Temporary Housing Residents' Satisfaction Analysis: A Case Study in Southern Taiwan

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Abstract

As the world faces increasing threat of natural disasters, temporary housing has become an important transitional space to assist disaster refugees in rebuilding their lives. This study explores on how to measure the performance of temporary housing. After the 2009 Typhoon Morakot disaster in Taiwan, a non-profit organization in southern Taiwan constructed two types of single-story temporary houses. The participants were people who resided in these houses. This research first employed a social science study of questionnaire survey and participant observations on their life satisfaction. Engineering measurements to evaluate and compare these two environmental deficiency identified by the survey follows. The results showed that although most residents were satisfied with the overall environment, poor sound and heat insulation were common problems in temporary houses. In one type of the houses, indoor temperature may be higher than the outdoor temperature in summer. Both types of houses only have acoustic impedance between 15 to 30 dB for neighbouring unit partition walls, way below the standard for new buildings of 55 dB. It is considered that fast-build temporary houses that are improperly designed and constructed may not provide a suitable living environment for refugees to begin the recovery process inside.

Keywords: **living satisfaction, temporary housing, heat insulation, sound insulation**

1. INTRODUCTION

During the 2009 Typhoon Morakot disaster in Taiwan, consecutive rainfall over three days exceeded 2500 mm, the highest rainfall level recorded on the island. The compound disasters of flooding and landslides caused serious damage to the buildings in the mountains. Subsequently, numerous aboriginal tribes were resettled in temporary housing on the plain near the disaster-stricken mountain areas for a couple of years in preparation for permanent housing settlement. However, the temporary houses provided varied and the residents' living backgrounds were also different. This led to numerous problems in the temporary housing

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camp, which had not been considered beforehand, such as excessive building usage and living problems.

Although the public and private sectors were experienced with temporary housing because of the 1999 Chi-Chi earthquake disaster in Taiwan, the government had not established appropriate principles or guidelines for future applications. The government had been criticized previously for a lack of alertness and preparedness to respond to large-scale flooding. Therefore, after the Morakot flood, the central and local government debated whether to provide temporary housing and what form of temporary housing to construct (The Control Yuan of The Republic of China, 2000). Thus, when the decision to build a number of temporary houses was finally made, there was little time to develop a quality design.

A non-profit organization (NPO) in southern Taiwan assisted in constructing two types of single-story temporary houses namely remodelled military barracks with wooden roof trusses and prefabricated light-gauge steel houses. This study examines the residents' satisfaction of the living environment in them. We first conducted a questionnaire survey to explore the residents' level of satisfaction. After analyzing the survey results, we further quantified the negative factors that caused the refugees discomfort in the temporary houses using physical environment measurements.

2. RESEARCH SUBJECT AND METHODOLOGY

2.1 Subject

This study selected the Chung-Cheng Resettlement Center (CCRC) constructed by an NPO in Pingtung of southern Taiwan as the study site. This was because the CCRC provides 91 remodeled military barracks and 20 steel houses as temporary housing for aboriginal tribal families (Figs. 1). Every house is approximately 50 square meter and equipped with a living room, a kitchen, a bathroom, and three bedrooms. The remodeled military barracks, featuring wooden trusses and brick walls, were of a similar size and layout to the newly built light-gauge steel houses, enabling us to conduct a comparative study of the advantages and disadvantages these housing types. The CCRC houses 44 households (166 individuals) from Taiwu Township and 67 households (333 individuals) from Laiyi Township. The resettlement period was from January 1, 2010, through to December 31, 2011.Initially we explored the refugees' lives periodically; however, 12 months after resettlement, when their lives had somewhat stabilized, we conducted questionnaires with the refugees under the permission of the management committee.

