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Thermal Comfort in Old Traditional Shophouses in Ho Chi Minh City, Vietnam

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Abstract. Cooling is the main requirement for occupant thermal satisfaction in buildings in warm to hot climates across much of the year. This is especially true in naturally ventilated housing, for example, in traditional houses of the tropics, which distinctive passive cooling design strategies including shading, natural ventilation, convective cooling, and light structure optimised to respond to the hot climate and retain the comfortable indoor environment. Thus, energy consumption can be reduced. Those effects are also found in traditional dwellings in Vietnam, in particular, traditional vernacular shophouses in Ho Chi Minh City (HCMC). However, due to the accumulative pressures of changing society, economy, and urban environment in the city, getting thermal comfort indoors has become difficult. The interplay between building, people, management, and comfort is usually complex in the towns preserving the values of the urban and architectural heritage of the city. The quality of traditional vernacular buildings has been degraded while local people desire comfortable living conditions and spatial expansion for the family extension. The paper aims to examine the building and urban characteristics of old traditional shophouses and their comfortable environment in Cho Lon town, HCMC, in which, a large number of traditional dwellings are reported. A case study built in the early 1900s on Trieu Quang Phuc street will be selected for analysing architectural features before and after renovation in 2007. Consequently, the indoor environmental impact due to the change of building features will be investigated. The problems of discomfort, renovation, and preservation will be explained. Then, some recommendations in design will be proposed to help designers/stakeholders renovate traditional shophouses toward achieving comfort, preserving vernacular architecture, saving energy, and getting occupant delight. The research techniques included field visits and numerical analyses to understand long-term environmental performances in such case studies and the effect of proposed design solutions.

Keywords: traditional shophouses, thermal comfort, indoor environment, Ho Chi Minh City.
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1. Introduction

Over 300 years of history, Cho Lon town in the heart of district 5, HCMC has been a specially attractive land, which is mixed with multi-cultures including indigenous Vietnamese, Indian, Chinese, and French [1]. The development of Cho Lon has been attached to the whole history of Saigon (which is a former name of HCMC used before 1975). In 1679, the first Chinese people coming from southern China settled in Saigon and built up Minh Huong commune – the precursor of current Cho Lon. The contribution of Cho Lon and the Chinese community to the cultural and economic profile of the city is significant, in particular, architecture. An extravagant collection of diverse and distinct buildings is found around the town with various typologies (residence, retail, apartment, school, temple, and community house) and the interference of many architectural styles, such as Southern China, Chinese mixed with French, Indochina, and Vietnamese Tropical Modernism [2]. Amongst them, the number of old traditional shophouse dwellings and their values for the architectural system of Saigon are dominant (Fig. 1).

Fig 1 - Cho Lon in 1900 (a), Cho Lon in 1906 (b), Cho Lon in 1950 (c) (Source: Manh Hai, 2010)

As previously mentioned, under the increasing impacts of climate change, uncontrollable urbanisation, and population extension, the pleasant environment inside old traditional shophouses has been highly vulnerable, which links to inhabitants' discomfort subsequently the need for renovation of their houses and installation of air-conditioners to retain thermal comfort. Additionally, less effective heritage management currently results in not only the loss of original architectural features of traditional buildings but unachievable comfort. The present study examines the environmental performance and the comfort level in the old traditional shophouses in HCMC, Vietnam through two typical housing cases found in Cho Lon including House No. 111 built on Trieu Quang Phuc Street in the 1920s and renovated in 2007. Some research steps were developed to achieve the aim. Firstly, the architectural characteristics of those dwellings before and after renovation were investigated by field observations. Especially, the responsive climatic design solutions applied to it were analysed. Secondly, the room thermal environment in the dwellings was evaluated by using computational analysis of the TAS software program. The comparison of environmental consequences between original and renovated houses was carried out. This action helps the author understand the influence of building envelop and less rational changes to it without concerns about vernacular architectural values on the low degree of comfort indoors. Finally, different cases of building improvement were proposed and tested with environmental impacts, and then, the analytical results were compared together in order to find out the best design option for the thermal satisfaction of occupants inside.

