighted in the article. The basic requirements are defined in the article. The list of finishing materials which can be used in these institutions without harming children's health based on the study of regulatory documents and scientific sources is systematized.

Keywords Finishing materials · Construction materials · Children's preschool institutions · Interior · Environmental friendliness

1 Introduction

The major development trends of global economy and trade comprise the extended range of all type consumable products differentiation, increment in wares transfer, growth of manufacturers' quantity using various technologies, augmentation synthetics, and non-natural materials in the production of commodities [1]. And today, the construction market offers a wide variety of options for finishing materials. Proper choice of such materials for children's institutions is a major task.

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It is known that children spend much of their time in kindergarten. And it is essential that the ambient should be ecological and high quality. Various factors influence on that as follows: air quality, electromagnetic radiation, household chemicals and hygiene accommodations, substances defined by the emitted material substance existence, etc. The wrong choice of modern finishing materials is also dangerous. Some researchers [2–5] established that ammonia, acrylonitrile, phosphoric anhydride, butyl and vinyl acetates, hydrogen cyanide, hexamethylene diamine, complex of organic phthalates, aromatic hydrocarbons, acrylates, methyl, butyl, and isopropyl alcohols, formaldehyde, phenols, and a number of other impurities can be emitted from finishing materials into the human environment in significant concentrations [1].

The issue of finishing materials choice for the internal environment of preschool institutions is directly related to the indoor environment condition and is becoming increasingly relevant. It should be mentioned that in the context of the increase in the quantitative diversity of materials, the quality level significantly decreases in course of co-option for the kindergarten rooms finishing. Mainly, it is resulted because non-professionals are tolerated in the purchase process, and the choice of any material often depends on the taste preferences and financial capacity of the parents whose children attend the associated kindergarten. Meanwhile, the fundamental requirements for the finishing materials used for such type of buildings are ignored, notwithstanding that they are recorded in the regulatory documents of Ukraine and must be strictly adhered. The basic requirement hereunder is safety, which ensures both the operational characteristics of material depending on the type of the room, and its environmental friendliness, which is directly related to children's health. Failure to comply with this requirement may lead to the formation of undesirable risk factors that adversely affect children's health and cause various allergic reactions, as well as affect the emotional and mental state. A significant tool for creating a healthy environment in kindergartens is observance of the concept such as "ecological environment—children's health" and involvement of professionals in this process.

Scholars regularly report on the results of their research in numerous scientific publications. Builders, architects, designers, physicians, ecologists, and teachers who deal with the outlined problems publish the results of their research in order to improve the situation at the level of constructional, architectural design, and maintenance work in childcare facilities.

Some scientists at the empirical and theoretical levels investigate the environmental friendliness of the used finishing materials, declare the relevance, and demonstrate the importance of this problem. These are works of V. P. Knyazeva, B. V. Gusev, V. M. Dementiev, I. I. Mirotoretsev, K. L. Antonov, V. V. Ovchinnikov, N. V. Zaitseva, V. A. Bardonov, Yu. D. Gubernski, A. Hodgson, L. Yu. Caranastas, M. J. Mendell, K. B. Rumchev, and K. I. Stankevich et al. Issues on material science for architects are discussed in the following works: D. P. Ayrapetov, V. G. Mikulsky, V. E. Bayer, P. V. Krivenko, M. P. Burak, Yu. M. Tikhonov, Yu. P. Panibratov, Yu. G. Meshcheryakov, T. V. Sheina, etc. Works of such scientists are focused on the studies of the internal environment of preschool institutions formation aspects, including the competent use of the finishing materials: V. O. Ryzhikov, E. N. Dautov, D. M. Kharitonov, A. N. Stasyuk, E. G. Yakushev, I. S. Katunin, P. S. Barkov, N. V. Dryukov, A. O. Kadurina, N. B. Blokhin, L. T. Vikhrov, G. M. Davydov. Scientific works of S.M. Novikov, L.Yu. Karanastas, A.A. Gladkovskaya, K.B. Rumchev, M.J. Mendell, C. G. Bornehag, and others are focused on the studies of negative health consequences of consumers under the influence of substances that migrate from products to the environment.

Thus, available accessible research activities analysis, constructional and architectural sources, and architectural and engineering materials enabled the allocation of factual material for research. The field and visual inspection of the interiors at a number of Ukrainian preschool institutions field inspection carried out by the author enable to confirm the validity of the applied theoretical and empirical methods and the reliability of the results of scientific research.

