Connect North and South Korean Separated Families
Higher Comfort – Lower Energy

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ABSTRACT: In 1953, 10 million Korean families were separated by a wall between North and South Korea. Today, over 140,000 are still separated. Nobody is allowed to cross this wall, and South Koreans may not enter North Korea. Since 2000, organized family reunions have been allowed to take place in North Korea which occur twice a year and last 6 days. The number of people allowed to participate in these reunions is limited by the building capacity. The largest number of family members has never exceeded 600. And separated families are running out of time (mostly over 80 years old). For them, it is their only chance to meet their relatives in their lifetime, like winning the lottery.

The goal of my proposed project is to connect North and South Korea by developing a new community that serves as a meeting point for the families to reunite. Shipping containers will be used to construct affordable houses in a short period of time.

Due to the extreme seasonal changes ranging between -15 and +35 degrees Celsius in this border region, the design should offer protection from snow, wind, rain, as well as wild animals. Also, greenhouses will be built where applicable to provide self-sufficient food in winter. The meeting point will give both shelter and comfort to bridge the gap caused by the separation. It will, therefore, act as a platform to rebuild relationships.

Keywords: Korea, separated families, reunion, new meeting point, thermal comfort, daylight availability, vernacular architecture

INTRODUCTION

It is important to understand the historical and geo-political context of the separated Korean families. The nature of the situation dictates the main criteria for the project: fast, low budget, controlled and accessible facility as a meeting point for reunification between North and South Korea. First, the design should allow for quick construction time and frequent family reunions. This is because most surviving family members are over 80 years old, and time is running out for them to reunite with their separated families. Secondly, low cost, pre-fabricated mobile sheltering units make it possible for more families to meet at a rapid pace. The design should allow the North Korean authorities to easily monitor and control the families. It should be easy to see all movements during the meeting period. Finally, easy accessibility by feasible transportation means from both countries, regardless of the season, should be a main priority for this project. The solution proposes moving the existing meeting point, which is located in North Korea, towards the middle border as a new meeting point. This reduces the travel time for the daily visits. Additionally, it allows sick people easy access to hospital facilities.

OBJECTIVE

The main targets for a climate-responsive design for the project are: user comfort, passive strategies and energy balance. Since 2000, family reunions have been held throughout the whole year excluding winter (December – January). To meet this climate challenge and to cater for the elderly's delicate health conditions, the comfort range for operative temperature is set from 20 °C (minimum requirement) to 28 °C and relative humidity between 30 % – 70 %. Passive strategies will be informed by the seasonal variations of the local climate. These strategies include shading, window-to-wall ratio by using one container to control solar gains and shading factor. To minimize heat loss in winter, the envelop makes use of insulating materials. Thermal mass also absorbs heat during the winter season. For cooling, shading and fans will be used. Stack effect by solar chimney and earth duct will be considered for natural ventilation. This is to meet the required comfort range. The energy will be a balance of solar thermal and PV as additional energy sources.

METHODOLOGY

The research process is divided into three main stages *(table 1)*. First, the proposed scenario is assessed in order to identify problems with the existing situation. Then a new meeting point in the border (DMZ) between North and South Korea is proposed to reduce meeting cost along with traveling or waiting time. Second, design concepts focus on special requirements at the border and climate seasonal changes. Finally, comfort evaluation is done via WUFI thermal and humidity model simulation.

	Assessments	*Descriptions*
1	Proposed scenario	By moving meeting location, to reduce meeting cost and waiting time.
2	Design concepts	Design for special requirements at the borderline and as well as local climate considerations.
3	Comfort evaluation	Improving material assembly, controlling indoor temperature and relative humidity for elders.

Table 1: Cases for assessments.

Figure 1: Existing situation for Korean family reunion at the North Korea side.

The existing situation of Korean family reunions is that it takes place on the North Korean side since 2000. Only a number of people are chosen according to the limited hotel capacity. This situation involves very high cost for transportation and hotel for 6 days *(figure 1)*. The Red Cross in Korea currently sponsors the event. The cost is $1.2 million per meeting. However, it is not sure how long this event can last, considering the high cost and long waiting time. Waiting time for one meeting could be 18 years in the worst case. This is a big problem because surviving families are over 80 years old, and may no longer be able to wait.