2. Location

The latitude and Azimuth of HCMC are 10.47°N and 106.4°E which highlights the tropical climate of southern Vietnam with two distinctive seasons: the dry season (December- April) and the rainy season (May-November) [3]. Its high level of average temperature and distinction of two seasons in a year significantly influence landscape and architecture. Because of the huge impacts of solar radiation, the temperature in HCMC is usually at a high level. The average temperature in HCMC is around 27°C and the average minimum temperature is over 20°C.

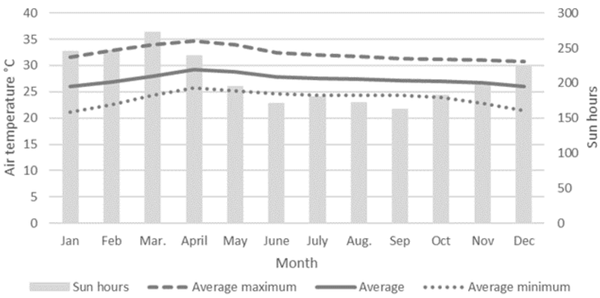

Fig 2 - The climatic characteristics in HCMC (Source: Science, 2009)

In the South of Vietnam, the highest temperature of the year occurs in the dry season from March to May. The annual average relative humidity is about 77%. Particularly in the rainy months, humidity is at 75 - 80% on many days and sometimes peaks at 100%, whilst the air might be drier in the first four months. HCMC is in a climatic zone that has a high annual average rainfall - about 1949mm per year, 90% of which is in the rainy season. Therefore, in architecture design, climatic responsive strategies are vital to allow benefits of natural conditions inside houses and to protect from harmful influences of climate.

3. Old traditional shophouse dwellings in Cho Lon

Shophouses are a popular residential style in Cho Lon with direct access to the street or alley. They are owned by individuals or rented by businessmen. Overall, their plot is a rectangle with a narrow width of 3 - 4 meters and a length of 18 - 20 meters [2].

Fig 3 - Shape of plots, street houses on Trieu Quang Phuc Street

The land is divided into a narrow plot to get as many street-front façades (for shops) as possible. Street (or sidewalk) and terrace play a role as communal spaces. Generally, most shophouses are two or three-storey terrace houses. At ground level, the front room is a commercial area, the kitchen and services are behind transverse walls, the stair is organised in the middle of the house. The family's living space is accommodated on the upper floors [2]. Most of these rooms are organized along a long corridor. It is very narrow and dark; its width is just enough for one person. In almost every Vietnamese household, the altar is a very sacred place where people worship their ancestors and a religious figure such as Buddha. The altar is often placed at a high point facing the street or an alley on the highest floor. Another "Fortunate God" altar is normally positioned on the ground floor facing the main entrance. Since most families in Cho Lon are business owners, altars are very important not only to their religious beliefs but to their trade.

Figure 4 shows a typical spatial section of the traditional shophouse in Cho Lon. On the building envelope, elements such as openings (windows, doors, and wall apertures), overhangs, and louvres/shutters/screens are applied to protect interior spaces from direct sunlight and rainfall while maintaining natural ventilation and daylight.