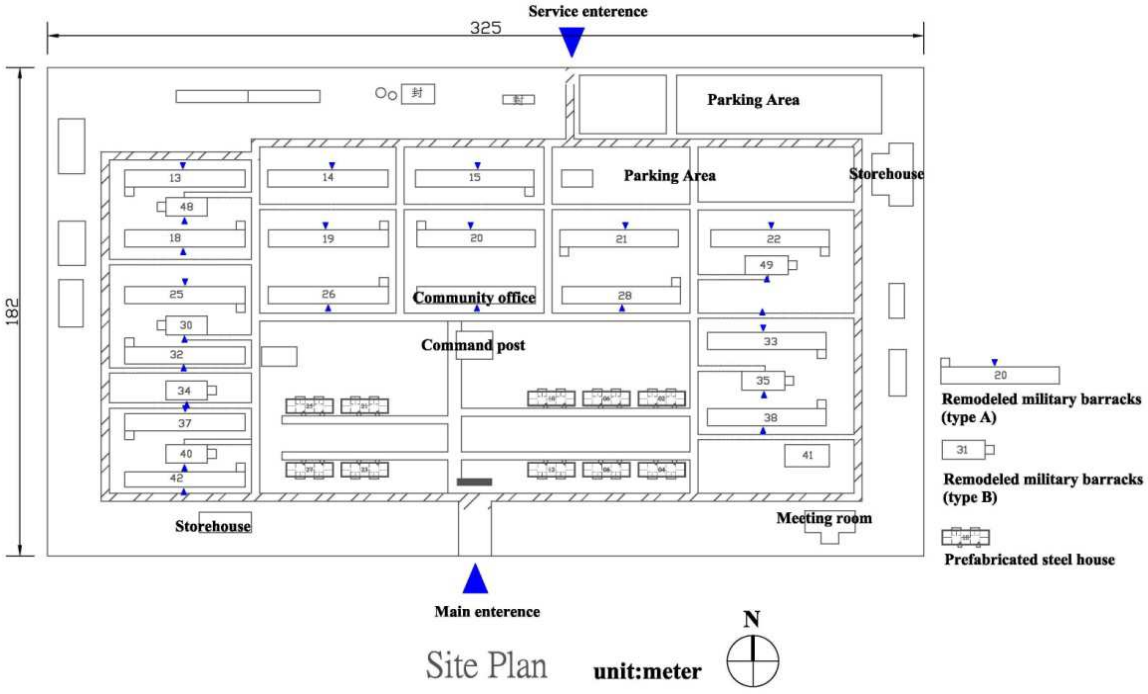

Figure 1.The CCRC Site plan

2.2 Methodology

As discussed previously, residents' safety, health, convenience, and comfort are the basic requirements for houses. We established 12 evaluation criteria for living environment by referencing the results of our literature review. After the questionnaire survey, we used SPSS version 10.0 and a t-test to analyze the questionnaire responses.

The survey results suggested that the residents were most dissatisfied with two items in the physical environment. Therefore, we endeavored to quantify this phenomenon by measuring the remodeled military barracks and the steel houses. Thus, we can collect quantifiable data to improve future temporary housing.

3. RESEARCH FINDINGS AND DISCUSSION

3.1 Residents' satisfaction level on living environment

We conducted the questionnaire using the census method, distributing questionnaires to 111 households. The survey period was one week from December 22, 2010, to December 28, 2010.We received 96 completed questionnaires for an overall response rate of 86.5%. The questionnaires that were incomplete or answered by minors, we eliminated. Thus, the number of valid questionnaires was 91, which accounted for 82% of the residents. Cronbach's α was 0.93, higher than 0.7, which indicates that the questionnaire survey had a high credibility.

1. Satisfaction level on living environment

The result for residents' satisfaction with the living environment was 3.74, which is between neutral and satisfied. The daylight criterion achieved the highest satisfaction level. These results suggest that temporary housing meets the refugees' needs to some extent. However, sound insulation receives the lowest satisfaction level, followed by waterproofing and indoor temperature. These results indicate that the quality of the living environment of temporary housing still requires improvements (Fig. 2).

