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Final Project Summary

Modernizing the Vietnamese Modern "Tube-House"
Higher Comfort – Lower Energy

VU HOANG[1], FELIX THUMM[2]

[1]Transsolar Academy, Transsolar Energietechnik GmbH, Stuttgart, Germany
[2]Transsolar Energietechnik GmbH, Stuttgart, Germany

ABSTRACT: Despite growing interests in green-building and energy-efficient building, many new green developments in Vietnam's construction sector mainly focuses on improving the design of mostly high-rise buildings by implementing new and high-tech active systems rather than offering passive and simple climate responsive solutions for better performance. Moreover, the tube-house, which accounts for 60% of Vietnamese urban population, is degrading due to not receiving proper interests.

Knowing as one of the most iconic images of Vietnamese's modern architecture, the Vietnamese modern tube-house has been designed for higher useful area on a minimum footprint. Because of this unique approach, several important aspects of architecture, such as: human comfort, energy usage, and even the cultural connection between tradition and modernity are often neglected, thus result is an inefficient design with limited access to daylight and heavily dependent on air conditioning.

This project aims to provide a range of passive solutions for the Vietnamese modern tube-house in order to not only solve problems in growing demands of usable spaces but also to achieve greater performance in thermal comfort and daylight availability while at the same time having lower environmental impacts. A casestudy representing the design of modern tube-house in Vietnam is selected and tested with distinct solutions for locations like Hanoi and Hochiminh City, two biggest cities in Vietnam which differ in term of climate.

The evaluation shows that an approach inspired by Vietnamese vernacular architecture in organizing different living spaces can offer better daylight condition, both in quantity and quality. In addition, having an improved façade as well as providing elevated airspeed can increase the thermal comfort while only using 50% of electricity in comparison with the basecase.

Keywords: Vietnam, modernizing, thermal comfort, daylight availability, vernacular architecture

INTRODUCTION

With a long history of development since 15-18th Centuries AD, the "tube-house" is a legendary icon representing both Vietnamese traditional and modern urbanism. Such particular name for a house is originated from the shape of the house itself, more specifically, a house having narrow façade yet incredibly long in depth and tall in height.

However, despite being so popular, Vietnamese modern tube-house and its' owners are suffering from uncomfortable living condition due to lack of awareness and innovations in tube-house design. Nowadays, the biggest problem with modern tube-house is multiplication process of an over-simplified and repetitive design in different locations, in different cities without any modifications or adaptation to surroundings and contexts.

Moreover, when green-building and energy-efficient building development is becoming a topic for different big stakeholders in Vietnam to start making changes, the tube-house itself is often neglected and not being brought into discussion. So far there has been no specific attempt being made to come up with suitable innovations for Vietnamese tube-house design while such information plays an essential for the continuous development in design or for a sustainable and harmonious future.

OBJECTIVE

The main goal for the project is to improve overall comfort (thermally and visually) as well as total energy consumption for the Vietnamese modern tube-house.

Proposed solutions take into account of not only specific conditions such as: sites, surroundings, climate conditions but also cultural aspects, especially when investigating the connection between how people live in past, present and future times. Considering the development of construction/building sector is distancing itself from the beauty of traditional architecture, another purpose for this project is as well to show an idea of how useful vernacular architecture features can actually integrate in the life of modern Vietnamese.

Furthermore, as the tube-house does not receive proper interests, this project aims to help Vietnamese people be more aware of this iconic building typology and more importantly, their living environment in general, of how typical people can easily make an impact through having a better understanding on advantages brought by passive solutions. By following the project’s process itself, hopefully people can have a better understanding of positive impacts which climate responsive design can bring to both designers and users.

METHODOLOGY

The research process is divided into three main performance-based assessments *(table 1)*. The basecase is assessed firstly in order to identify problems of current design, then later proposing different options in “retrofitting” and “modernizing” cases.

	Assessments	*Descriptions*
1	Basecase	Evaluating the selected casestudy.
2	Retrofitting	Improving chosen casestudy by additional design features without changing its’ structural components.
3	Modernizing	Presenting a new tubehouse design which has same footprint as basecase.

Table 1: Cases for assessments.

Chosen casestudy is a West-oriented tubehouse with 4.5m in width, 14m in depth and the height of 22m within a bigger cluster to represent an urban environment *(figure 1)*. This house was designed by Mr. Hoang Nga Van, a B.Eng in Civil Engineering who is living and working in Hanoi. The selected locations for this study are Hanoi and Ho Chi Minh City – two biggest cities in Vietnam with high population density in which tube-houses are often built. Through investigating two different cities which differs in term of climate condition, the final improved design therefore can be more diverse and adapted to regional climates.

