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Engineering Interpretation of the Traditional Kyrgyz Yurt and Its Adaptation for Sustainable Construction

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Abstract: The study investigates the architectural and structural principles of the traditional Kyrgyz yurt and evaluates their potential adaptation for modern construction. The Kyrgyz yurt represents a unique example of vernacular architecture that has evolved over centuries under the climatic, environmental, and socio-economic conditions of Central Asia. The research focuses on the analysis of the yurt's spatial organization, geometric characteristics, and structural behavior, including the interaction of its principal components: the lattice wall system (kerege), roof poles (uuk), central compression ring (tunduk), and tension belt (kur). The study employs a comparative architectural and engineering approach to assess the load transfer mechanisms, structural stability, climatic adaptability, and energy-efficiency potential of the yurt. Particular attention is given to the role of circular geometry in achieving uniform load distribution, improved aerodynamic performance, and reduced heat losses. The research further examines opportunities for integrating traditional construction principles with contemporary building materials and technologies. The results demonstrate that the structural concept of the Kyrgyz yurt possesses significant potential for application in modern low-rise, modular, and energy-efficient buildings. The proposed adaptation strategies include the use of engineered timber, lightweight structural systems, advanced insulation materials, and modular construction technologies. The findings confirm that traditional architectural knowledge can contribute to the development of sustainable and resilient construction solutions while preserving cultural identity and architectural heritage.

Keywords: Kyrgyz yurt, vernacular architecture, structural systems, sustainable construction, modular buildings, energy efficiency, architectural adaptation.

INTRODUCTION

The construction industry is currently undergoing a significant transformation driven by the need to reduce environmental impacts, improve energy efficiency, and promote sustainable development. Buildings account for a substantial share of global energy consumption and greenhouse gas emissions, prompting researchers and practitioners to seek innovative architectural and structural solutions capable of addressing environmental, economic, and social challenges. As a result, growing attention has been directed toward traditional building systems that evolved through centuries of adaptation to local climatic and geographical conditions and often embody highly efficient engineering principles. Recent studies indicate that vernacular architecture can provide valuable insights for the development of resilient and sustainable buildings adapted to contemporary requirements [1, 2].

In parallel, modular and off-site construction technologies have become one of the fastest-growing sectors of the global construction industry. Contemporary research highlights the advantages of modular systems, including reduced construction time, lower material waste, improved quality control, enhanced energy performance, and greater adaptability to changing functional requirements. The integration of digital technologies, prefabrication methods, and sustainable design principles has further strengthened the role of modular construction in the transition toward climate-neutral built environments [3, 4].

At the same time, architects and engineers increasingly recognize the importance of integrating traditional architectural knowledge into modern design practice. Recent investigations emphasize that vernacular building traditions contain valuable information concerning passive climate control, natural ventilation, material efficiency, and structural adaptability. The combination of traditional architectural intelligence with contemporary engineering technologies is now regarded as a promising direction for sustainable building development [5, 6].

Among the various examples of vernacular architecture in Central Asia, the Kyrgyz yurt occupies a special position. Developed over centuries within the nomadic culture of the Kyrgyz people, the yurt represents a lightweight, transportable, and environmentally responsive structure. Its architectural concept is based on a circular spatial organization combined with a collapsible structural framework consisting of lattice walls (kerege), roof poles (uuk), a central compression ring (tunduk), and a tension belt (kur). Such a configuration provides an effective balance between mobility, structural stability, climatic adaptability, and efficient use of locally available materials.

Despite considerable ethnographic and cultural research devoted to the Kyrgyz yurt, relatively few studies have examined it from the perspective of structural engineering and contemporary architectural adaptation. Existing publications primarily focus on historical, cultural, and anthropological aspects, whereas the engineering mechanisms responsible for structural performance, load redistribution, geometric efficiency, and environmental responsiveness remain insufficiently investigated. Furthermore, limited attention has been given to the potential application of traditional yurt principles in modern low-rise, modular, and energy-efficient buildings.

Recent international studies demonstrate increasing interest in the reinterpretation of vernacular architecture through modern technologies, including engineered timber, modular systems, advanced insulation materials, and digital design methods. Researchers argue that traditional spatial concepts can contribute to the development of innovative building systems capable of combining sustainability, cultural identity, and contemporary performance requirements [7, 8]. Research conducted by Mamatov et al. [9, 10] has highlighted the structural behaviour and damage mechanisms of traditional housing systems in Central Asia under dynamic loading conditions.

In this context, the Kyrgyz yurt may be considered not merely as a historical dwelling but as a rational spatial structural system whose principles remain relevant for twenty-first-century architecture. The circular geometry of the yurt contributes to uniform load distribution and improved aerodynamic performance, while its lightweight framework allows rapid assembly, disassembly, and transportation. These characteristics correspond closely with current trends in modular construction, sustainable tourism infrastructure, temporary housing, and environmentally responsive architecture.

The objective of this study is to investigate the architectural and structural principles of the traditional Kyrgyz yurt and evaluate their potential adaptation for modern construction. Particular attention is devoted to the analysis of geometric relationships, structural behavior, load-transfer mechanisms, and the interaction of principal structural components. The research further explores opportunities for integrating traditional yurt principles with contemporary materials and construction technologies to develop sustainable, modular, and energy-efficient building solutions.

The findings are expected to contribute to the growing body of knowledge on vernacular architecture and provide a scientific basis for the engineering adaptation of traditional construction systems within contemporary architectural practice.

The scientific novelty of this study lies in the engineering interpretation of the traditional Kyrgyz yurt as an efficient spatial structural system and in the development of a conceptual framework for its adaptation to contemporary sustainable construction. Unlike previous studies that primarily focused on ethnographic and cultural aspects, the present research investigates geometric relationships, load-transfer mechanisms, structural behavior, and adaptation potential of the yurt from an engineering perspective.

