The Integration of Felt into Architecture: a Tradition, a Heritage, and Environmental Sustainability

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Felt is one of the oldest materials used by the people of Kazakhstan, Central Asia, and Mongolia. For centuries, it has served as the foundation of housing structures and a symbol of the environmental awareness of nomadic people. Despite its great environmental and technological potential, its usage in modern architecture in Kazakhstan is still limited. The purpose of the study is based on a comprehensive analysis of the characteristics and opportunities of felt as a vernacular and environmentally oriented material within the framework of architectural activity in Kazakhstan. The main focus comes down to the definition of its role in the formation of regional identity and strengthening of continuity in accordance with global trends of sustainable development. The research methodology is a theoretical qualitative analysis, which is based on the study of: scientific literature on thermal insulation, environmental and operational properties of felt; characteristics of felt (thermal conductivity, resistance to moisture, durability, etc.) according to data from scientific publications. Comparative analysis involves comparing felt with other natural and synthetic materials in terms of environmental and functional parameters, as well as studying international experience in using felt and other natural materials in architecture, followed by the adaptation of successful solutions for use in Kazakhstan. One method is to evaluate not only the strengths, but also the weaknesses, of felt as a building material. This includes identifying problems related to adapting felt to the modern architectural industry in Kazakhstan. The results of the study support the potential of felt as a sustainable material for use in architecture and design, with its key advantages including thermal conductivity, biodegradability, durability, and cultural significance. The results of the study substantiate the recommendations for the integration of felt in modern architectural activity in Kazakhstan. The use of felt in architecture can contribute both to the preservation of cultural heritage and continuity, and to the strengthening of regional identity, while conforming to the principles of ecologically oriented design, and thus to the goals of sustainable development.

Keywords: environmental sustainability; felt; preservation of cultural heritage; responsible consumption; traditions in architecture.

Introduction

In the context of globalization, the problem of achieving sustainable architecture is a priority. At the same time, the rapid growth of urbanization and changes in the cultural landscape necessitate the introduction of such activity as the preservation of cultural heritage - an effective component of sustainable development. In this context, the search for materials and technologies that are environmentally oriented, economically viable, and contain socio-cultural relevance becomes acute. Such materials can be used in the construction of buildings and structures of a certain type, which can both comply with the program of sustainable development and become the result of the task of preserving cultural heritage.

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Environmentally safe vernacular materials created by the previous generation in the process of historical development of the territory are defined by UNESCO, together with tangible and intangible values, as cultural heritage. The preservation of heritage is a key tool for achieving environmental sustainability and strengthening the national identity (Aboulnaga et al., 2024). In the context of urbanization and globalization, heritage conservation faces serious challenges. The rapid development of settlements often leads to changes in the cultural landscape with the destruction of material monuments, neglect of vernacular materials and methods of their manufacture. The loss of patrimony is accompanied by their replacement by new accessible, economically advantageous, but often environmentally unfriendly and psychologically alien.

The symbiosis of modern and traditional, anciently tested technologies in the era of rational consumption is particularly relevant in the creation of sustainable architecture. Felt, a traditional material made of sheep's wool, has been used since ancient times by the peoples of Central Asia, Kazakhstan, Mongolia and Azerbaijan. The harsh climate of the region predetermined the widespread use of felt as the main material for creating yurts and household items. The unique heat-insulating, ventilating and absorbing properties of wooden products proved invaluable in a sharply continental climate, reflecting at the same time the philosophy and worldview of nomadic peoples, distinctive from the sedentary population.

Despite its rich history and significant environmental potential, felt has mainly been used in decorative and applied arts in modern Kazakhstan. Domestic enterprises in the country primarily process wool and produce felting and felt products for everyday use (Analysis of the market in Kazakhstan, 2025). The data presented confirms the fact that there is no use of felt in the architectural and construction industries.

In contrast to domestic practice, global trends show a growing interest in felt. Modern architecture in the pursuit of sustainability, reducing environmental impact and preserving cultural heritage widely exploits the properties of felt: environmental friendliness, insulation and ventilation properties, aesthetics and a significant potential for the revival of traditional technologies. This is especially important when it comes to insulating historical buildings, as it helps to protect these structures and their significance.

Research conducted by scientists from New Zealand, Spain, Italy, and Portugal confirms the potential of felt for use in architecture and construction (Ballagh, 1996; Oliveira, & António, 2024; Rubino & Aracil, 2021). Thus, the Italian National Foundation (FAI) has carried out a study on the construction of an interdisciplinary methodology for a sustainability course using felt in the framework of a program for the preservation of cultural heritage (Lucchi et.al., 2024).

The aim of this study is to identify the possible potential of felt as a construction, thermal insulation or finishing material in the architecture of Kazakhstan; to assess its environmental and operational properties; to propose recommendations for its integration into modern architectural practice.