The different proposed scenarios are examined based on three main aspects including:

1. Moving to a new meeting location
2. Design concepts on border and climate
3. Comfort evaluation

In terms of moving to a new meeting location, consideration is made for one that can be accessed by the existing public train. The aim is to reduce the travel time.

The design concept is based on special requirements at the borderline and climate seasonal configuration to maximise comfort during all seasons.

Comfort evaluation is done by simulating for thermal (20–28°C) and relative humidity (30-70%) requirements using the WUFI software. Furthermore, the envelop material, natural ventilation and floor heating or dehumidify by solar thermal is also investigated.

PROPOSED SENARIO

1. NEW LOCATION

The proposed scenario *(figure 2)* shows the possibility of tourists approaching the borderline between North and South Korea, even though it is presumed to be a dangerous place to visit. The location is suitable because the United Nation (UN) governs the area, even though high military personnel from both sides occupy it. The key is that this location allows for a day's visit with existing public transportation.

Figure 2: Proposed scenario by moving to new meeting location on border line(DMZ).

2. PPROPOSED CONCEPTS

The proposed concepts *(figure 3)* have three main aspects, including time, cost and comfort, to achieve the project goals. Time is reduced by building with pre-fabricated shipping containers (12m) from Incheon harbour transported in an hour to the borderline. Cost is reduced by using local material like Hanji (paper) on window and Hwangto (earth) on walls with a passive hydrothermal strategy. Comfort is achieved through floor heating and natural ventilation with operable windows and self-shading. This is inspired by vernacular architecture in Korea.

Figure 3: Proposed concepts of fast, low-cost and comfort for elder.

DESIGN CONCEPTS

The main idea for the design process is to offer ways to improve the shipping container with additional features without damaging the container itself. This allows the containers to be re-used after the temporary project period, hence reducing the cost of investment. This makes it feasible for the Red Cross to fund the meetings for the 140,000 surviving families, since the cost of hotel accommodation is eliminated.

1. Seasonal configuration

The different seasonal weather, acts as the biggest challenge to design. Figure 4 below shows that based on outdoor air temperature, winter in Korea is very cold (-15°C) and dry by Siberian wind. However, summer is very hot (+35°C) and wet by monsoon. Based on this, the design focuses on using a hydrothermal model to meet the requirements for comfortable temperature and relative humidity indoors.

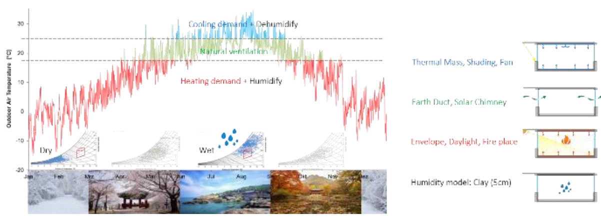

Figure 4: Weather data in Korea and climate concept for each season.

Figure 5 shows that based on the different seasons, the shipping container unit (12 x 2.5m) can be adjusted using operable window doors for daylight control and natural ventilation. Two units can be assembled together as one module (12 x 8m) to increase indoor space for seating and walking. Eight (8) modules can be arrayed in a circular arrangement with meeting and buffer areas serving as an inner courtyard to improve air quality. Wind can be captured from all directions and distributed equally to all modules. Unpleasant cold wind can also be blocked by over accenting.

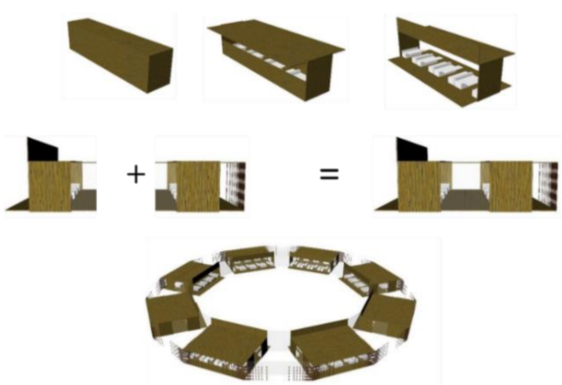

Figure 5: Seasonal configuration and assembly of shipping containers with unit and module.

