THE CONCEPT OF ENERGY EFFICIENCY AND ARCHITECTURAL PRINCIPLES IN LOW-RISE COURTYARD RESIDENTIAL BUILDINGS

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Abstract. Today, under conditions of global climate change and limited energy resources, increasing the energy efficiency of residential buildings has become one of the most important tasks of architecture. Especially in the sharply continental climate of Uzbekistan, with extremely hot summers and very cold winters, designing low-rise courtyard houses in harmony with the external environment, that is, applying a bioclimatic approach, is of great relevance.

Keywords: thermal energy, yurt, alternative energy, relief, bioclimatic, skylight.

Since the emergence of human society, people have sought to protect themselves from heat and cold by building shelters. For example, archaeological evidence shows that in the 4th century BC, people lived in caves around the area of the “Dinamo” stadium in Samarkand. In desert and flat regions, people built tents to protect themselves from wind, heat, cold, and external dangers. These tents were mainly made of wooden poles, reeds, large leaves, and animal skins. A skylight was left at the top of the yurt, which served for ventilation and allowed smoke to escape when heating the interior. The floor of the yurt was covered with felt, preventing ground moisture from penetrating inside. Yurta were mainly used by nomadic pastoral communities, while agricultural populations used underground dwellings. Over time, people began constructing permanent buildings. Even then, efforts were made to ensure energy efficiency: entrances and openings were oriented opposite to the north-south direction. Houses were built with thick walls to keep them cool in summer and warm in winter. Roofs were insulated using thick layers of reeds covered with soil, which was sloped and plastered with straw-clay to allow rain and snowwater to drain off.

Residential buildings were constructed as one- or two-story houses depending on the economic conditions of the inhabitants. To reduce the impact of solar radiation, trees such as elm, poplar, apricot, and grapevines were planted along the courtyard and near the house. These trees, with dense foliage, could reduce solar energy exposure by up to 5% (elm and poplar) and 1.5–2% (apricot and grapevine).

By the 1940s–1950s, due to the mass migration of rural populations to cities, the construction of residential, industrial, and public buildings accelerated rapidly. This was driven by fundamental economic changes and a sharp increase in demand for industrial products. As a result, construction became standardized on a global scale.

Standardization led to uniformity of buildings across the USSR. During this period, architects paid little attention to energy efficiency and focused mainly on meeting housing

demand. Local climate conditions, wind patterns, and environmental factors were often ignored. In short, construction followed centralized standards rather than site-specific needs. As a result, natural conditions, user needs, and environmental impacts were not considered in design. This contributed to environmental degradation on a global scale. The deterioration of the ecological environment, the spread of unknown diseases, global warming, water shortages, electricity shortages, and environmental changes led humanity to reconsider its relationship with nature. As a result, from the 1970s, countries such as the USA, Canada, European nations, China, Japan, South Korea, and Singapore began addressing ecological issues and promoting sustainable living. Due to the negative environmental impact of thermal, hydro, and nuclear power plants, the transition to alternative energy sources became an urgent priority. Alternative energy systems can be installed both on a large scale and in individual residential buildings.

The Republic of Uzbekistan is located in Central Asia and has a sharply continental climate with four distinct seasons. From the second half of February to December, the climate is dominated by heat, while winter lasts from December to mid-February. The hottest period occurs in July, with temperatures reaching 40–45°C, while in January temperatures can drop to –20°C. Due to the dry continental climate, the difference between day and night temperatures can reach 10–15°C. Under such conditions, when designing energy-efficient low-rise residential buildings, the following factors must be considered:

- the relief of the construction site;
- the density of the buildings;
- wind direction and solar orientation during building placement.

To ensure natural heating, cooling, and indoor microclimate:

- attention must be given to wall thickness, roof types, and materials used;
- window, terrace frames, and door dimensions, as well as solar radiation exposure;
- maintaining appropriate indoor temperature and hygienic conditions.

Relief of the Construction Site

In mountainous or uneven terrain, energy efficiency in residential design depends on slope degree and orientation. Wind direction and solar exposure must also be considered. In flat areas, buildings should be designed considering communication routes, utility lines, and irrigation channels.

In all cases, residential buildings must be designed with careful consideration of wind patterns and solar radiation based on the specific characteristics of the site.

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