The analysis of the world positive experience of introducing felt in architecture and construction is presented with an emphasis on the important advantage of using this material as one of the ways of reviving traditional technologies and strengthening cultural identity in the conditions of urbanization and globalization. The reviewed examples demonstrate modern architectural trends aimed at environmental sustainability and minimizing environmental impact while preserving cultural heritage. Some of these European projects are actively using felt for internal insulation of historic buildings to prolong their service life (Ballagh, 1996; Oliveira, & António, 2024; Rubino & Aracil, 2021).

Kazakhstan is a country with historically impressive resources and conditions for the use of felt in architecture: authentic experience in agriculture and hence raw material base (Tolykbekova, 2019). In recent years, there has been an increasing demand in the country for the use of wool in the creation and production of eco-friendly products. This is due to a renewed interest in felt, a traditional material that has new application possibilities (Oktyabrskaya, & Suraganov, 2013).

Thus, it can be stated that the advantages of felt as thermal insulation, ventilation and antibacterial properties are key factors in improving the energy efficiency and comfort of buildings, while preserving cultural heritage. The study proposes theoretical models for the integration of this vernacular material into modern architectural practices.

Research methods and implementation

In the methodology of research of the problem of integration of felt into architecture and construction industry of Kazakhstan a complex approach was used: study and analysis of literary sources - monographs, scientific works and reports of scientists, as well as various organizations on the use of environmentally safe materials in the framework of sustainable architecture and preservation of cultural heritage; study of archival materials - descriptions of traditional methods of vernacular construction, ethnographic data on felt with felt; analysis of the market of production and consumption of felts; Study of demand indicators for sustainable materials. Additionally, a sociological survey was conducted to gather the opinions of experts, including architects, designers, and specialists in cultural heritage.

It is expected that the methodological framework will identify key barriers and opportunities for the use of felt in architecture in Kazakhstan, offer recommendations for integrating it into the construction industry, and substantiate its role in promoting environmental sustainability.

The unique characteristics of felt and its beneficial qualities for both humans and the environment have been described in the works of researchers from various countries, including Kazakhstan, Central Asia, and Azerbaijan, among others (Alzhanova, 2017; Assadova, 2010; Tankayeva, 2022). The sources describe characteristics that are inextricably linked with history and culture, such as the tradition of using yurts and certain household items. In the context of this study, they focus on preserving and reviving these traditions.

Felt is a type of non-spun textile made from natural wool, and the production of which occupies a significant place in the creative activities of the Kazakh people. This is partly due to the availability of a suitable raw material base - the basis of nomadic production methods. Due to its accessibility and ease of production from the wool of farm animals, as well as its versatility in everyday life, felt has become one of the most important materials in the lives and cultures of nomads (Janibekov, 1982; Margulan, 1986; Mukanov, 1981) (Fig. 1).

One of the important properties of wool is its pliability - "obedient" transformation to any shapes and volumes. The nomadic way of life of Kazakhs predetermined the wide production of not only dwelling but also household items: bags - qorzhyn for transportation of household items; headdresses-helmets; "breathable" clothes in the form of vests (kezekey), jackets (kamzol), skirts (beldemshe) and coats (ton), felt boots (baypaq, pima). An obligatory complementary element of felt products was ornamentation: symbolic images made of the same felt, which traditionally served as a kind of writing of images and signs. These properties of felt point to the ingenious simplicity of achieving environmental friendliness, rationalism, and energy efficiency based on zero emissions. Felt has the potential to become a promising raw material that can be transformed into an eco-friendly material through a symbiosis between traditional knowledge and the latest advancements in technology in modern architecture (Fig. 1).

Much of the research in Central Asia and Kazakhstan on felt focuses on its use in the structure of nomadic dwellings - yurts. The emphasis shifts to the marking of felt's insulating and ecological properties and its designation as a component of cultural heritage. The yurt, a portable dwelling, has been an essential part of nomadic life since the Bronze Age in Kazakhstan, when there was a significant increase in cattle farming. Historical and archaeological evidence suggest that the increase in pastoralism led to a nomadic way of life, creating a need for movable housing from the periods of the Saks and Huns and remained relevant until the early 20th century (Maidar & Pyurveyev, 1980; Murzagaliyeva, 2019) (Fig. 1).