1.1 The Objective of the Study

The objective of the study is to determine the finishing materials and requirements. These materials can be used in the interiors of preschool institutions consistent with fundamental requirement.

1.2 The Methodology of the Study

Based on the existing methods of scientific research experience, the following methods were used in the paper: factual—for study of systematization of the available constructional, architectural, literature, and scientific sources; empirical—basing on analysis and comparison of the studied objects, with due regard to the current requirements; systemic—enabling to study this issue comprehensively, taking into account all its components.

1.3 Scientific Novelty and Practical Importance

Scientific novelty and practical importance consist in the systematization and addition, a list of finishing materials that can be used for the interiors of preschool institutions. The criteria of environmental friendliness, operational safety, compliance with fire safety requirements, and a number of other requirements depending on the functional purpose of the facilities are taken into account. The obtained results will help to make the internal environment and the microclimate of kindergartens more healthy, which will help reduce the risks of children’s health.

2 Results

Currently, the quality of raw materials for the production of building and finishing materials and the materials themselves is determined by such regulatory documents as the state building norms (DBN), the state standards of Ukraine (DST), SNiP, and specifications and is evaluated by technological and technical characteristics. The sanitary safety of finishing materials is determined by a set of sanitary-hygienic characteristics. They determine the potential hazard of the material to human health and compliance with sanitary requirements. The danger of finishing material may be manifested in air pollution of premise, or in direct human contact with such material. Deleterious health effect is the result of interactions combination between the material, environment, and individual [6].

The most dangerous material hazard factor for children's health is formaldehyde migration levels: in general, for all types of products, up to 16–25% for certain groups of goods (plywood, fiberboard, particleboard). The formaldehyde levels of 2.5 were registered in children's blood, which is higher than the comparison level ($p < 0.05$). Also among children being under conditions of the prolonged exposure, the presence of immunodependent inflammation is registered [1]. These scientific data are the source of serious concern for children's health and cause to select the finishing materials with all responsibility.

In order to prevent air pollution in children's educational institutions, it is extremely important to develop the industry of maxi safe finishing materials designed specially for kindergartens [1].

The master regulatory documents that regulate the use of finishing materials for kindergartens in Ukraine are the state building norms "Preschool Educational Institutions" B.2.2-4: 2018 and No. 563/28693 (Sanitary Regulations for Preschool Educational Institutions) approved on March 24, 2016. These documents indicate the main operational requirements and types of materials for various premises of these types of buildings [6]. In addition, the materials must meet fire safety requirements and several special requirements, depending on the functional purpose of the premise.

Requirements and materials for the interior decoration of the main premises of kindergartens are represented in Table 1. However, it should be pointed out that in the regulatory documents ignore data as for finishing ceilings. Also, finishing materials for the floor and walls are not indicated for all types of rooms, which are displayed in the table as empty cells (Table 1).

In this regard, based on interiors objects under investigation analysis, scientific, regulatory sources, and the existing market for finishing materials, the author has a supplemented list of the recommended materials for the interiors of preschool institutions.

Thus, the use of combustible materials is prohibited for walls and ceilings in the rooms which are used as evacuation routes (corridors, foyers, recreation areas, vestibules, stairwells). For that occasion, the best solution would be painting the walls with paint materials which form non-combustible film on the surface [8].

Table 1 Finishing materials and their requirements used in preschool institutions under the regulatory documents of Ukraine [7, 8]

Room designation	Floor finishing material	Requirements for the floor finishing material	Wall finishing material	Requirements for the wall finishing material
Common premises • Playroom • Changeroom • Bedroom	Homogeneous linoleum	• Humidity resistance • Base with glass wool • Low heat conductivity • Resistance to detergents and disinfectants • Non-slip surface • Safe heating systems are allowed		• Smooth surface • Humidity resistance • Possibility of wet cleaning • Light reflectance 50–70%
Tiring room	Ceramic tiles	Slip-resistant surface	Ceramic glazed tile	Minimal height of tile paving 1.5 м
Halls for PE and music	• Parquet board • Homogeneous linoleum		Non-combustible materials	• |Moisture resistance • Possibility of wet cleaning
Swimming pools Showers Toilets	• Ceramic tile • Terrazzo concrete	Non-slip surface	Ceramic glazed tile	Minimal height of tile paving 1.8 м
Medical facilities		Possibility of wet cleaning		
Administration premises Educational premises	• Homogeneous linoleum	• Moisture resistance • Possibility of wet cleaning • Light reflectance 50–70%		
Food department	Ceramic tile	• Non-slip surface • Minimal slope to the sewage system 0.03%		• Moisture resistance • Possibility of wet cleaning • Minimal height of tile paving 1.8 м