Scientific Contribution

The scientific contribution of this study consists in:

- developing an engineering interpretation of the traditional Kyrgyz yurt as a spatial structural system;
- identifying structural interaction mechanisms between the kerege, uuk, tunduk, and kur;
- establishing geometric relationships between the number of wall sections and overall structural dimensions;
- proposing a conceptual framework for adapting yurt principles to contemporary sustainable and modular construction.

RESEARCH METHODOLOGY

Research Approach

The research is based on a combination of architectural analysis, structural engineering interpretation, comparative assessment, and sustainability-oriented evaluation.

Research Procedure

The study was conducted in five stages:

- Stage 1 - analysis of the traditional architectural and structural organization of the Kyrgyz yurt;
- Stage 2 - identification of principal load-bearing components and load-transfer mechanisms;

- Stage 3 - investigation of geometric relationships and structural efficiency;
- Stage 4 – evaluation of climatic adaptability and energy-performance characteristics;
- Stage 5 - development of a conceptual adaptation model for contemporary construction.

Data Sources

The study utilizes:

- ethnographic and historical publications;
- architectural and construction literature;
- engineering studies on spatial structures;
- recent international research on modular and sustainable construction;
- the author's previous investigations related to structural behaviour and sustainable building systems.

ARCHITECTURAL FEATURES OF THE KYRGYZ YURT

The Kyrgyz yurt is a circular structure consisting of a collapsible wall system (kerege), roof poles (uuk), a central compression ring (tunduk), and a tension belt (kur). The architectural concept is based on a centralized spatial organization and a dome-shaped roof (figure 1) [11-13].

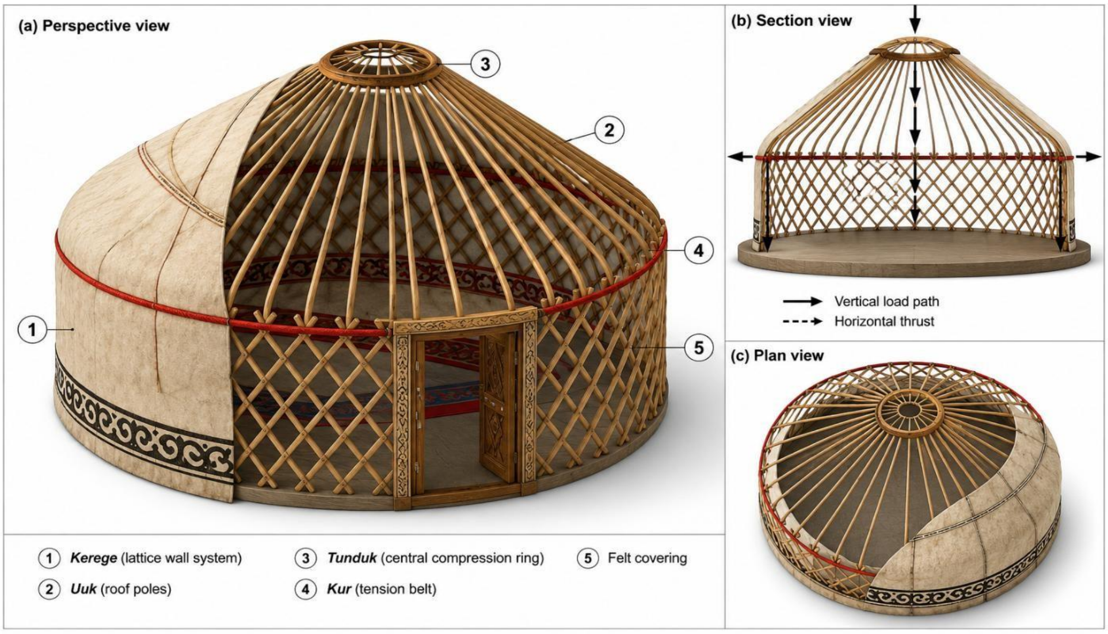

Figure 1: Traditional structural system of the Kyrgyz yurt showing the interaction of the principal structural elements: (a) perspective view; (b) section view; (c) plan view.

The circular geometry offers several advantages:

- efficient use of internal space;
- reduced external envelope area;
- improved aerodynamic behavior under wind loading;
- uniform distribution of structural forces;
- reduced thermal losses.

Traditional yurts typically range from four to twelve wall sections (kanats), allowing flexibility in size and functional capacity.

STRUCTURAL SYSTEM AND ENGINEERING BEHAVIOR

The structural efficiency of the traditional Kyrgyz yurt is achieved through the interaction of several interconnected load-bearing elements that together form a lightweight yet stable spatial system. Unlike conventional rectilinear buildings, the yurt utilizes a circular structural arrangement that promotes uniform load distribution and enhances overall structural integrity. The primary structural components include the lattice wall system (kerege), roof poles (uuk), the central compression ring (tunduk), and the circumferential tension belt (kur), as illustrated in Figure 2 [14].