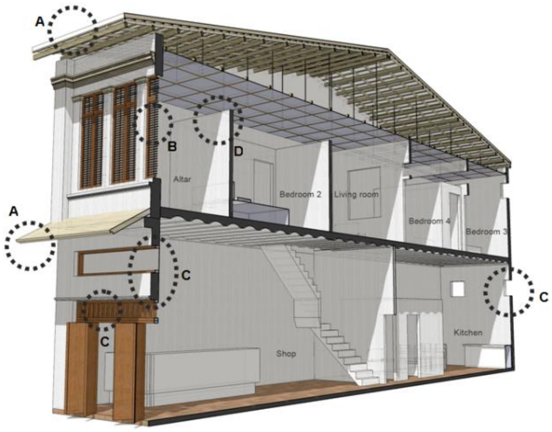

Fig 4 - A typical section of the ancient shophouses in Cho Lon (A - Roof overhang, B - Outer wooden shutters, C - Above windows + lattice wood screen, D - Low partition walls)

4. Research methods

In this study, the application of different analytical tools helped researchers to understand the daylighting control and thermal comfort inside the house with individual architectural elements. Three methods are applied:

- Photos and drafts, initial observations of the luminous and ventilative environment in rooms were drawn. Moreover, the climatic responsive design of the house is explained more.

- Three-dimensional computer simulations such as Ecotect and Radiance are used to assume daylight distribution in the building. The simulation is tested in overcast sky conditions as the worst scenario.

- Assessment of thermal environment inside the house was conducted by Thermal Analysis Simulation (TAS) in conditions of hot humid tropical climate in Vietnam: no heating and use of natural ventilation. This quantitative analysis illustrates the thermal performance of each room tested in different cases. Finally, a range of architectural modifications will be applied to improve the current thermal environment.

The comfortable conditions indoor the case study through TAS were compared and assessed according to the national standard TCVN 9411:2012 for designing rowhouses in Vietnam. Referring to that, the limit of thermal comfort is from 22 to 28°C and its wider range between 20 and 29°C is acceptable [4].

5. Case studies

House No. 111 Trieu Quang Phuc Street was constructed in the 1920s and brings similarities in size and land shape, style of architecture and type of business among ancient houses in Cho Lon. The interior was renovated entirely in 2007 because of the need for family extension and improving living quality. The original facade is retained despite material alteration. This is a popular trend happening with the adjacent ancient shophouses on this street (Fig. 5). The height of some houses rises to four or five floors and buildings have a big volume. The appearance of the new modern houses in the ancient town affects the general appearance of architecture in this area.

Fig 5 - Site plan, context and functionary section of house 111 Trieu Quang Phuc Street

5.1 Building layout

The interior of this house was rebuilt entirely. According to the owners, the original house of two floors was replaced by a house of two floors, a mezzanine and a terrace. The total floor area has a capacity of 7 people.

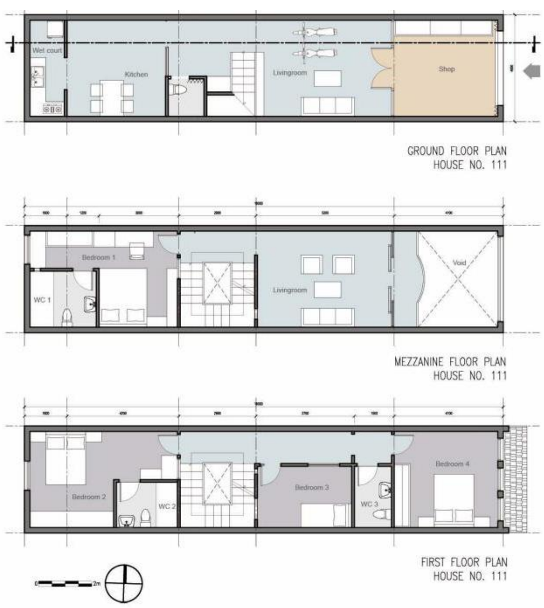

Fig 6 - Floor plans and section of House No.111

On the ground floor, the front room is a shop and the only entrance. The service rooms and stairs are positioned in the middle of the floor. A small living room is organised on this floor like a multi-function room - a public room, a place of motorbike parking at night and one of two altar rooms. The kitchen is minimised at the back of the house to leave a larger space for the dining room.

