The Status of Existing Building Materials in Thailand to Cope with Future Climate: Wall Component

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Abstract. Climate change tolerant building materials, such as high temperature resistance and flooding resistance, affect living condition of people in an accommodation. This study focuses on durability features of building material related with climate change in Thailand. The result suggests that the property of each wall material type cannot show proper value of tolerance and climate change resistance. Therefore, the conclusion for future tolerant building material properties are that the $U$-value should be greater than 0.64 W/m$^2$k, the $R$-Value should be greater than 0.64 m$^2$k/W, and the $K$-Value should be less than 0.155 W/m°C. Such values can cope with temperature up to approximately 49 degree Celsius. Apart from that, flood resistance should be less than or equal to 2%, water penetration should be less than or equal to 1.5% and swelling test should be less than or equal to 12%. This will be able to cope with flood that lasts about 60 days. The results of the study is a guideline for future wall material design and development.

1. Introduction
Climate change causes changes in temperature, rainfall, extreme weather condition, hurricane, storm surge and season period. Nowadays many countries face these problems. Similarly, Thailand is undergoing the rising temperature and flood[1]. According to Thailand's future climate change prediction, it is likely to have higher average temperature and more precipitation across the country[2]. The changes affect various sectors of the agricultural industry, including the housing and building sector which is relatively affected. The damage caused by climate change prompts many organizations to find ways to reduce environmental pollution and adapt themselves to cope with it. The high temperature has direct impact on roof and wall. Flooding causes the decay of wall and floor, while wall is affected by both high temperature and flooding[3]. In the past, material selection factors are price, quality, beauty and brand reliability[4]. However, wall material has to be able to tolerate with future climate change. Therefore, the high temperature tolerance and water resistance. Due to what mentioned above, this study will find the answers of the questions; what is the suitable building materials for future climate changes and how much material will be available to support that change. This study aims to find possibility of creating and developing wall material for future climate.

2. Methodology
2.1. Climate Change Information
This study use existing information of future climate to estimate wall material properties in order to cope with future climate. The RCM (regional climate model) from SEA START RC database is mainly used[5]. This data covered 100 years (2000-2099). In addition, the database from Meteorological Department, Geo-Informatics and Space Technology Development Agency (Public Organization) – GISDA[6] and Hydro and Agro Informatics Institute (HAI) are also used in this study. This study makes
use of the highest temperature (degree Celsius) and highest precipitation (millimetre) related to the number of flooding period of each year.

2.2. Climate Change Effect Analysis
After collecting climate change data, the data is put in a grid format and plotting lines to find out what the prominent value of the climate change is by dividing the most obvious period into four periods of 25 years. For high temperature, information is directly used from the database. Due to too many related factors such as speed, strength, water level, storm surge, water volume in the dam, drainage and frequency, the study investigates only flood data on rainfall and number of flood days by studying the damage that has occurred in the past. And because precipitation is the main cause of flood, estimating flood risk by using data from linear regression of the relation between precipitation and number of flood days is another method. ‘Figure 1’ is a figure's linear regression of flooding that demonstrates correlation (R) equal 0.597. Even if the number of correlation is not notable height, its consistency with rainfall is the most important factor creating flood.

![Figure 1. Linear regression of flooding](image)

After mentioned methods, the next is selecting the range of both temperature and flood line graph in ‘Figure 2’ where the lines are most sloping and similar to find the characteristic of durability of wall construction material.

2.3. Material Characteristic Analysis
The factor related to building material and climate change is heat resistance which includes U-Value, R-Value and K-Value. The followings are durability parameter and durability equation.

\[
Q = U \times A \times \Delta T \quad (1) \quad \quad \quad U = \frac{1}{R} \quad (2) \quad \quad \quad R = \frac{\Delta X}{K} \quad (3)
\]

Q = heat transfer rate \( W/(m^2 \cdot ^\circ C) \), \( U \) = overall heat transfer coefficient \( (W/m^2 \cdot ^\circ C) \), \( A \) = heat transfer surface area \( (m^2) \), \( \Delta T \) = difference in temperature, \( R \) = overall thermal resistance \( (m^2 \cdot ^\circ C/W) \), \( \Delta X \) = the wall thickness \( (m) \) and \( K \) = the thermal conductivity of the material \( (W/(m \cdot K)) \).

Water resistance properties include water absorption (%), permeability (%) and swelling test value (%).

2.4. Building Material Survey
Data is collected by creating a tool for collecting data from both building material and research. Wall material can be divided into 21 types which are 1. White brick 2. Brick or red brick 3. Light weight brick 4. Concrete block 5. Real wood 6. Artificial wood 7. PVC/plastic 8. Precast concrete 9. Metal/sheet metal 10. Iron/Steel 11. Aluminum 12. Glass 13. Gypsum 14. Fiberboard 15. Ceramic 16. Terracotta Tile 17. Granite Tile 18. Tile Lane 19. Insulation 20. Color and 21. Coating.

Primary survey comes from buan&BEYOND home department store, The Siam Cement Group Public Company Limited (SCG) and Global House Public Company Limited. Secondary survey comes from researching the information from websites of ThaiLIS –thai library integrated system and copyright information from department of intellectual property.

3. Result
3.1. Climate Change in the Future
According to the collection of highest temperature of each year. The second period (2025-2049) was chosen. By using a temperature of 49 degrees as the initial temperature to calculate the durability, the second period’s graph is steeply above the other ranges and the average temperature is 44.75 degrees Celsius[2]. The flood data can be used to estimate future climate by using historical data for making linear regression. The number of the longest flood period is 50-60 days, which is the flood occurred in Thailand in 2011.

