

Analysis of Technology System Applied to the Mongolian Traditional House for Energy Savings and Increased Comfort

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Abstract: The Mongolian traditional house, called “Ger” is a typical accommodation of Mongolian nomads and has reflected representative artistic and regional styles of the country. It is also made from natural resources and is a comfortable dwelling in which to live. It has a architectural design that includes a half sphere structural form and a round floor. The Ger has several characteristics including good illumination, heating and air circulation, it can be easily disassembled, transported and assembled and also features few other structural components to protect against the wind and earthquakes. This study is aimed at building a database for relevant studies by analyzing the heating and air circulation systems of Ger and further proposing the technology that can apply to residential buildings by a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis.

Key words: Traditional house, Ger, nomadic, heating, air circulation, analysis

INTRODUCTION

Ger is a round, portable tent-like structure where Mongolian nomads in the plains of Central Asia dwell. Ger has been constantly improved and developed to better adapt to Mongolia’s geographical features, changes in customs and experiences of its nomads. The Ger has a remarkable three-thousand history together with the nomads. Similar structures have been found in other countries as well. The Ger is the traditional home of the nomadic Turkmen, the Kyrgyz, the Kazakhs, the Uzbeks, the Kalmyks, the Buryats and the Mongolians. As the impact of the western modern world in terms of technological and behavioral changes has been somewhat less felt here compared to other regions, the use of the Ger is still widespread in the Mongolian steppes where nomads have maintained their traditional lifestyle for at least the past 800 years (Mauvieux *et al.*, 2014; Lubsangjab, 1974; Evans and Humphrey, 2002; Allsen, 2001).

The Italian explorer Marco Polo described the Ger used by Mongols in his time with them from 1274-1291. According to, historical records, the great Genghis Khan commanded his entire empire which stretched throughout

whole Central Asia from a large Ger. Thus, as the great Mongolian empire eventually reached Eastern Europe, the Mongols continued to bring their Ger with them at all times.

The traditional dwelling meets the criteria for a sustainable house as it reflects the demands of the present age. This is because it features natural cooling and air circulation, the maximum-volume structure enclosed by the minimum area and the use of harmless and indigenous materials for construction (King, 2001; Mrkonjic, 2006).

As previously mentioned, this study is intended to establish a database related to the architectural design of residential buildings by analyzing features of the typical dwelling patterns of Mongolia. The focus of the study will be on the Ger, specifically, its heating and air circulation systems. A SWOT analysis will be used for further evaluation.

Concept of Mongolian traditional house: According to precedent studies, some researchers have stated that Ger originated and evolved from a wig. However, it has actually developed in such a way that is suitable for Mongolian nomads to move three or four times a year as