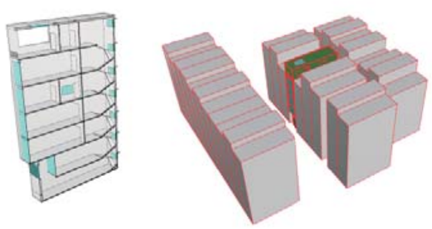

Figure 1: Typical section of a tube-house and typical cluster of tube-house with chosen casestudy (green).

Different proposed cases are later investigated based on three main aspects, including:

1. Daylight
2. Thermal comfort
3. Energy consumption

In term of daylight, used metrics are daylight autonomy (DA) and spatial daylight autonomy (sDA). Daylight autonomy shows percentage of time a defined lux threshold is achieved during operation period. For this study, chosen lux threshold is 300 lux. Meanwhile, spatial daylight autonomy describes how much of the space receives sufficient daylight of 300 lux for at least 50% of occupational time. Daylight assessments are carried out using DIVA for Grasshopper.

Thermal comfort is evaluated with Predicted Mean Vote (PMV) method (developed by P.O.Fanger). As one of proposed solutions in this study involved elevated air speed, therefore the PMV calculation also considers elevated air speed.

A single thermal zone representing lowest floor is setup and calculated using TRNLizard, a simulation tool was developed by Christian Frenzel at Transsolar Energietechnik GmbH. Total energy consumption is calculated as an output in thermal model.

BASECASE ASSESSMENT

1. Daylight availability

Daylight simulation result *(figure 2)* shows critical design problems of Vietnamese’s typical modern tube-house. Because of the depth of the room and very limited access to daylight through a narrowed façade, on lowest floors, the spatial daylight autonomy is only 25% for climate of Hanoi. For climate of Ho Chi Minh City, due to having more days with clearer sky conditions and overall higher solar radiations, the room performs slightly better with $sDA_{300,50\%}$= 27%.

The non-uniform distribution of light inside can also cause visual discomfort since the light intensity gets higher when being closer to façade.

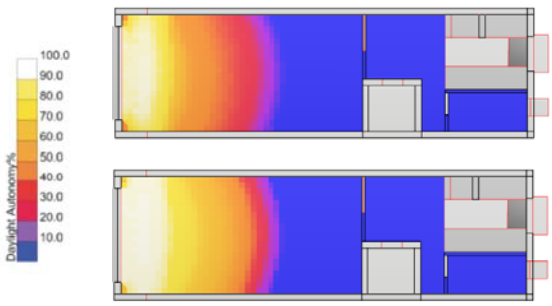

Figure 2: Daylight in lowest level in modern tube-house in Hanoi (upper image) and Ho Chi Minh City.

Moreover, current design only uses front façade as opening to access to daylight without considering bringing daylight from back facade. Therefore, the improvement can be made by opening up the back façade.

2. Thermal comfort

The tube-house normally has split air conditioning units as main source of cooling. There is no heating, even when for cities like Hanoi which has temperature in winter below 10°C.

Generally, tube-house in Vietnam is constructed with concrete as materials for floors, structural components and burned clay brick for walls (both external and internal) without any thermal insulation. The glazing used for windows is single pane glazing, thus there is high heat exchange between inside and outside. In this case, this heat exchange is considered to be unnecessary loss of cooling energy in summer.

Figure 3: Hourly thermal comfort in Hanoi (upper) and Ho Chi Minh City throughout the year.

For the climate with fairly cold winter like Hanoi, it shows that users can feel slightly cold during that time. Overall in Vietnam's summer, having an air conditioning unit can help maintain thermal comfort, however, the design is still inefficient and has high energy consumption due to high energy losses through building's façade.

RETROFITTING DESIGN

The main idea for retrofitting case is to offer ways improving tube-house's design by additional features and not damaging the house itself. This means that these options can be suitable for people whose cannot afford to build new houses.

1. Improving uniformity of light

After realizing non-uniform distribution of light inside current tube-house design, a solution is to use lightshelves with high reflection to redirect more like into the space. Different sizes and angle of lightshelf were tested in order to find the most suitable design for climate of Vietnam.

Figure 4 shows that based on spatial daylight autonomy values, a 0.9m long lightshelf and tilted 30° has highest performance. The visual effect of this 30° lightshelf is confirmed by visualization results showed in figure 5.