Latex and silicone paints are recommended materials for the walls for large premises, halls for athletics and music-making, and office premises. They are made using water-dispersed components, and therefore, do not form combustible films, toxic substances, and do not thermally decompose in case of fire. These paints are abrasion-resistant and enable wet cleaning with non-aggressive non-abrasive detergents [9].

It is also possible to use the fiberglass wallpaper, which has a glass base and consists of fibers of quartz sand, soda, lime, and dolomite—environmentally friendly minerals. Such fiberglass does not enable breeding ground for microorganisms; it is characterized by strength, water tightness, environmental friendliness, and fire resistance. This coating, "breathes," does not accumulate the static charge, is not susceptible to infection by fungi and mold, and helps to maintain microclimate in the room. Ceilings in the high air humidity rooms (food processing department, showers, laundry rooms, washrooms, toilets, etc.) should be painted with oil paint [10], Fig. 1.

All materials used for the interior decoration of the preschool educational institutions should have a positive conclusion by the state sanitary-epidemiological expertise.

In addition, it is necessary to turn attention to the specialized and innovative materials and technologies which can be used in the preschool institutions. These are the bioactive ceramics (innovative self-cleaning ceramic material Bios), developed by specialists from Casalgrande Padana in Italy. This material is able to reduce the number of four major bacterial strains by 99.9%, as evidenced by the Department of Microbiology of the University of Modena, Italy [11]. The base of the material is silver with antibacterial properties, and Bios does not contain health chemicals harmful to human.

The HYDROCERA technology merits attention, it breaks down bacteria that cause unpleasant odors and yellow spots by means of hybrid photocatalyst technology (a combination of photocatalyst and antibacterial metal) [12], Figs. 2 and 3.

It is also possible to use the antibacterial disinfectant paint with the addition of silver ions, in which composition cleans and disinfects the air, and can be effectively used in the preschool institutions. The effect is based on the principle of photocatalysis, which sets in motion under the influence of light [13].

3 Conclusions

The adverse effect of finishing materials on the human body is resulted from the release of harmful substances into the environment. In practice, this can be eliminated only by removing such material from the room. Therefore, at the design stage, it is necessary to predefine the right choice and introduce into the project such materials that are safe for humans only and reject materials that contain at least a microdose of the dangerous substances. This will encourage manufacturers. They shall be focused on the production of environmentally friendly materials only. Its implementation into the construction market should be predetermined by the consumer's deliberate

Fig. 1 Fiberglass wallpaper development phases [10]

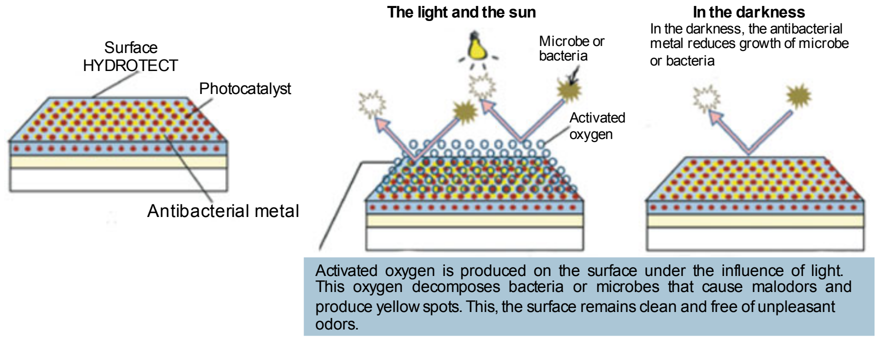

Fig. 2 Technology HYDROCERA [12]

Fig. 3 Field of HYDROTECT application [12]

choice—his refusal to purchase hazardous materials containing harmful substances [1, 14, 15]. It is also required that all materials, regardless of their range of application, shall be subjected to general requirements—they should not emit harmful substances into the environment. The use of materials containing substances detrimental to humans should always be avoided. In addition, strict control over the quality of finishing materials that are used in preschool institutions is required.

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