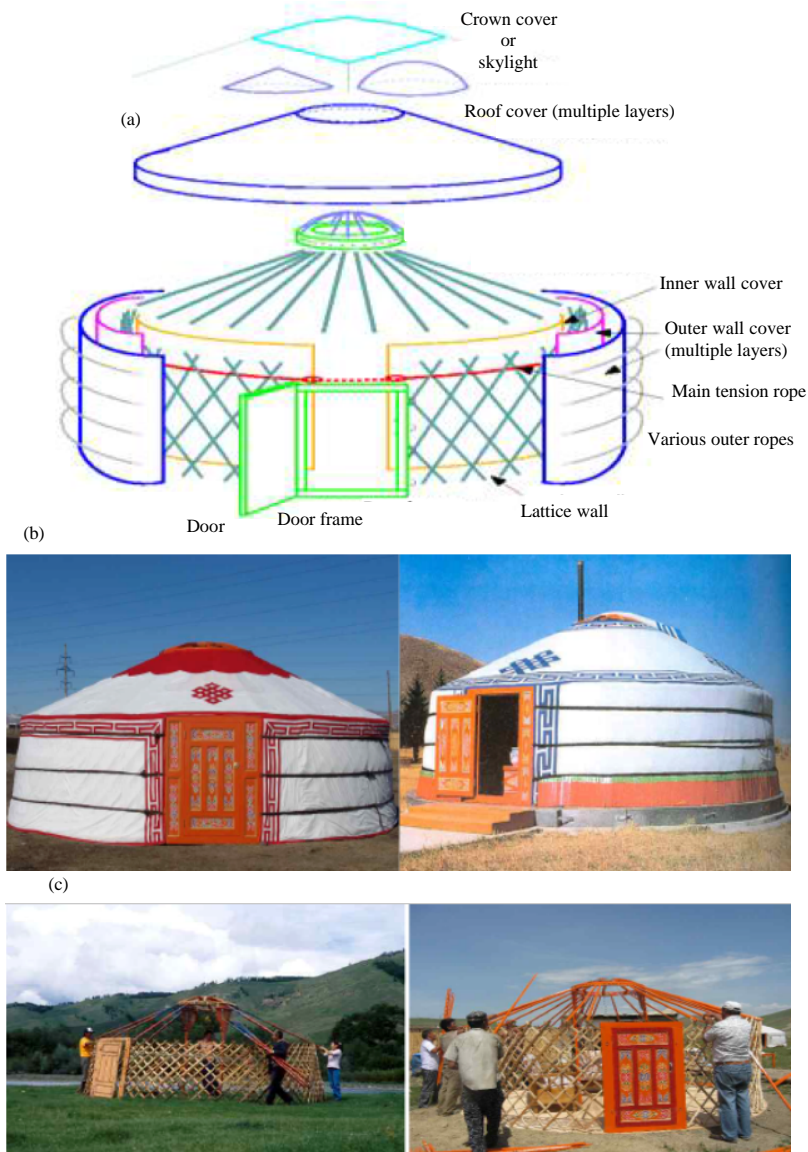


Fig. 1: Configuration and image of Ger: a) Structure of Ger; b) Image of Ger and c) Production process of Ger

they search for good grazing land. In this sense, Ger is designed to be easily disassembled, transportable and reassembled. Indeed, it can be completely dismantled in only 1 h and then loaded onto animals such as camels. Ger is characterized by a round form defined by the wooden frame (Anonymous, 2013; Saizmaa *et al.*, 2017). The felt coverings are the coats of the yurt. A set of straps could connect the frame sections and fasten the coverings onto the wooden supporting frame.

The wooden frame contains the following: Crown or Roof ring (toono), rafters or Roof poles (uni), 20-120 pieces depending on the number of the wall segments of the Ger, lattice walls (khana), 3-15 pieces depending on

the size of the Ger, pillars (bagana), 0-4 pieces depending on the size of the Ger and a door (haalga) (Fig. 1). The crown situated on the top of a Ger is similar to a window and it is designed well to manage airflow. It allows for the stars in the night sky to be viewed through the opening in the roof. Soft coverings consists of inside cotton canvas, sheep-wool felt for the roof, sheep wool felt for the walls, waterproof canvas, outside cotton canvas and crown sleeve (Saizmaa *et al.*, 2017; Zhang and Yu-Tong, 2017).

The roof of the Ger incorporates a unique architectural design. Roof poles or rafters meet in a crown where gravity produces toward the inside and the outside

	Helpful	Harmful
Internal	<p>S</p> <p>Strengths</p> <p>Low salary and benefits overhead</p> <p>Quick to respond to market changes</p> <p>Lightweight and flat hierarchy resulting quicker decision-making</p>	<p>W</p> <p>Weakness</p> <p>Existing workload too high</p> <p>No previous project planning experiences</p> <p>Missing expertise in some area</p>
External	<p>O</p> <p>Existing workload too high</p> <p>No previous project planning experiences</p> <p>Missing expertise in some area</p>	<p>T</p> <p>Threats</p> <p>Business partners has little loyalty</p> <p>Larger competitors get majority of market share and more famous brand name</p> <p>Cost of technology investment</p>

Fig. 2: SWOT analysis

pressure. The center ring holds the rafters in a state of compression. Because of this combination of the central compression ring at the top of the roof and the encircling tension band where the roof meets the wall, long roof spans are possible without any internal support system. The roof design of Ger is uniquely equipped to withstand natural disasters and heavy snow loads.