On the mezzanine, the layout is very simple with a large family room in the front and a master bedroom behind the staircase. The toilet is located at the end corner of the bedroom to leave space for a bed. On the second floor, due to the preservation of the ancient building envelope, the attic space was turned into three bedrooms. The front bedroom is also a mixed-use room: bedroom and altar. The bedrooms are connected by a narrow passageway. The expanded upper second floor is a terrace being used for storage and washing area and is being accessed by the iron stairs.

5.2 Environmental strategies

With most shophouses in Saigon, collecting outside daylight through side windows is very popular. However, the constraint of narrow frontage and a deep site plan is a reason for the glooming environment of middle rooms. The facade width and row housing typology also lead to few opportunities for side opening, even when the rooms are exposed to an open area of the neighbour. To increase light coming into the back of house 111, the envelope is pierced by windows casually in size, type and fenestration (Fig. 7).

Fig 7 - Windows on the back wall of bedrooms 1 and 2 of the house and on the facade looked from outside and inside of house 111

In the specific context of house 111, windows on the east façade are constrained. This also requires that the design of openings is attached to a design of shading elements. Unfortunately, the outer wooden shutters in the old house were also replaced by glass windows. The lighting penetration at 8:00 am is fine the sunlight in early mornings can reach all floors. At 10:00 am, the sunlight is cut off at the mezzanine and goes deep into the shop space. The roof overhang on the second floor starts to block out sunlight. This means that the direct light cannot penetrate inside the house after 10:00 am in all summer solstice, equinox and winter solstice except for shop. At noon, the sun is on the top. So, heat protection from the top is very important.

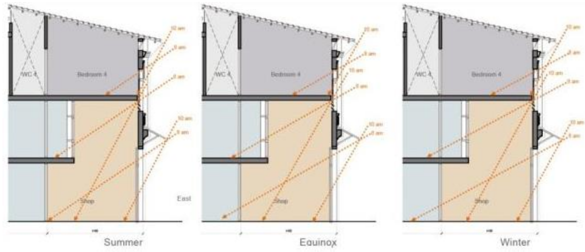

Fig 8 - Diagrams showing penetration and sun shading on facade hourly and seasonally

Through additional sunlight, the luminous environment of the lower spaces can be improved. The rooms on each floor towards the staircase open a sliding window to collect daylight in the courtyard. Thus, the luminous environment becomes better.

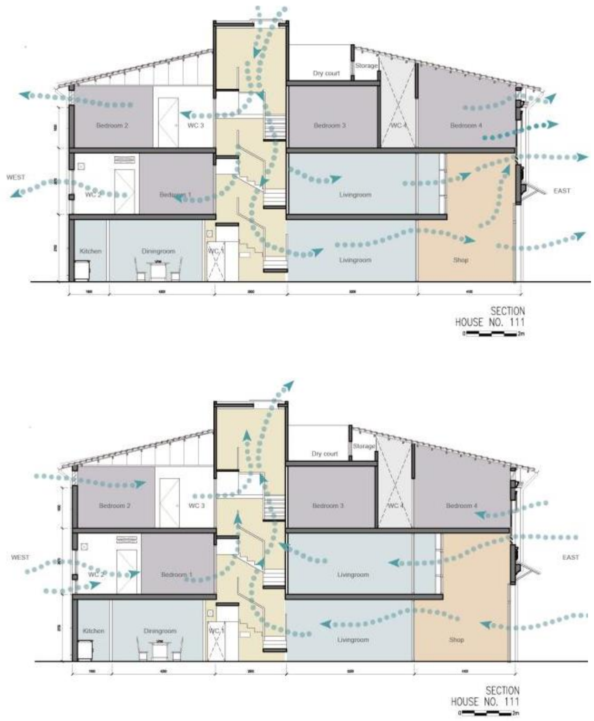

Fig 9 - Stack effect at daytime and night in house 111

In crowded urban development, the effectiveness of wind effects can meet difficulties. A solution to natural ventilation is the stack effect. If the stack effect can work, it can generate a moderate air exchange, but not a noticeable air velocity through the spaces [5]. In house 111, the use of stack ventilation and cross ventilation will control air movement better. The maintenance of moving air is to provide a balance of moisture in the air and cause a cooling effect as heat is removed from the body by convection and evaporation, especially in the dry seasons.

