

## A survey of housing features and thermal comfort of medium and low income earners in Thailand

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### Abstract:

House design is influenced by the climate and the culture of people at a location. Thailand is located in tropical climate with low wind velocity and ambient air is humid. Climate of each region is different due to their location. This paper aims to study typical house design of low and medium income in rural area of each region of Thailand including interviewing and measuring parameters required for thermal comfort assessment. Each houses type features are showed and analyzed comparing with living style, climate and tradition of people in each region. Thermal environment and comfort are also recorded and calculated for each region. Results indicate that typical houses features of low and middle income earners of each region are different up to their life style, climate and traditional. Neutral temperature of each region is also different. People in the southern feel comfort under higher operative temperature than other regions. And neutral temperature of Thai people is different from PMV assessment scale.

**Keywords:** Low income housing; residential house design; Tropical housing design

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## 1. Introduction

Traditional house design is up to living style, climate and knowledge of each region to provide thermal comfort and livable under disaster of each area. In the middle of Thailand, traditional houses are 2-story house and the downstairs are opened especially for houses near river area to be livable under annual flood situation (Faculty of Architecture, Silpakorn University, 2010). Traditional houses in northern (Faculty of Art and Architecture, Rajamangala University of Technology Lanna, 2010) and north-eastern (Faculty of Architecture, Khon Kaen University, 2010) of Thailand are near the same feature. Because of living style is the same. The rice field is in the low area while the house is located in the high area. The houses are 2-story, upper floor is constructed using wooden materials while lower floor is opened (but now is added by concrete walls). Traditional houses in the southern are constructed by using local materials such as wood, while modern houses are built from concrete materials (Faculty of Architecture, Rajamangala University of Technology Srivijaya, 2010). Thermal comfort study in typical houses of each region has not yet been done or only rough study has been done.

This research aims to study on features and thermal comfort of typical houses of in Thailand. House configurations of each region; advantage and disadvantage including thermal comfort are discussed and reported in this research.

## 2. Method

The method used in this research was a field survey. Four regions of Thailand were selected for this study i.e. The north, north-east, South and middle of Thailand. One province of each region was used in the survey (Fig. 1); Chiang mai (yellow), Ubon ratchathani (green), Pathum thani (red) and Phuket (blue) province were selected for north, north-east, south and middle region respectively. The target buildings include typical houses in each region and residential buildings of National Housing Authority (NHA) of Thailand who is a state enterprise that provide housing for low and middle income earners. Survey times of 12 houses and 12 NHA houses were selected per region for interviewing and survey (Table 1).



**Fig. 1** Survey location in each region.

**Table 1** Target building of the survey

Region	Building target	Units
Northern	Typical houses	12
	NHA houses	12
North-eastern	Typical houses	12
	NHA houses	12
Middle	Typical houses	12
	NHA houses	12
Southern	Typical houses	12
	NHA houses	12

A questionnaire and measuring items on house features, energy uses in buildings and thermal comfort was designed for the survey, required information are as in Table 2. Dry bulb temperature, relative humidity, wind velocity, globe temperature including activity and clothing level of interviewees are also measured and recorded.

**Table 2** Details of the required information in the questionnaire

Required data	Details	Interview/ Survey	Measure	Measured parameters
General information	General information of residents and houses	√	-	-
Data of energy uses	History of energy uses and energy uses for lighting, cooking, entertainment, convenient, small business or industrial and transportation	√	-	-
Changing trends in energy use	Changing trends in energy use	√	-	-
House configuration	Configurations, size and material of roof, wall, glazing and interior walls	√	-	-
Material types and quantities	Types and materials of construction materials	√	-	-
Thermal and visual comfort	Thermal and visual comfort level	√	√	DB temp, Globe temp, Wind velocity, %RH, Light illuminance

The data obtained from the surveys were used as follows; (1) to compare house features including advantage and disadvantage of each region, (2) to calculate thermal comfort assessment indicators using Fanger's comfort equation; Predicted mean vote (PMV), Operative temperature ( $T_o$ ) of each typical house type are calculated.

### 3. Results and discussions

#### 3.1 Features of typical houses of each region and thermal environment

##### ▪ Northern region

Most houses of low and middle income earners in the northern region are now renovated to be a single story house with high roof and gypsum board ceiling as shown in Figs. 2 and 3. Many old typical houses are renovated from 2-story wooden house to be the single story wooden house as shown in Fig. 2 because most people who stay in the houses are children and elderly people, to use the upstairs is very difficult for them.



**Fig. 2** single story wooden typical houses in the northern region

New houses are also constructed to be the single story house but wall materials are concrete block plaster as in the Fig. 3.