Concept and analytical methodology of SWOT: SWOT stands for “Strengths, Weaknesses, Opportunities and Threats”. This planning method was invented by Albert Humphrey who was a business consultant in the US. The method analyzes the internal and external environments that influence a company by identifying factors of strength, weakness, opportunity and threat and establishing the appropriate business strategy accordingly. Expanding its scope of application beyond all boundaries, SWOT is currently being utilized to analyze different areas of society, economy, culture and technology. Specifically, SWOT is a tool for defining and analyzing Strengths, Weaknesses, Opportunities and Threats (Fig. 2). It offers individuals and businesses the following advantages: discovery of the areas that have comparative advantages over competing companies, identification of characteristics that keep one business at a disadvantage to others, understanding of advantageous opportunity factors created by external factors and the awareness of external threat factors that may cause problems to one’s business (Anonymous, 2013a, b).

This study identifies the advantages and disadvantages of Ger the traditional Mongolian house with SWOT analysis. When identifying internal factors

(i.e., strengths and weaknesses) and external factors (i.e., opportunities and threats), the natural heating and self air circulation systems were highlighted.

MATERIALS AND METHODS

Heating and air circulation systems of Mongolian traditional house

Heating system: The heat loss generated by the building envelope is directly connected to the shape of the building. Ger, the traditional Mongolian house, costs less than standard houses in terms of air conditioning and heating due to its circular structure which has a smaller surface area in comparison to the size of the interior space of commonplace square buildings. The temperature in Mongolia ranges from -35 to $+40^{\circ}\text{C}$. The Ger is warm in the Winter, thanks to its wall design, insulation and coverings. Double covered woolen felt can retain heat during Winter. In Winter time the additional covers are used in order to preserve thermal comfort. Protection against the rain can also be accomplished during the rainy season.

The steel or cast iron stove installed inside Ger functions as heating or cooking elements as shown in Fig. 3 and is used to raise the temperature of the air inside the dwelling by burning wood or coal. This central-burning stove, along with the structure’s circular configuration, enhances the heating effect by supplying heat inside and generating a warm layer of air simultaneously. The nomadic dwelling house Ger is heated with natural fuel, derived from livestock which is considered to be an inexhaustible resource. Thus, it provides adequate heating capacity but is less harmful to the environment. Nowadays, exhausted natural resource that wood and coal are used for fuel.

In recent years, air pollution in Ulaanbaatar has become a major issue affecting all citizen of Mongolia. Population growth due to migration to urban areas is increasing air pollution in the capital city. As more people arrive in the city in their Gers, the number of stoves increases as well, each generating enough heat to keep the Gers warm through Winter (Amarsaikhan *et al.*, 2014; Guttikunda *et al.*, 2013; Guttikunda, 2007).

Air circulation: The crown of Ger is placed on the top as shown in (Fig. 4 and 5). This placement allows fresh air to naturally enter the interior space as the cold air flows downwards and the hot air flows upwards. In addition, the crown is located in the middle of the roof, ensuring that the air entering through the roof circulates fresh air all throughout the interior space. This feature contributes to the overall enhancement of the house air quality. As



