

The Importance of Roof Thermal Insulation: Awareness among Professionals and Terrace House Occupants

Farhana Mohd Razif
*School of Housing, Building and
Planning*
Universiti Sains Malaysia
Penang, Malaysia
farhanarazif@usm.my

Mohd Hamdan Ahmad
*Faculty of Built Environment &
Surveying*
Universiti Teknologi Malaysia
Johor, Malaysia
b-hamdan@utm.my

Leng Pau Chung
*Faculty of Built Environment &
Surveying*
Universiti Teknologi Malaysia
Johor, Malaysia
pcleng2@utm.my

Abstract— Terrace houses are the typical housing typology in Malaysia. Thus, study on thermal comfort is always associated with terrace houses. Installing roof thermal insulation is important in energy saving, however, due to the availability of air conditioning it has not been a regular practice. To reduce air conditioning usage, thermal insulation must be installed under the roof. The study aims to determine the awareness level among professionals and terrace housing occupants on the importance of installing roof thermal insulation in terrace houses in Malaysia. Studies were made on government's initiative towards roof thermal insulation, current practice by developers and architects, and terrace housing occupants' knowledge on roof thermal insulation. The study was supported by review and analysis of previous research, government's official publications, magazines, books and websites. The study found that professionals are aware on the importance of the roof thermal insulation for comfort and energy saving while occupants are very much less aware of its important.

Keywords— *roof thermal insulation, terrace houses, Malaysia, awareness, thermal comfort.*

I. INTRODUCTION

Achieving thermal comfort inside our own house does not only benefits one's health, but also giving the opportunity for someone to be comfortable and able to function effectively. While achieving thermal comfort was not an issue back in 1950s, it is quite hard to feel comfortable nowadays inside current brick and concrete houses, especially in the city area where the houses are very close to each other and trees are less available to shade the houses [12].

To overcome thermal discomfort, it is a common practice to install air conditioning due to its affordability, availability and popularity. However, using air conditioning for long hours leads to higher monthly electricity bill and more power usage which leads to greater release of greenhouse gases [11]. While using air conditioning to reduce indoor temperature is still preferred by occupants, the amount of heat that enter the building should be reduce by installing passive measures such as modifying house design or installing insulation and louvres.

This study focuses on terrace houses as it is the highest number of houses in Malaysia that is 36.4% out of 7.34 million houses [8]. For terrace houses, the highest heat gain is through the roof, where 50% of heat that enters double storey houses is through the roof. Further, at least 75% of heat that enters single storey terrace houses is through the roof.

To reduce heat gain from entering the building through roof, the study will focus on the practice and installation of roof thermal insulation. Various researchers find that by installing roof thermal insulation, indoor temperature can be reduce up to 5°C [15]. The aims of this research are to analyze government initiatives on roof thermal insulation and the awareness of roof thermal insulation among professionals and occupants.

II. THERMAL COMFORT IN MALAYSIA'S TERRACE HOUSES AND THE NEED OF ROOF INSULATION INSTALLATION

A. Evolution of House Typology and Occupants' Thermal Comfort

Most Malaysians during the earlier times live in traditional Malay houses that was designed to suit local climate and lifestyle. The houses were built from phosphorous materials and surrounded by trees. But as technology becomes more advanced over the years, Malaysia has made a lot of infrastructure improvement in terms of transportation, availability of various raw materials, urban planning, and building construction technology. Availability of these new technology and techniques allowed buildings to be rapidly built with less constraints such as remote location and unavailability of certain materials. This lesser limitation gives architects the flexibility to experiments various design such as international style that was famous during that time. Unfortunately, the international design was brought into Malaysia and was accepted by architects without considering the country's tropical climate of [5].

Previously, house owners have the power to decide in terms of house design, choosing the house maker, house location and other decisions related to the construction of a house. As construction technology changed, house owners no longer have much says in their house design. Nowadays, to own a house, someone must buy a land together with the

house that was designed and constructed by developers. Owners must accept the design and materials assigned by developers and consultants.

Now, most houses especially low-cost houses are constructed using heavy weight and high thermal materials such as concrete and brick that absorb, store and release heat into the house. These materials caused excessive thermal discomfort among occupants, but it is still the best materials from construction point of view because of cheaper price, availability, flexible to be shape and easier to mixed with other materials such as steel, timber and glass. [4,12]. Current house design and material used leads to thermal discomfort due to high indoor temperature [16].