**Fig. 3** new single story houses in the northern region.

There are many windows on wall facades with well shading, lead to use daylighting and natural ventilation in the spaces. No lighting and air conditioner were used during survey.



**Fig. 4** Interior of houses in the northern region.

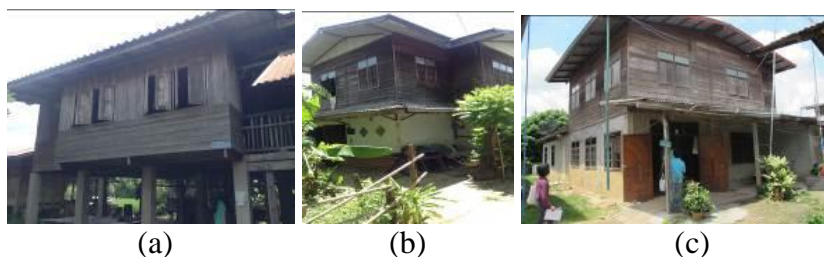
Thermal environments of the typical houses in the northern are as in the Table 3. Air and globe temperature in the spaces are not too high, most air movement is from natural ventilation and CO<sub>2</sub> is in the normal level.

**Table 3** Thermal environments of the typical houses in the northern

	Air temp. (°C)	Mean radiant temp. (°C)	Air speed (m/s)	Relative humidity (%)	CO <sub>2</sub> (ppm)
Max	34.1	34.5	0.8	70.3	537.0
Min	30.6	31.1	0.2	58.9	310.0
Ave	32.4	32.6	0.6	65.1	473.3

▪ *North-eastern region*

Typical houses in the north-eastern region are 2-story wooden houses (Fig. 5) like in the northern region before renovated. In the past, there is only the upper floor which is constructed by wood. Downstairs are opened as in the Fig. 5(a). Presently, the houses are renovated by adding concrete walls on the first floor as in the Fig. 5(b)-(c). Windows are in all direction of walls without shading device for the first floor, no lighting is needed during the daytime but temperature in the spaces is relatively warm.



**Fig. 5** 2-story wooden typical houses in the north-eastern region.

In most houses which has only elderly, the second floor are used just to be a storeroom. Bedrooms and appliances are moved to the first floor (Fig. 6 (a)-(b)) because during daytime the temperature is too high and difficult for elderly for climbing to the second floor during night time. The second floor is used just only a big family houses which has younger people who go to work or study in the daytime and go back in the evening (Fig. 6(c)).



**Fig. 6** Interior of houses in the north-eastern region.

Air and globe temperature in the spaces are high for typical houses in the north-eastern. Force ventilation by fan is used in most houses except in case of opened space of downstairs (Table 4). And CO<sub>2</sub> is in the normal level but slightly higher than the northern region.

**Table 4** Thermal environments of the typical houses in the north-eastern, Thailand

	Air temp. (°C)	Mean radiant temp. (°C)	Air speed (m/s)	Relative humidity (%)	CO <sub>2</sub> (ppm)
Max	36.2	38.2	3.8	68.9	564.0
Min	31.5	31.7	0.0	51.0	451.0
Ave	33.1	33.3	1.2	63.1	497.7

▪ *Southern region*

In the southern region, most typical houses are single story (Fig. 7). Most houses are constructed by concrete block with plaster.



**Fig. 7** Typical houses in the southern region

The roof is high but no ceiling is used in most houses (Fig. 8).



**Fig. 8** Roof and ceiling of houses in the southern region

In some houses, ventilation in the spaces is poor, a number of windows are very small or the windows are closed according to bad smell (Fig. 8) although wind speed is very high around the houses.



**Fig. 9** Interior of houses in the southern region

Air and globe temperature are high, small amount of natural ventilation is used (Most wind speed is from fan. And CO<sub>2</sub> level is normal (Table 5).

**Table 5** Thermal environments of the typical houses in the southern, Thailand

	Air temp. (°C)	Mean radiant temp. (°C)	Air speed (m/s)	Relative humidity (%)	CO <sub>2</sub> (ppm)
Max	34.0	34.7	4.1	65.4	615.0
Min	31.6	31.6	0.0	56.9	407.0
Ave	32.9	33.1	1.1	59.7	477.6

▪ *Middle region (Near Chao Phraya river)*

Houses in the middle region are mostly a 2-story to be livable under annual flood situation. The second floor is constructed by low mass materials such as wood or gypsum board while the first floor is opened or constructed by concrete walls (Fig. 10). Wind speed is around 0.3-1.5 m/s around the houses (near river) and there are many windows in all façades, natural ventilation and the use of daylighting is very effective.