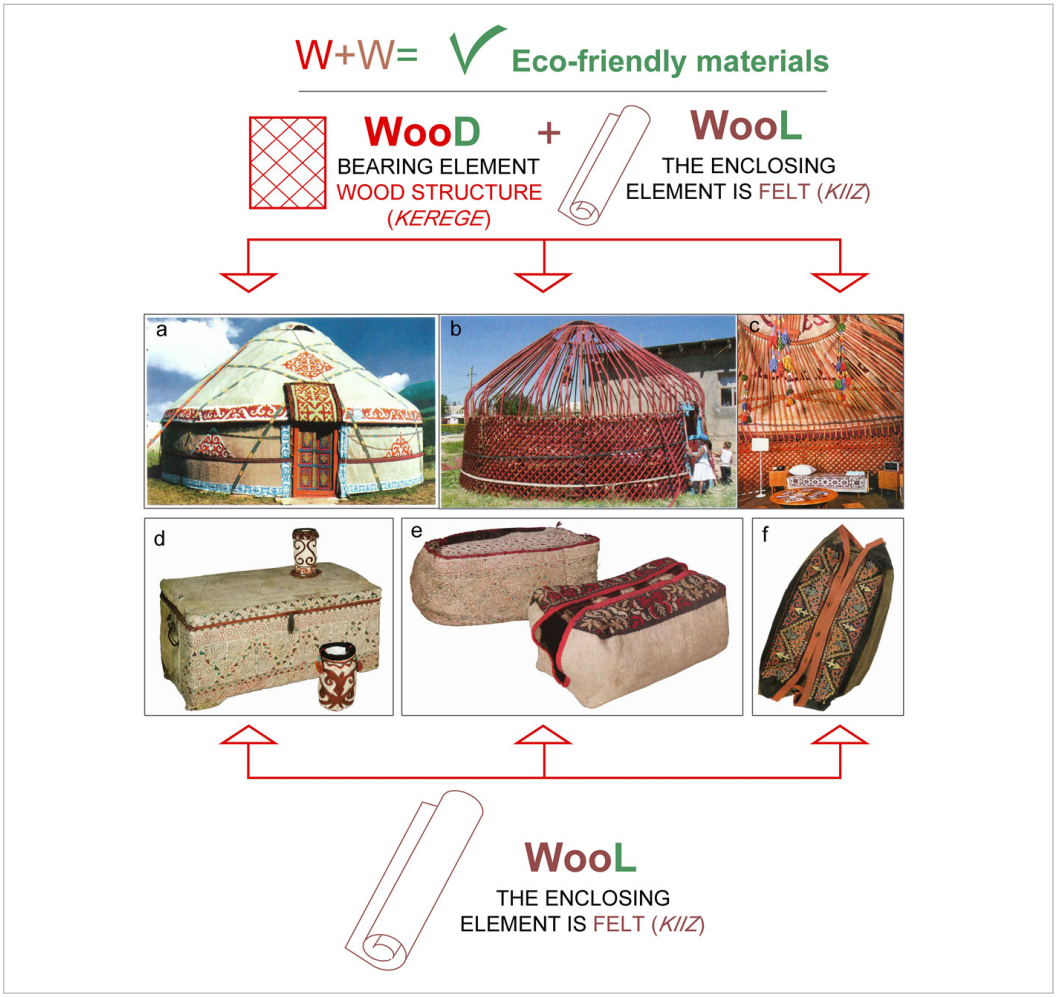

Fig. 1

Options for using felt: The yurt, a portable nomadic dwelling (a), wood structure of the yurt (b), the yurt interior (c) (Mukanov, 1981); a coffer and a household items in a felt covers (d), a felt box for blankets (e), a cushion in a felt cover (f) (Ospanuly, 2021). Figure: by E. Danibekova

In this study, the opinions of modern experts in the fields of architecture, cultural heritage, and its preservation are important in terms of environmental sustainability and the combination of traditional knowledge with relevant technologies in Kazakhstan. A survey conducted in January 2025 among architects confirmed the importance of the study for Kazakhstan, considering the availability of favorable conditions for its implementation. Due to the growing interest in environmentally friendly materials, their ease of processing, and the availability of raw materials, this solution seems promising.

The interviewees responded positively to the question about the possible use of felt in modern architecture in Kazakhstan. They noted the heat-insulating, noise-protective and ecological properties of felt, easy availability of wool in Kazakhstan, proposed ideas for combining it with building materials in order to enhance the above-mentioned qualities of the material.

In his research, Ardasher Yussupov, Professor of M. Auezov South Kazakhstan University, Candidate of Architecture, emphasizes the integration of the cultural heritage of the historical cities of the Silk Road and the traditions of folk architecture with the achievements of modern experience in the design of energy-efficient, affordable eco-houses, made on the principle of lightweight dome structures (Yussupov & Yussupova, 2022). According to Professor A. Yusupov, the integration of felt into architectural designs will have a positive impact on the development of agricultural production. The material, as an element of nomadic cultural traditions, has the potential to become a crucial building resource in Kazakhstan.

The professors of the International Educational Corporation (KazGASA) have agreed on the potential of using felt in architecture and construction. Gulnara Abdrassilova, a Doctor of Architecture, and Ainagul Tuyakayeva, a Candidate of Architecture, conduct long-term, in-depth research in the fields of regional architecture and urban planning. They pay special attention to the development of innovative methods of reconstruction and ways of adapting traditional technologies to create an eco-sustainable architectural environment (Kozbagarova, Abdrassilova & Tuyakayeva, 2022; Abdrassilova & Danibekova, 2021). Another professor of KazGASA, candidate of architecture Galym Isabayev, who has been engaged in research and design of energy efficient buildings for many years, is of value in this matter (Issabayev & Issabayeva, 2020).

The scientists have noted the high potential of felt, especially when it is used to create modern materials such as composites, exterior and interior finishes, as well as industrial and textile designs. However, despite its excellent thermal insulation properties and resistance to insects and pests after treatment, there are still concerns about fire safety, water repellency, and damage resistance.