B. Using Air Conditioner to Reduce Thermal Discomfort

To reduce indoor temperature of houses, occupants rely on air conditioning due to its popularity and easily available in the market. However, the usage of air conditioning leads to high energy consumption for cooling purposes [9]. Figure 1 shows a study done by Centre of Environment, Technology and Development Malaysia [6] on energy usage in Malaysia’s residential houses which indicates that the highest electricity usage is for mechanical ventilation, such as air conditioning and fan.

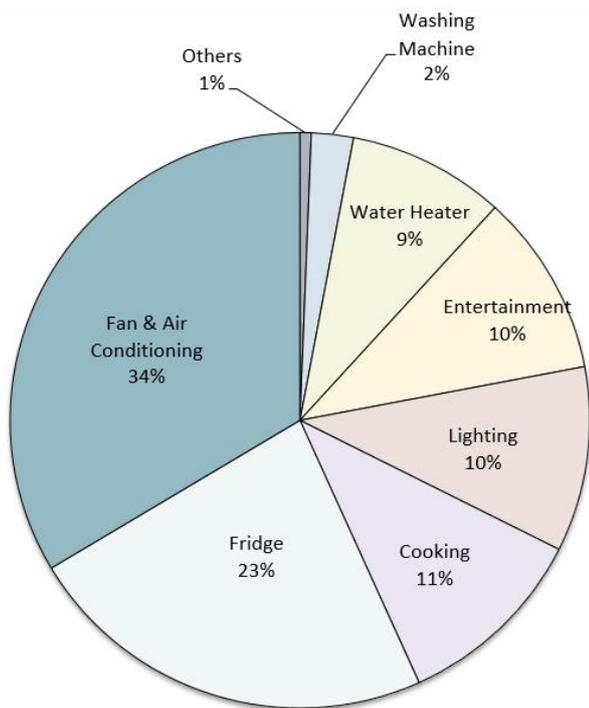


Fig. 1. Average electricity usage for selected houses in a few cities in Malaysia [6].

Another study on space cooling in hot and humid climates shows that between air conditioning, lighting, equipment, and others, air conditioning takes 56% from the energy consumption. The high energy consumption for air conditioning in hot and humid climate is also influenced by the need to deal with indoor air humidity by reducing the air temperature below its dew point, which resulting in even lower than the required temperature, thus further waste of energy [10].

C. Use of Thermal Insulation to Reduce Heat Gain through Roof

Installation of roof thermal insulation can reduce heat gain from the sun. A study by CETDEM on heat differences of a double storey terrace house before and after the installation of thermal insulation shows reduction in internal temperature. In the study, wool roof insulations are installed under roof tiles, and louvers are installed 600mm in front of all windows. The windows were opened periodically to maximize air flow through the building. Table 1 shows the temperature at three location inside the house, which are attic, 1st floor and ground floor. The measures applied were able to reduce internal temperature of a house up to 6°C [7]

TABLE I. TEMPERATURE AT DIFFERENT LOCATION INSIDE A HOUSE BEFORE AND AFTER THE INSTALLATION OF ROOF THERMAL INSULATION, SUN SHADINGS AND SCHEDULED VENTILATION [7].

Location	Before (°C)		After (°C)	
	Minimum	Maximum	Minimum	Maximum
Space between roof and ceiling (Installation of roof insulation)	34	37	28	31
First floor (Roof insulation and louvres)	31	33	28	30
Ground floor (Louvers)	30	32	27	30

Similar study was done by Malaysian Insulation Manufacturers Group (MIMG) and the result shows that the installation of roof thermal insulation can reduce internal temperature at 3°C to 5°C [14]. While studies show that installation of roof thermal insulation can lower internal temperature of houses, the usage of it is still not common among terrace houses occupants.

III. GOVERNMENT’S INITIATIVES AND DEVELOPER’S AWARENESS ON INSTALLATION OF ROOF THERMAL INSULATION AT TERRACE HOUSING IN MALAYSIA

A. Initiatives by Malaysia Government, Agencies, and Organizations to Promote the Installation of Roof Thermal Insulation in Malaysia

In the Malaysia Tenth Plan (or known as RM10) by Malaysian Government, one of the initiatives is to increase the use of roof thermal insulation in air-conditioned building to drive energy efficiency efforts. However, compared to the previous Malaysia Plan, there’s no tax exemption on roof thermal insulation purchasing. It is not the price of roof thermal insulation that is the concern but the awareness on importance of roof thermal insulation among occupants [4].