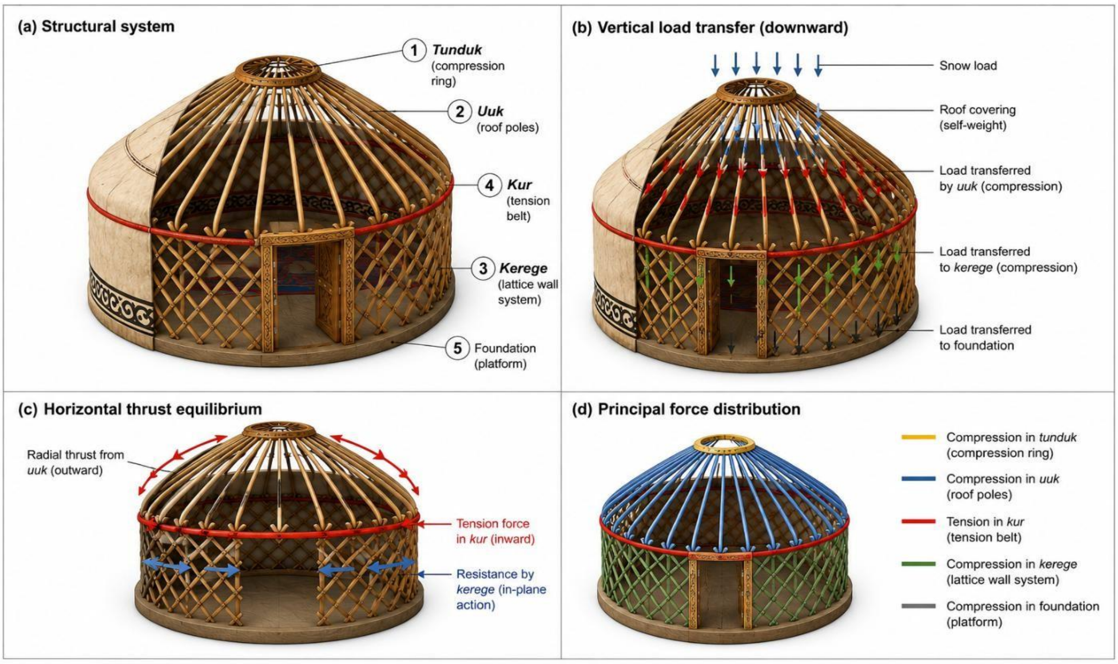

Figure 2: Load transfer mechanism in the Kyrgyz yurt: (a) structural system; (b) vertical load path; (c) equilibrium of horizontal thrust forces through the tension belt (kur); (d) principal force distribution within the structural system.

The structural behavior of the yurt is governed by the principle of spatial interaction between compression and tension members. The inclined roof poles (uuk) transfer vertical loads from the roof covering to the wall system while simultaneously generating horizontal thrust forces. These forces are balanced by the tension belt (kur), which acts as a circumferential restraint and prevents excessive outward deformation of the structure. As a result, the yurt functions as a self-equilibrated structural system capable of maintaining stability without rigid connections or massive supporting elements.

Structural Role of the Kerege

The kerege constitutes the vertical enclosing and load-bearing component of the yurt. It is composed of intersecting wooden slats connected through hinged joints, forming a collapsible lattice framework. This arrangement provides both structural flexibility and geometric adaptability.

From an engineering perspective, the kerege performs several important functions. First, it serves as the primary support for the roof system by receiving loads transmitted through the roof poles. Second, it acts as a circumferential stabilizing element that resists local deformations and contributes to the overall stiffness of the structure. Third, the hinged configuration enables the wall system to be folded during transportation and rapidly deployed during assembly.

The lattice geometry allows loads to be distributed through multiple load paths, reducing stress concentrations and increasing structural redundancy. Such characteristics are consistent with modern concepts of resilient and adaptive structures.

Structural Function of the Uuk

The roof poles (uuk) represent the principal radial members of the roof system. They connect the upper edge of the kerege to the central compression ring (tunduk), forming a dome-like structural configuration.

The uuk primarily operate in compression under gravitational loading. Vertical loads generated by self-weight, snow accumulation, and environmental actions are transmitted along the length of the roof poles toward the wall system. Due to their radial arrangement, the roof poles distribute loads relatively uniformly around the perimeter of the structure.

The inclined geometry of the uuk contributes to the efficient transfer of loads while simultaneously producing horizontal thrust forces. These forces play a significant role in the global equilibrium of the structural system and require appropriate restraint through the tension belt [15].

Engineering Significance of the Tunduk

The tunduk serves as the central compression ring of the yurt and represents one of its most distinctive structural features. All roof poles converge at this element, creating a unified spatial framework.

Structurally, the tunduk performs several important tasks. It ensures geometric stability of the roof system, redistributes forces among the roof poles, and contributes to the overall rigidity of the structure. The compression ring mechanism is conceptually similar to the crown rings used in many contemporary dome structures.

In addition to its structural role, the tunduk functions as an opening for natural lighting and ventilation, thereby improving indoor environmental quality. This multifunctional character demonstrates the integration of structural and environmental design principles within the traditional yurt.

Role of the Kur in Structural Stability

The kur functions as a circumferential tension member positioned around the perimeter of the yurt. Its primary role is to resist the horizontal thrust generated by the inclined roof poles.

Without the tension belt, outward forces would cause deformation of the wall system and potentially compromise structural stability. The kur therefore acts as a tension ring that balances radial forces and maintains the geometric integrity of the structure.

The engineering significance of the kur is particularly evident when analyzing the load transfer mechanism illustrated in Figure 2. The structural concept relies on the equilibrium between compressive forces within the roof system and tensile forces within the circumferential restraint.

This interaction between compression and tension members resembles the behavior of modern cable-supported and ring-stiffened structural systems [16].

Load Transfer Mechanism

The overall load-transfer process within the yurt can be described as a sequence of interconnected structural actions. Vertical loads originating from the roof covering are transferred through the roof poles to the wall system and subsequently to the foundation. Simultaneously, horizontal thrust forces generated by the inclined geometry of the roof are restrained by the tension belt and redistributed around the circumference of the structure.

Figure 2 illustrates this mechanism in a three-dimensional form. The structural system combines radial compression members, circumferential tension elements, and a central compression ring into a unified load-bearing framework. Such an arrangement enables the yurt to achieve remarkable structural efficiency while maintaining a lightweight and transportable configuration.