Professor of the International Educational Corporation (KazGASA) and member of the working group on material heritage of the National Committee for UNESCO and ICESCO in Kazakhstan, a Doctor of Architecture Mehirbanu Glaudinova noted that the potential use of felt in architecture and construction in Kazakhstan could give impetus to the development of new technologies and support the concept of national architectural identity by integrating this material into building practices.

Throughout the course of the survey, Mehirbanu Glaudinova and Sarsengali Bekeshov, an expert on material culture at the West Kazakhstan Museum of Local History and a regular participant in archaeological expeditions, expressed concerns about the proportional relationship between the required volume for full-fledged application in architecture and the increasing cost of the material in this case.

However, in the Soviet period, in order to reduce costs, synthetic material was used (Mukanov, 1981). However, during testing, these materials quickly demonstrated their unsuitability due to their lack of protection against overheating and stuffiness. In such conditions, felt, with its high thermal insulation qualities and environmental safety, proved to be much more preferable.

According to Berik Murzagaliyev, an expert in the fields of architecture and urban planning and a practicing architect with many years of experience, finely dispersed cement-coated felt slabs can be effectively used in construction as enclosing structures as well as for decorative and applied art and interior design. He mentioned the ease of processing and the availability of raw materials as factors that contribute to the potential for environmentally friendly construction using this material. According to B. Murzagaliyev, felt can be used to create self-supporting structures in a composite form, combining wool with concrete, resin, or other binding materials. These structures can take the shape of slabs or curved surfaces, and they have increased fire resistance and durability.

Similar international experience includes the creation of a pavilion made from felt panels. The felt fibers are reinforced with expanded foam to ensure the strength and stability of the structure (Aouf, 2017).

All respondents identified the lack of regulatory and technical frameworks, insufficient awareness among specialists and consumers, limited availability of high-quality raw materials, and economic and technological challenges as the main obstacles to the integration of felt into architectural and construction practices. However, the key obstacle remains the lack of support for pilot projects of initiative enthusiasts. It is necessary to thoroughly research the raw material base, market analysis, laboratory tests on the basis of which it is possible to develop a business plan to achieve product certification. Additionally, workshops and seminars should be organized to promote the use of felt as part of Kazakhstan's intangible cultural heritage.

Despite the fact that traditional methods of felt production have stood the test of time and proven their reliability and efficiency, the popularization of felt in architecture and construction should focus not on the usual forms of use, but on the development and implementation of modern building materials based on felt. Of course, the study of the world experience of integrating felt and other natural materials into architecture can be considered as an encouraging example for the development of sustainable architectural practice in countries where such solutions are not yet widespread and in Kazakhstan in particular.

In recent decades, research on the use of both felt and other natural local materials with low carbon footprints has been actively conducted worldwide, demonstrating the positive results of their safe impact on human health and the environment. Researchers from universities in Brno and Vienna have conducted a thorough assessment of the properties of felt as a potential building material (Zach et al., 2012).

The tests were conducted on sheep wool samples that had been processed in various ways. The researchers used these samples to evaluate the thermal conductivity, moisture resistance, and sound insulation properties of the material. The results obtained, particularly when compared to traditional insulation materials like mineral wool. Wool has a low thermal conductivity. It has good sound insulation properties. Such a property as the ability of wool to regulate moisture prevents the accumulation of condensation and increases the durability of structures. Overall, the results show that sheep wool can be an effective and environmentally friendly thermal insulation material, i.e. with sufficient potential for sustainable building applications.

Thus, lightweight fabric with a dense structure does not contain harmful microbes and does not emit toxic substances into the environment. On the contrary, it acts as an absorbent and antibacterial material, which is especially important for improving indoor air quality and reducing the risk of mold growth.

Scientists from the Polytechnic University of Turin are conducting research that is significant for environmentally sustainable architecture. They are searching for eco-friendly materials to solve the problems of thermal and sound insulation in walls. The research team is conducting various experiments, such as the Cartonlana project, to test panels made from recycled sheep wool or a combination of wool with plant fibers added to improve stiffness and tensile strength. Based on their previous work proving the positive environmental and insulating qualities of sheep wool panels, they have proposed an innovative semi-rigid version combined with technical hemp fiber as a solution (Bosia, et al., 2015; Savio, et al., 2018). Researchers have found that the addition of hemp fibers provides felt panels with a relatively high density and strength. Additionally, this method has a positive impact on soil conditions: organic waste from the cultivation of hemp contributes to soil recovery and carbon dioxide absorption from the atmosphere. This aligns with the global agenda for optimizing resource use, minimizing environmental pollution, and promoting material recycling.

The research results may be of great interest to Kazakhstan. Wild cannabis grows naturally on the territory of the country, covering large areas of the Shui Valley in the Zhambyl region. At present, local experts are exploring various options for utilizing wild cannabis for various purposes, such as producing medicine and consumer goods (Skripnik, 2023). As example, foreign experience in introducing manufacturing innovations, such as the use of hemp fibers in felt production, opens up opportunities for technology modernization. This ensures geometric stability and expands the prospects for using the material in construction. A well-established process for growing cannabis followed by its use in the production of felt panels can help solve the problem of uncontrolled plant spread, while improving soil quality and air quality. Combining plant fibers with wool will be able to create a strong and durable material that maintains its desired shape. This ensures both economic and environmental efficiency.