Even though there is no more tax exemption on roof insulation purchasing, government and government agencies are promoting the usage of thermal insulation in various platform. For example, in the Energy Malaysia magazine published by Energy Commission Malaysia, there is one section specifically on effective strategy for efficient energy that explains the benefits of installing insulation [4]. Similarly, in Green Technology, an activity book for students produced by Ministry of Energy, Science, Technology, Environment and Climate Change (KeTTHA), it is stated that installation of roof insulation can reduce indoor temperature and thus reduce electricity usage [22].

The application of roof thermal insulation is taken more seriously in Sabah. Starting from August 2017, Kota Kinabalu City Hall (DBKK) requires all new building plan submissions to incorporate energy efficient Overall Thermal Transfer Value (OTTV) and roof insulation codes [18]. Kota Kinabalu’s Mayor, Datuk Yeo Boon Hai state that installation of roof thermal insulation is important because roof receive the most solar radiation for the longest period throughout the day.

The initiatives made by agencies and organizations in Malaysia to reduce heat gain in building are increasing. Malaysia Green Building Confederation (MGBC), a body consists of consultants, academia and representatives from the building industry in Malaysia launched “Cooler Building” campaign on May 2018 [2]. During an interview regarding the campaign, its President stated that reducing the cooling load in the building is one of the key factors in the success of energy-saving measures. MGBC also has successfully work with ministries and professional body to incorporate new clause in Uniform Building By-Law 1984 (UBBL) which requires all new buildings to be designed to reduce heat gain.

B. Current Practice on Roof Thermal Insulation Installation among Developers and Architects

While in designing stage, the final decision is usually determined by developers or clients. A study by Farhana on developers’ initiatives to install green features shows that the developers did use ‘green’ and ‘healthy’ words when promoting their projects, but the green approach is on greeneries only [21]. They produce brochures that shows houses surrounding by nature and showcase their show houses situated inside lushes of greeneries to give the cool and healthy image. However, there are almost no installation of sustainable green feature on the houses. The study also found that the small percentage of houses that were installed with sustainable green feature are high cost projects.

The typical reason of installing sustainable green features including roof thermal insulation in high cost houses is mainly to increase the house value and price. House owner that afford to buy high cost houses have the luxury to choose houses with extra features. Meanwhile, for medium and low-cost houses, there are less consideration and promotion on green features because usually the buyers and house owners are more interested only with cheaper price that they can afford.

The study then continues to see architects’ awareness and influence on roof thermal insulation installation on new terrace housing projects. About 89% of the architects have assigned roof thermal insulation on houses that they designed. When asked who they think have the power to decide either to install roof insulation or not, 54% agree that architect have the power to decide while 46% said that the decision is on developers or owners.

This shows that the professionals are aware on importance of installing roof installation of terrace houses, but developers will only install roof thermal insulation on high cost projects. This finding is supported by Ahmad’s research that developers stated that they have no objection to install roof thermal insulation if requested by house owners, but only 60% of them willing to approve installation of roof thermal insulation if requested by architects [22].

IV. ROOF THERMAL INSULATION AWARENESS AMONG OCCUPANTS

A. Case Study 1: Occupants’ Awareness on Roof Thermal Insulation in Johor Bahru

The study aims to analyze occupants’ awareness and knowledge on the importance of installing roof thermal insulation in terrace houses. A total of 356 occupants were chosen from low cost housing, medium cost housing and high cost housing around Johor Bahru area [21].

The respondents were asked on their willingness to install roof thermal insulation in their houses and the results are shown in Figure 2. Out of the 356 respondents, almost half of them, that is 46% did not want to install roof thermal insulation. Another 19% have installed the roof thermal insulation, where some of them were installed from the beginning by developers when they constructed the house. 11% of the occupants are willing to install roof thermal insulation and another 24% did not know about roof insulation.

