

# ANALYSIS OF CLIMATIC AND SOCIAL PERFORMANCES OF LOW COST TERRACE HOUSING (LCTH): INTRODUCING THE AFFORDABLE QUALITY HOUSING (AQH) CONCEPT IN MALAYSIA

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## Abstract

*Low cost terrace housing (LCTH) is the most common form and popular typology of public housing in Malaysia. The provision of the houses is deemed to be the most suitable to fulfil the needs to house low income families, and also as an alternative to high rise low cost housing. Since the implementation of these housing types, development on the layout and sizes of the house has taken place to provide for better living conditions. Literature review on the current LCTH suggested that there are deficiencies in fulfilling the requirements to provide quality and affordable housing for the low income families. This paper presents the scenario of the LCTH design based on secondary findings by researchers on housing in Malaysia. The secondary data provided the grounds for the proposal of affordable and quality housing (AQH) to handle the problems that occurred at the LCTH. Both social and climatic considerations are included in the AQH, addressing issues on privacy, segregation of genders and community interaction; along with thermal comfort and natural ventilation. Decisions on the AQH are carefully extracted from a comparison analysis in the view to improve the current conditions. In order to verify some of the decisions on climatic design strategies, simulation results are presented. The results indicated that the design decisions have managed to improve on the natural ventilation conditions at the low cost houses. With reservations on the social conditions that are*

*yet to be tested at the actual houses, the AQH has proven to be a step forward towards the provision of a better living environment.*

## Keywords:

Low cost housing; affordable quality housing; social and climatic consideration; natural ventilation.

## Introduction

As the most common form and popular typology of public housing in Malaysia, the low cost terrace housing (LCTH) has been highly researched and received many attentive reports regarding its achievements and deficiencies. The Ministry of Housing and Local Government of Malaysia has outlined this category of housing with recommendation of a ceiling selling price, household income of the target group, built up area and minimum design standards for the housing to be constructed. The houses are targeted to be sold at a price of up to RM 25,000 to a target group with a household income not exceeding RM 750. The houses are built with minimum design standards that specifies built up area of 550-600 sq feet

with two (2) bedrooms, a living room, a kitchen and a bathroom. This standard has since been changed to meet the current economic situation in the country and also react to the needs of the people. New Straits Times (dated 24th Apr 2001) has also reported that the current notion has moved towards a better and higher quality of houses for people. This reporting is in line with the Eighth Malaysian Plan that gives priority to the provision of adequate, affordable and quality houses, particularly for low and lower medium cost houses. Hence, the ideas of affordable quality housing (AQH) that improve on the current standards provided in the LCTH have been explored.

### Affordable Quality Housing (AQH)

Affordable Quality Housing Research presents an opportunity to bring the issues of affordability and the importance of proper housing into the broader public and nation context. This research tackled on issues of providing quality housing at affordable cost. The research also aims to propose housing designs that provides thermal comfort by way of natural ventilation through new planning layout and design. Besides fulfilling the basic needs of shelter, that is protection from the natural elements i.e. sun and wind, the AQH is also aimed to provide for physiological and psychological needs of human being.

Affordable Quality Housing is planned as housing development at affordable price. Affordability here is seen through the relationship between income and effective demand of a commodity. Affordability can also be defined as the ability or potential of a person to buy a house. Rose (2002) states that people can only

own a house at an affordable price if it will only take an amount of 30% of the overall house hold income. In Malaysia, a person is eligible to buy a low cost house if the household are earning less than RM 2500 a month. With this amount of income, house buyers are expected to afford paying around RM 700 for a house per month. That amount can be considered too high for some household especially for those with a much lower income or a bigger household. Ibrahim Wahab, et al (1993) in his paper reported that a research done in Pulau Pinang revealed that around 72% of the respondent with a monthly income between RM 200 – RM 800 were not able to pay a monthly instalment of more than RM 200. However, it is hard to justify the market, value and cost of total development to balance it with the affordability and needs of the people. Therefore AQH needs to meet the demand of providing affordable houses at the stage of purchase and consequently the running or maintenance cost, and quality houses that answers to the comfort needs of the targeted income group.

