

# Field study seeking for affordable measures to improve living environment of urban gers located in Ulaanbaatar, Mongolia

プレブ, ウエルン, ウジン

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氏 名 : Uelun-Ujin Purev

Name

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(モンゴル ウランバートルに立地する都市定住ゲルの居住環境改善方策究明を目指したフィールド研究)

Title

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Category

## 論 文 内 容 の 要 旨

### Thesis Summary

Ulaanbaatar, capital city of Mongolia has suffered worst indoor and outdoor air pollution due to coal stoves for space heating. In Ulaanbaatar, 58% of the total households live at either self-build detached houses named *baishins* or *gers* in *ger* districts, where space heating is based on coal stoves. These two types of primitive housing located in *ger* districts lack urban infrastructure, such as water supply, sewage, and district heating. The *ger* is traditional Mongolian dwelling used for nomadic people. It has a circular shape made of wooden frame and felt sheet cover. 80% of air pollution in Ulaanbaatar is due to coal stoves used in *ger* districts. Therefore, it is a pressing issue to replace coal stove into clean electric heating system. However, Mongolia imported 18% of electricity from Russia, and current power plants cannot provide electricity supply to heat all *ger* district households. Hence the shift from current coal stoves into electric heating system requires the additional policy implementation to reduce thermal load of *gers* and *baishins*. With support of international organizations, Mongolian government partially support to insulation retrofitting for *baishins*. On the other hand, modern building insulation system cannot be directly apply for *gers* due to portable design. Furthermore, majority of the households live in *gers* are categorized as low income. With this background, this study intended to propose affordable measures to reduce thermal load and to promote the replacement of coal stoves with heating devices with low emissions in urban *gers* based on a series of field observation, field survey, and development of the insulation system.

Chapter 1 discusses background of the research and issues of rapid urbanization and solid fuel usage in Ulaanbaatar, Mongolia. Subsequently, the objectives of the research and thesis structure are described.

Chapter 2 presents the results of a field survey of 49 urban gers and 67 residents of gers located in *ger* districts of Ulaanbaatar, Mongolia. In this survey, the size of the gers, method of space heating, occupant's energy usage behavior, occupant's perception toward winter indoor environment, satisfaction

of the living condition and occupants' interest to improve current living condition were investigated. The results of the survey clearly shows the affordability of gers for low-income households owing to its price. Furthermore, the well standardized design and usage of local materials are suggested for realizing the affordable price. Although a ger is low cost, the high satisfaction of the respondents indicated that a ger can provide relatively comfortable environment for the rural migrants. On the other hand, such low-cost dwellings might create difficulties for people to motivate the investment to improve the thermal performance of their ger or to replace a coal stove with clean energy heating devices. The result of the interview also suggested the limited knowledge of residents about the thermal performance of felt sheets of ger envelope, even though the government recommends replacing the felt sheets every five years. Since the price of the annual coal consumption is much cheaper than electricity bill necessary for electric heating, the necessity of the measures to improve thermal performance of the ger envelope is identified. Chapter 3 presents a new retrofitting method of the ger envelopes to improve thermal insulation performance based on the results of Chapter 2. The purposed method consisted of insulation panels for wall and roof covered by fabric, and these panels are attached to the wooden structure from the inner side. The wall and roof panels are prefabricated and can be installed by residents by using Velcro and ropes. The prefabricated windbreak room was also proposed. The entire system was demonstrated at a ger located in Ulaanbaatar in winter.

Chapter 4 reports the results of field measurement of indoor thermal conditions of gers with and without insulation retrofitting in winter. The measurement period consists of three stages; first ten days gers are measured under the baseline conditions to identify the features of spatial and temporal temperature variations of gers heated by a primitive coal stove. In the second stage of ten days, one ger was insulated with proposed insulation prototype and coal stove is replaced by electric heating device. In the following ten days, a windbreak room developed in Chapter 2 was attached in both gers. The measurement of baseline condition showed diverse daily temperature fluctuation owing to unstable heating power of coal stoves. In addition, the large vertical temperature difference of indoor air temperature was confirmed under the coal stove heating compared to electric heating condition. The operative temperature of the baseline condition was estimated, suggesting that 74% and 85% of hours were above lower limit of ASHRAE comfort range in both the two gers. On the other hand, overheating occasionally occurred which causes occupants deliberately opened a door to introduce cold air from the outside. After the retrofitting, occupants' thermal perception toward insulation retrofitting was generally positive. However, average indoor air temperature was around 15°C due to the limited electric heating power. Throughout the measurement, floor temperature was generally low which suggested the necessity to improve the floor insulation by retrofitting.

Chapter 5 summarizes the conclusions obtained from this study and outlines future work.