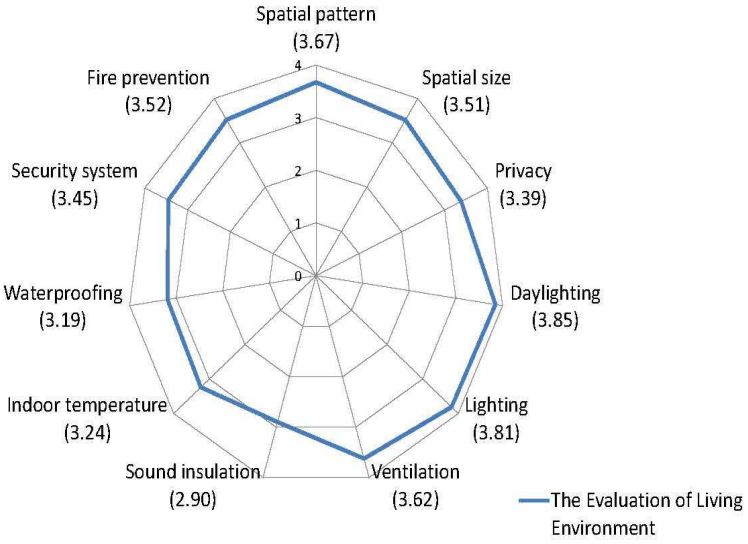

Figure 2.Analysis of the living environment of temporary housing

Residents living in the remodeled military barracks reported that on rainy days, the building had inundation problems. Following the onsite survey, we identified the primary factor contributing to the overflow of water was poor drainage systems, which could not drain at sufficient speed, causing inundation. Thus, 12 residents residing in remodeled military barracks experiecened water overflowing into their houses because of heavy rain. In contrast to the remodeled barracks, inundation did not occur in the newlybuilt steel houses because the design included a raised foundation and a comprehensive drainage system. In March 2011, the drainage problem was significantly improved after the government approved an upgrade budget.

Seven residents stated that the sound insulation of the temporary houses was poor; the primary noise source was their neighbors. This occurred in both steel houses and remodeled military barracks units. To understand how this affected the residents, we conducted an acoustic assessment to evaluate the sound insulation of the unit.

Regarding the indoor temperature, four respondents complained of overheating inside both types of temporary houses. Because the fluctuation of the indoor temperature is related to the airflow, we conducted an onsite indoor temperature and airflow experiment to examine the thermal insulation performance of both housing types.

2. Analysis of various levels of satisfaction with the living environment

Comparing the satisfaction level of residents living in remodeled military barracks with that of residents living in steel houses, the mean satisfaction level for people living in remodeled military barracks was 3.52, and the standard deviation was 0.71.The mean satisfaction level of the residents living in steel houses was 4.49, and the standard deviation was 0.62.The independent samples t-test showed that the residents living in steel houses were more satisfied with the living environment compared to their counterparts.

We then further analyzed the living environment evaluation criteria individually. The mean of the evaluation criteria for the steel houses was higher than that of the existing remodeled military barracks. The difference analysis conducted using a t-test found no obvious differences. This indicates that the satisfaction of residents living in steel houses is higher than that of the residents living in remodeled barracks.

According to the evaluation result, the sound insulation criterion achieved the lowest satisfaction level among residents of both the existing remodeled military barracks and the newly built steel houses. Refugees residing in both housing types experienced excessive indoor temperatures. Relevant authorities should examine the factors contributing to overheating problems and develop countermeasures to reduce these problems (Fig. 3).