### Deriving to the AQH Design

Affordable quality housing design is supported by the incorporation of environmental friendly concepts expressed by the climatic and social factors. Basically, the environmental friendly concepts for AQH are developed based on literature reviews and secondary data collected by numerous researches done on the LCTH. The formulation of the AQH will be described in detail in the following sections. In order to justify the AQH design, comparative analysis will be made with the LCTH for both climatic and social factors. The qualitative comparisons are shown in a table format for both climatic and social

concepts. In order to test the performance of the AQH design, CFD simulations are carried out to acquire the wind speed data that is one of the main contributors to thermal comfort at naturally ventilated buildings in the hot humid climate.

### Environmental Friendly Concepts for AQH

Incorporation of environmental friendly concepts is the key factor in the formulation of Affordable Quality Housing (AQH) design. The environmental friendly concepts are viewed from the perspectives of climate and socio-culture that is seen as important contributors to affordable and quality housing in Malaysia. The application of these two factors are discussed and presented in the form of design strategies. Implementing these design strategies in the design of AQH is imperative to improve on the deficiency in the LCTH designs. AQH is a broad concept that incorporates various architectural and engineering approaches in the provision of housing. Design approaches in both fields are important in gearing towards the provision of houses that are both affordable and habitable for the people. The notion of affordable housing can be linked to cost effective housing that practices reduced material and energy usage. In turn, reduced energy consumption in the houses can be related to environmental friendly concepts that include the economical usage of energy derived from the resources from the natural environment.

As mentioned earlier, the design of affordable housing should take the right directions and necessary steps from the conception of the ideas through the design decisions and construction. In the conception of ideas, the architects and engineers have to consider the human and

physical factors in the planning of the spaces. The design decisions should be based both on the socio-cultural factors along with the physical solutions such as materials and systems choices. These steps are to provide habitable houses that are environmentally friendly, healthy and efficient in the use of energy and resources Noor Hanita (2004a).

### The Climatic Considerations

Fundamentally, the design of affordable quality housing should consider and take advantage of the hot humid climate. As discussed earlier, adhering to the requirements of buildings in the hot humid conditions will contribute not only to the comfort of inhabitants but also to the issues of affordability. The housing development today has depended on the aid of technology to create a comfortable living condition Abdul Majid (1995). Fans or air conditioning is highly used to cool the internal spaces of houses in Malaysia. Even though the hot humid climate permitted for natural ventilation and daylighting applications all year long, the houses still relied heavily on mechanical ventilation and artificial lighting. This is due to the negligence by various parties involved in the provision and construction of the houses which main concerns are on profit making in the delivery of houses for the public. The incurrence of high bills has to be taken seriously as this affect especially those with a lower income or those who live in low cost housing development.

The AQH looks into providing a design solution that suits the hot humid climate of Malaysia. Generally, the climate in Malaysia is characterized by high temperatures and humidity but with very low wind conditions. Malaysia is located in the tropical hot humid

climate that is characterized by uniform temperature, high humidity and copious rainfall. Malaysian Meteorological Department stated that the annual temperature variation is approximately 2° C and ranges from 21° to 32° Celsius. The humidity ranges from 70% to 100% (at an average of 80%) while the annual rainfall is high at approximately 2,500mm (100inches). Hence, buildings in this region need to be equipped with suitable architectural solutions, i.e. building designs that take into considerations the external as well as internal environments for optimum comfort of the inhabitants.

The considerations of external and internal environments are important towards achieving optimal positioning for the building. Building orientation has a direct bearing on the heat gain and penetration of sunlight into the houses that will in turn cause discomfort for the inhabitants. The orientation of buildings is a compromise to achieve the most favourable sun shading and allowance for cross ventilation for buildings. Basically, rectangular shape is recommended for buildings in this region with the shorter sides directed towards the East and West. This step will minimize building envelope's exposure to the east and west sides where sun radiation has the most impacts. The fenestrations should be located on the longer facades of the buildings (North and South) and the application of sun shading devices are encouraged. Apart from maximizing shading effect, orientation of building may be an attempt to catch prevailing breezes. Hyde (2000) propagated that the effect of air movement in buildings will contribute towards the provision of sufficient quality and quantity of air for activities, and personal cooling for the inhabitants. Commonly the terraced or linked houses in Malaysia are mainly designed

as naturally ventilated buildings. Therefore the design of the houses should be supporting the natural ventilation processes for natural cooling and ventilation comfort of the inhabitants.