The effect of natural ventilation by the staircase is different during the daytime and at night. During the diurnal time, the air near the ground is burned rapidly, so the temperature here is also much higher and the relative humidity is lower than in upper zones [6]. This means that the air on top of the court is cooler and the relative humidity here is also better. This can produce a downdraft. As a result, heat input in each room is dissipated [7].

In contrast, at night, the air moves the opposite direction. The warmer air by the staircase will rise and be replaced at the bottom of the stack by cooler outside air. Especially, at nighttime, preservation of the air exchange and air velocity inside the house and through spaces is that the fenestration of openings should be deliberated because of security, rainwater. In house 111, to maintain the cross ventilation between rooms and staircase, sliding windows, doors and louvres upper room doors are organized on sidewalls.

6. Indoor comfort

6.1 Daylighting performance

In this section, Ecotect Analysis 2011 and Radiance software will show the daylight level of each room. These results will be evaluated with the requirements of CIBSE Comfort (2006). The daylight environment of all rooms is investigated in the worst condition – 12:00 pm under a cloudy sky in the winter.

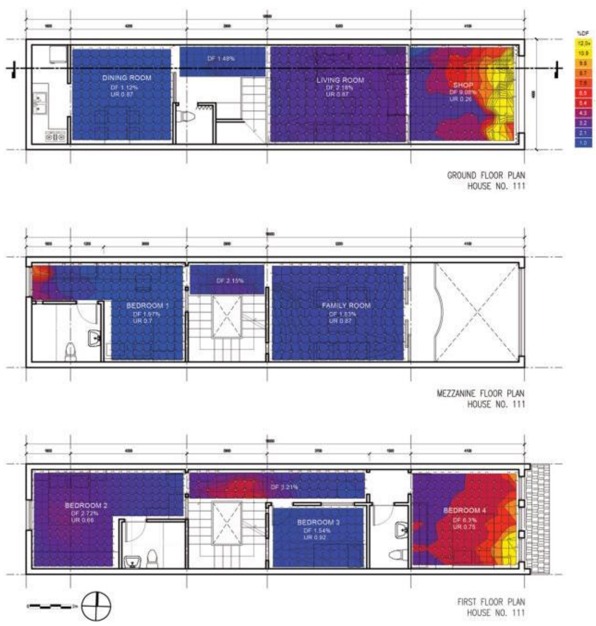

Fig 10 - Daylight distribution of all rooms in the existing house 111

Among the eight rooms, four have daylight factor is satisfied with a suggested minimum level of CIBSE Guide A (2006) – at least 1.5% for the bedroom and 2% for the living room. The daylight distribution of most rooms is even, whilst the luminous environment of bedroom 4 and shop is perceived as bright and over bright with DF of 6.3% and 9.08%. Although these rooms only welcome daylight during diurnal except in the early morning, the use of inappropriate finished materials and shading devices is the reason for excessive penetration of daylight. Over brightness means the number of heat absorbed by solar radiation is extreme.

In contrast, the light level of the kitchen, dining room and family room is the worst. The results for the two spaces are DF-1.12% for the kitchen and dining room and DF-1.83% for the family room. Artificial light is used regularly in the kitchen. Even if the full curtain wall in the front of the family room is designed to collect daylight as a secondary light adjacent space, this room still uses artificial light at certain times of the day.