2. Open and Controlled Views

The open view arrangement allows families to see other meeting families and provides a good view of the courtyard in the event of a big celebration. The closed view arrangement reduces the heating and cooling demand by saving thermal zone. This excludes the courtyard, but includes the inner circle ring, which serves as the meeting zone. To meet the special requirements at the borderline, it is important to have an arrangement that allows the checkers from North Korea easy access. This is because the North Korean authorities are strict in order to prevent the leaking of top military and the spread of a different idealism *(figure 6)*.

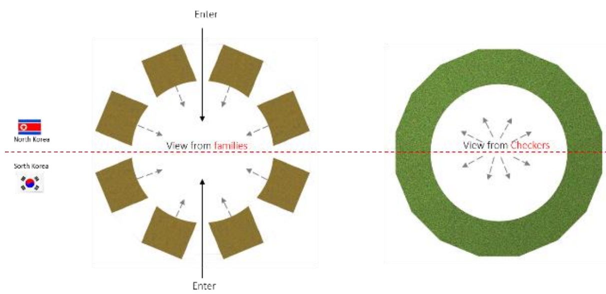

Figure 6: View for visual and security control.

3. Air buffer zone

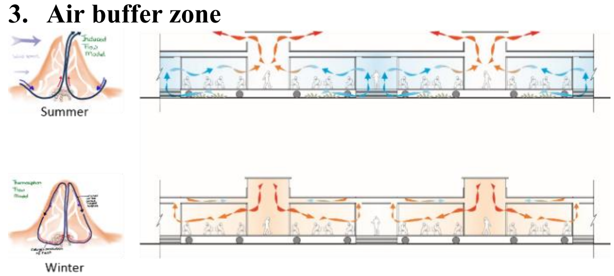

Figure 7: Air buffer zone is for pre-cooling and pre-heating the supply air in summer and winter, respectively.

In order to reduce the cooling and heating demand, supply air is pre-cooled or pre-heated, depending on the season, before entering the thermal zone. Pre-cooling is done by guiding summer air towards cool shaded areas under the building, and pre-heating the cold winter air by a solar chimney on top of the building *(figure 7)*. Subsequently, the shipping container's doors are adjusted to serve as shading in summer and to reduce solar internal gains. In winter, the opening serves to maximise solar gain in order to heat up the air *(figure 8)*.

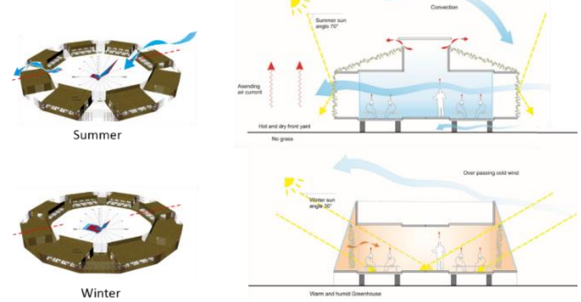

Figure 8: Seasonal configuration of air buffer zone by shipping container's door position.

COMFORT EVALUATION

1. Improving envelop material

Figure 9: Local materials for hydrothermal control.

In order to improve hydrothermal comfort quickly, the proposed solution is to maximize the humidity control and minimize heat loss. A layer of insulation with available material in Korea like Hanji and Hwangto *(figure 9)* is used. Hanji is breathing paper, which allows air supply and daylight but reduces heat loss and undesirable glare, instead of expensive glass window. It has a great water vapour diffusion resistance factor of 207*(figure 10)*.

Nr.	Material/Layer (from outside to inside)	ρ [kg/m³]	c [J/kgK]	λ [W/mK]	Thickness [m]	Color
1	Hanji	400	1500	0.1208	0.005	
2	Air Layer 10 mm	1.3	1000	0.071	0.01	

Figure 10: Material assembly for Hanji as window.