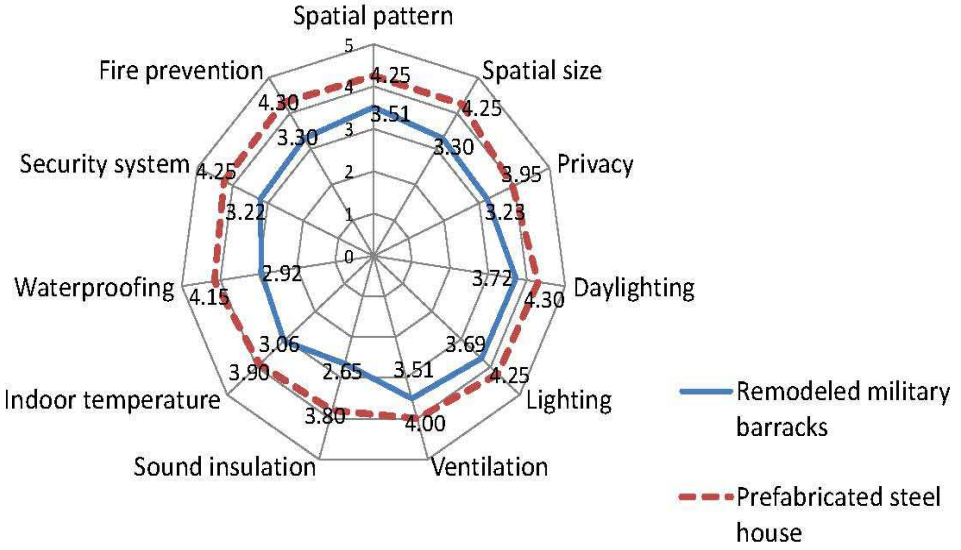

Figure 3.Temporary housing residents' evaluation of the living environment

3.2 Physical environment impact factors of different forms of housing

1. Sound environment analysis

We conducted an onsite test of the internal partition walls between two units of remodeled military barracks and steel houses to quantify the sound insulation performance.The sound insulation testing was based on EN ISO 140-4: 1998. We selected one remodeled military barracks and one steel house partition wall for testing (Figs. 4 and 5).The test result indicated that the transmission loss through the partition walls of the remodeled military barracks was 26 dB at 500Hz. At low-frequency

between 63.80 and 100 Hz, the resonate pattern was obvious, and the sound insulation volume decreased. The transmission loss of the steelhouse was 15 dB under 500 Hz, and the resonate pattern appeared at 125, 160, 2500, and 3500 Hz. The sound insulation volume also decreased. However, building codes in Taiwan only regulate the elements, materials, and thickness of the sound proofing walls; they do not specify the sound insulation performance level.Thus, we compared the data obtained in this study with that of commonly used 15-mm-thick RC partition walls in a laboratory to assess the sound insulation performance of the temporary houses (Fig. 6).