6.2 Thermal performance

The thermal performance of the spaces is investigated by TAS simulations. The model was made based on the architectural forms, detailed construction, Ho Chi Minh weather condition and building aperture types of house 111 Trieu Quang Phuc Street. There are two cases - with and without natural ventilation which are examined to explain the impacts of the building envelope and natural ventilation on the internal thermal environment.

Fig 11 - Thermal performance in two cases - base case (above): without ventilation, case 1 (below): with ventilation

Both cases are tested on the hottest day: day 185 (4th of July), at 12:00 pm. The external condition on the testing day is 31.5°C and 65% relative humidity. This condition is hot and out of the comfort zone. There are some same patterns of thermal performance in both cases. The rooms on the ground floor are cooler and the ones facing the roof directly are hotter. A concrete slab on the ground floor will provide a desirable heat sink for daytime rooms (living room, kitchen and dining room). Additionally, the impacts of the sun from the top are also prevented significantly in rooms in lower zones. So, indoor temperatures are close to the day's minimum [5].

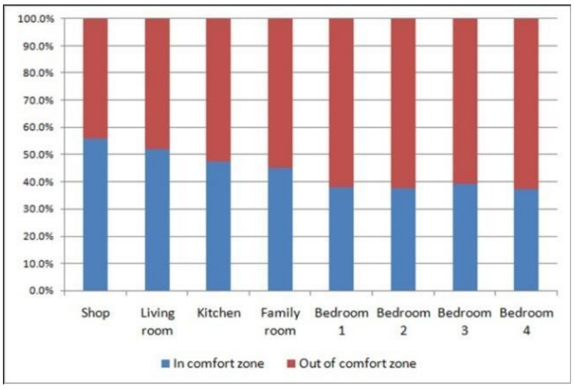

Fig 12 - Frequency of thermal comfort state of house No. 111– Base case

As observed from the above graph, in the base case, the conditions of the internal space are within comfort temperatures for about 40% of the time of the year. For the rooms on lower floors, total comfortable are greater (Fig. 12). In case 1, the thermal comfort is improved in all rooms. The frequency has stayed at 50%. Looking closer into the shop zone; the internal condition in case 1 is reduced slightly from the base case. Generally, natural ventilation shows a good strategy for expanding the thermal comfort zones of the internal spaces (Fig. 13).

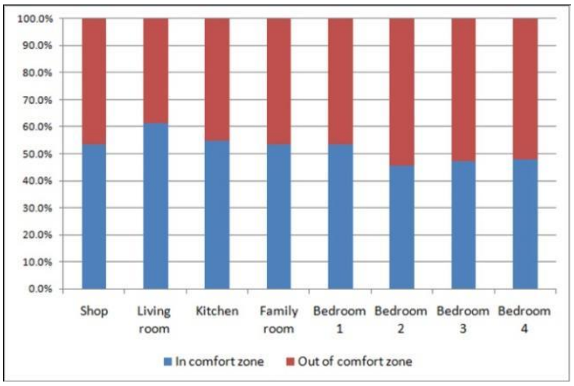

Fig 13 - Frequency of thermal comfort state of house No. 111– Case 1

7. Design proposal

From analyses of the advantages and disadvantages of house 111, seeking appropriate solutions to optimise the living condition in terms of environmental factors in the ancient street houses will be based on requirements of preservation of building envelope and budget. This means that the proposed ways of renovation will minimise demolition of the existing house but still ensure an increase of comfort for occupants.

For example, the renovation of the current house 111 is a typical scenario for ancient street houses in Cho Lon. To explain the results of each solution different case scenarios will be introduced:

Fig 14 – Base case

Base case: Indicates the current envelope: the window is a single-glazing aluminium frame, external/internal brick walls are 200mm and 100mm thick. The exterior doors/windows are closed (Fig. 14).

Case 1: Same as Base case, but the exteriors windows and entrance doors are opened on schedule. The result is that the thermal performance of the whole house may be changed. (Tested above) (Fig. 15).