Figure 11 demonstrates the positive impact of paper window in combination with Hanji and air layers for both summer and winter (simulation by WUFI hydrothermal software). There is an improvement in humidity comfort from 100% to 70% during the monsoon summer season. There is also an improvement in thermal comfort with the indoor air temperature increasing 10°C more than the outdoor air. The relative humidity increases dramatically from 25% to 80% in very cold and dry winter.

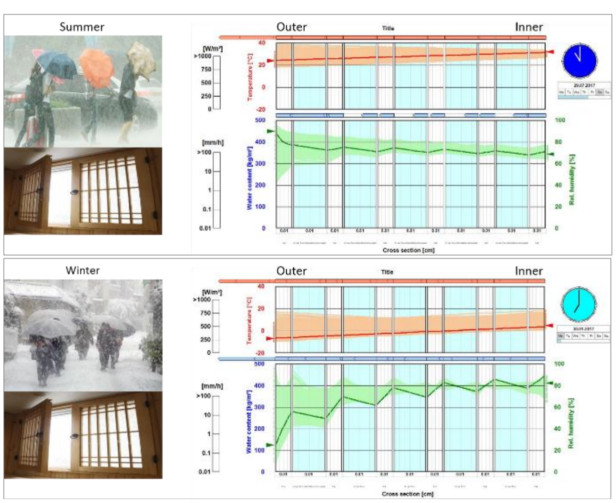

Figure 11: Hanji's hydrothermal results in summer and winter (simulation with WUFI software).

2. Assessing the performance of variants simulation

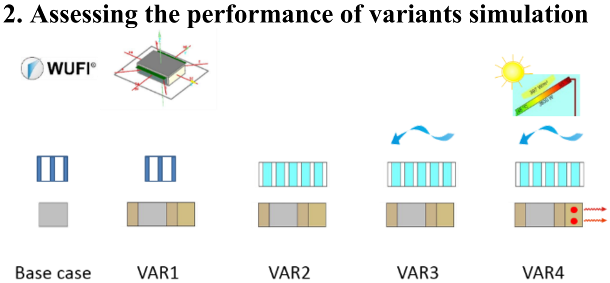

Figure 12: Simulation variants to optimise comfort.

The variant simulations have four different material combinations with ventilation and solar thermal. The simulation zone (12 x 8 x 3m) is facing south-west, which is the worst case for solar gain *(figure 12)*.

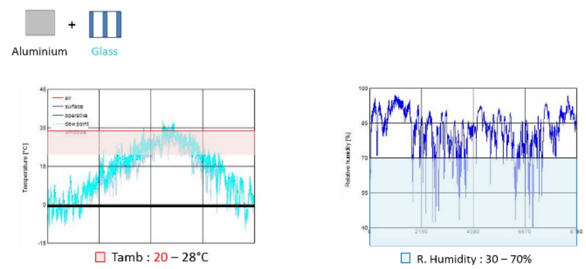

Figure 13: Base-case (aluminium and glass) for indoor ambient temperature and relative humidity.

The target is to maintain indoor temperature between 20°C and 28°C, and relative humidity between 30% and 70% to achieve the comfort range for elders using a passive strategy. Figure 13 shows the base-case with its indoor climate conditions combined with only aluminium (as shipping container and glass window).

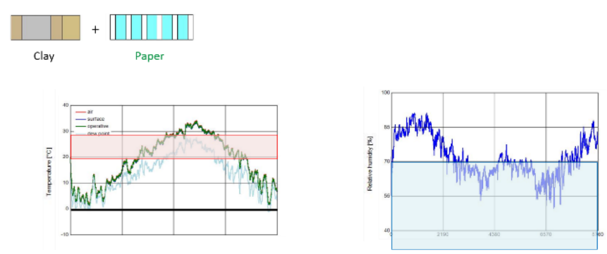

Figure 14: Variant two (2) - (clay and paper) of indoor ambient temperature and relative humidity.

Clay with heat insulated clay (U-value: 0.72W/m²) and Hanji paper window (U-value: 0.89W/m²) have positive impacts than glass hydrothermally in Korea climate condition *(figure 14)*.