Another study on the effectiveness of using waste from livestock products, such as wool, as a building material was conducted by other researchers. The results of this study were presented in their paper titled "Wool waste used as sustainable nonwoven for building applications" (Rubino & Aracil, 2021). Of course, empirical studies are conducted to identify specific characteristics of wool-based building materials. The positive results of the study on felt as a sound insulation lining material, instead of artificial mineral fibers, are shown in the work of scientists from New Zealand (Ballagh, 1996). Researchers from the University of Coimbra (Portugal) will conduct experiments to compare the acoustic characteristics of recycled animal products with those of artificial materials (Oliveira, & António, 2024).

In addition to insulating, ventilation and environmental characteristics, we can try to discover the potential of sheep's wool in expressing psycho-emotional and aesthetic qualities. The physiological and psychological comfort of users contributes to the overall quality of the space and positively affects their emotional state and perception. Psychologists use terms such as "emotional expressiveness" and "emotional connection" to describe the positive impact that an artificial material or spatial environment can have on a person's psychophysiological well-being (Lynch, 1960; Prak, 1968; Stepanov, et al., 1993). The consumer learns about the architectural environment by connecting the sense of understanding of space, perception of form and color by the viewer depending on his aesthetic preferences, conditioned by the peculiarities of culture. Comprehension of the space as a whole and its evaluation occurs on the basis of intuitive recovery of familiar images and meanings from memory, laid down by experience and tradition.

In this matter the synthesis of arts - architecture, design and decorative and applied arts - is of great importance. Thus, felt can be used in the creation of modern interiors of public spaces, providing both aesthetic and functional benefits and cultural continuity. The natural texture, softness and colors of felt wall panels ensure a consistent image and tactile sensation. By using a traditionally familiar material like felt, designers can create associations between the visual and tactile experiences of the space and the consumer. This can help to the consumer has associative both visual and tactile relationships.

There are now a growing number of successful examples of integrating felt into sustainable architecture - projects that combine traditional production methods with modern design solutions. A number of eco-hotels and tourist complexes can offer clients authentic interiors reflecting the cultural traditions of the region through the use of felt. This gives ordinary people a chance to better understand and appreciate the history and development of human civilization (Féline, 2024; Using, 2025). When decorating the interior of the Wolfgang Puck Bar & Grill restaurant, located on the premises of the MGM Grand Hotel and Casino in Las Vegas, the use of felt for wall decoration contributed to creating an authentic atmosphere. This choice of material was not only due to its visual appeal, but also because of its high sound insulation properties, which are important for catering and hospitality establishments (Industrial, 2024). In addition, the sound insulation properties of felt minimize acoustic interference, creating a more conducive atmosphere for work and business communication.

The listed material properties are directly proportional to a wide range of consumer products made of wool, including pharmaceutical packaging materials, hygiene products and other products. The insulating properties of felt regulate the degree of humidity and maintain a stable temperature (Sigaard, Berg, & Klepp, 2021).

Foreign research, in particular that conducted by European universities, has focused on developing innovative solutions for using sheep's wool as a sustainable building material. Experiments with processing wool and creating insulation panels have confirmed that felt is comparable to, and in some cases even superior to, traditional materials like mineral wool in terms of thermal and sound insulation. The potential of felt in sustainable architecture is well-established, driving

innovation and expanding its applications while promoting research into environmentally friendly materials.

Analyzing the key areas of application of felt in architecture, design, and construction in modern Kazakhstan, was summarized the data on its potential within the context of sustainable development strategies with the prospects for implementing this material in the future.

Thermal and sound insulation. Sheep's wool has characteristics similar to those of synthetic materials. Air pockets in the structure of wool provide excellent heat and sound insulation properties. Successful usage of traditional mobile dwelling - yurt (kiiz üi - literally "house made of felt"), going back to the depths of centuries is proof of the effectiveness of felt properties. For example, thermoregulatory properties of the yurt have always provided protection from external climatic impacts: in winter - from wind and temperatures down to -30 °C, in summer - from overheating at +29 °C with preservation of optimal microclimate inside (Glaudinov, 2019; Maidar & Pyurveyev, 1980).

Environmental sustainability. There is no carbon footprint in the production of felt: the material is a biodegradable, environmentally friendly material with no harmful emissions during the manufacturing and disposal phases and can be recycled and reused. Wool is able to "breathe", absorb odors and volatile compounds from the atmosphere, contributing to the creation of comfortable indoor conditions by preventing excessive humidity. These properties make felt a promising material for use by environmentally oriented architects, designers and builders.