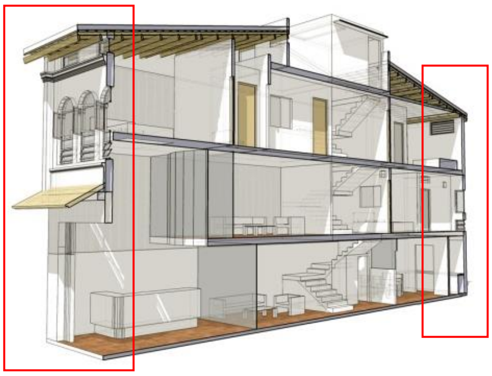

Fig 15 – Case 1

Case 2: as in Case 1, additional internal insulation is applied to external walls which are exposed to the sun. In the climatic condition of HCMC, the amount of solar radiation by horizontal and vertical exposure is high. This way, the building envelope can protect from heat absorption and reduce the mean radiant temperature.

Case 3: as in Case 2, back to a traditional way, the glass windows on the east facade are replaced by wooden shutter windows for purposes of natural ventilation and prevention of burning by the sun. A narrow and long opening organised the door of bedroom 4 plays a role as an outlet on the leeward side to increase air movement from the outside. Heat gain from the top down to this room is relieved better (Fig. 16).

Fig 16 – Case 3

Case 4: as in Case 3, in Vietnam, the sun's position is nearly at its peak and it radiates heat strongest in the middle of the day. The addition of overhead shading devices of rooflight not only ensures the effect of stack ventilation but also prevents direct sunlight partially. For this strategy, the height of shading bars needs to be considered to optimise the penetration of sunlight. The result is that the daylight and thermal environment is changed (Fig. 17).

Case 5: as Case 4: for the family room and bedroom 3, they are facing poor conditions of light and ventilation. The solid walls exposing the staircase are transferred by a full-height screen of wooden vertical louvres. One of two glazing curtain walls in the front of the mezzanine is taken out to bring tidiness to this room. The result is that the daylight and thermal environment of both rooms is changed (Fig. 18).

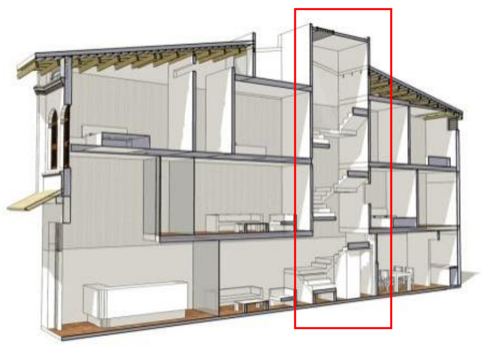

Fig 17 – Case 4

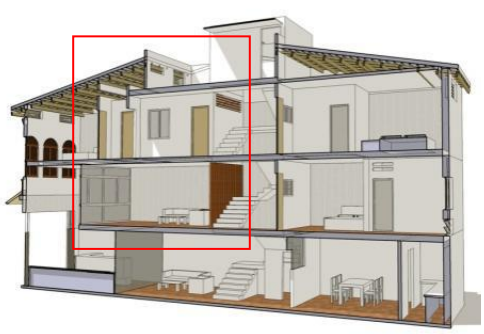

Fig 18 – Case 5

Case 6: as in Case 5: the layouts in the back of the house including kitchen and dining room, bedroom 1 and bedroom 2 is organised spatially: a void goes through from the ground floor to the roof; the windows of bedrooms and bathrooms are open to this void. The messy windows on the west wall are removed. A small nice green space is designed to bring spatial delight. The result is that the daylight and thermal environment of these rooms is changed (Fig. 19).