While Figure 2 illustrates the general mechanism of load transfer, Figure 3 demonstrates the structural interaction between the principal elements of the Kyrgyz yurt. The figure highlights the complementary functions of the compression members (uuk and tunduk), the tension element (kur), and the load-bearing lattice wall system (kerege).

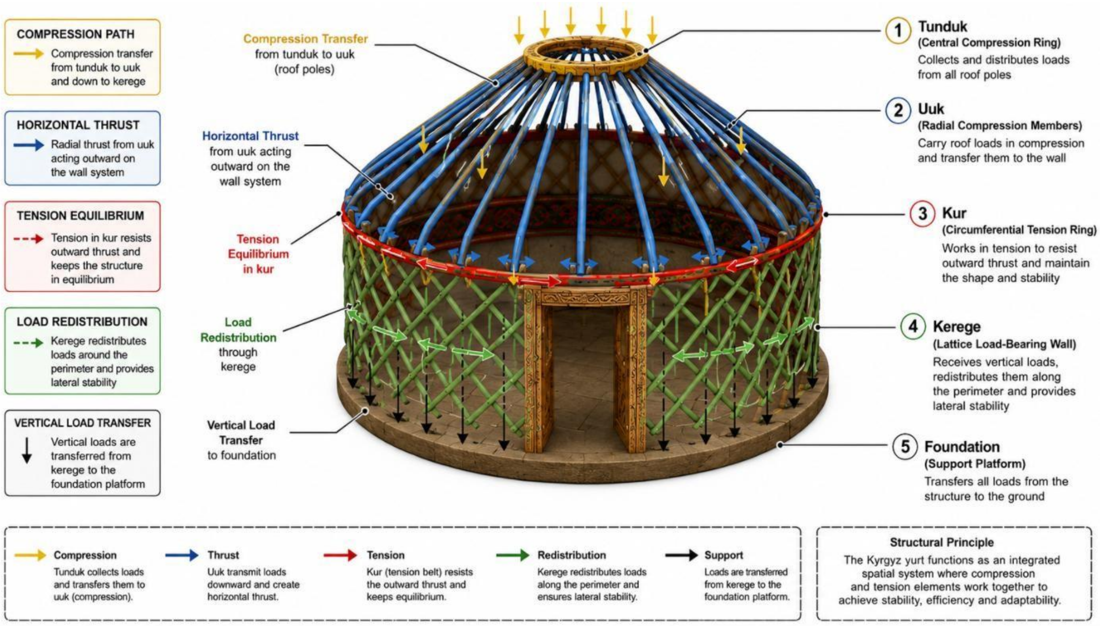

Figure 3: Structural interaction of the main elements of the Kyrgyz yurt showing the transfer of compression and tension forces within the spatial structural system.

The hinged joints of the kerege, shown in Figure 4, further enhance adaptability by allowing controlled movement and redistribution of local stresses. These joints contribute to the overall flexibility of the structure and represent an important factor in its long-term durability.

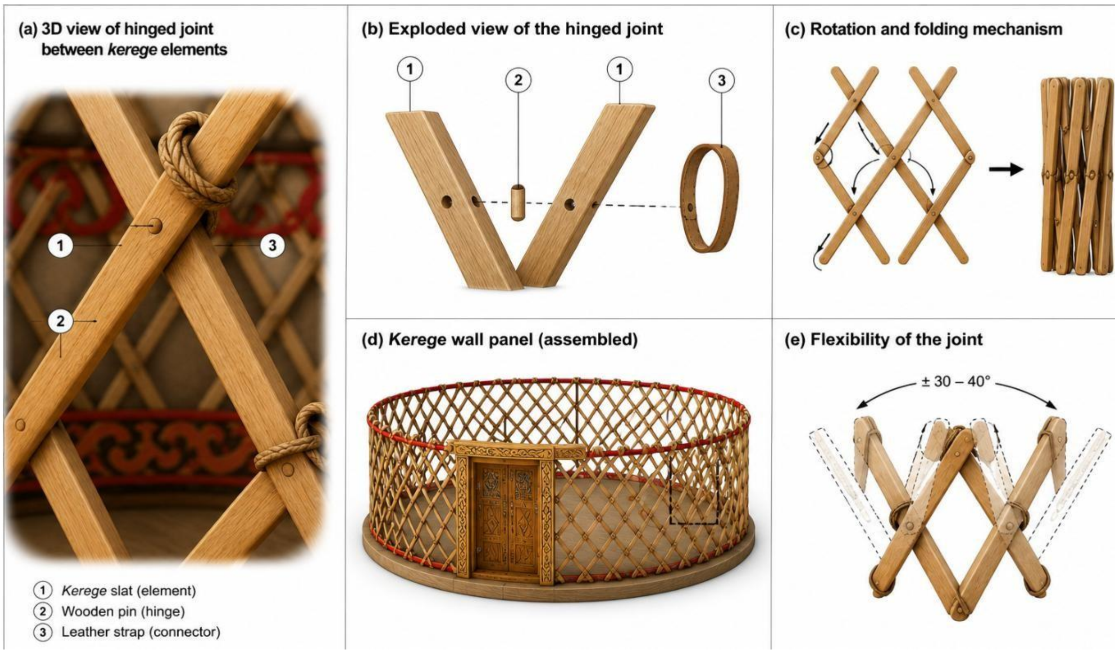

Figure 4: Hinged joint mechanism of the kerege (lattice wall system) in the traditional Kyrgyz yurt. The connection of wooden slats by pins and leather straps enables in-plane flexibility, rotation, and folding of the wall for transportation and rapid assembly.