The existing designs of LCTH fulfil the Uniform Building by Law (UBBL 1984) requirements in terms of provision of natural ventilation, i.e. fenestration area should be 10% of the size of a given room (Hui, 1998). Unfortunately, the air speed in Malaysia is very low and that resulted to poor indoor ventilation. Ninety-nine percent (99%) of the time, the speed inside the house is under the rate required and eighty-six percent (86%) of the time, the speed is below 0.25 m/s (Hui, 1998). This happens due to poor design solutions in inducing the wind to be utilised as passive means of ventilation. A similar study conducted also found that in low cost walk-up flats as well as two storey low cost terrace houses, the reading of the airflow meter shows that the air velocity is below 0.3 m/s. The research found that ninety-five percent (95%) of the inhabitants used active ventilation especially fans in their living and bedrooms in order to create air movement for comfort cooling, and seventy-three percent (73%) of them use active ventilation for 24 hours. This is in line with findings by Abdul Malik (2004) that suggests the possibility of achieving thermal comfort conditions with assistance of airflow. In another study, Abdul Razak (2003) proposed that the ideal velocity to achieve inside the houses is 1.0m/s or minimum of velocities between 0.25-1.0 m/s. Hence, the previous discussions showed that proper ventilation strategies and solutions are fundamental to improve the current thermal conditions of the LCTH.

To achieve total thermal comfort conditions at

naturally ventilated buildings is rather difficult. The average yearly data for Malaysia suggests that conditions are outside the thermal comfort zones recommended by many researchers. Webb (1959) and (1960) suggests that thermal conditions in the hot humid tropics can be achieved if temperature is up to 28.9°C; the humidity is 70% with an ideal velocity of 0.2m/s. A study in a thermal chamber on Malaysian by Abdul Malik (1993) also suggests that the comfort temperature acceptable for thermal comfort is between 25.5°C to 28°C. Even though the temperature conditions are similar to the comfort temperatures suggested earlier by Webb (1959 and 1960), Abdul Malik (1993) did not include the wind effect to his comfort studies. Based on the suggestions forwarded by the mentioned research works, investigations are conducted to gather the parameters that effect thermal comfort conditions in terrace houses.

Table 1 shows the field data gathered by a number of researchers on the current model of terrace houses. The data collected at different

field experiments shows similar data in terms of air temperature with the lowest reading is 26.3°C and the highest reading is 32°C. However, the highest reading is above the thermal comfort range as recommended by researchers of naturally ventilated buildings in the hot humid conditions. The humidity reading also shows more humid conditions than the suggested value of 70% by Webb (1960), while airflow is lower than the suggested minimum of 0.25m/s to achieve thermal comfort. In short, the field experiments clearly indicated thermally uncomfortable conditions at the samples of existing terrace houses.

In line with the provision of opening at ten percent (10%) of the floor area, the daylighting provisions are adequate. Studies on daylighting indicate that problems occur when proper daylighting strategies are not implemented at the living spaces of the LCTH that mainly has deep layout. Commonly LCTH has a narrow frontage and a deep layout with no openings on side walls that are shared with the houses on either side. The deep layout and location

Researcher	Air Temperature°C	(%) Relative Humidity	Air Velocity (m/s)
Harimi 2006	Outdoor 22.5-36.6 Indoor 26.3-31.1	-----	-----
Abdul Malik 1999	Indoor 26-32	-----	-----
Azni et. al. 2004 and Sri Wahyuni 2003	Indoor 27-31.5		0-0.14
Noor Hanita	Indoor 27-30	72-82	
Overall	Lowest reading 26.3 Highest reading 32	Lowest reading 72 Highest reading 82	Lowest reading 0 Highest reading 0.14

Table 1: Field Data Collected by Researchers on Terrace Houses. Source: Noor Hanita (2007).

of openings only at the front and rear facades have resulted to inadequate lighting levels for visual comfort in carrying out daily activities inside the houses.