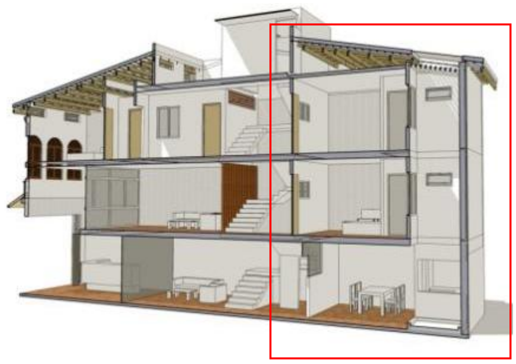

Fig 19 – Case 6

The step-by-step application of possible solutions shows an improvement of thermal comfort in house 111. Although there are some strategies which are only appropriate with some rooms, the achieved results are generally proved. In the above graph, the thermal performance in case 6 is the greatest in all cases with 4 solutions applied to increase internal living conditions. Particularly, the sixth step brings an impressive result for rooms at the back of the house: kitchen, bedroom 1 and bedroom 2. Their thermal condition increases more the 15% from the base case and more than 5% in Case 1. The appearance of another courtyard in the corner of the house introduces an opportunity to increase air convection and the effectiveness of both cross and stack ventilation, while categories of security and privacy are still ensured. In all cases 1-5, the annual total hours with comfort in the shop are stable. This best condition is achieved when the shop is closed and direct sunlight is kept out of the house while the low airflow is still preserved by an upper opening of the entrance door.

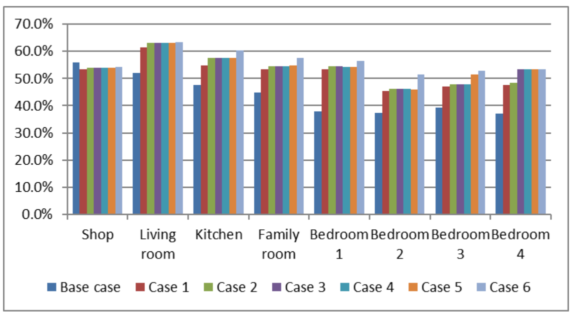

Fig 20 - Comparison in the percentage of thermally comfortable hours in different rooms between six cases

In the final scenario the internal daylight levels are numerically greater and the daylight distribution more even by applying solutions 3 to 6. The luminous environment of all rooms is perceived as well-lit and meets the minimum requirement of CIBSE Guide A except for the shop.

In conclusion, the renovation of house 111 in 2007 has improved the house significantly in terms of living spaces and utilities, there are still some problems of privacy and security of the bedrooms. From an environmental point of view, the opening of the skylight at the staircase brings many benefits to occupants both in terms of daylight and thermal comfort which disappears in the existing ancient street houses on Trieu Quang Phuc Street. Through the proposed design solutions, the internal thermal condition is also improved gradually and the greatest result can be achieved in case 6. The solutions are deliberately chosen in for them, low budget and the required preservation of the ancient town.

Fig 21 - Climatic responsive design of house 111 in the renovated case in daytime

8. Conclusion

Trieu Quang Phuc Street is one of the central roads in Cho Lon in the past and present. This place has an important value of history, culture and architecture in Saigon. One of the architectural identities in this area is shopouses which are facing challenges of the free renovation, urbanisation, modernisation and lack of awareness of local people even when they wish to live and keep their values of lifestyle, architecture and local culture [2]. The turbulent renovation has started in 1975 and has become an obvious need due to family expansions, improvement of living quality and the poor existing construction of the ancient dwellings. The special context of the ancient town will require strict regulations for renovation in preservation and development. The design strategies used in these dwellings, balance explaining how the exterior environment affected the occupants living in hot-humid climatic regions without artificial conditions.

Generally, the renovation proposal needs to fulfil environmental strategies and also the requirements of preservation in an ancient town as well as the needs of occupants. As mentioned above, it is clear that thermal comfort is influenced by many factors including design strategies, materials, exterior environment, lifestyle, activities of occupants and personal aspects. The success of renovation and conservation will require simultaneous contribution from urban managers, architects, conservation experts and occupants.

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