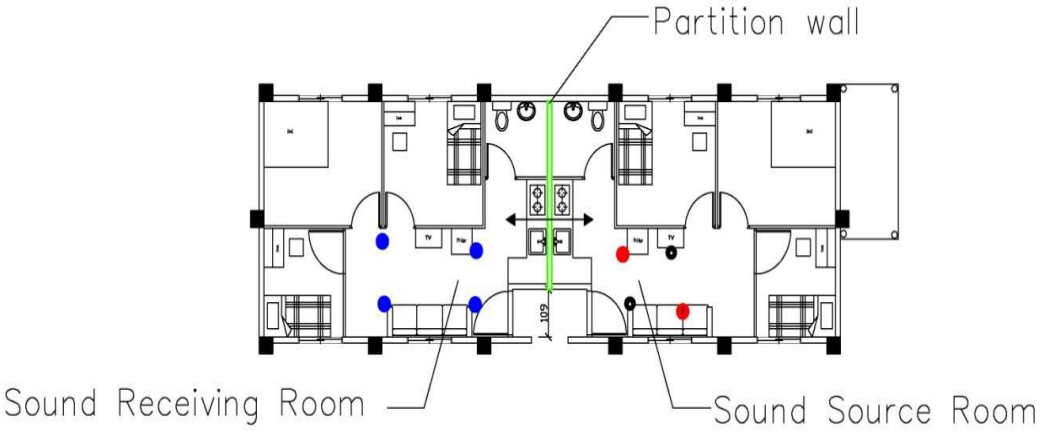

Figure 4. Layout of the sound insulation test performed in remodeled barracks

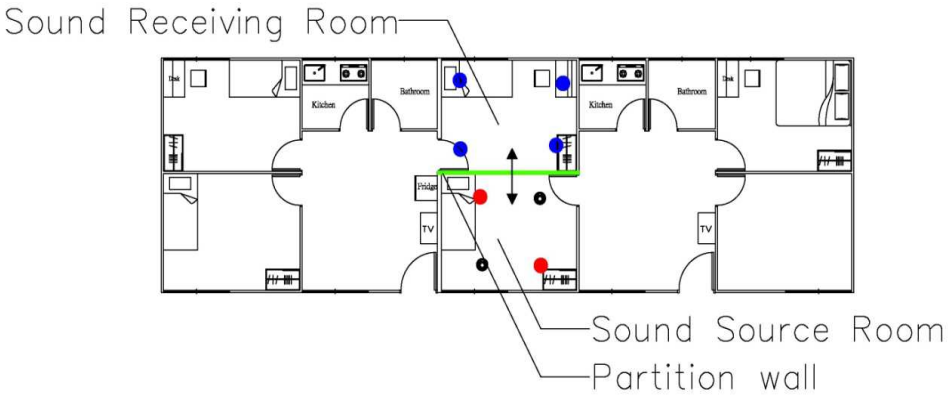

Figure 5. Layout of the sound insulation test performed in a steel house

Regarding the airborne sound insulation of buildings and building elements, the basic sound insulation level of internal walls must reach D-40, which means that noise at 125 Hz should be reduced to 25 dB, 500 Hz should be reducedto 40 dB, and 2000 Hz should be reduced to 50 dB, according to the JIS A 1416. The results of the onsite tests on the internal walls of the remodeled military barracks revealed that the transmission loss was 15 dB at 125 Hz, 23 dB

at 500 Hz, and 36 dB at 2000 Hz. The test result on the internal walls of the steel house revealed that the transmission loss was 2 dB at 125 Hz, 13 dB at 500 Hz, and 27 dB at 2000 Hz. Both housing types have a transmission loss that is significantly lower than the minimum standard; thus, they do not meet the JIS requirement.

We also applied EN ISO 140-4 to compare the sound insulation performance of various construction methods. For the normalized level difference, the Dn value of the remodeled military barracks was 29 dB, the prefabricated steel house was 15 dB, and the 15-cm RC wall was 50 dB. The value for the 15-cm RC wall was significantly higher than that of the other two building types, demonstrating the low sound insulation capability of the temporary houses. Similar results were obtained for the standardized level, DnT, and apparent reduction index R as shown in Fig. 6.