The engineering analysis demonstrates that the traditional Kyrgyz yurt possesses characteristics commonly associated with modern spatial structures, including structural redundancy, efficient load redistribution, adaptability, and material economy. These properties provide a scientific basis for considering the yurt as a prototype for contemporary sustainable and modular construction systems.

The engineering interpretation of traditional structural systems as spatial load-bearing frameworks has also been supported by recent investigations into earthen and timber-based housing systems in seismic regions [9, 10].

Simplified Engineering Assessment of Roof Load Transfer

To strengthen the engineering interpretation of the yurt structural system, a simplified load-transfer assessment may be introduced. In the traditional Kyrgyz yurt, vertical loads from the roof covering, snow, and self-weight are transferred through inclined roof poles (uuk) to the lattice wall system (kerege). Due to the inclination of the roof poles, each uuk develops both vertical and horizontal force components.

Assuming that the total vertical roof load is (P), the number of roof poles is (n), and the inclination angle of each uuk to the horizontal plane is (), the approximate compressive force in one roof pole may be expressed as:

where: - compressive force in one uuk; - total vertical roof load; n - number of roof poles; - inclination angle of the roof pole.

For example, if the total roof load is assumed as $= 12$, the number of roof poles is ($= 60$), and the inclination angle is $= 35°$, then:

$$\frac{12}{60 * 0.574} = 0.348, \to = 0.35$$

The corresponding horizontal thrust component generated by one roof pole can be estimated as:

$$= os \qquad (2)$$

$$= 0.35 * 0.819 = 0{,}29$$

This simplified calculation demonstrates that the vertical load is distributed among many radial roof elements, reducing the force acting on each individual member. At the same time, the inclined geometry of the uuk generates horizontal thrust, which must be resisted by the tension belt (kur). Therefore, the kur plays a critical role in maintaining the global stability of the yurt by balancing the radial forces and preventing outward deformation of the wall system.

Although this assessment is simplified and does not replace detailed structural modelling, it confirms the rational engineering principle of the traditional yurt: vertical loads are distributed through multiple compression members, while horizontal thrust is balanced by a circumferential tension element.

Engineering Interpretation. The interaction of compression elements (uuk and tunduk) and tension elements (kur) forms a self-equilibrated spatial structural system. Such behaviour is conceptually comparable with modern ring-stiffened shells and lightweight spatial structures used in contemporary engineering practice.

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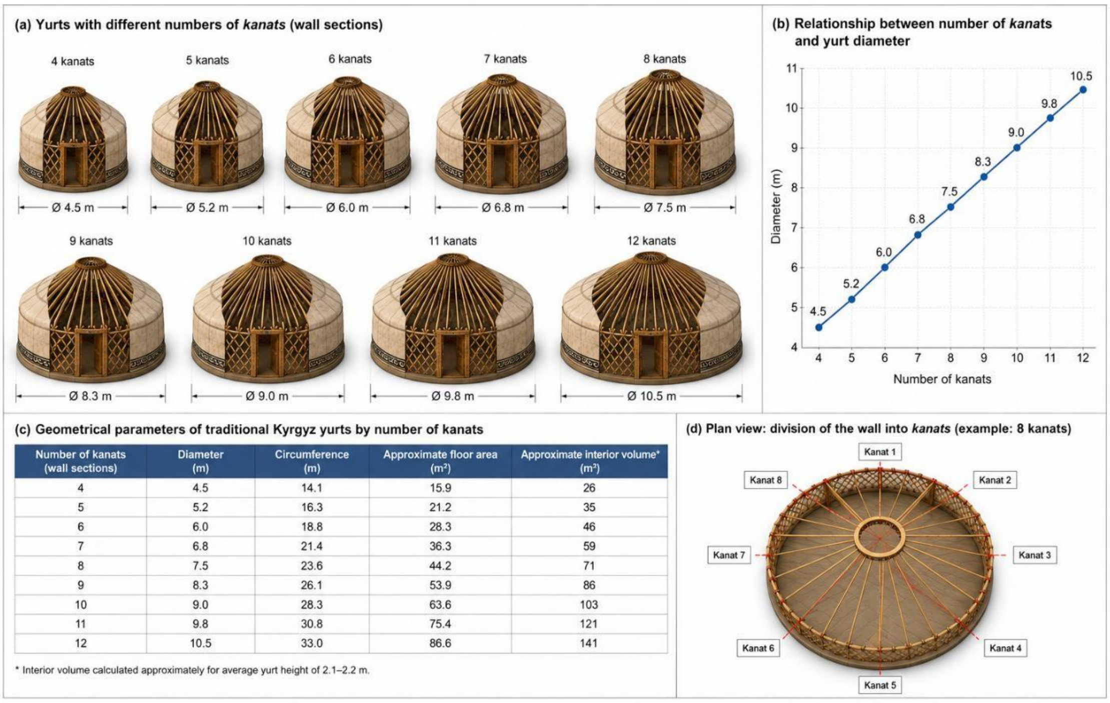
GEOMETRICAL RELATIONSHIPS AND STRUCTURAL EFFICIENCY

The geometric configuration of the Kyrgyz yurt plays a fundamental role in determining its structural behavior, spatial capacity, and functional adaptability. Unlike conventional rectangular buildings, whose dimensions are defined by independent linear parameters, the geometry of the yurt is governed by a modular circular system based on the number of wall sections (kanats). This traditional design principle allows the structure to maintain geometric proportionality while accommodating various spatial requirements as illustrated in Figure 5.



Number of kanats (wall sections)	Diameter (m)	Circumference (m)	Approximate floor area (m^2)	Approximate interior volume* (m^3)
4	4.5	14.1	15.9	26
5	5.2	16.3	21.2	35
6	6.0	18.8	28.3	46
7	6.8	21.4	36.3	59
8	7.5	23.6	44.2	71
9	8.3	26.1	53.9	86
10	9.0	28.3	63.6	103
11	9.8	30.8	75.4	121
12	10.5	33.0	86.6	141

* Interior volume calculated approximately for average yurt height of 2.1–2.2 m.