The AQH intends to look into providing the best layout that responds to the given climatic conditions of the hot humid climate of Malaysia. The secondary data gained from other researchers become the background of the proposed AQH design. It is hoped that this attempt will help in enhancing the thermal comfort conditions, reducing the energy costs, assisting possibilities for daylighting and encouraging desired air flow through suitable ventilation. This can be achieved through optimum architectural designs and suitable provisions to address the climatic factors.

### The Social Considerations for AQH

In the context of the Habitat Agenda, Malaysia is committed to building social and physical infrastructure such as housing and social facilities (Ong, 2001). On this note the housing development is focused towards providing houses that promotes the social agenda of a healthy community. Interactions between neighbours should be promoted through the planning and layout of housing. The design of common terrace or link housing units in Malaysia should support and enhance interactions between the residents. By sharing common spaces arranged linearly, possibilities of interactions are increased, i.e. arrangement of entrance and living areas at the frontage of houses. However, in actual living conditions the interactions are limited by the inclusion of the car porch in front of the living areas. This hinders the possibilities of effective social interactions between the residents and the passers-by.

Mohd Tajuddin and Ghofar (2003) promoted and stressed on the importance of walking culture in a housing community to enhance interactions between residents. Introducing walking routes and providing public amenities in a housing development should be a vital contributor in achieving the essential interactions among residents in a given neighbourhood. The interactions between the residents and the community can be enhanced by having longer façade for each housing units and re-positioning of the car porch in the AQH neighbourhood.

The family patterns and structure also have significant effect on the design and planning of the internal spaces in the housing units. The provision of housing in Malaysia has the requirement of a minimum of three bedroom units. This attempt was based on the social requirements of separations between parents and children, and among children of different genders. The specification imposed on housing units is deemed to be important to curb social problems that started in homes. A housing environment that is not supportive of the family activities and lifestyles will cause the inhabitants i.e. children to spend time outside the home Norhazlinah (1995) and Nurizan (2000). Apart from the number of bedrooms, the basic requirements are living, dining, kitchen and bathrooms of suitable sizes. A research by Zaiton (2000) discusses regulations of privacy by the residents of LCTH in relation to the layout and the activities at houses that have minimum standards at a built-up area of 500-600 sq. ft. (45-56 sq m). The mentioned researches revealed that the provisions of adequate and conducive spaces in the public housing are important to support and encourage healthy family interactions and activities. Based on

these findings the AQH design has included the provisions to cater for the family patterns and culture of the people through adequate number of rooms and suitable sizes to conduct the daily activities.

The designs of terrace or linked houses are generic for Malaysian families regardless of their religion or norms. The low cost housing is designed to accommodate the basic needs of a family and may not fulfil the needs of a specific religion. For example, the needs of gender segregation during social functions have not been the outlining criteria in the design of internal spaces of the public low cost housing. Even though traditionally this factor has been accommodated in the traditional house form of the Malay (Lim, 1987), for possible reasons due to considerations on cost and space constraints, some of the important religious and norm criteria are not met. This can be noted in the lack of priority given to meet the needs of privacy for Moslem ladies in the house in the presence of visitors. Open layout without partition walls allows for visual access from living area (public/male domain) to the kitchen area (female domain) where in this instance the women folks need to cover themselves according to the Islamic prescription. The design of fenestration at the houses may also affect the privacy requirements. The decisions for observing privacy needs may contrast the requirements of the climate where the privacy require for an enclosed space while the hot humid climate calls for generous openings to facilitate natural ventilation. The designers need to decide how to strike a balance between the two requirements.

The AQH needs to incorporate the

recommendations to achieve better social conditions inside and between the housing units. Issues of adequate number and sizes of rooms should be met for the comfort, privacy and requirements of the people.