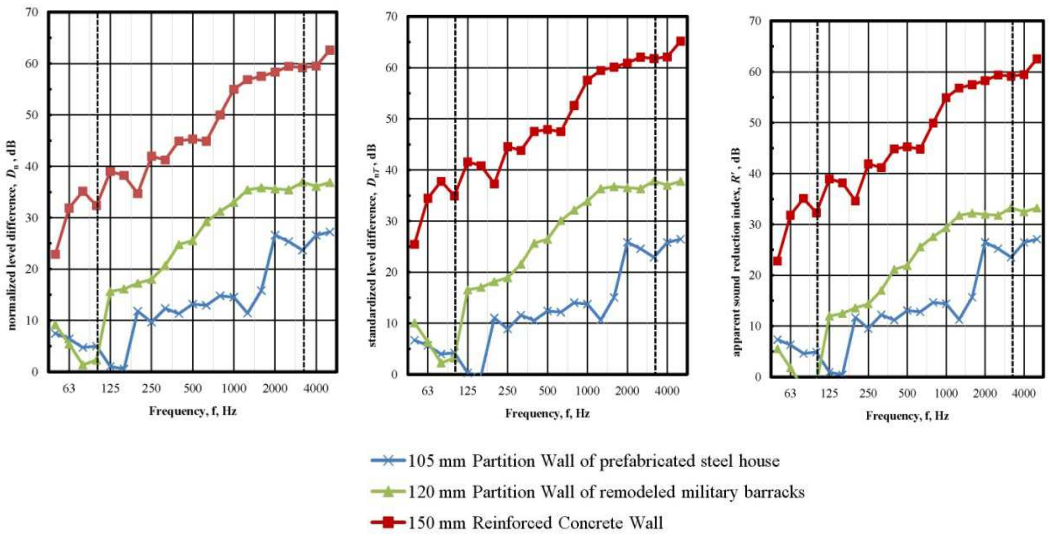

Figure 6. Comparison of the sound insulation performance of temporary houses

The sound insulation performance exhibited a resonate pattern under 100 Hz. This means that the thickness and weight of partition walls of the remodeled military barracks were insufficient, resulting in low-frequency resonance. This also led to the poor sound insulation performance of the partition walls. The wooden frame of the partition walls were composed of 25 × 45 mm square timbers. The centre of the walls was filled with 64K rockwool. The walls are flanked by 12-mm magnesium oxide boards. The thickness of the internal walls was approximately 7.5 cm.

Another reason for the poor sound insulation performance was that the suspended ceiling was constructed before the partition walls because of the limited timebefore the refugeesmoved in. Therefore, the partition walls did not reach the roof; instead they terminated at the soffit of the suspended ceiling. Additionally, the opening between the trusses above the suspended ceiling was not filled with sound-proofing rockwool nor equipped with flanking plates. Thus, the truss opening above the partition walls may provide an acoustic transmission passage. All these problems resulted in poor sound insulation and frequent noise interference among different units in the same building (Fig. 7).

The thickness of the internal wall in the steel house was 5 cm, and the main element of the wall is polyester foam. The wall was flanked by two 0.3-mm steel plates.The material of the wall also had a poor sound insulation performance. Furthermore, the material was not sufficiently thick or heavy, resulting in poor soundproofing in the steel house. Another disadvantage is that above the suspended ceiling, similar to the remodelled barracks, the partition wall plate only reached the bottom cord of the space truss. The opening in the truss was not equipped with sound insulation blanking plates. The sound may transmit through the truss opening and the wall plates. A schematic diagrem of the sound transmision through the truss opening and the wall plates is shown in Fig.8.

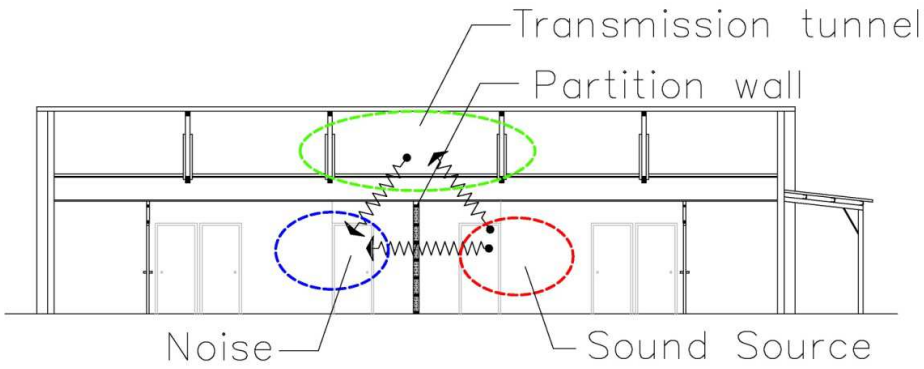

Figure 7. Sound transmission profile of the remodeled military barracks

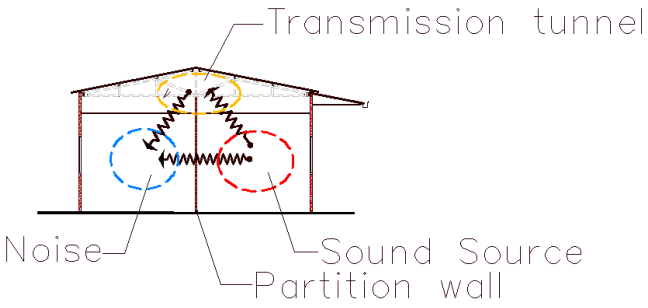

Figure 8. Sound transmission profile of the steel house

2. Thermal environment analysis

According to the questionnaire survey, overheating of the indoor environment was the second major problem experienced by the temporary housing residents. Therefore, this study investigated the fluctuations of the indoor thermal condition during August, the hottest month in Taiwan. We measured and recorded the internal and external temperature and humidity of the remodeled military barracks and the prefabricated steel house for one week in August 2011. The measurement time step was 10 min. All doors and windows were closed to create a windless experimental environment. The weather during the study period was sunny, which

is typical of the area.