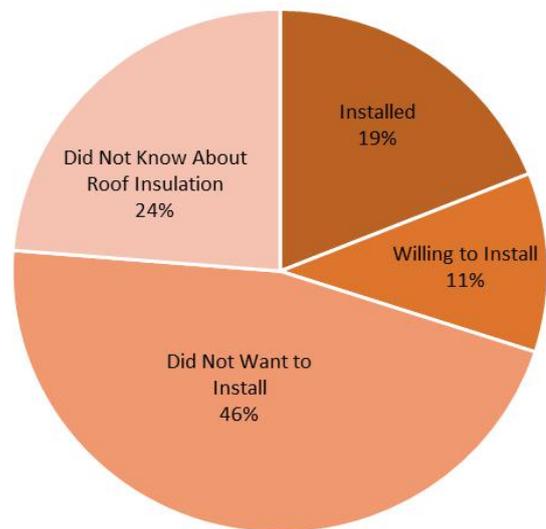


Fig. 2. Occupants’ willingness to install roof thermal insulation in their houses [21].

In another section, the respondents were given five statements and they are to rate them as either highly disagree, disagree, neutral, agree or highly agree. The five statements are as in table 2.

TABLE II. STATEMENTS TO DETERMINE OCCUPANTS’ KNOWLEDGE ON THERMAL INSULATION [21].

No	Statements
Statement 1 :	Installation of roof thermal insulation reduce indoor temperature.
Statement 2 :	Installation of roof thermal insulation will reduce electricity bill.
Statement 3 :	Roof thermal insulation does not need maintenance.
Statement 4 :	It is more economical to install roof thermal insulation than use air conditioning.
Statement 5 :	All houses need to install roof thermal insulation.

Figure 3 shows the result of the survey. More than two out of three respondents agree and highly agree with

Statement 1 that the installation of roof thermal insulation can reduce indoor temperature and Statement 2 that is the installation of roof thermal insulation will reduce electricity bill. For Statement 3 and 4, half of the respondents voted agree and highly agree, while 46% of the respondents agree and highly agree with Statement 5.

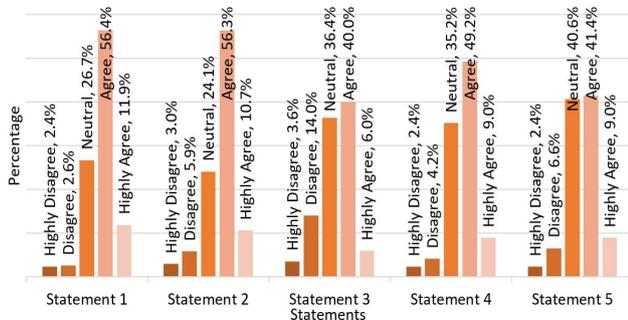


Fig. 3. Occupants opinion on statements as shown in Table 2. [21]

B. Case Study 2: Housing developers and home owners awareness on implementation of building insulation in Malaysia

The survey on occupants' awareness on roof thermal insulation was conducted to see how popular roof thermal insulation is among Malaysia's home owners. Out of 147 respondents, only 54% of them knows what building thermal insulation is. Later, the researcher explained to them about building thermal insulation and the benefits of installing insulation materials such as to lower electricity bills and reduction of greenhouse gases emissions. The brief explanation by researcher has managed to change home owners' perception that 90% of them later showed enthusiasm to install roof thermal insulation in their houses. The study showed that, when provided with enough information, occupants are willing to install roof thermal insulation in their houses [20].

V. CONCLUSION

The study discusses the current practice and awareness on installation of roof thermal insulation in Malaysia. The findings of this study are: -

- 1) Government are creating awareness to the occupants to install roof thermal insulation on their houses by educating them through magazines and starting young using school work book.
- 2) State government and city councils have the power to enforce the installation of roof thermal insulation on new houses. Kota Kinabalu city council has taken the measure.
- 3) Developers are willing to install roof thermal insulation if requested by house buyers but may not adhere to the advice by their architect.
- 4) Architects must make a common practice to specify roof thermal insulation in their house design.

- 5) Half of the terrace housing occupants were not aware of what roof thermal insulation is about, but after a good explanation, they became aware of the importance of roof thermal insulation that almost all of them were willing to install roof thermal insulation.