Visual and tactile comfort. Felt is a rather "warm" and cozy material as a decorative element or structural component. Its use in the interior will give the space a unique visual, expand the range of adoption of the results of traditional crafts. Such diverse implementations of felt open up promising opportunities for synthesis of arts in architecture and design and reveal its artistic-aesthetic and functional-technological aspects.

Scientists have expressed concern about the durability of felt when exposed to prolonged exposure to precipitation and winds (Glaudinov, 2019). However, archaeological finds speak about the unique property of the material - under certain conditions of storage felt can be preserved in an unchanged state even for hundreds of centuries. For example, fragments of felt carpets and chepraks were found during excavations of Pazyrak mounds in the Eastern Altai dating back to the 5th and 4th centuries BC. These fragments were preserved by about 80-90% (Ospanuly, 2021).

In connection with the above, despite the prejudices about the fragility of felt, which, under the right storage conditions, can last for centuries, the issues of increasing its moisture resistance and fire protection characteristics remain relevant. One way to extend the life of this material may be to encase the felt in membrane-like coatings.

Thus, the introduction of felt in the modern architecture of Kazakhstan is an environmentally safe, culturally close and economically promising way of combining tradition and innovation in the creation of architectural and spatial environment, which corresponds to global trends of sustainable development and contributes to the preservation of cultural heritage.

Results and Discussion

The current issue of environmental sustainability in architecture presents challenges related to the rational use of resources, reduction of waste, and the utilization of recycled materials. Within the context of finding environmentally friendly materials that have minimal impact on the environment and human health, felt, as a part of cultural heritage, possesses unique properties that need to be explored and adapted to contemporary conditions.

In the 20th century, in Soviet Kazakhstan, M. Mukanov noticed the high versatility, comfort, and adaptability of mobile dwellings to various climatic and landscape conditions. He gave examples of using traditional yurts and expressed hope for the popularity of the concept of "yurt camping"

as a promising architectural solution (Mukanov, 1981). Unfortunately, in fact such an idea has not been realized in Kazakhstan. For comparison: in the world it is practiced to design eco-hotels, tourist complexes of light camping with the use of felt with authentic interiors reflecting the cultural traditions of the region (Féline, 2024; Using , 2025).

In modern Kazakhstan, a three-dimensional and composite approach to architecture can take various forms, inspired by the traditional yurt. Theoretically, this approach can include canopies, bus shelters, pavilions, gazebos, and guest houses, among other structures. An innovative approach that combines modern environmentally friendly materials with traditional techniques can help preserve cultural traditions and create energy-efficient, environmentally friendly architecture. An integration of traditional materials into modern architecture can be seen in the development of modernized "yurts", which are mobile, modular, and stable structures that function as monofunctional buildings. This was also noted by interviewed experts.

Modernized "yurts", such as mobile structures that are characterized by high energy efficiency and mobility, can be easily modified to suit various needs (**Fig. 2**). The type of mobile housing proposed by the study can be embodied in farming due to the environmental friendliness, availability, cost-effectiveness of local raw materials and traditional technologies. This will be a favorable factor for sustainable development of rural areas.

At the same time, the heat and sound insulation features will ensure a comfortable temperature is maintained at all times and reduce energy consumption for air conditioning, according to recent research findings (Bosia, et al., 2015; Savio, et al., 2018). Another promising application of felt could be innovative visit-centers on tourist routes. In 2023, more than nine million tourists visited Kazakhstan, in particular those interested in ethno-tourism, cultural and natural heritage (Skripnik, 2024; Tourizm, 2025).