Fig. 3: The central wood-burning stove

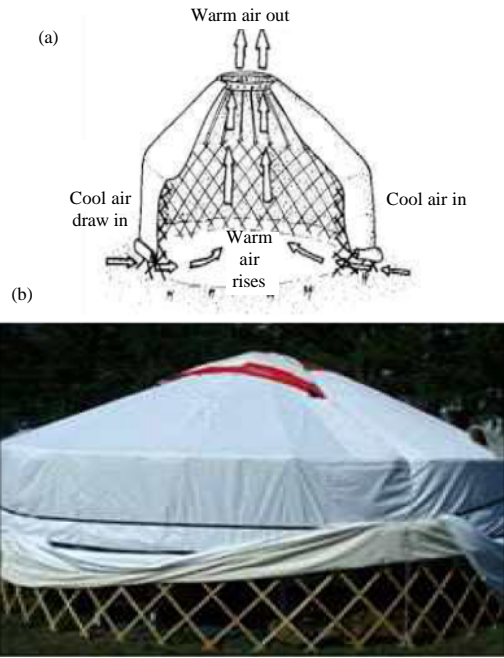


Fig. 5: Ger in summer

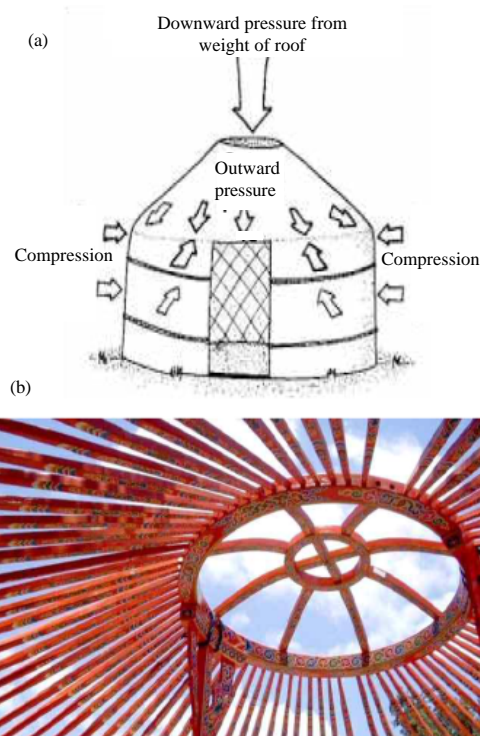


Fig. 4: Air circulation of Ger

fresh, outside air also enters the structure whenever the door is opened, the air circulation increase by virtue of the Ger's round form which is opened 360°.

As the rising indoor temperature causes the lower part of Ger to furl, this stimulates air circulation and lowers indoor temperature. The unique structure and characteristics increases the flow of air into the interior space and then enhances the air-circulating effect, providing a pleasant environment for dwellers (Mrkonjic, 2006).

RESULTS AND DISCUSSION

Figure 6 illustrates the advantages and disadvantages of the Ger with SWOT analysis. From this matrix one can see the Ger's internal unique strengths, weaknesses, opportunities and hazards.

Strengths: Mongolian nomads have to move around the country throughout the year. This is why Ger is designed to be easily disassembled, transported and reassembled. It is capable of being assembled or disassembled in one hour and can be loaded onto camels with ease. With its unique design, structure and practical features, the Ger is still a popular form of dwelling. The Mongolian Ger has attracted interest from people in many parts of the world as an ecologically friendly and attractive living space that can be used for a variety purposes. In Mongolia, Ger-tourism is already a popular attraction among foreign tourists. Also, in the UK, the US and Canada, there are hotels that offer very comfortable Ger type rooms.