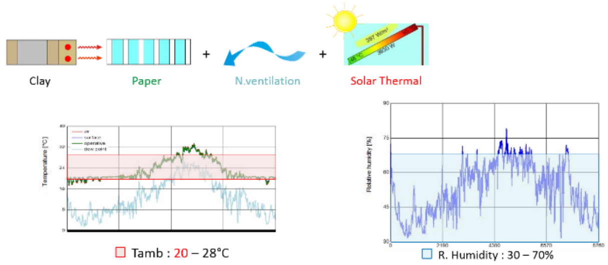

Figure 15: Variant Four (4) (higher rate of natural ventilation and solar thermal) of indoor ambient temperature and relative humidity.

Figure 15 demonstrates the positive impact of added higher ventilation rate (summer 1.3 ach, shoulder 1 ach, and winter 0.5 ach) and solar thermal to save energy in water tank for floor heating. By this, indoor ambient temperature and relative humidity can be in the comfort range during the whole year except some summer periods, which need fan supported cooling and dehumidification.

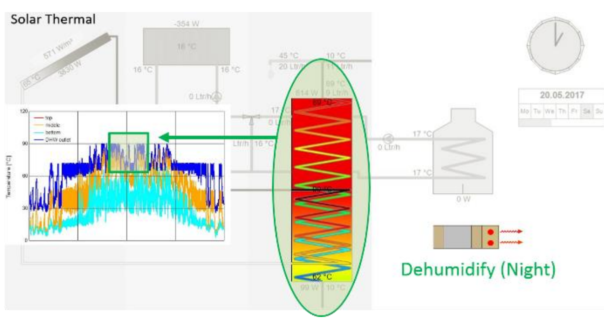

Figure 16: Water tank temperature of solar thermal.

In order to achieve a passive strategy, checking reusable energy around the location is important. Figure 16 shows the positive solar collecting potential on site by simulating solar thermal with heat water tank. This green energy serves as floor heating during the cold season; however, it can also be used during the hot season as night dehumidification to discharge clay moisture contents.

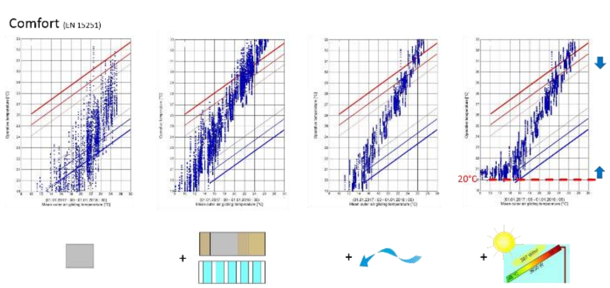

Figure 17: Comparison between four different cases in adaptive thermal comfort with relative humidity.

Figure 17 shows that the addition of improving material assembly, higher air change rate and solar thermal can adjust temperatures toward adaptive thermal comfort by using passive strategy with wind and sun.

CONCLUSION AND FUTURE POTENTIAL

Despite the extreme climate conditions at the borderline in Korea, simulation results show that by having a reasonable arrangement of spaces, a well-insulated façade, fans, and solar thermal, the design can offer a high level of comfort, both in terms of the temperature and humidity ranges, while at the same time operating with passive energy strategy.

The use of paper windows Hanji, known as breathing paper, supplies fresh air constantly into the space in a more comfortable range of humidity and temperature. The paper filters the air during the yellow dust season without glare. A combination of paper window with air layer is most suitable for the Korean climate, which has very hot and humid summer and very cold and dry winter. However, paper windows only perform well in climates with a lot of rain and very humid condition.

The function of the proposed 5cm clay wall is to absorb the moisture from the humid indoor air. It is necessary to discharge the moisture from the dehumidification process each night to allow for the same process the next day. This is achieved by floor heating during summer nights using hot water from solar thermal. This is also passive strategy to heat up the space during harsh cold winter period with less energy consumption. This prediction can only be clarified using a multizone thermal simulation with all floors included which was not done in this project. Therefore, another strategy using a fan assisted system will need to be investigated to identify a better system for cooling and dehumidifying which results in an increase in comfort compared to the one showed in this report.

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