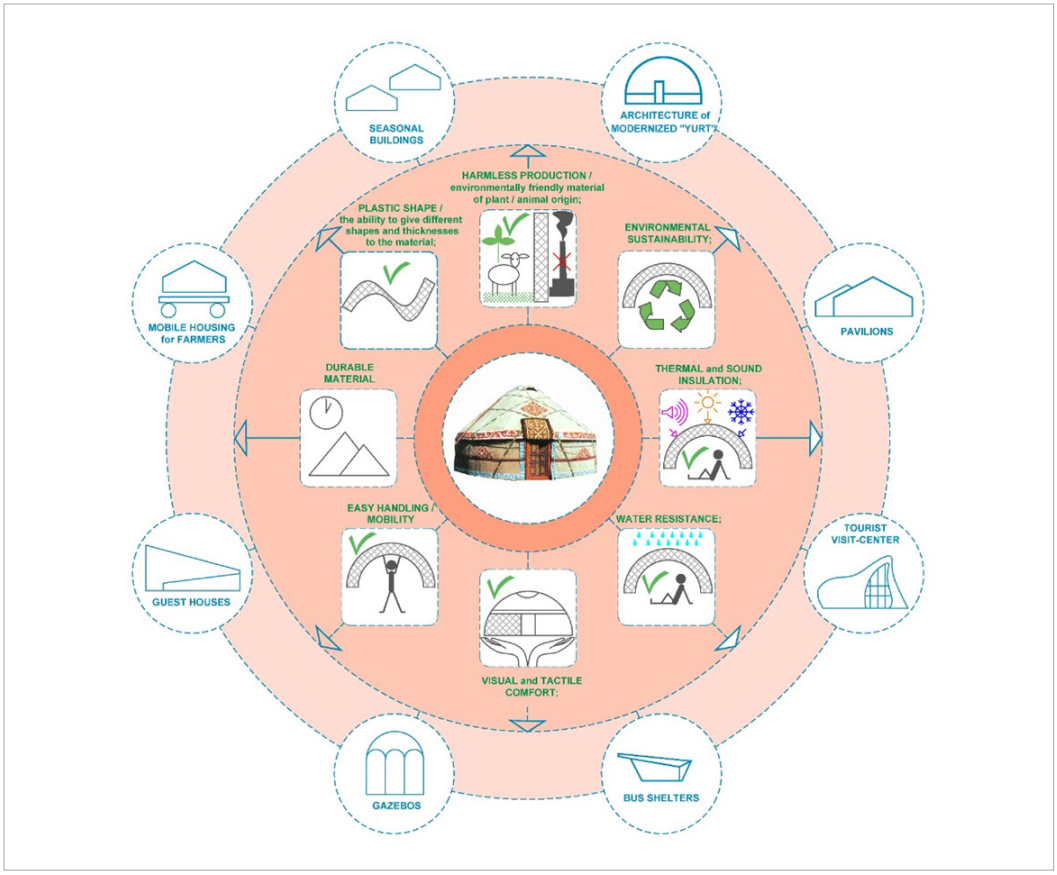

Fig. 2

The potential of felt in eco-friendly architecture. Figure: by B. Murzagaliyev

Potentially, visitor centers, as a type of lightweight structure (with a wooden frame or plant fibers), could become the main market for pilgrimage, cultural, educational, ethnic, agricultural, and eco-tourism in Kazakhstan due to the growing tourism industry. These centers could be created using traditional materials such as felt, which would combine mobility, cost-effectiveness, and adaptability to various conditions. A comfortable, visually expressive and functional environment for visitors can be achieved both by incorporating elements of national architecture and active integration of felt. As a result, the visit-center can become a key element of the tourist infrastructure as an object of cultural and national significance and will emphasize the uniqueness of the region.

Research into the benefits of using wool in sustainable green building projects is most relevant today (Hetimy, et al., 2024). The use of felt in the modern tourism industry of Kazakhstan will provide simultaneous comfortable familiarization with historical, cultural and natural monuments without any harm to the ecology of the region.

Equally effective is the promising use of eco-friendly and tactile felt materials in creating a physiologically comfortable rehabilitation environment. According to a survey of experts, S. Bekeshov noted the possibility of incorporating felt into wall coverings, floors, and furniture arrangements in medical and rehabilitation facilities, correctional centers, preschools, elementary schools, and other institutions.

Modern hospital architecture is focused on creating an environment that is both humanistic and aesthetically pleasing, with the aim of improving the well-being of patients. The incorporation of art and design elements, eco-materials in medical spaces can help to reduce stress levels and maintain the therapeutic effects of treatment (Awtuch & Gebczynska-Janowicz, 2017; Gebczynska-Janowicz & Konarzevska, 2018).

Visual and tactile comfort will be focused on the positive impact of the psycho-physiological characteristics of the environment on the users. Contributing to the creation of a favorable indoor microclimate, at the same time, modern interpretations of felt panels will enhance the historical and cultural context of the space, giving it a bright individuality and a completed sustainable regional image.

Nevertheless, the results of the study revealed a number of major problems related to the integration of felt in the modern architecture of Kazakhstan, among which are: stereotyping - felt is considered only as a decorative element associated with traditional culture, and its use is limited to decorating yurts as part of festive events; lack of awareness - low level of knowledge among architects, designers and builders about the positive possibilities of felt; insufficiently developed methods of felt processing and modification necessary for its integration into architecture.

Solving these problems requires an integrated approach based on scientific research, with the aim of developing a methodological model for the effective integration of felt into modern architecture and construction. This will involve the search for innovative technologies and the popularization of felt as a sustainable building material.

First, it is essential to develop educational programs and media initiatives to overcome the stereotypical perceptions of felt. It is crucial to organize seminars, exhibitions, and lectures, as well as publish articles, studies, and videos demonstrating the practical use of felt in architecture and its environmental advantages. This will help raise awareness of felt, revealing its not only decorative function but the full range of effectiveness of the material.

Also, the professional and scientific base of the architectural and construction industry should be expanded. To this end, training courses on the design and use of felt should be organized. It is also crucial to establish collaboration with educational institutions, by incorporating the topic of felt use into the curricula of architecture and civil engineering departments, as well as by contributing to scientific research in this field.

The next step should be the development of technologies for processing and modifying felt, based on the study of foreign experience. In order to achieve this goal, funding and support should be provided for laboratory research and innovation aimed at improving the moisture resistance and strength of felt, as well as its resistance to external influences. Cooperation with companies involved in the processing and production of felt will also be an important element, as it will help to develop new methods for processing and adapting this material in modern construction projects, in order to overcome its negative qualities.