REFERENCES

- [1] Abdul Halim, N. H., Ahmed, A. Z., Zakaria, N. Z. (2012). Thermal and Energy Performance of Pitch and Wall Insulation for Air-Conditioned Buildings in Malaysia. *Applied Mechanics and Materials* Vols. 209-211, pp. 1766-1769.
- [2] Ahmad, S (2018). How to make Malaysian buildings cooler while using less electricity. *Malay Mail*, Retrieved from <https://www.malaymail.com/s/1657861/how-to-make-malaysian-buildings-cooler-while-using-less-electricity>
- [3] Ashraf, S. M. (2017). *Practical Design of Reinforced Concrete Buildings*. Boca Raton, Florida: CRC Press
- [4] Aziz, H. (2017). Effective Strategy for Efficient Energy. *Energy Malaysia*, 12, pp. 24.
- [5] Cambon, N. (1990). *German Colonial Architecture in Togo*.
- [6] CETDEM (2006). *Malaysian Urban Household Energy Consumption Patterns*. Centre for Environment, Technology and Development, Malaysia. Retrieved on 31 May 2018 at http://cetdem.org.my/wordpress/?page_id=2600.
- [7] CETDEM (2007). *Demonstration & Documentation Centre for Sustainable Energy Solutions for Urban Households*. Centre for Environment, Technology and Development, Malaysia. Retrieved on 17 April 2018 from http://cetdem.org.my/wordpress/?page_id=2534#results.
- [8] Department of Statistics Malaysia (2013). *Characteristic of Living Quarters*. Putrajaya: Department of Statistics Malaysia
- [9] Ja'afar, M. F. Z. (2007) *Domestic air conditioning in Malaysia: Night Time Thermal Comfort and Occupants Aadaptive Behaviour*. Ph.D. Dissertation/Master's Thesis. UCL London
- [10] Katili, A. R., Boukhanouf, R., Wilson, R. (2015). *Space Cooling in Buildings in Hot and Humid Climates – a Review of the Effect of Humidity on the Applicability of Existing Cooling Techniques*. 14th International Conference on Sustainable Energy Technologies – SET 2015. Nottingham: Visit Nottinghamshire
- [11] Lehmann, S. (2014). *Low Carbon Cities: Transforming Urban Systems*. Abingdon: Routledge
- [12] Lim, J.Y. (1987). *The Malay house: rediscovering Malaysia's indigenous shelter system*. Kuala Lumpur: Institut Masyarakat.
- [13] Lubis, I. H., Koerniawan, M. D. (2017). *Reducing Heat Gains and Cooling Loads through Roof Structure Configurations of a House In Medan*. HABITechno International Seminar – Ecoregion As a Verb of Settlement. Bandung, Indonesia: Institut Teknologi Bandung.
- [14] Malaysian Insulation Manufacturers Group (2009). *First Malaysian Study on Mineral Wool Insulation in Malaysia Impact of Housing Insulation in Malaysia*. Kuala Lumpur: FMM – Malaysian Insulation Manufacturers Group.
- [15] MOSTI (2014). *September 2014 Monthly Weather Bulletin*. Ministry of Science, Technology and Innovation. Available at: http://www.met.gov.my/index.php?option=com_content&task=view&id=846&Itemid=1586 [Accessed 2017].
- [16] Nugroho, A. M., Ahmad, M. H. & Ossen, Dilshan Remaz. (2007). *A Preliminary Study of Thermal Comfort in Malaysia's Single Storey Terraced Houses*. *Journal of Asian Architecture and Building Engineering*, (May), pp.175-182.
- [17] Paramount Property (2012). *Sejati Residences Features*. Sejati Residences. Available at: <http://www.sejatiresidences.my/master-plan/green-mission/> [Accessed January 4, 2013].
- [18] Shalina, R. (2017, February). *New buildings required to meet green building requirements*. *Borneo Post Online*, Retrieved from <http://www.theborneopost.com/2017/02/19/new-buildings-required-to-meet-green-building-requirements/>
- [19] Szokolay, Steven V. (2014). *Introduction to Architectural Science: The Basis of Sustainable Design* 3rd ed. London: Routledge.

- [20] Yacouby, A. A., Sulaiman, S. A., Khamidi, M. F. (2011). Housing developers and home owners awareness on implementation of building insulation in Malaysia. *WIT Transactions on Ecology and the Environment*, Vol 148, pp 219-229. Southampton, UK: WIT Press
- [21] Mohd Razif, F. (2015). Tahap Penerimaan Semasa Pengguna terhadap Penebat Haba Bumbung Rumah Teres di Johor Bahru. PhD dissertation / master's thesis, Universiti Teknologi Malaysia.
- [22] Yunus, H. M. (2018). Modul Teknologi Hijau : Fizik (Aktiviti Murid). Universiti Sains Malaysia, Pulau Pinang: CETREE.