![Figure 2. Average high temperature and precipitation graph](image)

3.2. Properties of Wall Material Suitable for Future Climate Change.
For high temperature resistance, the heat transfers to the building wall shall be less than or equal to 30 watts per square meter[7]. The result is as following; Heat Resistance (U) ≥ 1.55 W/m2K from equation (1), Heat Resistance (R) ≥ 0.64 m2K/W from equation (2) and Heat Conductivity (K) ≤ 0.155 W/m °C from equation (3). Flood durability of wall material should have new criteria. According to the research, the material durability varies in each type. The method are collecting information and find the median value to determine the value that all types of material can use. The results are water absorption ≤ 2 % from EN 12087, water penetration ≤ 1.5 % and swelling test ≤ 12 %[8].

3.3. Present Situation of the Wall Materials
The situation is analyzed via GAP ANALYSIS and statistical data (Matrix Diagram), with creating the table with the new criteria. Durability data and the most durable value are shown by using bold and italic font to indicate the value qualified durable by the criteria specified in Table 1.

**Table 1.** Situation of the wall materials.

| No | Types         | Heat resistant | Water resistant | swelling test |
|----|---------------|----------------|-----------------|---------------|
|    |               | U ≥ 1.55 W/m²K | R ≥ 0.64 m²K/W | water penetration |
|    |               | K ≤ 0.155 W/m °C | water absorption | ≤ 2 %        | ≤ 1.5 %      | ≤ 12 %       |
| 1  | White Brick   | 0.75           | x               | < 18          | x            | x            |
| 2  | Brick         | x              | x               | ≤ 18          | x            | x            |
| 3  | Light weight Brick | 0.98 | x              | x               | x            | x            |
| 4  | Concrete Block | 0.15 | 0.13           | 30             | x            | x            |
| 5  | Real Wood     | x              | x               | ≤ 5           | x            | x            |
| 6  | PVC / Plastic | 1.854          | 0.539           | x             | x            | x            |
### Table 1: Material Properties

| No | Types                  | Heat resistant | Water resistant | Swelling test |
|----|------------------------|----------------|-----------------|---------------|
|    |                        | $U \geq 1.55$ W/m²K | $R \geq 0.64$ m²K/W | $K \leq 0.155$ W/m °C | water absorption $\leq 2\%$ | water penetration $\leq 1.5\%$ | $\leq 12\%$ |
| 7  | Artificial Wood        | $\times$        | $\times$        | $\times$      | $\times$ | $\times$ | $\times$ |
| 8  | Precast Concrete       | 0.88            | 1.14            | 0.175         | 13      | $\times$ | $\times$ |
| 9  | Metal / Sheet Metal    | $\times$        | $\times$        | $\times$      | $\times$ | $\times$ | $\times$ |
| 10 | Steel / Metal          | $\times$        | $\times$        | $\times$      | $\times$ | $\times$ | $\times$ |
| 11 | Aluminum               | $\times$        | $\times$        | $\times$      | $\times$ | $\times$ | $\times$ |
| 12 | Glass                  | 0.024           | $\times$        | $\times$      | $< 5$   | $\times$ | $\times$ |
| 13 | Gypsum                 | 0.191           | 5.592           | 0.027         | $\leq 2$ | $\times$ | $\times$ |
| 14 | Fiber board            | 1.854           | 0.539           | 0.083         | 30      | $< 5$   | $\times$ |
| 15 | Ceramic                | $\times$        | $\times$        | $\times$      | 10      | $\times$ | $\times$ |
| 16 | Terracotta Tile        | $\times$        | $\times$        | $\times$      | $\times$ | $\times$ | $\times$ |
| 17 | Granite Tile           | $\times$        | $\times$        | $\times$      | $\times$ | $\times$ | $\times$ |
| 18 | Tile Lane              | $\times$        | $\times$        | $\times$      | 0.05    | $\times$ | $\times$ |
| 19 | Insulation             | 0.025           | 2.679           | $\times$      | 0.00015 | $\times$ | $\times$ |
| 20 | Color                  | $\times$        | $\times$        | $\times$      | $\times$ | $\times$ | $\times$ |
| 21 | Coatings               | $\times$        | $\times$        | $\times$      | $\times$ | $\times$ | $\times$ |

Of 309 researches, the researches focusing on high temperature resistance are 98.38% and focusing on flood resistance are 1.61%.

### 4. Discussion and Conclusion

The gap of this study is flood resistant material. Material with high water resistance and water permeability is rarely found[9]. Swelling value, which is a test when the material is soaked and inflated, may pass the criteria but that is still not satisfying. Future material should have swelling value at least 12%. Because the value affects the most on material durability[10], this durability should be highly developed[11]. Flood resistant material is scarcely focused by researchers. Apart from that, despite not much satisfying, high temperature resistant wall material passes the new criteria. U-value is 0.304 W/m²K higher than new criteria. R-value with the highest thermal resistance is 5.592 m²K/W. K-value is 0.128 W/m °C. The results suggest that high temperature resistant wall material should be developed for better heat resistance.

Standard criteria of building material should always be adjusted and developed in order to support the current situation and cope with the future circumstance[12]. Besides, quality is another important factor for consumers. They should be able to distinguish the characteristics of each material in order to choose the most proper material for demanding application[13]. Because of not being well informed in the past,
they lacked understanding about building material properties. Therefore, the government and the council of Engineers should take part in acknowledging consumers[14].

5. References

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Acknowledgement
Financial support from the National Research Council of Thailand (Scholarships for Graduate Students) in 2018 for this research project is gratefully acknowledged.