One way to promote felt as a sustainable material could be to include it in programs and initiatives related to sustainable construction, such as "green" standards and certifications. It is also necessary to carry out demonstration pilot projects using felt in the construction of both residential and public buildings in order to demonstrate its practical capabilities and advantages.

An integrated approach, which includes scientific research, development of a methodological model for solving the problem, technological innovations, and active promotion of felt, will not only help preserve this material as a traditional part of cultural heritage but also establish it as an environmentally friendly construction solution. Overcoming existing barriers and successful integration into the modern architecture of Kazakhstan can contribute to a favorable impact on various spheres of society (Fig. 3):

Cultural and historical significance - revival of the centuries-old use of felt as an element of cultural heritage in modern architecture and design contributes to the strengthening of national identity.

Production benefits - availability of raw material base, historical experience of agriculture and animal husbandry is a powerful potential for its industrial use. The search for modern methods of processing and combining felt with other materials will make it competitive in the architectural and construction industry and design.

Environmental impact - felt as a natural, biodegradable material complies with the principles of ecologically oriented construction avoiding negative impact on the environment.

Socio-economic aspect - development of felt production and its integration into the architectural and construction industry will stimulate agriculture and small business. This leads to the creation of new jobs and the preservation of local craft traditions.

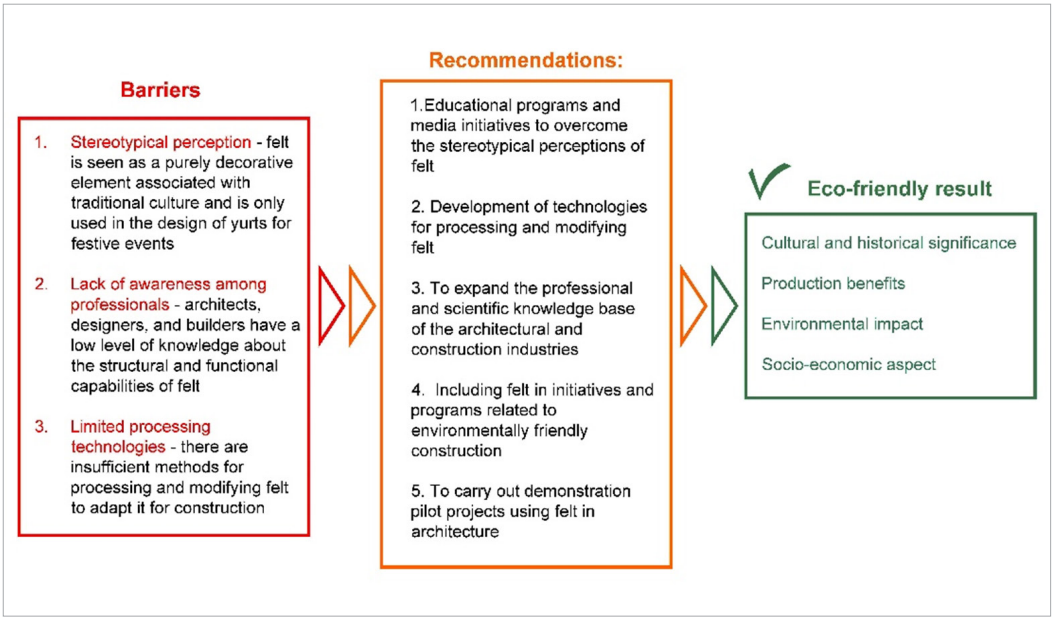

Fig. 3

The integration of felt into architecture. Figure: by E. Danibekova

Conclusions

1. The challenge of integrating felt into architecture within the context of preserving cultural heritage and promoting sustainable development in contemporary Kazakhstan necessitates addressing the following issues:
   - The successful integration of felt into the architectural and construction industries in Kazakhstan requires extensive scientific research, including empirical and quantitative studies, the development of a methodology for its use, and the creation of conditions for the development of new technologies for the processing and application of this material.
   - Integrated approach to breaking down existing barriers, including awareness raising among specialists, innovative technological developments, active promotion of felt as a sustainable material.
   - Joint international projects aimed at preserving and promoting cultural values.
   - Synthesis of arts, providing a unique opportunity to create multi-layered works combining architecture, design, decorative and applied arts, which interact and enhance each other.
2. Felt has enough potential to expand its field of application, for example in the form of a modernized "yurt". The type of lightweight structures can be realized in various version of objects - from sheds and gazebos to visit-centers, campsites and mobile homes for farmers.

Thus, felt is a valuable cultural heritage, its preservation and promotion in the architecture of Kazakhstan in symbiosis with modern environmental standards will open new horizons for sustainable development. This will improve the quality of life and comfort in both residential and public spaces, while also reducing the environmental impact and maintaining economic sustainability.

Despite the economic and production challenges, such as the high cost of producing felt, this material has every chance of becoming a symbol of harmony in architecture. It can represent a balance between the past and the present, tradition and innovation, and nature and technology. Felt can also contribute to sustainable development in various aspects, including environmental, economic, social, and cultural.

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