Our records show that the average outdoor temperature in a typical summer week during the study period was 27.95℃, the highest temperature was 32.29℃, and the lowest was 24.1℃. Under the same weather conditions, the highest indoor temperature of the remodeled military barracks was 31.79℃, and the lowest was 25.11℃. The highest indoor temperature of the steel house was 34.97℃, and the lowest was 27.19℃. The average indoor temperature of the remodeled military barracks was lower than the average outdoor temperature, and the variation range was narrow, indicating that the existing reconstruction had some shadding effect. Conversely, the indoor temperature of the prefabricated steel house was higher than the outdoor temperature. This explained the unbearably high temperatures in the steel houses and why residents were extremely uncomfortable. These results also indicate that the shading performance of the steel house requires further improvements (Fig.9).

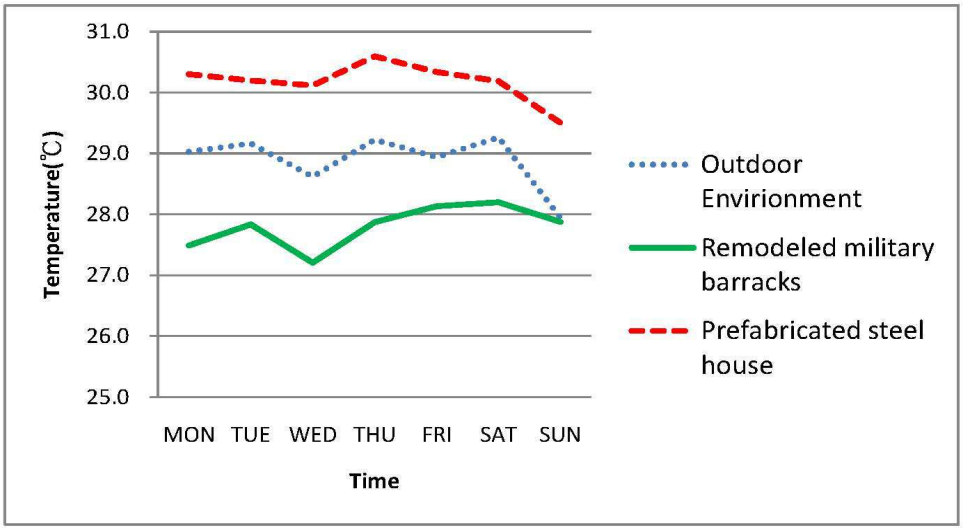

Figure 9. Comparison between the indoor temperatures of the temporary houses

4. CONCLUSION

Temporary houses not only relieve the tremendous stress felt by refugees of major disasters, but are also a starting point for post-disaster recovery. Thus, the condition of the living environment affects both the residents' satisfaction with their quality of life and their post-disaster recovery. This study conducted questionnaire surveys in a campground with two types of temporary houses to evaluate residents' satisfaction with their living environment. The results indicated that the residents of both types of houses were fairly satisfied with the overall living environment and particularly satisfied with the access to daylight, the lighting, and the layout. Through a detailed analysis of the survey results, we found that the residents were least satisfied with the sound insulation and heat dissipation performance.

The poor sound insulation performance causes noise disturbance to neighboring households. Onsite sound insulation measurements indicated that both temporary housing types have minimal acoustic impedance between housing units. The three main factors that contributed to the poor performance were inappropriate choice of partition wall material, inadequate wall thickness, and the existence of an acoustic transmission channel above the suspended ceiling.

Poor heat dispersal resulted in overheated rooms, which also received a low satisfaction score from the residents. Using temperature measurements, we identified that the performance of the steel house was worse than that of the remodeled barracks because the average indoor temperature was always higher than the outdoor temperature.

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