### Comparative Analysis of LCTH versus AQH

The external and internal environment should support the climatic and socio-culture requirements to achieve the environmental friendly concepts. Hence, the AQH should adhere to requirements of climatic factors that include geographical locations, solar shading, orientation, natural cooling and ventilation, and socio-cultural factors that include neighbourhood quality, family patterns / structure, daily activities, religions and norms. Table 2 discusses the comparative analysis of the social and climatic factors between LCTH and the proposed AQH design. It also highlighted the modifications and incorporations of design strategies to improve the current design of LCTH.

### Performance of the AQH

Both socio-cultural and climatic factors should be balanced in order to achieve successful design for the AQH. As suggested by Salmon (1999), a well-designed building in the hot humid climate should take advantage of the climate and designed to encourage interaction with the environment without compromising one's privacy. Based on the discussions on the application of environmental friendly concepts the AQH design was planned. Figure 1 (a-b) shows the AQH with the passive strategies incorporated into the design.

	Low Cost Terrace Housing (LCTH)	Affordable Quality Housing (AQH)
<b>CLIMATIC</b>		
Energy Use	<ul style="list-style-type: none"> <li>• Rely heavily on fan cooling, electrical lighting and air-conditioning due to deep layout and narrow frontage layout planning for LCTH.</li> </ul>	<ul style="list-style-type: none"> <li>• Minimize energy usage through passive design strategies that allow for cross ventilation through a wider frontage layout planning</li> <li>• Encourage stack effect passive cooling through inclusion of 'air well' or void.</li> <li>• Thermal comfort enhancement through encouraging natural ventilation and sunshading</li> </ul>
Cross Ventilation and Daylighting	<ul style="list-style-type: none"> <li>• Minimal openings limited indoor and outdoor contact and allowance for natural ventilation and day lighting.</li> </ul>	<ul style="list-style-type: none"> <li>• Wider frontage (9 meter) maximizes the potential for cross ventilation and natural daylighting to the AQH.</li> <li>• Introduction of full height windows that facilitates cross ventilation and day lighting.</li> <li>• Inclusion of void to facilitate/ encourage stack effect cooling</li> </ul>
Sun-Shading	<ul style="list-style-type: none"> <li>• Compartmented spaces that disrupt air flow.</li> <li>• No consideration on the housing orientation in response to the sun path. Considerations are mainly on maximising the number of saleable units in a housing development.</li> <li>• Minimal overhangs above opening (approximately 300-600mm) where the interior spaces are exposed to sun penetration</li> </ul>	<ul style="list-style-type: none"> <li>• Open layout at public and semi-public areas to allow for maximum airflow</li> <li>• The house orientation should take into consideration of the sun path. The layout of the houses is elongated on the east-west axis (up to 22' from the E-W axis) to minimise exposure to direct sunlight.</li> <li>• Suitable projection length for roof (900-1200mm) to promote sun shading and decrease direct heat gain inside the houses.</li> </ul>
<b>SOCIAL</b>	<ul style="list-style-type: none"> <li>• Layout are not designed according to the inhabitant culture core</li> <li>• The number of rooms does not provide privacy and separation for family members. The existing houses have two (2) or three (3) bedrooms and one (1) bathroom.</li> <li>• Sequence of spaces does not provide privacy to the family members especially during the presence of guests</li> <li>• Narrow frontage limit interaction to the outside due to the shorter perimeter facing the neighbours</li> </ul>	<ul style="list-style-type: none"> <li>• Consideration of social domain i.e. public, semi public and private in space planning.</li> <li>• Adequate number of rooms to meet current guidelines and requirements. Provisions of three (3) bedrooms and two (2) bathrooms for AQH.</li> <li>• Provisions of privacy through the articulation of the spaces where there is proper segregation between public, semi-public and private domains.</li> <li>• Wider frontage allow for greater interaction</li> <li>• Spaces are designed for conducive utilization</li> <li>• At the same time the wider frontage can be the alternative car park for owner or visitor</li> <li>• 1 car parking space provided</li> </ul>

Table 2: Comparison of Social and Climatic Considerations in Low Cost Housing and Affordable Quality Housing (Source: Author).



Figure 1 (a-b): Passive Strategies Incorporated into Design (Source: Author).