**Fig. 10** Typical houses in the middle region.

The bedroom and toilet are almost on the second floor except in case of the first floor is added concrete walls and there are 2 toilets in the houses, the first floor will be frequently used during warm and cold season (Fig. 11).



a) Upper floor bedroom      b) Upper floor toilet      c) Lower floor bedroom

**Fig. 11** Interior and toilet of houses in the middle region.

Air and globe temperature are not too high, most wind speed is from natural ventilation. And CO<sub>2</sub> level is normal (Table 6).

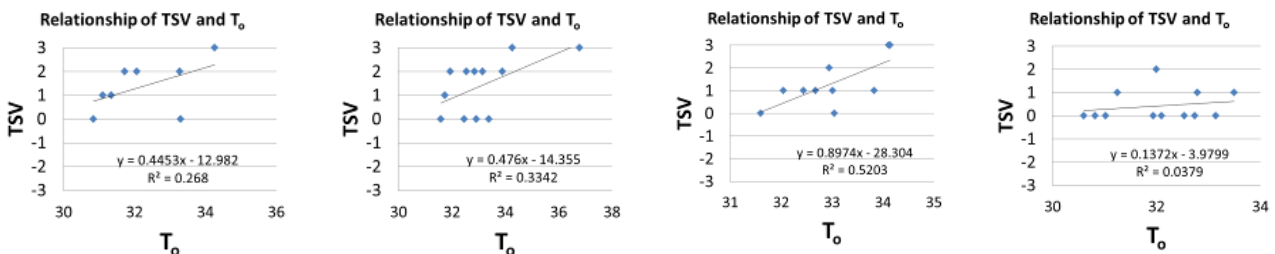
**Table 6** Thermal environments of the typical houses in the middle, Thailand

	Air temp. (°C)	Mean radiant temp. (°C)	Air speed (m/s)	Relative humidity (%)	CO <sub>2</sub> (ppm)
Max	33.5	34.1	1.7	67.7	619.0
Min	30.6	30.6	0.0	58.0	424.0
Ave	31.8	32.3	0.6	62.5	497.3

### 3.2 Thermal comfort assessment of each typical house type

- Thermal sensation value (TSV) and operative temperature assessment ( $T_o$ )

Fig. 12 shows that neutral temperature (Operative temperature) in the spaces of the northern, north-eastern, southern and middle of Thailand are 29.15, 30.16, 31.54 and 29.01 respectively. It indicates that thermal comfort of people in each region is different. People in the southern feel comfort at highest operative temperature while in the middle; people required the lowest operative temperature.

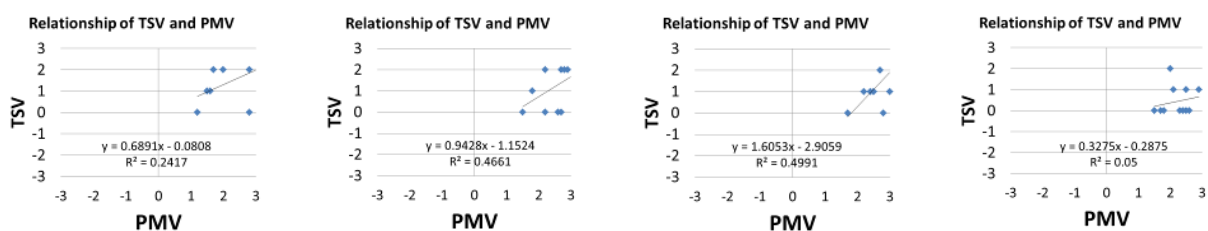


a) Northern      b) North-Eastern      c) Southern      d) Middle

**Fig. 12** Relationship of TSV and  $T_o$  of each region.

- Thermal sensation value (TSV) and Predicted Mean Vote assessment (PMV)

Fig. 13 shows relationship of TSV and PMV of each region and indicates that at the neutral temperature (TSV=0), PMV is in the positive zone. This result comply with many researches which indicate that people in the each region of the world is different and different from PMV assessment.



a) Northern      b) North-Eastern      c) Southern      d) Middle

**Fig. 13** Relationship of TSV and PMV of each region

#### **4. Conclusion**

Typical houses features of low and middle income earners of each region are different up to their life style, climate and traditional. Most old houses are constructed by wood while new houses are renovated or built by concrete materials. Neutral temperature (Operative temperature) of each region is also different. People in the southern feel comfort under higher operative temperature (31.54°C) than other regions while people in the middle feel comfort at the lowest operative temperature (29.01°C). In addition, neutral temperatures of Thai people are different from PMV assessment scale.

#### **5. Acknowledgement**

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