Figure 5: Geometrical relationship between the number of kanats (wall sections) and the overall diameter. The increase in the number of kanats results in a proportional increase in structural span, floor area, and interior volume.

Figure 5 illustrates the relationship between the number of wall sections (kanats) and the overall diameter of the Kyrgyz yurt. The results indicate an approximately linear increase in diameter with the growth of structural modules. This geometric relationship directly influences the internal volume, spatial organization, and structural behavior of the yurt. Larger yurts require a greater number of roof poles (uuk) and enhanced stability of the lattice wall system (kerege), while preserving the fundamental structural concept of the traditional design.

As illustrated in Figure 5, the overall diameter of the yurt increases with the number of kanats. The modular nature of the wall system enables gradual expansion of the enclosed space without altering the fundamental structural concept. Consequently, the same construction principles can be applied to structures of different sizes while preserving stability and geometric consistency.

Relationship Between Number of Kanats and Yurt Diameter

The number of kanats directly influences the principal geometric characteristics of the structure, including diameter, circumference, floor area, enclosed volume, and roof span. Traditional Kyrgyz yurts generally contain between four and twelve wall sections, resulting in diameters ranging approximately from 4.5 m to 10.5 m.

The relationship shown in Figure 5 demonstrates an approximately linear increase in diameter as the number of wall sections increases. This geometric scalability represents one of the most important advantages of the traditional system. Unlike many conventional buildings, expansion of the yurt does not require a complete redesign of the structural arrangement. Instead, additional wall sections and roof poles can be incorporated while preserving the existing load-transfer mechanism.

The increase in diameter is accompanied by a proportional increase in usable floor area and enclosed volume, allowing the structure to accommodate different functional requirements, ranging from temporary shelters to large communal spaces.

Influence of Circular Geometry on Structural Performance

One of the most significant engineering characteristics of the Kyrgyz yurt is its circular plan configuration. Circular structures exhibit more uniform stress distribution compared with rectangular forms, where stress concentrations frequently occur at corners and discontinuities.

The absence of sharp corners reduces local stress accumulation and improves the overall structural response under environmental loading. Wind loads acting on circular structures are distributed more evenly around the perimeter, resulting in lower aerodynamic resistance and reduced localized pressure zones. From a structural mechanics perspective, the circular geometry also contributes to improved load redistribution. Forces generated within the roof system are transferred continuously around the circumference through the lattice wall and tension belt, creating a highly efficient spatial equilibrium system. These characteristics explain the long-term durability and stability of traditional yurts under a wide range of environmental conditions [17].

Geometric Efficiency and Material Optimization

The geometry of the yurt provides a favorable relationship between enclosed volume and external surface area. Compared with rectangular buildings of equivalent floor area, circular structures generally require less external envelope material, resulting in reduced construction material consumption and improved thermal performance. The compact geometric form minimizes heat loss through the building envelope and contributes to more uniform indoor temperature distribution, which is consistent with recent studies on energy modelling and optimization of building envelopes [18, 19]. This characteristic is particularly important in regions with significant seasonal temperature variations, such as the mountainous areas of Central Asia.

The modular configuration of the kerege further enhances material efficiency. Because structural members are repeated throughout the system, fabrication and assembly processes can be simplified, reducing construction complexity and improving transportability. From a contemporary engineering perspective, such characteristics are closely aligned with the principles of sustainable construction and resource-efficient design.

Spatial Stability and Structural Adaptability

The geometric proportions of the yurt influence not only its size but also its structural stability. As the diameter increases, the number of roof poles and wall elements also increases, allowing loads to be distributed among a greater number of structural members.

This proportional growth contributes to maintaining structural equilibrium even in larger configurations. The radial arrangement of roof poles ensures that vertical loads remain uniformly distributed, while the circumferential tension belt continues to balance horizontal thrust forces generated by the roof geometry.

The geometric adaptability of the system is further enhanced by the foldable nature of the lattice wall structure. The ability to modify dimensions through the addition or removal of wall sections enables flexible adaptation to changing functional requirements without compromising structural performance.

Such adaptability is increasingly valued in contemporary architecture, particularly within modular, transportable, and rapidly deployable building systems.

Engineering Interpretation for Modern Construction

The geometric principles embodied in the traditional Kyrgyz yurt demonstrate remarkable compatibility with modern concepts of modular architecture and sustainable design. The scalability of the structural system, combined with its efficient use of materials and favorable structural behavior, provides a valuable foundation for contemporary engineering applications.

The analysis presented in Figure 4 confirms that the traditional proportional system can be translated into modern design methodologies. By utilizing engineered timber, lightweight steel components, and digital modeling technologies, the geometric logic of the yurt can be adapted to a wide range of architectural functions while preserving its fundamental structural advantages (table 1).

The engineering significance of the yurt therefore extends beyond its historical and cultural value. Its geometric organization represents a rational design strategy capable of informing the development of contemporary low-rise, modular, and energy-efficient structures [20-22].

Table 1: Comparative Characteristics of Traditional and Adapted Yurt Systems

Parameter	Traditional	Adapted
Material	Timber + Felt	Glulam + Insulation
Thermal Performance	Moderate	High
Durability	Medium	High
Assembly Time	Short	Short
Seismic Resistance	Moderate	Improved
Service Life	15–25 years	50+ years
Transportability	Excellent	Excellent
Sustainability	High	Very High
Structural Reliability	Moderate	High

ADAPTATION POTENTIAL FOR MODERN CONSTRUCTION

The growing demand for sustainable, energy-efficient, and rapidly deployable buildings has stimulated renewed interest in traditional structural systems that embody principles of resource efficiency, adaptability, and environmental responsiveness. Among such systems, the Kyrgyz yurt presents a particularly valuable example due to its lightweight construction, modular organization, transportability, and climatic adaptability.