### Verifications of the Climatic Concepts of AQH through CFD Simulations

The effectiveness of the climatic strategies as part of the environmental friendly concept implemented on the AQH is yet to be tested. The theories adopted for the passive design strategies are based on the results of previous researchers and vernacular approaches in the vernacular design of the hot humid climate Noor Hanita (2002 and 2004b). Hence, the CFD simulation is the tool to compare the performance of the LCTH to the AQH. The LCTH and AQH are simulated in a three row layout with two wind directions at 0° and 45° angles. The simulation results are shown in both numerical analyses; where wind profiles are taken at 1.5m and 4.5m heights. The numerical results show the horizontal distribution of averaged internal air velocities and horizontal deviation with reference to the preferred air velocity (Table 3 and 4). Overall the numerical results indicate that the average internal air velocity is higher in the AQH with lower deviation percentage from the recommended 1m/s air velocities.

Model	ROW	Range of Internal Air Velocity	% Deviation 1.0 m/s preferred Air Velocity (%)
EM	Row 1	0.14 to 0.19	-86 to -81
	Row 2	0.05 to 0.17	-95 to -83
	Row 3	0.01 to 0.13	-90 to -87
AQH	Row 1	0.39 to 0.50	-61 to -50
	Row 2	0.14 to 0.21	-86 to -79
	Row 3	0.41 to 0.53	-59 to -47

Table 3: Average Internal Air Velocity and the Percentage of Deviation for EM and PM (0° Wind Direction) (Source: Author).

LCTH indicate a low average internal air velocity at both wind directions. The results are similar to field test results with the range between 0.01 to 0.19 m/s at all rows at the 0° wind direction. However, at 45° wind direction, the average internal air velocities are higher at 0.06 to 0.27m/s. However, these figures are still weak and do not reached the 1m/s limit for thermal comfort. The deviation from 1m/s ranged

between 73-94%. The AQH shows higher figures at both 0° and 45° wind directions. The average internal air velocities at 0° are 0.39 to 0.50m/s with a percentage of deviation 50% to 61% from 1.0m/s. At 45°, the average internal air velocity for the AQH ranges between 0.03-0.70m/s with a deviation as low as 30% at row 3.

Model	ROW	Range of Internal Air Velocity	% Deviation 1.0 m/s preferred Air Velocity (%)
EM	Row 1	0.07 to 0.14	-93 to -86
	Row 2	0.04 to 0.27	-96 to -73
	Row 3	0.06 to 0.16	-94 to -84
AQH	Row 1	0.18 to 0.44	-82 to -56
	Row 2	0.03 to 0.19	-97 to -81
	Row 3	0.23 to 0.70	-77 to -30

Table 4: Averaged Internal Air Velocity and the Percentage of Deviation for EM and PM(45° Wind Direction) (Source: Author).

Overall, there are better performances of airflow in the AQH design that indicates an improvement to climatic design performances of the LCTH. However this preliminary attempt is still in the research and testing process. Modifications maybe required in altering the designs that were proposed solely based on literature review. Further research is planned to refine the design of the AQH to achieve the targeted indoor environmental conditions.

## Conclusions

The foregoing discussions suggested that the application of the climatic and socio-cultural considerations in housing planning and spatial

designs supports the environmental friendly concepts. The design of AQH based on these concepts shall indeed contribute towards cost and energy savings in the long run as much as it contributes to the household comfort and social well being of the people. The proposed new approaches towards Affordable Quality Housing suggested some measures to address some prevailing problems of the existing housing, in particular LCTH. The AQH could be the solution to enhance the thermal comfort conditions, reduce energy costs, and encourage the use of daylighting and natural ventilation. The CFD simulations indicate positive results that can be that basis of further improvement on the AQH design. The provisions of adequate and conducive spaces at the AQH would also support and encourage healthy family interactions and activities. It is hoped that this proposal will mark a beginning to new varieties of designs in catering for the needs of social and climatic issues in housing design. It is important to note that these considerations are indispensable part of realising affordable quality housing in Malaysia.

“It is a vision that every single house of future Malaysian will be able to live in a comfortable housing and environment.”

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