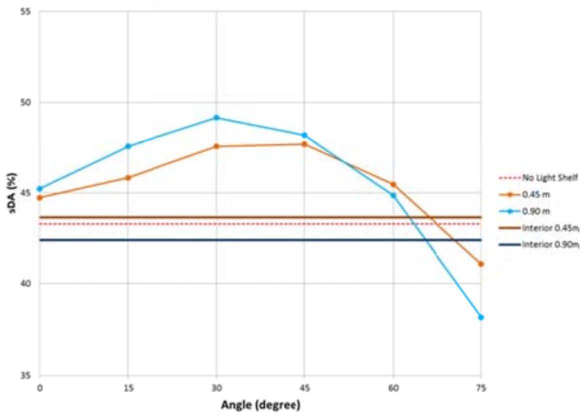

Figure 4: Lightshelf sizing and positioning

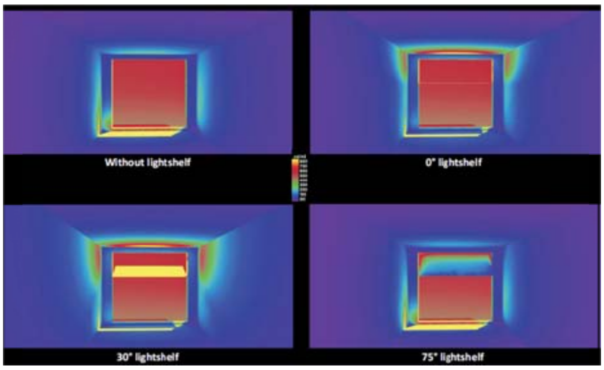

Figure 5: Lightshelf visualization.

The performance of lightshelf is later re-evaluated through total electricity consumption for artificial lighting, which is calculated by thermal simulation.

2. Providing access to daylight from back façade

The back façade also requires attention due to not being proper utilized in current modern tube-house design. Different windows with larger size are now introduced as well as a skylight above of staircase.

Figure 6 shows light distribution on 4th floor with new skylight and back windows. The front room and back corridor is now connected, thus allowing light from corridor to enter the room and helps eliminating dark corners.

However, when investigating results on lower floors, especially with two lowest levels, these new skylight and windows show no visible improvements to even the back space. This can be explained due to the staircase not allowing much light to go lower and also because of the neighbouring cluster with high density.

Based on these results, it is clear that the daylight can only be thoroughly improved by a new and proper arrangement of spaces.

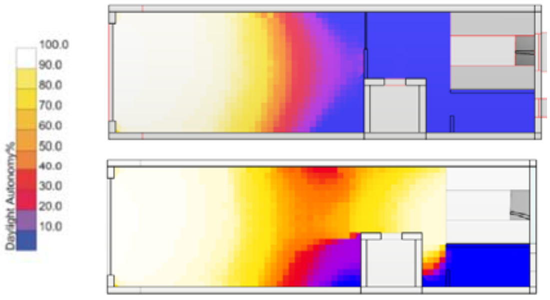

Figure 6: Comparing basecase and retrofitting case with climate of Ho Chi Minh city (4th floor)

3. Impact of well-insulated façade and elevated air speed on thermal comfort in tropical climate

In order to quickly improve thermal comfort, first solution is to minimize the heat loss. A layer of insulation with available material in Vietnam like bamboo was added to the front façade. Glazing for windows is also changed from single to double pane.

In addition, elevated air speed is provided using a simple ceiling fan.

The result in figure 7 shows a big improvement in term of comfort in Hanoi. Users no longer experience cold feeling during winter, this due to internal heats now being kept within the space during winter and helps to improve comfort.

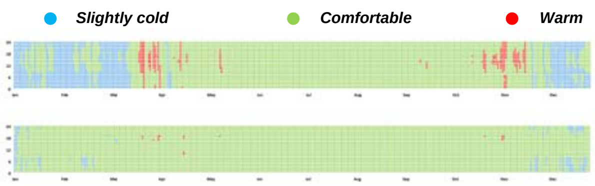

Figure 7: Different between basecase and retrofitting case (Hanoi climate) in term of thermal comfort

Figure 8 demonstrates the positive impact of well insulated façade and elevated air speed through reducing overall electrical energy consumption.

Not only there is an improvement in thermal comfort, the energy consumption is also dramatically reduced. Specifically for Hanoi, the comfort is 25% better with 46% less energy consumption. Meanwhile in Ho Chi Minh City, the retrofitting design has the same thermal comfort as basecase but only need 56% of energy to keep that comfort.

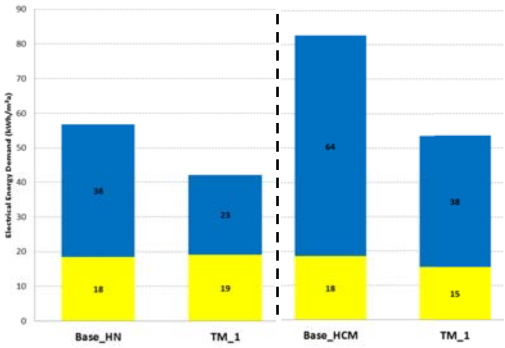

Figure 8: Electrical Energy Comparison between basecase and retrofitting case

The impact of lightshelf is also demonstrated with reduction in electricity consumption for artificial lighting in climate of Ho Chi Minh City but not in Hanoi. This can be explained by the difference between dominant sky conditions. While Ho Chi Minh City has a lot of sunny day in clear sky condition, allowing lightshelf to perform its' task, Hanoi has more cloudy days which dramatically reduced the performance of lightshelf.