Although originally developed as a nomadic dwelling, the structural and geometric principles of the yurt possess significant potential for application in contemporary architectural and engineering practice. Modern technologies and materials provide opportunities to reinterpret traditional construction concepts while preserving their essential structural logic and cultural identity.

Modernization of Structural Components

The adaptation of yurt principles to contemporary construction requires the modernization of several structural elements while maintaining the integrity of the original spatial concept.

As illustrated in Figure 6, traditional wooden members may be replaced or supplemented by engineered timber products such as glued laminated timber (glulam) and laminated veneer lumber (LVL). These materials provide improved mechanical properties, dimensional stability, durability, and fire resistance compared with traditional untreated timber.

Similarly, modern steel connectors may be incorporated into critical joints between roof poles, wall elements, and compression rings. Such solutions improve structural reliability while preserving the flexibility inherent in the traditional system.

Advanced waterproof membranes and high-performance insulation materials can replace traditional felt coverings, significantly enhancing thermal performance and resistance to environmental exposure.

Consequently, the modernized structural system retains the fundamental geometric and load-transfer principles of the yurt while achieving performance levels consistent with contemporary building standards [23, 24].

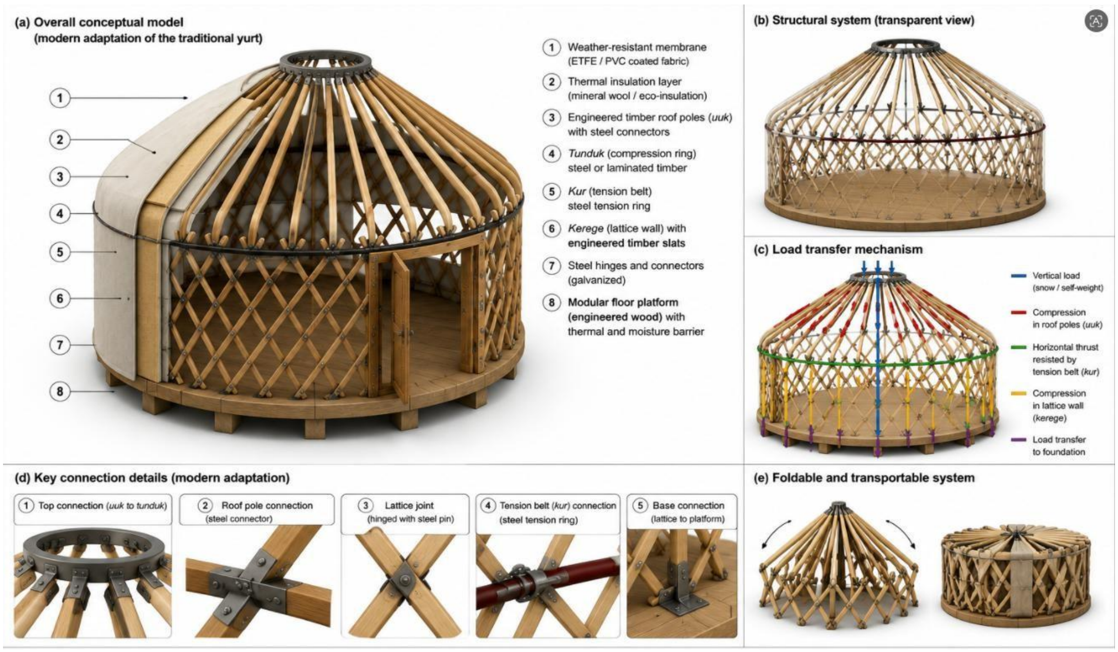


Figure 6: Conceptual adaptation model of the traditional Kyrgyz yurt using modern materials and technologies. The proposed system combines engineered timber, steel connectors, insulation, and weather-resistant membranes, ensuring structural efficiency, thermal performance, durability, and ease of assembly.

Adaptable and Foldable Structural Systems

One of the most remarkable engineering characteristics of the traditional yurt is its transformability. The hinged connections of the kerege wall system, shown in Figure 4, allow the structure to be folded, transported, and rapidly assembled without the need for specialized equipment.

From the perspective of modern construction, such adaptability represents a highly valuable characteristic. Contemporary modular buildings increasingly require transportability, rapid deployment, and flexibility in response to changing functional demands.

The foldable lattice system may therefore serve as a prototype for innovative deployable structures, including temporary shelters, exhibition pavilions, emergency housing units, and mobile service facilities. Furthermore, the integration of modern connection technologies can improve durability and operational reliability while preserving the original concept of geometric transformability [25].

Energy Efficiency and Environmental Performance

The traditional yurt incorporates several passive environmental design strategies that remain relevant in contemporary sustainable construction.

The circular form minimizes the ratio between external envelope area and enclosed volume, thereby reducing heat losses and improving energy efficiency. In addition, the central opening of the tunduk promotes natural ventilation and daylight penetration, contributing to indoor environmental quality.

Modern adaptation may further enhance these characteristics through the incorporation of:

- high-performance insulation systems;
- energy-efficient glazing;
- vapor-control membranes;
- renewable energy technologies;
- passive solar design strategies.

These measures correspond to the principles of modern building thermal physics and enclosure design [26]. As a result, the adapted yurt concept can satisfy contemporary requirements for low-energy and environmentally responsible buildings [27-29] while maintaining its traditional spatial identity.

Applications in Contemporary Architecture

The engineering and architectural characteristics of the yurt create opportunities for a wide range of modern applications, as illustrated in Figure 7.