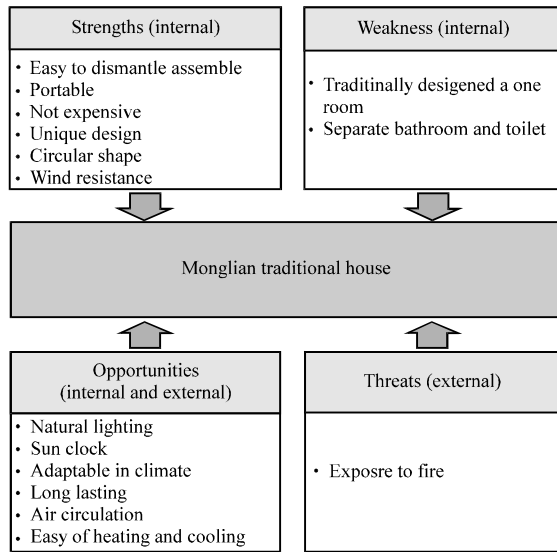


Fig. 6: SWOT analyze of Ger



Fig. 7: Ger withstands any disaster

This circular-structured house provides a large space for dwellers compared to that of rectangular-structured spaces. The surrounding space is also the most efficient type of space to heat (Kemery, 2006). Wind naturally moves round a Ger, instead of becoming trapped in corners. Because of its roof structures, the Ger is unusually strong and is able to withstand earthquakes, high winds and heave snow loads (Fig. 7).

Weakness: Since, it is used as a single space, the toilet and bathroom must be separated. Nowadays, there are also solutions to integrate 2, 3 or more Gers to effectively build a modern version of multi-room Gers and they also includes bathrooms and toilets (Fig. 8). There is even granted industrial designs (similar to a patent) on modern Ger design.



Fig. 8: Multi-room Ger



Fig. 9: Ger in the urban and rural area

Opportunities: The crown located on the top of Ger ensures air exchange and incoming solar radiation which warms the interior space. It is shaped like a window but is designed to control the indoor air flow.

The Mongolian Ger's door faces South and combines spatial and functional properties. The door is installed facing South and situated in such a way that on a sunny day, the sunlight reflects around the interior wall which helps maintain natural lighting. Furthermore, the natural light entering through the crown lightens the interior and also conveys to dwellers the lapse of time (Mauvieux *et al.*, 2014). The Ger is adaptable to every season. A single layered woolen felt (cover) is used in Summer to keep the inside of the Ger cool and double covers can retain heat in a Ger during Winter. Also, protection from rain can be achieved during the rainy season. The nomadic dwelling house that is referred to as Ger is heated with natural fuel, derived from livestock which is considered an inexhaustible resource. Thus, it has adequate heating capacity but is less harmful to the environment. Nowadays, finite natural resources such as wood and coal are being used for fuel. This has led to air pollution when traditional stoves are used in heavily populated areas. Right now in Ulaanbaatar, this has resulted in a serious air pollution problem (Fig. 9).

Hazards: All components of Ger include organic materials such as the bridging made of willow trees and inflammable materials such as the ropes made of animal hairs for the connector. Consequently, this house always has a risk of fire. To address this problem, it is necessary to use fire-proof materials designed to prevent the house from fire damage (Amarsaikhan *et al.*, 2014). High-quality floor-protecting equipment is also strongly advised.

CONCLUSION

The aim of this study is to introduce the features of the Ger the traditional dwelling structure of the Mongolian nomad, furthermore, the SWOT analytical tool was employed to assess the natural heating system and self air circulation system in the Ger. Several conclusions were arrived at on the basis of this analysis.

First, Ger has several advantages. These include ease of disassembly and assembly, convenient transportation, unique design, inexpensive cost and protection against wind and earthquakes. However, it has weaknesses in that it features a one room traditional design whereby the toilet and bathroom are separated from the main structure. Recently, the Ger structure has required modifications to better integrate with other multi-rooms such as a toilet to enhance its overall efficiency. Solutions must be proposed to address how other units can be incorporated into the house.

Second, the Ger possesses several positive features with respect to its natural lightening, sun clock, adaptability to climate, heating system and self air circulation. When the Ger is used in the countryside, it has retained those positive characteristics associated with a nomadic lifestyle whereas in highly populated urban areas, it is increasingly losing such characteristics. The original heating system of the Ger which could be categorized as an opportunity or advantage, may now be becoming a threat or hazard because of the air pollution it is creating in urban areas.

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