MODERNIZED DESIGN

1. New design with influences from Vietnamese vernacular architecture

As traditional houses were often design for comfort without being heavily depended on active measures, it is proven to be informative to look into traditional passive design in order to find new ideas. Interestingly enough, there is a pattern of having an internal courtyard within the Vietnamese traditional tube-house. This courtyard offers better cross ventilation and more importantly, better daylight availability.

However, as the traditional tube-house only has 2 stories while the modern tube-house can have up to 6-8 stories and is also built in much dense urban environment, therefore it is necessary to make certain adjustment in order to adapt this courtyard design into a part of modern Vietnamese tube-house.

Figure 9 introduces the proposed modernized design with two new internal light shafts working similarly as courtyards in traditional architecture. These light shafts allow light to enter to lower levels while at the same time works as exhausts for used air from within the space. This helps to increase cross/stack ventilation when needed.

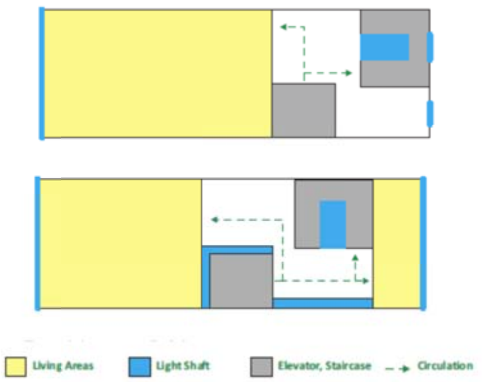

Figure 9: Modernized design (bottom) in comparison with current design

In addition, the usable space is now divided into two separated spaces, located on both front and back façade of the house in order to have more access to daylight. In comparison with current tube-house design, the modernized design offers in addition 6% more of useful area per floor.

2. Assessing the performance of modernized design

As the modernized design now have two different rooms per floor with reasonable dimensions, the overall performance in term of daylight is better than both the basecase and retrofitting design.

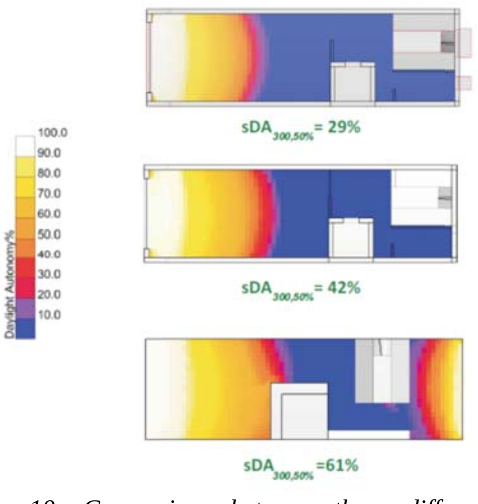

Figure 10: Comparison between three different cases (lowest level) in Ho Chi Minh City

The modernized design with spatial daylight autonomy of 61% is performing more than two times better than the basecase. The dark corners in bigger room are now eliminated. For upper floors like the 4th floor, results show that the modernized design now has 100% of spatial daylight autonomy, meaning 100% of the floor has good daylight condition throughout the year.

In term of thermal, similarly to the retrofitting design, the modernizing design can achieve nearly 100% of comfortable hour throughout the year while continuing to further reduce electrical energy consumptions.

For Hanoi, the total electrical energy demand of modernized design is 23.6 kWh/m² while for the retrofitting design and basecase is respectively 25.6 kWh/m² and 46 kWh/m².

The results for Ho Chi Minh City follow the same trend with 31 kWh/m² for modernizing design, 33 kWh/m² for retrofitting design and 41 kWh/m² for basecase.

CONCLUSION AND FUTURE POTENTIAL

Despite the extreme conditions of Vietnamese tube-house, it shows that by having a reasonable arrangement of spaces and a well-insulated façade with additional elevated air speed, the design can offer high level of comfort, both visually and thermally while at the same time operating with minimum energy consumption.

Lightshelf can offer better uniformity of light into the space. A lightshelf 0.9m long and 30° tilted is most suitable for Vietnam climate. However, lightshelf only perform good in climates with a lot of days with clear sky condition.

Moreover, as the proposed modernized design has more openings from back facades and light shafts, the front façade on upper floors therefore can be more opaque in order to lower the heat exchange between conditioned place and ambient conditions during non-favourable periods. This is predicted to help overall improve even further the reduction of total energy consumption. This prediction can only be clarified by a multizone thermal simulation with all floors included which is not the case of the model used in this project. Therefore, there is room for further studies in order to identify the reduction in term of energy consumption, which can easily be bigger than the number showed in this report.

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