<u>Figure 7</u>: Modern applications of adapted yurt principles in contemporary architecture and design.

The versatility of the yurt structural system allows its integration into various functions, including tourism, public spaces, housing, education, emergency shelters, and innovative architectural solutions

- **Tourism and Hospitality Facilities.** The growing popularity of eco-tourism and glamping has increased demand for culturally distinctive and environmentally responsive accommodation. Adapted yurt-based structures can provide comfortable tourist facilities while preserving local architectural identity [2].
- **Low-Rise Residential Buildings.** The geometric efficiency and modular nature of the yurt make it suitable for small residential buildings, vacation homes, and rural housing developments. The integration of contemporary materials allows compliance with modern requirements regarding comfort, durability, and safety.
- **Cultural and Educational Facilities.** Adapted yurt concepts may be applied in museums, cultural centers, exhibition spaces, educational facilities, and visitor centers. Such buildings can simultaneously serve functional requirements and promote national cultural heritage.
- **Emergency and Temporary Structures**. The lightweight and rapidly deployable nature of the structural system makes it particularly suitable for disaster-relief shelters, emergency accommodation, field hospitals, and temporary community facilities.

Proposed Conceptual Adaptation Model

Based on the analysis conducted in this study, a conceptual adaptation model is proposed (Figure 5). The model combines traditional spatial organization with contemporary engineering solutions and consists of:

- engineered timber lattice walls;
- modular roof systems;
- modern compression rings;
- steel tension elements;
- thermal insulation layers;
- weather-resistant envelope systems;
- modular floor platforms.

The proposed system preserves the fundamental structural principles of the traditional Kyrgyz yurt while significantly improving structural performance, thermal efficiency, durability, and functional versatility.

Such an approach demonstrates how traditional architectural knowledge can be transformed into an innovative construction strategy capable of addressing modern architectural and engineering challenges.

Future Perspectives

The adaptation of Kyrgyz yurt principles to contemporary construction offers promising opportunities for future research and practical implementation. Further studies may focus on:

- numerical structural modeling;
- finite element analysis;
- seismic performance assessment;
- wind resistance evaluation;
- optimization of modular systems;
- development of design guidelines for yurt-inspired buildings.

The integration of traditional construction wisdom with modern engineering technologies may contribute to the creation of sustainable, resilient, and culturally meaningful architectural solutions for the twenty-first century. The sustainability assessment of future yurt-inspired modular buildings may also be performed using integrated evaluation frameworks proposed in recent studies [30].

Special attention should be devoted to the seismic performance of yurt-inspired structures. The circular geometry, lightweight structural components, and flexible connections suggest favorable behavior under dynamic loading. Future studies should therefore include numerical simulations and experimental investigations aimed at evaluating the seismic resilience of adapted yurt-based construction systems.

Previous studies performed by Mamatov and co-authors [9, 10, 31] demonstrated the significance of structural integrity, damage accumulation processes, and seismic resilience in traditional building systems. These findings may serve as a foundation for future investigations of yurt-inspired structures subjected to dynamic loading.

LIMITATIONS OF THE STUDY

The present research is primarily conceptual and analytical in nature. Although the study identifies structural mechanisms and adaptation opportunities, it does not include finite element modelling, full-scale experimental testing, or quantitative structural verification.

Future investigations should therefore focus on:

- numerical simulations;
- finite element analysis;
- seismic performance assessment;
- wind resistance evaluation;
- experimental validation of proposed adaptation concepts.

CONCLUSIONS

This study investigated the architectural and structural principles of the traditional Kyrgyz yurt and assessed their potential adaptation for contemporary sustainable construction. The research demonstrated that the yurt represents not only an important element of cultural heritage but also a rational spatial structural system characterized by efficient load distribution, geometric adaptability, and environmental responsiveness.

The analysis showed that the structural stability of the yurt is achieved through the interaction of four principal elements: the lattice wall system (*kerege*), roof poles (*uuk*), central compression ring (*tunduk*), and circumferential tension belt (*kur*). The coordinated action of these components forms a lightweight self-equilibrated structural system in which compressive and tensile forces are efficiently balanced. The simplified engineering assessment confirmed the rational load-transfer mechanism inherent in the traditional design and demonstrated its compatibility with fundamental principles of modern spatial structures.

Particular attention was devoted to the influence of circular geometry on structural performance. The study confirmed that the modular organization of the yurt allows geometric scalability while preserving the original load-transfer concept. The circular configuration contributes to uniform force distribution, improved aerodynamic behaviour, material efficiency, and reduced heat losses, which correspond to contemporary requirements for sustainable and energy-efficient buildings.

Based on the conducted analysis, a conceptual adaptation model was developed that combines traditional architectural principles with modern engineering solutions, including engineered timber, steel connectors, advanced insulation systems, and modular construction technologies. The proposed approach demonstrates that yurt-inspired structures may be successfully applied in low-rise residential buildings, tourism facilities, educational and cultural centres, modular pavilions, and emergency shelters.

The scientific contribution of the research lies in the engineering interpretation of the traditional Kyrgyz yurt as an efficient spatial structural system and in the development of a conceptual framework for its adaptation to contemporary construction. The practical significance of the study is associated with the possibility of integrating traditional architectural knowledge into modern sustainable design while preserving cultural identity and architectural heritage.

Future research should focus on numerical modelling, finite element analysis, experimental validation, and seismic performance assessment of yurt-inspired structures. Such investigations will contribute to the development of engineering guidelines for the practical implementation of adaptive, resilient, and sustainable construction systems based on traditional architectural principles. Previous studies on structural damageability and seismic resilience of traditional building systems in Central Asia provide a promising foundation for further development of this research direction [29-31].

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